



King Tides

How this event has risen into our vocabulary

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D.CE, CFM

May 4, 2017

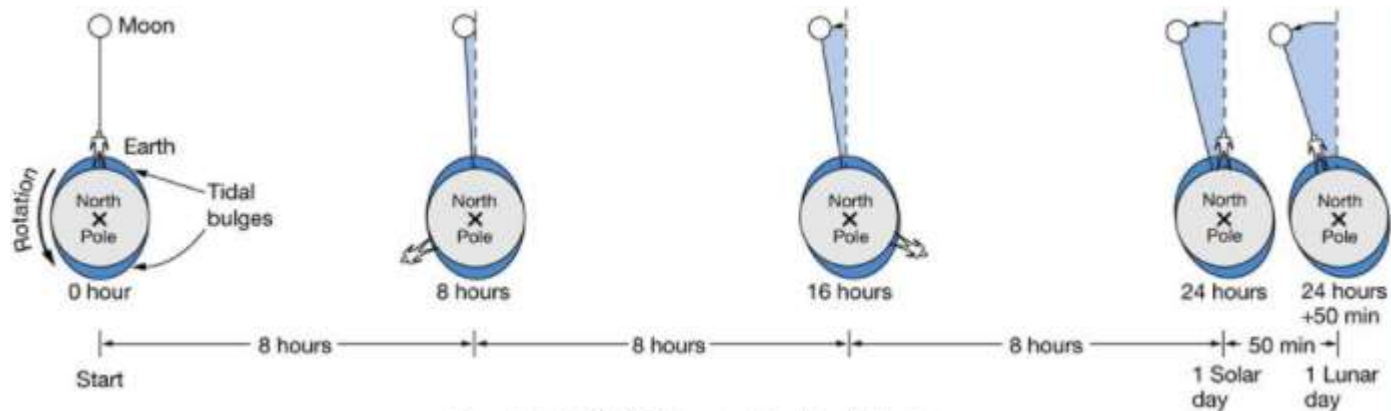


**CDM
Smith**

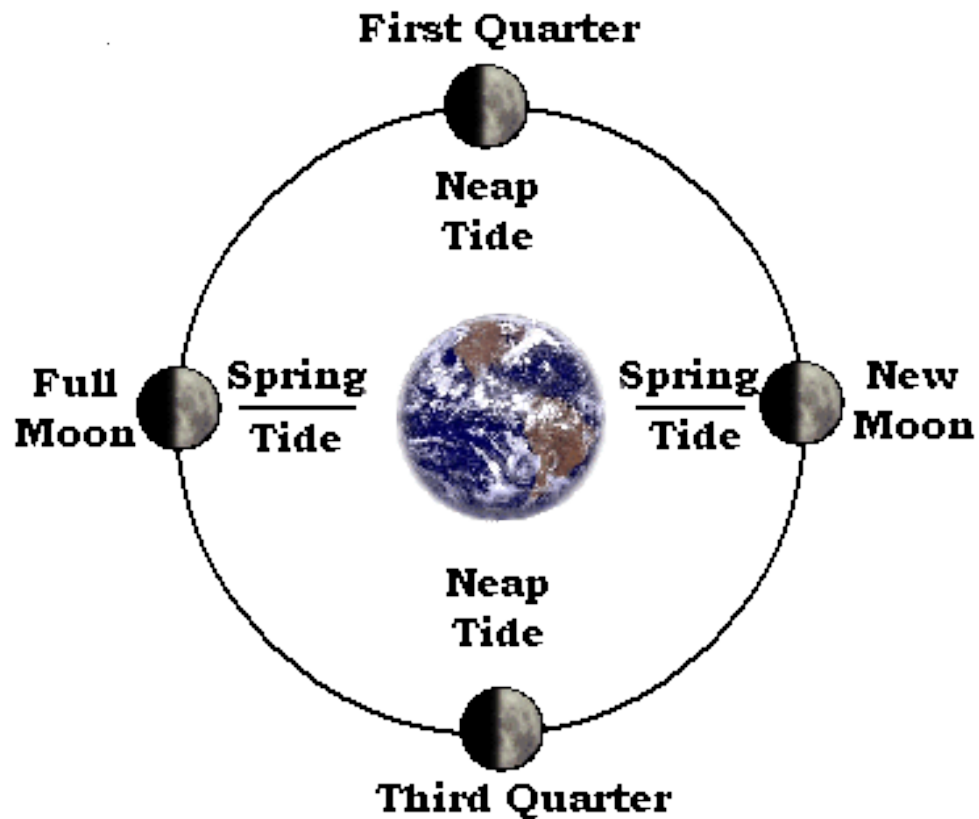
WATER + ENVIRONMENT + TRANSPORTATION + ENERGY + FACILITIES

The Truth About Tides

- Tides are reliable
- Pull on Earth's oceans by the sun and the moon
- Moon takes 28 days to rotate about the earth
- Therefore, it takes $1/28^{\text{th}}$ of 24 hours (50 minutes) for the earth to catch up to where the moon is now

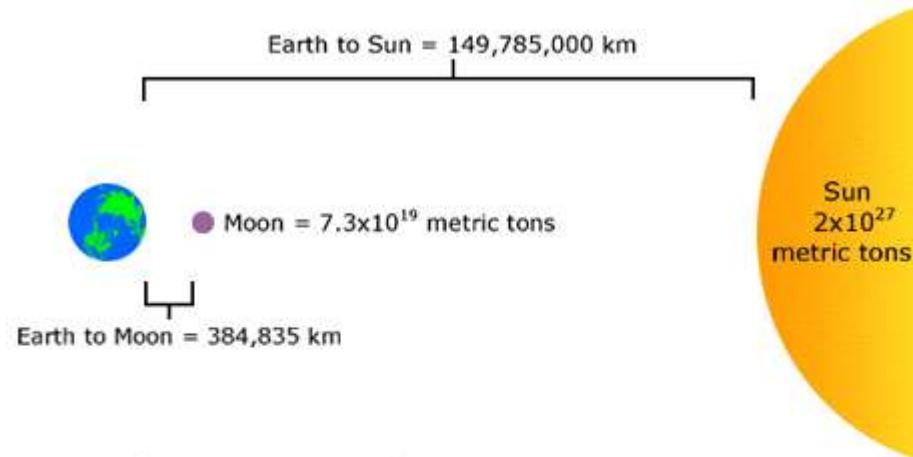


Lunar Cycle



<https://tidesandcurrents.noaa.gov/astronomical.html>

It's a Balance



$$\text{Tide-Generating Force} = \propto \frac{\text{Mass}}{(\text{Distance})^3}$$

$$\text{Tide-Generating Force of the Sun} = \propto \frac{\text{Sun's Mass}}{(\text{Sun's Distance to Earth})^3}$$

*NOTE: The sun has 27 million times more mass than the moon and is 390 times farther away from the earth than the moon.

$$(390)^3 = 59,000,000 \quad \text{So...} \quad \frac{27 \text{ million}}{59 \text{ million}} = 0.46 \text{ or } 46\%$$

Therefore the Sun has 46% of the tide-generating force of the Moon.

http://oceanservice.noaa.gov/education/tutorial_tides/media/supp_tide02.html

Why King Tide?

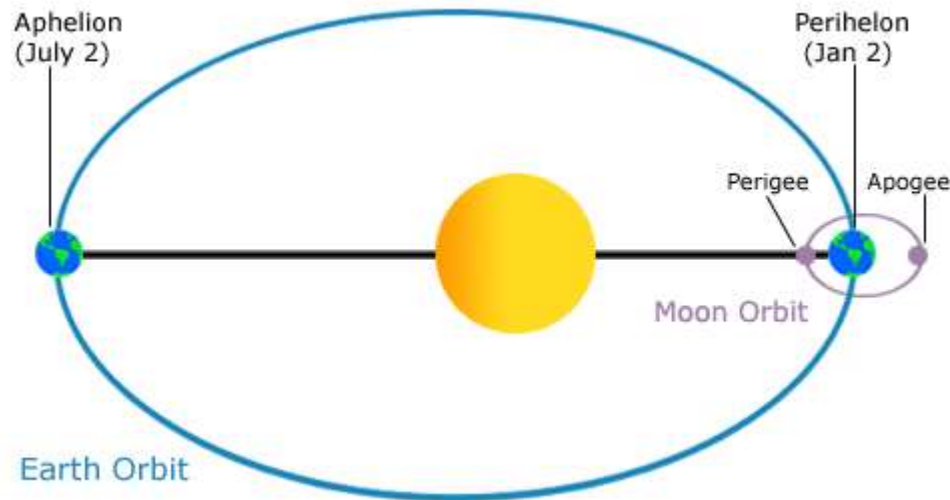


Why King Tide?

- 'King Tide' isn't a scientific term
- It is used on exceptionally high spring tides
- Occur naturally and regularly
- Predictable and expected
- Not an everyday occurrence

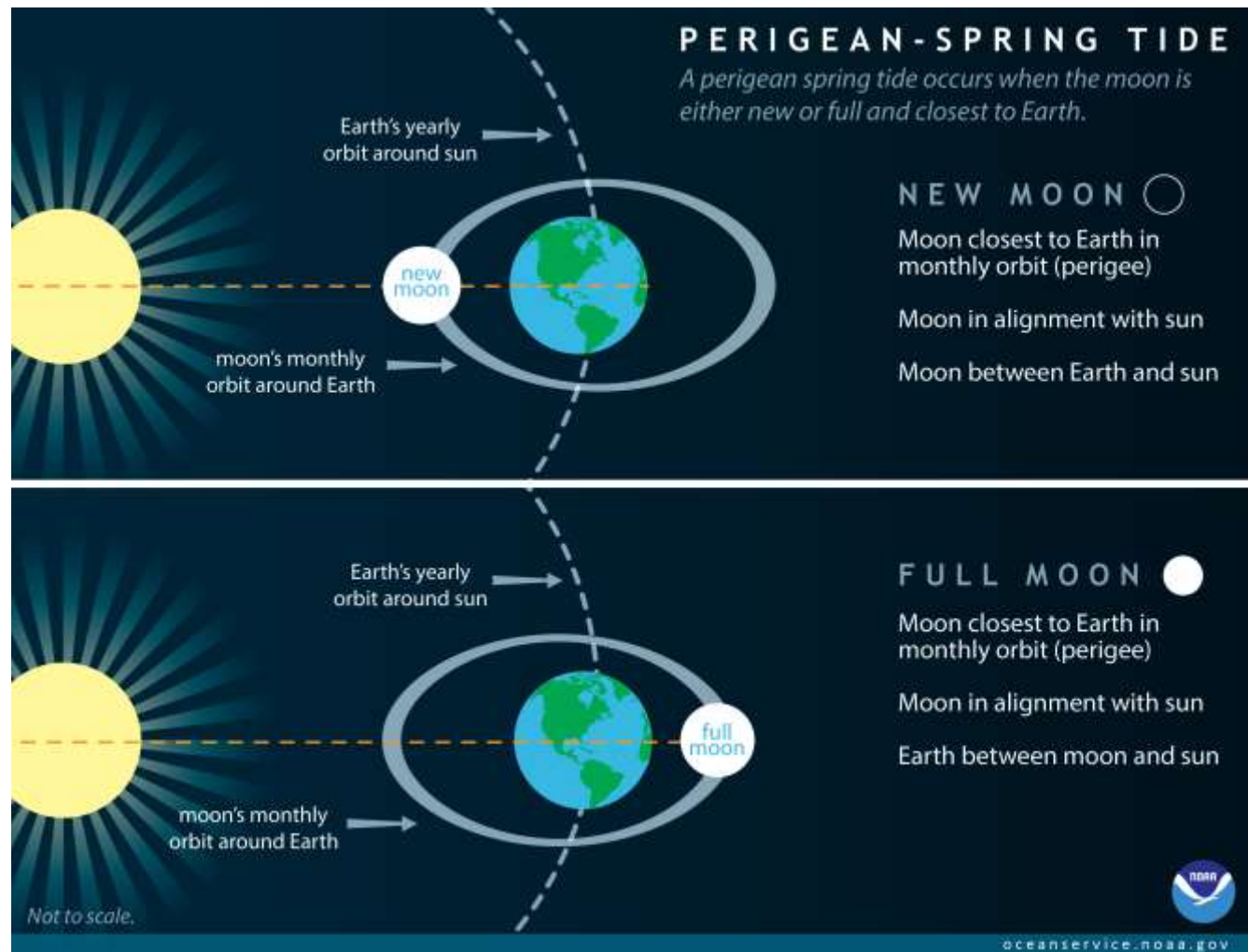
Perigean Tide

- Earth is at the closest to the Sun (Perihelion)
- Moon is located between the Earth and the sun (Perigee)



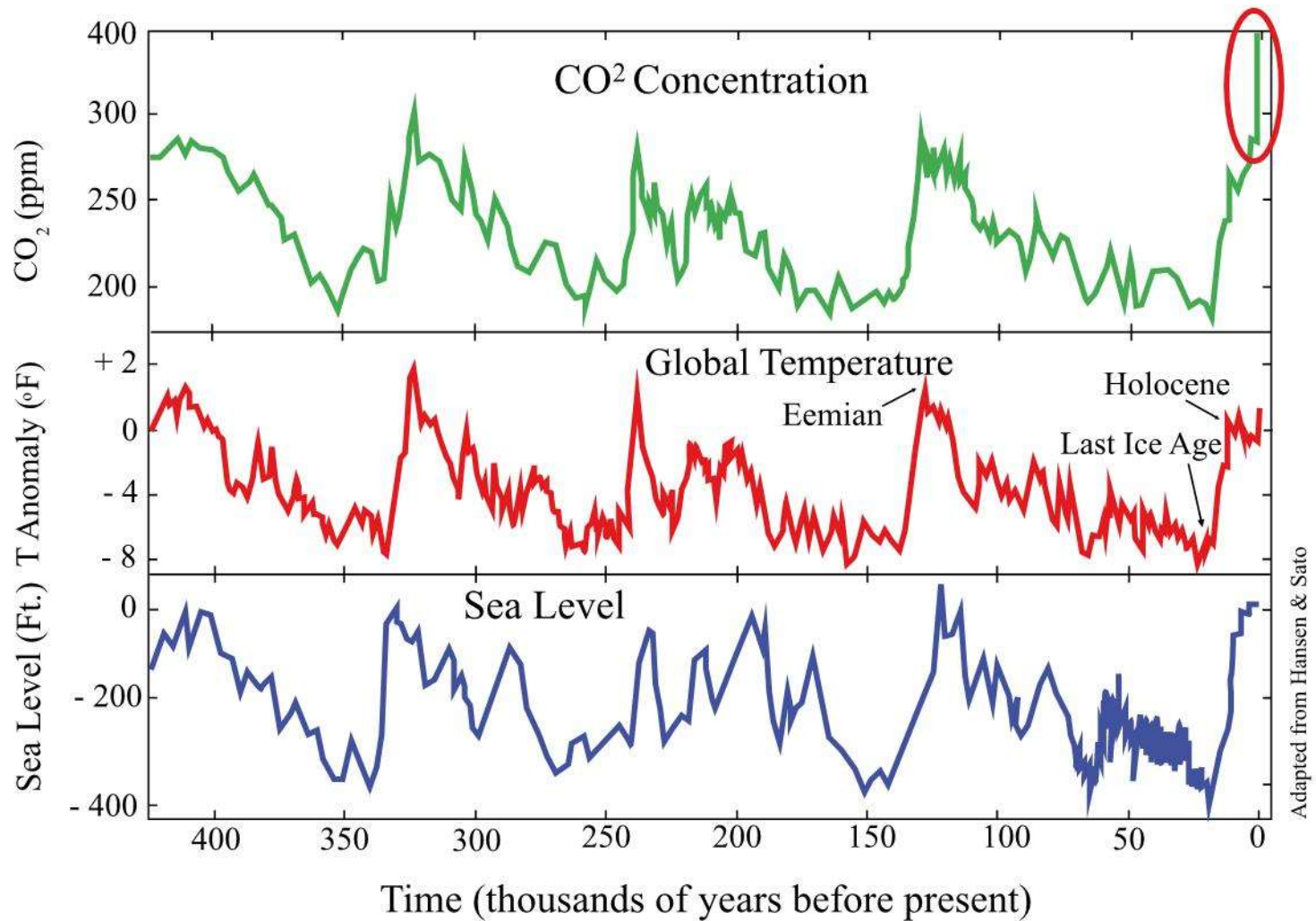
http://oceanservice.noaa.gov/education/tutorial_tides/media/supp_tide06b.html

Multiple Times a Year



<http://oceanservice.noaa.gov/facts/perigean-spring-tide.html>

Climate Change



Nuisance Flooding

- Sunny day flooding
- Increasing frequency of areas wetted during Spring Tides
- King Tide is an indicator of future vulnerability



Direct Marketing

The screenshot shows the Microsoft Outlook interface. At the top, the title bar reads "October 2016 CZ-Mail - Message (HTML)". Below it is a ribbon with tabs for "File", "Message", "McAfee E-mail Scan", and a search bar "Tell me what you want to do". The "Message" tab is active, showing a set of icons for actions like Ignore, Delete, Archive, Reply, Reply All, Forward, Reply & Delete, To Manager, Done, Create New, Move, Assign Policy, Mark Unread, Categorize, Follow Up, Translate, and Zoom. Below the ribbon, the email header shows a profile picture of a person, the date and time "Tue 10/4/2016 11:34 AM", the sender "CZ-Mail@state.ma.us", and the subject "October 2016 CZ-Mail". The "To" field lists "Caufield@bos-mailsec-004.state.ma.us; Caufield, Brian A.". Below the header is an "Action Items" section with a "+ Get more add-ins" link. The main body of the email is titled "Other Items of Interest" and contains two paragraphs. The first paragraph is about "Seeking King Tides Photos" and the second is about the "Ocean Awareness Student Contest".

October 2016 CZ-Mail - Message (HTML)

File Message McAfee E-mail Scan Tell me what you want to do

Ignore Delete Archive Reply Reply All Forward Reply & Delete To Manager Done Create New Move Assign Policy Mark Unread Categorize Follow Up Translate Zoom

Delete Respond Quick Steps Move Tags Editing Zoom

Tue 10/4/2016 11:34 AM

CZ-Mail@state.ma.us

October 2016 CZ-Mail

To Caufield@bos-mailsec-004.state.ma.us; Caufield, Brian A.

Archive Never

Action Items + Get more add-ins

Other Items of Interest

Seeking King Tides Photos - King Tide, the highest tide of the year, is rolling into Massachusetts October 17 through 19. The Massachusetts Bays National Estuary Program, Boston Harbor Now, the New England Aquarium, and the Museum of Science-Boston are teaming up to encourage people to document effects of this natural phenomenon on coastal structures and natural resources with cameras and smartphones. King Tides occur twice a year, when Earth, the moon, and the sun align and maximize gravitational forces to produce extreme tides and currents. October's high tide is expected to be more than 12 feet high in Duxbury and Barnstable, where the typical high tide is between 9 and 11 feet. Extreme high tides illustrate what may become—with sea level rise—the new tidal norm. Head out to the shore to document flooding using CZM's new MyCoast app, which is available for free on Android and Apple devices. See [MyCoast](#) for details. For more information, including a list of the best sites for observing the impacts, visit the [King Tides 2016 website](#).

Ocean Awareness Student Contest - The Bow Seat [2017 Ocean Awareness Student Contest](#) promotes ocean stewardship among middle and high school students and provides cash prizes for winning essays, art, and advocacy. This year's theme, *Ocean Pollution: Challenges & Solutions*, focuses on making meaningful connections between ocean health and human activity. Entries are due by June 19.

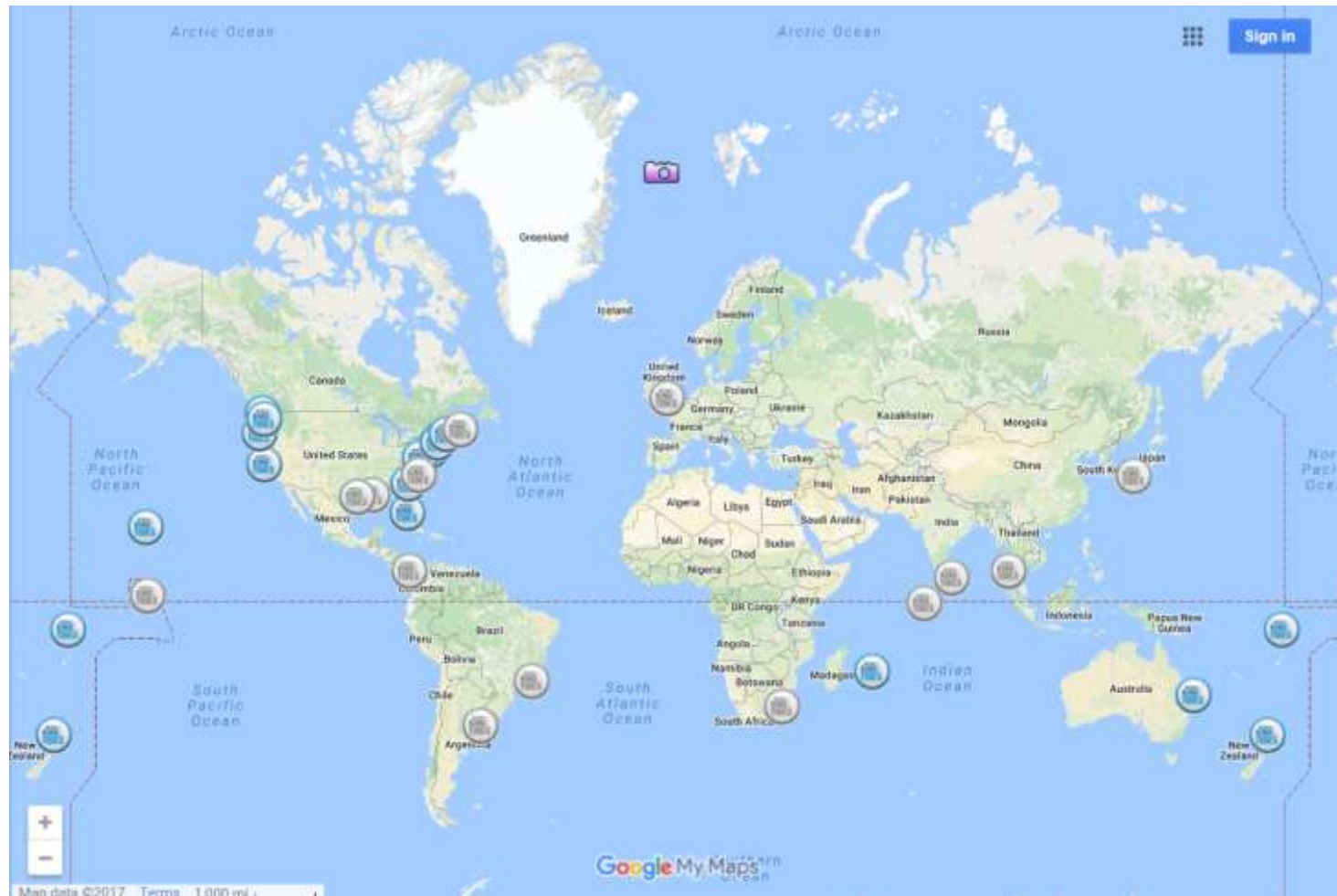
Crowd Sourcing





KING TIDES PROJECT

Snap the shore *See the future*



kingtides.net

Social Media - Facebook



Long Island
Sound Study
@longislandsoundstudy.net



 Like

 Follow

 Share

 ...

Sign Up

 Message

Albums > King tide photos, O...

King tide photos, Oct 2011

16 Photos · Updated 5 years ago

Photo documentation of the Oct 2011 King Tide. More info at:
<http://longislandsoundstudy.net/2011/09/capture-the-king-tide/>



High tide
Oct 20, 2011
5:41pm

Southold beach
Southold, NY







Social Media - Twitter



CA king tides
@CA_king_tides

We encourage Californians to photograph ultra-high [#kingtides](#) to promote awareness about how sea level rise will impact the places that matter most to us.

📍 California
california.kingtides.net

TWEETS	FOLLOWING	FOLLOWERS	LIKES	LISTS
1,768	842	1,127	1,283	2

Tweets Tweets & replies Media

 Pinned Tweet

 **CA king tides** @CA_king_tides · Jan 10
Thank you for adding your [#KingTides](#) photos to our [@Flickr](#) pool so they can be used for science, education, & policy flickr.com/groups/cakingtides...



MyCoast – Massachusetts King Tides



[MA MyCoast](#) [StormReporter](#) [King Tides](#) [Register](#) [Log in](#) [Support](#)

MyCoast: Massachusetts

A project of the [Massachusetts Office of Coastal Zone Management](#)

MyCoast: Massachusetts is a portal for the Massachusetts Office of Coastal Zone Management to collect and analyze pictures and data relating to coastal events. **Information collected through this site is used to visualize the impact of coastal hazards and to enhance awareness among decision-makers and stakeholders.** Scroll down to view existing reports, or use the button below to submit a new report.



Massachusetts MyCoast has 2 Tools Activated



King Tides

Capturing Massachusetts's
Highest Tides



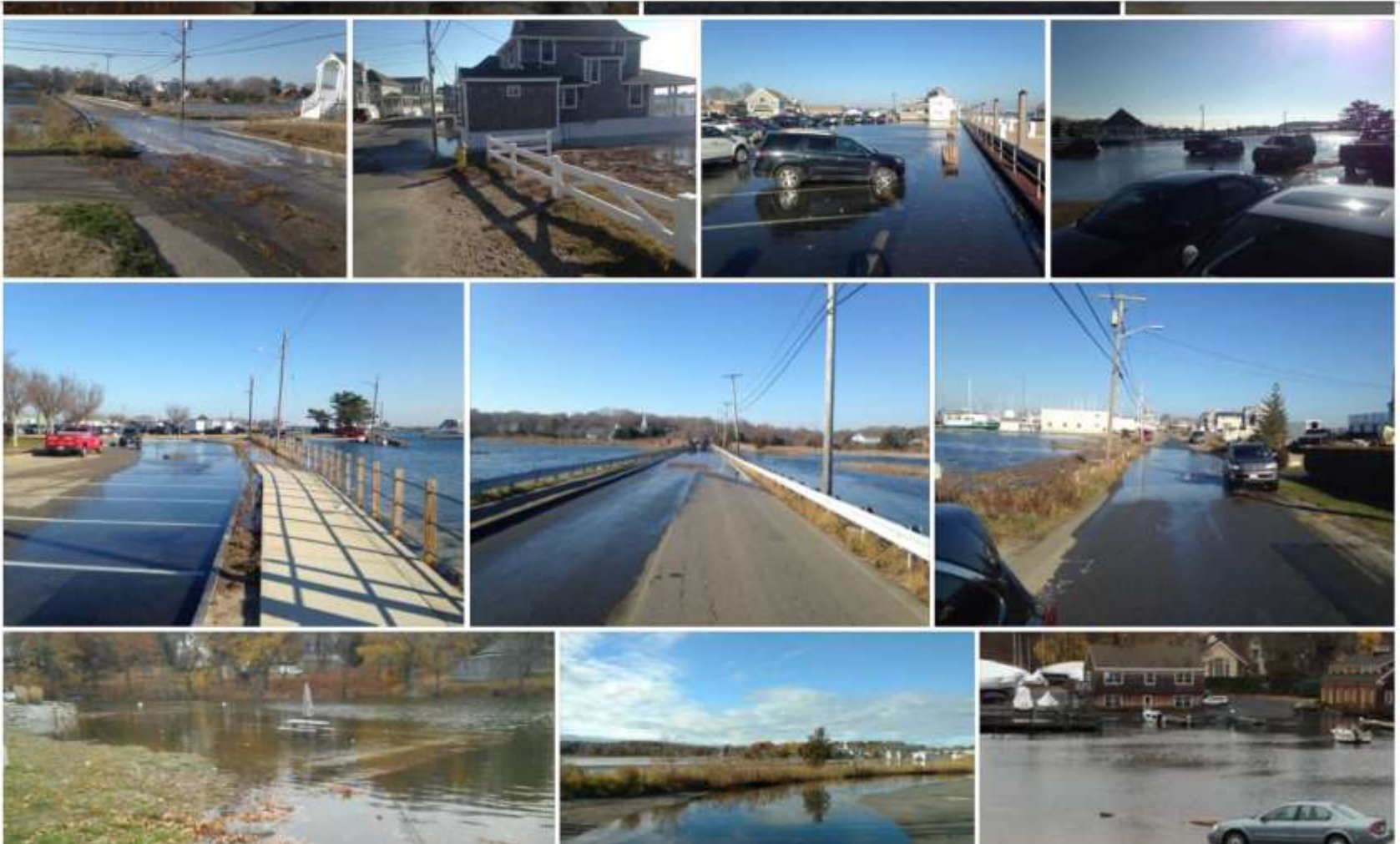
StormReporter

Documenting Storm Damage in
Massachusetts

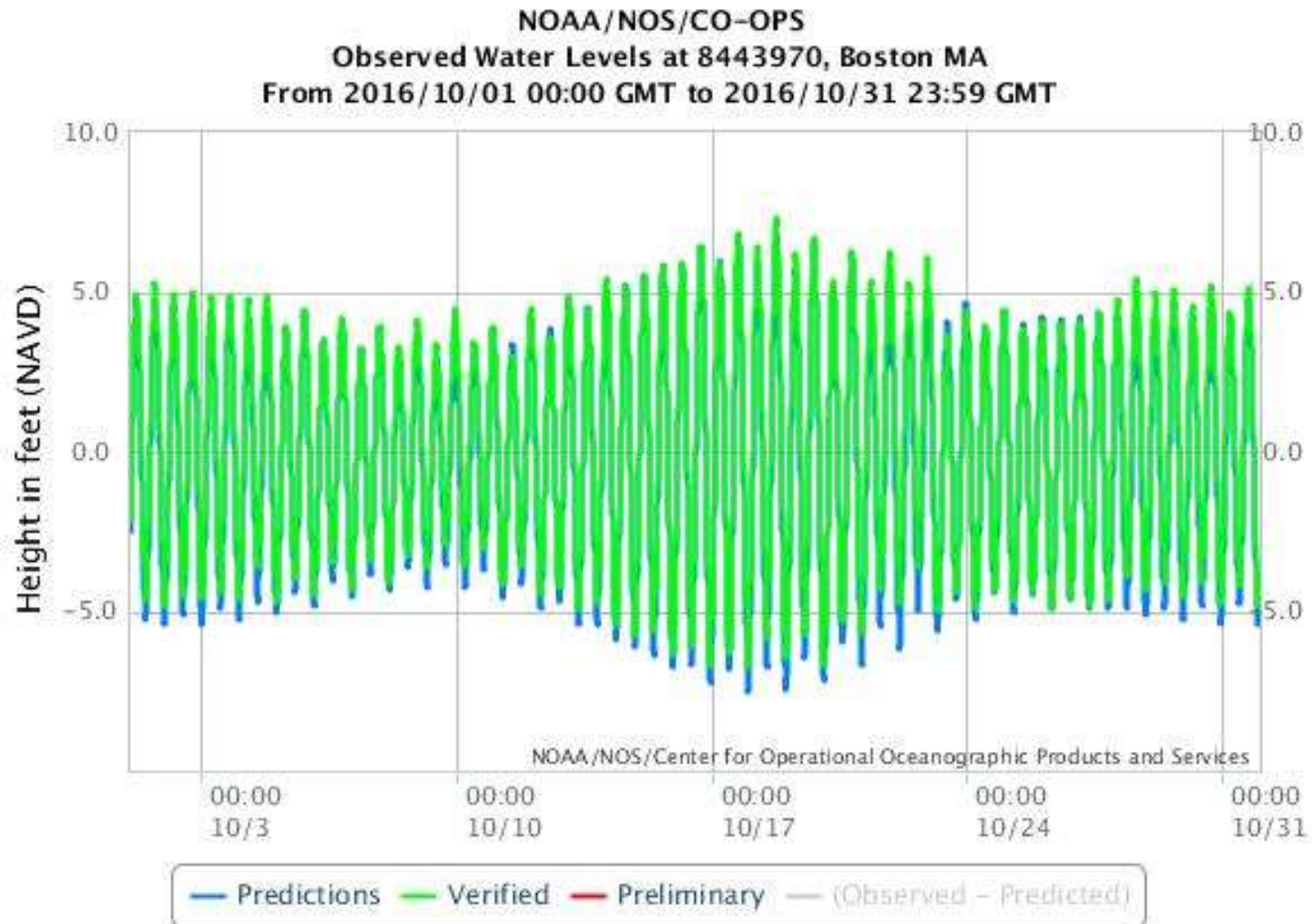
Photos



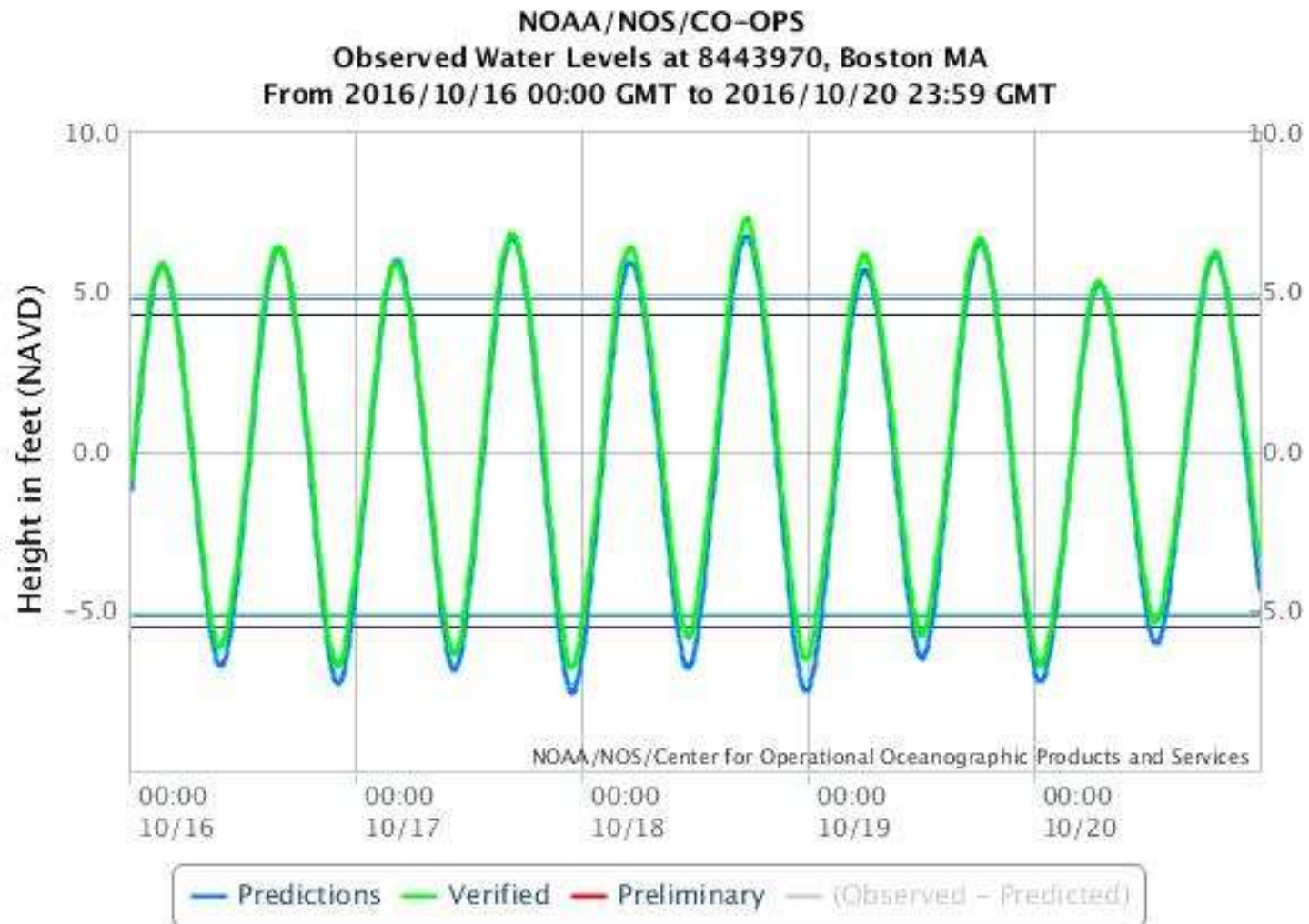
[MA MyCoast](#) [StormReporter](#) [King Tides](#) [Register](#) [Log in](#) [Support](#)

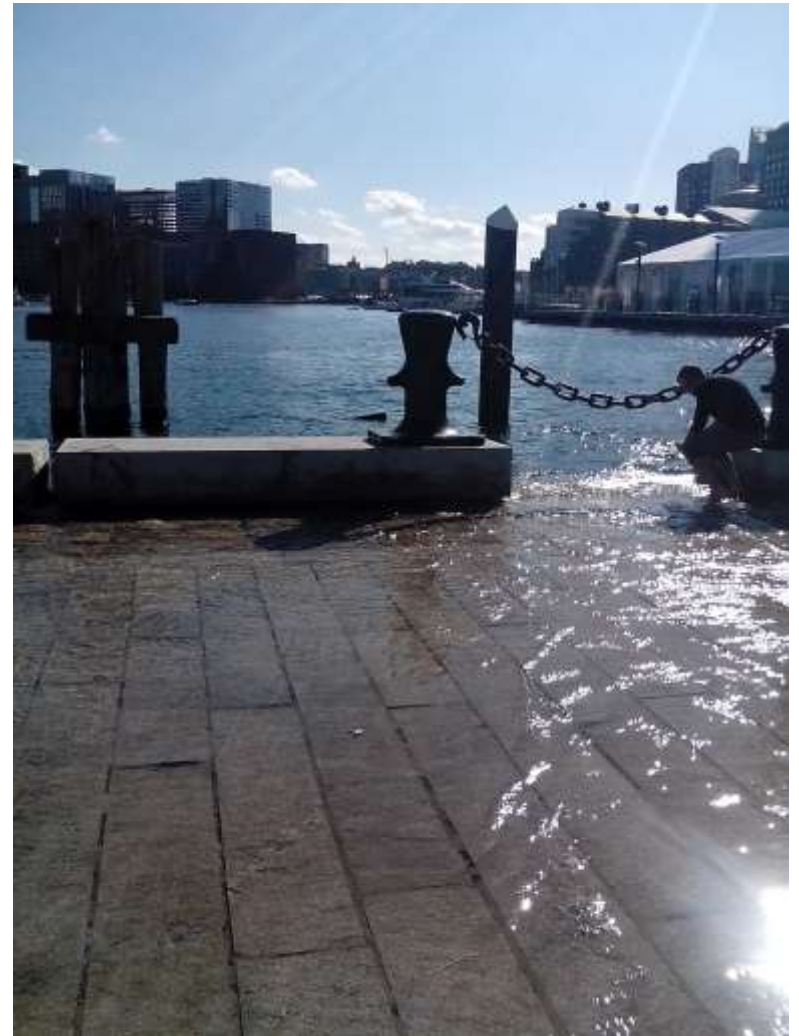


Tides in Boston

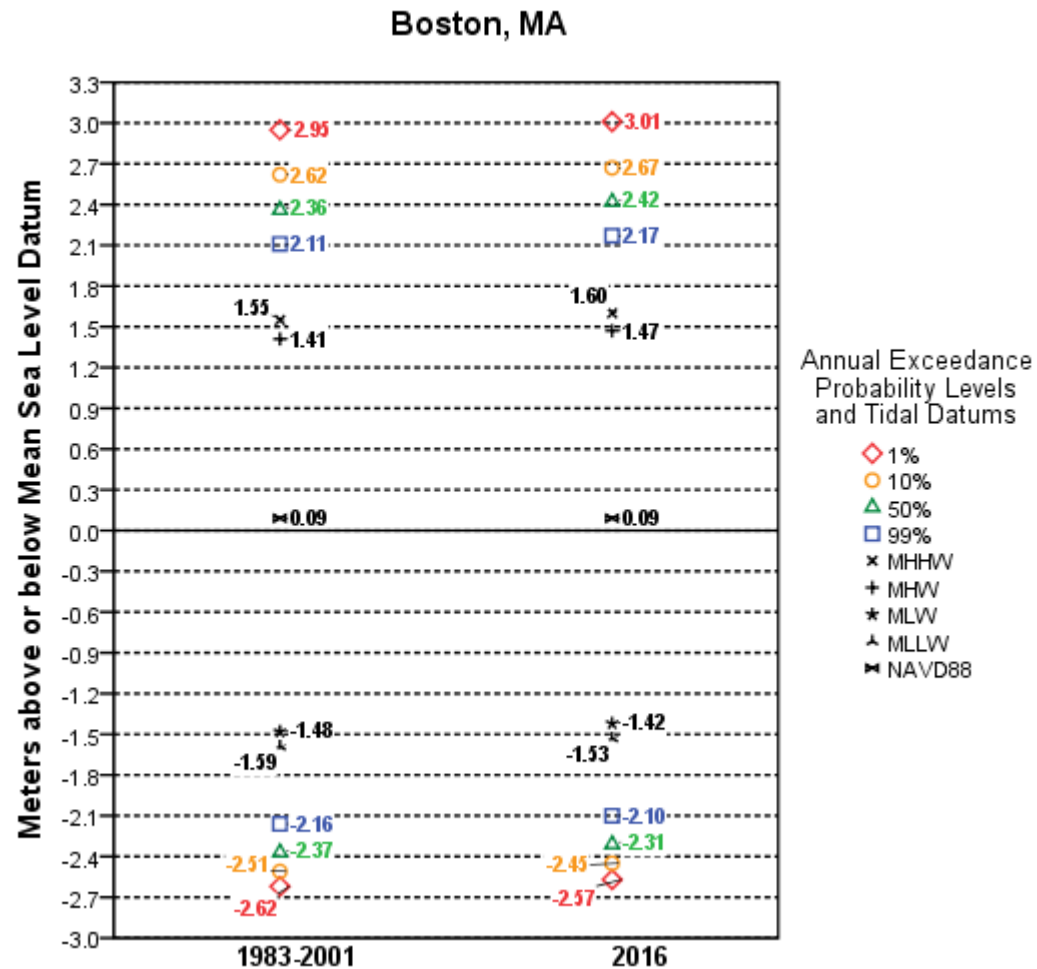


October 2016 King Tide





Extremals in Boston



NOAA Classification of Nuisance Flooding

NOAA Technical Report NOS CO-OPS 073

Sea Level Rise and Nuisance Flood Frequency Changes around the United States



City Dock in Annapolis, Maryland. Photo Credit: Amy McGovern

Silver Spring, Maryland

June 2014



noaa National Oceanic and Atmospheric Administration

U.S. DEPARTMENT OF COMMERCE

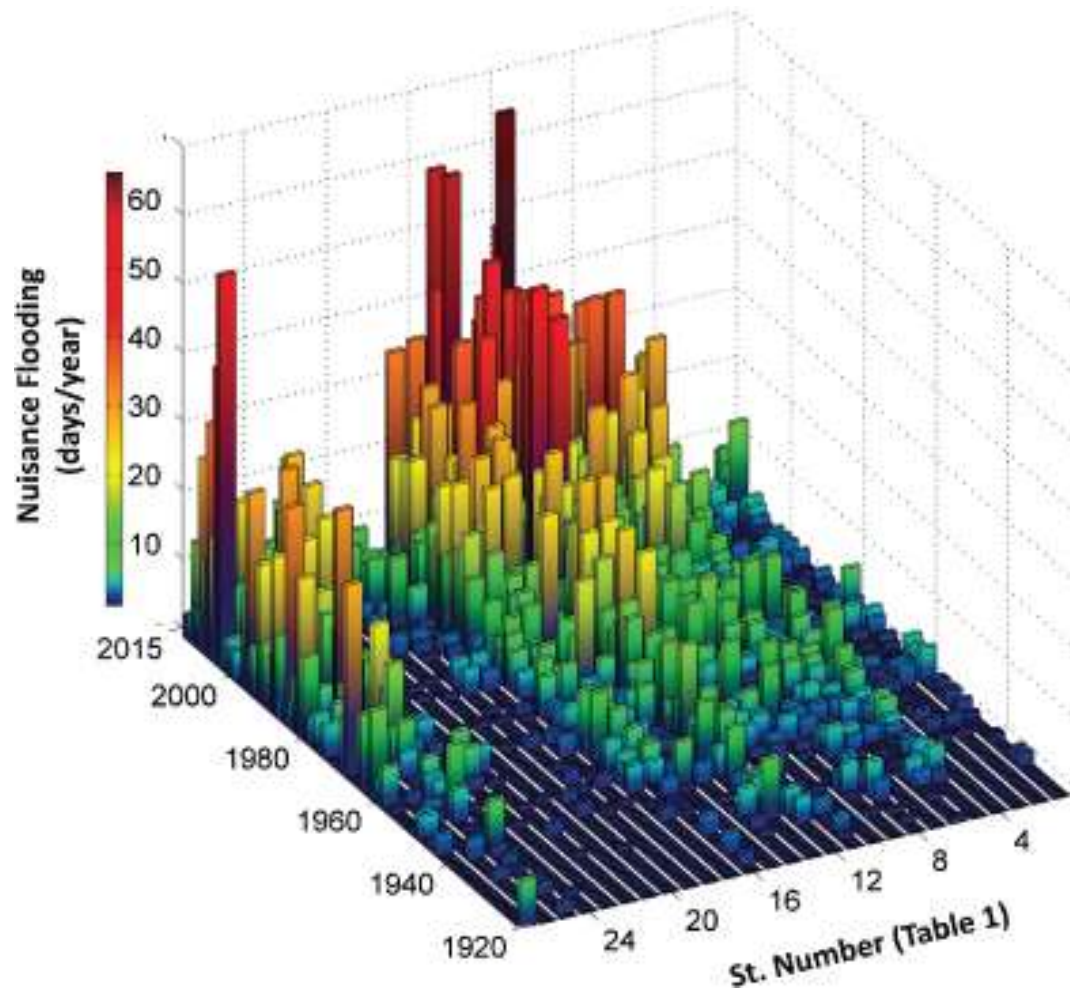
National Ocean Service

Center for Operational Oceanographic Products and Services

Table 1. NOAA water level gauges, location, start of analysis, MSL trend, and nuisance flood level (m)

NOAA Tide Gauge	St. ID	Longitude	Latitude	Analysis Start (years)	MSL Trend (mm/yr)	Nuisance Flood Level (above MHW)
1 Boston, MA	8443970	-71.052	42.355	1921	2.8	0.68
2 Providence, RI	8454000	-71.402	41.807	1938	2.26	0.66
3 New London, CT	8461490	-72.087	41.355	1938	2.57	0.60
4 Bridgeport, CT	8467150	-73.182	41.173	1970	2.87	0.48
5 Montauk, NY	8510560	-73.960	41.048	1947	3.2	0.60
6 Kings Point, NY	8516945	-73.765	40.810	1931	2.52	0.52
7 Battery, NY	8518750	-74.015	40.700	1920	3.15	0.50
8 Bergen Point, NY	8519483	-74.147	40.640	1981	4.93	0.52
9 Sandy Hook, NJ	8531680	-74.030	40.467	1922	4.08	0.45
10 Atlantic City, NJ	8534720	-74.418	39.355	1920	4.19	0.43
11 Cape May, NJ	8536110	-74.940	38.968	1905	4.61	0.38
12 Philadelphia, PA	8545240	-75.142	39.933	1920	3.09	0.49
13 Reedy Point, DE	8551910	-75.573	39.558	1979	3.67	0.42
14 Lewes, DE	8557380	-75.120	36.782	1920	3.46	0.41
15 Cambridge, MD	8571892	-76.068	38.573	1979	3.71	0.45
16 Baltimore, MD	8574080	-76.579	39.267	1920	3.25	0.41
17 Annapolis, MD	8575512	-76.482	38.983	1928	3.51	0.29
18 Washington D.C.	8594900	-77.022	38.873	1924	3.21	0.31
19 Wachapreague, VA	8631044	-75.687	37.607	1978	5.52	0.61
20 Kiptopeke, VA	8632200	-75.988	37.165	1976	3.57	0.48
21 Lewinetta, VA	8635750	-76.464	37.996	1970	5.59	0.46
22 Sewell Point, VA	8638610	-76.330	36.947	1927	4.58	0.53
23 Chesapeake Bay Bridge, VA	8638863	-76.113	36.967	1975	6.04	0.64
24 Duck, NC	8651370	-75.747	36.183	1978	4.58	0.55
25 Beaufort, NC	8656483	-76.670	34.720	1973	2.72	0.29
26 Wilmington, NC	8658120	-77.953	34.227	1935	2.02	0.25
27 Springmaid Pier, SC	8661070	-78.918	33.655	1977	3.62	0.58
28 Charleston, SC	8665530	-79.925	32.782	1921	3.11	0.38
29 Fort Pulaski, GA	8670870	-80.902	32.037	1935	3.01	0.46
30 Fernandina Beach, FL	8720030	-81.465	30.672	1920	2.21	0.59
31 Mayport, FL	8720218	-81.430	30.397	1928	2.43	0.44
32 Key West, FL	8724580	-81.808	24.553	1920	2.38	0.33
33 Naples, FL	8725110	-81.807	26.130	1965	2.34	0.35
34 Apalachicola, FL	8728690	-84.982	29.727	1976	1.77	0.42
35 Panama City, FL	8729108	-85.667	30.152	1973	1.57	0.35
36 Bay Waveland, MS	8747437	-89.325	30.325	1978	3.96	0.45
37 Sabine Pass, TX	8770570	-93.870	29.730	1981	5.49	0.58
38 Galveston, TX	8771510	-94.788	29.385	1957	6.61	0.60
39 Port Isabel, TX	8779770	-97.215	26.060	1944	3.79	0.34
40 La Jolla, CA	9410230	-117.257	32.867	1924	2.01	0.51
41 San Francisco, CA	9414290	-122.466	37.806	1920	2.00	0.35
42 Humboldt Bay, CA	9418767	-124.217	40.767	1977	3.93	0.56
43 Toke Point, WA	9440910	-123.967	46.707	1972	0.42	0.63
44 Seattle, WA	9447130	-122.339	47.603	1920	2.24	0.65
45 Honolulu, HI	9612340	-157.867	21.307	1920	1.24	0.22

Nuisance Flooding Days Across NOAA Tide Gages

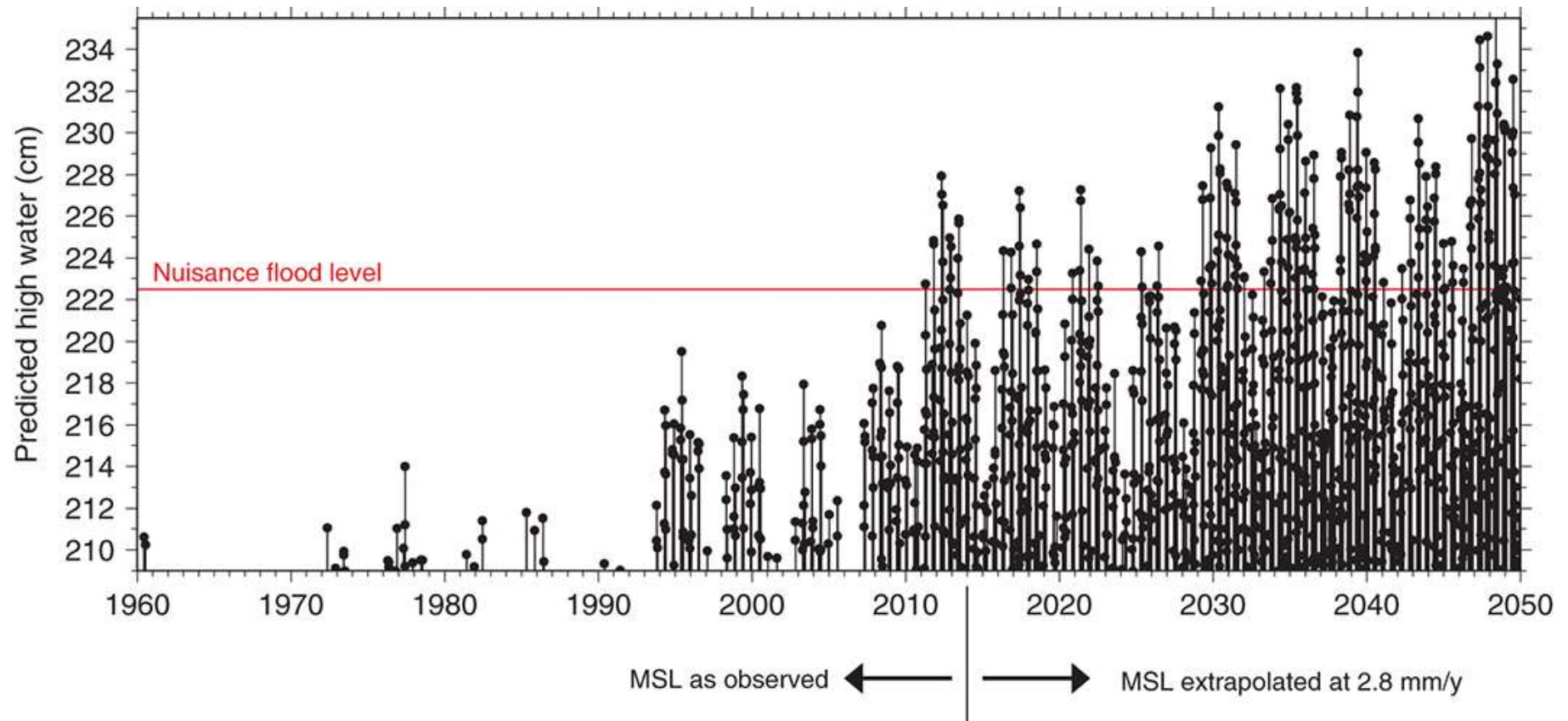


Earth's Future

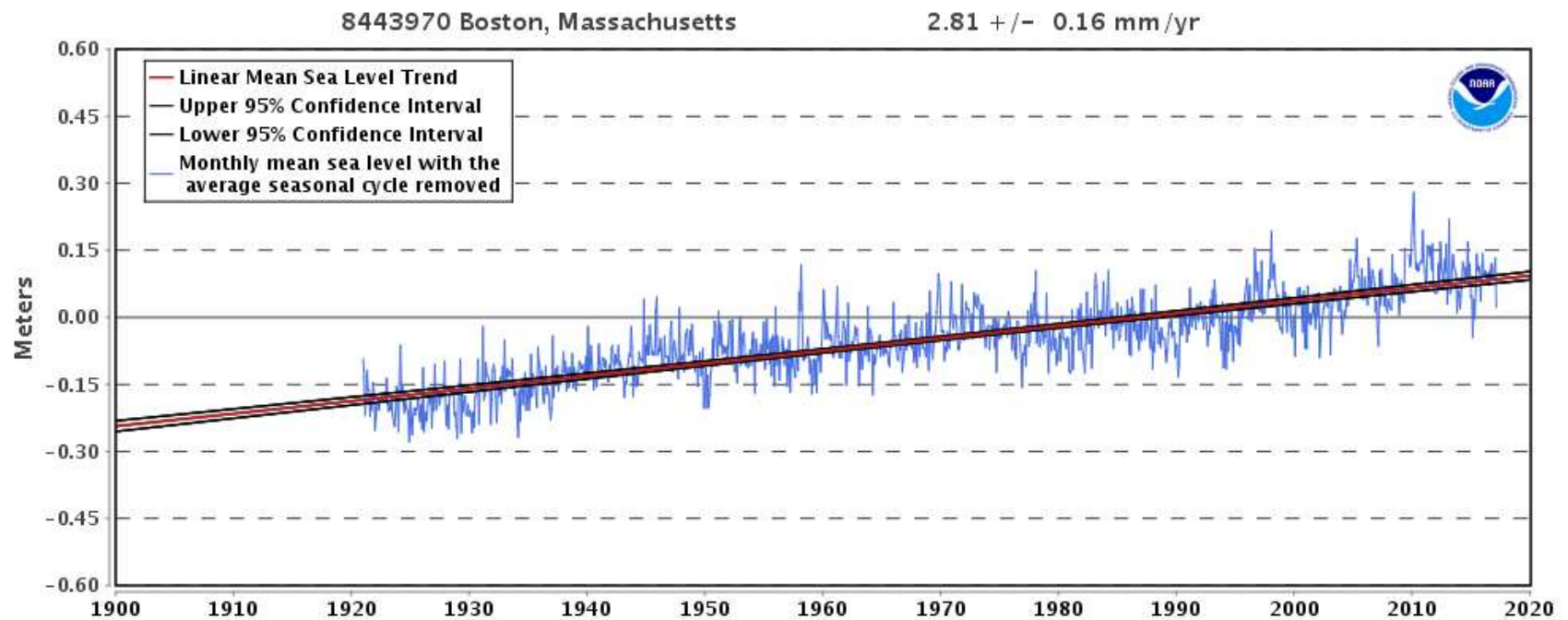
Volume 2, Issue 12, pages 579-600, 18 DEC 2014 DOI: 10.1002/2014EF000272

<http://onlinelibrary.wiley.com/doi/10.1002/2014EF000272/full#eft254-fig-0003>

Future Nuisance Flooding at Boston Caused by Astronomical Tides alone



NOAA Sea Level Rise Trend





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