



UNIVERSITY OF  
PLYMOUTH

National  
Oceanography  
Centre



# COASTAL HAZARD FORECASTING AND MONITORING IN THE SOUTH WEST OF ENGLAND



# WAVE FORMATION AND THE HAZARD OF LARGE WAVES

- Sea waves are formed by the wind blowing over the sea. Friction with the surface of the water causes ripples to form and these develop into waves.
- Wave height is determined by three factors:
  - *Wind speed*,
  - *Fetch* – the distance of water across which the waves have formed, and
  - *Wind duration* – the length of time the wind has been blowing.
- When waves approach land, wave height increases due to the shallower water. They become unstable and break along the coastline.
- Large breaking waves can be fast moving and have a weight of several tonnes. They can erode natural cliffs and beaches and damage artificial structures such as sea walls.
- A particular hazard is when storm waves overtop a sea wall and cause damage to the land behind it, including properties, roads and railways.



Dr Tim Poate, University of Plymouth, researching wave hazard as part of the NERC-funded CreamT project, 2021.

# WAVE OVERTOPPING HAZARD

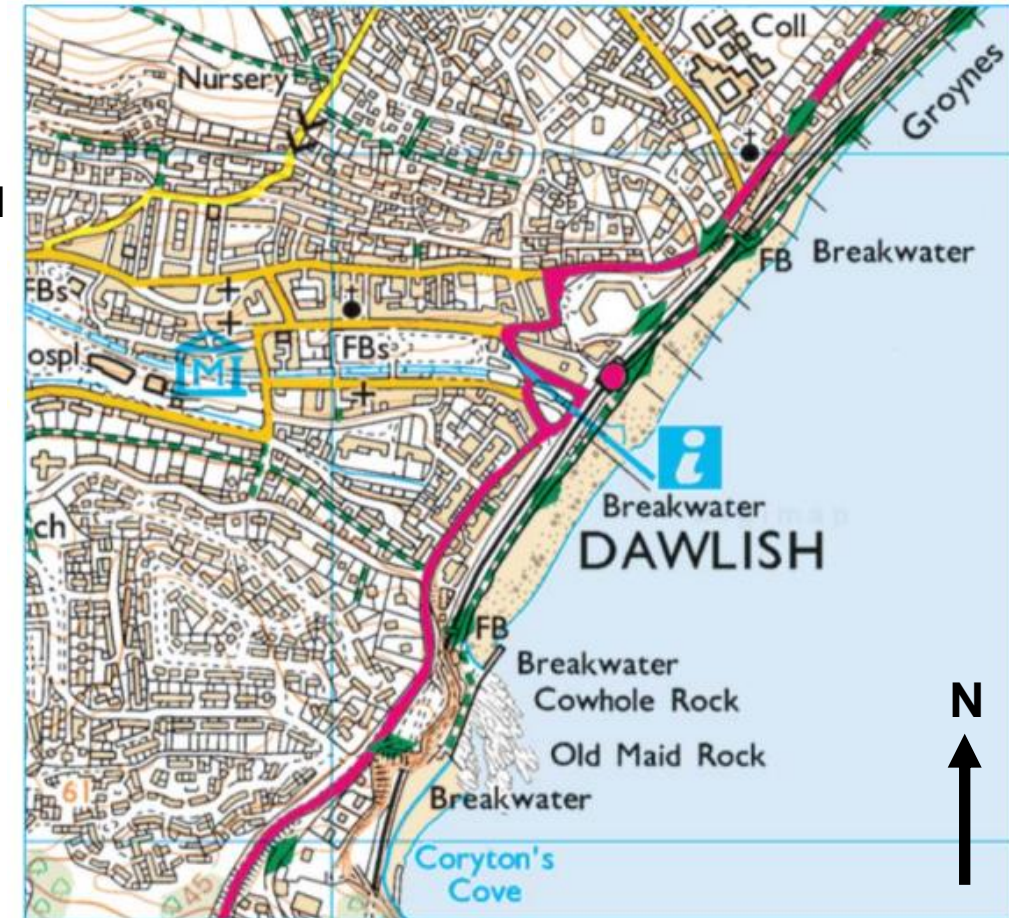
- Coastal wave overtopping is the transport of sea water inland over a sea wall or breakwater. It can be a flow of water, plume of spray or jets of water. The water is often fast moving and can carry debris from the beach, such as seaweed, pebbles and in extreme waves, rocks.
- Waves can overtop sea walls during storm conditions or when onshore winds and waves coincide with high tide.
- The water can pose a hazard to people, property and transport through the force of the wave or through flooding.
- Pebbles, sand and boulders can also be flung across sea walls damaging property or infrastructure such as railways and roads and the top of the sea wall itself.
- Coastal managers, local authorities and transport operators need to know in advance when hazardous overtopping is likely to occur to plan their response and implement safety protocols, such as road or rail closures and erecting flood barriers and warning signs.



Wave overtopping hazard, being measured by the CreamT project in Dawlish, April 2021. University of Plymouth camera footage.

# COASTAL HAZARDS AT DAWLISH

- Two places in the South West at risk from wave overtopping are Dawlish and Penzance.
- At **Dawlish** the sea wall protects the railway line from London and Bristol to Plymouth, Torbay and Cornwall, which runs along the coast.
- On the inland side of the railway line is the town of Dawlish, with houses, shops and business at risk of flooding and damage from storm waves.
- During Storm Petra in February 2014 and again during Storm Barra in 2021, waves overtopped the sea wall during storm conditions and when onshore winds and waves coincided with high tide. See:
  - [Storm Barra Dec2021, Dawlish, University of Plymouth / NOC Coastal research - YouTube.](#)
  - [Dawlish storm-hit train line battered again - BBC News.](#)
  - [Dawlish sea wall on storm-hit track is 'success' - BBC News.](#)



Source: Digimap for Schools



# WAVE DAMAGE AT DAWLISH

- Waves damaged the railway at Dawlish during Storm Petra 2014.
- The storm whipped up powerful waves along the south coast of England. The existing sea defences at Dawlish were breached and the railway line was left dangling in mid-air! It took engineers two months to repair the line during which time the southwest rail network of England was cut off from the rest of the UK.
- The original sea wall was built in the 1840s, and groynes were later added to assist the build-up of sand. Although there is a sandy beach at low tide, waves break against the sea wall at high tide.
- A new concrete sea wall was completed in 2023 to protect the railway line and Dawlish station.

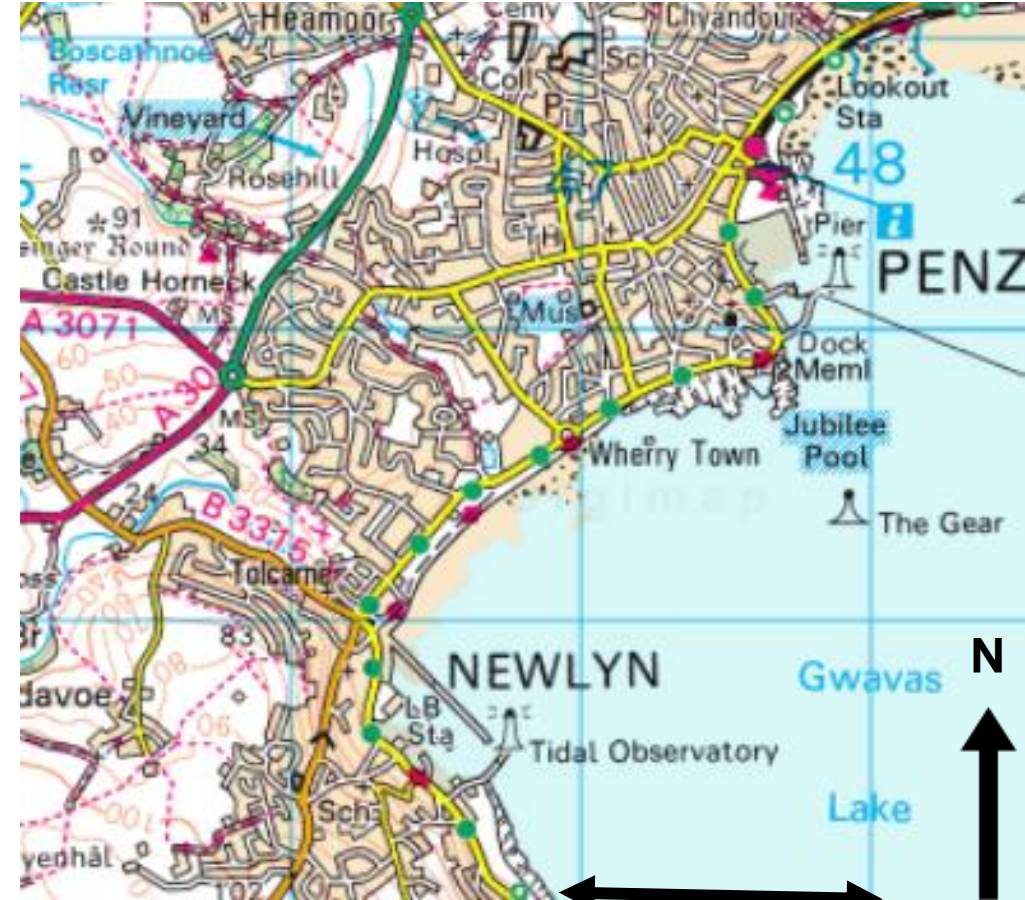


Damaged railway lines at Dawlish, 2014 Credit: Network Rail.

[Dawlish £80million sea wall work 'finished by 2023' - Devon Live.](#)

# COASTAL HAZARDS AT PENZANCE

- At Penzance, sea walls protect the railway to the east of the town where there is also a large beach and the harbour.
- West of the harbour, sea walls protect the coastal road between Jubilee Pool and Newlyn and coastal properties inland. Penzance has an historic coastal promenade along the sea front dating from 1844.
- The rock platform at Jubilee Pool and the beach between Wherry Town and Newlyn harbour breakwater are submerged at high tide, and storm waves hit the sea wall.
- Overtopping of the sea wall is a significant problem particularly for the promenade, road and nearby properties.



Source: Digimap for Schools

# COASTAL DAMAGE AT PENZANCE

- There is a long history of damage to the sea wall and promenade at Penzance. Severe damage occurred in March 1962, and again in the 2000s. The sea wall and promenade was badly damaged during 12 storms with overtopping events between 2013 and 2014.
- Further damage occurred when the sea wall was overtopped during Storm Callum in October 2018, two storms in December 2021, and Storm Franklin in February 2022.
- Repairs costing over £1 million were completed in 2022 after closure of the sea front during 2020-2021.
- Further coastal defences may be required as high seas still threaten the promenade and local properties.
- [Storm Callum: high tide batters promenade in Penzance - Bing video](#).



[Penzance sea wall damage from Storm Callum – source Shadow environment secretary Maria Eagle surveys the storm damage in Penzance | Penzance, Bristol, Storm \(pinterest.co.uk\)](#)

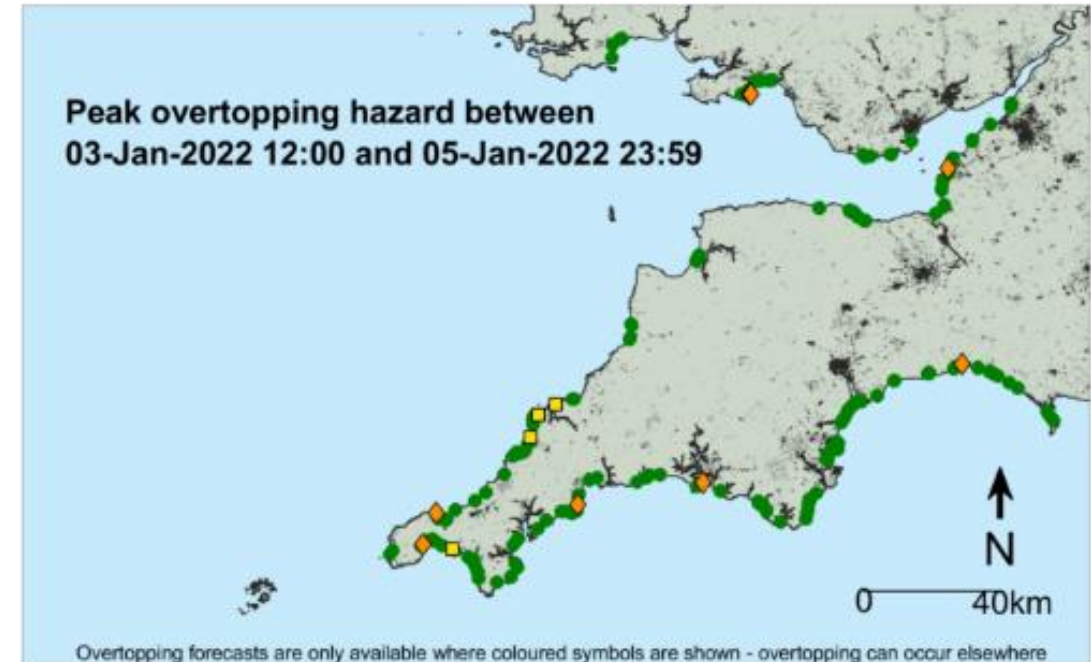
The background of the slide features a repeating pattern of wavy, undulating lines in two shades of blue, creating a sense of movement and depth, reminiscent of ocean waves or a topographical map.

# **COASTAL DATA COLLECTION AND FORECASTING IN THE SOUTH WEST**



# COASTAL FORECASTS ACROSS THE SOUTHWEST REGION

- To predict wave overtopping hazard in advance the University of Plymouth's Coastal Processes Research Group (CPRG) have developed a forecast service as part of The South West Partnership for Environmental and Economic Prosperity (SWEEP). Take a look, <https://coastalmonitoring.org/ccoresources/sweep/>.
- The system predicts waves, water levels, and wave overtopping hazard around the southwest coast of the UK. The online information is updated once a day, and provides a three-day forecast.
- Each location where a forecast is provided is shown on the map with an overtopping hazard symbol. The symbols update using a traffic light categories to rate the severity of the hazard.



## Coastal Overtopping Hazard:

- ▲ Hazard to Pedestrians/  
Property/Vehicles
- ◆ Hazard to pedestrians  
/property
- Hazard to pedestrians
- Hazard low

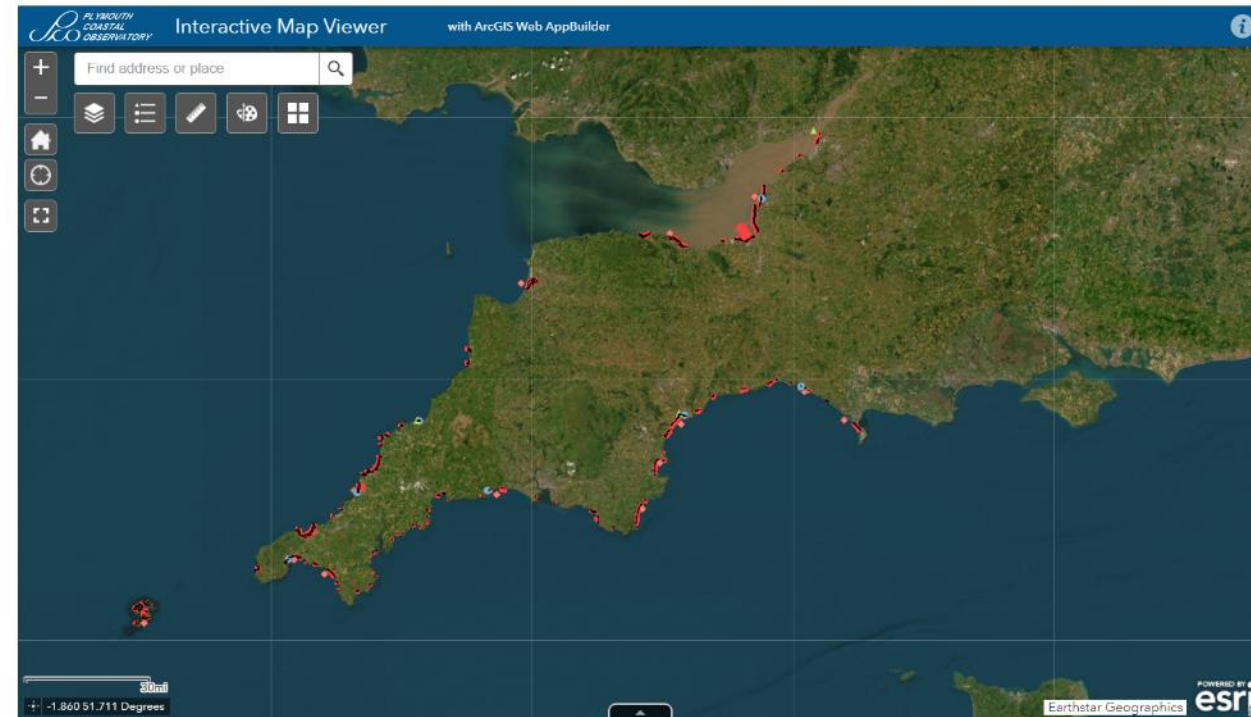
# FIELD MEASUREMENTS TO CALIBRATE WAVE OVERTOPPING PREDICTIONS

- The National Oceanography Centre engineered a new measurement system to collect information about wave overtopping. This was to improve the available field data to support the site-specific calibration of local forecasts.
- Many forecast services use generic rules from a European manual that provides guidance on predicting wave overtopping hazard, <http://www.overtopping-manual.com/>. When applied to a site the rules may need a “tweak” to better represent the local conditions.
- The system, called “WireWall”, is an array of capacitance wires that are charged and become discharged when a wave passes through the array connecting with the wires. The rate of discharge is proportional to the depth of water (the sum of the diameter of the individual spray droplets in the plume) that connects with a wire. Knowing the wire positions and recording the time and depth of the connection, the speed and volume of the overtopping can be calculated. Take a look, <https://youtu.be/a5Y33SWdNU4>.



# COASTAL MONITORING AROUND THE SOUTH WEST

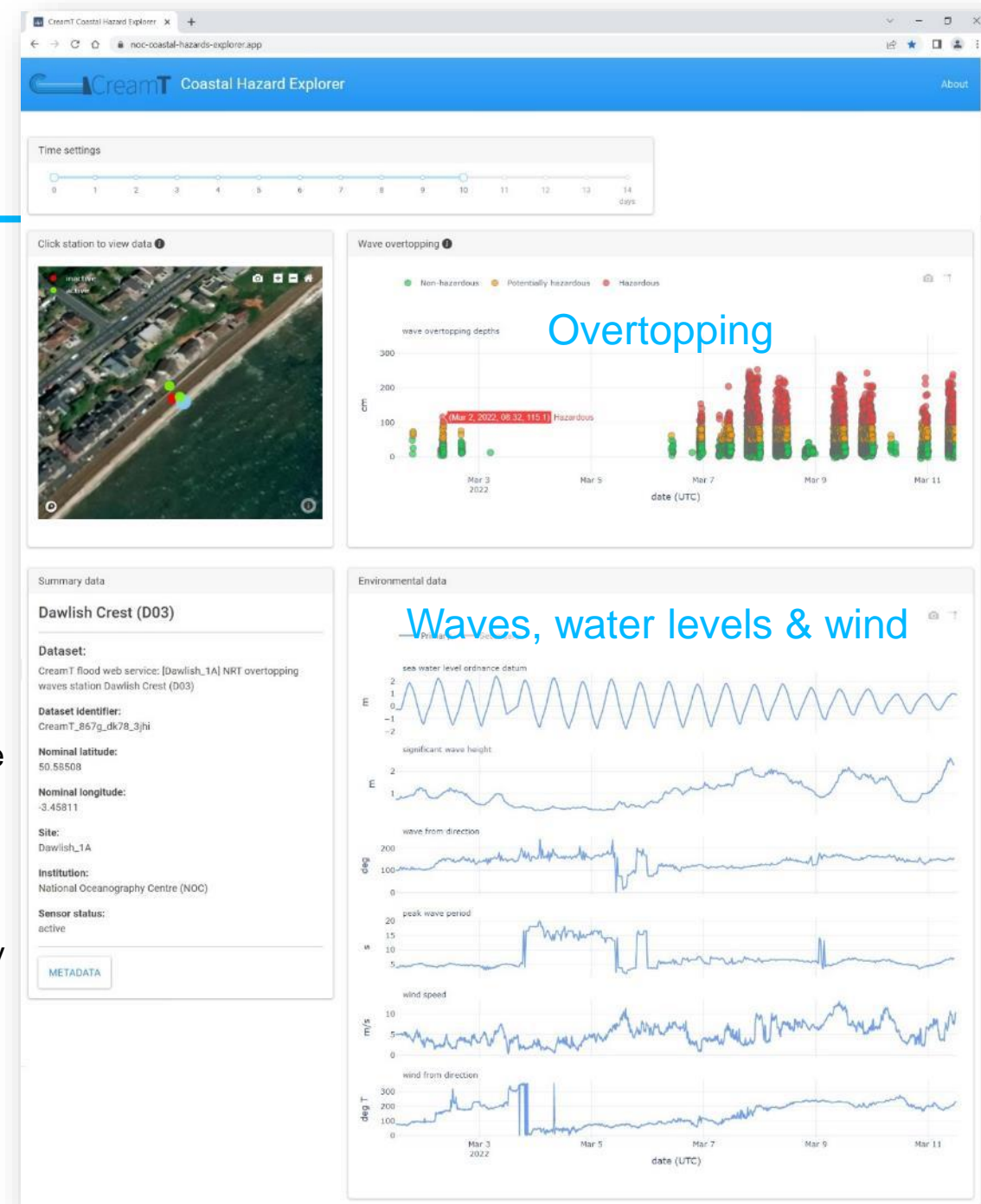
- The South West Coastal Monitoring Programme have a network of monitoring stations around the coast to measure waves, water levels and weather conditions. The live or past data can be accessed from their website, <https://southwest.coastalmonitoring.org/>.
- The live data is valuable to hazard responders, while the full data records provide information about long-term trends for coastal managers to assess climate impact at the coast and monitor sea level rise.
- They also collect bi-annual beach surveys to monitor seasonal change in the beach levels. For the “asset owners” responsible for the management of sea wall structures, knowing if the beach has a healthy volume or is lowering is important. Low beach levels can expose the foundations of a sea wall making it vulnerable, but also allow larger waves to reach the sea wall as a lower beach means the water levels are deeper so the waves can break closer to shore.





# MEASURING OVERTOPPING IN THE SOUTH WEST

- WireWall was deployed in Dawlish for a year from March 2021 to March 2022 and in Penzance for four months from November 2021 to March 2022.
- This research was part of the project called CreamT, which stands for **“Coastal Resistance: Alerts and Monitoring Techniques”**.
- The data are available online at <https://coastalhazards.app.noc.ac.uk/>. The overtopping information is presented using a traffic light system to show the overtopping hazard and the wave, water level and wind conditions from the South West Coastal Monitoring Programme are presented for the same time period.
- The data collected in Dawlish are being used by Network Rail to improve their safety protocols, i.e., when speed limits are applied to trains, when only the inland track can be used and when services have to be suspended.
- The data collected in Penzance are being used by the Environment Agency to calibrate overtopping predictions for present day conditions before simulating future conditions to use in flood hazard management plans.



# CITIZEN SCIENTISTS

- Since beach level is an important factor in coastal management an international citizen beach monitoring programme has been initiated “CoastSnap”. You might see posts appearing at many locations around the UK.
- In the south west a growing network of posts with phone cradles are being installed, so members of the public can contribute their photos of the beach.
- The phone cradle means the photos are all in the same location and same orientation. Image analysis can then be used to understand the changes in the beach in between bi-annual surveys.
- As part of CreamT, posts were installed in Dawlish and Penzance to monitor beach levels in front of the sea walls. The galleries are available online,  
[https://coastalmonitoring.org/gallery/grid/coastsnap\\_imagery](https://coastalmonitoring.org/gallery/grid/coastsnap_imagery).



**SOUTH WEST  
COASTAL  
MONITORING**

## Become a Citizen Scientist!

  
Scan me

### Snap it & Share it





Your photos will capture a valuable record of beach change at Wembury, helping us better understand erosion and recovery cycles.  
For more information please visit our website

### 1 Snap



Place smartphone in the cradle and take a photo

### 2 Share



After taking your photo, you can:

-  Submit on our website at:  
[southwest.coastalmonitoring.org/coastsnap](https://southwest.coastalmonitoring.org/coastsnap)
-  Email us: [coastal.observatory@plymouth.ac.uk](mailto:coastal.observatory@plymouth.ac.uk)
-  Message us: [plymouth.coastal.observatory](https://www.facebook.com/plymouth.coastal.observatory)

Please state photo date and time if not submitted immediately  
\*\*Photo authors remain anonymous\*\*



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**COASTAL HAZARD AND RESPONSE:  
WHAT ACTIONS WOULD YOU TAKE IN  
THE SOUTH WEST ?**