Coastal Engineering Technical Note

EFFECTIVE UTILIZATION OF WAVE DATA - A CASE STUDY

Introduction: The Field Wave Gaging Program (FWGP) collects, analyzes and stores wave data from deep and shallow water wave gages around the US coastline (see Figure 1). The data are used in conjunction with numerical hindcast models to develop wave climate statistics. Wave data are also used for validation of other theoretical, numerical, and physical models to relate system response to incident conditions, and for operational applications. Effective utilization of these data requires a gage deployment plan that best integrates the measured data in space and time with the models. Other FWGP efforts have treated optimizing regional gaging networks (O'Reilly and McGehee, 1991), and detailed siting of a gage once an area is selected (Basco and McGehee, 1990) in a generic sense. To illustrate some of the considerations and constraints in deciding on a gaging plan for a specific area, a case study is presented for Orange County, CA.

Background: The Coast of California Storm and Tidal Waves Study (CCSTWS) is a comprehensive effort to assess, evaluate, and analyze coastal processes in California's coastal zone. The South Coast Region, Orange County portion is a joint effort by the Federal government and Orange County, CA "... directed towards developing an adequate data base or improving planning, design, and better management of this coastal zone." (CESPL, 1992). The study is under the management of the U.S. Army Corps of Engineers Los Angeles District.

An objective of the CCSTWS is:

> "To establish and test techniques that allow assessment of shoreline response to natural forces and human activity on a local and regional basis."

The natural forces that dominate shoreline response in this area are the cumulative effects of wind waves, from long period swell as well as locally generated seas. While the stated objective is the assessment of shoreline response, an inherent objective is the prediction of shoreline response, to permit long-term planning for management of this dynamic environment. Prediction requires both a model of the response to the forcing function (waves) and a statistical projection of the forcing function into the future. As stated in the CCSTWS Scope and Plan of Action (CESPL, 1987):

> "Presently, wave climate estimates for the South Coast Region are not reliable as they are based on too short a period of record."

Models: Without long-term measurements at a site, two approaches exist for developing a reliable wave climate - transformation of waves from a second site with a long-term record, or a hindcast based on another long-term parameter, such as atmospheric pressures. The Southern California Swell (SCS) model developed at Scripps Institution of Oceanography is an example of the first approach. It uses refraction/diffraction to transform directional spectra measured offshore into nearshore sites. A variation on this approach uses inverse refraction to transform directional wave measurements at one nearshore site out to deep water, then forward refraction of those conditions to other, uninstrumented sites along the coast. The existing SCS model is being tested now using the forward transformation method in the Southern California Bight (SCB) for long-period (greater than 12 seconds) waves, but the technique could be applied over smaller spatial scales and extended to higher frequencies.

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The Coastal Engineering Research Center's Wave Information Study (WIS) hindcast is an example of the second approach. The WIS hindcast is presently being evaluated against measurements for the year 1988, and will be updated on a regular basis. Both SCS and WIS are two-dimensional spectral models, and both require calibration and verification using measured data to produce results with high confidence.

Existing Gages: FY 93 will see the collection of directional wave spectral from an unprecedented number of sites in the Southern California region. These sites are listed in the following table:

Site Name	Location (°N Lat/°W Long)	Depth (m)	Gage Type
Harvest Platform-1	34.5/120.7	204	Large pressure array
-2	34.3/120.7	183	3 m buoy
-3	34.5/120.7	200	Waverider .9 m buoy
Catalina Ridge	33.7/119.1	839	3 m buoy
San Nicholas Island	33.2/119.8	183	Waverider .9 m buoy
Redondo - offshore	33.8/118.5	78	3 m buoy
King Harbor	33.9/118.4	10-20	small pressure arrays
Edith Platform	33.6/118.4	30	Puv gage
Huntington Beach	33.6/117.9	10	midsize press. array
San Clemente	33.4/117.3	10	midsize press. array
Oceanside	33.2/117.4	10	midsize press. array
Imperial Beach	32.6/117.1	10	midsize press. array
San Diego Entrance	32.7/117.2	10	midsize press. array
San Nicholas	32.7/119.6	165	NDBC 10 m buoy
San Clemente Island	32.9/117.9	415	NDBC 10 m buoy

Though all of these gages cannot be guaranteed to operate simultaneously for the entire year, all are scheduled for operation and maintenance through FY 93. The available data from these sites will provide the best opportunity to date to validate either of the two models for the SCB.

Additional gages: Two plans that could be pursued by the CCSTWS to optimize the utility of these data for predicting response in Orange County are proposed below.

Plan A - Modify the existing SCS model to include higher frequency waves and develop a "county scale" numerical grid extending offshore to the depth contour of the Edith Platform (about 160 ft). Assume the Edith Platform gage is representative of the incident waves for this region and transform those waves into shallow water. Validate the transformation with the Huntington Beach and the San Clemente gages. Integrate this high resolution, high frequency model with the existing low frequency, SCS model to provide a broad spectrum output for the county. Alternatively, use the Huntington Beach gage as input for a county-scale inverse transform model. Verify the back refraction by using the Edith Platform gage. Forward refract the incident directional spectrum into all of the Orange County coastline.

Option 1 - Add a second nearshore gage at the south end of Orange County to validate the forward refraction model output, or as an additional input for inverse refraction. Given the variability of this coastline, a "roaming" gage that spent sufficient time (say 6-12 months) at several locations to observe a range of conditions may prove a good compromise between spatial and temporal variability. A directional Waverider buoy would be a practical option for this type of deployment.

Option 2 - Add a third gage at the southern end of the outer boundary of the grid to verify that conditions at Edith Platform are homogenous along the model boundary, or (if that assumption is invalidated) to develop and validate a more complex inverse refraction that produces an inhomogeneous boundary. A directional Waverider would again be an appropriate choice.

Plan B - Use the directional gages outside the SCB as validation for an updated (through 1993) WIS hindcast for positions outside the channel islands. Transform the WIS hindcast into Orange County using a shallow water transformation model, such as WISWAVE, and validate the results with the Huntington Beach gage, as well as the other nearshore gages.

Option 1 - Same as in Plan A.

Option 2 - Add a third intermediate depth directional gage between the innermost WIS station and the shallow water gages to insure that island sheltering effects are treated correctly. An NDBC 3-m buoy or a directional Waverider would be possible choices.

Plan A avoids some of the difficulties associated with island sheltering and diffraction, since the entire grid is inside San Pedro Channel. However, even if the model provides excellent predictions of wave conditions throughout the county, the climatic database is only as long as the measured record that is used as input (the Edith Platform gage was installed in 1985). Plan B would have the advantage of eventually producing a long-term database (on the order of 40 years) that makes extremal analysis much more reliable. The WIS Pacific Coast hindcast is a major effort that is periodically updated (the next update through 1992 is scheduled for FY 94). However, the update that includes the time period when all of the Orange County gages are deployed may not be completed in time to meet the CCSTWS schedules.

Selection of a final plan will be based on technical evaluation, as provided by a CCSTWS Technical Committee, and economic constraints. The CCSTWS is presently funding the Huntington Beach gage, and would fund any additional gages required by the above plans. some of the modeling requirements could be dovetailed into existing efforts, others would require funding by CCSTWS.

Conclusions: This technical note illustrates planning options that integrate measured data and hindcast methods to develop climatic statistics for a coastal region. Orange County, CA, was used as a case study of how decisions on location and length of wave gage deployments are affected by study objectives, local conditions, different model characteristics, and availability of other gage data. For additional information, contact David D. McGehee, FWGP manager at (601) 634-4270.

References:

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