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ALTERNATE APPROACHES TO THE PROBLEM OF FORECASTING HEAVY SURF

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Introduction

The National Weather Service (NWS) forecast offices issue a Heavy Surf Advisory (HSA) when a forecast of heavy (high) surf poses a threat to life or property along oceanic coasts (National Weather Service Operations Manual, 1993). The HSAs have traditionally been based primarily upon either forecast or observed offshore significant wave heights.

However, deepwater wave height alone does not give complete information as to the wave's capability to threaten life and property. Local needs, based on customer use in and near the surf zone, first need to be considered. In areas where a significant number of people can be expected to be in the surf zone, a simple threshold of forecast breaker heights may be the best choice for defining heavy surf criteria. In areas where erosion or other effects of wave action represent the primary concerns for heavy surf, selecting a criteria based on wave power (or energy flux) is more applicable as this represents the transmission of wave energy.

Arguments for the Use of Breaker Height and Wave Power

Offshore significant wave heights, as commonly measured by buoys, provide only fractional information about the wave characteristics as it moves into the surf zone. Additional information, such as wave period, bottom slope, and beach exposure adds information about the wave as it moves into, and interacts with, the surf zone.

On many beaches in the Unites States, due to the large numbers of people recreating or working in the surf zone, the primary threat of heavy surf is loss of life. In this case, computation of breaker heights is a much more applicable parameter to define heavy surf than is deepwater wave heights. The former is what is occurring or expected in the surf zone, which is not always the same as the latter. Breaker heights can be computed given deep water wave height and period, and bottom slope. As bottom slope may change with both time and location, it is probably best to use a single approximation to represent area beaches in determining a threshold value for issuing a HSA.

In some parts of the country such as the Pacific Northwest, swimming in ocean waters is generally less popular because of year-round cold water temperatures, frequent cool air temperatures, and cloudy skies in the summer. The surf in the Pacific Northwest may also be considered relatively dangerous to swimmers and others on the beach virtually year-round for several reasons. Wave heights on average are relatively large. At the mouth of the Columbia River, average deepwater significant wave heights vary from 1.4m (4.6ft) in July and August to 3.0m (9.8ft) in December. There can also be a high incidence of flotsam in the form of large logs in the surf and on the beaches. Finally, sneaker waves can be especially dangerous on the rocky beaches common in the Pacific Northwest because they can quickly cut off an individual's path of retreat from the water.

In cases such as the Pacific Northwest, the greater threat posed by heavy surf may be erosion or other effects of wave action. Wave power represents the transmission of wave energy and can be determined knowing only deep water wave height and period. This allows for some estimate of the surf's potential for beach erosion. Power can also allow for some estimate of the wave's ability to push flotsam forward.

As both breaker heights and wave power are functions of wave period and deepwater wave height, the two criteria may be related close enough to correlate the value of one with the other. In other words, in many cases the arguments for the use of one variable over the other may become academic as the correlation between the two is quite close.

Wave Power

Wave power, or the energy flux, per unit crest width of a wave is defined as:

$$P = n \bar{E} C$$

where "n" is a function of the relation of water depth to wave length and becomes 1 in shallow water, "$\bar{E}$" is the energy density of a wave, and "C" is wave celerity (Sorenson, 1993).

Substituting in terms of known or measured variables, wave power can be approximated as:

$$P \cong 0.19 \rho g H^2 T$$

where "ρ" is water density, "g" is acceleration due to gravity, "H" is the deep water wave height, and "T" is wave period.

As waves enter shallow water and interact with the bottom at varying angles of incidence, the transmission of wave power becomes quite involved. Factors such as refraction and the development of longshore currents need be considered. For areas with complex bathymetry, or man made structures such as jetties in the surf, the estimation of the distribution of wave power becomes even more difficult. Because HSAs generally apply to large stretches of coastline, it becomes nearly impossible to consider all these effects, and hence, goes beyond the scope of the product.

As a rudimentary way of accounting for a wave train's average amount of refraction for the coast as a whole, it is suggested that wave power be reduced for increasing angles of incidence. This can be accomplished with:

$$P_c = P(\cos\theta)$$

where "P_c" is average wave power per unit coastline, and "θ" is the wave angle of incidence with the coast.

Adapting Breaker Height or Wave Power to Local Needs for Heavy Surf

Most NWS forecast offices in the past have used a offshore significant wave height as their primary criteria for issuing a HSA. Because the locally established criteria were based on perceived customer requirements and climatology, the choice of a threshold value was somewhat subjective. As such, conversion to a breaker height or a wave power value need only approximate the old criteria to produce comparable results.

As an example, the NWS Weather Forecast Office in Portland, Oregon, previously used a 20 ft (6.1m) offshore significant wave height as a threshold value for issuing a HSA for the North Oregon and South Washington coast. Due to normally large breaker heights, and the relatively few people venturing into the surf zone, it was decided to utilize wave power as the criteria to consider for issuing a HSA. The new wave power per unit shoreline criteria was set at 100×10^4 J/ms to approximate the conditions for a 20 ft (6.1m) wave with a period of 15 s and a 0° an angle of incidence. This allows for a HSA to be issued for waves under 20 ft (6.1m) provided the period is sufficiently greater than 15 s, and conversely for no HSA to be issued in cases of seas greater than 20 ft (6.1m) unless the period is sufficiently longer.

Because both breaker height and wave power depend on the variables deep water wave height and wave period to approximately the same degrees, breaker height and wave power can almost be used interchangeably. It turns out that when the U.S. Army Coastal Engineering Research Center method for computing breaker heights (1984) is used for the preceding Portland scenario with an assumed beach slope of 0.02, wave power per unit shoreline of 100×10^4 J/ms approximates the same conditions where breakers of 25 ft (7.6m) would be expected.

Conclusions

In the past, HSAs issued by the NWS have been based primarily upon the forecast of offshore significant wave heights meeting a locally established threshold criteria.

Significant wave heights alone do not necessarily accurately reflect conditions in the surf zone. Depending on local needs, either breaker height or wave power can provide more information about waves as they move into, and interact with, the surf zone. Both can be approximated from standard observational data consisting of significant wave height and the dominant period. By re-establishing local advisory criteria in terms of either breaker height or wave power per unit shoreline, more meaningful information can be utilized in making the decision to issue or not issue a HSA.

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References

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