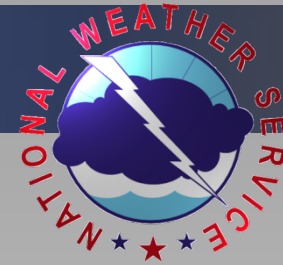
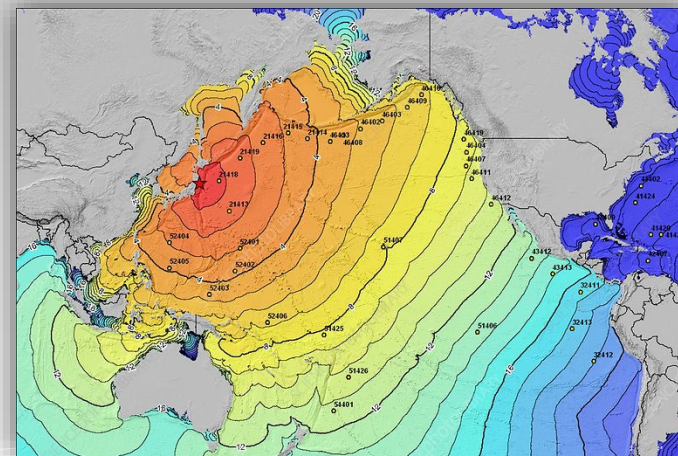


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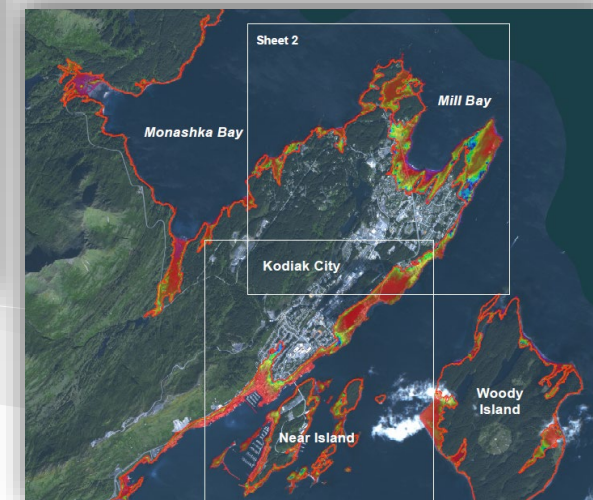


Coastal Mapping Applications in Tsunami Operations and Mitigation

Dec. 9th, 2020 Alaska Coastal Mapping Summit



Kara Gately
NOAA / NWS / National Tsunami Warning Center
Palmer, AK



Tsunami Warnings



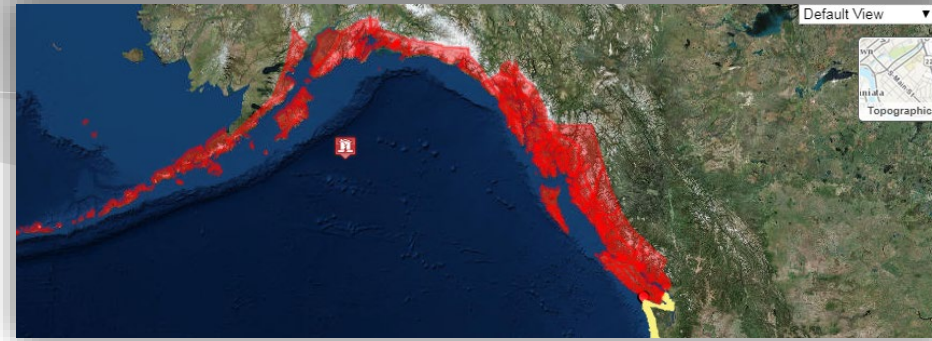
Initial Alert based on Earthquake

- Magnitude
- Location

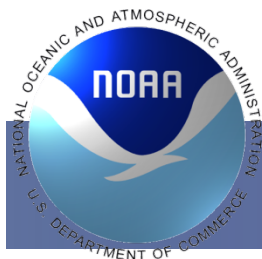


Revise based on Expected Impacts

- Tsunami observations
- Updated earthquake information
- Run tsunami models



Kodiak, 2018 Tsunami Event



National Tsunami Warning Center



Tsunami Travel Times

Models were the earliest type used operationally

Wave speed

Dependent on depth (D) of the ocean

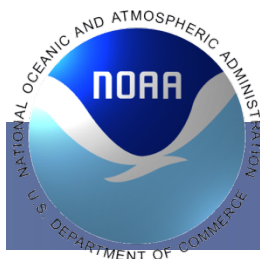
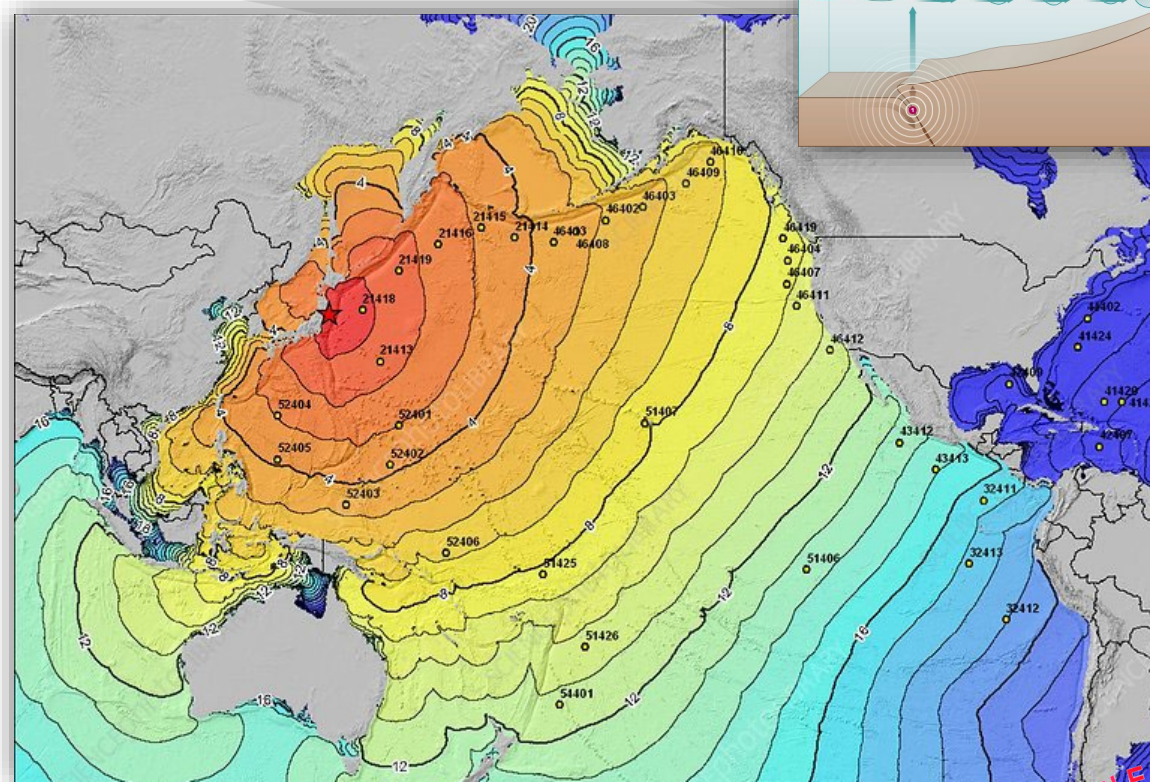
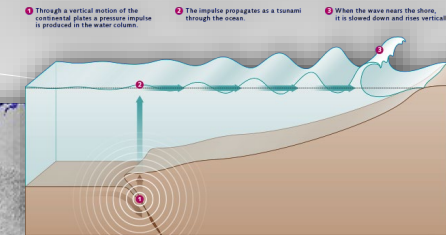
- 30 arc sec to 4 min ocean wide grids

$$c = \sqrt{gD}$$

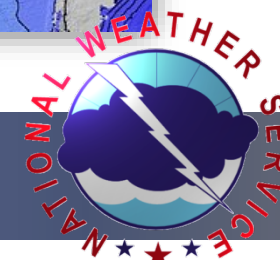
$c \equiv$ wave speed

$D \equiv$ depth

$g \equiv$ gravity



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Tsunami Propagation

Models first used operationally in 1997

Deep Ocean

- Linear Physics
- 4 min to 30 arc sec

Bathymetry directly Impacts

- Wave directionality
- Amplification
- Offshore safety depths

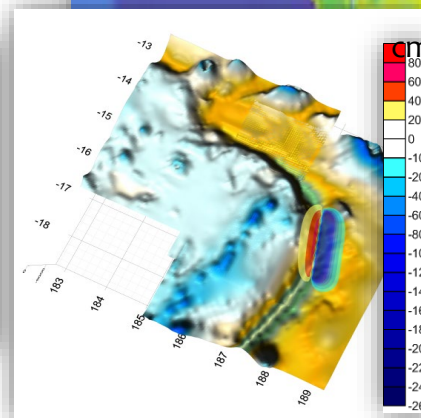
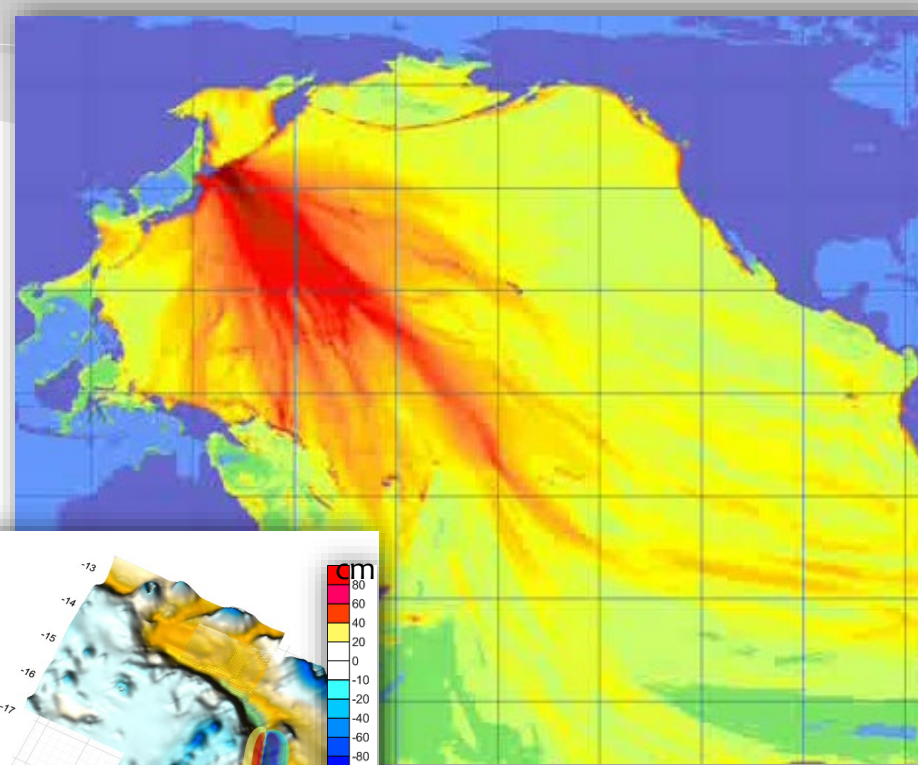


TABLE 1: Specific regional guidance for minimum offshore safe depths for maritime vessel evacuation prior to the arrival of tsunami.

State/Territory	Distant Source (ships in harbor)*	Local Source (ships at sea)*	Notes on this Update
California	30 fathoms	100 fathoms	Evaluated; evaluating potential safe areas within large bays and ports
Oregon	30 fathoms	100 fathoms	Evaluated; also evaluating Columbia River
Alaska	30 fathoms	100 fathoms	Evaluated; ships should be at least 1/2 mile from shore for all scenarios



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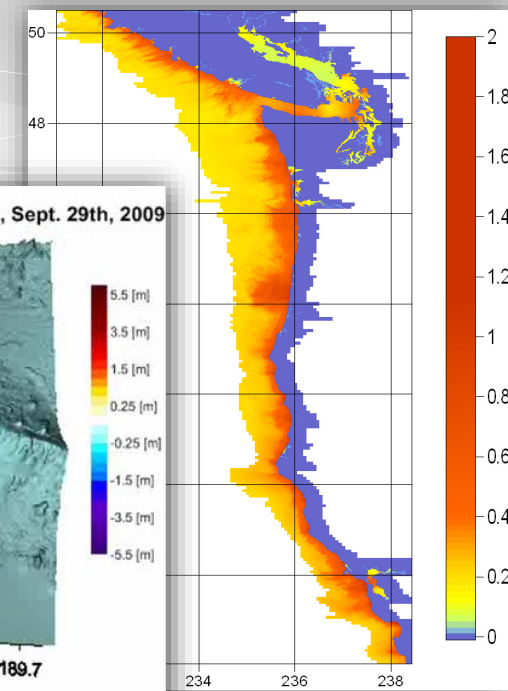
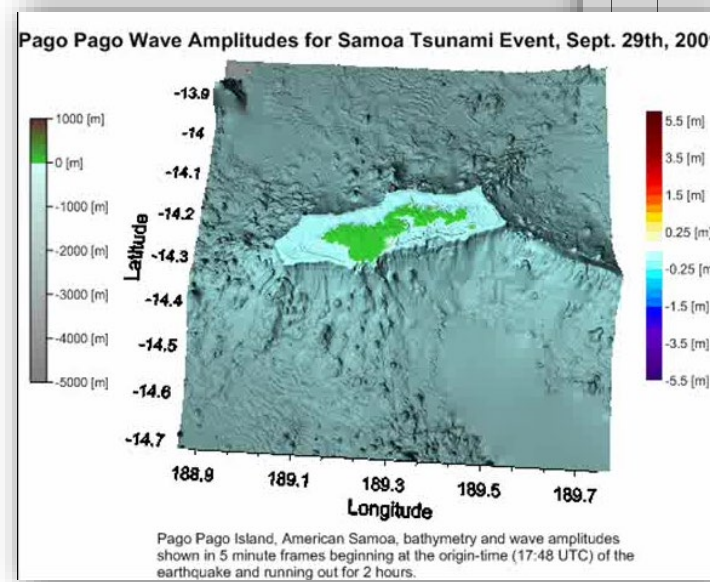
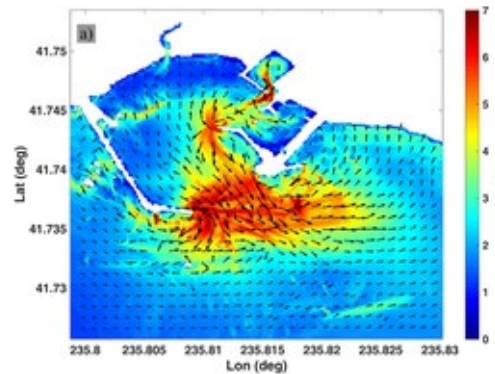


Tsunami Inundation and Currents

Models first used operationally in 2013

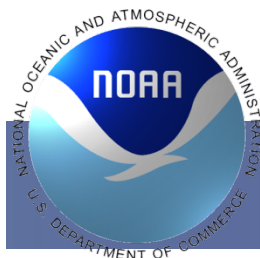
Coastal Ocean

- Complex Non-linear Physics
- 3 to 1/9 arc second
- Digital Elevation Models
 - Wave run-up
 - Coastal amplification
 - Inundation extent
 - Near-shore currents



Alaska Tsunami Forecast Model (ATFM)

MOST <https://doi.org/10.1002/2016JC012435>



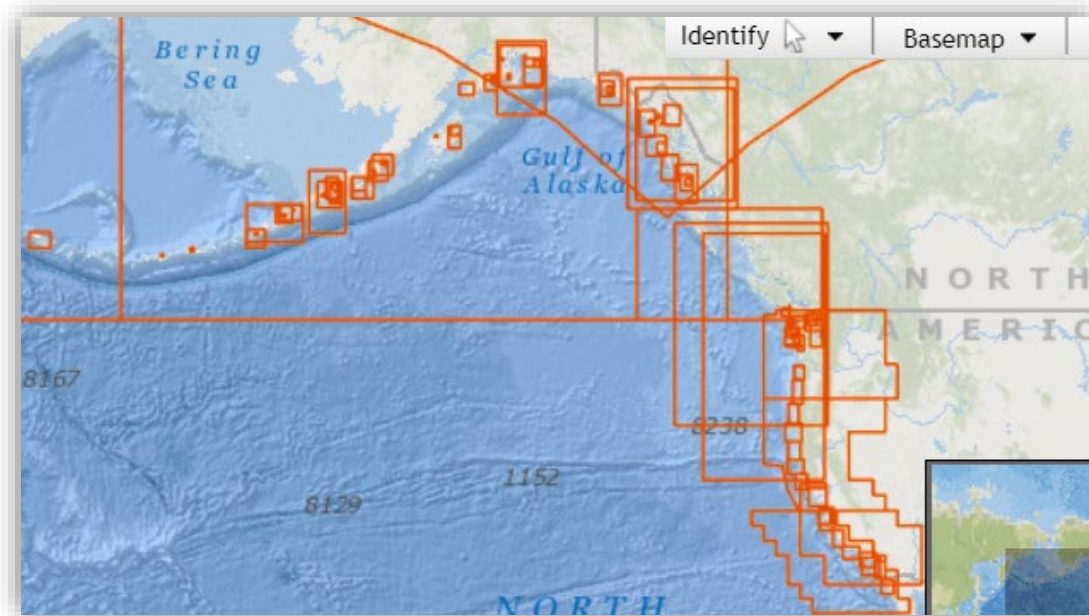
National Tsunami Warning Center



Tsunami Mitigation

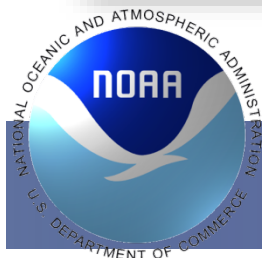
National Tsunami Hazard Mitigation Program (NTHMP)
NOAA's National Centers for Environmental Information (NCEI)

Coastal Digital Elevation Models (DEMs)



DEM Development

- Began in 2006
- High-Resolution
 - Multibeam LIDAR
 - Hydrographic Surveys
 - 3 to 1/3 arc sec for Alaska
- Used for modeling tsunami
 - Run-up
 - Inundation
 - Currents



<https://maps.ngdc.noaa.gov/viewers/bathymetry/>

National Tsunami Warning Center

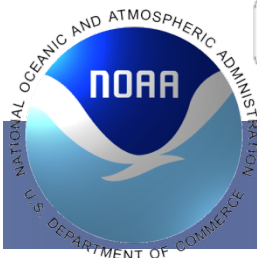


Tsunami Mitigation

National Tsunami Hazard Mitigation Program (NTHMP)
State of Alaska: DGGG, DHS&EM, and Alaska Earthquake Center

NTHMP

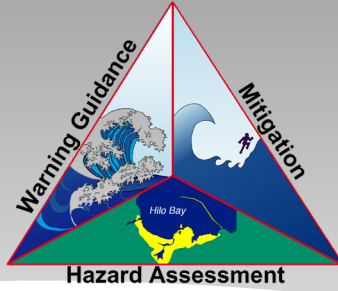
- Tsunami Mitigation
- Outreach
- Hazard Assessment
- Modeling & Mapping
- Warning Coordination
- Guidance
- Model Benchmarking



<https://nws.weather.gov/nthmp/>

National Tsunami Warning Center



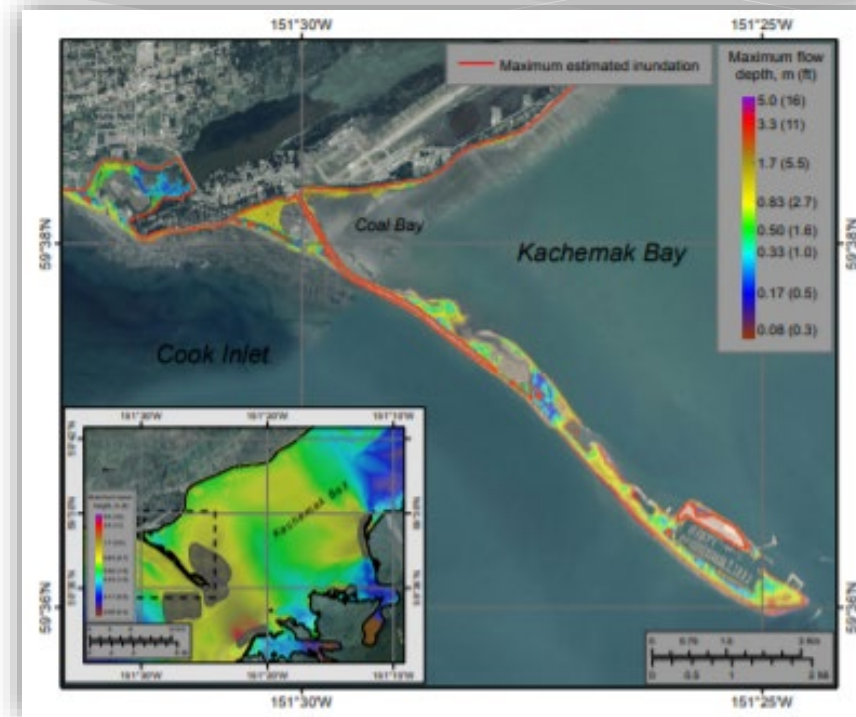
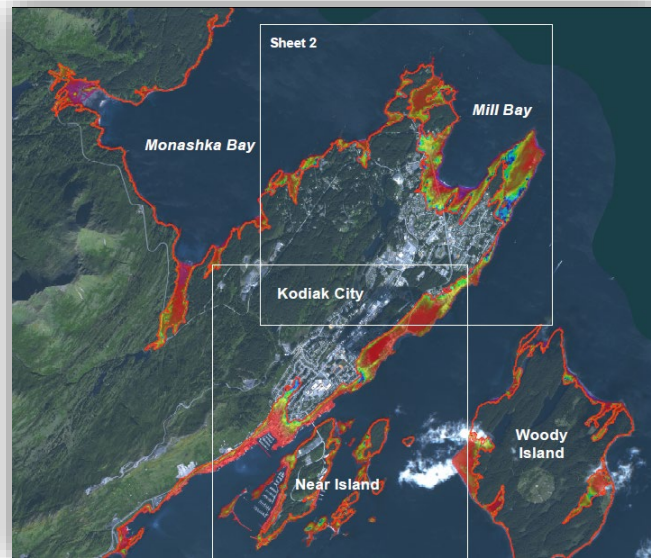


Tsunami Mitigation



State Tsunami Mapping

- Inundation Modeling
- Tsunami Evacuation Zones



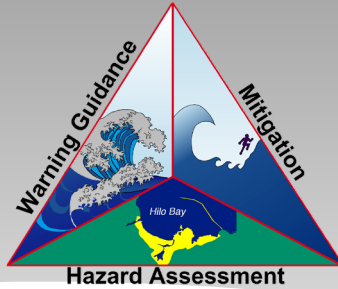
<https://dgggs.alaska.gov/>



National Tsunami Warning Center

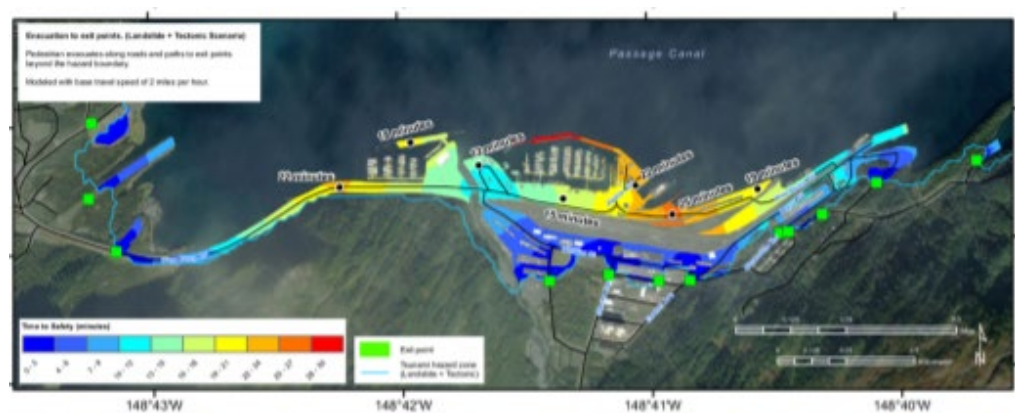


Tsunami Mitigation

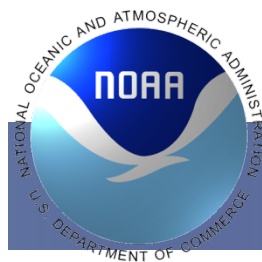
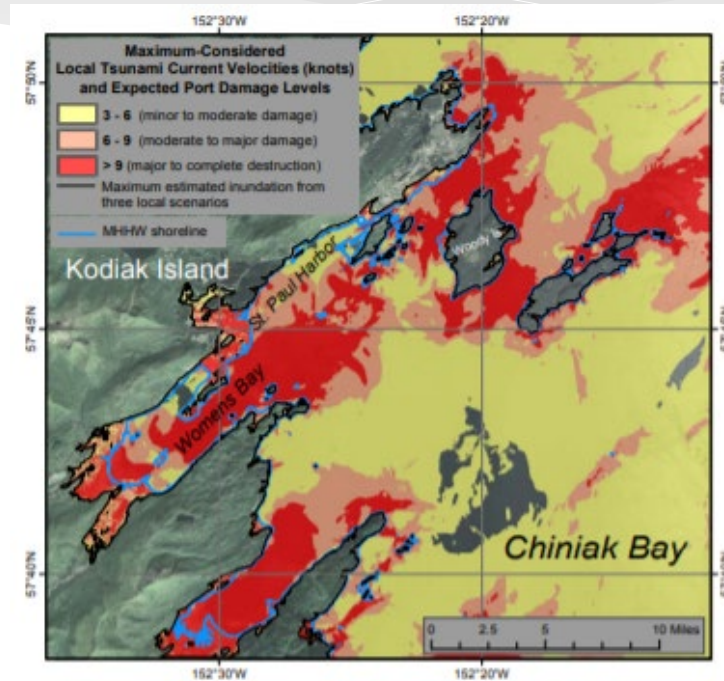


State Tsunami Mapping

- Tsunami Currents / Maritime Guidance
- Pedestrian Evacuation Maps (PEM)



Seward, AK PEM



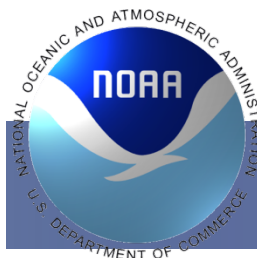
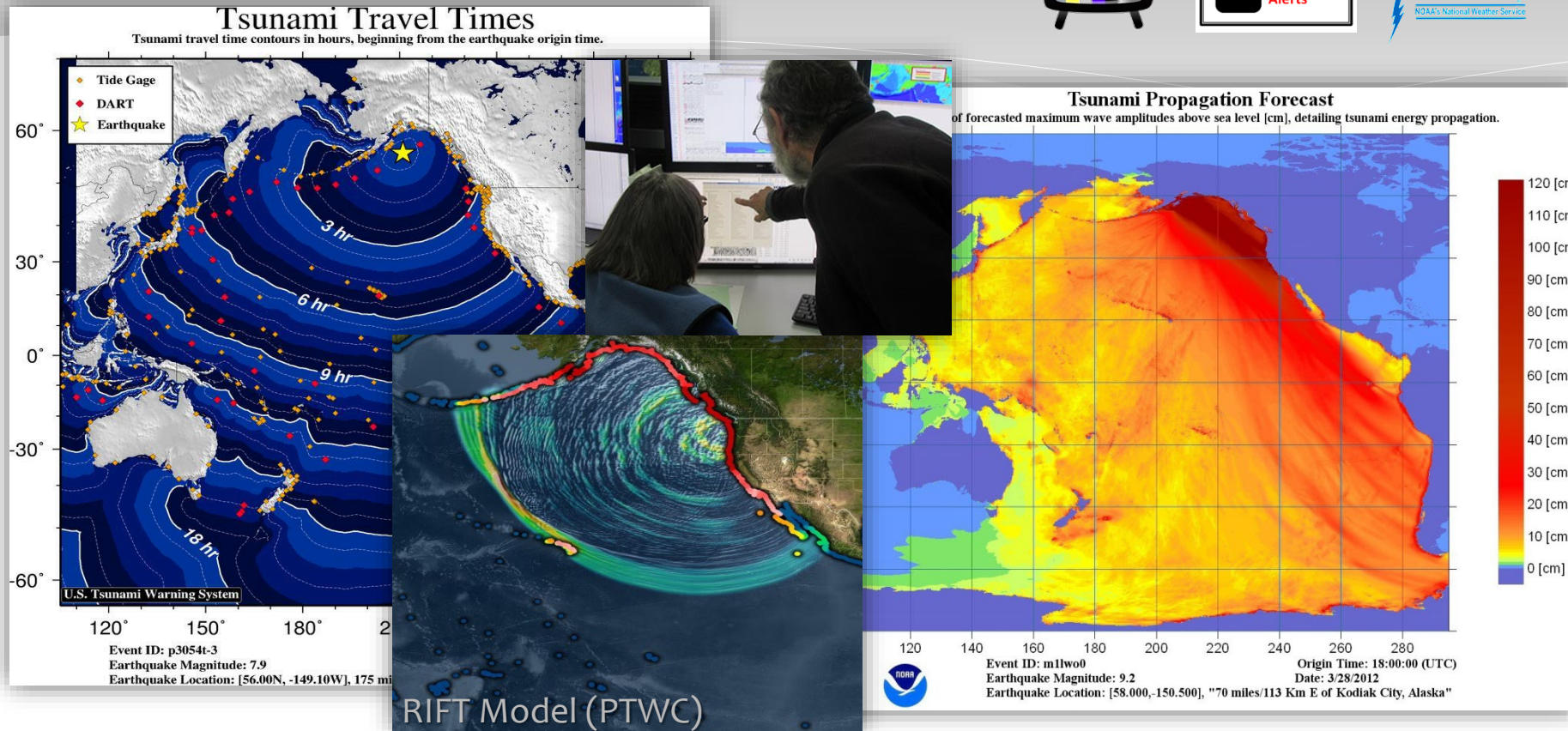
<http://earthquake.alaska.edu/tsunamis>

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Tsunami Warning Operations

Minutes Matter



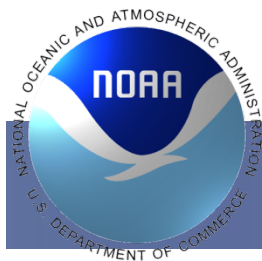
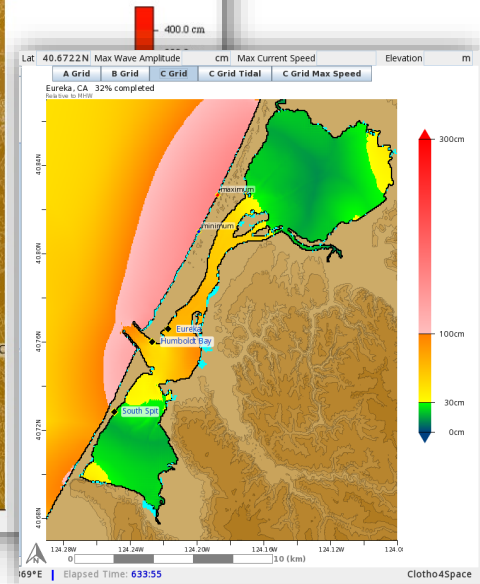
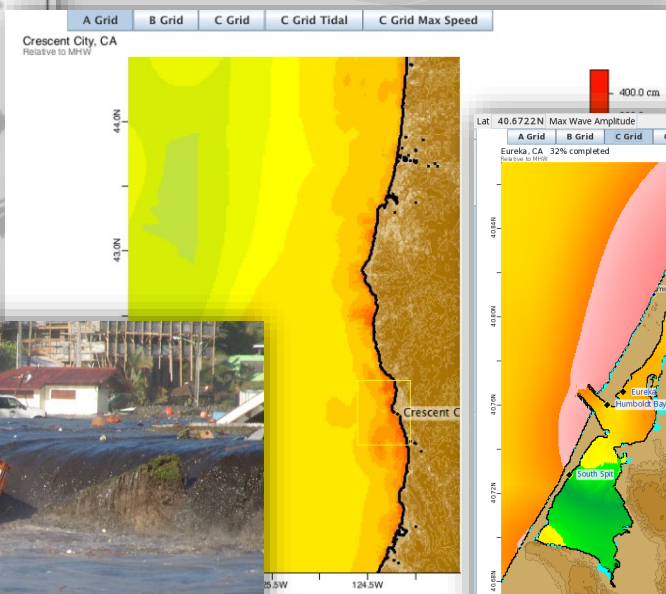
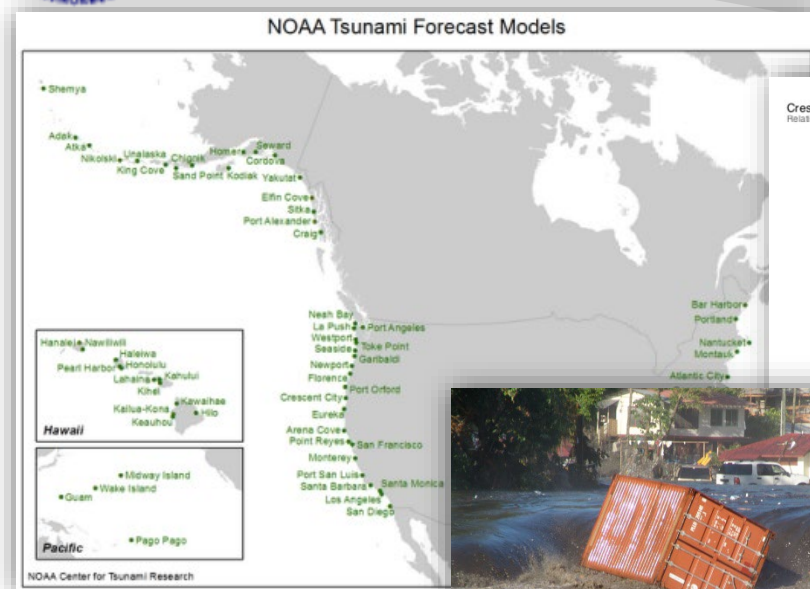
<https://tsunami.gov>

National Tsunami Warning Center



Tsunami Warning Operations

Short-term Inundation Forecasting for Tsunamis (SIFT)
Stand-by Inundation Models



National Tsunami Warning Center



Tsunami Warning Operations



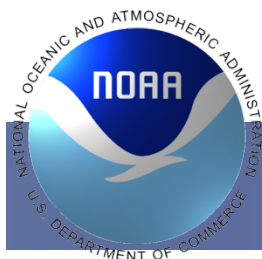
Short-term Inundation Forecasting for Tsunamis (SIFT)

Tsunami Inundation



Bonin petrel rescued from being stuck in the sand
<http://www.fws.gov/midway/tsunami.html>

SIFT model post-event run (yellow) and observed (red) flooding in Midway. Japan 2011.



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Tsunami Operations

Short-term Inundation Forecasting for Tsunamis (SIFT)

Tsunami Currents

RELATIONSHIP BETWEEN TSUNAMI CURRENT SPEED AND HARBOR DAMAGE: Analysis of recent tsunami damage indicates a relationship between current speed and harbor damage. The Damage Index (from Lynett and others, 2013) to the right has been used to determine the following relationship (see color codes here for blue, yellow, and red areas and on current threshold maps):

CURRENTS = DAMAGE

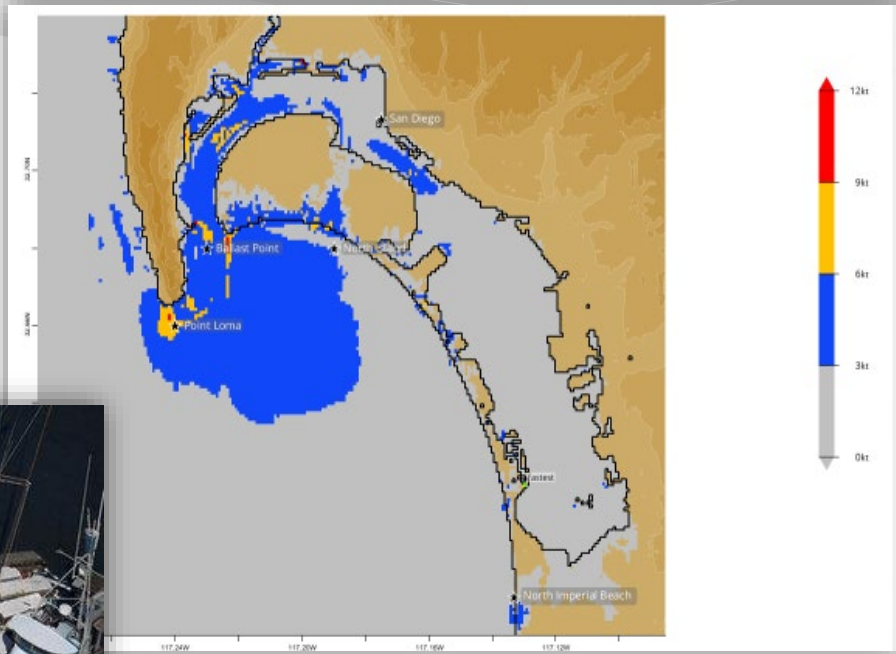
0-3 knots = No Damage

3-6 knots = Minor/Moderate Damage

6-9 knots = Moderate/Major Damage

>9 knots = Major/Complete Damage

Damage Index:	Damage Type:
0	no damage
1	small buoys moved
2	1-2 docks/small boats damaged, large buoys moved
3	Moderate dock/boat damage, mid-sized vessels off moorings
4	Major dock/boat damage, large vessels off moorings
5	Complete destruction

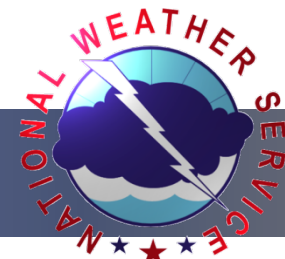


SIFT Model (San Diego, CA)

Damage from Tsunami Currents in Santa Cruz, CA. Japan 2011



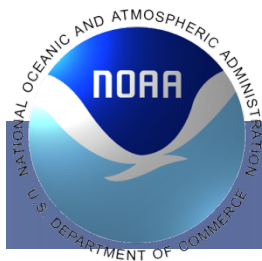
National Tsunami Warning Center



Thank you.

Without mapping we cannot assess tsunami impacts.

We really appreciate all the ongoing efforts mapping coastal Alaska!



Kara.Gately@noaa.gov

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