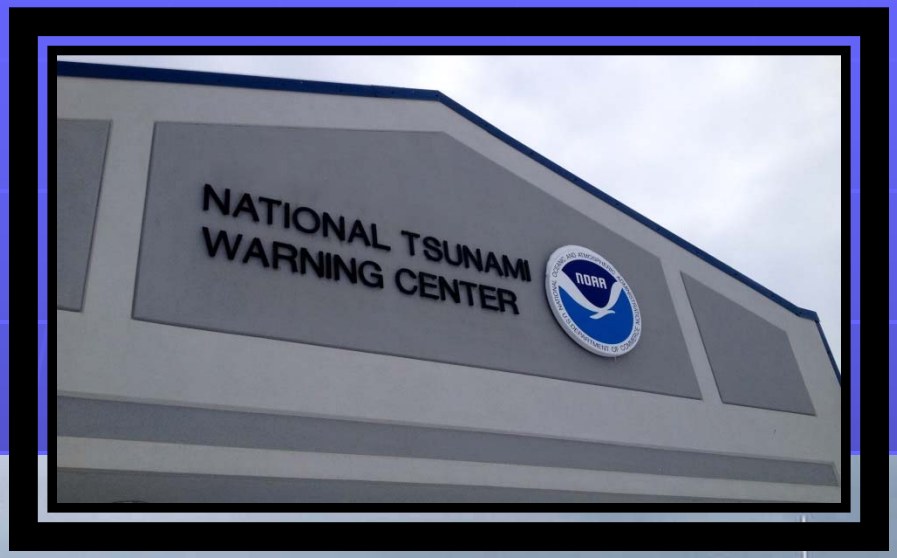
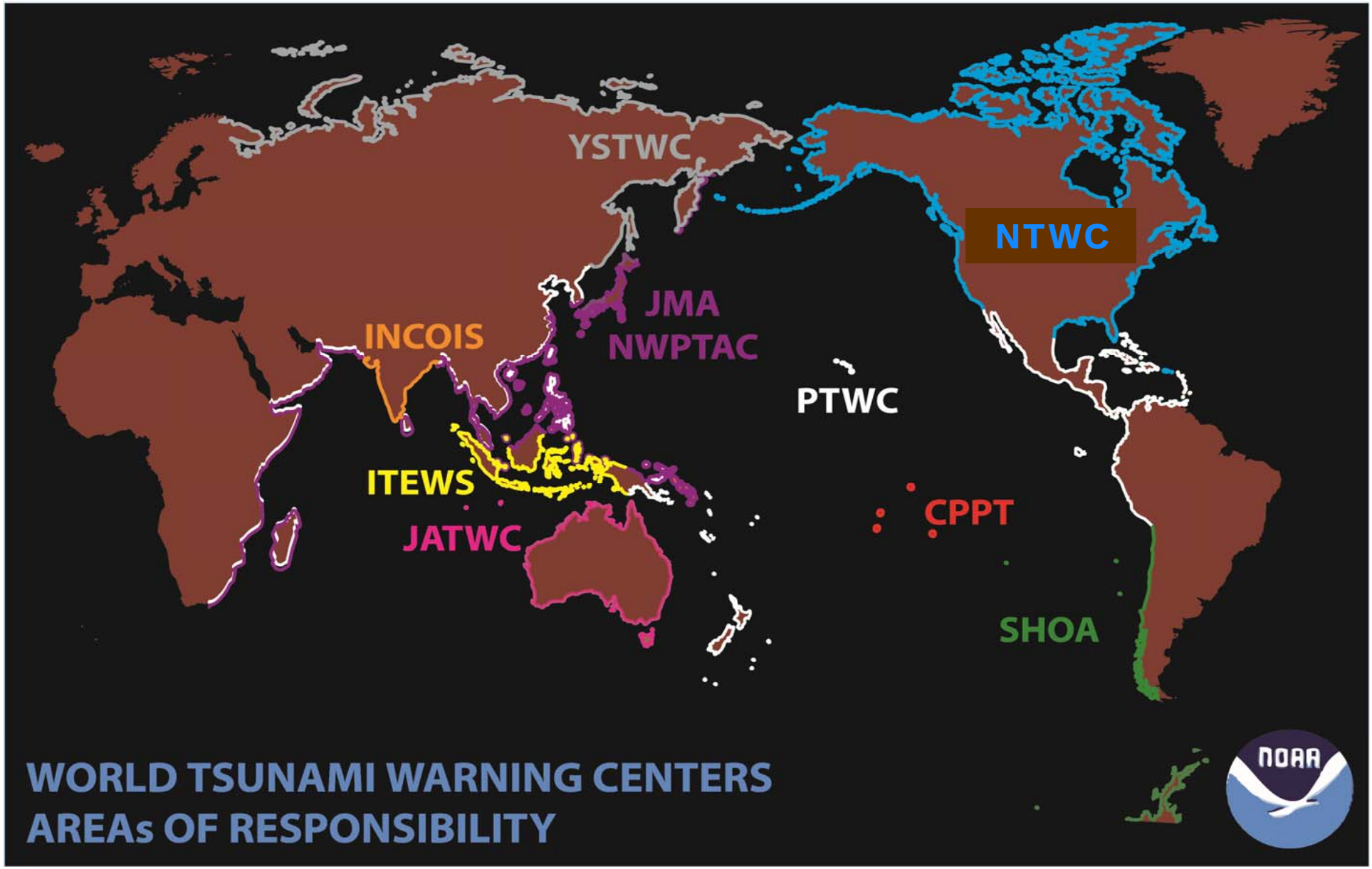
Remembering 1964



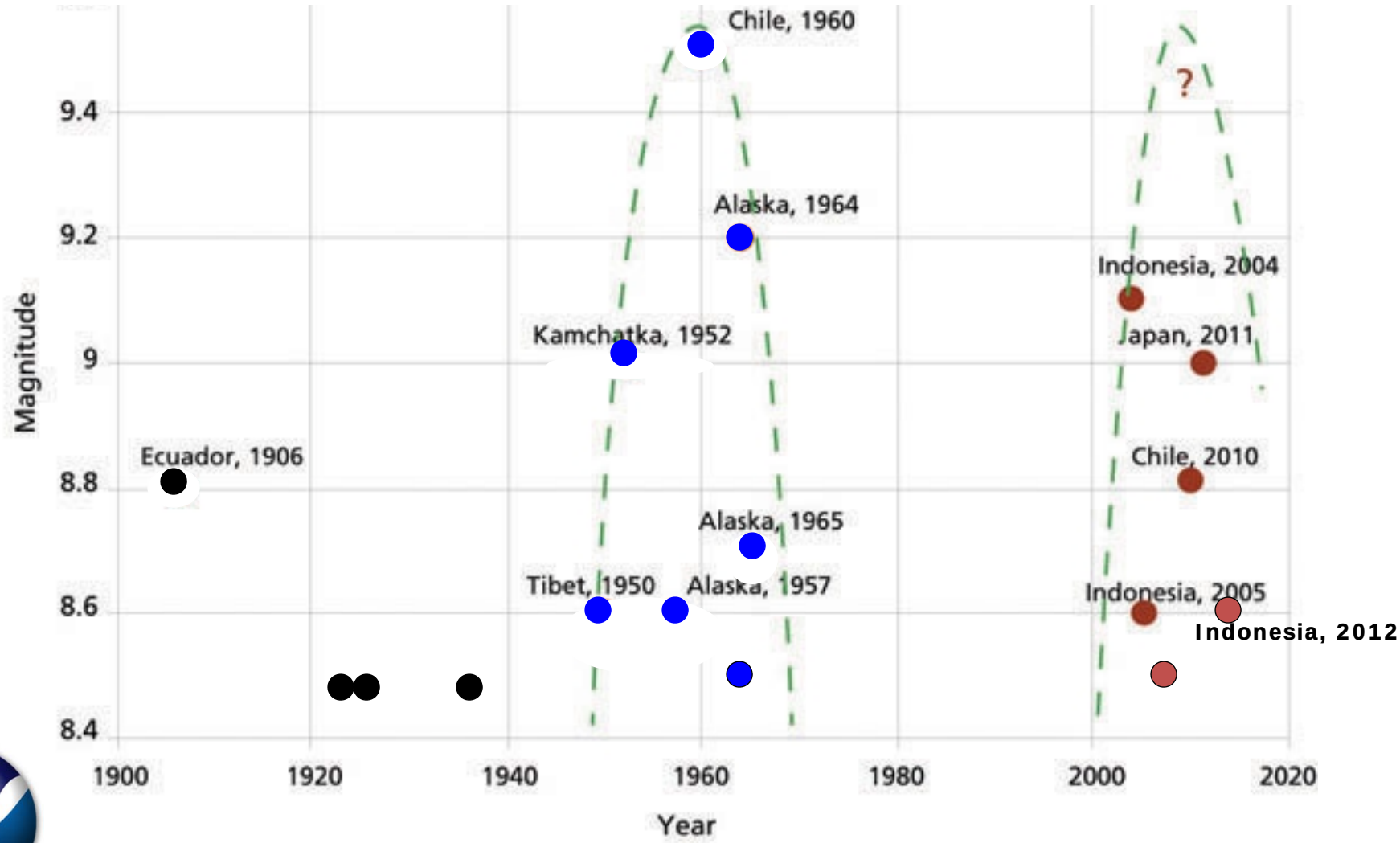
NTWC
PTWC
NOAA TSUNAMI WARNING SYSTEM AREAs OF RESPONSIBILITY
National Tsunami Warning Center (NTWC)
and Pacific Tsunami Warning Center (PTWC)
NOAA

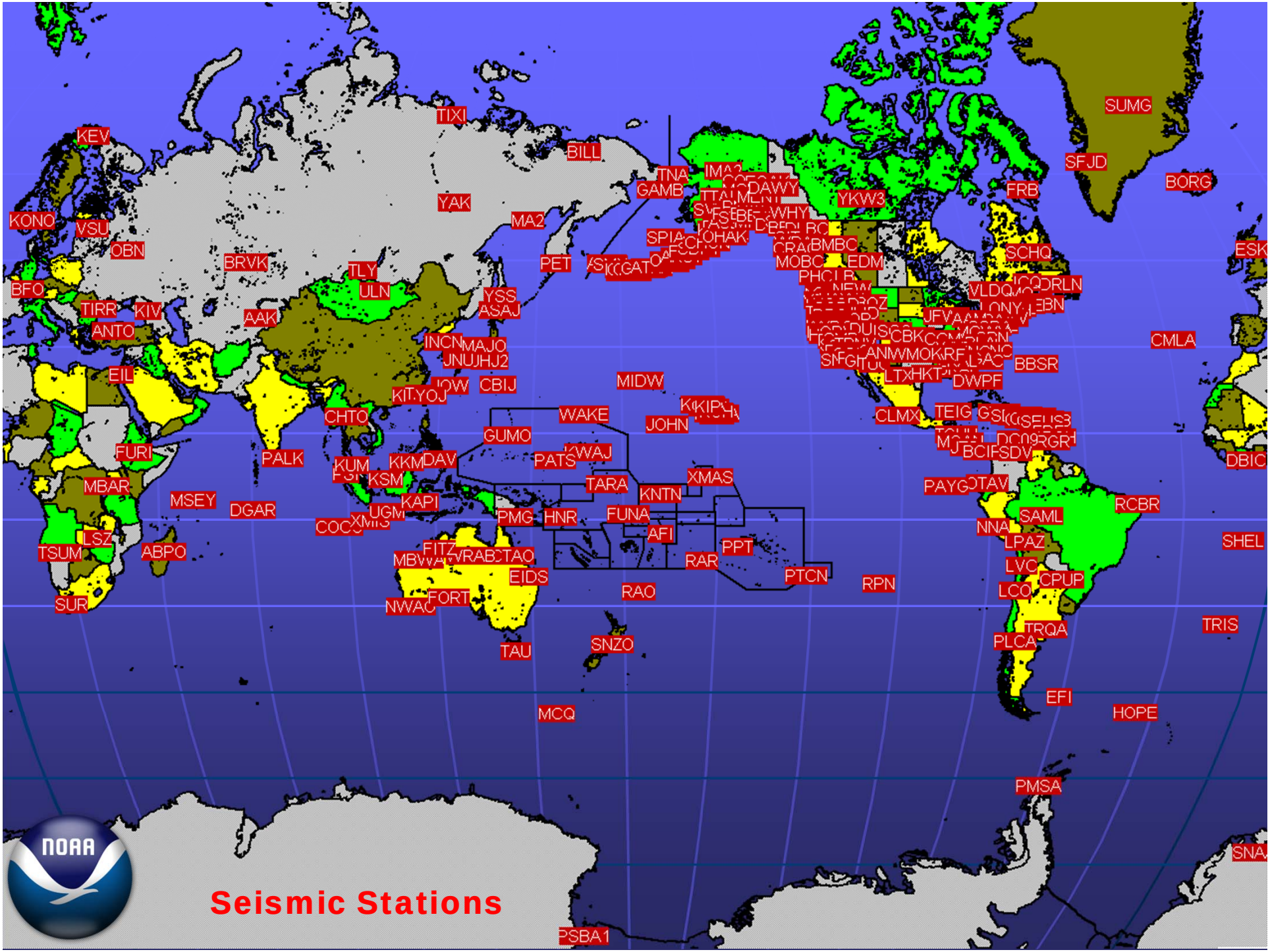
YSTWC - Yuzhno-Sakhalinsk Tsunami Warning Center
INCOIS - Indian National Centre for Ocean Information Services
ITEWS - Indonesia Tsunami Early Warning System
JATWC - Joint Austalia Tsunami Warning Centre

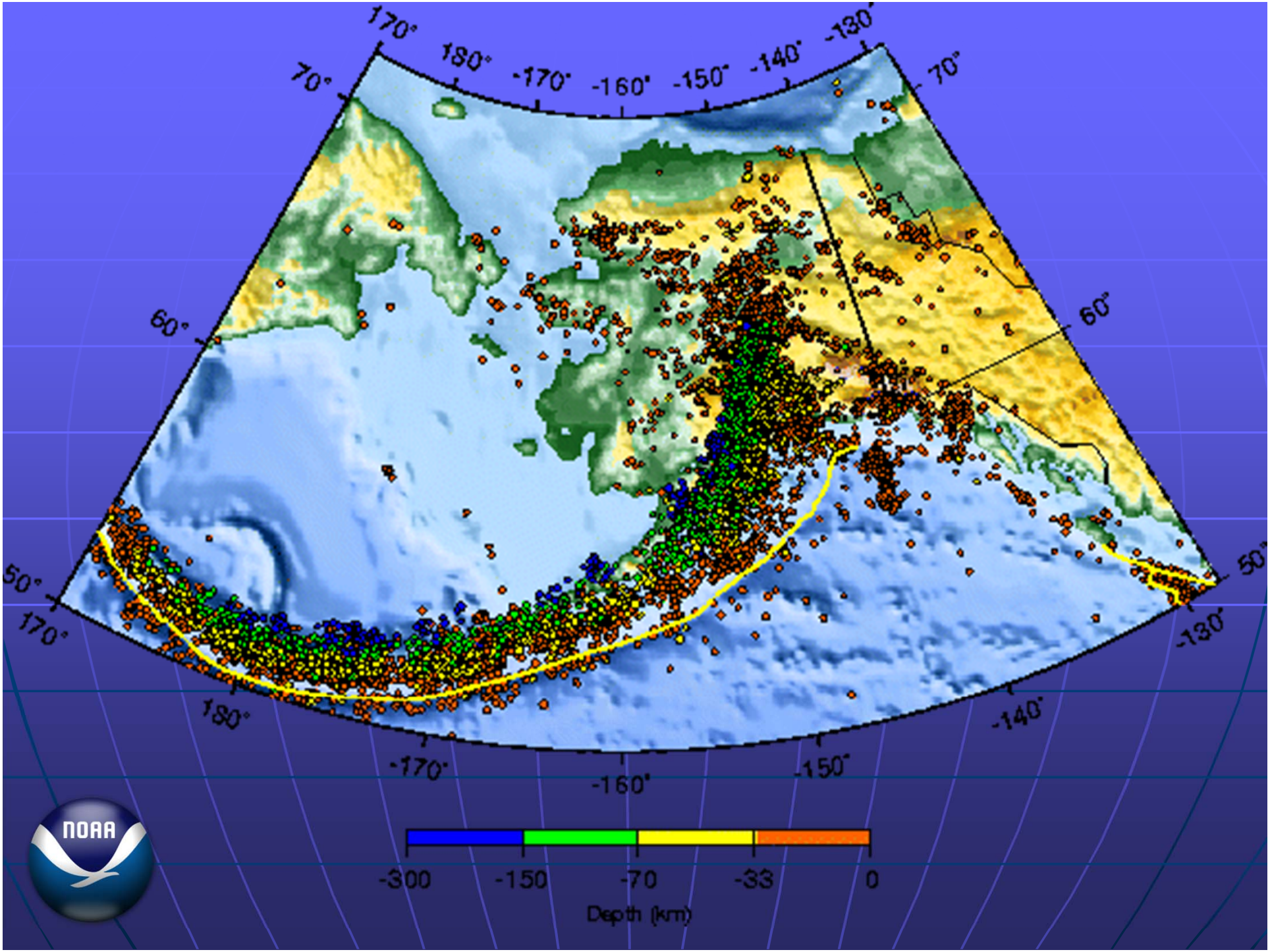
NTWC - National Tsunami Warning Center
JMA NWPTAC - Japan Meteorological Agency
North West Pacific Tsunami Alert Center
PTWC - Pacific Tsunami Warning Center
CPPT - Centre Polynésien de Prévention des Tsunamis
SHOA - Servicio Hidrográfico y Oceanográfico de la Armada



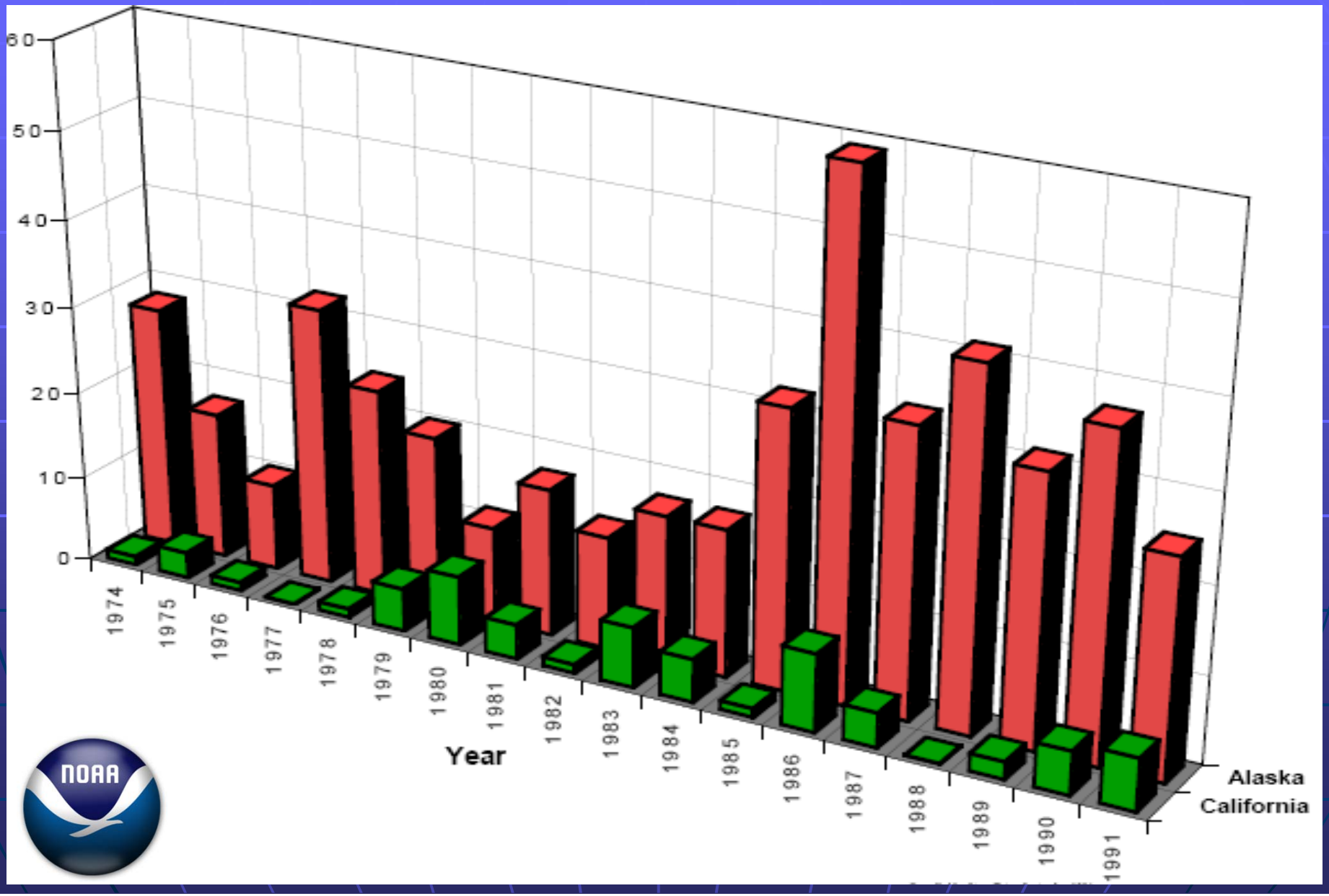
Temporal distribution of earthquakes greate or equal to 8.5 since 1900



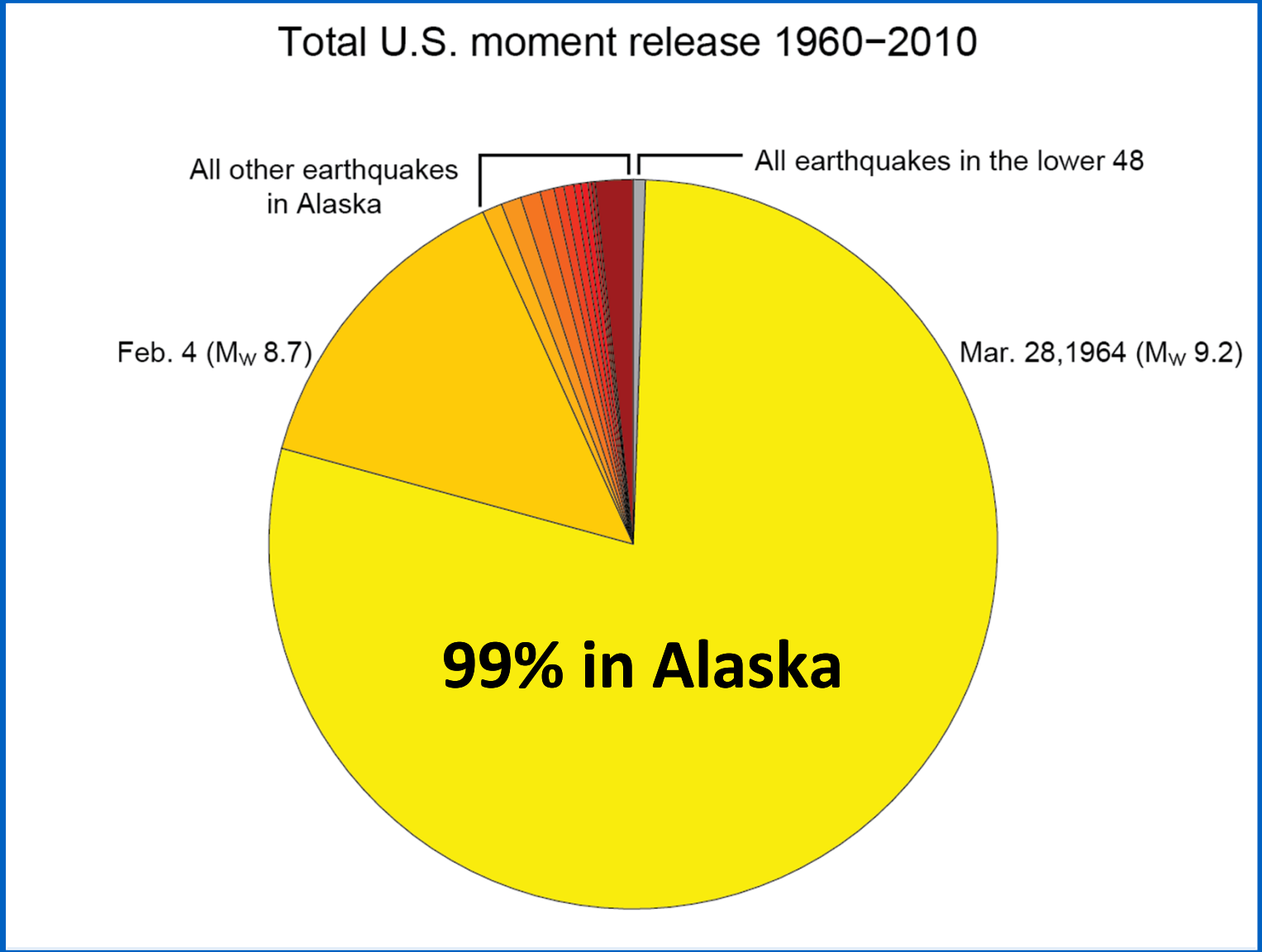

Seismic Stations
NOAA
KEV
TIXI
BILL
SUMG
SFJD
BORG
KONO
VSU
OBN
YAK
MA2
TNA
GAMB
YKW3
FRB
BRVK
TLY
ULN
PET
SCHQ
ESK
BFO
TIRR
KIV
ANTO
AAK
YSS
ASAJ
INCN
MAJO
JNU
HJ2
CMLA
EIL
CBIJ
MIDW
BBSR
DWPF
CHTO
WAKE
JOHN
CLMX
TEIG
GUMO
FURI
PALK
KUM
KKM
DAV
PATS
KWAJ
DBIC
MBAR
KSM
TARA
XMAS
PAYG
MSEY
DGAR
KAPI
KNTN
RCBR
UGM
PMG
HNR
FUNA
SAML
LSZ
AFI
NNA
LPAZ
SHEL
TSUM
ABPO
FITZ
RAB
TAO
PPT
RAR
LVC
EIDS
PTCN
RPN
CPUP
SUR
FORT
RAO
LCO
TRIS
TRQA
TAU
SNZO
PLCA
EFI
MCQ
HOPE
PMSA
SNA
PSBA1


170°
180°
-170°
-160°
-150°
-140°
-130°
70°
60°
50°
-300
-150
-70
-33
0
Depth (km)

Seismicity comparison (>5.5)

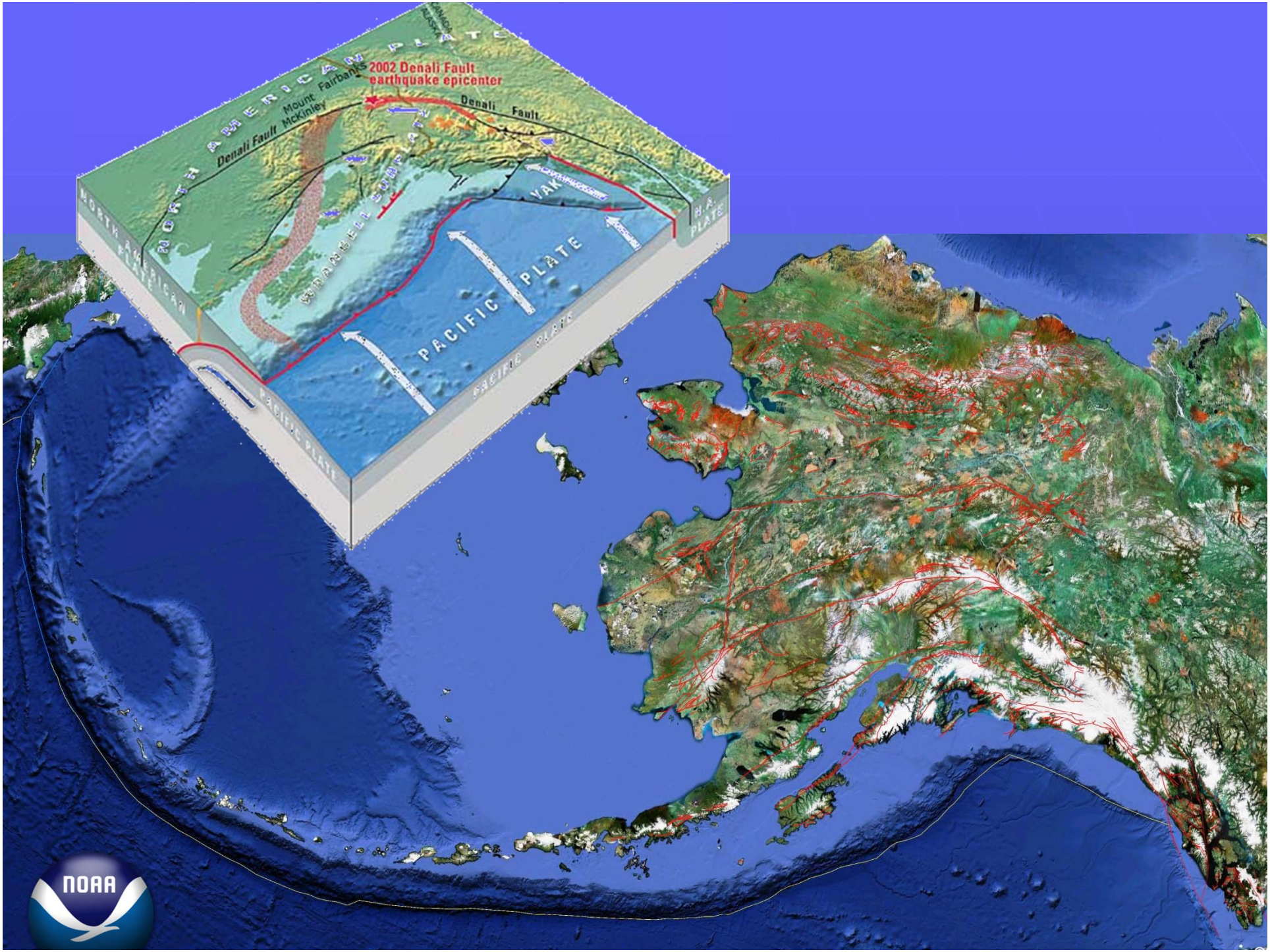


EQ energy release in the US 1960-2010

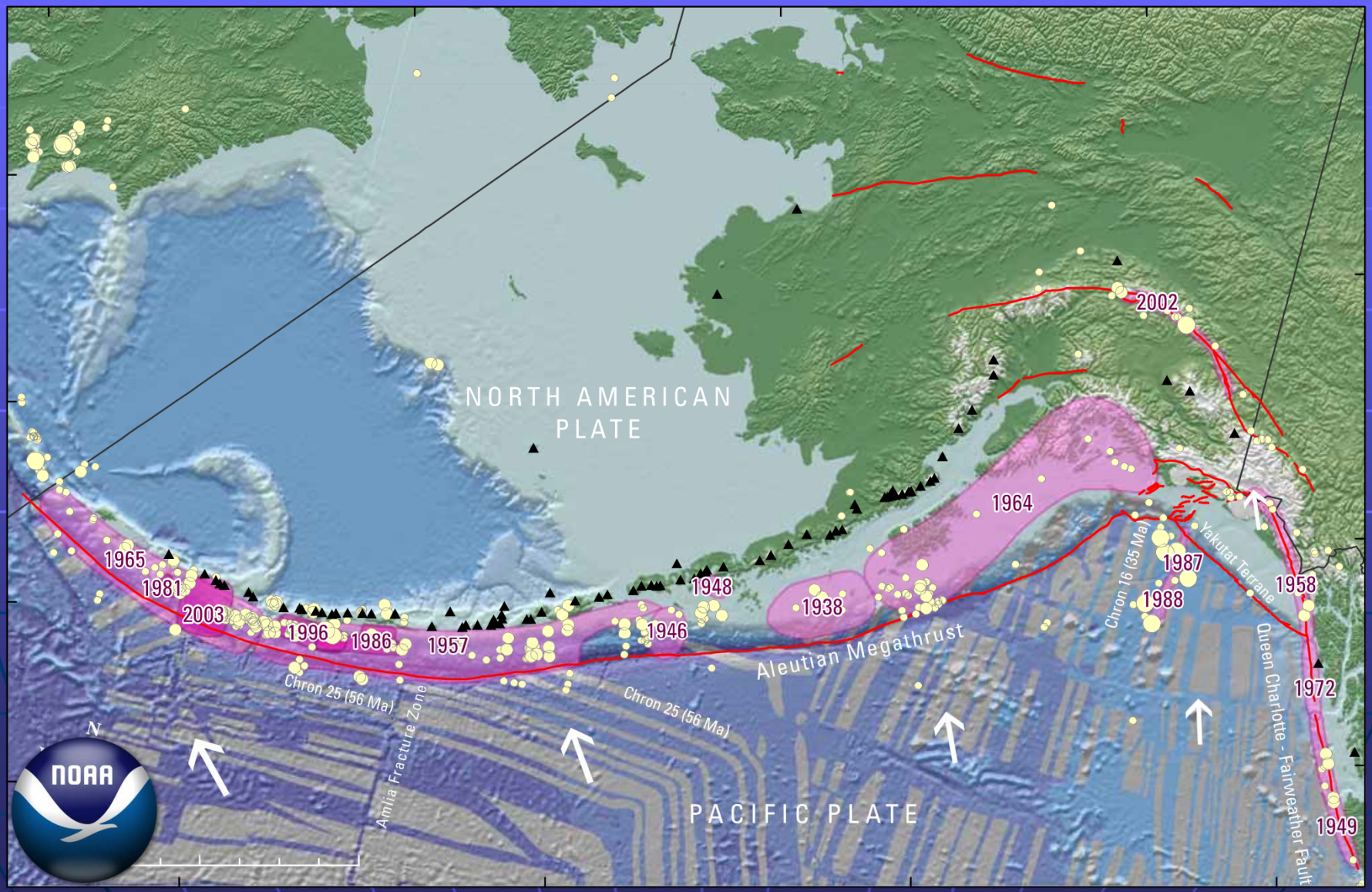


some perspective

M	Hiroshima Bombs (15KT TNT)	trade center collapse	world energy (443.1x1025 ergs / years)
-3	2.12149E-12	1.33017E-10	8.98662E-17
-2	6.70874E-11	4.20638E-09	2.84182E-15
-1	2.12149E-09	1.33017E-07	8.98662E-14
0	6.70874E-08	4.20638E-06	2.84182E-12
1	2.12149E-06	0.000133017	8.98662E-11
2	6.70874E-05	0.004206382	2.84182E-09
3	0.002121491	0.133017488	8.98662E-08
4	0.067087437	4.	2.84182E-06
5	2	133	8.98662E-05
6	67	4,206	0.003
7	2,121	133,017	0.09
8	67,087	4,206,382	2.8
8.5	377,260	23,654,225	15.9
8.6	532,894	33,412,482	23
8.7	752,733	47,196,385	32
8.8	1,063,264	66,666,666	45
9	2,121,491	133,017,487	90
9.1	2,996,685	187,892,195	127
9.15	3,561,567	223,310,292	151
9.2	4,232,931	265,404,780	179
9.5	11,930,020	748,012,302	505

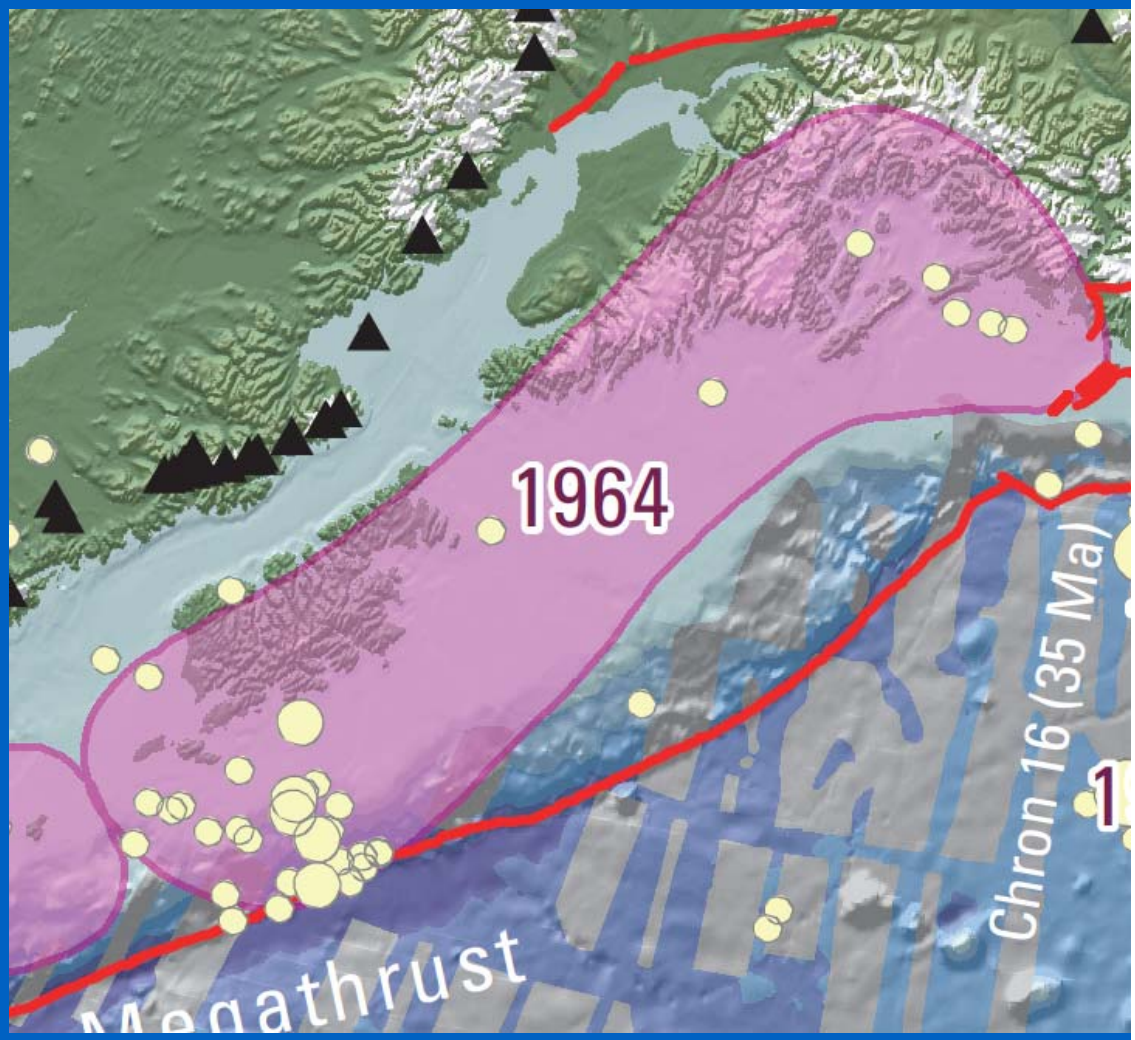

NORTH AMERICAN PLATE
2002 Denali Fault
earthquake epicenter
Fairbanks
Mount McKinley
Denali Fault
Denali Fault
WRANGELL SUBPLATE
YAKUTAT
PACIFIC PLATE
PACIFIC PLATE
NORTH AMERICAN PLATE
N.A. PLATE
NOAA

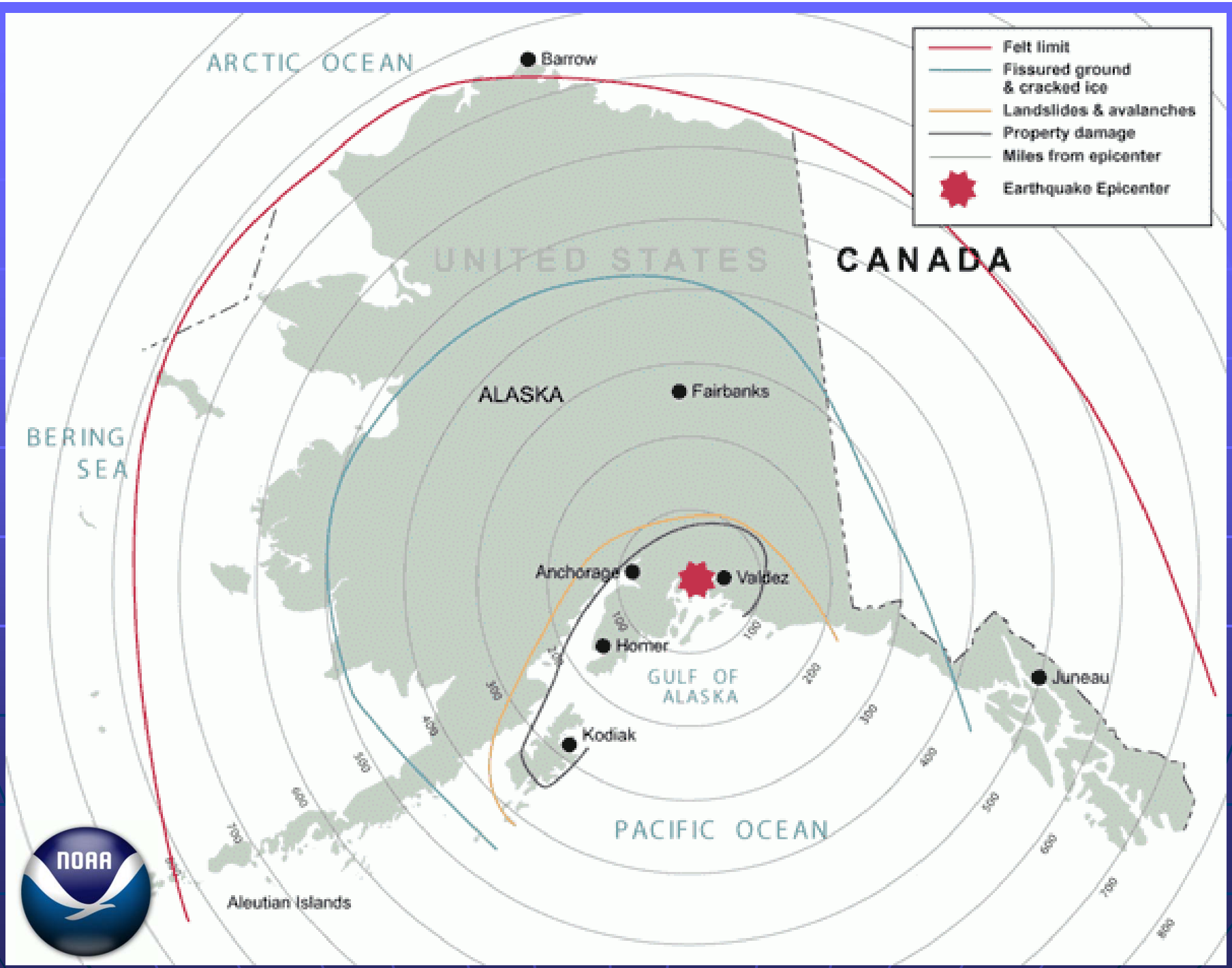
Active faults and significant earthquakes

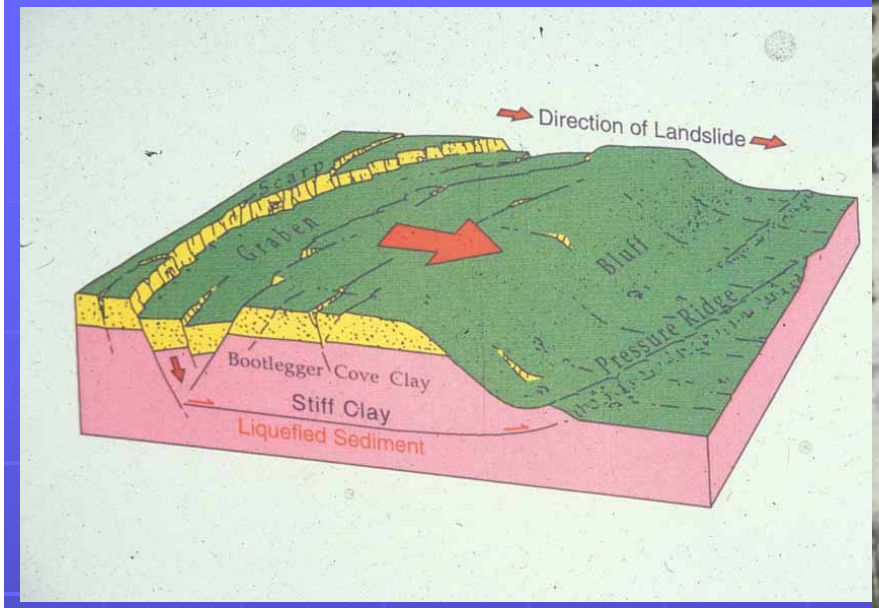


Overview of the 1964 earthquake

- March 27th, 1964, 5:36 PM. Good Friday
- M9.2, initially 8.6, related to rupture area
- shaking lasted about 4.5 minutes
- Hypocenter - 18 km
- 2nd largest earthquake ever recorded
- ~250x800 km rupture area
- Two slip patches



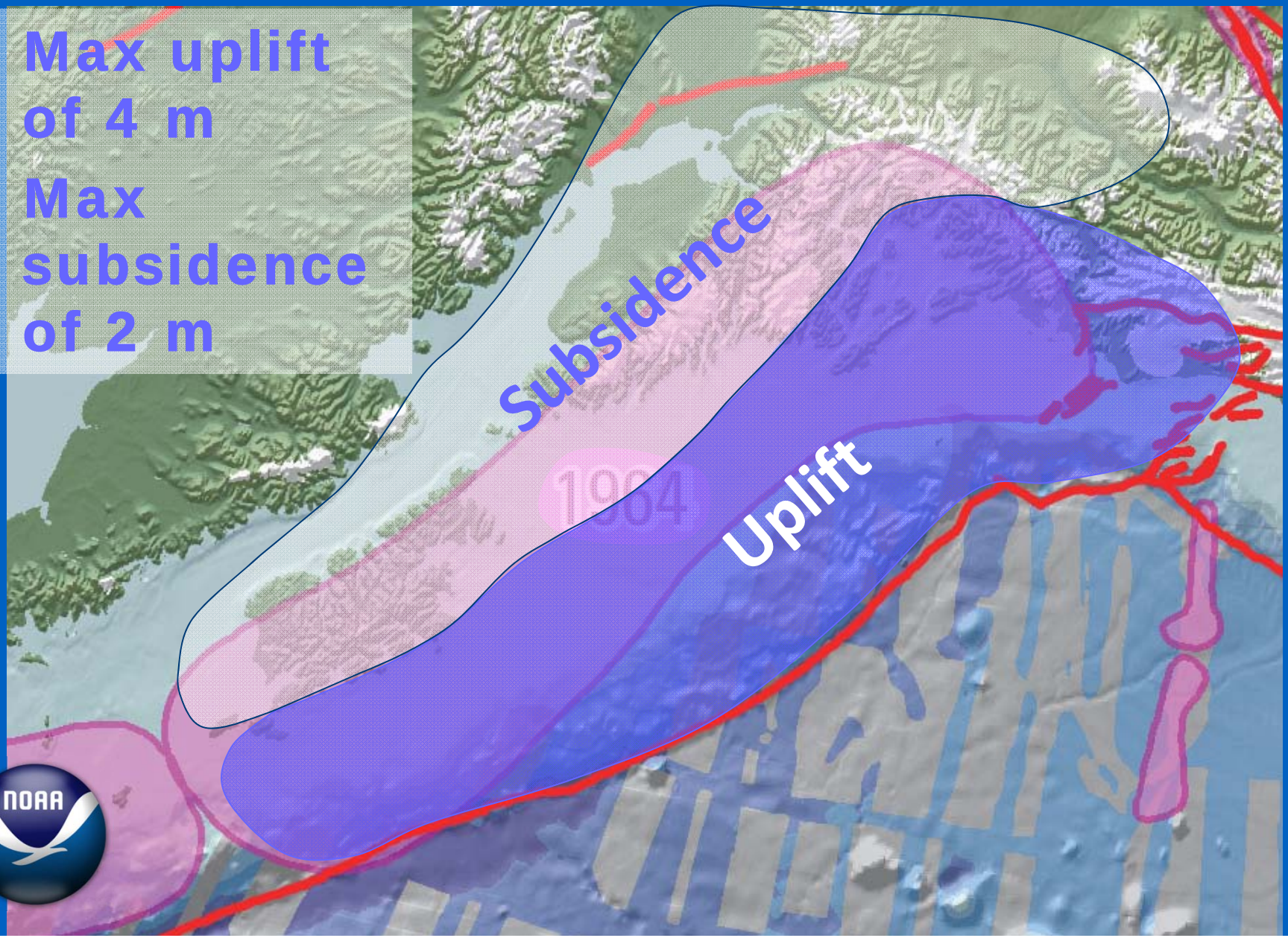

Felt limit
Fissured ground & cracked ice
Landslides & avalanches
Property damage
Miles from epicenter
Earthquake Epicenter
ARCTIC OCEAN
Barrow
UNITED STATES
CANADA
ALASKA
Fairbanks
BERING SEA
Anchorage
Valdez
Homer
GULF OF ALASKA
Juneau
Kodiak
PACIFIC OCEAN
Aleutian Islands
NOAA



- Ground shaking
  - Caused damage to unreinforced masonry buildings
  - Caused translational slides

Uplift and Subsidence

- Max uplift of 4 m
- Max subsidence of 2 m

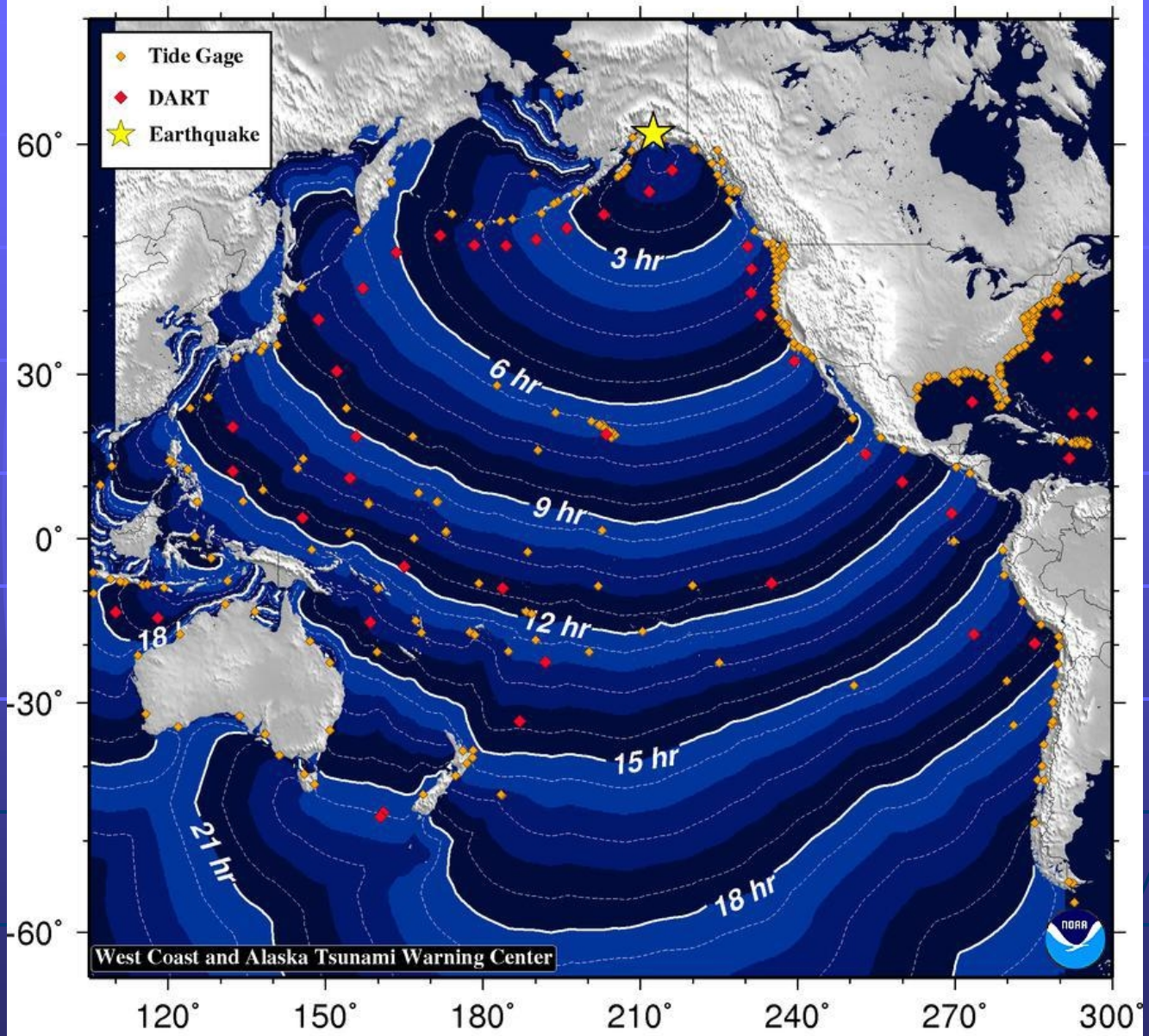


Montague Is, AK Prince William Sound
11 m uplift: Source USGS

Girdwood; 1964 (G Mull)

Tsunami Travel Times

Tsunami travel time contours in hours, beginning from the earthquake origin time.



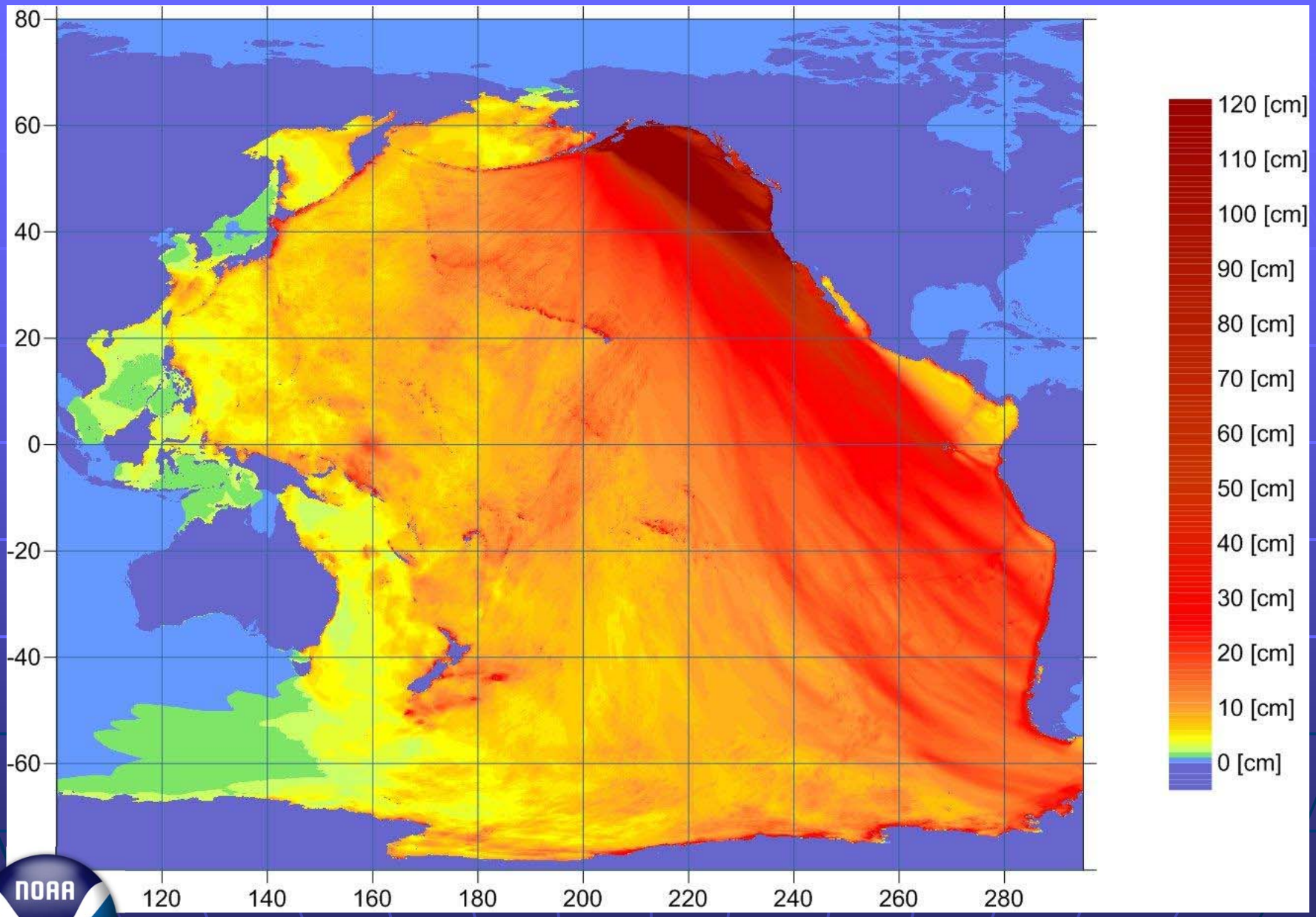
Event ID: 1w0t0z5-1

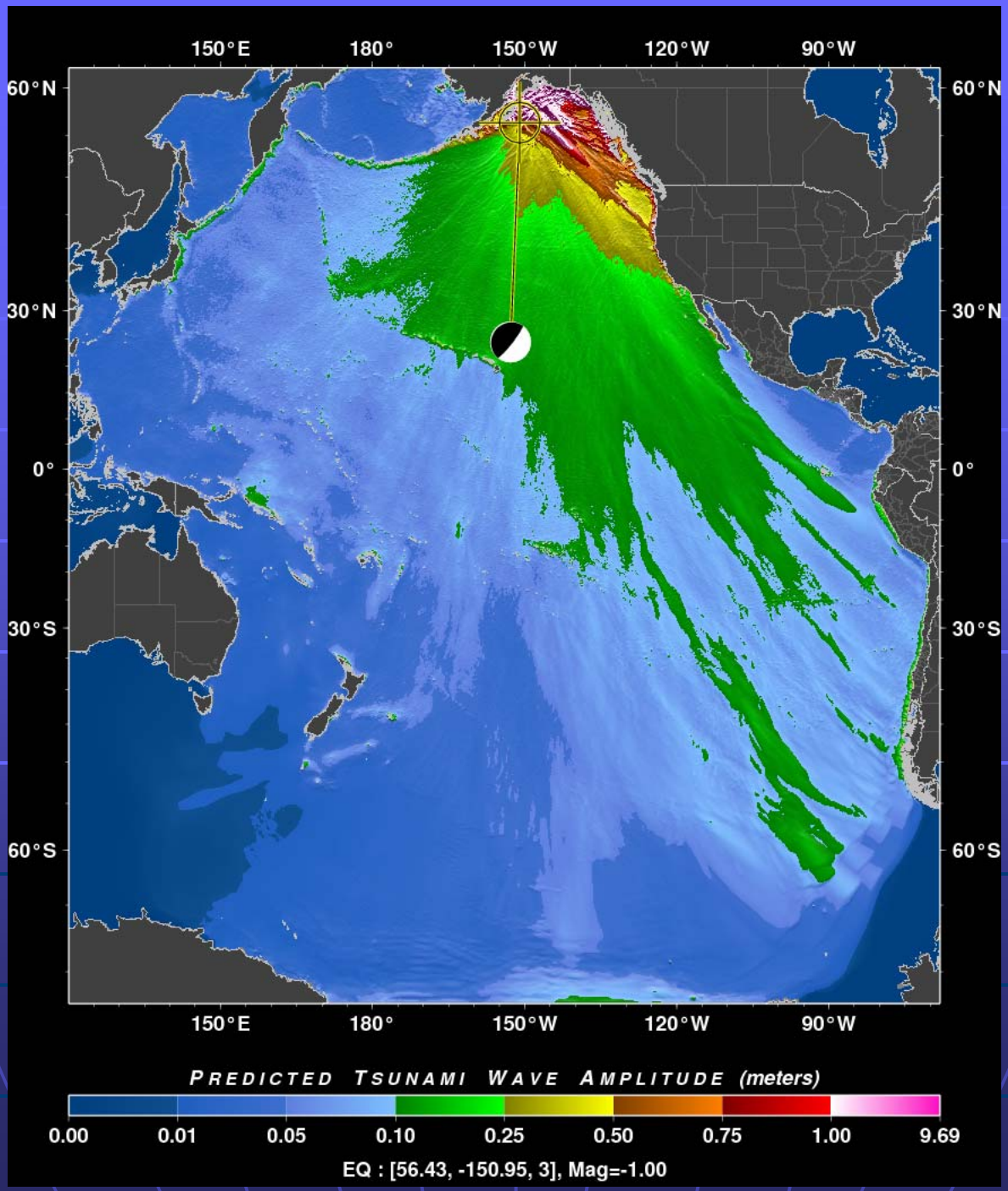
Earthquake Magnitude: 9.2

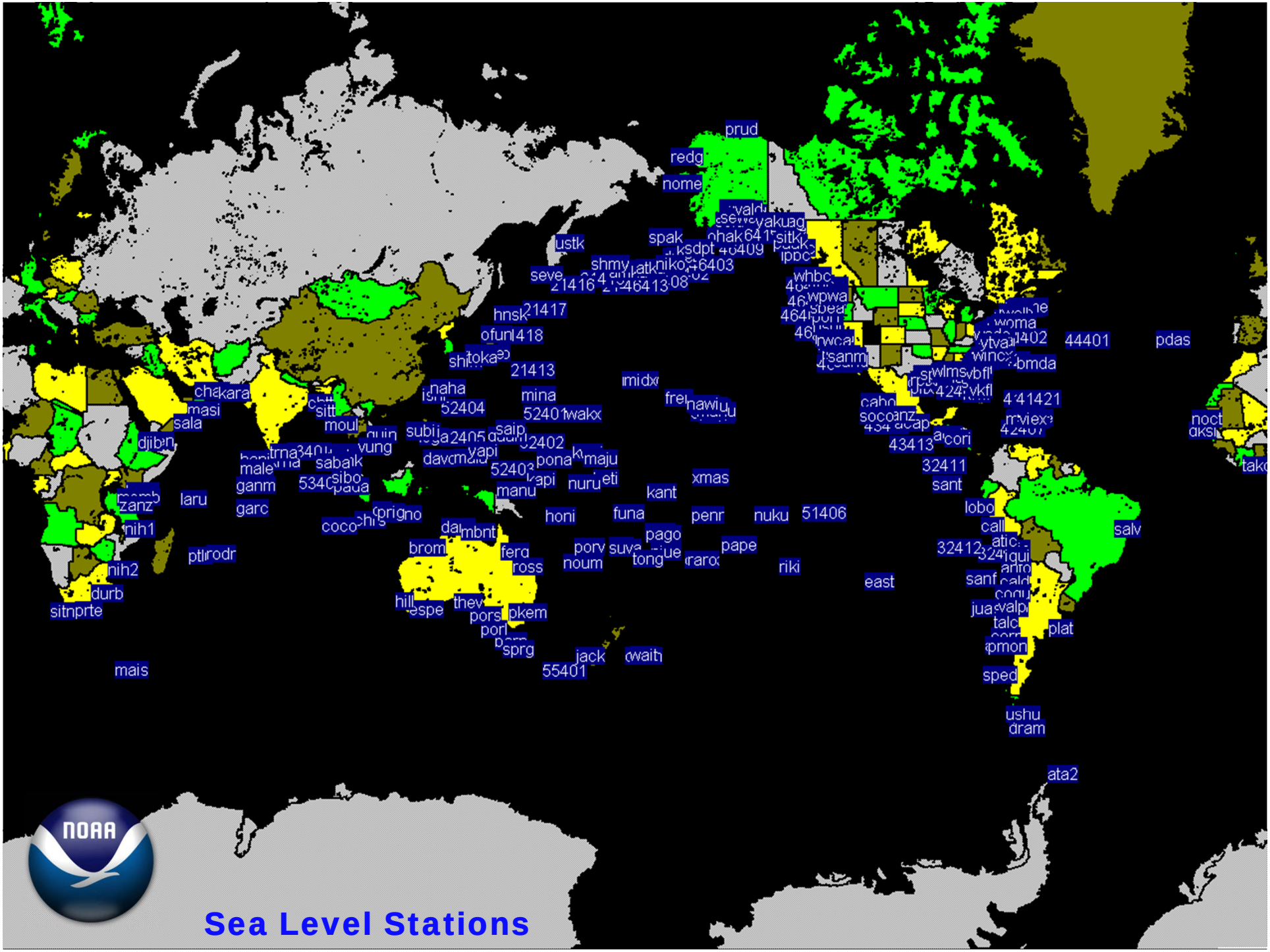
Earthquake Location: [61.05N, -147.48W], 40 miles W of Valdez, Alaska

Earthquake Origin Time: 12:36:00 (UTC)

Date: 3/27/1964

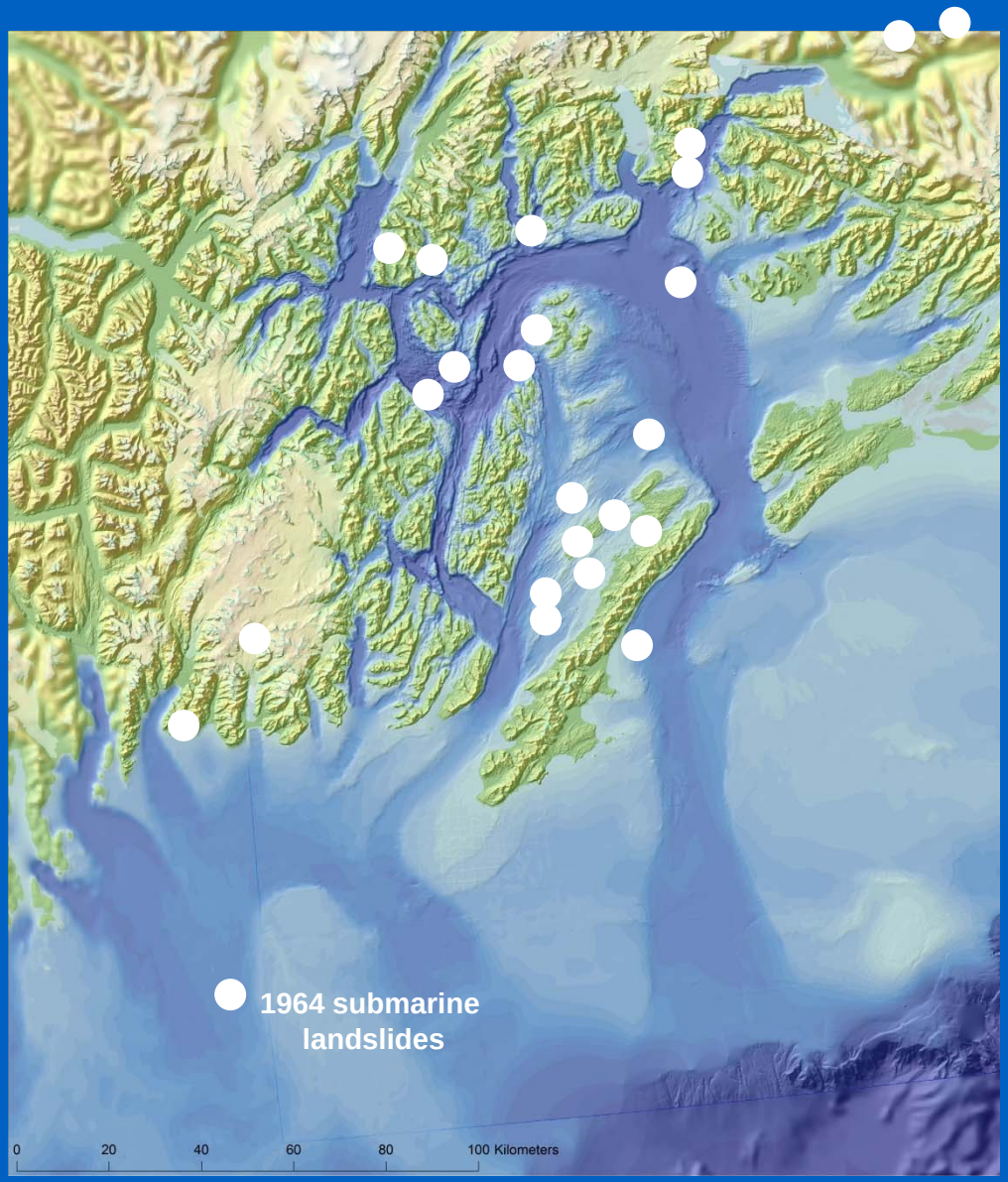

80
60
40
20
0
-20
-40
-60
120
140
160
180
200
220
240
260
280
120 [cm]
110 [cm]
100 [cm]
90 [cm]
80 [cm]
70 [cm]
60 [cm]
50 [cm]
40 [cm]
30 [cm]
20 [cm]
10 [cm]
0 [cm]

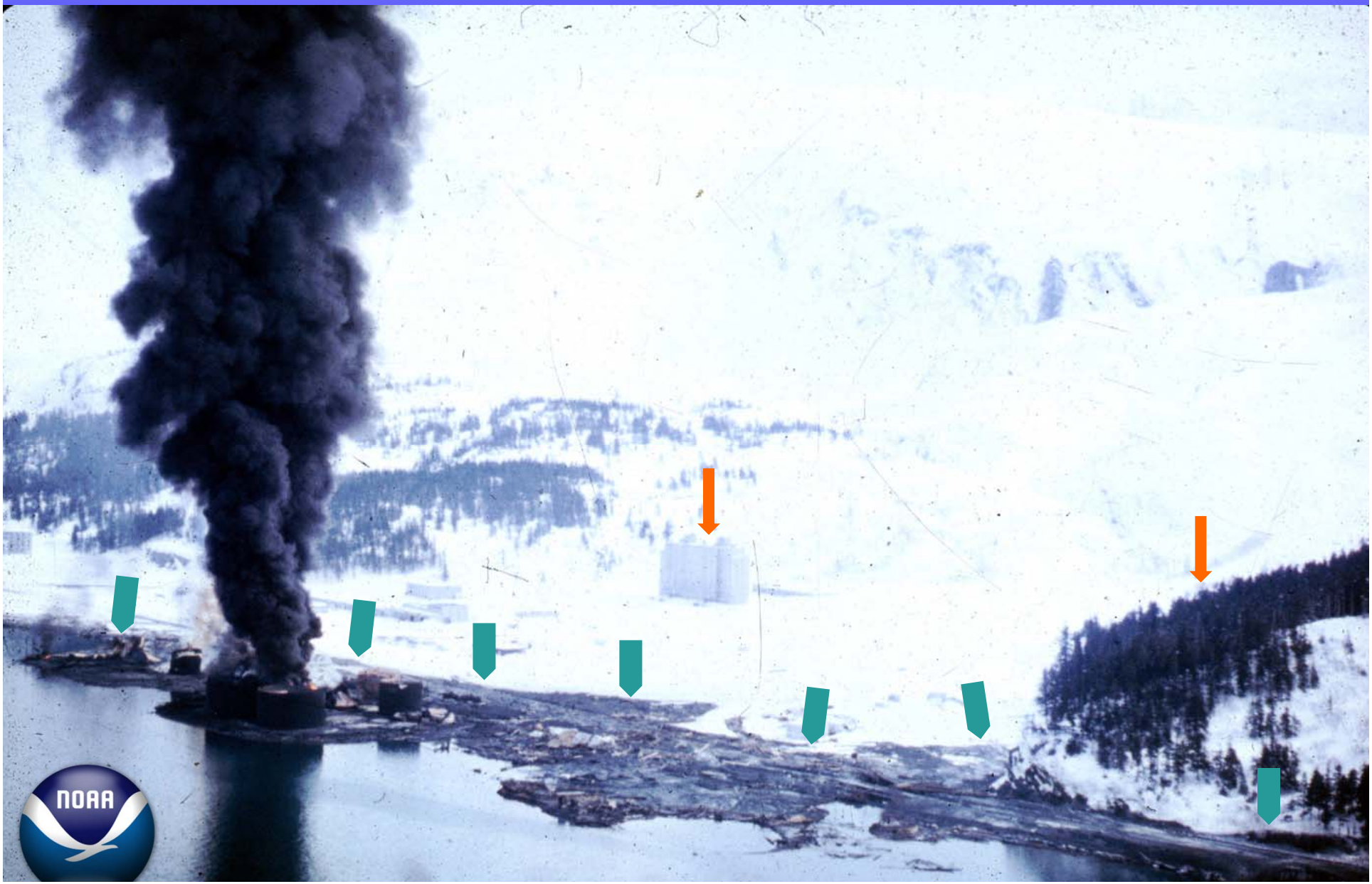

150°E
180°
150°W
120°W
90°W
60°N
30°N
0°
30°S
60°S
PREDICTED TSUNAMI WAVE AMPLITUDE (meters)
0.00
0.01
0.05
0.10
0.25
0.50
0.75
1.00
9.69
EQ : [56.43, -150.95, 3], Mag=-1.00

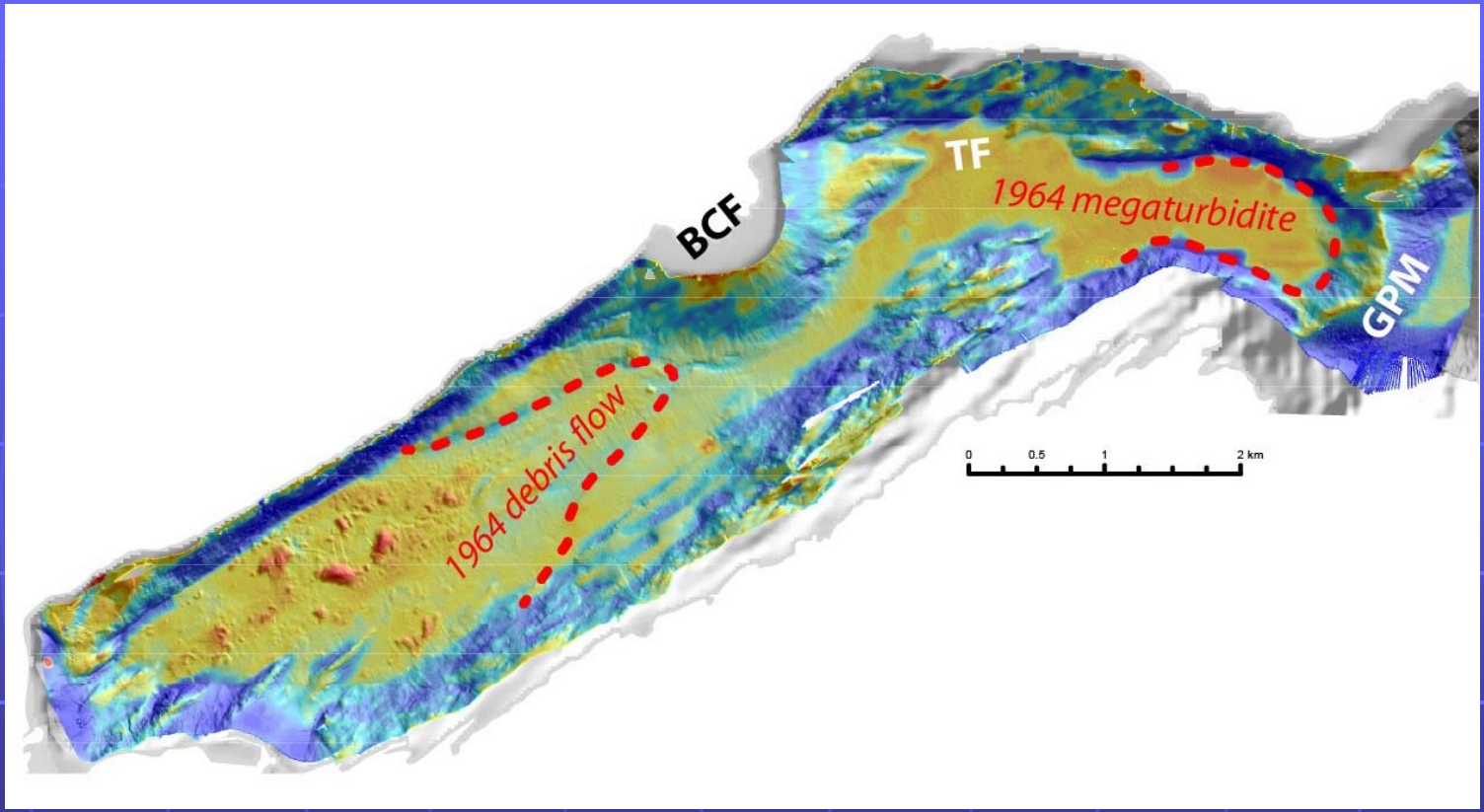


Sea Level Stations

Submarine landslides






BCF
TF
1964 megaturbidite
GPM
1964 debris flow
0
0.5
1
2 km

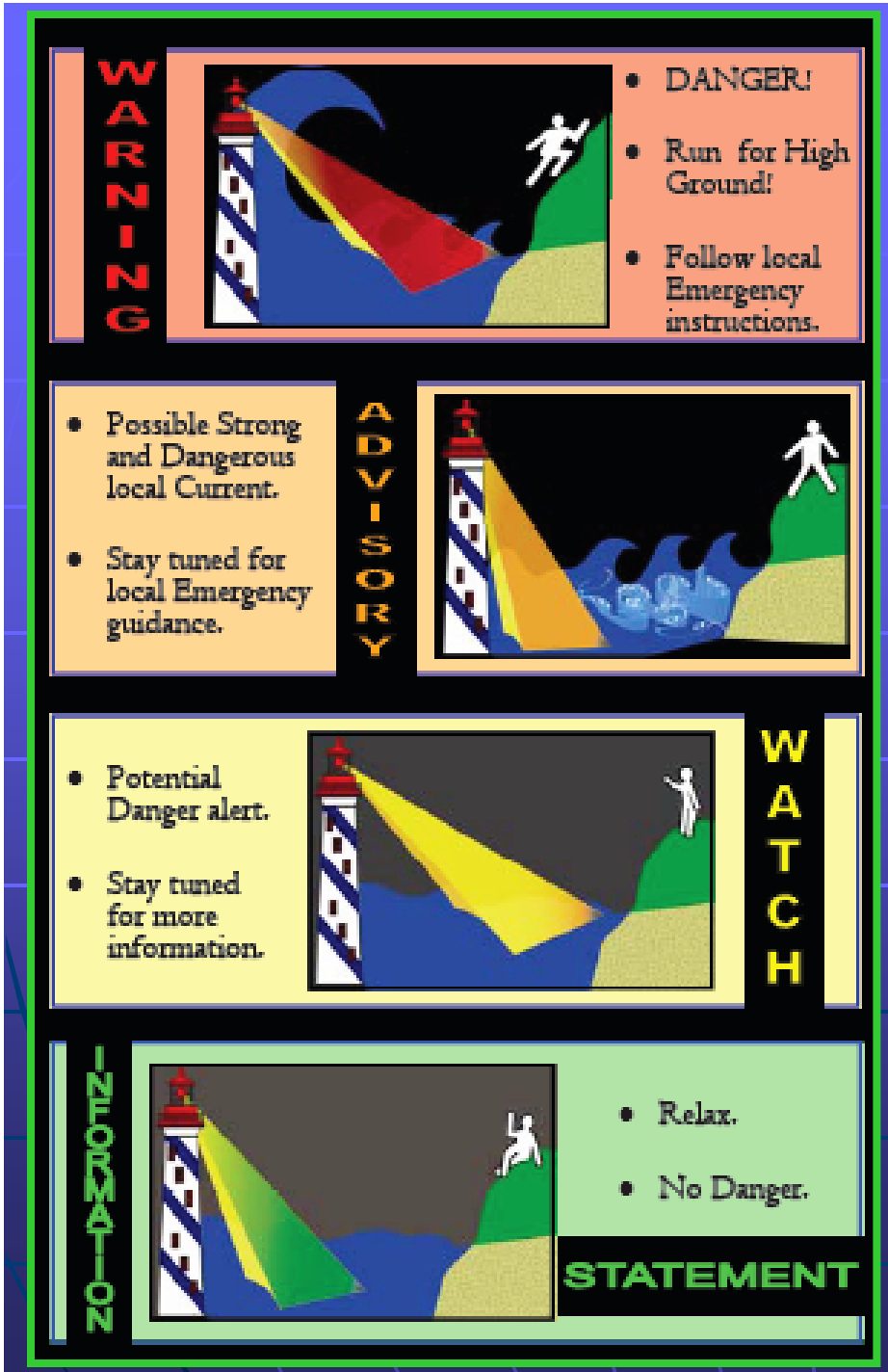
What happened in Whittier

- 3 waves, all locally generated:
  - Water rose to altitude of 8 m about 1 minute after shaking started (water surface, “glassy”)
  - A muddy breaking wave 1-1.5 minutes later rose to 12.5 m altitude
  - 45 seconds later slightly small wave
- 13 deaths (out of 70 local population)
- harbor, railroad, sawmill, oil tanks destroyed
- Numerous dead rockfish at surface
- $10M (~$74M in 2012 dollars) damage

9
Two Lakes
Park
Seward

What happened at Seward

- Within 30-45 seconds of the start of the earthquake, the waterfront started sliding into the ocean, and there was 8-9 m drawdown of water
- After 1.5-2 minutes, a 6-8 m high flaming wave came from the east and swept N along shoreline
- Another high wave at about 10 minutes
- Tectonic tsunami arrived around 30 minutes, same max height as the initial waves
- Area 1200-m long by 15-120 m wide slid into the bay



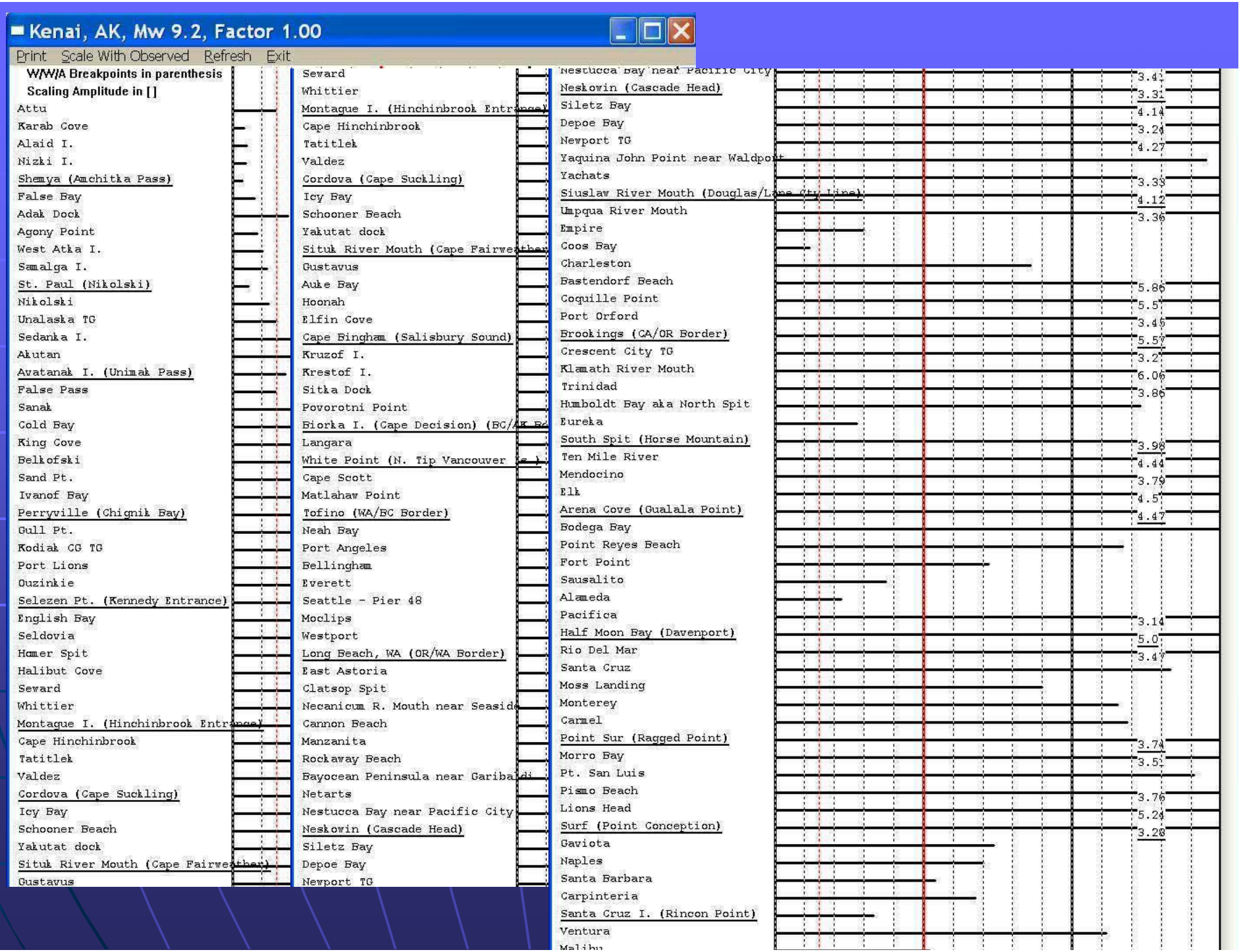
Evacuate per emergency managers *instructions*

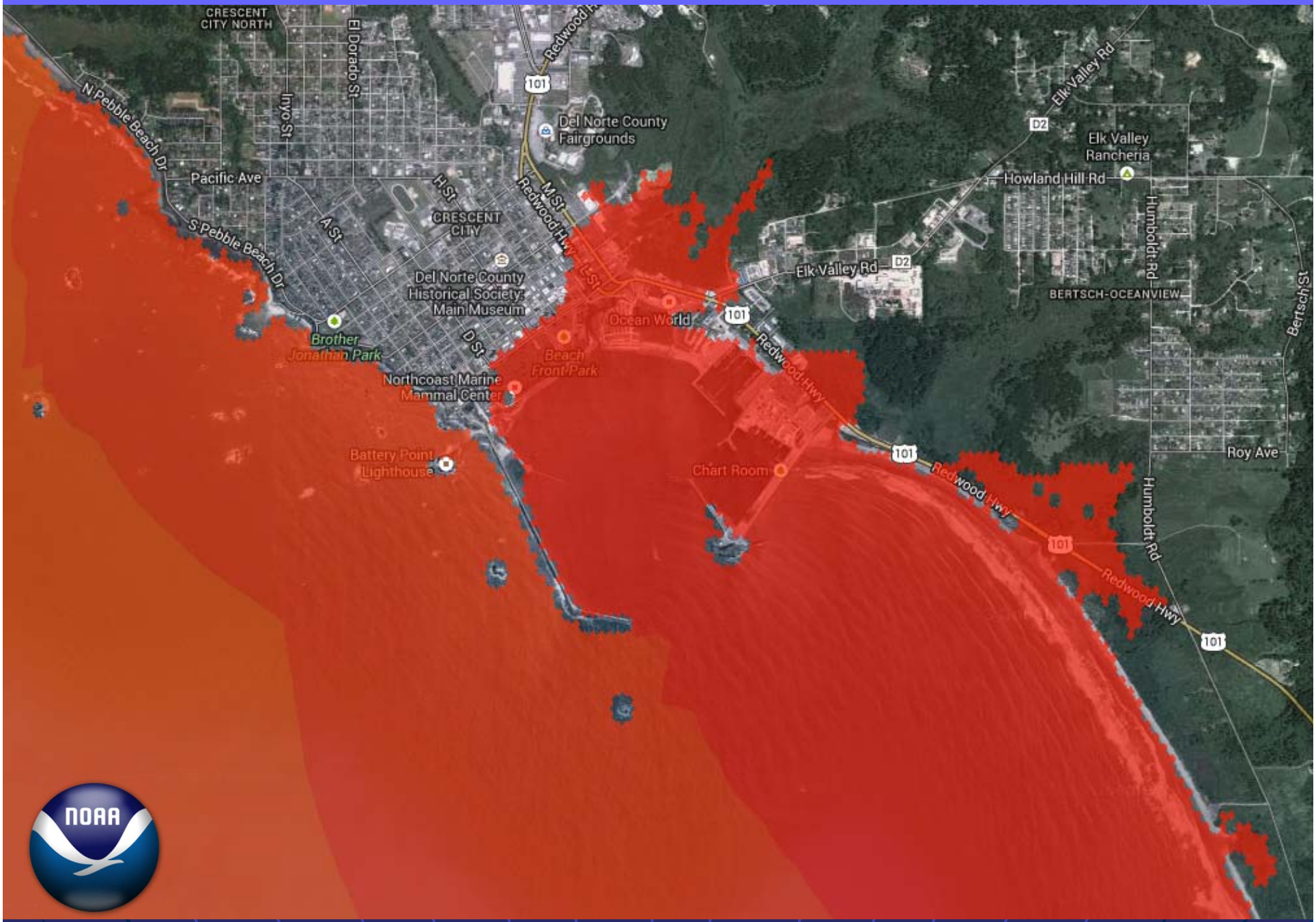
- **> 1 m**
- **0.3-1 m**

Clear harbors and beaches

Message Types

(issued in 5 minutes)


Kenai, AK, Mw 9.2, Factor 1.00
Print Scale With Observed Refresh Exit
W/W/A Breakpoints in parenthesis
Scaling Amplitude in []
Attu
Karab Cove
Alaid I.
Nizki I.
Shemya (Amchitka Pass)
False Bay
Adak Dock
Agony Point
West Atka I.
Samalga I.
St. Paul (Nikolski)
Nikolski
Unalaska TG
Sedanka I.
Akutan
Avatanak I. (Unimak Pass)
False Pass
Sanak
Cold Bay
King Cove
Belkofski
Sand Pt.
Ivanof Bay
Perryville (Chignik Bay)
Gull Pt.
Kodiak CG TG
Port Lions
Ouzinkie
Selezen Pt. (Kennedy Entrance)
English Bay
Seldovia
Homer Spit
Halibut Cove
Seward
Whittier
Montague I. (Hinchinbrook Entrance)
Cape Hinchinbrook
Tatitlek
Valdez
Cordova (Cape Suckling)
Icy Bay
Schooner Beach
Yakutat dock
Situk River Mouth (Cape Fairweather)
Gustavus
Seward
Whittier
Montague I. (Hinchinbrook Entrance)
Cape Hinchinbrook
Tatitlek
Valdez
Cordova (Cape Suckling)
Icy Bay
Schooner Beach
Yakutat dock
Situk River Mouth (Cape Fairweather)
Gustavus
Auke Bay
Hoonah
Elfin Cove
Cape Bingham (Salisbury Sound)
Kruzof I.
Krestof I.
Sitka Dock
Povorotni Point
Biorka I. (Cape Decision) (BC/AK Bo
Langara
White Point (N. Tip Vancouver I.)
Cape Scott
Matlahaw Point
Tofino (WA/BC Border)
Neah Bay
Port Angeles
Bellingham
Everett
Seattle - Pier 48
Moclips
Westport
Long Beach, WA (OR/WA Border)
East Astoria
Clatsop Spit
Necanicum R. Mouth near Seaside
Cannon Beach
Manzanita
Rockaway Beach
Bayocean Peninsula near Garibaldi
Netarts
Nestucca Bay near Pacific City
Neskowin (Cascade Head)
Siletz Bay
Depoe Bay
Newport TG
Nestucca Bay near Pacific City
Neskowin (Cascade Head)
Siletz Bay
Depoe Bay
Newport TG
Yaquina John Point near Waldport
Yachats
Siuslaw River Mouth (Douglas/Lane Cty Line)
Umpqua River Mouth
Empire
Coos Bay
Charleston
Bastendorf Beach
Coquille Point
Port Orford
Brookings (CA/OR Border)
Crescent City TG
Klamath River Mouth
Trinidad
Humboldt Bay aka North Spit
Eureka
South Spit (Horse Mountain)
Ten Mile River
Mendocino
Elk
Arena Cove (Gualala Point)
Bodega Bay
Point Reyes Beach
Fort Point
Sausalito
Alameda
Pacifica
Half Moon Bay (Davenport)
Rio Del Mar
Santa Cruz
Moss Landing
Monterey
Carmel
Point Sur (Ragged Point)
Morro Bay
Pt. San Luis
Pismo Beach
Lions Head
Surf (Point Conception)
Gaviota
Naples
Santa Barbara
Carpinteria
Santa Cruz I. (Rincon Point)
Ventura
Malibu
3.41
3.31
4.14
3.24
4.27
3.33
4.12
3.36
5.86
5.5
3.45
5.57
3.2
6.06
3.86
3.98
4.44
3.79
4.5
4.47
3.14
5.0
3.47
3.74
3.51
3.76
5.24
3.28

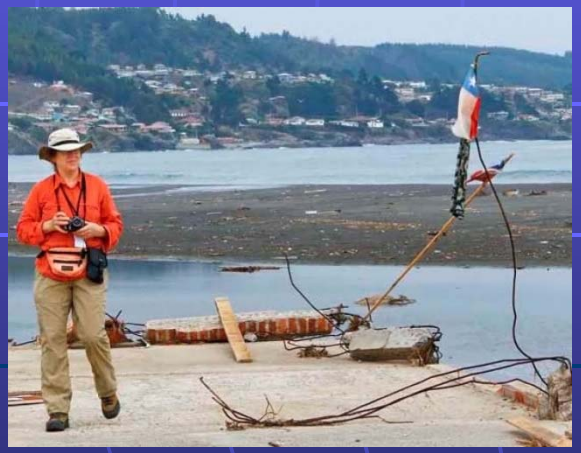

CRESCENT CITY NORTH
El Dorado St
Inyo St
N Pebble Beach Dr
S Pebble Beach Dr
Pacific Ave
A St
H St
M St
L St
D St
Redwood Hwy
101
Del Norte County Fairgrounds
CRESCENT CITY
Del Norte County Historical Society: Main Museum
Brother Jonathan Park
Northcoast Marine Mammal Center
Battery Point Lighthouse
Ocean World
Beach Front Park
Chart Room
Elk Valley Rd
D2
Elk Valley Rancheria
Howland Hill Rd
Humboldt Rd
BERTSCH-OCEANVIEW
Bertsch St
Roy Ave

cindi preller

noaa tsunami program manager

cindi.preller@noaa.gov

tsunami.gov



Lori Dengler

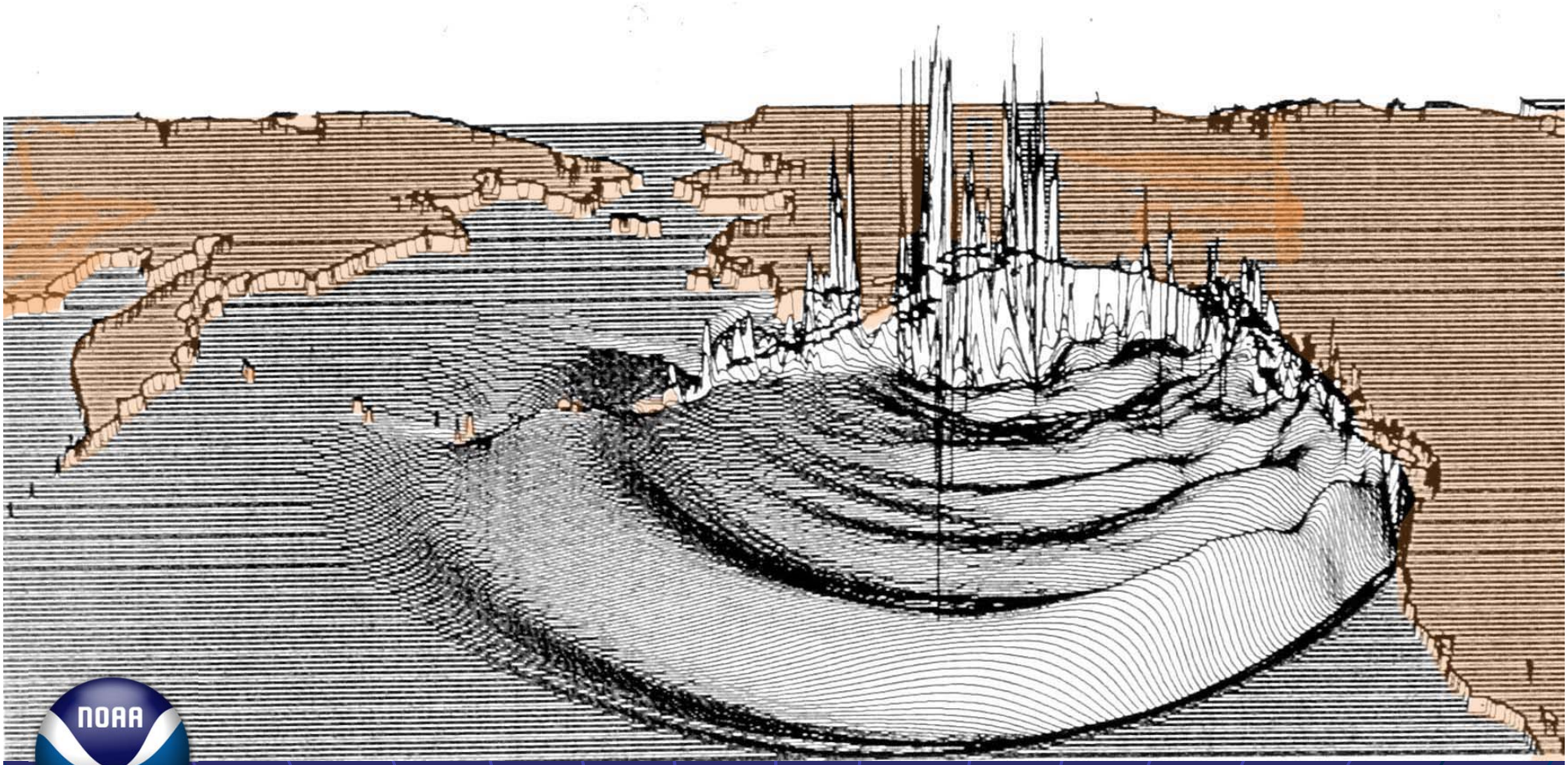
Ph.D., Professor of Geology,

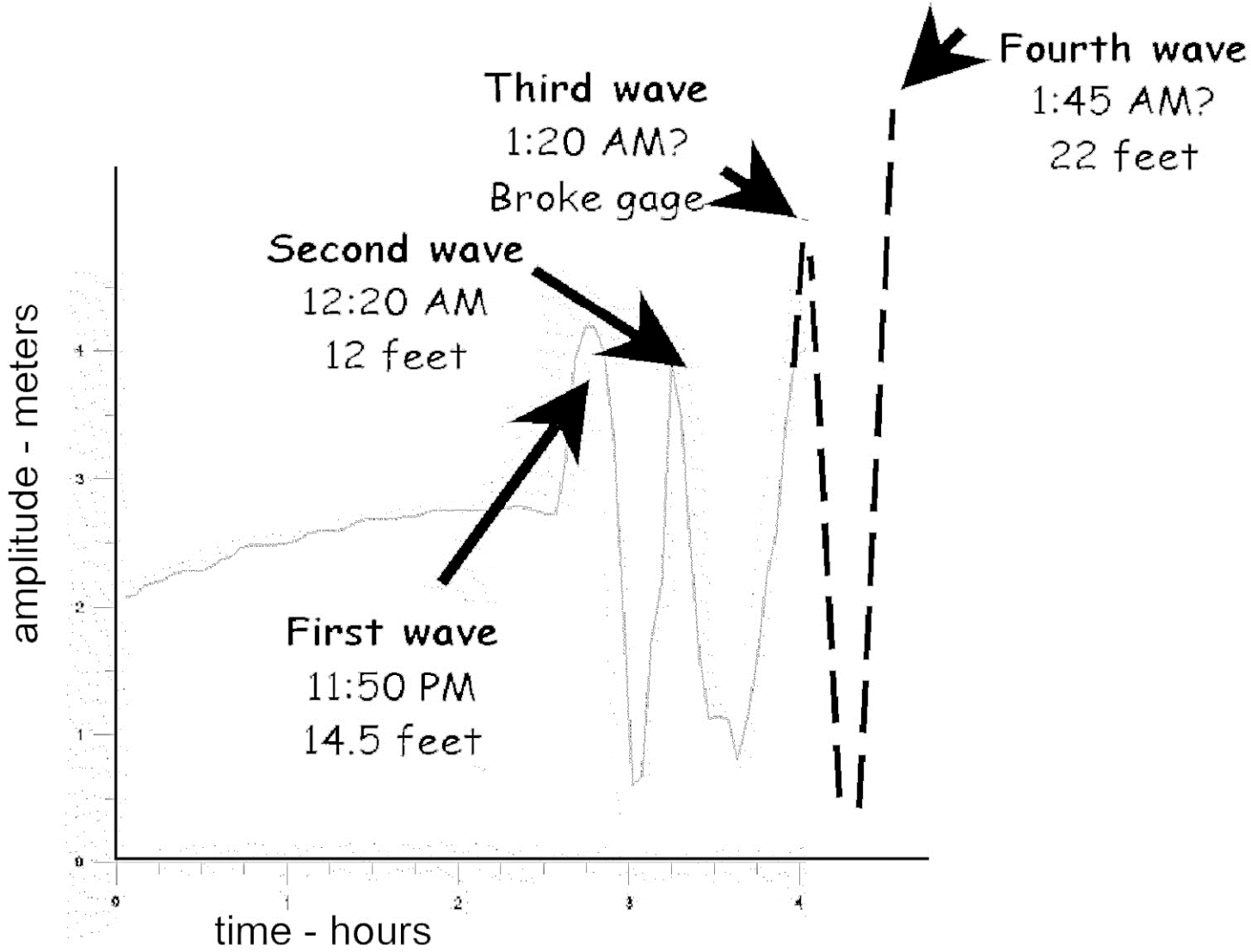
Humboldt State University

Lori.Dengler@humboldt.edu

http://www.humboldt.edu/geology/

1964 in Crescent City CA



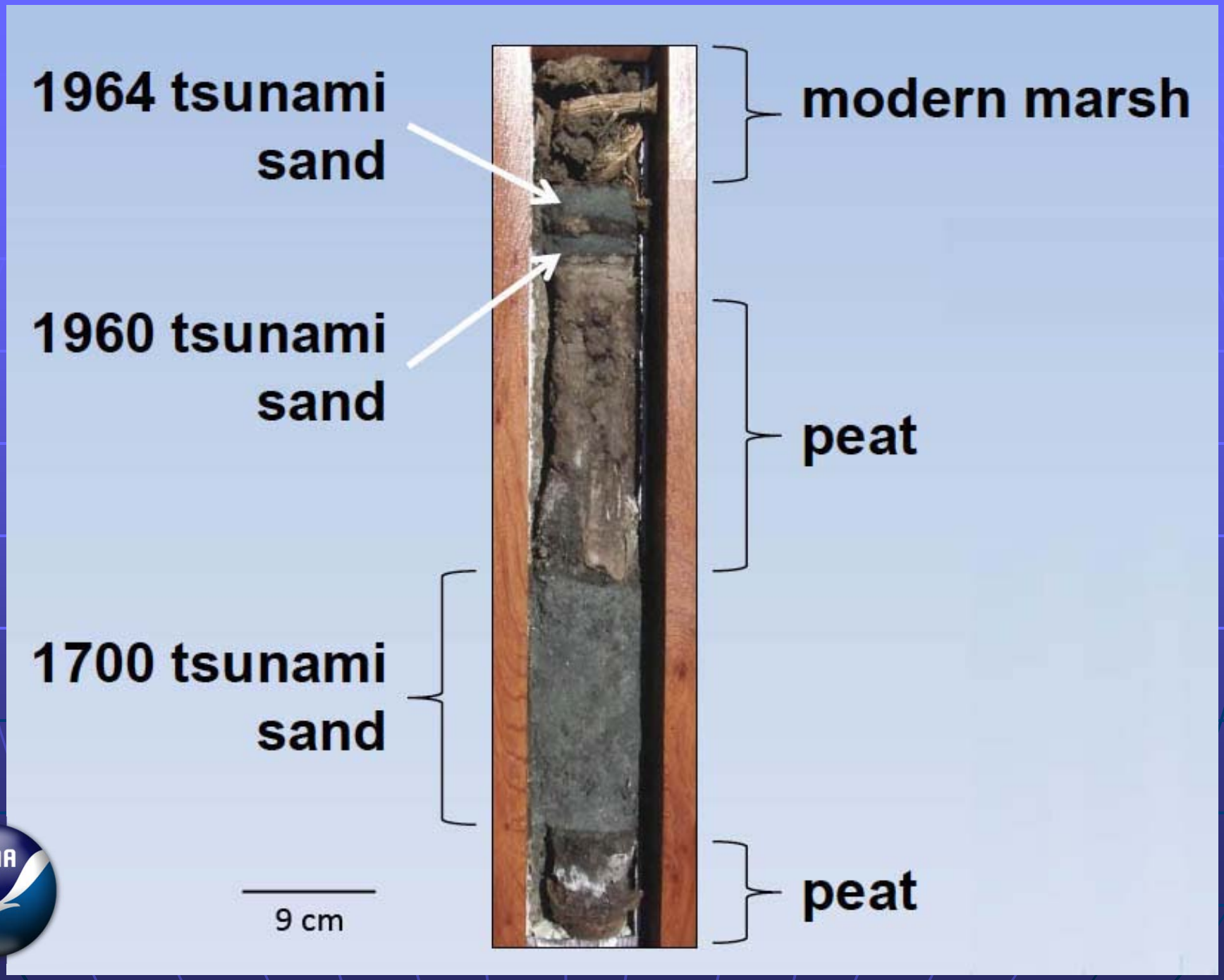

Fourth wave
1:45 AM?
22 feet
Third wave
1:20 AM?
Broke gage
Second wave
12:20 AM
12 feet
First wave
11:50 PM
14.5 feet
amplitude - meters
time - hours
0
1
2
3
4

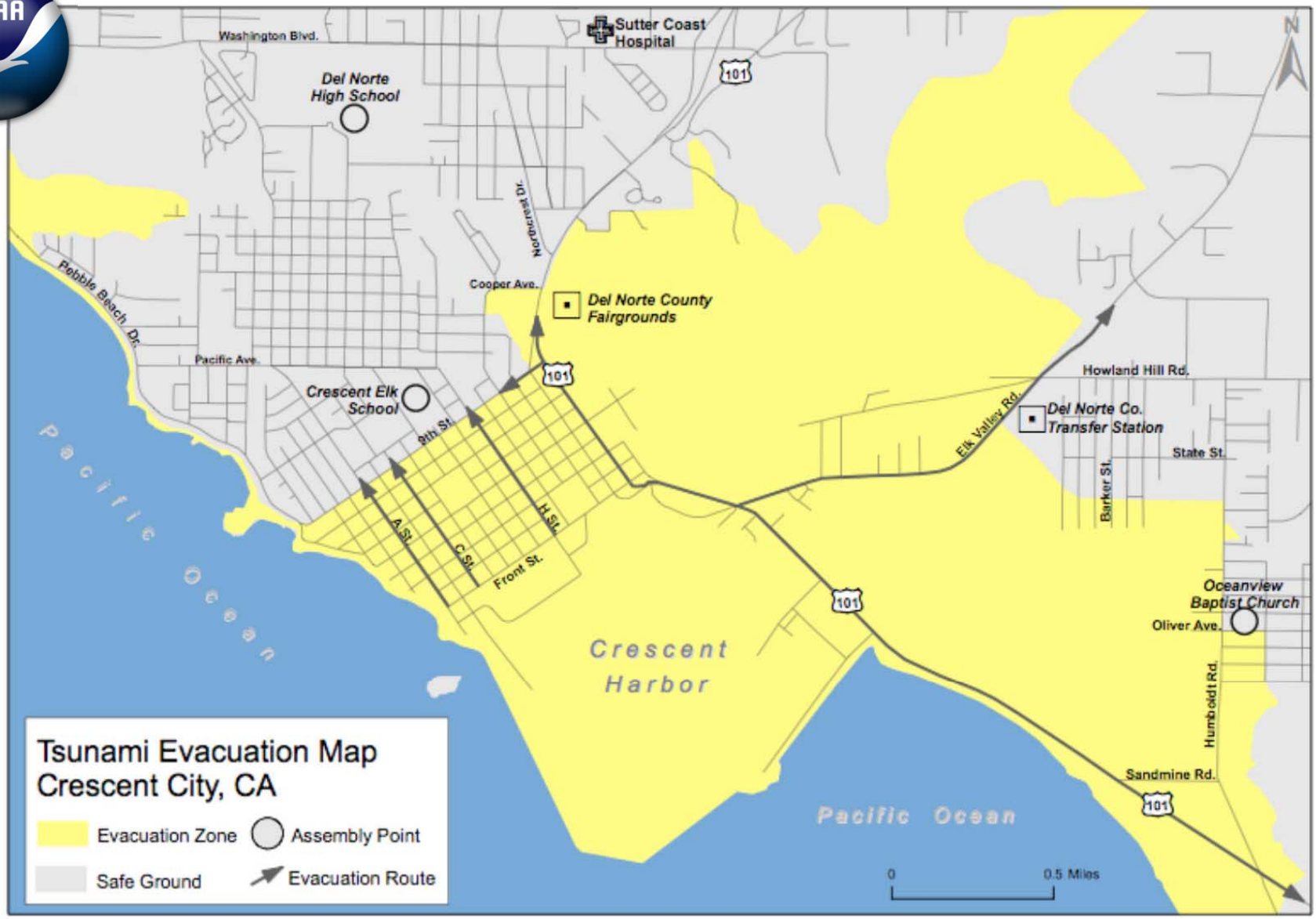
1964 in Crescent City CA

1964 in Crescent City CA

1964 in Crescent City CA

CRESCENT
F.P.D.
NO. 1


1964 tsunami sand
1960 tsunami sand
1700 tsunami sand
modern marsh
peat
peat
9 cm



Note: This evacuation map is based on the State of California inundation projections and the best currently available scientific information. It is intended for emergency planning purposes only. This map may be revised as new information becomes available.

http://preparedelnorte.com/index.html

DROP!
COVER!
HOLD ON!
Protect Yourself During Earthquakes

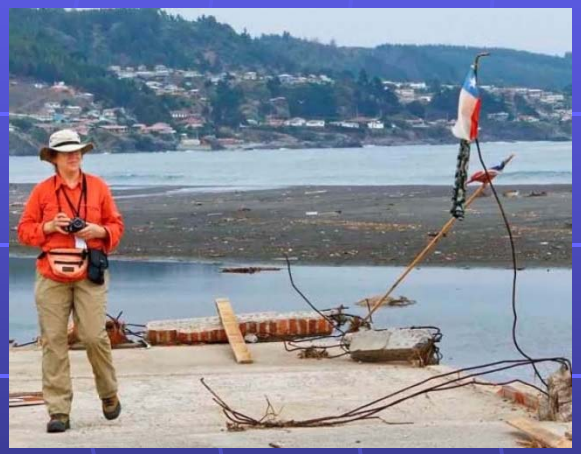
GO TO HIGH GROUND!
The Shaking is Your Tsunami Warning

STAY THERE!
Tsunami Waves May Arrive for Hours

THANK YOU FOR ATTENDING!

QUESTIONS?

Cindi Preller
NOAA/NWS Alaska Region
Tsunami Program Manager
cindi.preller@noaa.gov
tsunami.gov



Lori Dengler
Ph.D., Professor of Geology,
Humboldt State University
Lori.Dengler@humboldt.edu
http://www.humboldt.edu/geology/

Jeff Lorens
NOAA/NWS Western Region Headquarters
Tsunami Program Manager
Jeffrey.Lorens@noaa.gov