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A probability-based model of the beach process of marine plastics: Application to Hiroshima Bay

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Abstract

To comprehend and predict the adverse effects of marine plastics on the marine environment, it is necessary to estimate the standing stock of all categories of marine plastics in the marine reservoirs and the fluxes between them. Specifically, understanding and modeling the beaching-stranding-backwashing process, that is, the beach process, of the plastics will be a major issue to be addressed in the coming years. Here, we propose a model of the beach process of marine plastics by introducing beaching and backwashing probabilities. The backwashing probability was estimated from the average residence time of the beached plastics and the beach width, and then the beaching probability was from the flux-balance assumption between the beaching and backwashing plastic fluxes. The model was validated by means of linear system analysis and particle tracking experiments in a simple periodic channel. We then applied the model to Hiroshima Bay, where serious FPS pollution originating from oyster aquaculture rafts spreads out. The parameters of the model are the residence time (τ) of plastics on the beach and the partitioning coefficient (P_0) of the plastic count densities between the sea surface and the beach. In this study, we employed the following values: τ = 14/100 d; P_0= 3,050. Comparing the partitioning coefficient and the count densities among the beaches with the field survey, τ =100 d case reproduced well the observations. The simulation demonstrated that about 80% of FPS microplastics are on the beaches and the remains drift on the sea surface. Marine plastics with smaller specific gravities like FPS plastics are likely to be highly accumulated on the beaches. The maximum age of FPS microplastics was about 20 years, despite τ was set to 100 d. In the future, the degradation process could be implemented by using the age of the plastic.

Keywords

marine plastic, beach process, probability-based model