Measurement of Residence Time of Marine Plastics on Beaches and its Application in Beach Cleanup

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1. Introduction

Marine plastics which wash up on beaches undergo remarkable deterioration, ultimately leading to fragmentation, due to the heat of the beach surface and the intense ultraviolet radiation while on the beach. Fragmentation also rapidly increases the environmental risks caused by marine plastics (e.g., chemical contamination of the marine ecosystem by marine plastics). Accordingly, measurement of the residence time from wash-up on a beach until return to the sea is necessary and indispensable for study of measures to mitigate the environmental risks associated with marine plastics. This article introduces an example of measurement of the residence time of marine plastics which wash up on beaches and a method for quantifying the environmental risk mitigation effect of beach cleanup based thereon.

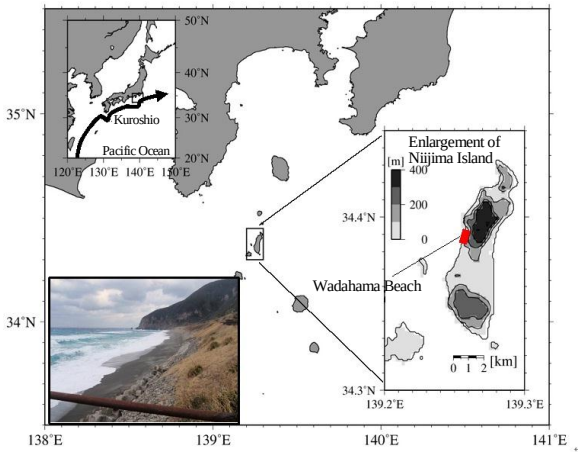

Fig. 1 Location and photograph of Wadahama Beach, Niijima Village, Tokyo.

2. Measurement of residence time at Wadahama Beach, Niijima Village, Tokyo

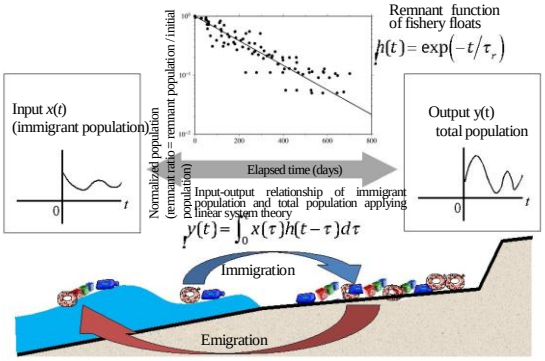

Fig. 2 Input-output relationship of immigrant population $x(t)$ and total population $y(t)$ applying linear system theory.
$h(t)$ is the remnant function (unit impulse response) of fishery floats, and τ_r is the average residence time. The total population $y(t)$ can be expressed by convolutional integration of the immigrant population $x(t)$ and the unit impulse response $h(t)$.

The decrease process (remnant function) of plastic fishery floats relative to the time of the remnant population was measured at intervals of 1-3 months over a 2 year period from September 2011 to August 2013 at Wadahama Beach (Fig. 1, total length: 1km, beach width: 30-50m) in Niijima Village, Tokyo, and the average residence time was calculated. The remnant function of the fishery floats could be approximated with extremely high accuracy by an exponential function which was determined solely by the average residence time. The average residence time of fishery floats on the same beach, as

estimated from the remnant function, was 224 days (95% confidence period: 208-224 days).

3. Quantitative evaluation of beach cleanup effect

Because the remnant function of fishery floats can be approximated by an exponential function, a beach can be regarded as a time-invariant linear system having a unit impulse response of the exponential function type (Fig. 2). Based on linear system analysis, we devised a formula for evaluating the amount of generation of plastic fragments, which are one serious environmental risk associated with marine plastics, and developed a method for evaluating the effect of beach cleanup in mitigating these environmental risks.

4. Conclusion

As a result of this research, it is now possible to make quantitative evaluations of the effect of beach cleanup in mitigating environmental risks originating from marine plastics, which could only be evaluated qualitatively in the past. In the future, if measurement of average residence time progresses at other beaches, it will become possible to select beaches with high priority for cleanup (i.e., beaches with long average residence times) and establish strategic beach cleanup plans.

【References】

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