

## Hawai'i and Pacific Islands King Tides Project - Summer 2017 Recap

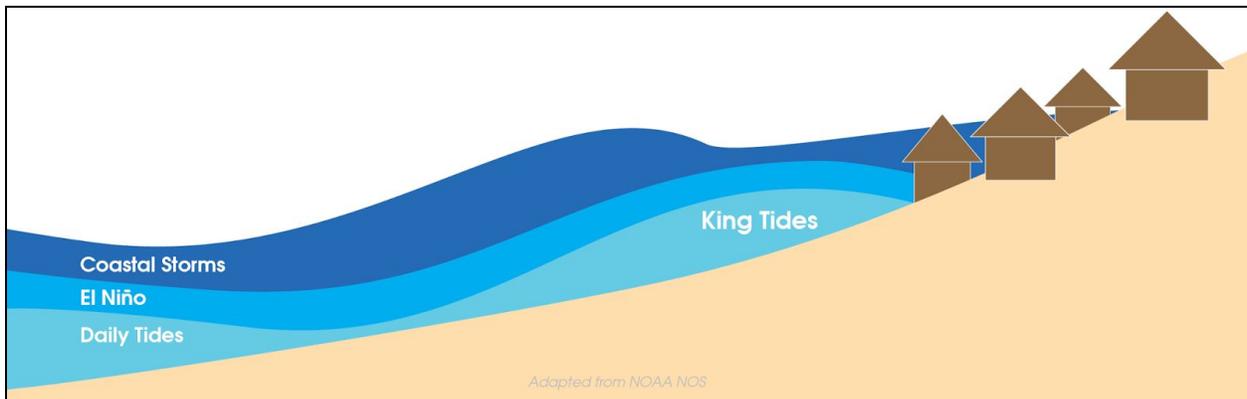
### King Tides Project Testimonial

*Citizen Scientist, dataset user, patogodfrey: "This campaign has been a success! The first round, I was telling folks what a king tide was. This third round, everyone who saw me taking pictures told ME about king tides! Lots of folks are now aware of the king tides!"*



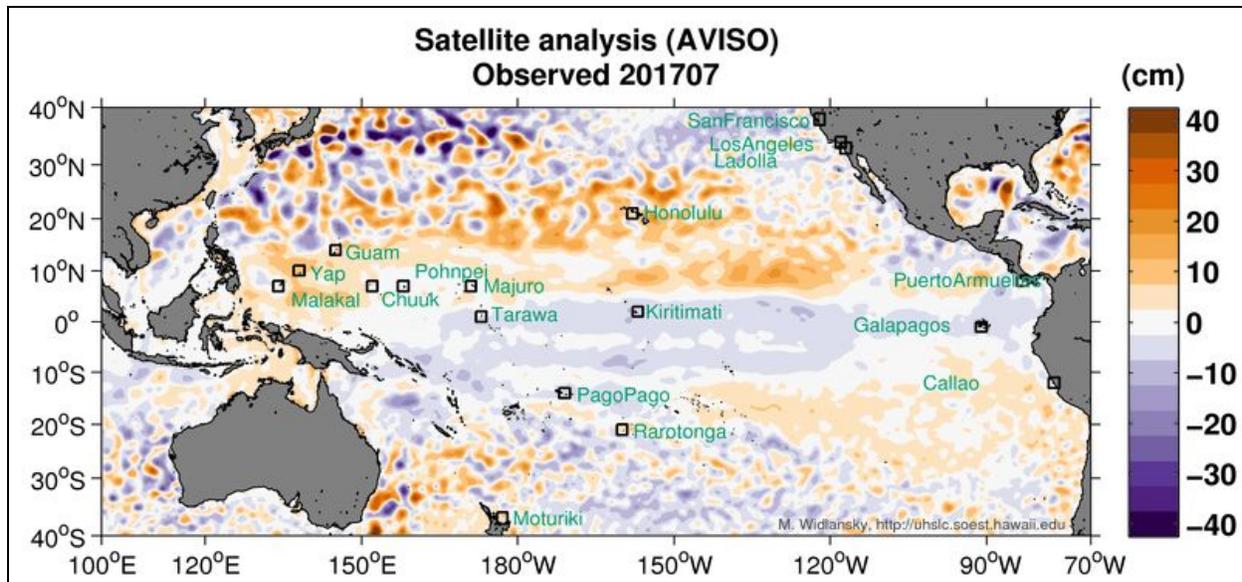
*Collage of June 2017 King Tides photo records. Top row (L-R): Mapunapuna, O'ahu; Kenolio Beach Park, Kihei, Maui; Pago Plaza, Pago Pago, American Samoa. Bottom row (L-R): Nawiliwili Small Boat Harbor, Kaua'i; Liliuokalani Gardens, Hilo, Hawai'i; Mapunapuna, O'ahu; Waikiki, O'ahu (Images credit: Hawai'i Sea Grant King Tides Project).*

August marks the close of our summer King Tides season in the Hawaiian Islands. Across the state, we typically see our King Tides - the highest astronomical tides of the year - the few months around the summer and winter solstices. But what is this extreme water level we have been observing this year? And what to make of King Tides anyway?



*Contributors to coastal water levels. Adapted from NOAA National Ocean Service: "Coastal Flooding in California."*

For two years the [University of Hawai'i Sea Grant College Program](#) has been leading a citizen science program through its [Center for Coastal and Climate Science and Resilience](#), supported by research and forecast tools out of the University of Hawai'i at Mānoa's School of Ocean and Earth Sciences and Technology (SOEST), namely the [UH Sea Level Center](#), [UH Pacific Island Ocean Observing System](#) (PacIOOS), and the [UH Coastal Geology Group](#). This season highlighted a need to coordinate and communicate within UH to better serve our coastal communities and planners and decision makers.



"Above-normal sea levels continue around the Hawaiian Islands... The Honolulu tide gauge anomaly was +20 cm during April, +17 cm during May, +9 cm during June, and +6 cm during July." University of Hawai'i Sea Level Center, Sea Level Forecasts: <http://uhslc.soest.hawaii.edu/sea-level-forecasts/>.

Using NOAA's water levels display for the [Honolulu Harbor tide gauge](#), we see peak monthly observed water levels from April-August 2017:

- April 29: Predicted - 2.169 ft; **Recorded - 3.091 ft**; Residual - 0.92 ft.
- May 26: 2.455 ft; **3.117 ft**; 0.66 ft
- June 23: 2.583 ft; **3.186 ft**; 0.6 ft
- July 21: 2.542 ft; **2.858 ft**; 0.32 ft
- \*August 20: 2.352 ft; **3.32 ft**; 0.97 ft (\*preliminary/unverified data)

So, the water levels we are seeing are really, "King Tides +," where the "+" is the eddies and other oceanographic and climatic variability, plus underlying climate change induced sea-level rise. So why have we had elevated water levels? It is an unusual combination of:

- Pacific-wide variability associated with the Pacific Decadal Oscillation and El Niño
- Ocean eddies with high centers moving through the islands
- Global sea-level rise due to climate change

Further exacerbated by:

- Seasonal highest high tides (“King Tides”)
- Wave action including potential swells or storm surge.

### What caused high sea of April 2017?

–Relative to current tidal epoch

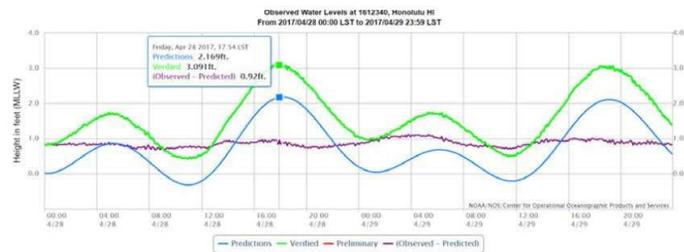
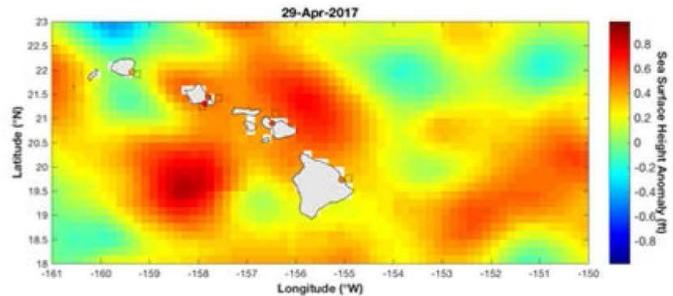
- 20% sea-level rise
- 23% ocean circulation
- 40% ocean eddies
- 17% inverse barometer

–Relative to 1950

- 34% sea-level rise
- 19% ocean circulation
- 33% ocean eddies
- 14% inverse barometer

–Relative to 1910

- 45% sea-level rise
- 16% ocean circulation
- 27% ocean eddies
- 11% inverse barometer



Mark Merrifield, PhD, Director, UH Sea Level Center

*Apportionment of relative causes of high water level observed in April 2017, and over multiple time scales. University of Hawai'i Sea Level Center, Dr. Mark Merrifield*

And though a main aim of our program is to engage in future looking sea level rise adaptation, these events caused problems for many today. Narratives from this season include: a recently reconstructed fish pond wall being overtopped and damaged by the ocean; monk seal habitat migrating inland onto and causing traffic along a coastal highway; harbor piers fully submerged for hours at a time; evening fireworks displays being cancelled; inundation of coastal residential and beach park recreation areas; and businesses deciding to close both temporarily and permanently due to recurring flooding.

Planners and community members have access to these tidal data and water level forecast resources. Hawai'i Sea Grant used the following to educate itself and communicate what to anticipate each of the past monthly peak high tide periods:

- National Oceanic and Atmospheric Administration (NOAA) Tide Predictions for Hawai'i and the Pacific: [https://tidesandcurrents.noaa.gov/tide\\_predictions.html](https://tidesandcurrents.noaa.gov/tide_predictions.html)
- NOAA Sea Level Rise and Coastal Flooding Impacts Viewer: <https://coast.noaa.gov/slr/>
- UH Sea Level Center, Sea Level Forecasts: <http://uhslc.soest.hawaii.edu/sea-level-forecasts/>
- PacIOOS 6 Day High Sea Level Forecast: <http://www.pacioos.hawaii.edu/shoreline-category/highsea/>
- PacIOOS Wave Run-Up Forecast: <http://www.pacioos.hawaii.edu/shoreline-category/runup/>

- NASA El Nino/La Nina Watch Data:  
<https://sealevel.jpl.nasa.gov/science/elninopdo/latestdata/>

A major message, however, is that the sea level is rising. Per Act 83 (2014), "Hawai'i Climate Adaptation Initiative," by the end of 2017 the Hawai'i Department of Land and Natural Resources Office of Conservation and Coastal Lands will provide the legislature with a *Sea Level Rise Vulnerability and Adaptation Report*, detailing new and more Hawai'i-specific coastal hazards and sea-level rise data, the vulnerabilities and consequences of those coastal hazards, and recommendations for sea level rise adaptation ([Hawai'i Climate Adaptation Portal](#)).

Dr. Mark Merrifield in *Voice of the Sea*, Season 4, Episode 9, "King Tides"  
(<http://mse.seagrant.soest.hawaii.edu/voice-sea>)

*"[I]t takes a King Tide to get our attention on one of these [flooding] events - and that's why King Tide is being associated with the flooding - **but it's really the sea level that's the problem.** And pretty soon it won't be the King Tide that we're worried about, but the spring tides, and then every high tide."*

*"We're getting into a place now or a time now where sea level is high enough where we're kind of reaching a tipping point, where these clear day flood events just due to the tide will start to become more prevalent. And so... I'll hear questions like, 'Well what's happened to the tide? Is the tide changing in some way?' **It's not the tide that is changing, it's the sea level that's going up and adding onto that.**"*

We know that sea level is rising in Hawai'i and across the Pacific. In addition, the existing problem of chronic erosion, which causes beach loss, damages homes and infrastructure, and endangers critical habitat, will likely worsen with sea-level rise. We are particularly interested in documenting those higher tidal and sea level events as representation of what our coasts may look like on a more regular basis in the future.

The challenges of sea-level rise are real and daunting. Environmental experience and photographic documentation of high water level events is intended to raise awareness of the present, near-term, and ultimate impacts to our coastal environments and infrastructure. The hard evidence is the necessary support for future research and policy development, and decisions related to sea-level rise risk and vulnerability and climate change adaptation.

#### King Tides Project Testimonial

*Researcher and PhD candidate, Shellie Habel: "The photos are extremely useful for researchers modeling sea level rise induced flooding. The best way to validate these kinds of models is to compare the output with documented flooding. For example, my research involves constructing models that simulate groundwater inundation caused by changes in sea level and variations in the tide. To validate the model, I simulate a specific event, such as a king tide and/or anomalously high sea level, like the event observed May of this year (2017). I then use photos taken by citizen scientists to make sure the simulations are accurate. By identifying match and mismatch in observed and simulated flooding, I can build a highly robust model in which higher sea levels can be simulated with increased confidence that the results are accurate."*

There are four main aims of the Hawai'i and Pacific Islands King Tides Project:

1. Educate and train citizen scientists on coastal processes and coastal hazards, including sea-level rise.
2. Observe and document water levels during King Tides.
3. Discuss how to prevent, withstand, adapt to, and recover from coastal hazards.
4. Apply citizen scientist-generated data towards research, policy, and climate change adaptation.

This season was successful in meeting aims 1 and 2, though we are quickly seeing the interest and urgency to engage fully in aims 3 and 4 from government agencies, businesses, and community members.

<u>Sea Level Rise Projections and Tidal Flooding Events</u>	
<b>2017:</b>	3 consecutive months HNL tide gauge recorded a +3.0 ft.
<b>2030:</b>	<u>3-4 days</u> (every King Tide)
<b>2050:</b>	<u>25-44 days</u> (every spring tide, i.e., new/full moon)
<b>2070:</b>	<u>92-218 days</u> (every other high tide)
Dr. Mark Merrifield, University of Hawai'i Sea Level Center	

As of August 1, 2017, more than 170 individual citizen scientists have contributed nearly 2,400 photographic records. From July 2015-April 2017, 510 photo records were contributed. From April-August 2017, an additional 1888 photo records were submitted - a 270 percent increase. This is likely attributable to expanded outreach and education, as well as, increased media coverage due to the anomalous stacking adding up for record-setting observed water levels.

For more information on this program, to access the public dataset and interactive online map, and learn how to participate and contribute as a citizen scientist, please visit the project webpage - [www.PacificIslandsKingTides.org](http://www.PacificIslandsKingTides.org). We look forward to seeing you out along the shore and mahalo for your participation and contributions!

[www.PacificIslandsKingTides.org](http://www.PacificIslandsKingTides.org)  
[KingTide@hawaii.edu](mailto:KingTide@hawaii.edu)



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COASTAL & CLIMATE  
SCIENCE & RESILIENCE



-**Matthew Gonser, AICP**, is an Extension Agent with the University of Hawai'i Sea Grant College Program (Hawai'i Sea Grant). He holds one of two Director-At-Large positions with APA-HI. Hawai'i Sea Grant supports an innovative program of research, education and extension services, directed to the improved understanding and stewardship of coastal and marine resources of the state, region, and nation (<http://seagrantsoest.hawaii.edu/>).