CHAPTER 112

THE DEVELOPMENT OF AN ON-LINE, INTERACTIVE, TSUNAMI-INFORMATION RESOURCE

Benjamin Cook[1], Catherine Petroff[2]

ABSTRACT

Tsunami! (http://www.geophys.washington.edu/tsunami/welcome.html) is a WWW site developed at the University of Washington with collaborative support from the global tsunami research community. The site originated as an on-line documentation of the 1994 East Java tsunami survey. The field survey documentation was developed to serve as a prototypical WWW resource whose form can be amended and improved upon for future on-line tsunami survey documentation. Educational and hazard mitigation resources were added to the site to provide the general public with an on-line source of tsunami information. The site's content and interface design were strongly influenced by the wide range of network connections and browser applications utilized by the target audience.

INTRODUCTION

The World-Wide Web (WWW) can be thought of as the virtual network of information accessible over the Internet using the HyperText Transmission Protocol (HTTP), the WWW communication standard. A collection of WWW documents with a common theme served by a computer(s) is often called a WWW or Web site. *Tsunami!* is a prototypical WWW site developed at the University of Washington with collaborative support from tsunami researchers around the world. Multimedia-supported resources currently available through the site include the following: Explanations of the physics of tsunamis; case studies of significant historical

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1) Hydraulic Engineer, WEST Consultants, 2101 4th Avenue, Suite 1050, Seattle, WA 98121, USA.

2) Assistant Professor, Department of Civil Engineering, University of Washington, Seattle, WA 98195, USA.

tsunamis; hazard management and prevention information; recent event documentation; and an index of tsunami-related WWW sites.

The site originated as an on-line documentation of the 1994 East Java tsunami survey. On June 3, 1994, a large earthquake occurred off the southeastern coast of Java near the east end of the Java Trench in the Indian Ocean (Figure 1). The 7.2 M_S earthquake generated a devastating tsunami that took the lives of approximately 200 East Java residents (Synolakis et al., 1995). An international tsunami survey team, which included tsunami scientists and engineers from Indonesia, Italy, Japan, and the United States, visited the impacted areas of Bali and Java from June 20 to June 25, 1994. Survey team members measured runup heights along the southwestern coast of Bali and the southeastern coast of Java (Figure 2), and examined tsunami-induced sedimentation and structural damage. They also interviewed coastal residents to determine the distribution of seismic intensity and collect eyewitness accounts of the tsunami attack (Tsuji et al., 1995). In addition to the quantitative data collected during the survey, visual data such as slides, photographs, and video footage were also gathered. The visual data include photographs that depict sedimentation and structural damage observed by survey team members (Figure 3), as well as water and debris marks noted in the runup surveys.

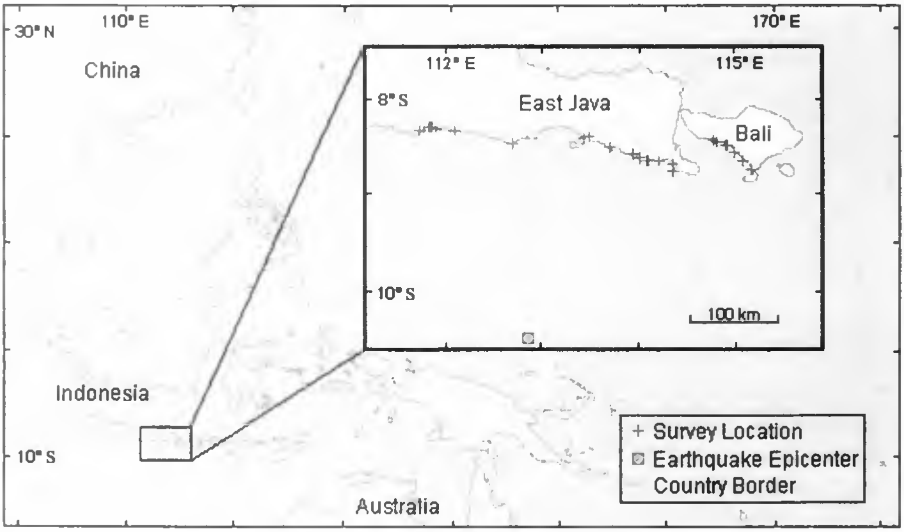

Figure 1. Locator map for the 1994 East Java survey.

Due to the limited number of tsunami scientists who were able to participate in the field survey, dissemination of the visual and quantitative data gathered during the survey was considered to be an important part of the documentation effort. Since the physical duplication and distribution of the visual data to tsunami scientists located throughout the world was logistically impractical, the feasibility of distributing digitized visual data with an Internet information-exchange service was explored. It was found that the WWW allowed for an easily implemented and distributed multimedia presentation of the survey data. Non-platform specific, the WWW enables the electronic publishing of documents, which can include both text and graphics, to any computer connected to the Internet and equipped with browser software. Browser applications, through their graphical interface, allow users to access and view WWW documents, often referred to as WWW pages. A variety of media resources, including graphics such as survey maps, as well as audio and video clips, can be incorporated into a WWW page. Another WWW feature, interactive graphics called image maps, allows users to retrieve information associated with a particular region of an image.

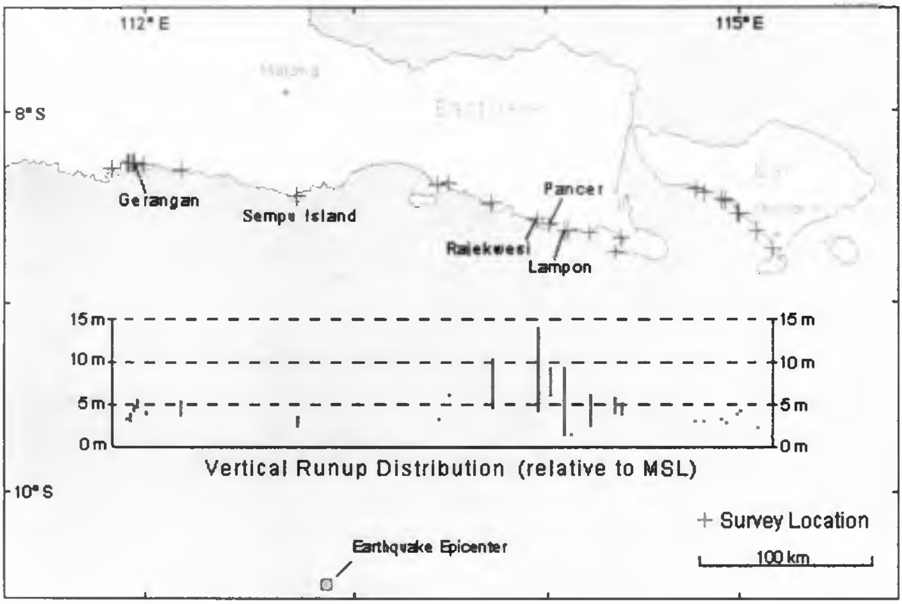

Figure 2. Interactive runup distribution map of 1994 East Java survey area.

FIELD SURVEY DOCUMENTATION

For the East Java survey, visual, damage, and runup data related to the event are accessed through an interactive runup distribution map of the survey area (Figure 2). Site-specific survey data are downloaded by selecting the survey location of interest from the image map. Runup data are presented in a tabular format including raw data (as recorded in the field) and corrected data that have been adjusted for the difference in the tidal level at the time of the tsunami attack and the time of the runup measurements (Tsuji et al., 1995). The visual data were prepared in two resolution formats. By default, the user is presented with small, low-resolution annotated

Figure 3. Sample digitized slide showing a scarp in Rajekwesi, East Java formed by tsunami-induced erosion.

digital images called in-line images. Relatively small in file size (less than 10 kilobytes), the in-line images are more quickly transferred over the Internet, facilitating the rapid navigation of the visual data. The in-line images function as links to higher-resolution images, which can be accessed by clicking on the in-line image of interest.

The East Java tsunami survey documentation was developed to serve as a prototypical document whose form can be amended and improved upon for future WWW tsunami-survey documentation. As shown schematically in Figure 4, a more comprehensive on-line documentation is proposed for future tsunami surveys that would serve as a data source for tsunami scientists and hazard management professionals. An event overview section could provide summary information about the event, the survey itinerary and team members, as well as links to other related WWW documents. Data sections accessible through the event overview could include earthquake source information provided by seismologists, historical data pertaining to local seismic and tsunami activity, and instrument records (when available) from tide gauges, deep-ocean pressure transducers, and remote sensing.

Data pertaining to specific survey sites could be accessed through an interactive survey area map, such as the one used in the East Java documentation (Figure 2). Survey site overviews could provide brief descriptive summaries of the observed local runup and flow characteristics, and tsunami-induced sedimentation and structural damage. A local map could be presented in conjunction with audio-visual data gathered at the survey location. Site-specific runup, sedimentation, damage, and emergency management data could be presented in subordinate sections. For example, a runup data section for a specific survey site might include an

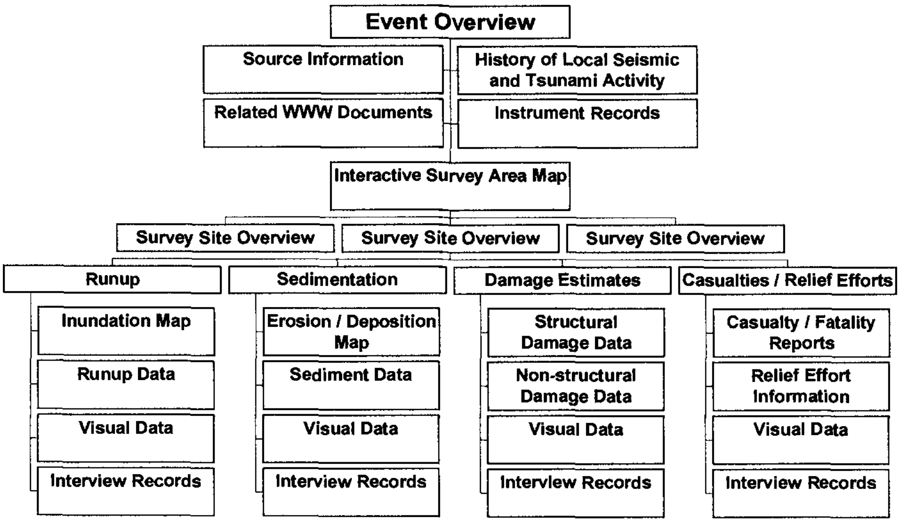

Figure 4. Resource hierarchy tree for tsunami survey documentation.

inundation map, surveyed runup measurements, annotated visual data showing water marks, trace evidence, and indicative debris, and interview records. Borrowing on the multimedia capabilities of the WWW, interview records could be presented in written form and as audio clips, both in the native language of the interviewee and in English.

At present, the preparation of an on-line multimedia survey documentation is technically challenging and labor intensive. Emerging software and hardware technologies should greatly facilitate future tsunami survey documentation efforts. For example, the use of digital cameras in field surveys would allow for the direct uploading and WWW publication of visual data. The level of detail of future documentation will vary as a function of the perceived scientific importance and human impact of a particular tsunami event. With limited public funding available for tsunami field surveys, the WWW enables the cost-effective documentation and world-wide dissemination of field survey data to tsunami scientists and emergency management professionals.

SITE RESOURCES

Additional resources were added to the site to meet the general public's broader needs for hazard mitigation and educational information. In addition to researchers and hazard management professionals interested in recent event data, the site's audience includes secondary and university students, and residents of tsunami-threatened coastal communities. In recognition of the diverse information needs of this group, *Tsunami!*'s on-line resources include educational information about the physics of tsunamis, significant historical tsunamis, the Tsunami Warning System and hazard mitigation. A top-level flow chart of the subject material presented on the site is shown in Figure 5. Referred to as a resource hierarchy tree, it represents, in a general sense, the logical order in which the site developers attempted to present the resources. The site's directory structure reflects the resource hierarchy tree, assuring continuity for inter-linked documents throughout the development process.

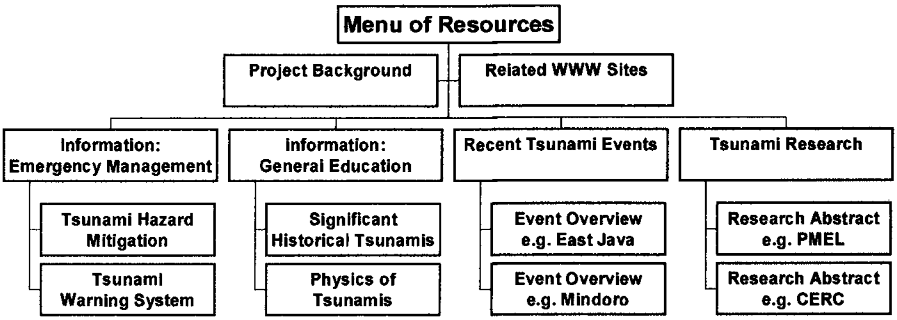

Figure 5. Top-level resource hierarchy tree for the WWW tsunami site.

With roughly 500 animation, audio, image, and text files accessible through the site, link management was an important issue that had to be addressed in site development. Similar subordinate flow charts were conceived for several of the more extensively-developed sections shown in Figure 5, including the "Physics of Tsunamis" and "Event Overview" sections (for example, see Figure 4).

CONTENT AND INTERFACE DESIGN

The site's content and interface design were strongly influenced by the technical constraints imposed by the wide range of network connections and browser applications utilized by the target audience. At present, there are some inherent technical limitations, such as network bandwidth, that strongly impact the design of a WWW site. Restricted local and global network bandwidth often prevents the rapid transfer of information necessary to allow the interactive navigation of the WWW. WWW-related computer hardware, software, protocols, and languages are also swiftly changing.

Several types of Internet connections exist. The fastest connections, commonly available on university campuses and at large corporate facilities, are Ethernet connections. Users accessing the Internet over Ethernet connections can consistently realize file transfer rates, or throughput, of over 100 kilobytes per second (KB/s). However, many of site's potential users are limited to dial-up Serial Line Internet Protocol (SLIP) or Point-to-Point Protocol (PPP) connections through modems, with typical baud rates (bits per second) of 9,600 - 28,800, limiting theoretical throughput over these dial-up connections to between one and three KB/s (Krol, 1994). Throughput can be further diminished by heavy local and regional network traffic.

This wide range in throughput poses a significant development problem as multimedia resources are information-rich and hence inherently large in file size. Image files, even when stored in the compressed formats cited later in this paper, can be well over 100 KB in size. Animations, even relatively short clips several seconds in length, can be one or more megabytes. Considerable effort was taken to present information on the site in the least data-intensive format for the primary links. Additional link-options, intended for users on high-bandwidth connections, are available to provide access to data-rich resources such as high-resolution images and animations. With the exception of the high-resolution images and animations, most of the site's pages have been kept to well under 50 KB, allowing even dial-up users to quickly download and browse through pages containing in-line images.

Compounding the at least two order of magnitude difference in throughput experienced by the site's target audience, the language used to format documents, HyperText Markup Language (HTML), continues to evolve. At the time of the site's initial development (summer 1995), most graphics-capable browsers supported HTML 2.0, but did not support the then newly-proposed standard, HTML 3.0. HTML 3.0 implemented several features, including table formatting and sophisticated image formatting, not available with HTML 2.0, and was used exclusively for the site's page development because of these advanced features. For site resources to be easily accessed and properly displayed, developers need to accurately assess the hardware and software capabilities of their site's prospective audience. Following this assessment, document formatting standards and multimedia content can be appropriately selected.

RESOURCE DEVELOPMENT AND SITE IMPLEMENTATION

The site presents a variety of media resources, including graphics, sounds, and animations. These resources were originally delivered to users over the Internet by a dedicated server set up specifically to support the site. It is beyond the scope of this paper to discuss in detail the digitization techniques and editing employed in the development of the site's multimedia resources. Digitization considerations include data preparation (e.g., cleaning of slides), digitization device and resolution selection. Post-digitization filtering, such as image sharpening, can greatly improve digital image quality. Various compression algorithms are available that significantly reduce file size while preserving visual and audio quality. The interested reader is referred to numerous on-line resources or in-print publications (see, for example, Murray, 1994).

Digitization Techniques

A variety of digitization devices are currently available for converting hard-copy images and analog audio and video signals into digital data. For this project, flatbed scanners were used to digitize hard-copy images such as slides and photographs. A Macintosh Quadra with hardware-assisted compression provided by a Digital Film frame-grabber board was used to capture video footage. *Adobe Premier* was used as the software interface for the capture board and served as a powerful editing environment for the acquired digital clips. Sounds were digitized with an analog-to-digital converter supported by the Macintosh's built-in sound capabilities.

Two types of graphics file formats were used to store the images presented on the site; the Joint Photographic Experts Group (JPEG) format is used for in-line and high-resolution digital images produced from photographic images, while the Graphic Interchange Format (GIF) format is used for maps, image maps, and icons that were digitally generated. JPEG images, with their 24-bit pixel depth, can contain over 16 million colors, while GIF images are limited to 256 colors because of the format's 8-bit pixel depth. Digital movies were stored in the cross-platform flattened QuickTime format with Cinepak compression. Lastly, the AU file format was used for audio clips.

HTTP Server Setup

WWW documents are distributed over the Internet by HTTP servers. In many cases, organizations may have an existing HTTP server, and the publication of WWW documents simply requires that newly-developed HTML files be transferred to the HTTP server. Although a departmental HTTP server was available with limited storage space, for this project a Macintosh HTTP server was initially set up to facilitate site development. The creation of the dedicated server allowed for the autonomous administration of the WWW tsunami site during the development period. The HTTP server consisted of a Macintosh SE-30 running *MacHTTP 2.2* that was connected to the University of Washington's Ethernet network. Remarkably, this somewhat outdated configuration performed almost flawlessly for one year, distributing data to the more than 10,000 users who accessed the site over this period. Increased server demand during the summer of 1996 necessitated the site's move to a UNIX-based workstation.

FUTURE WORK

As the tsunami research and hazard management community's information exchange and dissemination needs become better defined, *Tsunami!* can be easily expanded and revised. Future development efforts that have been considered include real-time tsunami warning dissemination, event management, and post-event survey administration. In cooperation with the Pacific Tsunami Warning System, tsunami warnings and preliminary event information could be globally disseminated over the WWW. Event information could be complemented by regional hazard management resources, including inundation maps and evacuation procedures. Post-event data collection could be facilitated with the on-line distribution of survey guidelines, survey itineraries, and preliminary visual and runup data. Finally, educational offerings could be expanded to include interactive demonstrations, which could be developed in the Java programming language, of tsunami generation, propagation, and inundation mechanisms.

ACKNOWLEDGMENTS

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