Nearshore wave energy dissipation patterns on a shore with multiple bars

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Rationale:

- determination of zones of validity of empirical equilibrium profile concept at coasts with multiple bars,
- determination of alongshore variability of wave energy dissipation using equilibrium profile framework,
- implications for beach fill design.
Polish coastline: study area km 125 – 219 of national coastal chainage.
Nearshore sea-bottom sampled in 2005 and 2011 every 500 m.
Equilibrium profiles have constant wave energy dissipation rate

Basic assumptions:
- monochromatic waves
- fully developed wave breaking regime

Dean equilibrium profile:

\[ h = A \cdot x^{2/3} \]

\[ E_r = \frac{5}{16} \rho g^2 \gamma^2 h(x)^{1/2} \frac{dh(x)}{dx} = \text{const} \]

\[ A = \left( \frac{24E_r}{5\rho g^2 \gamma^2} \right)^{2/3} \]
If the concept of equilibrium profile is applicable, then it should be retrieved from recorded seabed configuration, using signal processing tools (singular spectrum analysis, or empirical mode decomposition).

Empirical equilibrium profiles should retain monotonic component of profile configuration and resemble the theoretical curve of constant energy dissipation.

Further offshore energy dissipation should decrease to zero near the depth of closure.
km 176 – Dean regime with saturated wave energy dissipation can be applied from the inflection point onshore.
Features:
- empirical equilibrium profile is monotonic, so energy dissipation can be computed from:

\[ E_r = \frac{5}{16} \rho g^3 \gamma^2 h(x)^{1.5} \frac{dh(x)}{dx} \]

- morphological resemblance of empirical equilibrium profile to theoretical Dean function onshore the inflection point: it allows for assumption of constant and saturated wave energy dissipation, encapsulated in coefficient \( A \),
- empirical equilibrium profile explains more seabed variability than theoretical Dean function.
km 203 – profile with two zones of saturated wave energy dissipation, one from inner inflection point onshore, second from offshore inflection point to crest of bar 4
Features:

- profile with very complicated morphology: bar (3) inside trough and very large bar (4),
- huge bar (4) contributes to energy dissipation only during the mightiest storms,
- empirical equilibrium profile is not monotonic; it therefore presents two zones of saturated wave energy dissipation – one from inner inflection point onshore, second from inflection point near foot of bar 4 up to its crest,
- Dean coefficient associated with inner zone is 0.077 vs. 0.072 for all profile, for outer one it is equal to 0.083 – these values match better local sediment characteristics, according to CEM.
Implications for beach fill design:
- the greater the saturated wave energy dissipation and the greater the distance along which it operates the less energy will impact emerged beach and dune or cliff foot,
- the above information can be obtained for each profile and plotted alongshore to evaluate hot spots, where wave energy can reach the shoreline: this concept seems to be very useful in beach fill design, aimed at erosion control.
Conclusions:
- beaches with multiple bars can be parameterized with empirical equilibrium profiles in terms of their wave energy dissipation,
- inflection points in emp. eq. profiles determine whether there is one or two zones of saturated wave energy dissipation,
- ca. 80% of the analyzed profiles could be parameterized with one zone, the remaining 20% with two zones,
- the evaluated rates of wave energy dissipation can be used for identification of erosion hot spots and thus erosion control in form of beach fills,
- the presented method allows for simple parameterization of wave energy dissipation for coasts with multiple bars.
Thank you!