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TSUNAMI EDUCATION PLANNING WORKSHOP FINDINGS AND RECOMMENDATIONS

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Findings and Recommendations

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Executive Summary

The National Oceanic and Atmospheric Administration (NOAA) is developing a plan to reduce tsunami hazards along the coasts of the United States, with particular emphasis on the west coast. Public education is a key component of the plan. To identify important public education needs, NOAA's Pacific Marine Environmental Laboratory, Oregon Sea Grant, the International Tsunami Information Center, and the Alaska Tsunami Warning Center jointly convened a Tsunami Education Planning Workshop on October 26–27, 1994 in Newport, Oregon.

The workshop group (Appendix A) concluded that major and minor population centers, coastal industry, ports and harbors, and other major infrastructure on the U.S. west coast are increasingly vulnerable to potentially destructive tsunamis. Further, they agreed that broad-based public education is one of the most effective means for reducing risks of loss of both life and property at risk of this hazard. Key recommendations are summarized below and detailed in the full report. Although the focus is on tsunamis, workshop participants stressed that these recommendations are but one component of an all-hazards education program that should include other related seismic hazards.

Recommended Actions

1. *Networking for Improved Education* . A Cascadia Earthquake-Tsunami Information Network (CETIN) should be established to promote communication among agencies and organization interested in education about tsunamis and coastal earthquake hazards, and ultimately, to promote public education for effective tsunami preparedness, information sharing, and new information and materials development.

2. *Use of Internet*. A west coast internet discussion group should be established to promote the kinds of interactions and information sharing that CETIN will need to foster the kind of education efforts anticipated. More advanced communications technology should be incorporated as available.

3. *CETIN Roles*. CETIN activities should support, complement, and promote communication among existing centers of expertise, such as FEMA's Cascadia earthquake consortium, the Pacific and Alaska Tsunami Warning Centers, the International Tsunami Information Center, and other public and private groups dealing with related subject matter.

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4. *Preliminary Inundation Mapping* . Preliminary tsunami inundation maps should be produced for or by communities using a combination of relatively simple and proven techniques.

5. *Improved Inundation Mapping*. In the longer term, more accurate mapping of tsunami inundation, runup height, and currents is needed, particularly in areas with significant and growing populations and active ports and harbors.

6. *Warning Message Improvement*. NOAA should reevaluate the content of and procedures for tsunami warnings in light of the fact that many receivers (responders, media, etc.) of such information are ill-equipped to interpret them accurately; then develop and implement a broad-based education program.

7. *Warning Expert Availability*. NOAA and/or states should establish single-point tsunami expert contacts for users requiring clear interpretations of tsunami warnings and related information.

8. *Information Clearinghouse*. Existing tsunami (and earthquake) education materials should be identified, collected, cataloged, and disseminated to all potential users.

9. *Education Material Development and Needs* . Identify outstanding tsunami (and earthquake) educational materials and approaches from other areas and tailor them to the needs of the Cascadia region after assessing local needs; examples include:

    - Video productions: CSZ earthquakes and tsunamis, west coast tsunami hazards, and earthquake and tsunami preparedness

    - "Speakers bureau" with regional experts on earthquake and tsunami hazards

    - Media packets on tsunami hazards, interpretation of tsunami warnings, expert contacts for interpretation of tsunami information, etc.

    - Public service announcements for radio and television

    - Model tsunami response plans for distant- and locally generated tsunamis should be developed for coastal facilities and communities

    - Telephone book information on earthquakes and tsunamis (as in Hawaii and British Columbia)

10. *Warning and Evacuation Signs*. Universal tsunami hazard zone and evacuation route signs should be developed and used throughout the Cascadia region (and perhaps in other areas as well, such as Alaska, Hawaii, and other Pacific Basin areas).

11. *Quality Assurance*. A tsunami education materials quality assurance function should be established and implemented in the region.

12. *Teacher and School Programs*Teacher training and school programs should be given high priority.

13. *Museums and Traveling Displays*. Local and regional museums should develop, maintain, and circulate displays and exhibits on earthquake and tsunami awareness and preparedness.

Full Report

Introduction

Over the past several years, the National Oceanic and Atmospheric Administration (NOAA) has been developing a plan to reduce tsunami hazards along the coasts of the United States, with particular emphasis on the west coast. NOAA's Pacific Marine Environmental Laboratory and the National Weather Service have led this effort. The plan has evolved into a three-part, intertwined approach that includes (1) hazard assessment (identification and mapping of tsunami inundation potential); (2) real-time tsunami monitoring and warning systems (to alert response authorities and the public); and (3) public education (to improve public awareness and community response). Workshops to address each of these topics were held during 1993–94:

Hazard Assessment — Convener: E.N. Bernard, November 16–18, 1993, Honolulu, Hawaii. Report: Bernard, E.N. and F.I. González, "Tsunami Inundation Modeling Workshop Report," NOAA Tech. Memo. ERL PMEL-100, 139 pp., 1994.

Tsunami Warning System Workshop — Co-conveners: Hiroo Kanamori and Michael Blackford, September 14 and 15, 1994, Pasadena, California. Report: Blackford, M., and H. Kanamori, "Tsunami Warning System Workshop Report (September 14–15, 1994). NOAA Tech. Memo. ERL PMEL-105, 94 pp., 1995.

Tsunami Education Workshop — Co-conveners: James Good, Dennis Sigrist, and Thomas Sokolowski, October 26–27, 1994, Newport, Oregon.

This document is the report from the third workshop on education needs. This and the reports from the other two workshops will be synthesized and specific actions recommended by March 1995.

Tsunami Education Workshop Goals and Structure

The principal goal of this workshop was to develop a long range action plan for tsunami hazard education in the Cascadia region (northern California, Oregon, Washington, and British Columbia). This region is vulnerable to two kinds of tsunamis. *First*, the region is vulnerable to distant-generated tsunamis (waves caused by earthquakes and other sources in the Pacific Basin). Generally, with these events, the west coast has sufficient warning time to adequately spread the word to response authorities and the public. As we shall see, however, this system does not function as well as it might. *Second*, the region is vulnerable to locally generated tsunamis (waves caused by earthquakes along the Cascadia Subduction Zone [CSZ]). It is impossible to talk about locally generated tsunamis without also considering the other hazards that will occur in association with CSZ earthquakes, such as strong ground shaking, soil liquefaction, landslides, and subsidence and uplift. Although these other earthquake hazards were not the principal focus of this workshop, they have a significant effect on educational needs and approach for dealing with tsunamis generated by

local earthquakes. The results of the two earlier workshops were also vital to the discussion of education needs, as illustrated later.

Participants in the Tsunami Education Workshop, detailed in Appendix A, included federal agency representatives from NOAA (Pacific Marine Environmental Laboratory, National Weather Service, Pacific and Alaska Tsunami Warning Centers), the Federal Emergency Management Agency (FEMA), the International Tsunami Information Center (ITIC), British Columbia, state agencies in California, Oregon, and Washington (geologic hazards, emergency management and services, and coastal zone management), local emergency management personnel, the American Red Cross, and educators from academia, public schools, and private organizations. This diverse group provided the opportunity to discuss a wide range of education issues and opportunities in the region.

The workshop was structured as follows (see Appendix B):

- Information was presented about the results of earlier workshops on tsunami hazard assessment (inundation mapping) and warning systems (particularly how warnings are disseminated and interpreted locally).
- Information and materials about existing international, federal, state, and local tsunami education programs and materials in the Pacific Northwest and the larger Pacific basin were presented and discussed (see appendices for related materials).
- Regional and local area education needs were identified and discussed, considering a variety of audiences.
- Specific high-priority initiatives and projects were identified, along with recommended agency responsibilities, possible funding sources, and so on.

Workshop Summary

Tsunamis that have the potential to cause significant loss of life and property damage along the U.S. west coast have been relatively infrequent events in historic times. The last such destructive tsunami event was caused by the March 28, 1964 great earthquake in Alaska. Waves of more than 4 meters (13 feet) were recorded at several locations along the coast, with loss of life and property damage greatest in Crescent City, California. Since that time, several earthquakes in the Pacific Basin have resulted in tsunami warnings and/or measurable events along the U.S. West Coast, including the April 1992 Cape Mendocino earthquake, believed to have originated along the CSZ. None have resulted in major damage along the west coast. However, just since 1992, locally destructive tsunamis in Indonesia, Nicaragua, Japan, Russia, and the Philippines have claimed nearly 3000 lives. Further, since the 1964 Alaskan quake, there have been many millions of additional dollars invested in public and private infrastructure and development on the west coast that would be affected by major tsunamis in the future, especially a tsunami generated by a large local CSZ earthquake. **The infrequency of destructive tsunamis on the west coast—whether distant- or locally generated—coupled with the potential for major loss of life and property when the next**

one occurs, presents a significant education challenge: how to make people aware of tsunami (and earthquake) hazards on our coasts, how to get them to prepare for and respond appropriately when it does happen, and how to sustain that awareness and preparedness over the long term. This challenge was the focus of this workshop.

Who Are the Audiences for Tsunami Education?

Oregon's Coastal Natural Hazards Policy Working Group (PWG), as part of its recent policy evaluation effort (CNHPWG 1994), identified six key audiences for tsunami (and earthquake) education. These were (1) the emergency response network, including the various media, state and local emergency officials and volunteers, police, fire, medical, etc.; (2) local residents, business people, and workers, whether at home, at work, or out in the community; (3) young people under adult supervision, whether at schools, day care, or involved in community activities and programs; (4) coastal tourists and visitors; (5) the "development" community, including realtors, contractors, designers, consultants, and economic development personnel; and (6) the legal and financial sector, including lenders and insurers of property.

This breakdown of audiences suggests a dual focus for tsunami education: first, on the awareness, preparedness and response skills people need to have to act appropriately during a tsunami event; and second, on what people who influence decision-making processes can do to minimize exposure of people and property to increased tsunami risk in the future.

What audiences and education needs are highest priority? Another way of stratifying audiences suggested by workshop participants is to consider the different needs associated with the two kinds of tsunami threats on the west coast, namely those generated by a distant source versus a local event. What are those differences? First, there is a difference in the expected "lead time" for warnings (hours in advance for a distant event versus minutes for a local one). Second, the warning "message" itself is different; people will learn about the distant event directly or indirectly from widely broadcasted, formal alerts issued by the Alaska or Pacific Tsunami Warning Centers. For the local event, however, the "alert" is usually the strong ground shaking of the earthquake. A third difference is the likelihood of significant, concurrent earthquake-related injuries, property damage, and isolation associated with a major local earthquake. Finally, for the local event, it is expected that tsunami inundation and run-up height (and hazard) will be much greater. This tsunami-type approach to considering and prioritizing audiences for education initiatives strongly links the results of this workshop to the two earlier ones: tsunami inundation modeling and tsunami warning systems and information dissemination. These links are addressed in more detail below and reflected in workshop recommendations.

Importance of Tsunami Inundation Mapping to Education

The tsunami inundation modeling workshop report (Bernard and González, 1994) recommended that inundation maps for distant- and locally generated tsunamis be developed for the

U.S. west coast. NOAA will soon publish a model-based inundation map for the Humboldt Bay-Eureka and Crescent City areas of California that may serve as a prototype for other regional mapping efforts. This map will be published and made available to the general public as part of a California Division of Mines and Geology (CDMG) earthquake planning scenario for a magnitude 8.4 earthquake on the southern portion of the CSZ (Gorda) and will also include expected ground shaking intensities, landslides, liquefaction, and impacts on infrastructure. In Oregon, the Department of Geology and Mineral Industries (DOGAMI) is also working on model-based inundation map for the Siletz Bay area of Lincoln City; it also will integrate tsunami inundation with other CSZ earthquake hazards, such as ground shaking, liquefaction, subsidence, and landslides. Several other communities on the Oregon coast have developed evacuation plans and routes using inundation maps based on paleotsunami data from the geologic record (e.g., Cannon Beach, Oregon). But most of the vulnerable coastal communities, if they have a strategy at all, base tsunami evacuation plans on the general concept "go to high ground." Of course, the question for the people who live, work, or attend schools in these vulnerable areas is "how high is high?" Without answers to these and similar questions, credibility suffers and educational efforts are less clear and effective. More important, lives are put at risk.

Tsunami inundation modeling, then, is important for the distant-generated tsunami, but absolutely critical for the locally generated event. For the former, emergency responders need to know what areas should be evacuated under what situations well in advance so they can initiate an orderly evacuation. In the latter case, however, every person needs to know beforehand "how high high is" and what the fastest and safest routes to high ground are. There will be little or no time for coordinated emergency response and evacuation. Self-reliance and knowledge will have primacy. Good tsunami inundation maps for local population centers are thus a prerequisite for effective tsunami education and readiness.

Importance of the Tsunami Warning System to Education

In contrast to the above, the traditional tsunami warning system has more relevance to the distant-generated tsunami hazard, simply because there is usually sufficient advance warning associated with longer tsunami wave travel time. It was noted earlier that for a locally generated event, the best "warning message" is the strong ground motion felt in the area of the tsunami-generating earthquake. In such cases, formal warning messages may arrive too late or not at all because of earthquake damage to communication equipment and networks.

The October 4, 1994 Kuril Islands subduction zone earthquake (M8.2) provided an excellent pre-workshop "test" of the Pacific-wide tsunami warning system, illustrating both its strengths and weaknesses. In a retrospect, NOAA concluded that a tsunami warning should *not* have been issued for the west coast of the U.S., given the very small water level changes being recorded at tide gauge stations much closer to the source. Further, once the message was disseminated, its interpretation for the public left much to be desired. Upon hearing the news through local media, thousands of

visitors from inland population centers in Oregon converged on the coast (and beaches) to "watch" the event, clogging community evacuation routes and causing general disorder. TV and other media were among them. Luckily, the tsunami did not materialize and the warning was canceled. If it had materialized, however, perhaps hundreds of tsunami watchers and local residents attempting to evacuate might have been killed. In northern California communities, NWAS messages apparently were not received by the local emergency officials, resulting in widely varying responses. Officials in Del Norte, Humboldt, and Mendocino Counties were frustrated by both the lack of timely information and evaluation of information that was available. In a series of post-event interviews conducted by FEMA, it was clear that local communities throughout the Pacific Northwest received a variety of messages and interpreted them differently. Interpretations of tsunami warnings by commercial television and radio (the principal tsunami warning information source for the general public and even for some emergency managers) are particularly problematic, sometimes sensationalized, and sometimes ridiculed, especially when a potential tsunami does not materialize. Clearly, the media are a critical audience for education and an important ally in meeting broader public education challenges. For example, even when tsunamis are nondamaging, but waves have been recorded, the media should report on this "nondestructive event" in such a way as to promote awareness and respect for the hazard.

Tsunami Education Needs and Recommendations

Major cities, smaller communities, coastal industry, ports and harbors, and other infrastructures on the U.S. west coast are increasingly vulnerable to potentially destructive distant- and locally generated tsunamis. Broad-based public education is one of the most effective means for reducing risks of loss of both life and property at risk of this hazard. In addition to the public, the media and emergency responders are key audiences for such education. Reliable mapping of areas that might be affected by tsunamis is another prerequisite to meaningful education, as are clear and easily interpreted warning messages.

Needs and recommendations for developing and implementing an effective tsunami hazard education program are outlined below, but not necessarily in priority order. Although the focus of the recommendations is on tsunamis, workshop participants stress that these recommendations are but one component of an all-hazards education program. Because tsunamis are most often generated by earthquakes and because tsunamis generated in the vicinity of the earthquake are the most dangerous, it is particularly important to simultaneously educate all audiences about other seismic hazards and ways to minimize their total vulnerability.

NEED: The type of information exchange started at this workshop, involving individuals from throughout the region, from all governmental levels and functions related to tsunamis, from the private sector, and from the education establishment needs to be sustained if there is any hope of gaining support for and implementing the recommendations outlined here.

Recommended Actions

1. A Cascadia Earthquake-Tsunami Information Network (CETIN) is hereby established to promote communication among agencies and organizations interested in education about tsunamis and coastal earthquake hazards, and ultimately, to promote public education for effective tsunami preparedness, information sharing, and new information and materials development. Educators, public and private educational institutions and organizations, and other interested individuals in the region (Oregon, Washington, northern California, and British Columbia, and partners with similar needs outside the region, e.g., in Alaska and Hawaii) should be included in the network.

2. Oregon Sea Grant should establish a CETIN internet discussion group to promote the kinds of interactions and information sharing that will be needed to foster the kind of education effort these recommendations anticipate. In the long term, examine the potential for the University of Washington Geophysics Lab's new Mosaic server for use in more sophisticated information exchange and education.

3. CETIN activities should support, complement, and promote communication among existing centers of expertise, rather than duplicate other efforts, such as FEMA's Cascadia earthquake consortium, the Pacific and Alaska Tsunami Warning Centers, the International Tsunami Information Center, and other public and private groups dealing with related subject matter.

NEED: Tsunami inundation mapping for coastal population centers, particularly in coastal Washington, Oregon, and northern California are needed as soon as possible to mount effective education programs, particularly for locally generated tsunamis.

Recommended Actions

4. Preliminary tsunami inundation maps should be produced for or by communities using a combination of techniques, including relatively simple inundation modeling methods (e.g., methods used in Hawaii to produce maps displayed in local phone directories), use of paleotsunami data to verify modeling, and other information. At least two scenarios (probable worst case distant- and locally generated events). This should be a collaborative effort between NOAA, the states, academia, and local governments.

5. In the longer term, more accurate mapping of tsunami inundation, runup height, and currents is needed, particularly in areas with growing population and active ports and harbors. This effort, which will require a greater investment of time and financial resources than the preliminary mapping, should be started as soon as possible and be a collaborative effort between NOAA, the states, and academia. However, other public education efforts should proceed posthaste and not await production of such maps.

NEED: Improvements in the content, dissemination, and interpretation of warnings issued by the Alaska and Pacific Tsunami Warning Centers are needed to ensure the public and emergency responders are receiving sufficient information for informed decision making.

Recommended Actions

6. NOAA should reevaluate the content of tsunami warnings in light of the fact that many receivers (responders, media, etc.) of such information are ill equipped to interpret them accurately. Once this is accomplished, a broad-based education program for emergency responders and especially media should be undertaken.

7. NOAA and/or states should establish single-point tsunami expert contacts for emergency responders and decision makers, and for media requiring clear interpretations of tsunami warnings and related information. Alternatively or in addition, media should have a list of other tsunami experts that they could call before, during, or after an event. Interpretive materials about tsunamis and tsunami warning messages should be prepared for all users.

NEED: Potential users of tsunami education materials, such as brochures, videos, and curricula, are not always aware of existing materials that could be directly used or adapted for local use. Also evident at the workshop was that there are few, if any, high quality materials that deal directly with tsunami threats in the Cascadia region. Needed is more regional and local information covering such topics as tsunami evacuation routes, areas deemed "safe" from catastrophic hazards, availability of local emergency services, and location of food and water supplies. Whereas most general information deals with preparing for a catastrophic event, regional and local information is vital for the time during and immediately after just such an event.

Recommended Actions

8. Existing tsunami (and earthquake) education materials should be identified, collected, cataloged, and disseminated to all potential users. One means for doing this would be to develop an annotated bibliography of existing materials divided into categories by audience, type of media, purpose, and availability. At the international level, the International Tsunami Information Center in Honolulu serves this function and has a good deal of existing material; however, regional and/or state clearinghouses are also needed and should be established in the Puget Sound area, the Washington outer coast, on the Oregon Coast (e.g., at the OSU Hatfield Marine Science Center), and in northern California (e.g., at the Humboldt Earthquake Education Center). Availability of this information should be disseminated to educators and others in the Cascadia region through a cooperative effort of these centers.

9. Identify outstanding tsunami (and earthquake) educational materials and approaches from other areas. Tailor the material to specific audiences, learning styles, educational levels, and geographic areas of the Cascadia region. However, prior to major financial investments in education materials, regional needs should be assessed to ensure that proposed tsunami education materials are going to be well accepted. The needs surveys conducted by the Oregon Department of Geology and Mineral Industries and the Humboldt Earthquake Education Center are a beginning and should be expanded to the entire region. Personal interviews or participation in meetings of various audience groups might be an additional means of needs assessment.

   The following are examples of potential tsunami (and earthquake) education materials identified at the workshop:

   a. A video production on what is known about the seismicity of the CSZ and the potential for large earthquakes and tsunamis. Improved earthquake and tsunami awareness would be the goal of such a production. The video should also be supported with related publications that education program participants can take home with them or that can be used for teaching in schools. *Oregon, Washington, and California Sea Grant programs volunteered to take the lead on such a project in collaboration with the NOAA, the FEMA Cascadia earthquake consortia, and other interested parties.*

   b. Video productions dealing with earthquake and tsunami preparedness and response, applicable regionally. Local educational materials on these topics might better be based on less expensive media, such as slides and associated narratives that can be more easily adapted.

c. In collaboration with FEMA's Cascadia earthquake consortia, a "speakers bureau" should be established with regional experts on earthquake and tsunami hazards, techniques for reducing hazards in the home or office, preparing emergency kits, responding to disasters, and communicating after a disaster.

d. Media packets on tsunami hazards, interpretation of tsunami warnings, expert contacts for interpretation of tsunami information, etc., that radio, television, print, and other media could use.

e. Public service announcements for radio and television.

f. Model response plans for distant- and locally generated tsunamis should be developed for typical facilities, such as ports, industries, and small cities. Such plans could be used as the basis of education programs to tailor such plans to specific entities.

g. A telephone book information section on earthquakes and tsunamis should be developed for the Cascadia region, tailored to individual areas. As inundation and evacuation maps become available, they should be included in telephone books.

10. Universal tsunami hazard zone and evacuation route signs should be developed and used throughout the Cascadia region (and perhaps in other areas as well, such as Alaska, Hawaii, and other Pacific Basin areas). Prototype signs developed and currently accepted for use in Oregon and Washington should be used as a starting point for regional discussions.

11. A tsunami education materials quality assurance function should be established and implemented in the region, perhaps using a peer review process coordinated by CETIN or FEMA's Cascadia earthquake consortium.

12. Special efforts should be aimed at teacher training and school programs, including hands-on science projects. Possible funding sources include the National Science Foundation, Eisenhower funds, and other sources.

13. Local and regional museums, such as the Oregon Museum of Science and Industry (OMSI), and develop, maintain, and circulate displays and exhibits on earthquake and tsunami awareness and preparedness. OMSI's "Nature's Fury" exhibit on loan to Honolulu's Bishop Museum is an excellent example.

APPENDICES

A. Participants in the October 26–27, 1994 Tsunami Education Workshop
B. Final Agenda: Tsunami Education Workshop, October 26–27, 1994, Newport, Oregon
C. Tsunami Education Activities: NOAA and ITIC
D. The Alaska Tsunami Warning Center
E. History of the Cascadia Subduction Zone Working Group (FEMA)
F. Washington State Tsunami Education Activities and Needs
G. Oregon Tsunami Education Activities and Needs
H. California Tsunami Education Activities and Needs

APPENDIX A

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APPENDIX B

Final Agenda
Tsunami Education Workshop

OSU Hatfield Marine Science Center
Library Seminar Room
Newport, Oregon

WORKSHOP OBJECTIVES

to develop a long range action plan for tsunami hazard education in the Cascadia region (northern California, Oregon, Washington, British Columbia)

to identify both regional and local education needs, leadership and institutional responsibilities, and potential financial resources

to share existing tsunami education resources and materials for possible use or adaptation

to establish an earthquake-tsunami education network for continued collaboration

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DAY 1: Wednesday, October 26, 1994

0800 Car pool from the Whaler Motel to HMSC (out-of-town participants who arrived the evening of October 25)

0815 Coffee, tea, juice (HMSC)

0900 Introductions and goals (Jim Good, OSU Sea Grant; Dennis Sigrist, International Tsunami Information Center; Tom Sokolowski, Alaska Tsunami Warning Center)

0915 Context for the Tsunami Education Workshop: the NOAA Tsunami Initiative (Eddie Bernard, NOAA/PMEL)

0930 Setting the stage: A scenario for a CSZ earthquake and tsunami (George Priest, Oregon Department of Geology and Mineral Industries; Tom Sokolowski)

1000 International/Federal Panel Presentations/Discussion

A – What tsunami education programs, activities, and materials are in place?

B – What more do we need to do in the Cascadia region?

- FEMA (Chris Jonientz-Trisler, FEMA—Seattle) (30 minutes)

— BREAK —

- NOAA (Dennis Sigrist, Tom Sokolowski) (1 hour)
- BRITISH COLUMBIA (Fred Stephenson-Institute of Ocean Sciences) (30 min)

1215 — BOX LUNCH – CLASSROOM 30 —

1330 State Panel Presentations/Discussion

(same questions as above – A & B)

- WASHINGTON (Bob Goodwin, Washington Sea Grant) (30 min)
- OREGON (Jim Good) (30 min)
- CALIFORNIA (Susan McBride, University of California Sea Grant) (30 min)

1530 Wrap-up Discussion and Preparations for DAY 2 (Jim Good, Dennis Sigrist, Tom Sokolowski)

1600 Hatfield Marine Science Center Seminar: "Numerical modeling and tsunami preparedness: Any Relationship?" Antonio Baptista, Oregon Graduate Institute
Workshop participants are invited to stay and attend this specially-arranged seminar (abstract on back of agenda)

1900 Group Dinner Extravaganza: Sylvia Beach Hotel, 267 NW Cliff St. (walking distance from the Whaler Motel; from U.S. 101 turn west toward ocean on Olive by Bank of America, 6 blocks, last street on left is Cliff, take right and go to end of street...hotel is 3-story dark green bldg with red roof and cream trim)

DAY 2: Thursday, October 27, 1994

0800 Car pool from the Whaler Motel to HMSC (out-of-town participants)

0815 Coffee, tea, juice (HMSC)

0900 Introduction to DAY 2 (Good)

0910 Tsunami Warning Systems: Improvements Needed? (Panel and discussion)

Panelists: Eddie Bernard, Tom Sokolowski, Tom Ainsworth

Workshop Participants: the rest of us
- *How does the tsunami warning system work today?*
- *How should the system work and what is needed to effect those changes?*

1015 — BREAK —

1030 Tsunami Education Needs: Brainstorming and Priority Setting
(Information from our first day will be the starting point for our discussions, led by a facilitator)

Issues to be addressed:

a. Key audiences for tsunami education?

b. Region-wide education needs and/or materials? (things that the federal government might provide or sponsor)

c. Needs for specific localities (individual states or local areas)?

d. How do a–c translate into specific initiatives and projects or conversely, how do projects you want to do fit into the perceived needs?

e. What institutional mechanisms and financial resources might be available to do specific projects or undertake particular initiatives?

f. How might a "Cascadia Earthquake-Tsunami Education Network" function and what might its role be?

1215 — BUFFET LUNCH – CLASSROOM 30 —

1330 Reconvene (continue facilitated session, set priorities)

1500 Workshop Wrap-up (Bernard *et al.*)

1530 Concluding Field Excursion: Paleotsunami deposits in Yaquina Bay (Curt Peterson, Portland State University)
(Curt will lead a field trip; at this time, we plan to visit an across-the-bay site, so we'll be using the vans to take people over across the bridge...for people heading north or west, we can caravan, make the field stop, and then you can continue on your way)

1730 Adjourn

HMSC Seminar

"Numerical modeling and tsunami preparedness: Any Relationship?"

by

Dr. Antonio Baptista
Center for Coastal and Land-Margin Research
Oregon Graduate Institute of Science & Technology

4:00 p.m. Wednesday, October 26, 1994
HMSC Library Seminar Room

Abstract

"I live in [Oregon/Washington coastal town], on [street name], just across [supermarket name or similar]. Am I safe from the big tsunami that they are talking about??" Questions such as this are increasingly posed to researchers and to state and federal agencies. Answers are typically ambiguous, reflecting in part the random nature of tsunamis, but reflecting also the limitations of the current understanding of the possible impact of a Cascadia Subduction Zone event.

Significant expectations are increasingly attached to numerical modeling as a tool to improve tsunami education and preparedness. Are these expectations well founded? The answer is yes, but the expectation level needs to be clarified.

In this seminar we will review our current research on tsunamis in Nicaragua, Japan, and the Pacific Northwest, and will use such research as a basis for a systematic (but necessarily subjective) discussion of the information that numerical models should and should not be expected to provide, and how that information relates to tsunami preparedness.

APPENDIX C

Tsunami Education Activities NOAA and ITIC

DENNIS SIGRIST
ITIC, Honolulu, Hawaii

Introduction

The International Tsunami Information Center's (ITIC) involvement in tsunami awareness and education activities has been continuous since its inception in 1965. ITIC's extensive mission is to reduce the risk to lives and property in Member States (participating foreign countries) whose coastal areas are threatened by tsunamis, and to carry out this role by recommending improvements to the Tsunami Warning System; by promoting regional cooperation between Member States; by contributing to the scientific and technical training of tsunami experts, and the education of the general public in tsunami awareness; by encouraging the development of improved instrumentation and communication systems; by ensuring the exchange of information between participating countries as well as international and scientific organizations, and by offering assistance to the national and regional needs of Member States.

ITIC, located in Honolulu, Hawaii, is staffed by the Director, Associate Director (vacant, to be filled January 1995), support assistant and, on occasion, visiting scientific experts. Support for ITIC's day-to-day operation is generously provided by the Pacific Region Headquarters, National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA). Funding for specific ITIC tasks in support of the Member States is provided by the Intergovernmental Oceanographic Commission (IOC). In recent years, much of ITIC's mission is directed in support of public education and awareness activities. This has been due largely to reduced financial support and that education-related activities give the broadest opportunity to reach the user community. For example, the brochure *"Tsunami: The Great Wave"* was completely rewritten and published in May 1994 with financial support provided by National Weather Service Headquarters. Working in co-operation with the international community and with funding and technical support provided by the IOC and ITIC, Chile developed a series of four tsunami text books for students from pre-school through high school.

ITIC and the International Tsunami Warning System

Nearly 30 years ago, IOC, a part of the United Nations Educational, Scientific and Cultural Organization (UNESCO), accepted the offer of the United States to undertake the expansion of its existing Tsunami Warning Center in Honolulu to become the headquarters of the Pacific Tsunami Warning System. IOC also accepted the offer of other Member States to integrate their existing facilities and communications into this International Tsunami Warning System in the Pacific. At a

meeting in Honolulu, Hawaii, in 1965, an agreement was reached and the IOC established ITIC and the International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU).

The ICG/ITSU was established as a subsidiary body of IOC meeting every 2 years at a Member State to coordinate and review the activities of the Tsunami Warning System in the Pacific. Since 1965, and with IOC support, the Tsunami Warning System integrated with other regional tsunami warning systems, has become the nucleus of a truly international network. Twenty-six nations are now members of ICG/ITSU. Several non-member states maintain seismic and water level monitoring stations. The system makes use of numerous seismic stations, tidal stations and dissemination points scattered across the Pacific under the varying control of the Member States of ITSU.

Tsunami Education Activities, International

At the recent meeting of the ICG/ITSU (session XIV in Tokyo, Japan, September 1993), Chile reported on the development of a series of earthquake and tsunami text books for students and instructional materials for teachers. Not only do these books cover an awareness and preparedness theme, they discuss tsunami generation and propagation, basic seismology and local emergency planning. Teaching with the help of these books has already been implemented in coastal school districts in Chile where the books have been endorsed by the national education authority. The ICG/ITSU plans to publish the text books developed by Chile in other languages; the text is being reviewed for translation and publication to English. ITIC will make copies of the materials available to Member States and other interested parties upon request.

As part of the ICG/ITSU-XIV recommendation, ITIC collects tsunami educational materials in various media types which could be used as primary or supplemental materials for tsunami awareness programs. Video tapes depicting actual tsunamis and subsequent damage, pamphlets and brochures are made available as resource material for interested users. ITIC also maintains an extensive reference library on tsunamis that is frequently used by researchers, educators and the media.

The ICG/ITSU has an ongoing mandate to pursue an aggressive tsunami education strategy for the benefit of all people exposed to the tsunami hazard. This is accomplished through the ad hoc Working Group on Education that recommends methodologies and communication techniques to distribute tsunami awareness materials to reach a wide cross-section of people, taking into account cultural, financial and technological differences, funding limitations and the need for flexibility. Country-specific tsunami educational activities within each Member State of the ICG/ITSU can provide a wealth of diversity for any interested user(s). Inquiries can be directed to the National Contact of the Member State(s) or ITIC.

Tsunami Education Activities, Domestic US

The tsunami education effort in the US is largely an independent affair shared amongst the Federal government, states and local authorities with some to little coordination. There appears to be no national coordination authority for consistency of products, warning icons and signs, and methodologies.

Hawaii and Alaska, most recently ravaged by tsunamis in 1960 and 1964, have highly visible programs for tsunami awareness. The island-by-island telephone directories in Hawaii have depicted tsunami evacuation zones for years. An island-wide siren system to provide notification of tsunami warnings is tested on a monthly basis. Hawaii State and local Civil Defense authorities routinely conduct tsunami exercises to test the responsiveness of the warning and notification systems. With ITIC's location in Hawaii, there is frequent opportunity to interact with Civil Defense authorities and the State Department of Education to foster tsunami education activities. During the 1993/94 school year, ITIC and representatives from the University of Hawaii and the Pacific Tsunami Warning Center conducted a series of tsunami education workshops for fifth grade teachers. These workshops provide a basic review of tsunamis and the tsunami threat to Hawaii as well as educational materials that the teachers, in turn, present in their classrooms. It is expected the tsunami workshops will continue during the 1994/95 school year.

The majority of NOAA's tsunami education programs are conducted through the NWS which has the responsibility for the US national tsunami warning program. On the regional level, headquarters offices in Salt Lake City, Honolulu and Anchorage and associated coastal field offices coordinate a variety of tsunami educational efforts. The Alaska and Pacific Tsunami Warning Centers have provided tsunami education through facility tours, field visits and interviews with the media for years. The National Headquarters of the NWS, in Silver Spring, MD, provides financial support for travel and brochures to bring workshops and the tsunami message to local coastal communities. Funding constraints limit the scope of the programs from the number and frequency of workshops to quantity of brochures and pamphlets made available for distribution. Other NOAA offices, such as the National Ocean Service's Pacific Operations Group and the Pacific Marine Environmental Laboratory are available to assist with tsunami education planning and presentations but do not have structured programs themselves.

Tsunami Education Activities, Cascadia Region

As an existing information resource for domestic as well as international tsunami education materials, ITIC would be pleased to provide examples, develop strategies, and actively assist in education programs for users in the Cascadia Region. Examples of existing resources were discussed in the two previous sections.

An example of an integrated, hazard awareness education media tool was developed by Hawaii's Coastal Zone Management Program. The CZMP office produced an excellent 30-minute video that not only covers tsunami awareness but includes earthquake, hurricane, storm surge, etc.

hazards in the Hawaiian Islands. Also, two excellent brochures developed in cooperation with the National Weather Service (Alaska Tsunami Warning Center) and the Alaska Division of Emergency Services (*Tsunami: the Great Waves in Alaska and the West Coast*) could be easily adapted to a Cascadia Region tsunami event.

What's in the Future

The success of tsunami education and preparedness programs is ultimately dependent on local community involvement, by designing programs and educating the local citizens recognizing the specific and special needs of each individual community. ITIC supports this effort by making tsunami information resource and preparedness materials available for use in education programs. Coordination at the regional and state level, with guidance provided by national authorities, is equally important and ensures community programs will share a level of consistency in conformance with established warning dissemination and evacuation standards.

Japan, through their national television network (NHK) has produced a number of educational tsunami videos that document the devastating 1983 and 1993 Sea of Japan tsunamis. ITIC has widely distributed copies of these videos to users around the Pacific Basin. It is recommended the U.S. develop its own high quality, 15-minute video that documents the tsunami hazard and provides safety information to mitigate future tsunami fatalities. ITIC can provide research and presentation material for the video.

The color brochure *Tsunami: The Great Waves* was completely re-written and published earlier this year. Receiving wide distribution to a variety of users around the US, the brochure's purpose is to increase awareness and knowledge of tsunamis. Unfortunately, the initial printing of 10,000 copies is nearly depleted due to the overwhelming demand for tsunami education materials. A partnership with state and local governments is suggested to assist in future printings, lowering the per unit cost of the brochure. The brochure can be easily modified to incorporate the particular needs of a certain locality or region. A supplemental tsunami guide for children (full-color booklet and school workbook) was produced by ITIC in 1993. A very limited number of these publications remain in stock.

ITIC publishes the Tsunami Newsletter on a semi-annual basis. The Newsletter brings tsunami news to researchers, educators, government officials and public users throughout the world. A U.S. national Tsunami Education Newsletter may provide the forum to discuss tsunami education and awareness activities in the U.S. And, with the global availability to Internet, an electronic Tsunami Education Bulletin Board will provide quick access to education activities in many areas. These suggestions are not particularly expensive to implement but require a focal point or lead agency to coordinate the development and delivery.

APPENDIX D

The Alaska Tsunami Warning Center

THOMAS J. SOKOLOWSKI
NOAA, National Weather Service, Palmer, Alaska

Overview

The preliminary mission of the Alaska Tsunami Warning Center is to provide timely tsunami watches and warnings for Alaska, California, Oregon, Washington, and British Columbia in Canada, for potentially tsunamigenic earthquakes that occur in those regions. Tsunami warnings and other critical information are immediately disseminated to emergency offices in each of these areas, plus others such as Federal Emergency Management Agency, U.S. Coast Guard, Pacific Tsunami Warning Center in Hawaii, media, and many other recipients including both state and federal disaster preparedness agencies. Although numerous world-wide earthquakes are automatically detected and processed each day, only a small number of these earthquakes are released to officials and the public.

This service is provided on a 24-hour basis, for each day of the year, by two duty personnel. During those times that the Center is not staffed, the duty personnel are in a paid standby duty status, which requires that they respond to the Center within 5 minutes after being alerted that a significant earthquake has occurred. To ensure a rapid response to earthquakes occurring at night, weekends, or holidays, all personnel are required to live within 5 minutes travel time to the Center. They are notified of the occurrence of an earthquake, or irregularities in the Center's operations, by a radio-alarm system which is linked to a computer system. Tsunami warnings and other critical information are typically disseminated within about 12 minutes from the origin time of an earthquake. In addition to the above mission, the ATWC personnel process and disseminate collected data, maintain the current system, participate in fulfilling interagency cooperative agreements, create and implement software, develop equipment, and, conduct applied research development to improve the present system. We do not have funding for contract work.

The ATWC continues to improve its operations by developing and implementing an expert system which starts with the detection of a tsunami hazard and culminates in providing intended users with the degree of threat to mitigate this hazard. This system is expected to (1) automatically detect and analyze seismic data in real-time (2) immediately disseminate critical earthquake and tsunami information in near real-time (3) automatically detect and analyze tsunamis in real-time for near real-time from tidal data (4) rapidly discriminate tsunamigenic from non-tsunamigenic earthquakes and (5) reasonably determine estimates of probable tsunami wave heights and areas of inundation in the path of a tsunami. Neither 4 nor 5 can be accurately done with the present seismic data, which are accumulated at the Center. A network of broadband data are necessary for source mechanism studies and for input to tsunami models.

During the past decade, numerous changes have taken place in areas such as operational concepts and procedures—especially in response to emergency situations; micro computer concepts, computers, peripherals and associated equipment, seismic and tide networks, applied research developments, and communications for disseminating critical information. The integration of micro computers and applied research developments have already made a considerable improvement in performing ATWC's missions. Due to the accomplishments in (1) and (2) above, the average response time to issue a warning has been reduced by more than 50%. In addition to timeliness, procedures have been considerably simplified and standardized.

In earthquake processing, local, regional, and world-wide earthquake parameters are automatically computed and sized (mb, M1) within seconds after receiving appropriate data at real-time seismic sites distributed throughout Alaska and the lower 49 states. The automatic determination of an earthquake's parameters, plus the resident historical data bases, have enhanced the quality and quantity of resulting information disseminated to the TWS recipients. Long-period seismic instruments have been established at strategic coastal locations in Alaska to decrease the response time in computing magnitudes. The real-time data are automatically sized (MS), cycle by cycle, by the computer. Earthquake parameters are immediately available at the Center and/or transmitted by a computer and the radio-alarm system to the ATWC staff for an immediate response. As funding becomes available for additional micro computers and broadband equipment, enhancements to the ATWC system would include source mechanisms, moment magnitudes, and synthesizing earthquake signatures for determining potential tsunamigenesis.

Tsunami modeling and tide height determinations during expected time of arrivals of tsunamis at different locations are continuing efforts at the ATWC. In-house development is coupled with the transfer of scientific techniques and methods developed by other scientists for appropriate application to the ATWC requirements. The current and future modeling efforts use many of the past tsunamigenic earthquakes in duplicating their effects. The minimum expectations in this area include maximum predictive wave heights, or ranges, was currents and inundation zones for different locations in ATWC's areas of responsibilities. Actual tide heights during expected tsunami arrivals at different locations will be available to many areas from Alaska through southern California. The application of these results, along with others, will serve as valuable input for future artificial intelligence for determining a degree of threat.

Tidal data continue to be accessed in real-time from sites in Alaska. Tidal data are accessed and analyzed via micro computer(s) in near real-time from Canada and the U.S. West Coast. New NOS tide equipment, and communications via new circuits, satellite, and micro computers will be used in the near future to access and analyze Pacific tidal data in real-time and near real-time. Detection of tsunamis and dissemination of this critical information to intended recipients can be accomplished in the future. A new satellite system ground station was established at the Center which enhances the ATWC's capabilities to immediately disseminate critical information to numerous areas. This complements the present high speed teletypewriter system.

Getting the public to respond to critical earthquake/tsunami information is a vital part of the ATWC efforts and necessitates a continued educational community preparedness program. This program covers selected areas in large geographical areas, and in cooperation with other agencies and hazard officials. All staff members participate in this important part of the ATWC.

The ATWC maintains historical tsunami and earthquake data bases that were obtained from the National Geophysical Data Center and from the National Earthquake Information Center. The tsunami data base is used during all warnings to determine past hazard occurrences in and about an earthquake source to facilitate decision-making. The earthquake data base contains more than 7000 earthquakes of magnitude 6.0 or greater that have occurred in the Pacific Basin. The earthquake data base is cross referenced to the tsunami data base, which contains more than 1100 historical tsunamis that have occurred in the Pacific Basin. The historical earthquake and tsunami data bases are important for future models and during tsunami warnings.

The integration of micro computers with in-house and cooperative technique developments is critical to improving the tsunami warning services. Six micro computers communicate with each other via a local area network (LAN) to perform their various functions. Future micro computer(s) can be added to the LAN system to perform tasks as they evolve in the reactive or predictive parts of an operational system. This could also eliminate problems that result from an intensity of computations, input/output requirements, or interfacing equipment. The micro systems can communicate with each other using a LAN system, or function independently, to perform both operational and administrative tasks. Several functions are duplicated due to the critical nature of the task, or to facilitate personnel duties and research development. The future micro computers are expected to be upgraded periodically. Already this system has had a good effect on the ATWC's operations by being cost effective, providing a vehicle for task growth, maximizing aid for personnel, minimizing procedural responses in emergency situations, and permitting more effective use of personnel and their assigned development tasks. More information about the ATWC can be obtained from the list of references below.

Suggestions to Mitigate Tsunami Hazards

- Expand the existing community preparedness programs as a key critical part of mitigating the tsunami hazard in short-fuse situations. Community preparedness (CP) is the most effective way to mitigate the tsunami hazard for those who are caught in the immediate vicinity of a violent earthquake and subsequent tsunami. The closer one is to the source of a tsunamigenic earthquake, the less effective a warning will be due to the time required to initiate a warning plus the time to disseminate it to coastal residents by local officials. This is true for all tsunami warning centers, whether they be in Alaska, or extremely populated coastal areas such as Japan, the Kalapana area in Hawaii, California, etc. CP is also the most effective in areas known to experience shaking that results in the generation of slide/slump tsunamis within minutes after the shaking starts. Intense shaking is a natural warning, similar to the natural warning from a recession of water for an unusual distance from the shoreline.

- Conduct periodic system reviews to satisfy user needs. Establish an independent review committee of users (i.e. emergency officials from Alaska, Hawaii, Washington, Oregon,

California, and FEMA) to review existing tsunami warning centers (ATWC and PTWC) to determine present capabilities and future needs, and provide recommendations to improve the Centers and TWS. Emergency officials from Alaska, Hawaii, Washington, Oregon, California and FEMA should be core members with ad hoc members as needed.

- Integrate technology with emergency officials by taking into account site specific problems and their limitations.

- Integrate emergency officials who have community preparedness and other emergency responsibilities in all coordination and special meetings concerning TWS problems—especially for short fuse situations. Re-establish combined meetings of emergency officials, interagency personnel who participate in the TWS, researchers, and others as attendees at the TWS meetings.

- Re-define the Tsunami Warning System coordination meetings to include problem discussions among emergency officials, researchers, warning center personnel, NWS, and other participating agencies.

- All emergency officials should have access to existing communication systems, such as NOAA Weather wire Service, to receive immediate tsunami/earthquake information from both Centers.

- Provide coastal communities with expected wave heights or inundation levels for both teleseismic and local tsunamis.

- Provide emergency officials with historical tsunami data (software and database) for their area. The data can be retrieved for an impacted area from tsunamis throughout the Pacific Basin.

- Replace Center's existing seismic network with broadband seismometers and base tsunami warnings on moment magnitude (Mw) instead of surface-wave magnitude (Ms).

- Increase data coverage on the west coast to speed up parameter determinations, especially Mw magnitude. Circuits or NEIC data.

- Center's Funding: Increase funding $100K/year/Center to improve and enhance the present warning centers by transferring technology from research to applications. (Aya examples, Monterrey tide sites, glacier bays, Kanamori's work, ocean tide sites, etc.)

- Transmit future tsunami gage data to the ATWC & PTWC via GOES with standard NOS format for immediate evaluation and dissemination.

- Support research to determine immediately tsunamigenic earthquakes from non-tsunamigenic ones based on the seismic parameters.

- Support prediction of tsunami wave heights, currents, etc. away from the source zone based on earthquake source parameters and a near-source tide gage recording(s).

A caveat concerns the social and economic impact. Although I am attempting to define clearly a strategy for risk evaluation for which clear definitions are not always possible, there is always a built-in uncertainty of social and economic impact which must be considered. As stated by Adams (1988), "The cost to the State of Hawaii for the warning of 7 May 1986 is estimated at about 30 million dollars. Ultimately, the public's loss of confidence in the warning system will prove even

more expensive." A warning and subsequent evacuations are real and serious which affect credibility and future responses to dangerous tsunamigenic earthquakes. The potential danger inherent in any evacuation plus the damage to the warning Center's credibility may affect how the public views future warnings for great and dangerous tsunamigenic earthquakes.

Questions: Mitigating Tsunami Hazards

General questions

- Cascadia recurrence rate (300–1000 years)?
- Cost effectiveness of method, system?
- Time to respond before onset of tsunami?
- False alarm rate–(storm surges, communications failure, smaller quakes that trip alarms based upon acceleration levels, etc.)

Instrumentation: Tide–Seismic Sensors

- What kind of instruments (seismic, tide)?
- Geographical placement (every 50, 100 miles, etc.)?
- Will local communications survive in the epicentral area?
- Will land-based satellite dishes/systems survive in epicentral area?
- Will seismic and/or tide gauges survive in epicentral area?
- Will buoy systems survive in epicentral area?

Tide-Tsunami Instrument Testing

- Sensitivity of device and area of coverage?
- Ever tested in any epicentral area–results?
- Ever tested in any moderate or large earthquake and/or tsunami–results?
- Any quality control results available on instruments–hits, misses?
- Is there redundant routing and interpretation of data and/or information to warned areas?

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APPENDIX E

History of the Cascadia Subduction Zone (CSZ) Working Group

CHRIS JONIENTZ-TRISLER and JEANETTE BERRY
FEMA Region 10, Bothell, Washington

In 1992, one workshop with approximately 40 participants representing a variety of interests and agencies at all levels of government along the Cascadia Subduction Zone (Canada to California) occurred. Acknowledgment of the need for a regional organization to address Pacific Northwest earthquake issues occurred and general discussion on specific agency needs related to these issues began. Following the meeting, a questionnaire was developed and sent to all participants and additional agency representatives that had been suggested during the meeting. We received 26 responses from 20 different agencies. These responses were compiled into 50 pages, and "boiled down" to 20 pages.

In 1993, this compilation was made available to a core group representing British Columbia, Washington, Oregon, California, FEMA, Emergency Preparedness Canada, USGS, and NOAA. Most of the core group was available for a conference call discussion centered around the compilation of data. During the call, it was suggested that FEMA submit a Draft Concept Paper on the CSZ international, multistate and province working group regarding its possible organization and priority issues, and ideas drawn from the data compilation.

That paper is presently being developed to construct a vision for the desired regional effort. This vision should cover the next couple of years, deal with priority issues, and also sketch a longer term vision to address other needs that require a longer time period to accomplish. However, a need for more focused input has been identified prior to its compilation. A plan to address this began to take shape in May of 1994 when materials and participants for a workshop to address this need began to be identified and developed by core group members. It will take place in January or February 1995.

The workshop theme is "Finding the Weak Link—The Fragmentation of the Region during a CSZ event," and will better define the regional impacts of a Cascadia event. It will also propose a regional framework for addressing pre-event strategies of mitigation, make the impact visible to influential government and industry participants, and ask for commitment and input to a regional strategy from them. This workshop will involve three main groups of high level participants from lifelines, government, and industry chosen to represent the whole region in some mix. This group will define how the region can be fragmented during a subduction zone event and will develop a vision that will deal with priority issues. The vision, along with several papers received earlier and the 1993 responses, will help formalize a framework to coordinate present and future CSZ players, resources and activities. The framework will be the formal structure for a multistate and province

consortium which has existed since 1992 in a much more informal makeup until we had enough of a blueprint to proceed to build.

According to questionnaire responses and many discussions with various players, CSZ is desired to be an effective "retrofitter" of existing "bridges" of CSZ information and a builder of new ones. The new "bridges" are needed to link the many separately existing islands of expertise into a chain of islands that can be easily traversed by all CSZ communities and groups of players. None of the players are interested in or have resources to duplicate each other's efforts but wish to share experiences with their cross-border counterparts. Players can be any organization that has a reason (such as how natural hazards affect them economically, etc.) to buy into this vision. The strength of this approach is that when the Cascadia region takes action to prepare for and mitigate earthquake hazards, we effectively address issues related to other hazards spanning the region.

Cascadia Response to October 4, 1994 Kurile Islands Mw 8.3 Earthquake-Induced Tsunami Warning

A Mw 8.3 Kurile Islands tsunamigenic earthquake on October 4, 1994 triggered a Pacific-wide tsunami warning. The warning tested the information system and the state of tsunami readiness on the Cascadia coast. Responses varied.

Interviews were conducted using a survey questionnaire with province staff for three communities in British Columbia, Canada; with four communities in Washington; four communities in Oregon; and three communities in California. Community populations ranged from about 1,000 up to about 27,000. Elevation range was sea level to over 100 feet. Communities were located on ocean beaches, bays, inlets, and peninsulas.

Tsunami warning information was unclear and unusable to more than a third of communities, and updates were too slow for 71%. Almost 80% were in contact with neighbor communities, but about 30% had access to a local tsunami expert.

Vulnerability and readiness varied. Almost 80% have critical facilities at risk, and have city tsunami plans. Half of the communities had school tsunami plans. 70% have safe (high) places within a few minutes walking distance. Over a third have landslide hazards, and almost 80% have vulnerable bridges along their evacuation routes. Over half have tsunami warning sirens or fire sirens that would be used in tsunami notification. The average time estimate for safe evacuation was just over 2 hours, and ranged from 30 minutes to 6 hours. During peak tourist season, this estimate grew in some cases to a factor of 3 or 4 times more. (Some data for British Columbia communities was unknown as of this writing and will be further explored in the near future.)

On October 4, 90% of the communities' decision makers used wave height data from Hawaii to decide what level of response to make. 21% began city evacuation, 7% evacuated some facilities (not including port or Coast Guard facilities which responded according to their own authority), and 71% of the communities remained on standby status until the warning was canceled. Cancellation

occurred about 30 minutes before the wave was due on the West Coast when it would have been too late to evacuate for most communities.

Many communities feel the warning system needs improvement. Information should be made more timely and locally usable. Communication must flow two ways: 1) scientists must ask responders what kinds of information systems, formats, and tools they require for effective response, 2) and responders must ask scientists what limits exist for information and tools they are basing response decisions upon.

Vulnerability and readiness levels vary among communities. These communities have asked for such tools as local risk identification and expertise, training, and warning equipment.

Responses varied on October 4, 1994. A regional strategy should be developed to provide more consistency in Cascadia coastal communities, including such things as school tsunami plans and drills.

October 4 is a valuable learning exercise for distant tsunamis with several hours warning and for Cascadia tsunamis with immediate response required.

This is preliminary data. The community pool will be increased, county data will be added, and further verification and analysis is planned.

APPENDIX F

Tsunami Education Activities and Needs in Washington State

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Summary

Tsunami emergency management functions at the state level in Washington are housed in the Emergency Management Division of the Department of Community, Trade and Economic Development (DCTED), while geologists within the Department of Natural Resources' (WDNR) Geology and Earth Resources Division comprise the state's principal, in-house technical expertise on earthquakes. The State Seismologist, a faculty member of the University of Washington's Geophysics Department, operates under contract to the state out of the university's seismology lab, which also houses the Pacific Northwest Seismograph Network monitoring seismic events in Washingong and Oregon. While not involved directly in emergency management, the state Department of Ecology (WDOE) houses Washington's coastal management program and is responsible for oversight of local governments' shoreline planning activities, including wetlands and flood plain management. These agencies and institutions collaborate in a Cascadia earthquake consortium coordinated by the Region 10 Federal Emergency Management Agency (FEMA) office that has had some significant educational activity in Washington State recently. Finally, Washington Sea Grant Program Marine Advisory Services (WSGP MAS) conducts educational programming for coastal planners in local governments and provides advice and assistance to coastal communities through its field agents.

Prior to the Tsunami Education Workshop in Newport, Oregon, representatives of each of these entities were asked to provide Sea Grant with responses to the following questions:

1. Historically, what tsunami education activities has your agency undertaken?
2. What are the tsunami education needs that have not been met?

The principal input came from Susan Larson, Earthquake Coordinator, Emergency Management, DCTED. Additional information was gathered by phone from George Kaminsky, Shorelands and Coastal Zone Program, WDOE. Bill Steele, coordinator, UW Seismology Lab, attended the workshop and presented information about the education and outreach activities of the Lab.

[1] Summary compiled by Robert F. Goodwin, Washington Sea Grant MAS, from correspondence and telephone conversations prior to, and notes taken during, the Newport, Oregon workshop. Any errors are his alone.

Current Programs, Activities and Needs

DCTED

1. Education Activities

Prior to May 1993, little tsunami education was undertaken by the DCTED Emergency Management. Since hiring an earthquake preparedness coordinator, the division has funded compilation of a tsunami bibliography entitled: *Tsunamis on the Pacific Coast of Washington State and Adjacent Areas—An Annotated Bibliography and Directory*. This bibliography was compiled by Connie Manson, WDNR, in March 1994, and was sent to all Washington's coastal emergency management agencies and city and county planners. In addition to the bibliography, the earthquake coordinator developed a fact sheet entitled: *Tsunami Hazards on Washington's Coast* that was created for Washington's Earthquake Awareness Week in April 1994.

The earthquake coordinator is also in the process of developing a Washington-specific tsunami public education brochure that will be distributed through coastal emergency management agencies, state coastal parks and coastal rest stops.

In 1994 the Washington State Legislature awarded DCTED $650,000 to address the catastrophic earthquake threat. (Tsunamis were not specifically mentioned in the legislation, however.) With these funds the Emergency Management Division will hire a full time earthquake planner, a second full time public educator, four duty officers for round the clock response, funding for Earthquake Awareness Month activities to be held in April and funding for a Puget Sound 1995 earthquake exercise. The earthquake preparedness coordinator will continue to lend technical assistance and leadership.

Specific to tsunamis, the division will have four table-top exercises to address the tsunami threat and will update its internal tsunami response plan.

2. Unmet Needs

a) Standard Tsunami Signage: The division is interested in using the internationally recognized tsunami warning sign and a tsunami evacuation sign that could be placed along Washington's coast. The earthquake coordinator has received the artwork from Oregon's DOGAMI program and will be identifying state agency contacts at the Department of Transportation, Parks and Recreation Commission and WDNR to assist in making and installing the signs.

b) Brochure and Warning Signs: Funding is needed to print the tsunami brochure and the warning signs.

c) Regional Assistance Team: The division wants to establish a regional tsunami coastal planning/education support team to assist in local emergency managers' and planners' efforts directed to educating the public, media, businesses and government agencies about the threat from distant and local tsunamis.

UW Seismology Lab

1. Educational Activities

The state seismologist and lab coordinator have excellent media relations and the lab becomes the main focus of media attention whenever an earthquake or tsunami occurs anywhere in the world. Questions about science are answered by scientists from the UW geophysics program. The lab coordinator talks to K-12 school classes.

2. Unmet Needs

Outreach activities are bootstrapped due to funding limitations.

Cascadia Earthquake Consortium

1. Educational Activities

A tsunami workshop, hosted by Grays Harbor College, Aberdeen, was conducted in Long Beach, Washington for local planners, emergency managers and citizens at the request of local governments in the region. Participating were Steve Palmer and Connie Manson, WDNR; Curt Kyle, DCTED; Chris Jonientz-Trisler, FEMA; Brian Atwater, USGS; George Priest, OR DOGAMI; Antonio Baptista, Oregon Graduate Institute; Leonard Palmer, Portland State University; Al Aya, Cannon Beach Fire District; and Jim Phipps, Grays Harbor College (moderator).

At the request of a city commissioner, Grays Harbor College conducted a second workshop in Raymond, Washington during earthquake awareness week in April 1994.

2. Unmet Needs

The Long Beach peninsula, having little high ground throughout most of its length, is extremely vulnerable to locally generated tsunamis. Inundation maps are needed to plan evacuation routes and to advise property owners of the risk they face.

The October 4, 1994, Kuril Island distant tsunami warning and its interpretation resulted in some confusion on the Washington coast. Delayed follow-up to the first tsunami warning caused an information void. (Workshop notes suggested that better coordination mechanisms are needed between NWS duty meteorologist who receives tsunami warnings from NAWAS and the state earthquake coordinator in DCTED.)

WSGP MAS

1. Educational Activities

Earthquake/tsunami hazards was one of several coastal hazards topics featured at the January 20, 1994 winter meeting of the Shoreline/Coastal Planners Group in Olympia, Washington. This ad hoc group meets quarterly for information sharing and continuing professional development purposes. Brian Atwater, USGS, and Eddie Bernard, NOAA/PMEL addressed, respectively, the latest scientific knowledge on seismicity along Washington's outer coast and in the Puget Sound

region, and state-of-the-art tsunami run-up modeling and mapping. Matt Brunengo, WDNR geologist, discussed the linkages between earthquakes and the delineation of critical areas under the state's growth management act.

2. Unmet Needs

WSGP MAS plans to program more of its coastal resources specialist's effort in the coastal hazards area in the 1995–96 biennium. (A 3-year supplementary proposal to be submitted to the National Sea Grant College Program by Oregon State University Sea Grant would support a three-state regional coastal hazards specialist who would undertake educational programs throughout the Cascadia Subduction Zone. WSGP would collaborate with the regional specialist on a specific Puget Sound region earthquake/tsunami educational outreach effort as its part of the regional proposal. Targeted audiences would include ports, marinas and other shore industries.)

APPENDIX G

Oregon Tsunami Education Activities and Needs

JAMES W. GOOD
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Tsunami Education Activities

Several state agencies, local emergency management authorities, public education entities, public and private universities, and private non-profit organizations have been active in tsunami (and earthquake) education in recent years in Oregon. A partial list of these active groups are

- Department of Geology and Mineral Industries (DOGAMI)
- Oregon Emergency Management Division (OEM)
- Oregon Seismic Safety Policy Advisory Commission (OSSPAC)
- Department of Land Conservation and Development (DLCD)
- Oregon Department of Transportation (ODOT)
- Coastal County Emergency Managers
- Local fire and police departments (e.g., Cannon Beach)
- Portland State University Geology Department (PSU)
- Oregon Graduate Institute of Science and Technology (OGI)
- Oregon State University Extension Sea Grant Program (OSU)
- Selected Coastal Public Schools (e.g., Lincoln County District)
- American Red Cross (ARC)
- Others

Examples of activities being conducted include

Department of Geology and Mineral Industries

DOGAMI is the lead agency in Oregon for earthquake research, hazard mitigation, and information and education. Examples of tsunami education activities include (1) a mass-produced tsunami brochure, (2) tsunami hazard zone and evacuation route signs, (3) historic tsunami markers for roadside, (4) survey of public schools to assess tsunami education needs, (5) portable display explaining earthquake and tsunami hazards, (6) news media briefings and materials.

Oregon Emergency Management Division

OEM is responsible for state-level emergency response coordination. Tsunami-related education activities include (1) funding of community involvement in paleotsunami research activities with PSU and OGI researchers, (2) QUAKEX 94 full-scale Cascadia earthquake-tsunami exercise.

Oregon Seismic Safety Policy Advisory Commission

OSSPAC, established by the Oregon State Legislature in 1991 to provide advice on seismic hazard mitigation, has produced a draft Education Position Paper and is supporting several tsunami education initiatives of DOGAMI before the legislature.

Department of Land Conservation and Development

DLCD, Oregon's land use and coastal zone management agency, has supported tsunami education through financial assistance, including (1) major co-sponsorship of conferences and workshops, and (2) co-sponsorship of Oregon's Coastal Natural Hazards Policy Working Group and its education advisory committee (see below).

Oregon Department of Transportation

With DOGAMI and others, (1) development of highway and pathway signage for tsunami hazard zones and evacuation routes, and (2) development of highway interpretive signs in three coastal cities.

Coastal County Emergency Managers

Coastal county emergency managers have (1) developed educational pamphlets (e.g., *Rattling the Northwest*), (2) conducted numerous educational presentations (e.g., nearly 100 in Curry County in the past year), (3) educated school officials and teachers, hospital personnel, and other emergency responders, and (4) participated in QUAKEX 94 and real-time tsunami events (e.g., Kuril Islands tsunami warning).

Local fire and police departments

Cannon Beach Fire Department serves as a prototype of the role that fire and police might play in ongoing local tsunami education through its local tsunami warning system and evacuation planning.

Portland State University Geology Department

PSU, active in paleotsunami research along the Oregon coast, has (1) involved local community members, school children, and other community members in paleotsunami mapping exercises, and (2) made numerous presentations along the coast.

Oregon Graduate Institute of Science and Technology

OGI has displayed its tsunami modeling technology with audiences all along the coast through presentation and demonstration.

Oregon State University Extension Sea Grant Program

OSU and Sea Grant have (1) organized and presented public education conferences, workshops, and informal presentations dealing with tsunami hazards, (2) sponsored and coordinated Oregon Coastal Natural Hazards policy Working Group, (3) co-convened the current workshop, and (4), with Sea Grant and CZM programs in the PNW, is organizing an August 29–31, 1995 conference on Cascadia earthquakes and tsunamis.

Selected Coastal Public Schools

Lincoln County School Districts, for example, have (1) developed and implemented an earthquake curriculum adapted to the Cascadia region, and (2) implemented earthquake-tsunami drills, as have some other districts.

American Red Cross

ARC has initiated tsunami education programming through its recent volunteer conference and is continuing development efforts through the current workshop.

Tsunami Education Needs

The October 4, 1994 Kuril Islands earthquake-related tsunami alert provided ample evidence that recent efforts by many agencies and organizations to educate Oregonians and visitors about the dangers of tsunamis has been insufficient. Thousands of people, including media, converged on the coast (and beach in some cases) to "watch" the tsunami first-hand. Had significant tsunamis hit the coast, lives might have been lost unnecessarily. While awareness of tsunami hazards among local residents is increasing, much more needs to be done, especially as it relates to the most serious threat—a large Cascadia earthquake and associated hazards, including tsunamis. Examples of needs from a variety of Oregon sources:

- More and better information on the nature and extent of tsunami hazards, both distant and locally generated, so that education can be specific (e.g., inundation mapping)
- Regional, state, and local leadership, networking, and coordination among researchers, emergency service providers, traditional educators, and others
- Identification, collection, and cataloging of existing earthquake education materials and dissemination of information on availability
- Adaption and implementation of the best tsunami education materials and curricula for coastal schools and other audiences
- Media packets of tsunamis for use during warnings of distant-generated tsunami
- Model educational package with videos, slide sets with text, fact sheets, a simulated earthquake experience, and preparedness-response demonstrations that could be tailored to specific audiences or areas
- A Cascadia "speakers bureau" of regional experts on earthquake and tsunami hazards
- Required tsunami evacuation drills for schools and other groups
- Public education specialists for coastal areas (DOGAMI and possible Sea Grant initiatives)
- Broad-based public education programs for local residents, visitors, businesses, etc., with simple, up-to-date, regionally relevant information (beaches, state parks and waysides, motels, phone books, shopping bags, public events, mass media, etc.)

APPENDIX H

California Tsunami Education Activities and Needs

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Summary

Community Education Materials and Programs in California

California has addressed coastal hazard issues from a public policy level since initial state legislation passed in 1972. The California Coastal Initiative authorized three state agencies to regulate coastal development with regard to coastal hazards: the Department of Boating and Waterways, the Department of Parks and Recreation, and the California Coastal Commission. The Coastal Commission has included a description of tsunamis and the dangers associated with the waves in their publication "California Coastal Access Guide."

Legislation passed in 1986 (AB 3897) mandated inclusion of tsunami hazards in seismic hazard mapping when the information and funding is available. Two coastal counties, San Mateo and Humboldt, have identified or mapped tsunami run-up areas.

In the 1980's San Mateo County identified and mapped twelve high risk sites. From this information they developed a detailed tsunami response plan. Included in the plan were facilities that would be evacuated, traffic control, and designated local incident commanders. An information video was produced showing potential damage, high risk areas, and locations of evacuation centers. Tsunami pre-watch messages were prepared in English and Spanish with information on evacuation sites.

The Humboldt Earthquake Education Center at Humboldt State University in Arcata has conducted research, sponsored workshops, and produced publications to help Humboldt and Del Norte County residents prepare for earthquakes and related hazards. The publication "On Shaky Ground" has been widely distributed by the Center.

The Center is continuing their work to prepare and disseminate information on earthquake and tsunami preparedness. In 1994, a tsunami inundation map was completed for Humboldt Bay and Crescent City. The Center will conduct workshops in 1995 with a scenario of a locally generated tsunami used to define the tsunami problem. Information about interpreting tsunami alerts and what it means about the earthquake will be presented. The workshops will be directed to emergency management personnel and community groups. This information will be available to the general public in early 1995 in a new edition of "On Shaky Ground."

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[1] The following people provided me with information and material for this presentation. Nadja Christensen (Office of Emergency Services), Nancy Dean (National Weather Service), Lori Dengler (Humboldt State University), Leslie Ewing (California Coastal Commission), Dick McCarthy (California Seismic Safety Commission). Many thanks to all of you.

In 1992, the California Seismic Safety commission included a Tsunami Initiative in the 5-year planning document, "California at Risk: 1992–1997." This initiative laid the groundwork for recognition of the tsunami problem. It gave California the opportunity to ask the Federal government for funds for tsunami education and began the process of incorporating tsunami hazards into public policy. The California Seismic Safety Commission (CSSC) is the lead agency for the implementation of tsunami risk reduction recommendations in the initiative.

Another document, "The Tsunami Threat to California: Hearings before the California Seismic Safety Commission, October 1993" was the second in a series of discussions on the tsunami risk to California as mandated by AB 3897. The hearing resulted in authorization of the CSSC to develop tsunami hazard information for California in cooperation with NOAA, NSF, USGS, FEMA, and other interested agencies. The CSSC staff was also directed to investigate the possibility of linking Southern and Northern California warning systems together.

The CSSC also participated in research on the 1992 Cape Mendocino earthquakes which demonstrated the vulnerability of California's coastline to locally generated tsunamis. This research describes the Cape Mendocino earthquake and its unique large aftershocks, discusses the potential for near-shore tsunami sources, and presents some recommendations to establish tsunami risk mitigation. This research was published in the Proceedings of the 8th Symposium on Coastal and Ocean Management but is not widely available to the public.

The newsletter, "Natural Hazards Observer," published by the Natural Hazards Research and Applications Information Center at the University of Colorado at Boulder, covers all natural hazards and had two items on tsunamis in the September 1994 edition. One article described slide sets on the 1992 Nicaragua and Indonesia tsunamis available from the National Geophysical Data Center in Boulder, CO. The second described the recently released National Weather Service publication *Tsunami: The Great Waves*.

Since the initial coastal hazard legislation of 1972, much has been learned about the tsunami sources and propagation, but accurate information on the tsunami risk in California is still limited. We must continue to adequately interpret our present knowledge of factual and objective scientific information of the tsunami hazards and determine the most effective educational methods to make the public and decision makers aware of tsunami hazards. A unified approach to tsunami education and delivery of this information to local communities is part of the challenge.

In northern California we have a unique situation where the state experiences frequent strong earthquakes that do not have tsunamis associated with them. The concept of running to high ground when an earthquake occurs is not advisable for many of these earthquakes. This dilemma adds to the challenges of tsunami education. How can tsunami education programs handle this? In particular, emergency response personnel need education on how to accurately interpret tsunami information to determine whether or not to call for evacuations. Considering the varied response and interpretation of the two recent (Fall 1994) tsunami alerts in northern California, the education

programs need to be differentiated for specific audiences such as local media, emergency response personnel, the fishing industry, coastal residents, and other community groups.

A social issue in some areas of Humboldt County is lack of evacuation routes in the event of a great earthquake and tsunami. What do we tell people living in these areas?

In general, the tsunami hazard raises many difficult education questions. Most would agree we need a better understanding of the tsunami hazard with an overall goal of safety for coastal communities. To develop such a program we need to determine who will be responsible for tsunami education development, how do we convince people of the tsunami hazard given its rarity, how often we undertake education programs for tsunami risks; are public information and education programs effective, and what are the implications of a tsunami education program. There are many decisions that have not been made on tsunami education and awareness programs. This workshop certainly is a positive step towards making those decisions.

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