History of the National Tsunami Hazard Mitigation Program

by

Timothy J. Walsh

Washington Department of Natural Resources

Division of Geology and Earth Resources

February 3, 2016

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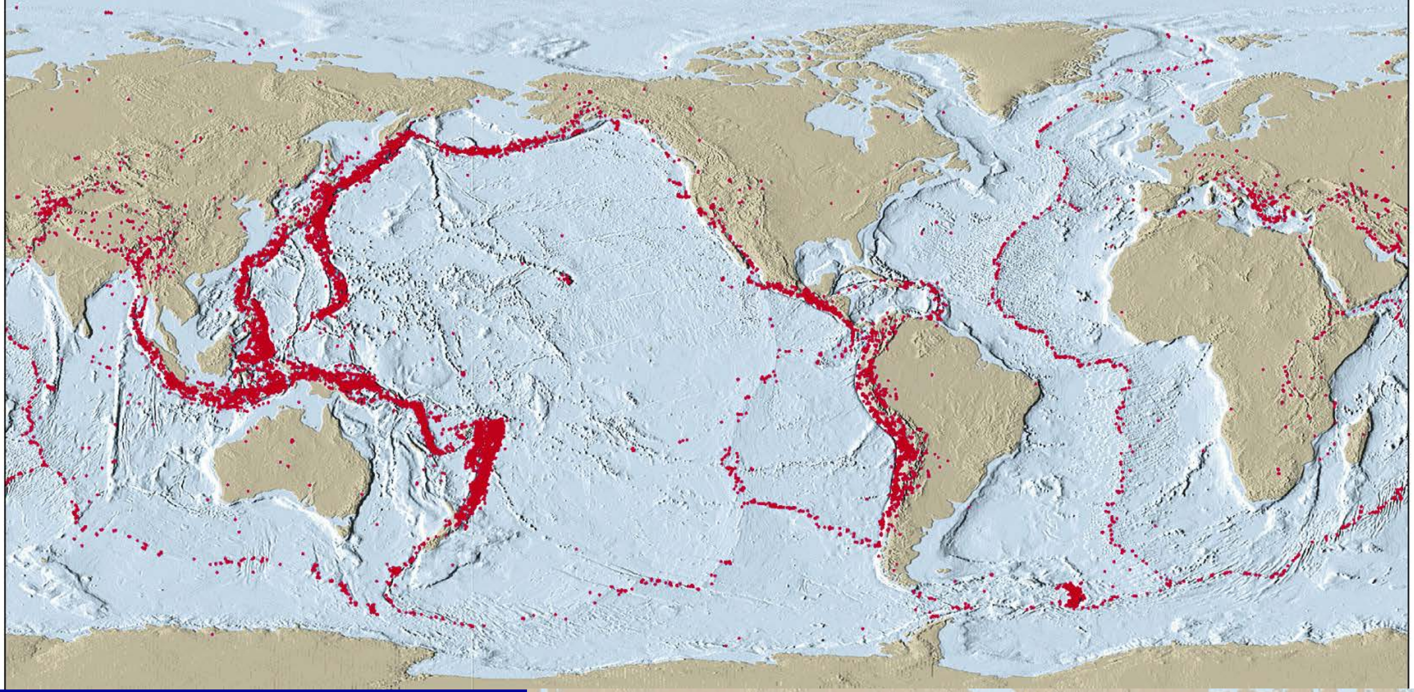
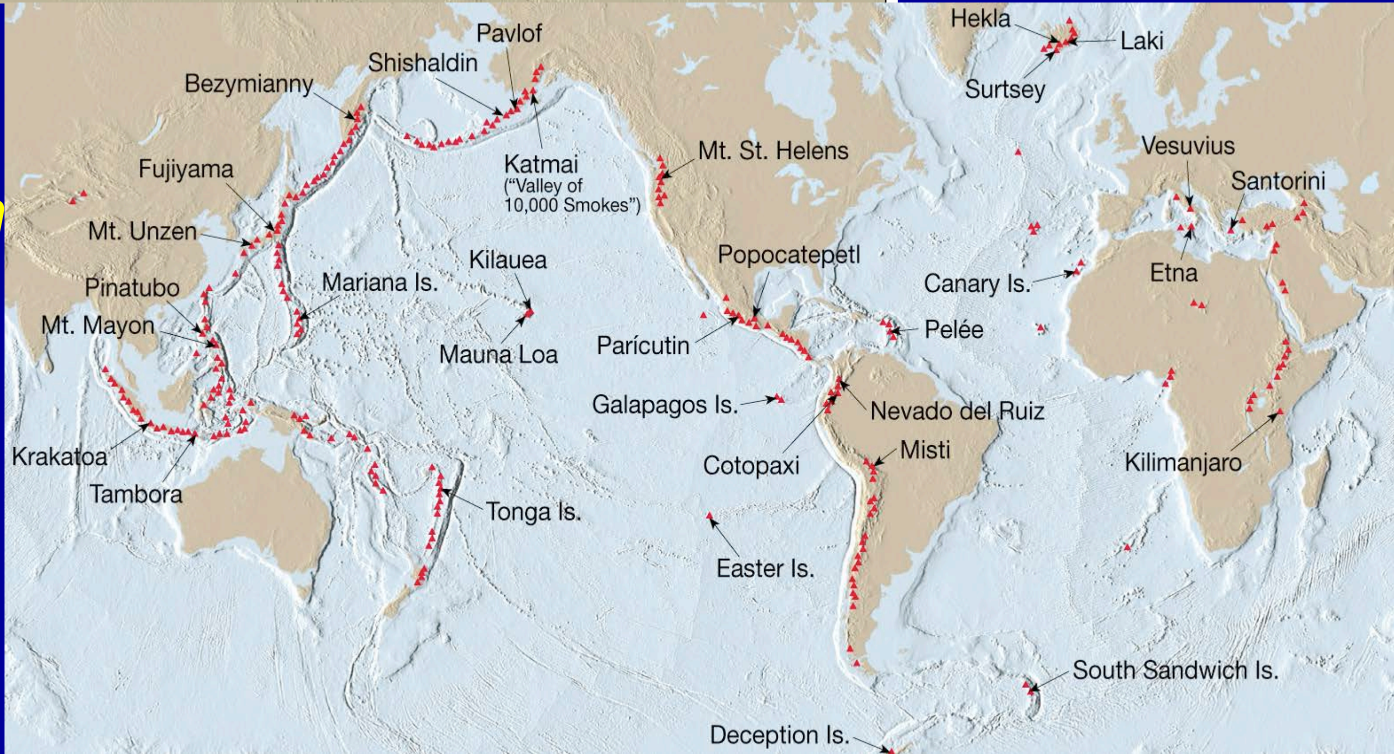
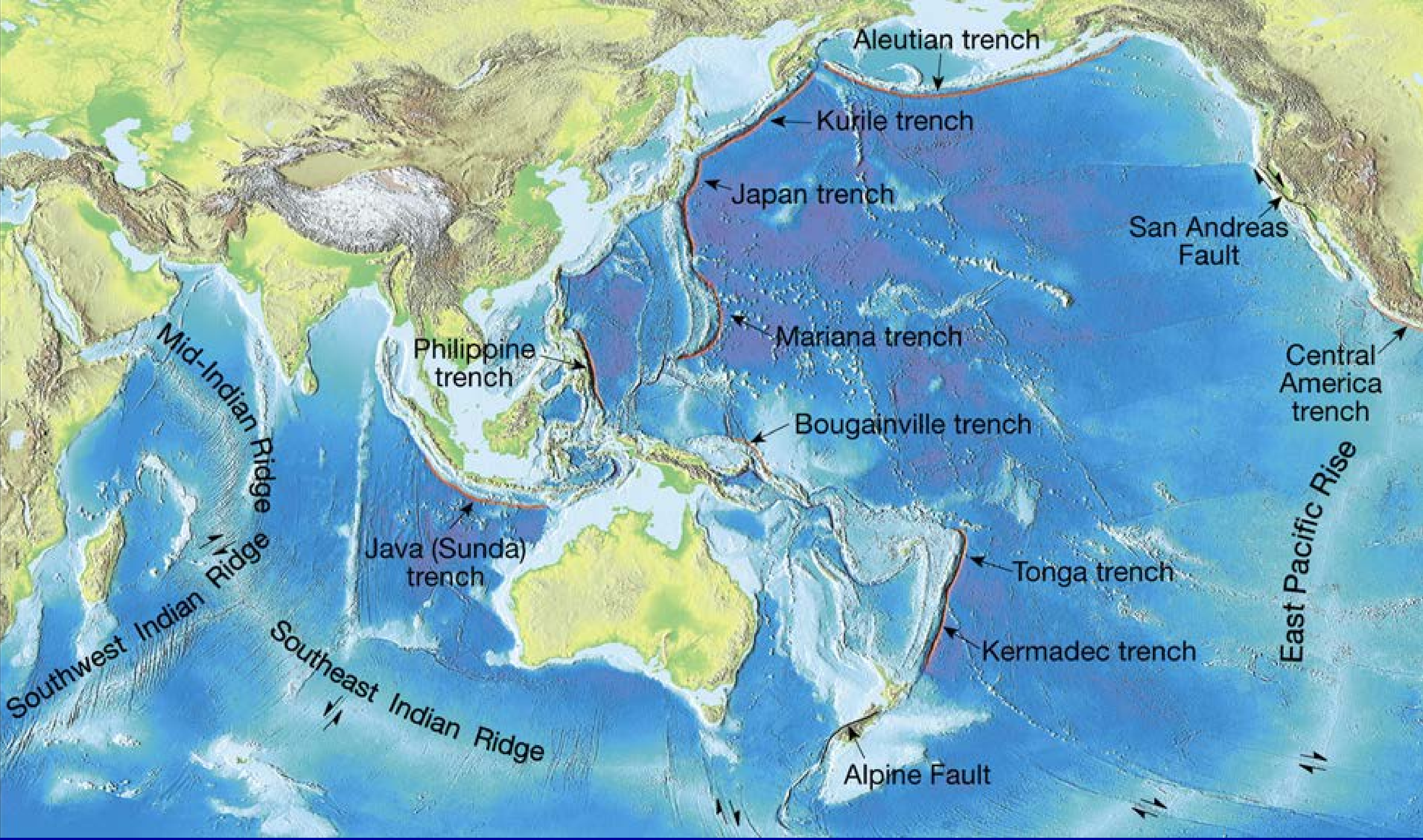


Distribution of magnitude 5 or greater earthquakes, 1980 - 1990

Distribution of some of the world's major volcanoes





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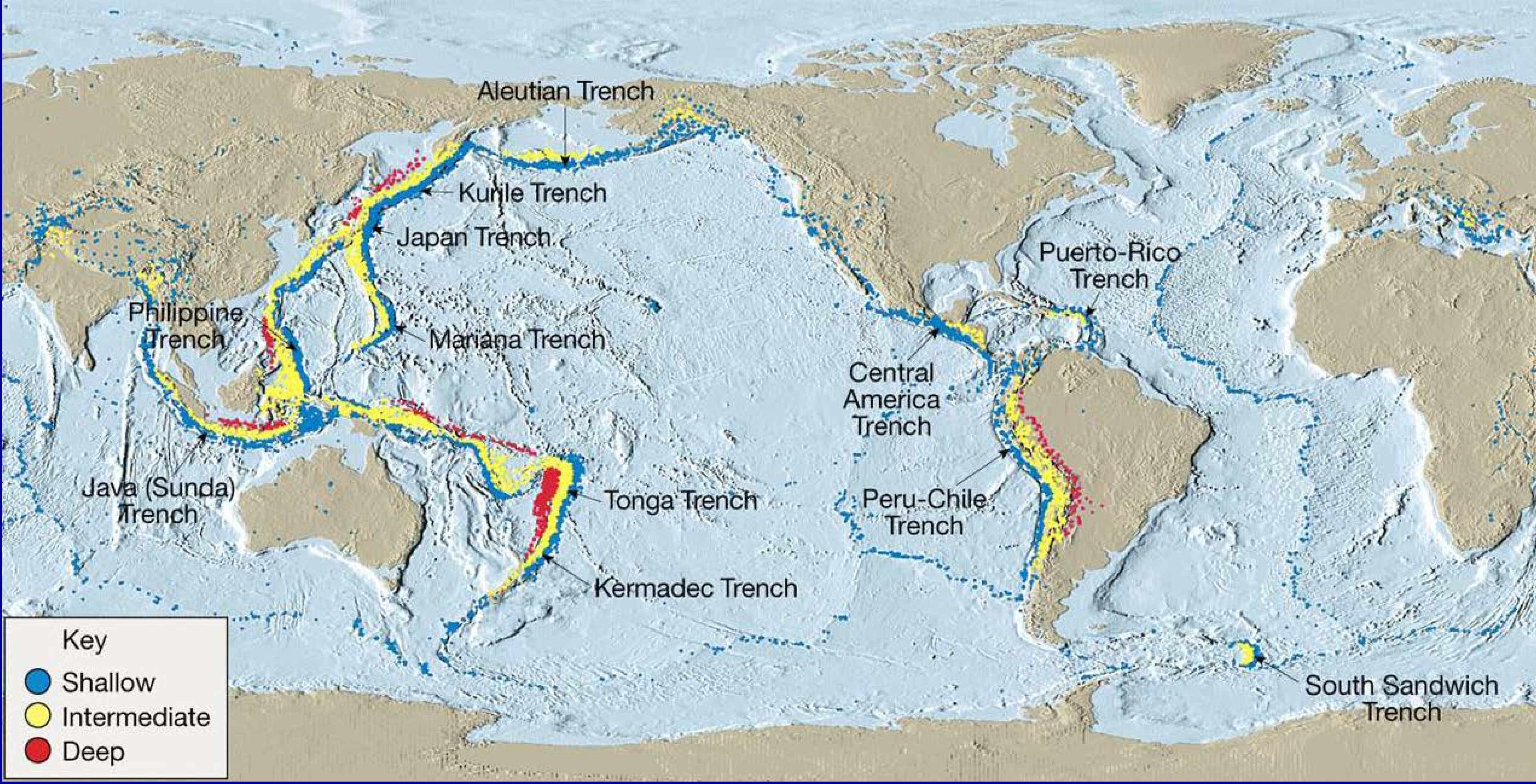

Trenches are the loci of large earthquakes that get progressively deeper as the subducting slab gets progressively deeper

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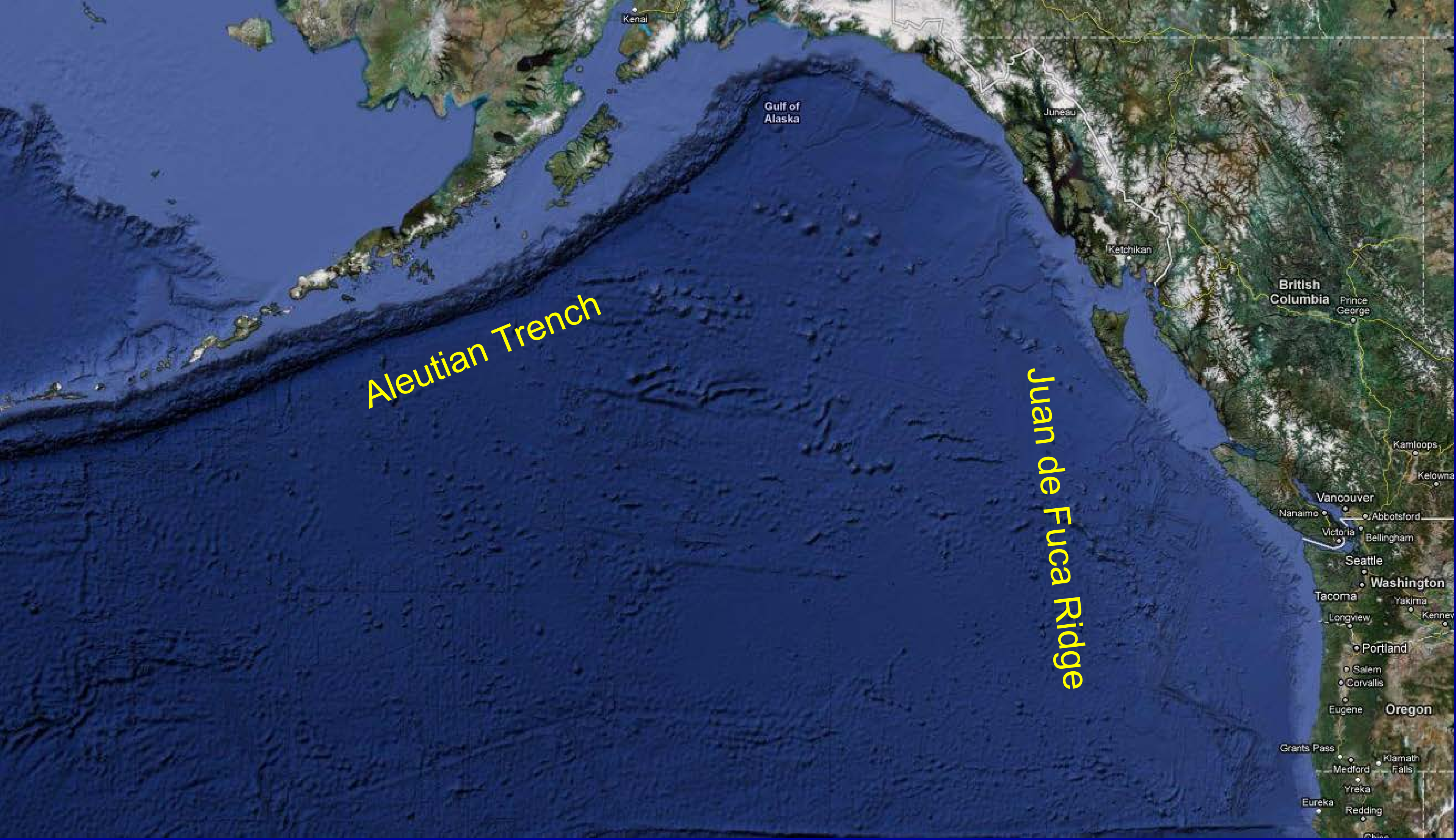

Note that there is no trench off the Pacific Northwest, even though there is a ridge system. Was there really an active subduction zone here?

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Note that the coast of Washington has very few earthquakes, and none on the subduction zone. How did we get to our present understanding?

In 1969, the Pacific Northwest Seismic Network was installed, beginning with 6 stations. After a year of monitoring, no earthquakes had been detected on the plate interface and a Wadati-Benioff Zone was not obvious. Crosson tentatively concluded that subduction had ceased.

Bulletin of the Seismological Society of America. Vol. 62, No. 5, pp. 1133–1171. October 1972

SMALL EARTHQUAKES, STRUCTURE, AND TECTONICS OF THE PUGET SOUND REGION

By Robert S. Crosson

ABSTRACT

The Puget Sound region of Washington lies along the tectonically active margin of western North America, a region which is important to the understanding of large scale plate interactions in the eastern Pacific. A six-station high-sensitivity telemetry network has been operating for more than a year providing data for an initial study of seismicity, structure, and tectonics. The network covers an area of about 200 km N-S by 150 km E-W in a zone of concentrated seismic activity. Earthquakes ranging in magnitude 1 to 4 are located within the network at a rate of about one event every 2 days.

Analysis of regional earthquakes lying outside the network yields an apparent P_n velocity of 7.79 km/sec. Lacking reliable refraction data, a crustal model is generated by minimization of P residuals. Using this model, the average depth of all located events is 21 km; however, earthquakes are reliably located as deep as 50 km and a few isolated events may be deeper. No strong lineations are observed in the pattern of hypocenters, although there are some general zones of high activity within the array. Magnitude estimates are successfully based on a coda-length scheme. Recurrence rates approximately obey the equation $\log N = 3.92 - 0.96\, m$ where N is the cumulative number of events above magnitude m per year.

Composite focal mechanisms for three groups of events in the region are suggestive of N-S compression and taken together with absence of a distinct Benioff zone indicate that crustal consumption may have ceased in the area. The N-S compressive tectonics reflect the regional stress field associated with the movement of the American plate with respect to the Pacific plate as defined by slip on the San Andreas and Queen Charlotte Islands fault systems. The Puget Sound-Olympic Mountains region may have occupied a position at the northeast corner of the Juan de Fuca plate during a latter phase of active underthrusting with the localization of seismicity caused by stress inhomogeneity at the plate corner.

Composite focal mechanisms for three groups of events in the region are suggestive of N-S compression and taken together with absence of a distinct Benioff zone indicate that crustal consumption may have ceased in the area. The N-S

VOL. 84, NO. B6 JOURNAL OF GEOPHYSICAL RESEARCH JUNE 10, 1979

Geodetic Evidence for Aseismic Subduction of the Juan de Fuca Plate

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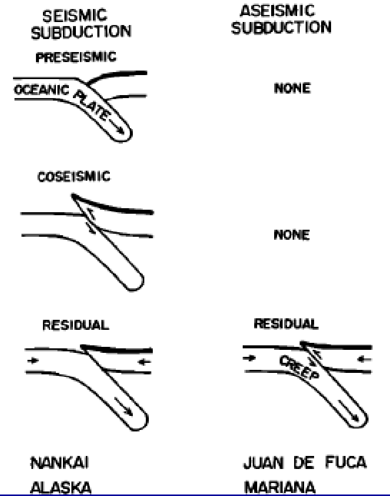
U.S. Geological Survey, Menlo Park, California 94025

EMERY I. BALAZS

National Geodetic Survey, National Ocean Survey, NOAA, Rockville, Maryland 20175

A down-to-the-east crustal tilt rate across western Washington disclosed by precise leveling over a 70-year period suggests that the Juan de Fuca plate is aseismically underthrusting the North American plate. According to this hypothesis, the frequent occurrence of large thrust earthquakes that ordinarily accompany plate convergence need not be expected along the Juan de Fuca subduction zone. This conclusion is consistent with the fact that there have been no great earthquakes in western Washington in historical time (the past 140 years).

In 1979, Ando and Balasz, on the basis of limited vertical geodetic modeling, concluded that Washington was tilted down to the east and that subduction was still occurring but was aseismic.



Geodetic Strain Measurements in Washington

J. C. Savage
U. S, Geological Survey, Menlo Park, California 92045

M. Lisowski
U. S, Geological Survey, Menlo Park, California 92045

W. H. Prescott
U. S, Geological Survey, Menlo Park, California 92045

Two new geodetic measurements of strain accumulation in the state of Washington for the interval 1972–1979 are reported. Near Seattle the average principal strain rates are 0.07 ± 0.03 μstrain/yr N 19°W and −0.13 ± 0.02 μstrain/yr N71°E, and near Richland (south central Washington) the average principal strain rates are −0.02 ± 0.01 μstrain/yr N36°W and −0.04 ± 0.01 μstrain/yr N54°E. Extension is taken as positive, and the uncertainties quoted are standard deviations. A measurement of shear strain accumulation (dilatation not determined) in the epoch 1914–1966 along the north coast of Vancouver Island by the Geodetic Survey of Canada indicates a marginally significant accumulation of right-lateral shear (0.06 ± 0.03 μrad/yr) across the plate boundary (N40°W strike). Although there are significant differences in detail, these strain measurements are roughly consistent with a crude dislocation model that represents subduction of the Juan de Fuca plate. The observed accumulation of strain implies that large, shallow, thrust earthquakes should be expected off the coast of Washington and British Columbia. However, this conclusion is not easily reconciled with either observations of elevation change along the Washington coast or the focal mechanism solutions for shallow earthquakes in Washington.

Citation: Savage, J., M. Lisowski, and W. Prescott (1981), Geodetic Strain Measurements in Washington, J. Geophys. Res., 86(B6), 4929-4940.

In 1981, Savage and others, on the basis of horizontal geodetic modeling, concluded that the subduction zone should be seismically active and that the vertical geodetics of Ando and Balasz were difficult to reconcile.

In 1984, John Adams of the Geological Survey of Canada, suggested that if there were great earthquakes in Cascadia, they should trigger landslides from the edge of the continental shelf, and that oceanographic studies by Vern Kulm and Gary Griggs had identified deposits of these landslides.

More on that later.

ACTIVE DEFORMATION OF THE PACIFIC NORTHWEST CONTINENTAL MARGIN

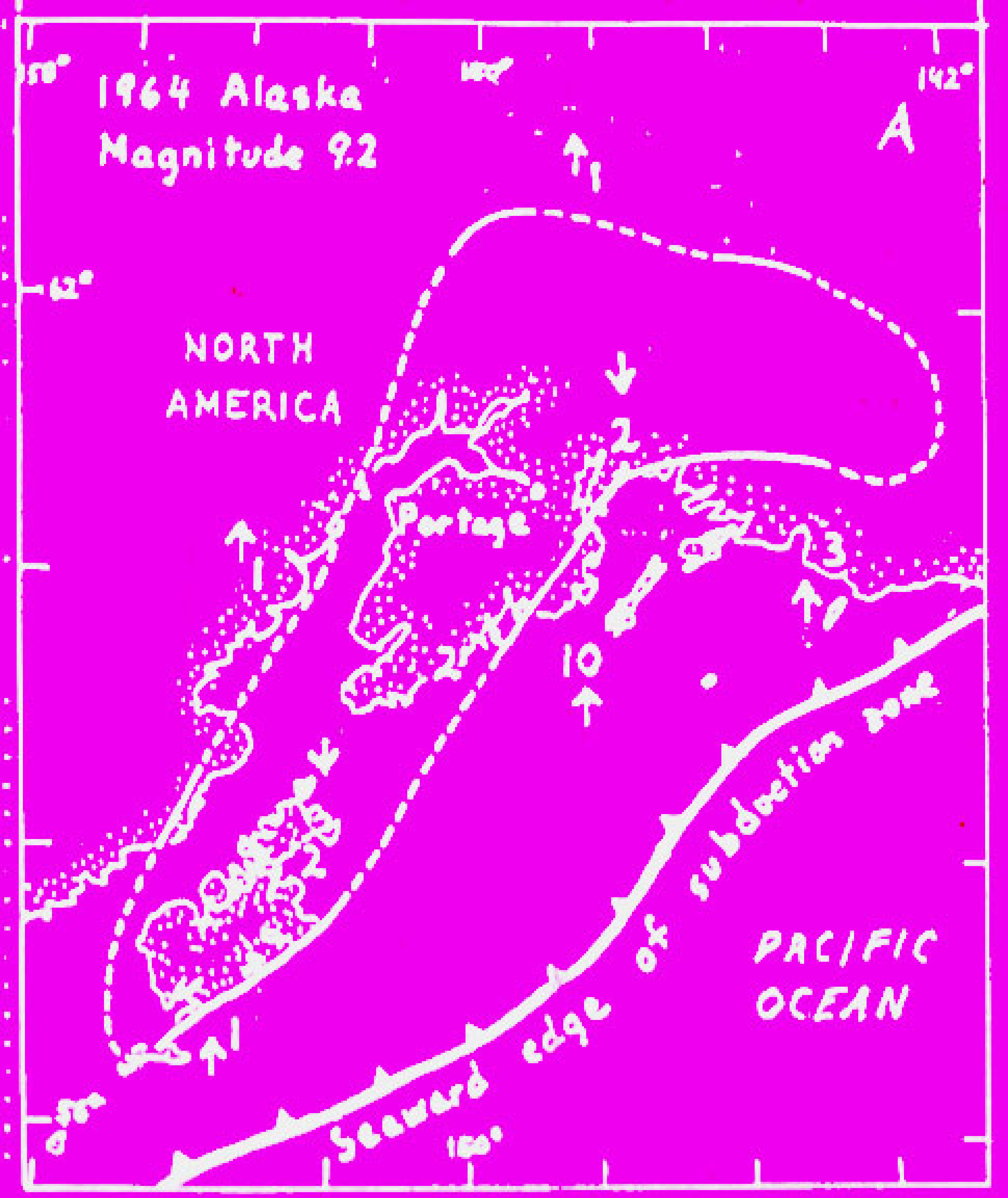
John Adams

Earth Physics Branch, Energy, Mines and Resources, Ottawa, Canada K1A 0Y3

A further effect of large earthquakes is the slumping of shelf-edge sediments, their transport by turbidity flows, and their deposition on the deep-sea floor as turbidites. Off the Columbia River mouth, Griggs and Kulm [1970] found evidence for turbidity flows every 400 to 500 years in the 6600-yr period since the deposition of the Mazama Ash. They note that the thickness of the hemipelagic clay between the turbidites varies by a factor of 2 or less, suggesting similar time intervals between flows, and that the thickness of the turbidites themselves are similar, suggesting a uniform time for sediment accumulation in the source area. While the regularity of the turbidity flows could be due to self-triggering (accumulation of sediment at constant rate until it becomes unstable), it is also consistent with an earthquake cycle. It is very unlikely that great thrust earthquakes beneath the shelf could fail to trigger slumps on the slope.

Therefore while large slumps could probably occur without an earthquake trigger, the turbidite record suggests that great earthquakes occur no more frequently than every 400 yr.

In Alaska in 1964, the ground sank 2 meters at Portage and at Kodiak; to the southeast, in Prince William Sound, uplift was as much as 10 meters on Middleton Island.



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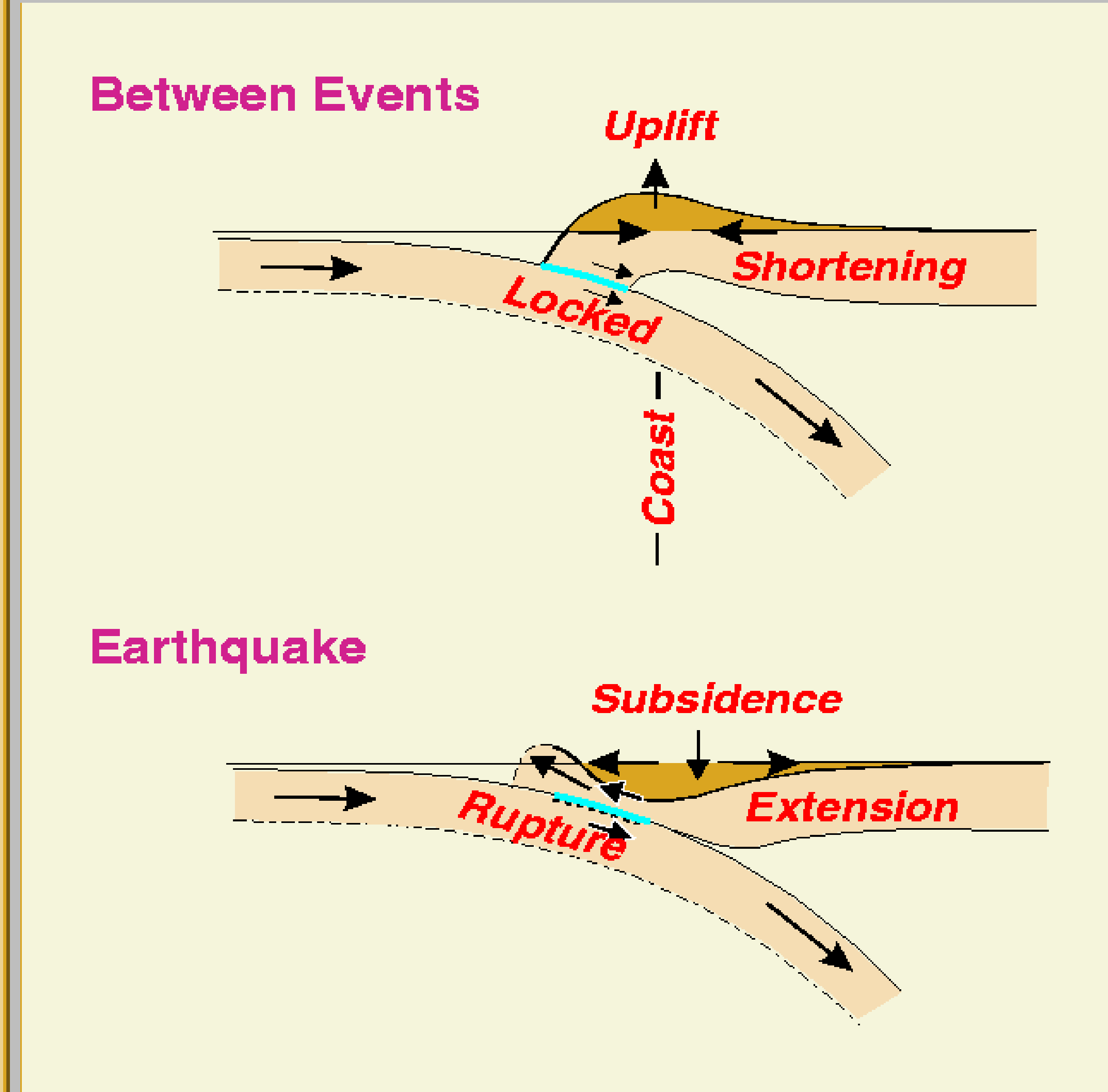
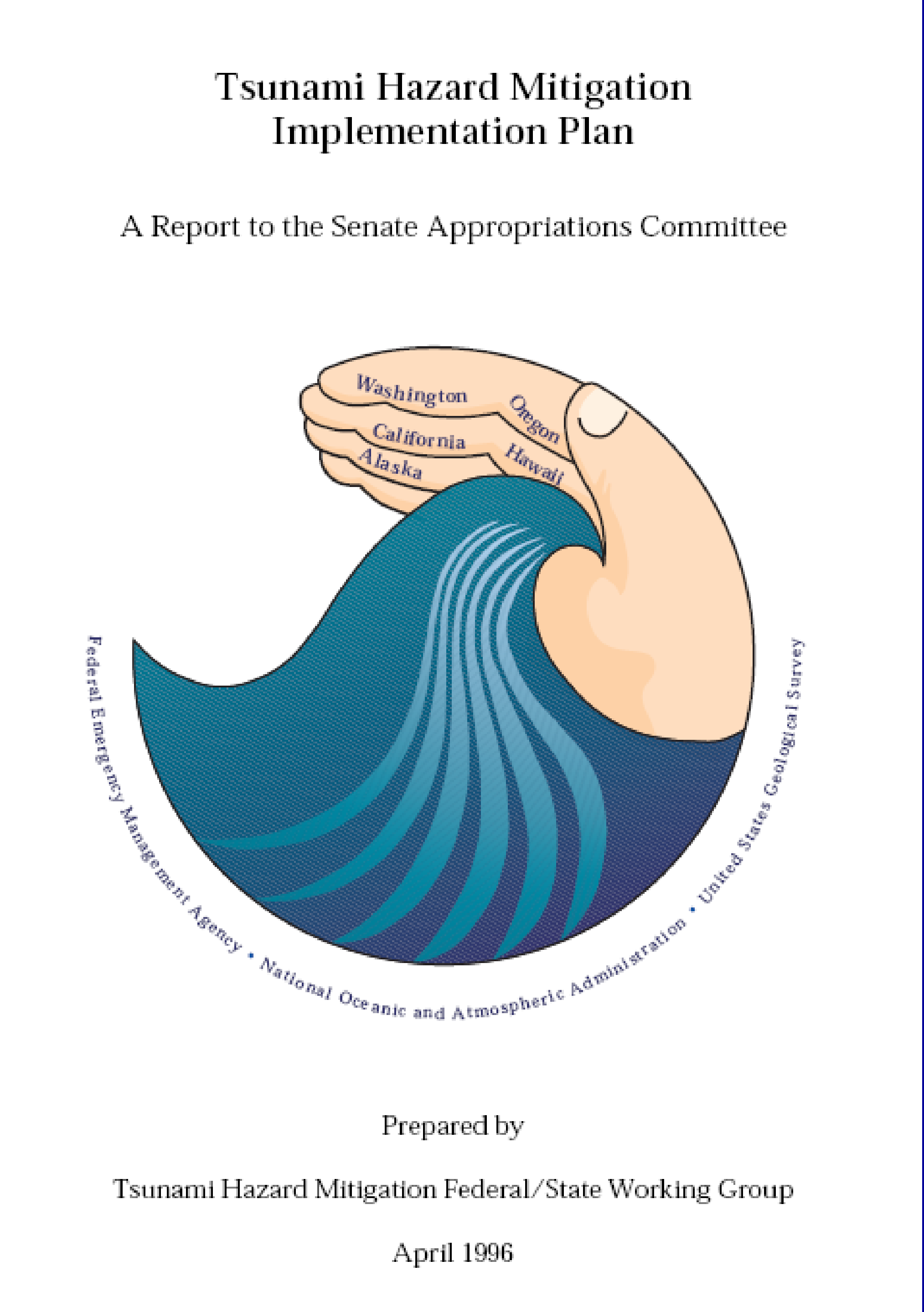
This former wave-cut platform in Prince William Sound was uplifted nearly 33 feet in the earthquake in 1964, stranding seaweed high above the beach.

Here is what was happening. Between earthquakes, uplift along the coast causes the tilting that Ando and Balasz observed, but the earthquake causes the abrupt subsidence that Atwater and others have observed.



In the early 1990's, a confluence of 3 events---the realization that the Cascadia subduction zone produced both major earthquakes and major tsunamis; the 1991 Petrolia earthquake, which generated a small local tsunami; and the 1994 Kuril Islands tsunami warning; ---led the Senate Appropriations Committee, chaired by Mark Hatfield, to direct NOAA to form a partnership with the 5 Pacific states to develop a plan to safeguard the west coast from local tsunamis


Tsunami Hazard Mitigation
Implementation Plan

A Report to the Senate Appropriations Committee

Prepared by

Tsunami Hazard Mitigation Federal/State Working Group

April 1996

“The Committee appreciates the timely NOAA report on tsunami hazard mitigation in response to concerns raised by the Committee about tsunami preparedness for the United States. The Committee is in agreement with the primary recommendation of the report that a federal/state working group be formed to discuss the 12 NOAA recommendations and write a plan of action. The Committee directs NOAA to serve as lead agency by forming the group by November 1, 1995, and submitting the action plan by March 31, 1996. NOAA should spend no more than $50,000 for group meetings and preparation of the action plan. The Committee directs the federal/state working group to formulate a budget to implement the tsunami hazard mitigation action plan.”

NOAA invited representatives from the five affected states—Alaska, California, Hawaii, Oregon, and Washington, along with the Federal Emergency Management Agency, the United States Geological Survey, and the National Science Foundation, to meetings on February 13–14 and March 21 to develop the action plan and budget contained in this report. The report preparation was delayed due to the unanticipated federal furlough. The cost to produce this plan was $15,000 for participant travel expenses and report preparation, reproduction, and distribution.

Tsunami Hazard Mitigation Implementation Plan

A Report to the Senate Appropriations Committee

Prepared by

The Tsunami Hazard Mitigation Federal/State Working Group

Alaska
Wayne Rush, Alaska Division of Emergency Services
Roger Hansen, University of Alaska

California
Richard Eisner, Office of Emergency Services
Lori Dengler, Humboldt State University

Hawaii
Brian Yanagi, State Civil Defense Division
Gus Furumoto, University of Hawaii

Oregon
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Don Hull, Department of Geology and Mineral Industries

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NOAA
Eddie Bernard, Pacific Marine Environmental Laboratory
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Richard Hutcheon, NWS Alaska Region

FEMA
Frank Tsai, Hazard Identification and Risk Assessment Division
Chris Jonientz-Trisler, Earthquake Program Manager, Region X

USGS
Craig Weaver, USGS Pacific Northwest Regional Coordinator for NEHRP (National Earthquake Hazards Reduction Program)

NSF
Clifford Astill, Program Director, Civil and Mechanical Systems Division

April 1996

BUDGET ($000)*

Year	1	2	3	4	5 and beyond
Distant Tsunami					
Recommendation 1 – Develop State/NOAA Coordination and Technical Support					
Five States	(500)	(500)	(500)	(500)	(500)
NOAA	(500)	(500)	(500)	(500)	(500)
Recommendation 2 – Deploy Tsunami Detection Buoys					
NOAA	800	800	800	800	600
Local Tsunami					
Recommendation 3 – Produce Inundation Maps					
Five States	(200)	(200)	(100)	0	0
FEMA	200	200	100	0	0
NOAA	200	200	125	125	125
Recommendation 4 – Develop Hazard Mitigation Programs					
Five States	(100)	(150)	(25)	(65)	(25)
FEMA	175	1,050	100	300	100
Recommendation 5 – Improve Seismic Networks					
Five States	(1,000)	(1,000)	(1,000)	(1,000)	(1,000)
USGS	1,000	1,000	1,000	1,000	600
TOTALS					
Five States	(1,800)	(1,850)	(1,625)	(1,565)	(1,525)
NOAA	(500)	(500)	(500)	(500)	(500)
Federal New Money	2,375	3,250	2,125	2,225	1,425

* Numbers in parentheses represent in kind contribution as match

EXECUTIVE SUMMARY

Senate Charge to NOAA: Form federal/state working group to

1. Review 12 recommendations from 1995 NOAA Report
2. Develop an action plan and budget

Primary Issues of Concern to States:

Alaska, California, Hawaii, Oregon, Washington

- Quickly confirm potentially destructive tsunamis and reduce false alarms
- Address local tsunami mitigation and the needs of coastal residents
- Improve coordination and exchange of information to better utilize existing resources
- Sustain support at state and local level for long-term tsunami hazard mitigation

ACTION PLAN

Objective – Develop state/federal partnership to reduce the impact of tsunamis through the implementation of five recommendations

Goals
- Raise awareness of affected populations (Recommendations 1, 4)
- Supply tsunami evacuation maps (Recommendation 3)
- Improve tsunami warning systems (Recommendations 2, 5)
- Incorporate tsunami planning into state and federal all-hazards mitigation programs (Recommendations 1, 4)

Time Line
- 4-year intensive development period – guided by steering committee
- Continued sustained effort

Distant Tsunami Problem

Recommendation 2

NOAA must establish a real-time reporting network of deep ocean tsunami detection buoys. The rationale for this is straightforward. With existing technology, warning centers are forced to make a warn/no-warn decision based on indirect and insufficient information, such as earthquake magnitude and location, past history of regional tsunamis, and a sparse network of tide gauges, which provide data only after the waves have passed and do not provide information that can directly predict wave heights at other locations. Thus, false alarms are issued because there is no direct verification that a destructive tsunami is propagating across the deep ocean toward a distant coastline. Additionally, there is an understandable tendency for warning centers to "err on the safe side." Detection systems strategically located seaward of known tsunami source regions will provide the needed verification within minutes of an earthquake through direct open ocean wave measurements. If no tsunami is detected, a false alarm evacuation will be averted. Conversely, if a tsunami is detected, the detection system will provide warning centers with the single most important piece of information required for decision making—the deep ocean tsunami amplitude. Consequently, this system will not only decrease false alarms, but will also quickly confirm a real tsunami and improve the speed and accuracy of true alarms. Existing technology can provide this tsunami detection network; ***NOAA has already designed and fabricated a prototype tsunami buoy system and successfully deployed it for several months off the Washington-Oregon coast*** (Figure 1).

Establish real-time tsunami detection network – NOAA: $800,000/year; out years: $600,000/year. Historical and paleoseismic data show that earthquakes capable of producing significant Pacific-wide tsunamis are identified in the shaded coastal regions on Figure 2. The proposed siting of buoys will ensure the detection of any tsunami within these regions within 30 minutes of the generating earthquake. NOAA has built and tested a prototype deep ocean tsunami detection buoy that measures the tsunami in the open ocean and transmits these data to shore in near real time. To protect U.S. coastlines, a six-buoy array is proposed to quickly detect the propagation of a tsunami from areas where earthquakes generate destructive tsunamis and relay tsunami data to the warning centers and the states

Local Tsunami Problem
Recommendation 2

Improve seismic networks. The current tsunami warning systems are triggered by information from earthquake seismic networks. Typically, earthquake magnitudes above certain levels cause tsunami warnings to be issued. Despite the use of earthquakes as a trigger, the earthquake and tsunami warning systems have remained separate.

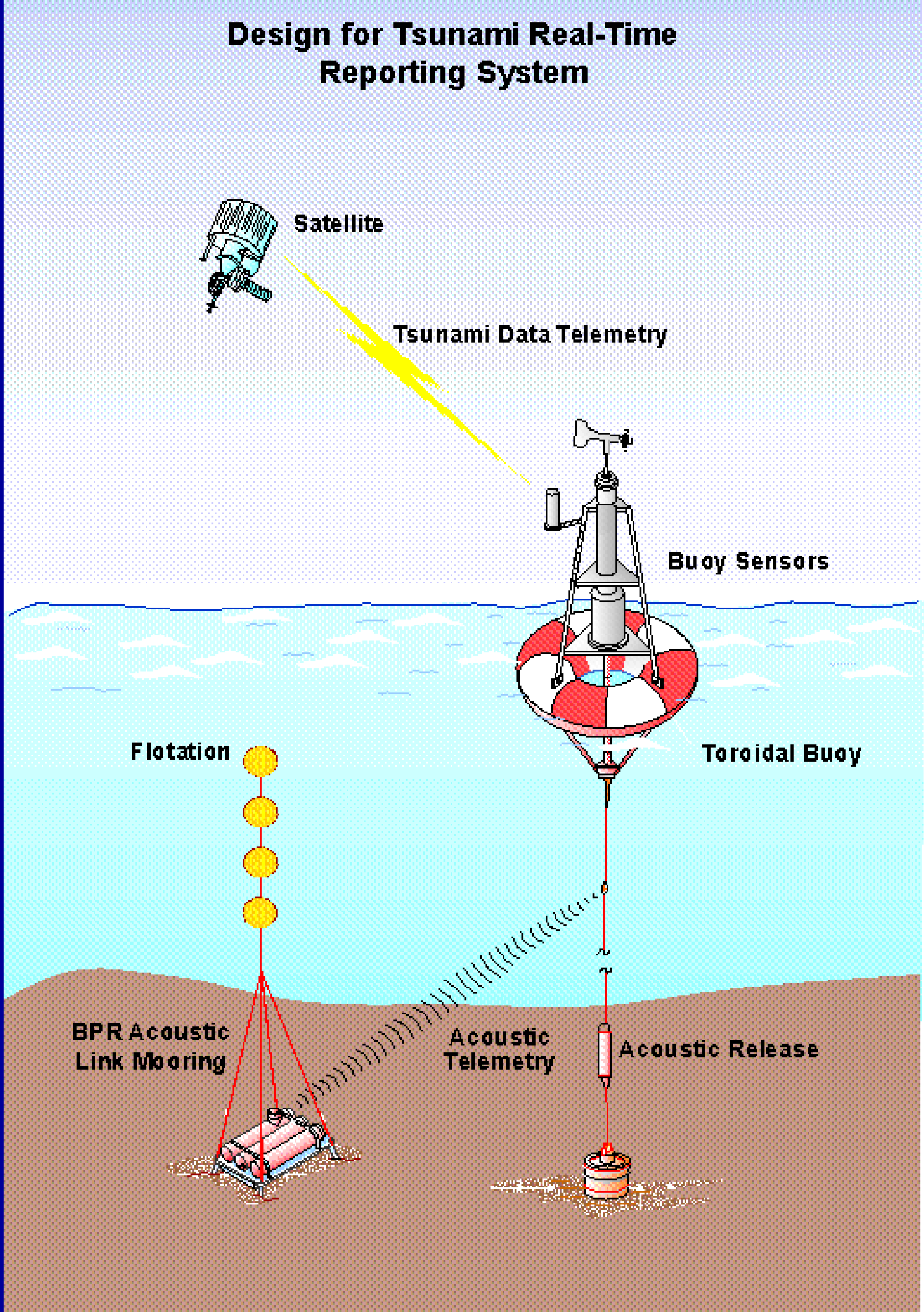
Because of increased capabilities in seismic network technology and tsunami warning systems, these two systems will be merged under this Plan. Indeed, as concerns have heightened along the west coast of the United States about consequences of a Cascadia earthquake producing both very strong ground shaking and a tsunami, combining the capabilities of the two systems becomes a necessary requirement for producing better warnings.

This Plan is designed to provide a virtually seamless, integrated tsunami warning system that delivers notification of a major earthquake within 2 minutes of the initial rupture. This initial notification will be followed within 3 minutes by detailed seismic parameters that provide an understanding of the likelihood of a tsunami and an estimate of the pattern of strong ground shaking. Because the rupture speed of a great earthquake is much slower than the initial seismic waves, this capability means that some portions of the west coast will be alerted before the shaking actually arrives. Reporting of a potential tsunamigenic earthquake in Alaska, Hawaii, or Cascadia, proposed under this Plan, would be complete in 5 minutes; currently the same level of detail not available until at least 1 hour after the event. That delay of notification is unacceptable given the lives and property at risk.

Currently, there are over 900 seismometers operating in northern California, Oregon, Washington, and British Columbia, Alaska, and Hawaii. These existing seismometers are telemetered in real time to seismic data centers in Menlo Park, California, Seattle, Washington, Sidney, British Columbia, Fairbanks, Alaska, and the Hawaiian Volcano Observatory (HVO). There, computers analyze the signals, look for earthquake signals, and run location routines.

Typically, earthquake locations are now available in 2 to 6 minutes; however, limitations of existing instrumentation make it impossible to offer additional information such as detailed strength of shaking or faulting parameters.

Another component of the program was the installation of buoys for direct detection of tsunamis in the open ocean, called Deep ocean Assessment and Reporting of Tsunamis (DART)



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•Buoy at the D-157 site just after being set in the water and riding high with no mooring load. Typical October seas in the North Pacific.

Seismic network implementation plan – Costs: Years 1–4: $2,000,000/year; Year 5 and beyond: $1,600,000. Under this Plan it is recommended that 36 existing seismic stations be upgraded and 16 new sites installed along the west coast, Alaska, and Hawaii (Figures 3–5). The proposed instruments, coupled with improvements to communication links and existing data processing centers, will provide state-of-the art warning capability. The 36 sites slated for upgrading are of two types. There are currently a few modern, digital, instrument sites (open squares in Figure 3) operating along the west coast. These broad-band sites are designed to provide detailed recording of earthquakes; for all but the largest local events these stations provide high-quality data in real time. However, a Cascadia event will produce ground motions that will saturate these stations. Therefore, we propose to install digital, strong ground-motion sensors at six sites (filled squares in Figure 3).

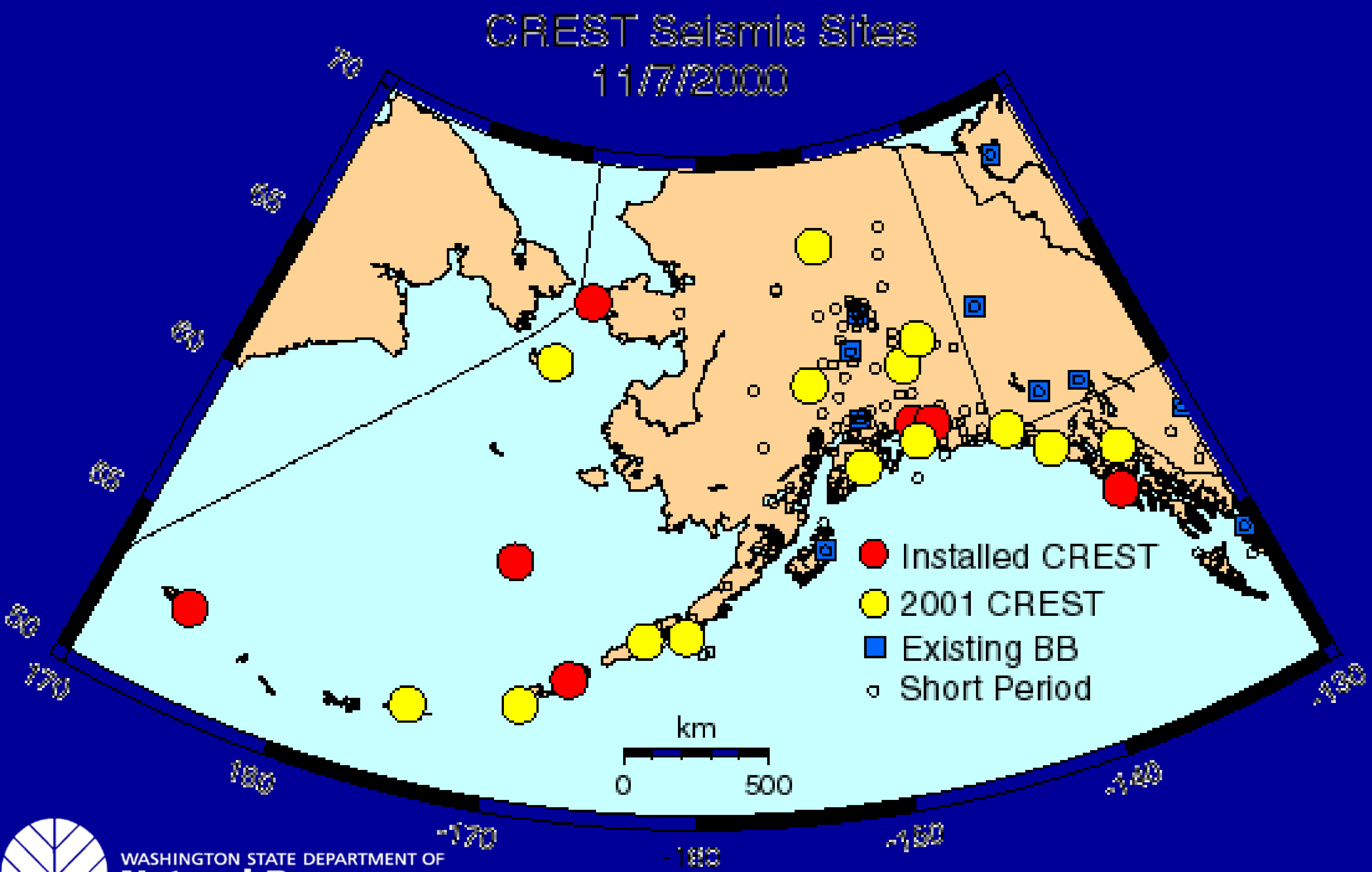
It is estimated that each training program will cost $50,000, funded by FEMA. The first year, training would be conducted for Washington and Oregon, while Alaska and California would be completed in year two and Hawaii would be completed in year three. The combined value of all the city/county engineers' time is estimated to be $100,000 and would be contributed by each community.

The Group also recognized that the one-dimensional models should be supplemented by two-dimensional models for certain communities. NOAA would continue its development of two-dimensional models through the formation of a tsunami inundation mapping center. The mapping center would consist of one contract employee plus supporting funds for a total of $200,000 for the first 2 years and $125,000/year thereafter.

In the first 2 years the mapping center would develop the necessary digitized data bases, adapting the two-dimensional model to run on supercomputers and the one-dimensional models to run on personal computers, and provide data and support for running the models. Support for the generation of inundation maps for appropriate communities would consist of providing required bathymetric and topographic data from the center's data bases and overseeing the running of the two-dimensional model. Support to other communities which wish to run the one- dimensional model would include providing a personal computer version of the one-dimensional model, the required data from the center's data bases, and instructions on how to apply the model.

After the tsunami flooding maps are completed, the Group recommends that a maintenance effort be established to keep the maps updated due to coastal developments and improved mapping technology. The cost would be $125,000/year for one full-time NOAA employee plus support.

Consolidated **R**eporting of **E**arthquake**S** and **T**sunamis (CREST)



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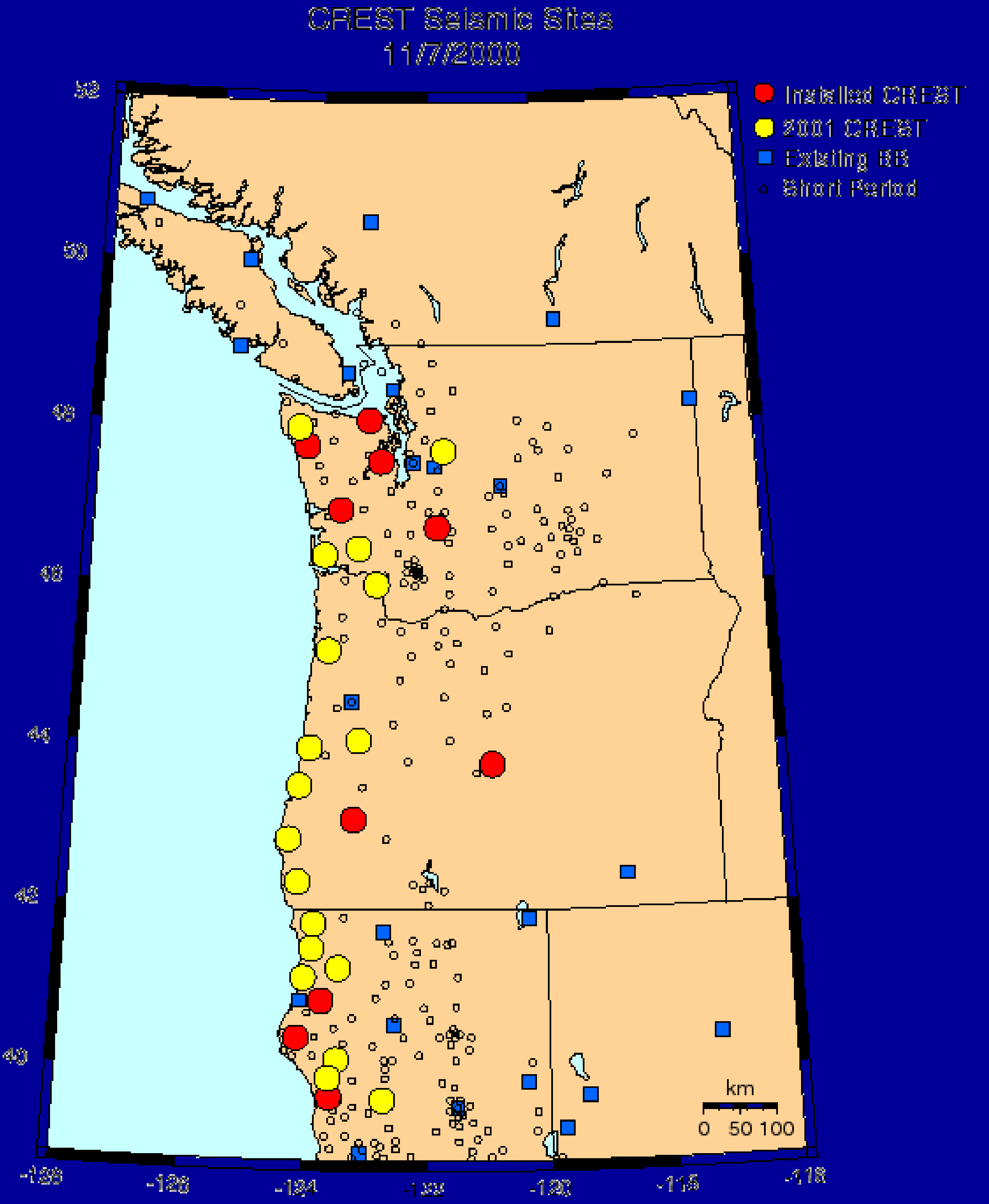
Consolidated **R**eporting of **E**arthquake**S** and **T**sunamis (CREST)



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Consolidated
Reporting of
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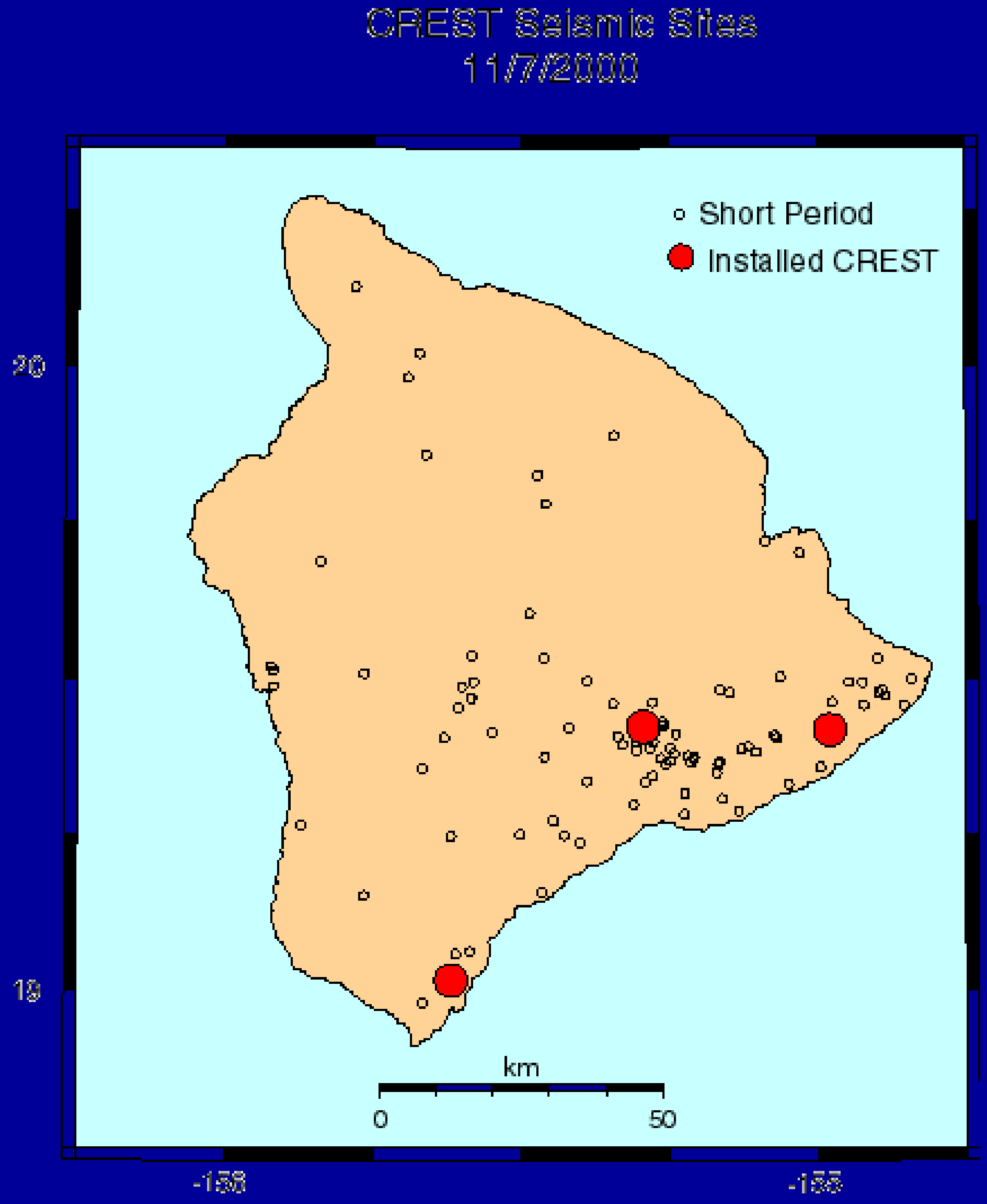

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Local Tsunami Problem

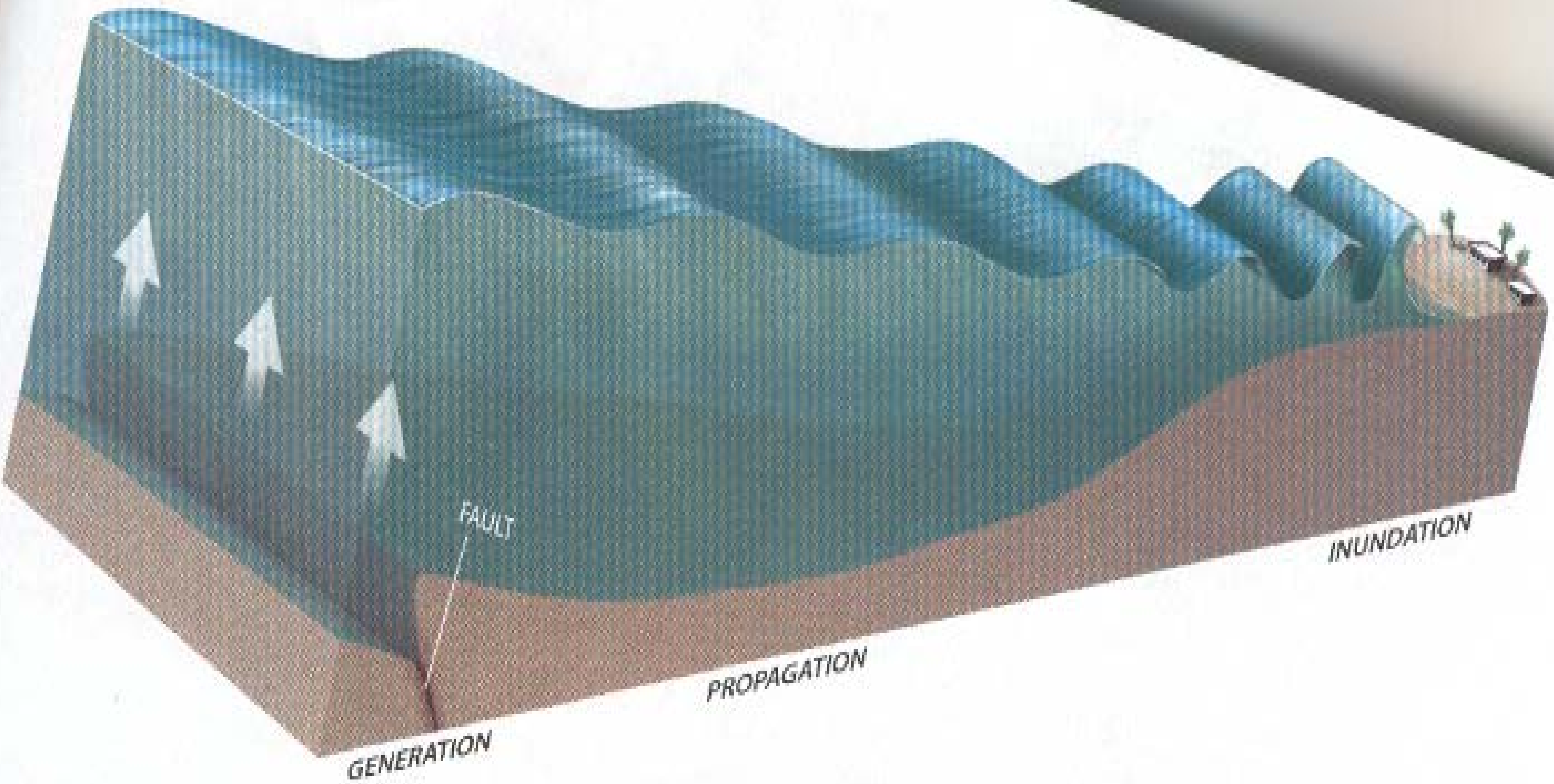
Recommendation 1

Compilation and distribution of inundation/evacuation maps. ***Maps showing the areas of likely tsunami inundation for at-risk communities will be constructed using one- dimensional models similar to those presently used in Hawaii for distant tsunami evacuation maps.*** For some communities more sophisticated models of inundation may be required. There was unanimous agreement among participants that inundation/evacuation maps are the basis of local tsunami hazard planning. Without a clear understanding of what areas are at risk and which areas are unlikely to be flooded, it is impossible to develop effective emergency response plans and education programs. If this Plan is funded, all communities will have an inundation map as a basic planning tool.

Tsunami inundation/evacuation maps – Costs: Year 1: $600,000; Year 2: $600,000; Year 3: $325,000; Year 4 and beyond: $125,000. The Group felt that the production of tsunami inundation maps was essential to the development of effective hazard planning. In order to produce these maps within 3 years of implementation of this Plan, the Group recommended the Hawaii approach to evacuation map production. Hawaii updated its tsunami evacuation maps in 1990 using a one-dimensional modeling technique developed at the University of Hawaii. The Group recommends that this technique be taught to city and/or county engineers (or state representatives) through a workshop format for each state that lacks inundation maps. The workshops will provide basic training on the application of the one-dimensional model and provide personal computer software with user manuals to aid in the calculations. The instructor will train the engineers at an initial 5-day workshop, be available for assisting the workshop participants for the next month while maps are being produced, and will conduct a concluding 3- day workshop to review the work and finalize the maps. This training process will yieldinundation maps and trained local engineers for each coastal community or state representatives to map all communities. As physical changes to the community occur, the trained engineer or state representative can modify the maps to reflect the changes. The trained engineer or state representative can also answer questions about the basis for the maps.

The original plan, however, did not work out for several reasons.:

- Misunderstanding of funding mechanism leading to an overly simplified modeling proposal
- underestimate of the size of the inundation mapping project
- difficulty creating the TIME Center
- need to revise the mapping and modeling program



The National Tsunami Hazard Mitigation Program, formed in 1995, develops tsunami inundation maps for vulnerable coastlines. These are based on a combination of numerical modeling, and , where possible, paleoseismology.

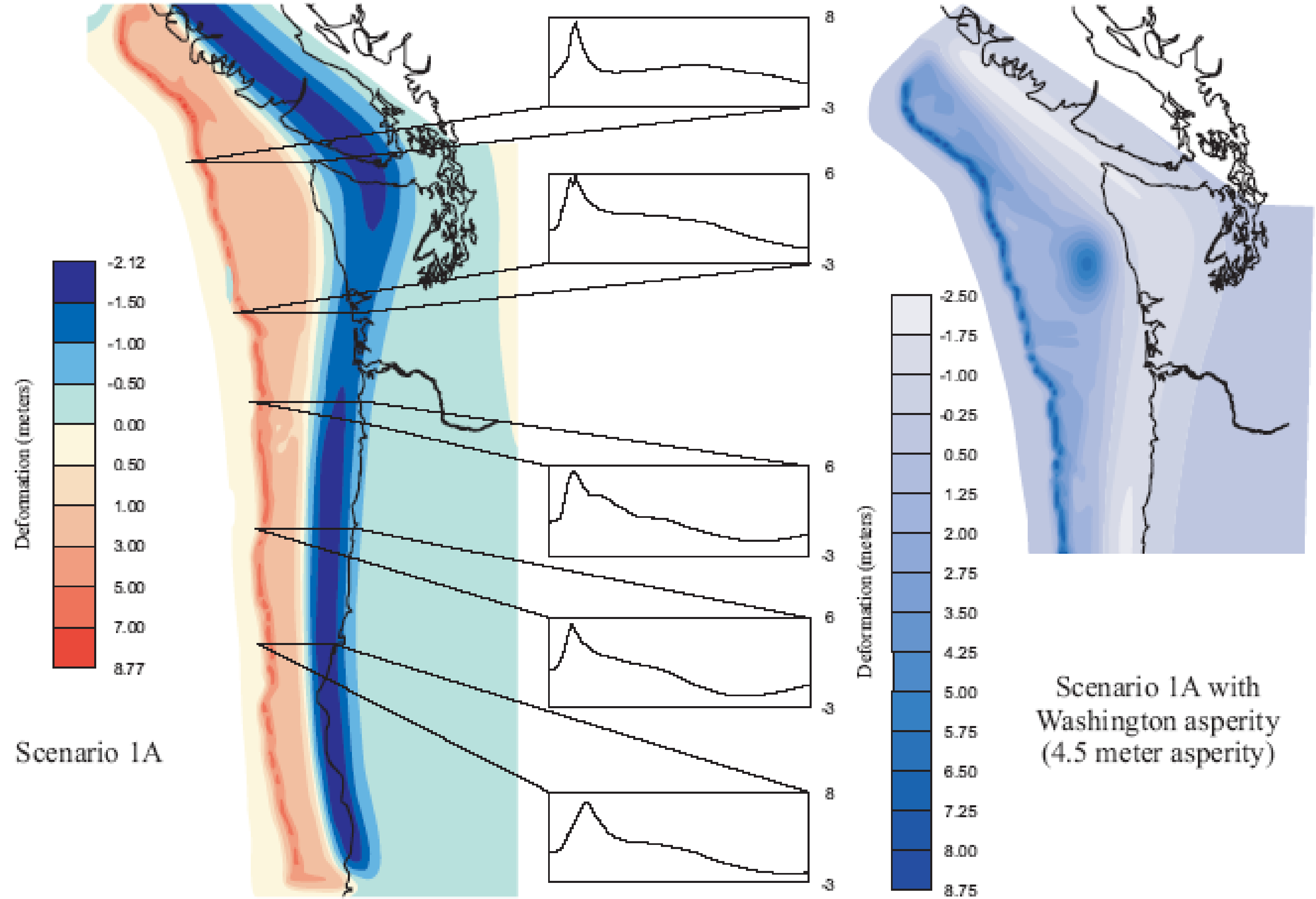
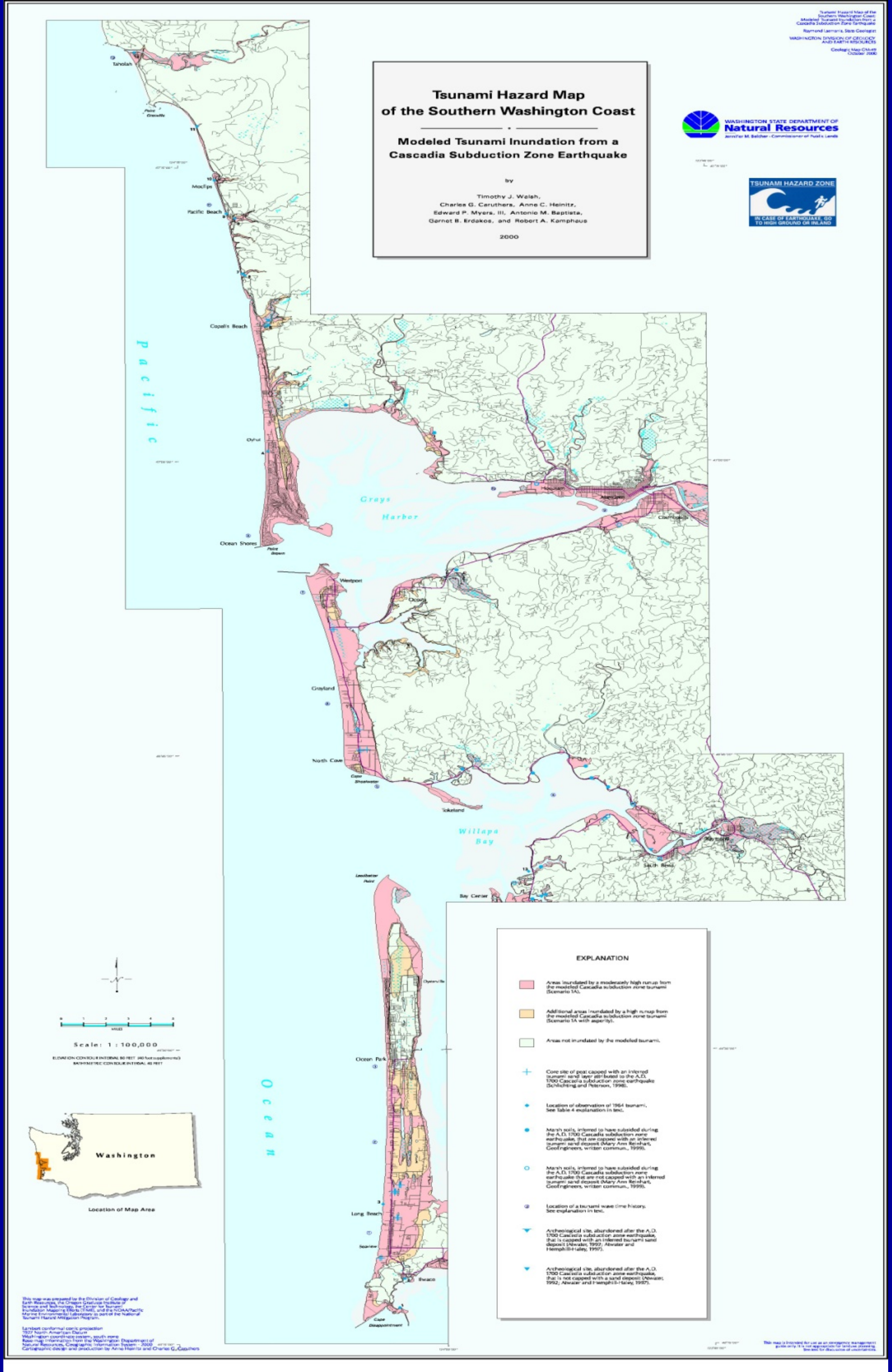


Figure 1. Map of fault uplift and subsidence showing Scenario 1A and Scenario 1A with 4.5-meter Washington asperity added. Scenario 1A shows time histories of modeled waves at various locations along the coast.

Figure 2. *(next three pages)* Time histories of the modeled waves at twelve localities immediately offshore of key communities, identified by community name and map number (in circle). These time histories give the change in water surface elevation with time for 8 hours of modeling.

George Priest at DOGAMI had already begun a tsunami modeling program with funding from NEHRP

This is the tsunami hazard map that we developed for the southern Washington coast. The area is within the Columbia River littoral cell and is dominated by accretionary shoreforms marked by low relief. This is where most of the resident population of the outer Washington coast lives and where evacuation is most difficult.



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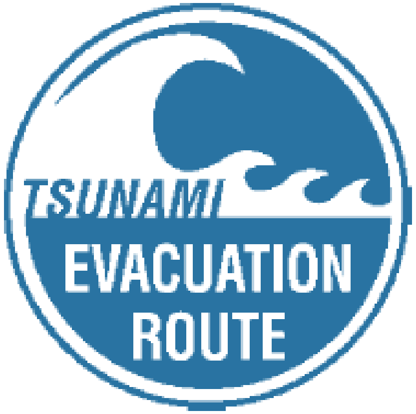
These products guide the placement of signs such as these and form the basis for our education and outreach programs.



These graphics were previously created by George Priest and colleagues and adopted by NTHMP as an international standard, even though we had no authority to do so

On November 21, 2002, George Crawford, Rich Eisner, Jane Preuss, and I held a workshop to investigate whether it was feasible to design facilities to withstand a nearfield M9 earthquake, suffer so little damage as to be attractive for an evacuation refuge, and also be high and resilient enough to serve as a shelter for people in the near-field.

PROCEEDINGS
of a
WORKSHOP ON CONSTRUCTION GUIDANCE
FOR AREAS OF HIGH SEISMIC AND TSUNAMI LOADING
convened by
TIMOTHY J. WALSH[1], GEORGE CRAWFORD[2], RICHARD EISNER[3], AND JANE V. PREUSS[4]
for the
NATIONAL TSUNAMI HAZARD MITIGATION PROGRAM
NOVEMBER 21, 2002

WASHINGTON STATE DEPARTMENT OF Natural Resources
Doug Sutherland - Commissioner of Public Lands
Division of Geology and Earth Resources
Ron Teissere - State Geologist

OES CALIFORNIA
Governor's Office of Emergency Services

GEOENGINEERS

1. Washington Department of Natural Resources, Division of Geology and Earth Resources, Olympia, Washington
2. Washington Emergency Management Division, Camp Murray, Washington
3. California Governor's Office of Emergency Services, Oakland, California
4. GeoEngineers, Inc., Redmond, Washington

Those two buildings and other Japanese tsunami defense structures formed the basis of a study of buildings that survived devastating tsunamis when everything else in the area was destroyed.

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Development of Design Guidelines for Structures that Serve as Tsunami Vertical Evacuation Sites

by Harry Yeh,
Ian Robertson,
and Jane Preuss

WASHINGTON
DIVISION OF GEOLOGY
AND EARTH RESOURCES
Open File Report 2005-4
November 2005

This report has not been edited or reviewed for conformity with Division of Geology and Earth Resources standards and nomenclature

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Doug Sutherland - Commissioner of Public Lands

We formed a partnership with FEMA and the Applied Technology Council to provide building code style guidance for building facilities to withstand a magnitude 9 earthquake and be suitable for vertical evacuation. Planning for the right size earthquake is critical.

Guidelines for Design of Structures for Vertical Evacuation from Tsunamis

FEMA P646 / June 2008

FEMA

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But how to build these? John Schelling launched Washington"s approach to tsunami evacuation in places that have no nearby high ground

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PROJECT SAFE HAVEN:

VERTICAL EVACUATION ON THE WASHINGTON COAST

Grays Harbor County, Washington

2011

FEMA

UNIVERSITY of WASHINGTON

Natural Resources

QUINAULT INDIAN NATION

Safe Haven Options (from FEMA 646):

Towers –
- Limited Space
- Blocks Views
- Few Options for Shelter

Buildings –
- Expensive
  - Better get it right the first time!
- Very Large, Likely to Block Views
- May require Private Development
  - Incentives for Height?

Berms –
- Least Expensive Option
- Can be Multi-Purpose
- May be Placed to Limit View Blocking

WE DID IT!

Sch Dist 172 - Ocosta Proposition No. 1 Bonds to Renovate Ocosta Elementary School
*Multi-county race. Results include all counties involved.

County	Measure	Vote	Vote %
Grays Harbor	Approved	865	69.87%
	Rejected	373	30.13%
Pacific	Approved	197	70.36%
	Rejected	83	29.64%
Combined Total			
All	Approved	1,062	69.96%
	Rejected	456	30.04%
Total Votes		**1,518**	**100%**

WASHINGTON STATE DEPART
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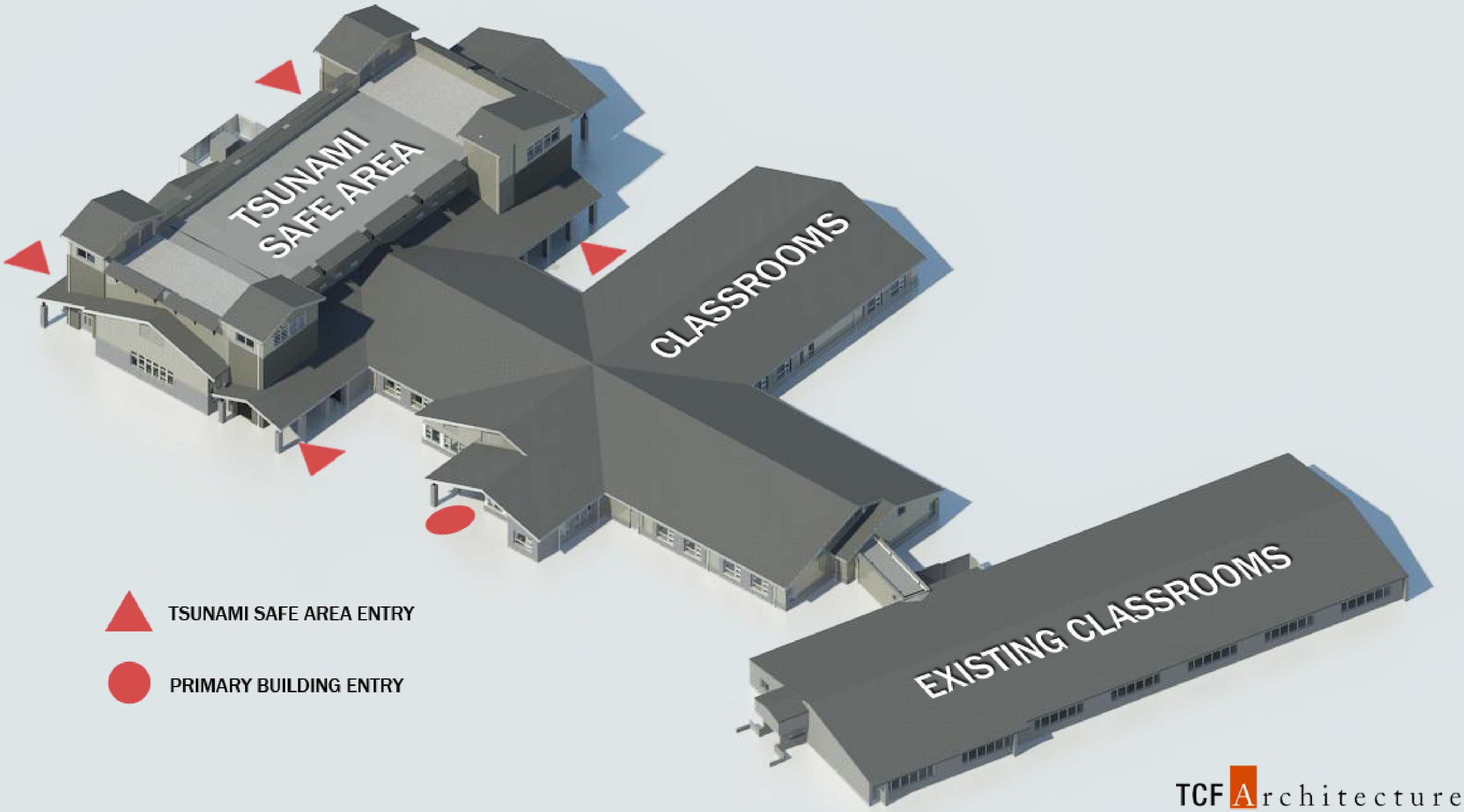
TCF Architecture


TSUNAMI SAFE AREA
CLASSROOMS
EXISTING CLASSROOMS
TSUNAMI SAFE AREA ENTRY
PRIMARY BUILDING ENTRY
TCF Architecture

Groundbreaking for the Ocosta Elementary School tsunami vertical evacuation refuge—first in the U.S.

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Ground-breaking ceremony for the first tsunami vertical evacuation refuge in the U.S., Ocosta Elementary School

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Other events along the way molded the course of the NTHMP:

- the original plan was never funded by congress, but rather the initial funding amount was renewed, again in appropriation language (state lobbying essential)
- after 5 years, NTHMP became base budget
- NOAA transferred NTHMP from PMEL to NWS Pacific Region
- Undersea tsunami observatory (TWEAK) added to NTHMP appropriation
- Rich Pryzswarty, AK Region director, suggested creating a companion program to StormReady, to be called TsunamiReady—Ocean Shores Washington the first recipient
- in Washington, George Crawford and then John Schelling implemented NOAA Weather Radio-on-a Stick

Washington State Tsunami Program

TsunamiReady Program

Governor's GMAP Item

- ❖ **Ocean Shores Recert - Jun**
- ❖ **Long Beach Recert – Sep**

Alert and Notification

Governor's Priority

- **NOAA Weather Radios**
  - **150 Radios to tribes, schools and counties**
- **AHAB Radio**
  - **2 installed – Sandy Point and Ocean Shores upgraded**
  - **Completed 30 site visits**
  - **30 Systems ordered – 11 on site pending installation and 9 in transient**
  - **EMD approved state funding of 2 systems for the Lummi Nation**
- **Satellite Control Unit bench tested due installation Oct 06**
  - **New AHAB Radios are satellite capable**

26 Dec 05, Banda Aceh, Indonesia

FUNDED SYSTEMS TO BE INSTALLED BY JUNE 2007 (32)

- Bay Center
- Cape Disappointment
- Clallam Bay
- Cohasset Beach
- Copalis Beach
- Diamond Point
- Fort Worden
- Grayland (2)
- Hoquiam
- Ilwaco
- Long Beach
- Lower Elwha
- Lummi Nation (2)
- Pacific Beach
- Pacific Park
- Point Hudson
- Port Angeles
- Ocean City
- Ocean Park (4)
- Ocean Shores (3)
- Seaview
- Surfside
- Taholah
- Tokeland
- Westport

OPERATIONAL (16)

- Aberdeen
- La Push
- McAlder
- McMillin
- Neah Bay
- Ocean Shores
- Orting
- Port Townsend
- Puyallup (2)
- Sandy Point
- Seattle (3)
- Sumner
- Westport

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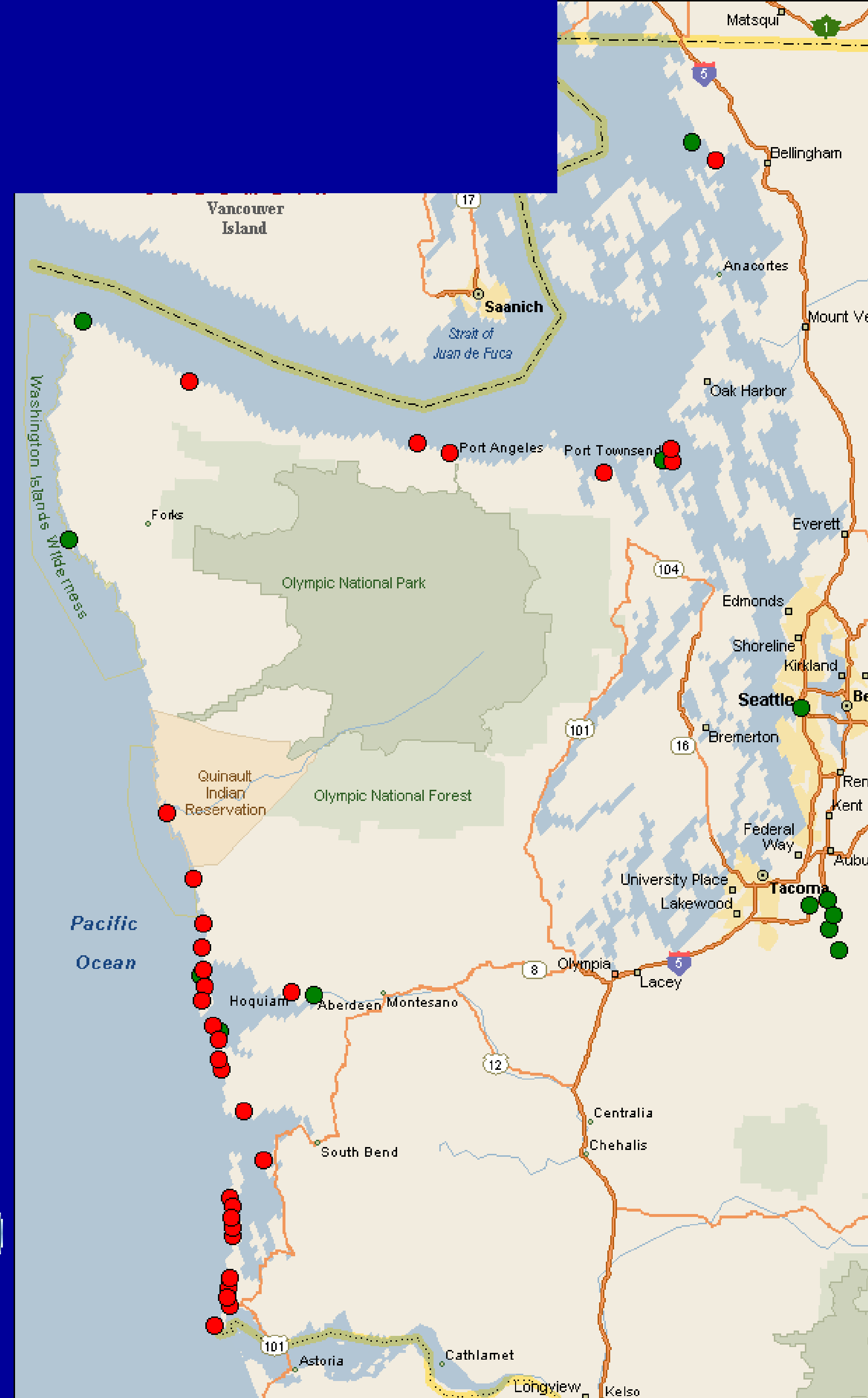

The December 26, 2004 Nicobar-Andaman earthquake and ensuing tsunami dramatically reorganized the NTHMP:

- Executive order expanding program
- Elevation of management from NWS Pacific Region to NWS headquarters
- TWEA, reorganizing NTHMP, taking the buoy program and seismology program into separate sections

Where are we going now? That's up to all of us