

Tsunamis: Background and Introduction to Detection, Forecasts, and Warnings

February 4, 2022

Background

Tsunamis are a series of extremely long waves caused by a large and sudden displacement of water in a large waterbody, such as the ocean or an inland sea. That displacement can be caused by underwater earthquakes, landslides, or volcanic eruptions, certain types of weather, and impacts from celestial objects such as asteroids. Most tsunamis are the direct result of earthquakes or of landslides caused by earthquakes. Tsunamis radiate from the point of initial displacement and move across the waterbody. When tsunamis reach a coastline, they grow in wave height due to the shallowing waters, sometimes causing coastal and inland flooding, destruction of infrastructure, injuries, and fatalities. **Certain coastal locations** are especially vulnerable to tsunamis due to their proximity to tsunami sources, the depth and characteristics of the waterbody bottom, and the topography and elevation of land near the coast. Large displacements may cause tsunami impacts around the world; for example, the **January 15, 2022, underwater volcanic eruption in Tonga**, a Pacific Island country, triggered a risk of tsunami impacts along parts of coastlines in U.S. Pacific territories, Hawaii, and the West Coast, among locations in other countries.

Detection, Forecasting, and Warnings

Congress has directed the National Oceanic and Atmospheric Administration (NOAA) to establish and operate a **Tsunami Program** focused on detection, forecasting, warnings, research, notification, outreach, and mitigation, as well as data collection and archiving, in consultation with federal and nonfederal partners (33 U.S.C. §§3201-3208). Among other responsibilities, Congress instructed NOAA's National Weather Service, in conjunction with other **NOAA line offices**, to administer the program and provide tsunami detection, forecasting, and warnings for the Pacific, Arctic, and Atlantic Ocean regions, including the Caribbean Sea and the Gulf of Mexico. To do so, the Tsunami Program maintains marine instrumentation, such as Deep-Ocean Assessment and Reporting of Tsunami (DART) buoys, two warning centers, and a tsunami warning system. It also supports other tsunami-related activities at NOAA and its partners.

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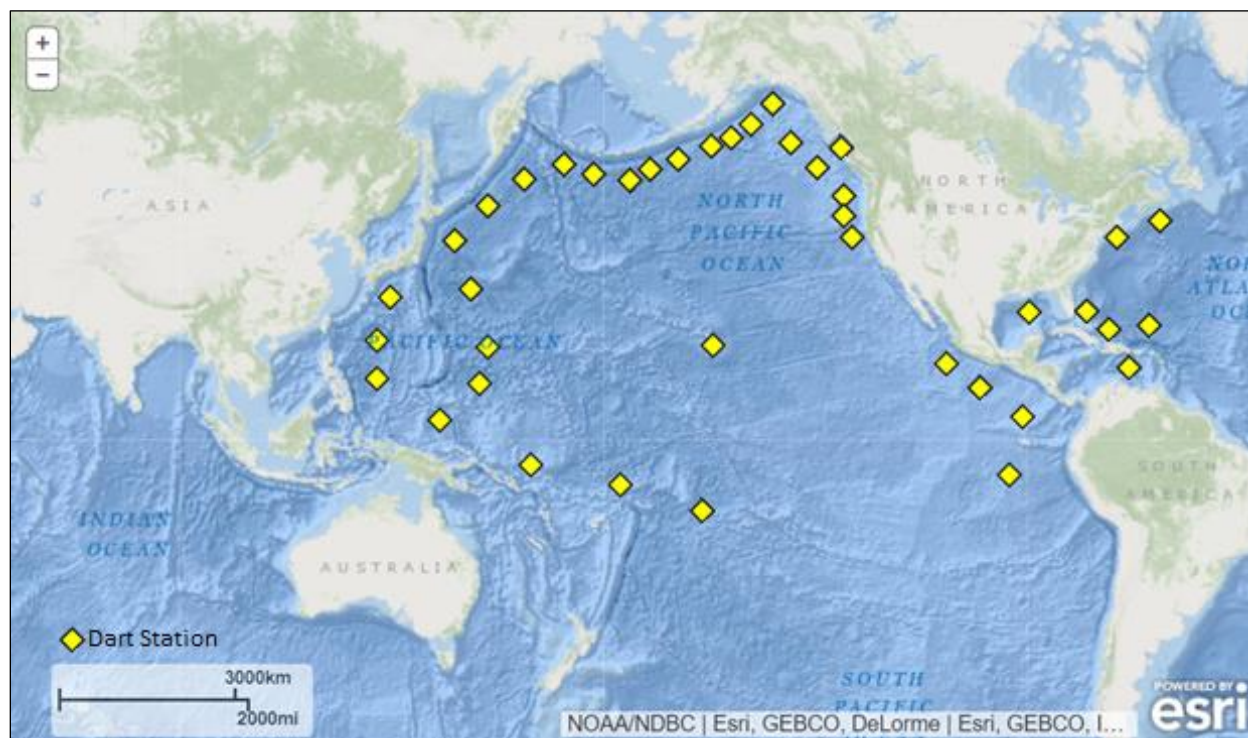
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Instrumentation

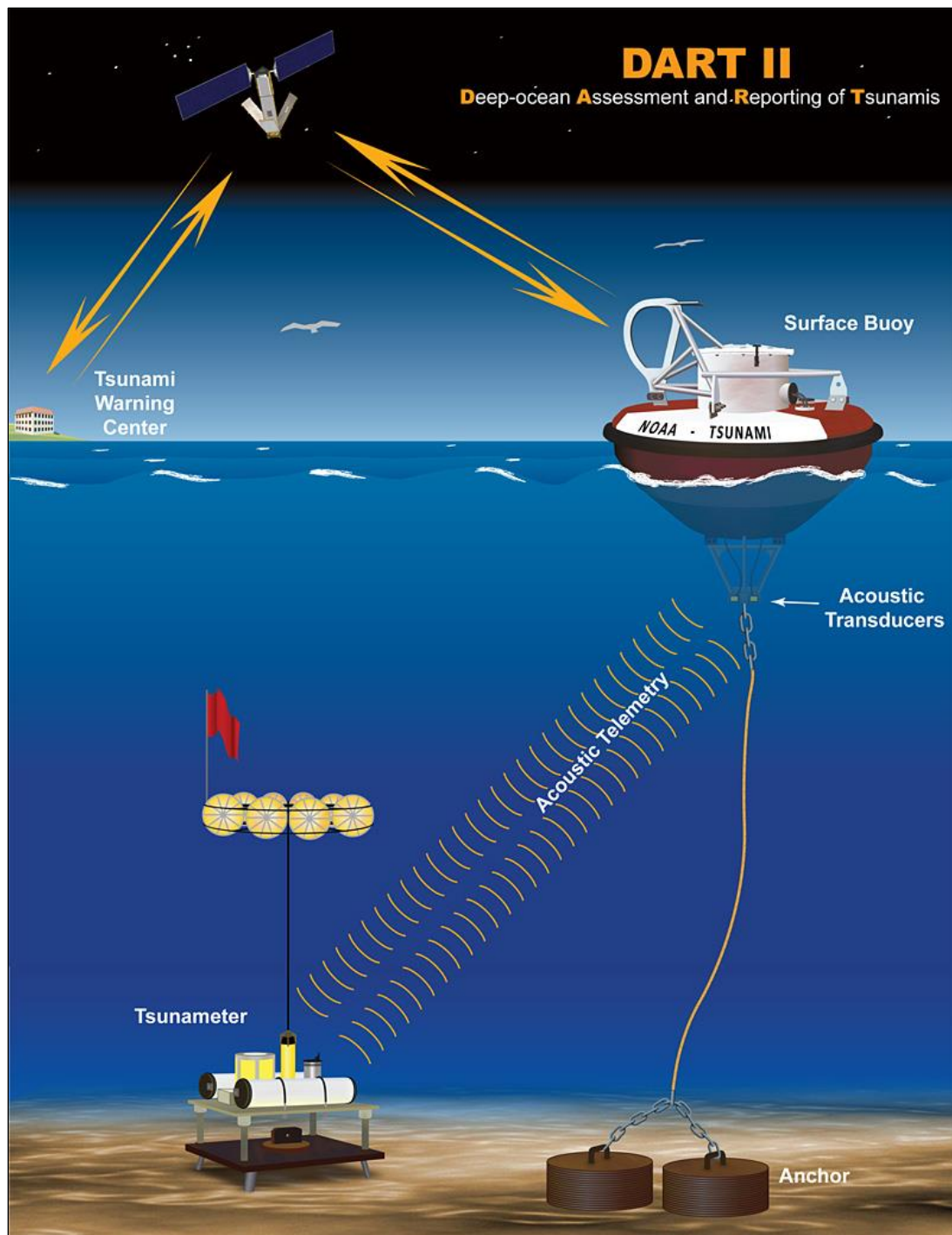
NOAA depends on earth observing networks on land and in the ocean to collect information about water levels and seismic activity. NOAA owns, operates, and maintains 40 DART systems located in the Pacific, Atlantic, and Caribbean basins (**Figure 1**) that measure and transmit water level changes via seafloor pressure recorders and moored surface buoys (**Figure 2**). International partners maintain additional DART systems and share the collected information with NOAA. DART systems, along with [tsunami capable tide stations](#), provide direct measurements to support coastal threat evaluation and forecasting. NOAA uses these data after an event to improve tsunami forecast modeling and coastal hazard assessments. NOAA uses seismic and other data collected by the U.S. Geological Survey (USGS) and other countries to track tsunami sources, such as [earthquakes](#), [volcanic eruptions](#), and [landslides](#), to determine if they might generate a damaging tsunami.

Figure 1. NOAA DART Station Locations

As of February 2, 2022



Source: NOAA, National Data Buoy Center, "[Interactive Maps-DART](#)."

Figure 2. DART Station Schematic

Source: NOAA, National Weather Service, "Deep-ocean Assessment and Reporting of Tsunami."

Warning Centers

NWS operates [two tsunami warning centers \(TWCs\)](#): the [National Tsunami Warning Center \(NTWC\)](#) in Alaska, which serves the continental United States (including Alaska) and Canada, and the [Pacific](#)

[Tsunami Warning Center](#) (PTWC) in Hawaii, which serves Hawaii, the U.S. Pacific and Caribbean territories, and the British Virgin Islands. PTWC acts as the primary forecast center for several international and national warning systems. If instrumentation detects a tsunami, NOAA uses the collected data to estimate potential impacts and amends forecasts with historical and event-specific data, as available. The forecasts are then shared with emergency managers, [the public](#), and other partners to warn about the potential for a tsunami.

Tsunami Warnings

TWCs may issue several types of [tsunami alerts](#), including information statements, watches, advisories, and warnings. Alerts may be updated as information becomes available. The public may become aware of an incoming tsunami in [two main ways](#). The first is via official tsunami alerts broadcast through local radio and television stations, wireless emergency alerts, [NOAA weather radio](#), NOAA websites, or outdoor sirens. Each type of [alert](#) provides information, including an estimate of the tsunami's arrival time, if applicable, potential impacts, and recommended actions to take, such as staying out of the water or moving to higher ground. The second is by experiencing ground shaking from the tsunami source itself, such as an earthquake, or noting changes in local coastal conditions. Some coastal populations near the tsunami source may not have enough time to receive tsunami alerts prior to the arrival of a tsunami.

Other NOAA Tsunami Program Activities

NOAA supports other activities under its Tsunami Program, in addition to detection, forecasting, and warning. Congress directed NOAA, in consultation with federal and nonfederal partners, to maintain a tsunami research program (33 U.S.C. §3205). The [program](#) focuses on improving tsunami measurement technology and monitoring networks; models for increased speed and accuracy of forecasts and warnings; and methods for predicting tsunami impacts on coastal communities and infrastructure. Congress also authorized a [national tsunami hazard mitigation program](#) led by NOAA in coordination with the Federal Emergency Management Agency, the USGS, and 28 states and territories (33 U.S.C. §3204). The mitigation [program](#) aims to reduce tsunami impacts through collaboration, coordination, and financial and technical support to partner states, such as through the support of nonfederal preparedness measures (e.g., the [TsunamiReady program](#)). Other parts of NOAA's Tsunami Program focus on [historical tsunami data collection and archiving](#). Congress also has directed NOAA to provide technical assistance, operational support, and training to support a global tsunami warning and mitigation network (33 U.S.C. §3206), in addition to its responsibilities for U.S. states and territories.

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