BUILDING TSUNAMI-RESILIENT COMMUNITIES IN HUMBOLDT COUNTY, CALIFORNIA

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Abstract: Humboldt County on California's North Coast is at risk from tsunamis generated locally from faults associated with the Cascadia subduction zone (CSZ), other regional fault systems, and from distant sources elsewhere in the Pacific. The Redwood Coast Tsunami Work Group (RCTWG), an organization of representatives from government agencies, tribes, service groups, academia and the private sector from the three northern coastal California counties, was formed in 1996 to coordinate and promote tsunami hazard awareness and mitigation. The RCTWG and its member agencies have sponsored a variety of projects including education/outreach products and programs, tsunami hazard mapping, and signage and siren planning. In 2007, Humboldt County was the first region in the country to participate in a tsunami training exercise at FEMA's Emmitsburg training facility and the first area in California to conduct a full-scale tsunami evacuation drill. Two Humboldt County communities were recognized as *TsunamiReady* by the National Weather Service in 2007. Six assessment surveys from 1993 to 2006 have tracked preparedness actions and personal awareness of earthquake and tsunami hazards in the county.

INTRODUCTION

On April 25, 1992, a magnitude 7.2 (M_w) earthquake occurred on California's North Coast near Cape Mendocino in Humboldt County. The earthquake produced a modest tsunami (Gonzales and Bernard, 1993) that arrived at the nearest tide gauge 26 minutes

after the earthquake. The location and orientation of rupture supported an origin on or near the Cascadia subduction zone (CSZ) (Oppenheimer et al., 1993) confirming the capability of the CSZ to produce large earthquakes and local tsunamis. The earthquake changed the perceptions of emergency managers, planners and government officials about both the risk posed by the CSZ and the near-source tsunami hazard and led to a number of tsunami mitigation efforts at the regional, state and federal levels.

Two recent events focused additional attention on the northern California tsunami hazard. In June 2005 a magnitude 7.2 earthquake, located 90 miles off the Humboldt County coast, triggered a tsunami warning for the entire West Coast of the United States and revealed numerous weaknesses in California's tsunami preparedness (California Seismic Safety Commission, 2005). In November 2006, tsunami alert bulletins were issued for the Pacific after a magnitude 8.3 earthquake in the Kuril Islands. The alerts were cancelled before waves were due to arrive in California but, Humboldt and Del Norte County (located north of Humboldt County) chose to conduct limited evacuations of the beach and harbor areas based on informal dialog with the warning center (Kelley, 2006). Strong currents produced by the tsunami caused $9.2 million in damages to docks at Crescent City harbor in Del Norte County, but the evacuations prevented injuries.

Recognition of the local, regional and distant tsunami hazards on California's North Coast has led to a number of planning, outreach and mitigation projects. This paper outlines the tsunami efforts in Humboldt County and summarizes a series of surveys conducted between 1993 and 2006 that assess the effectiveness of educational outreach.

THE TSUNAMI HISTORY OF HUMBOLDT COUNTY

Humboldt County, population 128,330 (2006 est.), is California's second most northerly County. Encompassing the transition between the San Andreas transform and Cascadia subduction zone tectonic regimes on the West Coast of the United States (Figure 1), the County and the adjacent offshore area is one of the most seismically active regions in the contiguous 48 states (Dengler et al., 1992). Since 1980, there have been four earthquakes at or above magnitude 7, and an additional six of magnitude 6 or larger within the county or adjacent offshore area. Nine earthquakes were strong enough to produce Modified Mercalli Intensities (MMI) of VII or greater. This contrasts significantly with the rest of the Pacific Northwest where large or damaging earthquakes have been much more infrequent in historical times.

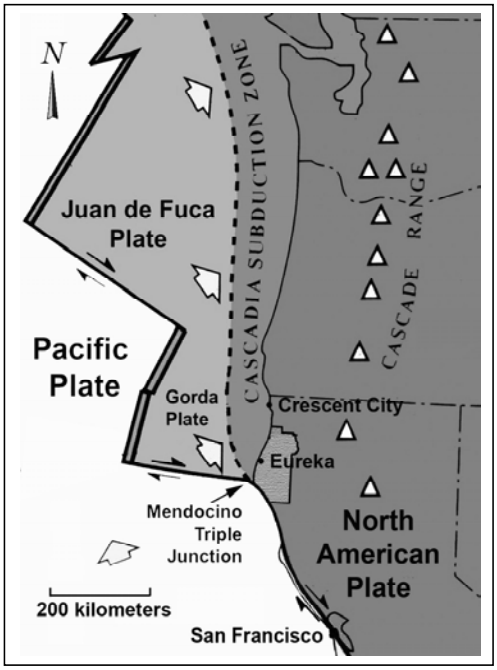

Figure 1. Location and plate tectonic setting of Humboldt County. Eureka, on Humboldt Bay, is the largest city in the county. *Figure Humboldt Earthquake Education Center, Humboldt State University.*

Thirty-one tsunamis have been recorded or

observed in California's North Coast since the first tide gauge in the area was installed at Crescent City in 1933 (Lander et al., 1993; NGDC). The record in Humboldt County is much shorter as a tide gauge wasn't installed until the late 1960s. Table 1 summarizes historic events, which likely would have triggered alert bulletins from the West Coast Alaska Tsunami Warning Center (WCATWC) for Northern California if the present tsunami warning criteria were in place at the time.

Table 1: Historic tsunamis in Humboldt and Del Norte Counties, California*

Date	Origin of Tsunami	Location of Effects	Water ht. (m)	Comments
1946 4/1	E. Aleutian Is. 8.1	Crescent City	0.9	Recorded
		Humboldt Bay	Observed	
1952 11/4	Kamchatka , Russia 9.0	Crescent City	0.72	4 boats overturned, buoys moved.
1957 3/9	C. Aleutian Is. 8.6	Crescent City	0.7	Recorded.
1960 5/22	S. Central Chili 9.5	Crescent City	1.7	$30,000 damages. 2 ships destroyed, others damaged.
		Humboldt Bay	Observed	Strong currents in Bay.
1963 10/13	Kuril Is., Russia 8.5	Crescent City	0.5	Recorded.
1964 3/28	Gulf of Alaska - Alaska Peninsula 9.2	Crescent City	4.85	11 dead, 35 injured,29 blocks flooded. $15 million in damages.
		Klamath River	observed	1 killed, $4,000 damages to dock and boats at Requa. Damage reported at least 2.6 km from mouth if Klamath River.
		Trinidad	4	5.4 m above MLLW at Trinidad Pier.
		King Salmon	1.4	
		Humboldt Bay	1.5	Eureka Municipal Boat Basin.
1968 5/16	Honshu, Japan 8.2	Crescent City	0.6	Recorded.
1992 4/25	N. California 7.2	Humboldt Bay	0.3	Arrived about 20 minutes after EQ.
	Cape Mendocino	Clam Beach	Observed	Water level changed several feet.
		Crescent City	0.6	Oscillations in harbor, 4th wave highest.
		Trinidad	0.9	Cars stuck on beach.
1994 10/4	S. Kuril Isl. 8.4	Crescent City	0.5	Pacific wide tsunami warning issued. Recorded.
1994 9/1	Mendocino Fault 7.0	Crescent City	0.14	Recorded on Crescent City tide gauge 45 minutes after earthquake.
2001 6/22	Southern Peru 8.4	Crescent City	0.4	Recorded.
2003 11/17	Rat Islands, Alaska 7.8	Humboldt Bay	0.05	Recorded.
2004 12/26	Indonesia 9.2	Crescent City	0.42	Recorded.
2005 7/15	N. California 7.2	Crescent City	0.1	Tsunami Warning issued for the US West Coast. Recorded.
2006 11/15	C. Kuril Isl. 8.3	Crescent City	0.88	$9.2 million damages to boat basin.
		Humboldt Bay	0.1	Recorded.
2007 1/13	C. Kuril Isl. 8.1	Crescent City	0.23	Recorded.

* from Lander et al. 1993 and the NGDC Historic Tsunami Data Base

There is no record of major tsunami damage to the Humboldt Bay region, Humboldt County's most populated area, in historic times. The most significant historic tsunami event was in 1964, produced by the Prince William Sound, Alaska M_w 9.2 earthquake. According to Lander et al. (1993), the tsunami breached a ten-foot seawall at the Eureka Boat Basin and Humboldt Bay was filled with logs and debris. Fourteen-knot currents

were reported in the channel opposite the Coast Guard Station near the mouth of Humboldt Bay. The impacts in Humboldt County were far less than in Del Norte County to the north where 29 city blocks were flooded and 11 lives lost in Crescent City (Dengler and Magoon, 2006) or in Mendocino County to the south where a number of boats and docks were damaged at Noyo (Lander et al., 1993). The 1964 water height estimated at Trinidad Pier ten miles north of Eureka was similar to that in Crescent City, suggesting that the size of the 1964 tsunami along the open coast in Humboldt County was probably comparable to Del Norte County.

Although there is no evidence of major tsunami damage in the Humboldt Bay region in historic times, there is mounting evidence that the region has been struck repeatedly in the past by very larger near-source tsunamis generated by ruptures on the Cascadia subduction zone. Paleoseismology studies suggest peak wave heights along Humboldt County's coast in the 25 - 60 foot (8 - 19 meter) range from past Cascadia events (PG&E, 2003; Leroy 1999; Patton and Witter, 2006).

MITIGATION AND OUTREACH EFFORTS

The concept of tsunami-resiliency was adopted by the National Tsunami Hazard Mitigation Program (NTHMP) in 2004 as a framework for US tsunami hazard mitigation projects (Bernard, 2005). A *tsunami-resilient community* "....should (1) understand the nature of the hazard, (2) have the tools they need to mitigate the tsunami risk, (3) disseminate information about the tsunami hazard, (4) exchange information with other at-risk areas, and (5) institutionalize planning for a tsunami disaster (Jonientz-Trisler et al., 2005). Table 2 below summarizes Humboldt county tsunami projects, programs and products over the past two decades within this framework. Items in bold are discussed in more detail below.

Table 2. Humboldt County Tsunami Mitigation and Outreach Efforts

Recognizing the Hazard	
1984 - 1991	Scientific awareness of the Cascadia subduction zone (CSZ) and local paleoseismic evidence of past great earthquakes and tsunamis.
1991	First conference of emergency managers, utilities and other agency representatives on the potential hazards of the CSZ, funded by the USGS.
1992	M 7.2 Cape Mendocino earthquake on the Cascadia subduction zone; generates small local tsunami.
2004	M 9.2 Indonesia earthquake and Indian Ocean tsunami – similarities to the Cascadia subduction zone.
2005	M 7.2 offshore Eureka earthquake triggers tsunami warning for West coast of US.
2006	M 8.3 Kuril Islands earthquake & tsunami. $9.2 million in damages at Crescent City.
Defining the Hazard	
1994	NOAA completed inundation models/mapping for Humboldt Bay.
1995	California Division of Mines and Geology Planning Scenario for a M 8.4 earthquake on the CSZ.
1995 - Present	Paleoseismology and paleotsunami studies in Humboldt and Del Norte Counties.
2003	PG&E report on tsunami hazard at the Humboldt Bay Nuclear Power plant site released.
2003 - Present	**Relative tsunami hazard maps of Humboldt County coastline.**
2005	California Seismic Safety Commission published "The Tsunami Threat to California" (Dec 05).

2008 (planned)	PG&E report on tsunami hazards at the Humboldt Bay proposed power plant site. Includes numerical modeling of tsunami heights and currents in Humboldt Bay.
Disseminating Information about the Hazard	
1993	First edition of "Living on Shaky Ground" published (100,000 copies). (Dengler & Moley, 1993)
	First Earthquake Room at Humboldt County Fair.
1995-2000	Earthquake Education Through Theater Arts: Earthquake and Tsunami Public Service Announcements. 1994 *For All You Know – Videotaped Earthquake Public Service Announcements* 1995 *Videotaped Earthquake/Tsunami Public Service Announcements* 1995-1996 *Play: Samoa Peninsula Seismic Tsunami Vaudeville Extravaganza* 1997 *Play: Blue Lake from Quake to Quake* 1999-2000 *Videotaped Tsunami Vignettes*
1995	Second edition of "Living on Shaky Ground" published (100,000 copies) (Dengler & Moley 1995).
	CSZ hazards conference for emergency managers in northern California and southern Oregon.
1996	Cascadia Region Earthquake Workgroup (CREW) conference at Humboldt State University.
	Earthquake and tsunami hazards meeting for federal and state agencies on the north coast California.
	Tri-fold tsunami hazard brochure.
1997	Draft tsunami curriculum developed by Humboldt Earthquake Education Center (ten activities).
1997 - Present	Tsunami! Geology 700 Class - Professional development course offered at Humboldt State University.
1998	"Living Safely in Your Schools" pamphlet distributed to all public school teachers and staff in Humboldt and Del Norte County.
	"Native American Stories of Earthquakes and Tsunamis in Redwood National and State Parks" report.
	Natural History Museum, Arcata display on Cascadia earthquakes and tsunamis.
	Manila Community Earthquake and Tsunami Safety Fair
1999 – Present	**Humboldt County Fair Earthquake and Tsunami Room. Posters and displays.** Fair Theme: 1999 – *Tsunamis: The Great Waves* 2000 – *Cascadia Subduction Zone Earthquakes and Tsunamis* 2001 – *Why is Humboldt County Earthquake Country?* 2002 – *1992 Cape Mendocino Earthquake and Tsunami* 2003 – *What Every North Coast Resident Should Know About Tsunamis* 2004 – *1964 Alaskan Earthquake and Tsunami: Lessons for the North Coast* 2005 – *2004 Indonesian Earthquake and Tsunami: Lessons for the North Coast* 2006 – *1906 "San Francisco" Earthquake: The Strongest North Coast Temblor in 150 years* 2007 – *Making Our North Coast Communities Tsunami Resilient*
1999	National Tsunami Hazard Mitigation Program meeting at Humboldt State University.
	Spanish version tri-fold tsunami hazard brochure completed.
	"Living on Shaky Ground" reprinted (25,000 copies).
2000	Interpretive tsunami signs posted in Redwood National Park.
2002	Tsunami field trip for Eureka City staff.
2004	Revised tsunami hazard information brochures combined with tsunami hazard maps.
	Humboldt County presentation to California Tsunami Planning Workshop in Burlingame, CA.
2005	RCTWG Media Briefing at NWS "Tsunami – When It Happens Here".
	Developed new Red Cross Training: Living on a Faultline Course addressing earthquake and tsunami hazards and preparedness. Training currently offered by Humboldt County Red Cross.
	Distributed Red Cross newspaper inserts for Times Standard on tsunami/earthquake hazards (60,000 distributed through newspaper).
	Humboldt and Del Norte County presentation to Seismic Safety Commission in Sacramento.

2006	"Shake, Rattle, and Roll: Awaking the Public's Curiosity in Geology via Interpretation", training manual on interpreting earthquakes and tsunamis in Redwood National and State Parks.
2007	Tsunami evacuation route signs posted in Samoa.
	Humboldt County OES, NWS, and HSU presentations to Board of Supervisors.
	Humboldt County OES and NWS Local Community Outreach/Education Presentations: Klamath, Orick, Fields Landing, Samoa.
	Redwood Coast Tsunami Workgroup develops 5-year Strategic Plan.
2008	4th Edition of "Shaky Ground" and interactive web site (planned).
Taking Action to Reduce the Hazard	
1996	**Redwood Coast Tsunami Work Group formed.**
	OES earthquake and tsunami table-top exercise for emergency planners using CDMG scenario.
1997	Pilot Sign Projects for Redwood National and State Parks, Crescent City and the Samoa Peninsula.
	Tsunami hazard information posted at Freshwater Spit, Redwood National and State Parks.
1998	Tsunami table-top exercises in Eureka and Arcata.
1999	Cascadia Region Disaster Medical Preparedness Project. CA EMS Auth. 1999-2000 grant identifies "Isolated Islands of Humanity" and response/relief plans.
	Two county (73 participants) FEMA-sponsored emergency management training at Emmitsburg, MD and functional Cascadia earthquake and tsunami exercise.
2000	Full-scale tsunami exercise in Ferndale.
	Tsunami hazard information posted at Samoa dunes and at entrance to the King Range.
2002	Humboldt County "Cascadia Earthquake and Tsunami Exercise" for federal, state, local agencies (200 people attended three-day training at Adorni Center, Eureka.
2004	Humboldt County Tsunami Contingency Plan table-top exercise.
2005	Orick TsunamiReady Planning: developed tsunami hazard maps for Orick Valley, developed criteria for evacuation route planning and established routes.
	Humboldt County Tsunami Contingency Plan table-top exercise.
	California tsunami signs approved as experimental signing by U.S. Department of Transportation, application led by Eureka NWS.
2006	Humboldt County and State OES Tsunami Planning Workshop and table-top exercise, Eureka.
2007	**Humboldt County emergency officials (74 participants) attend FEMA's first tsunami training.**
	Tsunami siren test PG&E/King Salmon.
	First tsunami evacuation drill in California – Samoa.
	Humboldt County Board of Supervisors approves $60,000 for tsunami signs.
2008	First End-to-End test of the Tsunami warning system using live codes (planned March 26, 2008).
(planned)	**Posting of Entering and Leaving tsunami hazard zone signs in Humboldt County.**
Institutionalizing Tsunami Mitigation	
1996 - Present	1995 CDMG Earthquake and Tsunami Scenario provide basis for all earthquake planning exercises at city, county and regional scales.
2000	Proclamation of Humboldt County Board of Supervisors that April 2000 "Humboldt County Earthquake Preparedness Month and the year 2000 as "Cascadia Earthquake Awareness Year. Recognition and inclusion of Cascadia earthquakes & tsunamis efforts for planning and mitigating effects from future great earthquakes in Humboldt County.
2007	Redwood National and State Parks Tsunami Contingency Plan approved by Park.
	Humboldt County Multi-hazard Plan including tsunamis (in State and Federal review process).
	Orick and Samoa designated "TsunamiReady" by the National Weather Service.

Redwood Coast Tsunami Working Group (RCTWG).

The RCTWG is a unique interagency task force of representatives from government, tribes, service groups, academia and the private sector that promotes a coordinated,

consistent tsunami mitigation and education effort on California's North Coast. Formed in 1996 as an ad hoc organization of members from Mendocino, Humboldt and Del Norte Counties, the RCTWG works to define the needs of local jurisdictions to develop tsunami resiliency. All of the efforts outlined in Table 2 have involved the participation and support of RCTWG members.

RCTWG efforts have focused in four areas: hazard assessment, response planning, education/outreach, and institutionalizing tsunami mitigation programs in Humboldt County. Examples of projects in each of these areas are discussed in more detail in the sections below.

The RCTWG was originally established in response to the California Mines and Geology scenario for a Cascadia earthquake and tsunami (Toppozada et al., 1995). The organization has endured and proved to be effective tool for instigating, promoting and coordinating regional tsunami mitigation efforts. In 2007 the group conducted a gap analysis and established a 5-year strategic plan. The top priority activity for 2008 is to develop a coherent set of messages and outreach materials. Some of the activities of the RCTWG and member organizations are highlighted below.

Tsunami Hazard Mapping

All tsunami mitigation efforts must begin with an estimate of the areas at risk. The Humboldt Bay region and Crescent City in Del Norte County were the first areas along the Cascadia margin where numerical modeling was used to estimate inundation (Toppozada et al., 1995, Bernard et al., 1994). These maps used an early generation numerical model, poor elevation data and the results were difficult for planners to use.

Beginning in 2003, faculty and students at Humboldt State University began a GIS-based mapping project to depict the relative tsunami hazard of Humboldt County (Patton and Dengler, 2006). These maps used four color zones to represent relative risk (Figure 2). Gradational boundaries help convey the continuum of possible events and the uncertainty in delineating distinct inundation lines for any particular event. The maps also differentiate the areas of high velocity wave impact along the

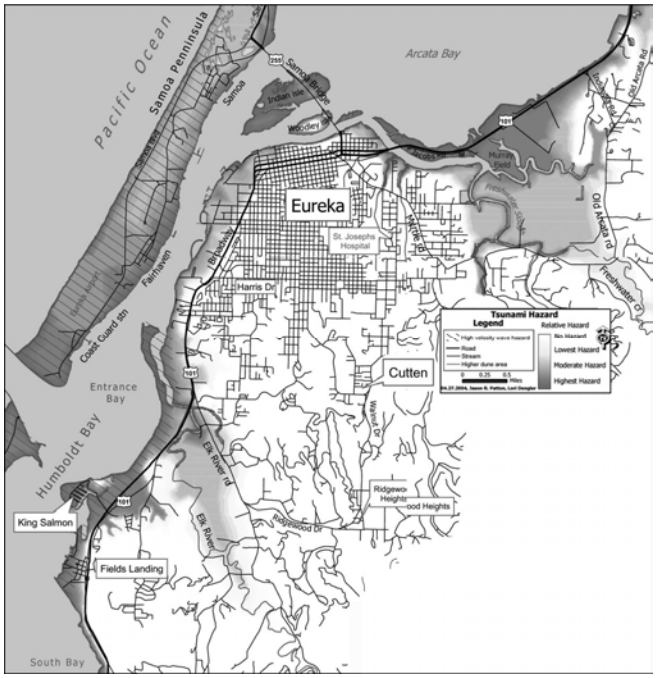

Figure 2. Relative tsunami hazard map of the Eureka area. Not diagonal lines designating high velocity wave impact areas along the Samoa Peninsula and in King Salmon opposite the mouth of the Bay. Color maps available online at http://www.humboldt.edu/~geology/earthquakes/rctwg/index.html

open coast from areas of flooding within the bay.

The advantage of the GIS-based technique is that the cost is low, the product is adaptable for use by planners and emergency managers, and can be easily updated as more information such as numerical modeling becomes available. The Humboldt County maps were developed with the input of RCTWG members and were presented for review by the general public at the Humboldt County Fair in 2003 and 2004. The maps have become an important educational tool and are being used in the County Tsunami Contingency Plan and evacuation route planning.

Tsunami Contingency Plan

The Humboldt County Tsunami Contingency Plan (TCP) has been developed over the past three years to guide the tsunami hazard response planning efforts and coordination procedures of over 30 local, state, and federal agencies operating in the County. The TCP provides a framework and detailed procedures for responding to the immediate tsunami threat by assigning, specific areas of responsibility and actions to individual agencies/departments. The TCP structure allows multiple agencies to immediately work together as one responding team to cover the entire 110-mile Pacific Ocean coastline of Humboldt County.

The main focus of the Humboldt County TCP is on a distant-source tsunami event where warnings are issued and the time is available for a coordinated agency response. In a local-source event, education is the key to survival, as there is no time to implement a plan prior to the arrival of tsunami waves and citizens and organizations must immediately take appropriate actions without official guidance. The TCP assists in that educational process. The plan's largest section details response operations, provides specific public notification and evacuation procedures, and directs search and rescue and initial damage assessment actions. The TCP's other two sections provide general information about the tsunami threat to Humboldt County and contain supplements such as tsunami hazard maps and warning sign placements.

The Humboldt County TCP has been used at several table-top exercises and was the basis for the FEMA training (below). The plan is always in a state of minor revision. Changes related to sirens, signs, mapping, and evacuation routes are currently being undertaken to address the acquisition of additional siren components, the implementation of a sign installation project, a new GIS support opportunity, and new coordination processes for establishing evacuation routes. Future changes will continue to be made to the TCP as new information is acquired and verified for appropriate inclusion.

FEMA Tsunami Training

FEMA's Emergency Management Institute (EMI) in Emmitsburg, Maryland, offers hundreds of sessions of emergency management-related courses throughout the year. The most prestigious of those courses is the Integrated Emergency Management Course for Specific Communities (IEMC-SC). The IEMC-SC focuses on a specific hazard such as an earthquake or flood and brings the community's emergency management team to

the Emmitsburg campus for the one-week course session. All participant travel and lodging costs for the course are provided by FEMA.

The selection process for the IEMC-SC is difficult, as only ten communities are chosen each year from several hundred applicants. In 1999, Humboldt and Del Norte Counties were jointly selected by EMI to attend a CSZ earthquake event EIMC-SC session. The exercises focused on post-event recovery. In 2006, representatives from the City of Eureka and the County of Humboldt inquired about a distant tsunami-focused IEMC-SC. EMI staff advised that they had not developed a tsunami hazard course but were interested in developing one, and they encouraged the application submission. City of Eureka and Humboldt County representatives quickly generated a tsunami-specific application package, stressing historic events affecting this area and the similarities of the potential CSZ hazard to the 2004 Sumatra, Indonesia event. Seventy-four participants from the county, City of Eureka and allied agencies and communities, including the Chair of the Board of Supervisors and the Mayor of Eureka, attended the training in March 2007.

The tsunami course was based on the Humboldt County Tsunami Contingency Plan. The training sessions, which focused on mitigation, preparedness, response, and recovery, was customized to Humboldt County and a distant source tsunami. Each phase of the course allowed participants to respond to a realistic scenario of events in an interactive environment. Community representatives were assigned appropriate Incident Command System positions in a functioning Emergency Operations Center based upon their professional qualifications and positions. The training and exercises allowed participants to focus their collective energy over a four-day period and expand their emergency management capabilities, and bond as a team. New contacts were made for future opportunities that are now being implemented. Every issue identified in the IEMC-SD application and implementation process resulted in a positive outcome and, for the participants, the experience was memorable and rewarding.

Signs

Tsunami hazard and evacuation route signs were developed by the Oregon Department of Transportation and adopted by the National Tsunami Hazard Mitigation program at their first meeting in 1996 for use in the five Pacific states. Although widely in use in Oregon and Washington, the California Department of Transportation (CalTrans) would not allow their use in the State until the signs were approved by Federal Highway Administration. CalTrans District 1 in Eureka, which covers the California North Coast, and the Eureka NWS, spearheaded the sign design approval process for California. The effort now has the full support of all participating local, state, and federal agencies. An underlying concern was that the sign project be comprehensive and that city, county, state and federal areas use accepted criteria for sign placement and signs installation will occur in all jurisdictions at the same time.

In early 2006, RCTWG team members from CalTrans District 1, the Eureka NWS Office, Humboldt State University, and Humboldt County OES began active planning efforts to identify needed area signs and sign locations, their cost specifics, any regulatory issues, and funding alternatives to install tsunami signs on Humboldt County roadways. By late 2006, the RCTWG team had identified at least 475 general sign

locations on State and Humboldt County roadways. The effort proceeded in parallel with other RCTWG team efforts for tsunami sirens, evacuation planning and exercises, hazard area mapping, TsunamiReady planning efforts and other educational opportunities.

Cost of sign acquisition and installation was a major barrier. A major turning point was the FEMA Emmitsburg training described above. RCTWG team members were invited to give a report to the Humboldt County Board of Supervisors (BOS) explaining the tsunami hazard for the county and the efforts being accomplished to mitigate the threat. As a result of the presentation, the BOS directed that a short-term study into the funding issue be undertaken, and they committed to expend current-year funding on tsunami sign acquisitions and installations. When the study was complete, a second BOS presentation was given by RCTWG team members in Oct 07 and the BOS appropriated $60,000 to fund all the identified tsunami signs for County roadways. The County and CalTrans are working together to identify specific sign locations by mile-post marker to ensure the proper and realistic placement of tsunami signs. All identified State and County signs are scheduled for installation in the spring of 2008.

Samoa Tsunami Evacuation Drill

The first full-scale tsunami evacuation drill in California was conducted in the town of Samoa on June 28, 2007. Samoa, located between Humboldt Bay and the Pacific Ocean on a barrier sand spit that is about ½ mile wide and ranges in elevation from sea level to 50 feet, is particularly exposed to the tsunami hazard (see Figure 2). The evacuation routes to high ground are unusually complex because the town lies within undulating mature dunes. Many routes require evacuees to go up hill, then down hill – while making multiple turns - before reaching an evacuation site. The evacuation routes were designed, using community input, to minimize the possibility of confusion during a real event while providing the shortest evacuation times. The drill was conducted to evaluate the newly developed evacuation plan for the town, and to provide an opportunity for community members to practice the skills needed to survive a real tsunami.

The drill was designed to simulate a Cascadia near-source event that would require pedestrian-based evacuation to high ground in less than ten minutes. Extensive outreach was used to notify the town about the drill and to prepare community members to participate in the drill. Educational materials and evacuation route maps were mailed to all residents; community meetings were held; and a door-to-door campaign was carried out to achieve a high participation rate. Local businesses were also included in the drill and arrangements were made for them to notify their patrons about the drill moments before it was started. The drill was commenced at 6:00 p.m. and was announced by activating the town's tsunami siren. Roughly 90 percent of the households in Samoa participated in the drill with 172 people arriving at the evacuation site. All community members were able to reach the evacuation site within 10 minutes at a normal walking pace. This included people of all ages. One woman made it in spite of being in a wheel chair, with assistance from other evacuees. Residents were encouraged to plan ahead for bringing their pets without slowing down their response, and many did bring cats in crates and dogs on leashes. After the drill, residents commented that the drill made them feel empowered and confident that they would be able to survive a real tsunami.

Lessons learned from the drill were used to fine tune Samoa's evacuation plan and will be used in the planning for other communities. Also, adjustments were made to general educational phraseology based on the drill. For example, the following wording is often used in tsunami educational material: "wait until the shaking stops, then evacuate to high ground". For towns like Samoa, however, that have very short wave arrival times, that wording has now been modified to: "Move quickly to high ground as soon as it is safe to do so" to suggest that evacuation can begin when the shaking has diminished to safe levels. This wording will encourage a response that may give evacuees several more minutes of critical evacuation time.

County Fair Earthquake-Tsunami Education Rooms

A major effort of the RCTWG has been outreach products and programs. Two editions of an earthquake-tsunami preparedness magazine have been published (Dengler and Moley, 1993, 1995) and a third edition will be published in 2008. RCTWG has sponsored an annual Earthquake/Tsunami Education room at the Humboldt County Fair beginning in 1999. Each year a different theme is chosen (see Table 2), and posters are developed to illustrate the theme. The Humboldt County Fair Association donates a secure room within the large Commercial Display building and exhibits include a tsunami wave tank, shake table and liquefaction display, Tsunami Theater, preparedness information and free publications. The room is staffed by HSU students and RCTWG members.

Figure 3. Making waves with the tsunami wave tank at the Humboldt County Fair, 2003.

TsunamiReady Communities

In 2001 the National Weather Service initiated the TsunamiReady program to improve community tsunami resiliency. The TsunamiReady program sets minimum guidelines for jurisdictions to follow for adequate tsunami readiness, encourages consistency in educational materials, response, and planning among coastal communities and recognizes communities who have taken the steps necessary to prepare their emergency response infrastructure and population for a tsunami emergency. In Humboldt County, the NWS, working with other RCTWG agencies has taken the lead in encouraging and assisting local communities to apply for TsunamiReady designation.

The Humboldt County approach to developing TsunamiReady Communities has been to identify jurisdictions in the highest hazard zones and to work with the unique mix of cultural, political and economic entities within the community to develop partners and a constituency for tsunami hazard mitigation. The Samoa and Orick communities were recognized as the 49th and 50th US TsunamiReady communities on December 18, 2007.

Assessment

Six telephone surveys have been conducted to assess awareness, preparedness and the effectiveness of hazard mitigation programs in Humboldt County from 1993 to 2006. The surveys ask a set of questions regarding actions people have taken to prepare for earthquakes and tsunamis and their perceptions of the risk. HSU students make calls to randomly selected telephone numbers over a two-week period. Each survey includes 400 to 600 responses. A summary of the responses to tsunami-related questions is shown in Figure 4. Over the 14-year period covered by the surveys, the percent knowing what a tsunami is increased from 78 to 98%, persons aware of the near-source tsunami hazard increased from 51% to 91%, and those aware that the first wave is not the largest increased from 65% to 95%. A discouraging trend is the increase in people who believe it is the government's responsibility to respond in the immediate aftermath of a disaster, not the community or the individuals affected.

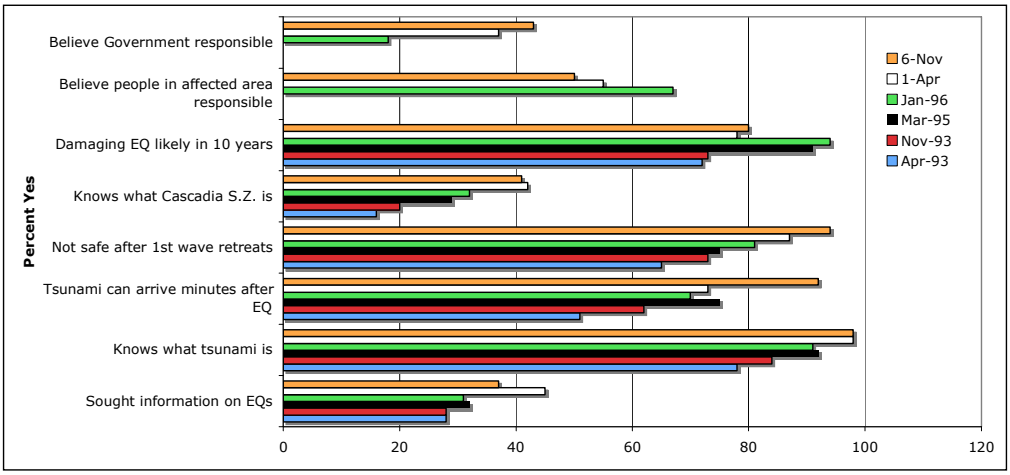

Figure 4: Comparison of Humboldt County Surveys

CONCLUSION

Humboldt County's unique location and tectonic history has placed it at the forefront of tsunami mitigation efforts on the US West Coast. The outpouring of scientific studies on the CSZ in the past two decades, coupled with recent local and distant tsunami alerts and the 2004 Indian Ocean tsunami, has created widespread awareness of and interest in tsunamis and a willingness to develop tsunami mitigation programs at all levels of government. The RCTWG, formed as an ad hoc organization of representatives from government agencies, tribes, service groups, academia and the private sector, has proven an effective tool for building a tsunami constituency and maintaining interest in tsunami hazards and pooling the resources for coordinated regional education and mitigation activities.

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