Numerical Prediction Method for the Impact of Flow-rate Variations on the Spawning Habitat of Ayu (*Plecoglossus altivelis*)

Background

Ayu (*Plecoglossus altivelis*), which inhabit clear-water rivers in Japan, are valuable fish as food and for recreational fishing. In recent years, the population of wild Ayu is in decline as a result of environmental aggravation. To solve this problem, it is necessary to improve spawning habitats in natural rivers for encouraging reproduction. It is known that the characteristics of the water velocity, depth and bed material are important factors for spawning habitats of Ayu. Optimizing flow rate is thus effective for improving the spawning habitat. However, it is difficult to estimate optimum flow rate because there are presently no methods for quantitative evaluation of spawning habitats of Ayu and quantifying the effects of flow rate change.

Objectives

To develop a numerical technique for predicting the impact of river flow fluctuation on the spawning habitat of Ayu.

Principal Results

1. Development of numerical analysis method for predicting river hydraulics and bed deformation

Water velocity, depth and river-bed material are important factors which affect the spawning habitat of Ayu. To predict these attributes at specific locations on a cross section of river, numerical analysis method was developed. In this numerical method, river hydraulics and bed deformation were simulated with curvilinear coordinate systems, which can be applied to a complicated shape of channel geometry like a natural river. The grain size distribution of the river bed was simulated using graded sediment transport model.

2. Development and validation of model for evaluating spawning habitat of Ayu

Suitability index criteria of water velocity, depth and bed material were developed on the basis of experimental results and field investigations. These criteria were assigned a relative value between 0 and 1, and indicate how suitable that attribute is for the spawning habitat. Using these suitability index criteria, a model for evaluating the spawning habitat of Ayu comprehensively was also developed (Fig.1). The spawning habitat value which indicates composite suitability for spawning was calculated by this model.

To validate the developed model, field measurement at natural spawning beds was carried out and the spawning habitat values at measured points were calculated using the developed model. As a result, it was found that the developed model can evaluate spawning habitats of Ayu correctly (Fig.2).

3. Test analysis of the impact of high flow rate discharge on spawning habitat

To predict the impact of river flow fluctuation on the spawning habitat of Ayu, the developed model was incorporated with the numerical analysis method for predicting river hydraulics and bed deformation. The developed numerical method was applied to the curvilinear river where fine sediments were deposited and therefore not suitable for spawning. The impact of high flow rate discharge on spawning environment for Ayu in the river area was predicted (Fig.3).

Future Developments

The model for evaluating spawning environment of Ayu will be further validated with experiments and field observations.
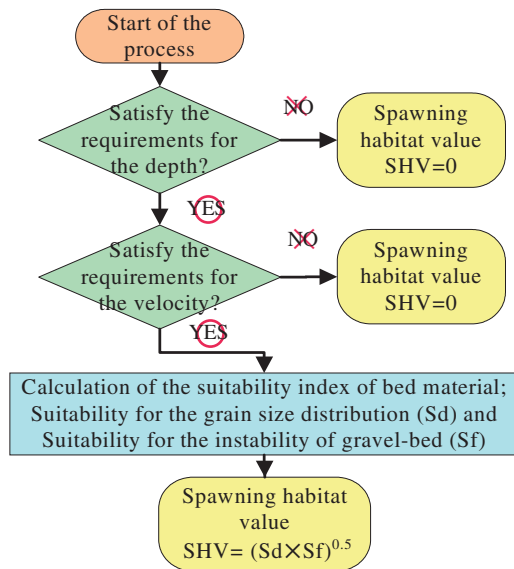
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Reference

R. Yamamoto and H. Honda., 2005, "Numerical Prediction Method for the Impact of Flow-rate Variations on the Spawning Environment of Ayu", Technical Report V04009 (in Japanese)

Fig.1 Flow chart of evaluation process

Ayu are selective about the location for spawning.Water depth and velocity have a major determination on spawning site. In addition, gravel size and instability of the gravel-bed are also important, because Ayu prefer the site where it is easy to dig a nest.
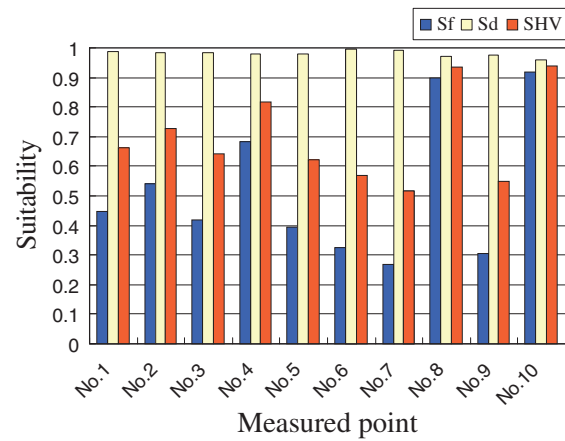

**Fig.2** Spawning suitability of measured points

Suitability indices of the grain size distribution (Sd), suitability indices of the instability of gravel-bed (Sd) and spawning habitat values (SHV) at natural spawning bed were calculated using the developed model. The graph shows that most of the measured points were suitable for spawning for Ayu.
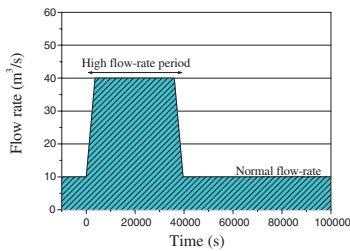
Hydrograph of High flow-rate discharge
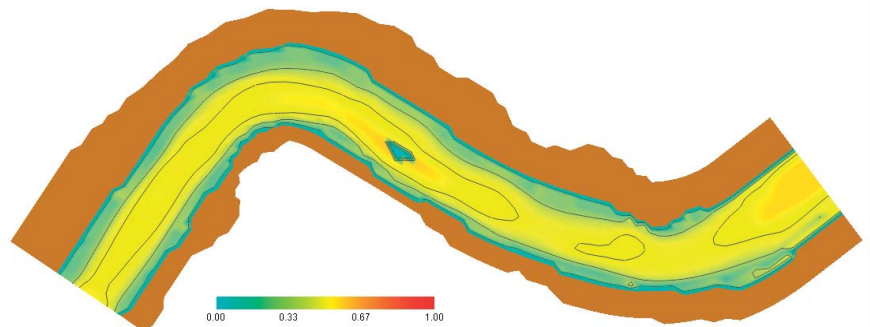
(a) Prior to high flow-rate discharge
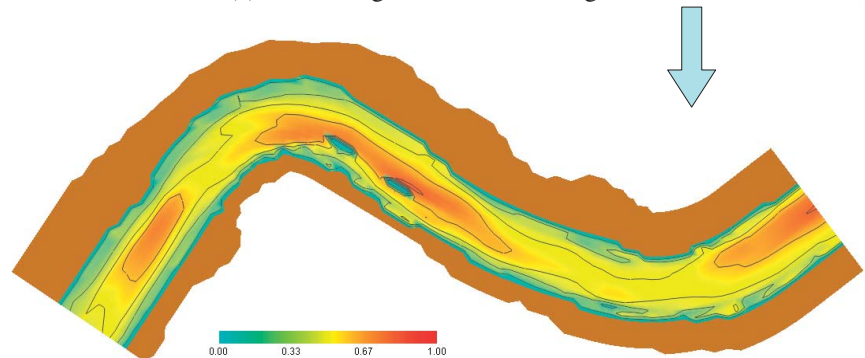
(b) After high flow-rate discharge

Fig.3 Contour maps of spawning habitat value

The effect of the high flow-rate discharge of 40m³/s for 10hours on spawning habitat of Ayu was predicted using the developed numerical method. Maps show the pre- and post-discharge distribution of spawning habitat value (SHV). Redder shaded areas are more suitable for spawning. The area suitable for spawning is extended after high flow-rate discharge, because fine sediment which is not suitable for spawning was flushed out.