Alternative Stable States of Ecosystems, Tipping Points and Management of the Coastal Seas

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Traditional view on ecosystems as systems with alone steady state is replaced by the Concept of alternative stable states of ecosystems (CASSE). It's important not only for ecological science but also for environmental management. In CASSE ecosystems are complex, adaptive systems that are characterized by historical dependency, nonlinear dynamics, threshold effects, multiple basins of attraction, and limited predictability of their behavior (Levin 1999). In ecosystem transit from one state to another one there are tipping points (TP). Transit from 1st steady state to another one goes through destabilization of ecosystem; TP is a defined level of system destabilization. Before TP system can goes back to 1st steady state, after TP it only can transforms in new steady state. It is evident from CASSE that an environmental management cannot be taken to one best strategy of nature using; it must be the set of alternative strategies. It's very important for environmental management to evaluate: How is ecosystem far from TP?

Using long-term date on changes in some the Black sea coastal ecosystems we analyze the shifts from one to another steady states in coastline and lagoons. Main reasons of such shifts are changes in regimes of winds, precipitation and temperature as well as anthropogenic disturbance. Some cases: Case of Bakalskaya spit (Crimea, Ukraine, Black sea). The Bakalskaya sand spit having formed through merging of two accumulative spits and now stretching along the northwestern coast of the Crimea. Now we observe a lost of sand from both spits, but much more from west one with rate about 5-10 m per year. 10 year long study shows us that this process is conditioned many reasons both natural/ climatic and antropogenic origin, and to divide the results of action of different reasons, as a rule, uneasily. Decreasing or grow of beach cause by sand balance on beach – input and output. There are three main sources of sediments input into beach: with rivers, from cliff erosion and biogenic produced in marine ecosystems, in our case - only clayey cliff erosion and mollusk shells. Part of Bivalvia shells was 15-30% of total mass of beach sediments. *Cerastoderma glaucum* prevailed, being 12-41% total mass of shells on the beach. *Chamelea gallina* was subdominant. We found a trend of decreasing of fresh shell part in total mass of shells. And it's one of the reasons why the beach loses its area. Decreasing of beach line area, which acts as natural mechanism of prevention of cliff erosion, leads to increasing of cliff erosion and as result to increasing of water turbidity and decreasing of sand bottom biotopes because clayey particles sediments. Of cause these reasons lead to decreasing of mussel settlements on bottom, change their species composition. And shell flow on beach decreases more. The mechanism of self-acceleration of lost of beach and erosion of bank is included. These reasons are not all ones causing increasing of beach lost on Bakalshaya spit. There is strong climatic reason – increasing of west winds causes wind tide. There are also anthropogenic reasons: illegal sand mining by local peoples, high level recreation press leading to dune devegetation. Devegetation increases sand leaving from beaches very much accelerating wind and water erosion. Smallest sediment particles are moved by wind from devegetated dunes and beaches to sea. It also leads to destruction of bottom sand biotopes with damage to Bivalvia settlements. A rate of going out of shells from a beach depends also on speed of their mechanical grinding by waves and recreational activities. As shown in experiments resting on the beach people walking along beaches increase a rate of shell grinding. Its mean high recreational press can leads to increasing of lost of sediments (shells) from a beach not only through devegetation. Increasing of coastal erosion is increasing of sediment flow in the sea and leads to acceleration of sea level rising. Acceleration of sea level rising increases coastal erosion. Shifts of marine and coastal communities led to shifts in options for people use. Tipping point in dynamics of spit ecosystem was passed. But it is didn't taken into account by local authorities, no changes in management of recreation on the Bakalskaya spit and there is accelerating destruction - irreversible shift in depredated steady state with decreasing options for people use.

Case of the Crimean closed lagoons. Using 10-year monitoring date we can identify 5-6 steady states of their ecosystems – different taxonomic and ecological groups of primary producers, as well as animals. Different states – different options for nature use. Reasons and consequences are discussed. To have time to prepare to new strategy of nature use is determined by our possibility to evaluate level of ecosystem destabilization TP. These issues are analyzed.

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