MANAGEMENT OF THE RIVER ENVIRONMENT PRESERVATION AT HITOKURA DAM
- COLLABORATION WITH REGIONAL RESIDENTS -

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ABSTRACT: Hitokura Dam is the multi-purpose dam whose functions are flood control, domestic water supply and maintenance of river environment etc., is constructed in the Ina River in the Yodo River System. Hitokura Dam's location is very close to the urban area and downstream of Hitokura Dam, there are Kawanishi City, Ikeda City, Amagasaki City and other cities. Due to the location, around 300,000 of people visit Hitokura Dam area every year to enjoy the rich environment around there. Under the circumstances, we have been implementing various measures to keep and improve the environment in the reservoir and downstream of the dam. We have been returning sedimentation in the reservoir to downstream of the dam by conducting flashing discharge (artificial small-scale floods) since April 2003 in order to improve the habitat in the downstream of the river. We also have been monitoring creatures in the river periodically to check the effectiveness of the flashing discharge. We have the meetings to exchange opinions with people in the neighborhood, environment NPOs, fishery cooperatives and residents' associations about how to keep and improve the river environment on regular basis. We also release fry of Ayu fish into the Ina River together with local residents experimentally. During the spawning season (from early June to mid July), there were not enough river water for fish downstream of the dam. To solve this problem, we operate the water level higher than the flood season control level on trial basis to increase the discharge to downstream and improve the river environment during this season. 4. The results of the survey about fish showed that almost of the half of fish in the reservoir is alien fish, bluegill and they endanger indigenous fish. To get rid of bluegill, we catch fish during the water level declining operation to the flood season control level from the normal water level. We use the fixed nets to catch fish. This way was newly developed for this purpose and it gives less damage to fish so that we can release indigenous fish into the river alive. We produce fertilizer from those alien fish and use it to grow vegetables in the garden at our office, then we use them for our lunch. We are also experimenting and researching the effective use of the fertilizer with local farmers. By operating the water level in the reservoir higher than the flood season control level, we can expand and create spawning grounds in shallow areas of the reservoir. On top of this, we put some artificial floating islands in the reservoir to secure spawning grounds that can catch up with the water level fluctuation.

KEYWORDS: Hitokura Dam, River management, Ina River

1. INTRODUCTION

The Hitokura Dam is a concrete gravity dam with total reservoir capacity of 33,300,000m3, dam body height of 75m, and drainage basin area of 115.1km2 constructed on the Hitokura - Ohroji River that is a tributary of the Ina River in the Yodo River system. Its purposes are floodwater control, supplying potable water and the constant maintenance of river flow performance. Twenty-four years have passed since it started management in April 1983.

The Ina River is a typical urban river, with the cities of Amagasaki, Toyonaka and Itami that form the core of the Hanshin industrial belt in its downstream basin, and the cities of Kawanishi and Ikeda and towns of Inagawacho and Toyonocho that are satellites of Osaka in its middle river basin. The Hitokura Dam supplies water to approximately 600,000 people. Only 1 hour by car from Osaka and Kobe, it is a typical urban dam visited by approximately 300,000 people every year who come seeking a natural setting for hiking, fishing, camping, and so on (Fig.1).

This paper reports on the results of measures taken experimentally since 2002 to improve the dam reservoir and downstream river environments and of monitoring surveys performed up to 2005.

2. CHANGE OF THE DOWNSTREAM RIVER ENVIRONMENT

Change of the river environment since construction of the dam can be broadly categorized as the following three processes. A variety of measures to deal with these changes have been taken since 2002 in response to strong demands for such measures by regional residents and an extremely strong sense of crisis at the dam management office.

i) The Ina River has traditionally been a thriving site for sweet trout fishing close to a major city. Since the dam was built in 1983, sweet trout were discharged for several years and fishing could take place normally. Afterwards, however, even though the sweet trout were still discharged for a while, they were no longer to be seen1). Furthermore, directly downstream from the dam, the bedrock was exposed due to the sediment supply being cut off, and the riverbanks were overgrown with reeds due to the flattening and reduced amount of water, meaning significant change in the river environment (Photo 1).

ii) Rainfall has tended to be light in recent years. Particularly, drought prevention measures had been implemented for three years running since 2000. Consequently, nearly all the discharge from the dam augments the amount of flow, ensuring the downstream standard. This created a depleted section (section with extremely small flow volume) for 5km from directly below the dam to the confluence with the Ina River.

iii) In recent years, exotic fish species have increased rapidly inside the reservoir. This is a result of predation of native fish species by exotic fish species, plus a decline in spawning grounds of native fish species by the rapid decline of the water level at the time of the transition to the limited water level during the flood season.

3. EVENTS LEADING UP TO THE IMPLEMENTATION OF THE COUNTERMEASURES

Upon implementing the countermeasures, a survey of the living flora and fauna in the river was performed in July 2001 to evaluate the status of the river environment2), and the survey has since been repeated every year 3), 4), 5) 6). The survey mainly examined the types of fish, attached algae, and benthic animal, and as a result of the 2001 survey, the following knowledge was gained pertaining to the reduction in the types of fish and benthic animal.

(1) Effects of flattening the Amount of River Flow

1 There has been a reduction in the spawning grounds of the fish and benthic animal due to the water and land areas becoming fixed
2 There has been a reduction in the growth of attached algae

(2) Effects of the Reduction of Sediment Supply

1 There has been a reduction in the spawning grounds of the fish and benthic animal due to the reduction in sediment

We chose fish (ayu [sweet trout], oikawa [freshwater minnow]), benthic animal (caddisfly), attached algae, and interstitial creatures as the index organisms for the evaluation of the countermeasures and the monitoring surveys.

4. COUNTERMEASURES TO CONSERVE THE RESERVOIR AND RIVER ENVIRONMENTS AT THE HITOKURA DAM

4.1 Improving the downstream river environment by flash discharge

4.1.1 Placing of boulders and the removal of reeds

Acting on the results of the environmental survey of the creatures living in the river that was performed in 2001, in 2002, boulders were laid and the reeds that were overgrowing on the water's edge were removed. Downstream from the dam, the bedrock under the riverbed was exposed and there were few small stones, so there were few places for fish to hide from external enemies such as birds. Therefore, transitional zones in the water and on the land and shallows were restored by artificially removing weeds and placing boulders.

This was done between the Hitokura Bridge and the Maekawa Bridge downstream from the dam (Fig. 2). In this section, 190m3 of boulders were placed in the river and reeds were removed from 2,000m2 of the river bank (right bank) (Photo 2).

4.1.2 Laying sediment and flash discharge

The result of an environmental survey of the habitat of living creatures in the river in 2002 showed that there had been a reduction directly downstream from the dam in terms of both pebbles and the growth of algae that was the food source of the river creatures. Consequently, with the guidance of Mr. Ikuko Morishita, President of the Institute of Freshwater Biology, countermeasures to restore the river environment were implemented beginning in 2003 by supplying sediment and performing a flash discharge using the cleaning flow of the discharge (in 2004, when only sediment was laid, a cleaning flow was established using a natural outflow). In addition, the flash discharge described here is an operation to increase the amount of discharge artificially while safeguarding the operating rules in order to preserve the river environment downstream from the dam, as opposed to rainfall and discharges done with the objective of irrigation.

The flash discharge was performed during the period that the reservoir level fell from its normal water level (elevation 149.0 m) to the flood season control level (135.3 m) (drawdown period: 1 April to 15 June) and to maintain safety, the discharge was done throughout the day with a duration ranging from 1.5 to 2.0 hours. The Hitokura Dam discharges a maximum flow volume of 20m3/s that can be discharged using only valve operations but without using the conduit gate. However, one problem is that because of the structure of the system, a discharge flow that exceeds a flow volume of 9m3/s may be taken in from the bottom of the reservoir where the temperature is low.

When flash discharge was done in 2006, sediment deposited in the old weir at the upstream end of the dam reservoir was used. It was confirmed that the deposition of sediment in the old weir and the luxuriant growth of land vegetation divided the river bank groves from the water surface, separating the habitat for insects that are food for fish from the waters edge. Therefore, in order to improve the river environment in the upstream river, the reeds growing luxuriantly at the waters edge and the land vegetation in the river were dug up and removed. This improved the environment of the river, river bank groves, and the waters edge at the same time as the large diameter stones etc. that were obtained by the excavation were piled directly downstream from the left bank of the weir in order to ensure a route for fish and benthic animal to travel upstream from the weir (Photo 3).

The sediment that was excavated was placed downstream from the dam then the flash discharge was used to extend the lifetime of the dam reservoir capacity and restore sediment downstream, thereby ensuring the continuity of the sediment transport downstream.

With flash discharge up to 2005 was done using valves, there were problems with the structure of the system, when the flow amount exceeded 9m3/s, cold water (water temperature of about 8°C) was discharged, harmfully impacting agricultural products and living creatures in the river. But the flash discharge conducted in 2006 was done at a water level that was higher than the elevation on the bottom of the crest gate (emergency equipment), so the crest gate was used to discharge the surface water with high water temperature to avoid the impact of the discharge of cold water downstream (Photo 4).

Photo 5 shows the state of the riverbed downstream from the dam before and after the flash discharge of June 2003. This confirmed the cleaning effects at locations where the algae usually floats to the surface and at locations where algae has flourished for a long time.

4.1.3 River Environment Survey

To survey the river improvement effects of flash discharge, a survey was done at the locations shown in Fig.3. Tables 1 and 2 show the results of surveys done from 2002 to 2005. There was a single sweet trout caught in 2001, but following the countermeasures in 2002, four were caught in August and two in October, and in 2003, when the flash discharge was implemented, the presence of sweet trout was confirmed between May and July. Furthermore, in 2004 and in 2005, the presence of sweet trout was confirmed and their individual numbers were also seen to be increasing.

There are numerous living creatures in the Ina River, and when they mature, the relationship between the length and wet weight of the oikawa (freshwater minnows (Zacco platypus) (index species), which eat algae like the sweet trout, is shown in Fig.4. It confirms that at two locations on the river flowing into the dam, some were 5cm or smaller. The results from survey site (8) show that no fish less than 5 cm in length were caught in 2002, but the 2003 and later results confirm the presence of young fish of 5 cm or less. Therefore, it is assumed that as a result of measures up to that time, the river environment was improved, giving it new spawning ground functions so that new generations of fish can appear.

Table 3 describes the results of surveys of benthic animal before and after the flash discharges done in 2003. This shows a tendency for the wet weight of algae to decline as a result of the flash discharge, confirming that it washes away attached algae on the riverbed. According to the survey conducted from 2002 to 2005, Homoeothrixjanthiina or Melosira varians and other filamentous cyanophyceae algae and filamentous diatoms that are species easily consumed by fish and insects tend to be dominant when many traces of eating by sweet trout are seen.

Table 4 describes the results of surveys of benthic animal before and after flash discharge. No clear changes in the dominant species or biological water quality levels were detected before and after the flash discharges. However, biological quantities changed and oligosaprobic hydropsyche appeared after flash discharge, confirming the agitation effects of the flash discharges.

4-2. Conducting flexible management trials (increasing river flow rate) by the limited water level transition method

To eliminate depleted sections downstream from the dam, flexible management trials based on the flood season control level were performed in 2006.

The Hitokura Dam is managed by lowering the reservoir water level from the normal water level (EL 149.00m) to the flood season control level (EL. 135.30m) in order to ensure flood control capacity in preparation for runoff by typhoons and the seasonal rain front during the flood period (June 16 to October 15). Normal low water management is management targeting the Mushu point as the reference point that is located downstream the confluence of the main Ina River and the Hitokura Ohroji River. Therefore when the flow volume on the Ina River was high, the quantity supplemented from the dam (quantity discharged) was low, the flow rate in the approximately 5km section downstream from the dam to the confluence with the Ina River was inadequate, and the depth and flow speed were below those necessary for habitation and spawning by fish from early June to mid July that is the fish spawning period. During the draw down period (mid April to mid June), the reservoir water level is lowered by 13.7m from the normal water level to the flood season control level, but the spawning and incubation by fish that spawn during this period could be obstructed by the drying of the eggs caused by the fall of the water level in the reservoir.

Therefore, through the flexible management trial based on the flood season control level transition method, the flowing water was stored in part of the flood control capacity (setting the usable water level), and this was used to improve the flow regime in the approximately 5km section to the confluence with the main course of the Ina River.

The flexible management trial based on the flood season control level transition method is, unlike the conventional method (setting a constant usable water level throughout the period), a method of improving the downstream flow regime by using a previously set usable water level and progressively lowering the water level during the utilization period (Fig. 5).

The reasons for introducing the flood season control level transition method are that there is a section without a levee in part of the river downstream from the dam and there is an extreme danger of flood control safety of the dam declining because of the fall of its flow capacity. After the utilization period, the limited water level transition method that can ensure the entire flood control capacity is adopted. The utilization period was set as the period until July 15 because clarifying past runoff occurrence periods shows that floods occur mainly beginning in mid July (Fig. 6), and by considering the spawning period of fish in the river downstream from the Hitokura Dam (particularly the index fish, oikawa) (Table 5).

The usable water level was set by considering the results of a preliminary study and by accounting for the capacity shortfall from the flow volume that permits prompt preliminary discharge when a flood discharge occurs and that is necessary for fish until mid July (Fig. 7), to set the water level as the flood season control level (EL. 135.30m) plus 1.40 (usable capacity 1.13 million m3). Consequently, the river environment was improved by increasing the flow volume downstream.

Figure 8 shows the water level measured during the flexible management trial and the flow regime at the Uneno point that is between the confluence with the Ina River and the Dam. This shows that it was possible to constantly ensure the flow volume necessary for fish at the Uneno point during the trial period.

4.3 Capture and reuse of fish by water level reduction type fixed nets

Figure 9 shows changes over years of the fish biota inside the Hitokura Dam reservoir from 1991 to 2005. It shows that since the 1991 survey, the percentage of all fish that are exotic fish has risen over years, and that in 2005 in particular, 70% of all fish were exotic fish; a result that is extremely undesirable from the perspective of biological diversity. Therefore, at the Hitokura Dam, a fish survey has been carried out using water level reduction type fixed nets since 2005.

The fish collection survey using water level reduction fixed nets was conducted by using multiple tunnel nets linked by a wing net near the upper end of the reservoir to completely enclose the shallows at the upstream end in the left and right bank directions, then by later lowering the reservoir water level (draw down) to capture all the fish in one net as they travel downstream (Fig. 10). The use of this fishing method has sharply reduced a gap among survey personnel in terms of the skills to catch fish. At the same time, it has inflicted far less damage on the fish than a gill net or other methods that caused great damage, permitting almost all of the native species of captured fish to be released. (Photo 6).

First the captured fish were examined by identifying their species, measuring total length and weight, then the native fish were re-released and the large mouth bass, blue gills, and other exotic species were killed and disposed of.

It is reported that when blue gill that is one of the exotic fish that were captured by the water level reduction type fixed nets are used as compost, they tend to produce extremely good tasting vegetables (beetroot) because of their high calcium content 7. Therefore, after their capture they should be dried and pulverized in a household use wet garbage drier and used as feed for native fish, or provided for trial reuse as compost for home gardens and dry fields. In the future, we wish to construct a reuse system based on the composting of exotic fish (Photo 7).

Performing the flexible management trial by applying the flood season control level transition method as was done in 2006, slowed the rate of decline of the reservoir water level from 18cm/day to 5cm/day by July 15, creating new spawning bed area equal to about 2.1ha in a wide area in the Kunisaki district upstream from the dam and confirmed the state of spawning of carp species (Photo 8).

The fish survey using the water level reduction type fixed nets will be continued at the same time a floating island constructed by employees as a native fish conservation measure will be used to create habitat space for native fish (Photo 9).

5. CONCLUSION

In addition to the above environmental conservation initiatives taken at the Hitokura Dam, a Japanese chestnut oak grove intended to conserve and nurture the native woodlands that is part of the Hitokura Dam Water Source Region Vision has been restored (a rural hamlet environment conservation and restoration model project of the Ministry of the Environment) (Photo 10), hands-on education by releasing sweet trout fry is conducted to increase people's understanding of rivers (Photo 11) and blue tide collection and other field tests (Photo 12) are carried out.

At the Hitokura Dam, the downstream Fishing Industry Association, local NPR, concerned local organizations, and academic experts and others meet annually to exchange views and undertake initiatives to conserve the environment around the reservoir (Photo 13).

We wish to continue to undertaken long-term environmental conservation measures adapted closely to the region while obtaining the views and understanding of the residents.

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Shiga Prefecture, Moriyama Fisheries Association wet garbage utilization method.

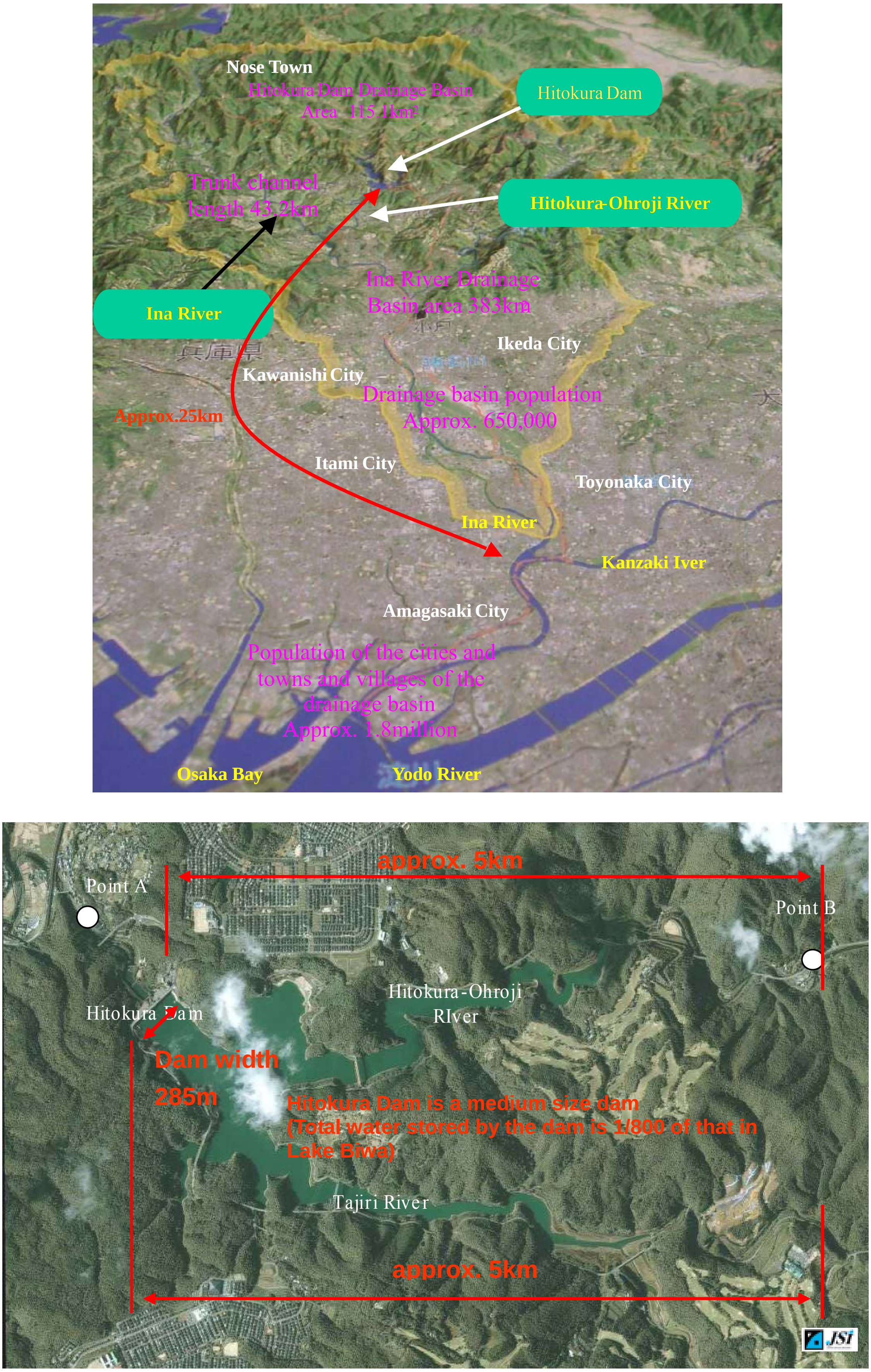


Fig.1. Ina River Drainage Basin Map

Photo 1. Conditions Downstream from the Dam when Constructed in 1982 (left), in 2002 (center), and in 2006 (right) (Looking upstream from point A)

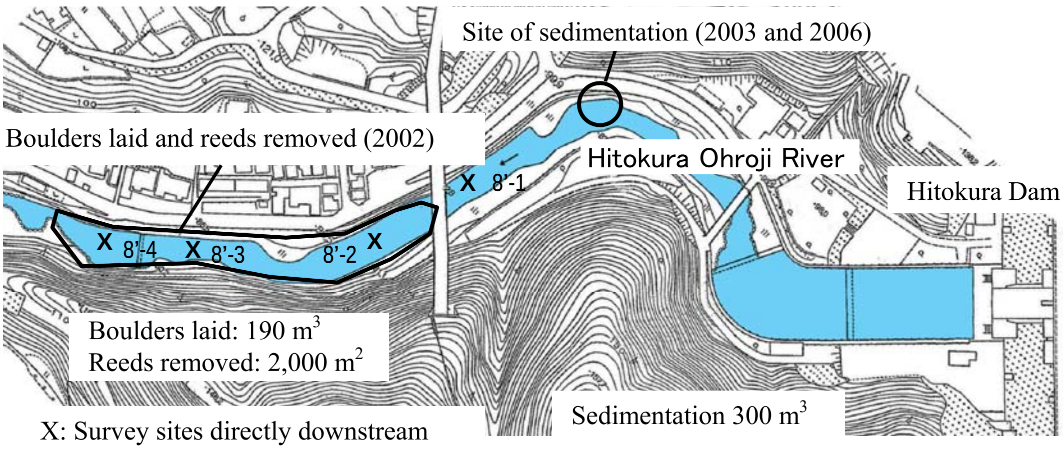


Fig. 2. Sites of Countermeasure Implementation and Survey Locations

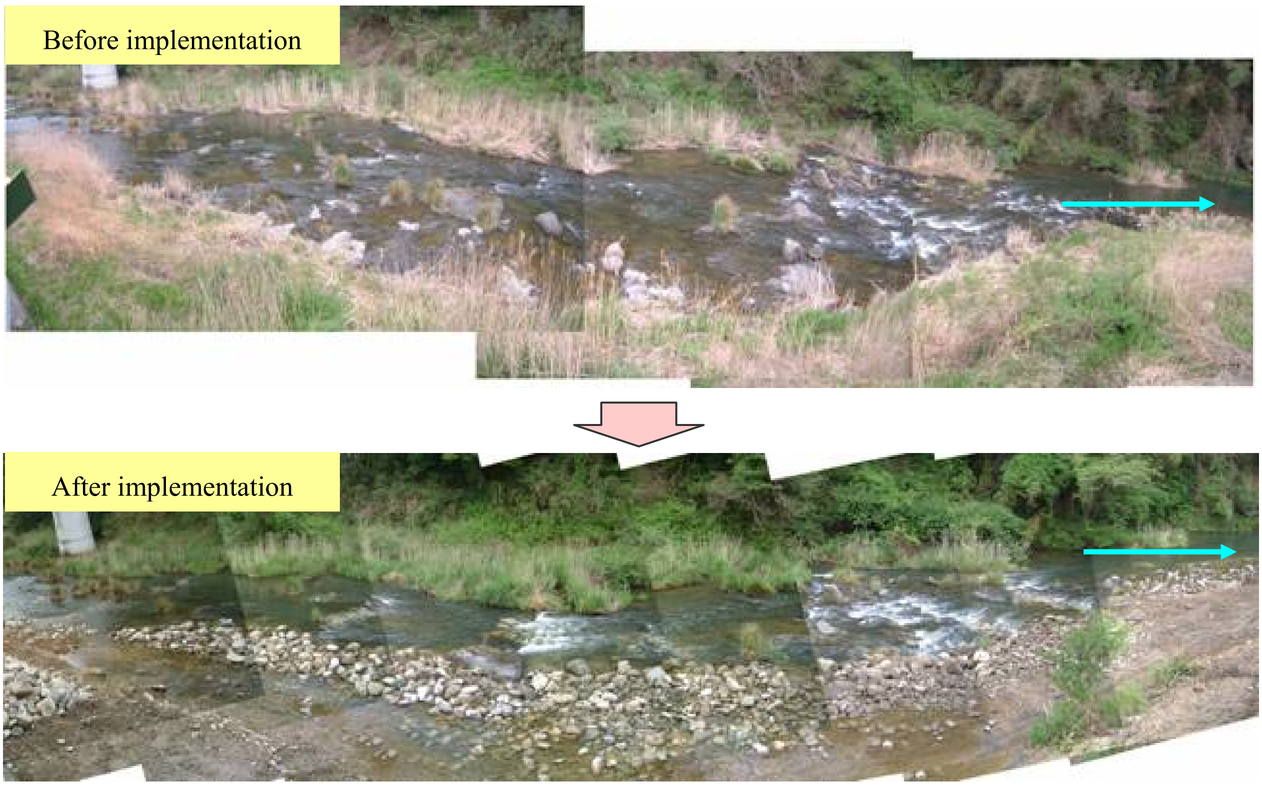


Photo 2. Measures Taken in 2002 (Placing Boulders and Removing Reeds)

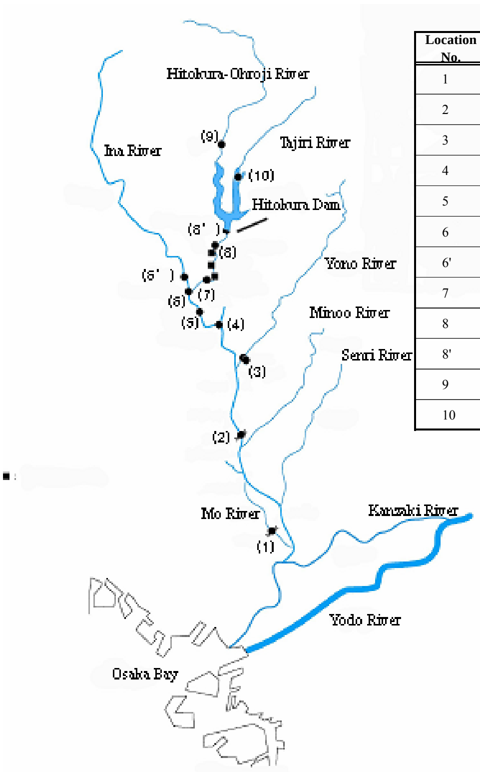
Photo 3. Excavation and Removal of Sediment Etc. at the Old Weir Upstream from the Reservoir (Fig. 1 Point B) (Left: before excavation, right: after excavation)

Photo 4. Views of the Flash Discharge of 2006

Photo 5. State of the Downstream Riverbed Before and After Flash Discharge (Before Discharge (Left): June 7, 2003, After Discharge (Right): June 10, 2003)

Table 1. Fish Survey Results (Downstream from the Dam)

Site No.	8～8'																																								
Site Name	Hitokura Shimbashi to Test Site Downstream from the Dam																																								
Year	2001		2002												2003												2004										2005					
Breed \ Month	7	9	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	4	6	7	8	9	10	11	12	6	7	8	9	10	11
Eel			1		1			1			1							1		1		2	1	2		1			4			1			2			1			3	
Carp									1														1								1	1										1
Gengoro crucian																																									2	
Ginbuna	1		2	1	4			9			1	1											2	1		1	3	2	1			2									6	10
Carassius																																						3				
Oikawa	1	7	3	8	3	3			2	3	14	5				1			1		6	1	2	7		7	4	1			3	5	6	3	7	2			2			
Type B Kawamutsu	1			1	2						1														2																	
Stripped shinner	1		1		3						2							1		1	1		2		1																	
Kamatsuka				3			2																			1	2		1													
Sugomoroko											1					1												1												2		
Nigoi																			3																							
Shimadojo				3																						1										1					1	1
Sujihimadoujo			3	2	3		2																							1								3				3
Dojo																							1																			
Gigi	2						1											1	1	5	1		1					1	2	3			2					1		1	2	
Flatfish	1																	1				1				1	1		1									2				
Sweet trout	1									4		2							1	4	1									18	3	4	1		4		4	17	4			
Rainbow trout	1	1				6																												1								
Blue Gill					1											1					1																					
Big-mouthed Bass																														1												
Donko (Eleotrid)																																									1	
Ukigori																																				1		1				
Oyoshi nobori																							1																			
Kawayoshi Nobori	4	10	1	2	5	2	1	3		6	3		2			1	2	1	2	1	4	3	6	9	8	4	1	4	16	5	2	1			2	6	3	20	4	4	3	9
Number of breeds	9	3	6	7	8	3	4	3	2	3	7	3	1	0	0	4	1	5	5	5	6	4	9	4	3	7	5	5	6	5	4	6	3	2	4	4	2	8	3	3	7	5
Number of fish	13	18	11	20	22	11	6	13	3	13	23	8	2	0	0	4	2	5	8	12	14	7	17	19	11	16	11	9	25	28	9	14	9	4	15	10	7	48	10	7	18	24



Location No.	River name	Site name
1	Mo River	Nakazono Bridge
2	Ina River	Gunko Bridge
3		Takahashi
4		Shio River Confluence
5		Tadain
6		Near the golf Bridge
6'		Ishimichi
7	Hitokura -Ohroji River	Near the Yahata Alarm Buiilding
8		Near Hitokura shinbashi
8'		Below the dam (test area)
9		Sengen
10	Tajiri River	Kunisaki

Fig.3. Environmental Survey Site Map

Table 2. Fish Survey Results (Upstream from the Dam)

Site No.	9																				
Site Name	Sengen																				
Year	2002												2003			2004			2005		
Breed \ Month	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	7	10	6	8	10
Eel																				1	
Carp		1			1				1												
Ginbuna	1	3	4	3	2	2		5			1			1	1					1	
Hasu					1												2		2	1	
Oikawa	43	13	8	7	10	11	5	7	10	1	4	7	7	44	6	1	16	1	10	100	22
Type B Kawamutsu	20	36	31	13	6	14	14	11	8		11	8		4	2	6		2	13	37	16
Stripped shinner	3	2	1		3	2	2	18	4	2	1	1					2		5	18	1
Kamatsuka	2	18	27	13	3	3	1	3	4		3	6		8	7	3	1			3	2
Nigoi					4											1				1	
Itomoroko																			1		
Sugomoroko										1										2	
Dojo																	1		1		1
Shimadojo		2	6	1	1																
Gigi				3		1		2										1			
Flatfish					3			1	1							1					
Akaza								1													
Sweet trout				3	42	45	22	18	9							1	3		29	9	
Donko (O. obscura)		1	1	2			1										1		1		
Oyoshi nobori				2																	
Kawayoshi Nobori		7	11	3	10	11	14	25	31		2			2	4	10	1		12	3	5
Rhinogobius																				1	
Number of breeds	5	9	8	10	12	8	7	10	8	3	6	4	1	5	5	7	8	3	9	12	6
Number of fish	69	83	89	50	86	89	59	91	68	4	22	22	7	59	20	23	27	4	74	177	47

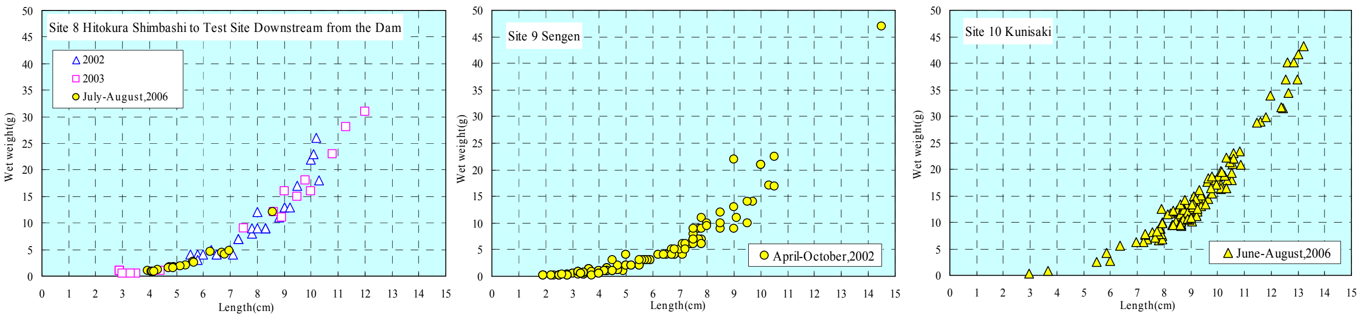


Fig.4. Relationship between the Wet Weight and Length of Oikawa

Table 3. Dominant and subdominant species and dominant species types of attached algae

Site name	Year	Date	Dominant species	Subdominant species	Type of dominant species	Traces of eating
8'-2 (Experimental area downstream from dam)	2002	May.29	*Melosira varians*	*Diatoma vulgare*	▲	
		June.11	*Melosira varians*	*Synedra acus*	▲	
		July.21	*Melosira varians*	*Synedra ulna*	▲	
		Aug.5	*Melosira varians*	*Synedra ulna*	▲	
		Aug.16	*Melosira varians*	*Synedra ulna*	▲	
		Sep.1	*Melosira varians*	*Synedra ulna*	▲	
		Oct.1	*Melosira varians*	*Synedra ulna*	▲	
		Oct.16	*Synedra ulna*	*Melosira varians*	△	
		Nov.7	*Diatoma vulgare*	*Synedra ulna*	△	
		Nov.22	*Cladophora glomerata*	*Melosira varians*	×	
		Dec.26	*Melosira varians*	*Diatoma vulgare*	▲	
	2003	Jan.9	*Melosira varians*	*Diatoma vulgare*	▲	
		Feb.7	*Diatoma vulgare*	*Melosira varians*	△	
		Mar.10	*Melosira varians*	*Diatoma vulgare*	▲	
		Apr.28	*Melosira varians*	*Synedra ulna*	▲	
		May.13	*Melosira varians*	*Navicula radiosa*	▲	
		May.27	*Melosira varians*	*Navicula radiosa*	▲	
		May.28	*Melosira varians*	*Oedogonium sp.*	▲	◎
		June.5	*Homoeothrix janthina*	*Melosira varians*	●	◎
		June.7	*Homoeothrix janthina*	*Melosira varians*	●	◎
		June.10	*Homoeothrix janthina*	*Phormidium retzii*	●	◎
		June.27	*Homoeothrix janthina*	*Ulothrix zonata*	●	◎
		July.2	*Homoeothrix janthina*	*Ulothrix zonata*	●	◎
		July.22	*Melosira varians*	*Diatoma vulgare*	▲	
		Aug.4	*Synedra ulna*	*Homoeothrix janthina*	△	
		Aug.28	*Homoeothrix janthina*	*Melosira varians*	●	
		Sept.3	*Homoeothrix janthina*	*Melosira varians*	●	
		Sept.30	*Homoeothrix janthina*	*Synedra ulna*	●	
		Oct.10	*Melosira varians*	*Synedra ulna*	▲	
		Nov.7	*Cladophora glomerata*	*Melosira varians*	×	
		Dec.22	*Melosira varians*	*Synedra ulna*	▲	
	2004	Jan.16	*Melosira varians*	*Synedra ulna*	▲	
		Feb.6	*Melosira varians*	*Cladophora glomerata*	▲	
		May.7	*Melosira varians*	*Navicula radiosa*	▲	
		May.13	*Diatoma vulgare*	*Melosira varians*	△	
		May.27	*Melosira varians*	*Diatoma vulgare*	▲	
		June.3	*Melosira varians*	*Diatoma vulgare*	▲	○
		June.17	*Homoeothrix janthina*	*Melosira varians*	●	○
		July.1	*Cladophora glomerata*	*Homoeothrix janthina*	×	
		July.29	*Cladophora glomerata*	*Hydrosera triquetra*	×	
		Aug.11	*Melosira varians*	*Homoeothrix janthina*	▲	
		Aug.20	*Cocconeis placentula*	*Melosira varians*	△	
		Sept.2	*Cocconeis placentula*	*Melosira varians*	△	
		Sept.28	*Melosira varians*	*Homoeothrix janthina*	▲	
		Oct.5	*Hydrosera triquetra*	*Melosira varians*	▲	
		Nov.8	*Melosira varians*	*Synedra ulna*	▲	
		Dec.2	*Melosira varians*	*Synedra ulna*	▲	
	2005	Apr.25	*Melosira varians*	*Synedra ulna*	▲	
		May.12	*Cladophora glomerata*	*Cocconeis placentula*	×	
		May.25	*Diatoma vulgare*	*Melosira varians*	●	
		June.27	*Melosira varians*	*Synedra ulna*	▲	○
		June.17	*Cladophora glomerata*	*Hydrosera whampoensis*	×	○
		June.29	*Melosira varians*	*Synedra ulna*	▲	○
		July.7	*Cladophora glomerata*	*Melosira varians*	×	○
		July.21	*Melosira varians*	*Diatoma vulgare*	▲	○
		Aug.2	*Cladophora glomerata*	*Hydrosera whampoensis*	×	○
		Sept.15	*Melosira varians*	*Homoeothrix janthina*	▲	
		Sept.29	*Hydrosera whampoensis*	*Melosira varians*	▲	
		Oct.7	*Melosira varians*	*Synedra ulna*	▲	
		Nov.4	*Melosira varians*	*Ulothrix zonata*	▲	

○ and △ represent algae edible for fish and insects and × indicates inedible algae.
● Filamentous blue-green algae, △ Mat diatom, ▲Filamentous diatom, × filamentous green algae and red algae
Eating traces: ○ Some, ◎ Many

Table 4. Results of Surveys of Riverbed Creatures (Before and After Flash Discharge)

Site name	Site No.	Date	Biological Quality Water Grade	Dominant Species	Wet Weight(g)
Test Site Downstream from thd Dam	8'-1	April.28	β-mesosaprobie	Cheutamopsyche	0.152
		May.13	β-mesosaprobie	Cheutamopsyche	1.743
		May.27	β-mesosaprobie	Cheutamopsyche	1.862
		May.28	β-mesosaprobie	Cheutamopsyche	0.908
		June.5	β-mesosaprobie	Cheutamopsyche	0.890
		June.10	Oligosaprobity	Hydropsyche tsudai	0.820
		June.27	Oligosaprobity	Hydropsyche tsudai	3.320
		July.1	β-mesosaprobie	Cheutamopsyche	3.051
	8'-2(rapids)	April.28	β-mesosaprobie	Cheutamopsyche	2.346
		May.13	Oligosaprobity	Hydropsyche tsudai	1.671
		May.27	β-mesosaprobie	Cheutamopsyche	1.183
		May.28	Oligosaprobity	Antocha	0.896
		June.5	β-mesosaprobie	Cheutamopsyche	0.740
		June.10	β-mesosaprobie	Cheutamopsyche	0.360
		June.27	β-mesosaprobie	Hydropsyche tsudai	3.760
		July.1	Oligosaprobity	Hydropsyche tsudai	2.598
	8'-3(shallows)	April.28	β-mesosaprobie	Cheutamopsyche	3.275
		May.13	β-mesosaprobie	Cheutamopsyche	1.545
		May.27	β-mesosaprobie	Cheutamopsyche	1.031
		May.28	β-mesosaprobie	Cheutamopsyche	0.711
		June.5	β-mesosaprobie	Cheutamopsyche	1.100
		June.10	β-mesosaprobie	Mystacides sp.	1.360
		June.27	Oligosaprobity	Hydropsyche tsudai	2.360
		July.1	β-mesosaprobie	Cheutamopsyche	3.086
	8'-4(shallows)	April.28	β-mesosaprobie	Cheutamopsyche	1.690
		May.13	β-mesosaprobie	Mystacides sp.	3.616
		May.27	β-mesosaprobie	Cheutamopsyche	0.636
		May.28	β-mesosaprobie	Antocha	0.625
		June.5	Oligosaprobity	Cheutamopsyche	1.210
		June.10	Oligosaprobity	Hydropsyche tsudai	1.950
		June.27	Oligosaprobity	Hydropsyche tsudai	4.400
		July.1	β-mesosaprobie	Cheutamopsyche	1.013

Flash Discharge Dates (1st time: 19 May, 2003, 2nd time: 27 May, 2003, 3rd time: 9 June, 2003)

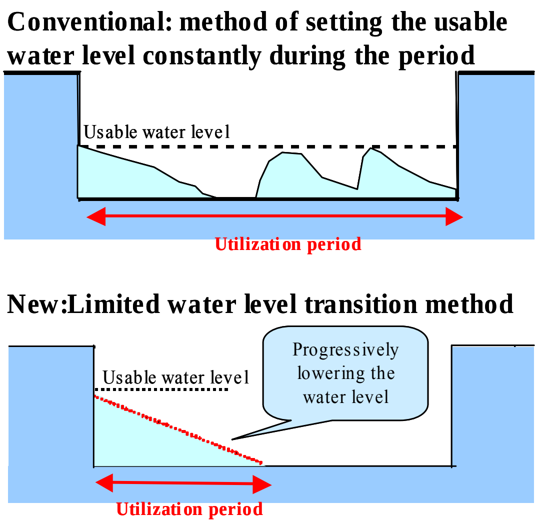


Fig.5. Image of the Flexible Management Method

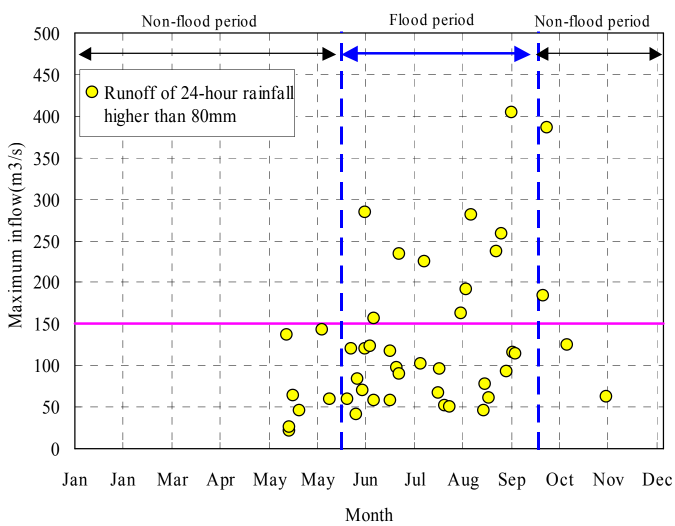


Fig.6. Relationship of the Runoff Discharge Period and the Maximum Inflow

Table 5. Flow Rate Desirable by Month by Fish Species

Object fish species	Conditions and foundations	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Oikawa	Ecosystem characteristics	Traveling				Spawning period				Traveling			
	Necessary water depth(cm)	10	10	10	10	15	15	15	15	10	10	10	10
	Necessary water volume(m^3/s)	0.171	0.171	0.171	0.171	0.438	0.438	0.438	0.438	0.171	0.171	0.171	0.171
	Necessary flow speed(cm/s)	-	-	-	-	5	5	5	5	-	-	-	-
Sweet trout	Ecosystem characteristics	Traveling									Spawning period		
	Necessary water depth(cm)	-	-	15	15	15	15	15	15	15	30	30	30
	Necessary water volume(m^3/s)	-	-	0.438	0.438	0.438	0.438	0.438	0.438	0.438	2.420	2.420	2.420
	Necessary flow speed(cm/s)	-	-	-	-	-		-	-	-	60	60	60
Nigoi	Ecosystem characteristics	Traveling			Spawning period			Traveling					
	Necessary water depth(cm)	20	20	20	30	30	30	20	20	20	20	20	20
	Necessary water volume(m^3/s)	1.218	1.218	1.218	2.420	2.420	2.420	1.218	1.218	1.218	1.218	1.218	1.218
	Necessary flow speed(cm/s)	-	-	-	-	-		-	-	-	-	-	-
Yoshinobori	Ecosystem characteristics	Traveling				Spawning period				Traveling			
	Necessary water depth(cm)	10	10	10	10	20	20	20	20	10	10	10	10
	Necessary water volume(m^3/s)	0.171	0.171	0.171	0.171	1.218	1.218	1.218	1.218	0.171	0.171	0.171	0.171
	Necessary flow speed(cm/s)	-	-	-	-	10	10	10	10	-	-	-	-
Necessary maximum flow volume(m^3/s)		1.218	1.218	1.218	2.420	2.420	2.420	1.218	1.218	1.218	2.420	2.420	2.420
Remarks		June 15,Non-flood period						Flood period June 16-October 15				Non-flood period Oct.16	

Drawdown period(April 1 to June 15) Utilization period

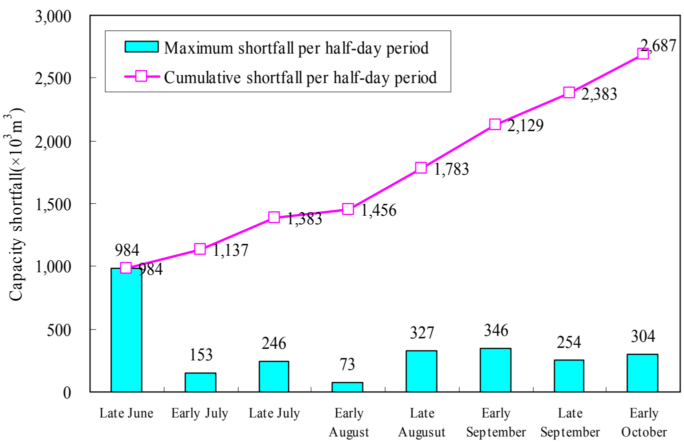


Fig.7. Capacity Shortfall From the Capacity Desirable for Fish

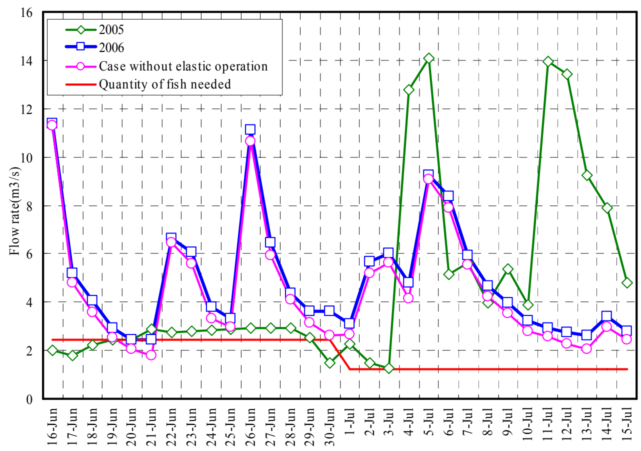


Fig.8. Flow Regime at the Downstream Reference Point (Uneno) in 2006

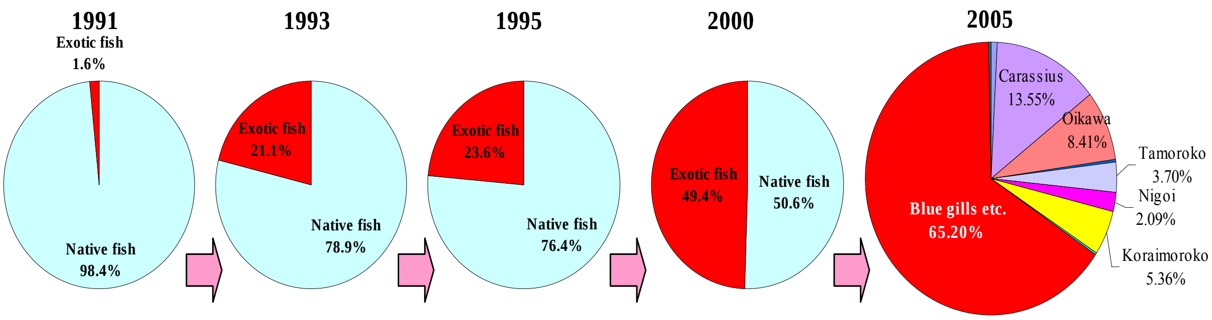


Fig.9. Change over Years of Fish Biota in the Dam Reservoir

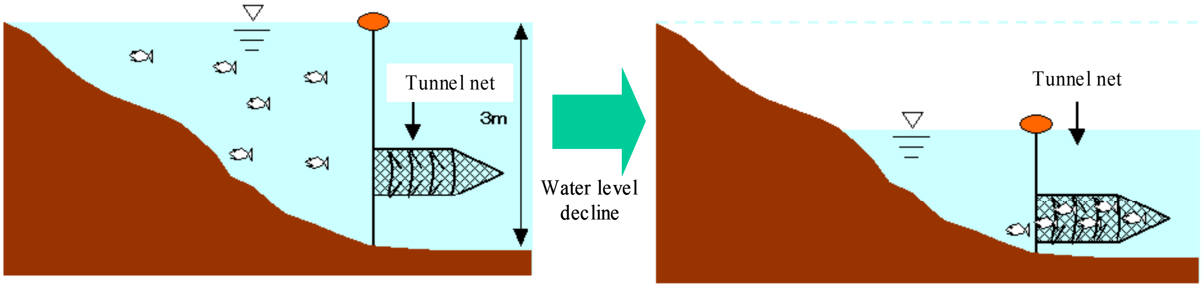


Fig.10. Capturing Fish With a Water Level Reduction Type Fixed Net

Photo 6. Capturing Fish and Measuring Native Species

Photo 7. Reusing the Captured Exotic Fish

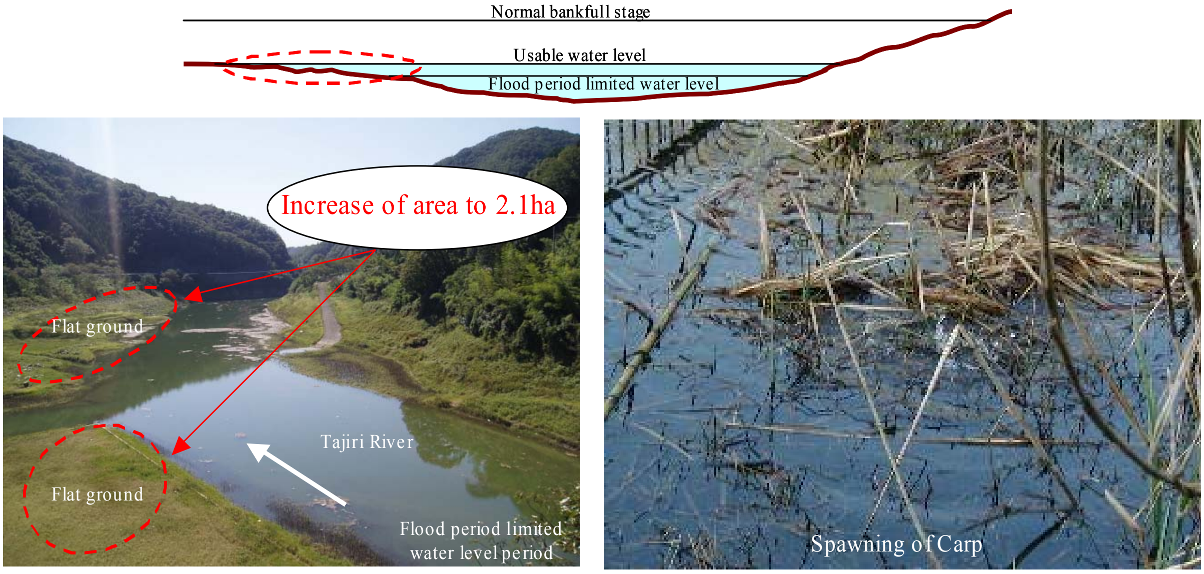


Photo 8. Ensuring Spawning Bed Area by Slowing the Rate of Reservoir Water Level Decline

Photo 9. Creating a Floating Island

Photo 10. Effort to Restore a Japanese Chestnut Oak Grove as a Water Source ForestForest

Photo 11. Trial Release of Sweet trout Fry (May 14, 2006)

Photo 12. Trial Collection of Blue Tide

Photo 13. Meeting to Exchange Views