High-Resolution Subsurface Physical and Optical Property Fields in the Gulf of Mexico: Establishing Baselines and Assessment Tools for Resource Managers

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Objective:

Provide high spatial resolution subsurface material property distributions as described by three-dimensional/data-assimilative ocean models when combined with satellite ocean color imagery and radiative transfer models.

In other words:

- **How much light is reaching the bottom?**
- **What is the temperature?**
- **How fast are the currents?**
- **Is the water turbid? What are the sediment loads?**

- **Establish BASELINE conditions**

Naval Relevance:

Ocean Nowcasts/Forecasts of subsurface Temperature, Currents, Optics – fundamental to a broad swath of operational ocean forecasting activities.

Operational Ocean Forecasting at NAVOCEANO

Anti-Submarine Warfare (ASW)
- products: temperature, salinity, currents
- sound speed / acoustic transmission

Mine Warfare (MIW)
- products: temperature, salinity, currents
- EOID System Performance

Flower Garden Banks National Marine Sanctuary

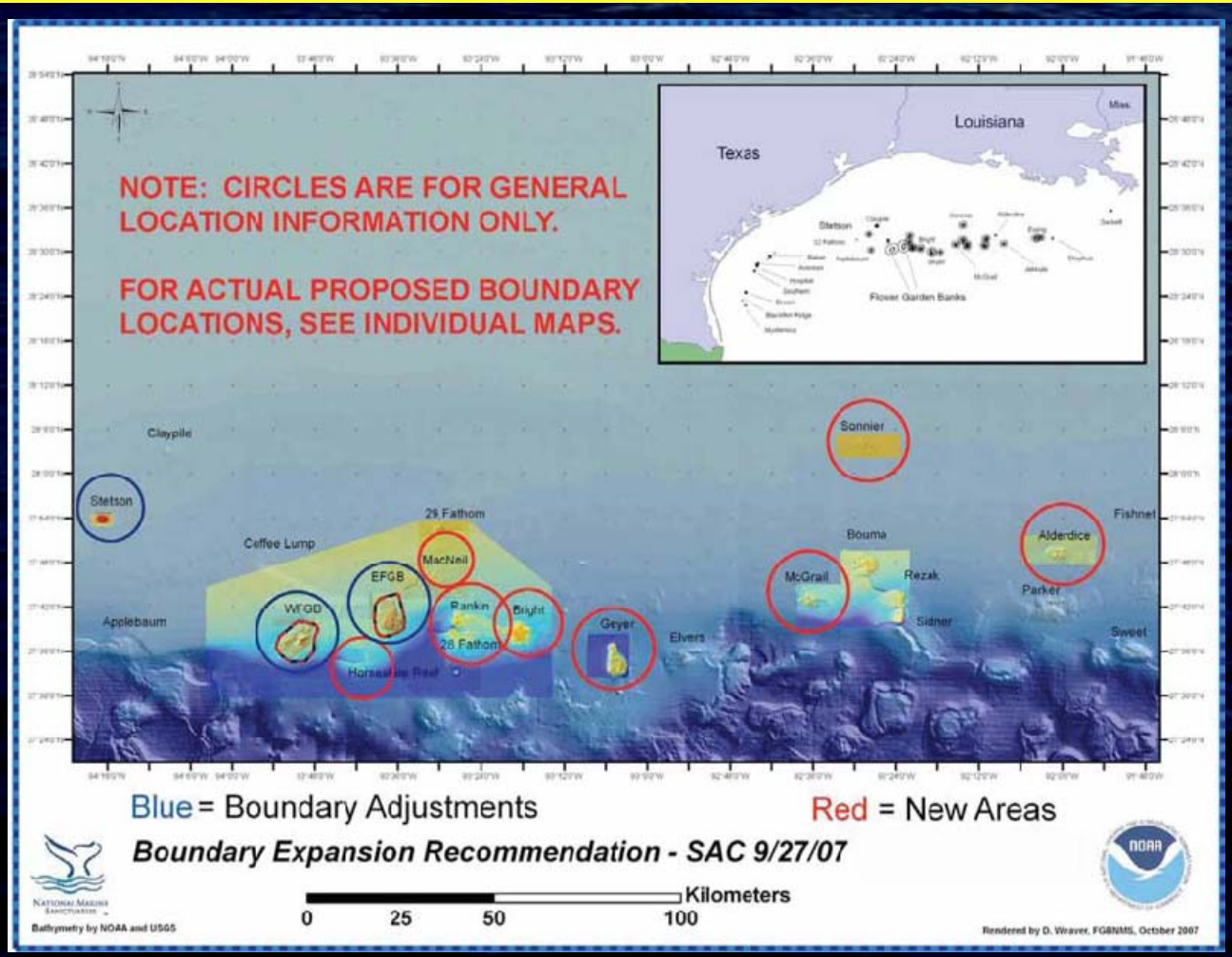


Figure 1. Location of FGBNMS and surrounding features shown with high-resolution, multibeam bathymetry. Proposed features considered by the Sanctuary Advisory Council for FGBNMS boundary expansion are shown in red. Reprinted from FGBNMS Sanctuary Advisory Council Boundary Expansion Recommendation Report, 2007. http://flowergarden.noaa.gov

Flower Garden Banks National Marine Sanctuary

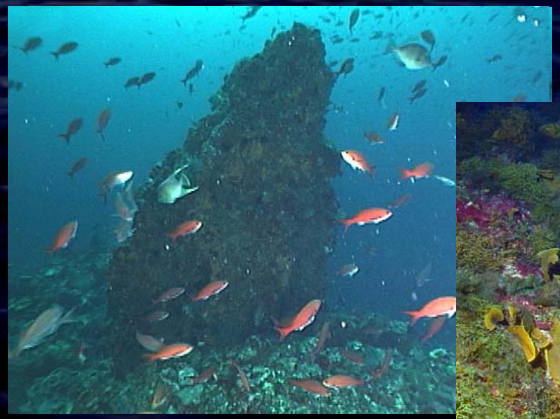
- Sanctuary Advisory Council periodic management reviews of current regulations. Potential boundary expansion has been identified as a priority management issue.

- The boundary expansion proposals and deliberations would be significantly aided by knowledge of baseline environmental conditions, such as light, temperature, and salinity, for benthic biological communities that may be ecologically linked to the presently protected areas.

Flower Garden Banks National Marine Sanctuary

There are numerous geologic features in the FGBNMS surrounding area that may support critical biological habitats.

Where are they? Some communities beyond SCUBA depth, ROV surveys limited and expensive.



[photos: http://oceanexplorer.noaa.gov]

Flower Garden Banks National Marine Sanctuary

Key Process: Match up subsurface environmental variables (light, temp., currents)
With known habitat maps – would then suggest where else these habitats occur when no biological survey has been performed.

** Critical Information for members of the Boundary Expansion Working Group (BEWG), established by the
Sanctuary Advisory Council.

They must present the latest scientific information on where critical habitats occur and what sites should be considered for additional protection.

United States Army Corps of Engineers

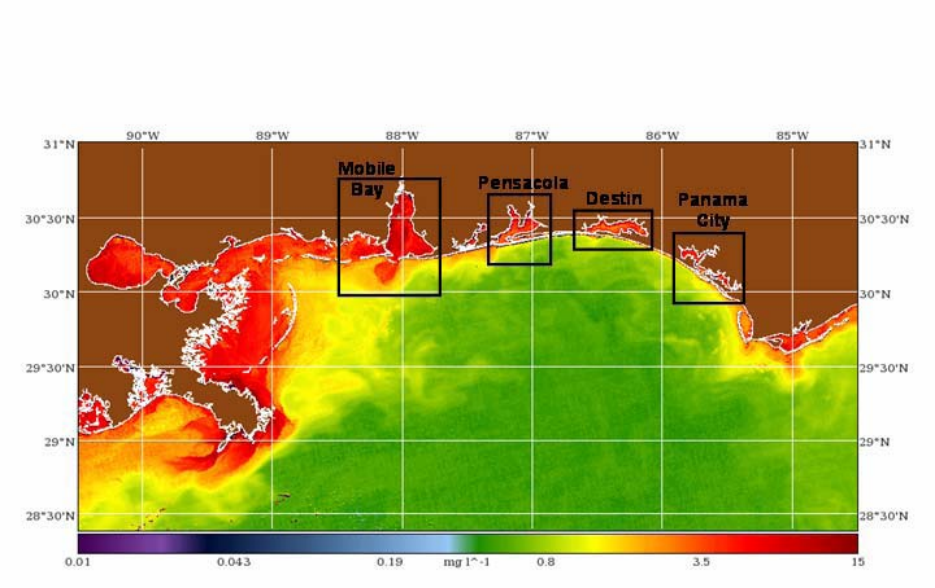
- The natural variability of coastal turbidity (suspended sediment load) is not known for local areas where the United States Army Corps of Engineers (USACE) are required to monitor during their dredging, flood protection, and coastal restoration activities.

- Knowledge of this natural variability would provide a baseline against which data from their monitoring activities may be assessed

- Utilize MODIS ocean color archive for the Gulf of Mexico
  - 250-meter resolution
  - suspended particulate matter algorithms
  - Automated Processing System (APS)

United States Army Corps of Engineers

We will provide a 4-year climatological data base of suspended sediment load with time-series analyses (weekly, regional mean values and standard deviations) for selected coastal regions of interest to the USACE coastal managers (Mobile Bay/Pascagoula, Mississippi; Pensacola, Destin, Panama City, Florida; other sites), to aid their decision-making process.



Subsurface Products:

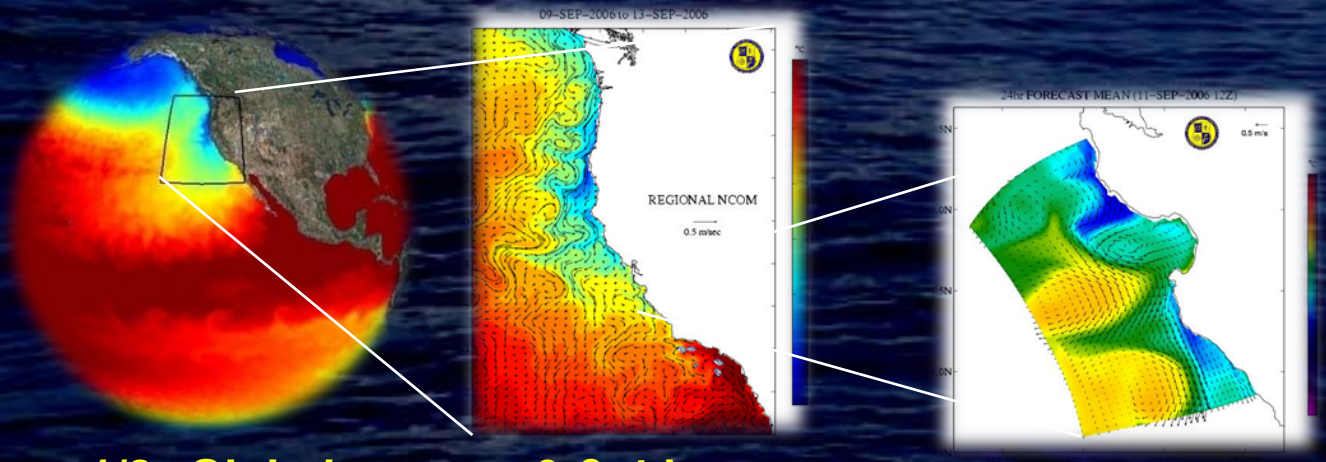
- **PHYSICAL MODEL – RELO-NCOM/NCODA**
  Relocatable (Nested) Navy Coastal Ocean Model
  Navy Coupled Ocean Data Assimilation System

- **High Resolution BATHYMETRY –**
  multibeam bathymetry surveys

- **SATELLITE OCEAN COLOR**
  MODIS/SeaWiFS/HICO*

- **SURFACE IRRADIANCE –**
  NASA's Ocean Atmosphere Spectral Irradiance Model
  (Gregg et al., 2009)

Operational Global Ocean Forecasting Systems also used as boundary conditions for nested or "Relocatable" higher resolution ocean models:



1/8° Global 9 & 4 km 1-4 km

RELOCATABLE NAVY COASTAL OCEAN MODEL (RELO-NCOM)

- OPERATIONAL HIGH-RESOUTION OCEAN MODELING
- 3-D CURRENTS, TEMPERATURE, SALINITY
- NEST DOWN TO < 1Km HORIZONTAL RESOLUTION

RELO-NCOM is cycled with
Navy Coupled Ocean Data Assimilation (NCODA)
Multivariate Optimal Interpolation

- **Sea Surface Temperature – MCSST Satellite Product**
  U.S. Naval Oceanographic Office (NAVOCEANO)'s AVHRR MCSST (Advanced Very High Resolution Radiometer Multi-Channel Sea Surface Temperature) real-time global area coverage Sea Surface Temperature (SST) daily retrievals from POES NOAA-14, NOAA-15, NOAA-16 and NOAA-17 satellites.

- **Temperature and Salinity In-Situ/Profiles**
  – Argo Floats, Moored Arrays, Bathythermographs (XBT)

- **Sea Surface Height – All Available Satellite altimetry – JASON, ENVISAT**

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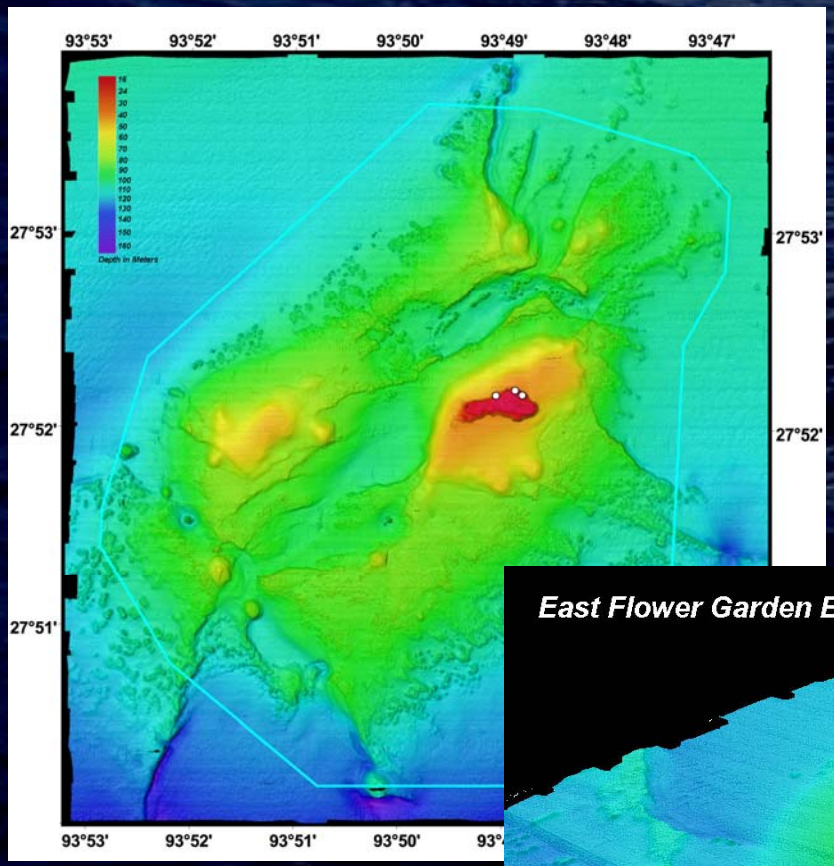
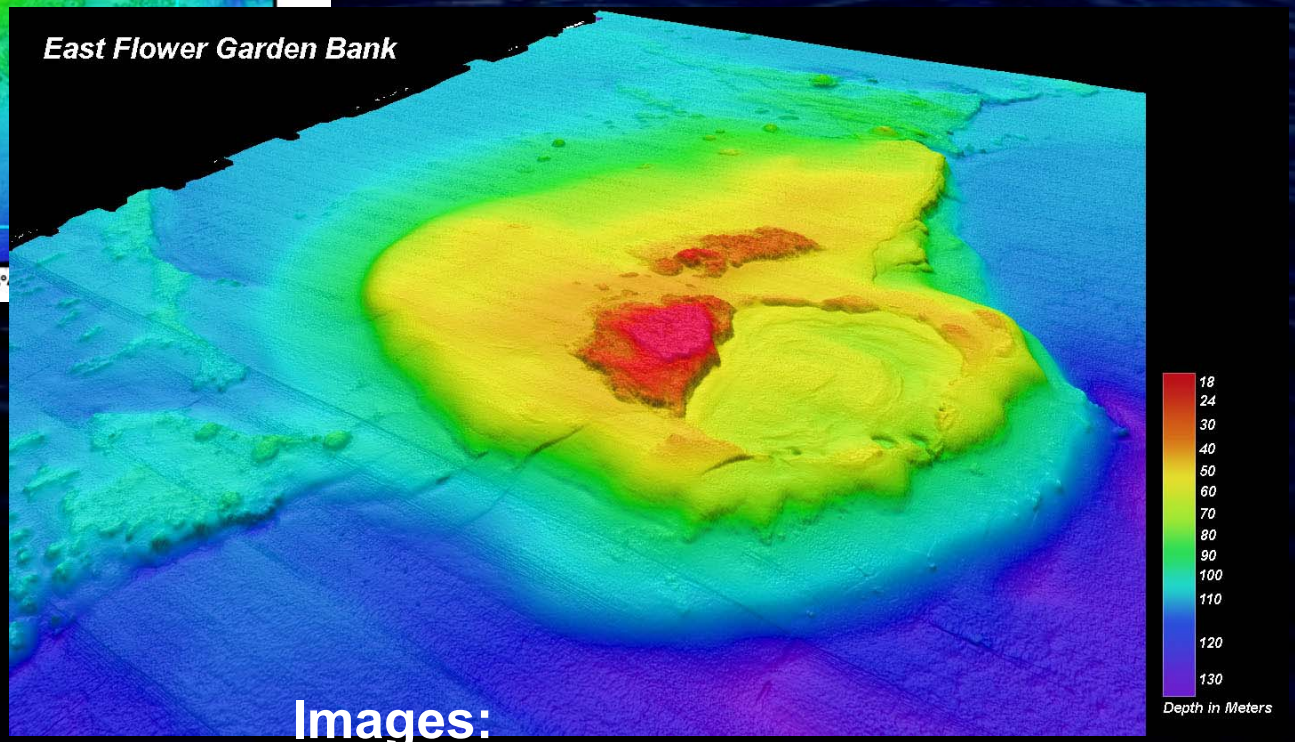
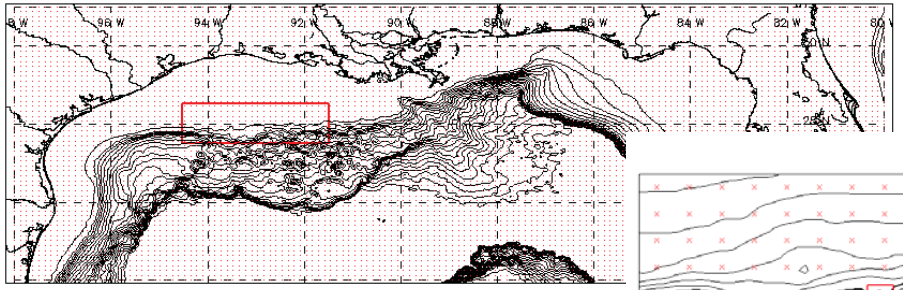




Images:

http://www.ncddc.noaa.gov/website/google_maps/FGB/mapsFGB.htm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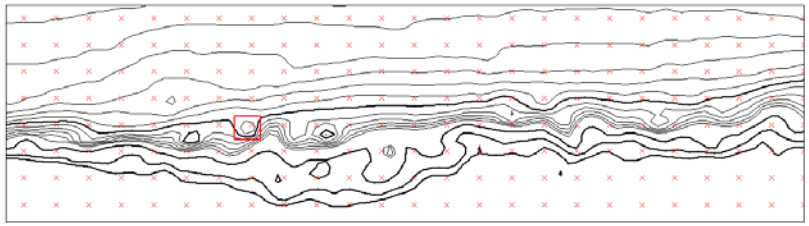
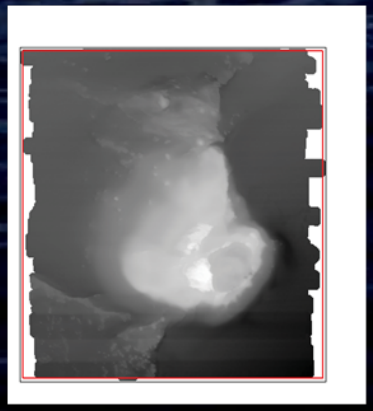
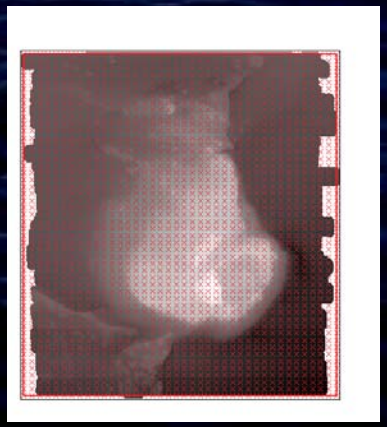
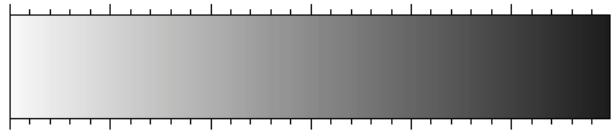
94 W
92 W
90 W
88 W
86 W
84 W
82 W
80
30 N
28 N





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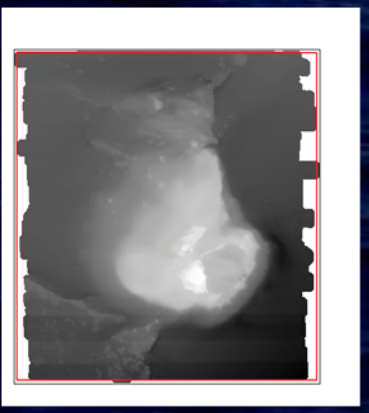
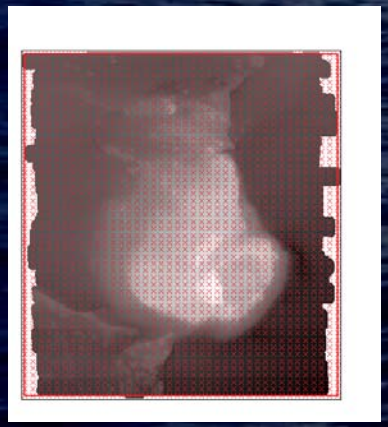
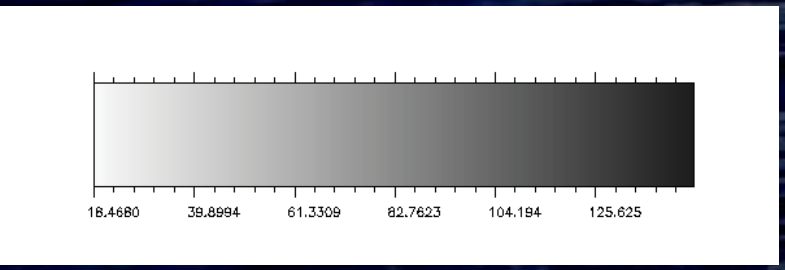
125.625







Sub-kilometer “Relo”
DOMAINS:
(1) East and West Flower Garden Banks;
(2) Stetson Bank,
(3) Bright and Rankin Banks,
(4) Geyer Bank,
(5) Jakkula Bank,
(6) Bouma, Rezak,
Sidner, and McGrail Banks,
(7) MacNeil Bank,
(8) Sonier Bank,
(9) Alderice Bank.

Subsurface Products:

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- High Resolution BATHYMETRY –
  multibeam bathymetry surveys

- SATELLITE OCEAN COLOR
  MODIS/SeaWiFS/HICO*

- SURFACE IRRADIANCE –
  NASA's Ocean Atmosphere Spectral Irradiance Model
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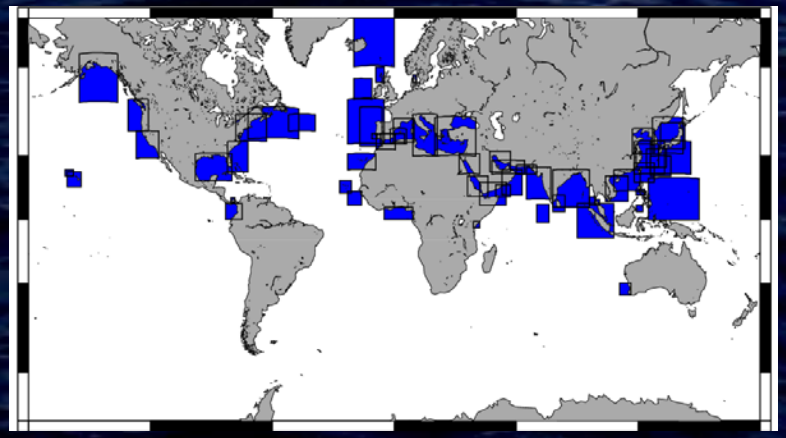
NRL Operational Ocean Color Satellite Processing

APS- Software used for Operational Products at NAVO

Data handling and product generation for real-time "global" satellite processing

MODIS/SeaWiFS



New Opportunity:
Hyperspectral Imager for the Coastal Ocean

- Controlled and Operated by NRL
- Launched <u>September 2009</u>
- 100 m Ground Sample Distance
- 128 channels (380 to 1000 nm)
- David Lewis 4PM

HICO Image
Pusan, South Korea: 11/18/09

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Table 1. Earth Science Data Sources, Products and Model Inputs

Data Source	Product	Input to Model/System
MODIS (Terra+Aqua)	Cloud droplet effective radius	OASIM
MODIS (Terra+Aqua)	Atmos. Aerosol Properties	OASIM
EP-TOMS	Atmos. Ozone	OASIM
ISCCP	Cloud cover/LWP	OASIM
NCEP reanalysis	sfc pressure/wind speed/	OASIM
NCEP reanalysis	rel humidity/precip. water	OASIM
AVHRR/GOES	satellite SST	NCODA
AMSR-E	microwave satellite SST	NCODA
Jason / Envisat	sea surface height anomaly	NCODA
ship/buoy observations	SST and T/S profiles	NCODA
CMAN stations	SST	NCODA
XBT/Argo floats	T/S profiles	NCODA
MODIS (Terra+Aqua)	ocean color products	NRL-APS

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[Temp, Salinity, Currents]

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Underwater Light Field – PAR propagation

Decision-Making Summary:

End-USERS FGBNMS-NOAA; USACE

Proposed Products -- Synthetic (a blend of models and data) three-dimensional, high-resolution six year historical (hindcast) record from Sep 2002 to Sep 2008:

- light (PAR)
- Temperature
- salinity
- current fields

Two-dimensional, 250m-resolution satellite maps at weekly and monthly time scales for a 4-year period (2005-2008) covering regions of interest specified by USACE (Mobile Bay, Perdido Pass, Bayou Labatrie, Pascagoula, Gulfport, East Pass Destin, Pensacola Pass, Panama City Harbor, others).

Product Usage/Relevance

(1) Identify likely locations of specific
benthic communities, such as mesophotic corals,
based on benthic light (PAR), temperature, and bottom shear stress
calculated from near-bottom current velocities;

(2) establish a baseline of standard environmental conditions,
with specific emphasis on light and temperature,
within the FGBNMS and in the aforementioned surrounding banks;

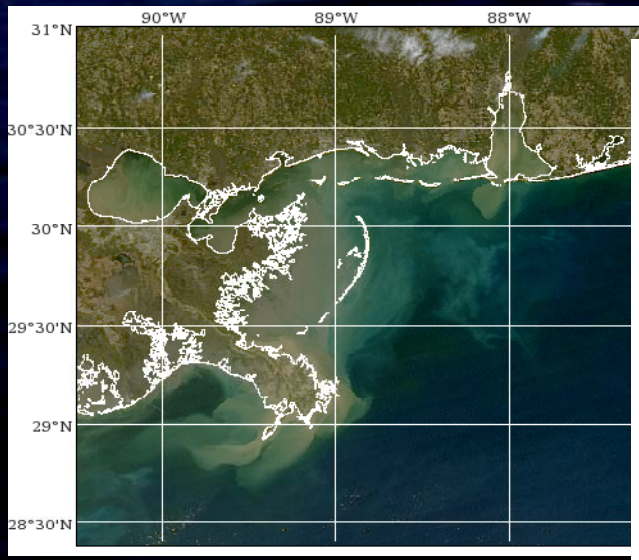
(3) identify zones undergoing stress from (a) excess light and high
temperature or (b) degraded water quality (increased turbidity)
due to the advection of coastal water masses;

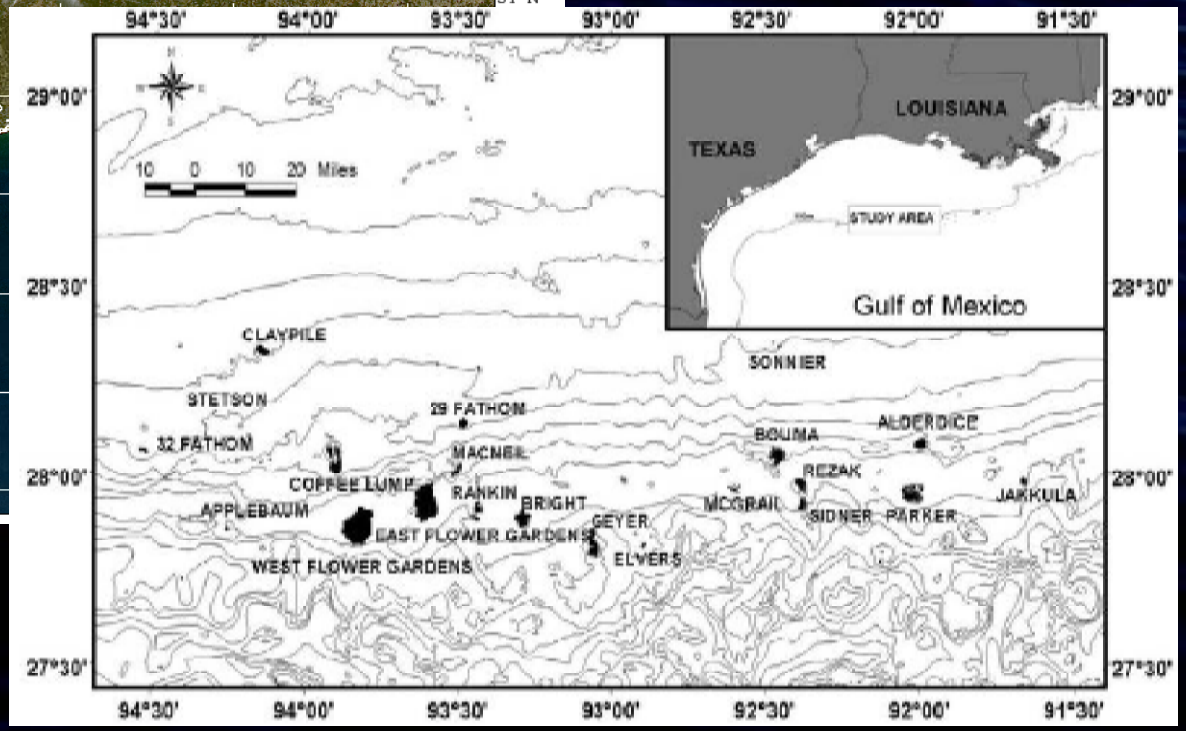
(4) Establish a baseline of SPM conditions. Provide quantitative
thresholds about how USACE activities impact the environment.

Key Proposal Elements:

Blending Models and Data to establish baseline environmental conditions for benthic biological communities

Using the historical ocean color archive and product algorithms to establish baseline quantities for sediment loads, discharges, and water-column clarity.





Transition Approach

NOAA's National Coastal Data Development Center (NCDDC).

"Flower Garden Banks Monitoring Site"--an interactive, web-based portal built upon the "Google Maps" graphical user interface.

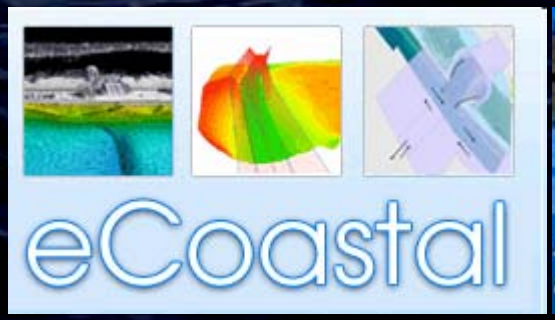
* user to access high-resolution, multibeam echosounder data
- Data from FGBNMS research staff monitoring surveys will be integrated into the system.
- CTD data from the FGBNMS Research Vessel Manta.
- The portal will also allow for access to datasets from buoy stations and monitoring stations on oil and gas platforms in the region.

http://www.ncddc.noaa.gov/website/google_maps/FGB/mapsFGB.htm

Transition Approach

- The weekly and monthly regional satellite sediment concentration maps for the 4-year time series (2005-2008) will provided directly to the RSMPG led by Larry Parsons at USACE, Mobile Bay Office and incorporated into their eCoastal web site: http://ecoastal.usace.army.mil/

- USACE eCoastal is a software architecture developed by USACE that uses spatial data standards, geo-database development, and PC-based software applications.



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Thank You