

Addendum 1

Key Themes and Identified Impacts from GCOOS-Sponsored Workshops (2000-2015)

Stakeholder Engagement

The GCOOS-RA is proud of its history of reaching out to stakeholders for determining priority products and needs. Our *Build-Out Plan* is a prime example of this with more than 630 people from 297 unique organizations participating in 17 workshops. The information provided by these stakeholders is now the backbone to the *Build-Out Plan*. A summary of stakeholder identified impacts that an integrated ocean observing system would provide and the key theme area(s) addressed are summarized here. Stakeholders can be both the advisor and consumer within the development of GCOOS products and services. We use an iterative process to not only address the needed product, but to refine the product to assure that it meets the needs of the stakeholders.



Key Themes and Identified Impacts from GCOOS-Sponsored Workshops (2000-2015)

| Product/Service | Sector | Impact | Strategic Plan Priority | | | | | | | Difficulty L, M, H | Exist/in development/Planned |
|------------------------------------------------------------|--------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|----|-----|----|----|-----|------------|-----------------------|------------------------------------|
| | | | CH | MO | Eco | PH | OE | LTC | | | |
| Surf conditions | Recreational Boaters | Coastal HFR for high resolution wave heights and current information at passes and near-shore out to about 20 nm | | x | | | x | | | | Planned/Requested |
| | Emergency Response | Surf and circulation conditions at bays, inlets and passes to develop and refine environmental sensitivity indices for spill response. Scales on the order of ten meters is desired | x | | x | x | | | | | Planned/Requested |
| | Beach-goers, divers | Rip current forecasts and sea state, with live cam at popular swimming and diving locations | x | | | x | x | | | | Planned/Requested |
| | Oil & Gas and supporting industries | Localized high resolution nearshore and offshore surf forecasts to support "go-no-go" decisions related to exploration and drilling operations | | x | | | | | | | Planned/Requested |
| | Restoration programs e.g., Water Inst. Of the Gulf | Long-term averages and extremes of surface conditons/land-sea interactions | x | | x | | x | x | | | Planned/Requested |
| | Recreational boaters, divers | Facilitate private sponsorship of buoys near reefs/diving spots with sensors that include aids to navigation | x | x | | | x | | | | Planned/Requested |
| | Commercial, recreational boating, shipping | Increase availability of local area pilot charts | | x | | | | | | | Planned/Requested |
| | Recreational Boaters | Improve where/when information delivered; e.g., at the ramp with visual/flag signal, VHF, local radio transmission, GIS on GPS units | | x | | | x | | | | Planned/Requested |
| | Recreational Boaters | Surface through bottom data on salinity, turbidity, chlorophyll, dissolved oxygen, bacteria | | | x | x | x | | | | Planned/Requested |
| | Oil & Gas drilling & operations, NOAA NWS, Living Marine Resources | Higher resolution and earlier forecasts of Loop Current position, characteristics (e.g., depth & T-S ranges) and eddy shedding events | x | x | x | x | x | x | | | Exist/in development |
| NUMERICAL MODELS | OR&R/ERMA and DIVER users | Models (HYCOM, ADCIRC others); HFR in N. Gulf, WFS, Miami and TX coming online | x | x | x | x | x | x | | | Exist |
| | Insurance industry, realtors, tourism | Water level, flood risk planning tools | | | | | | | | | Planned/Requested |
| Model Forecasts: surface currents from ROMS, WAVCIS | Ecosystem modelers, Gulf Environmental-related NGO programs | Continuous and discrete biological and physical models to bridge the continuum from land to ocean | x | x | x | x | | | | | Exist/Planned/Requested |
| | | Finite element model integration to create seamless boundaries land/inshore/offshore | x | x | x | x | | | | | In development limited areas |
| | HABIOS community | More precise location and tracking of HABs by combining offshore and nearshore surface currents, remote sensing data and models | | | x | x | x | x | | | Planned/Requested |
| | | A plan with cost estimate to routinely update continuous models | | | | | | | | | Planned/Requested |
| | USCG SAR, fishery stock assessments, marine transportation | Climatology products | x | x | x | x | x | x | | | Some exist/more requested |
| | | Ocean hydrodynamic models for surface current trajectories | x | x | x | x | x | | | | Exist/In development/limited areas |
| Model Forecasts: integrated open ocean to estuaries models | NOAA NHC, NWS, academia, NRL, Emergency Management | Enable integrated open ocean to estuaries models (e.g., USF OCG, UM Coastal and Shelf modeling, WFS ROMS) to be used in weather prediction (especially hurricanes) | x | x | | x | x | | | | Not yet operational |
| | Gulf NERRS programs, Resource management | Establish baseline conditions for integrated ecosystem model development | | | x | x | x | x | | | Planned/Requested |
| | Living Marine Resource Management and research | Integration with in situ data (buoys, LIDAR, HFR, AUV, Satellite RS) | x | x | x | x | x | x | | | |
| Gulf Gliders/AUVs | | | CH | MO | Eco | PH | OE | LTC | Difficulty | | |
| Glidens: GANDALF | Gulf glider network (TAMU, USF, MML, USM, Navy, Shell) | Expand Gulf AUV Network and Data Archiving Long-term Storage Facility; glider data and pilot support to enable coordinated missions and remove DM burden from glider operators | x | x | x | x | x | x | | | Exists/In development |

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| Gliders: Wave gliders | Nacent Gulf OA network, shellfisheries, resource managers, NOAA NMS, MBON | Build out Gulf-wide the USM and MSU Liquid Robotics platforms that house carbon dioxide, DO, pH and other sensors to monitor ocean acidification and other long-term changes | | | | | | | | | | | | | | | | | | Planned/Requested | |
|----------------------------------------------------------|---------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------|------------|-----------|-----------|------------|-------------------|---|--|--|--|--|--|--|--|--|--|-----------------------|-------|
| Marine Biodiversity Observing Network | | | | | | | | | | | | | | | | | | | | | |
| GCOOS Vampire for MBON | Marine Biodiversity Observation Network | Support MBON reef fish visual census, e.g., FKNMS aggregate counts, corals, other LMR; ERDDAP/TDS servers; link these biological data with physical, metocean and other data streams | | | | | | | | | | | | | | | | | | Exist/In development | |
| MBON: Biological Data | MBON and several in NGO Community | Connect with biodiversity:Genome map--indices for all Gulf species | | | | | | | | | | | | | | | | | | Planned/Requested | |
| | MBON and several in NGO community | Automated taxonomic classification via optical sensors, eDNA, cytobots, etc | | | | | | | | | | | | | | | | | | Exist in limited area | |
| | Marine Mammal Commission, academia, fish and wildlife, NMS, N Park Serv | Sustained monitoring to ID status & trends, stock structure, population demographics & reproductive rates of MM--nearshore (less than 200 m ie spotted dolphins) and offshore species ie Bryde's and sperm whales | | | | | | | | | | | | | | | | | | Requested | |
| | Academic, state and federal government with MM jurisdiction | Assess habitat use of MM spp--no sustained monitoring outside MS Sound and Sarasota Bay | | | | | | | | | | | | | | | | | | | |
| MODEL FORECASTS | | | CH | MO | Eco | PH | OE | LTC | Difficulty | | | | | | | | | | | | |
| Model forecasts: GOM HYCOM | Academia, navy, industry | RT 1/25 degree GOM HYCOM | x | x | x | x | | | x | | | | | | | | | | | Exist | |
| Model forecasts: wind-driven currents | Model developers | QuickScat winds FSU 6 hr winds at 0.5 degree resolution incorporated into model development for wind-driven currents and other forecasts | x | x | x | x | x | | | | | | | | | | | | | | Exist |
| Model forecasts: wind fields | Academia, navy, industry | NCEP NAM wind fields | x | x | x | x | | | | | | | | | | | | | | | Exist |
| Model forecasts: GNOME-ready input fields | OR&R, academia, navy, industry | General NOAA Operational Modeling Environment (GNOME)-ready input fields | x | x | x | x | | | | | | | | | | | | | | | Exist |
| Model resources: GCOOS WMS server | Academia, navy, industry | Open Geospatial Consortium's Web Map Service protocol for georeferenced map images | x | x | x | x | | | | | | | | | | | | | | | Exist |
| Model resources: THREDDS data server | Academia, navy, industry | UCAR's Unidata Thematic Real-time Environmental Distributed Data Services provides metadata and data access to RT and archived data sets from a variety of sources at a number of distributed server sites using a variety of remote data access protocols. | x | x | x | x | x | x | | | | | | | | | | | | | Exist |
| Model resources: WCS client for USF MODIS chla-a and SST | USF | OGC Web Coverage Service interface standard for USF IMaRS program to select GCOOS holdings of interest | x | x | x | x | x | x | | | | | | | | | | | | | Exist |
| Model resources: WCS client for LSU ESL SST | LSU | OGC Web Coverage Service interface standard for LSU ESL program to select GCOOS holdings of interest | x | x | x | x | x | x | | | | | | | | | | | | | Exist |
| Model resources: Hypoxia | Academia, Resource Management | Hypoxia simulation results catalog | x | | x | x | | | x | | | | | | | | | | | | Exist |
| Model Resources: Mean T & S profiles | | | | | | | | | | | | | | | | | | | | | |
| Mean T & S profile from GDEM V. 3 | Navy, academia | Mean T & S profile from the Generalized Digital Environment Model (GDEM) V.3, computed from T & S profiles extracted from the Master Oceanographic Observational Data Set (MOODS, 1995) | x | x | x | x | | | | x | | | | | | | | | | | Exist |
| Mean T & S profile from WOA | Navy, academia | Mean T & S profiles from the World Ocean Atlas 2005 | x | x | x | x | | | | x | | | | | | | | | | | Exist |

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| Synthetic T&S profile from SSHS | Navy, academia | High resolution 3-D temperature and salinity fields derived from in situ and satellite observations | x | x | x | x | | x | | Exist |
| Model resources: Historical data | MMS/BOEM | Enable transition of legacy data to new technologies without losing data | | | | | | | | Requested |
| | Modeling community | Create a searchable database of historical information that can be used to develop climatologies | x | x | x | x | x | x | | In development limited data sets |
| Model resources river discharge data set | | | | | | | | | | |
| Model resources: SSH and anomaly data | Modeling community, academia, navy | U CO daily fields of Sea Surface Height anomaly; model avg SSH for GOM | x | x | | | | | | Exist |
| | NCDDC, NODC, NRL, | Aggregate and host shape files in one place | x | x | | | | | | |
| Model resources: Model data viewer | NGO | Assess offshore pelagics, zooplankton abundance and distribution | | | x | x | x | x | | Requested |
| | NGO | Maps of inland/marsh bird species/migratory corridors | | | x | | x | x | | Requested |
| | NGO | Integrated data across state boundaries | | | x | x | x | x | | Requested |
| | NWS, ORR, Emergency operations, academic | Comparative model output to ID typical vs. extreme conditions, refine SLOSH, SLAMM surge models | x | x | x | x | x | x | | Exist/In development |
| | GOMRI, Gulf Modeling Task team | Enable the overlay of model output from various models | x | x | x | x | x | x | | In development/Planned |
| | GOMRI Deep-C and other DWH consortia | Merge continuous models with other data | x | x | x | x | | x | | Requested |
| | Ecosystem modelers | Overlay sediment, water, atmosphere, biogeochemical, species transport/couple circulation and biologic models | | | x | x | | | | Requested |
| BATHYMETRY | | | | | | | | | | |
| Bathymetry: entire GOM bathymetry and coastline-SRTM30PLUS-30 arc second SRTM land topography with measured and estimated seafloor topography | NGO | Link coastal species niche and distribution to elevation | | | x | | | | | Requested |
| | NGO | Appropriate spatial and temporal resolution | x | x | x | x | x | x | | Requested |
| | NGO | Transportation and hazard applications | x | x | | | | | | Requested |
| | | Standard elevation data formats and reporting | x | x | x | x | x | | | Requested |
| Bathymetry: N. GOM-NGDC Coastal Relief Model (CRM), multibeam arc info pt coverage, 50 m gridded and UTM zone format, and shapefile format | Recreational Boaters | Reduce hull strikes, boat groundings and habitat destruction with higher resolution bathymetry of coastal shorelines, inlets and passes | x | x | x | | | | | Data exist; stakeholder-specific products requested |
| | NMFS | Baseline information to support NMFS Essential Fish Habitat Maps | | x | x | | | | | Data exist; stakeholder-specific products requested |
| | NMFS, FWC, Marine Mammal Commission | Share protected species data/work of various NGOs | | x | x | | | | | Requested |
| | State and county response agencies | Habitat classification, NOAA Env Sensitivity Index, EPA, IEPECA | | | x | | | | | Requested |
| | NGO, GOM Data Atlas users | Habitat Classification standards (e.g., CMECS), sediment classification | x | | x | | | | | Exist for some |
| | NGO | Ability to seamlessly drill down to resolution needed | | | x | | | | | |
| | Many GCOOS stakeholders | Gulf-wide base map with nested spatial scales | x | x | x | x | x | x | | Requested/currently research mode only |
| Map layers | | | | | | | | | | |
| | CSC, CZM, GOMA Coastal Resilience PIT | Coastal hazards linked to coastal development, land use maps | x | | x | | | | | Requested |
| | NMS, NMFS EFH, NOAA Protected Spp | ID critical/sensitive habitat, protected spp, species distributions | x | x | x | | | | | Requested |
| | NOAA Habitat Blueprint, GAME | Map layers for habitat types, jurisdiction, land cover, public access sites | x | | x | x | x | x | | Requested |
| | Gulf Restoration community, FEMA | Insurance industry-scenarios under different land use | x | | x | | | | | Requested |
| | Gulf of Mexico Data Atlas users | Jurisdiction, state priority areas and species/sensitivity index | x | | x | x | | | | Requested |
| | NOAA CCAP, Mobile Bay USCG | ports/barge traffic/navigation | | x | | | | | | |
| | NOS, USACE, USGS, Protected Spp Division | Sediment loads | x | x | x | x | | | | Requested |
| | GO-Monitor | Sampling locations inventory | | | | | | | | Exist |
| OIL & GAS | | | | | | | | | | |

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| | Public, city planners, management | General platform, pipeline and lease data information | x | x | x | | | | | | | | | | | | | Exist |
|-----------------------------------------------|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|-----|----|----|-----|------------|---|---|--|--|--|--|--|--|-----------------------------------------------------------|
| DWH glider and float time series | Academia, Emergency Response, Mitigation teams | Trajectory predictions to refine numerical models, guide spill response, protect sensitive habitats | x | | x | x | | | | | | | | | | | | Exist |
| | | Pollutant source prediction e.g., backtrack to source | x | | x | x | | | | | | | | | | | | Exist |
| | | Pollutant fates forecasts | x | | x | x | | | | | | | | | | | | Exist |
| | | Contingency planning for oil spills--Environmental Sensitivity Index development | x | | x | x | | | | | | | | | | | | Data exist for some areas |
| DWH regional resources | Emergency response, resource management, education | Desired information: Hydrocarbons-natural background levels | x | | x | x | x | | | | | | | | | | | Requested |
| Satellite remote sensing products for boaters | Recreational Boaters | Higher resolution remote sensing products (e.g., USF IMaRS, Optical Ocean Lab, USM Ocean Weather Lab, LSU ESL, Roffers Ocean Fish Forecasting Service)to show weed line, temperature fronts | | | x | x | x | | | | | | | | | | | Data exist, need stakeholder-specific products |
| LIVING MARINE RESOURCES | | | | | | | | | | | | | | | | | | |
| LMR: lionfish observation tool | Audubon, TNC, TOC, TGLO, Digital Coast | Invasive species monitoring | | | | x | x | x | x | | | | | | | | | Exist |
| | | | CH | MO | Eco | PH | OE | LTC | Difficulty | | | | | | | | | |
| LMR: CAGES | Fisheries dependent, independent data users | Integrate SEAMAP, MARFIN, CAGES, NOAA Data Atlas, GOMA Atlas, OC Atlas, O&G industry | | | | x | x | x | x | | | | | | | | | Some data exist/Request for stakeholder-specific products |
| SEAMAP data | Living Marine Resource managers, academia, NGO | Trophic interactions/food web dynamics | | | | x | x | x | x | | | | | | | | | Some data exist/Request for stakeholder-specific products |
| | Living Marine Resource managers, academia, NGO | Guidance for restoration decisions, economic valuation | | | | x | | x | | | | | | | | | | Some data exist/Request for stakeholder-specific products |
| LMR: Animal Telemetry | Gulf ATN community (iTAG, FACT, OTN) | Ability to monitor aquatic animals over larger spatial scales | | | | x | x | x | x | x | | | | | | | | In development |
| | Gulf ATN community (iTAG, FACT, OTN) | Satellite and acoustic tracking infrastructure | | | | x | x | x | x | x | | | | | | | | In development |
| | ATN community | Technology: Arrays which can be used to track multiple species | | | | x | x | x | x | x | | | | | | | | Requested |
| | ATN community | Refine tags to enable environmental condition monitoring from animal platforms | | | | x | x | x | x | x | | | | | | | | In development by Vemco |
| | Modeling-LMR assessments | Demonstrate how data from ATN (e.g., natural mortality rates, migration rates) can fill gaps in assessment models | | | | | | x | | x | | | | | | | | Requested |
| | ATN community | Ability to integrate detection data with oceanographic data | | | | x | x | x | x | x | | | | | | | | Requested |
| | ATN community | Integrative research for assessment and management purposes | | | | x | x | x | x | x | | | | | | | | Requested |
| ATN Regional Coordination | LMR managers NMFS, MMC, FWC | Aligning federal and state initiatives related to monitoring fish movements | | | | x | x | x | x | x | | | | | | | | Requested |
| | | Create mechanism to leverage funding/ share resources—data, equipment, expertise, economies of scale | | | | | | x | | x | | | | | | | | Requested |
| | | Gulf ATN as a network that can facilitate data sharing by integrating with other telemetry networks | | | | x | x | x | x | x | | | | | | | | Exist/In development |
| | | Improve robustness of the Gulf acoustic and satellite tracking system | | | | x | x | x | x | x | | | | | | | | Requested/In development |
| | | Develop a coordinated sentinel array system that is consistently deployed and can detect rapid changes or odd behaviors | | | | x | x | x | x | x | | | | | | | | Requested |
| | | Establish a sense of community and collaboration to facilitate a regional approach to addressing bigger science questions | | | | x | x | x | x | x | | | | | | | | Exist/In development |
| | | Create a mechanism for researchers to learn about new technologies and to provide feedback to vendors on needs | | | | | | | | x | | | | | | | | In development |
| | | Host a universal data base to share detections of non-target species | | | | | | x | x | x | x | | | | | | | Requested |
| | | Use the Gulf network to ID gaps in spatial coverage where infrastructure is needed | | | | | | x | x | x | | | | | | | | Exist/In development |

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| | | Improve communication through annual meetings and forums | | | | | | | x | | | Exist/In development |
| River Discharge | NGO, state and federal water management districts, academia, emergency management | Better understand the drivers of fluctuation, FW/Groundwater input by the ~61 rivers draining into the N. GOM. | x | x | x | x | x | x | | | | Some data exist/need stakeholder-specific products |
| H-N Portal | NGO | Productivity-Coast/shelf/ocean exchange | x | | x | x | x | x | | | | Exist |
| | NGO | chlorophyll | | | x | x | x | | | | | Exist |
| | GOMA WQ Priority Issue Team, EPA | chlorophyll, nutrients, pollution, contaminants, turbidity, Total Suspended Solids | | | x | x | x | x | | | | Exist |
| | Beach monitoring, water management districts | standardized collection and reporting | x | x | x | x | x | x | | | | Some data/Request for consistent standards |
| | | Advance use of optical sensors, glider hyperspectral sensors, RS, ISUS | | | x | x | x | | | | | Some exist/Request for widespread use |
| | NGO, USF, MML, LUMCON, TAMU, USM, industry | DO from AUVs and or vessels | | | x | x | x | x | | | | Limited data exist/Request for more widespread sampling |
| | EPA, states, federal response, industry response | Couple H-N portal data with circulation models for pollution tracking | x | x | x | x | x | | | | | Data exist/specific products needed |
| Sea level shoreline: Global Shelf-consistent, Hierarchical, High-resolution Shoreline Database (GSHHS) | USGS, flood plain managers, coastal planners | Shoreline database for coastal vulnerability assessments from GSHHS | x | | | | | | | x | | Exists |
| Weather: SLAMM and SLR trends in GOM | NOAA CO-OPS | Water level-real time | x | x | | x | x | x | | | | Exist |
| | Recreational Boaters | General weather: Enhanced accuracy of real-time weather forecasts at more localized resolution, including environmental alerts and fog | x | x | | x | x | | | | | Exist for limited locations |
| | Recreational Boaters | At least 30-min advanced warning for hazardous weather development | x | x | | | | x | | | | Data exist/ need stakeholder-specific prod |
| Weather SLR scenarios | | | x | x | x | x | x | x | | | | Exist |
| Citizen Science Portal | Natures Academy, Galveston Bay Foundation, Florida Aquarium, NGO, formal and informal educators | Portal enables sharing of regional water quality, biodiversity and marine debris data collected by citizens, currently in TX and FL | | | | x | x | x | x | | | Exists |
| Beach Conditions Report | Public Health Officials, Coastwatch, Beachwatch, HABIOS, NRDA | Beach--stoplight maps for general public | | | | | | x | x | | | Exists but needs to be integrated and standardized across county and state borders |
| | Seafood industry, seafood consumers | Seafood consumption safety products | | | | | | x | x | | | Requested |
| HABS: TX observatory for algal succession time series (TOAST) | HABIOS, Beachwatch, Coastwatch | Near-real-time public health and WQ information | | | | x | x | x | x | | | Exists |
| | HABIOS, Beachwatch, Coastwatch, state/federal HAB monitoring programs | Phytoplankton abundance and distribution TX coast | | | | x | x | x | x | | | Exists |
| HABIOS | HABIOS community | Sampling technology: Expand/further develop automated/autonomous sampling approaches- OPD [Optical Phytoplankton Detector], flow cytobot, ESP [Environmental Sample Processor], gliders | x | | x | x | x | x | | | | In development, requires additional funding |
| | HABIOS community | Expand autonomous sampling technologies for HABS to detect species/taxa besides <i>K. brevis</i> | x | | x | x | x | x | | | | Requested |
| | NGO, Tourism, seafood safety industry | Improve accuracy of forecasting where/when toxins occur and measures of bloom intensity and toxicity | x | | x | x | x | x | | | | Requested |
| | | Develop an operational early HAB warning system | x | | x | x | x | | | | | Requested |
| | HABIOS | HAB reports for both living marine resources (manatees, dolphins, sea turtles) and public health | | | x | x | x | | | | | Requested |
| | | Historical ocean color/productivity products | | | | | | | | | | Requested |

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| Decision support tools | GOMA members | Understand natural vs. human coastal impacts Guidance for Coastal Marine Spatial Planning Data to support natural resource management | | | | | x | x | Requested Requested Requested |
| GCOOS Recreational Boater Website | Recreational Boaters, beach goers, divers, surfers | Visibly tag data that are not currently available Better tools and distribution for subsurface currents. VHF Distress call relay via buoys ("repeater" system to extend range of VHF offshore) Informaiton with common and understood terminologies and verbiage Targeted dissemination by audience (e.g., small boats, near-shore vs. larger boats, off-shore) | | x | | | x | | Requested Requested Requested In development Requested |
| TAMU-CC land use/habitat, Gulf Atlas | Spatial planners, USGS | Facilitate use by others | | | | | | x | Requested |
| Long-term Change | NRL, NAVO, GK-12, pre-service, universities, state DOH, industry, Maritime Communication Services, NGOs, aquariums, LMI, NOAA Xylem, Sontek, FUGRO, NERRS | Interpolation and extrapolation of climatology and extremes; understanding of long-term changes | x | x | x | x | x | x | Requested |
| Long-term Change | Academia, emergency response, insurance industry, realtors | Trends in HABS, pathogens Trends in coastal morphology | | | x | x | x | x | |
| Long-term Change | Academia | Changes in biozoogeography, especially of keystone and sentinel species | | | x | x | x | x | |

An Integrated Vision of the Future

The Gulf of Mexico Coastal Ocean Observing System's vision is to build a robust, user-driven, sustained, operational network that integrates physical, meteorological, biogeochemical, biological, bathymetric and other data from diverse providers, assures data consistency and quality and creates new data products needed by users. It will also provide accurate data, products and services to IOOS, decision-makers and the public in a timely and efficient manner to benefit human communities and the economy as well as natural ecosystems.

