HB 945 would appropriate funds for research and data analyses to reevaluate and update the capabilities of the tsunami warning system.

Our statement on this bill does not represent an institutional position of the University of Hawaii. The short notice of this hearing precluded our usual coordination of comments from other members of the University community in the preparation of this statement. Should other opinions be expressed, upon their review of the bill and this statement, we will provide an amended version for your records.

The tsunami warning system was established in 1948 following the devastating tsunami of April 1, 1946. Subsequently much information both theoretical and technical has been developed to better define the coastal tsunami hazard and inundation zones and through this definition to improve the safe and effective evacuation of the public from dangerous areas.

The research and experience gained over the past 40 years and particularly the results of the most recent experience of the May 7, 1986 tsunami warning, point to the need to support continuing research and to apply the existing, research and historical data to update and modify the tsunami warning procedures and evacuation zones.

The Environmental Center, through its former director, Doak Cox, has been directly involved in tsunami research since 1971 when the Center was established. We continue to be involved, since Dr. Cox's retirement, with coordination efforts pertinent to tsunami research and particularly in providing information from the University community to state and federal bodies, including the legislature, on issues relevant to coastal hazards. As part of this coordination function, we are appending to this statement a comprehensive review of the merits of HB 945 and certain background information pertinent to the tsunami issues at hand, prepared by Doak Cox for your use as general background information.

Attachment
1 March 1987

Memo to Jacqueline Miller, Env.Ctr.
From Doak Cox, JIMAR

HB 945

APPROPRIATION FOR TSUNAMI WARNING SYSTEM

HB 945 proposes an appropriation to the Department of Defense "for support of the tsunami warning system". My comments on the bill are based on some 40 years of part-time or full-time tsunami research experience and a few years experience as tsunami advisor to the Civil Defense Division of the Department of Defense.

The bill proposes that the activities to be supported by the appropriation include:

1. Integrating, updating, and validating the previous research on hazard and inundation zones;
2. Expanding and maintaining the tsunami monitoring system;
3. Refining local predictive capability; and

Hazard zone research in general

In my comments, I will consider together the investigations relating to hazard, inundation, and evacuation zones, using the term hazard zone to refer to space in which there is some degree of tsunami hazard, inundation zone to refer to space inundated, and evacuation zone to refer to the space to be evacuated on the occasion of a warning. I will also consider together under the general term research the "integrating, updating, and validating [of] previous research" and the "analyzing" to which reference is made in the bill.

At present two tsunami hazard zones have official status in Hawaii:

i) the evacuation zone, defined by the Civil Defense (CD) Division and delineated on maps at the fronts of the telephone directories, from which people are to be evacuated, under the direction of county CD's and police, following issuance of a tsunami warning; and

ii) the high-hazard coastal flood zone, defined under the National Flood Insurance Program (NFIP) as the 100-year tsunami inundation zone and delineated on maps issued by the Federal Emergency Management Administration, within which apply, by county ordinance, certain restrictions on construction and specifications as to construction standards. For brevity I will refer to this second zone simply as the NFIP zone.

Because the CD has no direct responsibility for the delineation of the NFIP zone or the management of tsunami hazard relating to that zone, I assume that the research whose support is proposed under HB 945 is intended to result in the validation or refinement of the evacuation zone. As I will indicate, however, the research should include reexamination of that on the basis of which the NFIP zone was delineated.
I am, probably more than any other single person, responsible for the present delineation of the evacuation zone. It is nearly identical to the "potential tsunami inundation zone" outlined in a report authored by me and published by the Hawaii Institute of Geophysics (HIG) in 1961; and the minor differences between the boundary of the zone delineated in that report and that of the boundary of the evacuation zone were introduced for administrative reasons as recommended in that report. The report resulted from the first research project undertaken by the newly established tsunami research program of the HIG, one intended to rectify a lack of reliable advice on the limits of the zone that should be evacuated that was then available to the CD and the public. Experience with the 1960 Chilean tsunami indicated that delineation of the zone which should be evacuated on the occasion of a tsunami warning was urgently needed. Hence the research was intended to develop rapidly and employ promptly a set of criteria for delineation even if the results were crude.

The potential inundation area delineated in the report included all areas that were inundated by the tsunamis of 1946 from the eastern Aleutian Islands, 1952 from Kamchatka, 1957 from the central Aleutian Islands, and 1960 from Chile. The criteria employed represented, essentially, only two of the many controls on the extent of tsunami inundation differing place to place along the coast. Representation of differences in coastal exposure was limited to the distinction between coasts facing southeast and all other coasts. Energy dissipation on the coast was considered constant with distance inland. For a few areas, the greatest of the extents of the inundation of the four historic tsunamis was substituted for the extent indicated by the criteria. The result was a potential for inundation to which no definite probability could be assigned.

It could not possibly have been anticipated that the evacuation zone established on the basis of the 1961 report would remain essentially unmodified for over 20 years. The reasons that change has not seemed necessary are, I think: first, that it turned out that at all places along Hawaiian coasts, the highest of the runup heights of the four tsunamis used in the 1961 analysis were probably as high or higher than the runup heights of any other historic tsunami; second, that until recently no better method of estimating place-specific tsunami hazard has been available; and, third, that the quality of the historical record in conventional geophysical sources does not yet justify use of an improved method.

In my opinion, most of the methodology needed for revision and much of the necessary analysis are now available in the forms used in the delineation of the NFIP zone. In the NFIP methodology, tsunami exposure place to place along the coast is represented in the form of place-specific frequency distributions of near-shore runup height based on the entire historic record of tsunamis in Hawaii since 1819, thus introducing appropriately the concept of probability. Energy dissipation inland is represented by a model including the effects of roughness.

The energy dissipation model, although it incapable of representing on-shore convergence or divergence, is a vast improvement over the 1961 assumption of constance of dissipation with distance. The 100-year average recurrence interval seems appropriately used in the delineation of the zone whose use in the NFIP is intended primarily for the protection of structures. It could, however, be replaced easily by the 200-year or 500-year average recurrence interval that would be a more appropriate base for delineating the evacuation zone intended for the protection of people. Hence the NFIP
methodology could easily be applied to redefinition of the evacuation zone, and the application would be appropriate if the place-specific frequency distributions of runup could be considered reliable, but the reliability of these frequency distributions is questionable.

The record of runup heights at each place which was subjected to frequency analysis was, first, limited to the 10 greatest runups in the historic record for that place. The historic record for most places was entirely synthetic and largely synthetic for all places. Most of the synthetic values resulted from adjusting to the sparse record of actual values, values produced by a model for trans-oceanic tsunami propagation; but those for tsunamis from the southwest and locally generated tsunamis were simply interpolated or extrapolated from the few actual values available. Synthetic marigrams produced by the model used closely match actual marigrams. However, the synthetic patterns of runup along the coasts produced by the model match actual patterns very poorly. Hence the reliability of the place-specific synthetic-historic runup heights, whether based on the model or not, depends critically on the method of adjustment to the actual historic values available and to the validity of those values.

I have been engaged for several years in checking and extending the record of runup heights of the historic tsunamis on the basis of contemporary reports, principally those in newspapers. Review of the contemporary reports of locally generated tsunamis resulted in corrections and extensions of the record that led to significant modifications of the NFIP zone before it was officially adopted; and review of the contemporary reports of tsunamis from Japan resulted in a major post-adoption revision in the NFIP zone along the Kona coast of Hawaii. I anticipate that some changes in the record will appropriately result from continuation of this work particularly as it relates to tsunamis originating from distant areas other than those of Japan.

Because corrections of the historic record would result in changes in the evacuation zone if the NFIP methodology or any similar methodology were used in the delineation of that zone, I would caution against the use of the NFIP or a similar methodology for redefinition of the evacuation zone until the process of validating and correcting the historic record is completed. However, research on alternatives to and variations of the NFIP methodology could appropriately be undertaken at any time, and research support such as is proposed in HB 945 could appropriately be used in part for completion and correction of the validation of the historic record and for subjection of the corrected record to frequency analysis.

The vertical dimension in hazard zonation

Soon after the adoption of the evacuation zone it was recognized that: a) in densely populated areas in which there are high-rise buildings, the problems of timely evacuation could be enormously reduced if persons were evacuated from low levels to the upper floors of those high-rise buildings whose structural integrity could be assured; and b) the methodology used in defining potential horizontal tsunami inundation limits also provided vertical limits to potential tsunami runup.

If there remain any questions as to the appropriateness of the concept of vertical evacuation or the extent to which it is applicable in any particular area or to particular buildings, the support proposed in HB 945 could very appropriately be extended to research settling those questions.
Tsunami monitoring

Warnings of tsunamis, whether of local or distant origin, now emanate from the Pacific Tsunami Warning Center (PTWC) of the National Weather Service, and both the seismic and tsunami monitoring used in Hawaii in the development of the warnings is conducted at stations of the TWC. Additional tsunami monitoring is conducted for research purposes. It is not clear to what parts of the tsunami monitoring system the expansion and maintenance HB 945 is intended to apply.

Refining local predictive capability

In the context of the tsunami warning system, predictive capability must be judged in terms of ability to provide warnings of significant tsunamis but to avoid false alarms and to provide the warnings in time to permit evacuation. It is unclear whether the predictive capability whose refinement is intended in HB 945 is capability in Hawaii to predict the arrival of tsunamis generally or capability to predict the arrival of tsunamis locally generated in Hawaii.

There is probably much room for improvement in the reliability of predictions of arrivals in Hawaii of tsunamis of distant origin, primarily to avoid false alarms. Improvement in the speed and reliability of the system for predicting the arrival of locally generated tsunamis would certainly be desirable. Such improvement might, however, depend more on expansions of the tsunami detection system, possibly unjustifiable economically, than on research.

Whether the CD can usefully become directly involved in the tsunami monitoring system that is used in the warning system and that are now provided by the PTWC is a question that should be seriously examined before the involvement is planned, and one pertinent to both the support of predictive capability refinement and the support of monitoring system expansion that are proposed in HB 945.
The Environmental Center submitted testimony on the companion bill HB 945. Our previous statement remains applicable to HB 945, HD 1.