NWS Science and Technology Roadmap

Marine Team

Team Composition

- Steven Pritchett NWS OS&T PPD
- John Kuhn NWS OCWWS/MCSB
- Jessica Schauer Clark NWS NCEP/NHC
- Troy Nicolini NWS WFO Eureka, Ca
- Reggie Beach OAR/Ocean Exploration
- Dave Feit NWS NCEP/OPC
- Bill Ward NWS PRHQ SSD

Vision/Benefits/Impacts

- **Team Vision:**

  On-demand customer centered observations, forecasts, warnings, and information from the coast to the high seas, with accuracies and lead times needed by decision makers to ensure the prosperity, livelihood, and resilience of coastal communities, and safe, economical marine navigation and exploitation.

- **Benefits**
  - Improve lead times for maritime and coastal warnings and for initiation of convection
  - Better ocean current information for applications such as marine navigation, pollutant dispersion, etc.
  - Better identification and communication of forecast/warning products for marine hazards (sneaker waves, lightning, debris fields, rip currents, harbor entrance conditions, etc.)
  - High impact warnings issued when forecast
  - Interactive marine products for enhanced decision support
  - Customized local and regional information for societal needs

- **Impacts:**
  - Improved marine forecasts of winds and waves create an economic benefit of $95M/year of commercial shipping from transit time savings and cargo lost reductions
  - Improved tropical marine forecasts creates economic benefits through savings of $31M/year through damage avoidance in recreational boating and associated activities.
  - Improved forecasts (i.e., rip current, lightning, harbor entrance, sneaker waves, storm surge, coastal erosion etc) diminish loss of life and property from predictable marine events.

Goals/Targets:
Customer Needs

Goal	Outstanding Issues
• Improve marine forecast skill and lead time: • Ocean wind forecast skill level equivalent to land • Improve marine warning lead time	• Current Observation networks are not sufficiently dense in time and space • Models have low temporal and spatial resolution
• Development of probabilistic model output and forecast products for the near shore. This is needed in general, but particularly for coastal marine hurricane hazards (i.e. wave, surge/inundation)	• Marine products are deterministic generally • Limited computational power
• Provide interactive coastal/marine products for enhanced decision support with customized local and regional information for NWS customers	• Insufficient customer centric NWS provided interactive capability for marine GIS support • Current NOAA network is deficient in identification of requirements for GIS and IT support

Goals/Targets:
Customer Needs

Goal/Target	Outstanding Issues
Expand marine hazard warning program. Include more specific warnings, including higher resolution specialized products, such as: •lightning – primarily initiation of convection •water spout •extreme waves •hazardous harbor entrance •storm surge watch and warning •Coastal ecosystem hazards (algae blooms, jelly fish, pollutants,e.g. chemical, health-hazardous, sewage, etc) •marine debris field	• Inadequate observing networks • Inadequate data assimilation • Inadequate mesoscale and dispersion models • Low Initiation of convection lead times over marine environment

Goals/Targets:
Emerging Science and Technology

Goal	Outstanding Issues
Improve or develop real-time analyses of marine parameters to more accurately depict the state of the ocean/atmosphere for the initialization of numerical models and the verification of forecasts such as: •Spectra or partitioned wave fields •Open ocean and coastal currents (including eddy and confused seas forecasts/warnings) •Sea surface and average mixed layer temperature •Salinity •Ice coverage •Depth of mixed layer •Offshore/high seas fog / visibility Use these analyses to develop a more detailed climatological record to more accurately model marine conditions.	• Real-time observational data are limited both temporally and spatially for most marine weather and oceanographic parameters • Models unable to assimilate new data platforms (e.g., HF Radar) and types (e.g., Ocean Color) • Inadequate observational record to model oceanographic features (e.g., sub-surface features, spectral wave data, climatological models) • Lack of viable climatological for modeling

Goals/Targets:
Emerging Science and Technology

Goal/Target	Outstanding Issues
Increase forecast resolution for present near shore marine forecasting parameters (winds and waves): •Very high resolution forecasts (10 to 100-m) for regionally specific high impact issues (i.e. rip current forecasts, storm surge forecasts, bar forecasts, and coastal erosion forecasts) •Mesoscale forecasts with 500-m spatial and 1-hr temporal resolution in coastal waters •High resolution gridded forecasts for offshore/high seas waters with 1 to 3-hr temporal and 10-km spatial resolution	• Observation and model spatial resolution insufficient • Lack of unstructured grid capabilities in coastal applications • Inability to address very high resolution issues due to limited coupling of wave and circulation models, • Not using the most advanced cutting edge wave model physics • Buoy-based verification does not provide an accurate assessment of forecast quality at high resolution over large ocean areas
Improve coastal inundation/storm surge forecasts and warnings. •Provide total water level forecasts •Provide information about the water over land (inundation) to the street level •Implement storm surge test bed •Deliver actionable information which is understood by our customers	• Surge forecasts dependant upon quality of the atmospheric forecast (e.g., wind speed and direction) • Surge models in use by NOAA neglect important physical processes (i.e., not coupled with ocean circulation/wave models, hydrologic models) • Inadequate water level data • No storm-specific warning product (for tropical and extratropical cyclones) at NWS – covered by coastal flood warning • No unique storm surge test bed

Goals/Targets:
Emerging Science and Technology

Goal	Outstanding Issues
• Provide marine observations with quality and coverage comparable to meteorological observations, while retaining meteorological observations capabilities	• For key ocean observations (waves, SSH, ocean profiles) satellite observations are only available as line observations (altimeter, ship tracks) . Spatial estimates will greatly benefit modeling, but only partial solution are available (SAR, HF radar). New technology needs to be developed (wide swath altimeter?) • Ocean vector winds no longer available from QuickSCAT.

Key Information Gaps

Gap	Solution Alternative	Impact
1. Insufficient Observations including: • Ocean surface winds • Wave height and direction • Water level data • Profile data - traditional, gliders • Currents • Salinity • Ocean Color (ecology and depth of penetration of radiation)	<u>One collective alternative:</u> 1. QuikSCATreplacement(s) (Ocean Vector winds) 2. Satellite Altimeters (sea surface height [SSH]) 3. Satellite Altimeters (wave height, wind speed) 4. Wide swath ocean surface obs: a) HF radar b) SAR wave wind and ice data. c) New technology to be developed (e.g., wide swath altimetry) 5. Leverage existing observation platforms - New sensors on present platforms - Data presently outside NWS obs suite - Enhance density of existing networks 6. New observation platforms (other than item 4 above) - Increase traditional obs - Salinity and ocean color - Unmanned glider vehicles - Marine animals as platforms 7. Enhancement of the Voluntary Observing Ship (VOS), Marine Report (MAREP), and Marine Observation (MAROB) programs	1. Improved analysis of wind field over the entire ocean. Weather analyses and general model validation/forcing. 2. SSH assimilation into ocean models for locating features (eddies and persistent currents). Minimum of three conventional altimeters needed unless wide swath capability is developed. 3. Like 2. for wave height products 4. Spatial assessment of model quality, massive improvement of analysis products. Moving from seasonal / monthly assessment of conditions and model quality to near-instantaneous assessment. 5. Expanding amount and types of data observed 6. High for wide-swath ocean products, medium for sparse data. 7. More ship-based in situ point observations * All of the above serve to improve forecasting for the marine and coastal environments

Key Information Gaps

Gap	Solution Alternative	Impact
2.Insufficent understanding for accurately predicting the state of the ocean, Great Lakes and the relationship between the ocean and coastal zones. (Earth System Modeling Framework) - ESMF	2.1 Develop a national backbone capability for ocean, coastal ocean and Great Lakes modeling as part of an integrated operational ESMF	• Needed guidance for service centers, improved weather forecasting, part of backbone capability within NOAA (with NOS, IOOS) and for the nation (with Navy, academia).
3. Inadequate resolution and physics of models to provide better guidance for high impact events	3.1 Develop workstation version of WAVEWATCH III capable of running locally at very high resolutions on AWIPS II,ideally coupled to an inundation/surge model. - Improve centrally run WAVEWATCH III resolution and physics- 2 km near shore, with 100m locally in tidal inlets, 10 km offshore	• Address high impact events that occur anywhere from the near shore zone to the high seas. • Allows for gridded model guidance to be fully integrated in the forecaster environment. Enable spiral development of centrally supported wave model applications.
4. Interaction between atmosphere, ocean, land, ice is not well understood and not reflected in operational forecast guidance.	4.1 Couple models (atmosphere/land/ocean/Great Lake coupling, i.e. ecosystems, coastal, river, wave, tropical and extra-tropical storm surge, etc.)	• Improve quality of all individual guidance and provide consistent "big picture."

Key Information Gaps

Gap	Solution Alternative	Impact
5. Data assimilation is relatively primitive. No wave physics used.	5.1 Use wave physics to estimate area of influence of observations. Use spectral wave information from buoys and synthetic-aperture radar (SAR)	• Improved accuracy of short term forecasts. • Improved accuracy of long term forecasts of swells for large basins.
6. No Platform for rigorous, transparent, and replicable testing of storm surge /inundation models	6.1 Develop storm surge/inundation test bed	• Enhances state of the art capability to model along the coast. • Leverage resources across NOAA, other federal agencies, DOD, and academia.
7. Forecasters lack adequate tool sets for enhanced marine forecast decision making.	<u>One collective alternative:</u> 7.1 a) Additional Safe Seas Application b) Additional research on needed tools for forecaster decision assistance.	• New Toolset and applications • NWS forecasters to increase situational awareness of local high impact events

Key Information Gaps

Gap	Solution Alternative	Impact
8. Inadequate Outreach and Decision Support Systems Lack of customer centric decision support service from back bone service capabilities	8.1 Apply social science methods to the marine environment to determine the marine what additional marine weather information are needed to provide decision support for a broad range of marine users. Include probabilistic tool sets.	• Clearly communicate information to save lives and property through the development of new marine products and services which can include uncertainty information and modeling.
9. Dissemination capability not responsive to emerging technologies. (e.g, lack of interoperable communication capabilities for marine weather information.)	9.1 Integrate and transition cutting edge dissemination technologies	• Marine products are accessible in a broad range of formats and mediums and that marine users are able to use this information effectively in their decision making process

Key Solutions: Analysis of Alternatives

Gap 9: Dissemination capability not responsive to emerging technologies

Alternative 9.1: Integrate and transition cutting edge dissemination technologies

- Risk Analysis:

Risk Factor	Probability of Occurrence	Impact	Mitigation
See Decision Support Services Roadmap			

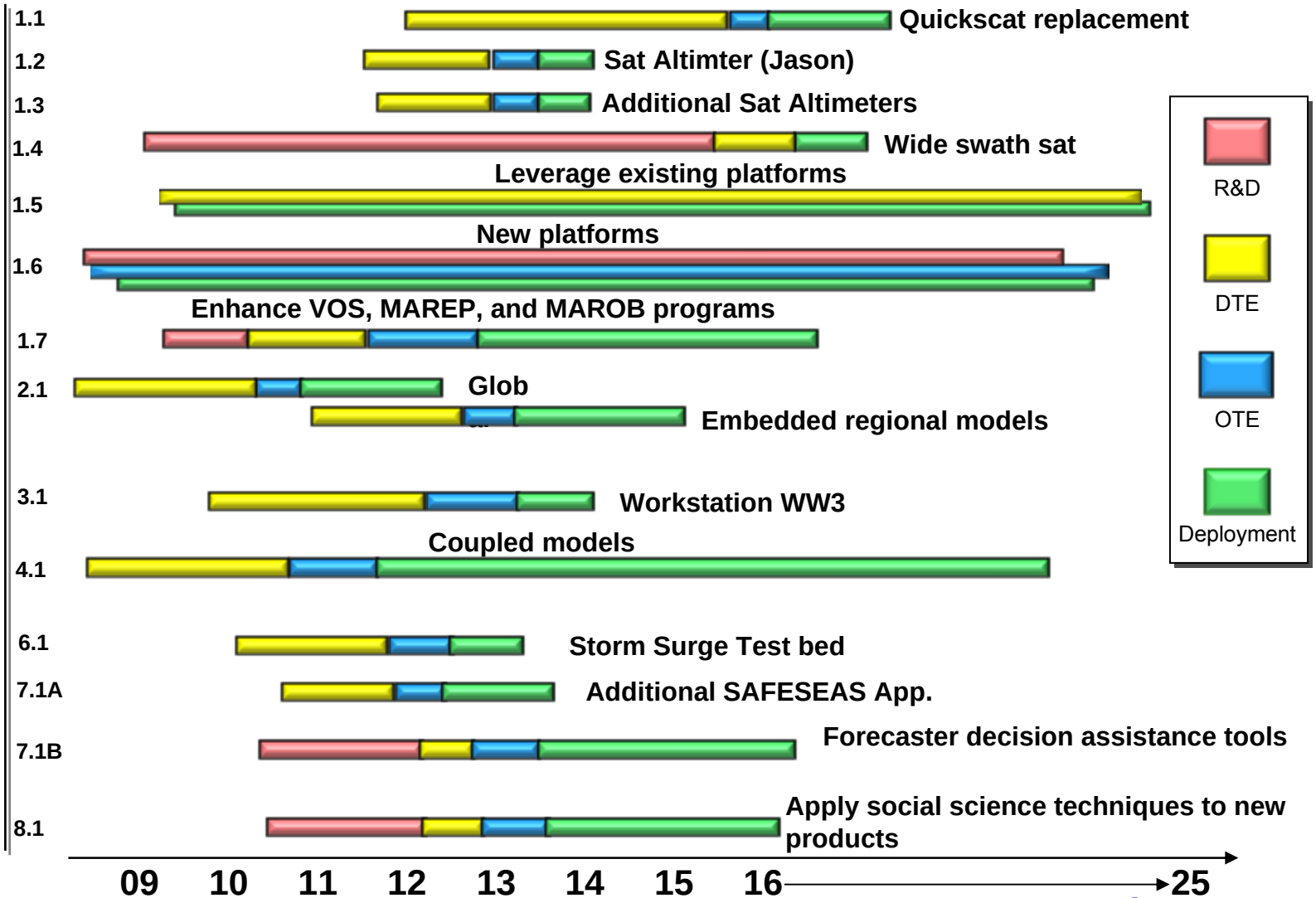
- Enterprise Integration: Linkage to Weather Information Database (WIDB)
- Milestones, deliverables, performance measures for path to operations:
- Sustainability: $XXX starting in FY 2015.

Research Needs and Opportunities

- **Short-term**
  - Social Science assessments/studies
  - Next generation physics for wave modeling from the shelf to deep ocean
  - New observation sensors
  - Reliable eddy resolving 3D global ocean modeling capability as the centerpiece of a backbone ocean modeling capability for NOAA and the nation (in close collaboration with Navy and academia).
  - Link global ocean modeling backbone capability with regional and coastal modeling capabilities (NWS-NOS-IOOS linkage within NOAA, linkage with navy and academia).

- **Long-term**
  - Improvements wave model in physics from shelf to shore including inundation and coupled wave-surge modeling.
  - Include global and regional modeling at all spatial and temporal scales in coupled Earth System Modeling (Atmos/ocean/land/ice)
  - New observation sensors
  - Expand long term thrust 2 to include ecosystems, air quality, and other environment factors (i.e. acidification)

Marine Alternative Solutions



Marine

Focus Area Team Summary: Marine Weather

Vision

On-demand accurate and timely weather information from coast to high seas, needed to ensure prosperity, livelihood, and resilience of coastal communities

R&D Needs & Opportunities

- Improve wave model physics from shelf to shore including inundation and coupled wave-surge modeling.
- Include global and regional modeling at all spatial and temporal scales in coupled Earth System Modeling
- Social science studies/assessments
- New observation technologies

Increasing Impact

Current Status:

- Improved model physics and resolution
- New obs sensors
- Improved awareness

Near-Term:

- Incorporate social science
- Coastal wave model – workstation
- More model coupling
- Storm surge & inundation test bed
- New obs sensors

Long-Term:

- Multi disciplinary emerging products with maritime focus
- Fully coupled modeling of atmos/ocean/land/ice
- Leverage emerging S&T advances to deliver NWS marine products for DSS
- New observation sensors

09 10 11 12 13 14 15 16 → 25

Marine

NWS Science and Technology Roadmap

Marine Team Additional Information

Performance Measures: Marine

Examples for [program plan] forecast elements based on 2008 national MAE (Mean Absolute Error). [Program Plan] element accuracy targets tagged to reflect zone accuracy

Proposed	Current (2010)	FY 16 Target Example	FY 25 Target Example
1. Wind Speed Accuracy	69	73	90
2. Wave height Accuracy	74	77	90
3. Marine Warning Lead Time	None	TBD	TBD
4. Storm Surge Accuracy (accuracy of Observed peak storm surge to peak forecast storm surge by percentage)	Baseline in 2010	+/- 10 percent (post storm using water level marks)	+/- 5 percent (post storm using water level marks)
5. Observations in support of Marine Products and services. Increase in percent from 2010 baseline.	Baseline in 2010	20 percent	40 percent