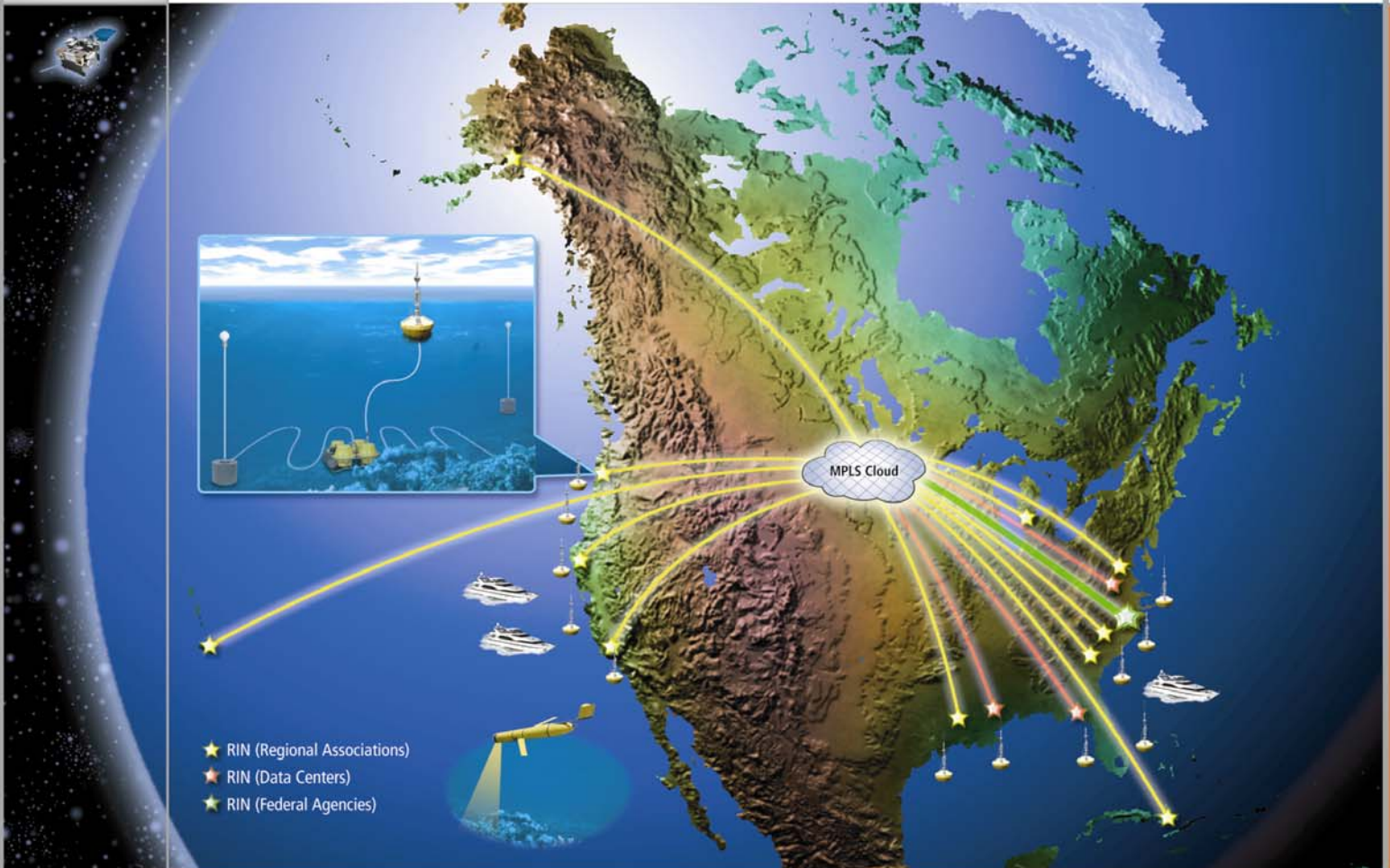




**IOOS**

U.S. Integrated Ocean Observing System

## Five Day Ocean Forecast



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## 1 Five Day Ocean Forecast Use Case

The qualitative difference the IOOS provides when compared to a collection of un-integrated assets is the ability to provide higher levels of understanding of the state of the oceans. This higher level of understanding most notably stands out in the generation of an integrated picture of the state of the ocean both retrospectively through reanalysis and predictively through forecasts. Figure 1 represents a Use Case for an operational system where the integrated picture of the state of the ocean is updated four times a day as a result of running multiple instances of five-day ocean forecast models in six hour cycles.

In this Use Case, all eleven Regional Associations are simultaneously performing five-day forecast modeling for the oceans within their physical regions using boundary conditions obtained from the last cycle of National and Global modeling, models tailored for the region, and specialized inputs from the observing systems within the region. Specialized data products unique to a region include, but are not limited to:

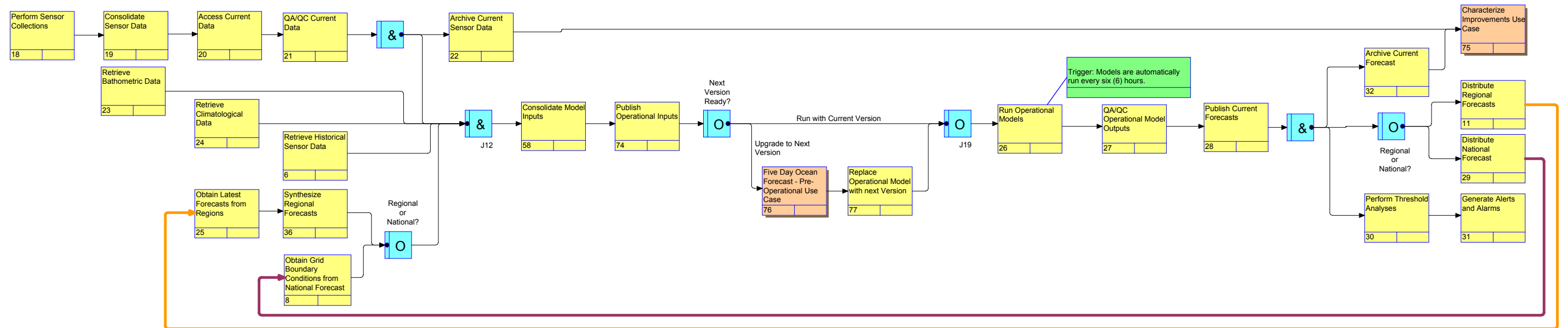
- sea ice tracking and break up for northern regions,
- coral bleaching event prediction for tropical regions,
- HAB event prediction and tracking
- pollution/overflow tracking and prediction
- hypoxia event monitoring/tracking
- tracking of specific fish and other sea life such as large mammals
- boat and ship traffic monitoring

In this Use Case, National and Global modeling is performed in one or two Data Assembly Centers, also adhering to a six hour cycle that results in updates to the integrated picture of the state of the ocean every four hours. National and Global modeling make use of the consolidated regional forecasts as boundary input to global (ocean basin) modeling and also take high resolution core variables provided by regional observing systems as input.

The steps of this Use Case, depicted in Figure 1, are being simultaneously executed in multiple locations (~15) at different levels (i.e., regional, national, and global) exchanging information between cycles, in order to provide continuous high fidelity nowcasts and forecasts for a true five day forecasting capability, similar to that of the National Weather Service, which is likely to provide billions of dollars of added value to the nation's ocean use, similar to the benefits the NWS provides.

Figure 1, has been extracted from Popkin's System Architect where it resides as an OV-6a diagram.

**Five Day Ocean Forecast - OV-6a Use Case**



**Figure 1, Five Day Ocean Forecast - OV-6a Use Case**

## 2 External Actors

This use case is a very rich use case in that it ties together all observations and provides new products unavailable in coverage or quality from any current data set. Therefore, the number of external actors is expected to grow rapidly from inception and as greater functionality is added. The current categories of external actors include:

- **Observing and Telemetry Systems:** Provide sensor data used as inputs to the forecasting models.
- **National Modeling Centers:** Consume regional modeling outputs from previous cycles and provide inputs to regional models for future cycles.
- **Regional Modeling Centers:** Consume national modeling outputs from previous cycles and provide inputs to national models for future cycles.
- **Local, regional, national, and international organizations:** Receiving alerts and alarms of hazardous situations that will in many instances trigger governmental actions such as closing beaches, evacuating coastal areas, or removing contaminated products from distribution channels.
- **Third Party Vendors:** Consumers of the Five Day Ocean Forecast that use it to produce value added products.
- **General Public:** Access the Five Day Ocean Forecast to provide guidance in their recreational and business decisions.

## 3 Interfaces

Most of the available sources would be accessed for any particular type of data, which means there are a plethora of interfaces that support this use case. None of the interfaces are unique to this Use Case and all of them can be tapped using either the Publish and Subscribe services or the single query pull services in conjunction with the Metadata services, all of which are provided as part of the Common Services in the conceptual design.

## 4 Functional Flows

### 4.1 Operational Five Day Ocean Forecasting

#### 4.1.1 *Pre-Condition*

The pre-condition for operational modeling at the regional, national, and global levels is that modeling systems and sensor networks are themselves operating normally and no specific special events (TBD) have occurred.

#### 4.1.2 *Trigger*

The trigger for setting off the next 6-hour forecast is time driven with the provision that all necessary input data has become available. This could be achieved via a data queue flag going green.

### 4.1.3 Process Description

Use Case Steps	Architecture Viability Assessment
<p><b>Step 10: Perform Sensor Collections</b> Remote and in-situ sensors take their measurements and readings. Sensors providing data include satellites, global sensors, etc. covering the ocean 15 km out from US coastlines.</p>	This function is performed by the observing system.
<p><b>Step 20: Consolidate Sensor Data</b> Data from each individual sensor is transported via a variety of different transport mechanisms into a central data store where the data from multiple sensors is combined, quality controlled, and made available for access.</p>	This function is performed by the observing system.
<p><b>Step 30: Access Current Data</b> Access data from observing system's central data store so subsets can be staged for initial processing.</p>	A Level 1 Data Access Resource Adapter performs this function.
<p><b>Step 40: QA/QC Current Data</b> Data obtained from the observing system's data store is subjected to a quality assurance/control process, which will include placing data into appropriate physical units (if not obtained that way) with metadata – GIS information, date/time stamps, statistical &amp; systematic errors associated with data.</p>	The data input preparation function is performed by the Five Day Forecasting application.
<p><b>Step 50: Archive Current Sensor Data</b> QA/QC'ed data will be archived for at least TBD days so that analysis, metrics, and reanalysis can be performed. Current data for this modeling cycle becomes historical data for future modeling cycles. See step 80.</p>	The persistence layer within the common services supports data storage.
<p><b>Step 60: Retrieve Bathymetric Data</b> Getting subset of data needed as input to ocean models.</p>	Steps 60 – 140 are handled by the data input preparation function, which is part of the preprocessor in the Five Day Forecasting application. The metadata and subscribe services, provided as part of the common Services are used extensively to retrieve the data and the Data Resource Adapters are essential to expose the data from collection
<p><b>Step 70: Retrieve Climatologic Data</b> Getting subset of data needed as input to ocean models as input to supplement sensor data.</p>	
<p><b>Step 80: Retrieve Historical Sensor Data</b> Getting data from archives to allow assimilation of past data for spin up of model.</p>	
<p><b>Step 90: Obtain Latest Forecasts from Regions</b> When performing National and Global modeling the outputs from the previous cycle of regional modeling (all 11 regions) are obtained to establish boundary inputs at 15 km from shore.</p>	
<p><b>Step 100: Synthesize Regional Forecasts</b> The 11 regional forecasts overlap in space requiring some type of blending and adjustments to the resolution are necessary because regional modeling uses a finer scale than the global grid</p>	

<p><b>Step 110: Obtain Grid Boundary Conditions from National Forecast</b> When performing Regional modeling the outputs from the previous cycle of National and Global modeling is obtained to establish boundary inputs.</p>	<p>systems to the enterprise.</p>
<p><b>Step 120: Regional or National Forecast?</b> If it is a Regional model being run, the grid boundary conditions from the National forecast are selected (Step 110). If it is a National or Global model being run, the synthesized Regional forecasts are selected as an input (Step 100).</p>	
<p><b>Step 130: Consolidate Model Inputs</b> Pull all the data prepared as input for the model together with correct format for model to operate.</p>	
<p><b>Step 140: Publish Operational Inputs</b> The inputs used for each run of an operational model are published so pre-operational and research models can be run in parallel using the same data set.</p>	
<p><b>Step 150: Next Version Ready?</b> Periodically, measured in months, a new version of the operational application with additional functionality, better performance, and different bugs is approved for transition into an operational state. If the next version is not ready for transition, skip to Step 180. If the next version is ready for transition, proceed to Step 160.</p>	<p>Not supported by the IOOS architecture. New versions are placed on the Queue IAW established configuration Management processes.</p>
<p><b>Step 160: Five Day Ocean Forecast – Pre-Operational Use Case</b> This is a separate but closely related Use Case that maintains and operates a Pre-Operational or Beta version of the Five Day Ocean Forecasting application. The Pre-Operational use case begins with the receipt of a change proposal generated as an output from the Academic Modeling and Algorithm Research Use Case. The use case runs the proposed change in parallel with the operational system and the improvements are repeatedly characterized until the change proposal is proven viable. The Pre-Operational Use Case ends with an approved change being queued for introduction into the operational system.</p>	<p>Not supported by the IOOS architecture. Approving changes to the operational system is a manual process chaired by the governing organization.</p>
<p><b>Step 170: Replace Operational Model with Next Version</b> This is a manual process executed by the Systems Administration staff to replace the current version of the operational system with the next version.</p>	<p>Not supported by the IOOS architecture.</p>
<p><b>Step 180: Run Operational Model</b> When the input data have been assembled the model is run.</p>	<p>The Operational model is run on IOOS servers at RIN nodes under the governance of Service Level Agreements (SLAs) established by the governing</p>

	organization.
<p><b>Step 190: QA/QC Operational Model Outputs</b> Multiple metrics are used to verify results from the model meet expectations.</p>	This is part of the post processing component of the operational model
<p><b>Step 200: Publish Current Forecasts</b> The operational model outputs are assembled into forecasts in a prescribed manner with the appropriate data structure and published through a web portal for general access. The results from a regional model are published on the web site maintained by the Regional Association. The results from a National or Global model are published on a web site maintained by the NOAA or other national level organization.</p>	The IOOS architecture provides Publish and Subscribe services as part of the Common Services.
<p><b>Step 210: Regional or National</b> If this is a Regional forecast, proceed to Step 190. If this is a National Forecast skip to step 200.</p>	N/A Flow step.
<p><b>Step 220: Distribute Regional Forecasts</b> Results of Regional Five day Ocean Forecasts are distributed to National and Global modeling centers for use in the next modeling cycle. Loop back to step 90. Data is also pushed to other subscribers including local, regional, and federal agencies, and to commercial interests for added value enterprises.</p>	The Publish and Subscribe services support this distribution, as does the notification service, all of which are part of the Common Services.
<p><b>Step 230: Distribute National Forecast</b> Results of National Five day Ocean Forecasts are distributed to all of the regional modeling centers for use in the next modeling cycle. Loop back to step 110. Data is also pushed to other subscribers including local, regional, and federal agencies, and to commercial interests for added value enterprises.</p>	Ditto.
<p><b>Step 240: Perform Threshold Analyses</b> Multiple processes ascertain whether specific indicators relevant to determining if a significant event has begun, is continuing, or has ended, e.g. tsunami, submarine earthquake, inundation/flooding, oil spill, hypoxia, or biological events such as HAB, coral bleaching, fish kills, etc. Threshold analysis is tailored for each regional, national, or global node performing the Five Day Ocean Forecasting.</p>	This is part of the Five-Day Forecasting application. Part of the Post Processing component.
<p><b>Step 250: Generate Alerts and Alarms</b> If a threshold has been exceeded, then appropriate bulletins, alerts, and/or alarms are broadcast to appropriate local, state, national, and international decision makers. This is governed by policies that took into consideration legal liability and other issues during their formulation.</p>	This could be highly automated as part of the Five Day Forecast Application. However, a more realistic approach is to automatically generate Alerts and Alarms for IOOS personnel and let the broadcast to appropriate decision

	makers be a manual process.
<b>Step 260: Archive Current Forecast</b> The forecast data should be stored for at least 5 days to allow evaluation of forecast against observed ocean state and archived for long-term trend analysis.	Supported by the IOOS architecture's data persistence layer.
<b>Step 270: Evaluate Forecasting Accuracy:</b> This is a complete "Child" Use Case that is periodically executed to evaluate forecasting accuracy and determine ways and means to increase that accuracy (i.e., additional sensors, model improvements, etc.).	This is a separate IOOS application and a completely separate Use Case.

#### ***4.1.4 Post Condition:***

Post condition for operational modeling at the regional, national, and global levels is that the system is in the same state as the precondition and ready to provide another 5 day forecast update.