11/66.

Working Paper 11

(DRAFT)

Seismic Sea-Wave Warning in Crescent City, California and Hilo, Hawaii

by

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SEISMIC SEA-WAVE WARNING IN CRESCENT CITY, CALIFORNIA AND HILO, HAWAII

Introduction

Following the March 27, 1964 Alaska earthquake, a series of seismic sea-waves spread across the Pacific Ocean. This resulted in massive destruction, loss of life and injury in Crescent City, California. In Hilo, Hawaii, on the other hand, little property damage occurred, and there were no deaths or injuries. There is one obvious explanation for the difference in outcome in the two communities--considerable wave action occurred in Crescent City following the earthquake, while in Hilo there was only mild wave activity and only a slight change in the ocean level. However, the evidence indicates that even if Hilo had been subjected to the violent wave action which hit Crescent City there still would have been little or no injury and loss of life due, to a large extent, to the implementation of warning techniques and procedures which had been conceived before hand. How do two coastal communities within the same nation differ so remarkably in their response to threats of seismic sea-waves?

In this paper, we will attempt to answer this question by analyzing the warning process and community responses to several seismic sea-wave emergencies. We will also consider some of the problems that local officials face in attempting to carry out their responsibilities during such emergencies. Data on which this report is based were collected on field trips by Dr. William Anderson, Professor J. Eugene Haas, and Dr. Daniel Yutzy of The Ohio State University's Disaster Research Center. The field trips were made to Crescent City during April, 1964, February,

1965 and March, 1966, and to Hilo in March, 1966. Data were secured through tape recorded interviews with public officials and scientists; also, relevant documentary information was acquired from a variety of public and private sources. The events which will be relevant to our discussion are as follows:

Crescent City, California	Hilo, Hawaii
March 27-28, 1964--Seismic sea-wave alert followed by disaster.	May 23, 1960--Seismic sea-wave alert followed by disaster.
February 3-4, 1965--Seismic sea-wave alert not followed by wave impact.	March 27-28, 1964--Seismic sea-wave alert followed by only slight wave damage.

We will begin by discussing disaster warning in a general, or somewhat theoretical sense, i.e., as a process. This will be followed by a brief discussion of the March, 1964 alert and disaster in Crescent City, which will then be compared with the February, 1965 alert in that community. In the concluding section, some comparisons will be made between warning patterns and procedures in Hilo and Crescent City.

Warning as a process

In this paper, disaster warning is conceived as a process. That is, it is viewed as consisting of a number of inter-related activities and procedures in which a variety of groups, organizations, and individuals become involved. This is not offered as a particularly new conceptualization, for a number of social scientists have analyzed disaster warning in a similar fashion before.[2]

Disaster warning conceived in such a manner underscores the interdependence of the various activities which comprise it. Thus, we become aware of the possibility that an inadequacy, or breakdown, in a certain

part of the disaster warning process may result in the failure of the system as a whole. And similarly, a modification in one aspect of a warning system may, indeed, result in change in another part of it.

The desired consequence or output of a warning system is, of course, a successful public response. A response which, given the potential for destruction and disruption of a disaster agent, allows for the maximum preparatory, protective behavior on the part of those who reside in the target area. Such a response would seem to occur only to the degree that each of the parts of a warning system makes an adequate contribution to the process.

A disaster agent is disruptive to the normal processes of a community to the extent that it destroys lives and property, and creates new and unusual demands with which the community's institutions and groups must come to grips. Often, effective warning will mitigate the impact a disaster agent will have on a community. The purpose of warning is to provide a threatened population with critical information regarding... "(1) the existence of danger, and (2) what can be done to prevent, avoid, or minimize the danger." [2] Thus, warning should alert the public to the possibility of a radical environmental alteration, as well as provide information regarding what should be the most desirable defensive measures to adopt. When these requirements are met, the likelyhood of an effective public response is enhanced.

Warning represents the beginning of the human adaptation to disaster. When a perceived crisis and warning activities are followed by an actual disaster, the period of warning can be viewed as one of the phases of the disaster.[3] Also, it needs to be emphasized that "In certain respects, the warning phase is the most important phase of any disaster. Events

which occur during this phase determine the magnitude of the impact of the disaster."[4]

There are a number of steps or activities in the warning process. Usually, a multiplicity of groups and organizations will eventually play some role in one or more of such activities. Williams sees the following activities or steps involved in disaster warning.

1. Detection and measurement or estimation of changes in the environment which could result in a danger of one sort of another.
2. Collation and evaluation of the incoming information about environmental changes.
3. Decisions as to who should be warned, about what danger, and in what way.
4. Transmission of a warning message, or messages, to those whom it has been decided to warn.
5. Interpretation of the warning messages by the recipients and action by the recipients.
6. Feedback of information about the interpretation and actions of recipients to the issuers of warning messages.
7. New warnings, if possible and desirable, corrected in terms of responses to the first warning messages.[5]

The focus here will be upon parts 2, 3, and 4 of the warning process. We will not consider to any great extent the activities and procedures involved in the detection and measurement of disaster cues, which in the case of seismic waves is largely done outside the local community. And neither will we devote much space to discussing the response of the general public to seismic wave alerts. Instead, we will be chiefly concerned with that segment of the warning system which is responsible for evaluating incoming warning data and disseminating such to the public, so that protective actions can be taken. Thus, our focus will be upon the problems and activities of local officials who have the primary role

in the evaluative and disseminative phases of the seismic sea-wave warning process.

The March, 1964 Crescent City Disaster

The United States Coast and Geodetic Survey operates an extensive seismic sea-wave detection and measurement technological system in the Pacific from its Honolulu Magnetic Observatory. Emergency information resulting from the detection of possibly destructive seismic sea-waves is relayed from the Observatory to established warninglocations. The California Disaster Office, which has its headquarters in Sacramento, as the designated initial warning point in California, is the recipient of seismic information and is responsible for alerting coastal counties and cities in the state, including Crescent City area. Thus, an important phase in the warning process (detection) is initiated at a considerable distance from Crescent City. And in the chain of procedures, public officials in Crescent City receive authoritative information from the C.D.O. in Sacramento which they must evaluate and act upon in terms of local needs. Such information is received, for the most part, in the form of teletype bulletins.

At 11:08 p.m. (P.S.T.), following the March 27 Alaska earthquake, the California Disaster Office issued its first of two emergency bulletins. The bulletin indicated that it was probable that a seismic sea-wave had been generated by the earthquake. A second bulletin was issued at 11:50 p.m. An estimated time of arrival of a seismic wave was given as 12:00 a.m. for Crescent City, the county seat of Del Norte County.

The two bulletins were received at the civil defense control center, located in the county sheriff's station a few blocks from the downtown

area. The sheriff and city-county civil defense director, who assume the major responsibility for alerting activities at the local level, were notified and arrived at the control center by 11:20 p.m.

The sheriff sent his deputies to alert persons in the low-lying areas of the city after the second bulletin was received at 11:50. They were still involved in door-to-door alerting when the first of four waves hit at 12:00 a.m., the estimated time of arrival. The initial three waves were fairly mild and they did little damage except deposit debris on the streets nearest the ocean front. The second wave came at approximately 12:40, and the third at about 1:20. The fourth and final wave, which struck at approximately 1:45, had the greatest impact, and had the first wave been as severe, there would have been more deaths and injuries due to the lateness in which alerting procedures had been initiated. Still, at least 11 persons were killed, and twenty-nine blocks were damaged. There was some difficulty in determing the exact number killed since there were a number of transients in the area who might not have been accounted for.

On February 3, 1965, less than a year after the March 27-28 disaster, Crescent City had another seismic sea-wave alert, which also followed an earthquake in Alaska. Fortunately, in contrast to the 1964 experience, a seismic sea-wave was not generated. Nevertheless, since warning procedures were initiated in the community, it afforded an unusual opportunity to make some comparative observations. The next section of this paper will be devoted to a discussion of some of the similarities and differences between the public response in Crescent City to the 1964 and 1965 alerts.

Some comparisons between the 1964 and 1965 response and public warnings in Crescent City

1. The seismic wave alert of Wednesday, February 3, 1965, like that of March 27, 1964, was due to the detection of an earthquake which had occurred in Alaska. In both instances, the U.S. Coast and Geodetic Survey felt the disturbances to be great enough that Pacific Coast communities should anticipate seismic waves. Following each of the earthquakes, the California Disaster Office relayed this information by teletype in emergency bulletins to sheriffs, chiefs of police and CD directors of coastal counties and cities. In each instance, Del Norte County and Crescent City officials were among those notified, receiving the information at the CD control center. At this broad, overall level, the organizational alerting procedure was the same in 1965 as in 1964.

2. The first bulletins received at the control center from the California Disaster Office following the 1964, and 1965, earthquakes were received late at night, at approximately 11:08 p.m. and 10:58 p.m. respectively. This meant that in each instance many of the public officials, who have the responsibility for making the important decisions in such emergencies, were off duty and had to be reached at home, or elsewhere. Fortunately, in neither case was it reported that any of the key officials could not be reached.

Also due to the lateness of the hour during which the beginning of both alerts occurred, the waterfront business area of the city was unpopulated except for a few bars and motels. Apparently, following the March 1964, earthquake, many of the merchants sustained heavy losses to their businesses because they were in their homes outside of the area and did not learn of the threat in sufficient time to make emergency

preparations. Recalling this earlier problem, public officials at the control center during this most recent alert decided to try to contact every merchant in his home, either directly or by telephone. This was accomplished well in advance of the 2:45 a.m. estimated arrival time of the seismic wave. It is reasonable to assume that if waves similar to those which struck in 1964 had also done so in 1965, property losses sustained by waterfront businessmen would not have been as great. For example, a car dealer thus contacted got additional personnel and drove all of his cars out of town. He had lost all of his cars in the 1964 disaster. Due to this apparent success and the need to contact merchants in their homes during such alerts, public officials anticipated incorporating this procedure into their public warning routine. Along this particular line at least, previous experience clearly changed part of the organizational response in the later threat.

3. Following the March 1964 earthquake, public officials in Crescent City received two emergency bulletins from the California Disaster Office, whereas, following the February 1965 earthquake, three bulletins were received. The first bulletin received during the 1965 alert was unlike either of the two received in 1964 in that it was a preliminary notification. It was sent before more complete information was available from the U.S. Coast and Geodetic Survey to provide local officials with early notification that a sizable earthquake had occurred. In Crescent City, this meant that local officials could be contacted from the control center and advised to remain where they could be reached in case further information warranted a full-scale alert. This particular change in the specific procedure of providing early information was highly

functional; it meant the availability of key organizational or public officials who might otherwise have made plans to leave the community on other business.

4. According to one high official, if information indicating the estimated arrival time of a seismic wave becomes available, this is sufficient basis for justifying a public declaration of a state of emergency. The two bulletins received by public officials during the 1964 alert, and the final two received during the more recent one were similar in that information was provided regarding estimated arrival times of possible seismic waves. This was the basis for a declaration of a state of emergency. In both instances, moreover, public officials did not publicly suggest evacuation until after the final bulletins had been received. In the 1964 situation evacuation was suggested after the second bulletin, and in 1965 after the third. However, there was little real delay in the 1965 alert because the third bulletin followed the second almost immediately. Essentially this means that the state of emergency in one sense was really initiated by officials quite distant from the local scene. This may or may not be the intent of the originating source of the seismic wave information, but this is the way the situation was defined, at least in Crescent City.

5. Seemingly, there was less hesitancy in declaring a public emergency following the February 1965 earthquake than after the March 1964 one. During the 1965 emergency, within a matter of approximately ten minutes after the Sheriff arrived at the control center and conferred with other officials present, a full-scale alert was initiated involving sheriff's deputies and police officers. Also, the local radio station KPLY began broadcasting the alert some several minutes later. This

contrasts with the response made in March 1964. In that instance, it was approximately thirty minutes after key officials had assembled at the control center that deputies and police officers were sent into the threatened area. This preceeded the arrival of the first seismic wave by only ten minutes.

The delay by local officials in beginning warning procedures following the March, 1964 earthquake has been attributed to the ambiguity in the wording of the emergency bulletins and to the officials' prior experiences.[6] Both of the bulletins indicated only that a wave was probable. In fact, the first bulletin stated that the probability evaluation had not been confirmed.

Local officials during the 1965 alert, as in 1964, also had the problem of evaluating ambiguous information. The second bulletin received from the California Disaster Office during the 1965 emergency stated: "This is not a tidal wave warning...it is still not known that a wave has been generated." This bulletin was immediately followed by the final one which contained both the following confusing statements in this order : "The U.S. Coast and Geodetic Survey reports the probability of a tidal wave..." and "...Repeat this is a tidal wave warning, a wave has been generated."

Local officials need to evalute the information that is made available to them and then make the decision whether or not to issue a public warning. If they do not make the proper decision, they may be subject to public sanctioning. If, for example, after receiving information of an emergency nature, however ambiguous it may be, and they they fail to call for evacuation they may be held publicly responsible

for loss of life and property. On the other hand, if they call for evacuation too frequently and there is a long period when disasters fail to materialize, they may be held up to public criticism and ridicule with a resultant loss of effectiveness. The hesitancy with which public officials decided upon initiating alert procedures in March, 1964 can be, in part, attributed to their having had a number of "false alarms" that year.[7]

Such a problem is well documented in the disaster literature. For example, Fritz has taken note of it:

> When people have had no recent experience with disaster or cannot actually perceive the danger in their immediate surroundings, successful public warning is much more difficult. The difficulties often start with the persons or agencies who are responsible for detecting the danger and for issuing the warnings. These agents are usually reluctant to issue a specific warning until they are reasonably certain that the danger will actually materialize. In many cases, waiting for this degree of certainty only delays the warning until it is too late.[8]

While Crescent City public offficials in 1964 did not wait until it was too late to issue a public warning, they did have only ten minutes from the time they received the second bulletin and acted, and the arrival of the first seismic wave. Fortunately, the first wave was relatively mild. If it had been as large as the fourth, loss of life and property would probably have been greater.

Local officials initiated public warning procedures more rapidly in 1965 than in 1964. Since, as in 1964, there was still ambiguity in the bulletins received by officials, the difference in response can, to a considerable degree, be attributed to the prior experience with the March, 1964 disaster. Having had this experience, local officials in 1965 were especially sensitive to disaster cues and, consequently, were less reluctant to issue a public warning.

6. Limited information upon which to base a crucial decision was another problem officials had in 1965 which was like that experience in 1964. For example, in 1964 no information was provided by an official outside source regarding the szie of the earthquake that had occurred or of the probable height of the wave. In 1965, the only information received from an official outside eource about the size of the earthquake was from an official at Region II, California Disaster Office, who advised that the information which he had received indicated that it was a "large one". Nothing was said about the probable height of the wave. Clearly such information would affect the degree of evacuation thought necessary. DRC has discovered that in other societies subject to seismic waves generated by earthquakes, such as Japan, the warning system not only indicates the time but the height of the wave that could be expected in any given region.

7. Fritz makes the follwoing observation: "People who have recently had direct experience with disaster become hypersensitive to signs of its recurrence, and warning under these conditions usually insures adequate protective actions."[9] This observation seems to hold true for the two situations discussed here. For example, when asked to compare public response to warnings during the 1964 alert with a year later, local officials expressed the belief that residents of the threatened area were more willing to evacuate during the 1965 emergency because they recalled the disaster the year before. One official noted: "Everyone was extremely cooperative and they moved very promptly. We didn't have to enter any arguments."

8. Finally, in both instances, officials did not <u>order</u> an evacuation of the threatened areas. Apparently, it would not have been legal to do so. Thus, persuasion rather than authority had to be used.

Problems of local authorities

Viewing disaster warning as a process suggests that each succeeding step or activity in the process is dependent to a considerable degree on those activities which precede it. Accordingly, the decisions local officials make regarding disaster warning reflect, in part, the informational inputs they receive from detection and measurement sources. Also, the response of the public will be related to the decisions made by local authorities and the means they utilize to implement them. Moreover, the experience community officials and private citizens have in responding to impending disaster soon become reflected in later processes of warning.

By now, it should be apparent that local officials play a crucial role in the warning process. Like the other activities which comprise warning, the responsibilities of local officials must be met if a successful warning response is to be achieved. In the final analysis, local officials must decide (1) if the public is to be warned, (2) if so, how it should be done, and (3) if evacuation should be advised. Decision making under "normal" conditions is often very difficult, when the consequences of alternative courses of action can be largely predicted and when time is not a crucial variable. It is not surprising, then, that decision making may become even more difficult when information is incomplete or ambiguous, when time is of the essence, and when it may have life or death consequences. Local officials with warning responsibilities often find themselves in such unenviable circumstances.

Local officials in Crescent City, as elsewhere in California, are solely responsible for making decisions concerning the response to be taken in the event of seismic sea-wave threats. For example, this is made explicit in a publication of the U.S. Coast and Geodetic Survey

which makes reference to the relationship between the CDO and community officials in California during seismic sea-wave alerts: "It should be noted that the California Disaster Office does not initiate or direct any action to be taken by local jurisdictions. Determination of such action remains the prerogative and responsibility of local officials."[10] Key decisions regarding warning, then, are left up to community leaders.

A number of considerations appear to be involved in whether or not local officials will decide to alert the general public and call for the evacuation of target areas; among them are: (1) the nature of the information received from sources external to the community, (2) changes in the community's environment that can be observed locally and which indicate impending disaster, e.g., increasingly high winds and water levels, (3) the past experience of officials, and (4) the anticipated reaction of the public, particularly in the event of a false alarm. Let us consider some of these factors further.

In the case of seismic waves, there may be few or no danger cues observable at the local level for either officials or residents to interpret. Consequently, responsible local authorities often have to depend almost entirely upon outside sources for information regarding such threats. This means that the action taken by these local officials will be, in part, a consequence of: (1) the speed bywhich information is sent to them and (2) the clarity and completeness of the information. Any inadequacy in either of these makes it the more difficult for local authorities to take appropriate action.

Apparently, state officials in California are aware of the problems local officials experience as they attempt to take the most appropriate

actions in meeting a threat to their communities. Following the 1964 seismic wave disaster, a series of meetings were held in San Francisco. They were sponsored by the California Disaster Office and attended by CD personnel throughout the state. One of the main topics considered was the problems that local community officials have in evaluating bulletins and messages sent to them by the CDO. The content of such bulletins and messages was discussed along with the need for them to contain certain kinds of information. At one such meeting a group of scientists provided basic information about the nature of earthquakes and seismic waves.

Such efforts as these are necessary if the problems are ever to be satisfactorily handled. That they are still formidable ones, however, is indicated by the fact that there continued to be some ambiguity in the bulletins received by officials in Crescent City from the CDO.

In addition to the problem of receiving ambiguous or inconsistent messages, local officials, such as those in Crescent City, sometimes experience the frustration of having to make critical decisions with incomplete information. Undoubtedly, on a number of specific occasions this problem has been due to the need for further refinement in scientific detection instruments, rather than the fault of any particular organization or agency which becomes involved in the warning process. Because the California Disaster Office is the established point in the warning process from which local officials in the state receive their official information, it frequently receives complaints about the lack of needed information on which decisions can be based locally. One CDO official noted: "The local people who really don't understand the phenomena complain that they don't get enough information. And, of course, what we're giving them is the message that we receive from the U.S. Coast

and Geodetic Survey through the agencies who have agreed to pass it on and we serve only as, you might say, the middle-man in passing on information."

One of the adaptations which can be expected to occur when there is a problem with information is that unofficial sources will be utilized and thus become included in the warning process. For example, during the 1965 alert in Crescent City several newsmen called the control center and provided officials there with information received from various news agencies. Ideally, the information used by local officials in determining local needs ought to come from official sources. However, when such information is ambiguous or incomplete, unofficial sources provide additional, though less firm, bases for evaluations.

Finally, involved in any decision on the part of local authorities regarding warning and possible evacuation are their past experiences with the particular danger and what they anticipate the public reaction will be. Local officials must face the problem of maintaining public willingness to comply with their suggestions. They may be especially difficult during periods in which there have been many false alarms. As indicated by the recent alert in Crescent City, people are willing to evacuate, and warning is easier, when there has been a recent disaster.

There also seems to be greater public tolerance for false alarms for a certain period following an actual disaster. It is during such periods of public "disaster sensitivity" that officials often find themselves able to introduce previously resisted emergency procedures. For example, one high official in Crescent City said that they are going to adopt a fan-out alerting procedure which would involve people in the low-lying areas and greatly reduce the time it will take to warn residents

of an approaching seismic wave. This same official noted: "We would have had it before, the only thing is most people concerned are quite individualistic and they objected..."

However, high public sensitivity to the possibility of disaster is difficult to maintain. Public officials in Crescent City are aware of this, and they anticipate tolerance to the false alarms to decrease as the period between disasters lengthens. Anxiety concerning the consequences of future periods of decreased public sensitivity is reflected in the following statement by one official: "If nothing occurs you feel like an idiot and you can be laughed at and it doesn't necessarily as an individual bother me to be laughed at, but it destroys basically a regard for future warnings."

Warning in Hilo

At 7:45 p.m. (H.S.T.), following the March 27, 1964 Alaska earthquake, public officials in Hilo received the first of several bulletins from Honolulu alerting them to the threat of seismic sea-waves. A later bulletin gave the estimated time of arrival of a seismic wave for Hilo at 11:15 p.m. However, all of the low-lying areas were reported to have been evacuated by 10:46. As noted earlier, relatively mild wave action developed in Hilo and only slight damage occurred with no deaths or injuries. Yet, it is probable that because of the public response to the danger there still would have been little or no loss of life and injury in Hilo even if seismic waves had struck the community with as great a force as those which hit Crescent City during the same period.

The response of local officials and residents in Hilo was due, in large measure, to their past experience. There appeared to be little hesitation on the part of responsible local officials to suggest that evacuation and other protective measures be taken by the public when

news of threat was received. And correspondingly, there was little resistance on the part of residents in complying with such suggestions. This can be attributed to the fact that on May 23, 1960 a seismic sea-wave generated by an earthquake in Chile took the lives of 61 persons and injured 282 others in Hilo.[11]

In addition to making public officials and residents in Hilo more conscious of the reality of seismic sea-wave dangers, the May, 1960 disaster had another effect on the reaction of the community to the March, 1964 emergency. It resulted in a number of improvements in seismic sea-wave warning and evacuation procedures utilized in Hilo. And the adaptation to the 1964 threat reflected the changes and improvements that had been made.

It should be noted that whereas the 1960 disaster generated considerable change in warning patterns in Hilo the somewhat comparable experience undergone by Crescent City in March of 1964 has not resulted in the same degree of change in that city's warning procedures and patterns. This was evident when the final field trip was made to Crescent City in May, 1966, over two years after the 1964 Good Friday catastrophe. In the remaining portion of this section, some of the salient public warning procedures that have evolved in Hilo will be contrasted with some of those which have developed in Crescent City.

A written warning and evacuation plan serves as the model for the response to seismic sea-wave threats in Hilo. This stands in sharp contrast to Crescent City which does not have a written plan, although a standard operating procedure has been worked out among officials. The plan presently in use in Hilo delineates the roles community agencies and organizations, such as civil defense, the police and fire departments,

etc., are expected to play during emergencies. It also describes the functions which key organizations are to provide for the community.

Similar to Crescent City, informational inputs are received in Hilo from the U.S. Coast and Geodetic Survey's Magnetic Observatory at Honolulu when earthquakes believed to be large enough to generate destructive seismic sea-waves are detected. Likewise, primarily on the basis of such information, local civil defense, police, and other responsible officials must decide whether or not to call for a general public alert or evacuation. The transmission of an evacuation alert is carried out in the main by fixed public sirens located throughout the city. Whereas public sirens play a key role in seismic sea wave alerts in Hilo, and indeed throughout the state of Hawaii, they are not systematically used in Crescent City.

In alerting the public to the necessity for evacuation, fixed siren signals are also supplemented by police car sirens in Hilo. When an alert is sounded, policemen are dispatched into the critical areas of the community to supervise evacuation, and to prevent ingress prior to the all clear notification. Also, local radio stations, in co-operation with civil defense and other community officials, broadcast critical information and are the means through which the all clear is given. Unlike Crescent City, there are radio stations in Hilo which operate on a 24 hour a day basis and the public is accustomed to turning to them for emergency information.

Prior to the declaration of a general public warning in Hilo, key governmental and organizational officials are systematically alerted by telephone in a fan-out procedure. Similarly, certain individuals and groups have been assigned the responsibility for promptly notifying

businessmen in their homes by telephone when seismic sea-wave advisories are received from Honolulu at night. Many businessmen have requested and routinely receive such information even when it has not been confirmed that a seismic sea-wave has been generated, and when it has yet to be decided whether or not a general public warning will be announced in the community. The receipt of such early information allows them additional time to secure their business establishments--time that they would not have if they were informed only as the general public was alerted. It will be recalled that a somewhat similar procedure for notifying businessmen was initiated in Crescent City during the February 3, 1965 alert. In contrast however, the procedure utilized in Hilo is more highly institutionalized.

During seismic sea-wave alerts in Hilo, there is a considerable increase in telephone usage as the community is mobilized. Accordingly, civil defense plans call for the local telephone company to have some employees stand-by at the various sub-stations to immediately replace blown-out fuses caused by over-loading on telephone equipment. Thus, lengthy breakdowns in this vital means of communication are minimized.

In addition to the danger of seismic waves impacting Hilo that are generated by seismic disturbances which occur far out in the Pacific, there is also the danger that they will be precipitated by local earthquakes. In such instances, a sea-wave could possibly strike the city prior to its detection by the U.S. Coast and Geodetic Survey, or before the agency could send information of the threat to local officials in Hilo. To guard against this possibility, a tide gauge has been located in the ocean front area of Hilo to detect any sudden rise or fall in the ocean level. Thus, a pronounced change in the ocean level, as detected by the tide gauge, could precipitate immediate evacuation of

the low areas of the city. This again differentiates warning patterns in Hilo from those in Crescent City. In the latter case, officials must depend completely on extra-community sources for detecting possibly critical local environmental changes.

As previously noted, many of the seismic sea-wave warning procedures and patterns presently relied upon in Hilo grew out of the experience of the May 23, 1960 disaster. For example, the following were among the improvements and changes that were made: (1) the improvement of civil defense emergency communications; (2) the addition of several new members to the local civil defense staff which had consisted of only one part-time person at the time of the disaster; (3) improvements in the radio broadcasting of warning information; (4) installation of remote control tidal gauge instruments to reduce the hazard to persons charged with the responsibility of taking readings of changes in the ocean level, and to make the instruments less vulnerable to destruction resulting in the loss of important data; (5) the delineation of areas or zones to be evacuated during seismic wave emergencies, and the outlining of evacuation routes to be followed; (6) the designation of additional shelter facilities; and (7) the publication of a warning and evacuation plan.

In accounting for the considerable change in warning patterns in Hilo following the 1960 disaster, and its lesser occurence in Crescent City after the 1964 seismic wave catastrophe, one can point to the occurrence of significant feedback after the disaster in the one case and the relative lack of it in the other. After the 1960 disaster in Hilo, local officials acquired considerable information from a number of authoritative sources regarding: (1) how well responsible agencies and organizations

performed their functions, (2) how well the general public responded to the crisis, (3) what the major shortcomings in the community's response to the demands of the disaster were, and (4) recommendations for improving the community's warning system. Williams also notes that such feedback may enter warning systems and lead to their subsequent modification: "Feedback does continue to occur..after the disaster is over. (It occurs, sometimes in the form of study by 'disaster researchers.') This slow feedback may and does result in changes in official warning systems and in other systems involved in the presumed effectiveness or ineffectiveness of the warning."[12]

Some feedback inputs were derived from a survey conducted by the local police department among the residents of Hilo following the 1960 disaster. The purpose of the survey was to acquire information which could be used by local officials in supervising emergency operations. For example, one of the questions asked residents in the survey was: "How can the governmental agencies best serve your family in an emergency period?"

Another source of feedback was a study conducted by three researchers from the University of Hawaii, which dealt with the response of the public to the 1960 disaster. They reported, for example, that a number of people failed to heed the sirens which signaled for evacuation prior to the impact of the seismic wave because "...they believed themselves to be in a safe area."[13] So that residents would be aware of the potential hazard to themselves, and thus be more predisposed to respond appropriately to an evacuation alert, it was recommended that danger zones be delineated and the public informed of their boundaries. The researchers, in the light of their investigations, also recommended the enlargement of the local civil defense organization.

Feedback as to how warning procedures might be improved in Hilo also came from the Hawaii Institute of Geophysics. A seismic sea-wave research program was established by the Institute after the 1960 catastrophe, and one of its projects was the delineation of areas to be evacuated during seismic sea-wave emergencies.[14] Whether or not given areas were designated as ones to be evacuated was based on geophysical considerations and the effect that previous seismic sea-waves had had on them. The danger areas, as outlined through the project, serves as a guide for civil defense, police, and other officials who supervise and control evacuation in Hilo, and these areas are detailed in the city's written evacuation plan. Officials in Hilo also maintain an up-to-date census of disabled persons living in the evacuation areas who require assistance. In the event of a seismic wave emergency, the local fire department is responsible for seeing that such persons are evacuated.

Unlike Hilo, evacuation areas have not been pre-determined in Crescent City. Instead, this is something which has to be decided each time an emergency develops.

A feedback process, then, appears to be rather closely associated with changes in warning patterns in Hilo following the 1960 disaster. Relatedly, much of this feedback was possible because of the concentration of interested experts near Hilo, and their availability to local officials. For example, the community of geophysicists and other experts in Hawaii who used their skills and knowledge to assist and advise local officials included those from the U.S. Coast and Geodetic Survey, in addition to scientists from the University of Hawaii. It seems that feedback to local officials in Hilo became part of the basis for altering local warning procedures because (1) new insights and ideas were acquired

by local officials concerning how to approach the problem of warning, (2) some of the information thus received by local officials served to confirm ideas they already had with regard to how warning procedures and patterns could and ought to be improved and modified, and (3) the recommendations and advice of experts provided legitimation for changes made in existing warning procedures.

Sometimes local officials are hesitant to make changes in warning procedures because they do not feel confident that their ideas are sound, and for fear of being criticized if they do not turn out as expected. Yet, such hesitation may be effectively neutralized if feedback suggests that there is a recognition of the need for change in the community and support for it, particularly if such support comes from a group or persons possessing relevant expertise. Indeed, one might argue that in such instances there is not only support, but actual pressure for change.

In sum, it is suggested that the warning procedures which evolved in Hilo subsequent to the 1960 seismic wave catastrophe resulted, in part, from feedback to local officials and organizations. Such feedback took the form of new ideas, confirming information, and legitimating information from experts. The data indicate that this kind of feedback did not occur to the same extent in Crescent City following the 1964 disaster in that community. Accordingly, it is argued that this may, to some degree, account for the absence of more change in warning procedures used in Crescent City since that disaster. Of course, as noted elsewhere, there have been some changes in Crescent City. For example, the one change probably having the most consequence is that there appears to be less reluctance on the part of local officials to advise public evacuation. However, it is possible that as feedback from residents shows an increasing resistance to evacuation in the event of a series of

false alarms, the old pattern may reappear.

Summary

In this paper we discussed the problems local officials in Crescent City experienced while discharging their responsibilities during seismic sea-wave emergencies in 1964 and 1965. Disaster warning has been viewed as a process consisting of inter-related activities and patterns. Thus, it was noted that the response of public officials in Crescent City was based, to a considerable degree, on the nature of the initial activities in the warning process that were begun at locations external to the community.

Local officials, such as those in Crescent City, are responsible, then, for evaluating incoming information concerning potentially disruptive environmental changes, and for determining if a public warning is to be issued, and if so, the form that such a warning should take. Among the problems that officials in Crescent City faced, while attempting to meet such responsibilities, was the lack of complete and unambiguous information on which to base critical decisions, and the difficulty of maintaining public willingness to comply to requests for evacuation when there have been repeated alerts not followed by disaster.

It was pointed out that the 1964 seismic sea-wave disaster in Crescent City exerted some influence on the warning process which emerged in the community in 1965. Yet, for the most part, warning patterns and problems remained the same.

We also discussed some of the facets of seismic sea-wave warning which have evolved in the community of Hilo, Hawaii. In comparing warning systems in Hilo and Crescent City, it was observed that the former has the more sophisticated one. That is, seismic sea-wave warning

is more routinized or institutionalized in Hilo. For example, evacuation areas have been pre-determined, and a warning and evacuation plan has been written, which serves as the blue print for public response. Moreover, in Hilo there appears to be a variety of fairly reliable mechanisms for transmitting seismic wave warning signals and information to the public, such as public sirens and broadcasting media.[15]

A number of the seismic sea-wave warning procedures presently employed in Hilo seem to be, in part, a result of feedback to responsible officials precipitated by the 1960 catastrophe. A lesser degree of modification in warning patterns seems to have evolved in Crescent City after the similarly destructive 1964 seismic sea-waves, and we have suggested that this may, to some degree, be explained by the relatively slight amount of feedback later received by local officials in that community.

Footnotes

1. Raymond W. Mack and George W. Baker, The Occasion Instant: The Structure of Social Responses to Unanticipated Air Raid Warnings (Washington, D.C.: National Academy of Sciences - National Research Council, Publication 945, 1961), Harry Estill Moore, et al, Before The Wind: A Study of the Response to Hurricane Carla (Washington, D.C.: National Academy of Sciences - National Research Council, Publication 1095, 1963), Harry B. Williams, "Human Factors in Warning-And-Response Systems," The Threat of Impending Disaster: Contributions to the Psychology of Stress, ed. George H. Grosser, et at (Cambridge, Mass.: The M.I.T. Press, 1964).

2. Williams, Ibid., p. 80.

3. John W. Powell, Jeannette Rayner, and Jacob E. Finesinger, "Response to Disaster in American Cultural Groups," Symposium on Stress (Washington D.C.: Army Medical Service Graduate School, 1953) pp. 178-181. Anthony F.C. Wallace, Tornado in Worcester: An Exploratory Study of Individual and Community Behavior in an Extreme Situation (Washington, D.C.: National Academy of Sciences - National Research Council, 1956), pp. 7-12.

4. Moore, et al, op. cit, p. 13.

5. Williams, op. cit., pp. 82-83.

6. Daniel Yutzy, "Aesop, 1964, Contingencies Affecting the Issuing of Public Disaster Warnings at Crescent City, California," (Columbus, Ohio: Disaster Research Center, The Ohio State University, Research Note No. 4, May 21, 1964) pp. 5-6.

7. Ibid., pp. 6-7.

8. Charles E. Fritz, Disaster," Contemporary Social Problems, ed. Robert K. Merton and Robert A Nisbet (New York: Harcourt, Brace and World, Inc., 1961), p. 664.

9. Ibid.

10. Tsunami: The Story of the Seismic Sea-Wave Warning System (Washington, D.C.: U.S. Department of Commerce, Coast and Geodetic Survey), p. 30.

11. Doak C. Cox and John F. Mink, "The Tsunami of 23 May 1960 in The Hawaiian Islands," Bulletin of The Seismological Society of America, Vol. 53, No. 6 (December, 1963), p. 1203.

12. Williams, op. cit., p. 96.

13. Roy Lachman, Maurice Tatsuoka, William J. Bonk, "Human Behavior During the Tsunami of May 1960," Science, Vol. 133, p. 1407

14. The report of this project is made in, Doak C. Cox, Potential Tsunami Inundation Area in Hawaii (Honolulu, Hawaii: Tsunami Research Program, Hawaii Institute of Geophysics, University of Hawaii).

15. Of course, our intent here is not to suggest that procedures used in Hilo are problem free. Undoubtedly, there are ways in which the warning system can be further improved. For example, while it is certainly true that the use of sirens in Hilo serves to call the public's attention to a possible seismic sea-wave emergency, it has been, nevertheless, suggested that there is a need for further clarification as to the precise meaning of such signals in terms of what the public response should be: "The exact meaning of the Tsunami siren signal is somewhat unclear. Some instructions indicate that the appropriate response is immediate evacuation, others, that the appropriate response is preparation for evacuation and checking with the radio for further instruction." Doak C. Cox, The Supply and Utilization of Information in the Tsunami Warning System of Hawaii (Honolulu, Hawaii: Hawaii Institute of Geophysics, University of Hawaii, July, 1963), p. 5.