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Typical scenarios of nonlinear wave transformation: criteria of realization and contribution in relief changes.

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Coastal zone is area which dynamical regime is formed by wind waves. While propagating to the coast, waves are transforming and then breaking. All energy of waves brought from deep water dissipates in coastal zone causing bottom sediment suspension. Wave asymmetry, which determines bulk and direction of sediment transport, also changes. These processes lead to bottom relief deformations, such as bar formations, beach erosion or accumulation. Occurrence of each situation depends on wave regime and mean bottom slope.

Purpose of this work is to find typical examples of manifestation of nonlinear wave transformation and to account its contribution to relief changes. This investigation can be used to classify coastal zones and estimate their vulnerability to wave impact.

Waves in coastal zone are weakly nonlinear dispersive due to near-resonant triad interactions between wave components. The main feature of nonlinear wave transformation in intermediate depth is periodical exchange of energy between first and higher harmonics of wave motion. This effect causes fluctuations of higher statistic moments of waves. The periodical fluctuation of amplitudes of nonlinear wave harmonics was used to develop classification of coastal zone.

"Skorpilovtsy-2007" field experiment data was analyzed and four scenarios of nonlinear wave transformation were determined. They were separated from one another depending on character of energy exchange between first and second wave harmonics:

1. Input waves have low second harmonics, their amplitude grows only near the shore 1,5 – 2 periods of energy exchange can be distinguished

2. There is only one full period of energy exchange with high relative amplitude of second harmonic. Second harmonic reaches its maximum within coastal zone

3. There is no obvious maximum of second harmonic and its amplitude changes very little in whole coastal zone. There are 3 and more periods of energy exchange.

4. Amplitude of the second harmonic on the seaward end of the coastal zone is quite high and decreases to the shore so nearly half of a period of energy exchange is observed.

It was found that Iribarren number (bottom slope to square root of wave steepness ratio) can be used as criterion of separation of these scenarios. Iribarren number less than 0,15 correspond to significant development of nonlinear effects in coastal zone (Saprykina et al., 2013) which is characterized by second harmonic amplitude reaching its maximum inside coastal zone and having big relative amplitudes.

Values of cross-shore sediment transport for previously distinguished scenarios were computed in all points of measurement across the coastal zone using simplified Bailard formula (Bailard, 1981).

Each scenario causes different qualitative type of relief deformation: first – erosion of the bottom slope and sediment transport to the shore, second – send bar migration to the coast by erosion of its crest, third – the same effect, but because of seaward slope erosion, and the last – degradation of the bar and sediment transport to the shore.

Field experiment data analysis shows that sediment transport induced by wave asymmetry is always directed to the shore. Different scenarios determine bar migration or degradation.

The determined criteria and principles were applied in Russian part of Baltic Sea coasts classification.

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