NEW CONSTRUCTION OF THE "SESERAGI FISHWAY" IN MIYANAKA INTAKE DAM AND ADAPTIVE MANAGEMENT

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The longitudinal continuity of communities is an important issue in rivers. The fishway at the Miyanaka Intake Dam in the middle reach of the Shinano River was re-constructed. In addition to the traditional fish ladder, a nature-like fishway was newly constructed. Experimental flushing was conducted. The monitoring results before and after the flushing indicated that there was not much impact on the composition of benthic flora and fauna, although benthic materials and benthic algae were sufficiently cleansed. Monitoring of fish species and macroinvertebrates composition indicated that it was extremely effective for organisms with low swimming ability, such as demersal fish and benthic macroinvertebrates.

1 INTRODUCTION

The division of the river with the dam has a major impact on the upstream migration of the fish. Miyanaka Intake Dam, which is a power-generated dam owned by East Japan Railway Company, is located in the middle reaches of the Shinano River. Although there was an traditional fishway before, it was a problem that the flow of water was unstable. Therefore, the existing large and small-sized fishways were re-constructed. While in addition to the traditional fishway, an nature-like fishway, "seseragi fishway", which is composed of a meandering stream with stony beds, was constructed targeting organisms with low swimming ability, such as benthic fauna, demersal fish, and crustaceans, particularly *Rhinogobius kurodai*, an endangered species in the reach. In this paper, we described the monitoring results of the newly-constructed "seseragi fishway".

2 DESIGNING OF FISHWAY AND METHODOLOGY

Miyanaka fishway has a half circular shape turning pool in the middle and is composed of three fishways (Fig. 1); the large sized traditional "Ice Harbor" fishway, the small sized simple ladder fishway, and natural stream style fishway, "seseragi fishway", which is a meandering channel with gravelly bed (Table 1). The fishway has the total length of approximately 209.5 m and has approximately 1/15 and 1/16.7 slope. Flow rate of each fishway is approximately 1.64 m^3/s and 0.133 m^3/s for the large and the small ice harbor types, respectively. The slope of "seseragi fishway" is 1/20, slightly less than others and its flow rate is approximately 0.022 m^3/s. The fishway was re-constructed in 2012.

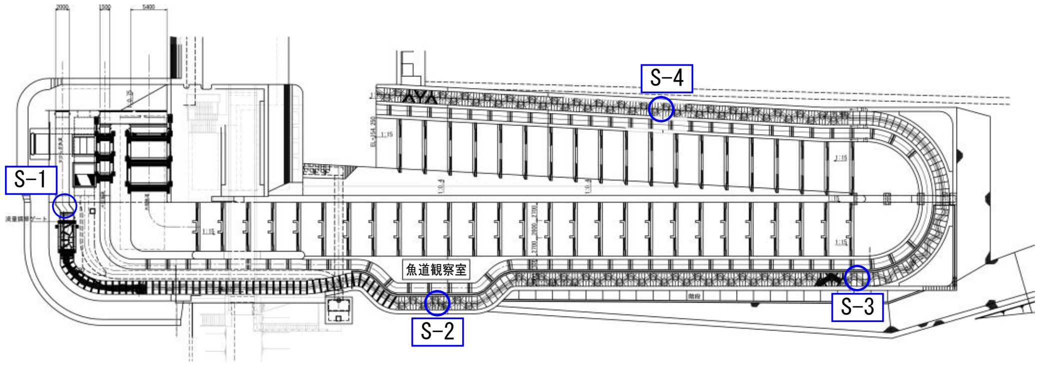


Figure 1. The plan view of Miyanaka fishway.

Table 1. The combination of the fishway type

Fishway type	Specifications	Target species
Fishway for large fish	Form…Ice Harbor type Slope…1/15 Width…8 m Flow rate…1.64 m^3/s	*Plecoglossus altivelis altivelis,Salvelinus pluvinus, Oncorhynchus masou,Cyprinus carpio, Tribolodon hakonensis, Tribolo, Don nakamurai, Hemibarbus barbus, Oncorhynchus keta, Oncorhynchus masou, Oncorhynchus mykiss*
Fishway for small fish	Form…simple ladder type Slope…1/16.7 Width…1.5 m Flow rate…0.133 m^3/s	*Carassius, Zacco platypus*
"Seseragi fishway"	Form…natural stream Slope…1/20 Width…0.25 m Flow rate…0.022 m^3/s	*Lethenteron japonicum,Anguilla japonica,Liobagrus reinii, Cottus pollux, Rhinogobius spp*

In 2013, the number and species of upstream migrating fish was counted hourly from 7:00 to 19:00 h every day from June 6 to July 10.
The flushing of fishway was conducted from 13:00 to 14:00 h on August 19, 2013, increasing the flow rate from 0.022 m^3/s (water depth 0.08 m) to 0.123 m^3/s (water depth 0.2 m).
Before and after the flushing, the following variables were measured.
First, the distribution of bed material sizes was measured to obtain the change in the physical condition of the bed by the flushing.
Then, benthic algae were sampled from a 5 cm x 5 cm quadrat on the surface of boulders at four sites along the fishway (Fig. 1).
Water quality parameters (temperature, PH, Dissolved Oxygen (DO), Suspended Solid (SS), and Chemical Oxygen Demand(COD)), were measured at 12:00 h before the flushing, and 16:00 h after the flushing. Benthic macroinvertebrates were sampled using a 50cm × 50cm wide server net and species composition was obtained.

3 RESULTS AND DISCUSSION

Figure 2 shows changes of the size of the sediment of fishway before and after the flushing.
By the flushing of water, mainly 2 mm or smaller sediments were flushed, but lager boulders, 100-150 mm particles, mostly remained. This indicates the possibility of cleansing of fine sediments by the magnitude of the flushing to maintain the suitable condition of the fishway.

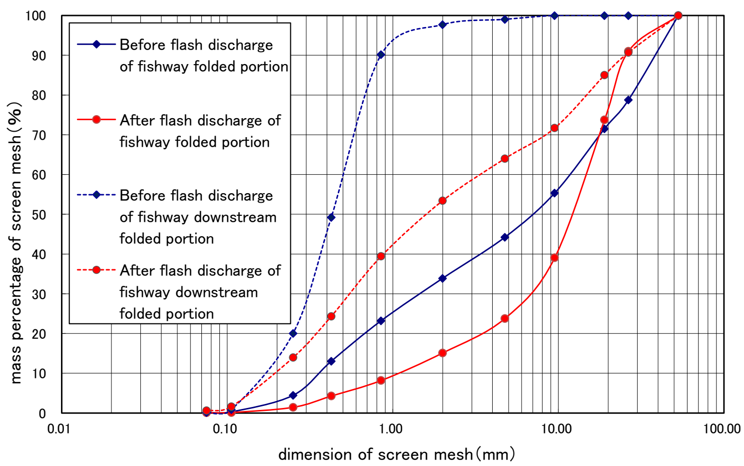


Figure2. Sediment particle size distribution

PH of water rose from the upstream to the downstream by one unit before the flushing and 0.5 unit after the flushing, respectively (Fig. 3). This indicates that although the photosynthesis was conducted by benthic

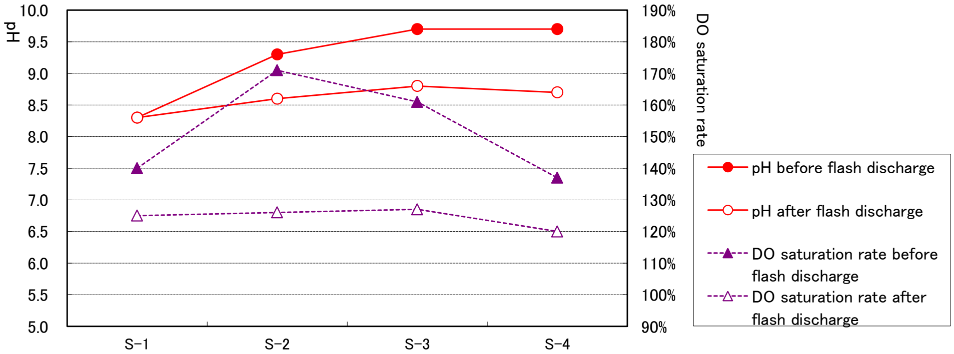


Figure 3. Changes in pH and DO

algae as to increase pH in the fishway significantly both before and after the flushing, the rate significantly decreased due to the reduction of benthic algae by flushing. Before the flushing, DO of water markedly increase from S-1 to S-2, while it declined in the downstream. The reduction is due to the shading by the side wall in the downstream half of the fishway. After the flushing, on the other hand, DO was maintained constant through the fishway. Clear decline before and after the flushing indicates the reduction of the photosynthesis rate by the flushing.

Figure 4 depicts the loss of ignition loss, LOS, before and after the flushing. Before the flushing, LOS was largest at the upstream site, gradually declined to the downstream because the suspended organic matter settled and accumulated after entering the fishway from the upstream river. However, after the flushing, the highest peak was observed at S-3. Organic matters on the bed seemed to be flushed and were trapped downstream.

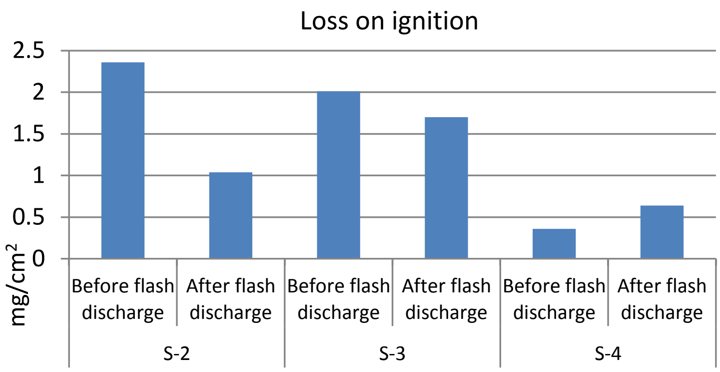
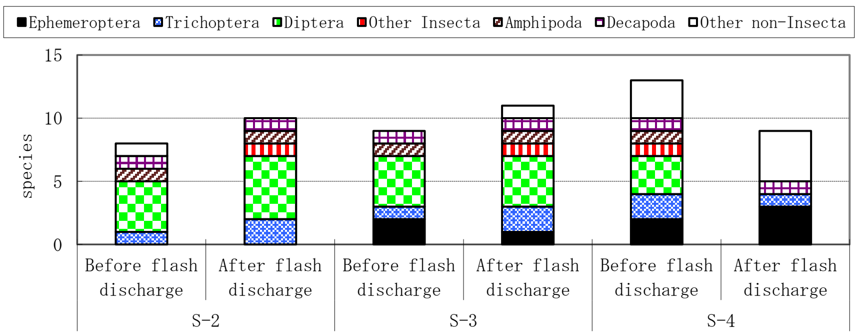
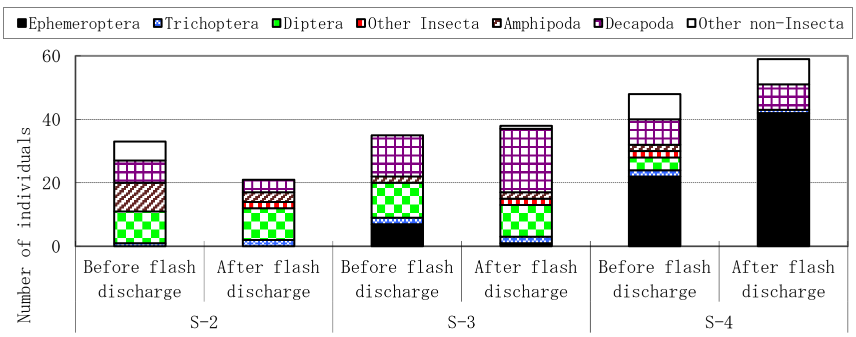


Figure 4. The ignition loss of the benthic algal

After the flushing, the species richness increased slightly in the upstream part of the fishway at S-2 and S-3, while declined in the downstream at S-4 (Fig. 5a). Species composition did not change significantly. The number of individuals declined significantly in the upstream by the flushing, while increased in the downstream reach (Fig. 5b). Ephemeroptera were mainly flushed downstream. However, unidentified species after the flushing were identified 1-2 individual before the flushing. So the flushing did not have much impact on the benthic fauna both in species composition and the numbers of individuals.



(a)



(b)

Figure5. Changes in the composition of benthic fauna

After the reconstruction of the large and small-sized fishways, 16-20 species of fish were trapped (Table 2). On the other hand, 7-10 species of fish were trapped in the "seseragi fishway". Four species, which were not confirmed before the construction of the "seseragi fishway" were *Tribolodon nakamurai, Oncorhynchus masou masou, Rhinogobius kurodai, Salvelinus leucomaenis pluvius*. Three of four species were demersal and low in swimming ability.

The construction of the "seseragi fishway" successfully increased the availability of the fishway particularly by organisms with low swimming ability. Also, it was confirmed that the design of the "seseragi fishway" was effective by confirming the upstream migration of target species, *Rhinogobius kurodai* .

Table 2. results of the fishway

Scientific name		【Before reconstruction】	【After reconstruction】					
		2010 fiscal year	2012 fiscal year		2013 fiscal year		2014 fiscal year	
		Large and small fishway	Large and small fishway	Seseragi fishway	Large and small fishway	Seseragi fishway	Large and small fishway	Seseragi fishway
Demersal fish	*Anguilla japonica*	O	O					
	Pseudogobio esocinus escinus	O	O		O		O	
	Paramisgurnus dabryanus					O		
	Misgurnus anguilicaudatus							O
	Cobitis biwae			O		O		O
	Pseudobagrus nudiceps	O	O		O		O	
	Silurus asotus				O			
	Liobagrus reinii			O		O		
	Cottus pollux	O	O	O	O	O	O	O
	Rhinogobius sp	O		O	O	O	O	O
Swimming fish	*Carassius auratus langsdorfii*	O	O		O			
	Zacco platypus	O	O		O	O	O	O
	Zacco temminckii		O		O		O	
	Phoxinus lagowskii steindachneri	O	O	O	O	O	O	O
	Tribolodon nakamurai		O					
	Tribolodon hakonensis	O	O		O	O	O	
	Pseudorasbora parva			O				
	Sarcocheilichthys variegatus microoculus	O	O		O		O	
	Gnathopogon elongatus elongatus				O			O
	Hemibarbus barbus	O	O		O		O	
	Squalidus chankaensis biwae	O	O		O		O	
	Plecoglossus altivelis altivelis	O	O	O	O		O	
	Oncorhynchus mykiss				O			
	Oncorhynchus masou masou	O	O	O	O		O	
	Salvelinus leucomaenis pluvius		O	O	O		O	
	salmo trutta		O		O		O	
	Micropterus dolomieu		O		O	O	O	
	Micropterus salmoides					O		
	28types	**14types**	**18types**	**9types**	**20types**	**10types**	**16types**	**7types**

4 CONCLUSION

Designing and constructing fishways is essential to preserve the aquatic fauna and to maintain the continuity of a river. In addition of the traditional type of fish ladder, the nature-like fishway, "seseragi fishway" has an enormous effect on the community to use the fishway. Regular flushing is effective to cleanse the fishway without any large impact on the community.

5. ACKNOWLEDGMENTS

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6. REFERENCE

[1] CHARLES H. CLAY. Design of Fishway and Other Fish Facilities (second Edition), Lewis Publishers, 1995, pp.63-73.