

# NASA Earth Science Division, Applied Sciences Program

## Ecological Forecasting

### Summary of Calendar Year 2012

The Ecological Forecasting Applications area combines satellite observations and many types of models to build capacity for forecasting changes in living systems. Natural resource managers, working on land and in the oceans, are a primary user community along with others involved in the conservation and sustainable use of ecosystems in the United States and abroad. In 2012, Ecological Forecasting had 17 projects.

Initial highlights of several projects resulting from the 2010 interagency solicitation, “Climate and Biological Response: Research and Applications,” include work with DOI, the National Park Service, and USGS. This work incorporates projections from global climate models into products to forecast changes in managed species and landscapes. Recently established DOI Landscape Conservation Cooperatives and regional Climate Science Centers are proving to be ideal partners for the NASA Applied Sciences Program, as they require satellite remote sensing products and model outputs at regional scales. In the face of a changing climate and wide-ranging suburban and exurban development, DOI is seeking enhanced coordination across its bureaus and beyond, and is thus engaging and working with other federal, state, and local agencies. NASA data products are helping DOI natural resource managers in their efforts to address challenges that are national and even international in scope.

An Ecological Forecasting project worked with NOAA to enhance Coral Reef Watch, a decision support tool using satellite observations to track water temperatures around coral reefs (<http://coralreefwatch.noaa.gov/satellite>). Extremely hot and cold temperatures threaten corals around the world, and temperature-related stress can lead to a loss of the ability of corals to photosynthesize their food. In 2012, the project team developed MODIS- and AVHRR-based heat and cold stress products (with cold stress a completely new product). The team also developed a 4-kilometer, AVHRR Pathfinder-based sea surface temperature climatology. These products help tell managers where serious impacts on coral reefs are likely to occur and inform decisions on limits to activities on or around these important ecosystems.

An international workshop in Germany in October 2012, Satellite Remote Sensing for Biodiversity Research and Conservation Applications, examined remote sensing needs of the global conservation community. The Committee on Earth Observation Satellites sponsored the workshop with the German space agency, DLR. The conservation community increasingly uses satellite observations to monitor changes in land cover, ocean surface conditions, and climate affecting areas of importance for species at risk of extinction. Workshop participants discussed key satellite observations for biodiversity research and conservation, identifying continuity of the *Landsat* and MODIS time series, hyperspectral imagery, and 3-D imagery from LiDAR sensors as crucial needs. Participants also discussed

the importance of free and openly available satellite imagery, especially to applied conservation in developing countries, and drafted an article on the importance of free and openly available data policies for publication in 2013.

Combining satellite observations and predictive models of changes in living systems is driving the development of the new discipline of ecological forecasting. Somewhat analogous to its impact on weather forecasting in the 1960s, satellite products are proving to be a key catalyst for progress in forecasting.

Over the coming year, at a combination of workshops, its team meeting, and sessions in the International Congress for Conservation Biology, the Ecological Forecasting Applications area will continue to work with users of satellite imagery in the conservation field. The goal is not only to determine their needs for NASA data products but how best to connect them with appropriate models forecasting changes to come. In addition, 2013 will bring crowdsourcing and citizen science techniques into the program element via a “feasibility-to-decisions” solicitation focusing on ecological forecasting for conservation and natural resource management. Exciting times!

## Summary of Projects: Calendar Year 2012

**Project:** WhaleWatch: A Tool Using Satellite Telemetry and Remotely Sensed Environmental Data to Provide Near Real-time Predictions of Whale Occurrence in the California Current System to Reduce Anthropogenic Impacts

Principal investigator: Helen Bailey, Center for Environmental Science, University of Maryland

Project year: 2

Year-end ARL: 3

Description:

This project is applying satellite technology and environmental data to generate near real-time predictions of whale occurrence in the California Current. Additional objectives:

- Reduce whale ship strikes and entanglements by providing near real-time predictions of whale occurrence.
- Apply remotely sensed environmental data to spatio-temporal models of whale habitat and predict where and when whales are most likely to be found.

Partner/end user: NOAA NMFS Southwest Fisheries Science Center

Data sources, models, technology: SSH, SST, chlorophyll, *TOPEX/Poseidon*, *Jason*, SeaWinds, MODIS, AMSR-E, SeaWiFS

Major accomplishments in CY 2012:

- Developed metrics in consultation with NOAA.
- Created initial website to support post-press release inquiries.
- Completed satellite tracking analyses.
- Combined whale telemetry and remotely sensed environmental data to create initial habitat-based model of occurrence and density.
- Applied state-space model to 104 blue whale satellite tracks.
- Identified blue whale core area.
- Integrated blue whale locations with remote sensing data to correlate whale occurrence/behavior with environment.

Plans or expectations for 2013:

- Finish integration of whale and environmental data.
- Apply habitat models for each species.

Projected final ARL: 8 (August 2014).

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**Project:** Animal Movement: Discovering Relationships between Climate and Animal Migration with New Tools for Linking Movement Tracks with Weather and Land Surface Data

Principal investigator: Gil Bohrer, Ohio State University

Project year: 2

Year-end ARL: 5

**Description:**

To better understand the relationships between climate and animal migration, this project is developing tools to link movement with weather and land surface data. Additional objectives:

- Develop GUI-based data annotation, analysis, and statistical research tools for the online database *www.movebank.org* to facilitate study of weather and land-surface effects on animal movement and migration tracks.
- Link NASA and other sources of environmental data to the existing Movebank tools, and develop new tools.

End users: USFWS, National Park Service, USGS, USFS; all Movebank users

Data sources, models, technology: *TRMM*, MODIS, AVHRR NDVI, Oregon State Ocean Productivity Reanalysis, North American Regional Reanalysis, ECMWF interim global mid-resolution reanalysis, NCEP Global Reanalysis 2, OSCAR, GlobCover, Columbia University Socioeconomic Data and Application Center, NOAA global climate indexes and teleconnections, ASTER ASTGTM 2

**Major accomplishments in CY 2012:**

- Developed software to link, extract, re-grid, and interpolate environmental data.
- Completed links to 12 data sets (~2,500 variables).
- Completed tool for processing Argos telemetry data.
- Held two user outreach meetings.
- Completed GUI design; started development.
- Published first implementation paper.

**Plans or expectations for 2013:**

- Complete GUI and open tool access to users.
- Complete database linkage.
- Develop and implement derived data sets.

Projected final ARL: 9 (September 2014).

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**Project:** Utilizing Ecosystem Information to Improve the Decision Support System for Central California Salmon (SAFARI)

Principal investigator: Francisco Chavez, Monterey Bay Aquarium Research Institute

Project year: 4 (final)

Year-end ARL: 6

Description:

This project seeks to improve forecasting and management of central California Chinook salmon. Its approach focuses on measurements and models that explore mechanisms that control ecosystem productivity in central California coastal waters.

End users: Pacific Fishery Management Council (PFMC), NOAA NMFS Integrated Ecosystem Assessment Program

Data sources, models, technology: SSH, SST, *Aqua*/MODIS, AMSR-E, SeaWiFS, *QuikSCAT*/SeaWinds, *Jason*, *GOES*, ROMS

Major accomplishments in CY 2012:

- Completed model and associated processes.
- Improved forecasting accuracy by 20 percent in comparative hindcasts.
- Improved forecasts by extending predictive capability from one year to three.
- Shared results with fishery managers through publications, presentations, and working relationships.

Plans or expectations for 2013:

- Conduct additional model nowcasts and forecasts.
- Publish results.
- Prepare salmon forecasts out to 2015.
- Provide input into PFMC process to develop recommendations on fishery management measures.

Projected final ARL: 6 (August 2013).

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**Project:** Ecosystems in Transition: Decision Support Tools to Measure, Monitor, and Forecast Climate Impacts on Migratory Species

Principal investigator: Robert Crabtree, Yellowstone Ecological Research Center

Project year: 2 (final)

Year-end ARL: 4

Description:

Using a variety of data and tools, this project aims to provide enhanced capabilities for ecosystem and water resource management decisions affecting migratory species.

Additional objectives:

- Assemble and provide easy access to large physical/habitat data sets (COASTER).
- Enhance tools that allow users to understand how past, present, and future ecological and environmental conditions affect migratory species (EAGLES).
- Transfer all data sets and tools to end user.

End user: USFWS

Data sources, models, technology: AMSR-E, MODIS (percent surface water, disturbance), *Landsat* via CASA Express (version for wetlands), TopoMet (ground meteorological data), TOPS, EAGLES, COASTER

Major accomplishments in CY 2012:

- Completed major upgrade to COASTER software (v3).
- Added support for additional variables in COASTER such as percent surface water.
- Updated performance metrics.
- Met/engaged with and held workshops and training sessions for key stakeholders from USFWS and North American Waterfowl Working Group.
- Upgraded EAGLES for migratory species.

Plans or expectations for 2013:

- Conduct mid-continent ecosystem assessment.
- Complete predictive modeling of mallards.
- Run what-if scenarios using predictive species model.

Projected final ARL: 8 (June 2013).

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**Project:** Development of RRSC Models for Use within the U.S. Fish and Wildlife Service's Strategic Habitat Conservation Framework

Principal investigator: Robert Crabtree, Yellowstone Ecological Research Center

Project year: 4 (final)

Year-end ARL: 7

Description:

This project seeks to increase the ability of USFWS to forecast ecological conditions and predict impacts of environmental change. Additional objectives:

- Enhance USFWS decision support through utilization of NASA Earth science products and enabling new capabilities via a user-friendly interface.
- Couple NASA and other remote sensing and modeling products with analysis and forecasting tools to help wildlife managers recover and sustain populations of key species.

End users: USFWS, National Park Service, Bureau of Land Management, state fish and wildlife departments

Data sources, models, technology: MODIS, *Landsat*, EAGLES, COASTER

Major accomplishments in CY 2012:

- Created five climate parameters; created eight water balance parameters; created 10 vegetation parameters.
- Delivered new parameters on COASTER (<http://www.coasterdata.net>).
- Upgraded COASTER software.
- Updated EAGLES tools.
- Conducted ecosystem assessments (Alaska and Northern Rockies).
- Conducted three training sessions.
- Finished analysis of four of five USFWS focal species data sets (case studies to demonstrate EAGLES tools).

Plans or expectations for 2013:

- Deliver all data on COASTER.
- Customize COASTER.
- Complete focal species analysis.

Projected final ARL: 8 (March 2013).

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**Project:** Improving Stream Temperature Predictions for River Water Decision Support Systems

Principal investigator: Eric Danner, NOAA NMFS

Project year: 4 (project completed)

Year-end ARL: 7 (final)

Description:

This project incorporates Earth observations to develop tools to optimize water releases to prevent excessive downstream temperatures and subsequent harm to reproducing salmon. Additional objectives:

- Enhance the decision support system used to minimize dam/water management impacts on endangered salmon in the Sacramento River by increasing spatial and temporal resolution
- Provide accurate, high resolution hindcasts, nowcasts, and forecasts of stream temperatures.
- Develop integrated river temperature visualization system for easy end user access to results.

End users: NOAA NMFS, USFWS, U.S. Bureau of Reclamation, California Fish and Game Commission

Data sources, models, technology: MODIS (leaf area index, fractional photosynthetically active radiation, snow cover), WRF model, TOPS

Major accomplishments in CY 2012:

- Completed the temperature simulation tools and the related visualization and scenario system.
- Made the system available to end users via an interactive website: <http://oceanview.pfeg.noaa.gov/RAFT/>.
- Provided water and fishery managers access to the complete temperature landscape: resolution of 1 km and 15 min., 72 hour forecasts, and full season hindcasts.
- NOAA agreed to continue system enhancements and expansion.
- Published paper in *Journal of Selected Topics in Applied Earth Observations and Remote Sensing* (December): Danner et al., "River Temperature Forecasting: a Coupled-Modeling Framework for Management of River Habitat."

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**Project:** Integrating Ocean Observing Data to Enhance Protected Species Spatial Decision Support Systems

Principal investigator: Patrick Halpin, Duke University

Project year: 4 (project completed)

Year-end ARL: 9 (final)

Description:

Understanding and mitigating adverse interactions with protected marine species depends on direct access to high-quality marine animal data, ocean observations, ecological models, and expert knowledge. Through an ongoing collaboration between the Marine Geospatial Ecology Lab at Duke University and NOAA's Southwest Fisheries Science Center, this

project expanded the use of Earth observations data in decision support tools for marine ecosystem and protected species management. Additional objectives:

- Incorporate and evaluate additional oceanographic measurements and indices for species-environment modeling.
- Implement more robust automated workflows for processing Earth observations for marine management use.
- Expand data dissemination and decision support functions using Web services architectures.
- Expand ocean observing data and analysis methods to provide a critical prototype for marine resource management decision systems development for the future.

End users: U.S. government agencies (NOAA, Navy, ONR, BOEM) and international organizations (OBIS, GBIF) with mandates for biodiversity monitoring and assessment.

Data sources, models, technology: SST, eddies, Generalized Additive and ROMS models, HYCOM

Major accomplishments in CY 2012:

- Built on an existing spatial decision support system and specifically expanded the use of satellite remote sensing data in the development oceanographic indices for the forecasting of cetacean species densities in U.S. waters.
- Contributed directly to the development of more accurate and robust forecasting tools for use by NOAA NMFS, Navy, BOEM, and other client organizations. Current versions of the forecasting models and products enhanced under this project are now being directly employed in critical applications such as ESA and MMPA stock takes assessments, EIS assessments, and the new Cetaceans & Sound program (CetMap).
- Developed and disseminated a growing suite of geospatial analysis tools Marine Geospatial Ecology Tools (MGET) to allow end users to directly access, process, and analyze Earth observations data for a variety of applications. More than 2,000 researchers and facilities around the world are now actively deploying these tools.
- Took an emerging decision support tools system from a prototype ARL ~4 to a more robust and fully implemented application at ARL 9.
- Won an award: The Wildlife Society's Spatial Ecology and Telemetry Working Group recognized the MGET development team, headed by Jason Roberts, with an award in July 2012 for "a spatial function, tool or service that has significantly enhanced the field of wildlife conservation and management."

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**Project:** Evaluating User Needs for Models and Decision Tools to Predict the Impacts of Climate Change on the Marine Environment

Principal investigator: Patrick Halpin, Duke University

Project year: 2 (feasibility study)

Year-end ARL: 1

Description:

This is a study to evaluate and refine the specific user needs for new models and decision support tools to forecast potential changes in marine environments and habitats under future climate change scenarios. Additional objectives:

- Expand the applications from cetacean species to also include other migratory marine species, including pelagic fisheries species, to broaden the societal value of these efforts.
- Determine what remote sensing and downscaling forecasting model products federal agency users require for the management of migratory pelagic species under changing climates.

Primary partners: NOAA NMFS, NOAA Geophysical Fluid Dynamics Laboratory

End users: NOAA NMFS, BOEM, USFWS, U.S. Navy are anticipated end users

Data sources, models, technology: SST, SSH, ocean color, salinity, TOPAZ, HYCOM

Major accomplishments in CY 2012:

- Significant developments have been occurring in both the technological aspects of ocean forecasting systems as well as fundamental changes in end user needs with respect to Coastal and Marine Spatial Planning.
- Developed with federal partners two intensive user workshops in 2012: NOAA CetMap Cetaceans and Noise (May), and U.S. Navy Cetacean Density Data-Gap Filling (Nov.).

Plans or expectations for 2013:

- As a Phase 1 Discovery & Feasibility study extension of an existing decision support tools system, we have both developed tools and clients.
- Explore a fundamentally new application area: extending marine animal distribution forecasting capabilities to cover long-term climate change time scales.
- Determine critical needs for end user clients (e.g., Navy and NOAA NMFS Southwest Fisheries Science Center).
- Development of scenarios and targeted dialogue with the end user community to provide guidance on the requirements and needs of these agencies and to define the potential future capabilities of forecasting tools and methods.
- Complete the core work of this effort in spring 2013 and report findings at the NASA Biodiversity and Ecological Forecasting team meeting at the end of spring 2013.

Projected final ARL: 3 (September 2013).

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**Project:** Landscape Climate Change Vulnerability Project

Principal investigator: Andy Hansen, Montana State University

Project year: 2

Year-end ARL: 3

**Description:**

This project seeks to demonstrate the four steps of a climate adaptation planning strategy in two DOI landscape conservation cooperatives using NASA and other data and models.

**Additional objectives:**

- Hindcast and forecast future climate and land use scenarios.
- Assess the vulnerability of ecological processes and key habitat types.
- Evaluate management options.
- Design and deliver management adaptation strategies.
- Inform decision support.

**Primary partners:** NPS Inventory and Monitoring Program, Great Northern Landscape Conservation Cooperative

**End users:** NPS, Great Northern Landscape Conservation Cooperative, Appalachian Landscape Conservation Cooperative

**Data sources, models, technology:** NASA multi-platform sensor data; NASA TOPS models and products as a basis for ecological forecasting; *Landsat* imagery for land cover classification to parameterize the SERGoM land use change model

**Major accomplishments in CY 2012:**

- Developed collaborative relationships with 10 federal agency partners and identified needs that the project can address.
- Made good progress on generating new science in the form of ecological hindcasting and forecasting, which will serve as the basis for vulnerability assessment.
- Developed specific methods for creating and evaluating alternative management scenarios for vulnerable elements.

**Plans or expectations for 2013:**

- Complete synthesis of current knowledge on climate change, land use change, and ecological consequences for the past century and projected for the coming century.

Projected final ARL: 8 (November 2015).

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**Project:** The Effects of Extreme Climate Events on Avian Demographics: The Role of Habitat Refugia in Mitigating Climate Change

Principal investigator: Patricia Heglund, USFWS

Project year: 2

Year-end ARL: 3

**Description:**

This project examines the effects of extreme climate and weather events on bird demographics, with the object of predicting these demographic effects. Additional objectives:

- Quantify the role of national wildlife refuges and national forests as refugia for waterfowl and forest birds, respectively, during extreme events, and to identify management actions to enhance this function.

End user: USFWS, USFS

Data sources, models, technology: MODIS, *SRTM*, AVHRR, AMSR-E, *Landsat*

**Major accomplishments in CY 2012:**

- Used temperature, precipitation, and potential evapotranspiration data provided by NLDAS to build base data sets of SPI (Standardized Precipitation Index), SPEI (Standardized Precipitation and Evapotranspiration Index), and an index newly developed in our project, STI (Standardized Temperature Index).
- Validated NLDAS data against observational data and found it to be accurate enough to provide good individual index estimates.

**Plans or expectations for 2013:**

- Develop a single index as a way to represent the total effect of heat and drought on birds, and biodiversity generally.
- Use the potential evapotranspiration variable in NLDAS to compare and evaluate simpler methods of obtaining potential evapotranspiration, which will be needed in scenario studies.
- Projected final ARL: 9 (September 2015).

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**Project:** Pelagic Habitat Analysis Module (PHAM) for GIS-based Fisheries Decision Support

Principal investigator: Dale Kiefer, System Science Applications

Project year: 4 (final)

Year-end ARL: 8

Description:

This project integrates satellite imagery, circulation models, and fishery survey data into the Pelagic Habitat Analysis Module (PHAM) custom software to define the habitat of species that are either commercially exploited or threatened. Additional objectives:

- Develop a module for the Inter-American Tropical Tuna Commission (IATTC) to aid the tuna fisheries of the eastern Pacific Ocean.
- Develop a second module for the NOAA NMFS Southwest Fisheries Science Center (SWFSC) to assist management of mako, blue, and thresher sharks along the Californian coast.
- Encourage the use of PHAM's capabilities by scientists and decision makers to better understand pelagic habitats and population dynamics of species of eastern Pacific tuna, California Current sharks, beaked whales of the western Pacific, and Atlantic menhaden.

Partners: NASA Jet Propulsion Laboratory, NOAA SWFSC, IATTC

End users: NOAA SWFSC, NMFS, IATTC

Data sources, models, technology: MODIS SST and chlorophyll, SeaWiFS sea surface chlorophyll imagery, IATTC catch data, NMFS survey data, ECCO model, etc.

Major accomplishments in CY 2012:

- Completed an interface that links PHAM'S geographic information system to "R" statistical software that is used by fishery scientists around the world.
- Subjected a time series of satellite imagery of sea surface temperature, chlorophyll, and height from the eastern Pacific Ocean to Empirical Orthogonal Function analysis; found that components 2 and 3 track ENSO variability and provide a capability to help predict the recruitment of skipjack, yellowfin, and bigeye tuna.
- Demonstrated how PHAM can extract information on the habitat preference of mako and thresher sharks in the California Current; used this information to map the seasonal migration pattern of thresher sharks as they pursue sardine prey.
- Completed, for Jet Propulsion Laboratory, GIS-based software for distribution of oceanographic satellite imagery as well as associated GIS data.
- Incorporated PHAM into "Fishscape," an NSF Coupled Human and Natural Systems sponsored project, which is an agent-based model of the eastern Pacific tuna fishery.

Plans or expectations for 2013:

- All design and implementation work is complete. Validation trials are largely finished.
- Hold meetings with partners to evaluate progress.
- Submit two or three papers for publication.
- Conduct workshops for end users to train them to build their own projects using PHAM.
- Expand user community through Physical Ocean DAAC.

Projected final ARL: 9 (June 2013).

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**Project:** Using the USGS “Resource for Advanced Modeling” to Connect Climate Drivers to Biological Responses

Principal investigator: Jeffrey Morisette, USGS

Project year: 2

Year-end ARL: 4

Description:

This project utilizes NASA computational capacity and satellite-derived predictor layers to enhance USGS habitat modeling. It seeks to improve land management decisions by connecting management targets to climate drivers. Additional objectives:

- Facilitate interaction between the USGS Resource for Advanced Modeling (RAM) and NASA Ames Research Center via VisTrails software.
- Connect with the land management community through interaction with Colorado State University and the DOI North Central Climate Science Center.

End user: DOI North Central Climate Science Center

Data sources, models, technology: RAM field data and modeling code, predictor layers from NASA TOPS, Ames high-end computing power

Major accomplishments in CY 2012:

- “Hardened” the Software for Assisted Habitat Modeling (SAHM) modules in VisTrails; completed user manual; made software available.
- Connected the VisTrails SAHM results with the visualization wall in RAM.
- Integrated VisTrails and SAHM software in some NASA Ames computing facilities (e.g., the NEX “sandbox”).
- Established partnership: RAM set as a primary habitat modeling facility for the DOI North Central Climate Science Center.
- Submitted article to *Ecography*: Morisette et al., “VisTrails SAHM: visualization and workflow management for ecological niche modeling” (to be published January 2013).
- Petr Votava (NASA Ames) lectured on the utility of the VisTrails software during the climate and remote sensing training session at Ames, June 2012.

Plans or expectations for 2013:

- Anticipate ARL 5 once VisTrails SAHM is run at NASA Ames and compared with results derived at the Fort Collins Science Center.
- Integrate basic components of field data and habitat modeling predictors so that the application can be tested in a simulated decision making environment.

- Validate model runs at Ames to show that the habitat modeling both a) functions with the predictor layers available through Ames and b) achieves improved performance.
- Projected final ARL: 9 (2014).

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**Project:** A Decision Support System for Ecosystem-based Management of Tropical Coral Reef Environments

Principal investigator: Frank Muller-Karger, University of South Florida

Project year: 4

Year-end ARL: 7

**Description:**

This project is augmenting the Coral Reef Watch (CRW) decision support system with higher resolution remotely sensed data to improve monitoring of the health of coral reefs and global mapping. Research is focused in the Gulf of Mexico, Caribbean, and Pacific coast of Mexico. NASA Ames Research Center is a partner.

End user: NOAA CRW

Data sources, models, technology: MODIS, AVHRR, *GOES*

**Major accomplishments in CY 2012:**

- Deployed new website at University of South Florida, with 1 km experimental CRW products (AVHRR) using new climatology (heat and cold stress products).
- Deployed new website at CONABIO (Mexico) with regional 1 km CRW products (MODIS, using MODIS climatology: 2002-2010).
- Finished processing advanced prototype of global, 4-km resolution SST climatology (AVHRR Pathfinder, 1985-2005) using NASA Earth Exchange at Ames Research Center.
- Deployed new 5-km heat stress product suite at NOAA CRW website using NOAA operational global daily 5-km SST from polar and geostationary satellites, and new 4-km Pathfinder climatology.

**Plans or expectations for 2013:**

- Publish at least two manuscripts.
- Implement MODIS experimental products at University of South Florida website (improved heat and cold stress products).
- Conduct training on application of CRW products at Florida Reef Resilience Program.
- Conduct team progress review meeting immediately prior to the Biodiversity and Ecological Forecasting meeting.
- Participate in the Biodiversity and Ecological Forecasting meeting.
- Work with NOAA on agreement to host experimental products on NOAA website.

- Mexico deployment of 1-km products (MODIS) and testing with standard 4-km climatology (Pathfinder SST).
- Research cold stress index.

Projected final ARL: 8 (October 2014).

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**Project:** Extending the Terrestrial Observation and Prediction System (TOPS) to *Suomi/NPP* Applications

Principal investigator: Rama Nemani, NASA Ames Research Center

Project year: 2 (feasibility study)

Year-end ARL: 1

Description:

This is a feasibility study to understand and quantify impacts of transitioning applications that use TOPS from MODIS to VIIRS data. Additional objectives:

- Understand the errors and uncertainties associated with the transition from MODIS to VIIRS with reference to Applied Sciences Program projects.
- Integrate *Suomi/NPP* data and products into existing applications by conveying the errors and uncertainties.
- Leverage TOPS and NEX to engage federal, state, and local partners in the *Suomi/NPP* mission by providing a platform for creating high-level products and rapid prototyping of applications.

End user: NASA PIs and projects

Data sources, models, technology: MODIS and VIIRS land products

Major accomplishments in CY 2012:

- Completed MODIS climatology and anomaly production.
- Obtained VIIRS “golden” tiles from VIIRS Land PEATE team.

Plans or expectations for 2013:

- Complete analyses of stability of VIIRS data and consistency of MODIS vs. VIIRS NDVI and LAI products.
- Ongoing cross correlation with climate variables.
- Projected final ARL: 1 (December 2014).

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**Project:** Management and Conservation of Atlantic Bluefin Tuna (*Thunnus thynnus*) and Other Highly Migratory Fish in the Gulf of Mexico under IPCC Climate Change Scenarios: A Study using Regional Climate and Habitat Models

Principal investigator: Mitchell Roffer, Roffer's Ocean Fishing Forecasting Service, Inc.

Project year: 2

Year-end ARL: 3

Description:

This project focuses on enhancing the management of multiple important highly migratory pelagic fish species in the Gulf of Mexico and surrounding waters, with particular focus on Atlantic bluefin tuna and other highly migratory tunas and billfishes. Our team has developed an innovative spawning habitat model for Atlantic bluefin tuna in the Gulf of Mexico in collaboration with NOAA NMFS. Additional objectives:

- Leverage present collaborations to project this habitat model into the future using IPCC climate models and scenarios to assess possible effects of climate change on the spawning habitat and fish population dynamics.

Partners: NOAA NMFS Southeast Fisheries Science Center, NOAA Office of Oceanic and Atmospheric Research/Atlantic Oceanographic and Meteorological Laboratory, University of Miami Cooperative Institute of Marine and Atmospheric Sciences, University of South Florida Institute for Marine Remote Sensing

End user: NOAA Southeast Fisheries Science Center, South Atlantic Fishery Management Council, other fishery management entities

Data sources, models, technology: HYCOM-AML, WRF models, MODIS, VIIRS, ocean color, altimetry, SST, IPCC-4 and 5

Major accomplishments in CY 2012:

- Provided real-time, satellite-derived oceanographic analyses to our research partners (John Lamkin and Barbara Muhling, co-principal investigators) for the NOAA NMFS SEFSC SEAMAP ichthyoplankton cruise during the research cruise. These analyses were used to set the "adaptive" targeted sampling strategy to evaluate spawning in the Caribbean Sea between Mexico, Haiti, and Honduras, as well as in the Gulf of Mexico, as well as to develop and refine the spawning habitat model for bluefin tuna along with the other highly migratory species of interest.
- NOAA NMFS Southeast Fisheries Science Center is now routinely using satellite data in their stock assessments of bluefin tuna.
- As a result of the successes of this project the use of satellite data in developing habitat models for use in stock assessments is also being used by others in fishery management (e.g., South Atlantic Fishery Management Council).

Plans or expectations for 2013:

- Collect and analyze fish (larvae and adults) data and environmental data.
- Complete habitat models for all species and define species guilds.
- Assess the effects of a range of climate change scenarios on fish (larvae, adult) distribution.
- Compare hindcast data from a suite of global climate models with climatological data, to determine biases and accuracy for each model.
- Improve the IPCC-AR4 downscaling using WRF.
- Generate average gridded fields and GIS products for simulated climate scenarios.
- Develop and refine biogeochemical models.
- Start transition stage planning: needs analysis, user metric, revised timetables.

Projected final ARL: 9 (August 2015).

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**Project:** Improving the NOAA NMFS and ICCAT Atlantic Bluefin Tuna Fisheries Management Decision Support System

Principal investigator: Mitchell Roffer, Roffer's Ocean Fishing Forecasting Service, Inc.

Project year: 4 (project completed)

Year-end ARL: 9 (final)

Description:

The activity improves the existing NOAA NMFS Southeast Fisheries Science Center (SEFSC) decision-making system for population assessment and management of Atlantic bluefin tuna (*Thunnus thynnus*). Additional objectives:

- Reduce the variance in the estimates of adult Atlantic bluefin tuna spawning stock abundance in the Gulf of Mexico through the development of spawning site habitat classification and catchability indices of the larvae.

End users: NOAA SEFSC, ICCAT

Data sources, models, technology: fisheries stock size model, tuna larvae forecast model, MODIS, CZCS (ocean color, SST, albedo), AVHRR (SST, atmospheric moisture), radar altimeters (SSH)

Major accomplishments in CY 2012:

- Achieved a statistically significant reduction in larval abundance estimate variance.
- Developed and refined spawning habitat classification models; NMFS used routinely.
- An increase in the number of Atlantic bluefin tuna larvae were caught using a combination of the spawning habitat modeling and new gear techniques developed as a result of this project.

- Transferred technology to NMFS, as agency now uses more satellite data routinely for fishery independent population assessments than had previously.
- Determined which characteristics of ocean circulation are relatively more important for capturing fish larvae.

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**Project:** A Decision Support System for Monitoring, Reporting, and Forecasting Ecological Conditions of the Appalachian National Scenic Trail

Principal investigator: Yeqiao (Y.Q.) Wang, University of Rhode Island

Project year: 2

Year-end ARL: 6

Description:

The purpose of the Appalachian Trail Decision Support System (A.T.-DSS) is to facilitate decision making for the NPS Appalachian National Scenic Trail, the Appalachian Trail Conservancy, and the USFS, and provide a means to easily convey meaningful information to the American public. Additional objectives:

- Develop a comprehensive set of seamless indicator data layers consistent with selected A.T. "Vital Signs."
- Establish a ground monitoring system to complement TOPS and integration of NASA data with *in situ* observations.
- Assess historical and current ecosystem conditions and forecast trends with data from TOPS in habitat modeling.
- Develop an Internet-based implementation and dissemination system for data visualization, sharing, and management to facilitate collaboration and promote public understanding of the A.T. environment.

End user: USFWS, University of Wisconsin at Madison

Data sources, models, technology: NASA multi-platform sensor data, TOPS models and products

Major accomplishments in CY 2012:

- Extracted/downloaded and analyzed multiple NASA data sets, e.g., land cover dynamics, snow cover, land cover type, vegetation indices, leaf area index, and land surface temperature.
- Collected and processed other data sets, e.g., National Elevation, LANDFIRE, existing vegetation type, existing vegetation cover, canopy height, and canopy cover.
- Secured \$20,000 for post-NASA funding system transition activities. The \$20,000 has been committed by the director of the North Atlantic Coast Cooperative Ecosystem Study Unit and the director of URI's Coastal Institute. This will support the system transition for one year.

Plans or expectations for 2013:

- Explore further development of a smartphone application (app) for the A.T.-DSS. It is hoped that the development of this app or similar products will be useful for popularizing the DSS and engaging professionals and the public.
- Projected final ARL: 9 (September 2015).

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## Acronyms

AML: atmospheric mixed layer  
AMSR-E: Advanced Microwave Scanning Radiometer-EOS  
ARL: Application Readiness Level  
ASTER: Advanced Spaceborne Thermal Emission and Reflection Radiometer  
ASTGTM 2: ASTER Global Digital Elevation Model, version 2  
AVHRR: Advanced Very High Resolution Radiometer  
BOEM: Bureau of Ocean Energy Management  
CASA: Carnegie Ames Stanford Approach  
CetMap: Cetacean Density and Distribution Mapping Group  
COASTER: Customized Online Aggregation & Summarization Tool for Environmental Rasters  
CONABIO: National Commission for Knowledge and Use of Biodiversity  
CRW: Coral Reef Watch  
CY: calendar year  
CZCS: Coastal Zone Color Scanner  
DAAC: Distributed Active Archive Center  
DOI: Department of the Interior  
EAGLES: Ecosystem Assessment, Geospatial analysis, and Landscape Evaluation System  
ECCO: Estimating the Circulation and Climate of the Ocean  
ECMWF: European Center for Medium-Range Weather Forecasts  
ENSO: El Nino–Southern Oscillation  
EOS: Earth Observing System  
ESA: European Space Agency  
GBIF: Global Biodiversity Information Facility  
GIS: geographic information system  
GOES: Geostationary Operational Environmental Satellite  
GUI: graphical user interface  
HYCOM: HYbrid Coordinate Ocean Model  
IATTC: Inter-American Tropical Tuna Commission  
ICCAT: International Commission for the Conservation of Atlantic Tunas  
IPCC: Intergovernmental Panel on Climate Change  
MGET: Marine Geospatial Ecology Tools  
MMPA: Marine Mammal Protection Act  
MODIS: Moderate Resolution Imaging Spectroradiometer  
NASA: National Aeronautics and Space Administration  
NCEP: National Centers for Environmental Prediction  
NDVI: Normalized Difference Vegetation Index  
NEX: NASA Earth Exchange  
NMFS: National Marine Fisheries Service  
NOAA: National Oceanic and Atmospheric Administration  
NPS: National Park Service  
NSF: National Science Foundation

OBIS: Ocean Biogeographic Information System  
ONR: Office of Naval Research  
OSCAR: Ocean Surface Current Analyses Real-time  
PFMC: Pacific Fishery Management Council  
PHAM: Pelagic Habitat Analysis Module  
QuikSCAT: Quick Scatterometer  
RAFT: River Assessment for Forecasting Temperatures  
RAM: Resource for Advanced Modeling  
ROMS: Regional Ocean Modeling System  
RRSC: Risk-Reward Spatial Capacity  
SAHM: Software for Assisted Habitat Modeling  
SeaWiFS: Sea-viewing Wide Field-of-view Sensor  
SEFSC: Southeast Fisheries Science Center  
SERGoM: Spatially Explicit Regional Growth Model  
SSH: sea surface height  
SST: sea surface temperature  
SWFSC: Southwest Fisheries Science Center  
TOPAZ: (Towards) an Operational Prediction system for the North Atlantic European coastal Zones  
TOPEX: Ocean TOPography Experiment  
TOPS: Terrestrial Observation and Prediction System  
USFS: United States Forest Service  
USFWS: United States Fish and Wildlife Service  
USGS: United States Geological Survey

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