

Atlantic/Caribbean CREIOS Workshop

Monitoring Physical and Chemical Processes Influencing Coral Reef Condition

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Physical and Chemical Monitoring

PRODUCTS/ACTIVITIES

- Improved Understanding of Ecological Processes
 - Physical - biological linkages
 - Causes of Ecological Change
- Long-term Climate Trends
- Online Continuous and Integrated Data
- Decision Support Tools
 - Nowcasts and Forecasts for Coral Bleaching, Disease
 - Near Real-Time Ecoforecasts for Spawning, Larval Drift, etc.
 - Hydrodynamic Models (bleaching, biology, chemistry, geology)
- Local Action Strategy Support
 - Climate
 - Land-based Sources of Pollution

Physical and Chemical Monitoring

Key Threats Addressed

- **Climate Change**
 - Ocean Warming
 - Ocean Acidification
 - Sea-level Rise
 - Changing Ocean Circulation, Storm Tracks and Intensities
- **Impacts of Fishing**
 - Biological Productivity
 - Larval Transport/Recruitment
- **Land-based Sources of Pollution**
 - Eutrophication
 - Near-shore Hydrologic Cycles
 - Near-shore Hydrodynamic Processes
- **Alien/Invasive Species**
- **Coral Disease**
- **Recreational Overuse**
- **Marine Debris**



CORE CAPABILITIES



Capability 1: *In Situ*, Fixed platform-based temporal oceanographic and water quality surveys



Capability 2: Ship-based spatial oceanographic and water quality surveys



Capability 3: Satellite-based synoptic observations



Capability 4: Regional Physical/Chemical Modeling

NOAA Capabilities

Capability 1: *In situ* Instrumentation



Near-real-time Instrumentation

- ICON/CREWS Pylons (proposed)
- MAPCO2 Moorings (OA)
- NDBC Buoys

Subsurface Instrumentation

- Wave & Tide Recorders (WTR)
- Ocean Data Platforms (ADCP)
- Current Meters (CM)
- Subsurface Temperature Recorders
- Ecological Acoustic Recorders (EARs)



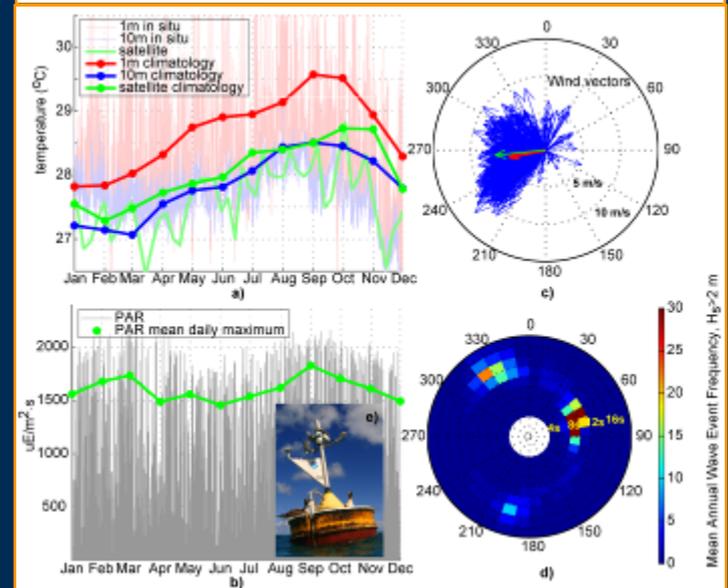
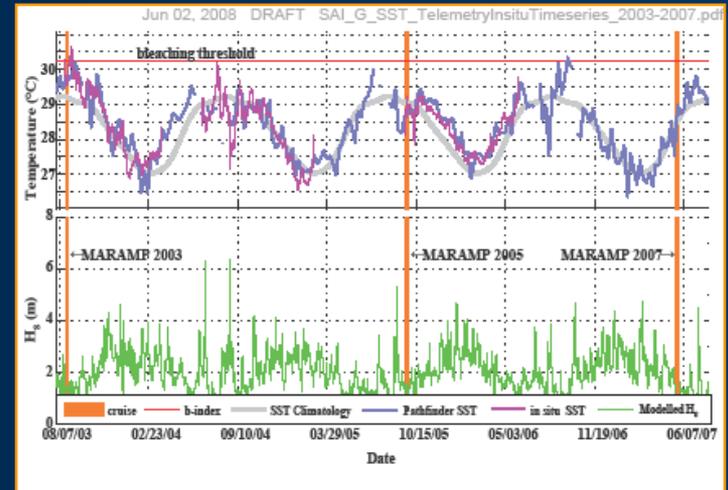
NOAA Capabilities

Capability 1: *In situ* Instrumentation



Parameters measured:

- Temperature
- Air Temperature, Pressure, and Wind
- Salinity
- Currents (profiles)
- Waves
- Light (PAR, UV)
- pCO₂
- Sound
- Nutrients



NOAA Capabilities

Capability 1: *In situ* Instrumentation



Map of Sites (now and proposed):



CRCP



NOAA Capabilities

Capability 1: *In situ* Instrumentation



Management Requests:

- ✓ Near-real-time monitoring (FL) – CREWS/ICON
- ✓ Currents for larval transport and connectivity (Region) – Drifters/ODP/CM
- ✓ Ocean acidification – MAPCO2 (Region)
- Regional Integration (Region) – CariCOOS and other Regional OOSes
- Continue reef SST monitoring (FL) – FKNMS
- Nearshore salinity (FL)
- Currents and waves for LBSP (PR, USVI)

Satellite and Model Initiation/Validation

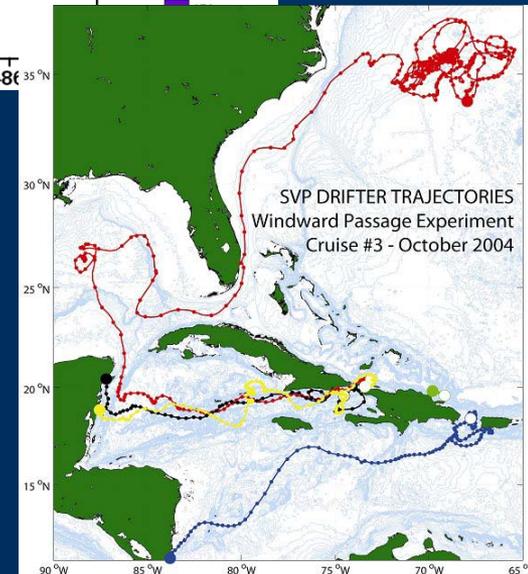
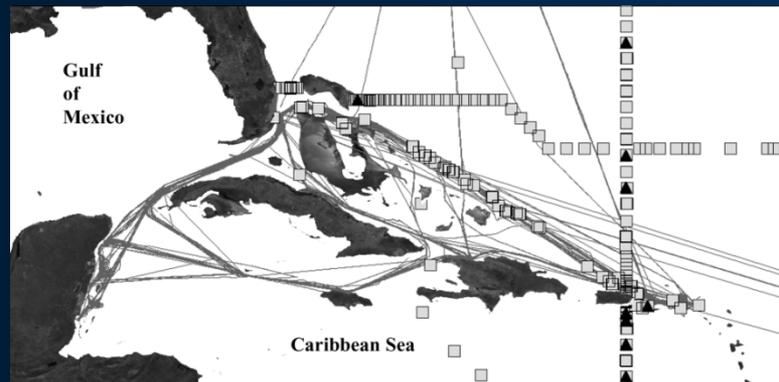
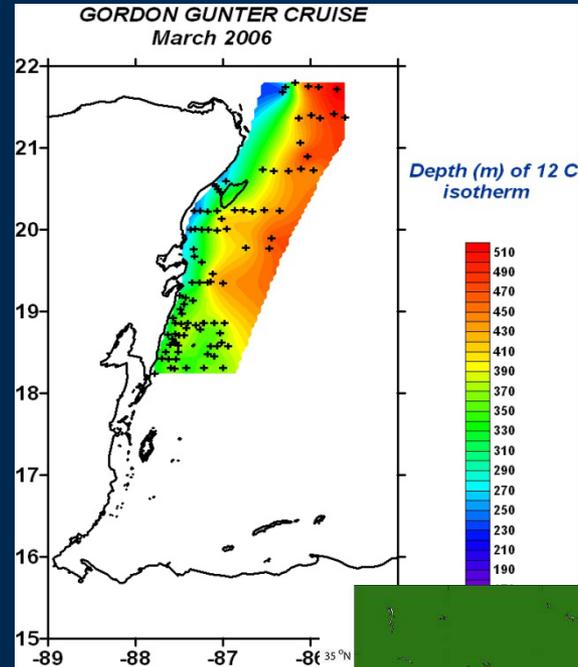
NOAA Capabilities

Capability 2: Ship-based Monitoring



Spatial Structure of:

- Temperature
- Salinity
- Chlorophyll
- Turbidity
- Nutrients
- Carbon chemistry
- Current Velocity



NOAA Capabilities

Capability 2: Ship-based Monitoring



Atlantic/Caribbean Oceanographic Cruises

Region	Project	06	07	08	09	10 ?
Caribbean	Reef fish/Larval Fish (NMFS)		X		X	X
GOM	Reef fish survey (NMFS)	X	X	X	X	X
GOM	Flower Garden Banks NMS (NOS)	X	X	X		X
GOM	Deep coral (NMFS)					X
FL	Pulley Ridge reef fish (NMFS)				X	X
FL	Florida Keys NMS (NOS)	X	X	X	X	
FL	Tortugas Ecological Reserve (NOS)		X	X	X	X
FL	Oculina Banks (NMFS)			X		
FL	FACE (OAR)		X	X		X
FL	Benthic habitat mapping (NOS)					X
PR/USVI	Benthic habitat mapping (NOS)	X	X	X	X	X (FL)
PR/USVI	Ocean Obs/fish larvae (OAR, NMFS)		X	X	X	X
PR/USVI	Reef fish recruitment (NMFS)					
PR	Vieques seagrass & coral (NOS)	X	X	X		
Navassa	Navassa NWR (NMFS, NOS)	X			X	

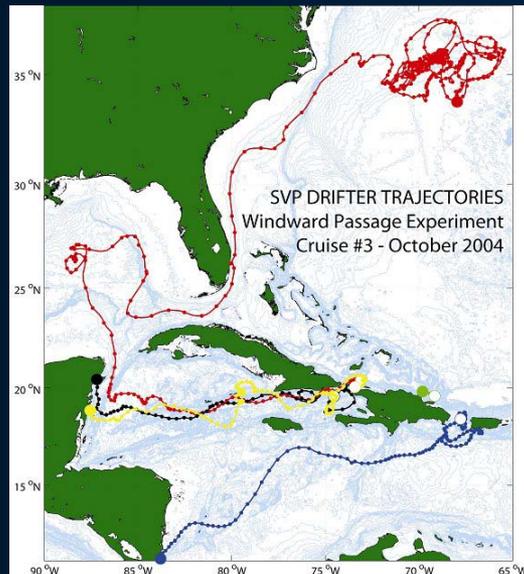
NOAA Capabilities

Capability 2: Ship-based Monitoring



Management Requests:

- ✓ Currents for connectivity (USVI)
- ✓ Currents and waves for LBSP (PR, USVI)
- See *in situ* list



Larval drift around Caribbean



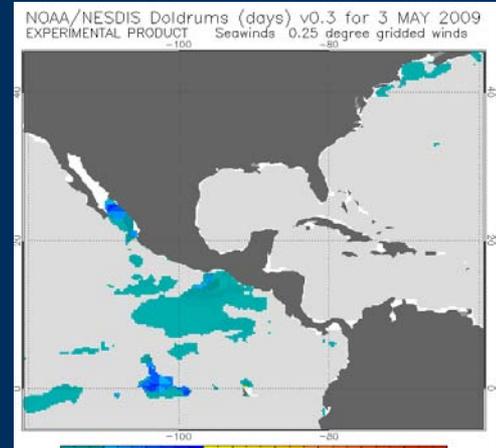
Caribbean CO₂

NOAA Capabilities

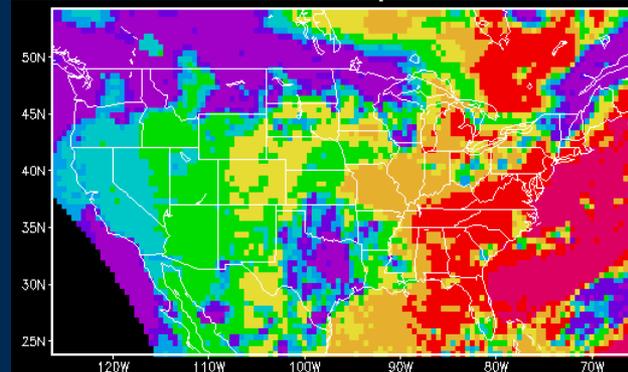
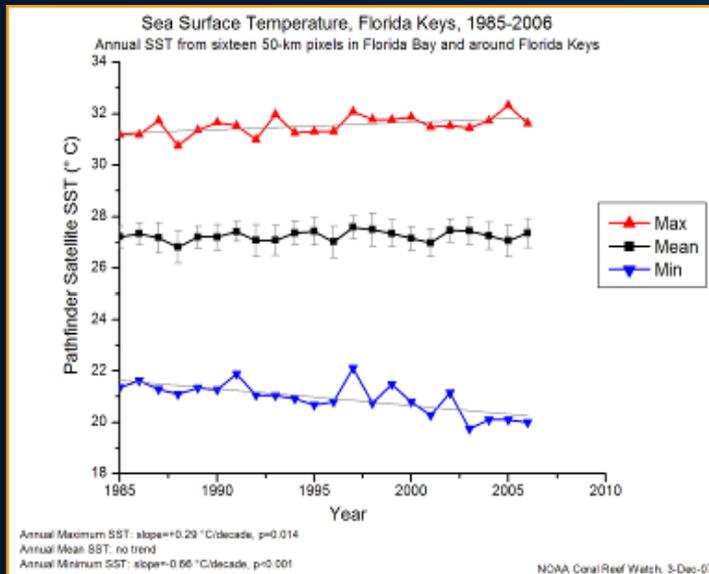
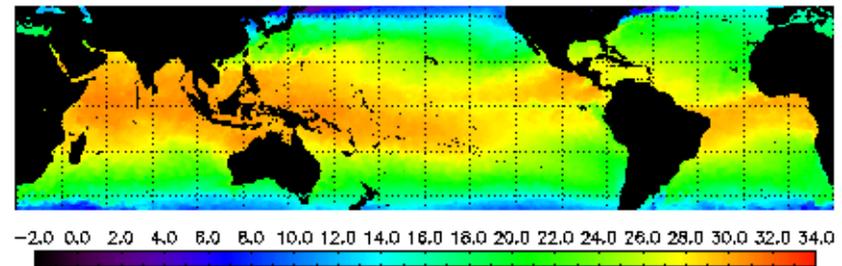
Capability 3: Satellite Monitoring



- SST
- Wind
- Ocean Productivity
- Sea Surface Height
- Light
- Coral-Specific Products

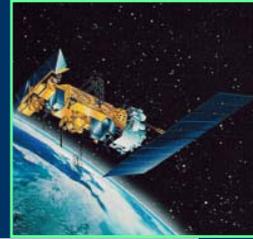


NOAA/NESDIS 50 km Nighttime SST (C), 5/4/2009



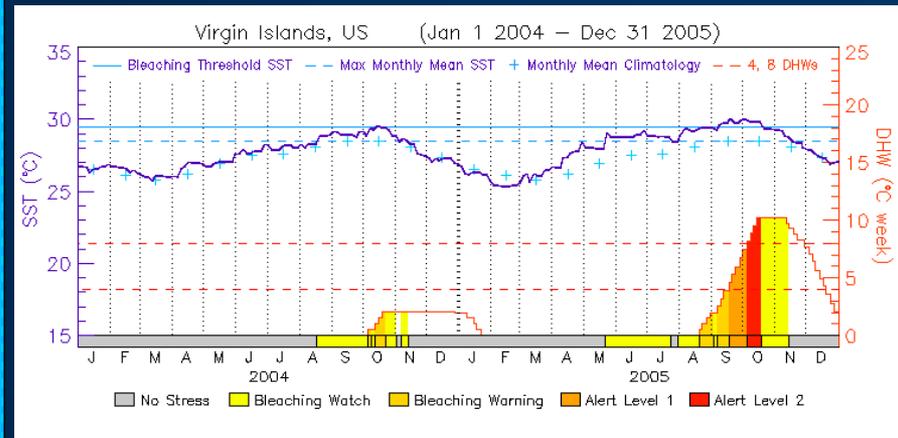
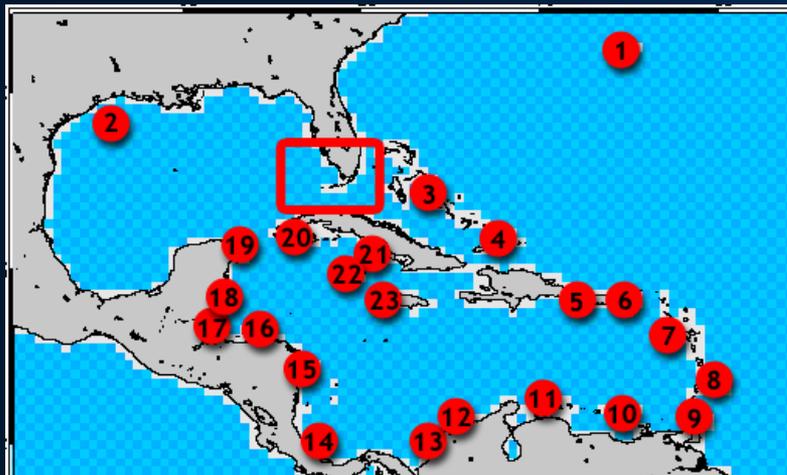
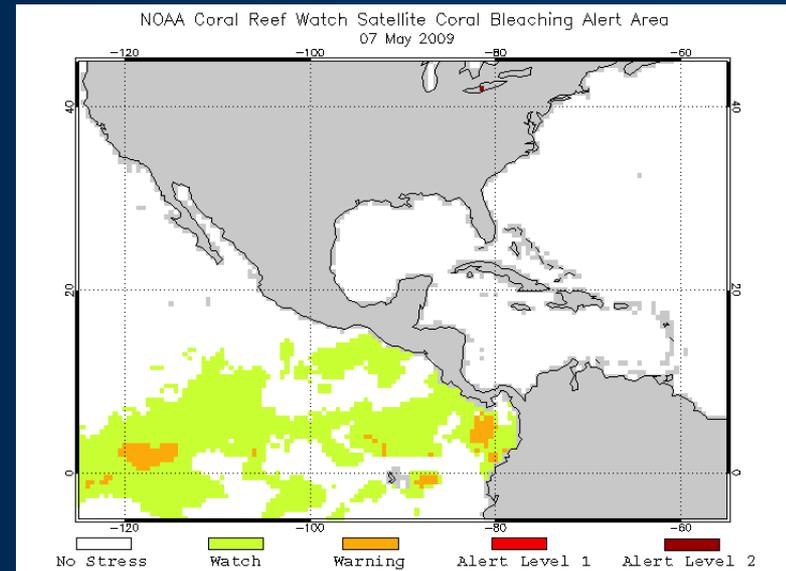
NOAA Capabilities

Capability 3: Satellite Monitoring



SST-Based Products:

- Coral bleaching nowcasts
- Satellite Bleaching Alerts
- Virtual Stations
- Near-real-time data
- Long-term data



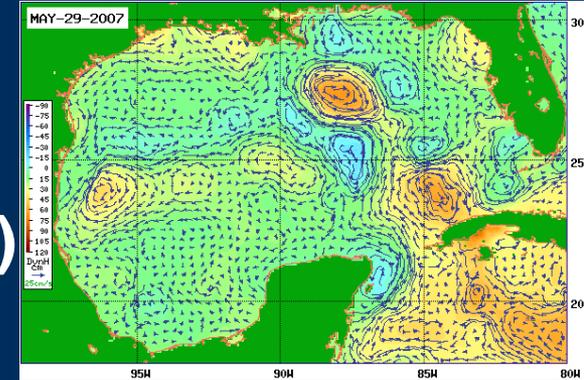
NOAA Capabilities

Capability 3: Satellite Monitoring

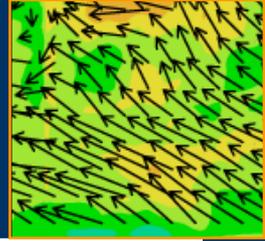


Management Requests:

- ✓ Circulation for:
 - Nearshore processes (USVI,PR)
 - Connectivity (USVI,Region)
- ✓ Coastal chlorophyll (FL) – AOML/CoastWatch
- ✓ Bleaching prediction & follow-up (USVI,PR) – CRW
- ✓ Nearshore & higher resolution SST (FL,USVI)
- ✓ Ocean acidification (PR) – AOML/CRW
 - Land use changes (USVI,PR)
 - Satellite bleaching detection (PR)
 - Climate Change: Biological impacts (USVI,PR), resilience (USVI,PR), Sea Level Rise (PR)



Capability 4: Physical/Chemical Modeling



NOAA Modeling: Synthesis and product development applications of prior capabilities

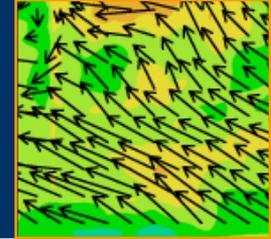
Modeling Products:

- **Bleaching and disease forecasts**
- **Ocean acidification**
- **Hydrodynamic Modeling**
 - **Conductivity**
 - **Near-shore processes**
- **Harmful Algal Blooms**
- **Other Ecoforecasting**



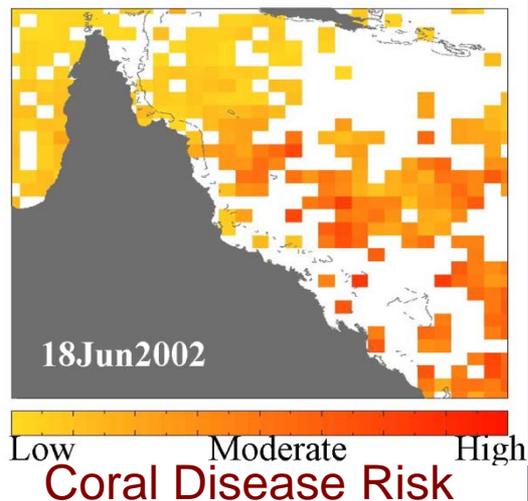
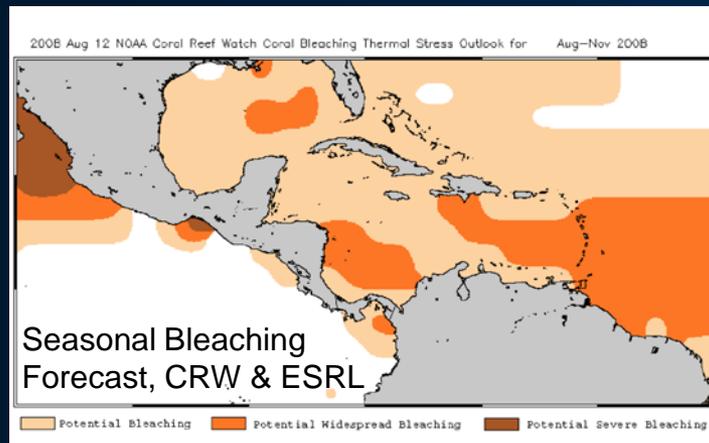
NOAA Capabilities

Capability 4: Modeling



Thermal Stress:

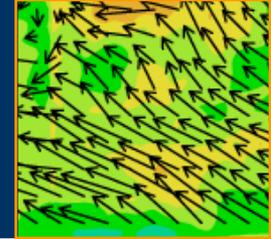
Bleaching and disease forecasts



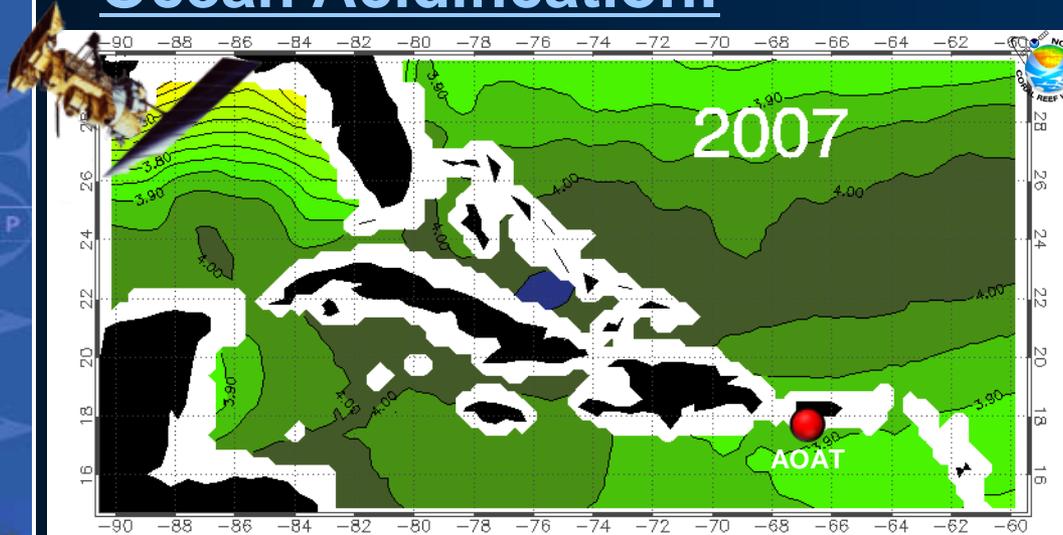
- A tropical coral bleaching outlook system
- NOAA ESRL SST model
- Forecast regions of potential thermal stress from one-week to four months
- SST-based Disease outbreak potential

NOAA Capabilities

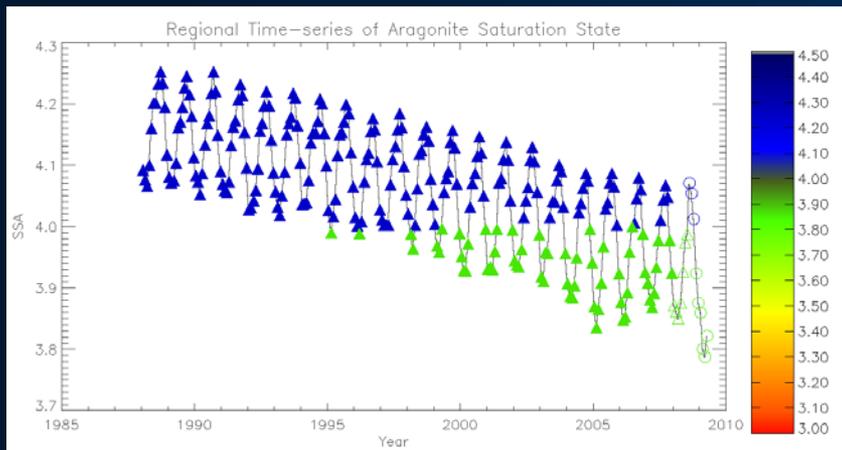
Capability 4: Modeling



Ocean Acidification:



- Monthly modeled environmental datasets estimates of sea surface carbonate chemistry in the Greater Caribbean Region.



NOAA Satellite and Information Service
National Environmental Satellite, Data, and Information Service partners

Coral Reef Watch

An Introduction to Ocean Acidification

What is Ocean Acidification?

Over the past few centuries, human-kind dramatically altered the composition of the earth's atmosphere through deforestation and the burning of fossil fuel. Atmospheric carbon dioxide (CO₂) concentrations have increased to the highest level experienced in Earth for at least the last 600,000 years (Trenberth et al., 1999; Solomon et al., 2000; Solomon et al., 2001). The global oceans are the largest natural reservoir for much of the excess CO₂—absorbing approximately one-third of that added to the human activities each year (IPCC, 2001). As a result, dissolved CO₂ in the surface ocean will likely double over the 21st century, representing perhaps the most dramatic change in ocean chemistry in over 20 million years (Zeebe et al., 2002).

As CO₂ reacts with seawater it forms carbonic acid, causing a reduction in seawater pH. Seawater is naturally buffered against these pH changes, but the buffering process consumes carbonate ions. Carbonate ion is an essential ingredient in the creation of calcium carbonate shells and skeletons produced by a large number of marine organisms.

Changes in atmospheric CO₂ and pH and pCO₂ at 10°N, 10°S, and 10°E

Year: 1980, 1985, 1990, 1995, 2000, 2005, 2010

CO₂ (ppm): 310, 320, 330, 340, 350, 360, 370, 380, 390, 400, 410, 420, 430, 440, 450

pH: 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 9.0, 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7, 9.8, 9.9, 10.0

pCO₂ (atm): 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0

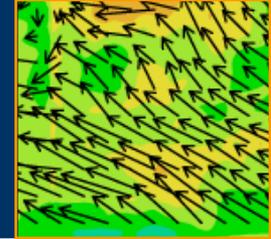
OA Products Home

- Introduction
- 1. Ocean Acidification
- 2. OA and Coral
- 3. Substrate Status
- Methodology
- 1. General Approach
- 2. Surface pCO₂
- 3. Total Alkalinity
- Validation
- References

http://coralreefwatch.noaa.gov/satellite/current/experimental_products.html

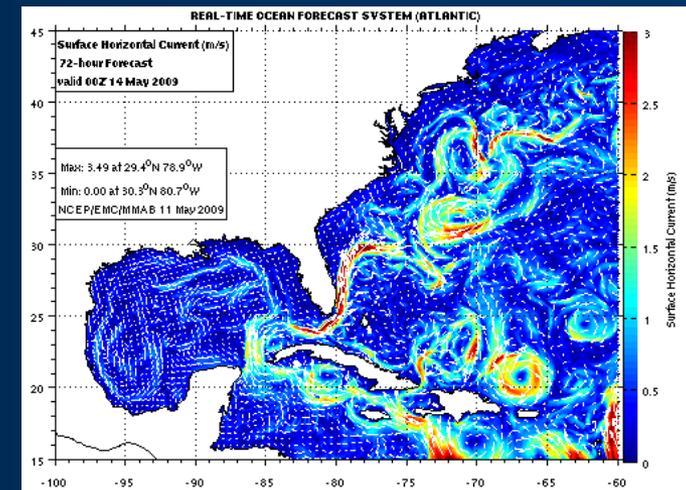
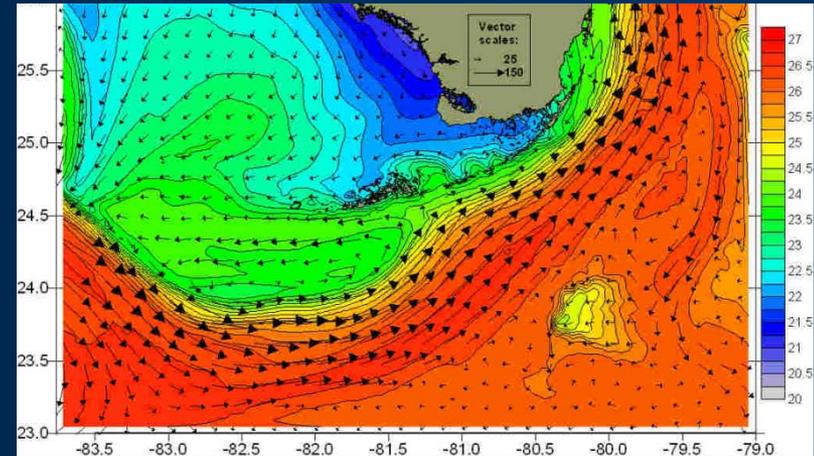
NOAA Capabilities

Capability 4: Modeling



Hydrodynamic Modeling:

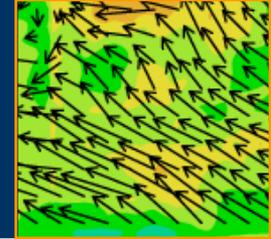
- Multiple scales: bay to basin
- Existing examples:
S FL HYCOM, PR/USVI
ROMS, RTOFS



NOAA Environmental Modeling Center
Real-Time Ocean Forecast System
(Atlantic)

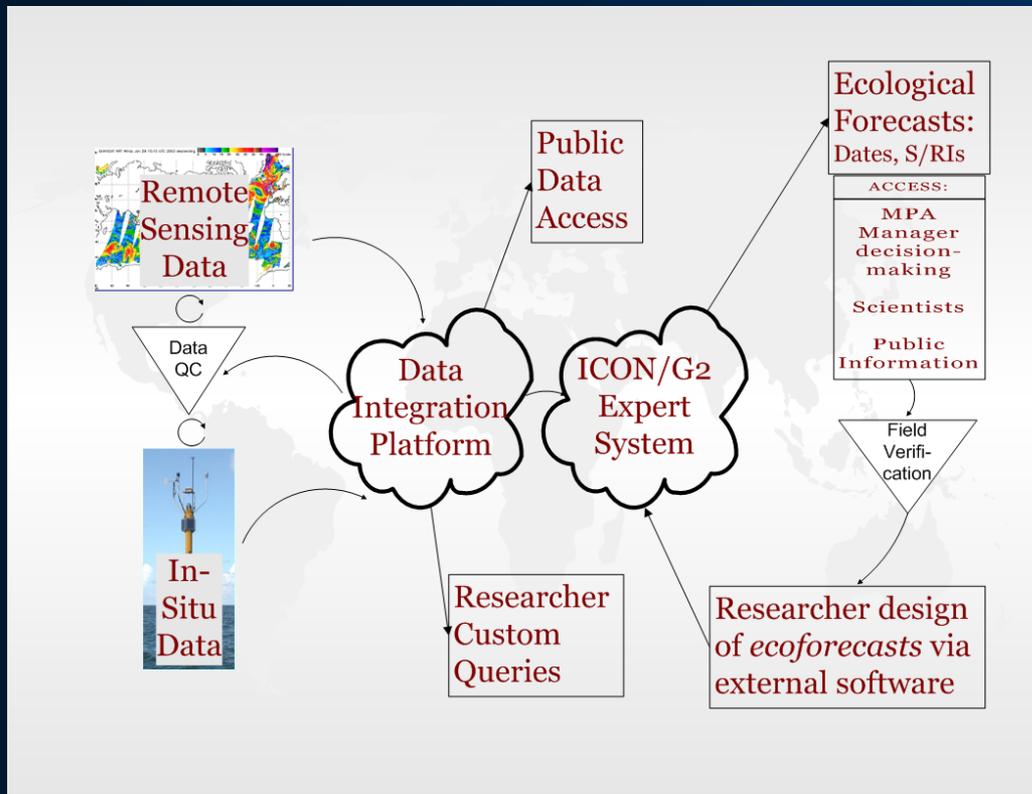
NOAA Capabilities

Capability 4: Modeling



Ecoforecast:

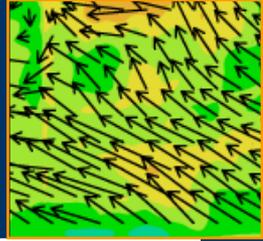
- **ICON/G2 Expert System**



- **Ecological forecasts predict the impacts of physical, chemical, biological, and human-induced change on ecosystems and their components.**

<http://ecoforecast.coral.noaa.gov>

Capability 4: Modeling



Management Requests:

- ✓ Bleaching event prediction (Region) - CRW
- ✓ Ocean acidification (Region) – CRW/AOML/UPRM
- ✓ HAB/Black water events (FL) – NCCOS
- Larval transport/recruitment (USVI)
- Sea level rise (PR,FL) – Climate & Coastal Program
- Near-shore currents for LBSP (PR, USVI)



Physical and Chemical Monitoring

Challenges:

- **Better integrate data**
- **Tailor products to management needs**
- **Improved access and more timely delivery**
- **Automate observations**
- **Better serve management**
- **New instruments to address known gaps**
- **Higher resolution data**
- **More tools for climate change impacts**
- **Model parameterization/validation**



Physical and Chemical Monitoring

Future Directions – Underway:

- **Light and temperature from satellites**
- **Bleaching and disease prediction**
- **Higher resolution data**
- **Standard systems for data access/analysis**
- **Training for data use and application**
- **Atlantic OA Test-bed, La Parguera, PR**

Future Directions – Down the Road:

- **Quantitative water quality and turbidity from satellites**
- **Ocean Acidification Monitoring Network**



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