ROUTING AND TRANSMITTAL SLIP

Date 9/23/2016

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REMARKS

Routing slip for the IOOS/CO-OPS FY2016 update to the RTAP Project Transition plan.

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OPTIONAL FORM 41 (REV. 3/2007)

~~DRAFT~~ Transition Plan

for

Chesapeake Bay Hypoxia Forecast

Approved on September, 2016, by:

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9/26/16

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1. Purpose/Objective

The purpose of the Chesapeake Bay Hypoxia forecast is to provide a real time, short term forecast of hypoxic conditions in the Chesapeake Bay to enable several stakeholder groups. Recreational fishermen will use the forecast to make informed decisions about fishing locations and what type of fishing (trolling vs. bottom fishing) would be most prudent, based upon the hypoxia nowcasts/forecasts. Commercial fishermen with mobile gear (haul seine, crab pots, etc…) will use the product to decide where best to place their gear in the Bay. Local coastal managers, water quality decision and resource managers will use the forecast to better understand the health of the Bay, success of nutrient reduction programs, and to make decisions about water quality and beach conditions. Health of the bay reports with respect to hypoxic conditions can be used by outreach programs as well. Finally, this forecast will meet some of the requirements set forth in the Harmful Algal Bloom and Hypoxia Research Control Act (HABHRCA) mandating NOAA provide operational hypoxia forecasts.

2. Research background

In the Chesapeake Bay, hypoxia has been a growing problem, with oxygen levels dropping so low that fish and other animals are stressed or killed. As a result of human activity on land, nutrients like nitrogen and phosphorus run off into the Bay increasing algal growth and subsequently the volume of low-oxygen water and the duration of hypoxic events. Animals that cannot move quickly away from such low oxygen environments, such as shellfish, are ultimately killed while free-swimming animals like fish, shrimp, and crabs are forced into less suitable habitat.

In response to the increase in hypoxia and in accordance with the HABHRCA, NOAA is working to monitor, understand and predict hypoxia in U.S. coastal waters like Chesapeake Bay to develop strategies for forecasting these events and minimizing their detrimental effects. Although it is generally accepted that increased nutrient loads to the system have increased the extent and severity of hypoxia, studies that directly correlate nutrient loads to inter-annual variations in hypoxic volume fail to explain the majority of the variability. One reason predicting hypoxia is so challenging is that biological processes (i.e. primary production in response to nutrient loading) and physical processes (i.e. river discharge, wind, and stratification) both have a significant impact on the extent and severity of hypoxia.

Forecast models are also needed to predict where hypoxia will occur in the Bay and for how long it might last. Short-term hypoxia forecasts can be important tools for managing fisheries like crabs, oysters, and shrimp.

The Coastal and Ocean Modeling Testbed (COMT) has evaluated a low cost solution to predicting hypoxia that is ready to be utilized as a production-level model for application to a range of living resource issues in the Chesapeake Bay. The goal of this plan is to transition the dissolved oxygen (DO) parametrization into the Chesapeake Bay Operational Forecast System (CBOFS) and to set up an interim DO forecast product at the Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS). Ultimately, the goal is to move the forecast production to a federal operational entity.

3. Business case

3.1. Who is the end user

Users for the product include fisherman, coastal managers, water quality managers, state and local decision makers.

3.2 Societal and Economic Benefits

Resource managers need to understand hypoxia and water quality impacts to make more informed decisions about fisheries as well as land management practices. For watermen and anglers it is important to have current and near term forecasts for hypoxia to make time, energy and fuel efficient decisions about when and where to fish. The fishing communities including those in the eco-tourism industry are critical to local economies. Local beach managers also need short term forecasts to anticipate necessary beach closures due to fish kills. Tremendous effort and cost are being invested in reducing nutrient pollution; regular, accurate quantitative assessments of hypoxic volume provide our best tool for evaluating the efficacy of these measures. We have the opportunity to provide an accurate, spatially explicit forecast for Chesapeake Bay hypoxia and make it available to watermen, anglers, and water quality and living resource managers.

3.3 User Requirements

User requirements are scenario forecasts and short term outlooks of hypoxia in the Chesapeake Bay. A formal stakeholder workshop will be held in 2016, but an initial focus group meeting held in December 2015 indicated that fisherman are interested in bottom and mid-depth DO nowcasts and forecasts. They are also interested in maps where individual points can be selected and more detailed information can be accessed. Other stakeholders and users will provide additional feedback next year.

3.4 Current (demonstration) system

The pilot forecast product is being hosted on a temporary research site through the IOOS COMT Chesapeake Bay project at Virginia Institute of Marine Science (VIMS).

The system under development is composed of several components that have their own independent system development lifecycles. By assembling components that are independently tested, financially supported, and regularly improved, we create a system that is efficient, inexpensive, and has formal defined mechanisms for enhancement and planned product improvement inherent to the design. As a result we decrease the total cost of ownership for the lifetime of the product and lessen the Operations and Maintenance burden on the operational host. This project is leveraging significant external resources which are described in a later section. A generic description of the composite system (Figure 1) provides a framework to show how the team members will collaborate to mature the system over the course of the project.

The Modeling System is composed of the underlying numerical circulation model which provides estimates of the ocean circulation and state (vertical and horizontal currents, temperature, salinity etc). Various versions of the Regional Ocean Modeling System (ROMS, https://www.myroms.org/) are in use by all project partners. Through the IOOS COMT, a simple parameterization of DO has been embedded into a research version of the ROMS code by project partners (M. Friedrichs and L. Lanerolle, CSDL). This proposed project is the next step in the transition of work from the COMT, which focuses on transitioning modeling research to operations in the coastal ocean.

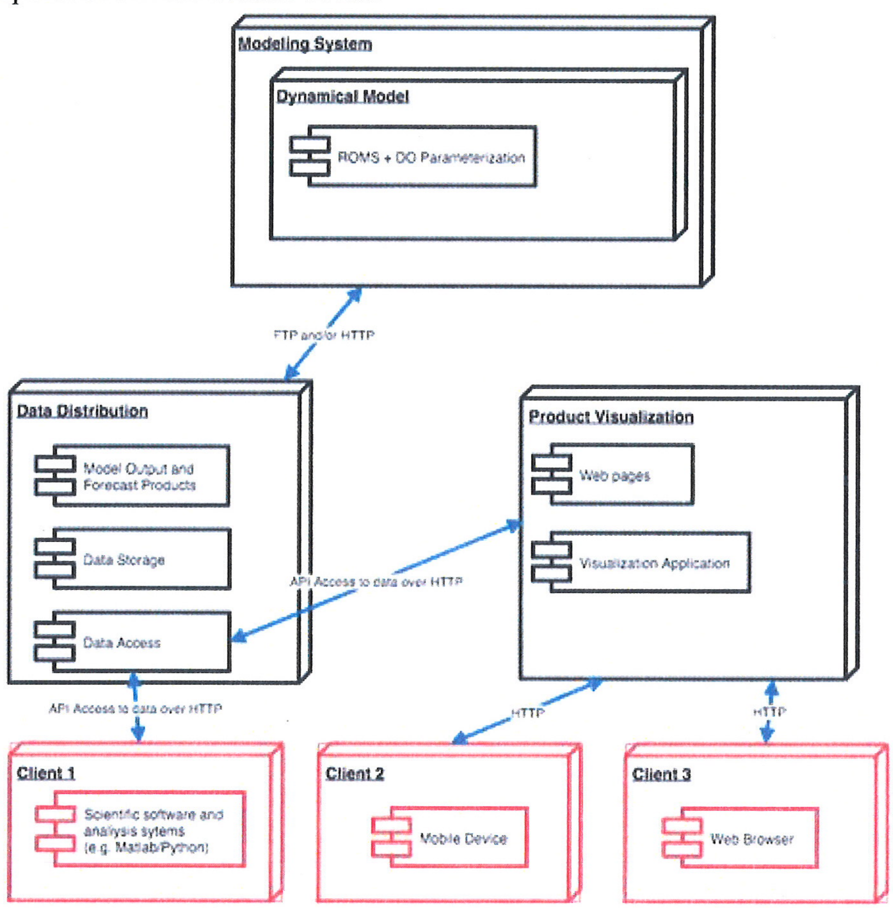

Figure 1: Deployment diagram showing the various components of the overall Dissolved Oxygen prediction system for Chesapeake Bay. The client applications are colored red to indicate that they are external to the proposed system and developed independently.

COMT investigators have evaluated several Chesapeake Bay models in their assessment of DO nowcast/forecast capability. Model skill evaluations showed that the simple oxygen formulation performed as well as or better than the complex and much more computationally intensive biological models that are required for other ecological forecasts such as harmful algal blooms. This is because oxygen variability is highly dependent on physical processes in the Bay (advection, wind-mixing, solubility), which are typically more variable than the relevant biological processes (photosynthesis and respiration). Thus, if it is known how oxygen is advected around the Bay and how wind and temperature affect oxygen, oxygen can be modeled effectively using a constant biological sink of oxygen. COMT investigators have demonstrated that the simple oxygen formulation performs as well in a research version of the CBOFS ROMS model (currently run at NOAA CSDL) as it does in their ChesROMS implementation, which is similar to the CBOFS ROMS model but uses a somewhat lower resolution grid to expedite model runs and parameterization testing.

The Data Distribution system is composed of modules that organize and aggregate the output of the Modeling System, including DO products. The Data Storage module includes cyberinfrastructure to ensure that the products are readily available and protected from loss. The Data Access module provides an Application Programming Interface (API) that allows machine access to the data and products to support web visualization as well as other client access. Finally, the Product Visualization system includes modules that provide graphical and textual products that can be viewed by customers using standard web browsers and mobile devices.

3.5 Justification/acceptance criteria for transition

COMT/VIMS PI and MARACOOS data managers will conduct transition of products to MARACOOS in a demonstration environment. After evaluation, COMT/VIMS PI and MARACOOS data manager will write a formal report detailing the MARACOOS production process and demonstrating compliance based on guidance from NOS. This will enable CO-OPS to assess the feasibility for inclusion of DO products in the CBOFS operational product suite.

4. Capabilities and Functions

4.1 Current (where is it now?)

The pilot forecast product is being hosted on a temporary research site through the IOOS COMT Chesapeake Bay project at VIMS. It is using the research model ChesROMS. The products are three maps depicting Nowcast Bottom Layer Oxygen, Forecast Bottom Layer Oxygen, and

Forecast Bottom Layer Oxygen Trend, which were vetted and approved at a stakeholder meeting this year.

4.2 Operational/Application (description of intended end state)
The operational products are intended to be the same as those demonstrated on the research site and approved at the stakeholder workshop. However they will be moved and provided by the IOOS Mid-Atlantic Regional Association (MARACOOS) until they can hosted at a NOAA federal operational center, like CO-OPS. Initially, MARACOOS will use the research model, ChesROMS to create the products, but the final model will be the Chesapeake Bay Operational Forecast System (CBOFS), run at NOAA/CO-OPS. As soon as CBOFS has been upgraded, MARACOOS will use that output to create the products.

4.3 Data collection and management
The Data Distribution system is composed of modules that organize and aggregate the output of the Modeling System, including DO products. The Data Storage module includes cyberinfrastructure to ensure that the products are readily available and protected from loss. The Data Access module provides an Application Programming Interface (API) that allows machine access to the data and products to support web visualization as well as other client access. Finally, the Product Visualization system includes modules that provide graphical and textual products that can be viewed by customers using standard web browsers and mobile devices.

Temperature, salinity and bottom DO are the most critical observations.
There are historical data available, including some continuous time series, that have been used to formulate the existing model. Presently monthly data - vertical profiles of T, S, DO, and other water quality parameters - are collected at discrete locationa by the CHesapeake Bay Program. The NOAA Chesapeake Bay Interpretive Buoy System provides 10 surface and 1 bottom DO continuous, real-time data. These data are used to validate both the research ChesROMS as well as CBOFS models.

5. Transition Activities:
Status of Activities scheduled for FY16 (with COMT funding and coordination with CO-OPS)
FY16: Nowcast/forecast forcing replaced hindcast forcing on 1-term DO model (in CSDL research version of CBOFS and in ChesROMS) - Nowcast Complete, Forecast will be completed in FY17.
FY16: Prototype ChesROMS DO nowcasts/forecasts tested on the VIMS website interface - Complete
FY16: Stakeholder workshop conducted to define desired end-user products - Complete
The stakeholders workshop was held at VIMS on April 26, 2016. This meeting brought together multiple recreational fishermen and charter boat captains as well as some commercial fishermen, and watermen. During the meeting we obtained feedback on how useful the demonstration

hypoxia forecast tools would be to them, what types of forecasts they currently use, and in what formats they might like to have forecasts of low oxygen provided to them in the future. The demonstration products were supported.

Proposed RTAP workplan:
FY17:
- MARACOOS (through RPS ASA data management and visualization services) will develop MARACOOS web services and visualization tools
- COMT PIs will work with MARACOOS to use research version of ChesROMS output to produce DO maps and other designated end-user nowcast/forecast products;
- COMT PIs will continue to work with CO-OPS to ensure the DO code is implemented in the updated ROMS operational trunk.
- MARACOOS will support collection of continuous (10 min), long-term (6-9 months) DO measurements at 10 significant sites at locations to be determined by COMT PIs. Sensors will be located at the bottom and subsurface depths to be determined by COMT PIs. -

FY18:
- MARACOOS PI will deliver DO data to COMT PIs for model validation and improvement.
- MARACOOS will transition to using CBOFS output directly for DO nowcast/forecast products
- VIMS analysts work with new observational data to compare model products to observations, ensuring that operational model accuracy is maintained (validation effort). Products will be evaluated by the VIMS analyst for future production at the NOS operational center.
- IOOS Project Manager evaluates alternative of using NOAA CoastWatch East Coast Node existing infrastructure as a more formal demonstration platform for generating the user-specified output products if a full operational transition to CO-OPS cannot occur.

5.1. Identify any "gates" and associated documentation for accomplishing progress from one maturity level to another required to be met by the appropriate Line Offices

Gate 1: Testing and evaluation completed in a testbed environment - Chesapeake Bay Hypoxia models and products have been compared and evaluated in the COMT environment amongst multiple PIs from different institutions.
Gate 2: Products and model requirements were reviewed by CO-OPS modelers and ROMS team for feasibility for transition to appropriate OFS (CBOFS) - This was completed.
Gate 3; Products were evaluated at a stakeholder workshop - Completed in FY16
Gate 4: Products are transitioned to a demonstration environment in MARACOOS - Scheduled for FY17
Gate 5: Demonstration environment will transition to using operational code to produce validated DO products - MARACOOS will use CBOFS output provided by CO-OPS to produce validated DO products.
Gate 6: Both products and code will be produced by federal operational entity - TBD

5.2. Identify any testbed and proving ground that will be involved
The U.S. IOOS Coastal and Ocean Modeling Testbed

6. Schedule and deliverables

6.1. Milestones
FY16:
1. Complete Stakeholder Workshop - Complete, See Section 5.
2. Define initial stakeholder deliverables- Complete, See Section 5.

FY17:
1. MARACOOS receiving ChesROMS output via THREDDS server and implementing DO product development and visualization
2. ROMS operational trunk code upgrade completed to include DO which will be available for nowcast/forecast products

FY18:
1. CBOFS update completed
2. RPS/ASA transition model ingest at MARACOOS from ChesROMS to CBOFS
3. Make decision for role of NOAA Coastwatch East Coast Node
4. Skill assessment and summary report submitted to CO-OPS for evaluation

Metrics:
We will evaluate and consider the following metrics to best assess the value of the project.
Outreach:
- Quantity and availability of external links to DO Products
- Media mentions
- Facebook / Social media activity
- DO Product Use as tracked by user analytics on MARACOOS and other display sites

Readiness:
- Tracking Readiness Levels and decision gates / Milestones against schedule
- Model Nowcast/Forecast Accuracy Metrics, against available data

6.2. Mechanism for updating the plan -
This project is associated with the Ecological Forecasting Roadmap(EFR) and the COMT. The EFR team meets as required by the Hypoxia team lead where updates are discussed and provided. Additionally, the COMT has a transition management group that meets quarterly and as needed to review transition progress for each project. This serves as an alternate forum for updating the transition plans.

7. Roles and Responsibilities (for the TRANSITION)

a. IOOS Program Office/COMT Manager: Provide oversight and coordination for the testing in the COMT. The COMT Project manager will coordinate with CO-OPS, CSDL, NMFS, and NCCOS to ensure the necessary enhancements or requirements are used to drive the testing in the COMT. COMT manager will also work with NOAA CoastWatch to investigate that infrastructure to host long term demonstration products if necessary for financial success. POC: Becky Baltes

b. CO-OPS: Identify operational requirements to maintain a forecast product, and determine personnel needs, even if they do not end up operating out of CO-OPS. POCs: Pat Burke, Carolyn Lindley
c. CSDL: Coodinate testing of code and transition to CO-OPS as part of System Development Life Cycle (SDLC). POCs: Ed Myers, Frank Aikman
d. NCCOS: Provide SMEs, coordinate with appropriate NOAA offices and evaluate research. POCs: Alan Lewitus, David Scheurer
e. NMFS: Ensure ecosystem forecast requirements and user needs are incorporated in product development. POCs: Howard Townsend, Bruce Vogt
f. EFR: Coordination across LOs and accross ecological forecast development to ensure development is uniform and aligned with other EF work. POCs: Allison Allen, Martha Blair
g. *In Situ* Observations - Deploy moored instruments for continuous Temperature/DO measurements at 10 locations determined by DO modelers to be significant model validation points: Doug Wilson, Caribbean Wind LLC, MARACOOS PI
h. Model testing and transition - Marjy Friedrichs, VIMS, COMT PI
i. Data management and product visualization - Conducted at demonstration host site, MARACOOS: RPS Applied Science Associates

8. Budget overview

8.1. Cost of current system

There is not a current hypoxia forecast system or other ecological forecast system. A hypoxia product for Chesapeake Bay could be produced from the existing operational system, CBOFS. This system is already funded and maintained through an existing operations and maintenance structure at CO-OPS.

8.2 Cost of transition

2 Years, FY17-FY18, Total Funding Request - $340K, See Budget-Spend plan below.

8.3 Cost of operational system and maintenance

The system under development is composed of several components that have their own independent system development lifecycles. By assembling components that are independently tested, financially supported, and regularly improved, we create a system that is efficient, inexpensive, and has formal defined mechanisms for enhancement and planned product improvement inherent to the design. As a result we decrease the total cost of ownership for the lifetime of the product and lessen the Operations and Maintenance burden on the operational host. This project is leveraging significant external resources.

9. Impacts of Transition
9.1. Budget- spend plan

	FY17	FY18
Personnel	$164,000	$145,000
Fringe Benefits		
Travel		
Equipment/ Vessel Time	$26,000	$5,000
Contractual		
Construction		
Other		
Indirect Charges		
Total	**$190,000**	**$150,000**
Leveraged Funds	**$244K COMT funds for Chesapeake Bay Estuarine Hypoxia; $105K IOOS Program Funding for the ASA Cyberinfrastructure (Environmental Data Server)**	**$105K IOOS Program Funding for the ASA Cyberinfrastructure (Environmental Data Server)**

Budget Justification:

MARACOOS data collection for model improvement and validation
Continuous (10 min), long-term (6-9 months) DO/Temp data will be collected at 10 significant sites, location / depths to be determined by COMT PIs. Caribbean Wind LLC, present MARACOOS subcontractor supporting CBIBS buoy operations, will deploy PME DOT Temp/DO recorders, recover, and deliver processed, quality controlled data to COMT PIs for use in evaluating 2017 model performance prior to becoming operational in 2018.

PME DOT Temperature / DO loggers 10 @ $1000 $10000

Mooring/float/release equipment for loggers	10@ $700	$7000
Deployment/Recovery vessel time	10@$400	$4000
Personnel	$4000	

Total $25,000

RPS ASA data management and visualization activities

FY17: RPS ASA is presently a MARACOOS subcontractor and leads MARACOOS DMAC activities which include both data management and web visualization products. In FY17 RPS ASA will contribute to this RTAP project by harvesting ChesROMS products from the VIMS THREDDS server into MARACOOS infrastructure. By hosting these model products on MARACOOS infrastructure, they will be available via the standard IOOS services used to access other MARACOOS data products. The data will also be integrated into the MARACOOS Asset Map, the new version of which will be based on the OCEANSMAP framework. The Assets Map will allow users to explore the data by mapping any available time step and creating time-series graphs or section views. The website will be mobile friendly. Other data exploration tools discussed at the Stakeholder meeting will also be considered for implementation.

Amazon Cloud Services: $5,000
Developer Labor Rate =$150/hr for 300hrs of service = $45,000
Total: $50,000

FY18: RPS ASA will update source of the hypoxia model forecast from ChesROMS to CBOFS. In addition, model output from CBOFS will be transitioned into the existing MARACOOS infrastructure and made available via the standard IOOS services used to access other MARACOOS data products. Similar to the ChesROMS forecasts, once the data are transitioned, they will be integrated into the MARACOOS Asset Map, which will allow users to explore the data. RPS ASA will also contribute to a report describing the transition process.

Amazon Cloud Services: $5,000
Developer Labor Rate =$150/hr for 300hrs of service = $45,000
Total: $50,000

VIMS model simulation, evaluation and transition activities

FY17: Through a subcontract to MARACOOS, VIMS investigators will modify their existing nowcast/forecast ChesROMS DO products to make them more user-friendly, based on lessons learned from the Stakeholders Workshop (to be held in late FY16). They will then help transition the latest nowcast/forecast ChesROMS DO products from VIMS to MARACOOS, while the model is still maintained and run in real-time at VIMS. Additional testing of the products will continue, specifically making use of the new data collected by the MARACOOS investigators as it becomes available. VIMS investigators are currently working with Rutgers scientists and CO-OPS to ensure the DO code that is working well in the research version of ROMS is transitioned into the ROMS operational trunk code and thus into CBOFS when it is next updated. This work will continue into FY17.

VIMS PI (2 months): $26,000 v

VIMS post-doc analyst (8 months): $43,000
VIMS IDC (45.7%): $31,000
Total: $100,000

FY18: In the second year of this project, VIMS investigators will continue running, evaluating and improving the ChesROMS DO products based on the new MARACOOS data, as it becomes available. They will work closely with ASA to make sure the products are being visualized in a manner most convenient for Chesapeake watermen. DO products from the operational CBOFS will also be analyzed as they become available. VIMS investigators will work with CO-OPS, or another relevant operational entity, to propose the integration of the Chesapeake Bay hypoxia products into the operational forecasting suite. A procedure for real-time evaluation of the DO products will be constructed and presented to the relevant operational entity for their future use.

VIMS PI (1.9 months): $26,000
VIMS post-doc analyst (7.7 months): $43,000
VIMS IDC (45.7%): $31,000
Total: $100,000

NOAA CO-OPS:
FY17: CO-OPS will use this funding to ensure Rutgers ROMS updates can be completed to include DO formulations to allow CBOFS to be updated.
PI Salary: $15,000

9.2. Risks and mitigation

Risk	Likelihood	Impact	Overall	Mitigation
Funding does not come through	High	Med	Med	Look for opportunities for leveraging existing projects and resources
CBOFS update is delayed due to loss of personnel	Med	Med	Med	Project could be delayed
Unable to obtain sensors for bottom DO measurement	Low	Low	Low	Use other observations for model validation

11. Signature page

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