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Strategic Implementation Plan for Tsunami Mitigation Projects

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Strategic Implementation Plan for Tsunami Mitigation Projects[1]

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Executive Summary

The National Tsunami Hazard Mitigation Program is a Federal–State partnership to reduce risks from tsunamis. The National Oceanographic and Atmospheric Administration (NOAA), United States Geological Survey (USGS), the Federal Emergency Management Agency (FEMA), and the States of Alaska, California, Hawaii, Oregon, and Washington are working together to assess tsunami hazard, facilitate communication of hazard information, improve early detection of tsunamigenic earthquakes, reduce false tsunami alarms, and support tsunami mitigation efforts for at-risk communities.

This strategic implementation plan responds to the need to define, prioritize and coordinate the mitigation efforts of the National Program. It emphasizes the efficient use of available resources, implementation of the technical results of the National Program at the state and local level, collaboration and sharing of information among the states and federal agencies, incorporation of tsunami issues into existing all-hazards programs, and the reporting and dissemination of program results.

Goal: *A tsunami resistant community* which:

- Understands the nature of the tsunami hazard
- Has the tools it needs to mitigate the tsunami risk
- Disseminates information about the tsunami hazard
- Exchanges information with other at-risk areas
- Institutionalizes planning for a tsunami disaster

The Strategic Plan provides a framework for the development of specific tools and policies for states and local communities to reduce the impact of future tsunamis. The plan address five strategic planning areas:

1. Education
2. Tools for Emergency Managers
3. Construction, Abatement and Land Use Guidance
4. Information Exchange and Coordination
5. Long-term Tsunami Mitigation

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Activities supported by the Mitigation Task of the National Program are in the following areas of emphasis:

- Improve tsunami education
- Provide tools to supply guidance and support local planners and emergency managers
- Create and strengthen links within and among states to support long-term tsunami mitigation
- Improve the mitigation science infrastructure
- Encourage innovation and local sponsorship of tsunami mitigation programs

This plan's approach to achieving the goal involves a 4-year intensive development effort followed by continued sustained effort:

Year 1:	Assessment of needs and resources
Year 2:	Feasibility studies and product development
Year 3:	Product development and implementation
Year 4:	Implementation and evaluation
Year 5 and beyond:	Implementation and maintenance

1. Introduction

The National Tsunami Hazard Mitigation Program is a Federal–State partnership to reduce risks from tsunamis. The National Oceanographic and Atmospheric Administration (NOAA), United States Geological Survey (USGS), the Federal Emergency Management Agency (FEMA), and the States of Alaska, California, Hawaii, Oregon, and Washington are working together to assess tsunami hazard, facilitate communication of hazard information, improve early detection of tsunamigenic earthquakes, reduce false tsunami alarms, and support tsunami mitigation efforts for at-risk communities. This strategic plan addresses the Mitigation Task of the national program.

Mitigation is the sustained effort taken by communities at risk before a disaster strikes to lessen its impact. Effective mitigation not only reduces loss of life and property, but facilitates disaster response and recovery. The purpose of the Mitigation Task of the National Tsunami Hazard Mitigation Program is to reduce the tsunami risk to coastal communities by providing essential mitigation tools, implementing and maintaining local and regional tsunami mitigation programs, and raising the awareness of individuals, businesses, emergency responders, and decision makers at the local, state, and federal levels. This plan is the beginning of an on-going process to provide coordination and a framework for tsunami mitigation activities. The plan recognizes:

- The different tsunami exposure and unique demographic situations of the five Pacific states

- The importance of utilizing existing materials and products when possible
- The need to incorporate tsunami efforts into existing earthquake and all-hazard mitigation programs for tsunami mitigation to be viable
- That mitigation is a complex task involving a variety of products and projects of differing scope and scale
- The need to couple product development with a well-defined method of distribution and dissemination
- That mitigation ultimately cannot succeed without the support of local populations

1.1 The Strategic Implementation Plan

Historically, tsunami mitigation efforts in the United States have followed disaster. The 1946 tragedy in Hawaii resulted in the establishment of the first tsunami warning center. When disaster struck Hawaii again following the 1960 Chilean earthquake, permanent land use changes were incorporated into the Hilo city plan. The 1964 Alaskan tsunami resulted in recognition of the near-source tsunami hazard and the establishment of the Alaska Tsunami Warning Center. Although post-disaster response has led to significant progress in mitigation, the urgency of the situation often precludes a well-thought out, coordinated effort. Many post-disaster efforts wane with time, becoming less effective as memory fades, leaving the populace more vulnerable to the next event.

This plan is intended to provide direction and coordination for tsunami mitigation activities in the absence of disaster. It articulates the goals, defines strategic planning elements, and outlines an implementation framework. Mitigation resources are limited, particularly for perceived "rare" events like tsunamis which have not caused serious damage to coastal property in the United States in over three decades. Strategic planning is essential for the effective expenditure of these scarce resources.

This plan recognizes that the five Pacific states have different tsunami exposure and histories, diverse populations, and different institutional structures and issues. No single solution or list of projects will fit the needs of all five states. The plan requires exchange of information and collaboration among the states to improve program effectiveness and guide the use of limited resources. However, it respects the unique circumstances of each state and provides the flexibility for projects tailored to each state's needs.

No mitigation effort will succeed without the involvement and support of local communities. A key underpinning of the plan is dialogue between state and local emergency managers/planners/responders and other local decision-makers. It supports information exchange between local communities and the professional tsunami community. It solicits the input of coastal communities in defining mitigation needs and assessing priorities. It recognizes that the ultimate responsibility for sustained mitigation efforts is with the users of the coastal environment.

1.2 Background

Tsunami mitigation in the United States has received relatively little research effort compared with other natural hazards. While there are a number of groups and institutions engaged in the science of tsunamis (modeling, propagation, inundation, historic effects, etc.), projects focused solely on mitigating tsunami hazards are few. There are numerous pamphlets and brochures which provide general information about tsunami hazards. While many of these materials are excellent, they are generally stand-alone documents, not linked to any comprehensive mitigation program and many are out of print or have limited access.

The International Tsunami Information Center in Honolulu maintains a library, publishes a quarterly magazine, and provides general tsunami information. However, many of the materials in the library are not catalogued and its location makes access to the information for other states difficult (Appendix 1). A bibliography of tsunami mitigation studies catalogued by the Natural Hazards Center in Boulder Colorado is given in Appendix 2. Summaries of three mitigation studies are given in Appendix 3.

1.3 Mitigating the Tsunami Hazard: Special Considerations

Tsunami mitigation is similar in many ways to mitigating other natural hazards. It requires knowledge of the hazard, its likely effects, and what can be done to reduce those effects. However, in several ways the tsunami hazard poses particularly difficult obstacles.

- **Destructive tsunamis are very rare events.**
  Even in Hawaii, which historically has had the greatest tsunami exposure, a whole generation has never experienced one. For most people, residents of coastal areas and emergency planners/responders alike, the tsunami hazard seems remote and of less importance that more frequently reoccurring problems. This increases the difficulty in allocating scarce resources and contributes to considerable confusion about tsunami risk and safety. Images promoted by the popular media increase public misconceptions and make tsunami mitigation more difficult. All mitigation efforts are more effective when undertaken before the advent of a natural hazard; for tsunami mitigation it is critical. The next event may well be the Big One with no "wake-up call" to spur mitigation efforts ahead of time.

- **Much of the at-risk area has low population densities.**
  In all five Pacific States, the majority of the coastline at risk of tsunami flooding is rural and, in many cases, sparsely populated. These regions often have difficulty competing with more populated areas for scarce mitigation resources. Current national mitigation priorities are targeted at urban areas. Even though sparsely populated, the potential loss of life, property and infrastructure to tsunami is large. The Big Island of Hawaii, with a total population of about 150,000 people, has lost over 220 lives

since 1946, more than twice the loss of life in the Loma Prieta Earthquake and Northridge Earthquake combined. About 120 lives were lost to tsunami in the Great 1964 Alaskan earthquake, in relatively small towns and cities.

- **Locally generated tsunamis are accompanied by significant earthquake effects.**
  Communities in the epicentral region of a major tsunami-generating earthquake must deal with significant earthquake-related impacts in addition to tsunami flooding and damage. This includes significant damage to roads, structures, communication networks, and other vital lifelines, in areas both within and outside of the zone of potential tsunami inundation. Dissemination of warning information and coordinated official evacuation will be virtually impossible. Major population centers away from the coast are likely to suffer other impacts from the earthquake and may be unable to lend immediate assistance to coastal communities.

- **Local tsunami mitigation must rely strongly on education.**
  Because of the difficulties in disseminating short-term warnings due to damaged infrastructure and the very short time period to take action, it is critical that all people in hazard areas immediately recognize that the earthquake is their warning and take immediate response. This involves a complicated set of behaviors—protecting oneself during the earthquake, identifying the earthquake as an event capable of producing damaging waves, identifying one's location as hazardous, knowing how to get to a safe area, and how long one must remain away from the coast before the danger period is over. All of these actions must be taken in the absence of any official guidance and during a time of extreme personal duress. The diverse population of coastal regions further complicates this problem. Information about the tsunami risk and appropriate response needs to be communicated to residents, workers (seasonal and year-round), regional visitors, and transient populations, all of whom have different exposure to the tsunami hazard.

- **Tsunamis and their effects are uncertain.**
  There is uncertainty in all natural hazards, but recognition of the tsunami hazard, particularly the locally generated or near-source tsunami, is relatively new to many areas of the coastal United States and the science is still young. For example, scientific studies supporting the potential hazard associated with the Cascadia subduction zone along the Pacific northwest coast are barely two decades old. Detailed inundation maps are available for few communities outside of Hawaii. Although the National Tsunami Hazard Mitigation Program will assist states in inundation mapping, tsunami hazard mitigation efforts must recognize that high quality maps for many areas, particularly rural areas, will not be available in the near future.

Potential local tsunami sources are also not fully understood, particularly in the seismically active areas off of southern California and Washington. Even less is known about the interaction of tsunami waves and structures and, in contrast to seismic design and engineering, no standards have been developed in the United States for the design of tsunami-resistant structures. This means that fewer tools are available for effective tsunami mitigation.

2. Goals and Objectives

2.1 Goals

The goal of the plan is to promote the development of *tsunami resistant communities* along our vulnerable coastlines.

A tsunami resistant community:

1) **Understands the nature of the tsunami hazard.** Knows the risk that tsunami waves, from both near and far sources, pose to its coastal areas.

2) **Has the tools it needs to mitigate the tsunami risk.** Has defined needed mitigation products, has access, and knows how to use them.

3) **Disseminates information about the tsunami hazard.** Has identified vulnerable populations, has materials which include areas at risk and safety, evacuation routes, appropriate response, and has developed a dissemination plan to provide information to all users of the coastal area.

4) **Exchanges information with other at-risk areas.** Supports mitigation efforts through the free exchange of information, products and ideas with other at-risk areas and learns from the mitigation efforts for other natural hazards.

5) **Institutionalizes planning for a tsunami disaster.** Has incorporated tsunami hazard mitigation elements into their long-term all-hazard management plans and has developed a structure to develop and maintain the support of local populations and decision makers for mitigation efforts.

2.2 Objectives

The following objectives indicate how the strategic implementation plan will achieve the above goals:

Goal 1 — Understands the nature of the tsunami hazard.

1. **Tsunami inundation map guidance.** Mapping performed as part of the National Tsunami Hazard Mitigation Program will provide inundation maps to targeted coastal communities in all five states. The Mitigation Task will support interpretation and dissemination of the maps to local communities.

2. **Guidance for regions without inundation maps.** Inundation maps will only be available for targeted communities. Even in mapped communities, some risks are not covered by currently available mapping techniques. For example, tsunami river bores have produced significant damage in past tsunami events and are not covered by the current inundation modeling task of the National Tsunami Hazard Mitigation Program. The mitigation program will support developing guidance for regions without maps.
3. **Knowledge of the past impact of tsunami events.** The magnitude of local risk can be estimated by understanding the frequency and impact of past tsunamis in the local area through compilation of historic events and, where possible, paleotsunamis. Data bases containing this information will be made accessible to coastal juridictions and updated as new information becomes available.

Goal 2 — Has the tools it needs to mitigate the tsunami risk.

1. **Identify needed mitigation tools.** Assess the needs of coastal emergency managers and planners for tsunami mitigation materials, products and programs.
2. **Tool Development.** Define and prioritize needed products and support development.
3. **Dissemination.** Provide coastal communities with products and training through workshops, meetings, or print/electronic media.

Goal 3 — Disseminates information about the tsunami hazard.

1. **Identify vulnerable populations.** Identify the diverse users of the coastal environment.
2. **Materials for identified populations.** Prioritize needed materials, and support development of materials as needed.
3. **Dissemination mechanism.** Define the mechanism to distribute information to the identified populations.

Goal 4 — Exchanges information with other at-risk areas.

1. **Resource Center for tsunami mitigation.** Identify or establish a center to archive existing tsunami mitigation products, projects and materials both within the United States and in foreign countries, make materials accessible to states and coastal communities, and maintain an electronic index to mitigation products. Provide contact and direction for inquiries from local communities. Consideration should be given to housing the Resource Center within an existing institution with tsunami and/or mitigation expertise.
2. **Workshops and meetings.** Support workshops and other meetings and publish proceedings/summaries for the exchange of information among the states. Encourage the use and sponsorship of existing forums such as

the Earthquake Engineering Research Institute, Western States Seismic Policy Council, and the Natural Hazards Workshop.

3. **Annual Report of Mitigation Projects.** Compile a report which will summarize the products developed and the projects undertaken by individual states and multi-state efforts. Case-study examples of mitigation efforts from each of the five Pacific states will be included.

Goal 5 — Institutionalizes planning for a tsunami disaster.

1. **Identify existing hazard mitigation programs.** Identify existing hazard mitigation programs within states and local jurisdictions and incorporate tsunami elements into them.
2. **Establish state and/or local tsunami work groups.** Support the formation of state, regional, and/or local tsunami working groups. Encourage broad representation including both government and private sectors with coastal interests and jurisdiction.
3. **Develop state tsunami mitigation plans.** Include long-term strategy for state support of tsunami mitigation. Incorporate a mechanism for continued assessment of coastal community needs and evaluation of the success of existing programs.
4. **Reward innovation in tsunami mitigation.** Recognize outstanding local and regional mitigation efforts in an award program, Annual Report, and/or financial support.

3. Strategic Planning Elements

The technological advances in tsunami modeling, inundation mapping, and improved warnings cannot protect coastal inhabitants from a near-source tsunami. When a large subduction zone earthquake occurs nearby, the first tsunami waves may reach the coast within minutes of the event. Local populations must be able to recognize the signs of impending tsunami hazard and seek higher ground immediately. Communities need to be informed of what areas are likely to be flooded and how to safely evacuate them. Planners, emergency responders, and local residents need to understand the multihazard ramifications of a very large local earthquake that will disrupt much of the infrastructure in their pre-tsunami planning. Local decision makers need to understand the nature of the risk and be provided with the mitigation tools in order to make reasoned planning decisions. A sustained program is needed to gain the long-term grassroots support of coastal populations and to institutionalize tsunami mitigation in an all-hazard approach to risk reduction.

A summary of the needs assessment conducted by the five Pacific states is given in Appendix 4. These needs can be grouped into five strategic planning elements:

1. Education
2. Tools for Emergency Managers
3. Building and Land Use Guidance

4. Information Exchange and Coordination
5. Long-term Tsunami Mitigation

3.1 Education

Education is essential to the success of any mitigation effort, but particularly so in mitigating the near-source tsunami hazard. There is no time for coordinated response after the earthquake occurs and individuals must be able to take appropriate action on their own. Tsunami education is further complicated by the diversity of audiences and, in many cases, the inadequacy of the technical information available. Much of the information about tsunamis is highly technical and not easily accessible to emergency managers, local decision makers, and the public.

Needs:

- Information for the general public on the coastal tsunami hazard, tsunami hazard signs, evacuation routes, and how to recognize and respond to the signs of an impending tsunami
- Information for businesses and other organizations on cost/risk benefits of tsunami hazard mitigation
- Information and training for emergency managers on the use and interpretation of tsunami inundation maps, and how to approach areas not covered by mapping
- Information for tourists, seasonal workers, and transients who occasionally visit coastal areas
- Curriculum materials for schools and training for teachers on how to present tsunami programs in the classroom
- Information and training for planners and other government officials on interpreting land-use, construction, and other tsunami guidance materials
- Information for local and state elected officials about the tsunami hazard and the importance of tsunami mitigation efforts

A tsunami education program needs to:

- Define the audiences
- Determine what the audience needs to know
- Define how to convey the message
- Assess existing materials and resources
- Select appropriate vehicles to reach targeted audiences
- Develop needed materials
- Define a dissemination mechanism
- Define a strategy for sustained support

Education efforts include electronic/print/audio/video media, posters and signs, curriculum programs, museums and information centers, public relations efforts, workshops, and other public forums.

3.2 Tools for Emergency Managers

In most coastal communities, disaster planning, response, and mitigation responsibilities are centered in the local civil defense or emergency services office. For tsunami mitigation efforts to be successful, these organizations must be the core of tsunami hazard reduction efforts at the local level. Local emergency managers often have few resources for mitigation and in many cases have little technical background on the tsunami hazard. They are faced with a multitude of day-to-day responsibilities and personnel turnover is often high. They are often in the difficult position of balancing State and Federal mandates with local realities. For effective tsunami mitigation, local emergency managers must be supported and actively participate in the assessment of mitigation needs and implementation of mitigation programs.

Needs:

- Interpretation of technical information—inundation maps, scenarios, modeling studies
- Understanding the tsunami warning systems and disseminating warning information
- Guidelines for establishing and operating local tsunami warning systems
- Guidelines for areas not covered by inundation maps
- Rapid access to technical advice during a tsunami alert situation
- Guidance for planning evacuation routes and siting of signs
- Mechanism for training new personnel about tsunami issues
- Exchange of information with other coastal emergency managers

3.3 Building and Land Use Guidance

The impacts of flooding and high velocity water flow caused by tsunamis are strongly dependent on construction and land use/planning in the inundation area. Wood-frame structures that perform well in strong ground shaking are likely to collapse when hit by rapidly moving water. Reinforced concrete structures may provide havens for vertical evacuation. Consideration of both the effects of moving water *and* strong ground shaking need to be included in construction codes. Vegetation may dampen the water velocity in some cases, but in others, add to the debris and projectile force of the flow. No guidelines addressing these issues are available to coastal communities.

Needs:

- Construction guidelines
- Coastal land use guidance such as siting of structures, open space, interactions of uses

- Infrastructure guidance such as issues facing utilities, bridges, roadway embankments
- Vegetation guidance

3.4 Information Exchange and Coordination

Tsunami mitigation efforts have been carried out by many coastal communities, states, and foreign countries. For example, Canon Beach, Oregon, Crescent City, California, and Port Alberni, British Columbia have all established local tsunami warning systems. Chile and Oregon have developed tsunami curricula. Construction guidance for buildings in tsunami hazard zones has been incorporated into the State of Hawaii's building codes. Few of these efforts have been described in journals or other catalogued media. As a result, it is difficult for a community to get information about other efforts, sometimes resulting in duplication of efforts and lost opportunities to learn from one another. Programs to mitigate other natural disasters such as flash flooding and hurricanes may offer valuable models for tsunami mitigation efforts. However, this information is not readily available to most emergency managers unless their community is also subject to these other hazards.

Coastal communities also need access to technical advice on tsunami issues. When a tsunami alert occurs, they may need consultation on how to interpret information. They may need assistance in interpreting inundation maps and land-use models. Printed guidance information will help but can't replace direct contact with technical experts for particular situations. Electronic information may assist these communities, but access to the internet is still difficult in many small coastal communities.

Needs:

- Resource Center to archive and catalogue existing and new mitigation programs and maintain electronic media
- Forums, workshops, and meetings to promote exchange among coastal community representatives
- Forums, workshops, and meetings to promote exchange between different hazard mitigation disciplines
- Access to technical advice and electronic media

3.5 Long-Term Tsunami Mitigation

Tsunami mitigation efforts, to be successful, need to become part of local, regional, and state hazard mitigation programs. Coastal communities must see tsunami mitigation not as a one-time short burst of effort, but as a sustained program. Local and regional tsunami work groups provide a framework for coastal constituencies to participate in developing priorities and strategies and to gain a stake in the results of hazard mitigation. State tsunami work groups provide a forum for coastal communities to exchange information and to keep state organizations abreast of tsunami mitigation efforts. Incentives, zoning, and legislation are all vehicles to institutionalizing tsunami mitigation into the fabric of a community. Long-term planning also involves consideration of post-tsunami recovery. After a tsunami strikes, a community may have unique opportunities to take long-term mitigation actions that are not currently available. These may include large post-disaster funding sources, political support for major legislative and land-use planning changes, and damaged coastal areas which can be more easily set aside from future development.

Needs:

- Regional and State tsunami work groups
- Identification of existing all-hazard mitigation programs where tsunami programs can be included
- State tsunami mitigation planning
- Guidance for post disaster tsunami recovery

4. Implementation

This section presents the approach to achieving the goals and meeting the objectives of the plan. Considerations included in this implementation strategy:

- Educating community decision makers of the present and the future on tsunami hazards
- Developing activist constituencies
- Motivating officials and citizens to reduce risk
- Encouraging action at the local level
- Developing incentives to encourage risk reduction
- Using limited resources effectively

4.1 Areas of Emphasis

Activities supported by the Mitigation Task meet the following areas of emphasis:

1) Improve tsunami education. The Mitigation Task will support efforts to develop comprehensive educational programs for the diverse users of the coastal environment. It encourages collaborative efforts among states and adaptation of existing education programs and strategies to meet local needs. It encourages all coastal communities to provide tsunami safety information in schools to guarantee awareness of the tsunami hazard in succeeding generations.

Addresses Goal 3, Objectives 1, 2, 3.

2) Provide tools to supply guidance and support local planners and emergency managers. The Mitigation Task will support activities that transfer the technical results of inundation mapping into local application. It emphasizes activities that facilitate structural and land use mitigation at the local level. This includes the development of guidelines for construction, siting of structures and open space, land use conflicts, infrastructure, the use of inundation maps, and local warning systems. The guidelines should recognize the cumulative effects of both high velocity water and earthquake effects. The development of products in itself is inadequate. All products supported in this effort must be part of a comprehensive program and be coupled with a well-defined method of distribution and dissemination. To best utilize resources, existing materials and products should be used or adapted when possible and tsunami considerations incorporated into general planning and established practices.

Addresses Goal 1, Objectives 1, 2; Goal 2, Objectives 1, 2, 3.

3) Create and strengthen links within and among states to support long-term tsunami mitigation. The Mitigation Task will support exchange of information about tsunami mitigation through the establishment of a Resource Center, workshops and meetings, and documentation of activities. It will create institutional frameworks for tsunami mitigation by the formation of tsunami work groups, incorporation of tsunami elements into existing mitigation plans, and developing a long-term state mitigation strategy.

Addresses Goal 4, Objectives 2, 3; Goal 5, Objective 1, 2, 3.

4) Improve the mitigation science infrastructure. The Mitigation Task will support activities to archive and catalogue existing mitigation studies both domestic and foreign and make information available electronically. Establishing a Resource Center, best housed within an existing institution, will provide a permanent home to oversee these activities and respond to local queries for information. It will support activities that promote interchange among tsunami and other hazard-mitigation sciences.

Addresses Goal 4, Objectives 1, 2, 3.

5) Encourage innovation and local sponsorship of tsunami mitigation programs. The Mitigation Task will support activities that recognize and support outstanding local mitigation efforts through awards and/or incentives. It encourages establishing and maintaining local tsunami work groups.

Addresses Goal 5, Objectives 2, 4.

4.2 Plan Management

The activities supported by the Mitigation Task fall into three areas:

1. Multi-state projects with products expected to benefit all, or a majority of the five Pacific states
2. Single state projects
3. Coordination and exchange of information

Plan management is the responsibility of the Mitigation Subcommittee of the National Tsunami Hazard Mitigation Program Steering Committee. Management is shared by the states through their state representatives and FEMA on a collegial basis. Each state represents its own interests and remains responsible for its own programs, but recognizes the value of cooperative actions.

The Mitigation Subcommittee is composed of the state representatives to the Steering Committee and a representative from FEMA. The FEMA representative will coordinate subcommittee meetings, facilitate communication among subcommittee members, and report activities of the Mitigation Subcommittee to the National Tsunami Hazards Mitigation Program Steering Committee. The Subcommittee will prioritize needs, develop criteria for assessing proposals, and determine the allocation of funds to multistate and single state projects. Each year, part of the federal mitigation funds may be allocated to support general projects targeted to benefit all of the states at risk of tsunami. The remainder of the funds will be distributed among the individual states for targeted projects that meet the goals of the strategic plan. The Subcommittee will oversee the coordination of efforts among the states. State representatives are responsible for supplying timely reports on all tsunami mitigation projects within their states to the Subcommittee.

4.3 Timeline

The National Tsunami Hazard Mitigation Program is a 4-year program of intensive development followed by continued maintenance. The following outlines the focus of mitigation activities during the years of the program:

Year 1:	Assessment of needs and resources
Year 2:	Feasibility studies and product development
Year 3:	Product development and implementation
Year 4:	Implementation and evaluation
Year 5 and beyond:	Implementation and maintenance

The plan is not a simple linear progression of the above. Some implementation projects have already been accomplished in the first year and additional needs and resources may be recognized in later years of the program.

1) Assessment of needs and resources. During the initial year, the states will conduct an inventory and needs assessment of existing educational programs, public information materials, and warning and mitigation programs. This initial evaluation of capability will establish a baseline against which products resulting from this plan can be assessed. This analysis is to include both domestic efforts on federal, state, and local levels, and foreign programs developed in other tsunami-prone regions.

2) Feasibility studies. In some cases, it may be necessary to conduct feasibility studies before embarking on final project contracts. For example, several choices may be available for developing guidance, curriculum, or establishing a Resource Center. In order to make a reasoned decision and the best use of available funds, activities may be supported that present the Mitigation Subcommittee with an analysis of the available options.

3) Product development. In the second and third year of the program, product development is emphasized. The program will develop tools to support coastal community risk reduction, including land use guidelines, construction guides and model codes, model awareness and preparedness programs, media materials, and education programs. Projects will utilize existing products where available and crossover information from other hazard mitigation efforts.

4) Implementation and dissemination. This is the application of mitigation programs at the local level. It may involve training and workshops, or media and publicity campaigns, depending on the nature of the activity.

5) Evaluation. The states are expected to qualitatively assess the success of tsunami mitigation programs within their states on an annual basis and report to the Steering Committee. In the fourth year of the program, the Subcommittee will conduct a more formal review looking at the output of the program in view of the goals and objectives of the plan.

6) Maintenance. In the out years of the program, maintaining programs initiated in the development phase is emphasized. This may include long-term training programs, reprinting of materials, and adaptation of programs as new information becomes available.

5. Measuring Performance

The goal of the tsunami mitigation effort is building tsunami resistant communities. Progress toward meeting this goal can be measured in terms of the program products, community awareness of the tsunami hazard and, eventually, the outcome of the next tsunami disaster.

This program is expected to produce tangible results in terms of the five strategic planning elements: educational materials and programs, tools for emergency managers, building and land use guidance, information exchange and output, such as the number of coastal communities posting tsunami signs, pamphlets and brochures distributed, classrooms presenting tsunami curriculum, evacuation routes established, tsunami elements introduced into planning efforts, and so forth. It is important to document these projects, not only in regards to final product, but also to describe the development and implementation process. For example, what issues were considered in the development of a product such as evacuation routing, or a curriculum package? What organizations and agencies worked together in making the final decisions? What were some of the difficulties encountered along the way? How has the targeted community responded? Only through full documentation can the activities of one state or group of states be fully understood by others and by succeeding generations of persons working in tsunami hazard mitigation.

Success in improving community awareness of the local tsunami hazard can be assessed through surveys of targeted populations and/or workshops and meetings with the constituent groups. Tsunami hazard mitigation will only be successful if it is embraced at the local level and feedback from local constituencies must be supplied for all activities supported by the mitigation task of the National Tsunami Hazard Mitigation Program.

Documentation of activities, products, and programs supported by the Mitigation Task will be included in an Annual Report. The Annual Report will include summaries of all supported projects whether by states or through a joint state effort. The reports will include:

- Project description
- Project/product development
- Resulting products
- Dissemination and use of products

The Annual Report will also include case study examples of at least one highlighted program from each of the states.

6. Plan Assessment and Revision

Strategic planning is not a one-time event. It is rather a process involving a continuum of ideas, assessment, planning, implementation, evaluation, readjustment, and revision. This plan is an initial product to approach a previously poorly recognized problem in the Pacific states, the risk to coastal communities from near-source tsunami waves. The National Tsunami Hazard Mitigation Program is new. The understanding of the tsunami hazard, particularly along the western coast of the United States, is still developing. As new information becomes available and new programs are initiated, the planning context may change. To respond to this need to reassess the plan, the Mitigation Subcommittee of the National Tsunami Hazard Mitigation Steering Committee will review the plan annually during the first 4 years of the program. A more formal and comprehensive review will be performed at the end of 4 years and may result in more substantive changes.

Appendix 1

Technical Assessment of the International Tsunami Information Center Library, Honolulu, Hawaii

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Introduction

Because of my unusual professional background, I was contracted by the U.S. Federal Emergency Management Agency (FEMA) to conduct a technical assessment of the International Tsunami Information Center (ITIC) Library in Honolulu, Hawaii. That assessment was performed August 11–13, 1997 during a visit to the ITIC office in cooperation with Chris Jonientz-Trisler of FEMA and Dr. Lori Dengler of Humboldt State University.

Physical Description

Physically, the collection is quite small: approximately 150 square feet of floor space, with approximately 200 linear feet of shelf space. Within that space are two extra desks and chairs (to be used, perhaps, by visiting researchers).

This "library" has no assigned equipment: no microfiche or microfilm readers, no computers.

Quantity of Materials

Monographs. There are approximately 3,000 books and documents. (However, it is notoriously difficult to estimate the number of volumes in collections like this that are such a chaotic mix of materials, and that include so many slender government documents.) There are multiple copies of some items.

Journal subscriptions. The journal collection is quite weak. There are complete runs with current issues of only three journals: ITIC Newsletter, Science of Tsunami Hazards, and Earthquakes and Volcanoes. There are about 15 journals for which there are partial, discontinued runs; these include hazard-related newsletters (e.g., NOAA Earth Systems Monitor; DHA News), and commonly held journals (e.g., Natural Hazards; Science; Oceans; Preliminary Determination of Epicenters).

Separate papers and/or reprints. There are approximately 1,000 items. This is an odd set of materials: copies of published journal papers, preprints, unpublished manuscripts, short monographs (some of which are also held in the document sets), press releases, newspaper clippings, and other ephemera.

Quantitative Comparisons to Other Collections

This collection is small but highly significant. A comparison to other collections, made via Internet searches of major library electronic card catalogs and databases, shows that the ITIC library appears to have the highest number and concentration of books about tsunamis known.

Number of Books about Tsunamis in Various Institutions

- ITIC Library — approx. 3,000
- University of Washington — 72
- University of California statewide — 388
- University of Oregon — 22
- University of British Columbia — 113
- OCLC (national catalog of 1000s of libraries) — 585
- GeoRef — approx. 560

(GeoRef, the international index to geoscience literature, includes about 2 million total citations—but only 1,872 citations to tsunamis. This would include books, journal papers, and conference abstracts. If we assume that the nature of publication about tsunamis mimics that of other geoscience disciplines, we could assume that those GeoRef citations would be comprised of about 30% books, 35% papers, and 35% abstracts (Manson, 1992), or about 560 items.)

Sources of Materials

The materials in the ITIC collection were issued by a very wide range of sources:

- government documents from national, state, and local agencies from many countries
- university and research organizations reports and proceedings from many sources
- 6 linear feet of Russian reports
- a total of 6 linear feet of reports in Chinese, Japanese, French, and Spanish

It would appear that the sources of tsunami studies are as odd and far-flung as tsunamis are.

Quality of Materials

Spot checks were done to assess the quality of the collection. (A thorough inventory was not possible in the time allowed.)

Those checks showed that the collection includes reports both about tsunami science and tsunami mitigation. Tsunami science dominates the collection: only (perhaps) 10% of the collection pertains specifically to mitigation.

For both subjects, specific items were rarely held at other libraries. Seven books (apparently significant works) were checked against the library catalogs of the University of Washington, University of Oregon, University of California (the Melvyl system), University of British Columbia, and the Research Libraries Group. Of those, two were held at no other libraries; one was held only at the University of Washington; two were held only at Scripps (one, only in microfiche); one was held at three UC campuses (but not Scripps); one was held at UBC and five UC campuses (including Scripps). Only one of the seven items was included in GeoRef.

This was a small test, but telling. From past experience, I would expect the precise numbers to fluctuate and the overall picture to stay the same. The collection at ITIC is rich, deep, and varied. It is not duplicated, either by any other known collection, or even by any combination of known collections.

A reverse check of the ITIC would be illuminating, but is not possible. Of selected items in those other libraries and indexes, how many are held at ITIC? In order to check that, the ITIC collection would have to be thoroughly indexed. It isn't. That's one of the problems.

The ITIC library is the beneficiary of "scientific exchange" with other tsunami research organizations. Those publishers deposit copies of their reports and proceedings at ITIC, immediately and for free. Those same reports could be acquired by a university library only with much staff time, high expense, and fierce justification. That difference goes far in explaining the relative quality and quantity of this collection.

Cataloging / Indexing Systems

The ITIC collection is very strong; the indexing systems are extremely weak.

There is a card file, not maintained since about 1986. That file gives apparently consistent author and title access, but very brief and inconsistent subject access, and no multiple author, series, or corporate author access. Because there was neither a call number system nor copy number control, there is (and was) no way to know where an item should be in the collection, nor how many copies were held. While considerable effort was clearly expended on this file, it would take more time than it's worth to incorporate it into a larger system. It should be ignored (but don't tell that to whomever spent so much diligent time on it).

ITIC staff had prepared a number of very good, old tsunami bibliographies. These were not, apparently, an index to the ITIC collection, however. They are now only in print, but could be scanned, and they would provide strength and depth to any larger system.

This summer, a graduate student has been preparing an index to the reprints in the ITIC collection. He is doing that on computer (that's good), using EndNote software (that's OK—it's convertible), but without sound knowledge of indexing practices (that's bad). That was the best ITIC could do: the index is needed, and his services were free. It might be possible, however, to salvage some of that work, to be incorporated into a larger system.

Current Use of the Collection

The collection now has extremely low use. It is used by Chip McCreery: although there is no catalog or inventory, he knows where some specific items are. Occasionally, tsunami researchers visit, and Chip helps them as he can. (Those duplicate items are very welcome then: Chip can loan or give duplicate materials to the researchers, without diminishing the quality of the collection.)

Other use is prevented by the geographic isolation of Honolulu and by the lack of a distributed catalog (be it in print or on-line).

Potential Use of the ITIC Collection, at ITIC

ITIC is a very small operation. There are only two staff members: Chip McCreery (who has many other duties and responsiblities) and the secretary. These people have neither the time nor the expertise to provide solid reference or interlibrary loan support for this collection. Full use of this collection would require either a significant increase in staffing (to add professional library expertise) or a significant shift in ITIC's mandate (to focus on providing good library service from the collection, at the expense of other efforts). There is no reason to believe such changes will be made, and in truth, no compelling argument for them.

Potential Use of This Information

This is apparently the single best tsunami collection in the world, both for tsunami mitigation and tsunami science. However, just as, if a tree falls, and there is no ear to hear it, does it make a sound? If these materials are unknown and unused—do they exist? Do they have value?

They need to be used:

- By emergency managers for tsunami mitigation: Local emergency managers have tremendous needs for information, both about successful tsunami mitigation strategies (available via examples from other regions) and about the specific tsunami risks in their areas (available via interpretations of the scientific research).
- By scientists in the tsunami community: Some argue that tsunami scientists don't need these materials, that they have all the research reports they

> need, at hand. (That position, however, is disputed by studies of the information-seeking-behavior of geologists and of engineers: Bichteler and Ward, 1989; Hallmark, 1994.) Others argue that full, ready access to these materials (e.g., via the Internet) would be a tremendous advantage to those scientists.

It should be clearly noted that it is the information needs of the mitigation community that are the focus of the current efforts—not those of the scientific community. However, I do not understand how tsunami mitigation efforts could be successfully conducted without solid access to the scientific information.

In my 20 years at the Geology Library, I have witnessed, time and again, the phenomenon of reports prepared for one purpose (e.g., science), used to provide critical information for quite different reasons (e.g., planning, local history, rescue, emergency management). Our end users in local government and planning and emergency management have been very well served by full access to the scientific reports on the geology, geologic hazards, and mineral resources of Washington. (I could numb you with specific examples.) I believe very strongly that wise mitigation strategies must be based both on successful mitigation models *and* on full, ready use of the scientific knowledge.

Thoughts

Cataloging the ITIC collection could be done simply (for a little money) or elaborately (for a lot of money). But either way, that would only be an index to this collection in this place. Does that get us to our solution?

Isn't the larger issue the need for solid tsunami mitigation and tsunami science information for the greater community? The ITIC collection appears to be the largest known concentration of tsunami materials. It must certainly be a central part of any tsunami information system; but it is not the whole.

Whatever is done should be done electronically (the paper card catalog is dead). Existing indexes and systems should be used as much as possible, to reduce time and costs. The goal should be to make both the full tsunami index and the specific reports easily and readily accessible to the widest possible appropriate audience.

A Possible Solution? The Virtual Tsunami Library

The ultimate goal is to provide access for the tsunami mitigation community to both the indexes to tsunami mitigation information and the reports themselves.

The first step would be to merge the present tsunami information from various libraries and databases. This would result in a combined index to the world's tsunami information, with holdings information from major libraries. In order to be fully usable by the entire target audience, the index would need to be accessible electronically on the Internet and also be issued in print.

The next step would be to check this master file against specific library electronic catalogs (e.g., UC, UW, etc.) to add library holdings. Once this basic list had been established it could be checked against the specific items in the ITIC collection. The items unique to ITIC could be added to the database. (A very simple shelf-order system could be added to the ITIC materials to help them locate their materials.) Post the searchable database on the Internet; keep it updated as appropriate.

(Interestingly, this approach would provide a catalog to the ITIC materials, but at the least cost and effort.)

Since researchers will need to own or borrow needed items, ensure that no items are unique to ITIC: find a university or research library willing to add copies (photocopies?) and loan or distribute copies of those previously unique items.

References

Bichteler, J., and D. Ward, 1989: Information-seeking behavior of geoscientists. *Special Libraries, 80*, 169–178.

Hallmark, J., 1994: Methods used by geoscientists to access and retrieve references cited in their journal articles. In *Finding and Communicating Geoscience Information* (C. Wick, editor). *Geoscience Information Society Proceedings, 24*, 111–119.

Manson, C. J., 1992: Types and uses of geologic literature—A statistical analysis of 100 years of citations on the geology of Washington State. In *International Initiatives in Geoscience Information—A Global Perspective* (D. Fracolli, editor). *Geoscience Information Society Proceedings, 22*, 175–193.

Appendix 2

Bibliographies

A. Warning Systems
B. Mitigation
C. Education

Appendix 2A

Bibliography: Warning Systems

General Tsunami Warning Systems

Tsunami! The story of the Seismic Sea-Wave Warning System.
INST. AUTHOR: U.S. Coast and Geodetic Survey
SOURCE: For sale by the Superintendent of Documents, U.S. Govt. Print. Off.: Washington, 1965; 46 p., illus. (part col.) maps (part col.), 26 cm.
PUB. TYPE: Monograph
CALL NUMBER: EERC: 335.3 U82 1965 [EERC]
RECORD ID: EERC-014885

Disaster warning and communication processes in two communities. Journal of Communication. 1969; 19(1):92-104.

Barrick, Donald E. Coastal radar system for tsunami warning. Remote Sensing of Environment. 1979; 8:353-358.

International Tsunami Information Center. National report of the United States of America. Tsunami Newsletter. 1987; XX(2):33-40.
This report presents the status of the U.S. Tsunami Warning System. Following a list of involved U.S. agencies and their responsibilities, the report discusses recent significant developments that have been implemented since 1985. Operational improvements are discussed for both U.S. tsunami centers—the Pacific Tsunami Warning Center (Ewa Beach, Hawaii) and the Alaska Tsunami Warning Center (Palmer, Alaska). Elements of the warning systems that are examined include seismic data acquisition and alert activation, earthquake evaluation, tsunami data acquisition and evaluation, computer automation, communications, warning exercises, community preparedness, and research activities. The newsletter also contains national reports from twelve other nations that maintain tsunami warning and research programs.

U.S. Dept. of Commerce. Communications Plan for Tsunami Warning System. Sixth ed. Rockville, Maryland: U.S. Dept. of Commerce, Environmental Science Services Administration, Coast and Geodetic Survey. 1969; 175 pp.

Pararas, Carayannis, George, editor, SECOND INTERNATIONAL WORKSHOP ON THE TECHNICAL ASPECTS OF TSUNAMI WARNING SYSTEMS, TSUNAMI ANALYSIS, PREPAREDNESS, OBSERVATION AND INSTRUMENTATION: NOVOSIBIRSK, USSR, 4-5 AUGUST 1989: SUBMITTED PAPERS., Unesco, [Paris, 1991]
AUTHOR AFFIL.: International Tsunami Information Center, P O Box 50027, Honolulu, HI 96850-4993, USA.
NOTES: Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, supplement.
QUAKELINE ABSTRACT: This workshop follows a similar conference in 1985 and attempts to highlight subsequent developments. Twenty-nine papers are presented starting with a discussion of international cooperation. Reports appear on existing tsunami warning and data processing systems in Hawaii, Chile, Alaska, Japan, French Polynesia, China, British Columbia, and the USSR. Topics surveyed include methods for rapid evaluation of tsunami potential, tsunami databases, instrumental observations, and preparedness. Presentations address conceptual improvements and the inner workings of warning systems with reference to computer applications, online processing, numerical modeling, data telemetry, and communication. A summary report containing abstracts of papers was previously published. Each

paper is more fully described in individual QUAKELINE records.
PUB. TYPE: Conference proceedings
CALL NUMBER: QUAKELINE: SEL GC219.I57 1989
RECORD ID: QKLN-9202359

Economic justification of tsunami research: A specific example based on reduction of false alarms in Hawaii. Marine Geodesy. 1979; 2(1):59-66.
This paper argues that the social science aspect of tsunami research deserves research funding, particularly in the event that such research is able to reduce the costs connected with false alarms. In this context, a false alarm is defined as a warning that is followed by an inconsequential or undetected tsunami. In 1977 U.S. dollars, it is estimated that the Hawaiian response to a tsunami false alarm costs about $777,000 and that the average annual response cost is $264,000. An analysis of both the immediate and deferred costs of tsunami false alarms theoretically would produce enough savings to justify a long-term program in tsunami research. Reduction of false alarms implies continued research in the geophysics of tsunami generation and detection, but research is also needed in the psychology of warning response, the engineering of protective works and architecture of flood proofing, the political science and sociology of land use controls, and the economics of all methods of tsunami hazard management. The research budget from a social science standpoint does not involve a better comprehension of tsunami phenomena as much as an improvement in the understanding of hazard management potential and limitations.

Adams, W. M., Tsunami anomalies and precursory phenomena having potential value as predictors., Preprints, Fifth World Conference on Earthquake Engineering, 8 p.
EEA ABSTRACT: The tsunamis generated within 600 km off the northeast coast of the island of Honshu, Japan are studied with respect to the frequency-magnitude relationship. Improvements in the definition of tsunami magnitude are found to be desirable, so new definitions are developed. For a logarithmically linear definition of tsunami magnitude, with correction for spherical spreading, an energy gap of more than one order is found. This is for a data base spanning one thousand years. Peculiar phenomena, both physical and biological, have occurred prior to some of the tsunamigenic earthquakes. These phenomena have potential predictive value. Additional instrumentation and field instrumentation are required.
PUB. TYPE: Conference paper
RECORD ID: EEA-31000129

Adams, W. M., Evaluation of Proposed Policies for Improving Natural-Hazard Warning Systems., Cooperative Institute for Research in Environmental Sciences, Univ. of Colorado: (Boulder)
NOTES: Also published as: distributed by Joint Tsunami Research Effort, Univ. of Hawaii, Honolulu, July, 1971.
EEA ABSTRACT: The federal government and many state governments have introduced some system of planning-programming-budgeting. To assist in meaningfully performing this activity for warning systems of natural hazards, a simulation model of a tsunami warning system has been developed in CDC Simscript 1.5. General characteristics of modeling a warning system are first presented, then the idiosyncracies of the chosen programming language are systematically explained and explored. A method is developed for the generation of random numbers in a manner which permits improved use of the simulation model. This improvement should result in reduced variance of the empirical relationships between model inputs and outputs. Six models, sequentially more complicated, of tsunami warning system have been programmed and debugged. The sixth model includes change of coastal population by birth, death, immigration, or emmigration. The warning system itself evolves with the simulation model. The faith of the public in the reliability of the system and the time interval since the last destructive tsunami are significant parameters in the feedback representation.
PUB. TYPE: Monograph
RECORD ID: EEA-1000051

Jervis, Michael. Tsunami warning! Emergency Preparedness Digest. (January-March 1990); 17(1):14-16.

Local Tsunami Warning Systems

Kato, Kenji. Development of tsunami detection and prediction systems by using sea level and seismic sensors for local municipalities. Tsunami 1993: Proceedings of the IUGG / IOC International Tsunami Symposium; Wakayama, Japan. Japan Society of Civil Engineers; 1993; 327-340.

Adams, William Mansfield, A signal-selective seismic trigger for local tsunami warning, Hawaii Institute of Geophysics, University of Hawaii: Honolulu, 1977.; viii, 71 p., ill., 28 cm., HIG (Series); 77-16.
INST. AUTHOR: University of Hawaii (Honolulu), Institute of Geophysics
NOTES: "December 1977." — "Prepared for Office of Civil Defense, State of Hawaii."
PUB. TYPE: Monograph
CALL NUMBER: EERC: 335.3 S54 1977 [EERC]
DOCUMENT NOS.: Report No.: HIG-77-16
RECORD ID: EERC-013182

Tsunami Warning Systems

Pacific Tsunami Warning System

Spaeth, Mark G., OPERATION OF TSUNAMI WARNING SYSTEM IN THE PACIFIC., Wind and seismic effects: Proceedings of the Tenth Joint Panel Conference of the US-Japan Cooperative Program in Natural Resources; Gaithersburg, Maryland, May 23-26, 1978; Lew-H-S, ed. National Bureau of Standards, Washington, DC, 1980, pages 38-1 - 38-6.
AUTHOR AFFIL.: National Weather Service, National Oceanic and Atmospheric Administration, USA.
NOTES: National Bureau of Standards Special Publication 560.
QUAKELINE ABSTRACT: Discusses the history and development of the Tsunami Warning System (formerly known as the Seismic Sea Wave Warning System in the Pacific). Explains the current method of operation of TWS and planned improvements.
PUB. TYPE: Conference paper
AVAILABILITY: Superintendent of Documents, US Government Printing Office, Washington, DC 20402.
CALL NUMBER: QUAKELINE: SEL QC100.U57 no.560
RECORD ID: QKLN-8701170

Dohler, G. C., A general outline of the ITSU master plan for the Tsunami Warning System in the Pacific., Natural Hazards, Vol. 1 Iss. 3, pp. 295-302; 1988. ISSN: 0921030X
EEA ABSTRACT: The objectives of the Tsunami Warning System in the Pacific Ocean are presented (1) to provide accurate and reliable tsunami warning services within the shortest possible time of tsunamigenesis to protect life and property within the risk zones and (2) to adequately inform and educate all persons living within the zones to adequately respond to the warnings when issued. Emphasis is given to the many miles of coastline exposed to tsunamis in North America, the east coast of Asia, the Pacific Islands, and south Central America and to the limitations of present tsunami prediction techniques.
PUB. TYPE: Journal article
CALL NUMBER: EEA: 750/N31
RECORD ID: EEA-7194
DATABASE: EARTHQUAKE ENGINEERING ABSTRACTS

Burton, Gordon D., PACIFIC TSUNAMI WARNING CENTER. Proceedings of the Second International Tsunami Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation; Novosibirsk, USSR, August 4-5, 1989; George Pararas Carayannis, ed. Unesco, [Paris, 1991], pages 7-12.

AUTHOR AFFIL.: Pacific Tsunami Warning Center, Ewa Beach, HI, USA.
NOTES: Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, supplement.
QUAKELINE ABSTRACT: This paper states that a tsunami warning center basically functions on the interaction of three parameters: 1) the acquisition and evaluation of seismic data for event detection and evaluation of tsunamigenic probability; 2) the acquisition and analysis of sea level data for tsunami confirmation and evaluation; and 3) a communications system for data exchange and information dissemination. In this context, the author provides a review of present capabilities and recent improvements at the Pacific Tsunami Warning Center (PTWC) in the areas of computer automation, seismic data acquisition, sea level data acquisition, communications, and improvement of tsunami warning services. (Abstract adapted from text).
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GC219.I57 1989
RECORD ID: QKLN-9202362

Pararas, Carayannis, G., TSUNAMI WARNING SYSTEM IN THE PACIFIC: AN EXAMPLE OF INTERNATIONAL COOPERATION., Natural and man-made hazards: proceedings of the international symposium held at Rimouski, Quebec, Canada, 3-9 August, 1986; El-Sabh-M-I, ed. D Reidel, Dordrecht, 1988, pages 773-780. ISBN: 90-277-2524-1
AUTHOR AFFIL.: International Tsunami Information Center, PO Box 50027, Honolulu, HI 96850, USA.
QUAKELINE ABSTRACT: The Intergovernmental Oceanographic Commission (IOC) has played a very important role in the formation of the International Pacific Tsunami Warning System. In 1965, the IOC undertook the expansion of its existing Tsunami Warning Center in Honolulu and established the International Tsunami Information Center (ITIC) and the International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU). ITIC was given the general mandate of mitigating the effects of tsunamis throughout the Pacific by: a) supporting Member States in ICG/ITSU in developing and improving preparedness for tsunamis; b) monitoring and seeking to improve the Tsunami Warning System for the Pacific; c) gathering and disseminating knowledge on tsunamis, and fostering tsunami research; and d) bringing to non-member states a knowledge of the Tsunami Warning System and information on how to become participants through ICG/ITSU. Twenty-three nations are now members of ICG/ITSU. The System makes use of approximately 31 seismic stations, 53 tidal stations and 101 dissemination points scattered across the Pacific. (Adapted from author's abstract).
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GB5001.N36 1988
RECORD ID: QKLN-8802373

TSUNAMI WARNING SYSTEM IN THE PACIFIC., International Tsunami Information Center, Honolulu, and International Oceanographic Commission (IOC), Paris, [1989]
NOTES: One folded page. Photograph. Map of reporting stations and tsunami travel times to Honolulu. Publication date is estimated.
QUAKELINE ABSTRACT: The International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU) was established by the Intergovernmental Oceanographic Commission (IOC) and involves many Pacific Member States. IOC also maintains an International Tsunami Information Center (ITIC) which works closely with the Pacific Tsunami Information Center (PTWC), the headquarters of the Operational Tsunami Warning System. This pamphlet provides general information on the responsibilities and operation of the Pacific Tsunami Warning Center (PTWC) such as tsunami watches and tsunami warnings. A map of the Pacific Tsunami Warning System showing reporting stations and tsunami travel times to Honolulu and twelve tsunami safety rules are presented.
PUB. TYPE: Pamphlet
CALL NUMBER: QUAKELINE: NCEER VF00322
RECORD ID: QKLN-9100888

Lockridge, Patricia A., DEVASTATING TSUNAMI INSPIRES EFFORTS TO REDUCE FUTURE TSUNAMI DESTRUCTION., Earthquakes and volcanoes, volume 19, number 2, 1987, pages 60-65. ISSN:

0894-7163
AUTHOR AFFIL.: National Geophysical Data Center, National Oceanic and Atmospheric Administration, Boulder, CO, USA.
QUAKELINE ABSTRACT: This article describes some of the worst effects of the tsunami which among other places, such as the Aleutian islands, struck Hilo, Hawaii on April 1, 1946. The efforts to establish a tsunami warning system which followed the disaster, the current state of tsunami prediction, and the prospect for similarly disastrous occurrences in the Pacific region now that population there has increased are also briefly discussed. (Abstract adapted from text).
PUB. TYPE: News article
AVAILABILITY: Superintendent of Documents, U S Government Printing Office, Washington, DC 20402.
CALL NUMBER: QUAKELINE: SEL Per QE531.N32a
RECORD ID: QKLN-8801298

Hidlebaugh, Theresa A. The Pacific tsunami warning system. East Lakes Geographer. (June 1982); 17:45-49.

Pararas, Carayannis, George, INTERNATIONAL COOPERATION IN THE FIELD OF TSUNAMI RESEARCH AND WARNING., Proceedings of the Second International Tsunami Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation; Novosibirsk, USSR, August 4-5, 1989; George Pararas Carayannis, ed. Unesco, [Paris, 1991], pages 1-6.
AUTHOR AFFIL.: International Tsunami Information Center, Honolulu, HI, USA.
NOTES: Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, suppleme nt.
QUAKELINE ABSTRACT: This paper discusses the need for international cooperation to mitigate the destructive effects of tsunamis in the Pacific region. Economic development and population growth in coastal areas has increased the potential for disaster. A tsunami will effect many nations and requires a service such as the Pacific Tsunami Warning System. The author also discusses international cooperation in science and engineering research, evaluation and prediction capability, regional warning systems, operational and emergency preparedness, planning and zoning criteria, and of public awareness.
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GC219.I57 1989
RECORD ID: QKLN-9202363

Alaska Tsunami Warning Systems

Sokolowski, Thomas J., TSUNAMI WARNING CENTER IN ALASKA. Proceedings of the Second International Tsunami Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation; Novosibirsk, USSR, August 4-5, 1989; George Pararas Carayannis, ed. Unesco, [Paris, 1991], pages 18-36.
AUTHOR AFFIL.: Alaska Tsunami Warning Center, Palmer, AK, USA.
NOTES: Publication date is estimated. Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, supplement.
QUAKELINE ABSTRACT: This article describes how the Alaska Tsunami Warning Center (ATWC) has implemented many major changes to provide timely and effective tsunami warning services for coastal populations in Alaska, the west coast of Canada, and the lower 48 states. New concepts, technical developments, procedures, computers, and equipment resulted in a highly automated warning system which analyzes data from potential tsunamigenic earthquakes in real-time, and immediately disseminates necessary critical information to affected coastal populations. These advancements lead toward an automated expert system. Seismic and tide data networks have been enlarged. All critical warning and watch information messages are generated by computers are linked to a satellite and high speed teletypewriter communication systems for rapid dissemination of information. (Adapted from author’s abstract).

PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GC219.I57 1989
RECORD ID: QKLN-9202360

Sokolowski, Thomas J., IMPROVEMENTS IN THE TSUNAMI WARNING CENTER IN ALASKA., Earthquake Spectra, volume 7, number 3, August 1991, pages 461-482. ISSN: 8755-2930
AUTHOR AFFIL.: Alaska Tsunami Warning Center, Palmer, AK 99645, USA.
NOTES: Professional journal of the Earthquake Engineering Research Institute.
QUAKELINE ABSTRACT: This article discusses the improvements that have been made by the Alaska Tsunami Warning Center (ATWC) in order to provide effective tsunami warning services for coastal populations in Alaska, the west coasts of Canada, and the lower 48 states. The integration of computers and associated applied research developments made these improvements possible. The new warning system analyzes data from potential tsunamigenic earthquakes in real-time, and disseminates critical information to affected coastal populations via satellite and high speed teletypewriter communication systems. Seismic and tide networks have been enlarged to improve the accuracy and timeliness in determining earthquake parameters and confirming the existence of a tsunami. ATWC's system has been exercised for seven recent potential tsunamigenic earthquakes with warnings being issued in an average of eleven minutes after an earthquake's origin time. ATWC has also expanded its community preparedness program to aid those caught in the immediate vicinity of a violent earthquake and its subsequent tsunami. (Adapted from author's abstract).
EEA ABSTRACT: The Alaska Tsunami Warning Center (ATWC) has implemented many major changes in order to provide timely and effective tsunami warning services for coastal populations in Alaska and the west coasts of Canada and the United States. The basis for these improvements was the integration of computers and associated applied research developments into the operations. New concepts, developments, procedures, computers, and equipment resulted in a highly automated tsunami warning system which analyzes data from potential tsunamigenic earthquakes in real-time and disseminates critical information to affected coastal populations via satellite and high-speed teletypewriter communication systems. Seismic and tide networks have been enlarged to improve the accuracy and timeliness in determining earthquake parameters and confirming the existence of a tsunami. This paper describes the details of the warning system.
PUB. TYPE: Journal article
CALL NUMBER: QUAKELINE: SEL Per TA654.6.E384 ÿ EEA: 400/E2395
RECORD ID: QKLN-9102528 ÿ EEA-11747

Alaska Dept. of Military Affairs. Alaska Seismic Sea-Wave Warning Plan. Alaska Dept. of Military Affairs, Disaster Office. 1969; 30 pp.

Haas, J. E.; Trainer, P. B., Effectiveness of the tsunami warning system in selected coastal towns in Alaska, Preprints, Fifth World Conference on Earthquake Engineering, 10 p.
EEA ABSTRACT: The objectives of the Alaska Regional Tsunami Warning System and the special conditions which necessitate it are stated. A combination of the speed of onset and of physical cues is used to suggest a typology of tsunami events and possible preventive action. Descriptions are given of both pilot research conducted to measure the effectiveness of an attempt to educate coastal inhabitants of Alaska about the tsunami hazard and the warning system, and of the behavior exhibited by residents of Sitka, Alaska, during a summer 1972 tsunami evacuation following a nearby earthquake. Implications for timely and effective actions are noted.
PUB. TYPE: Conference paper
RECORD ID: EEA-31001484

British Columbia

Erb, J. H.; Wall, P. J., Tsunami Warning in British Columbia., EMO National Digest, Vol. 12 Iss. 1; 1972.
EEA ABSTRACT: The authors describe the activities of the International Tsunami Warning Sys-

tem, the Alaska Regional Warning System, and the British Columbia Provincial Civil Defence Office in providing advance warning of tsunamis for the Pacific coast of British Columbia. Descriptions are also presented of the coordination of lines of communication between and among various Canadian and U.S. government agencies dealing with tsunami detection and warning.
PUB. TYPE: Journal article
RECORD ID: EEA-21001036

Foster, Harold D. and Wuorinen, Vilho. British Columbia' s tsunami warning system: An evaluation. Syesis. 1976; 9:113-122.
The paper draws attention to many implicit assumptions underlying British Columbia's Tsunami Warning System and the weaknesses they create in its potential performance. These weakness include: 1) contending with a possible delay in watch or warning bulletins issued by the International Tsunami Information Center in Honolulu; 2) contending with habitually poor communications systems with Honolulu; 3) only one British Columbia coastal community (on Vancouver Island) has local tsunami warning plan despite previous inundation of several settlements; 4) Vancouver Island's warning system has not been thoroughly tested; 5) the legal chain of command for many small, isolated communities may be confused enough to actually inhibit an official warning. The author concludes that previous experience has shown that unless the public has been fully informed about potential tsunami hazards and has detailed information readily available describing how to respond to warnings, many will not evacuate threatened areas, even if inundation is virtually certain. Such information is not sufficiently available on Vancouver Island and an extensive public education program is essential.

California

Anderson, William A. Tsunami warning in Crescent City, California, and Hilo, Hawaii. The Great Alaska Earthquake of 1964: Human Ecology. Washington, D.C.: National Academy of Sciences, National Research Council, Committee on the Alaska Earthquake; 1970; pp. 116-124.
Compares a total of four tsunami warnings, the first resulting in a disaster and the second in slight wave damage, for both communities. Focuses upon the decision-making role of the local official and the warning system he has to work with.

Anderson, William A. Seismic Sea-Wave Warning in Crescent City, California, and Hilo, Hawaii. Columbus, Ohio: Ohio State University, Disaster Research Center. 1967; Research Report No. 13. 29 pp.

Yutzy, Daniel. Aesop 1964, Contingencies Affecting the Issuing of Public Disaster Warnings at Crescent City, California, Columbus, Ohio: Ohio State University, Disaster Research Center. 1964; Research Note No. 4. 8 pp.

China

Yang, Huating, INTEGRATED WARNING SYSTEM FOR TSUNAMI AND STORM SURGES IN CHINA., Proceedings of the Second International Tsunami Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation; Novosibirsk, USSR, August 4-5, 1989; Pararas-Carayannis-George, ed. Unesco, [Paris, 1991], pages 184-194.
AUTHOR AFFIL.: China Institute for Marine Development Strategy, Beijing, China.
NOTES: Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, supplement.
QUAKELINE ABSTRACT: Tsunami and storm surges result in unusual oscillations of sea levels, and flooding the coastal zones in China. There is one severe storm surge disaster every two years. Monitoring, forecasting and warning for storm surges, including drop in water level, are a major part of operational oceanographic services in China. A warning system has been

set up and operated by the State Oceanic Administration since 1974. The results of the historical study of tsunami in the last few years indicates that sea level anomalies generated by tele-tsunamis originating in the Pacific Ocean Basin are less than 30 cm on the mainland coast, but local tsunami in the China Sea can be very dangerous. It is impossible to set up an independent tsunami warning system in China but more practical to set up an integrated warning system on tsunami and storm surges. (Adapted from author's abstract).
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GC219.I57 1989
RECORD ID: QKLN-9203097

Fiji

Prasad, G., TSUNAMI WATCH AND WARNING IN FIJI., Proceedings of the Second International Tsunami Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation; Novosibirsk, USSR, August 4-5, 1989; Pararas-Carayannis-George, ed. Unesco, [Paris, 1991], pages 82-88.
NOTES: Publication date is estimated. Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, supplement.
QUAKELINE ABSTRACT: This article states that Fiji is protected from major tsunami damage by coral reefs. Recording stations for seismic and tidal activity are described. A table lists past tsunami that have affected Fiji. Communications and disaster plans are described.
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GC219.I57 1989
RECORD ID: QKLN-9203089

French Polynesia

Talandier, J., FRENCH POLYNESIA TSUNAMI WARNING CENTER (CPPT), Natural hazards: journal of the International Society for the Prevention and Mitigation of Natural Hazards, volume 7, number 3, May 1993, pages 237-256. ISSN: 0921-030X
AUTHOR AFFIL.: Laboratoire de Geophysique, Commissariat a l'Energie Atomique, Centre Polynesien de Prevention des Tsunamis, Boite Postale 640, Papeete, Tahiti, French Polynesia.
QUAKELINE ABSTRACT: The authors describe the tsunamic warning center of French Polynesia. The article begins with a brief description of the Polynesian seismic network, the equipment used for data acquisition, and the computer system configuration. The process used to evaluate tsunami risk from recorded data is outlined.
EEA ABSTRACT: Since 1964, the Geophysical Laboratory in Tahiti has been charged with the responsibility of issuing tsunami warnings. But this research laboratory is also designed to conduct other missions. One of them is to study and oversee seismicity and volcanism in the South Central Pacific. For this activity, the Geophysical Laboratory, which is also the French Polynesia Tsunami Warning Center (CPPT), processes the data recorded by the Polynesian Seismic Network, which includes 21 short-period stations, 4 broad-band three-component long-period stations, and 2 tide gauge stations. The tsunami warning method used by CPPT is described in detail. An automatic system to estimate tsunami risk is briefly discussed.
PUB. TYPE: Journal article
CALL NUMBER: QUAKELINE: SEL Per GB5000.N39 ¶ EEA: 750/N31
RECORD ID: QKLN-9304269 ¶ EEA-237956

Hawaii

Adams, W. M.; Nishioka, R., Experimental Observational Tsunami Warning System of Hawaii. Cooperative Institute for Research in Environmental Sciences, Univ. of Colorado: (Boulder)
NOTES: Also published as: distributed by Joint Tsunami Research Effort, Univ. of Hawaii, Honolulu, Apr., 1971.

EEA ABSTRACT: The historical seismicity of Hawaii, as reported by Furumoto, indicates the current need to recognize the hazard of severe tsunamis from local earthquakes. Therefore, a system of detectors and transmitters has been designed and installed by the University of Hawaii for the Environmental Science Services Administration (now National Oceanic and Atmospheric Administration). The purpose of this experimental network is to provide information about ground motion and offshore water level in real-time to the Pacific Tsunami Warning System at Ewa Beach, Oahu. Data from five seismometers and two vibratrons are telemetered via two relay stations to Oahu. Technical details for all components of the system are provided in thirteen appendices; a bondgraph analysis of the system is also formulated.
PUB. TYPE: Monograph
RECORD ID: EEA-1000052

Adams, William Mansfield, A signal-selective seismic trigger for local tsunami warning. Hawaii Institute of Geophysics, University of Hawaii: Honolulu, 1977.; viii, 71 p., ill., 28 cm., HIG (Series); 77-16.
INST. AUTHOR: University of Hawaii (Honolulu), Institute of Geophysics
NOTES: Prepared for Office of Civil Defense, State of Hawaii.
PUB. TYPE: Monograph
CALL NUMBER: EERC: 335.3 S54 1977 [EERC]
DOCUMENT NOS.: Report No.: HIG-77-16
RECORD ID: EERC-013182

Burton, Gordon D., HAWAII REGIONAL TSUNAMI WARNING CENTER. Proceedings of the Second International Tsunami Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation; Novosibirsk, USSR, August 4-5, 1989; George Pararas Carayannis, ed. Unesco, [Paris, 1991], pages 13-17.
AUTHOR AFFIL.: Pacific Tsunami Warning Center, Ewa Beach, HI, USA.
NOTES: Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, supplement.
QUAKELINE ABSTRACT: This article describes how the Pacific Tsunami Warning Center in Hawaii also serves as the regional warning center for Hawaii. Tidal information and seismic data are required to accurately predict an approaching tsunami. Since only seismic information is immediately available, care must be taken to avoid false tsunami warnings. Efforts are being made to improve tidal data.
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GC219.I57 1989
RECORD ID: QKLN-9202361

Cox, Doak C. Supply and Utilization of Information in the Tsunami Warning System of Hawaii. Honolulu, Hawaii: University of Hawaii, Hawaii Institute of Geophysics. 1963; IGR 39. 12 pp.

Cox, Doak C. and Morgan, Joseph. Local Tsunamis in Hawaii: Implications for Warning. Honolulu, Hawaii: University of Hawaii, Institute of Geophysics. 1984; HIG-84-4. 104 pp.

Cox, Doak C. Performance of the Seismic Sea Wave Warning System, 1948-1967. Honolulu, Hawaii: University of Hawaii, Hawaii Institute of Geophysics. 1968; HIG-68-2. 79 pp.

Geophysical Society of Hawaii. Tsunami Warning System Review. Geophysical Society of Hawaii. 1960; 14 pp.

Economic justification of tsunami research: A specific example based on reduction of false alarms in Hawaii. Marine Geodesy. 1979; 2(1):59-66.
This paper argues that the social science aspect of tsunami research deserves research funding, particularly in the event that such research is able to reduce the costs connected with false alarms. In this context, a false alarm is defined as a warning that is followed by an inconsequential or undetected tsunami. In 1977 U.S. dollars, it is estimated that the Hawaiian response to a tsunami false alarm costs about $777,000 and that the average annual response cost is $264,000. An analysis of both the immediate and deferred costs of tsunami false alarms

theoretically would produce enough savings to justify a long-term program in tsunami research. Reduction of false alarms implies continued research in the geophysics of tsunami generation and detection, but research is also needed in the psychology of warning response, the engineering of protective works and architecture of flood proofing, the political science and sociology of land use controls, and the economics of all methods of tsunami hazard management. The research budget from a social science standpoint does not involve a better comprehension of tsunami phenomena as much as an improvement in the understanding of hazard management potential and limitations.

Japan

Hamada, N., JAPAN TSUNAMI WARNING SYSTEM., Proceedings of the Second International Tsunami Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation; Novosibirsk, USSR, August 4-5, 1989; George Pararas Carayannis, ed. Unesco, [Paris, 1991], pages 37-38.
AUTHOR AFFIL.: Earthquake and Tsunami Observation Division, Japan Meteorological Agency, Tokyo, Japan.
NOTES: Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, supplement.
QUAKELINE ABSTRACT: This paper describes the organization of tsunami warning services in Japan and the types of equipment used to collect data.
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GC219.I57 1989
RECORD ID: QKLN-9202364

Uchiike, Hiroo. Japan tsunami warning system, present status and future plan. Tsunami 1993: Proceedings of the IUGG/IOC International Tsunami Symposium; Wakayama, Japan. Japan Society of Civil Engineers; 1993; 755-770.

Yoshii, Hiroaki. Responses to a Japanese tsunami warning and lessons for planning countermeasures. Disaster Management. 1990; 3(2):90-93.
At 3:25 A.M. on November 2, 1989, a magnitude 7.1 earthquake struck 105 km off the northeastern Japan coast, precipitating a tsunami warning nine minutes later. Research carried out by the author after the event revealed that only 23% of the municipalities in the warning (high risk) and advisory (lesser risk) target areas called out their emergency response officers just after the quake took place, that only 15% of the seaside municipalities warned residents to evacuate, and that 54% of the municipalities received their first tsunami warning through the prefectural emergency radio network 15 to 24 minutes after the earthquake. Other findings from the survey of 2098 residents in the Sanriku region: 1) the alerting of residents of a possible tsunami was carried out by 80% of municipalities in the warning area, but only 14% in the advisory areas; 2) nearly all the residents obtained the tsunami warning through television news and the municipal radio communication network; and 3) considerable confusion accompanied the evacuation orders that were issued.

Yamamoto, Masahiro; Sasakawa, Iwao; Nagai, Akira; Kakishita, Takeshi; Wakayama, Akihiko; Uhira, Koichi; Seino, Masaaki, BROADBAND STRONG-MOTION SEISMIC OBSERVATION NETWORK OPERATED BY JAPAN METEOROLOGICAL AGENCY., Proceedings of 23rd Joint Meeting of the US-Japan Cooperative Program in Natural Resources, Panel on Wind and Seismic Effects; Public Works Research Institute, Tsukuba, Japan, May 14-17, 1991; Noel J Raufaste, ed. National Institute of Standards and Technology, Gaithersburg, MD, 1991, pages 75-86.
AUTHOR AFFIL.: Seismology and Volcanology Division, Japan Meteorological Agency.
NOTES: Twenty-third Joint Meeting of the US-Japan Cooperative Program in Natural Resources, Panel on Wind and Seismic Effects. Series: National Institute of Standards and Technology Special Publication 820.
QUAKELINE ABSTRACT: The Japanese Meteorological Agency (JMA) has deployed a strong motion seismic observation network of newly developed seismometers, digital 87 type electromagnetic strong motion seismograph, installed in 74 station in October 1989. The seis-

mometer has an electromagnetic force feedback which operates over the frequency band 0.005 to 10 Hz and the dynamic range 0.03 to 980 gal. The analysis of data from two earthquakes with magnitude 7.1 and 6.5 is presented in this paper. From the latter earthquake, a strong motion seismogram at near field (epicentral distance: 13.3 km) was obtained without clip. The focal process analysis based on the new seismographs is also presented. For the data obtained in the frequency band less than 0.05 Hz, however, the computed displacement seismograph becomes noisy due to the limitation of minimum resolution to 30 mgal. (Authors' abstract).
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL TA654.5.J64 1991
DOCUMENT NOS.: REPORT: NIST-SP-820
RECORD ID: QKLN-9201317

NOWPHAS: NATIONWIDE OCEAN WAVE INFORMATION NETWORK FOR PORTS AND HARBOURS. Japan Ministry of Transport, Port and Harbour Institute, Yokosuka, date of publication unknown; 1992.
NOTES: Publication date is estimated.
QUAKELINE ABSTRACT: This pamphlet briefly describes the ocean wave monitoring system developed and maintained by the Japanese Port and Harbour Institute. Text and illustrations describe the large volume of data collected by this system, the location of observatories throughout Japan, various instruments used to collect data, etc.
PUB. TYPE: Pamphlet
CALL NUMBER: QUAKELINE: NCEER VF01095
RECORD ID: QKLN-9600459

Portugal

Mendes Victor, Luis A.; Baptista, Maria Ana Viana; Simoes, Jose Z., DESTRUCTIVE EARTHQUAKES AND TSUNAMI WARNING SYSTEM. Terra Nova, volume 3, number 2, 1991, pages 119-121.ISSN: 0954-4879
AUTHOR AFFIL.: Centro de Geofisica da Universidade de Lisboa, R da Escola Politecnica 58, 1200 Lisboa, Portugal.
NOTES: Journal of the European Union of Geosciences.
QUAKELINE ABSTRACT: The Portuguese coast has been affected several times in the past by strong earthquakes that generated tsunamis which severely damaged Lisbon. The need to reduce the social and economic impact of these events led to the Destructive Earthquakes and Tsunami Warning System in Eastern Portugal Project sponsored by the European Economic Community and funding agencies in Portugal. The project is being conducted by the Geophysical Centre of the University of Lisbon and began in April 1988. This article describes the main objectives of the project and the geological setting of the ocean bottom seismometers. In addition, the data acquisition and transmission systems are summarized. Some problems that may arise as the system continues to operate conclude the article.
PUB. TYPE: Journal article
CALL NUMBER: QUAKELINE: SEL Per QE1.T42
RECORD ID: QKLN-9101736

Russia

Kouznetsov, Boris A., TSUNAMI WARNING SYSTEM IN THE USSR. Proceedings of the Second International Tsunami Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation; Novosibirsk, USSR, August 4-5, 1989; George Pararas Carayannis, ed. Unesco, [Paris, 1991], pages 39-43.
AUTHOR AFFIL.: Yuzhno-Sakhalinsk, USSR.
NOTES: Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, supplement.
QUAKELINE ABSTRACT: This article describes the Tsunami Warning System, SPTS, in the for-

mer Soviet Union. The network includes five stations along the 4500 km Pacific coast. The author discusses computer equipment and other developments which should improve the accuracy of the warning service
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GC219.I57 1989
RECORD ID: QKLN-9202365

Kuzminykh, I.; Malyshev, M.; Metalnikov, A., GOALS AND EFFICIENCY OF THE AUTOMATED TSUNAMI WARNING SYSTEM PROJECT IN THE FAR EAST OF THE USSR., Proceedings of the Second International Tsunami Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation; Novosibirsk, USSR, August 4-5, 1989; Pararas-Carayannis-George, ed. Unesco, Paris, 1991], pages 171-183.
NOTES: Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, supplement.
QUAKELINE ABSTRACT: This paper discusses the United Automated Tsunami Warning Service (UATWS) for the Far East coast of the USSR which is subject to the effects of tsunamis generated closely in the Kuril-Kamchatka trench and the sea of Japan, and distantly in the Pacific. Tsunami Warning Services were organized in Sakhalinsk and Kamchatsk regions in 1956. In 1983 service was set up in the Primorsky Krai area. The Warning Services use 6 seismic and 53 tide stations. The principal method of tsunami prediction is seismic based on the registration of earthquake waves preceding the tsunami wave, by determining earthquake magnitude, epicenter, and tsunami generation probability based on these parameters. Sea level observations are of secondary importance but are used in the forecasting of waves far from the source. (Abstract adapted from text).
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GC219.I57 1989
RECORD ID: QKLN-9203096

Rybin, G S. COASTAL TSUNAMI WARNING STATION: MEGA., Proceedings of the Second International Tsunami Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation; Novosibirsk, USSR, August 4-5, 1989; Pararas-Carayannis-George, ed. Unesco, [Paris, 1991], pages 255-256.
AUTHOR AFFIL.: USSR State Committee for Hydrometeorology, per Pavlika Morozova, 12 123376 Moscow, USSR.
NOTES: Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, supplement.
QUAKELINE ABSTRACT: This paper describes the automatic tsunami warning system and the Mega coastal warning station in the Soviet Far East. The station also serves as an oceanographic observation unit.
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GC219.I57 1989
RECORD ID: QKLN-9203104

U.S. Dept. of Commerce. United States National Report—Tsunami Warning System. Second Meeting of the International Coordinating Group of the Intergovernmental Oceanographic Commission on the Tsunami Warning System; 1970 May 12-1970 May 14; Vancouver, B.C., Canada. 1970; 35 pp.

Ocean Bottom Sensors

Gonzalez, Frank I., DEEP OCEAN RECORDINGS OF TSUNAMIS., Twenty-second Joint Meeting of the US-Japan Cooperative Program in Natural Resources, Panel on Wind and Seismic Effects. Series: Pacific Marine Environmental Laboratory's Tsunami Project contribution 1195.
AUTHOR AFFIL.: National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory, 7600 Sand Point Way NE, Seattle, WA 98115, USA.
NOTES: Availability refers to entire proceedings and not to individual papers.

QUAKELINE ABSTRACT: The author describes the deep ocean tsunami measurements recently acquired in the Gulf of Alaska using bottom pressure recorders developed over the last decade at NOAA's Pacific Marine Environmental Laboratory. The observations were made as part of the Pacific Tsunami Observation Program, which has maintained a deep ocean network since 1986. Successful acquisition of these data demonstrates the feasibility of long-term tsunami monitoring in the deep sea with self-contained instrumentation on the ocean bottom. (Adapted from author's abstract).
PUB. TYPE: Conference paper
AVAILABILITY: Superintendent of Documents, US Government Printing Office, Washington, DC 20402-9325.
CALL NUMBER: QUAKELINE: SEL TA654.5.J64 1990
DOCUMENT NOS.: REPORT: NIST-SP-796
RECORD ID: QKLN-9200060

SCIENTISTS WANT TSUNAMI ALERT SYSTEM., Oregonian, Portland, OR, January 4, 1994.
QUAKELINE ABSTRACT: The article describes a proposed tsunami warning system for the coast of the northwestern United States. The stations would be installed on the floor of the Pacific Ocean to monitor the occurrence of tsunamis in the Cascadia subduction zone. Estimated costs are given for system installation and annual maintenance.
PUB. TYPE: News article
CALL NUMBER: QUAKELINE: NCEER clipping file
RECORD ID: QKLN-9401581

Kerr, Richard A. Tidal waves: New method suggested to improve prediction. Science. (May 5, 1978); 200(4341):521-522.
Problems still exist in the Tsunami Warning Sytem (TWS), a cooperative international organization operated by the U.S. Weather Service. An innovation in the methods that possible tsunami-generating earthquakes are monitored may soon help to reduce the number of false alarms and increase public cooperation in areas such as Hawaii and Alaska, where the most rapid warnings are needed. Although arrival times can be accurately determined thousands of miles from an earthquake's epicenter, the magnitude of a tsunami's size when it reaches land remains rather unpredictable. Some researchers feel that measuring the strength of seismic waves of very long period (thought to be most responsible for tsunami generation) will prove more accurate in predicting a tsunami hazard alert. Seismographs tied to the present TWS use 20-second waves to calculate an earthquake's magnitude, but 100-second waves are felt to be a better predicting parameter. Very long period seismographs have been in operation for about ten years, but until recently none have been integrated into the TWS. Now, two of these seismographs are being used in tsunami research, one in Hawaii, and the other on an island northeast of Vladivostock. A third is being readied at the Alaska Warning Center in Palmer, Alaska.

STATIONS SOUGHT TO WARN OF WAVES., The New York Times, NY, January 3, 1994.
QUAKELINE ABSTRACT: The article describes a tsunami warning system proposed by the National Oceanic and Atmospheric Administration (NOAA). Warning stations would be installed on the floor of the Pacific Ocean to monitor the occurrence of tsunamis in the Cascadia subduction zone off the coast of the northwestern United States.
PUB. TYPE: News article
CALL NUMBER: QUAKELINE: NCEER clipping file
RECORD ID: QKLN-9401583

Tsunami Hazards Reduction Utilizing Systems Technology

Jacobson, Muriel, comp. Proceedings of Workshop Forty-Fourth: The Seventh U.S.-Japan Seminar on Earthquake Prediction, Vol. 1. Menlo Park, Calif.: U.S. Dept. of the Interior, Geological Survey. 1990; Open-File Report no. 90-98. 272 pp.
For the seventh time since 1964, a seminar was convened under the U.S-Japan Cooperation

in Science Program. Held September 12-15, 1988 at Morro Bay, California, the seminar provided researchers with an opportunity to share recent progress and future plans in the continuing effort to develop the scientific basis for predicting earthquakes and to identify practical ways to implement new prediction technologies. Most of the 35 papers deal with technical subjects, but a few of the contributions address the broader issues associated with earthquake prediction. Such papers include discussions on the feasibility of real time earthquake warnings, the THRUST (Tsunami Hazards Reduction Utilizing Systems Technology) project, new directions in the U.S. earthquake prediction program, and on Japan's sixth earthquake prediction plan. A paper by Dennis Mileti presents conclusions from social science research on earthquake prediction research in the U.S. for the period 1974-1988.

Brennan, Ann M. and Lander, James F., eds. Second UJNR Tsunami Workshop: Proceedings Boulder, Colo.: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, National Geophysical Data Center; 1991; NGDC Key to Geophysical Records Documentation No. 24260 pp.
The second UJNR (United States-Japan Natural Resources Development Program) Tsunami Workshop, held in Hawaii in November 1990, addressed three main topics: predictions and observations of tsunami behavior in coastal waters and on land, applications of numerical modeling techniques, and protective measures in the U.S. and Japan with regard to the use of numerical models and the design tsunami concept. While most of the papers are distinctly technical, several contributions address subjects of interest to disaster planners. These include 1) an analysis of criteria for identifying tsunami events likely to produce far-field damage; 2) an evaluation of Project THRUST (Tsunami Hazards Reduction Utilizing Systems Technology); and 3) a study of urban planning for tsunamis in Grays Harbor, Washington and Lima, Peru. Technical papers deal with subjects such as the simulation of runup distances, tsunami propagation, and the development of warning criteria.

Bernard, E. N. and Behn, Richard R. Thrust—Third Annual Report. Seattle, Wash.: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory. 1986.

Bernard, Eddie N.; Behn, Richard R., REGIONAL TSUNAMI WARNING SYSTEM (THRUST), Wind and seismic effects: Proceedings of the 17th Joint Panel Meeting of the US-Japan Cooperative Program in Wind and Seismic Effects; Tsukuba, Japan, May 21-24, 1985; Raufaste-Noel-J, ed. US Department of Commerce, National Bureau of Standards, Gaithersburg, MD, May 1986, pages 644-646.
AUTHOR AFFIL.: Pacific Marine Environmental Laboratory, National Oceanic and Atmospheric Administration, Seattle, WA 98115, USA.
QUAKELINE ABSTRACT: The National Oceanic and Atmospheric Administration (NOAA) has embarked on a 3-year project, Tsunami Hazard Reduction Using System Technology (THRUST), to create a pilot regional tsunami warning system. THRUST, which is being funded by the Agency for International Development (AID) and developed by the Pacific Marine Environmental Laboratory (PMEL) for the country of Chile, is utilizing existing instrumentation connected to satellite communication to establish an early warning system. All pre-event work has been completed including hazard map, numerical modeling simulations, and the creation of an emergency operating plan. Instrumentation design has been completed and bench testing is expected to begin in summer of 1985. (Abstract from text).
PUB. TYPE: Conference paper
AVAILABILITY: National Technical Information Service, Springfield, VA 22161, USA.
CALL NUMBER: QUAKELINE: SEL TA654.5.J64 1985
DOCUMENT NOS.: REPORT: NBS-IR-86-3364
RECORD ID: QKLN-8800006

Bernard, E. N., On mitigating rapid onset natural disasters: Project THRUST., EOS Transactions, American Geophysical Union, Vol. 69 Iss. 24; 1988. ISSN: 00963941
EEA ABSTRACT: The concept is presented of a local warning system that exploits and integrates the existing technologies of risk evaluation, environmental measurement, and telecommunications. Project THRUST, a successful implementation of this general, systematic

approach to tsunamis, is described. The general approach includes pre-event emergency planning, real-time hazard assessment, and rapid warning via satellite communication links.
PUB. TYPE: Journal article
CALL NUMBER: EEA: 300/E59
RECORD ID: EEA-5354

Tsunami Hazard. Bernard, E. N., ed. Natural Hazards. 1991; 4(2-3):1-228
This topical journal issue reprints 13 papers from the Fourteenth International Tsunami Symposium held in Novosibirsk in 1989. Those papers, covering tsunami generation, propagation, modeling, coastal effects, observations, tectonics, and hazard mitigation, form the core of this volume. They are supplemented by brief reports from other meetings. Subjects addressed useful to hazard managers include damage prediction to aquaculture, runup calculation, hazard mitigation for tsunami hazard on the West Mexican coast, a tsunami warning system for Chile, and an evaluation of Project THRUST (Tsunami Hazards Reduction Utilizing Systems Technology).

Assessment of Project THRUST: Past, present, and future. Natural Hazards. 1991; 4(2-3):285-292.

Hyvernaud, Oliver; Reymond, Dominique; Talandier, Jacques; Okal, Emile A., FOUR YEARS OF AUTOMATED MEASUREMENTS OF SEISMIC MOMENTS AT PAPEETE USING THE MANTLE MAGNITUDE M SUB M: 1987-1991.
AUTHOR AFFIL.: Laboratoire de Geophysique, Commissariat a l'Energie Atomique et Centre Polynesian de Prevention des Tsunamis, Boite Postale 640, Papeete, Tahiti, French Polynesia., Tectonophysics, volume 217, number 3/4, January 30, 1993, pages 175-193. ISSN: 0040-1951
NOTES: Research funded by the Commissariat and l'Energie Atomique (France) and the National Science Foundation. Special section: Estimation of Earthquake Size, selected papers from a workshop on the Estimation of Earthquake Size, held as part of the XX General Assembly of the Union of Geodesy and Geophysics, the International Association of Seismology and Physics of the Earth's Interior, Vienna, Austria, August 19-20, 1991, Seweryn J Duda and Titiana B Yanouskaya, editors.
QUAKELINE ABSTRACT: The authors report on a 4 year experiment of routine automatic determination of seismic moments using the mantle magnitude M sub m. They have developed a system performing automatic detection and location of distant earthquakes, on the basis of three-component broadband records at a single seismic station. This system, which has been operational since 1987 at Papeete, Tahiti, computes M sub m from the spectral amplitude of the mantle Rayleigh waves. Based on a dataset of 474 earthquakes, they show that M sub m provides an excellent estimate of the quantity log sub 10 M sub 0-20, where M sub 0 is the seismic moment in dyn-cm, as published subsequently by the Harvard and USGS groups. The average residual is 0.07 units of magnitude and the standard deviation 0.22 units. This method, which necessitates minimal hardware, has powerful applications in the field of tsunami warning. (Author's abstract).
PUB. TYPE: Journal article
CALL NUMBER: QUAKELINE: SEL Per QE500.T25
DOCUMENT NOS.: GRANT: NSF EAR-87-20549
RECORD ID: QKLN-9301330

Appendix 2B

Bibliography: Mitigation

General Tsunami Mitigation

Tinti, S., PROJECT GITEC: A EUROPEAN EFFORT TO ADDRESS TSUNAMI RISK. Natural Disasters - Protecting Vulnerable Communities: Proceedings of the Conference held in London, 13-15 October 1993; Merriman-P-A, et al, eds; Thomas Telford, London, 1993, pages 147-155.
AUTHOR AFFIL.: University di Bologna.
QUAKELINE ABSTRACT: This paper provides an overview of a project of the early 1990's, known as project GITEC, intended to study the "Genesis and Impact of Tsunamis on the European Coasts". The paper first provides a brief review of recent European tsunamis, the history of European tsunami research, and the tsunami hazard along the coasts of various European nations. It then describes GITEC's goals and participants. It discusses in particular GITEC's assessment of a number of different tsunami warning systems.
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GB8014.N36 1993
RECORD ID: QKLN-9500203

Hays, Walter W., ed. Facing Geologic and Hydrologic Hazards: Earth-Science Considerations. U.S. Dept. of the Interior, Geological Survey. 1981; USGS Professional Paper 1240-B. 108 pp.
Note: Manual.
Utilizing an attractively illustrated format, this publication overviews that causes and consequences of earthquakes, tsunamis, various types of flooding, landslides, expansive soils, subsidence, and volcanic eruption. It was designed to answer some of the broader questions about hazards in a manner which would be acceptable to the planners and public officials who must confront these problems in future years. The recognition or prediction of each hazard is treated, and suggestions are made for actions based on earth-science considerations which may be taken at all levels of government and by the private sector to reduce the economic impact of these hazards. Each chapter is authored by a USGS expert with many years of experience investigating the hazard being examined. A concluding chapter offers general planning guidelines for community preparedness and the integration of different levels of public planning.

Tomblin, John. Earthquakes, volcanoes, and hurricanes: A review of natural hazards and vulnerability in the West Indies. Ambio. 1981; 10(6):340-345.
The West Indies have the dubious distinction of being vulnerable to a variety of deadly natural hazards. As the area becomes developed, the risk exposure tends to change with respect to each hazard. Risk factors which are discussed include population movements, changing building practices, and technological advances in hazard prediction and warning. It is pointed out that continuing waterfront development is placing more of the population under the threat of storm surge or earthquake-generated tsunamis. Changes in building construction methods and materials have both positive and negative effects. For example, increased use of masonry products has augmented the resistance of residences to hurricane winds. This form of construction, however, greatly increases the structure's vulnerability to damage from earthquakes. In a similar vein, growing industrialization has resulted in the investment of ever-expanding proportions of the total national assets in earthquake-susceptible structures such as dams, refineries, pipelines, electric power transmission grids, and harbor facilities. Reducing the vulnerability to future catastrophic events involves 1) the evolution of more reliable prediction and warning capabilities; 2) the implementation of emergency planning programs; and 3) the development of acceptable risk standards.

Petak, William J. and Atkisson, Arthur A. Natural Hazard Risk Assessment and Public Policy. New York, N.Y.: Springer-Verlag, Inc.; 1982. 489 pp.

In the first of three parts, the authors examine natural hazards as public policy problems, their physical characteristics and mitigation measures, and public policy approaches to managing these hazards. Part II examines in detail methodologies for hazard analysis, natural hazard exposure and risk analysis, and the costs and impacts of mitigation measures. Features of this part include sections on scenario development, the analysis of social impacts, a natural hazard loss analysis for the years 1970-2000, and the estimation of hazard/exposure/ vulnerability. Part III deals with problems concerning policy makers and stakeholders, constraints on public hazards management policy making, and the public policy alternative possibilities available for local, state, federal, and private groups. The authors contend that future policy making faces serious problems because 1) low levels of citizen concern for natural hazard risks feed a system in which apathy and long timelines are all too characteristic; 2) at the federal level, a contradictory mix of disaster relief and tax policies is now in force;and 3) the losses to natural hazards now being experienced are a direct result of the policy choices which have been made in the past by builders and subdividers, by architects, engineers, and other professionals, by state and local governments, and by property purchasers and investors.

Ayre, Robert S. Earthquake and Tsunami Hazard in the United States: A Research Assessment. Boulder, Colo.: University of Colorado, Institute of Behavioral Science, Program on Technology, Environment and Man. 1975; Monograph No. NSF-RA-E-75-005. 150 pp.

Discusses the nature of the two hazards and their adjustments, and recommends a shift in research direction. Research into land use management; earthquake-proofing; earthquake prediction and warning; insurance; community preparedness, relief and rehabilitation; and earthquake reduction are discussed. A simulation of California earthquakes is presented.

Houston, James R. State-of-the-Art for Assessing Earthquake Hazards in the United States: Tsunamis, Seiches, and Landslide-Induced Water Waves. Vicksburg, Miss.: U.S. Dept. of Defense, Army Engineer Waterways Experiment Station, Geotechnical Laboratory. 1979; Miscellaneous Paper S-73-1. 90 pp.

The report, the fifteenth in a series of earthquake hazard assessments, is primarily concerned with hydrodynamic aspects of risks stemming from hazards associated with tsunamis, seiches, and landslide-induced water vaves. Tsunami hazard maps for the United States are shown that display tsunami elevation zones that have a 90 percent probability of not being exceeded in a 50-year period. There is also a brief discussion of the methods used to determine forces exerted on structures by tsunamis. Details about the hazards are interspersed among the technical data. For example, the 1964 Alaskan earthquake caused extensive seiche action in lakes, ponds, canals, rivers, and waterways along the Louisiana and Texas coasts. Damage was minor but widespread, with many reports of damage to boats, docks, and marine service facilities.

Hulman, Lewis G.; Bivins, William S., and Fliegel, Myron H. Tsunami protection of coastal nuclear power plants in the United States. Marine Geodesy. 1978; 1(4):375-384.

Hebenstreit, Gerald T. and Whitaker, Robert E. Assessment of Tsunami Hazard Presented by Possible Seismic Events: Near-Source Effects. U.S. Dept. of State, Agency for International Development. 1981; 265 pp.

Tsunamis obviously cannot be prevented, and at present, they cannot be predicted with any degree of certainty. In order to cope with these conditions, a tsunami hazard assessment program has been established which has as its objectives: a systematic research and development study of the Pacific-wide tsunami threat; sensitizing at-risk populations and their political leaders to the potential hazard from tsunamis; planning appropriate mitigative measures; and enhancing the present status of warning systems so that real-time emergency decision-making can be effectively implemented. This report discusses the initial stages of one part of the R&D phase of the program: the augmentation of the existing historical tsunami data base with computer simulations of the effects of hypothetical tsunamis. The Pacific coast of South America in the vicinity of the Peru-Chile Trench is the locale for three specific areas of

inquiry: 1) the identification of tsunamigenci earthquakes by combining historical seismicity patterns with the theory of seismic gaps; 2) the simulation of tsunami wave generation and its propagation to both near-source and distant costal areas; and 3) the identification of coastal zones most threatened by tsunamis.

Africa

Lewis, James., Natural disaster mitigation: Environmental approaches in Tonga and Algeria. The Environmentalist. 1982; 2(3):233-246.

The nations of Tonga and Algeria are dissimilar in almost every respect but one—their vulnerability to natural disasters. In Tonga, since 1875, there have been 41 damaging earthquakes; 24 earthquakes of Richter M7.0 or above; seven periods of severe drought; nine volcanic eruptions; three known tsunamis; and a number of severe cyclones. Since 1716, Algeria has experienced more than 100 damaging earthquakes with casualties reaching as high as 20,000 deaths for a single event. One characteriestic which the nations possess in common is their recent political independence from colonial administrations. Trying to deal with these repeated extreme natural events has exposed the shortcomings of post-colonial but largely inherited administrative systems, and to bring opportunity, as well as the need, for adjustments of priorities in social and economic development to take account of natural disasters. The author suggests that a judicious application of appropriate mitigative technologies has its limitations in reducing hazard vulnerability. Social and institutional measures are as important as technology in maximizing each society's resistance to disaster. In addition, varying time scales of relevant implementation mean that each sector of mitigative activity has to be applied simultaneously and comprehensively, not in turn. The role of socioeconomic development planning in hazardous environments is to incorporate all possible comprehensive measures for vulnerability reduction.

Alaska

Chubarov, L B.; Shokin, Yu I.; Simonov, K V., USING NUMERICAL MODELLING TO EVALUATE TSUNAMI HAZARD NEAR THE KURIL ISLAND. Natural hazards: journal of the International Society for the Prevention and Mitigation of Natural Hazards, volume 5, number 3, May 1992, pages 293-318. ISSN: 0921-030X

AUTHOR AFFIL.: Computing Center of Siberian Division of the Academy of Sciences of Russia, Krasnoyarsk-36, 660036, Akademgorodok, Russia.

QUAKELINE ABSTRACT: A sequence of computer experiments is used to study questions concerning the tsunami problem as a quantitative estimate of tsunami danger, detailed geographical tsunami classification, determination of the parameters of critical tsunami waves, and the conditions of their development. A wave is critical, if its impact on the coast is most hazardous. Using the Middle Kuril Island as an example, the authors present results of a computer experiment which includes determining the wavefields on the shelf and estimating the effects connected with the deepwater Bussol and Diana Straits. Numerical simulation of tsunami waves of different sources permits the assessment of the extent of tsunami danger in different areas of the coastal zone of Shimushir Island, depending on the location of the focus zone and their geometry. The major singularities of the wavefield arise in zones of the deep-water straits. The distribution of the amplification factors is determined by both the global parameters of the wavefields and the local properties of individual harbours. The results obtained for a particular harbour in the northern part of Simushir Island, formed the basis for the quantitative estimate of tsunami danger for this area. (Authors' abstract).

PUB. TYPE: Journal article

CALL NUMBER: QUAKELINE: SEL Per GB5000.N39

RECORD ID: QKLN-9203367

Hays, Walter W. and Gori, Paula L. A Workshop on 'Evaluation of Regional and Urban Earthquake Hazards and Risk in Alaska'. Reston, Virginia: U.S. Interior Dept., Geological Survey. 1986; Open-File Report No. 86-79. 450 pp.
There are 22 authored papers in this proceedings volume from USGS Conference XXXI, held September 5-7, 1985, in Anchorage, Alaska. Approximately one-half the papers deal with technical topics, such as regional tectonics, local seismicity, ground failure, and the like. The remaining papers deal with a variety of subjects, such as tsunami preparedness measures, siting and land use planning, liability, lessons learned from the great 1964 earthquake, federal response planning, emergency preparedness, and personal preparednss. The volume also contains background information, a summary of workshop accomplishments, a participant list, and a glossary of technical terms.

Combellick, Rodney; Head, Rodger, and Updike, Randall G., eds. Earthquake Alaska—Are We Prepared? U.S. Dept. of the Interior, Geological Survey. 1994; Open-File Report 94-218. 196 pp.
Note: OBSERVER 20, No. 1 (September 1995): 21.
In 1992, a conference was held in Anchorage, Alaska, to examine the similarities of two regions that had experienced devastating earthquakes—Anchorage and Santa Cruz County, California. This volume contains the proceedings of that meeting. Although Anchorage was the site of one of the strongest and longest duration earthquakes in North America in 1964, that city has grown from the then-sparse population of 35,000 to an urban center with 250,000 residents, considerable infrastructure, and high-rise buildings. This volume includes papers on seismicity in Alaska, disaster response in Santa Cruz County following the 1989 Loma Prieta quake, disaster preparedness in Anchorage schools, volunteers, long-term recovery, reconstruction, economic impacts, the public works aspects of recovery, regional tsunami potential. and lessons learned from both earthquakes.

City of Seward, Alaska. Seward Tsunami Hazard Education Program: City of Seward, Alaska. 1970.

Haeussler, Peter. The Next Big Earthquake in Southern Alaska May Come Sooner Than You Think. Anchorage, Alas.: U.S. Dept. of the Interior, Geological Survey, Branch of Alaskan Geology. 26 pp.
This booklet, prepared by the U.S. Geological Survey, in cooperation with the Alaska Division of Emergency Services and three other agencies, contains information about residential preparedness, personal safety, and regional seismic risk. Other features of the booklet include information about anchoring wood stoves and propane tanks; earthquake magnitudes; local susceptibility to seismically-caused subsidence and liquefaction; tsunami risk, safety rules, and warning systems; and why earthquakes are inevitable in the state. Some Alaska earthquake statistics: the state has 11 percent of the world's earthquakes; it experiences 52 percent of all U.S. earthquakes; and on the average, one magnitude 8 or larger quake occurs every 13 years and one magnitude 7 to 8 quake occurs every year. References to publications and other sources of information are provided.

Pruess, J. PLANNING FOR RISK: COMPREHENSIVE PLANNING FOR TSUNAMI HAZARD AREAS., Urban Regional Research, place of publication unknown, 1988.
INST. AUTHOR: Urban Regional Research
NOTES: All materials incorporated in this work were developed with the financial support of the National Science Foundation.
QUAKELINE ABSTRACT: This book discusses tsunami preparedness for areas on the Pacific Coast of the United States which may be at risk, particularly Alaska. An introductory section provides an overview of tsunami damage patterns through a discussion of historical events and development of a numerical simulation. Included in the discussion are water forces, debris impact, contamination, fire, sand transport, and marine installations, such as wharves, piers, docks and boats. Much of the work centers around Kodiak, Alaska which suffered a major tsunami in 1964. A chapter explores the low velocity, creeping-bore type tsunami experienced in Mexico in 1985. Several chapters develop damage control provisions through barrier or sea wall style damage prevention measures. Also presented are life safety procedures involving evacuation. An appendix lists toxic materials which may create a hazard in the event of a tsunami.

PUB. TYPE: Monograph
CALL NUMBER: QUAKELINE: SEL GC221.2.U72 1988
DOCUMENT NOS.: GRANT: NFS CEE-8408237
RECORD ID: QKLN-9200884

Alaska Division of Emergency Services. Hazard Summary Report. Anchorage, Alas.: Alaska Division of Emergency Services. 1978; 154 pp.
This report presents an overview of Alaskan hazards that have the greatest likelihood to re-occur and jeopardize human life and property. A detailed approach to mitigating the vulnerability of individual communities to disasters is contained in local or interjurisdictional disaster emergency plans prepared by each borough and/or city within Alaska. The introduction emphasizes that potential hazards should be thoroughly investigated prior to the commitment of new land to development. In addition to more conventional flood problems a unique hazard exists in Alaska—glacial outburst flooding. Earthquakes and tsunamis are the most important geological hazards, but landslides, avalanches, volcanos, and coastal and island erosion must also be contended with. Seiches are known to have occurred in Alaska, but there is no evidence of any comprehensive seich hazard studies in any of the literature reviewed for the report. Forest and grassland fires are some of the most frequent and dangerous hazards to both wilderness and inhabited areas.

Selkregg, Lidia L. and others. Seismic Hazard Mitigation: Planning and Policy Implementation—The Alaska Case. Seattle, Wash.: University of Alaska-Anchorage, Urban Regional Research. 1984; 332 pp.
In 1968 the National Academy of Sciences published an exhaustive 8-volume study concerning the great Alaska earthquake of 1964. The present report assesses the degree to which recommendations from the earlier study have been implemented. The research found that most of the research recommended by the original study had been undertaken, but interviews with planners and administrators throughout southeast Alaska and land use analyses of the area indicated that the recommendations resulting from the research are rarely put into practice. Persons interviewed were pessimistic about the prospects of improved mitigation efforts, and cited specific impediments such as technical geological issues, land use allocations, government organization, and planning and management problems. It was found that political obstacles to mitigation measures are broader and more difficult to specify but are probably more important. Inadequate leadership, aspects of political culture, and ill-defined levels of governmental responsibility are a few variables that prevent effective mitigation activities.

Acharya, Hemendra, ESTIMATION OF TSUNAMI HAZARD FROM VOLCANIC ACTIVITY - SUGGESTED METHODOLOGY WITH AUGUSTINE VOLCANO, ALASKA AS AN EXAMPLE., Natural Hazards: An International Journal of Hazards Research and Prevention, volume 1, number 4, 1989, pages 341-348. ISSN: 0921-030X
AUTHOR AFFIL.: Geotechnical Division, Stone & Webster Engineering Corporation, PO Box 2325, Boston, MA 02107, USA.
QUAKELINE ABSTRACT: A general approach for the estimation of tsunami height and hazard in the vicinity of active volcanoes has been developed. An empirical relationship has been developed to estimate the height of the tsunami generated for an eruption of a given size. This relationship can be used to estimate the tsunami hazard based on the frequency of eruptive activity of a particular volcano. This technique is then applied to the estimation of tsunami hazard from the eruption of the Augustine volcano in Alaska. Modification of this approach to account for a less than satisfactory data base and differing volcanic characteristics is also discussed with the case of the Augustine volcano as an example. This approach can be used elsewhere with only slight modifications and, for the first time, provides a technique to estimate tsunami hazard from volcanic activity, similar to a well-established approach for the estimation of tsunami hazard from earthquake activity. (Abstract from journal).
PUB. TYPE: Journal article
CALL NUMBER: QUAKELINE: SEL Per GB5000.N39
RECORD ID: QKLN-8901796

British Columbia

May, Bradley K. Tsunami damage and factors influencing risk. Port Alberni, B.C. Emergency Planning Digest. (April-June 1983); 10(2):8-10.
Note: 1964 Alaska earthquake included.

California

California Office of Emergency Services. Standard Operating Procedures Tsunami SOP-3. California Office of Emergency Services. 1972.

Wilson, B. W., Tsunami-Responses of San Pedro Bay and Shelf, Calif., Journal of the Waterways, Harbors and Coastal Engineering Division, ASCE, Vol. 97 Iss. WW2, pp. 239-258; 1971.
EEA ABSTRACT: The lowest modes of free oscillation of the continental shelf off San Pedro Bay, Calif., are determined analytically from geometric models which approximate the shelf as the sector of a cone overlying a verticalconvex circular-cylindrical continental slope. The shelf is also modeled as a sloping basin coupled with the deep San Pedro Channel between the Santa Catalina Island and the mainland. The lowest modes of oscillation of the adjacent oceanic basins most likely to affect San Pedro Bay are also determined by modeling them geometrically as open-mouth, semi-ellipsoidal (Gulf of Santa Catalina) and closed, ellipsoidal (Santa Cruz Basin to Gulf of Santa Catalina). Marigrams from several tide-stations in Los Angeles-Long Beach Harbors, which recorded the tsunamis of Nov. 11, 1922 (Chile), April 1, 1946 (Aleutian Trench), May 23, 1960 (Chile) and March 28, 1964 (Alaska), have been analyzed for their power spectra and reveal numerous peaks of high energy recurrent at the widely separated times. These periods of resonance agree quite closely with many of the calculated periods of free oscillations. Knowledge of these responses is important to harbor planning because of dangerous surge currents generated in the harbors.
PUB. TYPE: Journal article
RECORD ID: EEA-1000050

Davidson, Keay, TSUNAMI COULD MAKE SURPRISE COASTAL HIT., San Francisco Examiner, CA, July 23, 1993.
QUAKELINE ABSTRACT: A brief history of tsunamis in the coastal regions of the United States is presented. The risk and impact of a possible tsunami in California is assessed. In particular, the possible damage to the Bay Area is evaluated using computer models.
PUB. TYPE: News article
CALL NUMBER: QUAKELINE: NCEER clipping file
RECORD ID: QKLN-9400692

Olson, Robert A. and Walace, Mildred M., eds. , Geologic Hazards and Public Problems Santa Rosa, Calif.: U.S. Office of Emergency Preparedness, Region 7; 1969; 335 pp.
Contains 20 articles on various aspects of several geologic hazards concentrating on earthquake hazard and the Pacific coastal region. Conference was held May 27-28, 1969.

Toppozada, Tousson R.; Borchardt, Glenn; Haydon, Wayne; Petersen, Mark; Olson, Robert; Lagorio, Henry, and Anvik, Theodore. , Planning Scenario in Humboldt and Del Norte Counties, California for a Great Earthquake on the Cascadia Subduction Zone. Sacramento, Calif.: California Dept. of Conservation, Division of Mines and Geology. 1995; Special Publication 115. 164 pp.
Note: OBSERVER 20, No. 1 (September 1995): 20. 16 plates.
The Cascadia Subduction Zone (CSZ) is a 750-mile long thrust fault extending offshore from northern California (where it joins the San Andreas fault) to southern Canada. In 150 years of recorded history, the CSZ has generated no great quakes (M>8) and very few large quakes (M>7), with the 1992 Petrolia event the largest modern earthquake. This scenario is based, in part, on a rupture of the Gorda segment of the CSZ—extending 150 miles from Cape Mendocino to Cape Blanco—which generates a M8.4 great earthquake; which generates a

destructive tsunami due to sea floor deformation; and which supposes a maximum sea floor displacement of 26 feet. Most of the scenario explores the effects of the design quake on lifeline capabilities, such as highways, airports, railroads, telecommunications, water supply and waste water lines, electrical power, and natural gas and petroleum pipelines. Other sections of the report deal with the region's earthquake history, the seismologic and geologic components of the scenario event, and anticipated impacts on hospitals, schools, fire and police facilities, and buildings in general.

Dengler, Lori; Moley, Kathy, LIVING ON SHAKY GROUND: HOW TO SURVIVE EARTHQUAKE AND TSUNAMIS ON THE NORTH COAST., Humboldt Earthquake Education Center, Humboldt State University, Arcata, CA, [1995]
AUTHOR AFFIL.: California Governor's Office of Emergency Services; Federal Emergency Management Agency (FEMA); Humboldt Earthquake Education Center, Humboldt State University
QUAKELINE ABSTRACT: This pamphlet provides the general reader with an overview of the seismic hazard in Northern California. It presents simplified accounts of plate tectonics and earthquake source mechanisms; outlines the recent seismic history of the area; discusses the serious tsunami hazard of the Northern California coast. In addition, the pamphlet offers a variety of earthquake preparedness advice for individuals, families, and homeowners. It covers the formulation of a family earthquake plan; duck and cover drills; the stockpiling of emergency supplies; bracing and anchoring water heaters, propane tanks and wood burning stoves; and dealing with children after an earthquake. It provides the homeowner with advice on retrofitting various types of foundations. The pamphlet also includes an abridged earthquake scenario for the Northern California region: a subduction zone earthquake (magnitude 8.4) which, in addition to causing serious damage due to ground shaking, also generates a tsunami seriously affecting the Humboldt Bay and Crescent City areas.
PUB. TYPE: Pamphlet
AVAILABILITY: Humboldt Earthquake Education Center, Humboldt State University, Arcata, CA 95521-8299, USA.
CALL NUMBER: QUAKELINE: NCEER VF01232
RECORD ID: QKLN-9600662

Mader, Charles L. and Bernard, E. N. Modeling tsunami flooding of Crescent City. Tsunami 1993: Proceedings of the IUGG / IOC International Tsunami SymposiumWakayama, Japan: Japan Society of Civil Engineers; 1993; 321-326.

U.S. Federal Emergency Management Agency. Assessment of the State-of-the-Art Earthquake Loss Estimation Methodologies. Washington, D.C.: U.S. Federal Emergency Management Agency. 1994; FEMA-249. 300 pp. (Earthquake Hazards Reduction Series; 70).
Note: OBSERVER 19, No. 2, p. 16.
This report contains the results of an assessment conducted by the National Institute of Building Sciences (NIBS) and FEMA to develop a nationally applicable standard method for estimating potential earthquake losses in each region of the U.S. The report surveys the existing literature, identifying studies relevant to loss estimation; evaluates selected studies to determine their potential as components of a standard method; identifies gaps in existing methods; and recommends ways to fill these gaps. It outlines potential hazards, such as ground shaking, ground failure, and tsunamis; examines potential direct physical damage to the general building stock, emergency facilities, and lifelines; describes potential damage due to fire, hazardous materials releases, and floods following earthquakes; and explores economic and social losses as well.

Caribbean

Organization of American States., Primer on Natural Hazard Management in Integrated Regional Development Planning. Washington, D.C.: Organization of American States, Executive Secratariat for Economic and Social Affairs, Dept. of Regional Development and Environment.

1991; 446 pp.
Note:. Manual. Copy 3 is in Spanish as Manual Sobre el Manejo de Peligros Naturales en la Planificacion para el Desarrollo Regional Integrado.
This is a reference document for practitioners in Latin America and the Caribbean to guide integrated development planning teams in the use of natural hazards information during the different stages of the planning process. It is divided into three sections. The first, "Incorporating Natural Hazard Management Into the Development Planning Process," describes integrated development planning as practiced by the OAS, indicates hazards management activities associated with each stage of that process, describes how to conduct natural hazard assessments for selected economic sectors, and offers a set of strategies for implementing the recommendations. The second section, "Natural Hazard Risk Reduction in Project Formulation and Evaluation," discusses the use of remote sensing devices and geographic information systems. Part three, "Resource Evaluation and the Role of Ecosystems in Mitigating Natural Hazards," provides detailed guidelines on how to assess flood hazards, desertification, landslides, earthquakes, volcanoes, tsunamis, and hurricanes.

Gori, Paula L. and Hays, Walter W., eds. A Workshop on Earthquake Hazards in the Virgin Islands Region. U.S. Geological Survey. 1984; Open-File Report No. 84-762. 141 pp.
One hundred and five people with expertise in earth science, social science, architecture, engineering, and emergency management gathered in St. Thomas in April of 1984 to discuss the history of damaging earthquakes and tsuanmis in the Greater and Lesser Antilles, and the prospects of even greater losses in the future due to increased building and population density. Papers were presented on the nature and extent of the earthquake hazard; increasing hazard awareness, personal preparedness, and response capability; land use, building codes, and earthquake-resistant design; and public education and other mitigation techniques. Fourteen authored papers appear in the proceedings.

United Nations Economic Commission for Latin America and the Caribbean. Tsunami of September 1992 in Nicaragua and Its Effects on Development. 1992; LC/L.708, LC/MEX/L.209. 37 pp.

Note: Observer 17, no. 3 (Jan. 1993): 17.
On September 1, 1992, a major earthquake centered off the coast of Nicaragua generated a tsunami with waves measuring from 8 to 15 meters high. The waves struck more than 250 kilometers of Nicaragua's pacific coast, killing 116 persons (another 63 remain unaccounted for), directly or indirectly affecting more than 40,000 people, and causing total damage and losses estimated at $25 million. This latest UNECLAC report on the economic consequences of natural disasters describes the effects on both the local and national economies, list objectives for reconstruction, and presents guidelines for the use of international disaster assistance.

United Nations Economic Commission for Latin America and the Caribbean. The Water Resources of Latin America and the Caribbean: Planning, Hazards and Pollution. Santiago, Chile: United Nations Economic Commission for Latin America and the Caribbean (UNECLAC). 1990; LC/G.1559-P. 252 pp.
The primary purpose of the reviews in this volume is to provide water managers in Latin America and the Caribbean with an insight into developments in water management in nations other than their own and to provide a comparative evaluation of the different national experiences. Three reviews are spotlighted because little information previously was available on them: the formulation of national water resource plans; water-related natural hazards; and water pollution. The section on natural hazards presents a brief discussion of their geographical distribution, overviews the salient characteristics of relevant hazards, and discusses the measures for their mitigation. The section on water pollution discusses both point-source and non-point source pollution problems, the impact of pollution on public health, and pollution control mechanisms such as legal constraints and water quality monitoring. There are 25 pages of notes, and annexes contain information on national disaster management organizations, and national emergency plans and disaster legislation.

China

Qinghai, Zhou and Adams, W. M. Tsunami risk analysis for China. Natural Hazards. 1988; 1(2):181-195.

Iida, K.; Iwasaki, T., Tsunamis: their science and engineering, Proceedings of the International Tsunami Symposium, 1981, IUGG Tsunami Commission, May, 1981, Sendai-Ofunato-Kamaishi, Japan., Terra Scientific Publishing Co.; D. Reidel Publishing Co.: (Tokyo, Japan; Dordrecht, Holland), 563 p.; 1983.
The international tsunami symposium convened by the Tsunami Commission of the International Union of Geodesy and Geophysics was held during May 25-28, 1981, on the island of Honshu, Japan. This volume presents 39 papers that were selected for publication in the sypmposium's proceedings. As the title implies, most of the papers deal with the scientific and technical aspects of tsunami research and mitigation. A few papers, however, explore the social and economic impacts of tsunami hazards. They are: "The Tsunami Impact on Society," by G. Pararas-Carayannis; "Study on the Earthquake and the Tsunami of September 20, 1498," by Y. Tsuji; and "Land Management Guidelines for Tsunami Hazard Zones," by J. Preuss. The 39 papers have been classified and arranged in seven major subject areas: the tsunami impact on society (2 papers); tsunami source and earthquake (6 papers); historical and statistical studies of tsunamis (9 papers); tsunami generation and propagation (4 papers); topographic effects on tsunami waves (7 papers); sea walls and breakwaters (4 papers); and tsunami runup (7 papers).
EEA ABSTRACT: Of the 54 papers presented at the symposium, 39 have been printed in this proceedings. These papers are classified and arranged into seven major sections: The Tsunami Impact on Society; Tsunami Source and Earthquake; Historical and Statistical Studies of Tsunamis; Tsunami Generation and Propagation; Topographic Effects on Tsunami Waves; Sea Walls and Breakwaters; and Tsunami Runup. A subject index is included. None of the papers are individually cited or abstracted in this issue of the AJEE.
PUB. TYPE: Conference proceedings
CALL NUMBER: EEA: 335/T78/1983
RECORD ID: EEA-132000037

Columbia

Gueri, Miguel; Guerra, E. S.; Gonzalez, L. E.; Martinez, N. A.; Olivares, A. V.; Rosero, E., and de Ville de Goyet, C. Health implications of the Tumaco earthquake, Colombia, 1979. 1983; 7(3):174-179.

DISASTER MITIGATION PROGRAM IN COLOMBIA 1988-1991., United Nations Disaster Relief Coordinator, Geneva, 1991.
INST. AUTHOR: United Nations Disaster Relief Coordinator (UNDRO)
NOTES: This publication was financially supported by the Canadian International Development Agency (CIDA).
QUAKELINE ABSTRACT: This report concerns the Disaster Mitigation Program in Columbia during 1988-1991. This report describes the following projects: 1) Seismic Risk Mitigation in Cali, 2) Tsunami Risk Mitigation in Tumaco, 3) Landslide Risk Mitigation in Paz del Rio, 4) Volcanic Risk Mitigation in Ibague, 5) Combeima River Flood Risk Mitigation in detail under separate headings. The text is accompanied by maps and photographs. Furthermore, the related topics of industrial risks, aid, rescue and general strategies for disaster mitigation are examined. Conclusions and lessons learned are provided at the end of this report.
PUB. TYPE: Monograph
CALL NUMBER: QUAKELINE: NCEER VF00670
RECORD ID: QKLN-9300370

Costa Rica

Earthquake Spectra-Oakland, Calif. Costa Rica Earthquake Reconnaissance Report. Earthquake Spectra. 1991; 7(Supplement B, Publication 91-02):(127 pp).
On April 22, 1991, a magnitude 7.5 earthquake struck the Talamanca Mountains region of Costa Rica. Felt throughout Costa Rica and northern Panama, the earthquake caused 53 deaths, destroyed or severely damaged 7,145 homes and businesses, and left approximately 30,000 people homeless. The economic impact of the quake was estimated at more than $500 million in property damage and lost revenue. In addition to seismological, geological, and tectonic information about the event, this report covers damage to buildings, industrial facilities, bridges and other lifelines, and describes some of the socioeconomic impacts caused by the quake. Observations include: the nation's Indian population did not receive governmental assistance commensurate with its needs; patients were evacuated from the City of Limon Hospital although the building was in fact structurally safe; banana plantations were affected due to the filling of drainage ditches by liquefaction and sand infiltration; and Costa Rica lacks government support for the effective prevention and mitigation of natural disasters. A sizable tsunami also was generated by the quake.

Equador

United Nations Disaster Relief Coordinator. Disaster Prevention and Preparedness Project for Ecuador and Neighbouring Countries. Geneva, Switzerland: United Nations Disaster Relief Coordinator (UNDRO). 1990; 19 pp.
Located along part of the "Ring of Fire," Ecuador not only experiences earthquakes and volcanoes, but is at risk from tsunamis, severe floods, and massive landslides as well. The nation's growing population has been moving into numerous high-risk zones in which a severe earthquake or volcanic eruption could wreak havoc on the residents. Typical of the threats that the nation must confront are the young stratovolcanoes of the Andes. Cotopaxi has generated 9 major lahar disasters since 1742 and a gigantic rock slide generated on Chimborazo in the recent past traveled more than 20 km into a valley that is now populated. In addition to describing Colombia's natural hazards, this document provides information about how the nation is dealing with its hazards and presents background on international scientific programs designed to assist national mitigation goals.

Hawaii

Heliker, Christina. Volcanic and Seismic Hazards on the Island of Hawaii. U.S. Dept. of the Interior, Geological Survey. 1990; 48 pp.
This well-illustrated booklet outlines the risks posed by earthquakes, volcanoes, and tsunamis to residents of the island of Hawaii. It describes the various hazards posed by volcanoes—including lava flows, airborne lava fragments, volcanic gases, explosive eruptions, and ground deformation—and discusses at length the lava flow hazard zone mapping project for the island. The latter part of the booklet describes the earthquake and tsunami hazards and the ways that individuals can adjust to these dangers.

Raine, Laurence M. The Determinants of Risk Perceptions of Tsunamis in Oahu, Hawaii: Public Health Implications. Ann Arbor, Mich.: University of Hawaii; 1995; c1996. 305 pp.
Note: Published by UMI Dissertation Services. Questionnaire. Glossary. Bibliography.
Tsunamis are a real hazard to Hawaiian residents. On Oahu alone, approximately 60,000 individuals live within a tsunami inundation zone while many others work and /or travel within these danger zones. This Ph.D dissertation presents the findings of a survey conducted on a random sample of the jury pool obtained from the First Circuit Court in Honolulu, which in turn, was drawn from the adult population of the City and County of Honolulu. A self-administered questionnaire was distributed to the pool to determine how individuals

viewed the tsunami threat. Also, tsunami-related newspaper articles from 1900 to 1995 were categorized and evaluated as to risk perception content. Findings include 1) various sociodemographic characteristics of the survey participants, such as age, gender, education, length of residency, total family income, racial or ethnic characteristics and religious preferences all influence tsunami risk perception; 2) respondents who had lower educational attainment and income levels were far more fearful of tsunamis than those of higher educational and income levels; 3) religious persuasion did not appear to influence risk perception; and 4) the media, most notably the electronic variety, is the primary source of tsunami-related information with less information received from personal experience, family, and friends and schools.

Cox, Doak C. Potential Tsunami Inudation Areas in Hawaii. University of Hawaii, Hawaii Institute of Geophysics, Tsunami Research Program. 1961; Report No. 14. 26 pp.

Heliker, Christina. Volcanic and Seismic Hazards on the Island of Hawaii. U.S. Dept. of the Interior, Geological Survey. 1990; 48 pp.
This well-illustrated booklet outlines the risks posed by earthquakes, volcanoes, and tsunamis to residents of the island of Hawaii. It describes the various hazards posed by volcanoes—including lava flows, airborne lava fragments, volcanic gases, explosive eruptions, and ground deformation—and discusses at length the lava flow hazard zone mapping project for the island. The latter part of the booklet describes the earthquake and tsunami hazards and the ways that individuals can adjust to these dangers.

Cox, Doak C. Hurricane Iwa Experience and Coastal Flood Hazard Estimation in Hawaii. University of Hawaii, Environmental Center. 1983; 11 pp.
The report comments on a recommendation made by the FEMA interagency team investigating the effects of Hurricane Iwa. The recommendation suggests that consideration be given to revising, for some Hawaiian coasts, the flood elevations shown on flood insurance rate maps used for the National Flood Insurance Program (NFIP). Investigation results indicate that the near-shore flood height at Poipu, Kauai, should be increased significantly, if proper attention is to be paid to the NFIP'S 100-year recurrence interval criteria. Data is utilized from five high-wave events (including two tsunamis) whose records have not previously been used in estimating the coastal flood hazard in the vicinity of Poipu. Conclusions from the report suggest that 1) high wave estimates of the hazard, based on tsunami experience alone, are inadequate for some coastal areas; 2) by itself, the Iwa experience cannot be used in estimating the hazard on any coastal area; 3) in areas where the present NFIP estimates are inadequate, the experience of both tsunamis and hurricanes should be combined in revising them; and 4) considering the inescapable arbitrariness, the NFIP numerical estimates should be open to challenge by those who have reliable information at variance with that used in their preparation.

Economic justification of tsunami research: A specific example based on reduction of false alarms in Hawaii. Marine Geodesy. 1979; 2(1):59-66.
This paper argues that the social science aspect of tsunami research deserves research funding, particularly in the event that such research is able to reduce the costs connected with false alarms. In this context, a false alarm is defined as a warning that is followed by an inconsequential or undetected tsunami. In 1977 U.S. dollars, it is estimated that the Hawaiian response to a tsunami false alarm costs about $777,000 and that the average annual response cost is $264,000. An analysis of both the immediate and deferred costs of tsunami false alarms theoretically would produce enough savings to justify a long-term program in tsunami research. Reduction of false alarms implies continued research in the geophysics of tsunami generation and detection, but research is also needed in the psychology of warning response, the engineering of protective works and architecture of flood proofing, the political science and sociology of land use controls, and the economics of all methods of tsunami hazard management. The research budget from a social science standpoint does not involve a better comprehension of tsunami phenomena as much as an improvement in the understanding of hazard management potential and limitations.

Cox, Doak C.; Hom-ma, Masashi; Suzuki, Masatsugu; Takahasi, Ryutaro, and Wiegel, Robert L. Physically Feasible Means for Protecting Hilo From Tsunamis. Hawaii County, Hawaii Board of Supervisors, Tsunami Advisory Committee. 1965

Indonesia

Kawata, Yoshiaki. Response of residents at the moment of tsunamis: The 1992 Flores Island Earthquake Tsunami Indonesia. . Tsunami 1993: Proceedings of the IUGG/IOC International Tsunami Symposium; Wakayama, Japan. Japan Society of Civil Engineers; 1993; 677-688.

Jeffery, Susan E., OUR USUAL LANDSLIDE: UBIQUITOUS HAZARD AND SOCIOECONOMIC CAUSES OF NATURAL DISASTER IN INDONESIA., University of Colorado, Boulder, June 1981.
AUTHOR AFFIL.: Centre for Development Studies, School of Humanities and Social Sciences, University of Bath.
NOTES: Natural hazard research, working paper no 40. "June, 1981."
QUAKELINE ABSTRACT: The central argument of the paper is that social and economic processes may increase the vulnerability of populations to natural disaster and, insofar as they do this, such processes are to be considered as causes of disaster in the same way as the more obvious physical or environmental phenomena. The concept of natural hazard as a normal part of a population's relationship to its environment is discussed. It is suggested that populations are able to adapt to a certain range of hazard, but that external factors may change the population-environment relationship; the population's capacity to deal with hazard is restricted, thereby increasing its vulnerability to natural disaster. After a review of previous work on these themes, the analysis of vulnerability to natural disaster preoceeds through a description of aspects of land use, settlement, migration and indigenous techniques and practices, which are set in the historical context of governmental policies and the development of the national Indonesian economy in relation to peasant subsistence production. Much of the case-study material is drawn from fieldwork on the islands of Lembata and Flores in Nusa Tenggara Timur in Indonesia. The paper concludes with a discussion of the theoretical and methodological implications of its analysis of vulnerability. (Abstract from text).
PUB. TYPE: Monograph
AVAILABILITY: Gilbert F White, Institute of Behavioral Science, University of Colorado, Boulder, CO 80302, USA. Price: $3.00 per copy.
CALL NUMBER: QUAKELINE: SEL GB5005.N37 no.40, NCEER: GB5005.N37 no.40; GB5005.N37 no.40 [Science and Engineering Library]
RECORD ID: QKLN-8700807, NCEER-ADM0059

Jamaica

Naughton, Patrick W. Establishing the Risk and Priority for Mitigation Under Disaster Conditions for Kingston, Jamaica. Boulder, Colo.: University of Colorado, Institute of Behavioral Science, Natural Hazards Research and Applications Information Center. 1981; 22 pp.
Metropolitan Kingston, with its estimated population of one million, is subject to earthquakes, flood, landslides, hurricanes, and tsunamis. This paper establishes the hazard potential for these evvents on an areal basis, and explains a method which can be used to establish mitigation priorities for the entire urban district. Following the delineation of high risk zones, it is possible to establish priorities for development, re-development, land use zonation, and the possible removal of potentially collapsible structures. Mitigation priority is fixed by finding the product of the severity ratings of the major hazards, population density, and housing types. Following this procedures, a sequential relational rating can be determined which will allow hazard planners to identify matters most needing mitigative attention. The delineation of high risk zones is a fundamental concern wherever mitigation strategies are being examined, but particularly so in a region which is threatened by a variety of serious hazards. The findings

from the study were used as the basis for the disaster plan recently developed by the Jamaican government.

Japan

Goto, Chiaki; Tanimoto, Katsutoshi, PRESENT STATE OF TSUNAMI NUMERICAL SIMULATION., Wind and Seismic Effects: Proceedings of the 21st Joint Meeting of the US-Japan Cooperative Program in Natural Resources, Panel on Wind and Seismic Effects; Public Works Research Institute, Tsukuba, Japan, May 16-19, 1989; Noel J Raufaste, ed. National Institute of Standards and Technology, Gaithersburg, MD, 1990, pages 255-262.
AUTHOR AFFIL.: Port and Harbour Research Institute, Ministry of Transport, Japan.
NOTES: Availability refers to entire proceedings and not to individual papers.
QUAKELINE ABSTRACT: In this paper, the authors present numerical simulation methods for tsunami propagation and tsunami run-ups. These are used to predict the tsunami hazard for Japan. They also introduce simulations for transoceanic wave propagation and soliton fission of tsunamis. A discussion of the models which simulate timber spreads and oil spreads dispersed by tsunami wave action is included.
PUB. TYPE: Conference paper
AVAILABILITY: Superintendent of Documents, US Government Printing Office, Washington, DC 20402-9325.
CALL NUMBER: QUAKELINE: SEL TA654.5.J64 1989
DOCUMENT NOS.: REPORT: NIST-SP-776
RECORD ID: QKLN-9200119

Yabe, G.,TSUNAMI RESISTANT CONSTRUCTION AND DESIGN. Proceedings of the Second International Conference on Earthquake Resistant Construction and Design; Berlin, 15-17 June 1994; Savidis-S-A, ed; A A Balkema, Rotterdam, 1994, volume 2, pages 1107-1112. ISBN: 90-5410-394-9
AUTHOR AFFIL.: Sangyo Kagaku Kenkyusho, Tokyo, Japan.
NOTES: Series: DGEB-Publication Number 8.
QUAKELINE ABSTRACT: The authors discusses tsunami resistant design in Japan. The paper begins with a list of previous tsunamis that have struck the coast of Japan and the losses that were experienced. Methods to mitigate the damage caused by tsunamis are listed.
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL TA658.44.I57 1994 v.2
RECORD ID: QKLN-9600826

Miyano, M.; Lu, H J.; Mochizuki, T., METHOD FOR ESTIMATING AREAL SEISMIC RISK POTENTIAL.
AUTHOR AFFIL.: Osaka City University, Japan., Proceedings of the Tenth World Conference on Earthquake Engineering; Madrid, 19-24 July 1992; A A Balkema, Rotterdam, 1992, volume 10, pages 6129-6132. ISBN: 90-5410-060-5; 90-5410-070-2
QUAKELINE ABSTRACT: A method for estimation of areal seismic risk potential in the region of Kochi Prefecture, Japan is given. Visible outcomes are obtained through analyses of the paper, the classification map of ground condition, distribution map of seismic intensity, liquefaction potential map, tsunami risk map, slope collapse potential map and damage distribution map of wooden buildings. Based on these results, the distribution of various risk potentials can be grasped and overall estimations of regional seismic hazards can be carried out. (Authors' abstract).
EEA ABSTRACT: A method for estimation of areal seismic risk potential in the region of Kochi Prefecture, Japan is given. Visible outcomes are obtained through analyses of the paper, the classification map of ground condition, distribution map of seismic intensity, liquefaction potential map, tsunami risk map, slope collapse potential map and damage distribution map of wooden buildings. Based on these results, the distribution of various risk potentials can be grasped and overall estimations of regional seismic hazards can be carried out.
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: EERC 400/W66/1992/v.10; SEL TA654.6.W67 10th v.10 EEA:

400/W66/1992/v.10
DOCUMENT NOS.: Quakeline: 9300247

Noh, Toshio. Sanriku Coast prepared for tsunami. Science Reports Seventh Series (Geography). (March 1966); 15 (Tohoku University, Faculty of Science, Sendai, Japan):1-24.

Morgan, Joseph. Tsunami Hazard in Tohoku and the Hawaiian Islands. Science Reports Seventh Series (Geography). (December 1979); 29(2):150-159.
Note: Tohoku University Faculty of Science, Sendai, Japan.

Tanimoto, Katsutosi; Kimura, Katsutoshi, STABILITY OF SUBMERGED DIKE AT THE OPENING SECTION OF TSUNAMI PROTECTION BREAKWATERS.
AUTHOR AFFIL.: Hydraulic Engineering Division, Port and Harbour Research Institute, Japan., Wind and seismic effects: proceedings of the 20th Joint Meeting of the US-Japan Cooperative Program in Natural Resources, Panel on Wind and Seismic Effects; Gaithersburg, MD, May 12-20, 1988; Raufaste-Noel-J, ed. US Department of Commerce, National Institute of Standards and Technology, Gaithersburg, 1989, pages 291-299.
NOTES: Series: National Institute of Standards and Technology special publication 760.
QUAKELINE ABSTRACT: The deepest breakwaters in the world are under construction in Kamaishi Bay in order to protect the port area from tsunamis as well as storm waves. Because of the narrowness, strong current of 8.2 m/s is expected for the design tsunami attack. The submerged dike consisting of a rubble mound foundation and a crown caisson must be stable against the strong current. In the present paper, the outline of an experimental study which has been carried out to give the design information is introduced. The model scale is 1/50 and the following subjects are investigated: 1) flow pattern around the opening section due to steady flow; b) stability of armour units for the submerged rubble mound foundation against periodic flows; c) hydrodynamic forces and stability of the submerged caisson. (Adapted from authors' abstract).
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL TA654.5.J64 1988
DOCUMENT NOS.: REPORT: NIST-SP-760
RECORD ID: QKLN-9000608

Kawaguchi, T.; Takeuchi, H., and Itoh, S. New tsunami countermeasures that take into consideration the development of the living environment and coastal landscape. . Tsunami 1993: Proceedings of the IUGG / IOC International Tsunami Symposium; Wakayama, Japan. Japan Society of Civil Engineers; 1993; 481-493.

Kim, Sung Kyun and Shimazu, Yasuo. Simulation of tsunami run-up and estimate of tsunami disaster by the expected Great Earthquake in the Tokai District, Central Japan. Journal of Earth Sciences. (December 1982); 30:1-30.

Tokyo Bureau of City Planning. Planning of Tokyo 1980. Tokyo: Tokyo Metropolitan Government. 1980; 59 pp.

Sakai, Sunao and Oshima, Nobora. Special problems in development of fishing communities in high tsunami risk regions. . Tsunami 1993: Proceedings of the IUGG / IOC International Tsunami Symposium; Wakayama, Japan. Japan Society of Civil Engineers; 1993; 599-612.

Iida, K. and Iwasaki, T., eds., Land Mangement Guidelines for Tsunami Hazard Zones. Tsunamis—Their Science and Engineering. Tokyo: Terra Scientific Publishing Co.; 1983; pp. 527-539.

Pararas-Carayannis, George. Tsunami Impact on Society. Iida, K. and Iwaska, T., eds. Tsunamis—Their Science and Engineering. Tokyo: Terra Scientific Publishing Co.; 1983; pp. 3-8.

Hadfield, Peter. Sixty Seconds that Will Change the World: The Coming Tokyo Earthquake. Boston, Mass.: Charles E. Tuttle Co.; 1991. 207 pp.
NOTES: Originally published: London: Sidgwick &Jackson, 1991

QUAKELINE ABSTRACT: This book, written by a British journalist living in Japan, discusses earthquake hazard for the Tokyo metropolitan area. He states that a major earthquake in Tokyo is imminent, and, through studying the Great Kanto earthquake of 1923 and its aftereffects, predicts that the losses will be devastating. He states that, with a population over 31 million people and the world's largest stock exchange, Tokyo would suffer extreme human and property losses in the event of a major earthquake, and the economic losses would be felt around the world. According to the author, the government of Japan has not done enough to prepare for an earthquake of any great magnitude, despite major work done by researchers in engineering and geology. The author includes interviews with people working in Japanese government, earthquake research, and economics.
EEA ABSTRACT: Sometime in the next few years geologists believe that Tokyo will experience a severe earthquake — one far worse than the Kobe earthquake of January 1995. The impact of a Tokyo earthquake will be cataclysmic both in human and economic terms. The financial shock waves will be felt in markets from New York to London, spurring a major worldwide recession. The author provides a chilling future economic scenario based on in-depth interviews with Japan's leading geologists, engineers, and economists.
PUB. TYPE: Monograph
CALL NUMBER: QUAKELINE: SEL QE537.2.J3.H33 1991 ¶ EEA: 755/H22/1995 NCEER: QE537.2.J3 H33 1991 [Science and Engineering Library] ¶ EERC: 755 H22 1992 [EERC]
RECORD ID: QKLN-9300796 ¶ EEA-253592 ¶ NCEER-EAU9160 ¶ EERC-005973

Yoshii, Hiroaki. Responses to a Japanese tsunami warning and lessons for planning countermeasures. Disaster Management. 1990; 3(2):90-93.
At 3:25 A.M. on November 2, 1989, a magnitude 7.1 earthquake struck 105 km off the northeastern Japan coast, precipitating a tsunami warning nine minutes later. Research carried out by the author after the event revealed that only 23% of the municipalities in the warning (high risk) and advisory (lesser risk) target areas called out their emergency response officers just after the quake took place, that only 15% of the seaside municipalities warned residents to evacuate, and that 54% of the municipalities received their first tsunami warning through the prefectural emergency radio network 15 to 24 minutes after the earthquake. Other findings from the survey of 2098 residents in the Sanriku region: 1) the alerting of residents of a possible tsunami was carried out by 80% of municipalities in the warning area, but only 14% in the advisory areas; 2) nearly all the residents obtained the tsunami warning through television news and the municipal radio communication network; and 3) considerable confusion accompanied the evacuation orders that were issued.

Yanev, Peter I. and Scawthorn, Charles R. Hokkaido Nansei-oki, Japan Earthquake of July 12, 1993. Buffalo, N.Y.: State University of New York-Buffalo, National Center for Earthquake Engineering. 1993; Technical Report NCEER-93-0023. 140 pp.
Note: OBSERVER 19, no. 1 (September 1994): 22.
This document reviews the damage caused by the magnitude 7.8 earthquake that occurred off the Island of Hokkaido in Japan on July 12, 1993. The quake caused moderately strong ground shaking over a wide area and was followed by tsunami, which devastated the town of Aonae. In addition to general seismological information about the event, the report describes damage to lifelines and critical facilities, including highways, bridges, tunnels, power generating facilities, telecommunications, chemical storage tanks, ports and harbors, and underground fuel lines. Also discussed is damage caused by the tsunami, landslides, and a severe fire started by the quake. Although the earthquake and the ensuing events affected a lightly populated part of the least populated major island of the Japanese archipelago, it can be regarded as a microcosm of what could happen to Tokyo and other large coastal cities situated in the Pacific Basin. The most important lesson imparted by the event and its aftermath is that the triple hazards of earthquake shaking followed by tsunamis and fires can be devastating to modern cities.

Hwang, Li San; Hammack, Joseph, JAPAN SEA CENTRAL REGION TSUNAMI OF MAY 26, 1983: A RECONNAISSANCE REPORT., National Academy Press, Washington, DC, 1984.
AUTHOR AFFIL.: Tetra Tech, Inc, Pasadena, CA, USA.
INST. AUTHOR: National Science Foundation (U.S.)

NOTES: Prepared by the Committee on Natural Disasters, Commission on Engineering and Technical Systems, National Research Council. Study supported by the National Science Foundation and the National Academy of Sciences. Supported by the National Science Foundation, CEE-8219358
QUAKELINE ABSTRACT: This report describes the effects of a tsunami that struck Japan on May 26, 1983 following an earthquake in the Japan Sea. Text and photographs describe the wave formation and note the progress of the series of waves along the entire coast of the Japan Sea including Korea and parts of the USSR. Variations in run up are noted. Much damage resulted from collision with floating structures and it is recommended that such structures be moved out to sea as soon as a tsunami warning is received. Protective structures including levees and seawalls designed to withstand storm waves were damaged by the tsunami. It is noted that public education is required to encourage people to heed tsunami warnings and to make officials aware of the need to circulate tsunami warnings with urgency.
EEA ABSTRACT: This report focuses on the tsunami generated twelve minutes after the Japan Sea earthquake occurred. The tsunami affected the entire Japan Sea, reaching the surrounding coastline of the Korean Peninsula and the U.S.S.R. The data presented were collected during site visits to Japan and South Korea approximately six weeks after the earthquake.
PUB. TYPE: Technical report, Monograph
AVAILABILITY: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. NTIS price codes: PC A03/MF A01.
CALL NUMBER: QUAKELINE: SEL GC221.2.H8 1984 ¶ EEA: 705.62/1983A/H92 EERC: 705.62 1983A H92 [EERC]
DOCUMENT NOS.: GRANT: CEE-8219358; REPORT: CETS-CND-026, Report No.: CETS-CND-026
RECORD ID: QKLN-9202979 , EEA-141286, EERC-006647

Uda, Takaaki; Omata, Atsushi, DAMAGES TO COASTAL AND RIVER STRUCTURES CAUSED BY THE NIHONKAI-CHUBU EARTHQUAKE TSUNAMI. Wind and seismic effects: Proceedings of the 17th Joint Panel Meeting of the US-Japan Cooperative Program in Wind and Seismic Effects; Tsukuba, Japan, May 21-24, 1985; Raufaste-Noel-J, ed. US Department of Commerce, National Bureau of Standards, Gaithersburg, MD, May 1986, pages 299-313.
AUTHOR AFFIL.: Public Works Research Institute, Ministry of Construction, Ibaraki-ken 305, Japan.
NOTES: Seventeenth Joint Panel Meeting of the US-Japan Cooperative Program in Wind and Seismic Effects.
QUAKELINE ABSTRACT: The 1983 Nihonkai-Chubu Earthquake Tsunami damaged many coastal structures and river administration facilities. These were investigated by using photographs taken right after the tsunami. The dominant types of damage were scouring around the structure, collapsing of the structure, and scattering of the blocks of detached breakwaters or wave dissipation breakwaters. Damage patterns are classified with respect to the kind of structure and estimated external force. Finally, all instances of damages are counted. In total, 63 coastal structures and 12 river administration facilities were damaged. (Abstract from text).
PUB. TYPE: Conference paper
AVAILABILITY: National Technical Information Service, Springfield, VA 22161, USA.
CALL NUMBER: QUAKELINE: SEL TA654.5.J64 1985
DOCUMENT NOS.: REPORT: NBS-IR-86-3364
RECORD ID: QKLN-8701123

Okazaki, Shintaro; Shibata, Kosuke, and Shuto, Nobuo. Road disaster prevention against tsunamis along Sanriku coast in Iwate Prefecture. . Tsunami 1993: Proceedings of the IUGG / IOC International Tsunami Symposium; Wakayama, Japan. Japan Society of Civil Engineers; 1993; 423-434.

Nakano, Takamasa and Matsuda, Iware. Earthquake damage, damage prediction, and countermeasures in Tokyo. Essays in Geography of Tokyo: Geographical Reports of Tokyo Metropolitan University. 1980; (14-15):141-153.
The Tokyo Earthquake and Fire Protection Ordinance, adopted in 1971, mandates a

compulsory regional survey in order to ascertain 1) how damage from earthquakes can be minimized, 2) the means by which earthquake awareness can be furthered among Tokyo's citizens, and 3) where earthquake and fire countermeasures should be allocated and given priority status. Elements which were surveyed included the distribution of wooden houses, the social characteristics of each block, and the distance to open spaces in case emergency evacuation measures should be found necessary. The Tokyo Metropolitan Government's overriding concern for fire prevention and suppression is evidenced by its main countermeasure proposals, such as the laying of water tanks along roads to open space evacuation points and construction of fire-resistant high-rise buildings. Although the amenities of urban civilization undoubtedly allow Tokyo residents to live a more comfortable life than in past years, technology has greatly complicated the problems anticipated from the occurrence of another major earthquake. Should they catch fire, the area's huge store of chemicals can produce very toxic gases; people may be trapped in the proliferating subway system and underground shopping centers; and should a tsunami be generated, Tokyo could be vulnerable to massive flooding due to subsidence from ground-water withdrawal which has left nearly 68 square kilometers lying below sea level.

Nakamura, Shigehisa, NOTE ON NUMERICAL EVALUATION OF TSUNAMI THREATS BY SIMPLE HYDRODYNAMIC AND STOCHASTIC MODELS REFERRING TO HISTORICAL DESCRIPTIONS., Bulletin of the Disaster Prevention Research Institute, volume 37, part 1, number 322, March 1987, pages 1-18.ISSN: 0454-7675

QUAKELINE ABSTRACT: This work is a speculative study to clarify what is essential for hydrodynamic or stochastic studies of the tsunamis and what are important in the historical descriptions and the tsunami catalogs for numerical simulation and prediction and for stochastic evaluation of practical tsunami protection works. First, a brief description of the historical documents of past tsunamis are introduced and evaluated in order to give a local chronological tsunami catalog which will aid in understanding what should be remarked at reading the tsunami descriptions. Next to the descriptive tsunamis, numerical simulation of the past tsunamis were reviewed and evaluated. The author's finite difference method with a uniform grid spacing is introduced in order to show an agreeable result as a simulation of a tsunami. The author has used a uniform grid spacing in his numerical model because he knows that it is helpful in minimizing the truncation error in a numerical model of a finite difference method. In any numerical simulation case, the historical descriptions are the essential references to confirm how successful the simulation is. Although, no numerical model can predict when the next tsunami occurs. The stochastic model is now very useful in making probabilistic prediction. This measure is for long-term practical planning of tsunami protection works with reliable references selected out of the historical documents of the past tsunamis and the tsunami catalogs well revised. (Author's abstract).

EEA ABSTRACT: This work intends to clarify what is essential for conducting hydrodynamic or stochastic studies of tsunamis and to identify what is important in the historical descriptions and the tsunami catalogs for numerical simulation and prediction and for stochastic evaluation of structures to protect them from tsunamis. Historical documents for past tsunamis are briefly described and evaluated to give a local chronological catalog which will aid in understanding what should be noted when reading the historical tsunami descriptions. Numerical simulations of past tsunamis are reviewed and evaluated. A finite difference method developed by the author that uses a uniform grid spacing is introduced for simulating tsunamis.

PUB. TYPE: Journal article

AVAILABILITY: Disaster Prevention Research Institute, Kyoto University, Gokasho, Uji, Kyoto, 611, Japan.

CALL NUMBER: QUAKELINE: SEL Per TA495.K9, EEA: 320/K95

RECORD ID: QKLN-8800734 EEA-5606

Mexico

Pruess, J., PLANNING FOR RISK: COMPREHENSIVE PLANNING FOR TSUNAMI HAZARD AREAS., Urban Regional Research, place of publication unknown, 1988.

INST. AUTHOR: Urban Regional Research
NOTES: All materials incorporated in this work were developed with the financial support of the National Science Foundation.
QUAKELINE ABSTRACT: This book discusses tsunami preparedness for areas on the Pacific Coast of the United States which may be at risk, particularly Alaska. An introductory section provides an overview of tsunami damage patterns through a discussion of historical events and development of a numerical simulation. Included in the discussion are water forces, debris impact, contamination, fire, sand transport, and marine installations, such as wharves, piers, docks and boats. Much of the work centers around Kodiak, Alaska which suffered a major tsunami in 1964. A chapter explores the low velocity, creeping-bore type tsunami experienced in Mexico in 1985. Several chapters develop damage control provisions through barrier or sea wall style damage prevention measures. Also presented are life safety procedures involving evacuation. An appendix lists toxic materials which may create a hazard in the event of a tsunami.
PUB. TYPE: Monograph
CALL NUMBER: QUAKELINE: SEL GC221.2.U72 1988
DOCUMENT NOS.: GRANT: NFS CEE-8408237
RECORD ID: QKLN-9200884

Farreras, Salvador F.; Sanchez, Antonio J., TSUNAMI THREAT ON THE MEXICAN WEST COAST: AN HISTORICAL ANALYSIS AND RECOMMENDATIONS FOR HAZARD MITIGATION., Natural Hazards: Journal of the International Society for the Prevention and Mitigation of Natural Hazards, volume 4, number 2/3, 1991, pages 301-316. ISSN: 0921-030X
AUTHOR AFFIL.: Division de Oceanologia, Centro de Investigacion Cientifica y de Education Superior de Ensenada (CICESE), Apartado Postal 2732, Ensenada, Baja California 22800, Mexico.
NOTES: Supported by Mexican National SciTech Council and National Science Foundation. From a special issue on Tsunami Hazard, edited by E N Bernard, consisting of selected papers from the Fourteenth International Tsunami Symposium; Novosibirsk, USSR, July 31-August 3, 1989. Reprinted in "Tsunami Hazard: A Practical Guide to Tsunami Hazard Reduction" (Kluwer Academic, Dordrecht, 1991).
Utilizing information gathered from newspaper archives, previous catalogs, local witness interviews, and tide gauge records, the authors have compiled a catalog of west coast Mexican tsunamis stretching back nearly two centuries. This article discusses the methods used to compile the catalog and describes some of the worst events, such as the great June 1932 Cuyutlan tsunami. Warning systems affecting Mexico's Pacific shores are examined and the article also explores the tsunami threat to Mexico's expanding tourist and shipping industries. Suggestions are made for delineating coastal hazard zones, particularly in Santa Cruz, where a major petroleum shipping facility is located. The population of Santa Cruz also is much at risk from tsunamis since the only realistic evacuation route passes through an extremely congested intersection crossed by railroad tracks. Thirteen other articles on tsunamis are included in this topical issue of Natural Hazards.
QUAKELINE ABSTRACT: From an inspection of all tide gauge records for the western coast of Mexico over the last 37 years, a database of all recorded tsunamis was made. Information on relevant historical events dating back two centuries, using newspaper archives, previous catalogs, and local witness interviews, was added to produce a catalog of tsunamis for the western coast of Mexico. This information and knowledge of local undersea faulting characteristics along the Mexican Pacific coast leads to a clear differentiation of two zones of potential tsunami hazard. Based on this zonation, two types of tsunami warning systems are proposed: real-time for the southern zone, and delayed-time for the northern. A description is provided of the Baja California Regional Tsunami Warning System that is presently operational in the northern zone. Several major industrial ports and tourist resort areas are located in the southern zone, and are therefore most vulnerable to local destructive tsunamis. Some of these sites represent important socioeconomic resources for Mexico, and have therefore been chosen for a vulnerability assessment and microzonation risk analysis. Land use patterns are identified, risks defined, and recommendations to minimize future tsunami impact are given. One case is illustrated. (Abstract adapted from journal).
PUB. TYPE: Conference paper; Journal article

CALL NUMBER: QUAKELINE: SEL GC219.T76 1991; SEL Per GB5000.N39
DOCUMENT NOS.: GRANT: P218CCOC880065; ICCNXNA-031341; NSF INT-8709972
RECORD ID: QKLN-9101653

New Zealand

Hastie, W J.; Van Dissen, R J., ASSESSMENT OF SEISMIC HAZARD IN THE WELLINGTON REGION, NEW ZEALAND., Proceedings [of the] Pacific Conference on Earthquake Engineering; Auckland, New Zealand, 20-23 November, 1991; New Zealand National Society for Earthquake Engineering, [Wellington], 1991, volume 2, pages 135-145.
AUTHOR AFFIL.: Wellington Regional Council, Wellington, New Zealand.
QUAKELINE ABSTRACT: The Wellington Regional Council and the New Zealand Department of Scientific and Industrial Research (DSIR) have jointly developed a multi-tiered approach for seismic hazard assessment in the Wellington region. The key components of this investigation include an assessment of the fault rupture, ground shaking, tsunami, liquefaction and lateral spreading, landslip, and locally significant hazards within the region. Results to date from the tsunami and ground shaking hazard assessment are presented. This prescription for seismic hazard assessment, though developed for the Wellington region, is applicable to other areas throughout New Zealand, both on a regional and site-specific scale. (Authors' abstract).
EEA ABSTRACT: The Wellington Regional Council and the New Zealand Dept. of Scientific and Industrial Research (DSIR) have jointly developed a multi-tiered approach for seismic hazard assessment in the Wellington region. The key components of this investigation include an assessment of the fault rupture, ground shaking, tsunami, liquefaction and lateral spreading, landslip, and locally significant hazards within the region. Results to date from the tsunami and ground-shaking hazard assessment are presented.
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL TA654.6.P33 1991 v.2 ¶ EEA: 400/P212/1991/v.2
RECORD ID: QKLN-9303793 ¶ EEA-13088

Speden, Ian and Crozier, M. J., comp. Natural Hazards in New Zealand. New Zealand National Commission for UNESCO. 1984.
New Zealand's distinctive physical environment and its level of scientific development contribute to making this locale a particularly suitable geographical area for the multidisciplinary study of natural hazards. Specific chapters deal with the following hazards: flooding, drought, frost, heavy snowfalls, severe hailstorms, lightning, fog, high winds, natural air pollution, climatic change, landslides and other slope instabilities, snow and ice avalanches, earthquakes, volcanoes, tsunami, subsidence, expansive soils, and naturally caused fires. Other chapters examine the social and economic implications of natural hazards in context with land use planning, the law, insurance, reconstruction alternatives, and public health. The contributed papers reveal a major gap in the understanding of natural hazards on the islands, particularly with regard to the national cost in social and economic terms. While the economic costs of some hazards (i.e., flooding), are known, there appeared to be no systematic framework for aggregating and recording the total community and individual costs on a hazard/time/location basis. Another study finding suggests that legislation and regulations covering natural hazards often are confusing, inadequate, or completely ignored.

Ridgway, N M., TSUNAMI HAZARD IN NEW ZEALAND., Scientific, economic and social reviews of natural hazards in New Zealand; Speden-Ian, comp. New Zealand National Commission for UNESCO, Wellington, 1984, pages 375-382.ISBN: 0-477-06719-0
AUTHOR AFFIL.: Division of Marine and Freshwater Research, DSIR, New Zealand,
NOTES: Tsunamis experienced in New Zealand.
QUAKELINE ABSTRACT: This report gives a basic view of tsunamis in New Zealand. It contains a list of tsunamis experienced in New Zealand since 1848, their size, and the originating volcano or earthquake. The author discusses coastal zoning, present research, prediction, costs and economic impact, and hazard mitigation.
PUB. TYPE: Technical report

CALL NUMBER: QUAKELINE: SEL GB5011.9.S34 1984
RECORD ID: QKLN-8801747

Peru

Kuroiwa, Julio. Tsunami studies and their application to Peru's soci-economic development and emergency planning. Tsunami 1993: Proceedings of the IUGG / IOC International Tsunami symposium; Wakayama, Japan. Japan Society of Civil Engineers; 1993; 849-860.
Note: 8 references.

Philippines

Haas, J. Eugene. The Philippine earthquake and tsunami disaster: A re-examination of behavioral propositions. Disasters. 1978; 2(1):3-11.

United Nations Centre for Regional Development. The Challenge of Mindoro: Report of the Quick Response Investigation of the Mindoro Island Earthquake in the Philippines on 15 November 1994. Nagoya, Japan: United Nations Centre for Regional Development. 1995; 42 pp. (UNCRD Research Report Series; 11).
Note: OBSERVER 20, No. 3 (January 1995): 21.
The Mindoro quake—a magnitude M7.1 event—killed 78 people, 41 of whom were drowned by a tsunami. In addition, 1,500 homes were totally destroyed and an additional 6,000 were damaged. The economic cost to the Philippines was estimated at 500 million pesos. This report includes background geologic information about the quake, information about the resulting tsunami and liquefaction, a description of these hazards' effects, a discussion of response and relief operations, an inventory of lessons learned, and recommendations. The Rossi-Forel earthquake intensity scale is presented in an appendix.

Washington

Hays, Walter W., ed,. Workshop: Evaluation of Earthquake Hazards and Risk in the Puget Sound and Portland Area. Reston, Virginia: U.S. Dept. of the Interior, Geological Survey. 1988; Open-File Report No. 88-541. 339 pp.
Held April 12-15, 1988 in Olympia, Washington, the 42nd "Regional Earthquake Hazards Assessment" workshop undertook three basic tasks: to assess the status of knowledge about earthquake hazards in Washington and Oregon, including scientific, engineering, and hazard reduction components; to determine the need for additional scientific, engineering, and societal response information; and to develop a strategy for implementing programs to reduce potential earthquake losses and to foster preparedness and mitigation measures. Seventeen papers discuss seismological and geological aspects of earthquake and tsunami hazard in the region, and 16 papers address the preparedness and mitigation projects either functioning or being planned in at-risk areas. Topics examined in the latter category include government liability, education and awareness programs, safety in the schools, land use planning, and public policy options for achieving maximum seismic safety practices.

Hays, Walter W. and Gori, Paula L., eds., Earthquake Hazards in the Puget Sound, Washington Area. Reston, Virginia: U.S. Dept. of the Interior, Geological Survey. 1986; Open-File Report No. 86-253. 258 pp.
Seventeen papers appear in the proceedings of USGS Conference XXXIII, held October 29-31, 1985, in Seattle, Washington. The papers can be divided into two general categories: technical papers related to local seismicity, ground shaking, ground failure, regional tectonics, and other geotechnical information; and contributed articles (6 of them) that deal with earth-

quake preparedness and hazards reduction. Topics addressed in the latter context include earthquake awareness and education programs, response planning, the status of local seismic building codes, warning systems and contingency planning for tsunamis, damage estimates, and liability issues. The volume also provides background information, a summary of workshop accomplishments, a participant list, and a glossary of technical terms.

Preuss, Jane; Hebenstreit, Gerald T., INTEGRATED HAZARD ASSESSMENT FOR A COASTAL COMMUNITY: GRAYS HARBOR, U.S. Geological Survey open-file report; 91-441-M. |
AUTHOR AFFIL.: Urban Regional Research, Seattle, WA 98101, USA.
INST. AUTHOR: U.S. Geological Survey
NOTES: Research sponsored by US Geological Survey. Series: Earthquake Hazards in the Pacific Northwest of the United States.
QUAKELINE ABSTRACT: This paper describes a project to develop and apply a methodology for an integrated hazard assessment which treats the earthquake-generated tsunami/flood event not as the sole threat but as the initiator of a suite of interrelated hazards. Since vulnerability to discrete risk factors varies from community to community, a risk-based urban planning approach is developed which balances the needs of waterfront activities (industrial and resort) with safety and preparedness requirements in coastal areas vulnerable to tsunamis and earthquake-induced flooding. The implications of the tsunami hazard generated on the outer Washington coast and impacting Grays Harbor is used as a case study. This study area generally corresponds to the location of sand lenses discovered on the outer Washington coast at Willapa Bay and Grays Harbor which have been interpreted as the area which has experienced tsunami impacts from great subduction events in the past. (Adapted from authors' abstract).
PUB. TYPE: Technical report | Monograph
CALL NUMBER: QUAKELINE: SEL QE75.O74 no.91-441-M | NCEER: QE75.O74 no.91-441-M [Science and Engineering Library] | EERC: 380.1 E277 1991 441-M [EERC]
DOCUMENT NOS.: GRANT: USGS-14-08-0001-G1346
RECORD ID: QKLN-9303923 | NCEER-EBM0798 | EERC-011278

U.S. Dept. of the Interior., Third Annual Workshop on Earthquake Hazards in the Puget Sound, and Portland Area. Reston, Virginia: U.S. Dept. of the Interior, Geological Survey. 1989; Open-File Report 89-465. 329 pp.
The 200 researchers, practitioners, and other concerned persons who attended this workshop shared both technical geologic and engineering information as well as more fundamental information on earthquakes and human behavior that could be used to enhance earthquake mitigation, planning, and response. The nontechnical papers examine such topics as fundamental earthquake effects on land and water, effects on buildings and lifelines, loss estimation by insurance companies, earthquake hazard information dissemination and use, volunteer earthquake response organizations, risk reduction policies and practices in the Puget Sound area, and postdisastaer emergency response in urban settings. Other subjects addressed include regional seismicity and tectonics, landslide potential, risk assessment, proposed state seismic safety legislation, local tsunami hazard, liquifaction mapping, earthquake effects on land and water, lifelines, and safety measures in schools.

Whitmore, Paul M., EXPECTED TSUNAMI AMPLITUDES AND CURRENTS ALONG THE NORTH AMERICAN COAST FOR CASCADIA SUBDUCTION ZONE EARTHQUAKES., Natural hazards: journal of the International Society for the Prevention and Mitigation of Natural Hazards, volume 8, number 1, July 1993, pages 59-73. ISSN: 0921-030X
AUTHOR AFFIL.: Alaska Tsunami Warning Center, 910 S Felton Street, Palmer, AK 99645, USA.
QUAKELINE ABSTRACT: Tsunamis are numerically modeled using the nonlinear shallow-water equations for three hupothetical Cascadia subduction zone earthquakes. Maximum zero-to-peak tsunami amplitudes and current are tabulated for 131 sites along the North American coast. Earthquake source parameters are chosen to satisfy known subduction zone configuration and thermal constraints. These source parameters are used as input to compute vertical sea-floor displacement. The three earthquakes modeled are moment magnitude 8.8, 8.5, and 7.8. Maximum zero-to-peak tsunami amplitude for the M sub w

= 8.8 earthquake is near 6 m normal to the fault break and maximum current is near 3.5 sub s. Maximum amplitudes decrease by about one-half north and south of the fault break in the source region. Tsunami amplitudes vary along the Alaskan coast from less than 0.5 to 1.6 m. The modeled amplitudes for the M sub w decrease 8.8 quake decrease to less than 0.4 m south of Point Conception, CA. The M sub W = 7.8 earthquake generates a tsunami with a maximum amplitude of less than 1 m normal to the source. North and south of the fault break the maximum amplitude again decreases by about one-half. In all the models, amplitudes and current are less than one-sixth of the outer coast value within Puget Sound. (Abstract from journal).
EEA ABSTRACT: Tsunamis are numerically modeled using the nonlinear shallow-water equations for three hypothetical Cascadia subduction zone earthquakes. Maximum zero-to-peak tsunami amplitudes and currents are tabulated for 131 sites along the North American coast. Earthquake source parameters are chosen to satisfy known subduction zone configuration and thermal constraints. These source parameters are used as input to compute vertical sea-floor displacement. The three earthquakes modeled are moment magnitude 8.8, 8.5, and 7.8.
PUB. TYPE: Journal article
CALL NUMBER: QUAKELINE: SEL Per GB5000.N39 ¶ EEA: 750/N31
RECORD ID: QKLN-9502195 ¶ EEA-238168

Land Use

Curtis, George D. Methodology for developing tsunami inundation and evacuation zones. Honolulu, Hawaii: University of Hawaii, Joint Institute for Marine and Atmospheric Research. 1990; 6 pp.

White, Gilbert F.; Baker, Earl J.; Baumann, Duane D.; Chow, Willard T.; Downing, Thomas E.; Lord, William B.; Marts, Marion E.; Mitchell, James Kenneth; Platt, Rutherford H.; Sorensen, John H.; Tubbesing, Susan K., and Waterstone, Marvin. Natural Hazard Management in Coastal Areas. Washington, D.C.: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Office of Coastal Zone Management. 1976; 249 pp.
The handbook consists of 1) an executive summary, 2) a definition and discussion of possible adjustments for the major coastal hazards: hurricane, flood, coastal erosion, landslide, earthquake, tsunami, volcano, avalanche and land subsidence, 3) a section on problems and recommendations, and 4) a discussion of hazard management in each of the thirty coastal states. Section 5 is an annotated bibliography; section 6 a directory of federal, state and voluntary agencies concerned with natural hazards in the coastal zone. The six appendices include legal aspects of coastal zone hazard management, possible adjustments to regional hazards problems, and a checklist of relevant state programs.

American Society of Civil Engineers. Coastal Zone '78: A Symposium on Technical, Environmental, Socioeconomic, and Regulatory Aspects of Coastal Zone Management New York, N.Y.: American Society of Civil Engineers; 1978; 3091 pp.
Sponsored by the ASCE, the Conservation Foundation, and the U.S. Office of Coastal Zone Management in cooperation with 14 other public and private agencies, the symposium was held in San Francisco, California during March 14-16, 1978. Coastal Zone '78 was designed to stimulate productive discussion and interaction on pertinent coastal issues, and to provide a forum which would lead to a better understanding of the inter-relationships between the environmental, socioeconomic, engineering, and regulatory decisions involved. Two hundred papers presented at the meeting are reproduced in these four volumes. Approximately one-fourth of the papers deal with topics of direct interest to natural hazard managers, while the remaining contributions treat subjects such as offshore energy development, the management of port facilities and urban waterfronts, water quality, coastal mapping, and the like. Hazard-related matters are dealt with by papers on west coast tsunami hazard, coastal legal issues, model building codes, flood insurance studies, citizen participation, and a variety of

flood and wetland issues. An extensive subject index adds considerably to the usefulness of the publication.

Nichols, D. R. and Buchanan-Banks, J. M. , Seismic Hazards and Land-Use Planning. Washington, D.C.: U.S. Dept. of the Interior, Geological Survey. 1974; USGS Circular 690. 33 pp.

Office of the United Nations Disaster Relief Coordinator (UNDRO), DISASTER PREVENTION AND MITIGATION: VOLUME 3, SEISMOLOGICAL ASPECTS., United Nations, New York, 1978.
NOTES: The set, "A compendium of current knowledge".
QUAKELINE ABSTRACT: This volume, deals mainly with ways of studying earthquakes and the measures which can be taken to mitigate or prevent their disastrous effects. It discusses the different methods devised for this purpose and identifies subject areas in which research is still necessary. Fundamental considerations of seismic waves, aftershocks and foreshocks are given. The microseismic and macroseismic study of earthquakes is discussed. The earth's seismicity and the major seismic zones are covered. There is a chapter on prediction. Acceleration measurements, response spectra and methods for calculating structural response are treated. The role of seismological studies in land development and town planning is discussed. The effects of earthquakes in terms of the economic distress they create is also treated, and there is also a brief chapter on tsunami, one of the more severe side-effects of earthquakes. (Abstract adapted from text).
PUB. TYPE: Monograph
CALL NUMBER: QUAKELINE: SEL GB5005.U54 1976 v.3
RECORD ID: QKLN-8801416

Urban Regional Research , LAND MANAGEMENT GUIDELINES IN TSUNAMI HAZARD ZONES.
SOURCE: Publisher, place of publication unknown, 1982.
NOTES: Prepared for the National Science Foundation.
QUAKELINE ABSTRACT: This project develops a variety of practical solutions addressing the complicated problem of land management in tsunami hazard zones. It proposes a dual approach to land management. One is the regional level utilizing the tsunami hazard as a factor in allocating land uses and planning major public investments. The other is development of definitive criteria for specific project areas. The focus of the project methodology is on nonstructural measures. A chart of water depth compared with wave speed and a chart of average tsunami speeds for Hawaiian tsunami are included.
PUB. TYPE: Monograph
CALL NUMBER: QUAKELINE: SEL GC220.3.L25 1982
RECORD ID: QKLN-9002525

Preuss, Jane., Tsunami Hazard Reduction Through Risk Management. : Bernard, E. N. Proceedings of the International Union of Geodesy and Geophysics; 1987 Aug 18-1987 Aug 19; Vancouver, B.C., Canada. 1987.
Note: Proceedings.

Preuss, Jane; Hebenstreit, Gerry, TSUNAMI THREAT IN THE PACIFIC NORTHWEST UNDER TODAY'S LAND USE CONDITIONS. Proceedings of conference XLVIII: 3rd annual workshop on earthquake hazards in the Puget Sound, Portland area; March 28-30, 1989, Portland, Oregon; Hays-Walter-W, ed. US Geological Survey, Reston, VA, 1989, pages 114-121.
AUTHOR AFFIL.: Urban Regional Research, Seattle, WA, USA.
QUAKELINE ABSTRACT: The authors briefly describe a project to provide estimates of the risk that a tsunami will strike the coast of Washington or Oregon. The project, conducted jointly by the Science Applications International Corporation (SAIC) and Urban Regional Research, develops a methodology for defining the characteristics of coastal tsunami risks and for projecting the vulnerability of the geographic area.
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL QE75.O74 no.89-465
DOCUMENT NOS.: REPORT: 89-465
RECORD ID: QKLN-9001357

Preuss, Jane, APPLICATION OF MICROZONATION CONCEPT TO LAND MANAGEMENT IN TSUNAMI HAZARD ZONES., Third International Microzonation Conference: proceedings: Seattle, June 28-July 1, 1982; Publisher, place of publication unknown, 1982, volume II, pages 717-728.
AUTHOR AFFIL.: Urban Regional Research.
NOTES: Research funded by the US National Science Foundation. Vol. II
QUAKELINE ABSTRACT: The purpose of the project described in this paper is to apply a two tier concept of microzonation to development of an approach to land management in tsunami high hazard zones. The proposed planning approach is organized into two interrelated components based on the dynamics of the tsunami hazard. Part I of the paper describes technical issues at the regional scale which relate to definition of the hazard zone in terms of locational susceptibility. Once an administrative decision has been made to permit development in an identified tsunami hazard zone, the tsunami issues which must be addressed will pertain to the varying aspects of wave forces. Part II of the project therefore proposes a more refined zonation approach to protect scale planning. Definition of these sub-zones within the project area are based on the dynamics of the tsunami wave in relation to characteristics of the coastal segment. (Adapted from author's abstract).
EEA ABSTRACT: The purpose of the project described in this paper is to apply a two-tiered concept of microzonation to development of an approach to land management in high-risk tsunami hazard zones. The proposed planning approach is organized into two interrelated components based on the dynamics of the tsunami hazard. Part I of the paper describes technical issues at the regional scale which relate to definition of the hazard zone in terms of locational susceptibility. Planning and microzonation issues at the regional scale are thus concerned with the allocation of land uses, with major open space planning and with the location of major connecting transportation routes. Once an administrative decision has been made to permit development in an identified tsunami hazard zone, the tsunami issues which must be addressed will pertain to the varying aspects of wave forces. Part II of the project therefore proposes a more refined zonation approach to project scale planning. Definition of these sub-zones within the project area is based on the dynamics of the tsunami wave in relation to characteristics of the coastal segment. Project scale or site planning consists of the integrated arrangement of three primary elements: buildings and structures, open spaces, and roads. This section develops hazard-based performance criteria for each site plan component designed to maximize development potential while minimizing exposure to the hazard.
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL QE531.I568 1982 v.2 | EEA: 45.1/I57/1982/v.II
DOCUMENT NOS.: GRANT: NSF PFR-7823884
RECORD ID: QKLN-8903635 ¶ EEA-121001320

Cox, Doak C., Hawaii Coastal Zone Management Program: Shoreline Property Boundaries in Hawaii. University of Hawaii, Environmental Center. 1980; Technical Supplement No. 21. 132 pp.
Because much of Hawaii's coast is vulnerable to tsunamis and severe storms, the question of how far seaward the ownership of private real property extends is more than just an exercise in legal maneuvering. The study examines court decisions dating as far back as 1858, but focuses primarily on four recent cases of important legal consequence. Pertinent constitutional, legislative, and administrative provisions are examined in detail, and seaward (or "makai") boundary desiderata are closely scrutinized. The meanings of more than 30 specific boundary descriptors, both English and Hawaiian, are discussed in terms of their precise or legal meanings and of their imprecise and ambiguous semantic connotations. The author suggests that although the makai boundary question is of obvious importance to coastal zone management programs, the significance of private seashore ownership may be considerably diminished due to extensive government regulation of the coastal zone. Legislation is suggested which would resolve some of the existing problems and lead to a coherent and consistent management policy for the coastline.

Clark, John R. Coastal Zone Management Handbook. Boca Raton, Fla.: Lewis Publishers; 1996. 694 pp.

Proceedings

Disaster Preparedness Resource Centre. Abstracts for the Pan Pacific Hazards '96 Conference and Trade Show; 1996 Jul 29-1996 Aug 2; Vancouver, British Columbia. Vancouver, B.C.: University of British Columbia Press; 1996; 320 pp.
Note: Papers on CD ROM inside front cover. OBSERVER 21, No. 1 (November 1996): 20.
The printed volume contains the abstracts of papers presented at Pan Pacific Hazards '96, the first international conference held in Canada to focus on tsunamis, earthquakes, and volcanoes. It includes abstracts on earthquake response, the use of geographic informations systems, business resumption planning, the use of volunteers in rescue operations, and many other topics. Drawn from a variety of disciplines, the abstracts include the names of presenters and/or authors, their affiliation, and complete contact information for obtaining the full papers. The CD-ROM contains all the abstracts in the printed document as well as the full text of 90 conference papers. Abstracts can be accessed by title, name of author, country of author, and keyword.

Bernard, E N., editor, TSUNAMI HAZARD: A PRACTICAL GUIDE FOR TSUNAMI HAZARD REDUCTION. Kluwer Academic Publishers, Dordrecht, 1991. ISBN: 0-7923-1174-4
AUTHOR AFFIL.: Pacific Marine Environmental Laboratory, NOAA, Seattle, WA, USA.
NOTES: Reprinted from Natural Hazards, volume 4, numbers 2-3, 1991 (SEL Per GB5000.N39), a special issue of selected papers from the Fourteenth International Tsunami Symposium; Novosibirsk, USSR, July 31-August 3, 1989.
QUAKELINE ABSTRACT: This work presents 13 selected papers from the Fourteenth International Tsunami Symposium held in Novosibirsk, Siberia, July 31-August 3, 1989. The major topics around which these papers revolve are: 1) field observations and data analysis; 2) the analytical models of tsunamigenic and wave processes; and 3) tsunami hazards mitigation. This volume also includes the symposium's opening address and meeting reports from the Tsunami Workshop and the International Oceanographic Commission's Twelfth Session of the International Coordinating Group for the Tsunami Warning System in the Pacific.
PUB. TYPE: Monograph
CALL NUMBER: QUAKELINE: SEL GC219.T76 1991
RECORD ID: QKLN-9302523

Tsuchiya, Yoshito and Shuto, Nobuo, eds. Tsunami: Progress in Prediction, Disaster Prevention and WarningBoston, Mass.: Kluwer Academic Publishers; 1995; Advances in Natural and Technological Hazards Research 4368 pp.
Note: OBSERVER 20, No. 5 (May 1996): 22.
This volume contains the proceedings of the International Tsunami Symposium held in Wakayana, Japan, in 1993 by the Tsunami Commission of the International Union of Geodesy and Geophysics and the International Coordination Group of the International Oceanographic Commission. It includes an overview of the symposium; photographs of recent tsunami disasters; and several papers that address prediction and simulation, prevention and mitigation, tsunami observations and warning systems, survival actions taken by victims, and public education and awareness for tsunami planning.

Pararas, Carayannis, George , RISK ASSESSMENT OF THE TSUNAMI HAZARD. Natural and man-made hazards: proceedings of the international symposium held at Rimouski, Quebec, Canada, 3-9 August, 1986; El-Sabh-M-I, ed. D Reidel, Dordrecht, 1988, pages 183-191. ISBN: 90-277-2524-1
AUTHOR AFFIL.: International Tsunami Information Center, (Intergovernmental Oceanographic Commission (IOC)), P O Box 50027, Honolulu, HI 96850, USA.
QUAKELINE ABSTRACT: The risk potential of tsunamis is of extensive interest to governmental, non-governmental agencies, and to industries and the public in general. While some degree of risk is acceptable, government agencies should promote new development and population growth in areas of greater safety and less potential risk. Furthermore, these agencies should establish proper training for public safety personnel, and formulate land-use regulations for given coastal areas particularly if these areas are known to have sustained tsunami damage in the past. Finally, in designing important engineering structures in the coastal

zone, the risk resulting from the tsunami hazard should be evaluated and construction should incorporate adequate safety features. This paper provides some of the appropriate guidelines and methodology needed for the evaluation of the tsunami risk in terms of frequency of occurrence, severity of occurrence, severity of impact, design adequacy of important coastal structures, and finally, in terms of preparedness and planning for hazard mitigation. (Author's abstract).
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GB5001.N36 1988
RECORD ID: QKLN-8802385

Dawson, A G.; Shi, S.; Smith, D E.; Long, D., GEOLOGICAL INVESTIGATIONS OF TSUNAMI GENERATION AND LONG-TERM TSUNAMI FREQUENCY. Natural Disasters - Protecting Vulnerable Communities: Proceedings of the Conference held in London, 13-15 October 1993; Merriman-P-A, et al, eds; Thomas Telford, London, 1993, pages 140-146.
AUTHOR AFFIL.: Coventry University.
QUAKELINE ABSTRACT: This paper provides a brief geological and geophysical view of the generation of tsunamis by both submarine earthquakes and landslides. It discusses, for example, analysis of sediments associated with the prehistoric Storegga landslides off the coast of present day Norway, which produced a large tsunami in the North Sea. Other examples of the value of studying tsunami sedimentation and runup are provided. The paper also discusses the accuracy of numerical models of tsunami generation and propagation. Consideration of ways of mitigating the threat posed by tsunamis to the world's coastal populations concludes the paper.
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GB8014.N36 1993
RECORD ID: QKLN-9500204

Shuto, N., NUMERICAL SIMULATION OF TSUNAMIS: ITS PRESENT AND NEAR FUTURE. Natural Hazards: Journal of the International Society for the Prevention and Mitigation of Natural Hazards, volume 4, number 2/3, 1991, pages 171-191. ISSN: 0921-030X
AUTHOR AFFIL.: Department of Civil Engineering, Tohoku University, Aoba, Sendai 980, Japan.
NOTES: From a special issue on Tsunami Hazard, edited by E N Bernard, consisting of selected papers from the Fourteenth International Tsunami Symposium; Novosibirsk, USSR, July 31-August 3, 1989. Reprinted in "Tsunami Hazard: A Practical Guide to Tsunami Hazard Reduction" (Kluwer Academic, Dordrecht, 1991).
QUAKELINE ABSTRACT: Hindcasting of a tsunami by numerical simulations is a process of lengthy and complicated deductions, knowing only the final results such as run-up heights and tide records, both of which are possibly biased due to an insufficient number of records and due to hydraulic and mechanical limitation of tide gauges. There are many sources of error. The initial profile, determined with seismic data, can even be different from the actual tsunami profile. The numerical scheme introduces errors. Nonlinearity near and on land requires an appropriate selection of equations. Taking these facts into account, it should be noted that numerical simulations produce satisfactory information for practical use, because the final error is usually within 15 percent as far as the maximum run-up height is concerned. The state-of-the-art of tsunami numerical simulations is critically summarized from generation to run-up. Problems in the near future are also stated. Fruitful application of computer graphics is suggested. (Abstract from journal).
EEA ABSTRACT: Hindcasting of a tsunami by numerical simulations is a process of lengthy and complicated deductions resulting in run-up heights and tide records which may be biased due to an insufficient number of records or to the hydraulic and mechanical limitation of tide gauges. In this paper, the state of the art of tsunami numerical simulations is critically summarized from generation to run-up. Problems anticipated in the near future are examined. The application of computer graphics is considered.
PUB. TYPE: Conference paper; Journal article
CALL NUMBER: QUAKELINE: SEL GC219.T76 1991; SEL Per GB5000.N39 ¶ EEA: 750/N31
RECORD ID: QKLN-9101458 ¶ EEA-12530

De Blij, H. J. Nature on the Rampage. Washington, D.C.: Smithsonian Books; 1994. 224 pp.

A more densely-populated planet has led to larger cities, burgeoning coastal settlement, a vulnerable built environment, and simply, less room to hide from natural catastrophes. This volume provides a visual and practical guide to what is currently known about hazardous natural forces and how to employ common sense in dealing with them. Following an introduction by the editor, four chapters address different aspects of natural phenomena. "Weather's Fury," by Richard Lipkin, explores the word of hurricanes, tornadoes, lightning, floods, and winter storms. "From Fire to Ice," By Elizabeth Culotta, traces the physical and social impacts of climate extremes from cold, ice, and glaciation to drought, desertification, and wildfire. The dangers presented by earthquakes, volcanoes, and tsunamis is dealt with by Richard Monastersky in "The Unstable Earth." In "The Nature of Risk," Dennis Flanagan explains how the concept of risk analysis has evolved and how public education can provide a basis for making rational decisions about coexisting with natural hazards. Many stunning photographs underline the text's cautions about not taking nature's forces lightly.

Proceedings of the Second International Tsunami Workshop

Lander, James F., HISTORICAL APPROACH TO THE STUDY OF TSUNAMIS: RESULTS OF RECENT UNITED STATES STUDIES. Proceedings of the Second International Tsunami Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation; Novosibirsk, USSR, August 4-5, 1989; Pararas-Carayannis-George, ed. Unesco, [Paris, 1991], pages 226-237.

AUTHOR AFFIL.: Cooperative Institute for Research in Environmental Science, University of Colorado, Boulder, CO 80309, USA.

NOTES: Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, supplement.

QUAKELINE ABSTRACT: An essential element in developing an appropriate response to a tsunami hazard is a detailed knowledge of the effects of prior tsunamis. From this the design tsunami can be selected to be used with the contemporary coastal zone development and variables such as possible tide stages and time of day and data effects. Warning systems, education, insurance, emergency planning (including evacuation, and search and rescue), modeling and engineering options may be combined to mitigate the hazard. An analysis of the historical tsunami record from Hawaii, Alaska, the United States' West Coast and the Puerto Rico/Virgin Islands area shows the hazard to be quite different among these areas and among localities within each region. Although the quality of the compiled historical record for United States tsunamis has been substantially improved, further improvements can be made. (Author's abstract).

PUB. TYPE: Conference paper

CALL NUMBER: QUAKELINE: SEL GC219.I57 1989

RECORD ID: QKLN-9203101

Gusiakov, V K.; Marchuk, An G.; Titov, V V., APPLICATION OF NEW NUMERICAL METHODS FOR NEAR-REAL TIME TSUNAMI HEIGHT PREDICTION. Proceedings of the Second International Tsunami Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation; Novosibirsk, USSR, August 4-5, 1989; Pararas-Carayannis-George, ed. Unesco, [Paris, 1991], pages 162-170.

AUTHOR AFFIL.: Computing Center, Siberian Division of the USSR Academy of Science, Novosibirsk, USSR.

NOTES: Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, supplement.

QUAKELINE ABSTRACT: This article discusses the use of computers and numerical methods to compute tsunami models in order to issue warnings in a timely manner for specific areas.

PUB. TYPE: Conference paper

CALL NUMBER: QUAKELINE: SEL GC219.I57 1989

RECORD ID: QKLN-9203095

Gonzalez, F I.; Bernard, E N.; Milburn, H B., PROGRAM TO ACQUIRE DEEP OCEAN TSUNAMI MEASUREMENTS IN THE NORTH PACIFIC. Proceedings of the Second International Tsunami Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness, Observation and Instrumentation; Novosibirsk, USSR, August 4-5, 1989; Pararas-Carayannis-George, ed. Unesco, [Paris, 1991], pages 238-246.
AUTHOR AFFIL.: NOAA/PMEL, 7600 Sand Point Way N E, Seattle, WA 98115, USA.
NOTES:Series: Intergovernmental Oceanographic Commission (IOC) workshop report number 58, supplement.
QUAKELINE ABSTRACT: Deep ocean tsunami measurements are needed to provide open ocean boundary conditions for testing numerical models in hindcast studies, and to improve the understanding of tsunami generation and propagation. A portion of the Aleutian Trench, which includes the Shumagin Island group, has been identified as a seismic gap (the Shumagin Gap). Estimates indicate that the probability of a great earthquake is significantly higher for this region than any other in the US. Because tsunamigenic earthquakes along a major portion of the seismically active Aleutian trench threaten Hawaii and the US west coast, and because a large tsunami is possible in the event of a great earthquake in the Shumagin Gap, this region has become the focus of a long-term monitoring program by the Pacific Marine Environmental Laboratory (PMEL) of the National Oceanic and Atmospheric Administration (NOAA). (Adapted from authors' abstract).
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: SEL GC219.I57 1989
RECORD ID: QKLN-9203102

The International Emergency Management and Engineering Society

Sullivan, James D.; Wybo, Jean Luc, and Buisson, Laurent, eds. The International Emergency Management and Engineering Conference (TIEMEC) 1995—Globalization of Emergency Management and Engineering: National and International Issues Concerning Research and Applications Dallas, Tex.: International Emergency Management and Engineering Society (TIEMES); 1995; 581 pp.
Note: OBSERVER 20, No. 3 (January 1996): 19.
This volume contains the proceedings of the TIEMES annual meeting, held in Nice, France, May 9-12, 1995. It includes sections on policy issues in emergency management, social science issues, planning, management issues, training and the use of computerized systems, forest fires, avalanches and landslides, floods, severe weather, nuclear hazards, chemical hazards, research and modeling, geographic information systems, decision support systems, technology transfer, warning systems, safety issues, and other applications.

Sullivan, James D. and Tufekci, Suleyman, eds. Bridging the Gap Between Theory and Practice: The International Emergency Management and Engineering Conference—TIEMEC '94. Dallas, Tex.: The International Emergency Management and Engineering Society (TIEMES). 1994; 448 pp.
Note: OBSERVER 19, no. 1 (September 1994): 19. Hurricane Andrew.
Over sixty papers by authors from six continents make up the proceedings of the first TIEMEC conference, held April 18-21, 1994, at Hollywood Beach, Florida. They cover a wide range of topics and appear under the following broad categories: "Geographic Information Systems in Emergency Management" (3 papers); "Communication Systems in Emergency Management" (3 papers); "Statistics of Disasters" (3 papers); "Management Issues in Disasters" (3); "Risk Management" (3); "Aspects of Emergency Management in Norway" (3); "Advanced Technology for Emergency Management" (3); "Technological Disasters" (4); "Research and Applications" (3); "Recent Research in Emergency Management" (3); and ten other subject areas, including "Earthquakes" (3 papers).

Wind and Seismic Effects—Proceedings

Hebenstreit, G. T.; Krumpe, P. F., United States foreign assistance program on tsunami hazard., U.S. National Bureau of Standards: (Washington, D.C.); Wind and Seismic Effects, Proceedings of the 14th Joint Panel Conference of the U.S.-Japan Cooperative Program in Natural Resources, pp. 507-521; 1983.
EEA ABSTRACT: The authors describe a tsunami assistance program being developed by the Office of Foreign Disaster Assistance, U.S. AID, and Science Applications, Inc. The object of the program is to make the results of current tsunami research techniques available to disaster control officials in developing nations which are subject to potentially severe tsunami hazards. The program uses a combination of historical study of past tsunamis and computer modeling of possible future tsunamis to assess the threat to specific areas. This paper outlines the techniques used in the computer modeling, the choice of specific earthquake sources, and the results of early studies. Research is currently under way to examine in more detail tsunami behavior in areas which appear strongly threatened. The authors discuss briefly their approach to this phase of the problem and their plans for transferring the results of the program to officials in developing nations.
PUB. TYPE: Conference paper
CALL NUMBER: EEA: 500/W552/1982
DOCUMENT NOS.: Report: NBS Special Publication 651
RECORD ID: EEA-132000194

Raufaste, Noel J., ed. Wind and Seismic Effects—Proceedings of the 18th Joint Meeting of the U.S.-Japan Cooperative Program in Natural Resources, Panel on Wind and Seismic Effects. Gaithersburg, Maryland: U.S. Dept. of Commerce, National Bureau of Standards, Center for Building Technology. 1987; Publication NBSIR 87-3540. 495 pp.
Note: Manual. Proceedings.
The 18th Joint Meeting of the Panel on Wind and Seismic Effects was held in Gaithersburg, Maryland, May 12-15, 1986. Thirty-eight technical papers appear in the proceedings under five categories: wind engineering, earthquake engineering, storm surge and tsunami, U.S.-Japan Cooperative Research Program, and the Mexico City and Chilean earthquakes. Topics of interest include 1) a 40-page outline of a manual developed by the Japanese dealing with repair methods for structures damaged by earthquakes; 2) the delineation of flooded areas caused by tsunamis or storm surge through the use of satellite data; 3) an assessment of damage to Chilean port facilities following the 1985 earthquake; and 4) overviews of damages caused by the 1985 Mexico City earthquake. The meeting was the Panel's eighteenth consecutive annual gathering.

Western States Seismic Policy Council

Bausch, Doug, comp. WSSPC '95: Annual report and Sixteenth Meeting of the Western States Seismic Policy Council; 1995 Sep 18-1995 Sep 20; Flagstaff, Arizona.: Western States Seismic Policy Council; 1996; 167 pp. OBSERVER 21, No. 2 (November 1996): 20.
Note: Some papers have references.
This document contains the proceedings of the 1995 meeting of the WSSPC. It includes papers on tsunami hazard mitigation; paleoseismological studies in the Salt Lake City, Utah, and Flagstaff, Arizona, regions; hazard legislation; federal disaster funding; disaster insurance; hazardous materials and earthquakes; hazard mapping; and the use of consortia to reduce seismic risks.

PMEL

Bernard, E. N., ed. International Tsunami Symposium Proceedings: 1987. Seattle, Wash.: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration (NOAA), Pacific Marine En-

vironmental Laboratory. 1988; Contribution No. 1041. 340 pp.
Note: Questionnaire.
Twenty-eight research reports and 7 abstracts are reprinted in this proceedings volume from the thirteenth symposium of the Tsunami Commission of the International Union of Geodesy and Geophysics. The volume is organized into three broad categories of tsunami research: "Observations," "Physical Processes," and "Hazard Mitigation." Items of interest to hazard managers include a questionnaire for rapid tsunami damage assessment, an account of historical tsunamis affecting the U.S. and its territories, a paper on the structure of a tsunami early warning system, and a discussion of the effectiveness of tsunami warnings and related communication processes during the Nihon-Kai Chubu (Japan) earthquake of 1983. In addition to national tsunami research status reports from the U.S. and Japan (each with an extensive set of references), the volume presents analyses of the risks due to tsunamis for the west coast of Mexico, the Black Sea, China, parts of the Mediterranean region, and Washington State/ British Columbia. The meeting was held August 17-18, 1987, in Vancouver, British Columbia.

Bernard, E. N.; Lander, James F., and Hebenstreit, Gerald T. Feasibility Study on Mitigating Tsunami Hazards in the Pacific. Seattle, Wash.: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory. 1982; Technical Memorandum No. NOAA-TM-ERL-PMEL-37. 41 pp.
This study shows that many aspects of existing U.S. technology have potential applications to the problem of providing early tsunami warning information in developing nations of the Pacific that do not currently possess their own regional warning network. A simple conceptual model is developed that shows how these technologies could be integrated into an early warning system. The system—to which the acronym THRUST (Tsunami Hazard Reduction Utilizing System Technology) is applied—would be a significant step toward achieving the goal of hazard mitigation in the developing areas of the Pacific community.

Effects of tsunami on society. Impact of Science on Society. 1982; 32(1):71-78.

General Hazard Mitigation

Green, C H , HAZARD AND VULNERABILITY ANALYSIS. Publisher and place of publication are unknown; 1990.
AUTHOR AFFIL.: Flood Hazard Research Centre, Middlesex Polytechnic, Queensway, Enfield EN3 4SF, United Kingdom.
NOTES: Paper prepared for the Commonwealth Science Council Workshop, Hazard Management and Mitigation with a Focus on Floods, Dhaka, Bangladesh, January 28 - February 2, 1990.
QUAKELINE ABSTRACT: This paper discusses flood hazard management within the context of overall social, economic and environmental management and, the role of government in enabling more effective hazard management by the public. The author examines causes of flooding including: 1) rainfall; 2) snowmelt; 3) icemelt; 4) tsunami; 5) tides; 6) cyclones, hurricanes, typhoons; 7) dam failure and; 8) the greenhouse effect. Components of vulnerability analyses are given as: 1) direct damages or 2) indirect or consequential losses; 3) human resources; 4) resources; 5) constraints; and 6) risk to life. The final section of the paper deals with the public's role in hazard management.
PUB. TYPE: Conference paper
CALL NUMBER: QUAKELINE: NCEER VF00640
RECORD ID: QKLN-9204361

Perez, Eddie and Thompson, Paul. Natural Hazards: Causes and Effects. Madison, Wis.: University of Wisconsin, Dept. of Engineering Professional Development, Disaster Management Center; 1986. 154 pp.
This textbook is about natural hazards, disasters caused by some of those hazards, the effects they have on people living in areas where they occur, and the effects on the environment in general. Used in an extension course that focuses on high priority/high incidence hazards in

developing nations, separate chapters are devoted to earthquakes, tsunamis, volcanoes, tropical cyclones, floods, drought, desertification, and deforestation. Information presented in each chapter typically includes event frequency and geographical distribution; event impact, particularly on development; preparedness; and post-event recovery. An extensive glossary of international disaster assistance terms accompanies the text, each chapter has its own set of references, and a list of organizational resources and information sources is included. A study guide (35 pp.) consisting of course objectives, a pretest, and self-assessment tests also is available to the students.

Kovach, Robert L. Earth's Fury: An Introduction to Natural Hazards and Disasters. Englewood Cliffs, N.J.: Prentice Hall; 1995. 224 pp.
This monograph is designed for students interested in natural hazards, their impacts on humans, risk assessment, and hazard prevention and mitigation. Its chapters address specific severe natural hazards, their causes, and their mitigation. Topics include volcanoes, earthquakes, earthquake engineering, landslides and land movements, desertification, land degradation, drought, atmospheric hazards, tsunamis, storm surge, river floods, and accident scenarios. Each chapter contains a list of review questions, and appendices describe basic probability theory, statistics, seismic measurement, and volcanic and seismic risk analysis. While most of the chapters are descriptive in nature, acquaintance with college algebra enhances the material presented.

El-Sabh, M. I. and Murty, Tad S. Natural and Man-Made Hazards. Boston, Mass.: D. Reidel Publishing Co.; 1988. 894 pp.
This volume contains the proceedings of an interdisciplinary symposium held in Rimouski (Quebec), Canada in August, 1986. Objectives of the symposium were to determine and explore mitigation possibilities applicable over a range of hazards, to review developments in selected hazard fields, to outline new directions for future research, and to encourage interaction among scientists, administrators, and policy makers working in hazards mitigation. The proceedings comprise 54 papers grouped under the following headings: geological hazards, tsunami and storm surge hazards, ice and iceberg hazards, sea level/flood/drought hazards, human intervention in the marine environment, water and air pollution, climatic hazards, and hazard preparedness. Two introductory essays discuss the similarities among various hazard phenomena and the modeling of relationships between natural and human-caused hazards. Session summaries also present some of the information put forward at the symposium.

Ebert, Charles H. V. Disasters: Violence of Nature and Threats by Man. Dubuque, Iowa: Kendall-Hunt Publishing Co.; 1988. 274 pp.
Although it is unlikely that a single book could satisfactorily explore the complexities associated with all types of natural and human-caused hazards, this addition to the hazards literature thoroughly examines a wide range of potential disasters and sensitizes the reader to the impacts and consequences of such events. The text stresses an interdisciplinary approach that demonstrates and strengthens the relationship between the physical and social sciences. The volume is organized into five parts. Part I explores disasters involving the lithosphere and surface materials (earthquakes, volcanoes, landslides and avalanches); Part II deals with disasters in the hydrosphere (tsunami, storm surge, riverine flooding); Part III with those in the atmosphere (hurricanes, tornadoes, thunderstorms/lightning, dust storms, blizzards, and meteorological hazards affecting aviation); Part IV with biosphere disasters (drought, desertification, wildfire). A final section overviews disasters induced by human society, including overpopulation, hazardous wastes, climate change, air and water pollution, and war. With its 15-page glossary, index, and extensive chapter-by-chapter references, the book could serve as either a main text or supplementary reading for college-level courses.

Chapman, David. Natural Hazards. Melbourne, Australia: Oxford University Press; 1994. 174 pp.
The author, an Australian geographer, wrote this book to educate college students about natural hazards and their impacts on society and the environment. He provides a taxonomy of natural hazards and outlines their place in history, their psychological impacts, and methods for coping with their effects. He then turns to specific hazards with chapters that examine

biohazards; wildfires; severe storms; earthquakes, volcanoes, tsunamis, and mass earth movements; floods; and drought. He concludes by offering a management model for natural hazards and speculation about future impacts. Some of his observations are: 1) a completely risk-free society is not a realistic goal; 2) despite our technological sophistication, it is not at all apparent that we have culturally adapted to the realities of natural hazards; and 3) mitigation will emerge through social-economic-political means, in minimizing exposure to hazard by tightening the nexus between choice and responsibility, between action and consequences, between knowledge and behavior.

Bryant, Edward, NATURAL HAZARDS.Cambridge University Press, Cambridge, 1991. ISBN: 0-521-37295-X

QUAKELINE ABSTRACT: This work presents a sweeping and yet detailed account of natural hazards of all kinds. It broadly divides its subject matter into: 1) climatic hazards, such as wind-storms, droughts and floods; and 2) geological hazards, such as volcanoes, earthquakes, tsunamis and the various consequences of land instability. Lesser-known hazards, such as sea-ice hazards and beach erosion, are also treated. Separate chapters describe the characteristics and effects of these various natural hazards, as well as providing accounts of the physical causes of these phenomena in considerable scientific detail. The work also provides historical accounts of major natural disasters exemplifying each type of natural hazard. The reader will find, for example, detailed accounts of the eruptions of Mt Pelee, Krakatoa, and Vesuvius as part of the book's discussion of volcanoes. One of the book's major themes concerns the role which human error or indifference plays in exacerbating natural hazards until they turn into disasters. A final chapter concerning disaster mitigation discusses such things as warning and evacuation before imminent hazards, preparedness activities, disaster response, resettlement and the psychological impacts of disasters.

PUB. TYPE: Monograph

CALL NUMBER: QUAKELINE: SEL GB5014.B79 1991 ¶ NCEER: GB5014.B79 1991 [Lockwood Library; Undergraduate Library] ¶ EERC: 215 B792 1991 [EERC]

RECORD ID: QKLN-9203469 ¶ NCEER-EAX3535 ¶ EERC-002034

Merriman, P. A. and Browitt, C. W. A. Natural Disasters: Protecting Vulnerable Communities. London: Thomas Telford; 1993. 591 pp.

Note: Papers have references. Cyclone. Typhoon. OBSERVER 20, No. 2 (November 1995): 16.

This volume contains the proceedings of a meeting held in London, October 13-15, 1993. There are five sections: "Vulnerability of Communities" includes papers presenting world-wide data on disaster impacts and information on risk communication, reducing vulnerability through design and mitigation, and dealing with slow-onset events. "Forecasting and Warning" discusses such activities globally, as well as tsunami risk, wind mitigation, mass earth movements, storm and flood prediction, and seismic and volcanic eruptions prediction. "Preparedness and Protection" provides technical information on lava flow, emergency planning and modeling, floodplain management, mapping, and housing rehabilitation. "Lessons Learned in Recovery" examines vulnerability assessment in low-income communities, the role of insurance, and aid and rehabilitation. "Technology, Knowledge Transfer, and Future Opportunities" discusses ways to improve building construction through building design, retrofitting, construction techniques, and repair.

Heathcote, R. L.; Cuttler, C., and Koetz, J., eds. NDR 96: Papers Presented to the Conference on Natural Disaster Reduction 1996; 1996 Sep 29-1996 Oct 2; Surfers Paradise, Queensland, Australia. Barton, A.C.T.: Institution of Engineers-Australia; 1996; 422 pp.

Note: OBSERVER 21, No. 4 (March 1997): 19.

This collection of papers, an Australian contribution to the IDNDR, addresses many aspects of natural disasters. It includes discussions about the past 20 years of disaster management in Australia, Australian education and training activities and programs, and the use of technology to reduce the impacts of disasters. It also includes papers on natural disaster reduction in China, bushfires, general disaster management, disaster response, floods, insurance issues, hazard monitoring, legal issues, tropical cyclone hazards, and risk management, as well as case studies of significant disasters. Other topics addressed include managing animal disease disasters, the role of GIS and other spatial technologies, an overview of fatalities caused by natural hazards in Australia, disaster welfare services in New South Wales, environmental impacts of cyclones striking the Great Barrier Reef, great flood disasters in China's history, disaster management in South Pacific island nations, changing perceptions of wildfire, natural hazard management and tourism, coping with natural disaster warnings, the Newcastle Earthquake Database, a reinsurer's perspective on natural disaster reduction, tsunami risk in Australia, a business approach for modeling Australian emergency management legislation, and threshold issues for designing safer communities .

Wijkman, Anders and Timberlake, Lloyd. Natural Disasters: Acts of God or Acts of Man? Washington, D.C.: International Institute for Environment and Development; 1984. 145 pp.
This book is the result of a collaborative effort between the Swedish Red Cross and Earthscan, a London-based news and information service dealing with environment and development issues. The authors maintain that 1) the common view of "natural disasters" is due for a radical change; 2) some disasters (flood, drought, famine) are caused more by environmental and resource mismanagement than by too much or too little rainfall; 3) the impacts of other catastrophic geologic or meteorologic disasters are magnified by unwise human planning and development; and 4) in the Third World, where disaster mitigation is desperately needed, current disaster relief is often inadequate to the task. Separate chapters examine disasters caused by floods, drought, tropical cyclones and other extreme winds, earthquakes, tsunamis, and volcanoes. Extensive discussions of disaster relief and development as a mitigative tool round out the volume.

U.S. Office of Emergency Preparedness. Report to the Congress, Vol. 3: Disaster Preparedness. Washington, D.C.: U.S. Government Printing Office. 1972; 143 pp.
Consists of ten chapters covering causes and effects, threat and vulnerability, and technological countermeasures of the hazards river floods, tornadoes, and grass fires, earthquakes, landslides, tsunamis, volcanoes, frosts and freezes, and droughts.

Vogt, Barbara M. and Sorensen, John H. Evacuation in Emergencies: An Annotated Guide to Research. Oak Ridge, Tenn.: U.S. Dept. of Energy, Oak Ridge National Laboratory. 1987; ORNL/TM-10277. 190 pp.
This very useful bibliography reviews significant recently published social science and emergency planning literature that explores issues related to the emergency evacuation field. While organizing the material, the authors primarily looked for articles and reports that included either a theoretical or empirical basis for their findings. Entries are organized by natural hazards (earthquake, flood, hurricane, tsunami, volcano, other hazards), human-induced hazards (hazardous materials, nuclear power, war/attack), and items dealing with multiple hazards. The introductory essay presents an overview of the literature on evacuation and comments on the strengths and shortcomings of evacuation research, as reflected in the annotated documents. Specific key findings from each of the approximately 150 cited publications follow the annotations.

Ebbs, Leslie. Waiting for the wave. Emergency Preparedness Digest. (January-March 1995); 22(1):7-8.

Chrostowski, J. D.; Eguchi, R. T., and Hart, Gary C. Building Losses From Natural Hazards: Yesterday, Today, and Tomorrow. U.S. National Science Foundation. 1978; 22 pp.
This publication overviews the results of building loss forescasts developed as a basis for establishing research priorities and public policy directions that may help mitigate future losses from natural hazards. The intent of the studies is to reveal primarily the percentage by which building damage might be reduced if some of the most frequently discussed or promising mitigations were to be applied. Nine hazards were studied because of their historic impact on buildings. They are: earthquake, landslide, expansive soil, hurricane wind/storm surge, tornado, riverine flood, local wind, local flood and tsunami. Damage to infrastructure, such as roads and bridges, is not covered by these studies.

Finkl Jr., Charles W. Coastal Hazards: Perception, Susceptibility and Mitigation. Journal of Coastal Research. 1994; Special Issue No. 12:1-372.

Note: OBSERVER 19, no. 5 (May 1995): 25.
This publication deals with the hazards and vulnerabilities associated with marine and coastal environments. Thirty-four authors from 10 countries provide different perspectives from coastal regions around the world. The book is divided into seven parts that deal with hazard recognition and evaluation: coastal hazards brought about by human activities, such as pollution; impacts associated with relative sea-level rise, such as subsidence and saltwater intrusion; effects of storms, including hurricanes and storm surges, on coastal-marine environments; the stress of waves and currents on coastal and off-shore structures; the damage potential of coastal hazards on natural and cultural features, particularly coral reefs and sand dunes; and examples of hazard mitigation and management.

Maybury, Robert H. Violent Forces of Nature. Mount Airy, Maryland: Lomond Publications; 1986. 377 pp.
Note: 53 references plus chapter references.
Directed toward persons interested in the formulation and implementation of public policy designed to mitigate the effects of natural catastrophes, this volume provides an overview to all local, state, provincial, national, and international policy makers; scientists and engineers; planners and local officials. Hazards that receive special attention include earthquakes, volcanoes, hurricanes, floods, avalanches, tsunamis, lightning, and drought. The book's 20 chapters, written by recognized world authorities in the various fields, are organized into five sections: "Earthquakes," "Mountain Hazards," "Water Hazards," "Hazards of Climate," "and "Preparedness and Rescue." Included is a selected bibliography of natural disasters and hazard mitigation. The core papers originally appeared as an issue of the UNESCO journal "Impact of Science on Society," and the volume is published with the cooperation of UNESCO.

DISASTER PREVENTION AND MITIGATION: VOLUME 6, CONSTRUCTION AND CIVIL ENGINEERING ASPECTS. OTHER TITLE: Prevention et attenuation des catastrophes: aspects relatifs a la construction et au genie civil., United Nations, New York, 1981.
INST. AUTHOR: Office of the United Nations Disaster Relief Coordinator (UNDRO)
QUAKELINE ABSTRACT: This volume presents the state of the art in concepts, safety standards and recommended construction practices for buildings and other civil engineering structures in regions exposed to violent natural phenomena, having, for the most part, geophysical or atmospheric origins. It evaluates risks and vulnerability, and describes both permanent and temporary measures which may prevent catastrophes and problems associated with them. Both methodology and data collection are treated. It also defines those areas where further research and activity are still needed. Earthquakes, floods, violent winds, tsunami, landslides, fires and avalanches, are the particular phenomena discussed, again, especially in relation to their effects upon buildings and engineered structures. Recommended techniques and the use of codes, standards, and planning and zoning to decrease the destructiveness of such phenomena to engineered structures are discussed separately for each sort of disastrous phenomenon. (Abstract adapted from text).
LANGUAGE: French
PUB. TYPE: Monograph
CALL NUMBER: QUAKELINE: SEL GB5005.U54 1976 v.6
RECORD ID: QKLN-8801419

Majumdar, Shyamal K.; Forbes, Gregory S.; Miller, E. William, and Schmalz, Robert F., eds. Natural and Technological Disasters: Causes, Effects and Preventive Measures. Easton, Penn.: Pennsylvania Academy of Science. 1992; Publication No. 16. 561 pp.
All of the 41 papers in this anthology incorporate the premise that social benefits accruing from technical advances in disaster mitigation will be severely curtailed unless specific political, economic, and sociocultural considerations become an integral part of planning and implementation programs. In addition to separate chapters dealing with nearly twenty natural or technological hazard agents, other contributions to the volume explore a variety of topics related to disaster mitigation, such as natural hazard mapping, risk communication, disaster insurance, tropical zone deforestation, posttraumatic stress disorder, and moral issues and dilemmas that accompany high risk technology.

Cheng, F. Y. and Wang, Y. Y. Post-Earthquake Rehabilitation and Reconstruction. Tarrytown, N.Y.: Elsevier Science; 1996. 483 pp.

Following natural disasters, measures requiring immediate attention include damage assessment, rehabilitation, response, amelioration of social consequences, and repair and reconstruction. The United States and the People's Republic of China now regularly organize bilateral symposia to investigate hazard mitigation, and this book contains state-of-the-art reports presented at a US/PRC Symposium Workshop held in Kunming, Yunnan, China, in May 1995. It addresses damage assessment, recovery and reconstruction, public policy, land use options, repair and retrofit of lifelines, socioeconomic problems, human and organizational behavior, and real-time monitoring of earthquake response and damage.

Appendix 2C

Bibliography: Education

General Tsunami Education

U.S. Dept. of Commerce. Tsunami! The Great Waves. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Weather Service. 1975; NOAA/PA74027. 19 pp.

TSUNAMI: THE GREAT WAVES. National Oceanic and Atmospheric Administration, Silver Spring, MD, [1994]
NOTES: Year of publication estimated.
QUAKELINE ABSTRACT: This pamphlet provides the general reader with basic information on tsunamis. The pamphlet first discusses the causes of earthquakes. It then presents some of the important physical facts about tsunami waves including wave speed and the relationship between wave height and water depth. Finally, the pamphlet recommends protective measures which individuals should take in the event a tsunami is imminent
PUB. TYPE: Pamphlet
AVAILABILITY: National Oceanic and Atmospheric Administration, 1325 East-West Highway, Silver Spring, MD 20910, USA.
CALL NUMBER: QUAKELINE: NCEER VF01233
RECORD ID: QKLN-9600503

Ebbs, Leslie. Waiting for the wave. Emergency Preparedness Digest. (January-March 1995); 22(1):7-8.

Tsunami! The story of the Seismic Sea-Wave Warning System.
INST. AUTHOR: U.S. Coast and Geodetic Survey
SOURCE: For sale by the Superintendent of Documents, U.S. Govt. Print. Off.: Washington, 1965; 46 p., illus. (part col.) maps (part col.), 26 cm.
PUB. TYPE: Monograph
CALL NUMBER: EERC: 335.3 U82 1965 [EERC]
RECORD ID: EERC-014885

United Nations Educational, Scientific and Cultural Organization. International Coordination Group for the Tsunami Warning System in the Pacific—Twelfth Session. Paris, France: United Nations Educational, Scientific and Cultural Organization (UNESCO), Intergovernmental Oceanographic Commission. 1990; IOC/ITSU-XII/3 or SC-90/WS 2. 49 pp.
Note: Held in Novosibirsk, USSR, 7-10 August 1989, the twelfth session of this international group addressed the following topics: implementation of the resolutions and recommendations of the 11th session held in Beijing, China during 8-12 September 1987; improvement of the tsunami warning system; training assistance for the public in tsunami preparedness; participation in the IDNDR; consideration for a new earthquake magnitude scale, the Mantle Magnitude Mm; and tsunamis in the Indian Ocean.

United Nations Educational, Scientific and Cultural Organization. International Coordination Group for the Tsunami Warning System in the Pacific, Second Meeting; 1970 May 12-1970 May 14; Vancouver, B.C., Canada. Paris: United Nations Educational, Scientific and Cultural Organization (UNESCO), Intergovernmental Oceanographic Commission; 1970; SC/IOC/CG.4/2.
Note: Proceedings.

Walker, Daniel A. Tsunami Facts. Honolulu, Hawaii: University of Hawaii, School of Ocean and Earth Science and Technology. 1994; SOEST Technical Report 94-03. 93 pp.

Note: Educational materials stapled to the report.
All of the major Hawaiian islands and their entire coastlines are at risk from tsunamis generated from both local and distant earthquakes. Also, the "wrap around" effects can cause large amplitudes on entire shorelines. Large tsunamis striking the Hawaiian Islands during this century have swept several hundred feet inland in low lying areas and have reported maximum heights of the sea surface in some of those inland areas of more than 50 feet. From 1900 through 1965, a total of 13 significant tsunamis (i.e., those with wave heights greater or equal to one meter) produced by distant earthquakes were reported for the Islands. However, from 1965 to 1993, no Pacific-wide tsunamis have struck, thus leading to a false sense of complacency and lack of awareness that may add to the dangers associated with the hazard, particularly for the youth of Hawaii. Also, since 1965 the population has experienced substantial growth with much of the development in potential tsunami inundation zones. This document contains island and county summaries of runups for large tsunamis for Hawaii, Maui, Oahu, and Kauai. It also contains an island by island comparison for large tsunamis; comparisons of runups at Hilo versus runups on the North Shore of Oahu for large tsunamis generated in the North Pacific; island-wide runups for the April 1, 1946 tsunami; tsunami facts and emergency instructions; and an extensive self quiz. Appendices list locally generated tsunamis and Pacific Basin tsunami travel times to Honolulu. Other educational materials produced for children include handouts titled: "The Story of Laupahoehoe;" "Tsunami Safety Guide;" "Tsunami Safety Guide;" and "Tsunami Coloring Book." Basically prepared for children and young adults, the report still contains much technical information about tsunami threat for the islands.

Dudley, Walter C. and Lee, Min. Tsunami! Honolulu: University of Hawaii Press; 1988. 132 pp.
Historical records kept since 1813 reveal that a total of 95 tsunamis have struck the Hawaiian Islands, or about one every two years. This informative layman's introduction to tsunami phenomena describes the origin and operations of the Tsunami Warning System, provides information about how they are formed, and describes the damage and social disruption caused by several devastating seismic sea waves that have run ashore in Hawaii in recent years. Historical documents and personal interviews conducted among survivors of several great waves provide vivid anecdotal accounts of the havoc wrought by the tsunamis of 1946, 1952, 1957, 1960, and 1964. Of particular interest is a chapter that tries to ascertain what went wrong with the alert systems following the great 1960 Chile earthquakes. The resulting tsunami killed 61 people in Hilo even though the warning system accurately predicted the existence of a tsunami and its arrival time at the Hawaiian Islands. In retrospect, it seems that science did its job properly, but Hilo residents had not received information about either the nature and seriousness of the hazard nor the proper steps to take for personal safety. A final chapter that examines recent warnings suggests that these messages are still not being seriously acknowledged.

City of Seward, Alaska. Seward Tsunami Hazard Education Program: City of Seward, Alaska. 1970.

Haeussler, Peter. The Next Big Earthquake in Southern Alaska May Come Sooner Than You Think. Anchorage, Alas.: U.S. Dept. of the Interior, Geological Survey, Branch of Alaskan Geology. 26 pp.
This booklet, prepared by the U.S. Geological Survey, in cooperation with the Alaska Division of Emergency Services and three other agencies, contains information about residential preparedness, personal safety, and regional seismic risk. Other features of the booklet include information about anchoring wood stoves and propane tanks; earthquake magnitudes; local susceptibility to seismically-caused subsidence and liquefaction; tsunami risk, safety rules, and warning systems; and why earthquakes are inevitable in the state. Some Alaska earthquake statistics: the state has 11 percent of the world's earthquakes; it experiences 52 percent of all U.S. earthquakes; and on the average, one magnitude 8 or larger quake occurs every 13 years and one magnitude 7 to 8 quake occurs every year. References to publications and other sources of information are provided.

Dengler, Lori; Moley, Kathy, LIVING ON SHAKY GROUND: HOW TO SURVIVE EARTHQUAKE AND TSUNAMIS ON THE NORTH COAST., Humboldt Earthquake Education Center, Humboldt

State University, Arcata, CA, [1995]
AUTHOR AFFIL.: California Governor's Office of Emergency Services; Federal Emergency Management Agency (FEMA); Humboldt Earthquake Education Center, Humboldt State University
QUAKELINE ABSTRACT: This pamphlet provides the general reader with an overview of the seismic hazard in Northern California. It presents simplified accounts of plate tectonics and earthquake source mechanisms; outlines the recent seismic history of the area; discusses the serious tsunami hazard of the Northern California coast. In addition, the pamphlet offers a variety of earthquake preparedness advice for individuals, families, and homeowners. It covers the formulation of a family earthquake plan; duck and cover drills; the stockpiling of emergency supplies; bracing and anchoring water heaters, propane tanks and wood burning stoves; and dealing with children after an earthquake. It provides the homeowner with advice on retrofitting various types of foundations. The pamphlet also includes an abridged earthquake scenario for the Northern California region: a subduction zone earthquake (magnitude 8.4) which, in addition to causing serious damage due to ground shaking, also generates a tsunami seriously affecting the Humboldt Bay and Crescent City areas.
PUB. TYPE: Pamphlet
AVAILABILITY: Humboldt Earthquake Education Center, Humboldt State University, Arcata, CA 95521-8299, USA.
CALL NUMBER: QUAKELINE: NCEER VF01232
RECORD ID: QKLN-9600662

Bernstein, Joseph. Tsunamis. Scientific American. (August 1954); (4 pp).

Hindley, Keith. Beware the Big Wave. New Scientist. (9 February 1978); 346-347.

Forrester, Frank H. Tsunami! Weatherwise. (April 1987); 85-89.

Resources

American Geophysical Union. Seismic Sleuths: A Teacher's Package on Earthquakes for Grades 7-12. Washington, D.C.: U.S. Federal Emergency Management Agency. 1994; FEMA-253. 367 pp.
Note: OBSERVER 19, No. 4 (March 1995): 22.
The American Geophysical Union (AGU), in cooperation with FEMA, has developed this activity-based, self-contained earthquake curriculum package. It was developed to assist teachers promote an understanding of the processes that cause earthquakes and the impact of earthquakes on buildings and other structures. The package provides educators with information and tools to help their students comprehend how concepts from science, mathematics, and social studies can be applied to reduce earthquake risk through prudent seismic design, construction, land use, and emergency planning. The curriculum is divided into six units, each of which contains several lessons. Each lesson includes a rationale for the activity, focus questions, objectives, a list of materials needed, as well as additional tips on how to present the materials. Topics explored in the curriculum include plate tectonics, earthquakes in geologic time, seismographs and seismograms, the BOSS model—building oscillation seismic simulation, quake prediction, rapid visual screening of buildings in the community, lifeline preparedness, and earthquake preparedness simulation.

Ross, Katharyn E. K. Earthquake Education Materials for Grades K-12. Fourth Revised ed. Buffalo, N.Y.: State University of New York-Buffalo, National Center for Earthquake Engineering Research. 1992; Technical Report NCEER-92-0018. 132 pp.
Note: NCEER Bibliography of Earthquake Education Materials," Technical Report NCEER-89-R010, 1989. OBSERVER 18, no. 1 (September 1993): 22. NTIS no. PB93-114023/GAR.
In May 1988, NCEER initiated an earthquake education project focusing on earthquake awareness and seismic safety education in school programs for grades K-12. The center's

goals were to identify what had been already been accomplished in the field, develop a package of materials designed to accomodate different age groups and interest levels, and test these materials in a program at the elementary school level. Public response to the first bibliography was positive enough to warrant compilation of this updated and amplified revised version. References in the bibliographic section are arranged to provide citations to articles/books appropriate for grades K-3, grades 4-6, and grades 7-9; to aid teachers and parents in identifying supplemental materials; and to help with a teaching/writing curriculum. The education resources section lists references to five types of reference information: elementary science curricula, supplementary materials, selected software products, a list of resource organizations, and an earthquake education curricula summary. The bibliography also is a useful resource for establishing seismic safety education programs in the home, school, or neighborhood. Teaching materials on tsunamis, volcanoes, and plate tectonics are included.

Sigrist, Dennis J, HOKKAIDO NANSEI-OKI TSUNAMI, JULY 12, 1993. National Geophysical Data Center, Boulder, CO, [1994]
AUTHOR AFFIL.: International Tsunami Information Center, Honolulu, HI, USA.
NOTES: Year of publication is estimated.
QUAKELINE ABSTRACT: The slides in this set illustrate the damage caused by the tsunami that followed the 1993 Hokkaido Nansei-Oki earthquake. Damage to the communities of Aonae and Monai (located on Okushiri Island) is featured, and includes damage caused by fires that followed the tsunami. Most slides show debris, including clocks, roofing materials, personal effects, and fishing boats, left by the tsunami at various sites. The accompanying guide provides background information about the earthquake and tsunami, and details of damage to Okushiri Island, Hokkaido, Korea, and the coast of Russia. It also provides commentary on each slide.
PUB. TYPE: Slides/photographs
AVAILABILITY: National Geophysical Data Center, NOAA, Code EGC1, 325 Broadway, Boulder, CO. Product number: 648-A11-003.
CALL NUMBER: QUAKELINE: EQE GC220.4.J3.H64 1994
RECORD ID: QKLN-9600511

Earthquakes and Tsunamis

U.S. Federal Emergency Management Agency. Are You Ready? Your Guide to Disaster Preparedness. Washington, D.C.: U.S. Federal Emergency Management Agency. 1990; Publication No. H-34. 96 pp.
Designed for the family unit, this guidebook answers the question: Why prepare for disaster? It describes household-level activities to prepare for meteorological and geologic hazards, together with the more common technological disasters and national emergencies. The document provides evacuation guidelines, emergency shelter design suggestions, preparedness checklists, and additional references.

Bolt, Bruce A. Earthquakes. New York, N.Y.: W.H. Freeman & Co.; 1993. 331 pp.
First published in 1978, this book is an excellent layman's introduction to earthquake phenomena and the means to mitigate their devastating effects. Often used as a textbook in high schools and colleges (and translated into six languages), the revised edition features additional material on seismology, artificially caused earthquakes, more up-to-date ways to measure earthquake magnitudes, and recent case histories that reinforce the physical relationship between earthquakes and volcanoes. Separate chapters deal with earthquake prediction, self-protection in an earthquake, and environmental studies for earthquake-resistant design. Other features include an earthquake quiz (with answers), an extensive glossary, and appendices dealing with wave motion, sample calculations of seismic magnitudes and energy, and the seismic instrumentation of important large structures.

Gere, James M. and Shah, Haresh C. Terra Non Firma: Understanding and Preparing for Earthquakes. New York, N.Y.: W.H. Freeman and Company; 1984. 203 pp.

Written by two professors at Stanford University's John A. Blume Earthquake Engineering Center, this is an excellent introduction to earthquakes and related phenomena. Technical subjects explained include plate tectonics, types of fault movements, liquefaction, the measurement of energy released by earthquakes, tsunamis, and the efficacy of various predictive methods. Mitigative measures also covered by the authors include structural design and construction practices, building codes, structural retrofitting, lifeline protection, zoning and land use planning, earthquake insurance, securing building contents, education programs, individual earthquake preparedness, and conduct before, during, and after an earthquake

Walker, Bryce. Earthquake. Chicago, Ill.: Time-Life Books; 1982. 176 pp.
One of a series of books dealing with our planet's geology, atmosphere, and oceans, this beautifully illustrated publication is an excellent introduction to the study of seismology. Written for the intelligent layman, it presents the rudiments of plate tectonics together with a historical account of how man has gained his knowledge of the earth's interior workings. Anecdotal accounts of past earthquakes are often accompanied by photographs or paintings of great historical and artistic interest. An example of this is a cross-section drawing of Frank Lloyd Wright's famed Imperial Hotel (Tokyo) designed in 1915 to withstand major earthquakes. Other topics that are discussed include techniques for predicting earthquakes, induced seismicity, tsunamis, seismic construction techniques, seismic recording devices, and earthquake preparedness. Indexed and contains an extensive bibliography.

Verney, Peter. Earthquake Handbook. New York, N.Y.: Paddington Press; 1979. 224 pp.
This is a readable introduction for the layman to the phenomenon of earthquake hazard. Although a considerable amount of historical material of an anecdotal nature is presented—incidentally, much of it quite interesting—there is useful information about earthquake prediction, structural design, land use and zoning, survival measures, tsunamis, and seismology either woven into the text or allotted a chapter of its own. Many vintage photographs and illustrations add to the attractiveness of the volume.

Appendix 3

Summaries of Selected Tsunami Mitigation Studies

A. Preuss, J., 1988, Planning for Risk: Comprehensive Planning for Tsunami Hazard Areas. Prepared by Urban Regional Research for the National Science Foundation.
B. Ayre, R.S., P.B. Trainer, and D.S. Mileti, 1975, Earthquake and Tsunami Hazards in the United States: A Research Assessment. Program on Technology, Environment and Man, Monograph #NSF-RA-E-75-005, Institute of Behavioral Science, University of Colorado, 150 pp.
C. Steinbrugge, K.V., 1992, Earthquakes, Volcanoes, and Tsunamis, An Anatomy of Hazards. Skandia America Group, New York, New York, 392 pp.

Appendix 3A

Summary of Preuss, J., 1988, Planning for Risk: Comprehensive Planning for Tsunami Hazard Areas; prepared by Urban Regional Research for the National Science Foundation

Part I. The Planning Context

Chapter 1. Project Objectives and Methodology

Not only do tsunami hazards involve multiple risk factors, they vary throughout the community at risk. Although we have a general understanding of the generation of a tsunami, the end effects are less understood. Because the end effects are so poorly understood, the first step in application of a tsunami-based planning methodology is to specify and understand the historical damage. The planning process should minimize risk and maximize life safety, and should consist of three components:

1. Risk assessment/Identify risk characteristics
2. Risk reduction measures
3. Risk management program

The risk assessment develops a clear understanding of the physical parameters on end effects of a tsunami by defining the exposure characteristics of the community. Once the characteristics of the hazard are understood, the nature of the risks in terms of vulnerability to damage and life loss are evident. Risk reduction measures based on probability end effects is to a large extent a function of land use and land base variability, such as topography and soil strength. The administrating framework of a risk management program combines structural and non-structural measures to reduce risk and consists of two components: 1) alternative regulatory and land use, and 2) the concern with life safety and emergency preparedness.

Since tsunami events occur so infrequently, numerical simulation has become the focus for risk assessment, using nonlinear long wave equations. Numerical models consist of four components:

1. The base equations
2. Initial/source conditions
3. Off-shore boundary conditions
4. Runup boundary conditions

Three stages are usually distinguished within a tsunami; therefore, three different environments must be modeled:

1. **Source:** generation characteristics including the process occurring at and near the source
2. **Far Field**: Propagation characteristics in deep water
3. **Near shore:** propagation characteristics in shallow water and on shore

In the far field calculations where depth is greater than 200 m, linear long-wave equations are used.

The purpose of the source model is to evaluate the location of the tsunami source. Once generated the tsunami can take a variety of paths to any location. As the tsunami wave reaches the near shore, environmental changes occur which are associated with dissipation of energy as the wave enters shallower water. The speed of the wave decreases and the height increases, which increases the runup wave and therefore the source of damage. Long-wave equations have two basic assumptions: 1) that the wave length is long compared to the water depth, and 2) that the wave height is small, i.e., the deeper the water, the longer the wave and the shorter the height. These factors become important as the wave approaches shore.

The remainder of this report demonstrates the application of both the historical and numerical methodologies as the basis for developing an integrated and multi-faceted risk reduction program.

Chapter 2. Overview of Damage Patterns: 1964 Alaska Tsunami

Damage and effect of a tsunami are a function of its attributes interacting with shore-based variables. The interactions between wave characteristics and local conditions vary dramatically from community to community as well as within communities. As a result, the risk factors resulting from a tsunami are extremely complex.

Direct causes of damage are attributed to water pressure from whole or partial submergence and to hydrodynamic forces. There are essentially two types of hydraulic forces. One is from water surging inland, and the other is from drag forces created during both runup and rundown. Secondary impacts are essentially caused by direct water forces interacting with the environment. Indirect impacts are caused by damage from the primary and secondary forces. Loss of life results from direct, secondary, and indirect effects. Of the 131 deaths from the Great Alaskan Earthquake, 119 were attributed to the tsunami, specifically from inadequate opportunity for warning and evacuation, as in Alaska, and inadequate warning and evacuation, as in Oregon and California, where 14 people died.

There is a long list of diverse causes of tsunami damage. Analysis of these experiences indicate that complete avoidance of damage is virtually impossible. Reduction of damage must be based on a firm understanding of the nature of tsunami end effects. The first step in a vulnerability analysis is to identify past damage: after damage patterns have been determined, differences in causes can be explained. The remainder of this chapter is a historical analysis of five communities that experienced a range of impacts from the 1964 Great Alaskan earthquake and tsunami. These communities are Kodiak, Seaward and Whittier, AK; Grays Harbor, WA; and Crescent City, CA. These communities represent both locally generated and distantly generated experiences. For each community, damage discussion is organized according to four categories:

1. Structures on land
2. Marine uses and structures (boats, docks, and wharves)
3. Lifelines
4. Others (stored materials, oil tanks)

Part II. Risk Assessment

Chapter 3. Kodiak 1964: Retrospective Assessment

In order to forecast the behavior and characteristics of a tsunami it is first important to verify the numerical model in use. This is done by taking a known event, numerically modeling the expected effects, and then comparing them with what actually happened. In this study the far field analysis defines characteristics as the tsunami travels from the source towards Kodiak, Alaska. This was performed by computing the propagation path at three decreasing regional scales and grid sizes. Region A consisted of the North Pacific at a scale of 1:5,000,000 and a grid size of 24.3 km^2. Region B consisted of Southeast Kodiak Island at a scale of 1:1,000,000 and a grid size of 8.1 km^2. Region C consisted of a scale of 1:200,000 and a grid size of 2.7 km^2.

During the 4-hour period set for this study the astronomical tide was fixed. In the far field analysis, the most important variable is the tsunami front. The boundary for the far field and the near field region was set at the entrance of Chiniak Bay, at the boundary between region C and region D.

The purpose of the near shore calculations is to bring the wave to the shore and to project the inundation area and runup characteristics. These are the calculations that were used for evaluating risk. Accordingly, the non-linear and frictional variables, which can be ignored for the deeper ocean, are very important factors within the near shore environment. For the near shore calculations four grid sizes were used. Region D consisted of Chiniak Bay at a grid size of 900 m, Region E consisted of Womans Bay at a grid size of 300 m, Region F consisted of Near Island at a grid size of 100 m, and Region G consisted of Kodiak City at a grid size of 33 m. Once the wave has been brought to the near shore region it becomes possible to project water elevations. A major objective at the near shore scale was to correlate the regional boundaries with existing land use patterns/administration policies.

Risk is essentially a function of land use interacting with tsunami characteristics. A major objective then is to correlate computational boundaries with existing land use. When the boundaries of the 33-m grids (Region G) are averaged, the computed and observed inundation patterns are very similar. Projecting elevation and arrival times is to reconstruct the magnitude and sequence of events which can then further be used for preparedness and response planning. In this study there was approximately a 20-min difference in arrival time between the simulated and the observed effects. Among other variables, damage is also a function of the velocity of the water. Maximum computed speeds in the vicinity of Near Island (Region F) were 2.3–4 m/s. However, the calculation methodologies for shallow water were a problem and were not resolved due to lack of empirical verification. However, numerical models for the 1983 Japan Sea event estimated velocities at 4–5 m/s, which was verified by observation.

Most of Kodiak is underlain by bedrock or a thin veneer of unconsolidated sediment, and little damage occurred as a result of ground shaking. The location of unsalvageable structures in 1964 were in areas of more than 4 m of water and therefore appears to reflect the importance of water depth. Additionally, the type of structure was important. Where virtually all of the wood frame structures were destroyed, more substantial buildings constructed of hollow wood blocks and concrete withstood the tsunami. Computer water depths in this study compared closely with damage patterns. Also noted is that the highest velocities were experienced in areas of highest water elevations.

In spite of the complexity of the Alaskan coast, with its many islands, bays, inlets, and continental shelves, the authors conclude that the numerical simulation of the 1964 Alaskan tsunami generally agreed with observed inundation areas and maximum wave heights at Kodiak. In fact, in some small areas computed wave heights were larger and wave form steeper. Additionally, the model predicted first wave arrival 20 min earlier than actual. These discrepancies are important margins for evacuation; however, they are not important for mitigation. Additionally, the authors note that computational wave velocity appears to be somewhat lower than the level of damage seems to warrant.

Chapter 4. Kodiak 1986: Vulnerability Today

As the basis for projecting general vulnerability and risk, the tsunami source model is applied to Kodiak under present conditions. This projection consist of three parts:

1. Identifying baseline conditions
2. Numerical simulations
3. Vulnerability assessment

For this study shoreline contours and topography were defined for downtown Kodiak seaward of 100-ft elevations. During the 1965 reconstruction, grading plans indicated that the devastation area was regraded and filled to a 20-ft elevation. A comparison of the 1965 grading plans with 1985 surveys reveals that Kodiak has rebounded approximately 2 feet since the 1964 earthquake. The ground elevation at the waterfront ranges from 15.5 to 17.5 ft above MLLW. The area closest to the shore is higher than in 1964, while ground elevations 250–400 m inland are lower than in 1964. Vegetation in 1985 is limited to a few decorative trees and is too sparse to create measurable friction or to catch debris.

In the numerical simulation the authors assume an event comparable in magnitude to the 1964 tsunami. This model also assumes a 1.7-m (5.6-ft) subsidence. At this point the authors interject a note of caution that these calculations are for an area-wide planning purpose. They are not intended for site-specific interpretation. Also, the numerical simulation is presented for Regions F and G only. The projections for maximum elevations and inundation area are comparable to 1964.

The depth of flooding is strongly influenced by topography. However, because of the long wave period, the maximum water level (wave height) is relatively unaffected by small topographic variations. Because of the fill placed during reconstruction, the area from the shoreline to approximately 120 m is now at a higher elevation than in 1964 and therefore water depths are less than in 1964. From 120–230 m inland, the ground elevation is approximately the same as in 1964 and flooding is expected to be comparable. From 230 m inland to 500 m grade elevations are lower and therefore this area is subject to more flooding than in 1964.

Velocity calculations establish a relationship between the drag force of the tsunami and the resistance of rocks and breakwaters. Documented experiences in the Japan Sea showed rocks that weighed less than 5 tons moved if wave velocities were over 4 m/s. The analog is that if rocks in the breakwater or embankment are less than 5 tons the edges of these structures may be washed away. The model predicts wave velocities at approximately 4 m/s in downtown Kodiak will occur at the mouth of the harbor and at the edge of the breakwater. Based on observed damage the predicted velocities appear realistic.

Numerical simulations are the basis for defining vulnerability under present conditions. The vulnerability of direct impact focuses on:

1. Land use/potential disruption
2. Vulnerability to structure damage

The center of Kodiak's commercial activity, represented by retail uses and the fishing industry, is in the area projected to experience up to 3 m of water. Approximately 1/2 of this area is expected to experience water velocities of greater than 4 m/s. Additionally, because much of the fishing industry is seasonal and during the busy season between June and September, 1,200–1,500 workers, many of whom do not speak English, work along the docks. In 1964 waves funneled mud and debris up roadways into Kodiak's primary electrical power station, disabling it for a period of days. Today the present roadway alignments are the same as in 1964.

The vulnerability to structures is largely dependent on construction type. The majority of the buildings within the predicted inundation area are either wood or light steel frame, with slab on grade foundation. This type of construction is not expected to withstand a repeat of the 1964 event. This includes the newly constructed shopping mall on the waterfront.

Secondary impacts of tsunamis includes loss of ground support. Virtually all of the inundation area is now on fill and is highly vulnerable to strong erosive forces. The most critical area of downtown is located on approximately 10 feet of fill. In addition to the erosive forces of a tsunami, compaction and/or liquefaction during ground shaking could destabilize buildings and underground utilities, possibly resulting in fire.

Kodiak is one of the largest valued ports in the United States. During the peak seasons, 350–400 boats would become floating debris to be thrown against structures under high velocity conditions. Additionally, debris includes parking lots along the waterfront which were not there in 1964, and easily dislodged wood frame structures.

Although there were no fires in Kodiak in 1964, conditions comparable to communities which did have fires exist today. Because Kodiak is such a major port for Alaska there is a variety of fuels, both above ground and buried, that exist within and around the ports and city center. Of additional concern are contamination hazards. These hazards would occur from materials used by the canneries, and shipped through the port. After 1964 much of what was residential is now industrial/canneries.

The loss of human life is always a major concern and the greatest potential will be from high-occupancy uses and populations with restricted mobility. In Kodiak these include a movie theater and bowling alley, the jail, a senior citizens' residence and possibly second-story residents above the mall. Although the Kodiak police department has prepared an evacuation plan, it will be time consuming. Additionally, the main telephone switching equipment, the police, and fire departments are within the hazard area. Although evacuation plans exist, there is a lack of efficient evacuation routes, which become even worse during the winter months.

In general, based on projections of a repeat of 1964, it appears that the overall risks in Kodiak are greater today than they were in 1964.

Chapter 5. Mexico 1985: Retrospective Assessment

The September 19, 1985 earthquake off the west coast of Mexico was a very atypical subduction earthquake. It was what some scientists refer to as a "slow" or "weak" earthquake. This region, where the Cocos plate is being subducted beneath Mexico, is one of the most seismic zones in the western hemisphere and has produced seven tsunamigenic earthquakes this century. The authors use this earthquake to distinguish between different types of tsunamigenic earthquakes. Although the form of a submarine tectonic displacement is difficult to determine, the time-displacement history of an ocean ground bed section deformation during an earthquake can be characterized by three parameters:

1. Amplitude of vertical displacement
2. Half-width of the underwater block (b)
3. Characteristic time displacement (T)

Hammack (1972) shows that three-dimensional combinations of the above parameters, including water depth, are important in determining the characteristics of the generated tsunami wave:

- A disturbance-amplitude scale
- A disturbance-size scale
- A time-size ratio $T(gh)_{1/2}/b$

Of particular importance as an indicator of the type and shape of the generated tsunami is the time-size ratio. Three distinctive configurations have been identified:

1. Impulsive Case—Time-size ratio less than one
2. Transitional Case—Time-size ratio on the order of one
3. Creeping Case—Time-size ratio greater than one

While the Alaskan earthquake was an impulsive case and is applicable to most tsunamis with a time-size ratio of 0.06, the 1985 Mexican tsunami was a typical creeping case. The Mexico earthquake time-size ratio was approximately 1.69. Impulsive type earthquakes produce breaking wave profile type tsunamis, while creeping type earthquakes produce bore wave profile tsunamis. Impulsive-breaking type tsunamis are much more impact-drag damage dangerous than the creeping-bore type. The 1985 Mexico tsunami entered mildly, receded slowly, and developed a bore up local rivers and did not show any kind of breaking wave pattern or velocity effects at the beaches. The characteristics of the generated tsunami seem to be applicable to few tsunamis on a worldwide basis because (h) is larger (deeper) and (b) is small (narrow). Damage to coastal communities from this tsunami was minimal compared to the 1964 tsunami, due in part because of the type of wave and the limited population and industry. Additionally, it is difficult to estimate future tsunami risk because of the lack of historical data. Although Lazaro Cardenas, which is an important industrial port for the west coast of Mexico, experienced the most damage in 1985, the city, port, and industrial facilities were built only 15 years prior to the earthquake on the uninhabited sandy shoals of the Balsas River delta.

A 1975 study determined that Lazaro Cardenas was not under tsunami risk: experience clearly demonstrated otherwise. Additionally, evidence suggests that repeat times of large earthquakes along any region of the Mexican subduction zone average about 30–70 years. Postulated runup heights in Lazaro Cardenas are believed to be:

- 3 meters every 27 years
- 7 meters every 54 years
- 10 meters remotely possible

At the time of this writing the Civil Defense Plan of Mexico did not include instructions for tsunamis, and the National Urban Development Plan did not contain any specific policy for tsunami hazard zones planning. However, the National Disaster Prevention Systems planned to increase tsunami research. In addition to assessing tsunami risk, the authors state the need for public education for residents, tourists, and others who find themselves in coastal areas during an earthquake.

Part III. Risk Reduction Framework

Chapter 6. Balancing Tsunami Risk in High Impact Areas

The historical description of the 1964 Alaskan tsunami demonstrates that damages are caused by both direct and indirect forces. Once vulnerabilities of a community are understood the risk reduction process can begin. Risk reduction programs are based on evaluation of considerations such as:

- Economic loss/foundation failure vs. economic magnitude of construction cost

- Socio-political cost of loss vs. mitigation
- Danger of toxic and hazardous contamination
- Containment of fire
- Reduction of injury and life loss

There are two fundamental approaches to tsunami risk reduction:

1. Construction of engineered barriers
2. Risk management policies

Engineered barriers consist of breakwaters, sea walls, and dikes designed to retard the volume of water. Three alternatives have been identified for Kodiak and are evaluated through the same numerical model used earlier.

Barrier Concept #1: Increase Barrier Height

The purpose here is to retard the volume and velocity of water by increasing the elevation of breakwaters by 8 ft from 22 to 30 ft. Although numerical simulation projects that these breakwaters will not be overtopped, the long period of tsunamis (80 minutes) would result in the downtown being flooded with water from the mouth of the breakwaters as seriously as if no changes were made.

Barrier Concept #2: Seawall and Reinforced Buildings

The goal of reducing the volume and velocity of water is achieved by increasing the top of the southwest barrier to 30 ft, plus building a 28-ft seawall along the waterfront. Additionally, reinforced buildings are constructed behind the seawall, thereby decreasing the through-flow of water. Numerical simulation projections indicate that the inundation area and water depth are only marginally less (approx. 20 cm) than either Concept #1 or no change. However, high current velocities are predicted to be generated between the reinforced buildings, and therefore additional reinforcement would be required within the structural designs. Despite increased construction cost, damage would be comparable to that under existing conditions.

Barrier Concept #3: Elevated Dikes

This plan once again increases the highest of breakwater plus constructing a 28-foot elevated seawall along the shore with a roadway on top. In this scenario the inundation area does not extend as far inland and total flood elevations are reduced about 2 m. Flooding is caused by water flowing around the open ends of the seawall. Total velocities are decreased with highest velocities adjacent to breakwaters and the inland side of the seawall. This plan would decrease water depth in most of the inundation area to approximately 0.5 m. In 1964 this level of flooding resulted in only slight damage. A major disadvantage of this concept is that the elevated roadway is extremely expensive, anesthetic, and would disrupt impacts on economic activities in the waterfront/downtown area.

A risk management program responds to the implications, or characteristics of risk. It selectively reduces characteristics of tsunami risk, differing from barrier concepts by managing the risk rather than blocking the water. Decision makers must balance losses against mitigation cost.

Two case studies are presented to display different approaches to risk management:

1. Kodiak, Alaska: vulnerability to high velocity/impulsive events
2. Lazaro Cardenas/Ixtapa-Zihuatanejo: vulnerability to low velocity/creeping events

Specific risks in Kodiak to high velocity events includes:

- Water effects
- Loss of ground support
- Debris impact
- Fire/contamination

Risk characteristics are primarily a function of uses and location. Four use-oriented districts within the inundation area have been defined:

1. Commercial/mixed use
2. Marine use and shore
3. Industry
4. Life safety

Communities on Mexico's west coast exemplify different vulnerabilities. Three types of vulnerable area have been defined for this region:

1. Industry
2. Resort Area
3. Villages

In summary, all of the barrier plans would be expensive while not completely preventing damage in the downtown area. Risk management is directed toward reducing specific risks and therefore can be tailored to each community.

Chapter 7. Reducing Risk in Commercial Areas

Risk management objectives in the commercial areas are:

- Minimize the effects of flooding (water volume and velocity) for designated structures
- Minimize secondary effects of debris both in terms of creating debris (parked vehicles) and impact from debris (boats) on the structures
- Protect or strengthen targets of debris impact
- Minimize life loss through attention to evacuation requirements

Some uses are inappropriate for inundation areas. Some examples are:

- Public facilities and assembly uses, such as theaters
- Populations with limited mobility
- Jails
- First responder headquarters
- Gas stations

Decisions made with respect to expandability are determined for individual buildings. Primary criteria include:

- Use not subject to high life loss
- Uninterrupted functions not critical

While discussing siting and construction standards in high impact areas the authors provide alternative construction examples for the mall in downtown Kodiak. These include such designs as elevating ground floors, protecting parking areas, using structures as buffer zones, including front-line defenses, increasing shear walls and using concrete retention walls, securing foundations of expendable buildings so as not to add to debris, and traffic considerations.

Chapter 8. Reducing Risk to Marine and Shore Areas

This district encompasses the shore area and the small boat harbor. It is assumed it will be destroyed and become floating debris and therefore part of the hazard. Additionally, because of their vulnerability, these structures are considered expendable. Risk management objectives address three primary considerations:

1. Minimize the compounding effects of severe erosion and/or loss of ground support
2. Inhibit the source of debris created by marine uses, buried tanks, and structures
3. Protect inland uses from debris impact

Uses in the immediate waterfront area and their performance expectations:

- **Shore:** the shore in its capacity to anchor piers and wharves and to buffer upland uses from debris plays a critical protective role between boats and downtown.
- **Boats:** with warning, boats are expected to evacuate to safety. Those that do not, become debris

- **Docks, wharves and piers:** floating docks, wharves and piers anchored to the shore are expected to break away. They are therefore considered expendable structures.

Using Kodiak as an example, the authors propose many ways in which to reduce these risks along marine and shore areas, much as they did for reducing risk in commercial areas.

Chapter 9. Reducing Risk in Industrial Areas

The boundaries of industrial/marine commercial district encompasses canneries and port related activities. These facilities are typically where water volume and velocities will be highest and at greatest risk from secondary hazards of fire and contamination, and ground failure. Risk management objectives in the industrial area are to minimize the effects of these hazards. Specific objectives address:

- The source of ignition
- The susceptibility to fire spread
- Destabilization of potentially flammable uses on unstable fill
- Debris created by stored material

Many industrial uses pose risk of fire and toxic contamination. Where possible, hazardous use, i.e., gas stations, should be located outside the inundation zone. Bunk houses or housing should be located outside the inundation zone.

Performance objectives are to prevent fires and to contain them once started. Standards for industrial uses of risk can be roughly classified as ignitors, ignitable materials, and contaminators. The authors spend the remainder of this chapter defining these terms and providing specific examples for siting and construction, storage, circulation, and buffers.

Chapter 10. Reducing Risk in Low-Velocity Areas (Mexico)

For discussion purposes this chapter uses a creeping, low-velocity event. It characteristically has runup heights of 7 m with 2–3 m of flooding. The reoccurrence interval is 54 years. The boundaries of this event encompass the inundation area, the roadway, and the transportation network. Risk management objectives are to:

- Minimize impacts on lifelines
- Minimize from fire and possible surface contamination
- In resort areas, minimize function loss and economic dislocation
- Maximize friction created by obstructions to retard inland transportation of debris

Because low-velocity events are not devastating, performance standards are oriented toward minimizing secondary and indirect effects. The remainder of this chapter discusses a variety of land uses and appropriate which can be used or have been successful elsewhere, and pertain to industry and resorts, siting and performance standards, transportation, and buffers.

Part IV. Implementation

Chapter 11. Administrative Framework

Effective risk reduction is implemented through an integrated program involving many jurisdictions and agencies.

Appendix 3B

Summary of Ayre, R.S., P.B. Trainer, and D.S. Mileti, 1975, Earthquake and Tsunami Hazards in the United States: A Research Assessment. Program on Technology, Environment and Man, Monograph #NSF-RA-E-75-005, Institute of Behavioral Science, University of Colorado, 150 pp.

Introduction

This report is broken into two sections, Part I, Earthquakes, and Part II, Tsunamis. Within the summary the authors state that a change of research focus from geophysical, seismological, and engineering research to insurance and community preparedness is needed if economic loss and social disruption are to be reduced. Key points include:

- Land use management
- Earthquake-proofing
- Earthquake prediction and warning
- Insurance
- Community preparedness, relief and rehabilitation
- Earthquake reduction

Part I. Earthquakes

In Chapter I, *Dimensions of Earthquake Problems in the United States*, the authors provide a comprehensive historical review of earthquakes and earthquake-related studies, engineering interest, and legislation passed. They discuss certain populations affected by earthquakes and provide a method of looking at those populations. While looking at the impact on human social systems they state that "the interrelationships between the earthquake and the social system can occur at six different levels:

1. The individual
2. The small group
3. Organizations
4. The community
5. The region
6. The nation

Stating that the impact of earthquakes may be felt, and adjustments adopted, at each of these levels, they then proceed to discuss briefly some of the relationships and their costs and benefits. They state seven adjustments which comprise the adaptive process to earthquakes:

1. Earthquake reduction and prevention
2. Earthquake-resistant construction
3. Land use management
4. Forecast and warning systems
5. Insurance
6. Adjustments to associated hazards (fire, landslides) triggered by earthquakes
7. Community preparedness, relief, and rehabilitation

They then discuss each adjustment individually in detail. They also consider the costs and benefits of the hazard as well as look at the role of the Federal government.

In Chapter II, *Simulations of Earthquake Loss Management*, they state that "the importance of being able to assess the likelihood of earthquake loss, the magnitude of loss that may occur, and the means of adjustment to that loss can scarcely be overestimated." The purpose of Chapter II is 1) to discuss the simulation of earthquake loss management from a very general point of view, and 2) to present the computed results of the simulation of a large selected sample of earthquakes (44) acting on a large diverse community.

Chapter III relates to future *Research Recommendations*. The authors break their recommendations into six major categories:

1. Earthquake reduction
2. Earthquake-resistant construction
3. Land use management
4. Prediction and warning
5. Insurance
6. Community preparedness, relief, and rehabilitation

The authors note that the judgments presented are for research related to *earthquakes as hazards to life and property*. The judgments are not concerned with the basic research of geophysics on occurrence of earthquakes, the nature of ground motion, etc., as important as that research is in the long run. Their suggestions include 1) estimated current annual levels of support, 2) suggested total additional research in person years, and 3) suggested time horizons for additional research years.

Part II. Tsunamis

Chapter IV, *Dissemination of the Tsunami Hazard in the United States*, begins with the definition of tsunamis by Cox (1963): "a train of progressive waves generated in the ocean or a small connected body of water by an impulsive disturbance." Further description of tsunamis include their *Physical Characteristics*. The authors have broken the physical descriptions of tsunamis into 1) their origin and dynamic, and 2) the types of damage typically incurred in tsunamis.

Science has advanced since this article was written. At the time they state an inability to know if a tsunami is generated. We now have a greater ability to determine focal mechanisms more rapidly, which in turn provides us with important information about the type and location of an earthquake. They also state that it is "commonly accepted that the earthquake must have a magnitude of 7 Richter or greater to be accompanied by a tsunami of significant magnitude." However, earthquakes of lesser magnitude may generate local tsunamis that might cause damage in confined areas near the epicenter.

Other characteristics about tsunamis noted here are the speed, the variability of runup heights, the repeatability of events, and the number of waves in a train. Tsunami waves can travel at speeds of 350–600 mph and can traverse the entire 12,000–14,000 miles of the Pacific Ocean in 20–25 hours, and still be capable of causing great destruction. The apparent period of a tsunami can be 5–60 minutes or longer (crest–crest) and the wave length can be between 50–100 miles or more. In shallow waters the wave speed and length decrease and wave heights increase greatly. At the coast, speeds are typically less than 40 mph with run-up heights of 50 feet or more.

Although a variety of procedures are used to report tsunami data, the authors present four ways to describe the height of a tsunami as determined by instrumental data:

1. The absolute height of wave crest above current stage of tide
2. The absolute range of the wave (wave height) from trough
3. The amplitude, which is the absolute range divided by two
4. The relative height above a certain datum, which requires knowledge of the tide's stage at the time of reading

Although most tide stations report method 1) or 2), a tsunami's amplitude is frequently referred to in more general discussions and the term runup height is also commonly used, referring to the elevation reached by waves as they inundate the land above the tide level at the time of the tsunami.

The section on *Incidence and Affected Populations* concerns itself with 1) areas of risk, and 2) populations at risk. Determining areas at risk has largely been dominated by researching historic tsunamis and associated damages. Although tsunamis have been documented in other oceans "it can be said that tsunamis are generally confined to the Pacific Ocean." While discussing the potential populations at risk they tend towards historic evidence, especially when considering populations not at risk. This is a dangerous practice as science continues to present current geologic and archeological evidence that may suggest differently. Table IV-I is a list of sources for tsunamis that have affected Hawaii. Tables IV-II and IV-III reflect past casualties and damage as well as potential endangered populations by Pacific tsunamis. Therefore the authors state that a definition of Tsunami Hazard Area is necessary and needs to be defined in terms of elevation for steep-sloped coastlines and horizontally for gentle-sloping topography. They quote a standard widely used:

> Tentative standards for hazard areas on Pacific coasts define the potential danger areas as those within one mile of the coast that are lower than 50

feet above sea level for tsunamis of distant origin and lower than 100 feet above sea level for tsunamis of local origin (OEP, 1972, v. 3, p. 103).

The authors spend a good deal of time discussing the *Adjustments to the Hazard*. While presenting adjustments to the hazard there is the understanding that there must be some acceptable degree of risk for economic reasons. The economic benefit gained by locating transport and commercial facilities on the shoreline and the aesthetic pleasures of living by the sea will undoubtedly contribute to the increased density of populations and structures in the tsunami hazard zone. They point out six categories of adjustments and discuss each one. Some adjustments are appropriate to other natural hazards; however warning systems are one adjustment that have characteristic peculiarities to tsunami hazard and are discussed in detail in this report.

I. Engineering Works and Land Use Management. This is broken down into two categories,
   1) Suitable structural design
   2) Selective zoning
II. Warning and Evacuation
   1) Pacific Tsunami Warning System, its origin, use, responsibilities, and effectiveness;
   2) Regional Warning Systems: the definition and usefulness;
   3) Message Dissemination at the Local Level: Certain stipulations apply to the effectiveness of any message from a warning center (modified from Haas and Trainer, 1973):
      a) It must be relayed promptly at each relay point;
      b) The essential information must not be altered and insertion of misleading information must not be permitted;
      c) The message or signal must contain all information necessary, when coupled with the information readily available to the recipients, to permit rapid, rational decisions;
      d) The ultimate recipient must be motivated to take appropriate timely action;
      e) There must be safe areas that the ultimate recipient can reach in time;
      f) The ultimate recipient must be motivated not to re-enter hazardous areas until the hazard has passed.
   4) Utility and Limitations: Haas and Trainer (1973) have developed a fourfold typology for tsunamis:

      Type I: Water action is almost simultaneous with earthquake ground motion. No type of warning can be of assistance.

      Type II: Tsunami waves, if generated, will arrive within 5–10 minutes of ground shaking. Strong ground motion for 30 seconds to several minutes are the physical cues, and if properly interpreted can act as an adequate warning device.

Type III: Clearly noticeable, but not large, earth shocks are felt for up to a few minutes and can act as an alert to the population to check with responsible officials. However, waves may arrive within 15–30 minutes and there is little time for evacuation after official notification. Therefore prompt action is required and the rule of thumb becomes "if earth tremblers are felt for more than 30 seconds, immediate evacuation is in order." This course of action covers both Type II and III events.

Type IV: Depends on the external tsunami detection and warning systems, as there are no natural cues that provide adequate notice. Fortunately, most events are Type IV, where planned warning and evacuation systems can be effective if they can be kept operational over long periods between warnings.

III. Community Preparedness: There is much a community can do
   1) to develop a perception of the tsunami hazard and its extent;
   2) to prepare its members to take appropriate measures to protect themselves from a possible tsunami if a large earthquake is felt:
   3) to prepare its officials and the general public to make intelligent use of warnings from a regional and general system, as well as
   4) to discern the possibilities of property protection by engineering and zoning approaches and the property loss adjustment by insurance.

However, evidence from Alaska suggests that short-term public education efforts, even intense ones, do not have measurable, lasting effects (Haas and Trainer, 1973). Nonetheless, a similar study in Hawaii showed that continuing efforts in the schools led to more optimistic conclusions. Although rapid warning of the people is very critical, procedures for providing early warning can be incorporated into local agencies.

IV. Tsunami Insurance: Although not available in 1960 and 1964, the National Flood Insurance Act, as amended in 1973, extends Federal flood insurance subsidy provisions to cover tsunami risk.

V. Relief and Rehabilitation: although the Federal government played its usual important role in 1960 and 1964, all levels of government may be involved in the long-term rehabilitation programs and it is especially reasonable and timely to institute feasible protective measures for the future.

VI. Combination of Adjustments (based on Cox, 1974): Because the adjustments discussed may be combined, they site many examples of the interactions among the various adjustments.

The last two topics covered in Chapter IV are the Role of the Federal government and the Cost Benefits of the Hazard.

In Chapter V, *Futures: Simulation and Scenario*, the authors did not attempt a simulation of tsunami loss management as they did for earthquakes, but they state that it would not be fundamentally different in principle from the simulation of loss management for earthquakes and hurricane storm surge. They do, however, discuss a number of aspects that could or should be incorporated into a simulation of loss management.

I. Selection of the Natural Event or Sequence of Events
   1) Statistical selection
   2) Arbitrary selection of historical or maximum expected events
II. Population and Facilities-at-Risk
III. Selection of the Study Area
   1) Macro- and micro-studies
   2) Local topography
IV. Warning Time: Locally versus Distantly-Generated Tsunamis
V. Selection of Data-Base Grid Cell Size
VI. Simulating the Adjustments
   1) Modification of the natural event
   2) Modification of the human-use system
   3) Modification of the loss distribution

Alternative Futures

Should the scenario technique be persuasive for tsunamis, there are three pieces of writing which provide examples of 1) narratives, 2) dramatic writing for persuasive purposes, and 3) comparative information on separate tsunami events in the same city and/or in different cities. Although these are not scenarios, as actual events they may prove useful in scenario preparation. Narratives are historical accounts of what it looked like before hand, what happened and what was done during, and what actions were taken afterwards. Dramatic writing should be performed with the intent of presenting in an interesting and understandable way the inception and working of tsunamis. Comparative material can be utilized in two ways. The first is to compare multiple locations within the same event, such as Crescent City, California and Hilo, Hawaii in 1964, or to look at the same location during multiple events such as Hawaii in 1960 and 1964.

In Chapter VI, *Research Recommendations and a Comparison of Losses due to Earthquakes and Tsunamis*, a study of the historical dollar damage and the lives lost in the United States and its possessions, since 1900, earthquakes cause 10 times as much damage in dollars than do tsunamis, and earthquakes cause 2.5 times as much death than do tsunamis. These figures appear to be in the right direction if one considers the lesser frequency of occurrence and smaller area of vulnerability for tsunamis than earthquakes. In an attempt to assess research opportunities, the effort has been to canvass the full range of possible adjustments, the dynamic factors affecting them, and the total benefits and cost to the society of introducing new information and techniques through research. Although the authors state that there is a need to know about tsunamis and the effects, their relatively low frequency and the relatively low population at risk makes it difficult for them to justifiably suggest large absolute expenditures. However, they do suggest that 1) tsunami detection and warning dissemination systems must be continued; 2) it would be desirable to do some research on mapping tsunami risk zones; and 3) some research could be justified on tsunami-resistant construction techniques. Tables VI-I and VI-II provide further suggestions for research opportunities and suggested funding levels. Again, as noted in Part I, the judgments presented in this report relate to tsunamis as a hazard to life and property. They do not attempt to encompass all geophysical research on the hazard.

Appendix 3C

Summary of Steinbrugge, K.V., 1982, Earthquakes, Volcanoes, and Tsunamis, an Anatomy of Hazards. Skandia America Group, New York, New York, 392 pp.

Introduction

The moderator at a seminar on earthquake underwriting observed "I think too many of us are writing too much earthquake insurance and we do not know what we are doing." There is a concern in the insurance industry that they will be unable to respond to their contractual obligations when a major catastrophe occurs. Successful underwriting includes consideration of the source of business, risk selection, and adequate pricing. The Skandia America Group felt there was a need for a consolidated information source for the catastrophic perils of earthquakes, volcanoes, and tsunamis. This text attempts to address some of the known and the theoretical information available on earthquakes and associated hazards by providing a readable and substantial amount of useful, timely, and credible data. While at times the information in this publication is dated, in general it is well illustrated with tables and charts, figures and photos. In this publication many topics concerning underwriting technology and hazards are discussed and illustrated for the benefit of both the seasoned underwriter as well as the newcomer.

Chapter 1: What Is an Earthquake? This chapter begins with a historical overview of earthquakes which includes some of the facts and fantasies that have been associated with earthquakes through time. Primarily focusing on mythology and religion, this section is focused on pre-modern day science. The author then takes you through the beginnings of the scientific approach to earthquakes by discussing some of the earliest attempts at scientifically understanding earthquakes from the 18th century until the present. In a discussion on influential earthquakes the author notes that influential can mean different things for different people. For example, one might consider the loss of life while others consider the magnitude. Another view on influential earthquakes provided here is from an earthquake insurance engineering standpoint. Additionally, influential earthquakes mean those selected significant events that have caused major changes in philosophical, scientific, and engineering thinking leading to today's practices in earthquake hazard reduction.

In a section entitled "Why We have Earthquakes" the author presents a brief and simplistic discussion on continental drift and the making and destruction of the earth's crust. While making only a brief mention of the plate tectonics theory, in his discussion on the destruction of crust he makes no distinction between continental and oceanic crust and states that the process is called subduction of continental plates. In his discussion on earthquakes, faulting, and energy the author talks about the Elastic Rebound theory and discusses the strain stored in rocks prior to the stress release in earthquakes. As an example the author uses a fence built across the San Andreas fault prior to the 1906 earthquake and the bending and eventual offset of the fence which would take place. In his discussion on the recording of earthquakes the author briefly describes the three major types of seismic waves, the Primary (P) and the Secondary (S), both of which are body waves and surface waves, which he breaks down into Love and Rayleigh waves. Also discussed are two of the instruments used to measure earthquakes: basically, how seismographs are used to measure the size and location of earthquakes, and the use of strong motion instruments.

Chapter 2: Earthquakes – Where, How Often, and How Large. The knowledge of the distribution in time, location, and size of an earthquake is essential for insurance rating and underwriting purposes. While providing a few documented sources for historical earthquakes the author points out the variance in complete seismic records. While in some parts of the world records have been kept for thousands of years, in some parts of the western United States earthquake records barely exist for the last 100 years. The author also presents two figures that depict an uneven record of the seismicity of the United States. While defining earthquake terminology the discussion is limited to magnitude, epicenter, and focus. While doing a good job of defining these terms and how they relate for insurance purposes or damage, the author only touches upon the concept of earthquake intensities, a far more pertinent subject with respect to the destructive nature of earthquakes. The author provides a brief discussion of instrumental recording of seismology and the benefits of being able to record earthquakes around the world. With seismicity maps of the world the author discusses some of the more tectonically active regions of the world. However, instrumental recording of earthquakes is relatively new and therefore provides a rather short historical record. At the time there was a relatively new method of geologic investigation that was beginning to evolve, presently called paleoseismicity. In this discussion the author presents paleoseismic work by Dr. Kerry Sieh and his work along Pallet Creek along the San Andreas fault. The applications of historic, instrumental, and geologic records of earthquakes become useful to the underwriter when utilized to develop seismic risk maps. Presented are a number of seismic risk maps for the United States that were produced from the Uniform Building Code of 1982. Although these maps were current at the time of printing, some major changes have been made in regard to earthquakes along the Pacific northwest within the last two decades which greatly increases the hazard levels of northern California, Oregon, and Washington. Also presented are Insurance Service Office (ISO) zoning maps by county for the states primarily west of the Rockies. Again, while these maps were current at the time of publication, they are obsolete, particularly for the northwest.

As a first step toward evaluating the potential damage in the event of a great earthquake, it is necessary to define a great earthquake in terms that would be useful for insurance studies. Two sizes of earthquake should be studied, the Maximum Credible Earthquake (MCE) and the Maximum Possible Earthquake (MPE). The MCE is the maximum earthquake that appears capable of occurring under the conditions of the currently known geologic environment. Worldwide the author concludes that the MCE is 9.0, whereas in California the MCE is 8.5, most likely along the San Andreas fault. This is based primarily on historic earthquakes and again is prior to the substantial knowledge that we currently have regarding the Cascadia subduction zone. Additionally, throughout the discussion of magnitudes, the author does not use moment magnitudes, which he referred to in an earlier section on magnitudes, and while he states that the 1906 San Francisco earthquake was a M 8.3, he states that the 1964 Alaskan earthquake was a M 8.4. The

MPE, on the other hand, is the maximum earthquake that, on a statistical basis, will most likely occur during a certain interval of time, often being 300 years for insurance purposes. The author presents some results from earthquake vulnerability studies on four cities, San Francisco, Los Angeles, the Puget Sound region, and Salt Lake city, for the potential effects of the MPE and the potential monetary losses for Los Angeles and San Francisco under two different earthquakes and two different faults for each city.

In a discussion of earthquake prediction the author discusses the usefulness of an accurate earthquake prediction. Although at the time of this writing no clear method had been proven, he states the potential for a limited, yet assured prediction capability to exist within the next decade (by 1992), and acknowledges that this might be quite wrong. At this time (1997) there is still no assured method, although earthquake prediction is still an ongoing research. The author sites some of the successful and unsuccessful predictions that have been made in the past. He also points out that in order to be a meaningful prediction it must specify time, place, and magnitude range. He continues further to discuss the formation of the National Earthquake Prediction Evaluation Council and the California Earthquake Prediction Evaluation Council as well as to define Earthquake Advisory, Earthquake Watch, and Earthquake Warning. The author concludes this discussion with a comment on the economic impact of accurate predictions, both beneficial and detrimental, and the hazards associated with false alarms.

Chapter 3: Implications of Active Faults, Magnitude, and Intensity. The author begins this chapter with definitions of faults, fault traces, active faults, and dead faults. While the definitions are basic, he sites the current criteria of the Nuclear Regulatory Commission for an active or *capable* fault as "movement at or near the ground surface at least once within the past 35,000 years or movement of a reoccurring nature within the last 500,000." Current definitions used by geologists deem a fault to be active if it has moved within the last 10,000 years. The author then proceeds to make good use of figures and photos to discuss and explain different types of faults and their historic motions.

Geologic and fault maps are useful tools for insurers and underwriters in determining risk factors. For insurance purposes practical published fault maps were at the time of this publication restricted to California and Utah. While useful for those regions, the scarcity of maps at this time was limiting. However, the author demonstrates that earthquake damage is not necessarily related to the distance from a fault surface. If all things considered were equal it would make sense that the greater the distance from a fault the less damage there would occur; however, all things are not equal, plus he sites examples of dwellings very near a fault that experienced low damage levels. Although used in many situations, Alquist-Priolo maps have had negligible insurance impact on low value structures. However, intensity maps, originating from the felt effects of historical earthquake, provide a measurement of what happened during an event and can be used for predictions for future similar events. However, there are limitations to intensity data, as they are subjective and reflect a variety of different aspects. And as such, an isoseismal map of one earthquake may not be useful for predicting damage from an earthquake in a different location. Additionally, it is not practical to make a direct correlation with earthquake magnitude and earthquake intensities, as felt effects vary depending on length of ground shaking, focal depth, and rock and soil types.

Chapter 4: Landslides and Poor Ground. Through the use of microzonation maps this chapter relates to three geologic hazards with respect to construction: 1) active fault traces, 2) potential landslides, and 3) poor ground, such as marshes and soil-liquefiable locations. The author provides a number of photographs and figures that display the anatomy of a landslide as well as some of the effects of landslides and liquefaction. The interaction of earthquakes and soil effects or "poor ground" can have profound implications. Poor ground is usually not well defined for insurers' purposes; however, common to all definitions are soft compressible soils such as marshes and poorly engineered man-made fills. Poor ground maps are of such importance to insurance underwriting, as well as rating, that the ISO had published maps for structurally poor ground for the San Francisco Bay area, Long Beach, San Diego, and Eureka at the time of this writing. Another aspect of building on poor ground noted by the author is that differential settling which may take place prior to an earthquake would affect the overall integrity of a building and potentially produce a greater hazard of damage during an earthquake.

The next three chapters: **Chapter 5: Building Classifications and their Basis**, **Chapter 6: Building Damage**, and **Chapter 7: Non-Building Damage** deal more with building classifications and specific examples of damage to each, both structural and non-structural. Also mentioned is special legislation that has resulted from past earthquake damage. Because these chapters relate more toward insurance underwriting than the actual science of earthquakes, volcanoes, and tsunamis, these sections were only briefly reviewed. In **Chapter 5: Building Classifications and their Basis** the author states that, as a starting point toward any insurance discussion relating to earthquake rates or losses to buildings, there must be a clear understanding of what constitutes a building as well as a practical building classification system. This chapter is divided into four parts, 1) basis, 2) U.S. Classifications, 3) Puerto Rico Classifications, and 4) Canadian Classifications. As with the rest of this book, this chapter is well illustrated with figures, photos, and tables. In **Chapter 6: Building Damage** the discussion is limited to certain concepts behind the mathematical design approach, plus a view toward the insurance significance of the end product. Again, very well illustrated, this chapter looks at both long- and short-period motions as well as earthquake-resistant design and damage to buildings by their building class and building content. **Chapter 7: Non-Building Damage** covers some of the many non-building construction types, such as above-ground tanks, dams, power and chemical plants, as well as several specialized building types such as docks and other waterfront structures.

As with some of the earlier chapters, **Chapter 8: Comments on Rates and Deductibles** and **Chapter 9: Probable Maximum Loss** are written more for the insurance underwriter audience and as such are not reviewed in any detail. However, once again the many tables, charts, and photos the author has provided give a thorough review of these topics.

Chapter 10: Fires Following Earthquakes. Fires following earthquakes is commonly mentioned when discussing past earthquake disasters. Uncontrolled fires burning large areas (conflagration fires) for long periods of time in a future great earthquake worry many insurance executives, public officials, and fire protection engineers. This chapter is largely a case study of three great earthquakes and fire disasters: the 1923 Tokyo, Japan earthquake; the 1973 Managua, Nicaragua earthquake; and the 1906 San Francisco earthquake, in which great detail is given. Conflagration fires have three main elements: 1) fire load per unit area, 2) degree of impairment of fire response facilities, and 3) adversity of climatic conditions.

Chapter 11: Tsunami (Seismic Sea Wave). While often called tidal waves by the public, the implied relationship to ocean tides is incorrect. The only significant relationship to tsunamis and tides is that their height may be additive or subtractive. The term tsunami originates from the Japanese tsu (harbor) and nami (wave). Within this chapter are a number of eyewitness accounts that document the ground shaking and the devastating effects of the tsunami. Through historical accounts, photos, figures, and tables, the author provides a seemingly thorough account of historic tsunamis. Tsunami may be strictly defined as a long-period ocean wave normally associated with offshore earthquakes. In the ocean they are waves with periods ranging from 5 minutes to well over 60 minutes; period is the length of time between one wave crest and the following one at any given location. The distance between wave crest in the ocean may be on the order of 50 miles and the wave height no more than 2 feet. Tsunami runup is defined as the elevation above sea level, at the time of the tsunami, reached by a tsunami wave. While commonly a rapidly rising tide, tsunamis sometimes take the shape of a bore. A bore has the appearance of an almost vertical wall of water. Tsunamis normally have a tectonic (earthquake) origin, although landslides and volcanoes may also be their cause. When many thousands of square miles uplift or downdrop in terms of many feet, then large bodies of water are displaced. One of the most disastrous modern tsunamis occurred on June 15, 1896, in the Sanriku region on the northeast coast of Japan. About 20 minutes after feeling a slow gentle motion of long duration the sea receded to return as a wall of water some tens of feet high, killing 27,122 persons. Based on historic record, geologic evidence, and plate tectonics, only certain regions beneath the oceans appear to have the potential to generate tsunamis, which typically originate from regions of subduction, where thinner oceanic crust is being subducted beneath thicker continental crust. In general, major tsunamis are normally the result of major earthquakes accompanied by large-area ocean displacements. It has been observed that the energy from tsunamis is directional, that is, it does not radiate with circularity from a point source. For example, a tsunami originating off the coast of Chile affected Hawaii and Japan, but not as significantly along the Pacific Coast of the United States. On the other hand, the 1964 Alaskan earthquake caused larger comparative damage along the Pacific Coast than at Hawaii. In an explanation to this the author states that a tsunami moves at right angles to the major axis of an ellipse which has the same orientation as the fault that ruptures, providing it is an earthquake-induced tsunami. This accounts for some of the directivity which has been observed in historic tsunamis.

Tsunamis also occur as a result of volcanic action. Most notably among these types was the August 26, 1883 eruption of Krakatoa in Sunda Strait between Java and Sumatra. This tsunami was estimated at 100 feet in height in nearby regions, inundating the coast of Java and Sumatra with large loss of life.

Seiches, which occur in closed bodies of water, may also be tectonically induced. The Great Lisbon earthquake of 1755 caused seiches throughout Europe, including Scandinavia and Finland. The August 15, 1950 Assam (India) earthquake resulted in water waves in at least 37 lakes and fjords in Norway, with waves up to 3 or 4 feet in height. Also noted is the 1954 Dixie Valley-Fairview Peak, Nevada earthquake. As a result of long period ground motions there was damage to reservoirs and tanks in the Sacramento Valley, California.

About 80% of the tsunami activity occurs in the Pacific Ocean. About 10% occurs in the Atlantic Ocean and the remainder occurs elsewhere. The largest Atlantic tsunami originated near Portugal and Morocco. Historic evidence suggest that the eastern U.S. has only remote possibilities of significant tsunami effects from distant origins, yet has experienced some locally generated tsunamis. On November 18, 1929, in the Grand Banks, south of Newfoundland and east of Nova Scotia, an earthquake (M 7.2) occurred in the Atlantic Ocean. A tsunami accompanied the shock, resulting in 27 deaths. Ships reported a seaquake, with one captain wondering if the propellers were broken. While siting examples of Atlantic tsunamis, the author concludes that the eastern U.S. and Canada have no apparent significant tsunami hazard. Puerto Rico and the Virgin Islands, as well as the West Indies, have significant hazard from locally generated tsunamis, as well as great tsunamis originating off Portugal and Morocco. Within the Pacific Ocean the author proposes three principal areas of interest for this publication: 1) Hawaii, 2) southern coast of Alaska, 3) the Pacific coast of Canada and the United States. In reference to category three, within the United States the author sites two locally derived, southern California examples and none for Washington, Oregon, and British Columbia, and states that the risk of locally generated tsunamis is small. At the time of this writing, very little was known about the Cascadia subduction zone and its true potential for creating large, locally generated tsunamis. There is clear evidence from the historic record that Alaska has significant tsunami hazard along its southern shorelines. About 20–25 historic tsunamis are known for Alaska, but only about 1/4 had runups over 3 feet. In 1964, tsunami damage in Alaska was enhanced by submarine landslides at Seaward, Whittier, and Valdez. At Seaward tsunami damage was extensive along the seaboard while building damage in the city due only to ground shaking was minimal to moderate and included non-earthquake-resistant masonry buildings. Similar accounts are reported from Whittier, Valdez, and Kodiak. In each of these communities it was reported that most, if not all, of the lives lost were as a result of the tsunamis rather than from ground shaking.

Due to Hawaii's central location within the Pacific Ocean the Islands have experienced numerous tsunamis from distant sources such as Alaska, Chili, Japan, Kamchatka, Indonesia, and the South Pacific, as well as locally generated tsunamis.

After the 1946 tsunami the Seismic Sea Wave Warning System for the Pacific Ocean, currently the Pacific Tsunami Warning Center (PTWC), became operational. This system is a cooperative program among nations around the Pacific and functioned successfully for Hawaii and elsewhere for the 1952 Kamchatka Peninsula, the 1960 Chilean, and the 1964 Alaskan earthquakes and tsunamis.

The steps taken by the PTWC are to monitor conventional seismic instruments throughout the Pacific in order to detect, locate, and measure major earthquakes. If an earthquake occurs with a magnitude sufficient enough to potentially generate a tsunami an automatic seismic alarm is triggered. If the earthquake is on or near the ocean an advisory tsunami watch is posted. Continuous recording tide gauges in the vicinity of the earthquake are monitored, and if a local confirmation of an earthquake is confirmed, a tsunami warning is issued with estimated arrival times.

For the insurer and the underwriter, their interest is in identifying buildings and areas that are subject to flooding from tsunamis. This can be done with reasonable confidence in only a few coastal areas where historic tsunami occurred. Even a few miles away the character of the runup may be substantially different. An incoming tsunami may come as a bore in one location and a rapidly rising tide nearby. The location and vertical displacement of the ocean floor introduces major variables. In some cases mathematical modeling has been used to develop theoretical runups. The author sites two examples of tsunami hazard mapping put out by the U.S. Army Engineer Waterways Experiment Station for the Federal Insurance Administration. However, the author cautions that runup mapping still has a long way to go, and none of the maps should be used with 100% assurance.

Chapter 12: Volcanoes. Up until 1976 damage from volcanic eruption was included with earthquake insurance in the Eastern United States. These rules were replaced by the ISO when they developed their nationwide earthquake rules. There was no parallel rule for volcanoes in the western states. After the 1980 Mt. St. Helens eruption the ISO made changes to its Earthquake Extension Endorsement to fire policies in the eleven "Pacific" states. Based on figures within this chapter those eleven states are Hawaii, Alaska, Washington, Oregon, California, Nevada, Idaho, Wyoming, Utah, Arizona, and New Mexico. Those changes were not successful and as of January 1983 revisions provided an optional separate volcanic action endorsement. The author then states that there would be no need for a separate volcanic endorsement if earthquake coverage was taken since earthquake insurance continues to include volcanic action. Interestingly enough, due to changes in earthquake zoning in Oregon and Washington, earthquake rates went down in those states and at the time of this writing no provisions existed that reflected the hazards associated with the active volcanoes of the Cascade Range in Washington, Oregon, and northern California. Additionally, building classification systems used in determining rates for earthquake insurance applies only to earthquake forces and is inappropriate for volcanic eruptions.

The author defines volcanoes as vents in the crust of the earth through which molten rock (magma) is extruded onto the surface of the earth as lava and volcanic debris flows and also into the earth's atmosphere as volcanic gases and rock fragments. A number of volcanic processes accompany eruptions which become hazards when they threaten the life and/or safety of man. Out of 1,200 volcanoes that have been active in one form or another over the past 10,000 years, approximately 500 have documented historical activity that has resulted in at least 190,000 deaths and significant property damage. Some of the more important and well documented historical eruptions are summarized in this chapter. It is important to point out that "historical" eruptions is ambiguous and varies from several thousand years for areas around the Mediterranean, to several tens of years for Antarctica. It is believed that most of the volcanoes that have been active in the last 10,000 years have the potential to erupt in the future. Approximately 60% of the world's active volcanoes are located around the Pacific "Ring of Fire" margin.

Volcanoes can be classified or grouped by shape, rock type, types of deposits that are either blown out or flow out, the tectonic setting, and the character or kind of eruption. For assessing the kinds of volcanic risks, the more important classification may be the characterization of eruption types. Additional classifications are based on activity. The author presents an appropriate classification as: *active* — those volcanoes which are in the process or have erupted in the last 2,000 years, *potential earthquake* — those which have not erupted in the last 2,000 years, but have erupted within the past 2 million years, and *inactive or extinct* — those with their last activity exceeding 2 million years. The author provides a fairly comprehensive history of volcanic areas of the United States and Canada. Included in this summary are the Cascade Range, the Aleutian Arc, the Hawaiian Islands, Mono Craters, the Basin and Range volcanic fields, and the Snake River Plains. Interestingly the author attributes volcanism in the Cascade Range to the subduction of the oceanic plates to the west, yet this tectonic setting is notably missing from previous sections of this text as well as seismic zoning maps that existed at this time.

In a discussion of volcanic processes and associated hazards, the author notes that to the underwriter or loss control person, the type of volcanic hazard is of little consequence, since it does not affect the claim. However, it seems reasonable that an understanding of some of the phases of the eruptive process as related to damage will improve underwriting in various risk zones. In some cases this understanding can be important to insurance consequences. The author breaks down and discusses volcanic processes into Primary and Secondary, where Primary includes ash falls (pyroclastic air falls), pyroclastic flows (mud flows, glowing ash clouds), lava flows, explosion phenomena, earthquakes and ground deformation (uplift, subsidence, and faulting); and Secondary processes include flooding, fires, and tsunamis. As an example of some of the complications that can arise from volcano damage the author uses the May 18, 1980 Mt. St. Helens volcanic eruption. As there was essentially no actuarial insurance experience within the United States there was little precedence in the insurance industry for handling claims from this event. Also included in this chapter is a selected glossary of volcanic terms.

Appendix A: Earthquake Experiences in the United States and Canada. Experience data are the keystones to all kinds of insurance rate studies. However, for reasons expressed in Chapter 8 they have restricted value for earthquake rate studies, yet they do form the basis for simulation studies, underwriting guidelines, and background for many business decisions. Appendix A summarizes the more important information and also provides a brief history of earthquake damage. Also included is an extensive bibliography. With the use of tables, figures, and photos the author provides a comprehensive account of earthquake damage for the following events:

- New Madrid, Missouri and Charlston, South Carolina, Earthquakes
- San Francisco, California, 1906 Earthquake
- Puerto Rico, 1918 Earthquake
- Santa Barbara, California, 1925 Earthquake
- Long Beach, California, 1933 Earthquake
- Helena, Montana, 1935 Earthquake
- Imperial Valley, California, 1940 Earthquake
- Santa Barbara, California, 1941 Earthquake
- Puget Sound, Washington, 1949 Earthquake
- Kern County, California, 1952 Earthquake
- Churchill County, Nevada, 1954 Earthquake
- San Francisco, California, 1957 Earthquake
- Hebgen Lake, Montana, 1959 Earthquake

- Alaska, 1964 Earthquake
- Puget Sound, Washington, 1965 Earthquake
- San Fernando, California, 1971 Earthquake

Appendix B: Terminology, Definitions and Discussion. The author has compiled a glossary of useful earthquake, earthquake-related, and building terminology.

Appendix C: Earthquake Insurance Manuals, United States and Canada. The author breaks this appendix into three parts. Part 1 includes reproduction of selected pages from the ISO Commercial Lines Manual, along with instructions on how to use them. Part 2 describes Canadian practices as represented by the earthquake tariffs of the Insurers Advisory Organization of Canada. Part 3 contains the classification system used by the Department of Insurance of the State of California.

Appendix 4

State Needs Assessments

A. Alaska
B. California
C. Hawaii
D. Oregon
E. Washington

Appendix 4A

Alaska Tsunami Mitigation Needs

as inferred from projects or items already in place

Public Information Materials

Alaska is in the process of purchasing signs for installation during the spring.

Recommendation

- Educational outreach should accompany the installation of signs so as to inform the public of their intended purpose and meaning. This could be incorporated into the current revisions of their tsunami brochure and Public Service Announcements.

Educational Programs

Recommendations

- Develop classroom curriculum for their youths as well as training materials for regional and local decision makers/planners and emergency management/responders

County and Community Needs

While developing baselines and assessments for 100 communities they have found that many communities have evacuation routes. However, many communities may have secondary damage resulting from a tsunami-generating earthquake, such as landslides, which will block or alter previous existing evacuation plans.

Recommendations

- Develop alternative evacuation routes from coastal communities

Model Codes and Regulations / Tsunami Legislation / Inundation Mapping

Only a few communities have adopted building and zoning codes, regulations, and land use guides. There is no tsunami legislation and tsunami inundation mapping is limited.

Recommendations

- Increase tsunami inundation mapping
- Develop state-wide building codes and regulations and develop land use guidelines that incorporate tsunami inundation mapping in coastal regions

Warning Programs

Tsunami warning is performed in a variety of ways and may differ from state to local community and from community to community.

Recommendation

- Develop an official dissemination plan for tsunami watch and warnings from federal and state officials to local authorities. This would include a public educational outreach effort to insure that local residents understand the procedures

Mitigation Programs

Currently mitigation programs are handled at the community level and there is little continuity between communities.

Recommendations

- Develop a comprehensive educational/mitigation program that would include an agreed upon message and goal that can be adopted by individual communities
- Work with communities at higher risk to develop a uniform message to be broadcast to local residents as well as those that may enter the region seasonally
- Develop methods of communicating the tsunami threat to individuals who may be seasonal workers with potential language barriers

Appendix 4B

Recommendations for the State of California

Summary of Findings from "Findings and Recommendations for Mitigating the Risks of Tsunami in California"

Introduction

The Governor's Office of Emergency Services convened a workshop of state and local government agencies representing coastal communities and programs in May 1997. This is a summary of the workshop report.

Proposed Action Plan

Tsunami Mitigation Goal

The goal of tsunami mitigation planning is to develop a local, state, and federal partnership to reduce the effects of tsunamis through the implementation of the proposed mitigation recommendations.

Objectives

The National Tsunami Hazard Mitigation Program should provide

- Guidance and technical support to enable the improvement and incorporation of tsunami mitigation planning into local and state all-hazard mitigation planning (recommendation A)
- Improved tsunami inundation and evacuation maps (recommendation A)
- Training and education to coastal land-use planners and building officials
- A means to raise and maintain awareness of affected populations (recommendation D)
- Improvement of the tsunami warning system through the incorporation of modern communication technology (recommendation B)

These recommended objectives should be achieved over a 5-year intensive development and implementation period, followed by an indefinite period of sustained efforts.

The goal of California's Tsunami Mitigation Planning is the development of hazard mitigation tools and strategies to reduce the damage and losses from future tsunamis.

Tsunami Modeling, Mapping, and Preparedness Planning

Objectives

- Develop a comprehensive set of usable, updatable, tsunami inundation maps for land-use planners and emergency management at all levels
- Integrate tsunami education elements into existing operational area training and exercising
- Develop informational materials and resources and prototype information for public education, i.e., pamphlets, inundation maps, community preparedness presentations, model response plans, reference library, and model warning systems response procedures

Watches, Warnings, Notification, and Governmental Response

Objectives

- Develop a resource directory for local jurisdiction use, to assist them with the development of warning systems. The directory should include
  - summary listings of the various types of warning systems
  - their typical utilization
  - advantages and disadvantages
  - cost
- Develop state-wide CMAS contracts for warning systems and services and establish firm pricing for system engineering and materials, including installation
- Develop SOP guidance to cover
  - information dissemination from county warning points
  - field personnel response procedures
  - information feedback from field to warning point to state/NWS
- Enhance coordination of information given to "down wave" areas and provide feed back mechanism

Land Use Planning and Building Mitigation

Objectives

- Prioritize and develop initial tsunami inundation maps for the California coast
- Develop tsunami hazard reduction guidance including building codes, prototype mitigation measures, and planning approaches (target local government general plan, safety element)
- Provide information, education, and training on policy options related to land use and development and the preservation of life and property to local government land use planners, planning commissioners, and councils/supervisors

Public Awareness and Education

Objectives

- Develop materials and create a dissemination process for tsunami educational materials to local residents, tourists, and visitors
- Develop and disseminate tsunami education through school curriculums
- Develop 1-hour presentation to incorporate tsunami element into existing Emergency Operations Center (EOC) course using slides, videos, speakers, and overheads for emergency management staff to present to emergency managers in all coastal operational areas

Other Issues and Concerns to Workshop Participants

Although the principal objective of the California workshop was the development of an integrated coastal strategy to better prepare California for future tsunamis, a number of parallel issues were recognized during the working group discussions.

The biggest barrier to a comprehensive Cascadia earthquake mitigation program is the lack of sustained financial commitment.

Objectives

- There is a need to prioritize areas requiring enhanced tsunami warnings and obtain funding for implementation of warning systems. In addition, there is a need to have an organized effort to obtain funding for tsunami programs from all levels of government.
- Develop printed and visual materials to communicate effectively with special populations. Target delivery of materials as appropriate.

Appendix 4C

The Needs of Hawaii

as presented by the Oahu Civil Defense Agency

City and County of Honolulu

Introduction

Issues discussed in meetings dating back to July 9, 1996 include locally generated tsunamis, improved identification of evacuation zones, real-time modeling to improve forecasts, the reliability of tide gauge and surface wave data in predicting significant tsunamis, research advancements potentially capable of reducing false warnings, asteroid impact-generated tsunamis, and the need to increase public awareness of tsunami hazards.

Actions taken by State Civil Defense (SCD) and County Civil Defense Agencies (CDA) and the Pacific Tsunami Warning Center (PTWC) based on these discussions could substantially reduce the number of false warnings, improve forecasting of state-wide tsunami run-up values, and minimize future injuries and loss of life.

Locally Generated Tsunamis

During this century, five locally generated tsunamis with runup values of 1 m or more have been reported. The problems that have been identified with locally generated tsunamis are

- Significant local tsunamis can be, and have been, generated by moderate or small earthquakes
- Not all large local earthquakes have generated significant tsunamis
- Real-time estimates of local magnitudes may have been unreliable
- There may be little or no time for warnings where they are most needed
- “Panic” warnings for other islands could kill and injure more people than the tsunami itself

Recommendations

1. Adopt and implement a clear protocol for locally generated tsunamis based on historical data and the consensus opinion of our available scientific experts and the emergency management system

Improved Identification of Evacuation Zones

Problems identified with existing evacuation maps include

- There are gaps in the mapping of evacuation zones

- Although generally viewed that current maps are appropriate for worst case scenarios for tsunamis generated by earthquakes in Kamchatka, the Aleutians, Alaska, and South America, comparable earthquakes have not yet occurred in this century in the western or south Pacific (i.e., the Kurils, Japan, Marianas, Solomons, Santa Cruz, and Samoa) or along the west coast of Canada, the U.S. mainland, or Central America. Thus existing mapping may be inadequate for large earthquakes in these regions.

Recommendations

2. Improve existing maps of evacuation zones
3. Examine possible runups associated with large earthquakes from other regions

Real-Time Modeling to Improve Tsunami Forecast

Recommendations

4. Modeling techniques should be tested against a wide spectrum of historical tsunamis for which sufficient historical data is available
5. If successful, those techniques should be used and evaluated in real-time during future watches and warnings

The Reliability of Tide Gauges and Surface Wave Data

Identified problems include the cancellation of watches or warnings for earthquakes in remote regions of the North Pacific based only on small tide gauge readings and surface wave data, which could prove extremely dangerous.

Recommendations

6. If at all possible, cancellations of watches and warnings from earthquakes in remote regions of the North Pacific should not be based solely on readings at distant tide gauge stations

Research Advancements

Recommendations

7. To support the acquisition and analysis of data from deep ocean pressure gauges
8. To determine watch/warning thresholds based on the combined use of surface wave magnitudes and moment magnitudes

Asteroid Impacts and Additional Local Tsunamis

Although rare, these events are not unlike local tsunamis generated by massive submarine landslides, or more moderate local tsunamis generated by earthquakes or smaller submarine landslides closer to islands other than the Big Island.

Recommendations

9. Remain aware of the possibility of these non-conventional tsunamis.
10. Maintain an urgent tsunami warning protocol.

Increasing Public Awareness of Tsunami Hazards

Without an educated populace, tsunami watches and warnings will not be optimally effective. The more than 30-year hiatus of significant tsunamis has eroded public awareness as evidenced by the large number of people in or near the ocean during the October 4, 1994 warning.

Recommendations

11. Support educational efforts whenever and wherever possible
12. Examine the state's preparedness to survive the next large tsunami in terms of critical utilities and businesses

General Recommendations

In addition to the 12 recommendations presented above, the following recommendations are based on recent meeting discussions and/or correspondence.

- Revise the State of Hawaii's "Disaster Instructions and Warning Procedures", updated January 1992, so as to be consistent with the 12 previous recommendations already cited
- Encourage, maintain, and improve dialog between appropriate federal, state and county agencies, our advisors, and the research community
- Provide a continuous mechanism whereby collective consensus on scientific advancements can be incorporated into tsunami watch and warning criteria and protocols
- Formulate strategies and time lines, and identify available resources, if necessary, for the operational adoption of these recommendations

Appendix 4D

The Needs of Oregon

and Strategy for Tsunami Mitigation and Public Awareness
as presented by the Oregon Department of
Geology and Mineral Industries

Introduction

The State of Oregon's Tsunami Mitigation Strategy addresses the topics of public education, the regional warning system, inundation mapping, siting of critical and essential facilities, improvement of national policy on hazards insurance, and recognition awards for tsunami risk reduction.

Public Education

- Beach front warning signs
- Tsunami Sign Program including *(note: the tsunami sign program involves a partnership between cities, county parks, port facilities, U.S. Coast Guard, Sea Lion Caves, factory stores in Lincoln City, Oregon Coast Aquarium, DOGAMI, Oregon State Parks and Recreation Dept., Oregon Dept. of Transportation)*
    - Tsunami Hazard Zone
        - Low-lying areas (beach fronts, affected roads, etc.)
        - Oregon state parks "all-hazard warning boards"
        - Logo design adopted for use in California, Oregon, Washington, Alaska, and Hawaii
    - Tsunami Evacuation Routes
        - Coastal communities that have evacuation routes established
        - Coastal schools that have approved evacuation routes
        - Logo design adopted for use in California, Oregon, Washington, Alaska, and Hawaii
    - Tsunami Interpretive Signs
        - Placed in coastal communities at locations that have a higher visitor count
        - 24"36" fiberglass embedded panel, various support structure options available
        - Oregon historical/geologic marker program at frequently visited locations
- Articles in popular magazines and in technical journals
- State legislation requiring training and evacuation drills in K–8 schools
- Newspaper editorials, brochures

- Videos distributed to coastal schools and local groups
- Signs in motel and hotel rooms
- Public Polling to measure long-term effectiveness
- Evacuation instructions in telephone books

Regional Warning System

- Utilize existing seismometer network
- Install warning sirens in coastal towns and parks
- Link seismometers via satellite communications to sirens
- Conduct training drills

Inundation Mapping

- Priority list of vulnerable communities
    - Seaside
    - Newport
    - Gold Beach
    - Coos Bay
    - Warrenton – Astoria
    - Reedsport – Winchester Bay
    - Tillamook
    - Waldport

Improving Siting of Critical and Essential Facilities

- Systematic mapping of inundation zone as needed tool
- Siting of critical facilities
- Long-range land-use planning
- Identification of safe evacuation routes

Improve National Policy on Hazards Insurance

- Federal Legislation
- H.R. 219
- H.R. 230
- H.R. 579

Recognition Awards for Tsunami Risk Reduction

- School disaster plan certificates of completion

Department of State Police
Oregon Emergency Management

Identified Local Needs and Assessments

- Enforceable and do-able construction and land use guides for building in the inundation zone (development will occur there because tourism dollars are important to offset losses in other industries). Strategies to relocate critical structures out of inundation zone.
- Education materials that cater to different users
    - Official disseminators of incident information — to make ironclad how official information is acquired and provided to coastal populations and local authorities
    - Public officials
    - General public (local and tourist) — design a top-quality, carefully designed instruction film to air periodically on television
    - Schools — literature to students that could be taken home to parents
    - Businesses — convince them that information on tsunami and earthquake hazards are not detrimental to business and probably in the long run will be beneficial financially
- Uniform coastal warning system specifically designed for tsunamis that can be recognized by all (tourist and locals) along the coast. Develop ways to contact isolated populations that are outside this uniform warning system.
- All jurisdictions contacted agreed that there is a need for model land use guides, building code provisions, abatements projects, construction guides, and prototype education and training materials. Specific ideas about what kinds of land use guides, etc., they would like to see implemented (except for education and training) were few. Perhaps, specifics will surface during the model development phase. The locals believe it is important that they be included in all phases of model development in the second year of the Tsunami Mitigation Program.

While understanding the importance of mitigation and the need for mitigation projects such as evacuation plans, which several communities have completed or are in the process of completing, many local emergency managers' big concerns are with response and recovery. They include evacuation of elderly, connection with isolated populations, and dissemination and adequate supply of resources, given that the coast will be isolated for long periods of time (maybe a week or more). There will be a lag in time between the event and disaster proclamation and national guard mobilization and the local supplies will be rapidly exhausted, especially if the event occurred during the peak of tourist season.

Appendix 4E

The Needs of Washington

as presented by the Washington Local/State Tsunami Workgroup

as Stated in the Meeting Notes for November 21, 1996

Introduction

Inundation Mapping

Inundation mapping is needed while coordinating evacuation routes and identifying safe areas. Inundation mapping lends credence to signs and brochures due to the solid documentation for their locations. They emphasized the importance of understanding the offshore topography in order to better understand the vulnerability of certain communities. The difficulty noted here is the need for funding and the expertise to carry out such a project.

Signage and Public Education

The group considers these two efforts in support of each other. Public education supports the by helping locals and tourists to understand the meaning and importance of the signs. These activities are projected to have a positive cost/benefit. Oregon is highlighted for the example they have set and it is proposed that Washington follows in suite. The group would like to work on this issue, ideally in conjunction with inundation mapping.

Technical Support in the EOC

The group found this to be an area of opportunity.

Distant Tsunami Warning System

The group feels that the Federal/State effort is worthwhile and should be supported.

Tsunami Mitigation Workshops

The group expressed interest in conducting workshops for local and emergency managers on ways to successfully mitigate against tsunami damage. A proposed format included talking about the existing hazard, describing success stories from places like Oregon, and discussing ways to apply those successes in Washington.

Tsunami Web Sites

http://www.wa.gov/mil/wsem/

Sister Cities

http://www.wa.gov/mil/wsem/ops/emlist.htm

Statement of Work Overview

1. Tsunami Mitigation Workshops — Workshops coordinated with production of signage, indoor signage and interpretive signs. Estimated cost: $1,400
2. Indoor Signage — Signs placed in hotels, schools, and tourist-oriented sites to advise of hazard and coordinated with warning/evacuation signs. Estimated cost: $11,500
3. Interpretive Signs — Signs that provide education about tsunami hazards and warning/evacuation signs. Estimated cost: $11,500
4. Brochures. Estimated cost: Any funds not spent for 1–3

Mitigation Plan

The Washington Local/State Tsunami Workgroup identifies the great vulnerability of the coastal tourist population and the importance of educating this population without creating excessive anxiety about the hazard. The chief goal of the group's mitigation plan was to change the behavior of tourists, thus reducing the vulnerability of their communities to tsunamis.

Workshops

The local emergency managers note that the first step in changing the behavior of tourists would be working with the businesses they patronize. Educating local proprietors will make them more receptive to efforts to educate tourists and thus make the project more effective.

Workshops will also be helpful in training local elected officials, businesses leaders, utility/school district officials, and residents about tsunami mitigation efforts in their town. The group anticipates four workshops to be coordinated with workshops conducted through the tsunami inundation mapping project.

Estimated Cost: $1,000 for goods, services, and travel

Indoor Signage

In Pacific and Greys Harbor Counties indoor signs are being proposed for hotels and motels and tourist oriented businesses. This exposure will provide tourists with the understanding of the meaning and purpose behind the warning and evacuation signs on the beach. The same strategy is proposed for educating permanent residents through placement of signs in schools.

Estimated cost: $12,000 for production of and distribution of signs

Interpretive Signage

Proposed as an effective means to reach tourist in all counties, especially those where tourists may not be staying in hotels or see signs in local businesses such as Jefferson and Clallam Counties.

Estimated cost: $10,000 for production and installation of 20 signs at an estimated cost of $500 each

Brochures

Remaining funds could be used for development and production of brochures based on the successful design used in Oregon and California.

Estimated cost: $1,400 for production and distribution of brochures