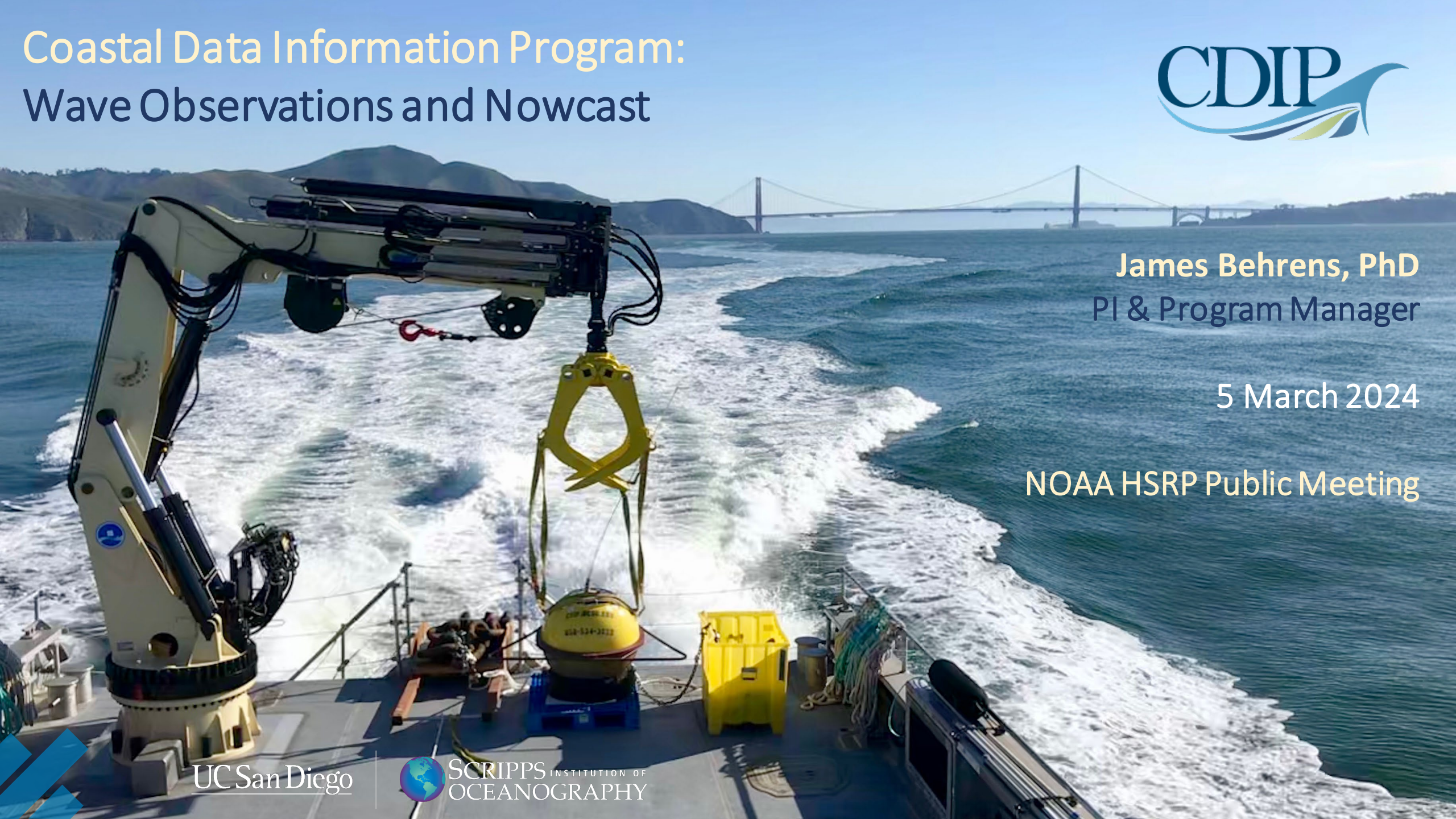
Coastal Data Information Program:
Wave Observations and Nowcast



James Behrens, PhD
PI & Program Manager

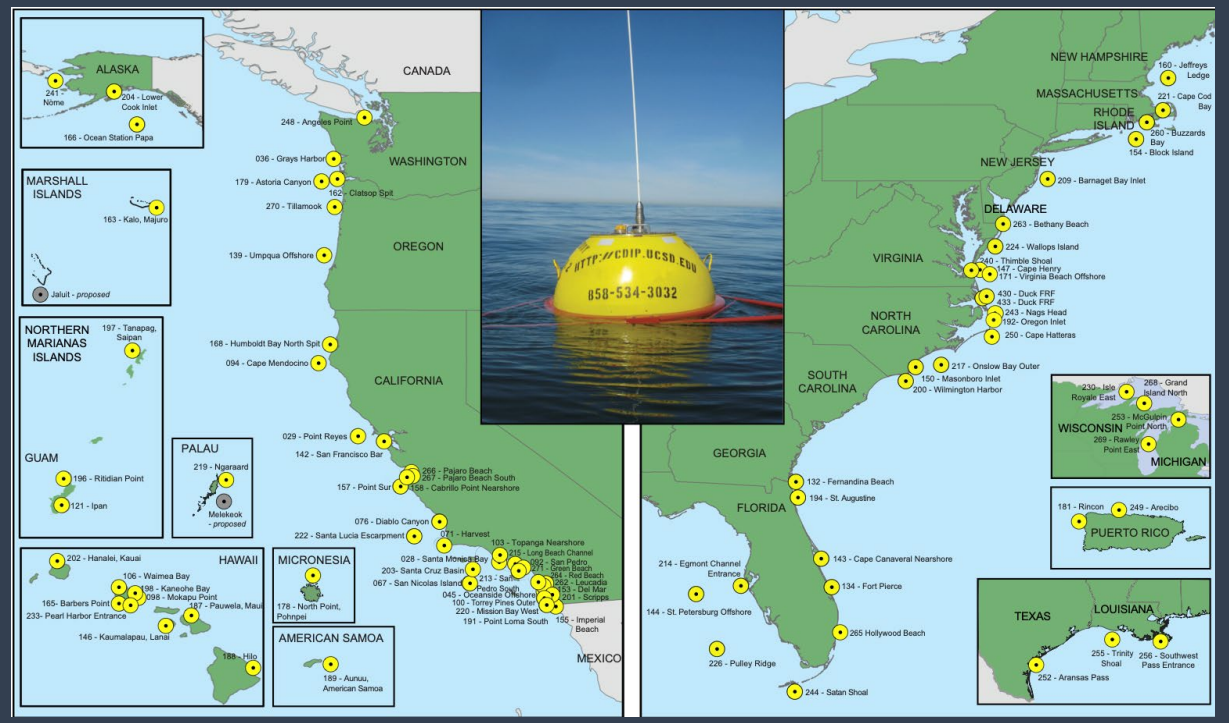
5 March 2024

NOAA HSRP Public Meeting

UC San Diego | SCRIPPS INSTITUTION OF OCEANOGRAPHY

COASTAL DATA INFORMATION PROGRAM

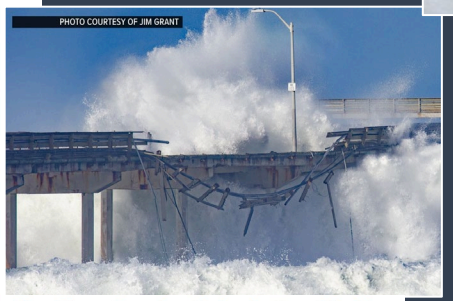
- Established 1975
- ~ 90 wave buoy stations worldwide, ~25 in California
- 15-person CDIP Waves operations team
- Major Funding from:
  - US Army Corps or Engineers
  - California State Parks
  - Navy
- Partners:
  - ***NOAA IOOS Regional Associations***
  - ***Ports and Industry: Marine Exchange, Marathon, Chevron, Columbia River Bar Pilots***
  - DOE National Renewable Energy Laboratory



Coastal Data Information Program

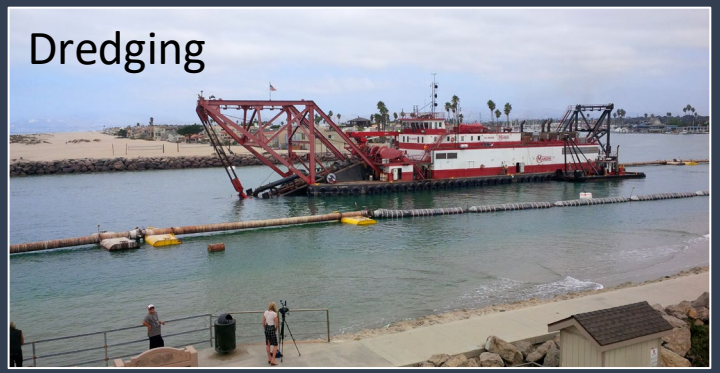
- Precision wave monitoring nationwide
- California wave model
- *Coastal Engineering, Inundation, Erosion*
- *Real Time Conditions*
- *Maritime Safety*
- *National Security*
- *Climate Record*

Severe coastal erosion, Ocean Beach at Sloat, San Francisco, California. Photo source: ©© *Shields*



San Diego beaches being battered by big waves and king tides

By CBS News 8 Team Connect

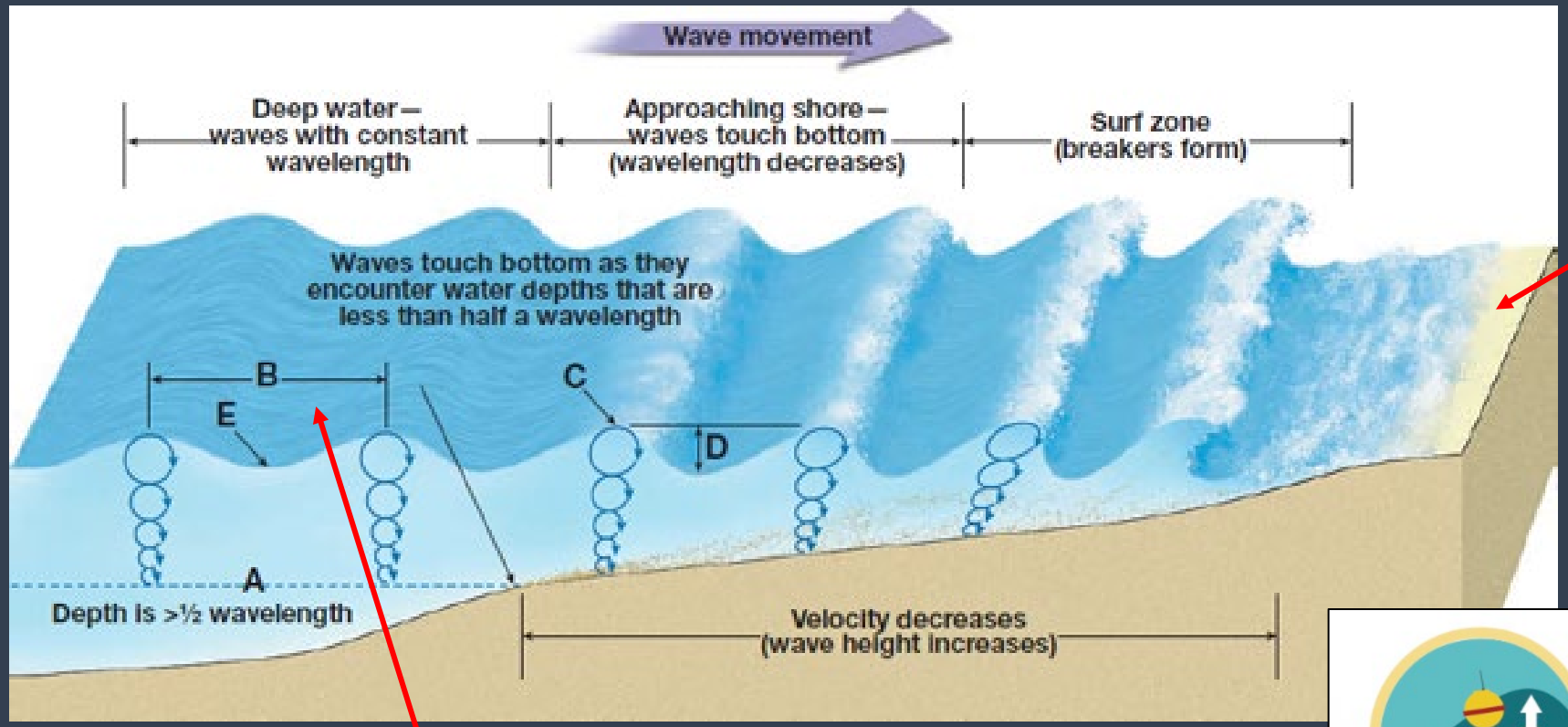


Datawell BV
oceanographic instruments

Waverider buoys

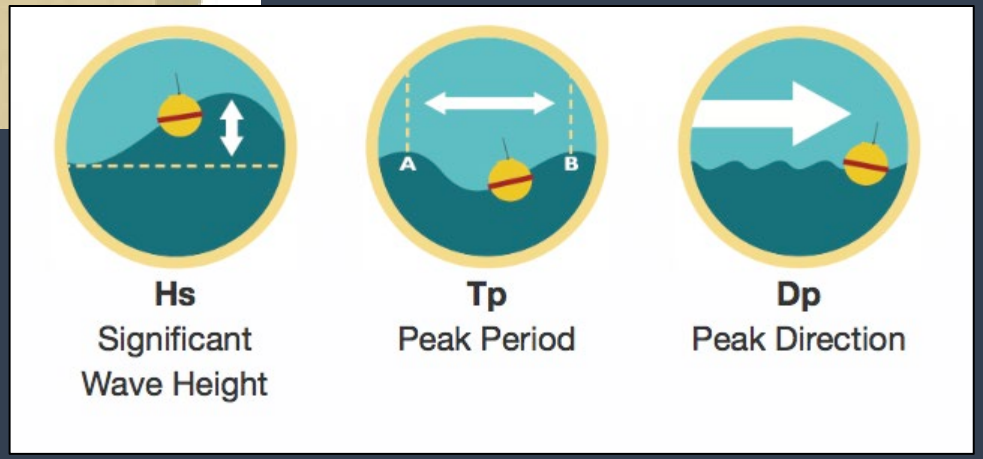
- Wave Energy Spectrum
- Directional Spectrum
- XYZ (E,N,V) Displacements
- Sea Surface Temperature
- *Sea Surface Currents*
- *Air Temperature*

Wave motion

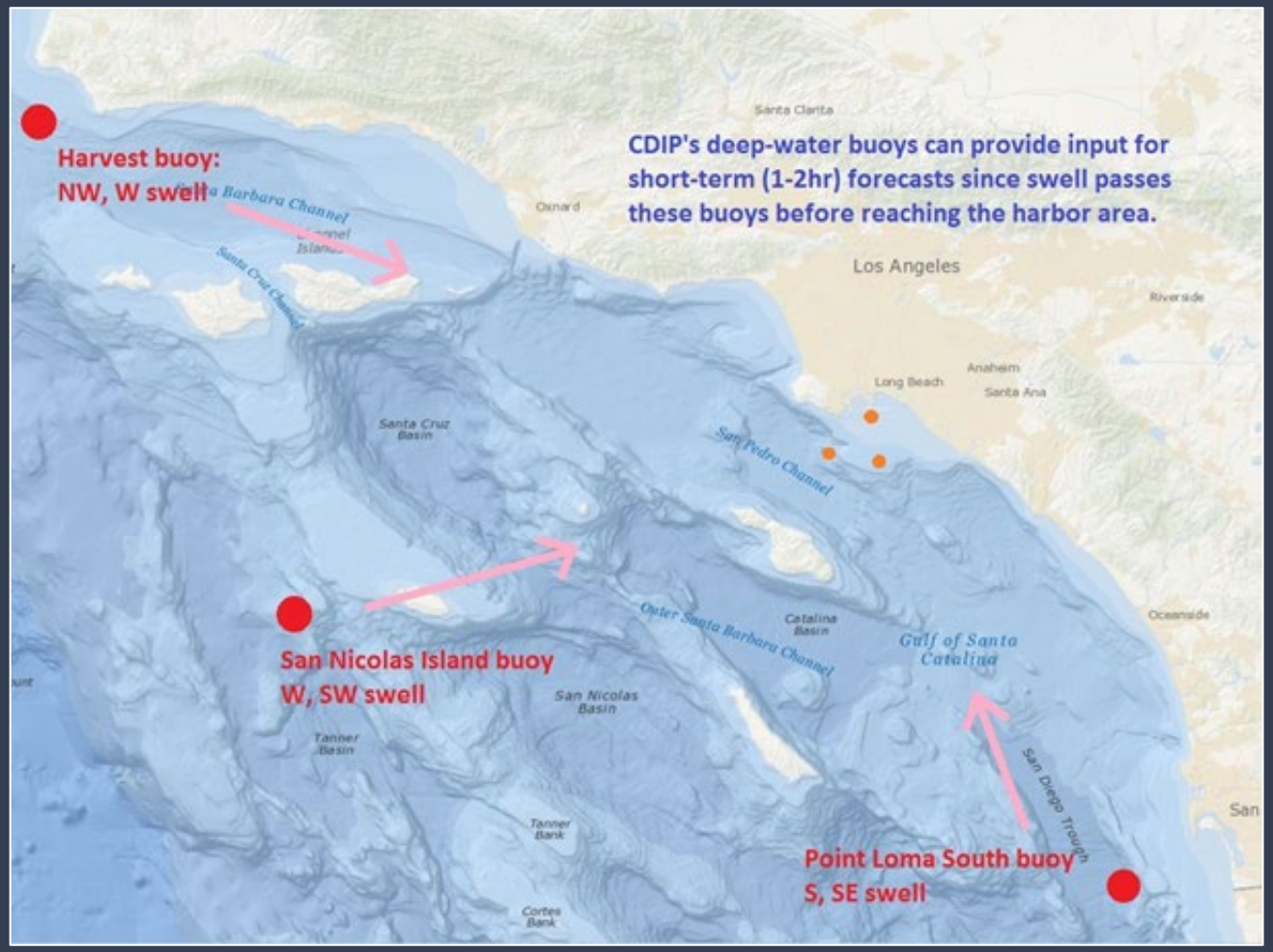


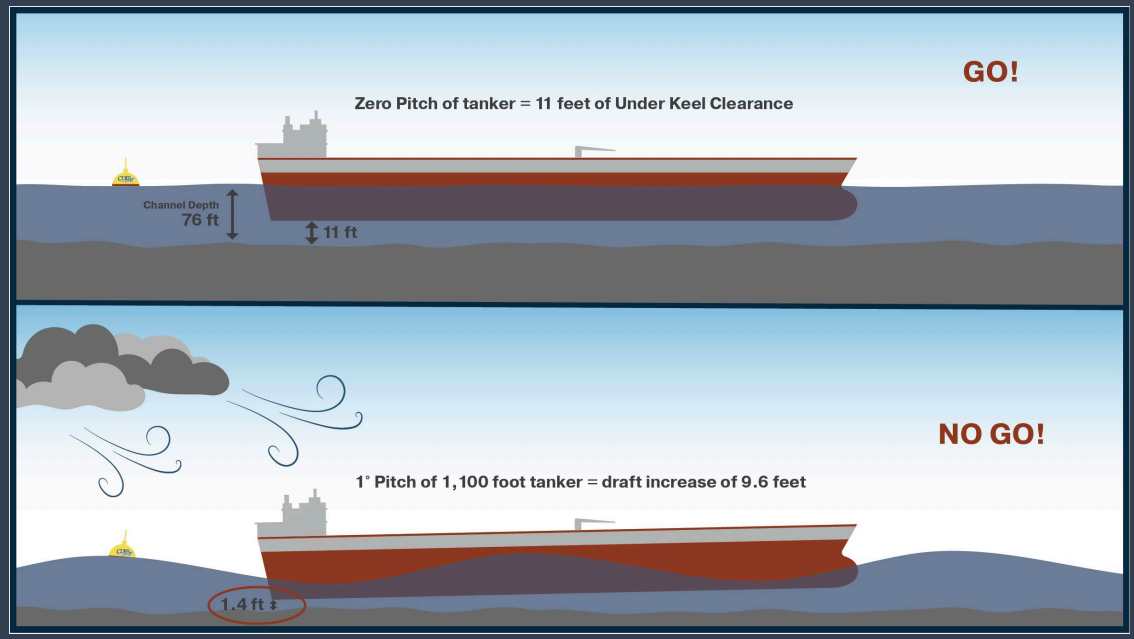
Wave runup,
Erosion,
Infrastructure risk

Maritime conditions



Under-Keel Clearance: Port of Long Beach

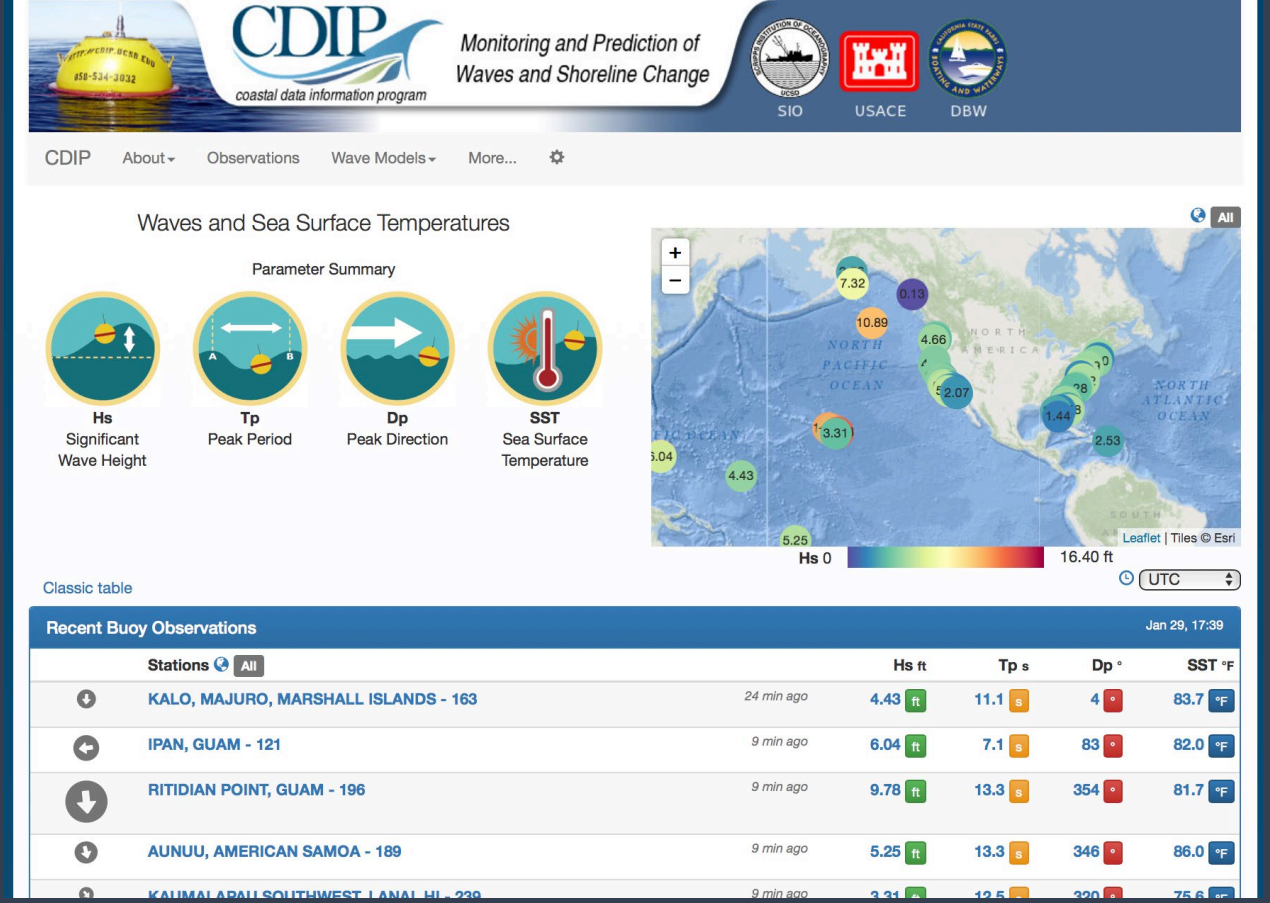




- In collaboration with Marathon and Marine Exchange of Southern California VTS.
- CDIP buoy-driven 1-3 hour forecast is used to make final ”go / no-go” decision on VLCC transits.
- **~2 vessels per month now transit with 65’-69’ draft**

Operations & Maintenance

- Batteries
- Moorings
- Anchors
- Acoustic Releases
- Service & Repairs
- Paint
- **Calibration**
- Travel
- Vessels
- Vehicles



Data Dissemination

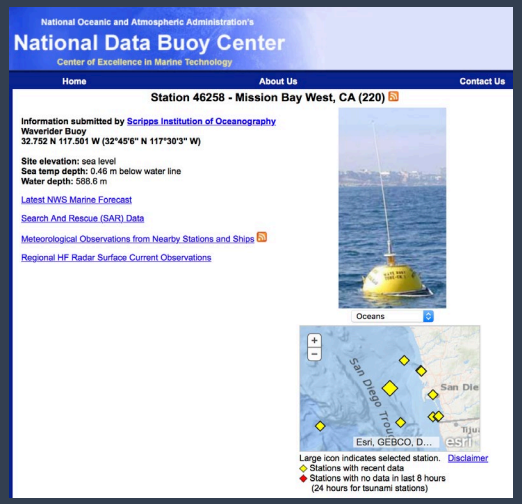
Updates every 30 minutes (> 99% reliable)

CDIP Website (~17,000 unique visitors per day)

National Data Buoy Center / NOAA (NWS)

National Centers for Environmental Information

Physical Oceanographic Real-Time System (PORTS®): Humboldt Bay, San Francisco, LA/LB

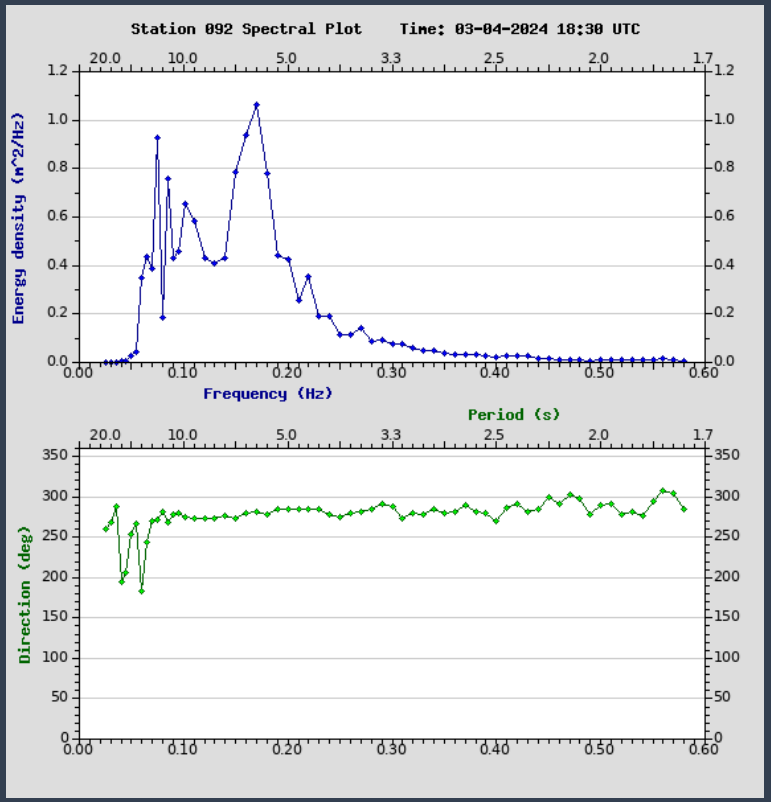


Quality Control

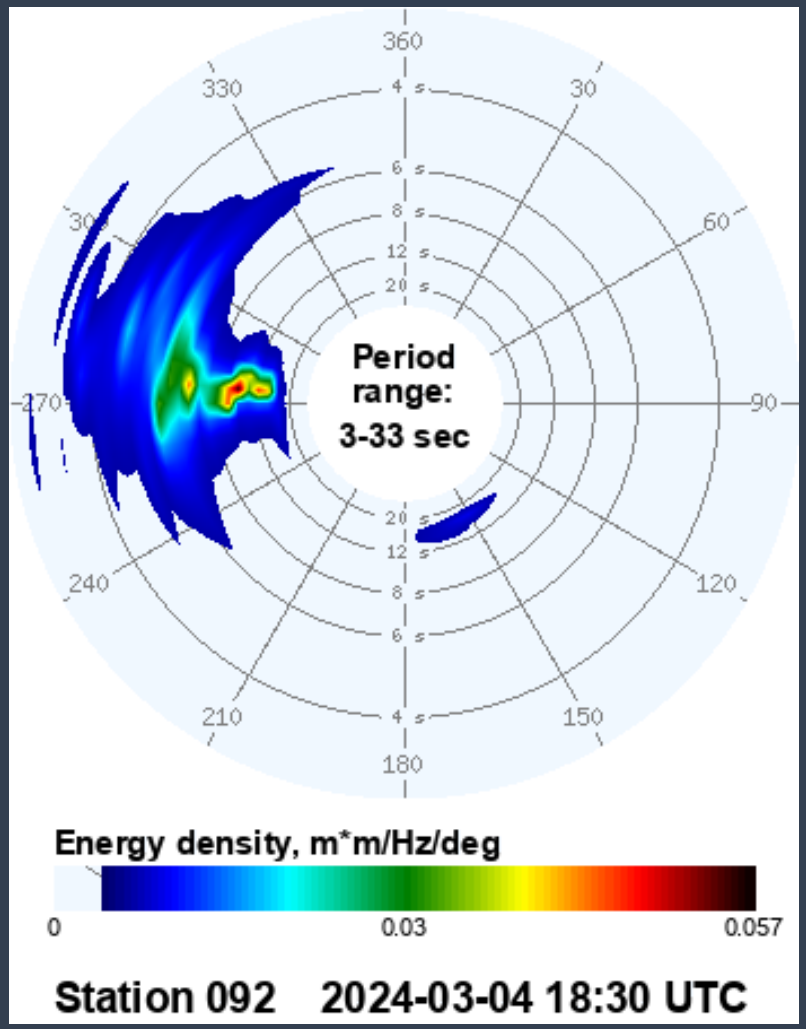
Instrument Calibration

Automated messaging

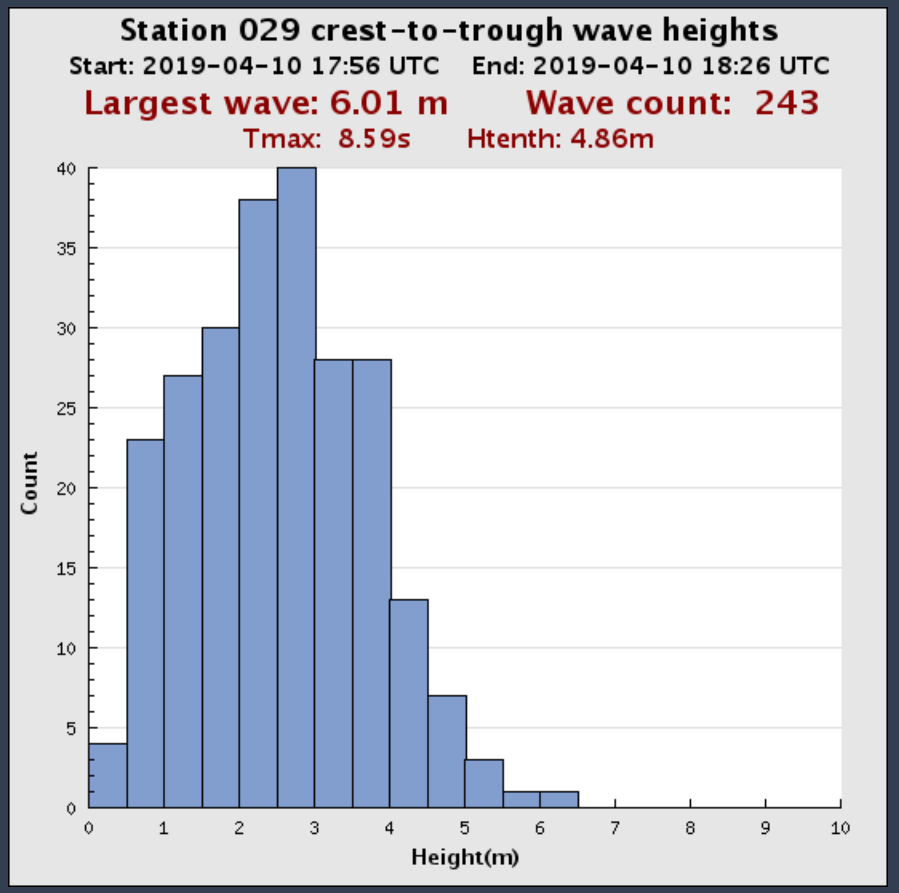
Sensor and Mooring Status



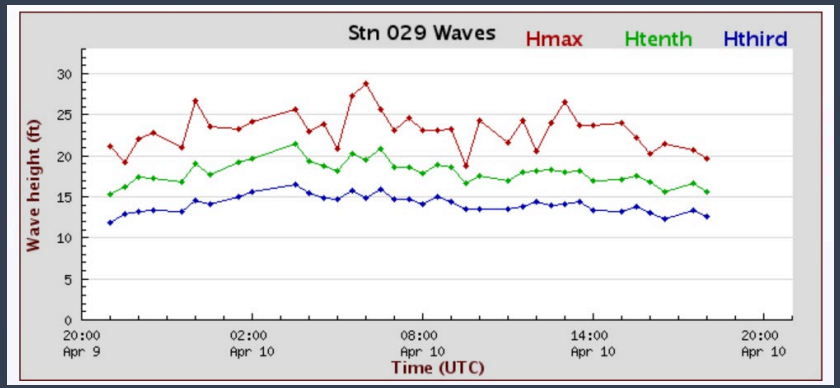
Wave Energy Spectra
(1 - 30 sec)



Directional Spectra



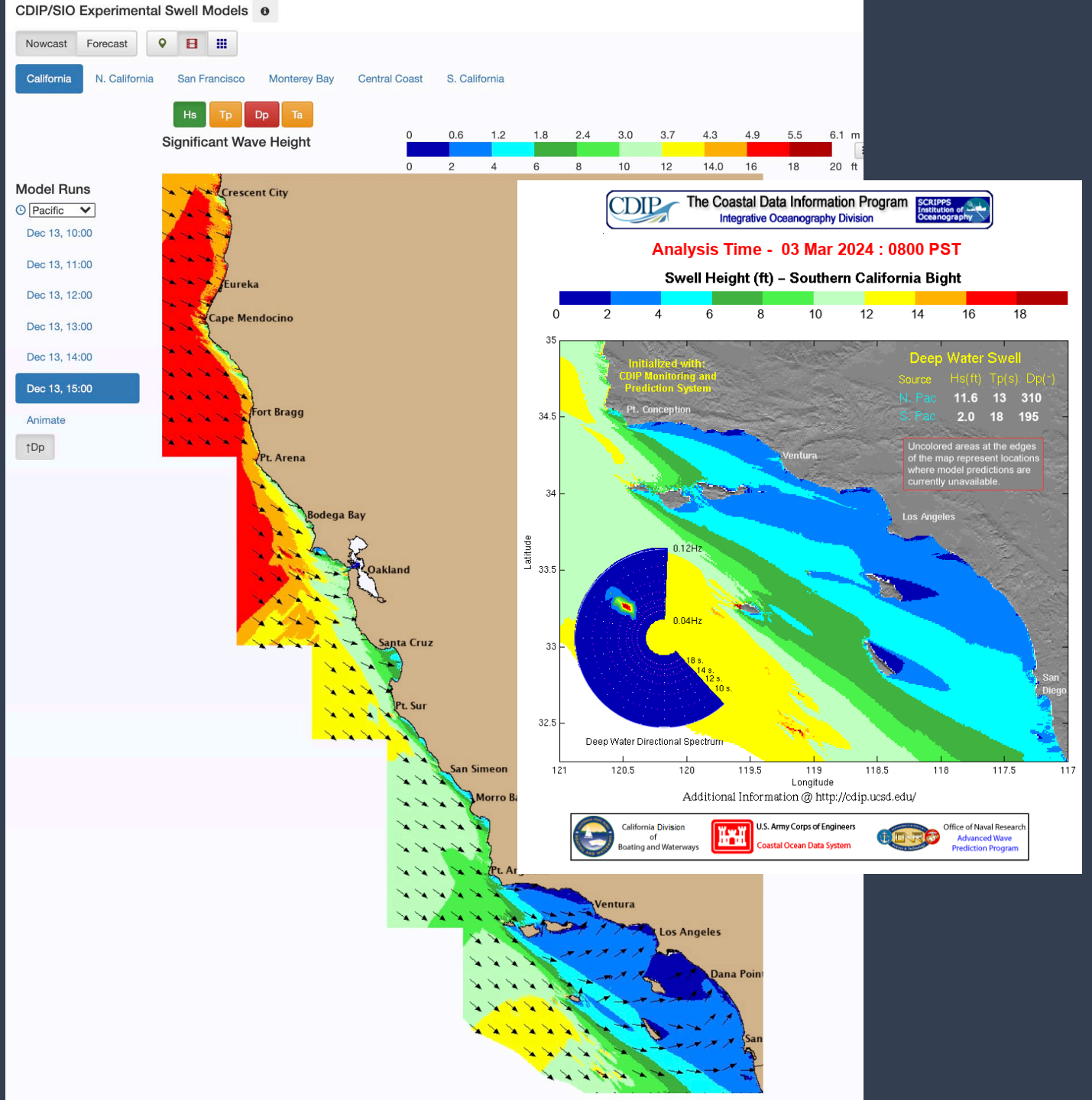
Individual Waves



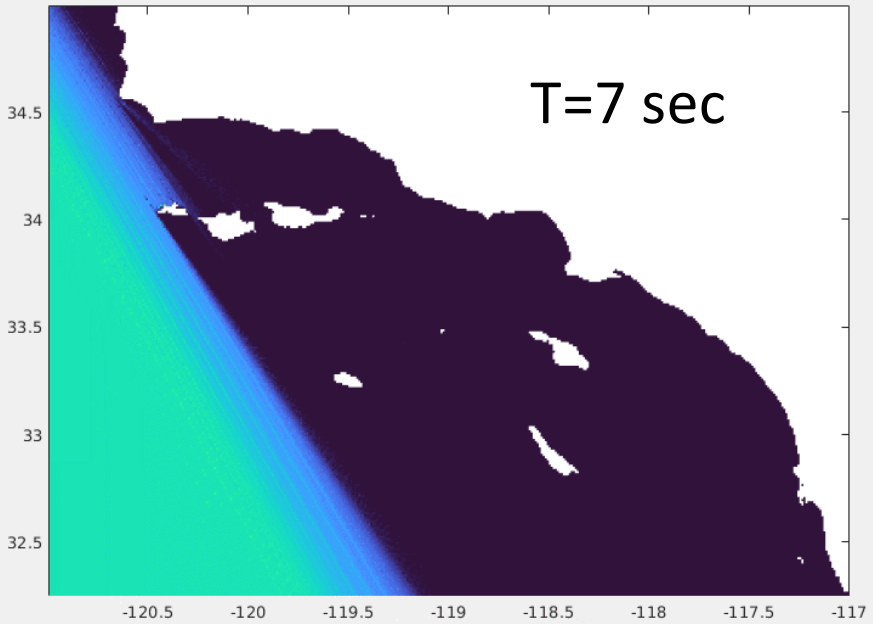
CDIP California Wave Model

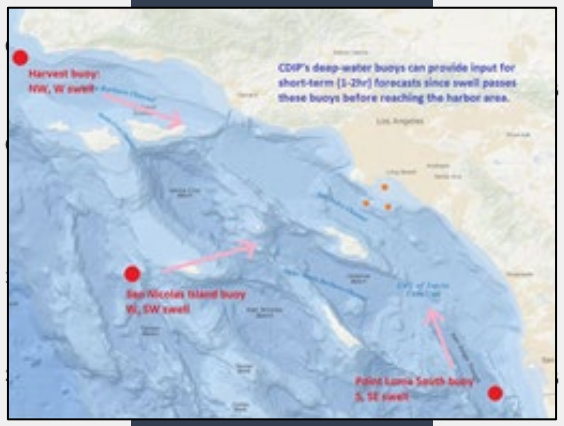
"Nowcast" and hindcast (back to 2000) model driven by **buoy data** + bathymetry + physics

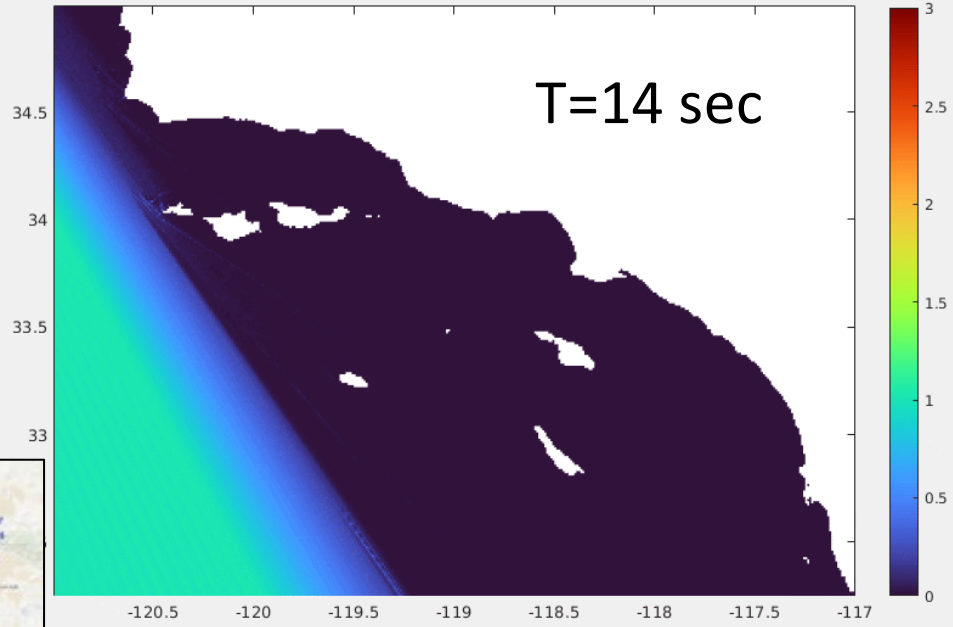
Output points every 100 - 200 m along the coast

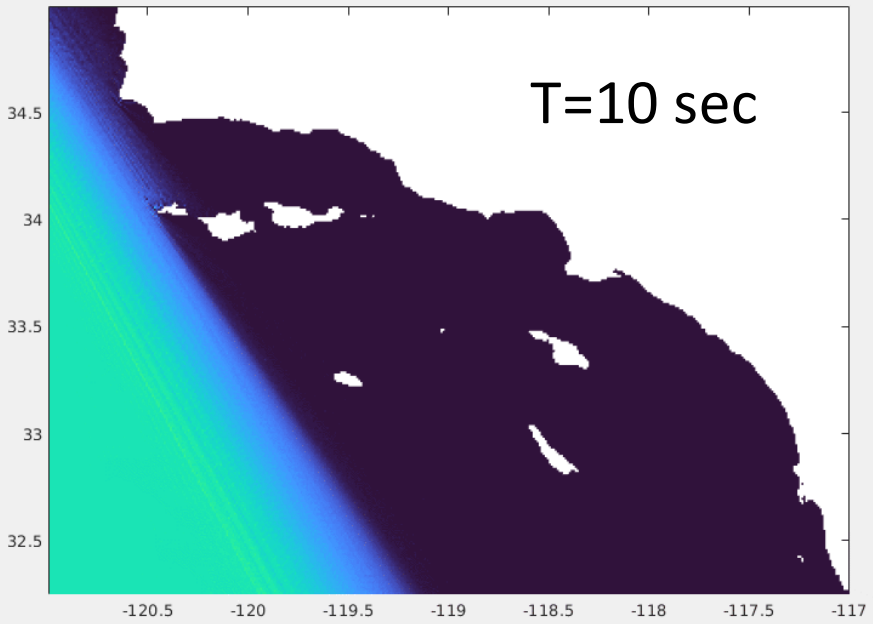


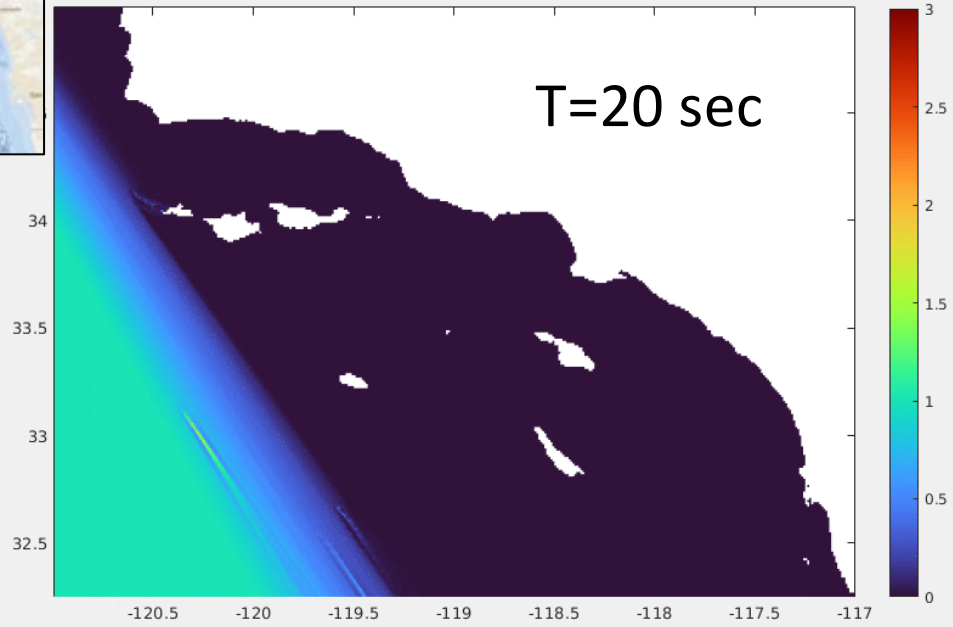
Wave shadowing and refraction

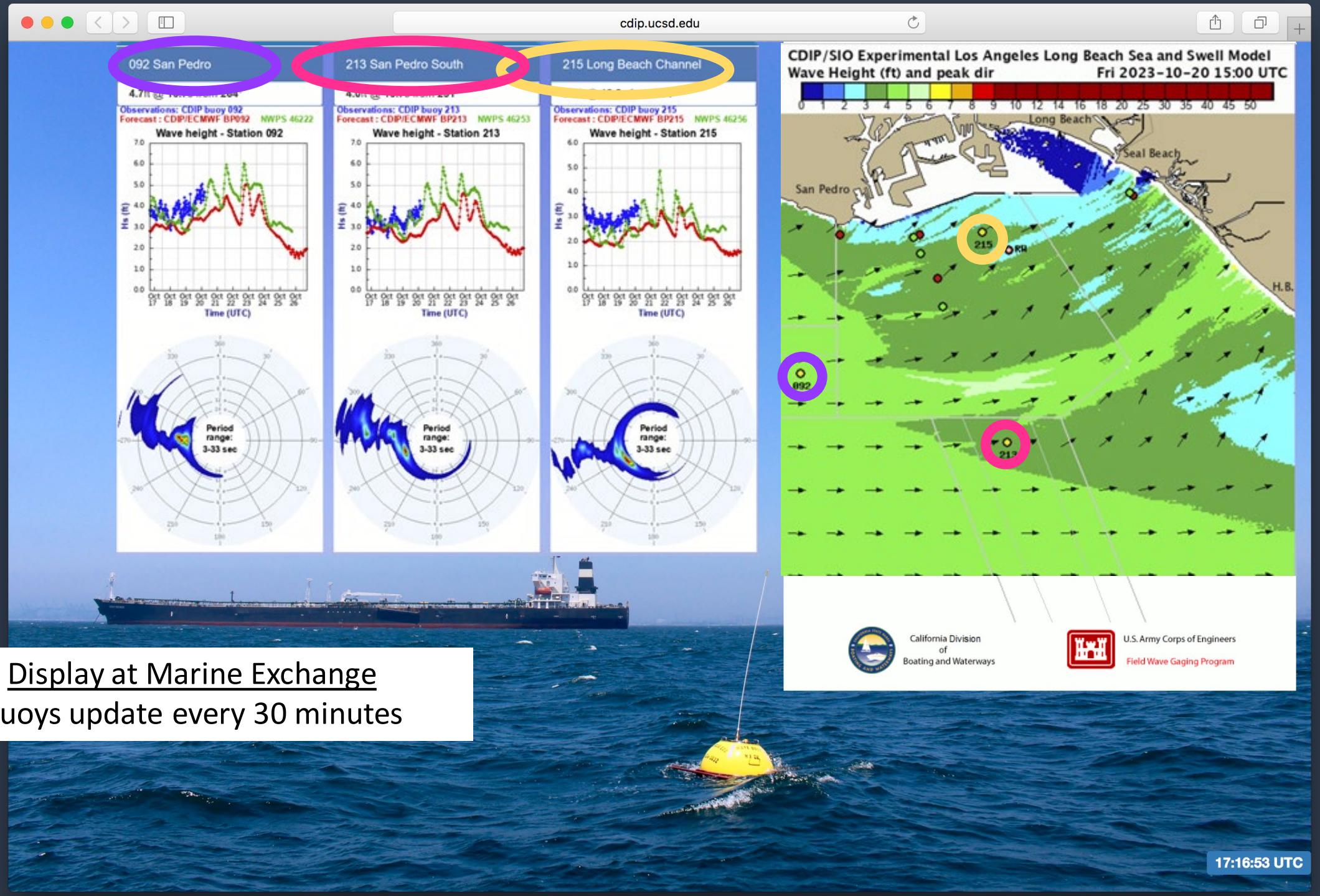












Display at Marine Exchange

Buoys update every 30 minutes

Validation of CDIP wave model using CDIP buoy data

Dataset comparison:
092 and BP092

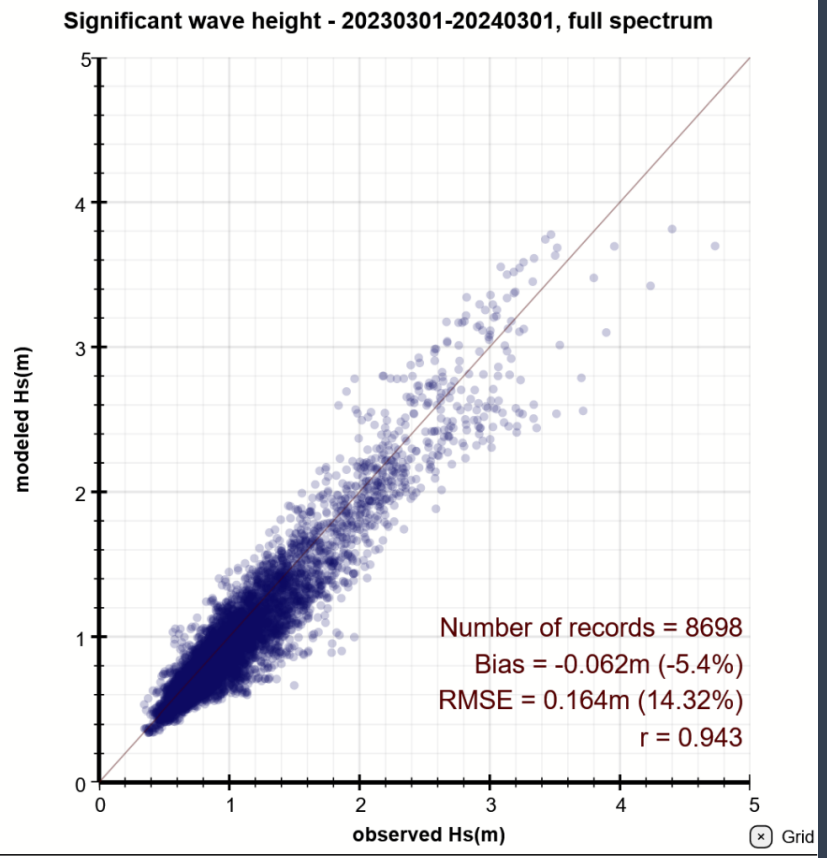
Parameter: Hs | Ta | Dp | Tp

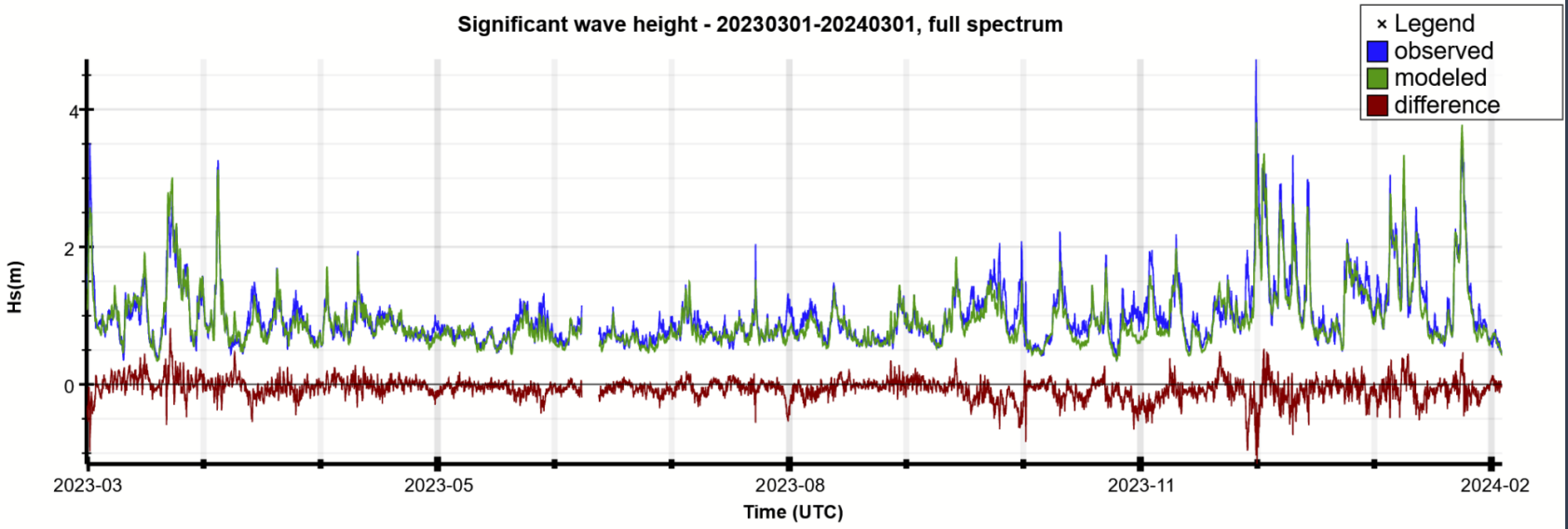
Frequency range:
- Full spectrum
- Forerunners, below 0.05 Hz
- Long swell, 0.05 to 0.08 Hz
- Short swell, 0.08 to 0.12 Hz
- Long seas, 0.12 to 0.25 Hz
- Short seas, 0.25 to 0.40 Hz
- Wind chop, over 0.40 Hz

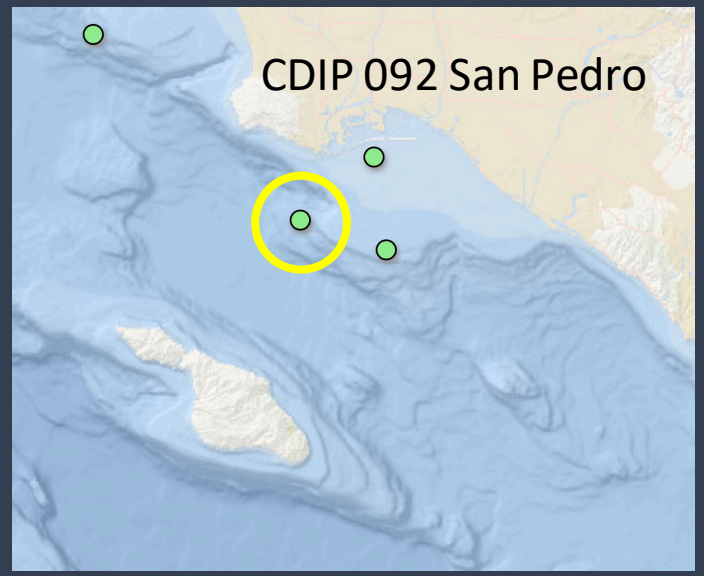
Year: 2000 | 2000 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024

Month: 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12

Click and drag horizontally to zoom in the plot below.



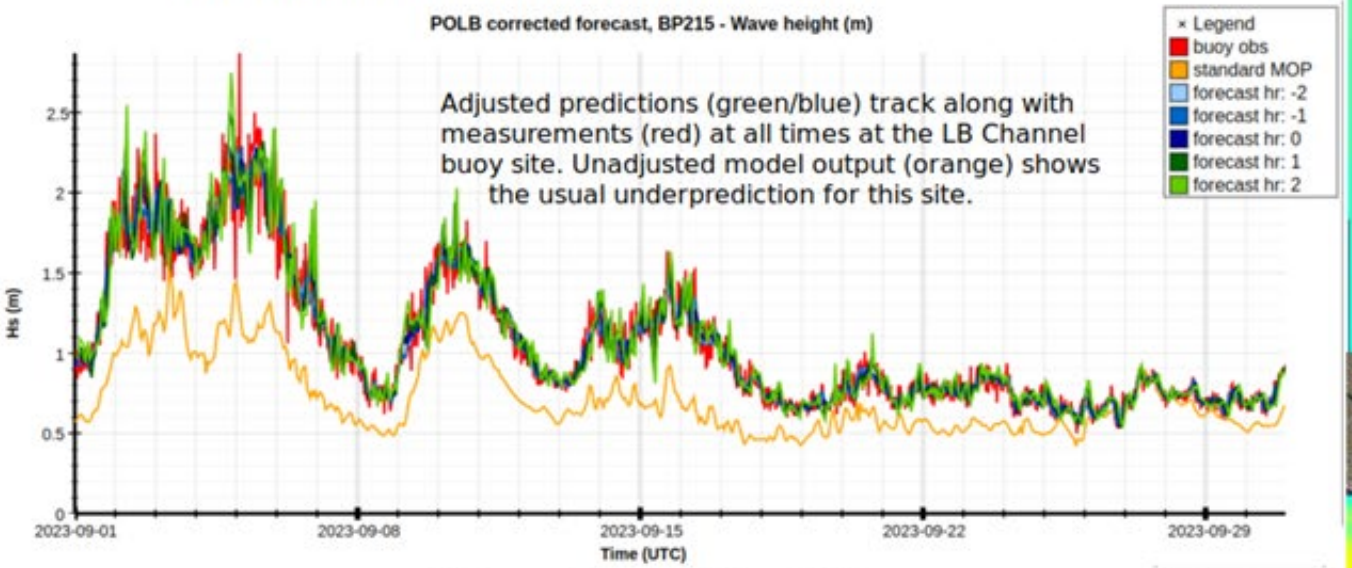


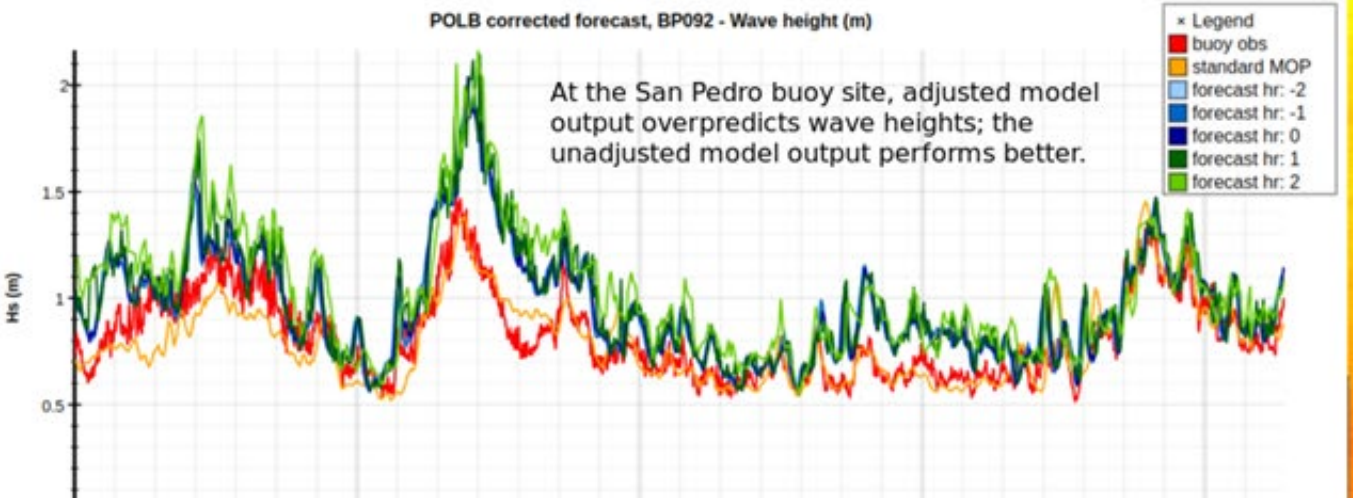


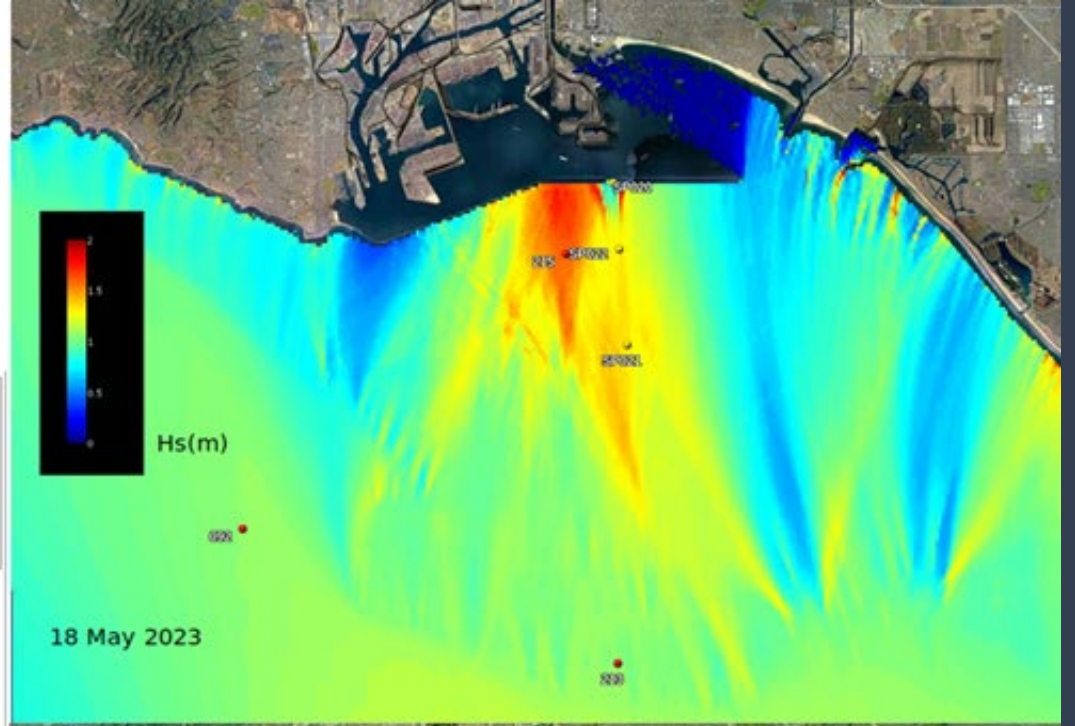
Using LB Channel buoy data to adjust model predictions

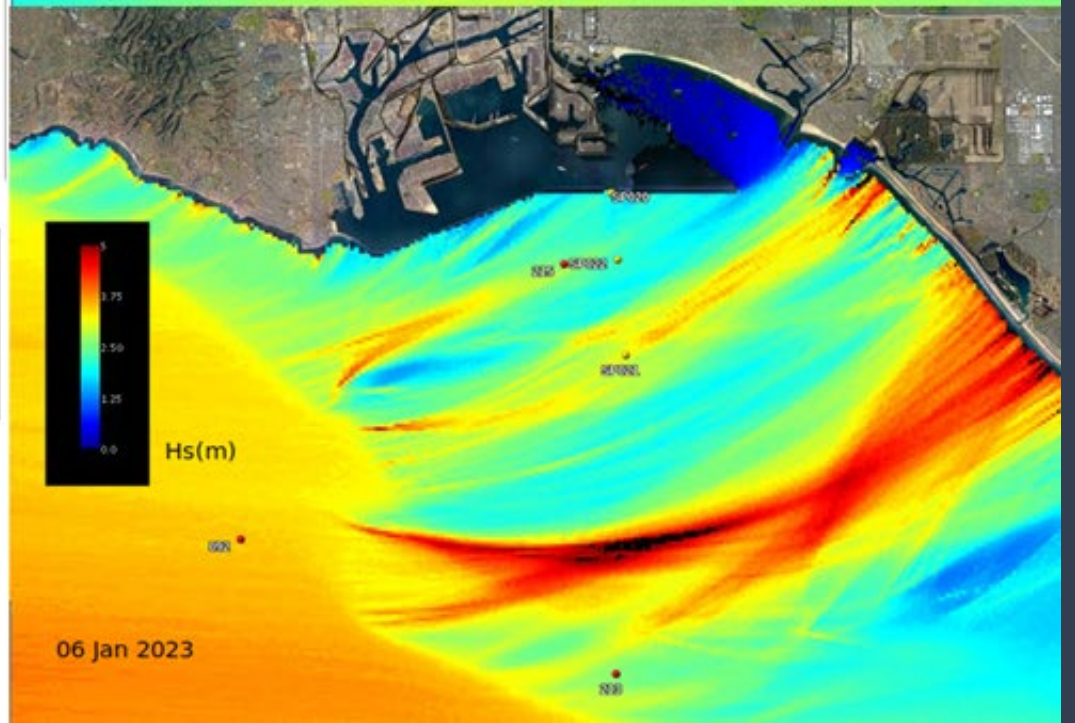
- Adjusted values are likely to be an improvement in close proximity to the buoy used, where depths are similar and variability in the wave field is limited.

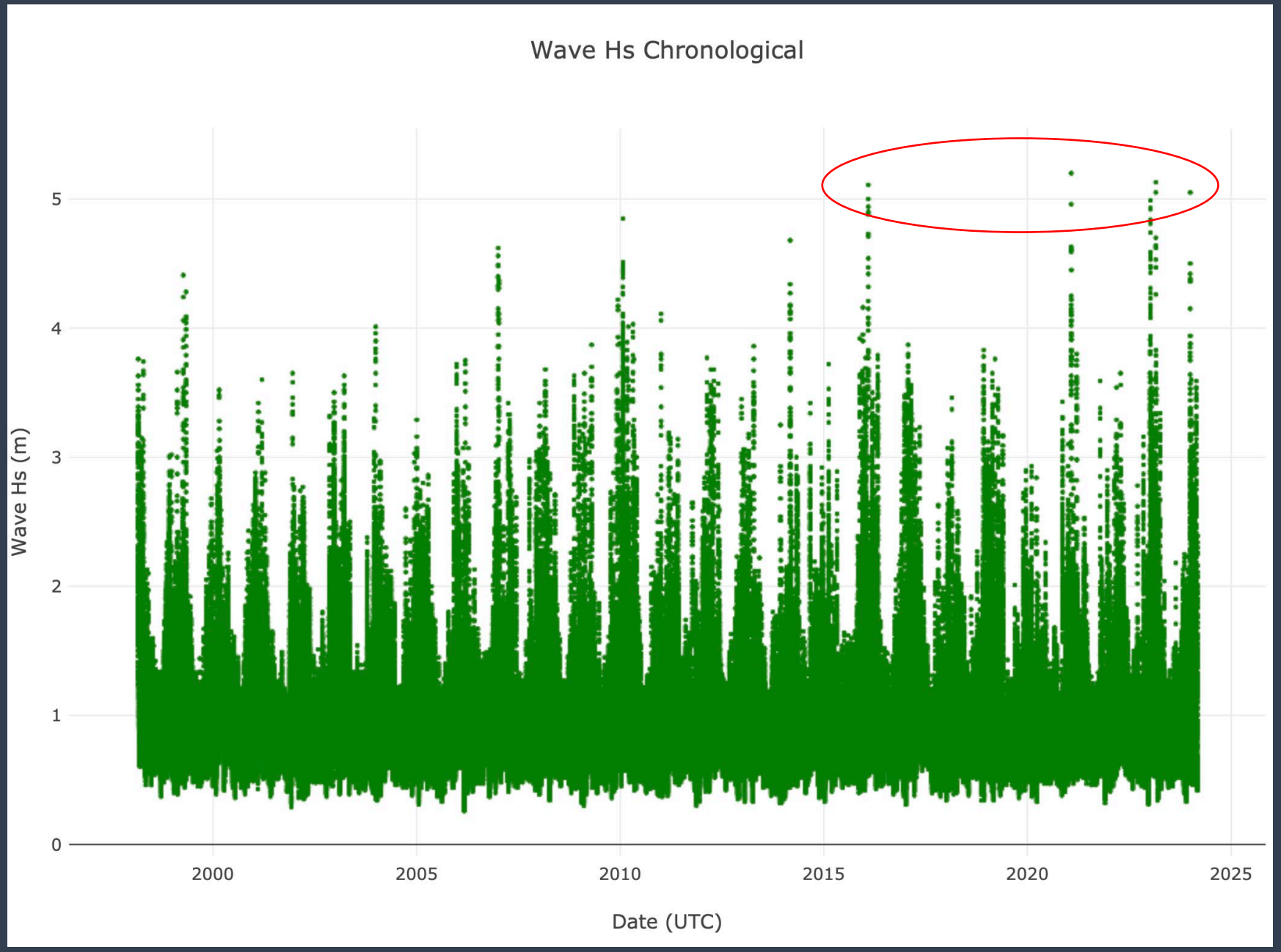
- Adjusted values based on buoy 215 do not improve predictions at the 092 and 213 buoy sites. The extent to which predictions may be improved for SP020 and SP021 is unknown.



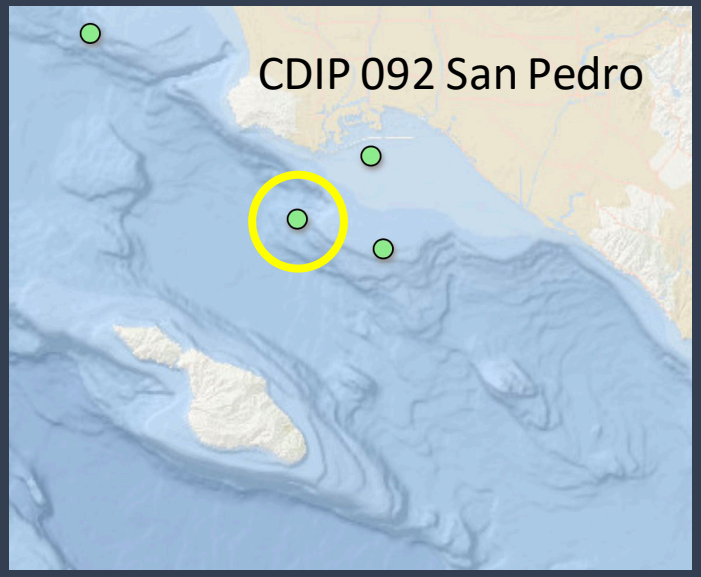








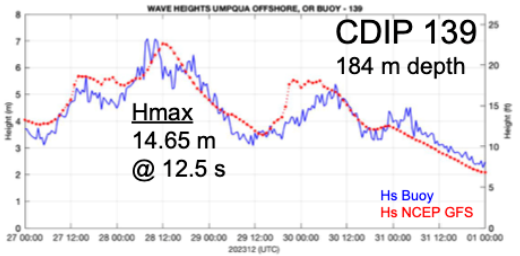
Historic extreme wave events have been occurring in recent years at the Port of Long Beach

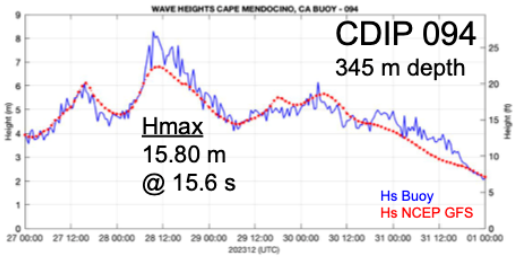


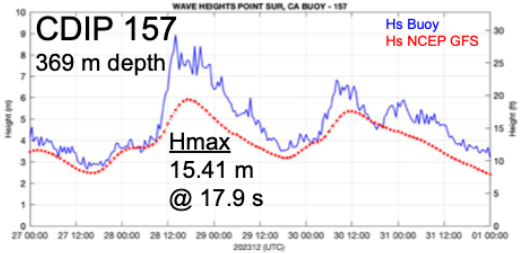
CDIP Wave Observations:
West Coast Storms
December 28 - 31, 2023

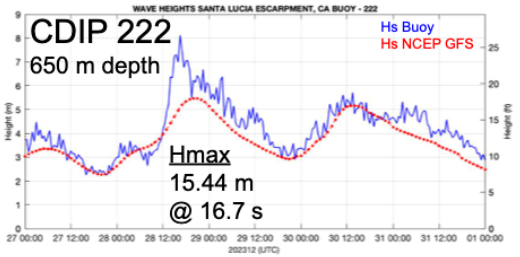
coastal data information program

US Army Corps of Engineers

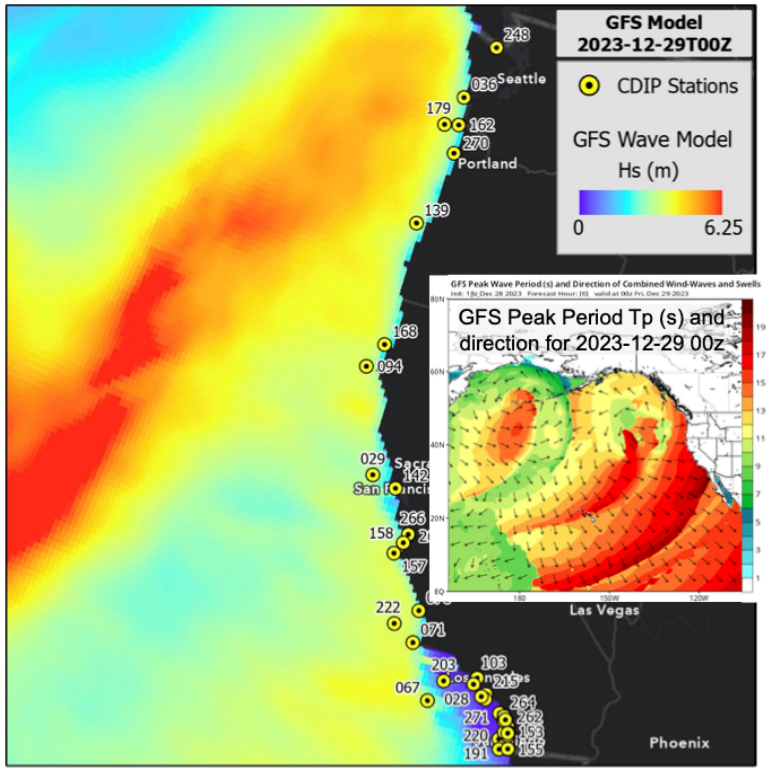








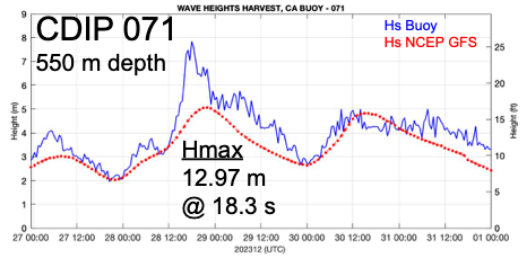
Left: Waves crash into the Ventura Pier (Eric Boldt -Ventura County Star)
Right: Flooded Streets in Capitola, California (Nic Coury/AP)

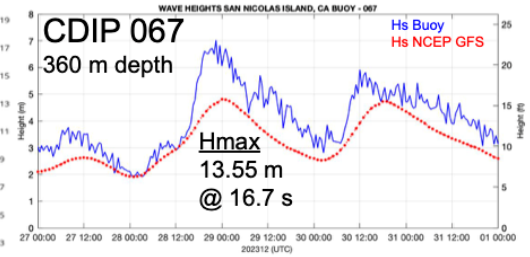


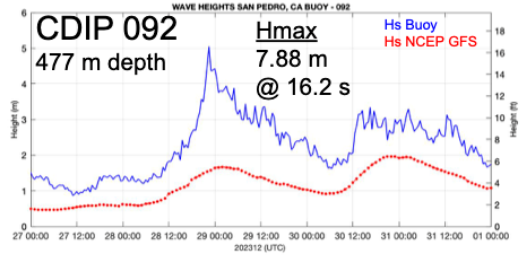
- Extratropical low pressure systems in the North Pacific Ocean generated a series of swells impacting the West Coast late December into the new year. Large waves over high tides caused inundation flooding and significant coastal erosion.
- Wave heights during the swell that arrived 28 Dec exceeded 8 m Hs at some CDIP stations, up to 3 m greater than the NOAA GFS wave model for the California coastline in particular, with exceptionally long average period Ta > 15 seconds.
- Peak Hs values were near historic records at CDIP stations 092 San Pedro (established 1998), 157 Point Sur (est. 2008) and 222 Santa Lucia (est. 2016).
- Elevated storm activity in the Pacific Ocean is consistent with El Niño conditions which are forecast to continue through the winter.

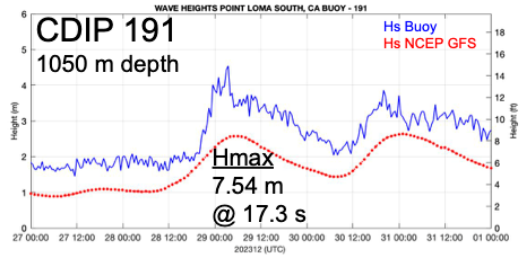
Hmax = largest individual wave
Hs = significant wave height

CDIP wave bulletins:
cdip.ucsd.edu/themes/cdip?d2=p12









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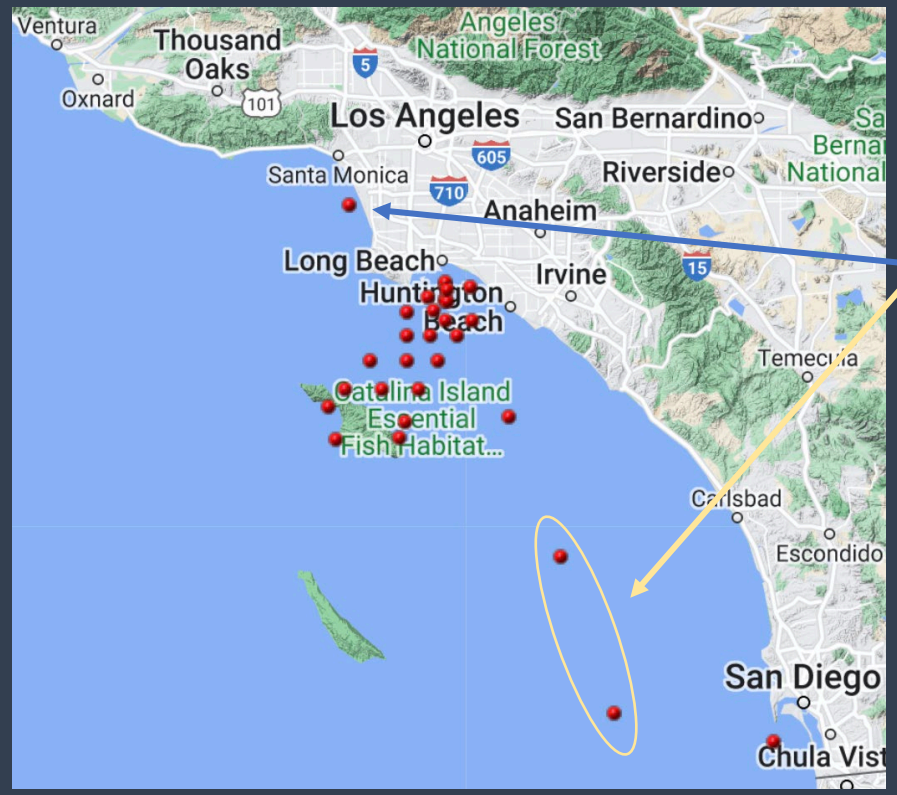


Automated Forecast Threshold Messaging:

- Echo-PAL Offshore Lightering Zone
- El Segundo Marine Terminal

uproc@model-e.cdip.ucsd.edu Inbox - Exchange Yesterday at 9:52 PM

Echo-PAL wave forecast warning

To: cdip-cdipsw, cscwwl@chevron.com

Prediction site: SP401 - Echo-PAL North
Total wave height threshold (8ft) exceeded

Date (PST)	14+ Hs (ft)	14+ Tp (secs)	14+ Dp (deg T)	Tot Hs (ft)	Tot Tp (secs)	Tot Dp (deg T)
2023-03-30 02:00 pm	2.40	14.29	275	8.04	11.11	282

Link:
https://cdip.ucsd.edu/mops/?moplist=San_Pedro_Harbor&mop=SP401&xitem=forecast&xperiod=14&tz=PST&units=english

Prediction site: SP402 - Echo-PAL South
Total wave height threshold (8ft) exceeded

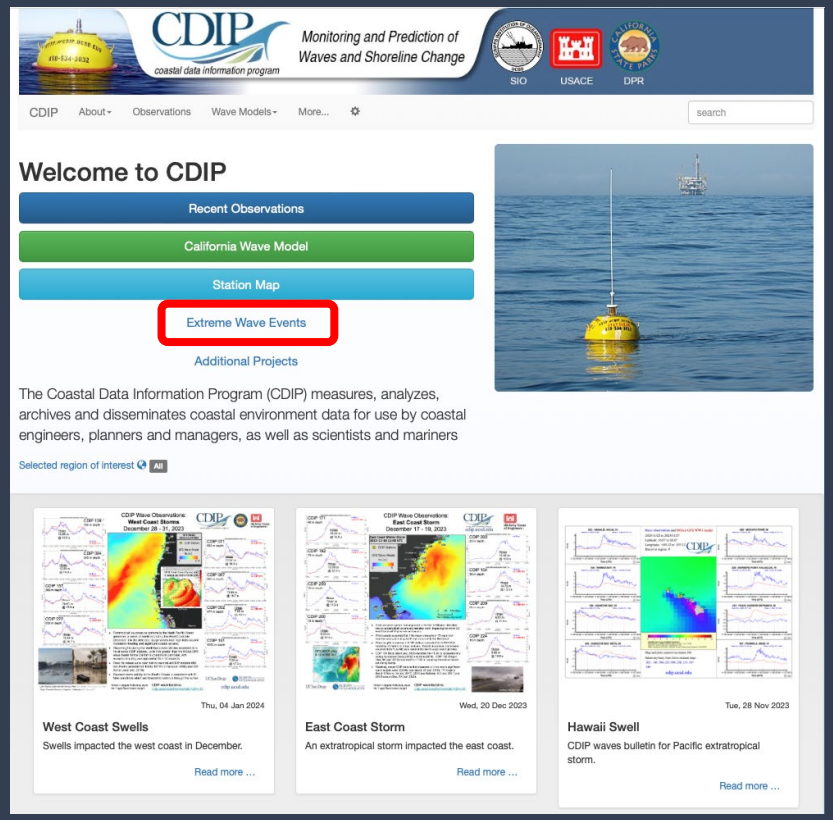
Date (PST)	14+ Hs (ft)	14+ Tp (secs)	14+ Dp (deg T)	Tot Hs (ft)	Tot Tp (secs)	Tot Dp (deg T)
2023-03-30 11:00 am	2.69	14.29	281	8.79	7.69	268
2023-03-30 02:00 pm	3.12	14.29	281	9.88	11.11	283
2023-03-30 05:00 pm	2.85	14.29	281	9.19	11.11	282
2023-03-30 08:00 pm	2.36	14.29	280	8.07	11.11	284

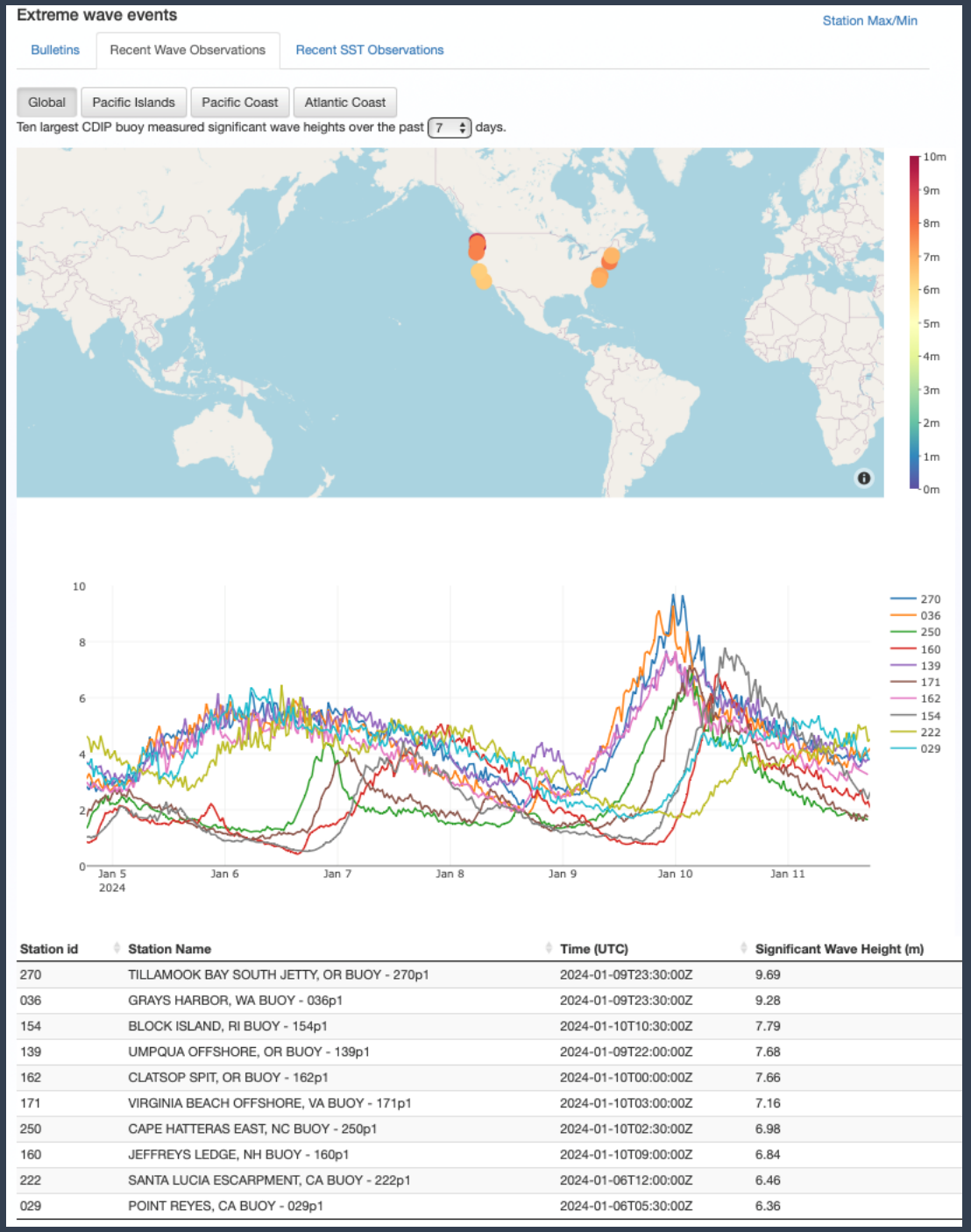
Link:
https://cdip.ucsd.edu/mops/?moplist=San_Pedro_Harbor&mop=SP402&xitem=forecast&xperiod=14&tz=PST&units=english

Recent observations

Extreme wave events

cdip.ucsd.edu





Station id	Station Name	Time (UTC)	Significant Wave Height (m)
270	TILLAMOOK BAY SOUTH JETTY, OR BUOY - 270p1	2024-01-09T23:30:00Z	9.69
036	GRAYS HARBOR, WA BUOY - 036p1	2024-01-09T23:30:00Z	9.28
154	BLOCK ISLAND, RI BUOY - 154p1	2024-01-10T10:30:00Z	7.79
139	UMPQUA OFFSHORE, OR BUOY - 139p1	2024-01-09T22:00:00Z	7.68
162	CLATSOP SPIT, OR BUOY - 162p1	2024-01-10T00:00:00Z	7.66
171	VIRGINIA BEACH OFFSHORE, VA BUOY - 171p1	2024-01-10T03:00:00Z	7.16
250	CAPE HATTERAS EAST, NC BUOY - 250p1	2024-01-10T02:30:00Z	6.98
160	JEFFREYS LEDGE, NH BUOY - 160p1	2024-01-10T09:00:00Z	6.84
222	SANTA LUCIA ESCARPMENT, CA BUOY - 222p1	2024-01-06T12:00:00Z	6.46
029	POINT REYES, CA BUOY - 029p1	2024-01-06T05:30:00Z	6.36