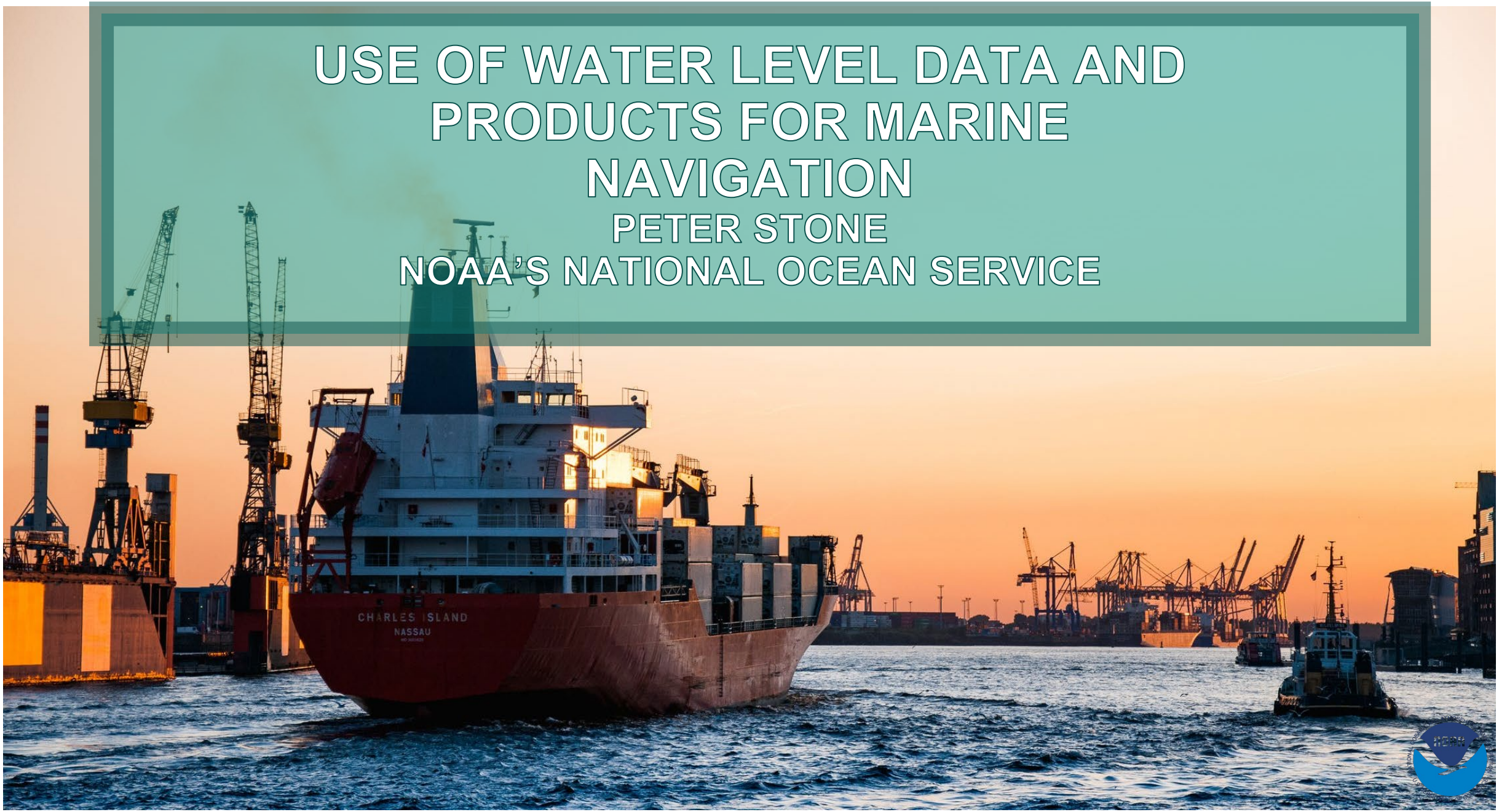
USE OF WATER LEVEL DATA AND PRODUCTS FOR MARINE NAVIGATION

PETER STONE
NOAA'S NATIONAL OCEAN SERVICE

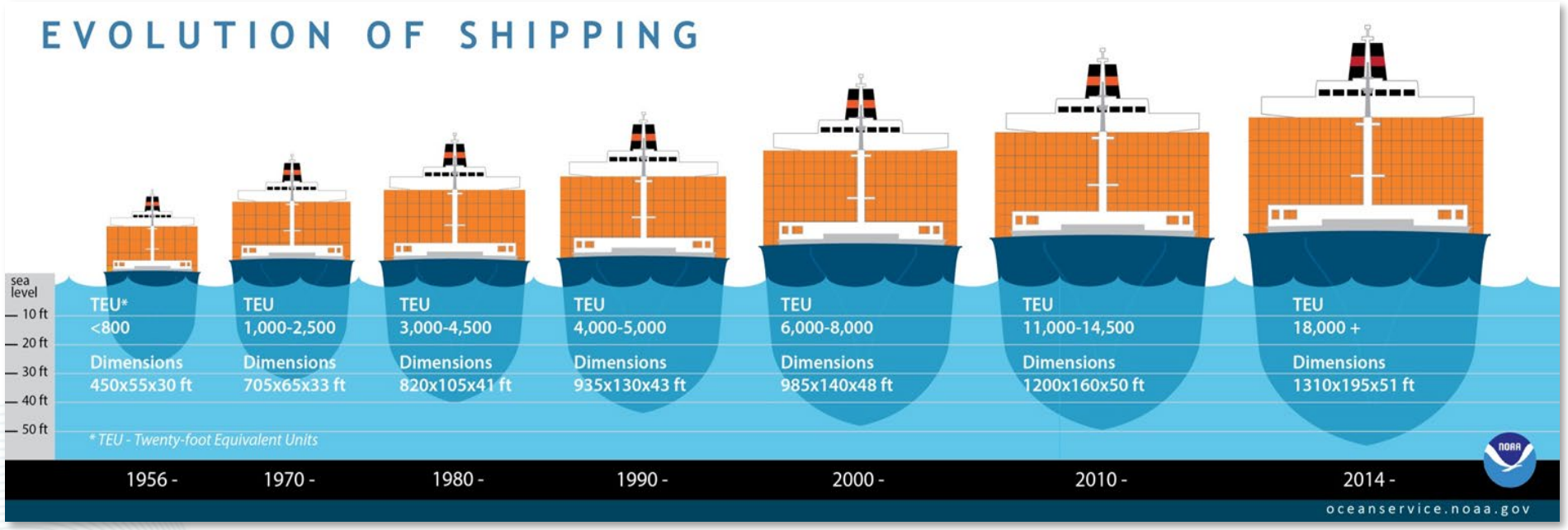


Topics

- Uses of Water Level Data
- Water level data and derived products used for marine navigation (Predictions, datums, models) – all important for navigation.
- Integrated Products
- Value of long time series
- Applications
- Benefits of Navigational Products

Marine Navigation

- Ships are getting larger and waterways more congested
- Margin of error for safety is decreasing
- Shipping companies want to maximize reliability, predictability, and efficiency
- Commercial Navigation is risk intolerant



Uses For Water Level Data

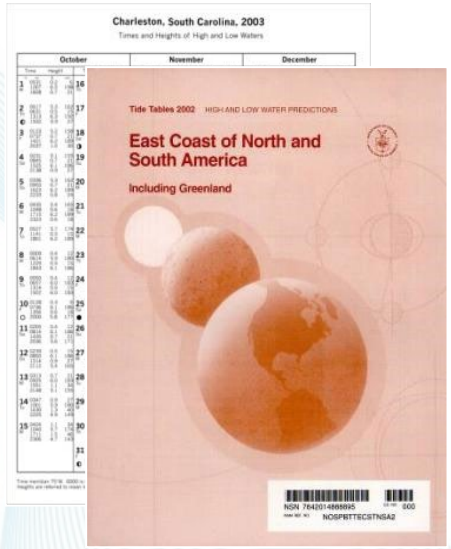
Each application has its own standards and accuracy requirements

- **Marine Navigation**
- **Hydrographic Survey Support (Charting/Mapping)**
- **Storm Surge**
- **Tsunami Detection**
- **Operational Oceanography**
- **Datums and Marine Boundaries**
- **Sea Level Change and Climate Studies**
- **Coastal Management and Restoration**

Water Level Data and Products for Navigation

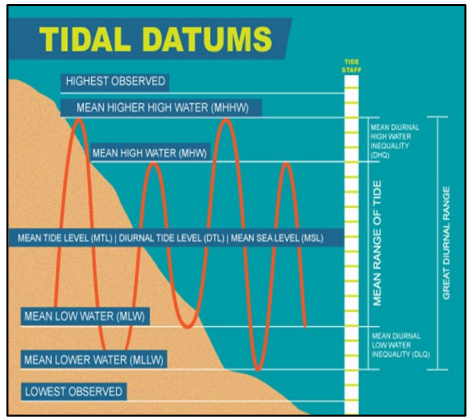
Tide Prediction

Extremely useful for planning and other applications. Requires high quality historical data



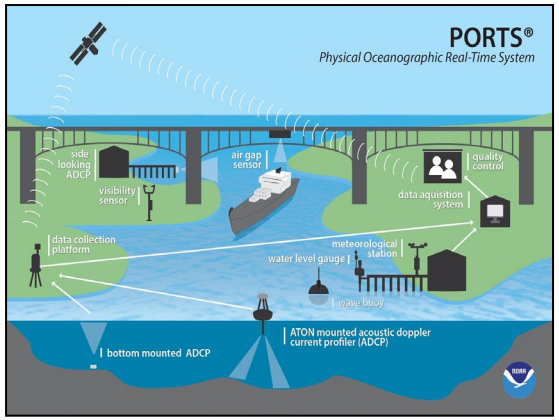
Datums

Sets reference elevations for nautical charts. WL observations need to be on chart datum. If observation-based, requires high quality historical data.



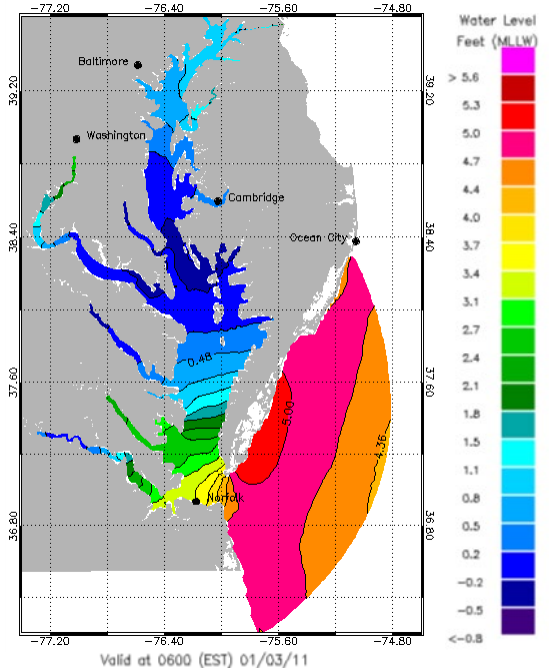
Real-time Data

Information on conditions right now



Model Forecasting

Provides information where observations are not available. Can take into account Meteorology and river flow. .

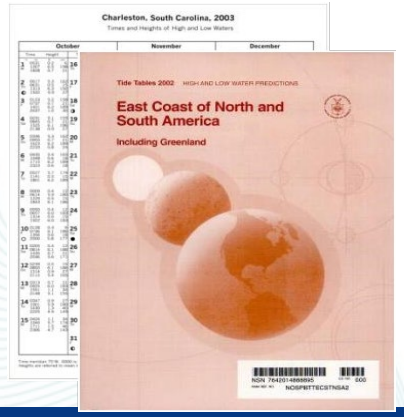


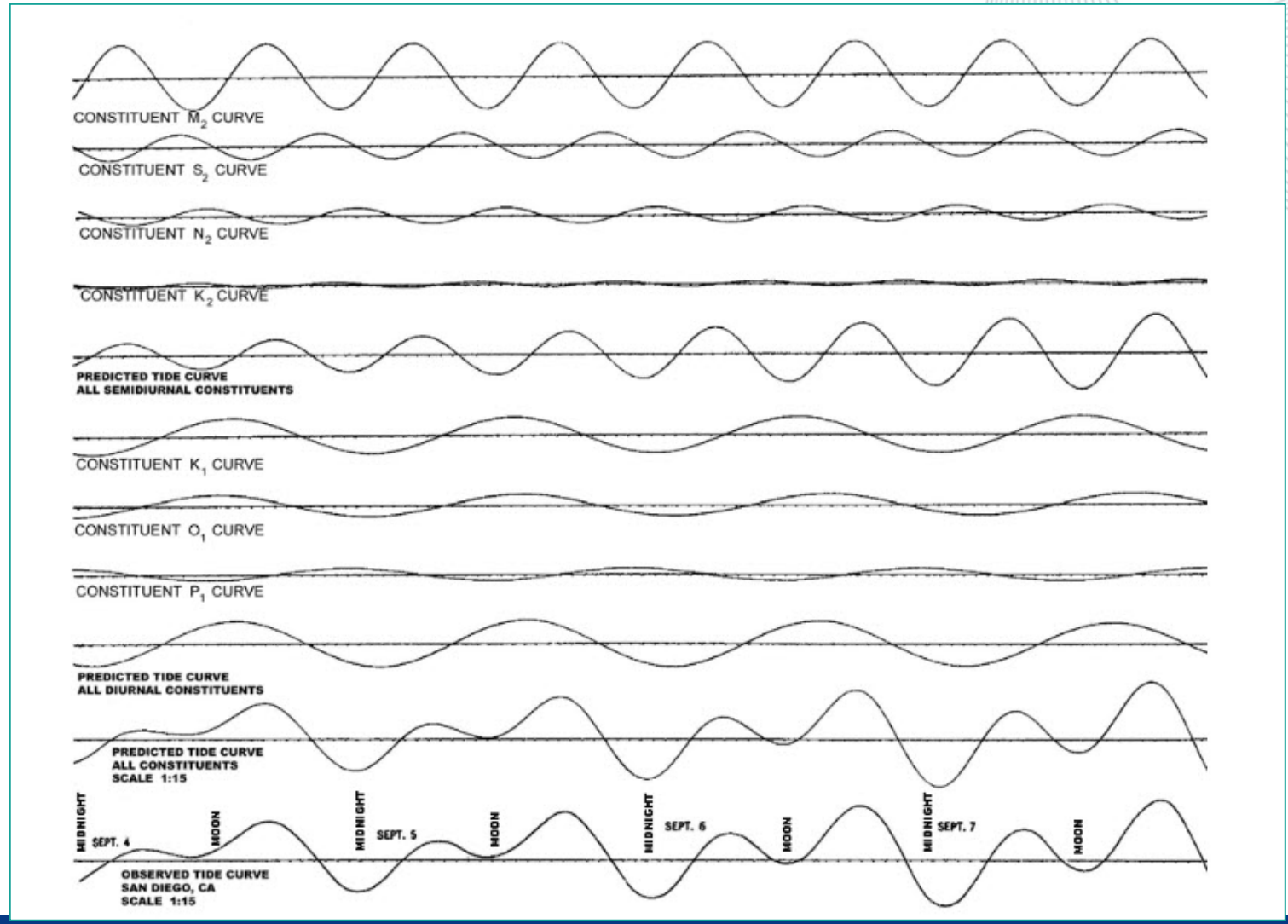
Tide Predictions

- Fundamental Product, can predict the tide for any time in the future or the past
- Only predicts the astronomical component of water level change. Requires long data time series

- The key to an accurate tidal prediction is determining the amplitudes and epochs for the most tidal constituents that can be calculated with a given length data time series.

- The shorter the time series;
  - Fewer constituents
  - Less accurate predictions



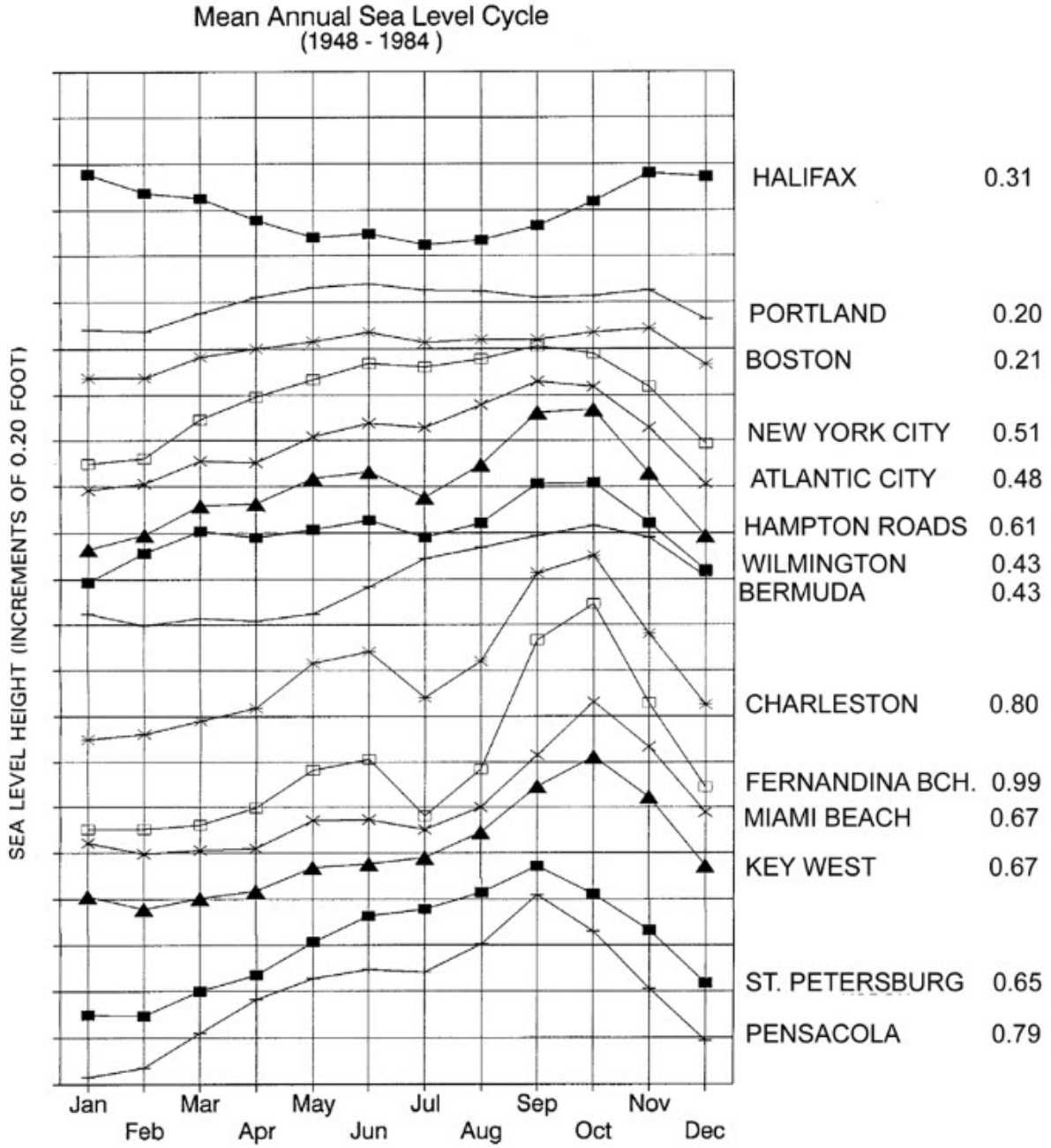


Tide Predictions
Contribution of Annual Sea Level Cycle

Resolving SA and SSA

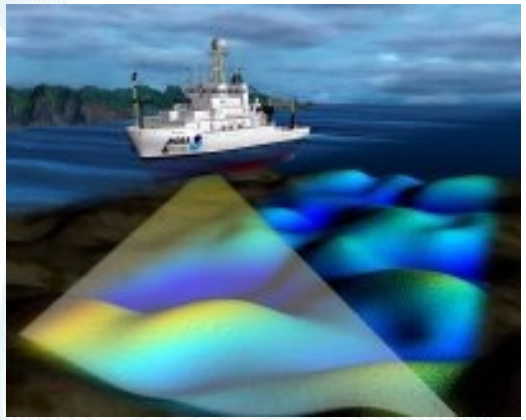
SA – Solar Annual Constituent
SSA Solar Semiannual Constituent

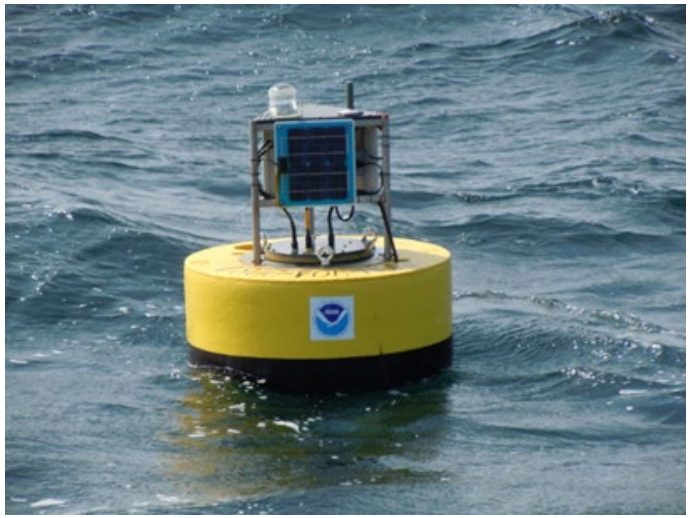
A minimum of 2 years of data is required to resolve. 5 years is better.



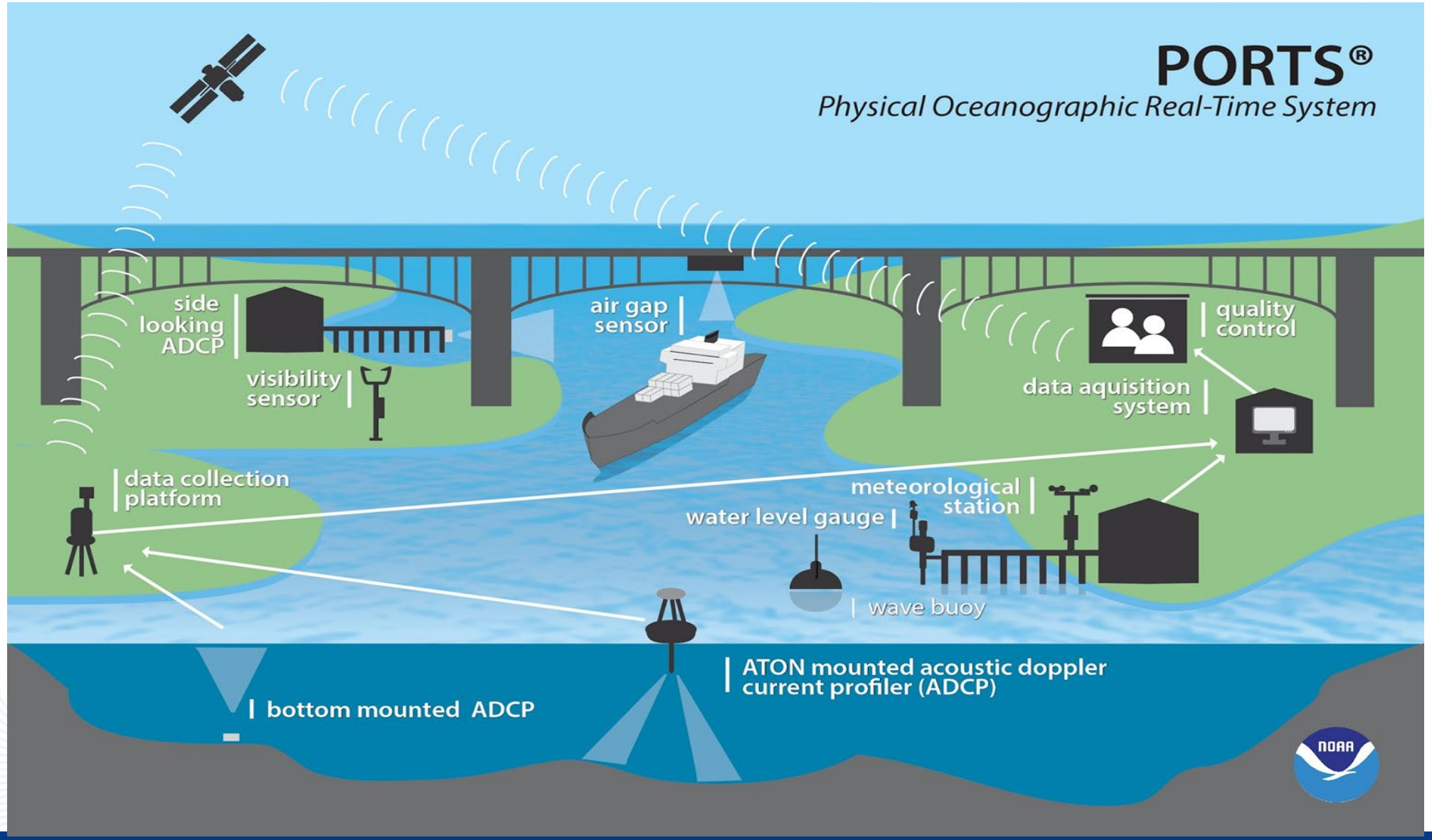
Water Levels is Not the Only Important Parameter for Navigation

- Currents
- Winds
- Waves
- Visibility
- Density (Temperature/Conductivity)
- Bathymetry

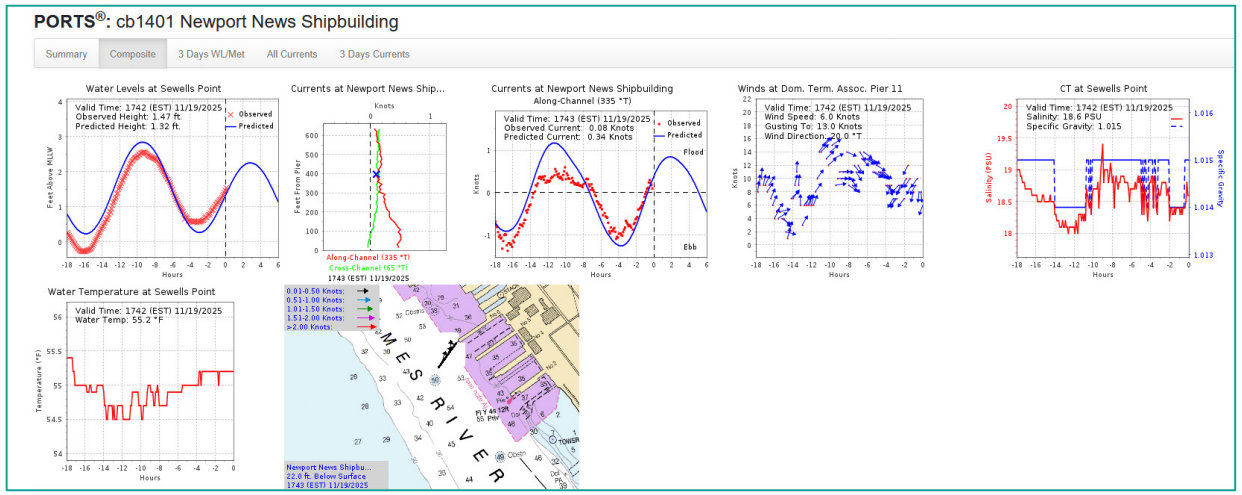




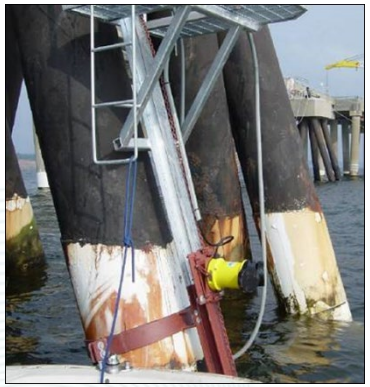
Integrated Real Time System

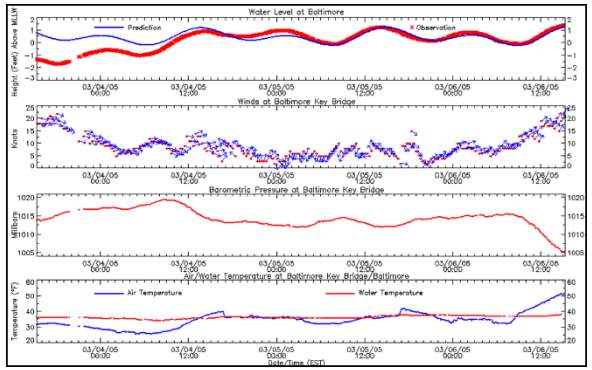


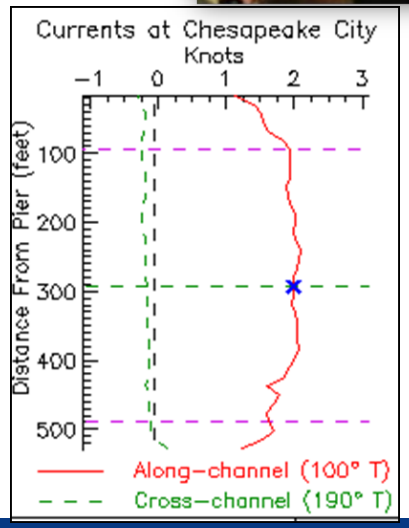
Real Time Product Example



- **All CO-OPS observations are 6 minute interval**
- **No longer than 18 minute data latency**
- **Real time quality control**





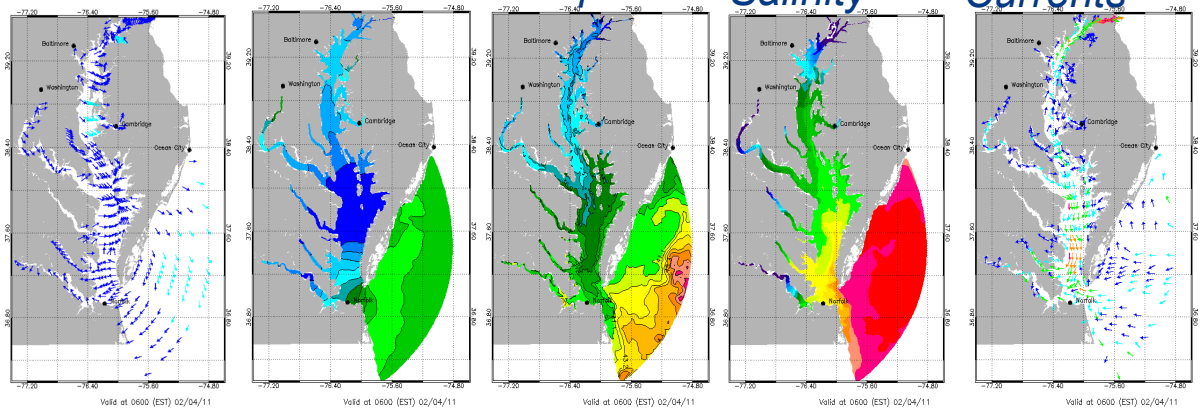


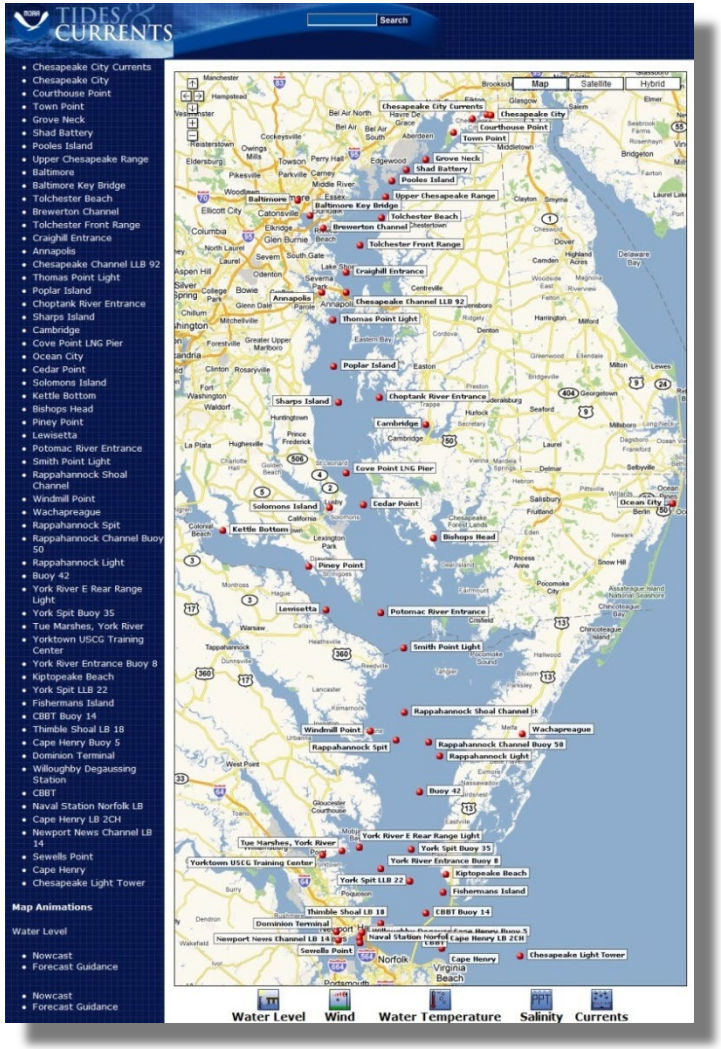
Forecast Models

Operational Nowcast and Forecast Hydrodynamic Model Systems

- Discrete model domain
- Provides nowcasts (current conditions over domain)
- Provides short-term (0 -48 hr) forecasts
- Accuracy contingent on inputs and forcings
- For water levels forecasts– Two Dimensional is sufficient. Currents require high resolution 3D
- Observations needed for skill assessment

Winds *WL* *Temp.* *Salinity* *Currents*

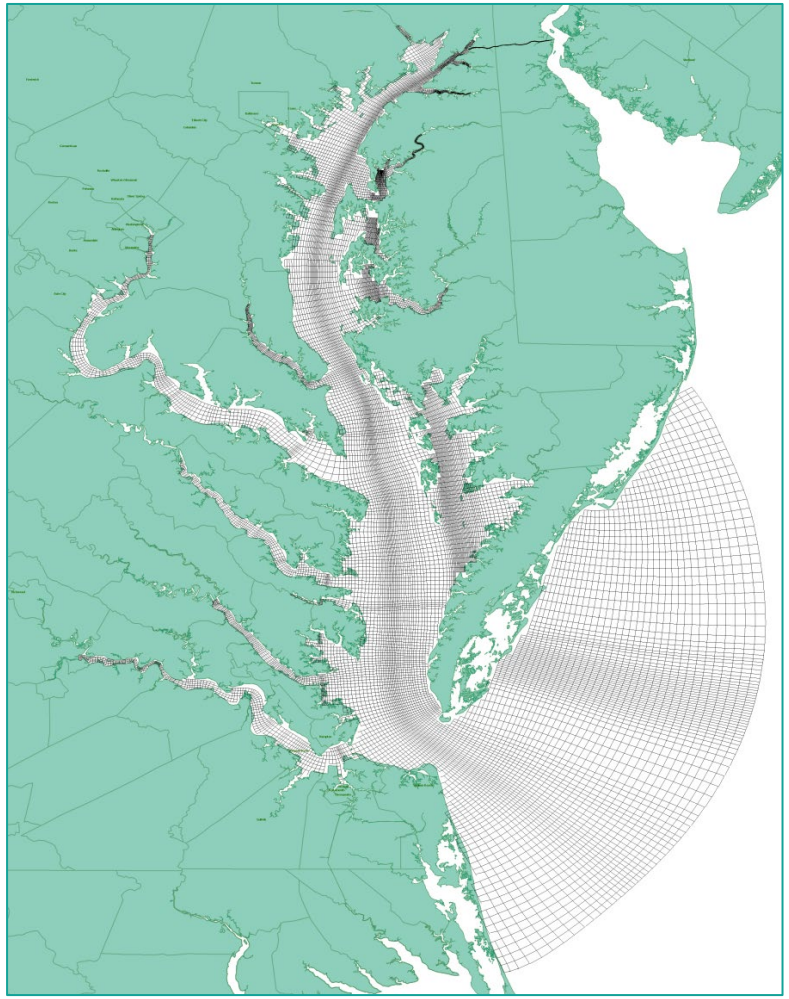




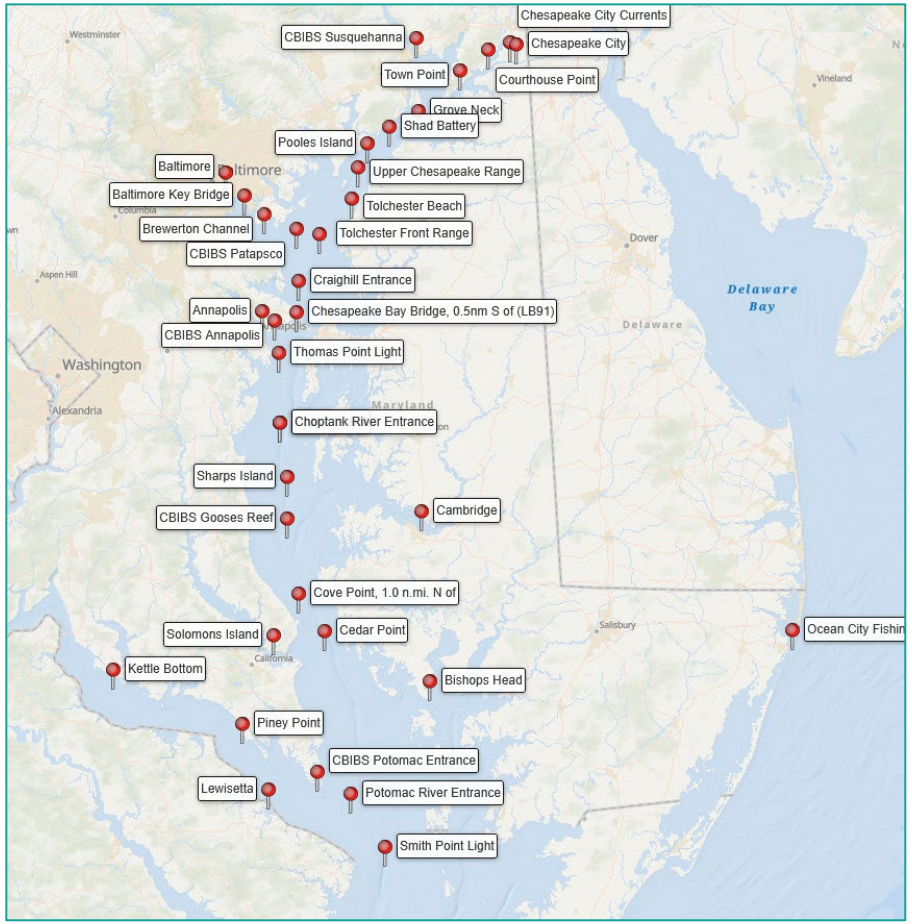
Link to CBOFS

Operational Forecast Models

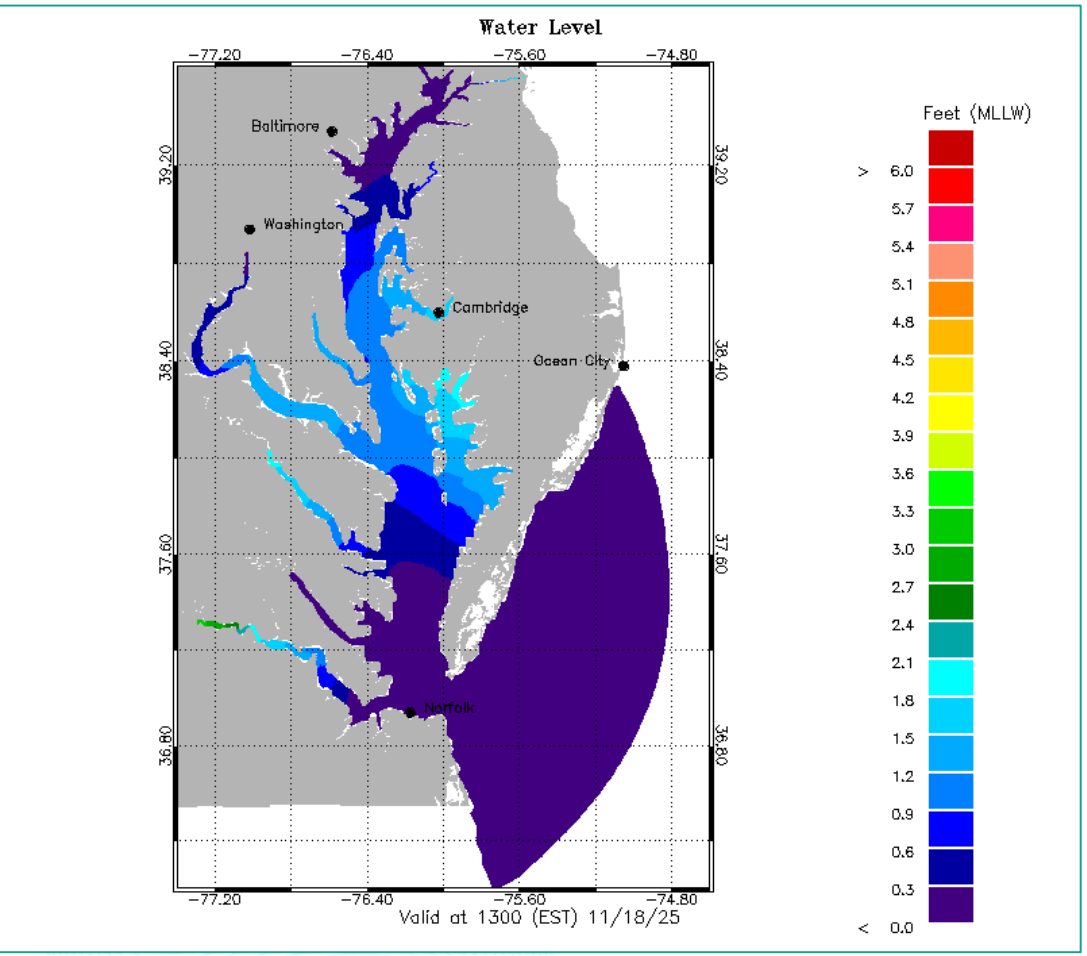
Chesapeake Bay Operational Forecast System (CBOFS)

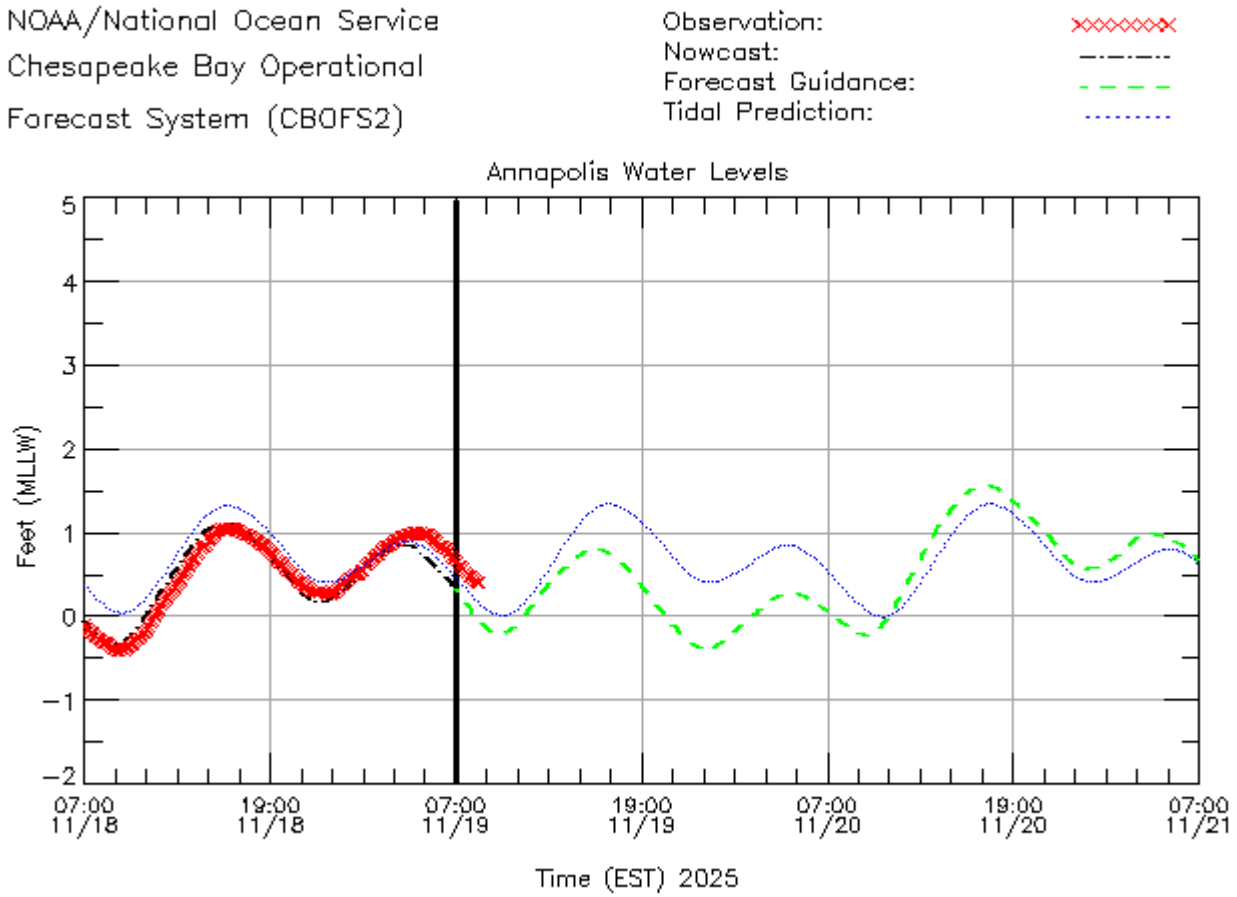


- Regional Ocean Modeling System (ROMS) – community based modeling system
- Parameters modeled: Water Levels, Currents, Temperature, Salinity
- Runs 4 times per day
- Operational environment
- Weather model forcing
- Field and point displays
- Worked with mariners to identify important navigation areas

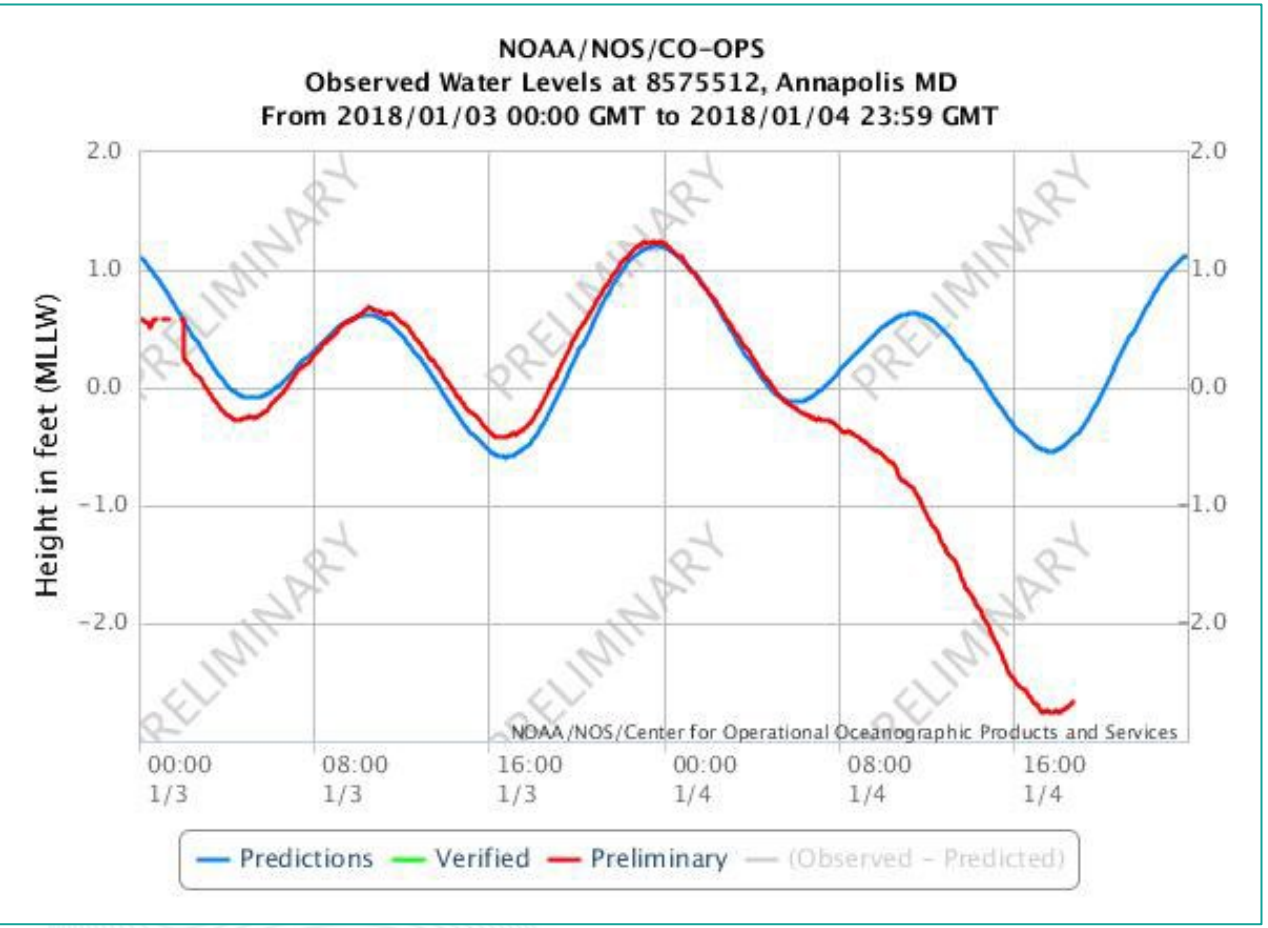


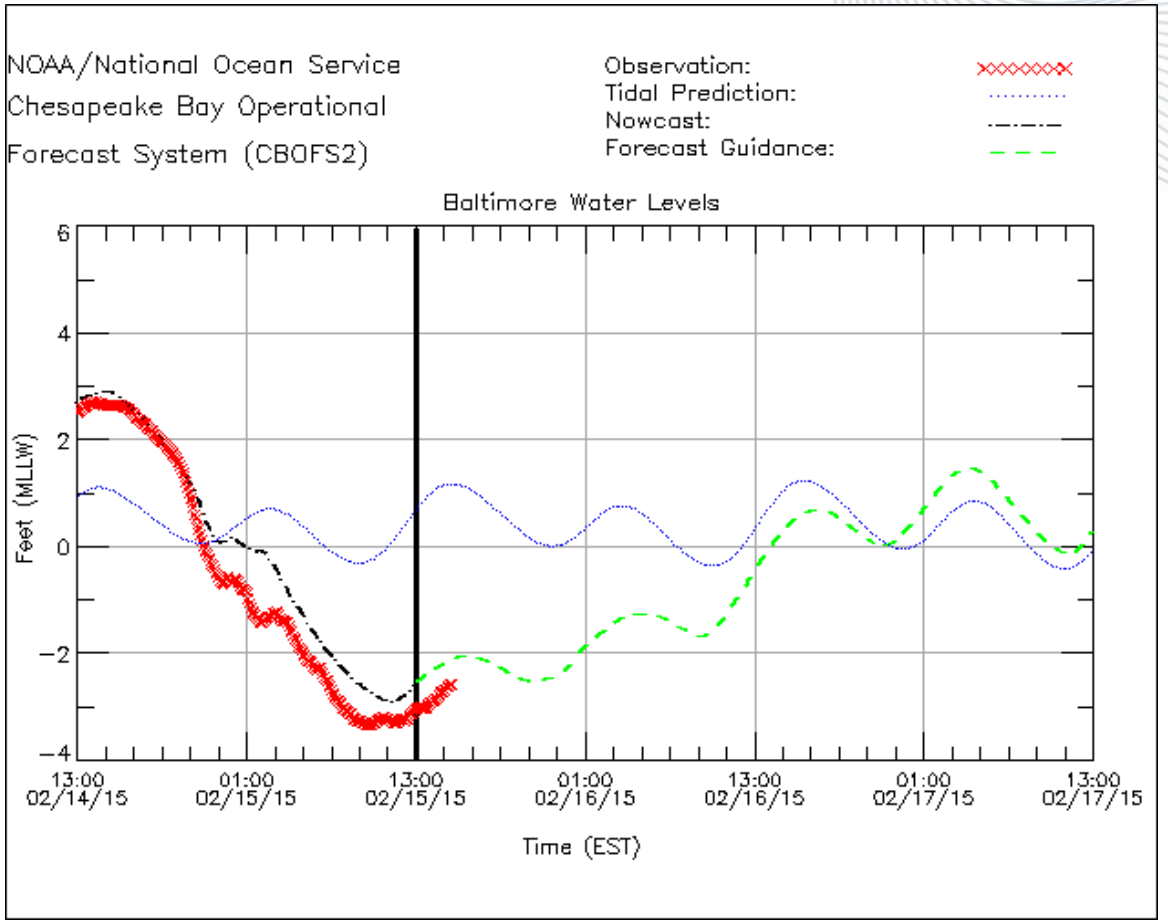
Example of Model Output



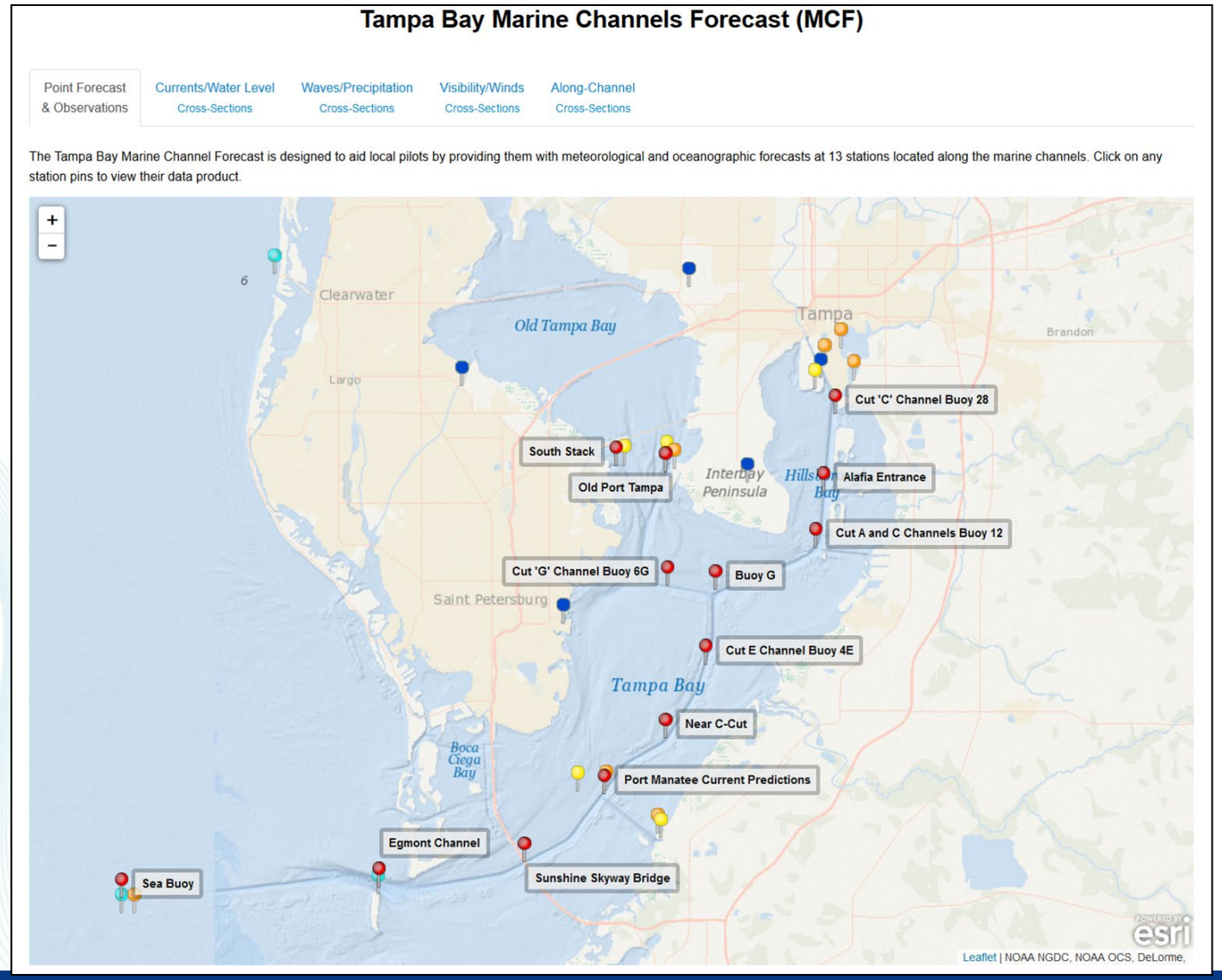


Example of Utility of Forecast Products



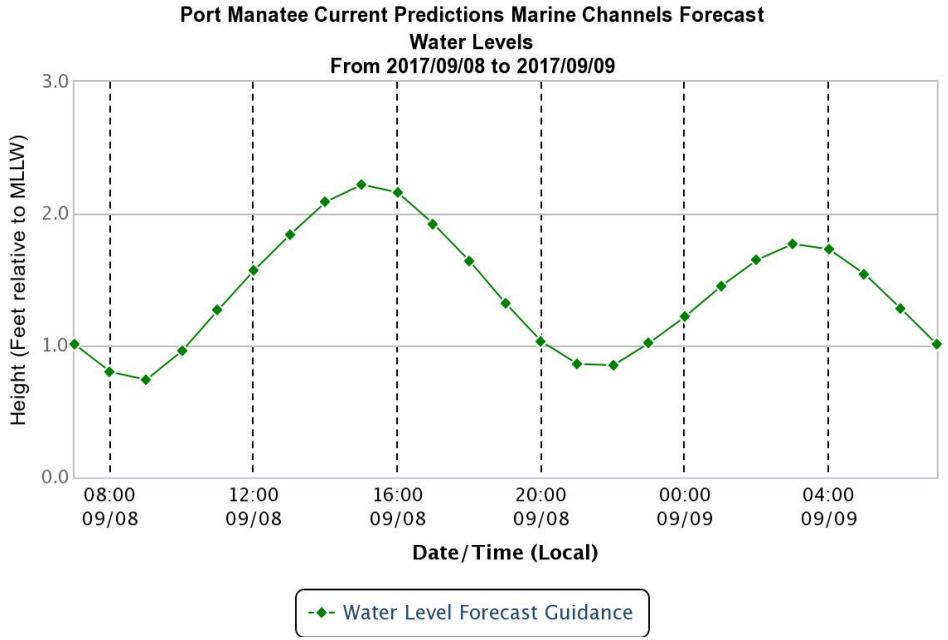


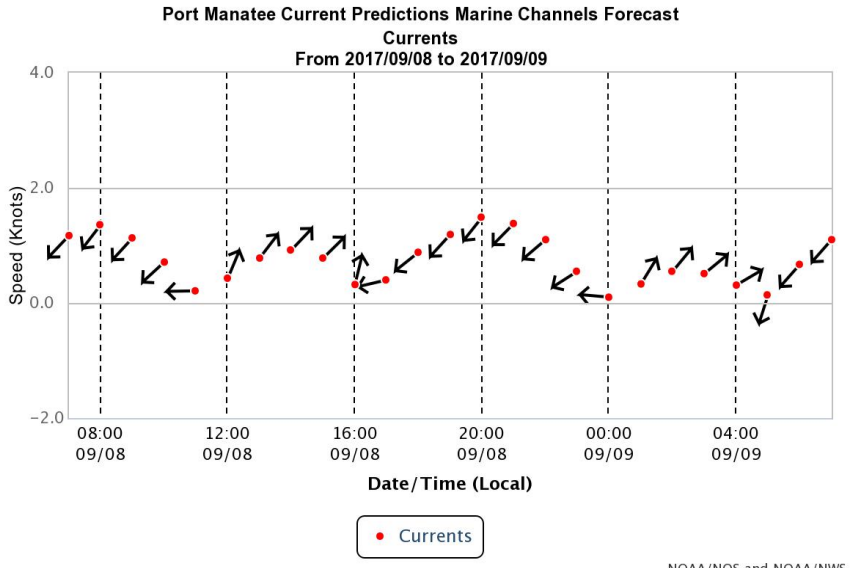
Example of Integrated Forecast Product

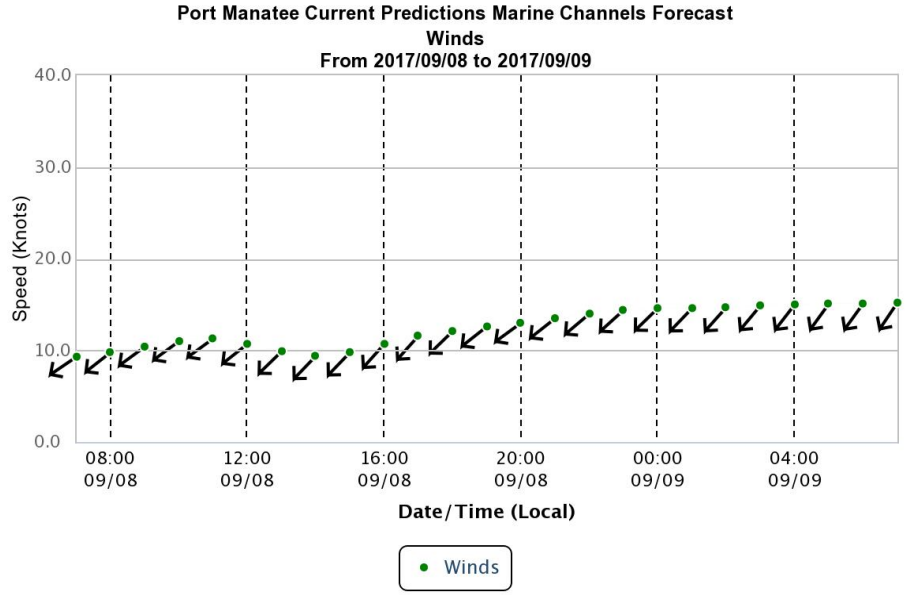


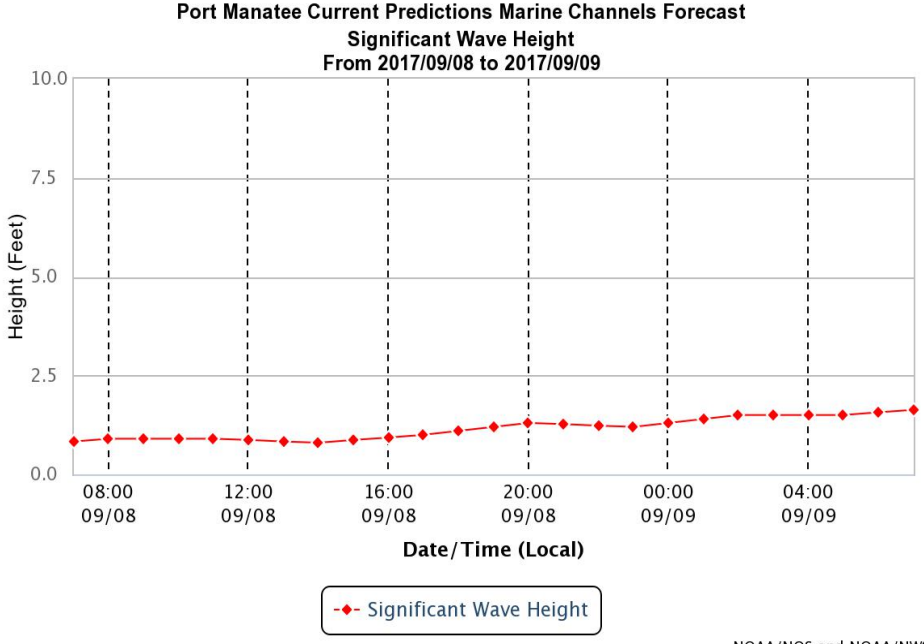
- Combines oceanographic obs. & hydrodynamic model output with meteorological obs. Model output.
- Parameters: Wind, waves, water levels, currents, visibility Combines PORTS data, OFS forecasts, NWS obs and forecasts
- https://tidesandcurrents.noaa.gov/ofs/tbofs/tbofs_mcf.html

Example Products

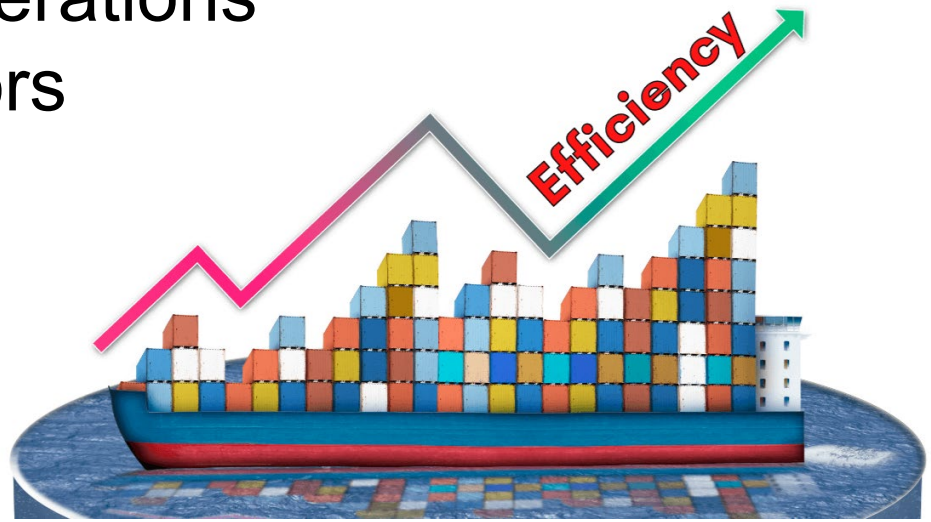








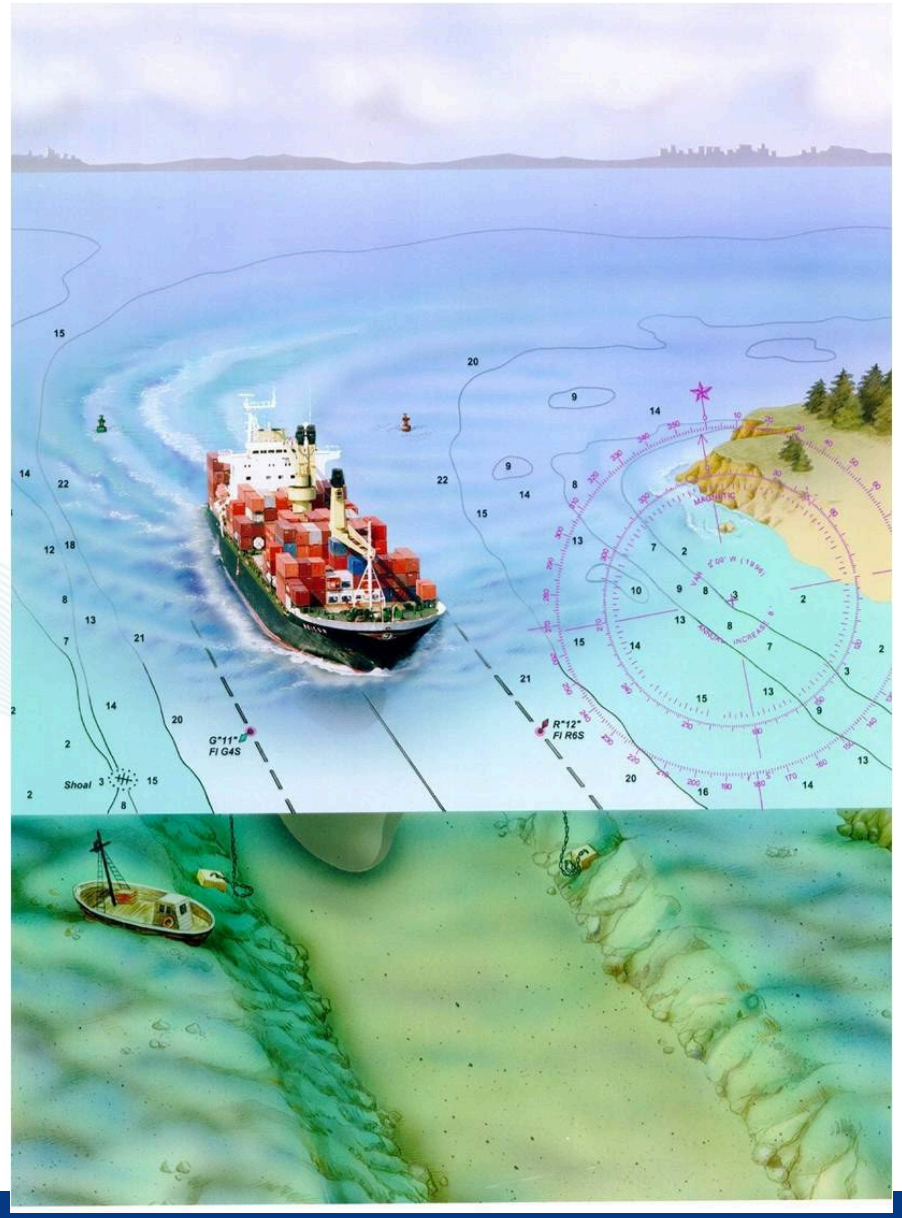
Vessel Planning & Routing
Critical for Safe and Efficient Operations
Water Level Related Factors



- Draft
- Under Keel Clearance
- Arrival Time
- Departure Time

Other factors
- Trim
- Density

Under Keel Clearance (UKC)

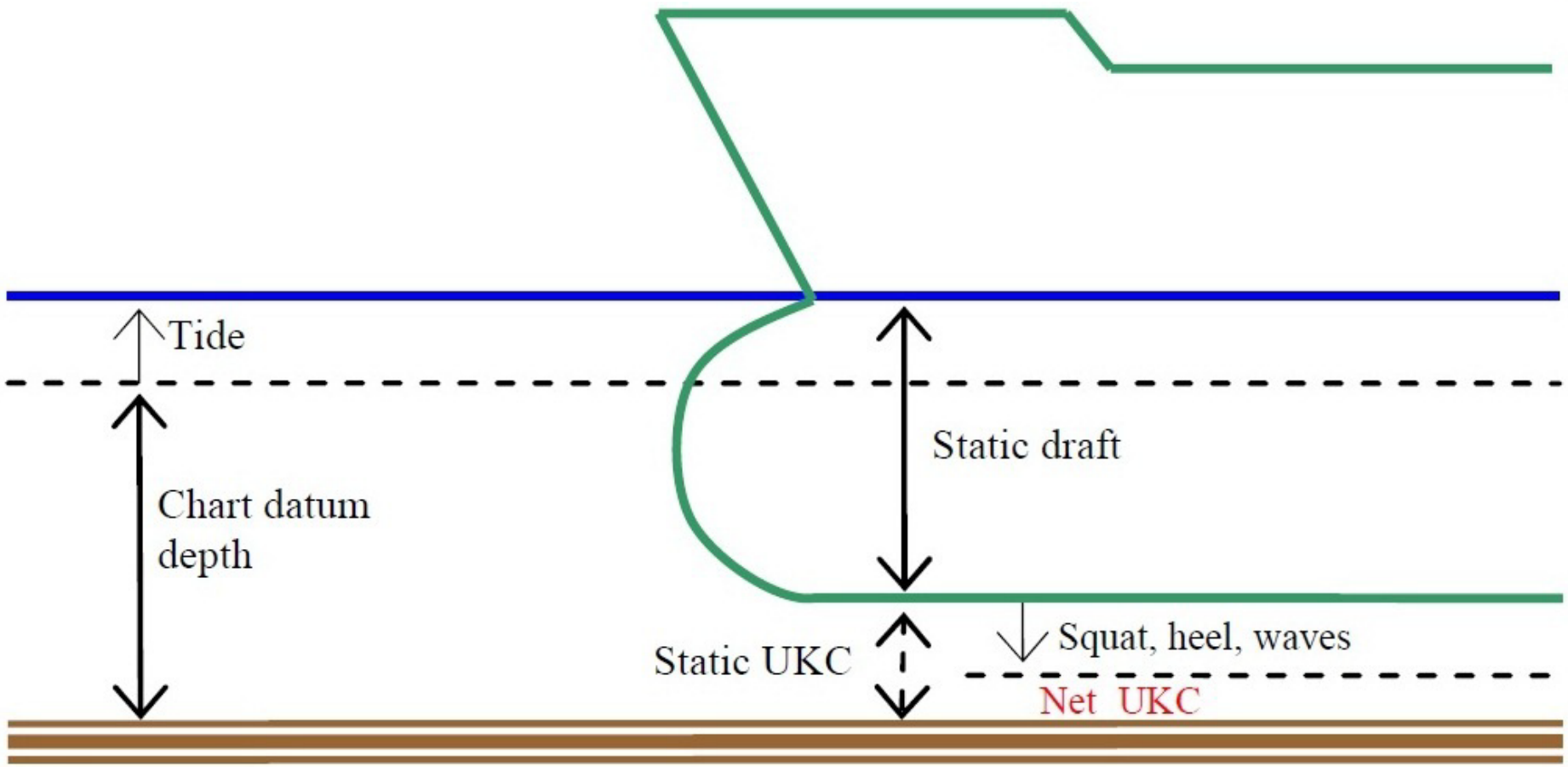


Factors Affecting UKC

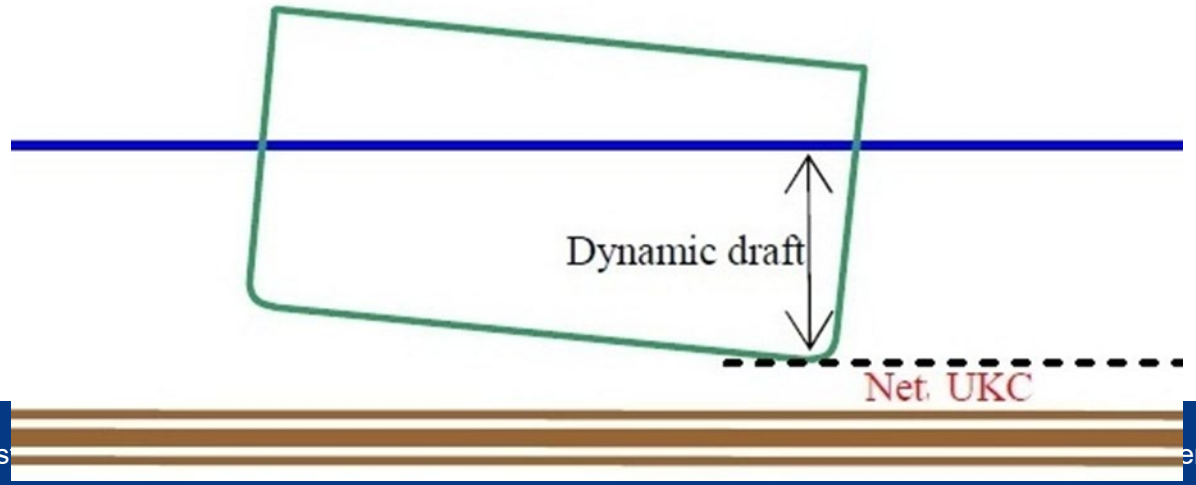
- Water level
- Waves/Swell
- Channel Bathymetry
- Density
- Speed
- Trim

Static Under Keel Clearance

Fixed amount based on draft at the dock
2 ft, 3 ft or 10% of draft

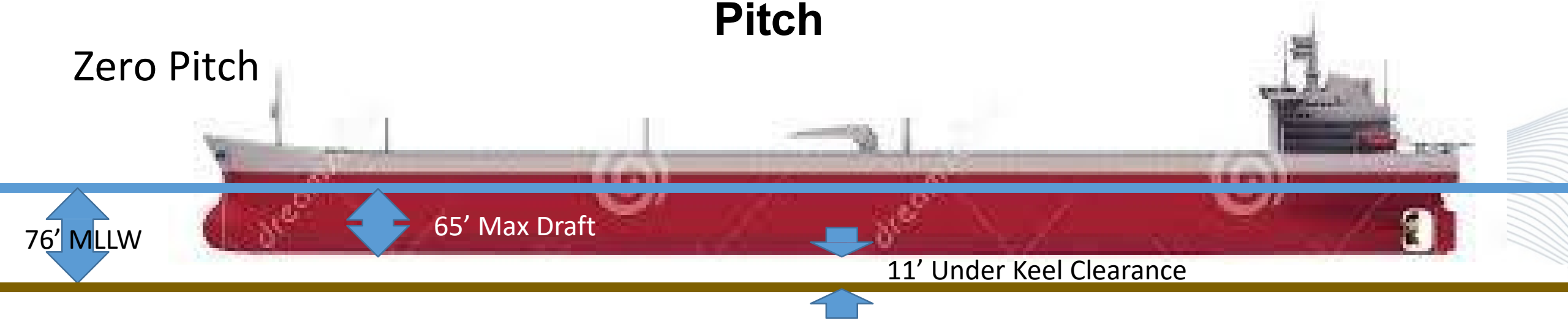


Roll / Heel

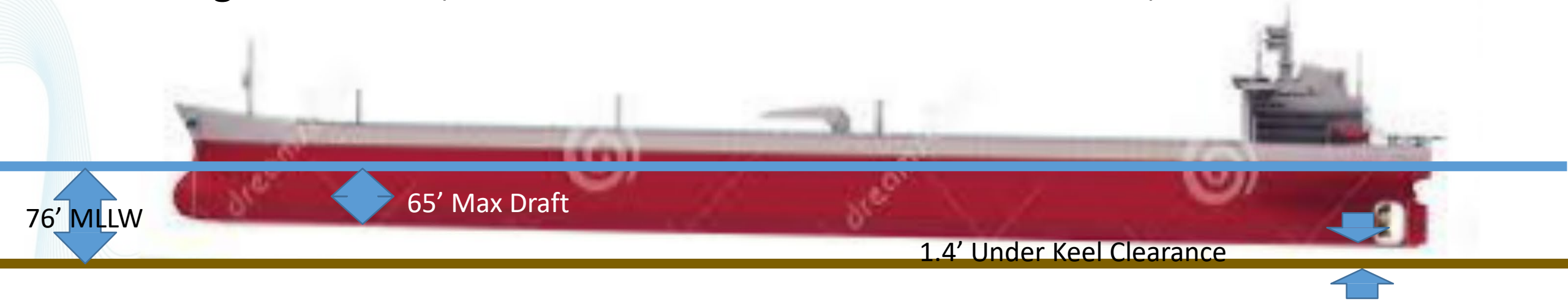


Pitch

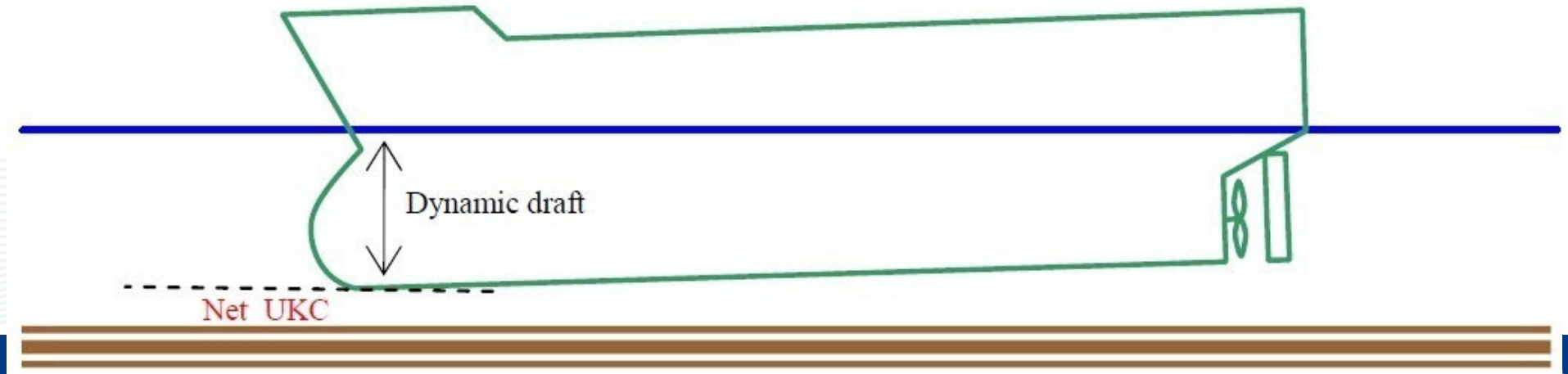
Zero Pitch



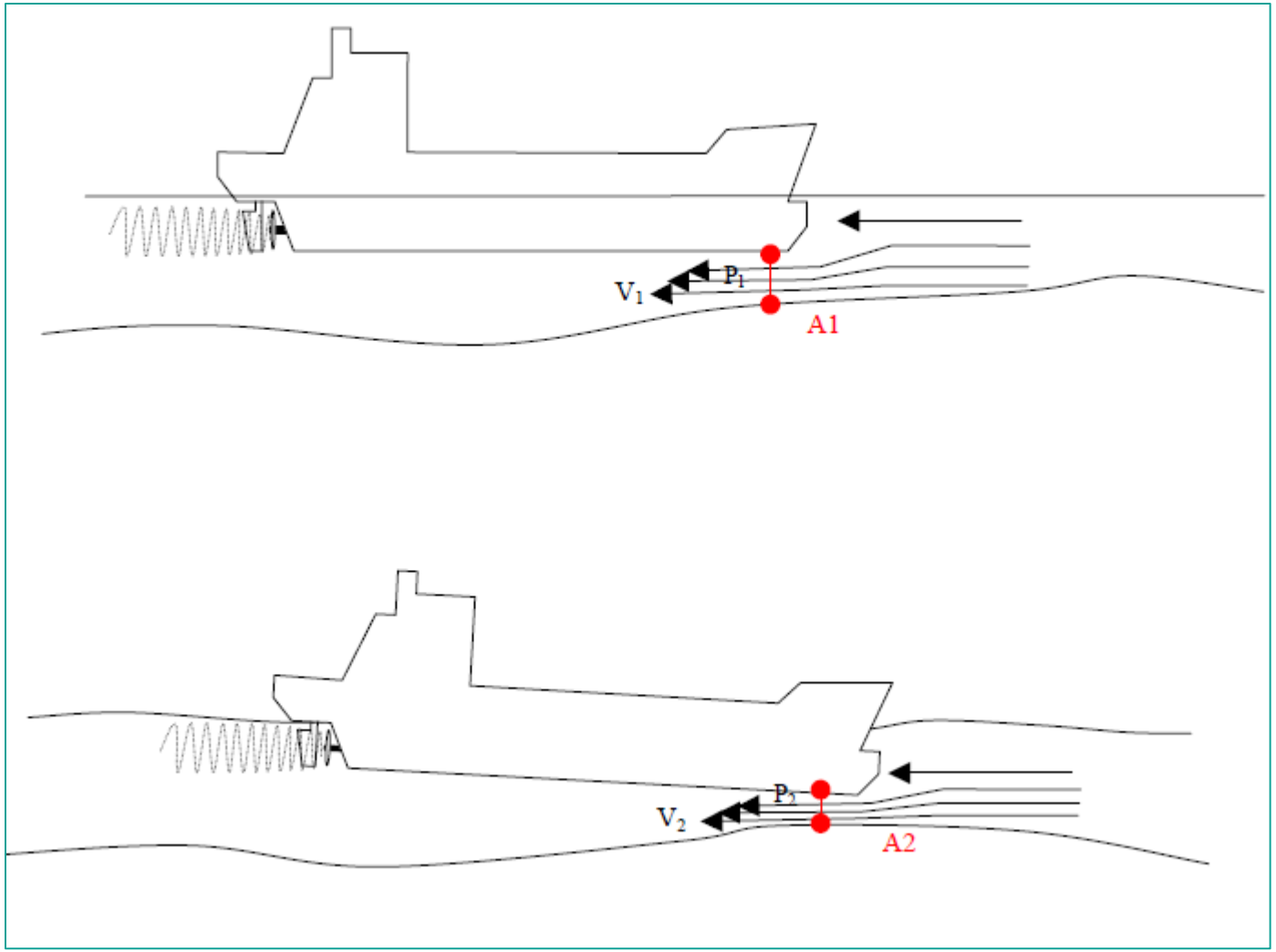
With 1 degree of Pitch, there is a 9.6’ increase in draft for a 1,100 foot tanker:



Squat

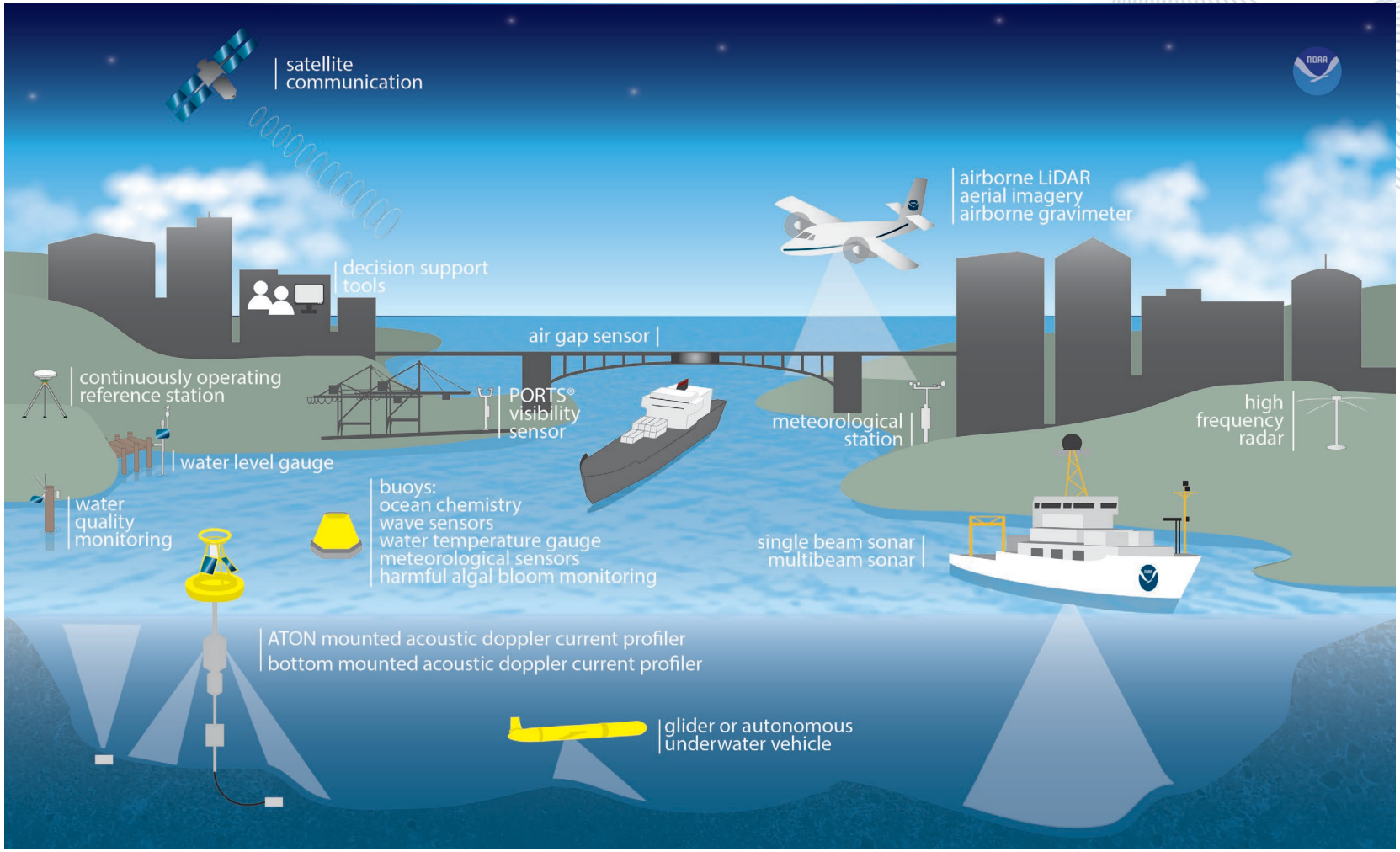


Squat changes with speed and bottom contours

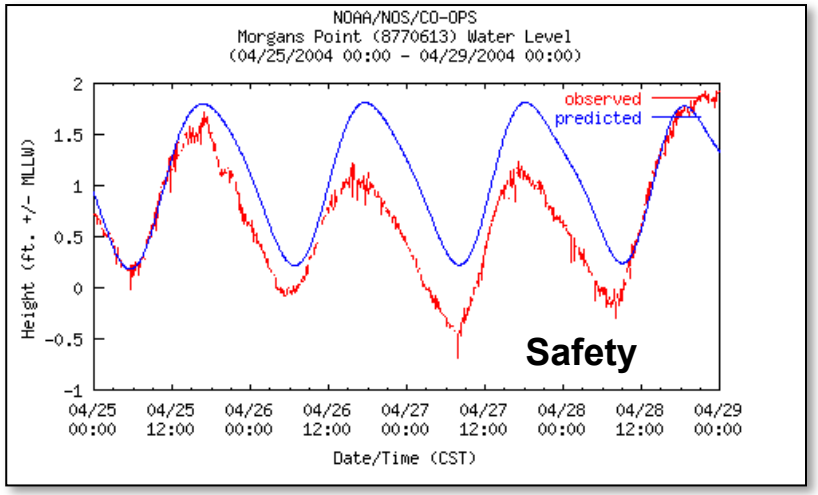


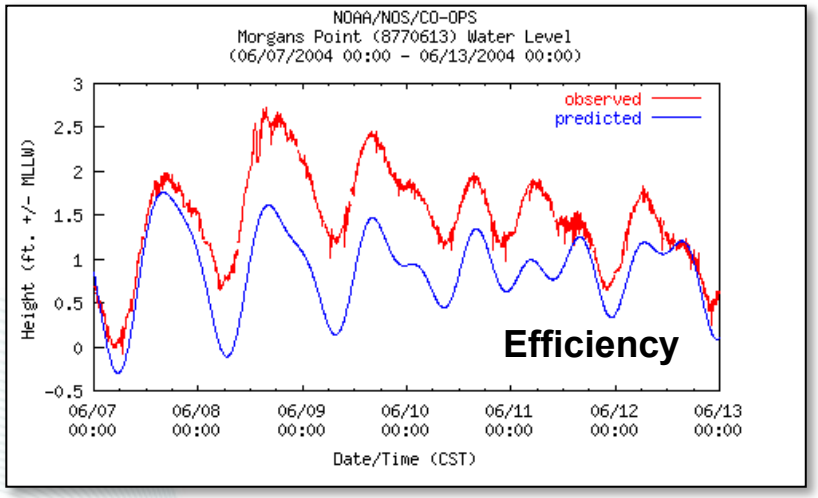
Why Providing Navigation Services are Important

- Reduces risk of groundings, collisions and allisions
- Efficient response to hazardous spills and Search and Rescue (SAR)
- Increased cargo carried per transit
- Reduced delays
- Improved environmental planning



The Value of Real-Time Data





REAL OUTCOMES

Accidents have been reduced at seaports currently served by PORTS®.

Collisions and Groundings

- ↓ **59%** Groundings
  (33% when groundings are combined with collisions)
- ↓ **37%** Property damage
- ↓ **45%** Injuries
- ↓ **60%** Deaths

Oil spills have been reduced at seaports currently served by PORTS®.

Oil Spills

- ↓ **21%** Reduction in oil releases due to collisions and groundings at seaports currently served by PORTS®.

COMPELLING FACTS - ECONOMICS

One Foot of Additional Draft Equals

- 20,000 – 22,000 barrels of crude on an average 500,000 barrel Crude tanker
- Extra tanker every 25 voyages or 2 months
- Extra trip cost $1.5 Million / $9 M annually
- Added congestion
- Increased dock utilization
- Increased mathematical risk of grounding, collision or allision

Summary

- Water Levels are very important for marine navigation but it is not the only important parameter
- Water Level data has many different applications – each application has its own requirements and specifications
- The marine navigation community is very risk intolerant. Systems need to be accurate and robust.
- For marine navigation, should integrate multiple parameters (based on user needs) into single product (see S-100 presentation)
- Need long time series of high quality water level data (and metadata) to produce navigationally important products such as Predictions, Datums, Model Forecasts
- Real Time navigation products are cost effective through reduced accidents, and increased efficiency
- All data and products MUST be accurate, timely and reliable