

Assess and Characterize U.S. Coral Reefs: Coral Reef Ecosystem Integrated Observing System (CREIOS)

Program Review

NOAA Coral Reef Conservation Program

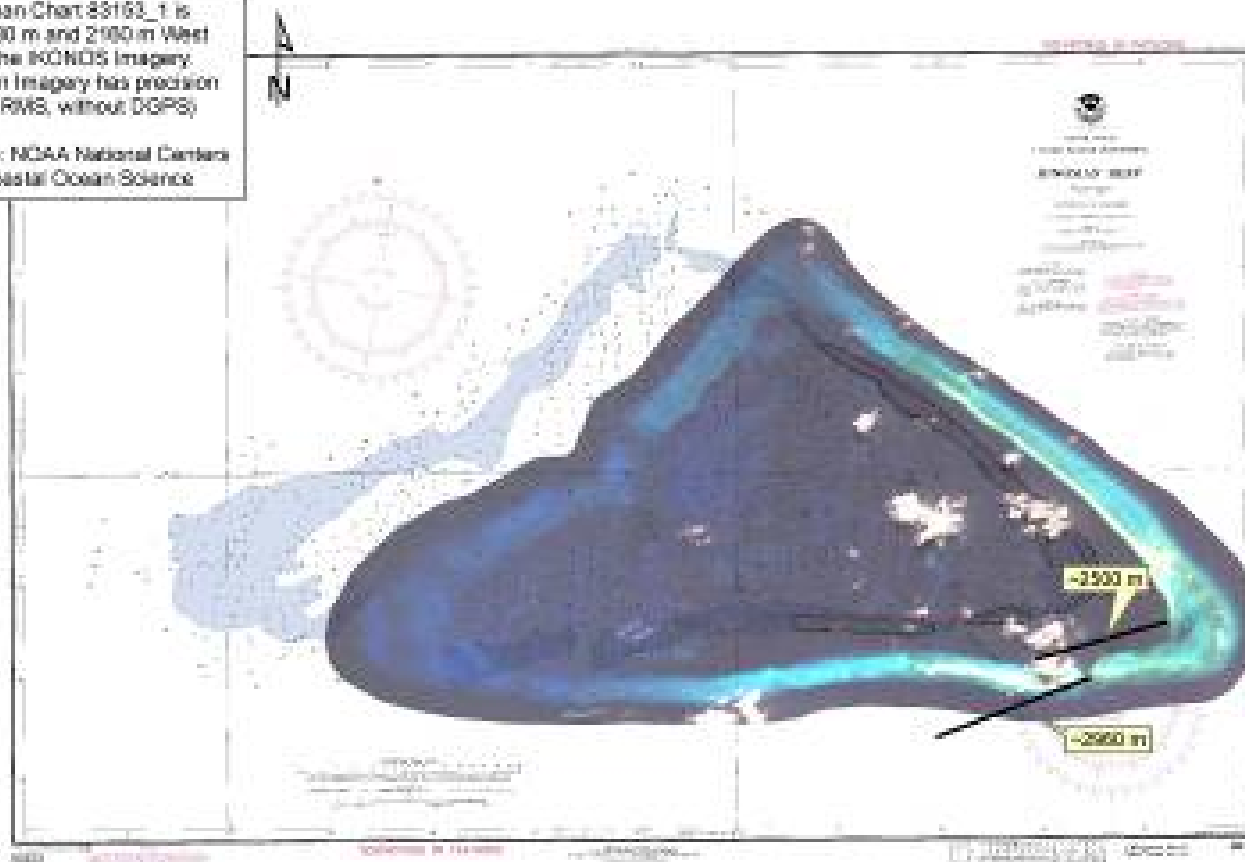
September 25th, 2007

Mapping & Monitoring Pre-CRCP

- Lack of information about the extent and distribution of U.S. reefs and associated habitats
- Data collected were difficult to discover or obtain
- Differences between Atlantic/Carib and Pacific efforts
- U.S. Caribbean: jurisdiction-specific monitoring, not spatially or temporally comprehensive, and few long-term datasets
- U.S. Pacific: little or no prior biological assessments, few on-going monitoring
- Lack of accurate bathymetric and location information, especially for remote islands and atolls

Kingman Chart 83163_1 is
North 100 m and 2100 m West
from the ICONEIS Imagery
(Kingman Imagery has precision
~10m RMS, without DGPS)

Reference: NOAA National Centers
for Coastal Ocean Science



Significant chart offsets for many reefs – ~2 km

Limited Prior Ecosystem Assessments

Example: percentage of new records of reef fish species (best known taxonomic group) after first Pacific RAMP cruise to U.S. Line and Phoenix Islands.

- **Kingman Atoll: +96%**
- **Palmyra Atoll: +35%**
- **Jarvis Island: +72%**
- **Howland Island: +60%**
- **Baker Island: +78%**

CRCP Goals

To effectively manage and conserve coral reef ecosystems, managers must know:

- where the resources are (mapping)
- what the resources are (assessment)
- how they change over time (monitoring)
- how to access information (data dissemination)

National Coral Reef Action Strategy

Theme 1: Understanding Coral Reef Ecosystems

Goal 1: Map all U.S. Coral Reefs

Goal 2: Assess, Monitor, and Forecast Reef Health

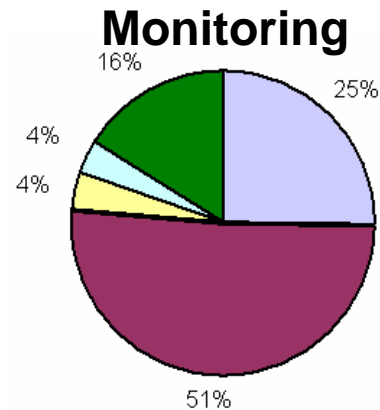
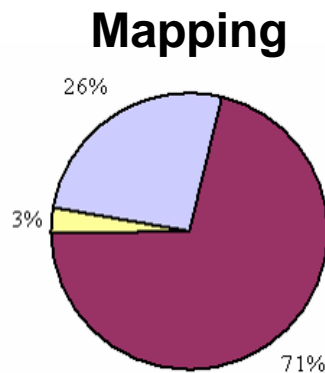
CREIOS Vision

The CREIOS goal is to understand the condition and health of and processes influencing coral reef ecosystems to assist stakeholders in making improved and timely ecosystem-based management decisions to conserve coral reefs.

CREIOS provides a diverse suite of long-term ecological and environmental observations and information products over a broad range of spatial and temporal scales.

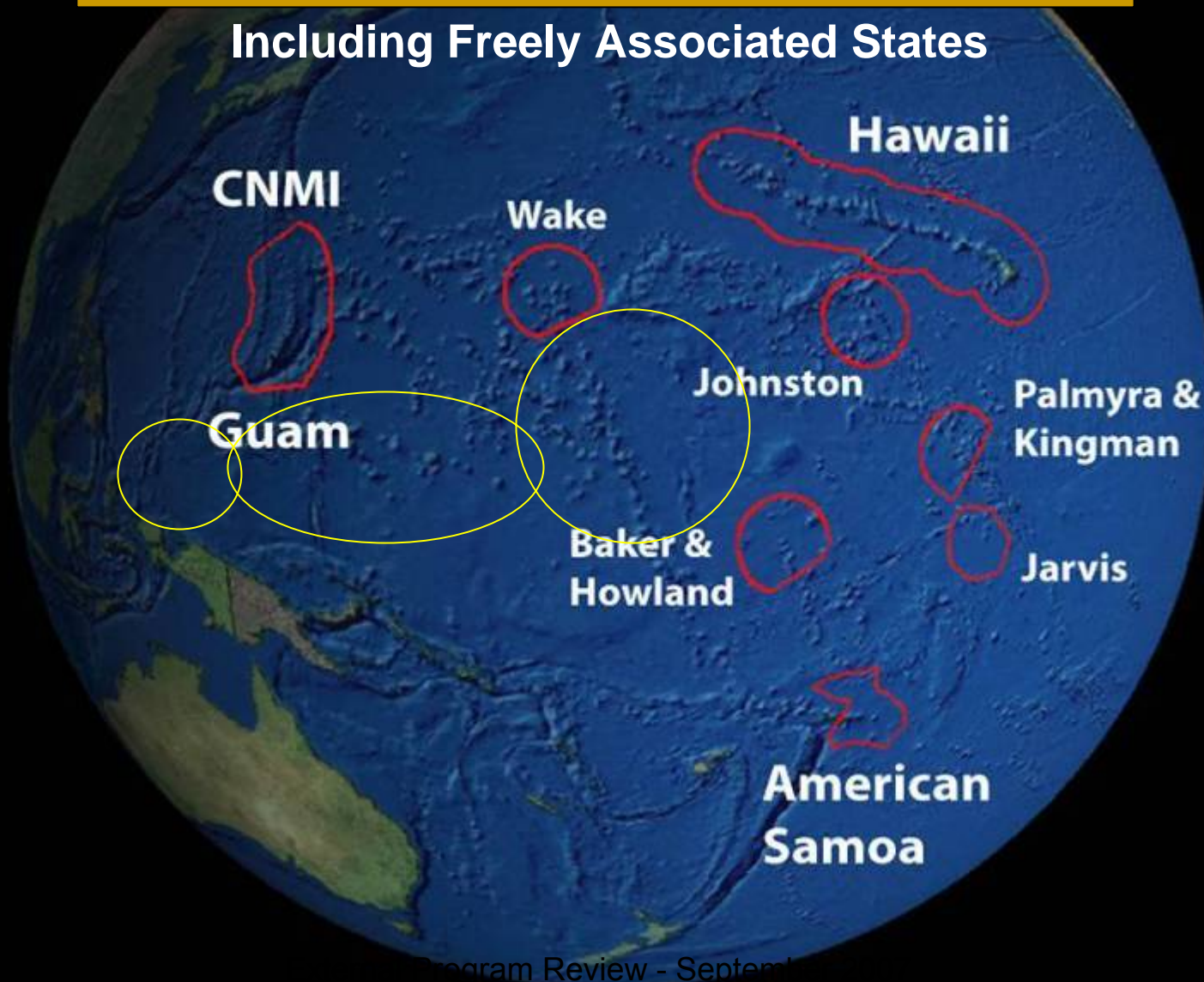
CREIOS Funding

- 199 Projects (15% total CRCP)
- \$42.2 M (33% total CRCP)
- Tools:
 - 90% Mapping/Monitoring
 - 2% Management
 - 8% Outreach
- Subcategories:
 - Mapping (36%)
 - Monitoring (55%)
 - Data Dissemination (9%)
- Efforts concentrated in the Pacific region

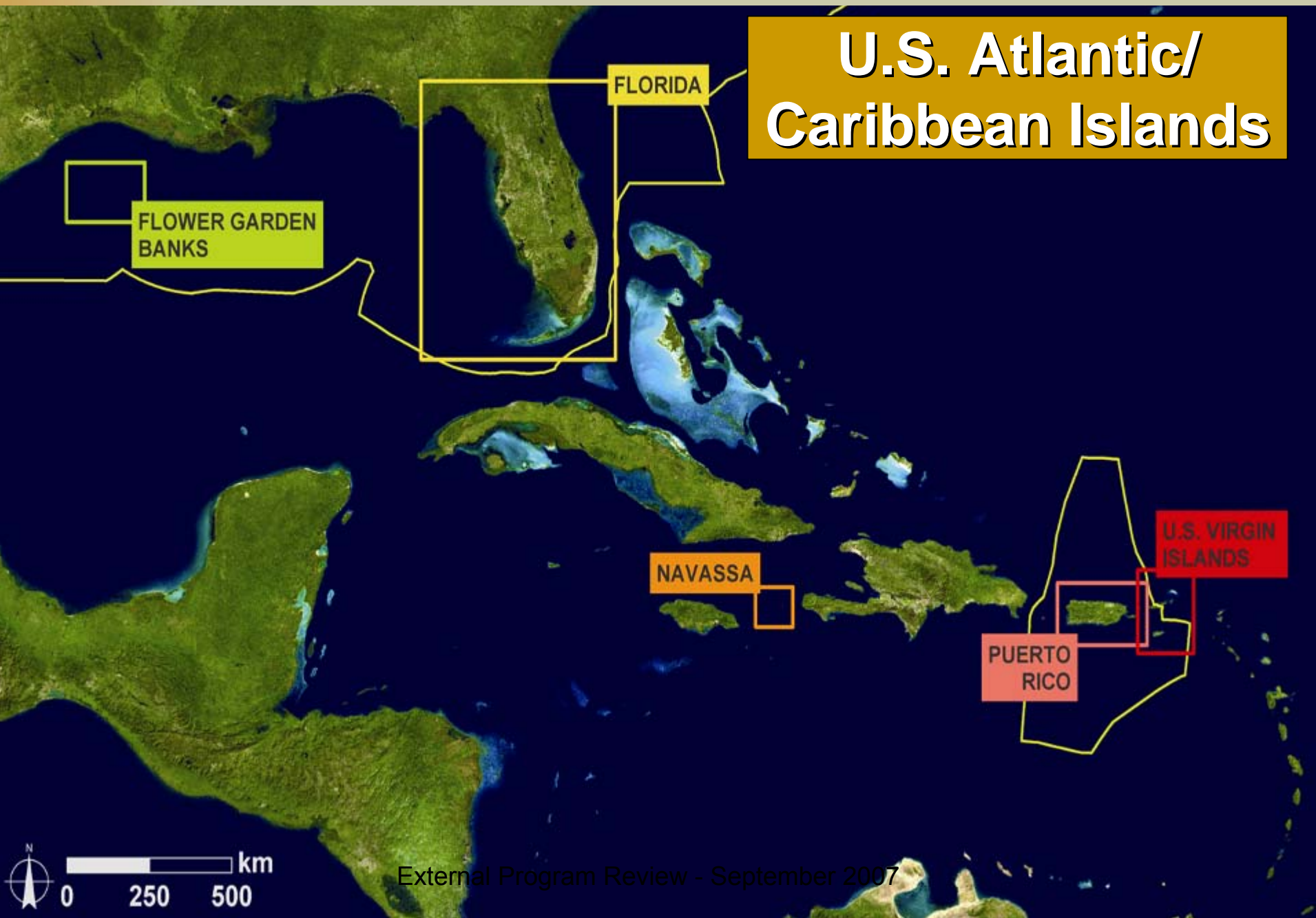


U.S. Pacific Islands

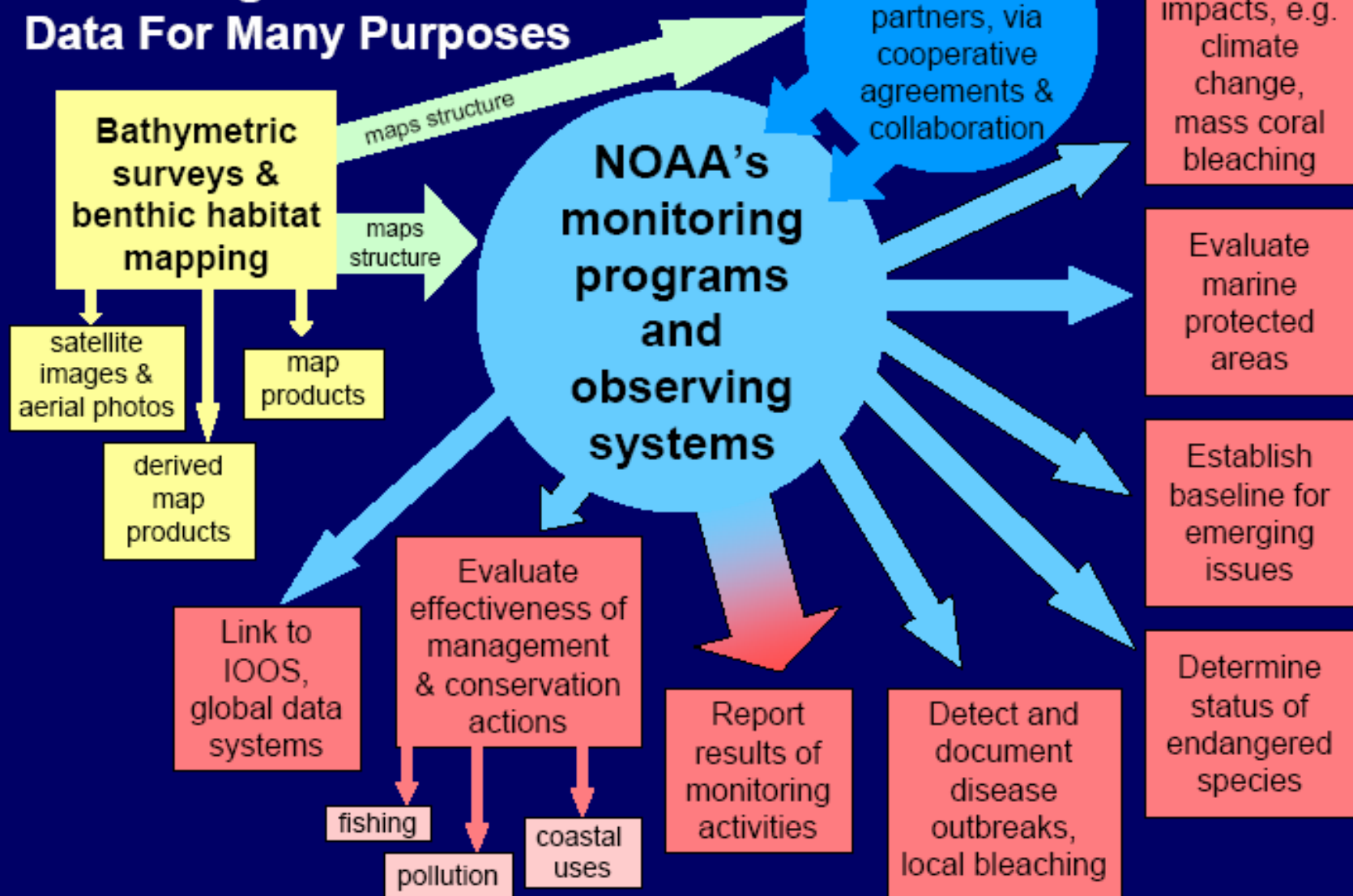
Including Freely Associated States



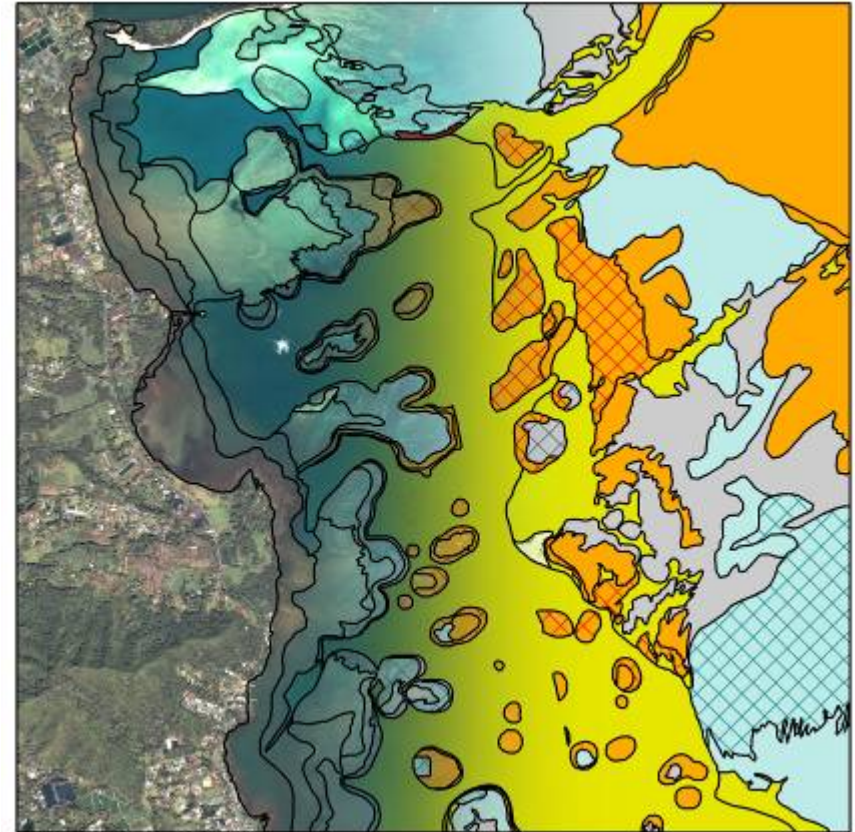
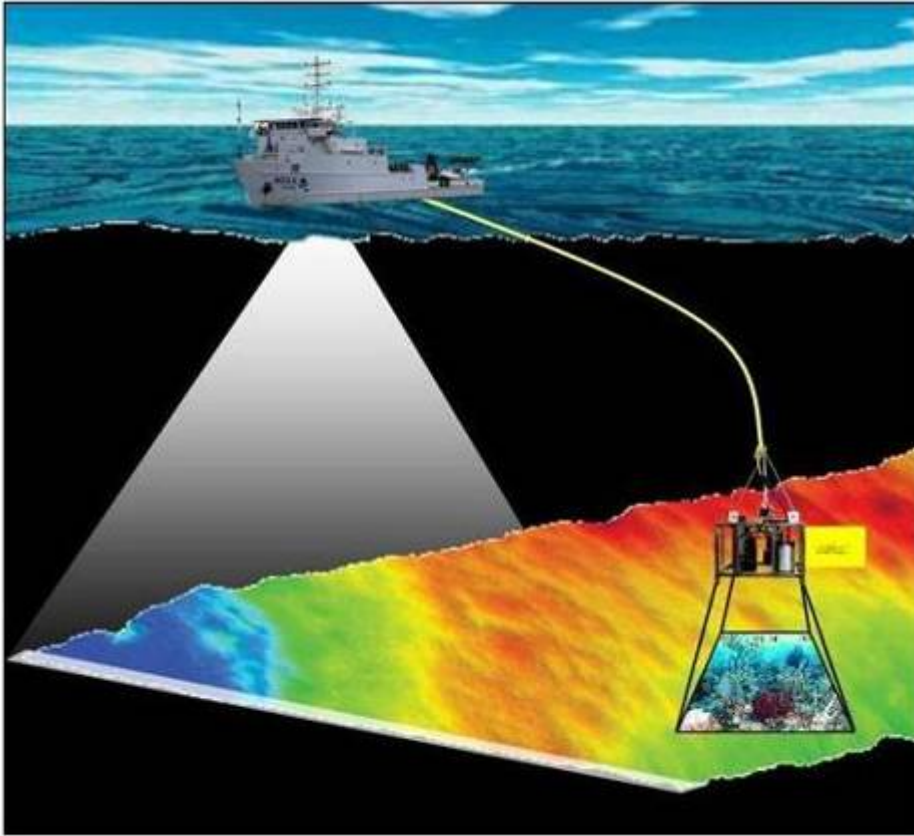
U.S. Atlantic/ Caribbean Islands



NOAA's Integrated Mapping and Monitoring Activities Provide Data For Many Purposes



Overview: Coral Reef Ecosystem Mapping



Mapping Goals

- Provide a comprehensive suite of habitat mapping products for U.S. coral reefs to:
 - establish MPAs,
 - structure monitoring,
 - assess damage to resources,
 - plan coastal development and mitigation activities,
 - prioritize conservation efforts
- Develop mapping technologies to more efficiently map shallow and moderate-depth habitats

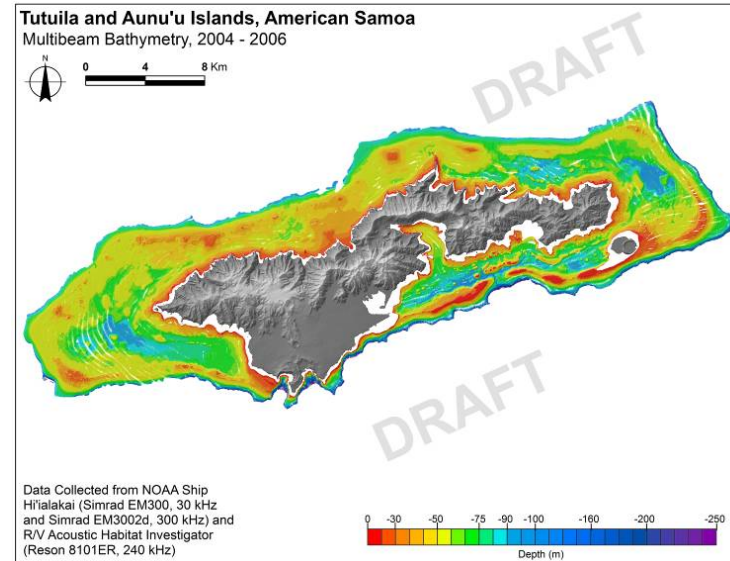
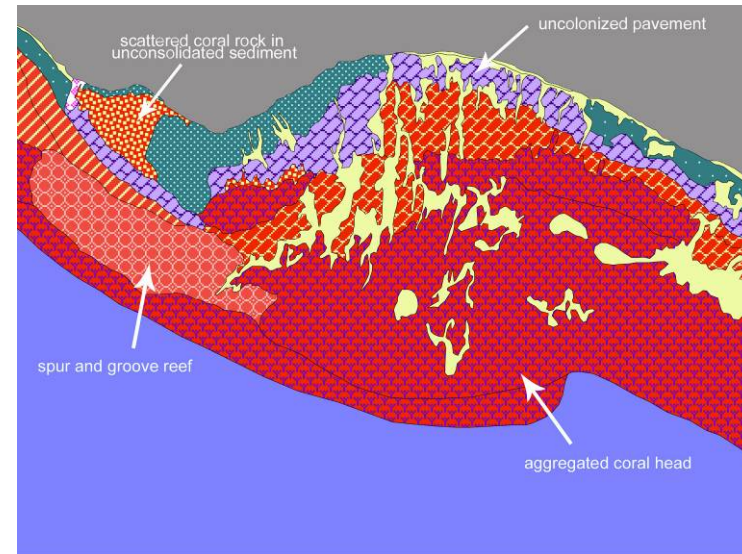
Overview: Mapping Approaches

Habitat Mapping

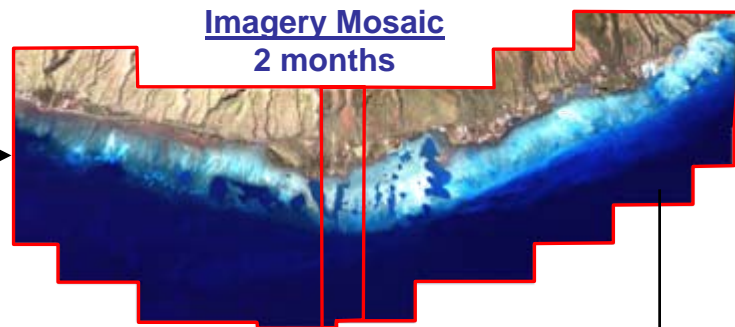
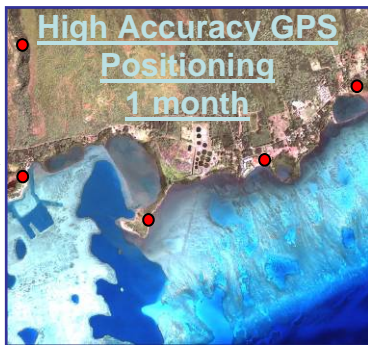
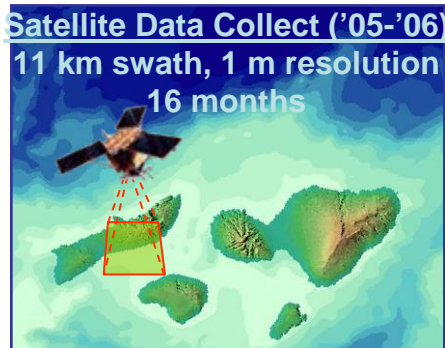
- Shallow, nearshore areas to visible depth ~30m
- Uses satellite imagery, hyperspectral imagery, aerial photos, etc.
- Humans delineate habitat boundaries, assign classes
- Result in maps of structure and biological cover

Bathymetric surveys

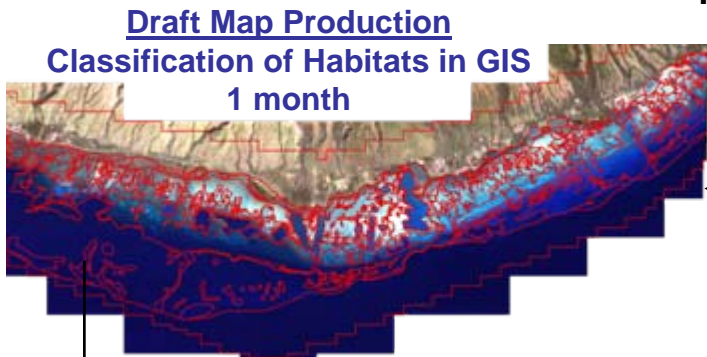
- Mid- and deep-water habitats, 20-200m
- Uses multibeam acoustic technologies
- Measure acoustic backscatter of the seafloor
- Result in high resolution bathymetry, some information about location of hard and soft features
- Supported by optical observations from towed cameras, ROVs, AUVs, etc.



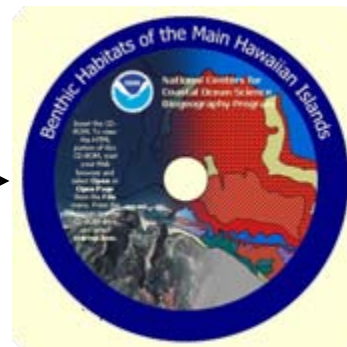
Imagery Collection and Processing



Mapping Production

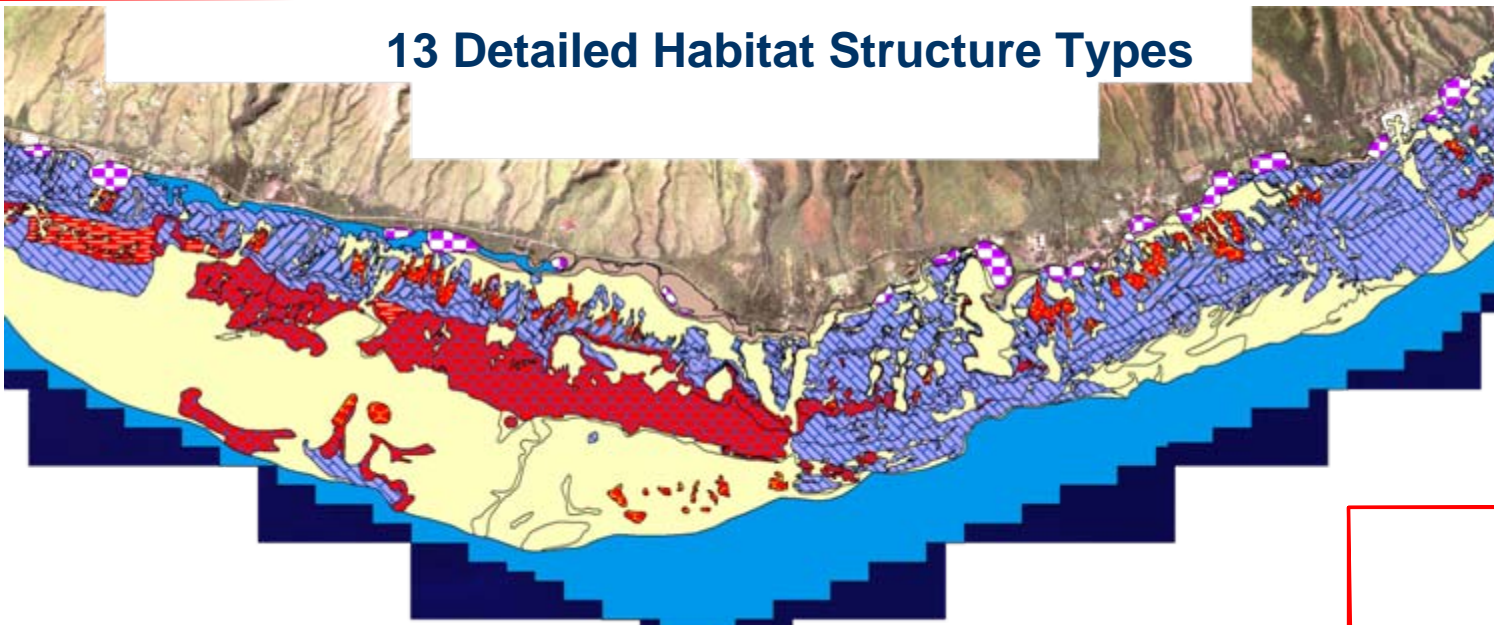


Product Development



Final Product
CD-Rom, website,
color Atlas
4 months

13 Detailed Habitat Structure Types



- Habitat Structure**
- Sand
 - Mud
 - Spur and Groove
 - Individual Patch Reef
 - Aggregate Reef
 - Aggregated Patch Reef
 - Scattered Coral/Rock
 - Pavement
 - Rock/Boulder
 - Rubble
 - Pavement with Sand Channels
 - Artificial
 - Unknown

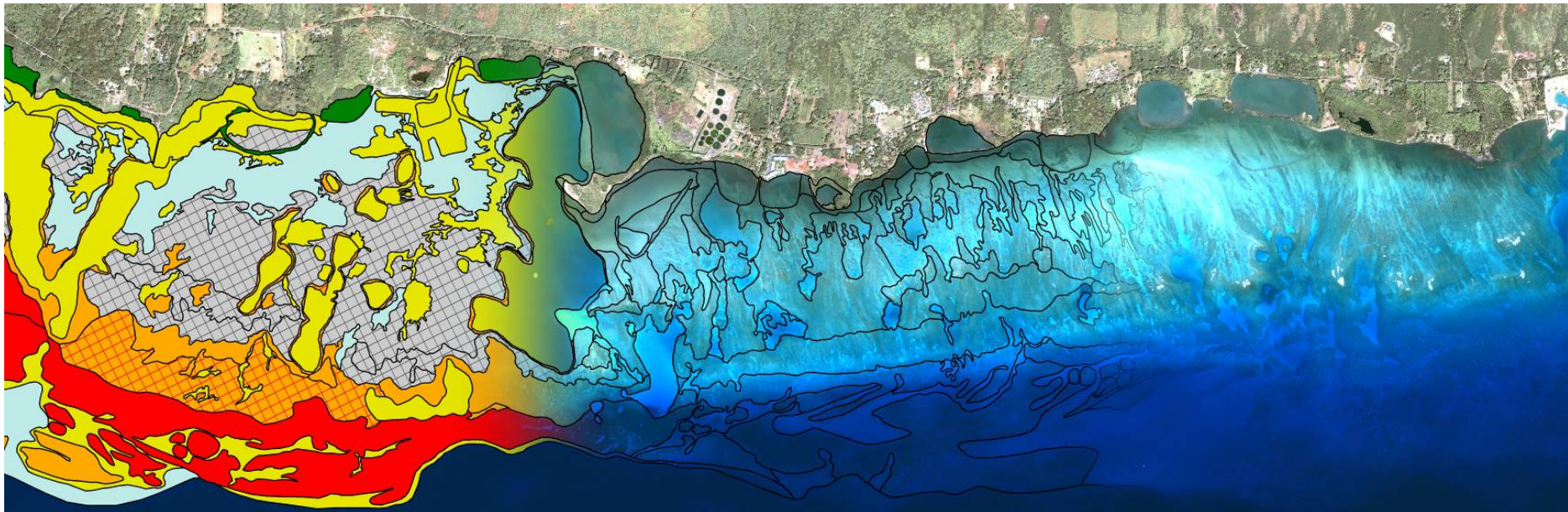
21 Detailed Habitat Cover Types



- Habitat Cover**
- Unknown
 - Uncolonized 90%-100%
 - Uncolonized 50%-<90%
 - Unclassified
 - Turf 90%-100%
 - Turf 50%-<90%
 - Turf 10%-<50%
 - Seagrass 90%-100%
 - Seagrass 50%-<90%
 - Seagrass 10%-<50%
 - Macroalgae 90%-100%
 - Macroalgae 50%-<90%
 - Macroalgae 10%-<50%
 - Emergent Vegetation 90%-100%
 - Emergent Vegetation 50%-<90%
 - Emergent Vegetation 10%-<50%
 - Coralline Algae 90%-100%
 - Coralline Algae 50%-<90%
 - Coralline Algae 10%-<50%
 - Coral 90%-100%
 - Coral 50%-<90%
 - Coral 10%-<50%

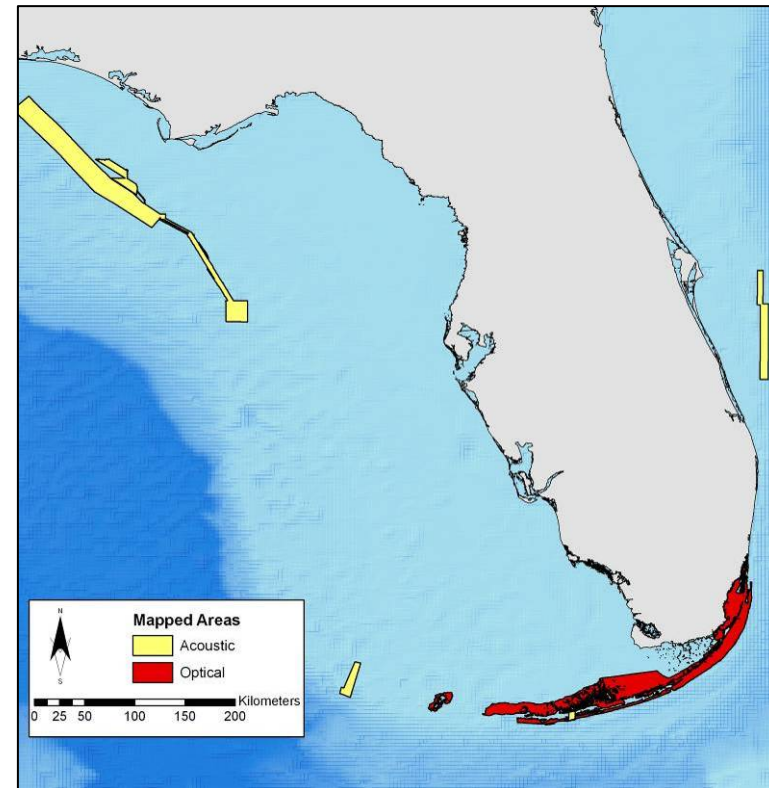
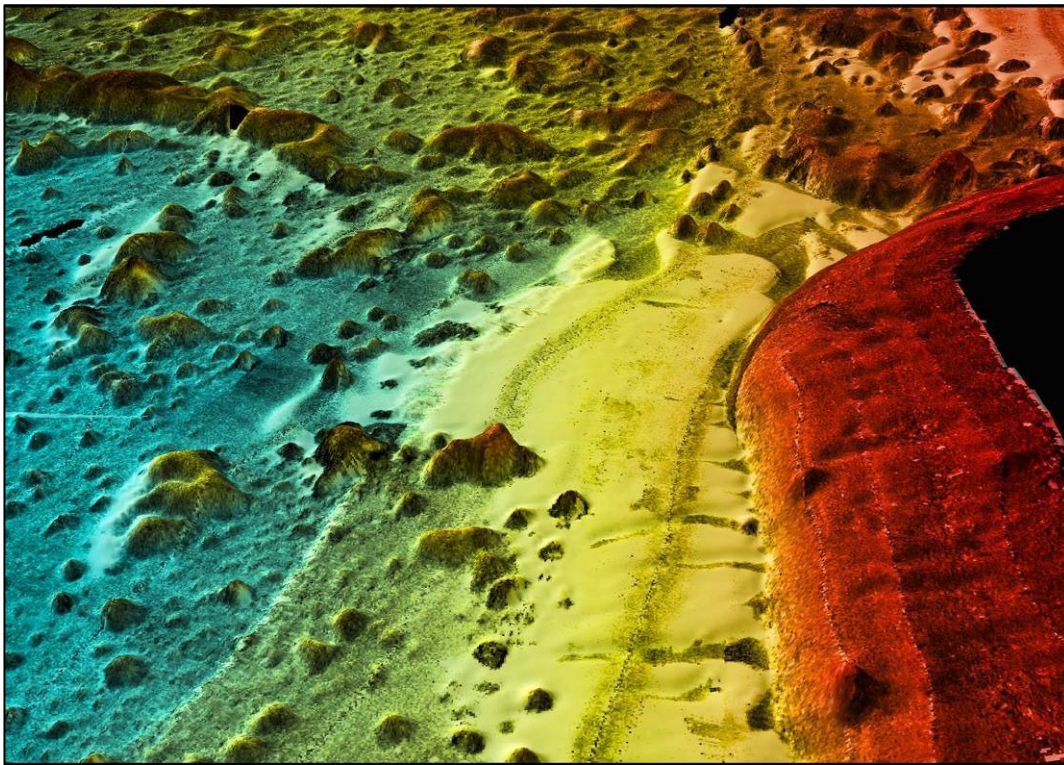
Benthic Habitat Mapping Activities

- Shallow-water benthic habitat maps produced with an accuracy $\geq 90\%$
- Products meet USCRTF requirements, provide critical informational to regional, state, and local coastal managers, and provide spatial framework for monitoring activities.
- Provision of source imagery and habitat digitizer software allows users to generate finer-scale products for areas of particular interest.



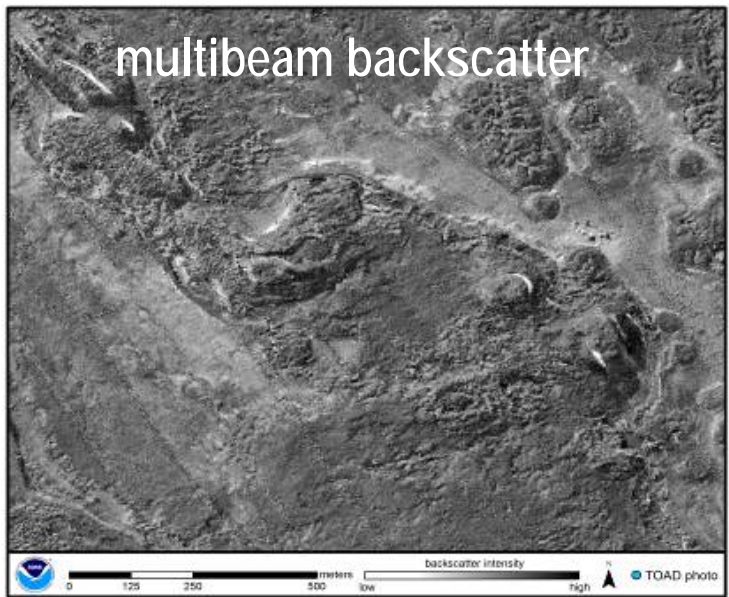
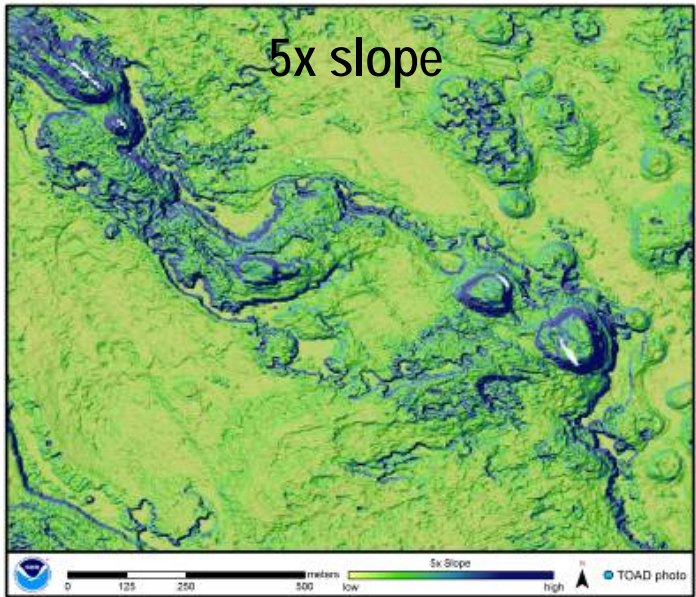
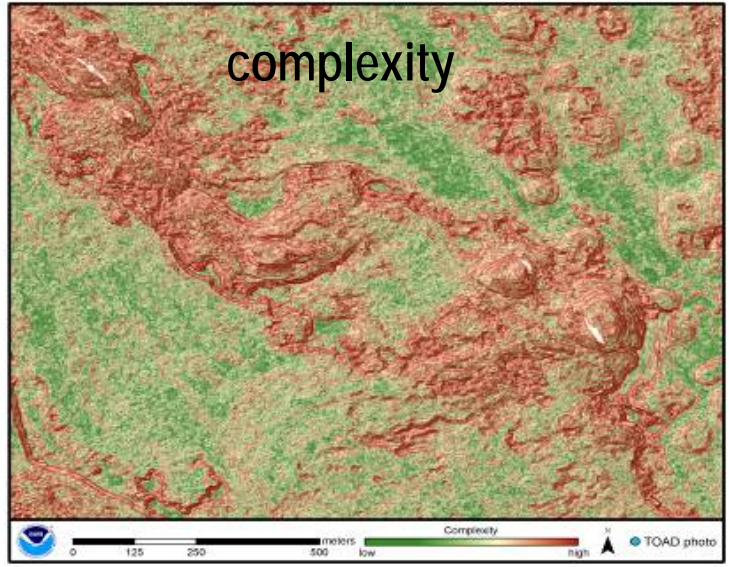
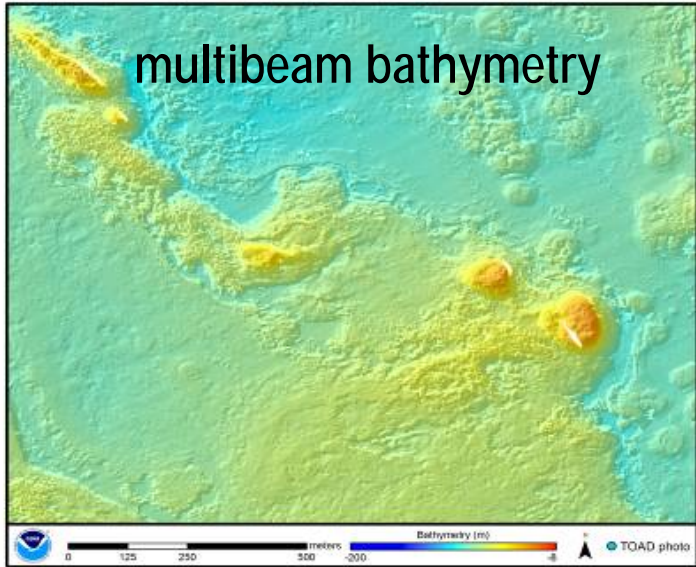
Bathymetric Survey Activities

- Data used to develop a suite of mapping products, e.g. bathymetry, slope, rugosity, backscatter (hard/soft).
- Delineate EFH / HAPC, define boundaries delimited by particular isobath, identify seafloor features important to living marine resources.

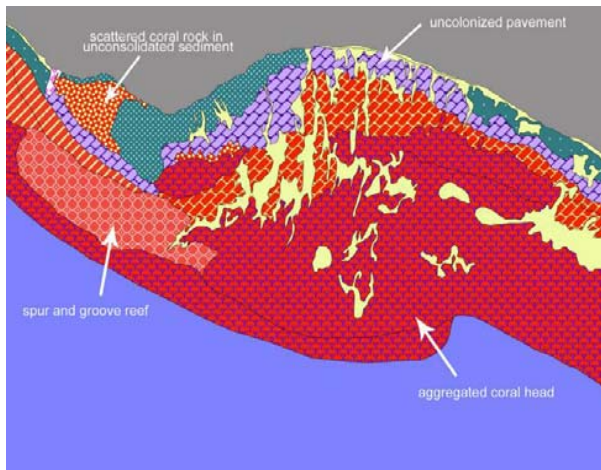


Multibeam bathymetry and backscatter Saipan, CNMI

Moderate-depth Mapping Outputs



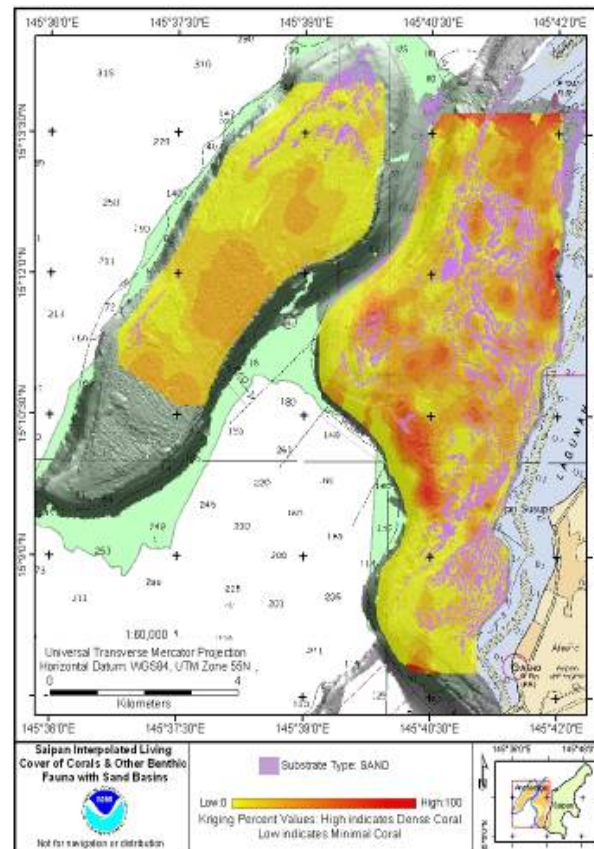
Mapping Outputs



Shallow-water Mapped Area:
Total **9,535 km²**

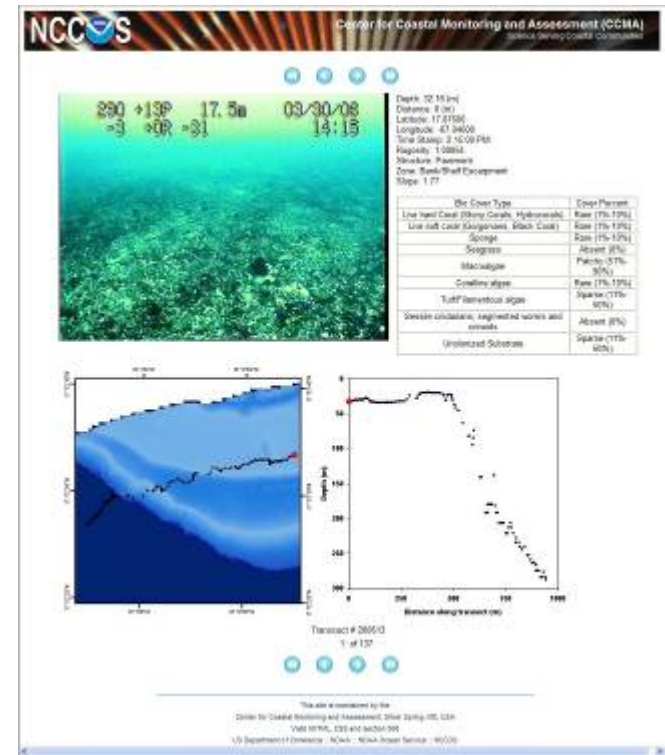
Moderate-depth Mapped Area:

| | |
|-----------------------|------------------------------------|
| U.S. Caribbean | 600 km² |
| NWHI | 41,705 km² |
| MHI | 3,081 km² |
| CNMI/Guam | 13,095 km² |
| Am. Samoa | 1,385 km² |
| PRIAs | <u>4,461 km²</u> |
| Total | 64,636 km² |



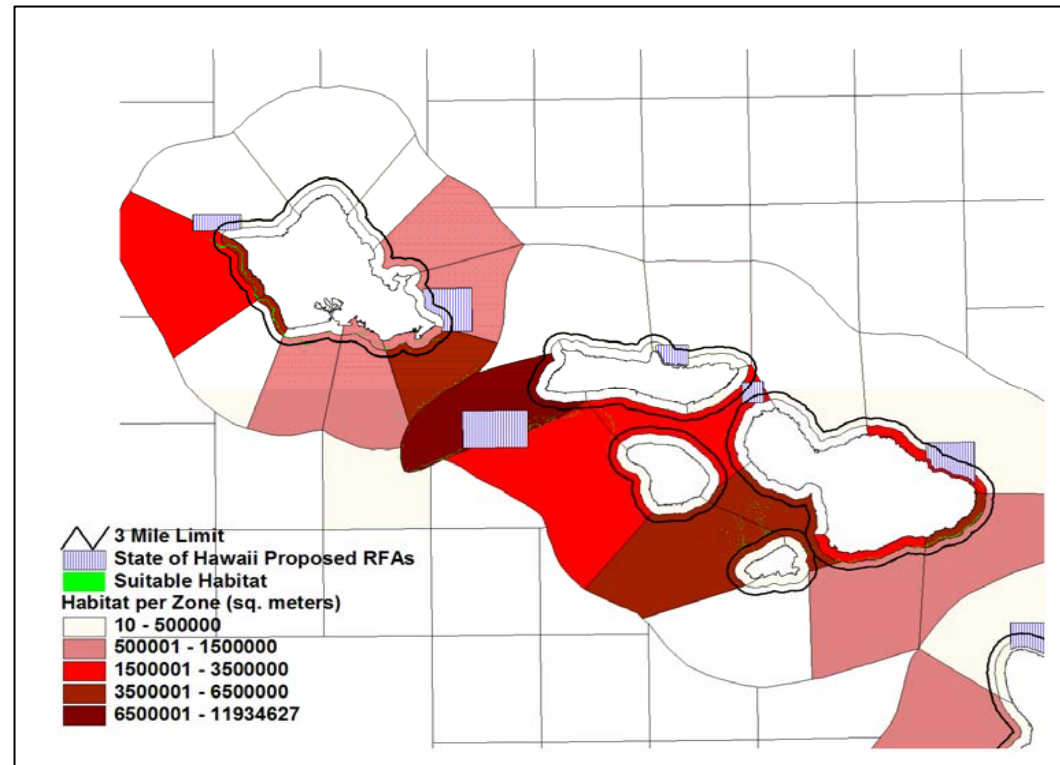
Mapping Outputs

- Development of new tools and capabilities
- Improved dissemination of data and map products
- Development of protocols

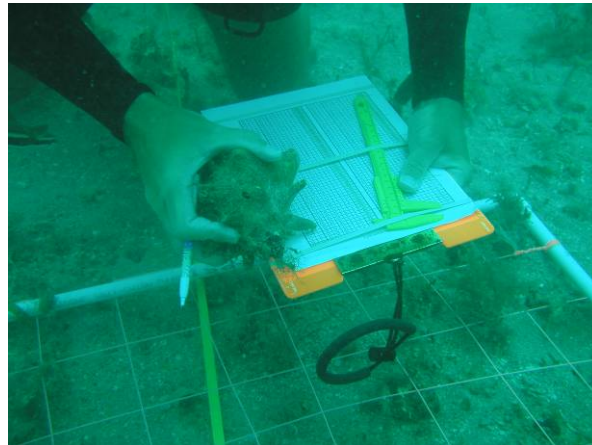


Mapping Outcomes

- Extension of area closures in Gulf of Mexico MPAs
- Greater protection of Oculina Banks HAPC closure
- Bottomfish restricted fishing area closures in the Main Hawaiian Islands
- Delineated anchorages in the USVI to minimize damage to reefs
- Delineated Papahānaumokuākea Marine National Monument boundaries



Overview: Coral Reef Ecosystem Monitoring



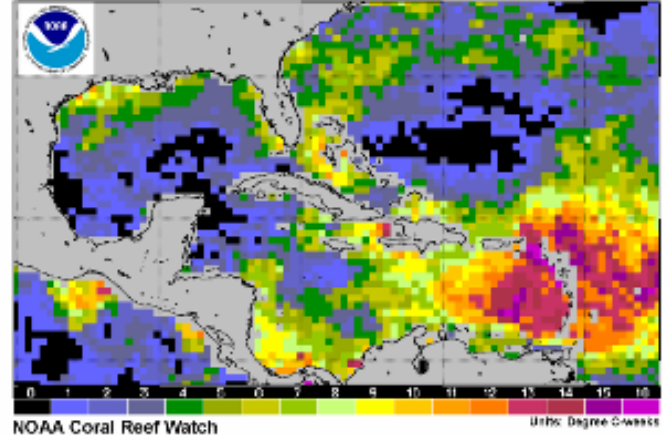
Monitoring Goals

- Implement a comprehensive, nationally-coordinated long-term monitoring program to:
 - assess the condition of U.S. coral reef ecosystems
 - increase local capacity to support coral reef ecosystem management
- Support jurisdictional agencies, academics, others to conduct work that addresses local priorities and complements efforts of NOAA and Federal partners
- Monitor ecological impacts of climate change

Monitoring Activities

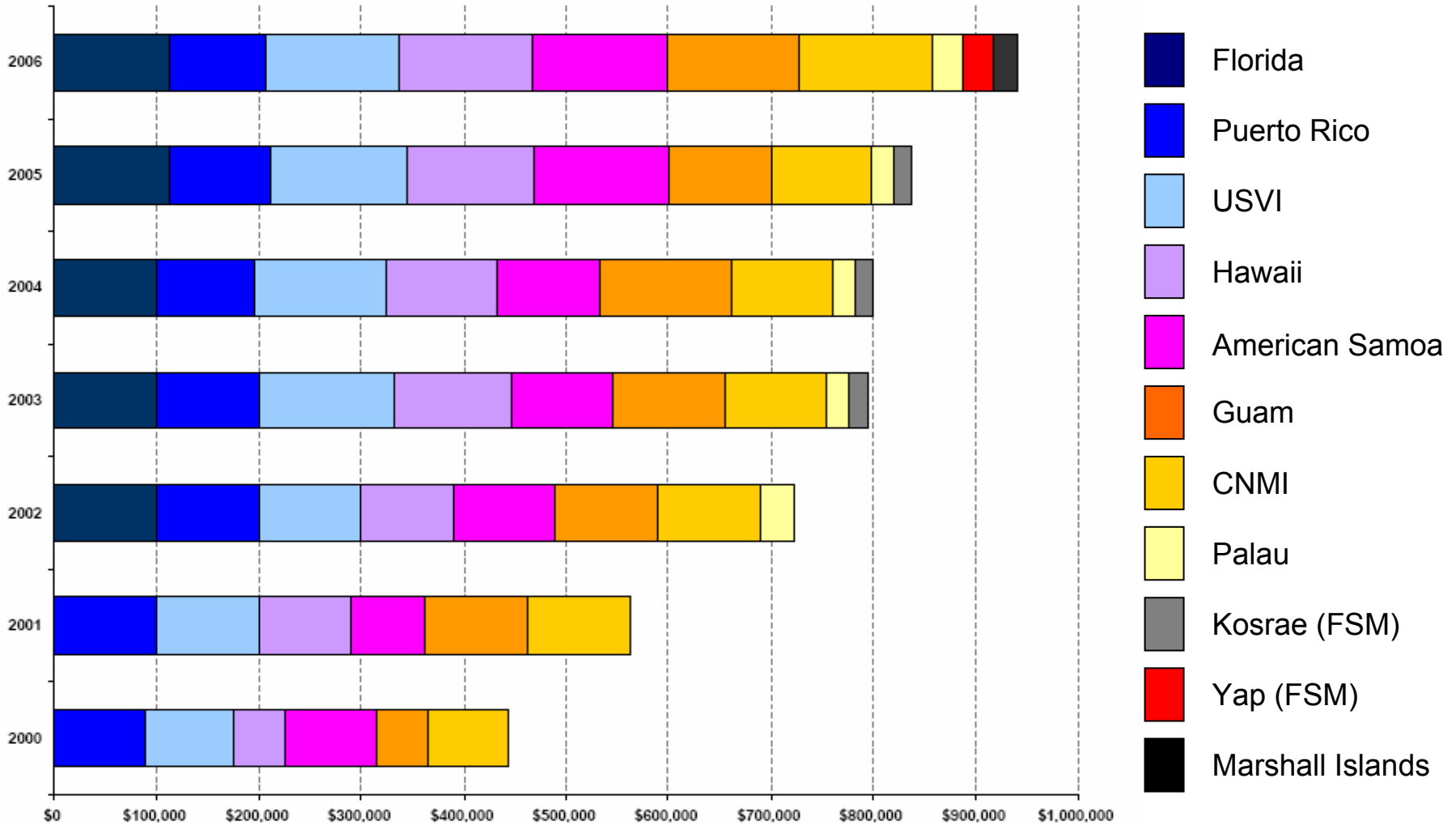
- *In situ* monitoring (Grants)
- *In situ* monitoring (NOAA)
- Automated observations
- Satellite observations

2005 Annual Composite of Maximum Twice-weekly Degree Heating Weeks





Monitoring Grants Funding



Coral Reef Ecosystem Monitoring

Benthic Habitats



Kip Evans

- Cover (live, dead, etc.)

- Abundance

- Condition

- Size class distribution

- Indicator species

- Diversity

Water Quality and Oceanographic Conditions



- Nutrients

- Turbidity

- Chlorophyll

- Currents

- Temperature

- Wave energy

Associated Biological Communities



Kip Evans

- Abundance & distribution

- Size class distribution

- Indicator species

- Diversity

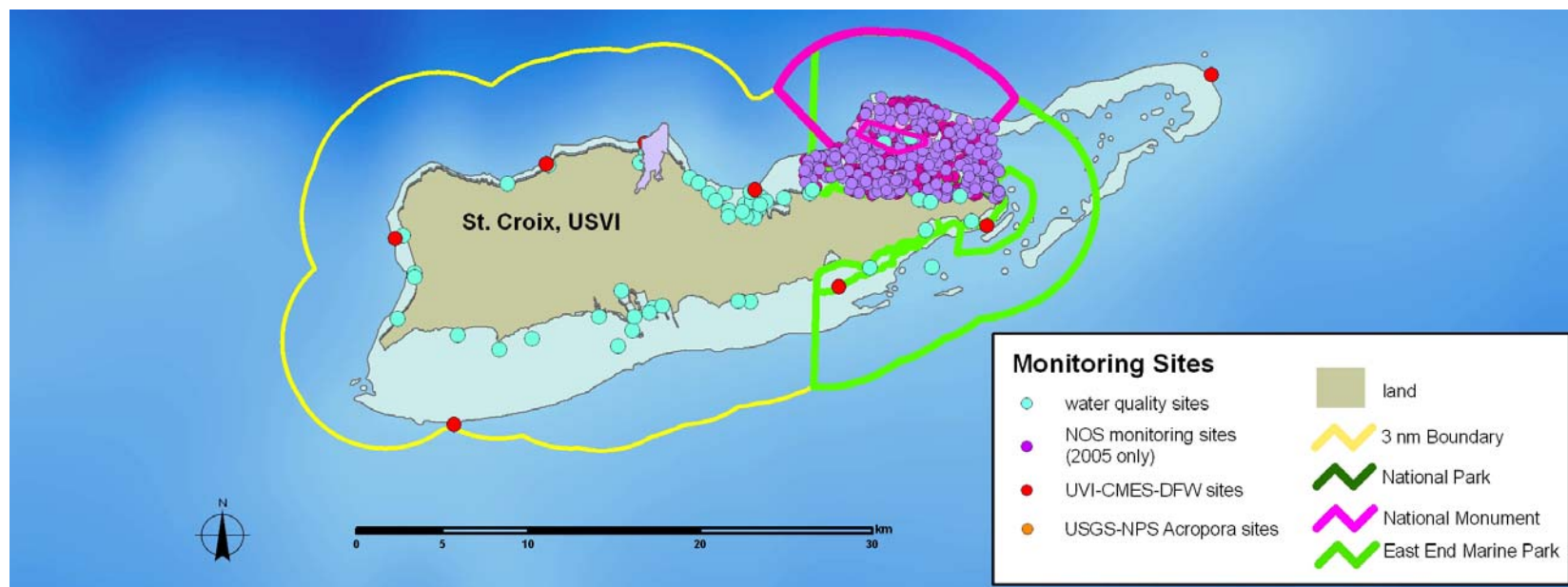
- Richness

- Evenness

Example Target Parameters

In situ Monitoring Activities

- NOAA's Pacific RAMP conducts consistent and comprehensive ecosystem monitoring across the Pacific region
- No comparable consistent comprehensive NOAA monitoring program in Atlantic or U.S. Caribbean; CRCP is evaluating the need / feasibility
- Major partners include jurisdictional agencies, NPS, USGS, USFWS, EPA, universities



Automated Observations

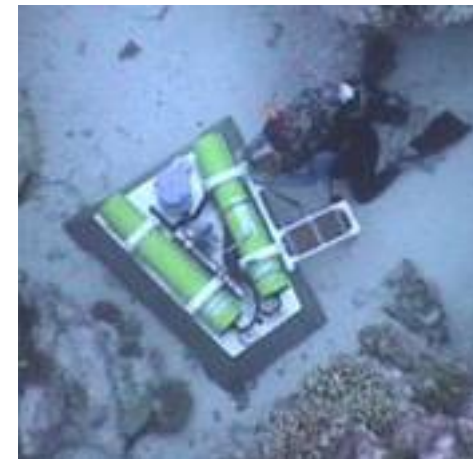
Western Atlantic/Caribbean

- Integrated Coral Observing Network (ICON) stations
- Temperature loggers
- Acoustic tags and receiver arrays (fish, conch)



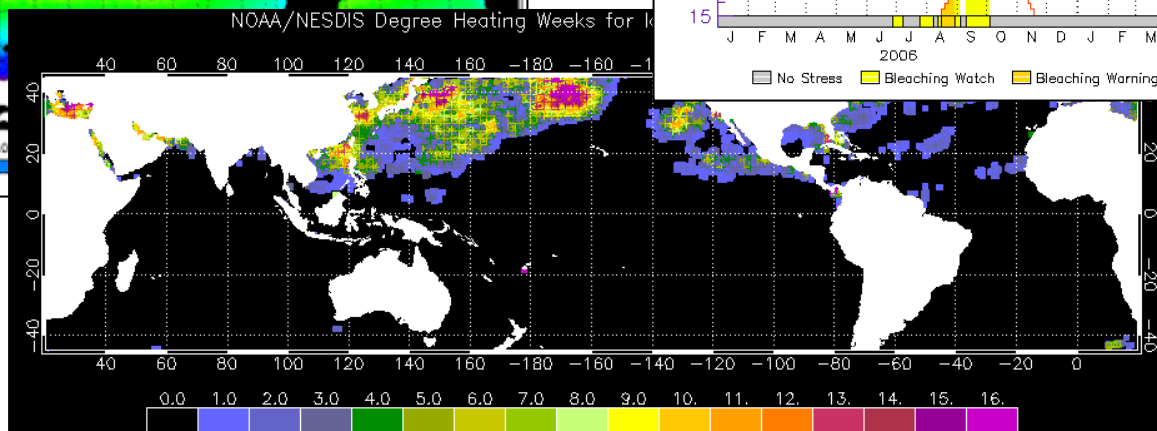
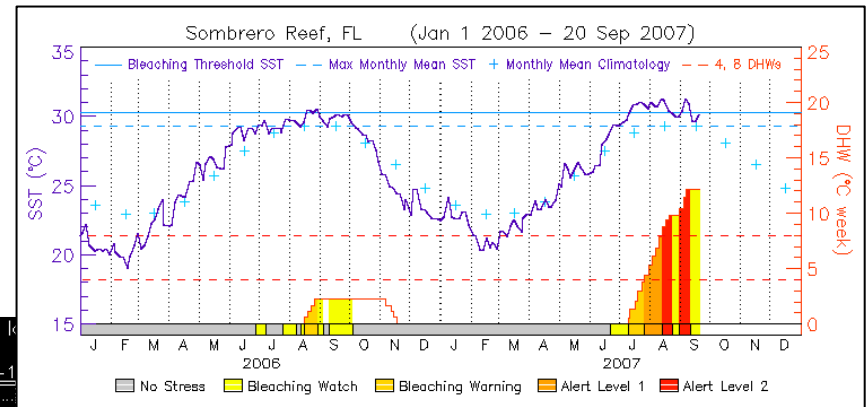
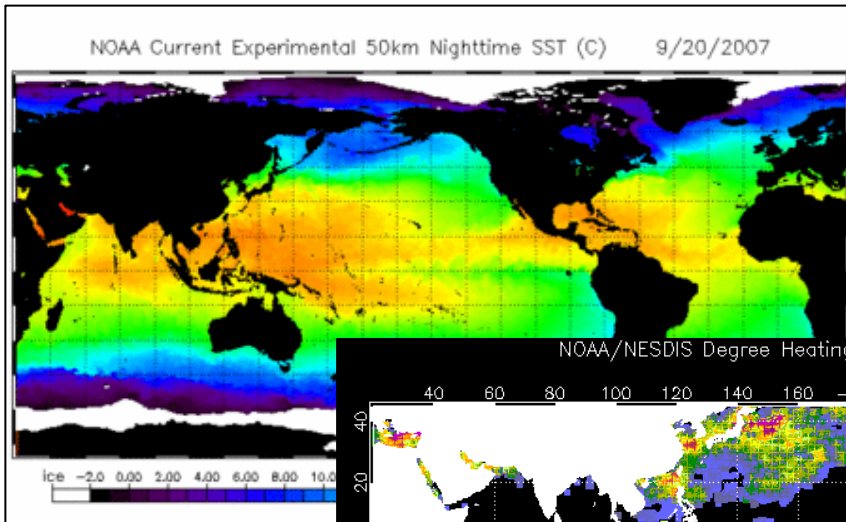
Pacific

- Coral Reef Early Warning System (CREWS) buoys
- SST buoys, Subsurface Temperature Recorders
- Ocean Data Platforms
- Wave and Tide Recorders, Current Meters
- Ecological Acoustic Recorders (EARs)
- Autonomous Reef Monitoring Structures (ARMS)



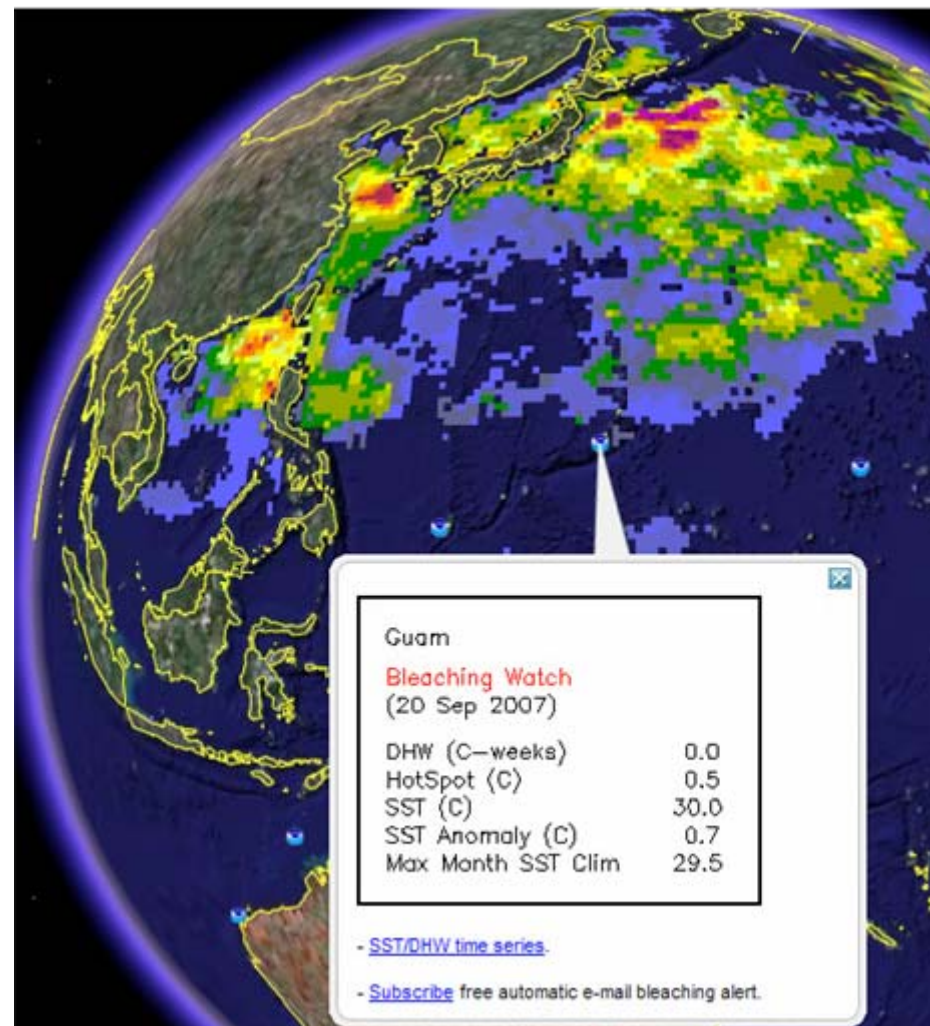
Satellite Observations

- NOAA satellite measurements of sea surface temperature
- Global data on thermal stress on coral reefs
- Time series data for Virtual Stations worldwide
- Satellite product research, development, and implementation

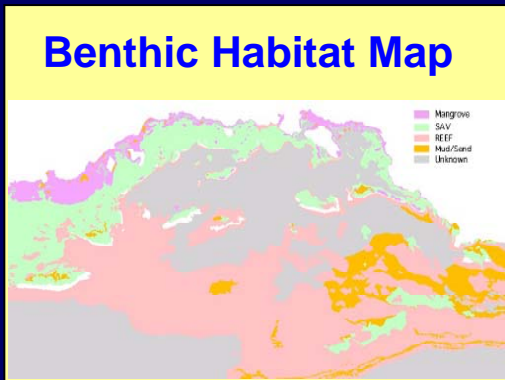


Observing Outputs

- Satellite Bleaching Alerts warn users of bleaching conditions
- Integrated ecological forecasts:
 - Mass coral bleaching
 - Doldrums and extreme weather conditions
 - Physical environmental stresses
- Near-real-time oceanographic data from satellites, ICON, CREWS, SST stations and instruments



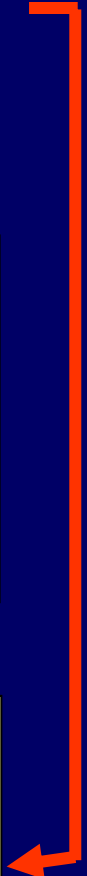
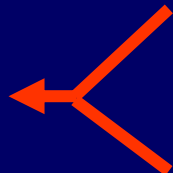
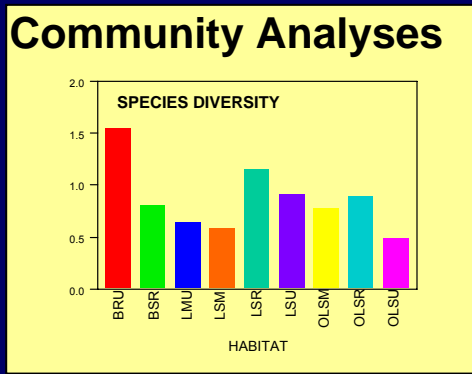
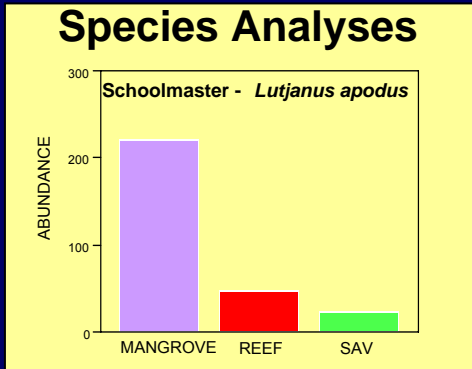
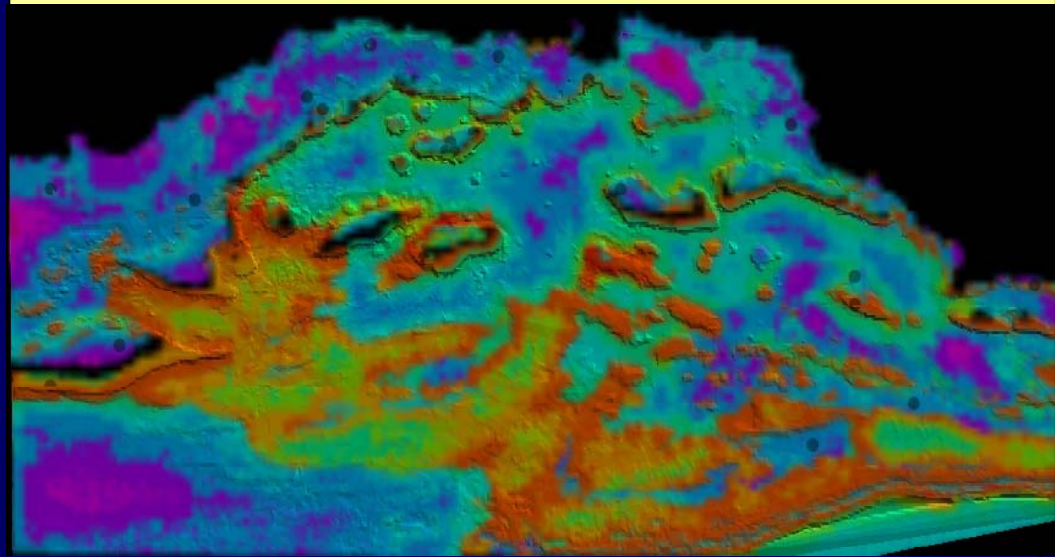
Integrated Mapping, Monitoring & Assessment



Random Stratified Sampling

Organism Surveys by Habitat Type

Tools for Management (e.g., Modeling, MPA Assessments)



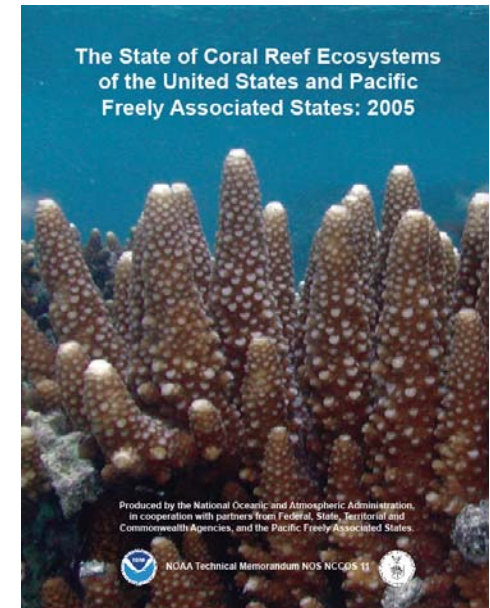
Integrated Outputs

Integrated assessments of the condition of U.S. and FAS coral reefs using data from NOAA and jurisdictional partners:
State of the Reefs Reports (2002 and 2005)

- Overview of Threats
- 14 jurisdiction chapters
- Condition of resources based on quantitative monitoring data for:









Water Quality & Oceanographic Conditions,
Benthic Habitats, and
Associated Biological Communities

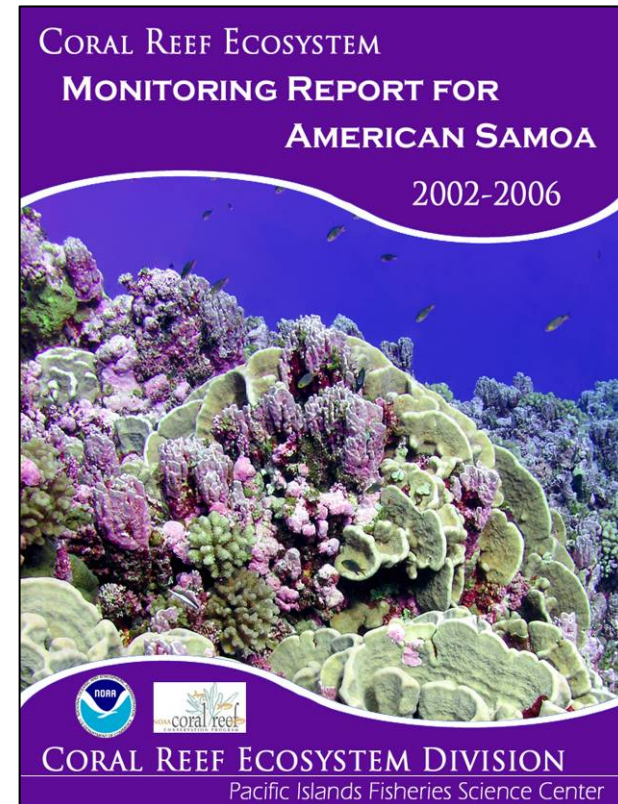
- National-Level qualitative assessment or 'scorecard'
- 2008 report is currently under development



Integrated Outputs

Content for each Island and Archipelago Chapters

-  Geopolitical Context
-  Survey Effort
-  Benthic Habitat Mapping and Characterization
-  Oceanography and Water Quality
-  Coral and Coral Disease
-  Algae
-  Benthic Macroinvertebrates
-  Reef Fish
-  Island Summary and Integration

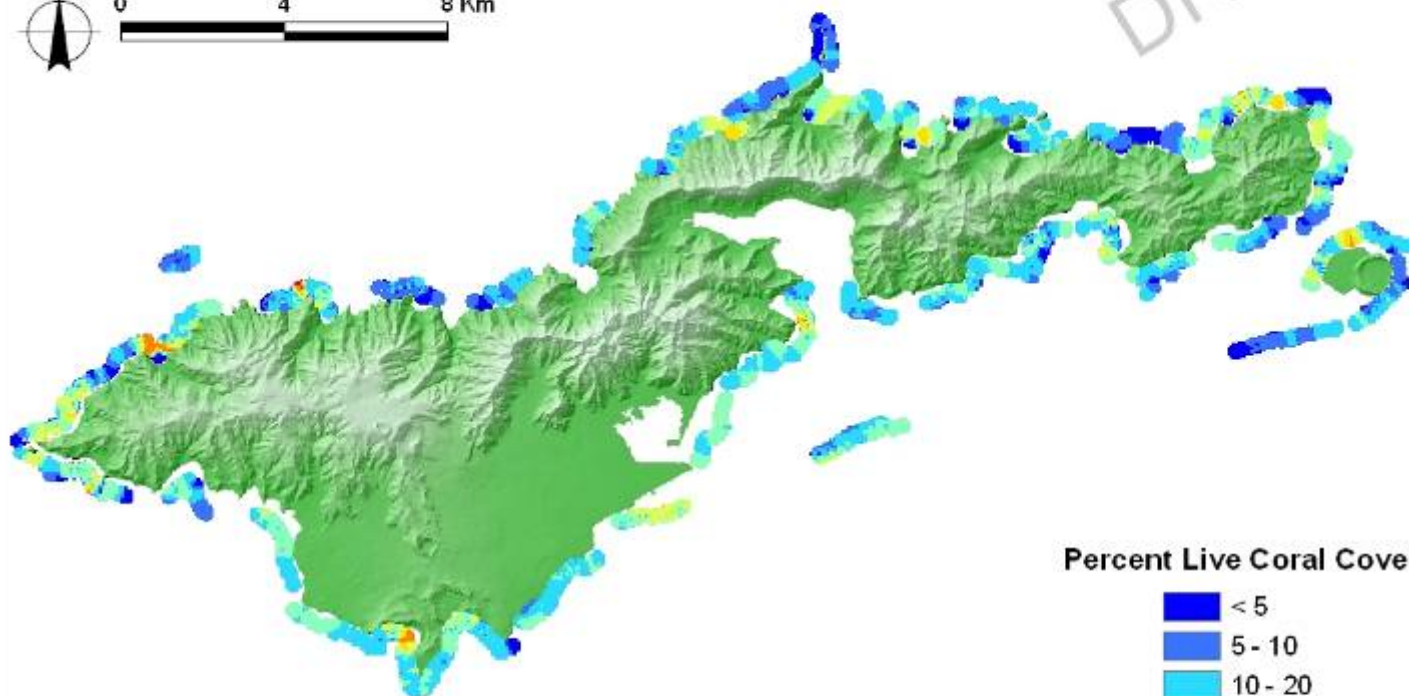
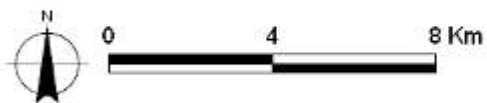


Mapping and Characterization

Tutuila Island, American Samoa

Towed-diver Benthic Surveys, 2002, 2004, and 2006

Live Coral Percent Cover



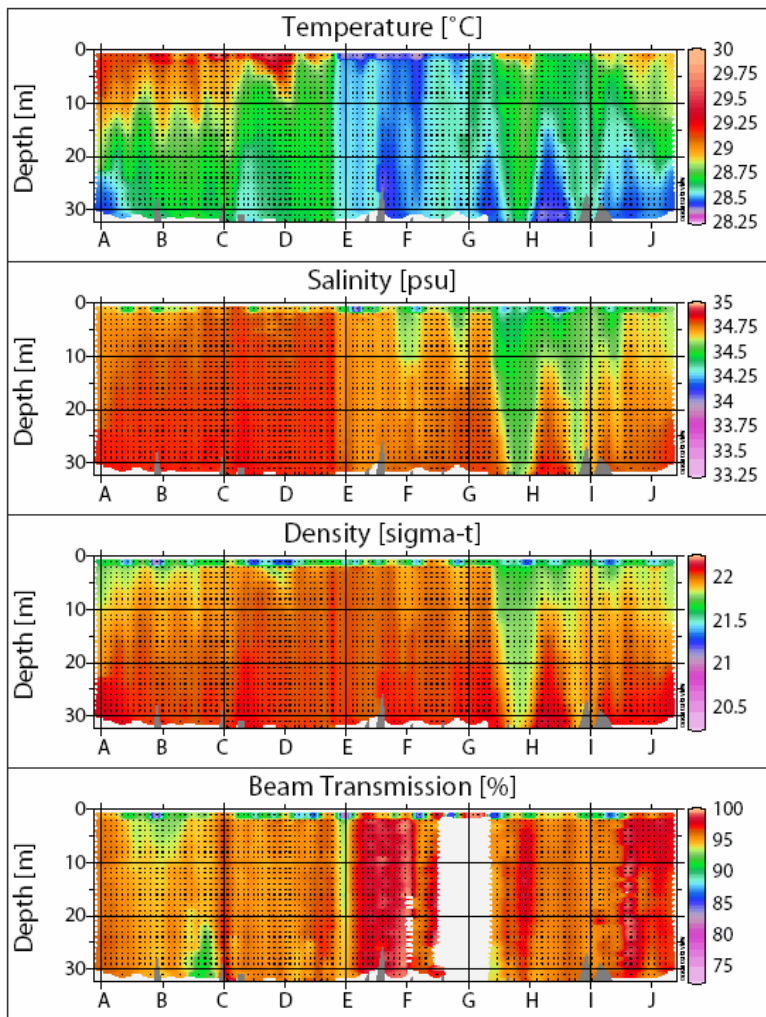
Percent Live Coral Cover



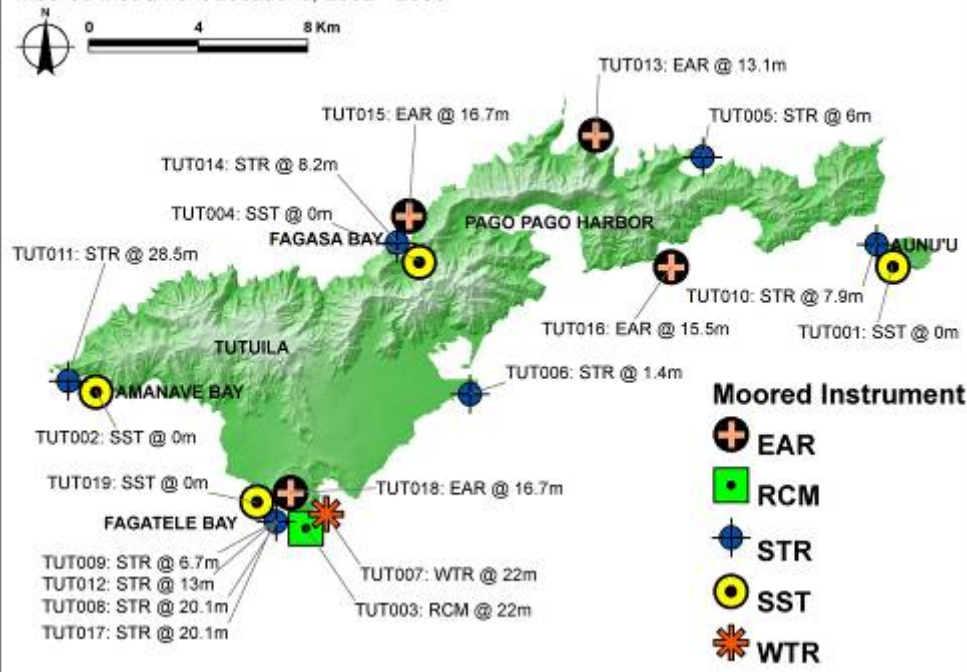


Oceanography/Water Quality

HI0602 TUTUILA

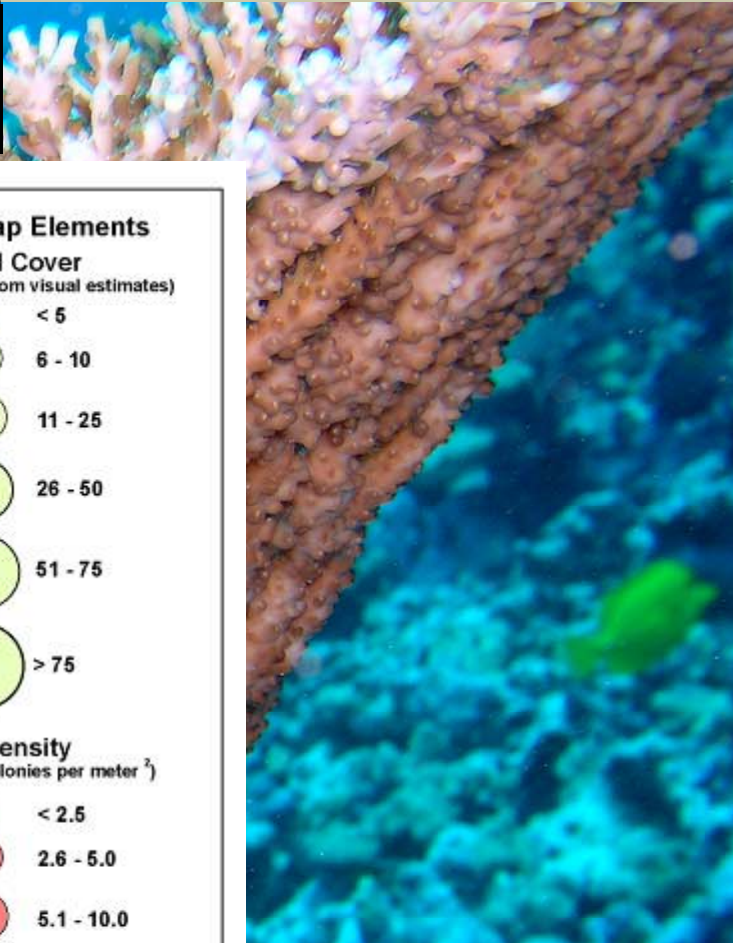


Tutuila Island, American Samoa
Moored Instrument Locations, 2002 - 2006



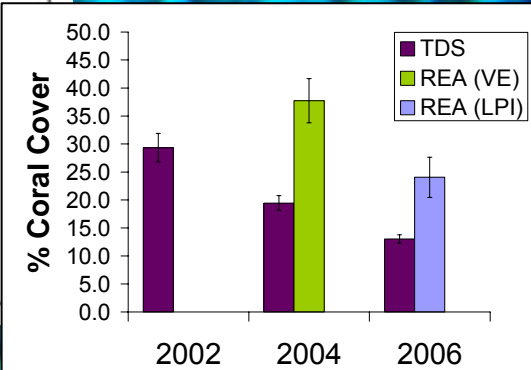
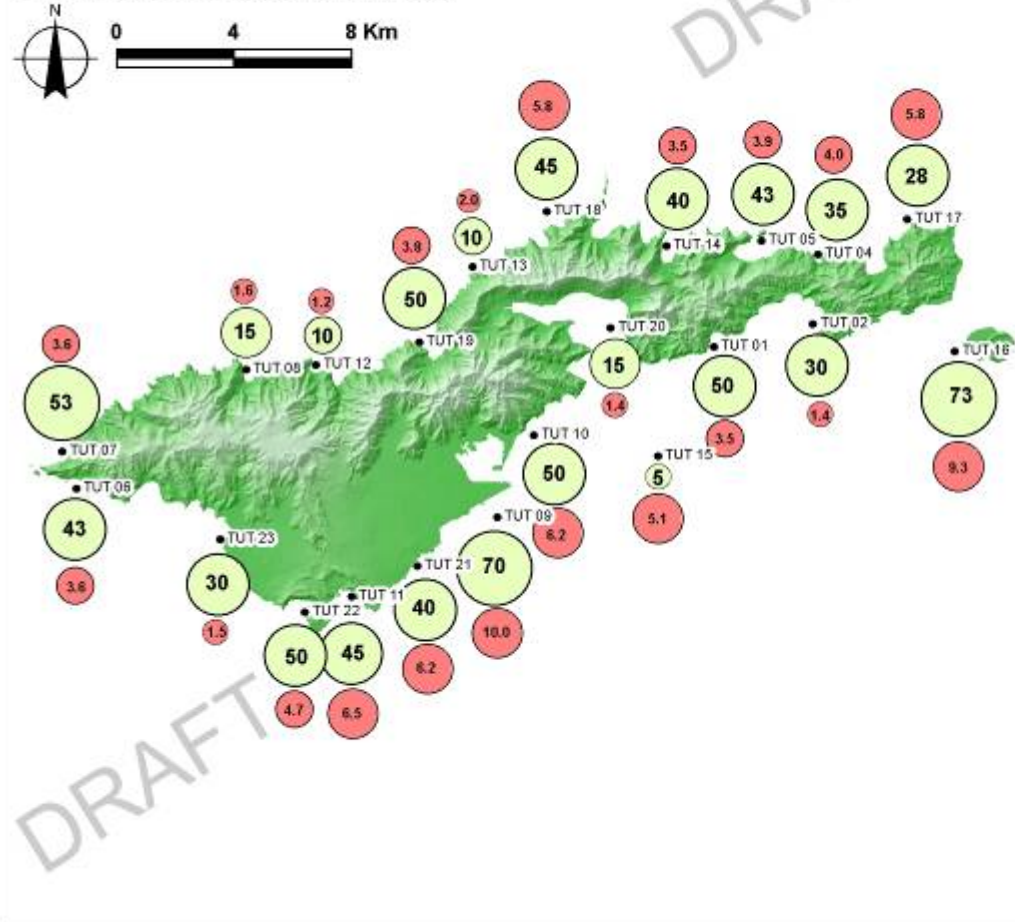


Corals



Tutuila Island, American Samoa

REA Benthic Survey, 2004
Coral Cover and Coral Density

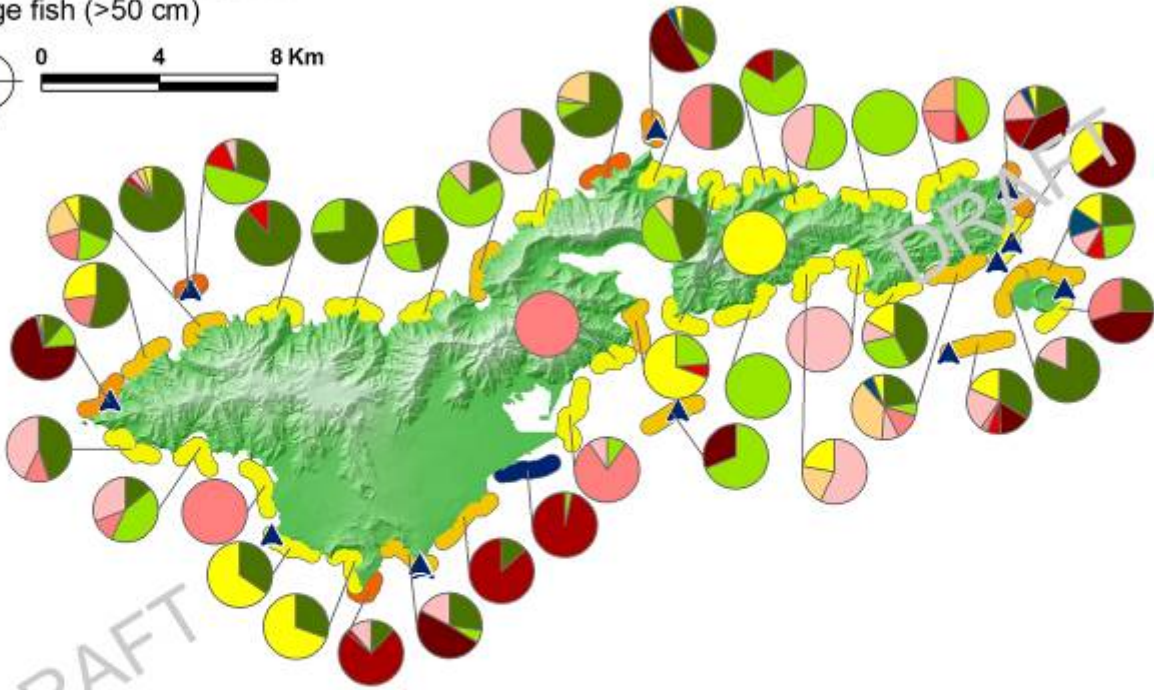


Reef Fish

Tutuila and Aunu'u Islands, American Samoa

Towed-diver surveys, 2004

Large fish (>50 cm)

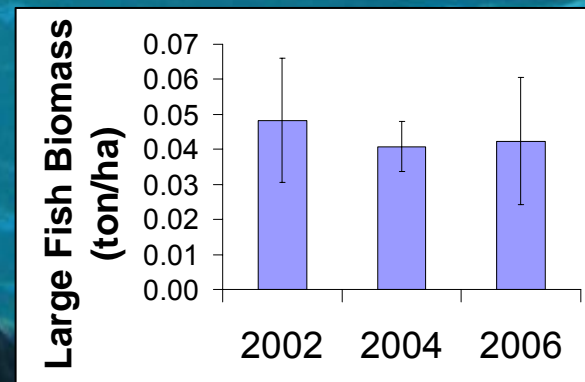
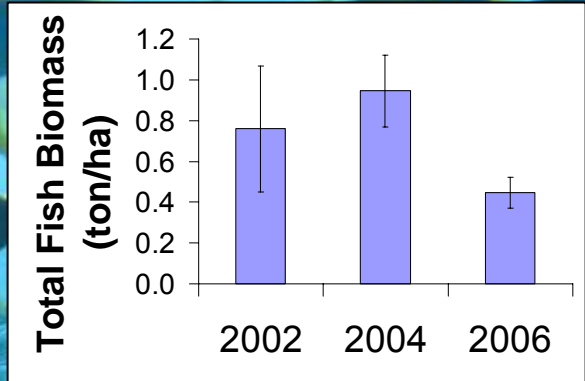
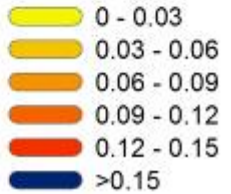


Family Composition



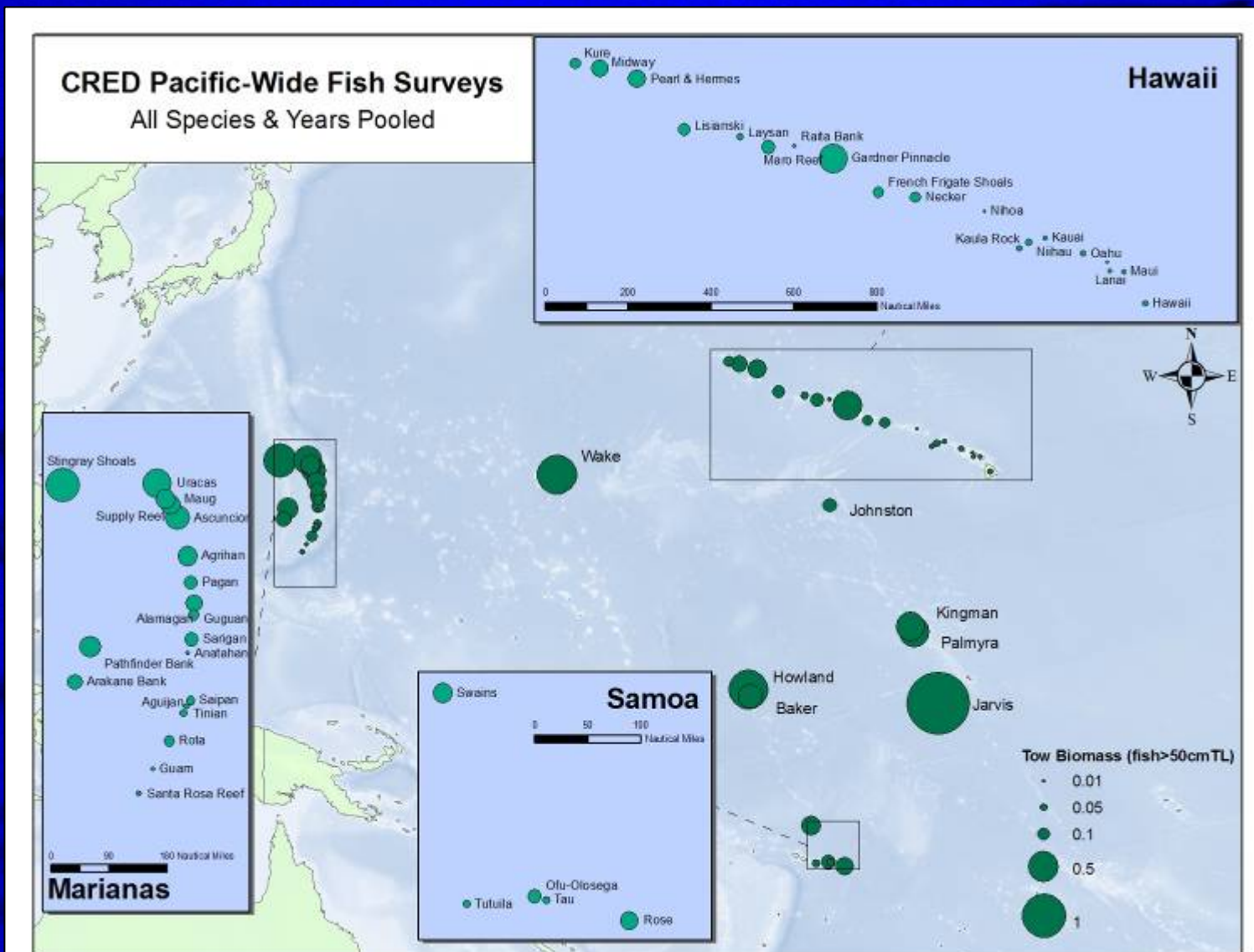
Sightings
▲ Shark

Biomass (t/ha)





Pacific-wide Reef Fish Biomass

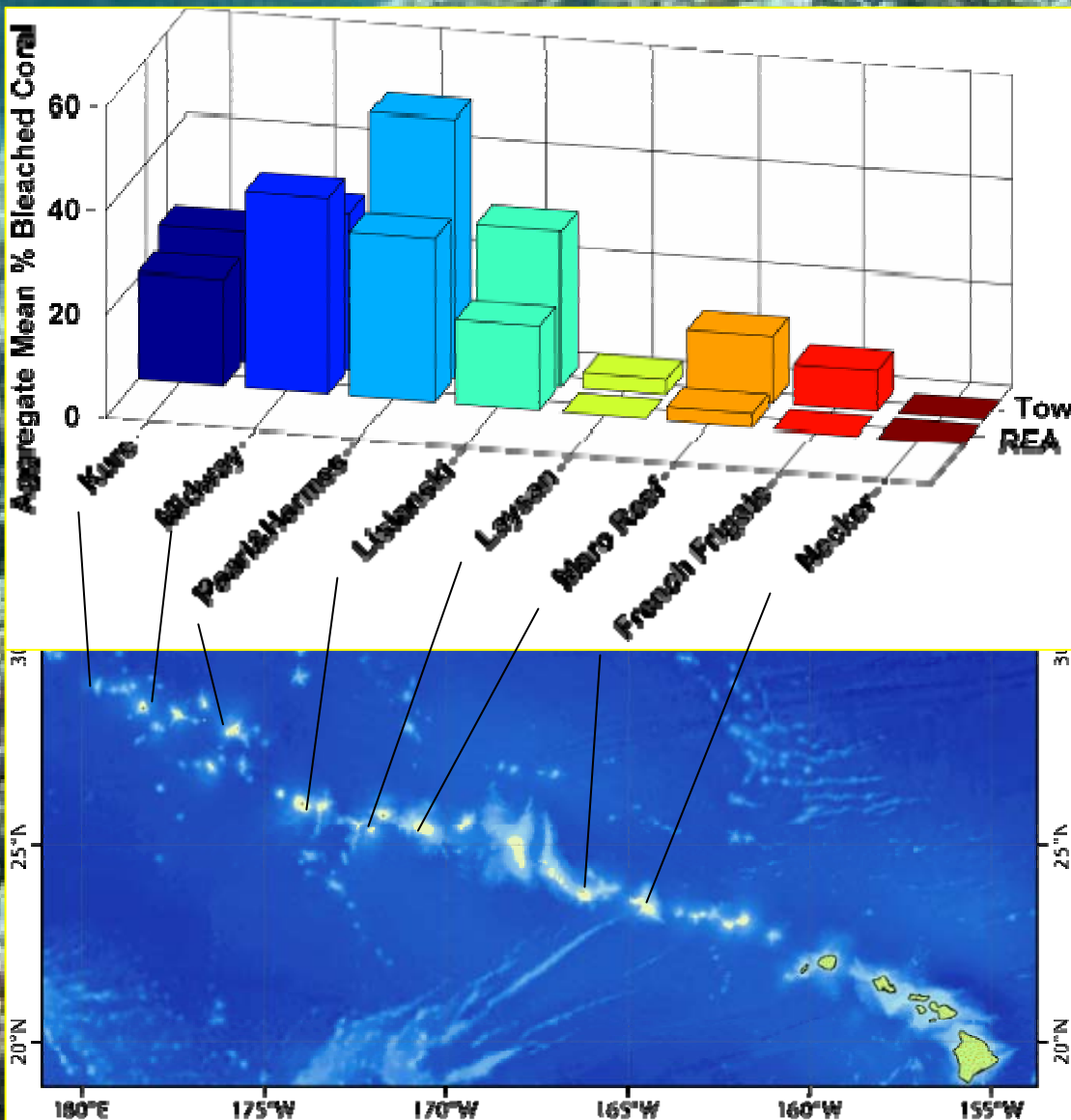


Management Outcome: American Samoa

- “American Samoa might become first territory to give complete protection to all large species of reef fishes in all seasons throughout the territory.”
- “At 18th US Coral Reef Task Force meeting, Governor Tulafono announced American Samoa is beginning the process of protecting the big fishes. These big fishes are now rare and therefore they are especially vulnerable to additional harvest.”
- “The most compelling scientific support for this decision came from a massive report [*Coral Reef Ecosystem Monitoring Report for American Samoa*] under review at this time.”

from Dr. Charles Birkeland on Coral List 9/07

Management Outcome: NWHI



- 1st *State of the Reefs Report* (2002) - mass coral bleaching had not been reported from NWHI and global climate models suggested NWHI among least likely places to experience mass bleaching.

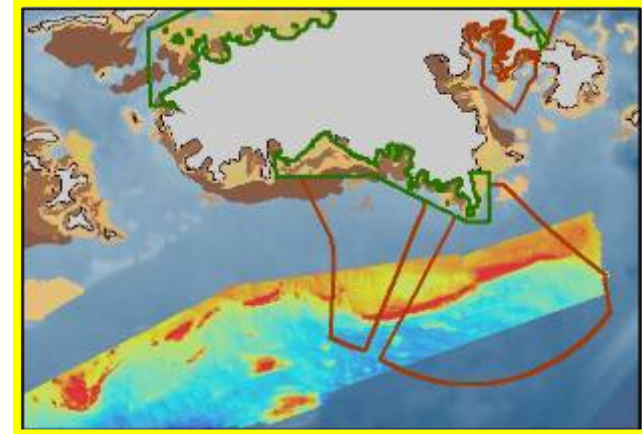
- July 2002 - Satellite bleaching alert issued for Midway. Buoys confirmed warm waters.

- Aug/Sept 2002 - CREIOS surveys documented first ever mass coral bleaching event in NWHI.

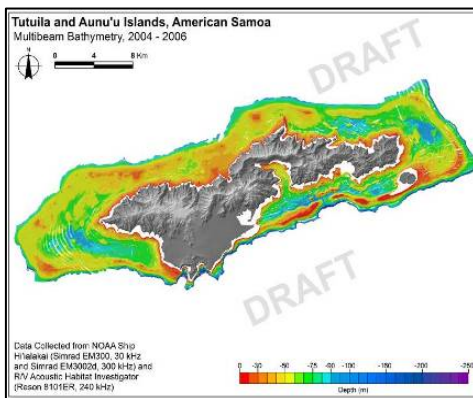
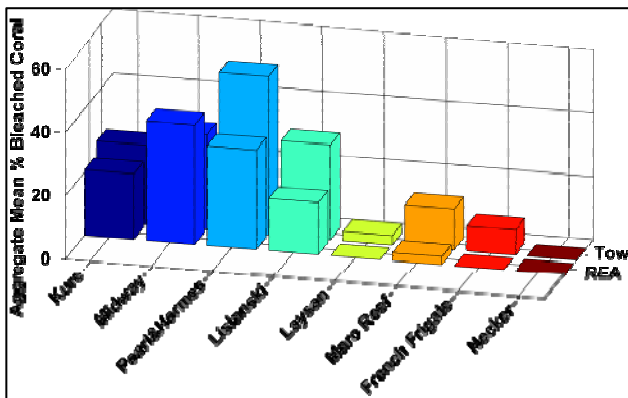
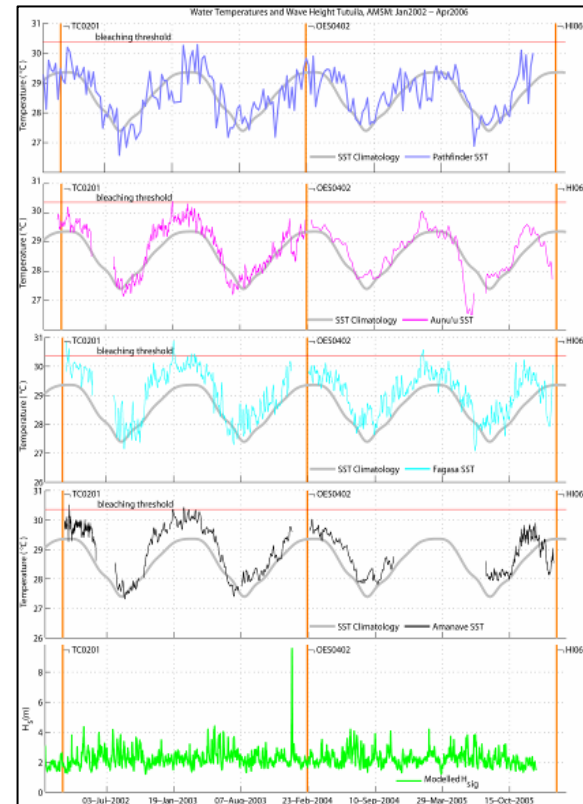
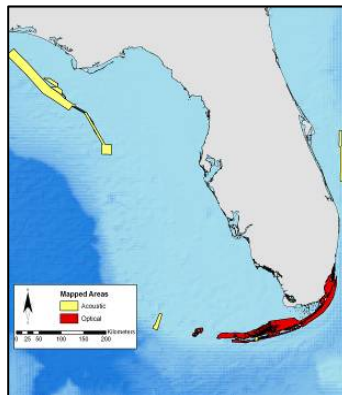
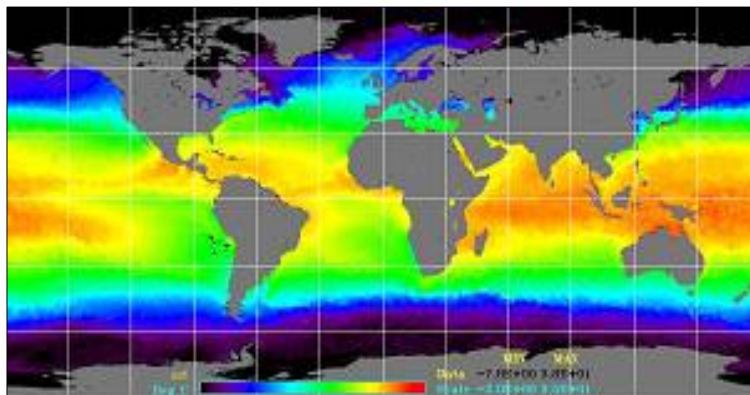
- CREIOS fundamentally changed management focus in NWHI. Climate change-related bleaching/acidification now viewed as most significant threats.

Management Outcomes

- *Acropora* monitoring supports listing
- Showed effectiveness of Hawaii MPAs; data used to modify legislation
- Helped define replenishment areas for aquarium trade
- Documented severity of bleaching event and loss of coral cover
- Potential MPA Boundary modification in St. John
- Proposed Bumphead and Humphead protections at Wake Atoll



Overview: Data Dissemination



Overview: Data Dissemination

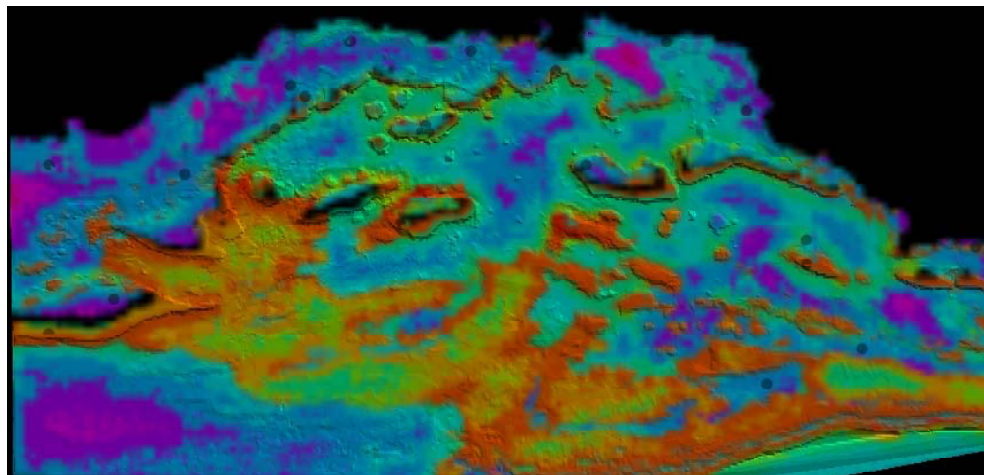
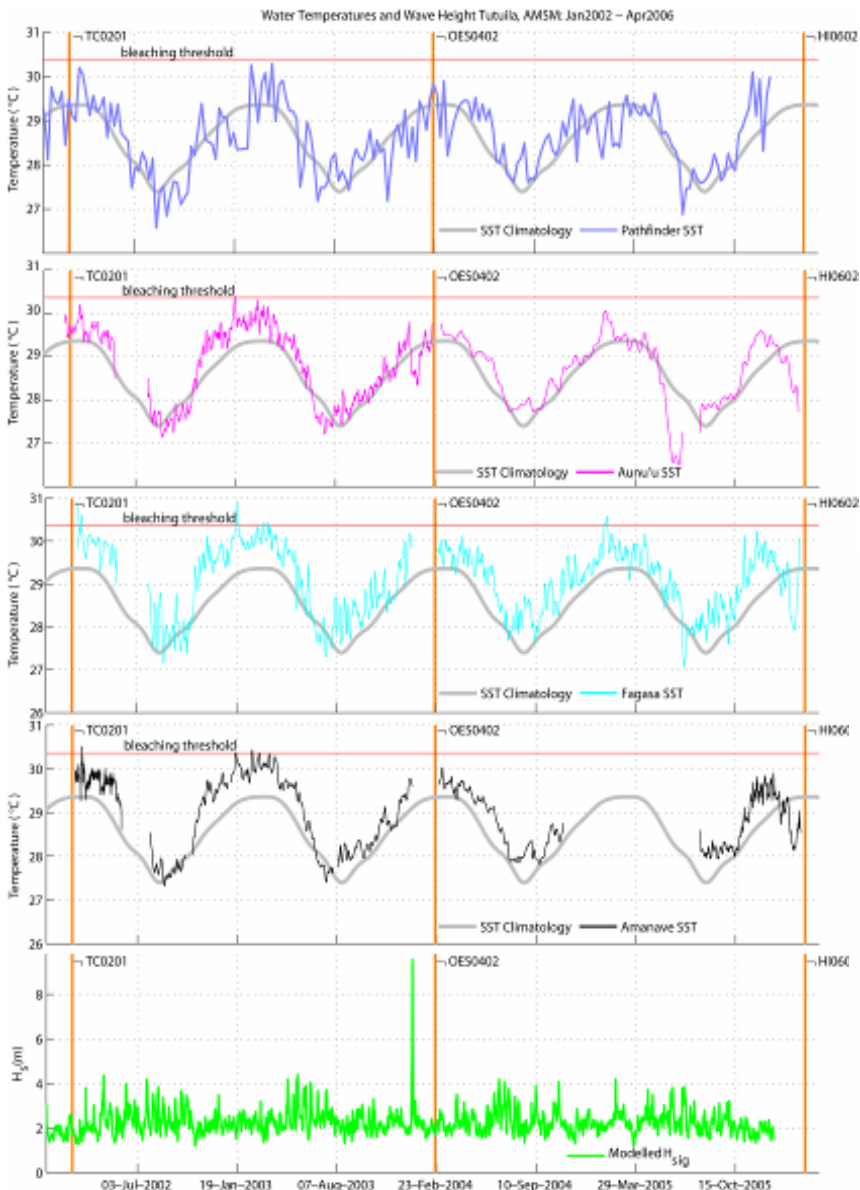
- CREIOS products are routinely provided to the public via: reports, hard copy and digital maps, peer-reviewed publications, and databases
- CREIOS data are disseminated to coral reef managers and other users through a variety of NOAA websites and databases
- Quality-controlled historical data and metadata archives are maintained by the NOAA National Data Centers, in coordination with CoRIS

CoRIS

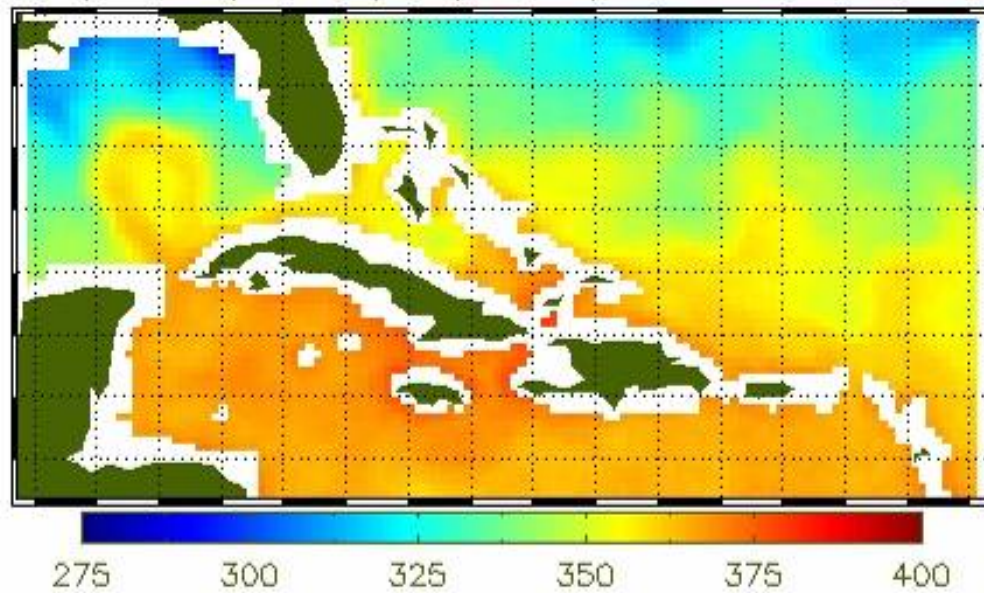
- The Coral Reef Information System (CoRIS) serves as a single portal for managing NOAA's coral reef metadata
- CoRIS manages more than 1400 metadata records for over 16,700 individual data and information products
- CoRIS Coral Library includes 1376 publication citations and website links
- CoRIS Glossary includes more than 5000 terms
- CoRIS website gets more than 75,000 visitor hits per month



CREIOS Challenges/Future Directions



NOAA/NESDIS Experimental pCO₂ (micro atm) for Jan 27 2007



CREIOS Challenges/Future Directions

- Continue to support the CRCP National Program with baseline data and ecological trends
- Integrate activities across Atlantic and Caribbean with Pacific RAMP
- CREIOS presence in the jurisdictions for coordination and technical support *on mapping and monitoring activities*

CREIOS Challenges/Future Directions

Mapping

- **Develop integrated shallow to mid-water mapping products**
- **Improve efficiency of moderate-depth habitat mapping using AUV technologies**
- **Improve cost effectiveness of shallow-water bathymetry using LiDAR and UAS technologies**
- **Develop standard suite of habitat mapping schemes (GIS layers)**
- **Develop biological habitat utilization maps to support living marine resource management**

CREIOS Challenges/Future Directions

Monitoring

- Extend spatial coverage of automated observations
- Better integrate data streams and improve access
- Increase spatial (depth and area) and temporal resolution of data collection
- Improve capacity to monitor biodiversity
- Expand monitoring capabilities to detect, model, and predict ecosystem impacts of climate change
- Create mechanism to fund teams that can respond to extreme events

CREIOS Challenges/Future Directions

Data Dissemination

- **Develop software to integrate and serve data from multiple sources, e.g. video**
- **Archive coral reef data at the NOAA National Data Centers**

CREIOS Implementation Issues

- **Continue efforts to standardize methods and protocols**
- **Need increased funding for operations, R&D, and product development**
- **Increase coordination across NOAA and with other entities**

Conclusion

CREIOS provides a diverse suite of integrated long-term ecological and environmental observations and information products over a broad range of spatial and temporal scales to support improved and timely ecosystem-based management decisions to conserve coral reefs.

Questions?

