UNDERKEEL CLEARANCE SHIP SQUAT & TIDES

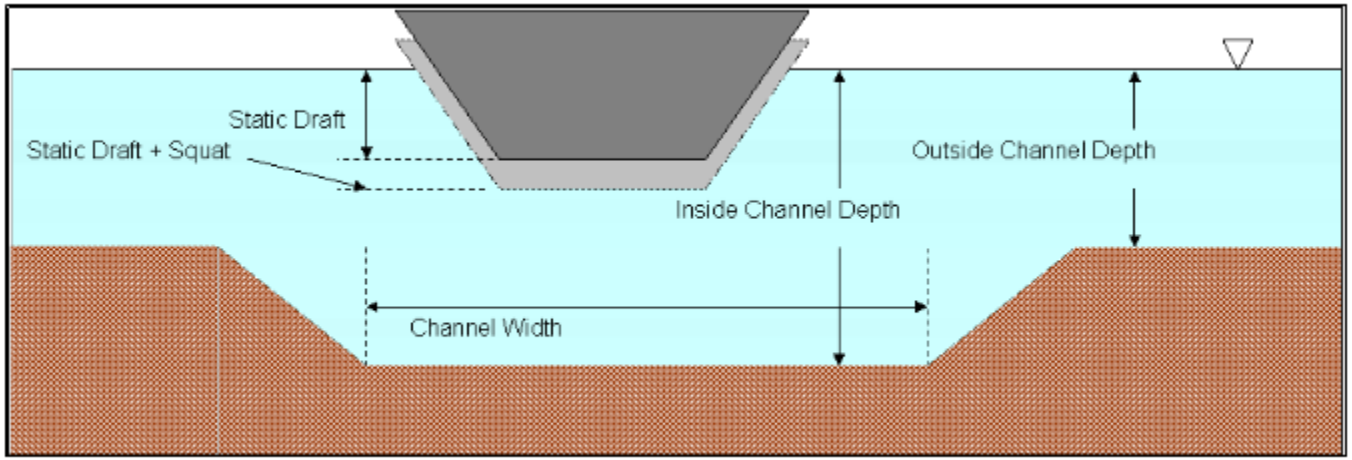
BEST NAVIGATION PRACTICES

DEFINITION OF SQUAT

REDUCTION OF UNDERKEEL CLEARANCE (UKC) CAUSED BY A SHIP'S MOVEMENT THROUGH THE WATER.

(IT IS *NOT* AN INCREASE IN DRAFT. RATHER, IT IS THE BODILY SINKAGE OF A VESSEL WHICH PLACES IT CLOSER TO THE SEA BOTTOM.)

STATIC DRAFT + SQUAT

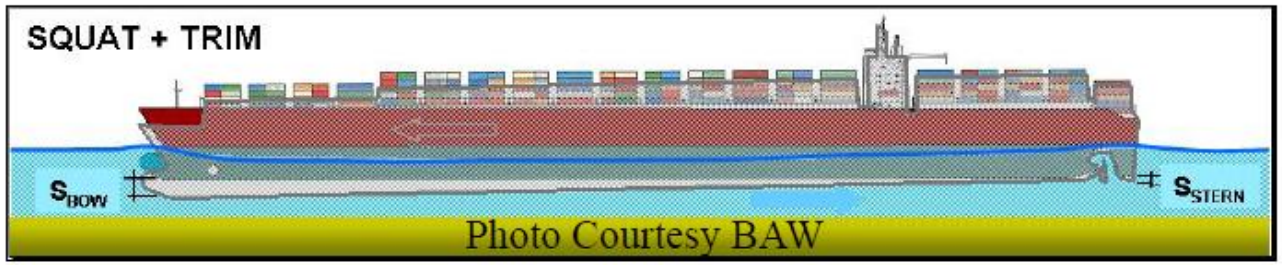


SQUAT FACTS

- C□ >.7 (bulker) squats by bow. C□ < .7 squats by stern
- Squat varies *directly* with breadth (doubling breadth doubles squat)
- Squat varies by the *square* of speed (doubling speed quadruples squat)
- Squat can be *doubled* when meeting another ship

SQUAT FORMULAE

- **Five of most user friendly and "popular"**
  - **Barrass**
  - **Eryuzlu et al**
  - **Huuska/Guliev**
  - **Römisch**
  - **Yoshimura**
- **All give bow squat**
- **Stern squat**
  - **Only Römisch predicts stern squat for all channels**
  - **Barrass stern only for unrestricted or open channels and other channels depending on C_B value**



BEST GENERAL FORMULA

V squared/100= S_{meters}

Speed=6KTS

36/100=.36 meter squat

Speed=12kts

144/100= 1.44 meter squat

Doubling the speed quadruples the squat

HULL TYPES
BLOCK COEFFICIENT (C_β)

LARGE BLOCK HULL

$C_\beta > .7$

FINER HULL

$C_\beta < .7$

VARIOUS SQUAT FORMULAE YIELD SIMILAR CONCLUSIONS

$$Squat = (\frac{1}{30}) * C_b * ((S_2)^{\frac{2}{3}}) * V^{2.08}$$

- You can fiddle away with the parameters and get a feeling of the influence on UKC for a ship sailing in shallow water.
- The really important thing about this formula (and all the other squat - formulae, which all look-alike) is what happens with ship's speed.
- Fill in a ship's speed of 5 knots, or 10 knots, the result of the formula is 25 versus 100.
- **Double speed gives four times higher squat**.

SQUAT PREDICTIONS

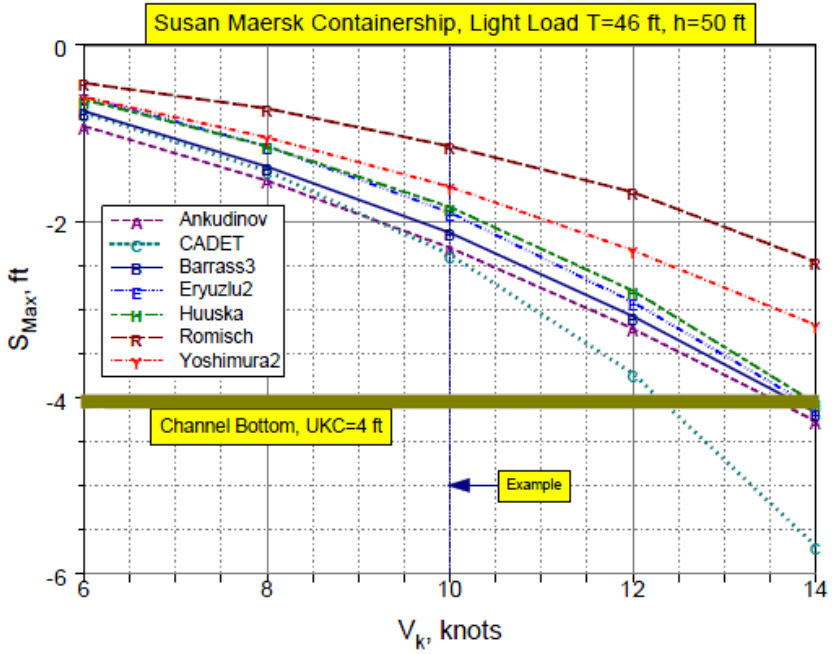
Susan Maersk Containership

- L_{pp} = 1,088 ft
- B = 140.4 ft
- Draft
  - Light load T = 46 ft
  - Full load T = 47.5 ft
- C_B = 0.65
- V_K = 8 to 14 kts

TIDAL CONSIDERATIONS
ZERO TIDE

Light Load T=46 ft, h=50 ft (h/T=1.09)

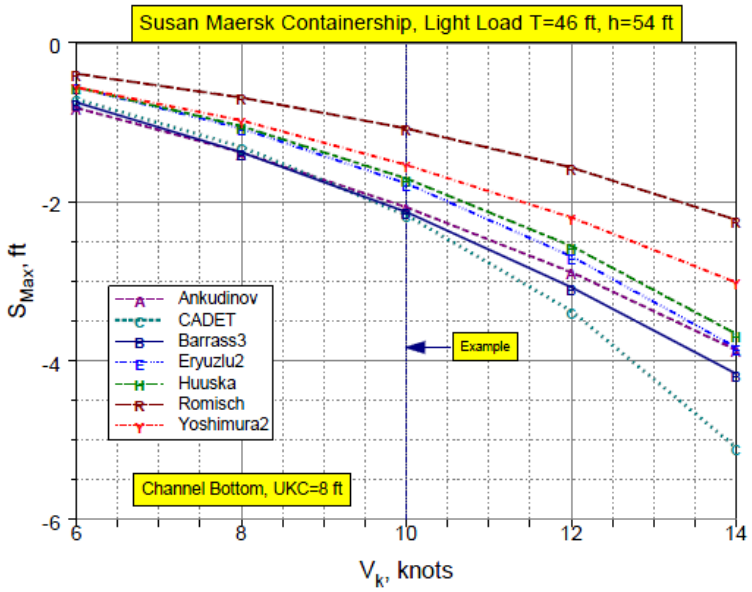
- **No tide**
- **Available UKC=4 ft**
- **Ankudinov & CADET general agreement with PIANC predictions**
- **Both conservative**
- **Ankudinov tracks OK**
- **CADET tracks OK to V_k=10 kt**
- **Example @ V_k=10 kt**
  - **PIANC Ave=1.7 ft**
  - **Ankudinov=2.3 ft**
  - **CADET=2.4 ft**
- **Grounding due to squat at V_k=12+ kt**



TIDE +4 FEET

Light Load T=46 ft, h=54 ft (h/T=1.17)

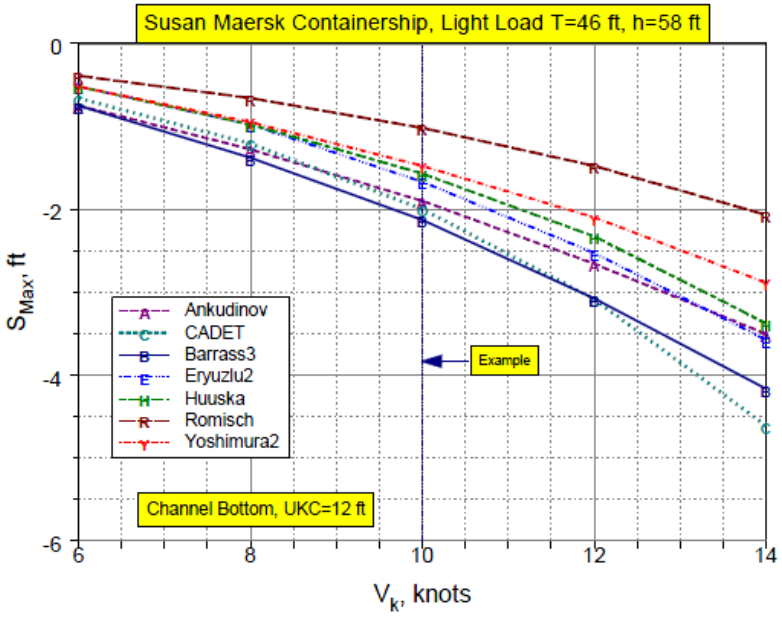
- **Tide=4 ft, 4 hr/day, 365 days/yr**
- **Available UKC=8 ft**
- **Ankudinov & CADET general agreement with PIANC predictions**
- **Both conservative**
- **Ankudinov tracks OK**
- **CADET tracks OK to V_k=12 kt**
- **Example @ Vk=10 kt**
  - **PIANC Ave=1.6 ft**
  - **Ankudinov=2.1 ft**
  - **CADET=2.2 ft**
- **No grounding due to squat**



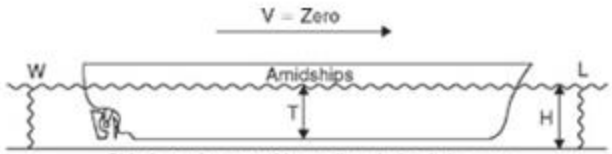
TIDE +8 FEET

Light Load T=46 ft, h=58 ft (h/T=1.26)

- **Tide=8 ft, 1 hr/day, 7 days/yr**
- **Available UKC=12 ft**
- **Ankudinov & CADET general agreement with PIANC predictions**
- **Both conservative**
- **Ankudinov tracks OK**
- **CADET tracks OK to V_k=12+ kt**
- **Example @ V_k=10 kt**
  - **PIANC Ave=1.6 ft**
  - **Ankudinov=1.9 ft**
  - **CADET=2.0 ft**
- **No grounding due to squat**

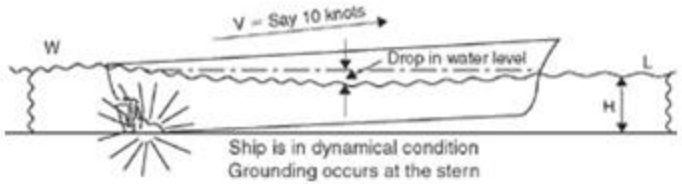


GROUNDING DUE TO SQUAT



Ship is stationary, with small underkeel clearance
Trim ranges from being on even keel,
to being 1/500 by the stern

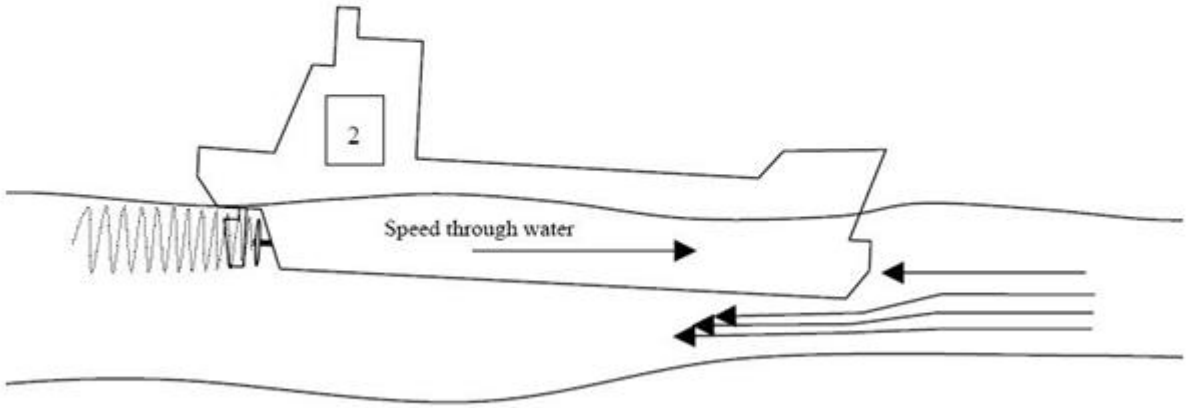
Ship Squat



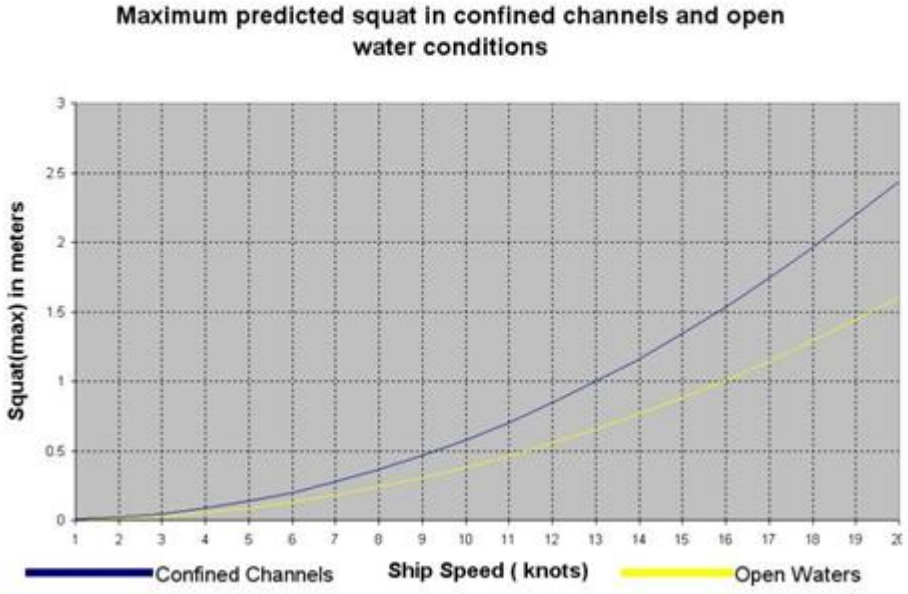
Ship is in dynamical condition
Grounding occurs at the stern

- Vertical squat is ***not*** extra draught due to shallow water effect. (Ships would *sink*, if this was true.)
- Vertical squat is due to waterflow being restricted under the ship's hull (and in a channel; also along the sides of the ship). It's called Bernoulli's Law.
- Waterflow is restricted
- Waterspeed is increased
- Waterpressure drops
- Waterlevel drops

Bernoulli's Law Illustrated



Increased Effect in Confined Channels



PILOT'S CONSIDERATIONS

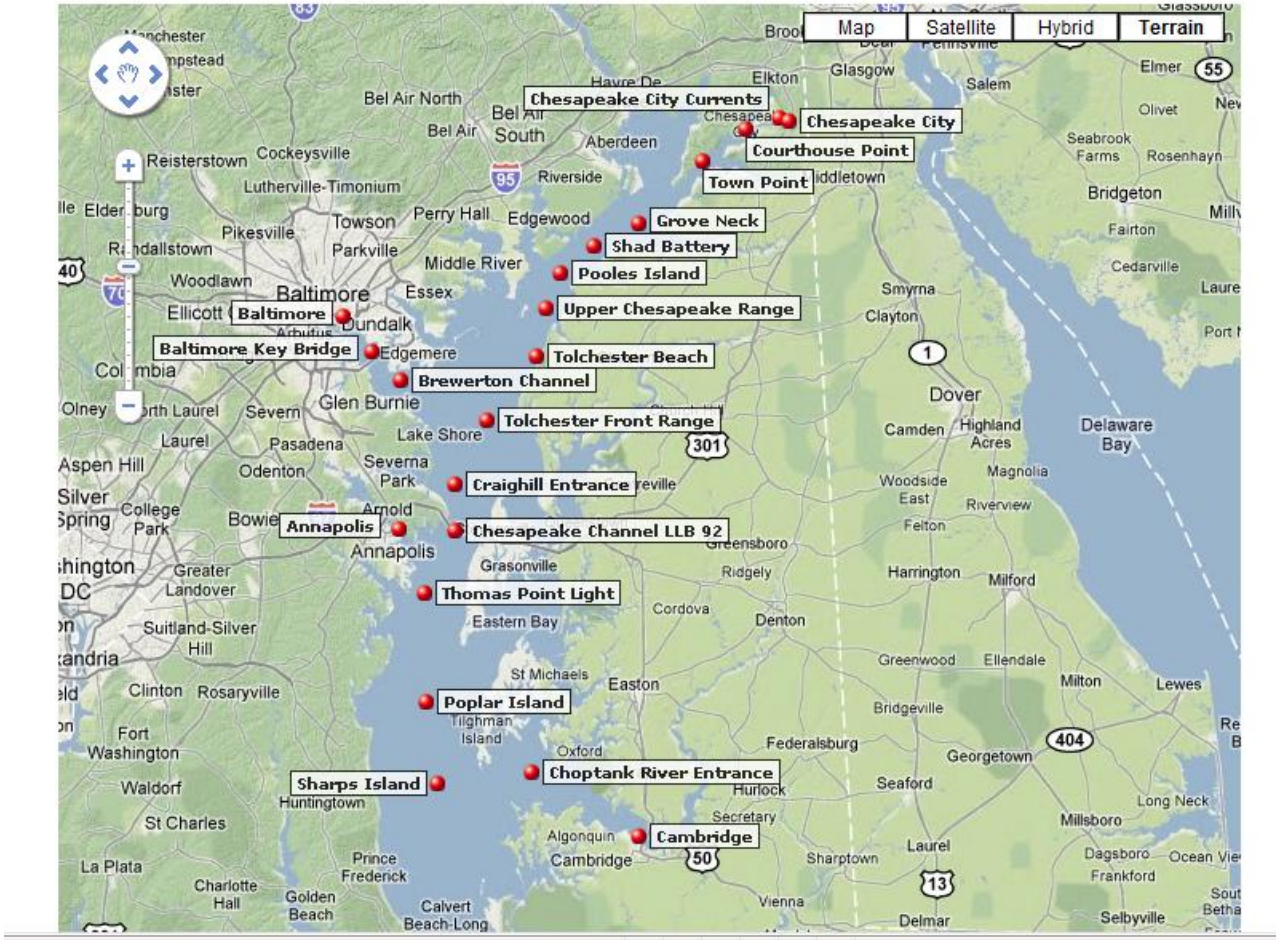
- Warning: every ship reacts different in shallow water, concerning trim, list during turning, steering capabilities, course stability.
- And you have to be ***really*** sure about some values:
- waterdepth in the channel: that means the channel has to be multibeamed completely, and the depth of the shallowest part has to be measured beyond any doubt. Nothing less will do..
- Tidal height has to be an actual measurement, not simply an astronomical (calculated) tidal height. You'll need realtime online tidal height onboard.
- The ship's draught sensors have to be reliable, accurate and exact,
- and don't forget to adjust the density of the seawater in your loadcomputer

TIDAL CONSIDERATIONS

USING TIDE TO GOOD ADVANTAGE

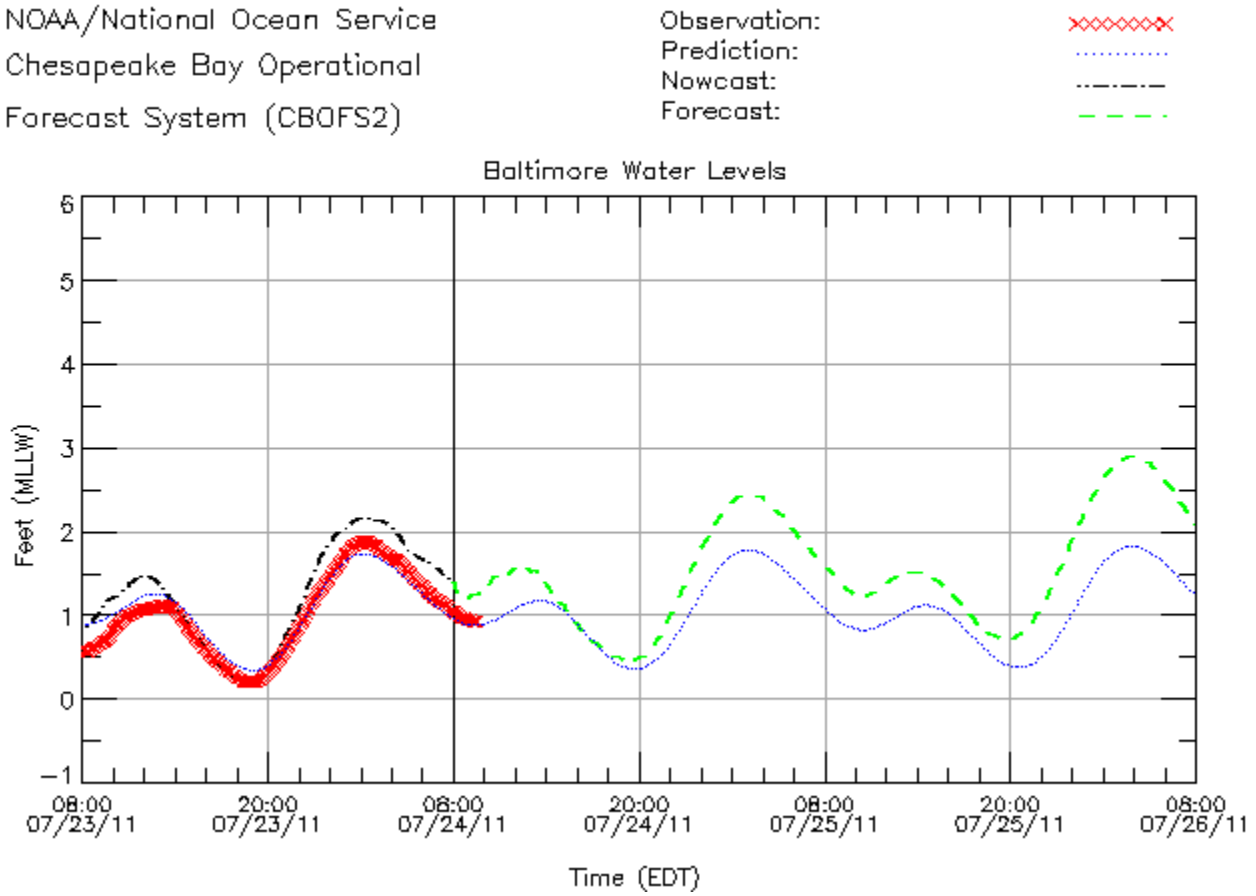
- NOAA'S "PORTS" TOOL ONLINE
- LOCAL KNOWLEDGE OF PILOTS
- CREDIBLE PREDICTIONS OF METIORILOGICAL FACTORS ON TIDES (NOAA'S FORECAST PROGRAM)

NOAA'S OPERATIONAL FORECAST SYSTEM



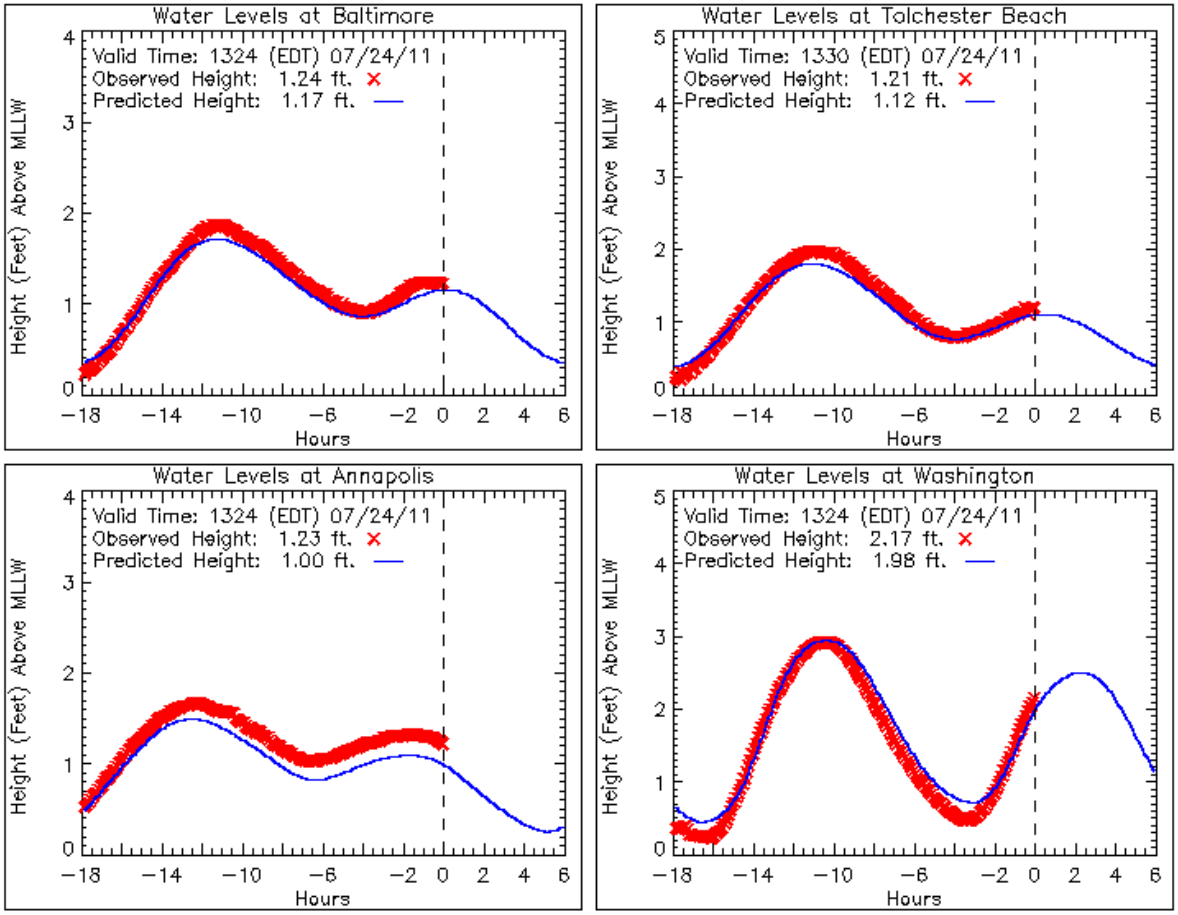
OPERATIONAL FORECAST SYSTEM

SCREEN SHOT 7/24/11



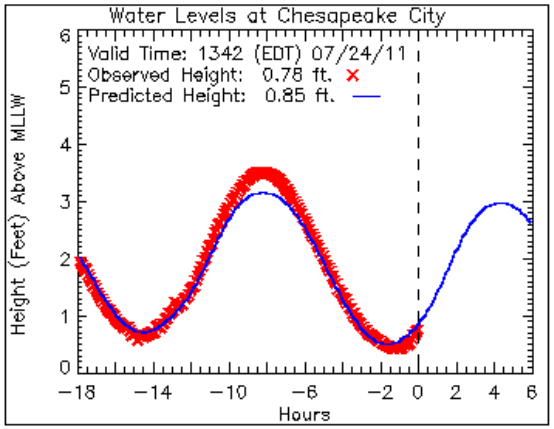
NOAA'S PHYSICAL OCEANOGRAPHIC REAL-TIME SYSTEM (PORTS)

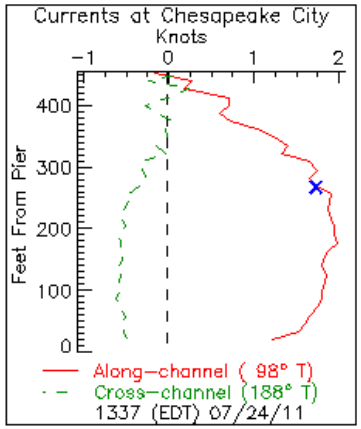
SCREEN SHOT 7/24/11

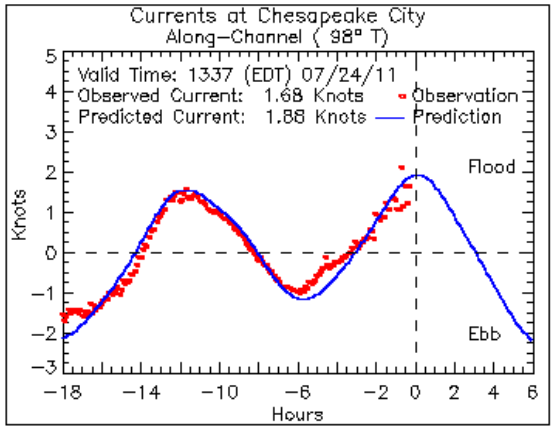


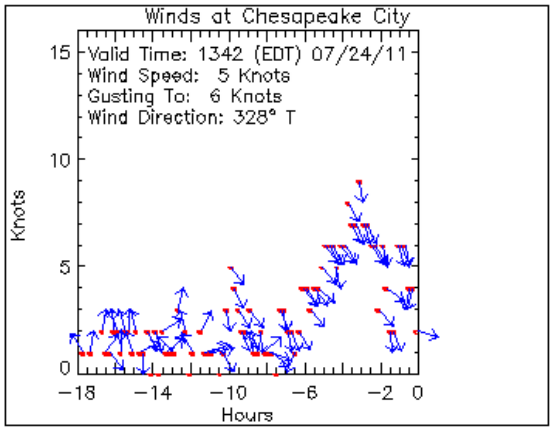
NOAA'S SEARCHABLE STATIONS
www.tidesandcurrents.noaa.gov

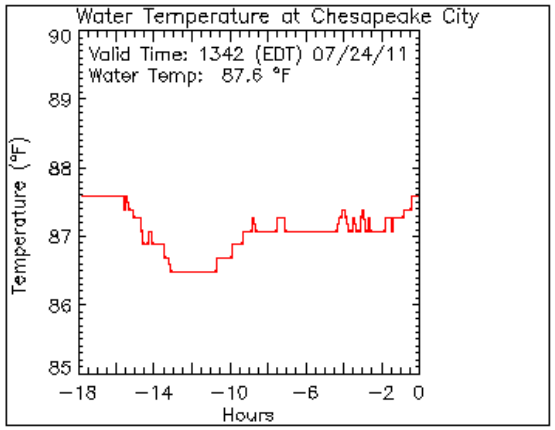
PORTS COMPOSIT PAGE
CHESAPEAKE CITY, MD

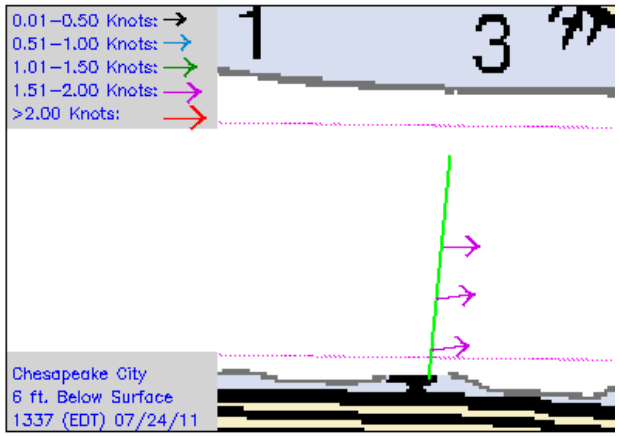






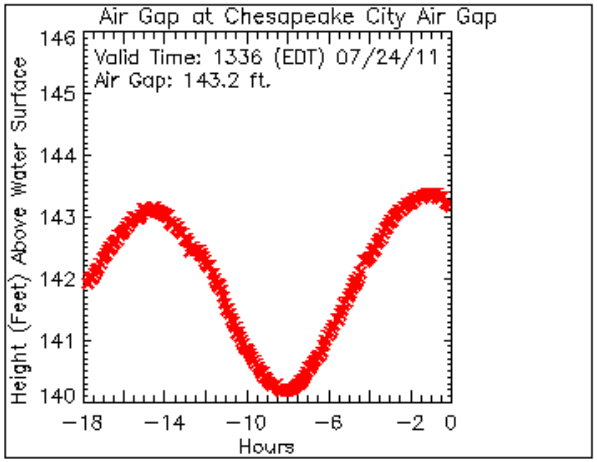


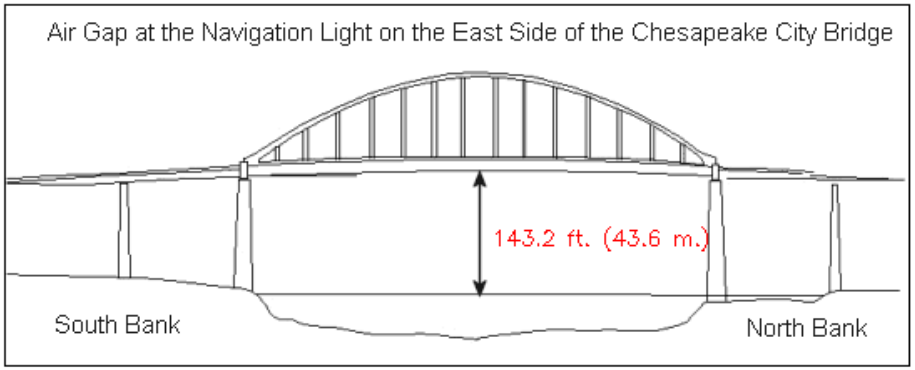


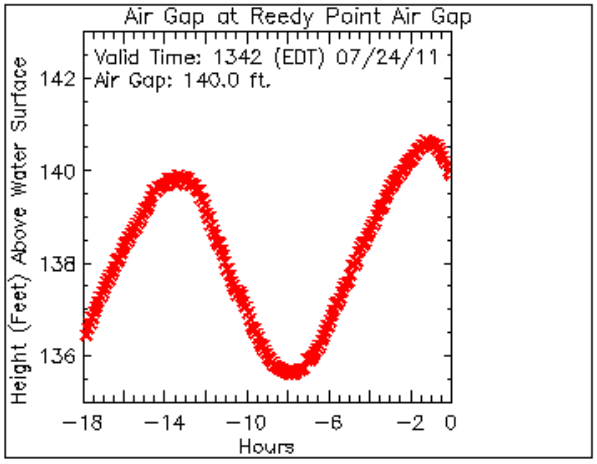


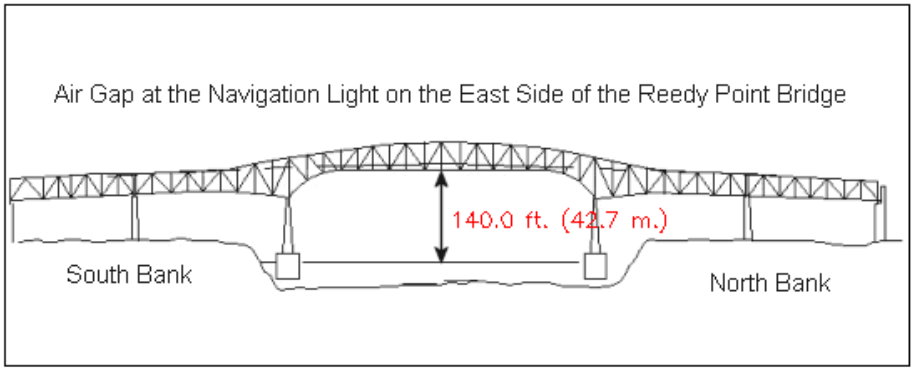
PORTS AIRGAP OBSERVATIONS

C&D CANAL









“H” FLAG
PILOT ON BOARD