Application of Satellite Data to Protected Species Management and Bycatch Estimation

By Chris Orphanides

Goals of Presentation

1) Provide a brief overview of the use of satellite-derived datasets in the NEFSC

2) Show how these data have been made accessible and used for Protected Species Bycatch Estimation and Management

Monitoring Ecosystem Primary Production

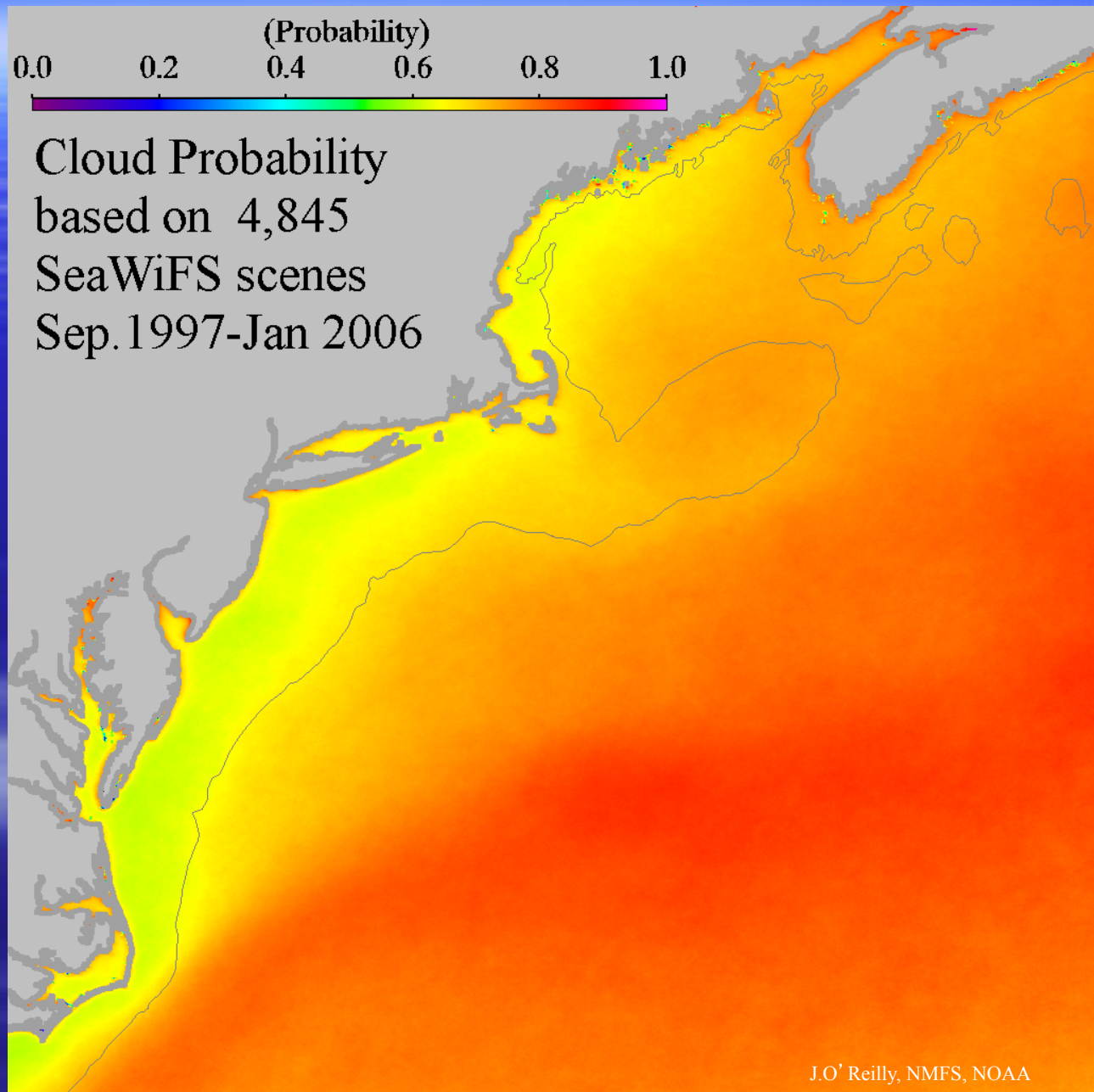
With Satellite Ocean Color & Thermal Sensors

Clouds ???

Region	Good Data
Nearshore	~ 2.5 days
Outer Shelf	~ 4 days
Slope Water	~ 5 days
Gulf Stream	~ 9 days

Satellite Sensors: Good ecosystem monitoring method for this region

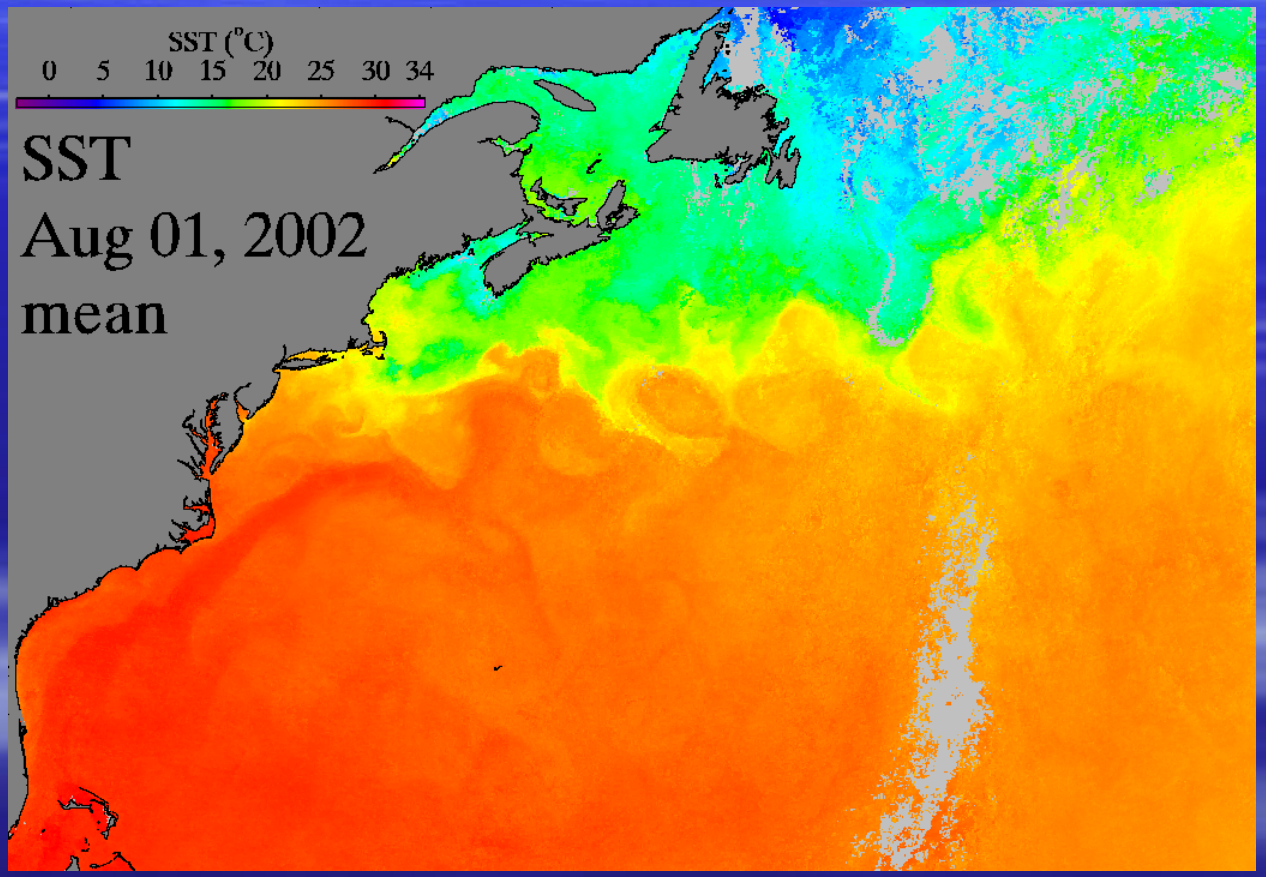
Cloud Probability



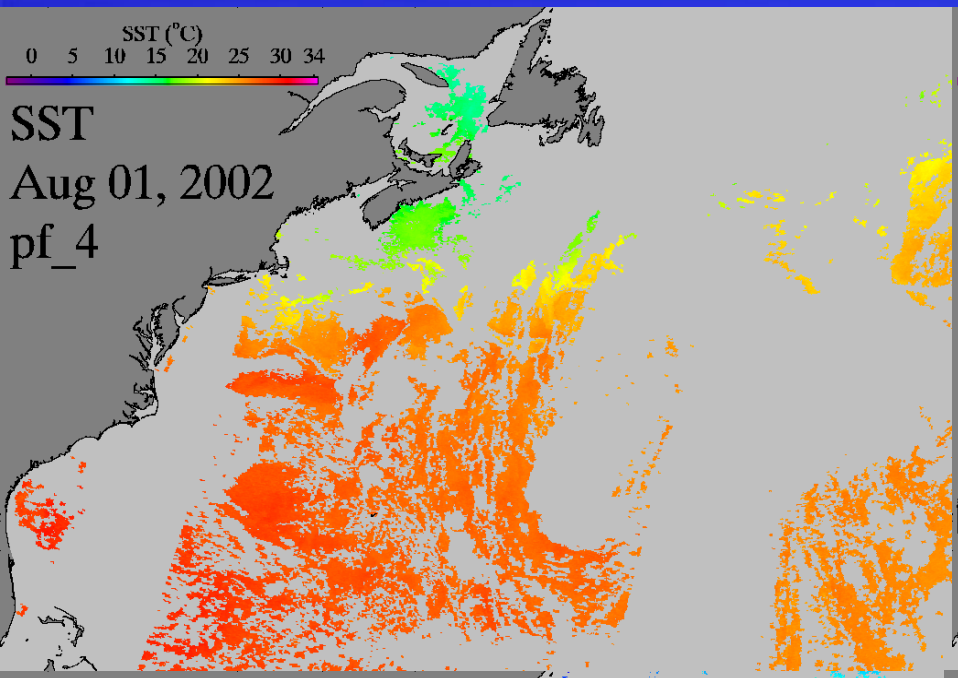
J.O' Reilly, NMFS, NOAA

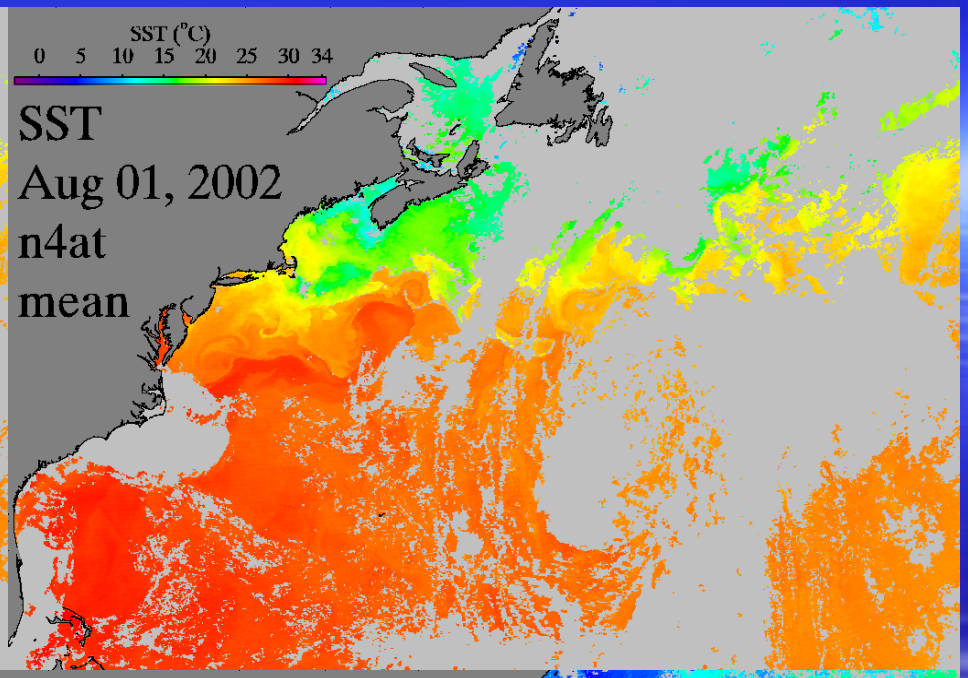
Sea Surface Temperature
- Merged Product -

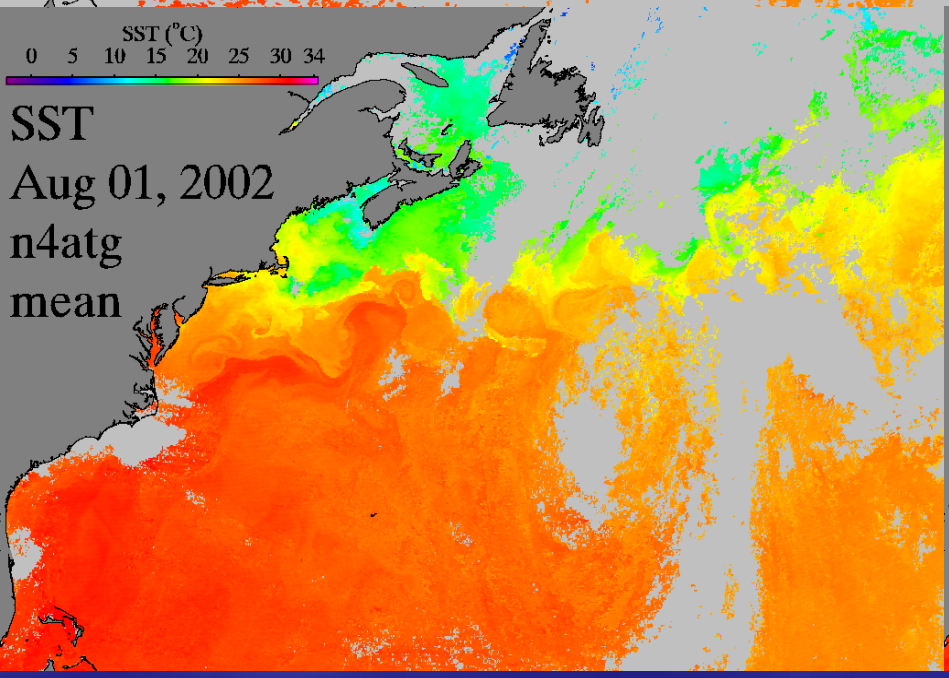
- SST derived from multiple satellites to remove clouds
- Sources include: Pathfinder (AVHRR), MODIS Aqua, MODIS Terra, and GOES

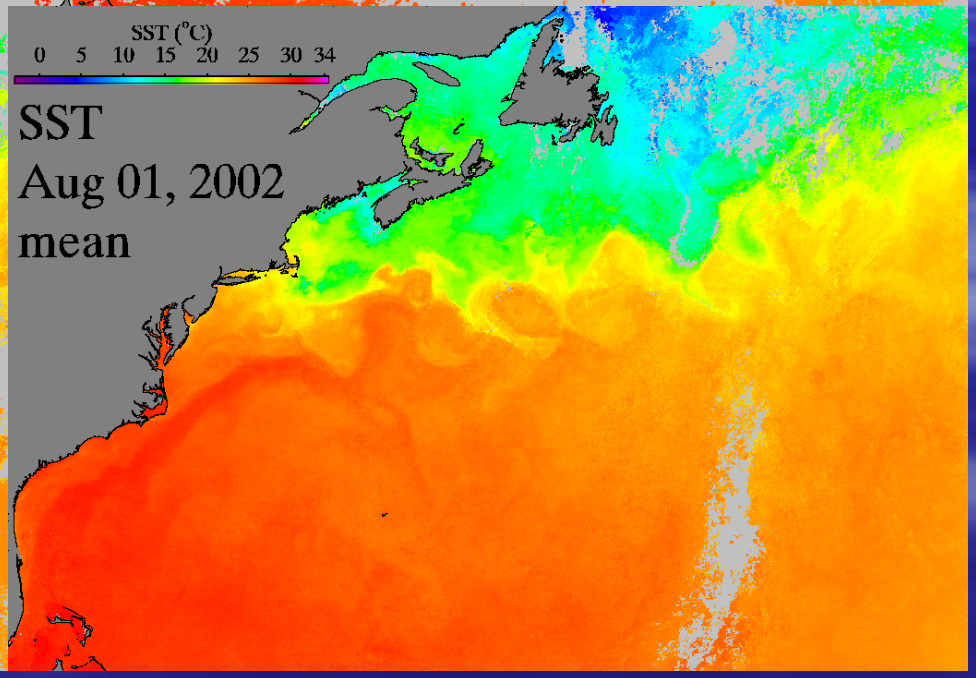


Credit: J. O'Reilly, C. Orphanides, T. Ducas, and G.Wood


SST (°C)
0 5 10 15 20 25 30 34
SST
Aug 01, 2002
pf_4

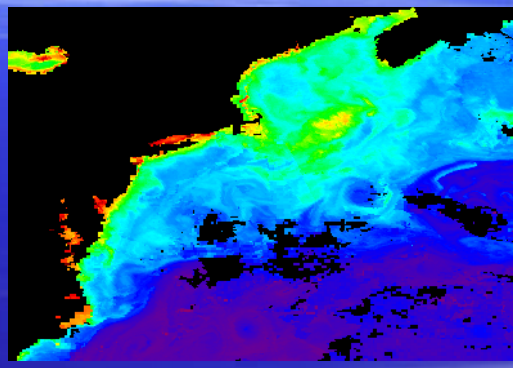

SST (°C)
0 5 10 15 20 25 30 34
SST
Aug 01, 2002
n4at
mean

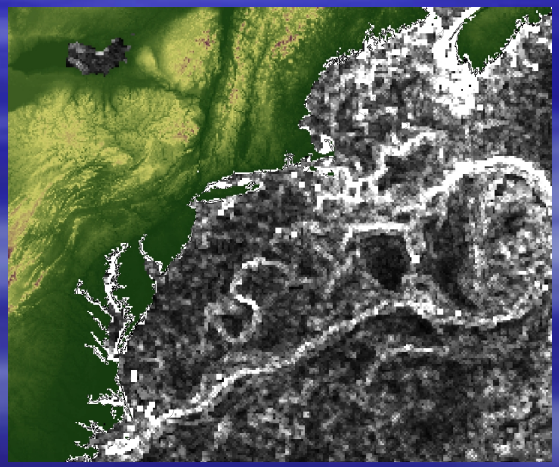

SST (°C)
0 5 10 15 20 25 30 34
SST
Aug 01, 2002
n4atg
mean

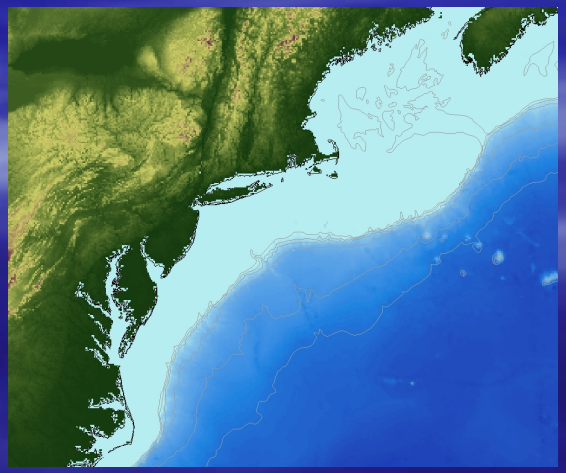

SST (°C)
0 5 10 15 20 25 30 34
SST
Aug 01, 2002
mean

Oceanographic and Environmental Data Types

- Sea Surface Temperature (SST)
- Surface Chlorophyll *a*
- Productivity Model
- Oceanographic Fronts
  - Frontal Strength (gradient)
  - Frontal Direction
- Bathymetric data
  - Bottom Depth
  - Bottom Slope







NEFSC Use of Satellite Data

Some NEFSC Uses of Satellite Data:

- Definition of ecological sub-units
- Development of productivity model
  - Input into EMAX (Energy Modeling and Analysis eXercise) ecological modeling program
  - Input into ECoS (Eastern Continental Shelf Carbon Budget)
- Analysis of Atlantic Herring Fishery
- Proposed analysis of Northern Shrimp Fishery
- Protected Species Analysis

NEFSC PSB Use of Satellite Data

Application of Satellite Data in the NEFSC Protected Species Branch :

- Development of tools to link satellite data with fisheries datasets
- Analysis of turtle bycatch in longlines
- Bycatch estimates of turtle bycatch in bottom trawl and scallop dredge fisheries
- Bycatch estimates of cetaceans in trawl fisheries
- Assisting in marine mammal abundance surveys
- Habitat investigations

Workflow – Applying Satellite Data to Fisheries Datasets

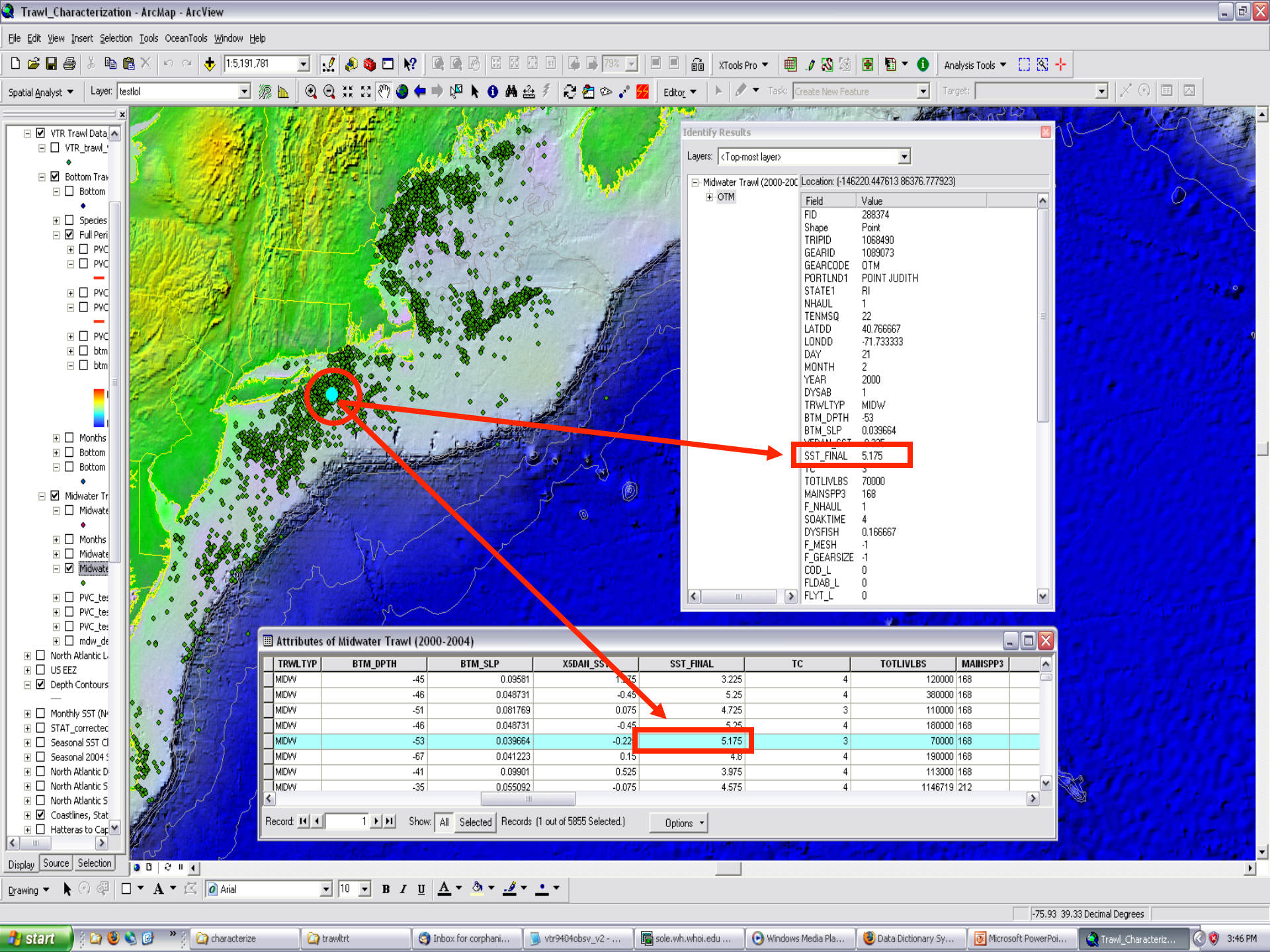
1. Download Satellite Data
2. Make composite satellite images (using IDL)
3. Convert Images to ArcGIS ready format (using IDL)
4. Read images into an ArcGIS raster format (with ArcGIS)
5. Set proper map projections (with ArcGIS)
6. Sample satellite data for fishing locations using custom tools

Tool Example – Retrieving Satellite Data for Fishing Locations

Select Fishing Location Shapefile

Default locations of Satellite Data provided

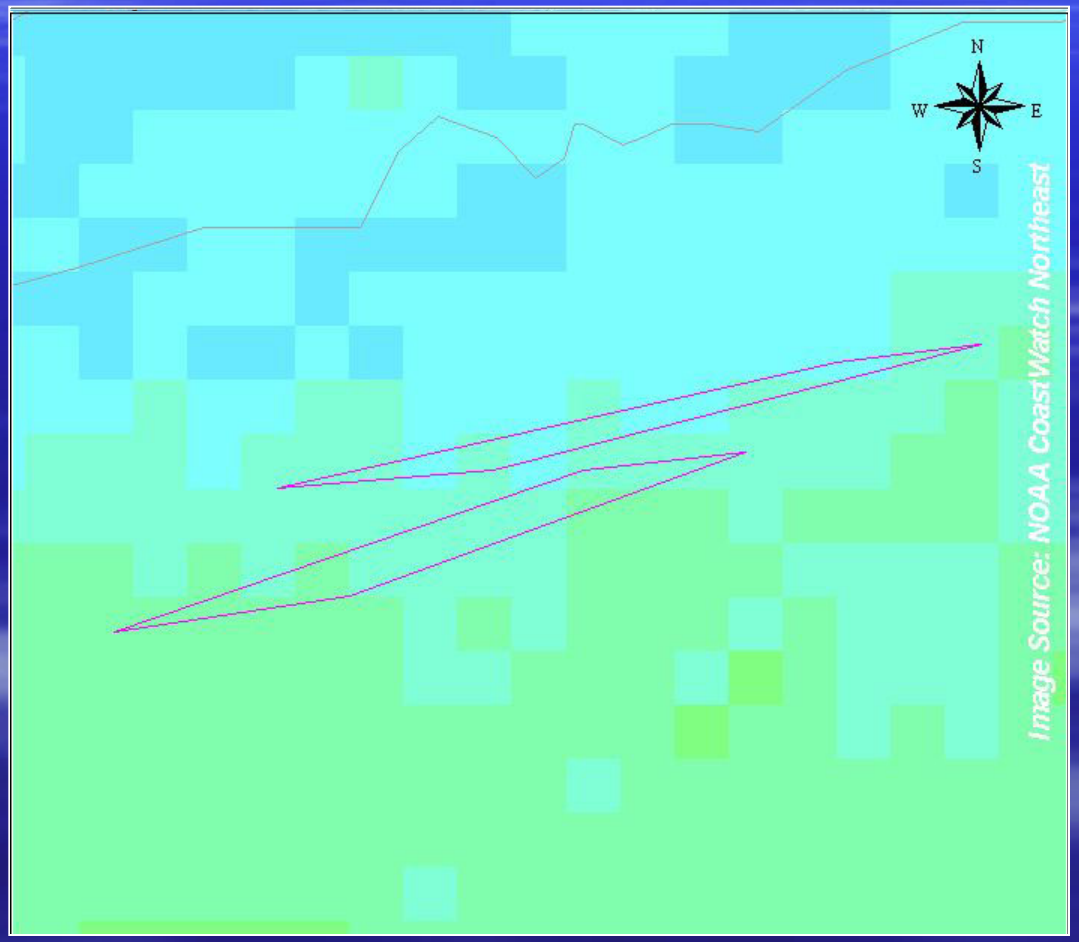
Specify Desired Products

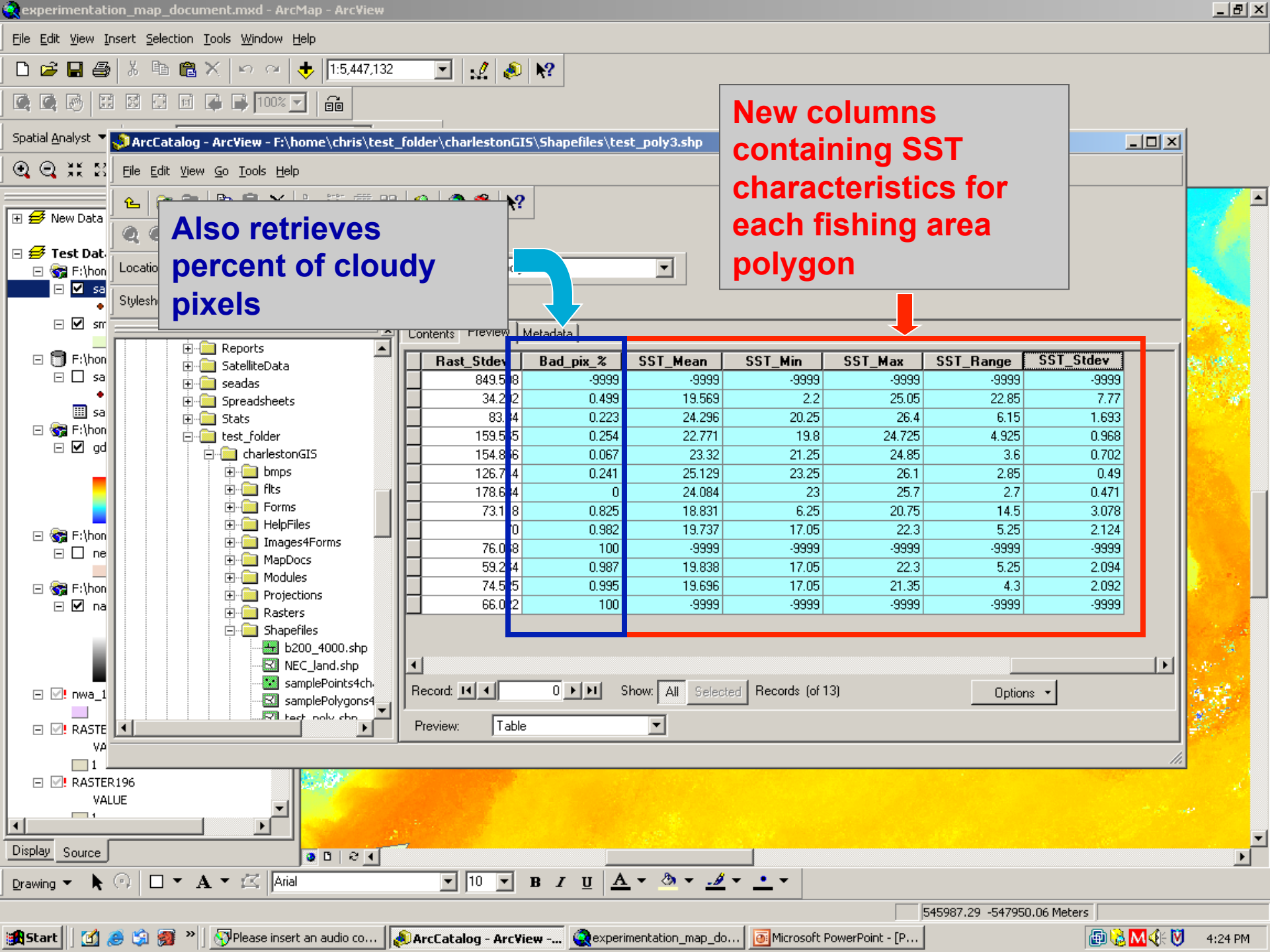

Trawl_Characterization - ArcMap - ArcView
File Edit View Insert Selection Tools OceanTools Window Help
Identify Results
Layers: <Top-most layer>
Midwater Trawl (2000-200
OTM
Location: (-146220.447613 86376.777923)
Field Value
FID 288374
Shape Point
TRIPID 1068490
GEARID 1089073
GEARCODE OTM
PORTLND1 POINT JUDITH
STATE1 RI
NHAUL 1
TENMSQ 22
LATDD 40.766667
LONDD -71.733333
DAY 21
MONTH 2
YEAR 2000
DYSAB 1
TRWLTYP MIDW
BTM_DPTH -53
BTM_SLP 0.039664
SST_FINAL 5.175
TOTLIVLBS 70000
MAINSPP3 168
F_NHAUL 1
SOAKTIME 4
DYSFISH 0.166667
F_MESH -1
F_GEARSIZE -1
COD_L 0
FLDAB_L 0
FLYT_L 0
Attributes of Midwater Trawl (2000-2004)
TRWLTYP BTM_DPTH BTM_SLP X5DAN_SST SST_FINAL TC TOTLIVLBS MAINSPP3
MIDW -45 0.09581 3.225 4 120000 168
MIDW -46 0.048731 -0.45 5.25 4 380000 168
MIDW -51 0.081769 0.075 4.725 3 110000 168
MIDW -46 0.048731 -0.45 5.25 4 180000 168
MIDW -53 0.039664 -0.22 5.175 3 70000 168
MIDW -67 0.041223 0.15 4.8 4 190000 168
MIDW -41 0.09901 0.525 3.975 4 113000 168
MIDW -35 0.055092 -0.075 4.575 4 1146719 212
Record: 1 Show: All Selected Records (1 out of 5855 Selected.) Options
VTR Trawl Data
Bottom Trav
Bottom
Species
Full Peri
Months
Midwater Tr
Midwate
Depth Contours
Monthly SST
STAT_correctec
Seasonal SST Cl
Seasonal 2004
North Atlantic D
North Atlantic S
Coastlines, Stat
Hatteras to Cap
Display Source Selection
Drawing
Arial
-75.93 39.33 Decimal Degrees
start
characterize
trawltrt
Inbox for corphani...
vtr9404obsv_v2 - ...
sole.wh.whoi.edu ...
Windows Media Pla...
Data Dictionary Sy...
Microsoft PowerPoi...
Trawl_Characteriz...
3:46 PM

Retrieving Satellite Data for Fishing Areas (polygons)

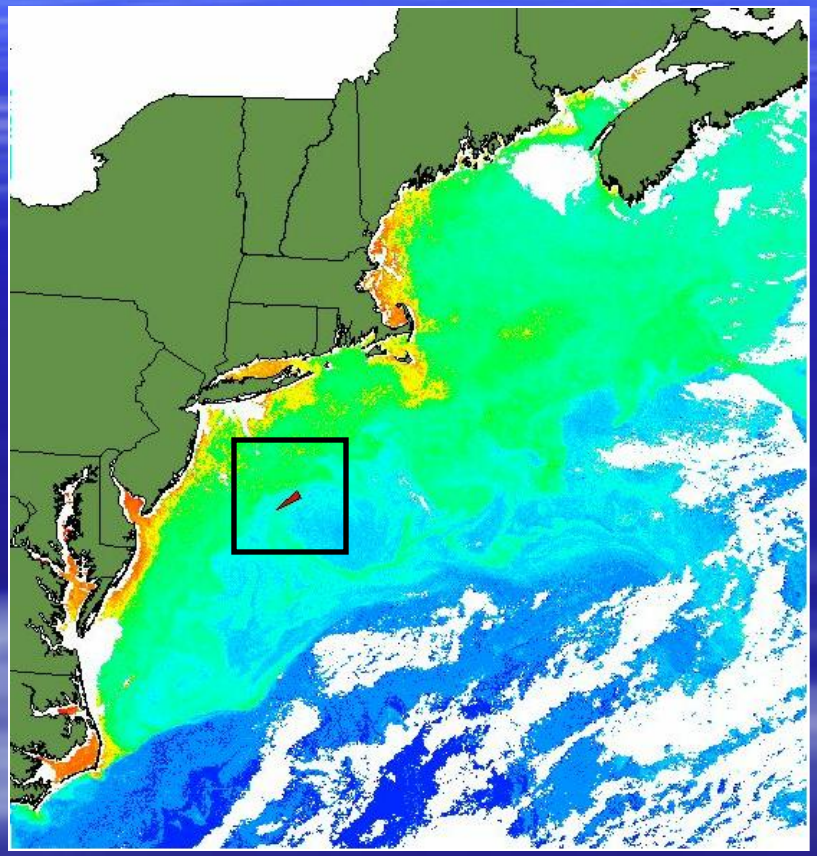
Polygons representing longline sets are plotted and overlaid onto satellite imagery or other imagery. The values within these polygons, representing temperature for example, are extracted.

To the right are two polygons representing longlining sets. The four points in each polygon represent the begin set, end set, begin haul, and end haul locations.



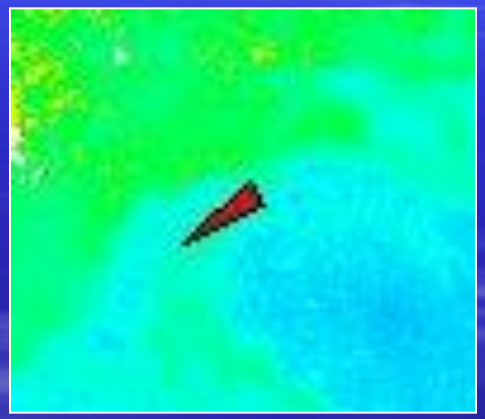

Also retrieves percent of cloudy pixels
New columns containing SST characteristics for each fishing area polygon
ArcCatalog - ArcView - F:\home\chris\test_folder\charlestonGIS\Shapefiles\test_poly3.shp
Rast_Stdev
Bad_pix_%
SST_Mean
SST_Min
SST_Max
SST_Range
SST_Stdev

Example of SeaWiFS Chlorophyll Image and a Corresponding Longline Set in December 2001



Fishing set from December 2, 2001 shown as a red polygon overlaid over a December 4, 2001 single-day SeaWiFS chlorophyll image.

Close up of set sampled

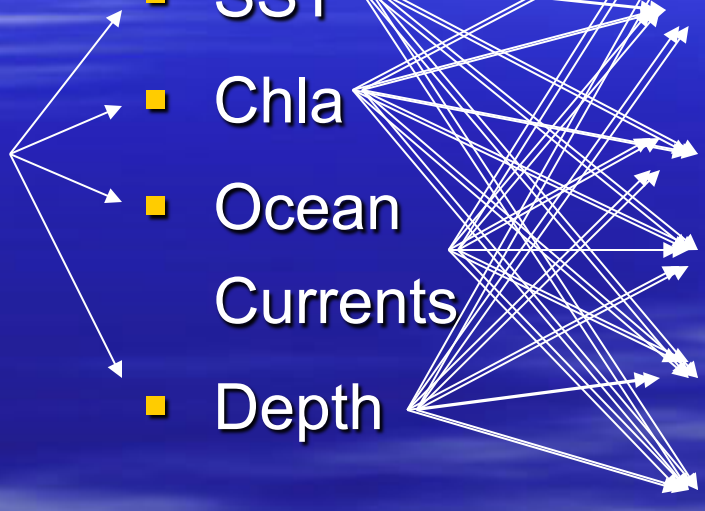


SeaWiFS Chlorophyll (mg/m^3)					
Arc Set ID	Mean	Min	Max	Range	Std Dev
200133606W01	0.8529	0.1689	16.861	16.6919	1.5044

SeaWiFS chlorophyll characteristics for longline set on December 2nd of 2000.

Resulting Data Set
(using polygons representing sets)

- For each longline set



- % Cloudy Pixels
- Mean
- Min
- Max
- Range
- Std. Dev.

- Plus the original data in the observer database such as number of lightsticks, set time and haul, fish caught, etc.

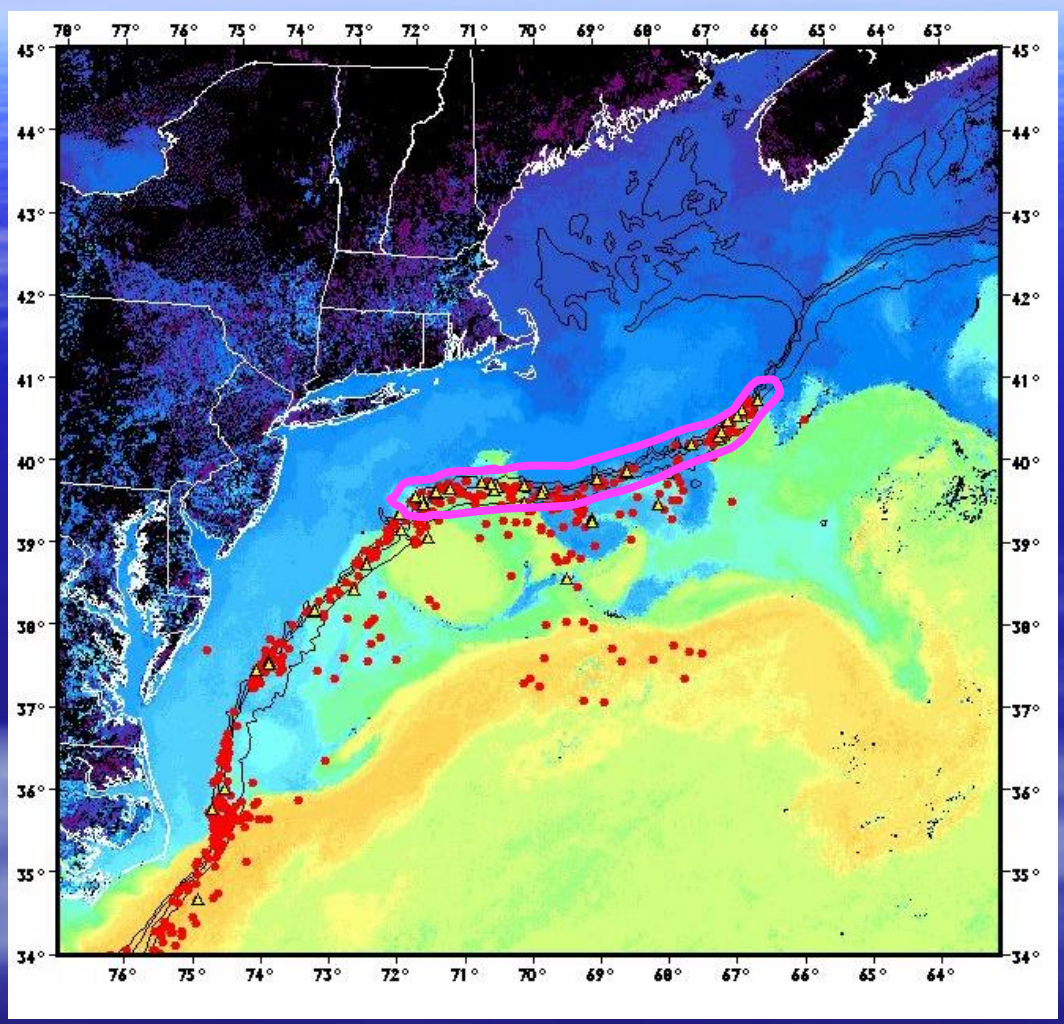
Northeast Variables Considered

- Latitude
- Longitude
- Day of Year
- Depth
- Bottom Slope
- Chlorophyll
- Temperature
- Frontal Strength
- Lunar Cycle
- Canyons
- Soak Time
- Watermass
- Wind-driven Ekman Transport

Variables important in distinguishing Northeast sets that caught loggerheads

- Latitude
- Longitude
- Day of Year
- Depth
- Bottom Slope
- Chlorophyll
- Temperature
- Frontal Strength
- Lunar Cycle
- Canyons
- Soak Time
- Watermass
- Wind-driven Ekman Transport

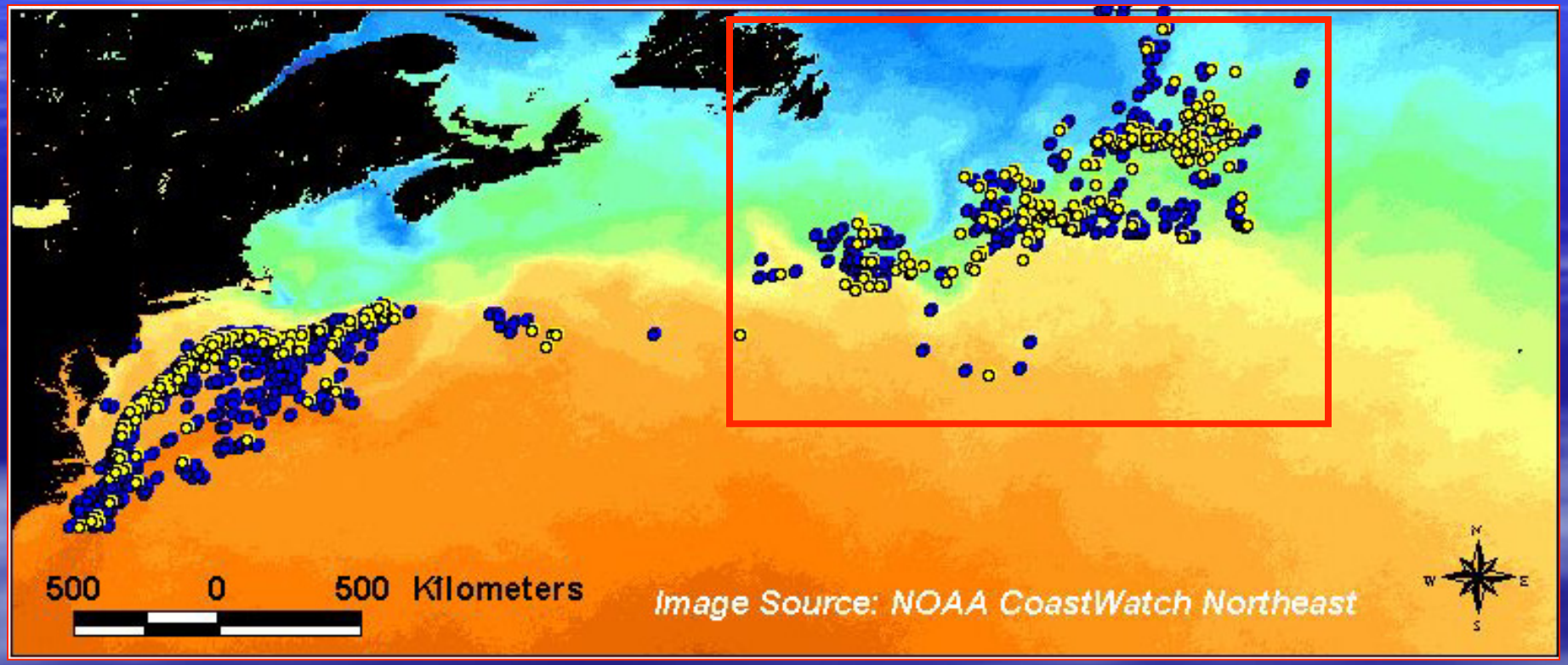
Longline Turtle Bycatch Analysis



- Apparent temperature preference between 18 and 24°C
- Occupied shallower waters than the average longline set in the NEC region (500 - 1200 m)
- Preference for the shelf break north of 39° latitude, particularly in the fall
- Primarily associated with northern edges of warm core rings and the shelf/slope front
- Preference for fishing areas over submarine canyons
- Showed no distinction from longline sets with respect to bottom slope, chlorophyll levels, or perceived frontal strength

Majority of loggerhead population is likely concentrated along the mid-continental shelf, inshore and south of the majority of longlining effort

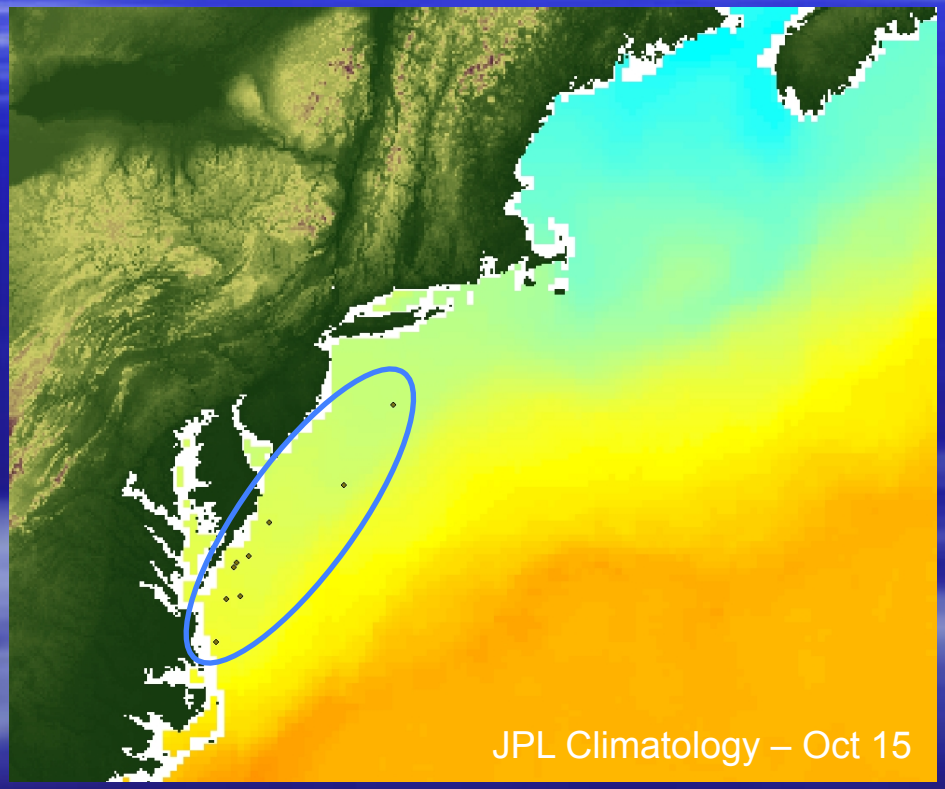
Longline Turtle Bycatch Analysis



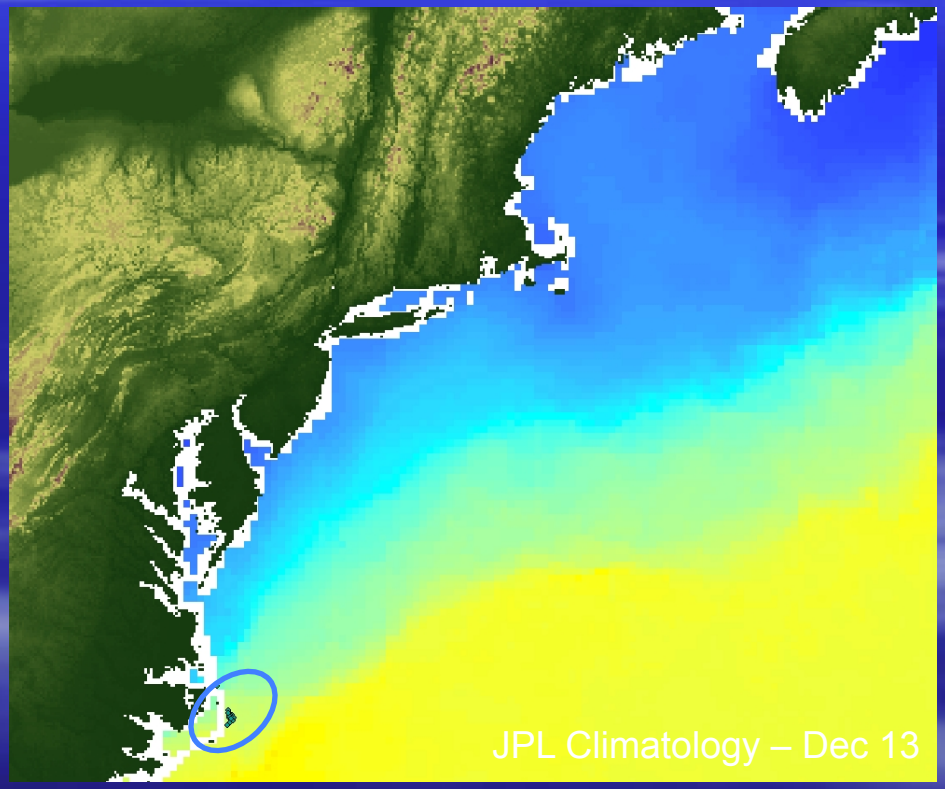
Loggerhead Bottom Trawl Bycatch Modeling

SST has been an important factor in modeling loggerhead bycatch

October Loggerhead Bycatch



December Loggerhead Bycatch



Loggerhead distribution shifts with seasonal temperature changes

Bycatch estimate modeling by Kimberly Murray

Sea Scallop Dredge Turtle Bycatch Modeling

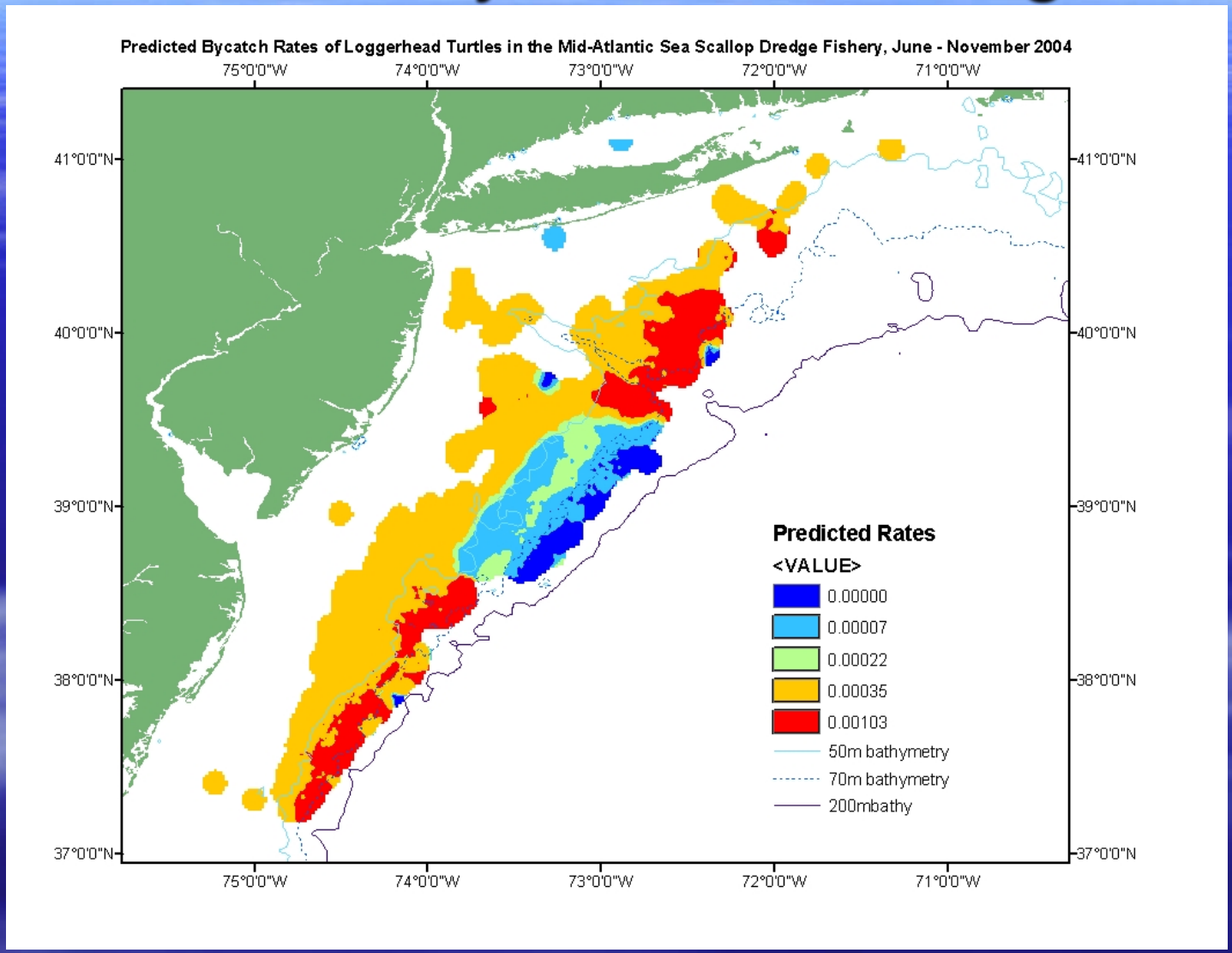
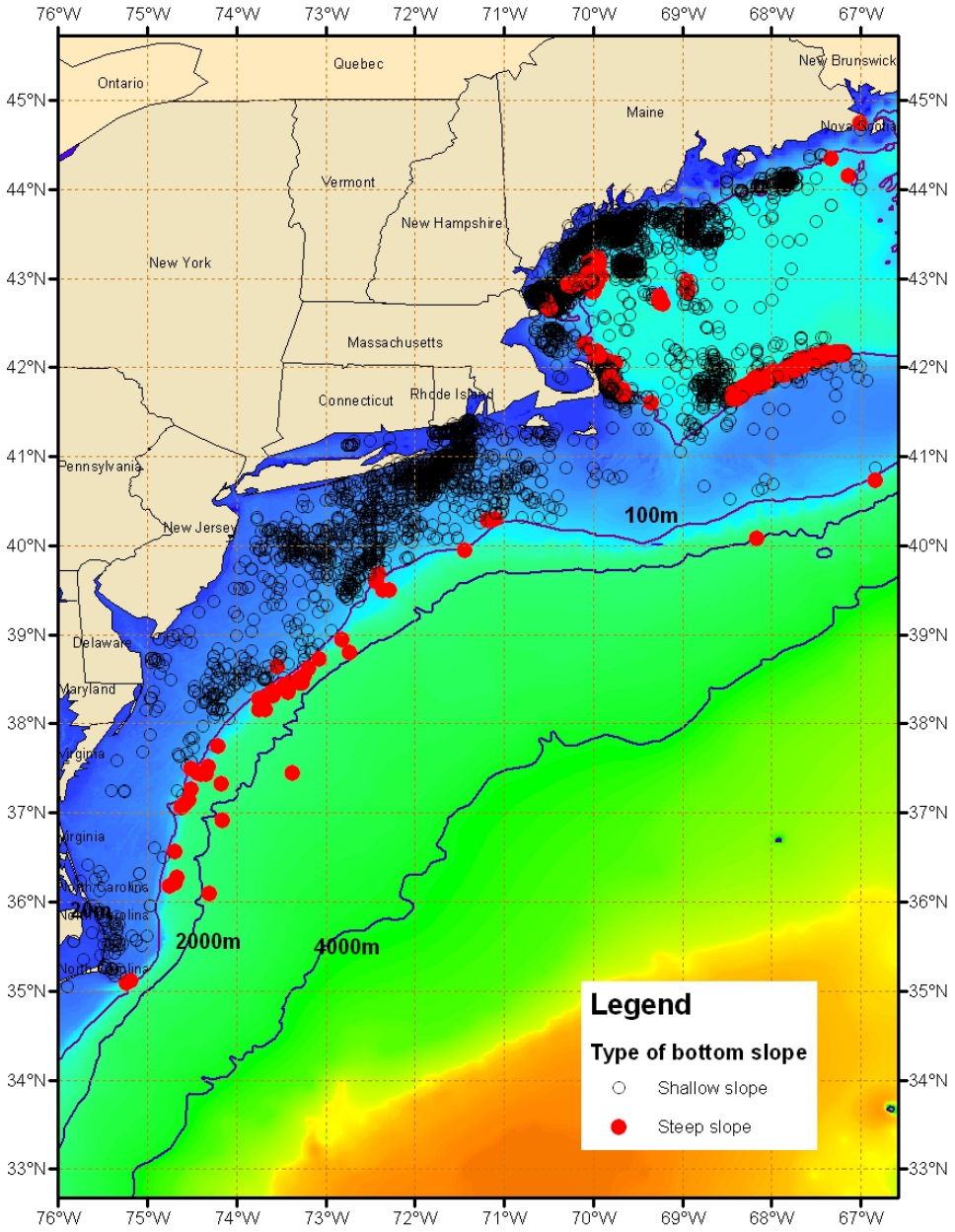


Image courtesy of Kimberly Murray



Marine Mammal Midwater Trawl Bycatch Modeling

Model in development found ***bottom slope*** to be a significant factor for predicting bycatch of cetaceans in mid-water trawl fisheries.

Areas of steep bottom slope had higher rates of bycatch, and likely serve as a proxy for other oceanographic factors.

Images courtesy of Debra Palka

Marine Mammal Bottom Trawl Bycatch Modeling

Common Dolphin bycatch in the trawl fishery

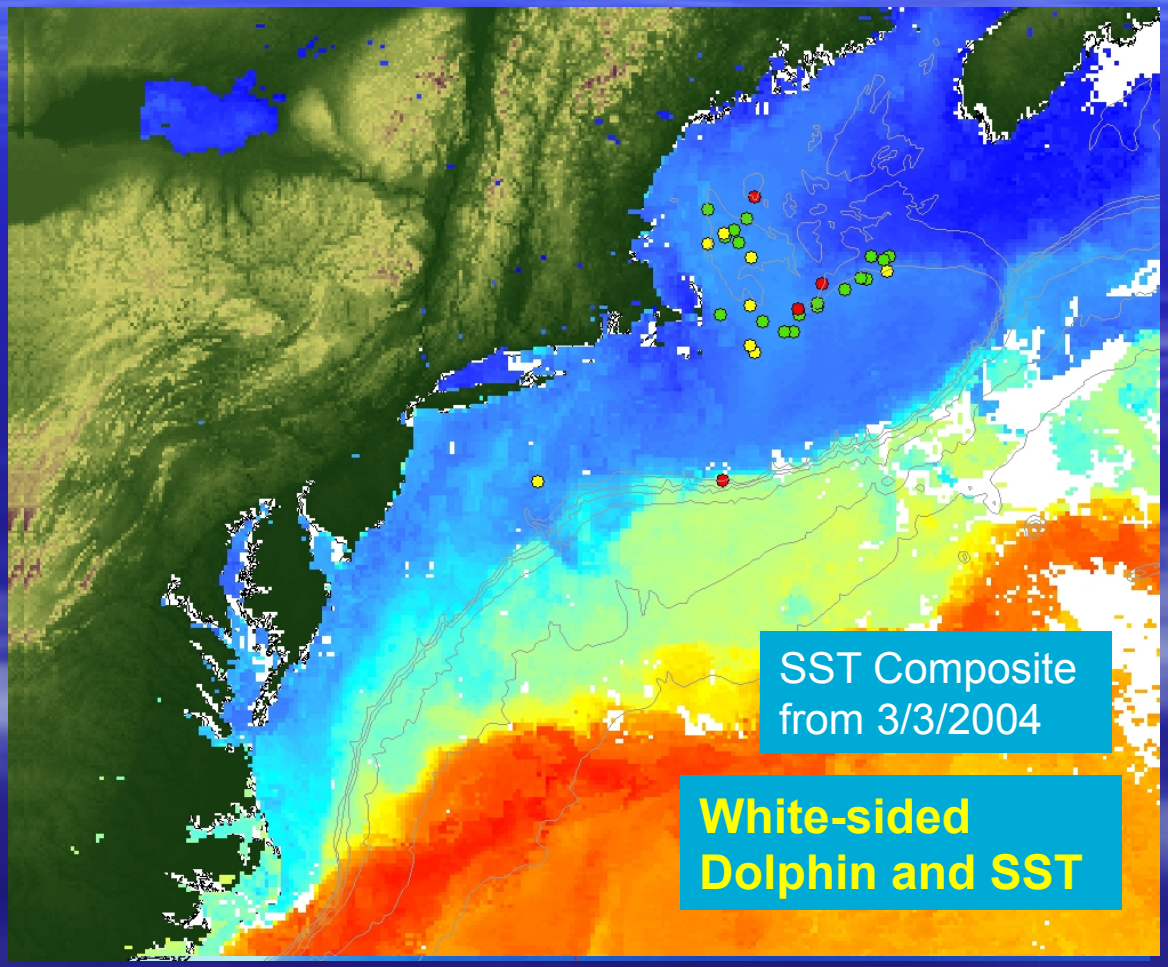
Model in development found ***bottom depth*** to be a significant factor for predicting bycatch.

Pilot Whale bycatch in the trawl fishery

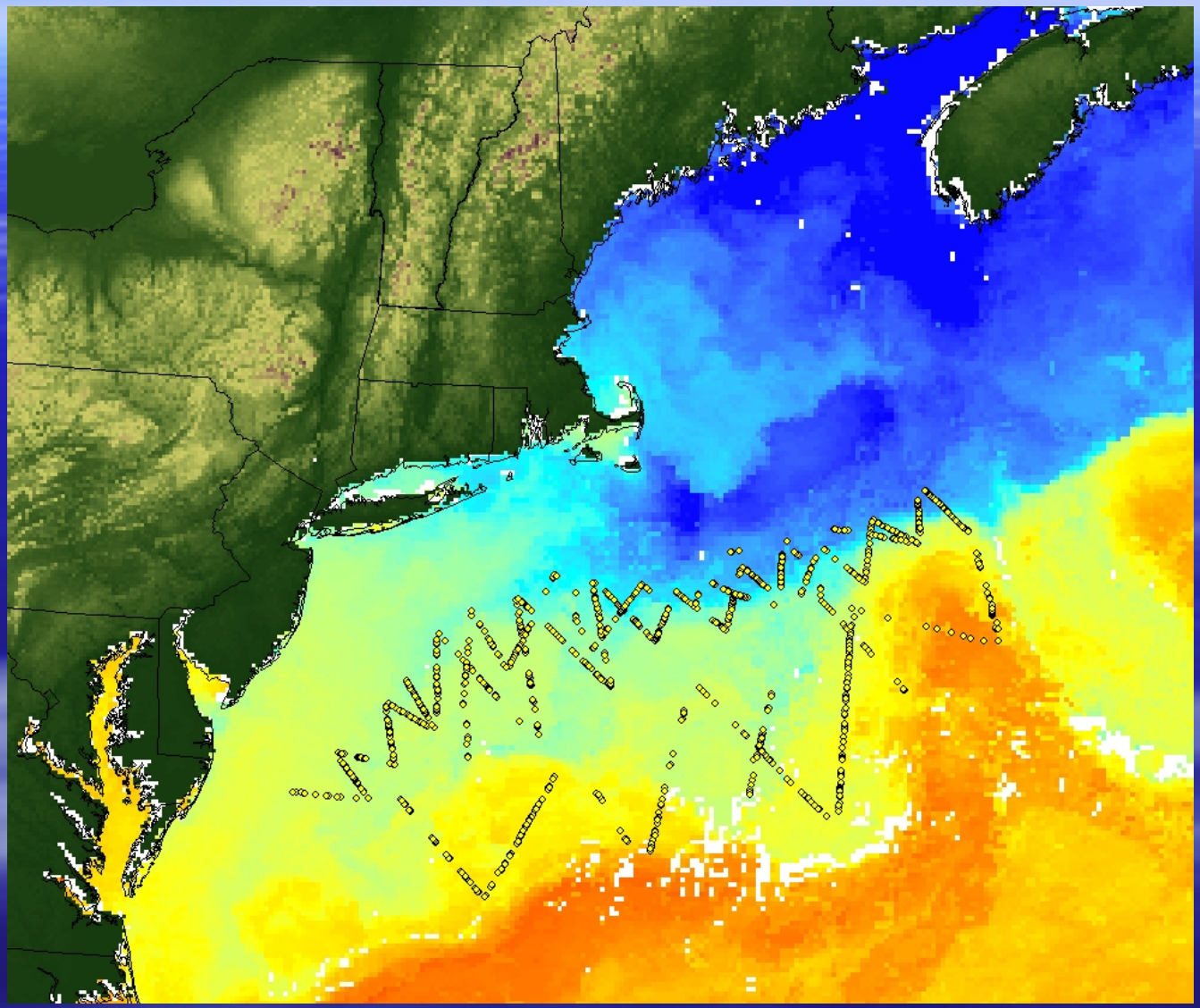
Model in development found ***bottom slope*** to be a significant factor for predicting bycatch.

White-sided dolphin bycatch in the trawl fishery

Model in development found ***SST*** and ***Depth*** to be a significant factor for predicting bycatch.



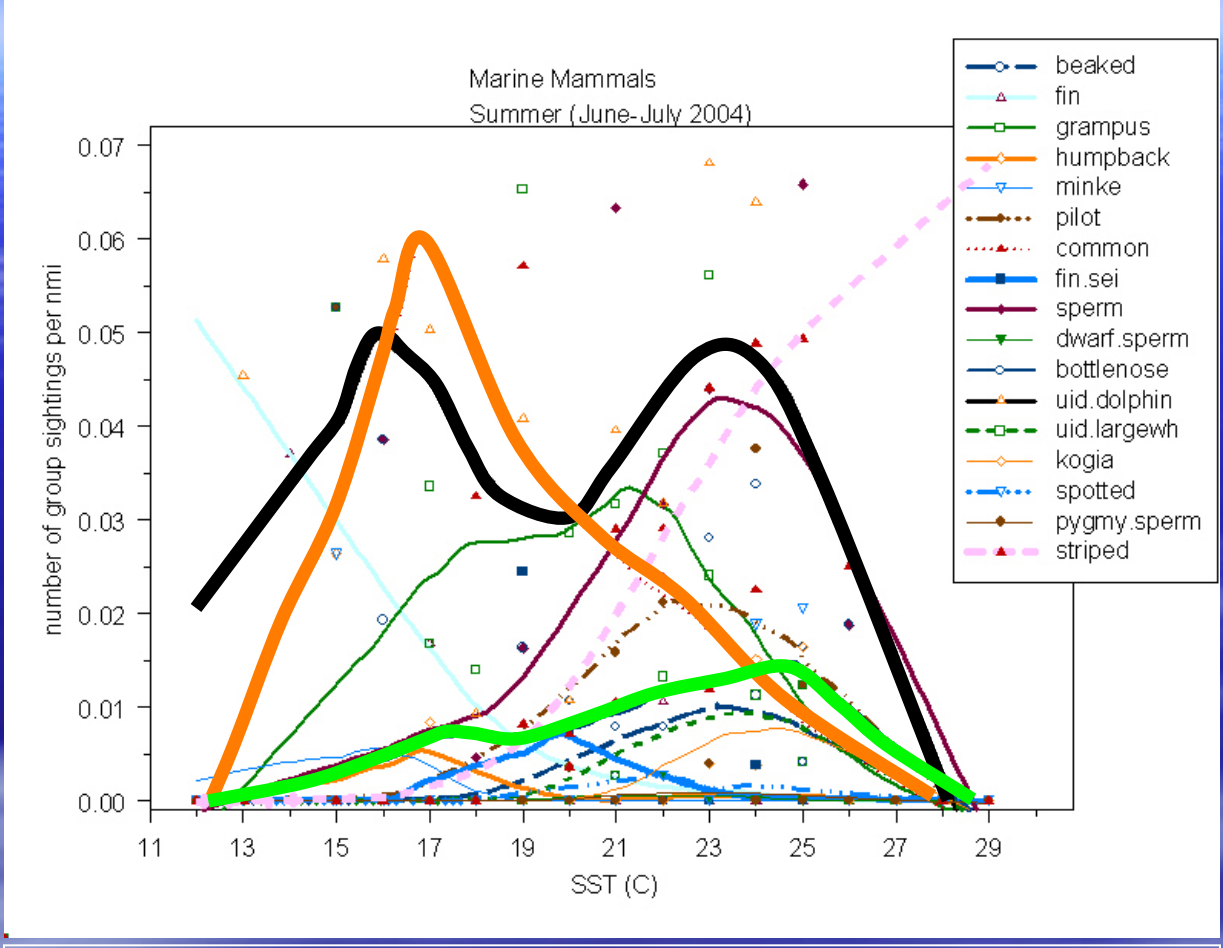
Marine Mammal Survey Data



- Maps of SST used to guide shipboard marine mammal surveys.
- Primarily looking for frontal regions

- Points show track of ship

Marine Mammal Survey Data



Unidentified dolphin likely two species, common dolphin and possibly bottlenose dolphins

Unidentified Dolphin

Common Dolphin

Bottlenose Dolphin

Identification of unidentified animals in abundance survey using SST

Image courtesy of Debra Palka

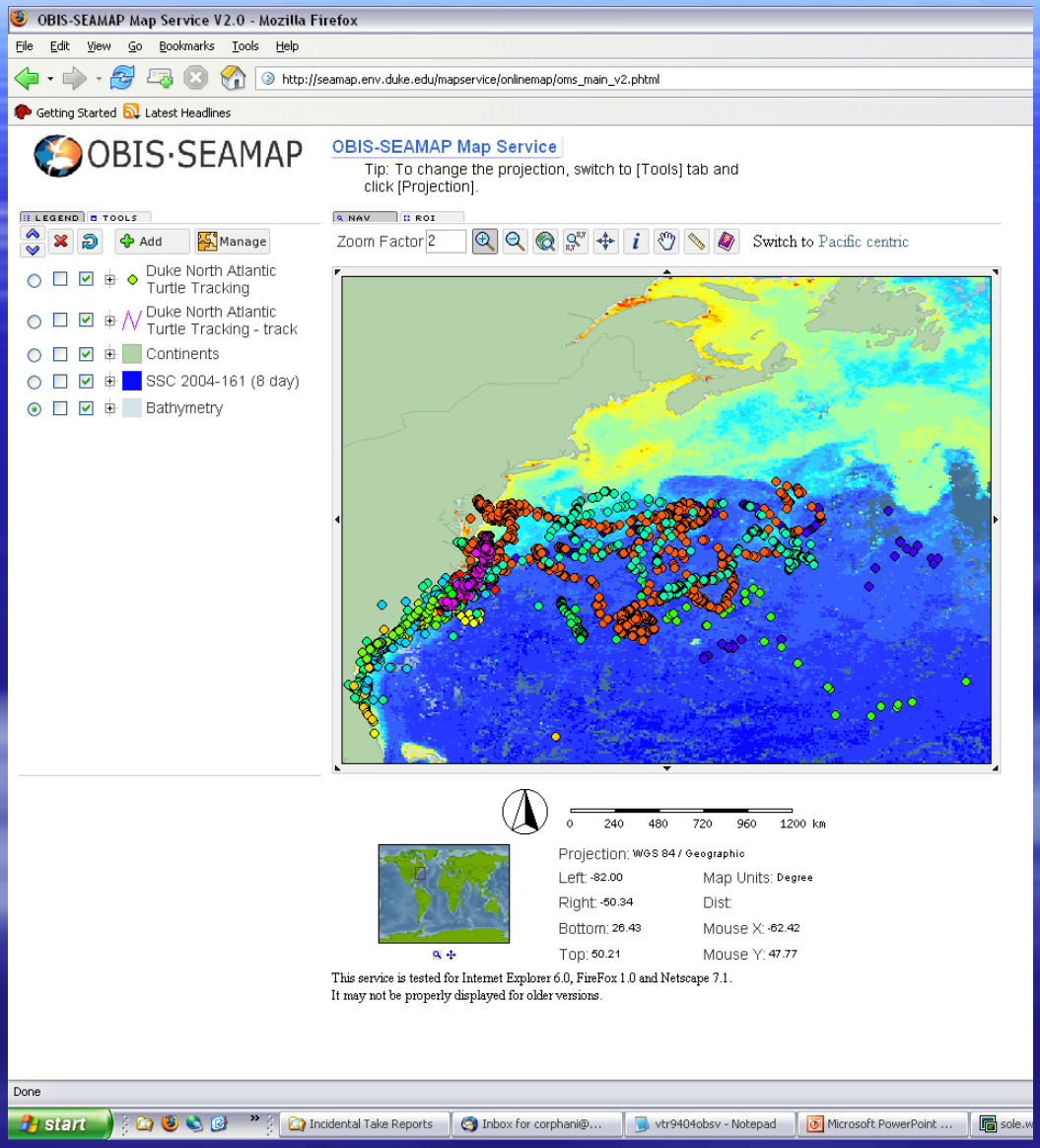
Other Current and Future Projects Applying Satellite Data

- Examining possible link between sea turtle bycatch and high inter-annual variability in summer chlorophyll off the coast of New Jersey
- Examining sea turtle bycatch distribution across multiple fisheries relative to a number of environmental variables (including SST, chlorophyll, oceanographic fronts, bathymetric features, bottom temps, water column stratification, etc.)
- Distribution of satellite tagged leatherbacks relative to oceanographic variables
- Harbor porpoise gillnet bycatch model

Summary

1) Satellite data is being used effectively in the NEFSC, particularly with protected species. However, it could be made much more user-friendly.
2) Due to dynamic ocean and cloud cover, downloadable 3 and 5 day satellite data composites would be very useful.
3) Providing data in a GIS-ready format would facilitate use by fisheries scientists.
4) Providing tool, ideally online, for retrieving data from satellite data from time series in a batch mode for fishing locations and areas

OBIS-SeaMAP Project



Ocean Biogeographic Information System - Spatial Ecological Analysis of Megavertebrate Populations

Example – Satellite tracked sea turtles over 8-day chlorophyll image

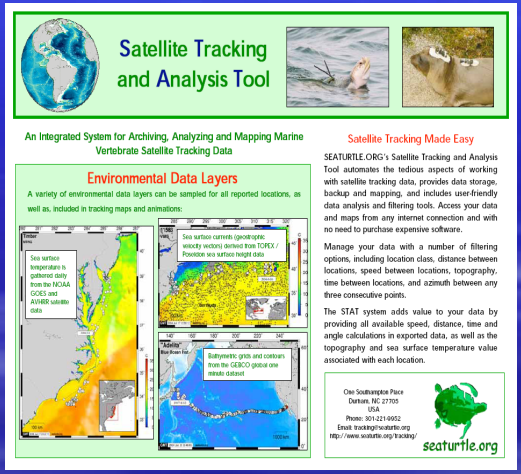
Developing online mapping capabilities, mapping marine data over satellite data

Source: http://seamap.env.duke.edu/

Satellite Tracking and Analysis (STAT) Tool

STAT is an online tool for linking satellite data to satellite-tagged marine animals

In their words: 'An integrated system for archiving, analyzing, and mapping, marine vertebrate satellite tracking data'



SOURCES:

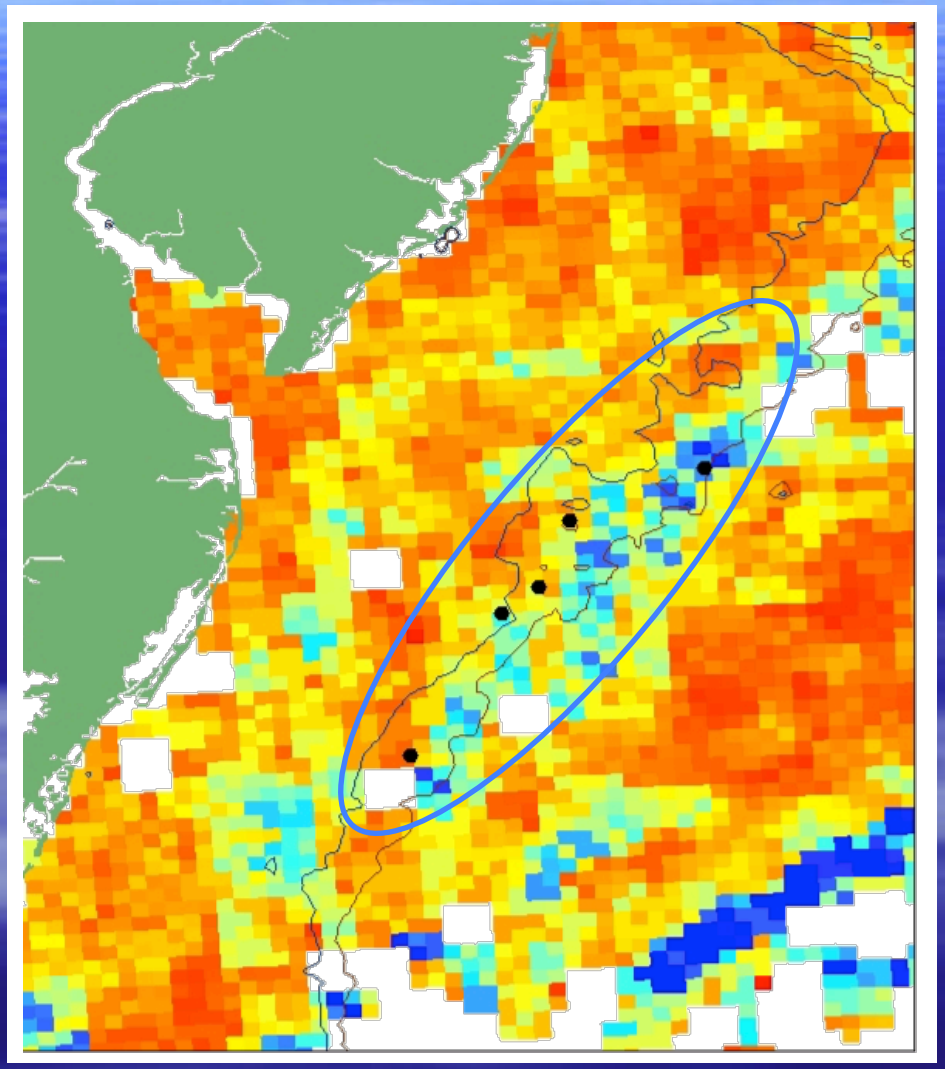
- Published in Marine Ecological Progress Series by M.S. Coyne and B.J. Godley (www.int-res.com/articles/feature/m301p001.pdf)
- More information can be found on seaturtle.org and specifically at: www.seaturtle.org/STAT.pdf

THE END

Special Thanks to:

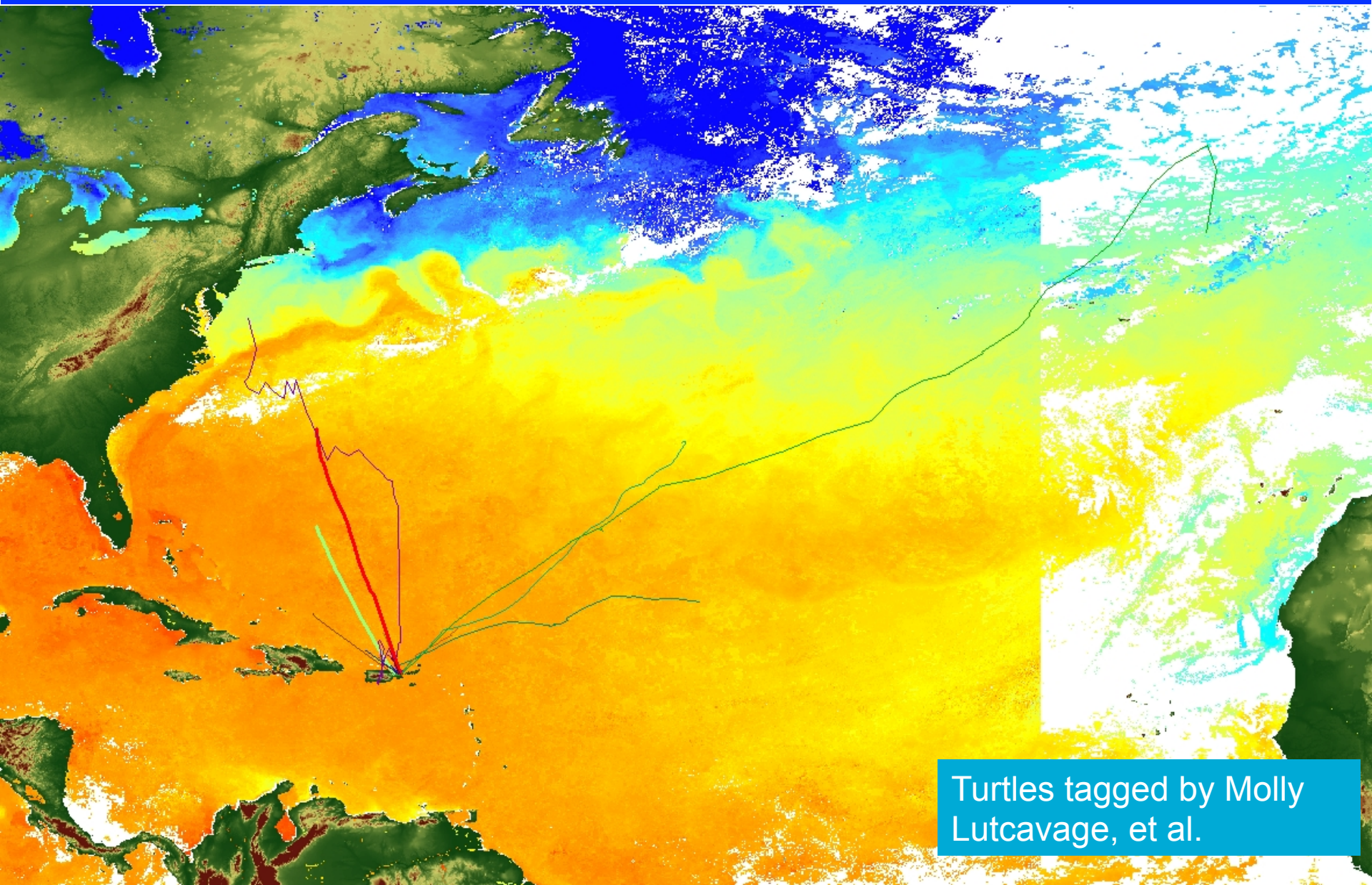
Cara Wilson for inviting me to present, and to Jay O' Reilly, Debra Palka, Kimberly Murray, Marjorie Rossman for their contributions to this presentation.

Loggerhead Bycatch Modeling

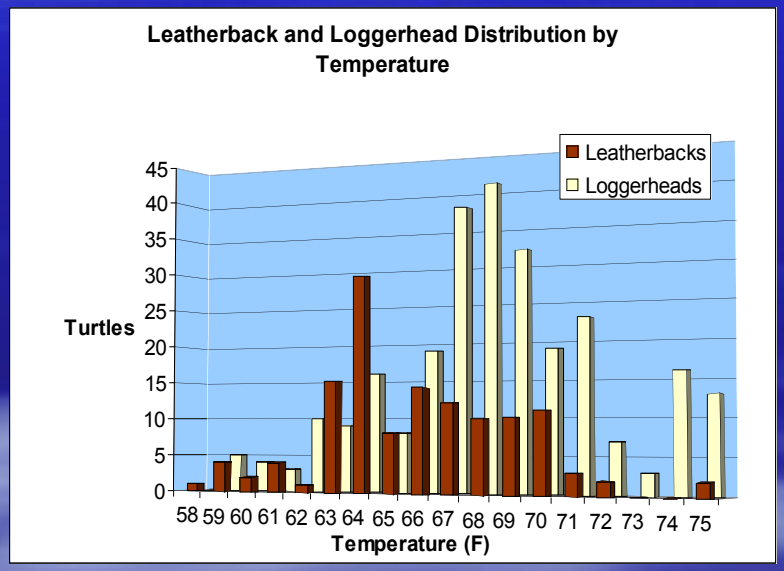


PSB is also investigating loggerhead bycatch relative to oceanographic fronts

Leatherback Migration

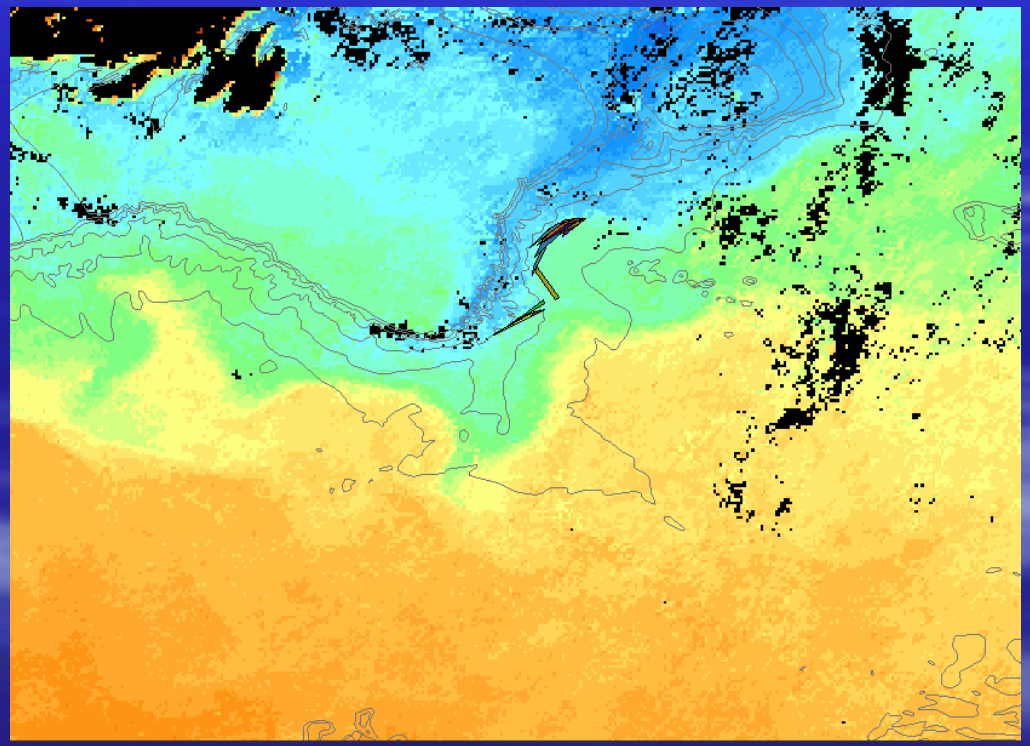


Turtles tagged by Molly Lutcavage, et al.



Graph based on observer data from 1990-2000

2001 day 251 GOES SST 5-day composite



2001 sets that caught loggerheads from days 248 to 256