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Chemical Water Quality and Fish Component Analyses in the Periods of Before- and After-the Weir Constructions in Yeongsan River

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Abstract

The objective of this study was to analyze chemical water quality, ecological characteristics of fish compositions, and ecosystem health before- (B_{wc}; 2008-2009) and after-the weir construction (A_{wc}; 2011-2012) at Juksan Weir and Seungchon Weir of Yeongsan River watershed. Suspended solids (SS) and chlorophyll-a (Chl-a) in Juksan Weir increased, whereas nutrients such as total nitrogen (TN) and total phosphorus (TP) decreased in the epilimnetic water. In Juksan and Seungchon weirs, fish species distribution analysis in the periods of B_{wc} and A_{wc} showed that sensitive species were rare and tolerant species were dominant in the community. In the analysis of trophic guild, relative abundance of carnivore species are increased to 22% and 12%, respectively, after the constructions of Seungchon Weir and Juksan Weir. Mann-Whitney U-tests of nonparametric statistical analysis indicated that omnivore and carnivore species had significant differences ($p < 0.05$) between the B_{wc} and A_{wc}. The massive population growth of an exotic species, *Micropterus salmoides*, was evident in Seungchon Weir to influence on the structures of fish communities. The model values of mean Index of Biological Integrity (IBI), based on fish assemblages, were < 15, which indicates "poor" condition in the river health, and the significant difference of IBI values was not found between the B_{wc} and A_{wc}.

Keywords: fish composition, stream health, water chemistry, weir construction, Yeongsan River

INTRODUCTION

Constructions of weir or dams on the lower parts of the streams and rivers can cause longer water residence time and modifications of physical habitat structures, resulting in modifications of chemical regimes (N, P). These factors directly or indirectly affect fish communities and other biota (Poff et al. 1977, Gorman and Karr 1978). Such ecological impacts are largely demonstrated by Serial Discontinuity Concept (SDC), which was developed by Ward and Stanford (1983) in river research. Some reasons for the decline of some fish populations (i.e., sensitive species or riffle-dwelling species) and modifications of fish community structures (Schlosser 1982, Jurajda 1995) may be related with channelization, the destructions of riparian zone, and submerged vegetation during the weir or dam constructions. The biggest impacts of numerous causes by the weir constructions are frequently a barrier (obstacle) effect of fish migration (Lucas and Frear 1997).

The ecological impacts of freshwater fish on weir or small dam constructions are widely reported in USA (Holmquist et al. 1998), Canada (Townsend 1975), United

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Kingdom (Lucas and Frear 1997), Norway (Fjellheim and Raddum 1996), Sweden (Rivinoja et al. 2001), and Australia (Gehrke et al. 1995, 2002). These studies pointed out that various impacts of fish may be related to the weir constructions. Water quality was degraded rapidly due to accumulations of nutrients and sediments along with modifications of physical habitats for fish. In addition, water volume is considerably reduced during the dry season, so the water quality and quantity in the downstream may be dramatically changed. Also, higher residence time in the upstream region of the weir increase phytoplankton growth or algal bloom at a given nutrients (N, P). Under the circumstances, even the riverine fish adapted to fast current may be substituted into lacustrine-type fish. The trophic compositions, thus, may be modified from insectivore fish to omnivore fish due to accumulations of benthic sediments (Gorman and Karr 1978, Angermeier and Karr 1984, Poff and Allan 1995). Such conditions also may have negative impacts on the aquatic fauna and compositions after the weir constructions. The weirs could isolate partially or largely the upstream resident fish, even if the fish ways are present, and the resident species may congregate at the downstream of the weirs. Thus, the weirs on the rivers obstructed the route of the long and mid-distance migratory fish, resulting in effects of physical barrier on the migratory fish. The main problem regarding the analysis of effects of weir constructions on the river system, however, is the absence of data from the affected reach prior to the alteration (Groffman et al. 2003).

The weir construction was initiated from the Korean government's five-year national plan of "Four Major Rivers Project" in July 2009. The government invested 17.3 billion dollars for the project. The original plan had five core objectives such as 1) securing abundant water resources to solve problems of water scarcity, 2) implementing monsoon-flood control measures, 3) improving the water quality and restoring ecological river health, 4) creating multipurpose spaces for local residents, and 5) regional cultural development centered on the rivers. The government tried to secure adequate water supply (1.3 billion m^3) to prepare future water scarcity and severe drought due to global climate change. For this reason, 16 weirs were constructed in the watersheds of four major rivers and the two weirs of Seungchon Weir and Juksan Weir were constructed in the watershed of Yeongsan River. Contrary to the original purposes, numerous studies reported on some hydrological modifications (Kim et al. 2009), chemical impacts and ecological problems of algal blooms and some fish kills. One of the prominent characteristics was abrupt increases of water residence time and nutrients (N, P) along with severe surface scums and algal blooms in the upper region of the weirs. Furthermore, abrupt massive fish kills occurred in some weirs after the weir construction and thus the government worried about the deterioration of the river ecosystem. This is reason why we conducted to analyze some impacts on fish population and community structure in this study.

The objectives of the research were to compare chemical water quality and the fish community structures along with the ecosystem health before the weir construction (B_{wc}; 2008-2009) and after the weir construction (A_{wc}; 2011-2012) at Juksan Weir and Seungchon Weir of Yeongsan River watershed. In addition, ecological components of trophic guilds and tolerance guilds were analyzed in the upper-reach and lower-reach of Seungchon Weir and Juksan Weir, respectively.

MATERIALS AND METHODS

The study watershed and sampling sites

The watershed area of Yeongsan River is 3,371 km^2, and the length from the headwater to estuary reaches 136 km. Major of tributaries in Yeongsan River watershed include Hwangryong River, Jisuk Stream, Gomakwon Stream, Hampyung Stream, Manbong Stream, and Gwangju Stream (Fig. 1). It is largely influenced by many nonpoint sources such as rice paddies as well as point-source of wastewater disposal plants and sewage treatment (MEK 2012). Two artificial weirs were constructed in the midstream and downstream of the Yeongsan River in 2012. Seungchon Weir (longitude, 127˚62′92″; latitude, 35˚06′48″) and Juksan Weir (longitude, 126˚62′92″; latitude, 35˚06′48″) were constructed by the 4 major river restoration project. Seungchon Weir is 9.0m tall and 540m long in the width with control water level of 7.5m. Juksan Weir located in the downstream of Seungchon Weir and is 4.85m tall and 622m width with control water level of 3.5m.

Fish collections and sampling gears

Fish were collected in upstream site of each weir ($S\text{-}U_s$ / $J\text{-}U_s$), and in downstream site of each weir ($S\text{-}D_s$ / $J\text{-}D_s$). Also, all habitat types such as riffle, run, and pool were included for the fish sampling according to the approach of wading method (Ohio EPA 1989) based on the catch per unit effort (CPUE). The distance and time elapsed in the sampling was at least 200 m and 60 minutes, respectively.

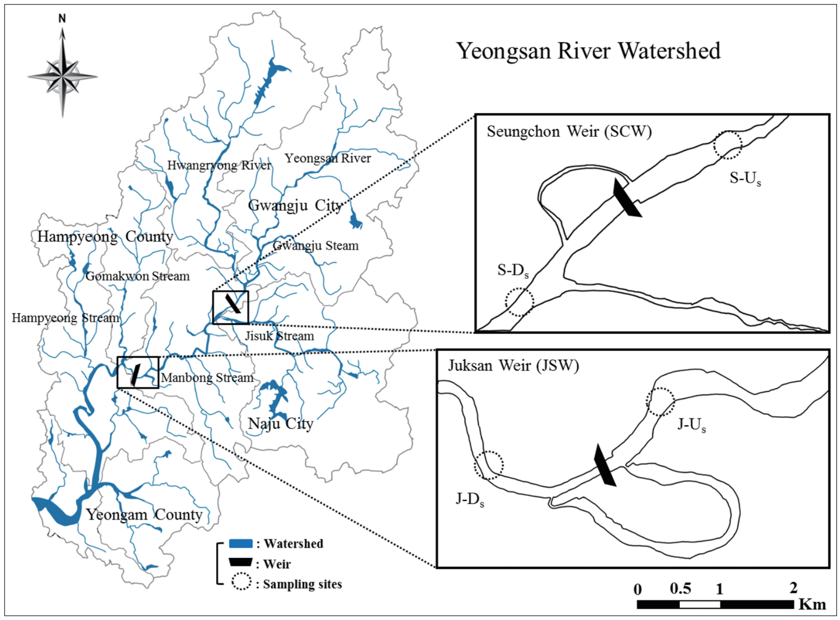

Fig. 1. The map showing Seungchon Weir and Juksan Weir in the watershed of Yeongsan River.

The sampling gears of casting net (7 × 7 mm) and kick net (4 × 4 mm) were used for the analysis of sampling sites, which are the most popular fish sampling gears in Korea. All fishes were identified at field, and released immediately. Tolerance and trophic guild analyses were based on the previous regional studies (An et al. 2002, 2004).

Physical habitat evaluation

The habitat quality assessments on the upstream and downstream of the artificial weirs in the Yeongsan River were conducted by using the model of Qualitative Habitat Evaluation Index (QHEI). The QHEI model, based on the habitat evaluation by Barbour et al. (1999), was revised by An and Kim (2005), for regional applications and each rank per a variable value classified by the criteria of An and Kim (2005). The health conditions of the habitat were categorized as four levels such as "Excellent" (182-220), "Good" (124-168), "Fair" (66-110), and "Poor" (8-52) conditions.

Chemical water quality

Chemical water quality was analyzed at sampling sites between before (B_{wc}, 2008-2009) and after weir construction (A_{wc}, 2011-2012). To evaluate how fish distribution characteristics are related to chemical water quality, various parameters such as total nitrogen (TN), nitrate nitrogen (NO_3-N), ammonium nitrogen (NH_4-N), total phosphorus (TP), chlorophyll-a (CHL-a), electric conductivity (EC), and suspended solids (SS) were analyzed. Also, chemical measurements of biological oxygen demand (BOD) and chemical oxygen demand (COD) were conducted by the approach of Eaton and Franson (2005).

Ecological health assessment model (IBI)

The ecological health of the river was evaluated by using the original approach of rapid bioassessment protocol (RBP) recently developed by Barbour et al. (1999). For the study, eight metric models of the IBI were applied, instead of original 12 metric models originally suggested by Karr (1981). The model was established by the regional application (An et al. 2002, 2004). The variable values per metric were scored by "1", "3", and "5", and then was added up. The health condition was categorized as four levels such as "Excellent" (36-40), "Good" (26-35), "Fair" (16-25), and "Poor" (< 15) conditions.

RESULTS AND DISCUSSION

Water quality of physiochemical parameters

Mean concentration of total nitrogen (TN) was 8.32 mgL^{-1} in Seungchon Weir and TN decreased by 23% af-

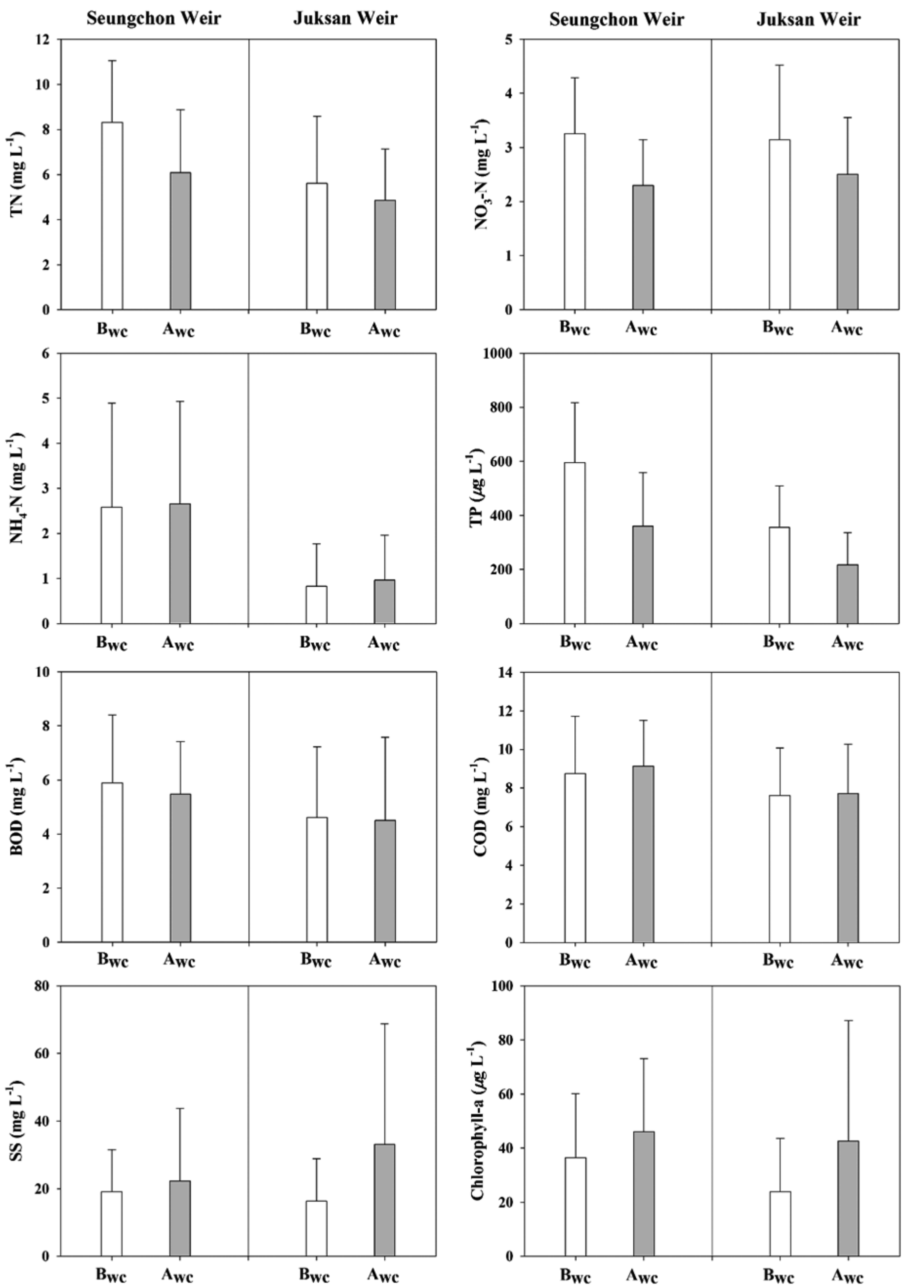

Fig. 2. Nutrients, organic matter, suspended solids and chlorophyll-a before the weir construction (B_{wc}) and after the weir construction (A_{wc}) in the two artificial weirs.

ter the weir construction. NO_3-N had similar trend with TN (Fig. 2). Unlike the decrease of TN, NH_4-N showed a slight increase and this was due to influences of livestock, fertilizers, and sewages from the watershed in the circumstance of reduced water residence time (WRT). Total phosphorus (TP) concentration was 590 *u*gL^{-1}, which was the remarkable decline by 40% after the weir construction. Unlike the other nutrients, phosphorus had the high concentration of sedimentation and might have been affected by dredging river bed. Phosphorus was a key factor for the algal growth, and Chl-a (mean value: 30 *u*gL^{-1}) increased up to 44 *u*gL^{-1} after the weir construction. The increase of Chl-a was due to greater WRT and less washing-out in the water column. Also, the variations of BOD and COD were minor (Fig. 2).

Before the construction of Juksan Weir, TN was averaged 5.60 mgL^{-1}, while after the construction TN was decreased to 13%. The water quality in Juksan Weir de-

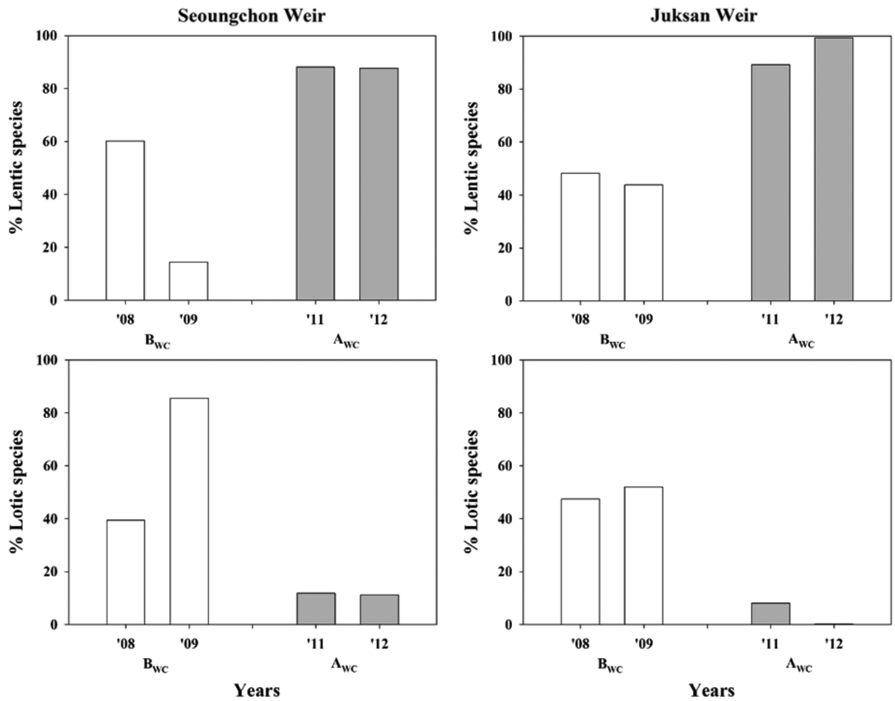

Fig. 3. Lentic and lotic fish compositions before the weir construction (B_{wc}) and after the weir construction (A_{wc}) in the Seungchon Weir and Juksan Weir.

clined less than it in Seungchon Weir. Concentrations of NO_3-N and NH_4-N in Juksan Weir, however, were similar to them in Seungchon Weir (Fig. 2). Concentrations of TP were averaged to 350 ugL^{-1} and declined by 40% after the construction. We believe that nutrient declines of TN and TP were closely associated with increasing WRT. In other words, the system was changed from river type (flowing water type) to lake-like type (stagnant water type). Concentrations of BOD and COD in Juksan weir were similar to them in Seungchon Weir. Mean concentration of Chl-a was increased by 27% after the Seungchon Weir construction. The results were in inverse proportion to the decrease of TN and TP, and it consequentially increased WRT of water body. Unlike Seungchon Weir, SS of Juksan Weir showed the remarkable increase, and it had an interesting mutual relation in the fish analysis (Fig. 2).

The first change of this water body stretched out the weir construction sites in the midstream and downstream of the mainstream in the Yeongsan River. More than 50% of the mid-area was used as farmlands, forests and fields, and fisheries. The tributaries such as Hwangryong River, Gwangju Stream, Gomakwon Stream, Jisuk Stream, Manbong Stream joined to the mainstream, and they were vulnerable from the pollutant source. Thus, the tributaries had the serious eutrophication (Kang and An 2006). This vulnerable ecological environment in the river are variables in barrier effect by the weir construction.

Shifts of species compositions

During the study period, total 6 families and 28 species were collected in the sampling sites. Total numbers of fish species sampled were 23 for 1,803 individuals and 23 for 797 individuals in Seoungchon Weir and Juksan Weir, respectively. The population of *Zacco platypus* was dominant species (Relative abundance (RA): 23%) in the fish communities and *Squalidus chankaensis tsuchigae* was subdominant species (RA: 15%). In Seungchon Weir (Table 1), *Z. platypus* was dominant (RA: 59%) to stretch widely over small pools and riffles during 2008-2009 (B_{wc}). After the weir construction, however, the relative abundance of *Z. platypus* was decreased sharply by 7%. The rapid changes showed that microhabitat disappeared due to dredging and channelization for the weir construction, and consequentially the lotic system was replaced by the lentic system. The lotic-type fish population of *Z. platypus* decreased from 527 at B_{wc} to 73 individuals at A_{wc}, while lentic-type fish of *C. auratus* increased from 44 at B_{wc} to 209 individuals at A_{wc}. The relative abundance of *Acanthorhodeus marcropterus* went up from 1.1% at B_{wc} to 4.4% at A_{wc}, it of *S. chankaensis tsuchigae* rose from 9.9% at B_{wc} to 17.8% at $A_{wc,}$ it of *O. uncirostris amurensis* was increased from 2.9% at B_{wc} to 16.1% at A_{wc}, it of *H. eigenmanni* was increased from 0.5% at B_{wc} to 16.6% at A_{wc}, and it of *M. salmoides* increased from 6.2% at B_{wc} to 14.6% at A_{wc}. It shows that the number of individuals has the remarkable increase after the weir construction. As a result, the simplification of trophic singularity by the dominance of omnivore species should be made water ecosystem health condition index worse (Barbour et al. 1999). In addition, it means the changes of water body environment in the characteristics of the fish composition (Fig. 3).

Characteristics of tolerance guilds

According to the analysis of the fish tolerance guild, tolerant species increased from 72% at B_{wc} to 77% at A_{wc} and intermediate species decreased from 28% at B_{wc} to 23% at A_{wc} in Seungchon Weir. According to guild researches of Karr (1981) and Klemm et al. (1993), the number of individuals and species in tolerant species increased with degradations of chemical water quality. Such condition made tolerant species dominant in the Yeongsan River (Fig. 4). After the weir construction in Juksan weir, tolerant species decreased from 89% at B_{wc} to 67% at A_{wc} and intermediate species increased from 11% at B_{wc} to 31% at A_{wc}. It indicate that tolerant species declined and intermediate sharply increased.

In 2012, sensitive species were rare in both weirs (Fig. 4). In the above analysis, it was different from the general phenomenon in the upstream and downstream of the river. It should be attentive and observed if it was transitional phenomenon by the construction or if there were

Table 1. Fish fauna and its relative abundance (RA) along with tolerance guilds (TO_g) and trophic guilds (TR_g) before- and after-the weir construction in two artificial weirs

Scientific name	TO_g	TR_g	HA_g	Seungchon Weir				Juksan Weir				TNI	RA (%)
				B_{wc}		A_{wc}		B_{wc}		A_{wc}			
				2008	2009	2011	2012	2008	2009	2011	2012		
Cyprinidae													
Cyprinus carpio	T_S	O	-	7	1		2	9	4	1	5	29	1.12
Carassius auratus	T_S	O	-	26	4	1	111	6	8	1	96	253	9.73
Carassius cuvieri†	T_S	O	-	2		1	16				8	27	1.04
Acheilognathus lanceolatus	Is	O	-							1		1	0.04
*Rhodeus uyekii**	I_S	O	-		7							7	0.27
Acanthorhodeus macropterus	I_S	O	-		2	1		8		67	6	84	3.23
*Acanthorhodeus gracilis**	I_S	O	-	1				2	3	3		9	0.35
Pseudorasbora parva	T_S	O	-			7	3			4		14	0.54
*Sarcocheilichthys nigripinnis morii**	I_S	I	-	1	1							2	0.08
*Squalidus gracilis majimae**	S_S	I	-			2				5		7	0.27
*Squalidus japonicus coreanus**	T_S	O	-			4				6		10	0.38
*Squalidus chankaensis tsuchigae**	I_S	O	-	48	34	16	193	10		45	43	389	14.96
Hemibarbus labeo	T_S	I	-	3	8	14	4		1	42	1	73	2.81
Hemibarbus longirostris	I_S	I	-	3	10		2		3			18	0.69
Pseudogobio esocinus	I_S	I	-	8	24	2	38		4	4		80	3.08
Abbottina rivularis	T_S	O	-			2				1		3	0.12
*Microphysogobio yaluensis**	I_S	O	RB	3	47		1					51	1.96
Zacco platypus	T_S	O	-	63	378	48	22	55	31	2	1	600	23.08
Opsarichthys uncirostris amurensis	T_S	C	-	15	8	98	90		4	46	35	296	11.38
Cluter brevicauda	Ts	C	-							1		1	0.04
*Hemiculter eigenmanni**	T_S	O	-			227	30	3	2	14	15	291	11.19
Bagridae													
Leiocassis nitidus	Ts	I						3				3	0.12
Mugilidae													
Mugil cephalus	Ts	H								4	1	5	0.19
Centrachidae													
Lepomis macrochirus†	T_S	I	-	3	3	1	7	9		4	8	35	1.35
Micropterus salmoides†	T_S	C	-	15	19	63	45	11	13	8	128	302	11.62
Odontobutidae													
*Odontobutis platycephala**	Sc	C								2		2	0.08
Gobiidae													
Rhinogobius giurinus	T_S	O	-				7					7	0.27
Rhinogobius brunneus	I_S	I	RB				1					1	0.04
Total Number of Species				14	14	15	16	10	10	20	12	28	
Total Number of Individuals				198	546	487	572	116	73	261	347	2600	

TO_g: Tolerance guild, TR_g: Trophic guild, HA_g: Habitat guild, S_S: Sensitive species, I_S: Intermediate species, T_S: Tolerant species, O: Omnivores, I: Insectivores, C: Carnivores, H: Herbivores, TNI: Total number of individuals, RA: Relative abundance, * : Endemic species, †: Exotic species

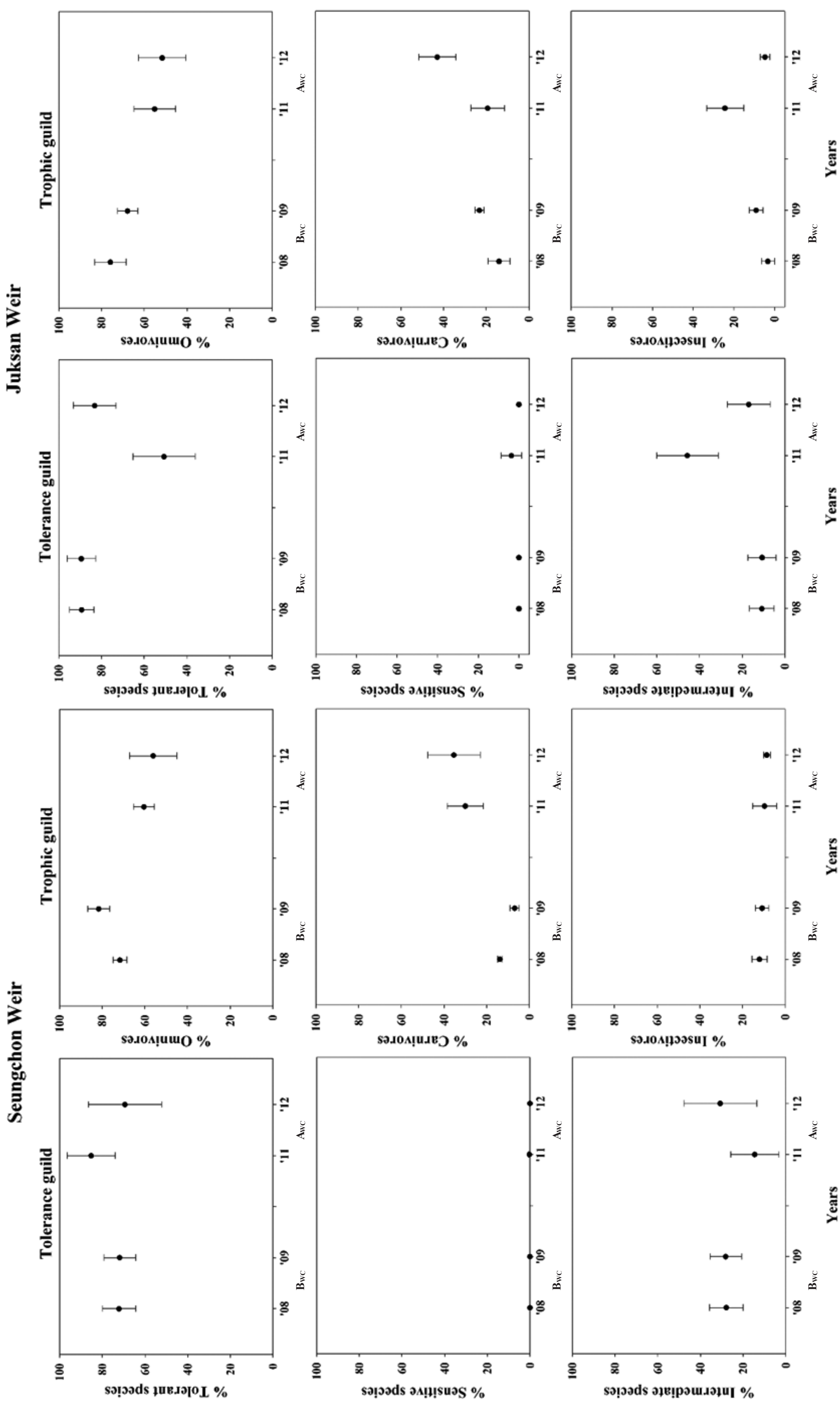

Fig. 4. Fish tolerance and trophic guilds before the weir construction (B_{WC}) and after the weir construction (A_{WC}) in the two artificial weirs.

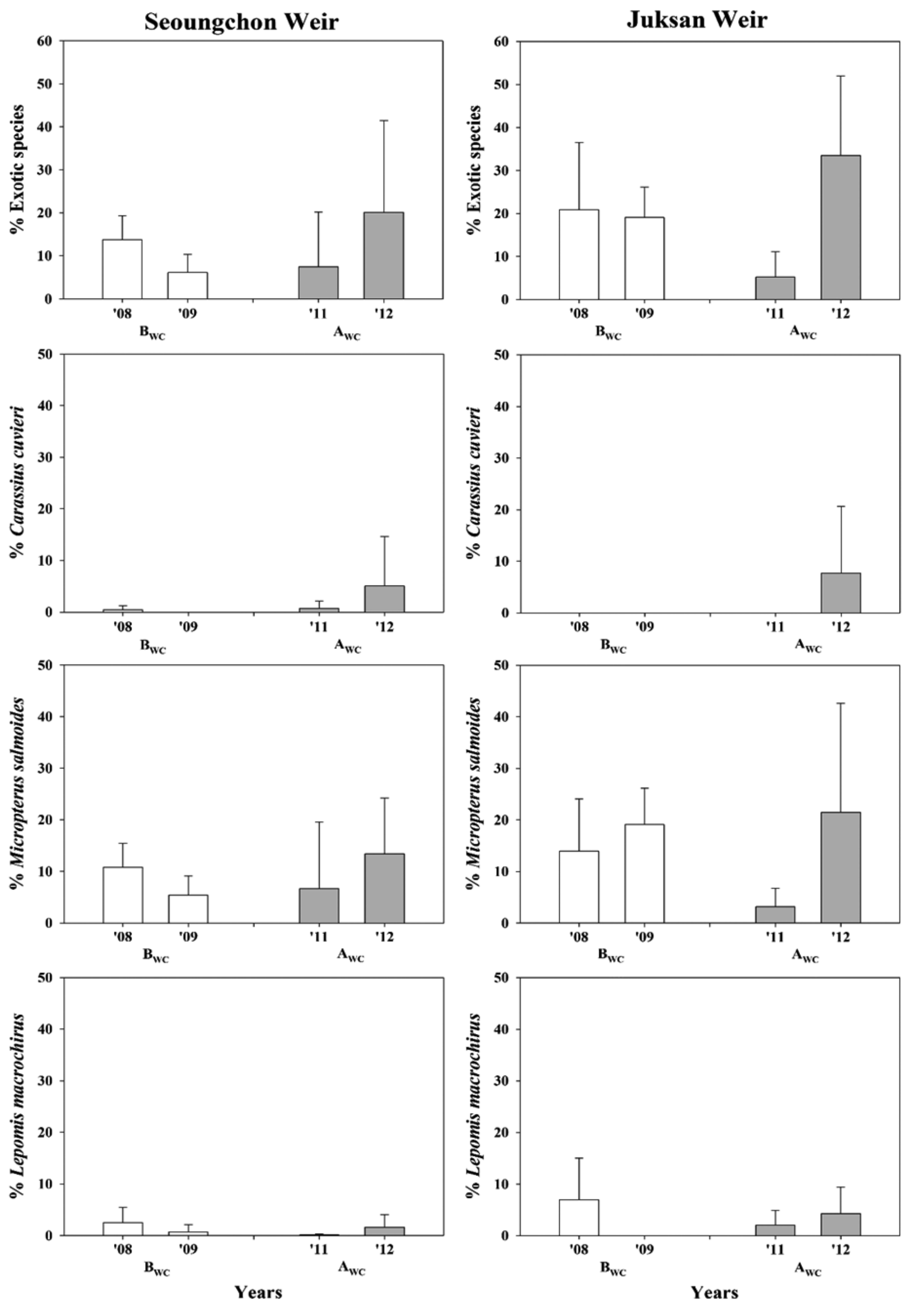

Fig. 5. Relative abundance of total exotic species and each exotic species (*Carassius Cuvieri*, *Micropterus salmoides* and *Lepomis macrochrus*) before the weir construction (B_{wc}) and after the weir construction (A_{wc}) in the two weirs of Seungchon Weir and Juksan Weir.

another factors. The factor that sensitive species emerged in both areas in 2011 was also considered to be caused by dredging river bed in the temporary water environment. According to the Yeongsan River research report, sensitive species emerged in the integrated areas of the mainstream and the tributaries. The case study site of this research was the mainstream. The differences of the emerged species showed how poor the aquatic environment was. After the weir construction, they decreased by about 20% - 25% in the Yeongsan River (including the mainstream and tributaries). There were only 0.1% of emergence in tolerant species and sensitive species. It showed the past and present environment in the Yeongsan River.

Trophic compositions and some impacts

According to the trophic guild analysis, before the weir construction, 9 species of omnivore species and 5 species of insectivore species were collected in Seungchon Weir (Table 1). Omnivore species dominated the community as 76% in the relative abundance. The Yeongsan River research (Wui et al. 1977) in 1970s reported that the numbers of omnivore and insectivore species were 14 and 15, respectively. After the weir construction, the numbers of omnivore and insectivore species increased to be 20 and 16, respectively, but since the relative abundance (RA) of carnivore species obviously increased by 33%, RA of omnivore species rather declined. According to the research by Barbour et al. (1999), the increase of stream order brought about the inflow of organic matter and the toxic material in the aquatic ecosystem that makes the simple trophic structure and ecosystem health worse.

Before the weir construction in Juksan Weir, omnivore and insectivore species were 7 and 5, respectively (Table 1). After the weir construction, 12 omnivore species and 4 insectivore species were collected. Omnivore species was 53% and carnivore species was 15% in the relative abundance. This research shows that omnivore species decreased and insectivore doubled can be interpreted that the water environment was improved. But the change of the downstream by the weir construction should be observed. Carnivore species increased by 31% which was 1.7 times. It showed the transitional ecological characteristics which interacts with the other environmental factors.

Mann-Whitney U-test was carried out to evaluate the characteristics in trophic guilds by the weir construction statistically. Its result shows that except for insectivore species, omnivore species (Z = -2.310, p = 0.021) and carnivore species (Z = -2.310, p = 0.021) have the statistical signification ($p < 0.05$). Composition analysis of trophic guilds suggested that after the weir construction, the proportion of omnivore and carnivore species increased.

Compositional modifications of exotic species compositions

Previous report of Yeongsan River showed that exotic species did not exist before the 1970s (Wui et al. 1977). Two exotics of *Carassius cuvieri* and *Lepomis macrochirus* appeared in early 1980s, and the proportion was only 0.02% of the total communities. Exotic species were composed of 1 - 3% in the relative abundance since 2000 (Song and Lee 1987, Nah 1989, Song and Kim 1995, Song and Yang 1995). In 2012, *M. salmoides* had 18% of the total, which was subdominant species in the sites (Fig. 5). Exotic species collected in this study were *C. cuvieri, L. macrochirus*, and *M. salmoides*. The three species were accounted for 10% in the fish communities. Before the weir construction, exotic species in Seungchon Weir was 6% in the relative abundance, while after the weir construction it was 13% in the relative abundance. In Juksan Weir, before and after the construction, exotic species are 18% and 26% in the relative abundance (Fig. 5). Before the construction of Seungchon and Juksan Weir, *M. salmoides* was 8%, while after the construction it is increased as 15%. The total exotic species began to emerge from 0.02% in 1980s to

Table 2. Qualitative Habitat Evaluation Index (QHEI) at four sampling sites in Yeongsan River

Habitat Parameters	Sampling Sites							
	S-U$_s$		S-D$_s$		J-U$_s$		J-D$_s$	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
M_1 Substrate / Instreamcover	8	10	3	3	3	8	3	6
M_2 Embeddedness	15	15	5	5	6	10	13	13
M_3 Flow velocity / Depth combination	13	6	3	11	3	15	13	15
M_4 Sediment deposition	18	6	6	16	16	20	20	20
M_5 Channel flow status	16	6	6	16	11	20	20	20
M_6 Channel alteration	8	6	1	1	8	8	10	13
M_7 Channel sinuosity	1	1	1	1	6	6	10	10
M_8 Bank stability	8	6	4	0	8	8	10	13
M_9 Bank vegetative protection	4	2	2	0	6	8	12	16
M_{10} Riparian vegetative zone width	9	8	0	0	5	5	10	10
M_{11} Dam construction impact	1	1	3	3	1	1	3	3
Total Score	101 (Fair)	67 (Fair)	34 (Poor)	56 (Poor)	73 (Fair)	108 (Fair)	124 (Good)	139 (Good)

S-U$_s$: Seungchon weir upstream, S-D$_s$: Seungchon weir downstream, J-U$_s$: Juksan weir upstream, J-D$_s$: Juksan weir downstream.

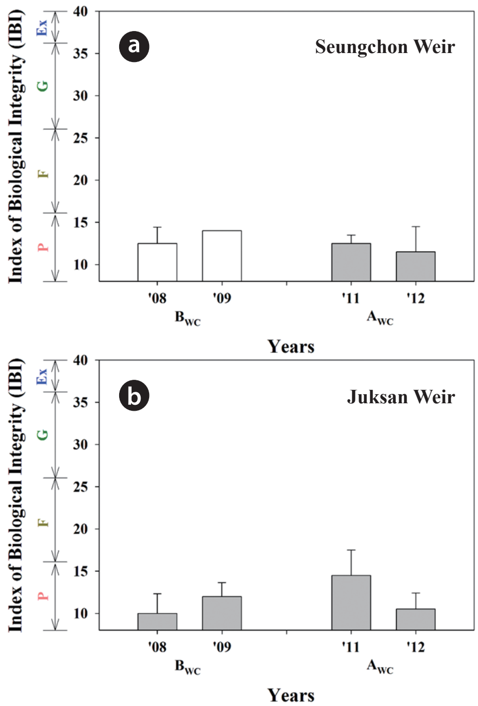

Fig. 6. River ecosystem health, based on the index of biological integrity (IBI) before the weir construction (B_{wc}) and after the weir construction (A_{wc}) in Seungchon Weir (a) and Juksan Weir (b): P, poor; F, fair; G, good; Ex, excellent.

3.2% in 2000s (Song and Lee 1987, An et al. 2007). After the weir construction, exotic species were about 12% in Seungchon Weir, and they were about 20% in Juksan Weir. Among the total exotic species, *L. macrochirus* decreased, and *C. cuvieri* increased slightly. *M. salmoides* was subdominant species with the relative strength (Fig. 5). The Yeongsan river research (MEK 2012) reported that there were no emergences of exotic species before 1970s, and there were *C. cuvieri* and *L. macrochirus* (0.02%) in 1980s. Exotic species have increased evidently from 1% to 3% since 2000. In 2012, *M. salmoides* was increased as 18%, which is subdominant species in Seungchon and Juksan weirs

Physical habitat evaluations

After the weir construction in 2011, the mean of Qualitative Habitat Evaluation Index (QHEI) was 65 in Seungchon Weir and the mean of QHEI was 111 in Juksan Weir. The physical habitat was in the "fair" condition. The result of the each section was that the average value was 45 in the "poor" condition in the downstream of Seungchon Weir, and it was 132 in the "fair" condition in the downstream of Juksan Weir (Table 2). Overall, the differences between upstream and downstream in Seungchon Weir and Juksan Weir were found in the areas influenced by the water flow, dredging of river bed, and the channelization of the river. It would cause the quality deterioration of the habitat, and to make the abundance and diversity of the species decrease. The simplification by the specific species dominance might take place.

Assessments of IBI in Seungchon Weir and Juksan Weir

The model value of IBI was evaluated in Seungchon Weir and Juksan Weir between B_{wc} (2008-2009) and A_{wc} (2011-2012). In the total assessment, the two sites were under 15 in the poor state (Fig. 6). The model value was 13 and 12 in Seungchon Weir and Juksan Weir, respectively. There were no significant differences between the B_{wc} and A_{wc} in Seungchon Weir and Juksan Weir. These results suggest that ecological health, based on the IBI, did not change during the short-term period. Long-term monitoring for the ecological health evaluations are required to detect the ecological modifications in the river.

CONCLUSIONS

Suspended solids and chlorophyll-a in the watershed of Yeongsan River increased after the weir construction and this is probably due to the increased WRT. This condition influenced the fish compositions. The large increase of exotic species (*M. salmoides*) was evident, and this may influence compositions of other prey fish. Such circumstances might have modified the ecological functions of trophic relations (food chain; omnivore *vs.* insectivore species) and tolerance compositions. The relative abundance of lotic-type fish (*Z. platypus*) decreased after the weir construction, whereas lentic-type fish increased. Overall, ecological river health, based on the Index of Biological Integrity, was judged as "poor" conditions in both periods of B_{wc} and A_{wc}. To cope with these circumstances of ecological disturbances, long-term fish monitoring are required for efficient river managements.

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