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A New Fish Biological Health Index for Assessing River Health Environment in the Muromi River Japan

Rita Lopa[1]; Hiroki Iyooka[2]; and Koreyoshi Yamasaki[3]

[1]Associate Professor, River Engineering Laboratory, Department of Civil Engineering, Hasanuddin University, Makassar, P.O. Box 90245, Indonesia. E-mail: ritalopa04@yahoo.com

[2]Associate Professor, Hydrosphere Laboratory Fukuoka University, Japan. E-mail: iyooka@fukuoka-u.ac.jp

[3]Professor, Hydrosphere Laboratory Fukuoka University, Japan. E-mail: yama@fukuoka-u.ac.jp

Abstract

This research was carried out to develop and apply a new fish-based biological health index (FBHI) to assess the river health and to diagnose the current state of the Muromi River basin in Japan. The research system was the Muromi River (33°34' 46.38"N, 130° 20' 8.7" E) class B river which flows past the city of Fukuoka prefecture, Japan and confluence destination the Hakata Bay. Data on fish assemblages collected via fishing net. We used the scientific literature and expertise from regional fish researcher to provide a comprehensive functional description of the FBHI, than we screened 14 candidate metrics from inter-regional variation in metric utility which has five main sources, all of which are illustrated in this research: the origin fish community, life history type, swimming layer, suitable flowing type and spawning ecology type. We can quickly calculate the assessment result of an FBHI score using fish data collected from a river section. Hashimoto Bridge was in much better condition than the other four locations, as the area around it exhibited a diversity of habitat types. Hamaide Weir, Hanadate Weir and Tochigawara Weir were all in poor condition, meanwhile Otoide Weir were in moderate condition. According to these results, we suggest some detail design planning to the each site referring to the lacking habitat: to construct floodplain, to make a variety of flow velocity using, and to install some spawning vegetation.

INTRODUCTION

Assessing the river health should be simplified and practical to measure. Lack of the environment assessment (EA) method is thought to be one of the reasons of the former issue. Especially, we don't have an idea that how to install the result of EA to restoration planning. This can be done with a biological index that integrates biological data within a particular indicator group. Appropriate indicators, for example collected fish community attributes, need to be tested and justified, and linked to measuring units (metrics) that can be used to index ecological condition. In this context, biological indices are used to quantify the condition or health of the river.

Biological index is a simple and informative representation of the condition of the biological community. A biological index summarizes results of the numbers, types, and condition of organisms in a particular environmental setting (streams, lake, wetlands). Indices can report narratively or numerically. Index outcomes are compared a “thresholds” to determine the overall health of a biological community (David Neils, 2012).

MATERIALS AND METHOD

Study design

A The research system was the Muromi River (33°34’ 46.38”N, 130° 20’ 8.7” E) class B river which flows past the city of Fukuoka prefecture, Japan and confluence destination the Hakata Bay. The Muromi River Basin encompasses approximately 99.1 square kilometers of catchment area and length of 15.1 km. The urban area of downstream, Muromi River river side park that spans 4.7km extension is made, it has become a place of recreation and relaxation for citizens. This park has been selected as one of the "Fukuoka amenities hundred election" in 1993.

We selected research sites from reaches of the Muromi River to represent the full spatial extent of the river and conditions along it (Figure 1). In the upper section of the Muromi River, we selected around Hamaide Weir (130.326524, 33.566347), around Hashimoto Bridge (130.325655, 33.559224), around Otoide Weir (130.325014, 33.554519) around the Hanadate Weir (130.324164, 33.540322) and around Tochiganara Weir (130.322367, 33528442) on the lowest reach. We conducted biological monitoring to assess the health of riverine environments utilizing fish.

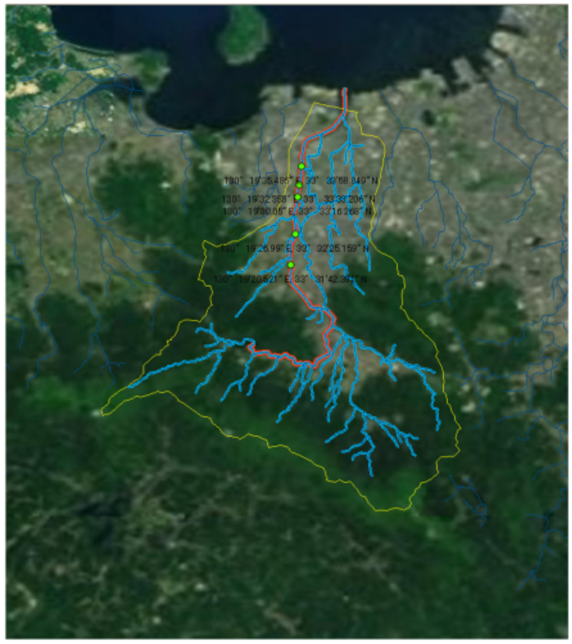

Figure 1. The Muromi River Basin

Fish Sampling

We sampled fish at each site through use of fishing net, because the site is not too deep or shallow. Sampling conducted in Summer July 10 and July 18 of 2013. Sampling sites were mainly selected based on access points (bridges, weir, fish way and roads) using topographic maps (1:50.000) and then selecting a stratified random sample. We recorded net sampling effort as the number of fish capture per square 5 meters and we classified the species. The captured fish were measured total number and length and immediately released a life.

Data collection and analysis

This Environmental Health assessment has been prepared to evaluate the potential environmental impact in Summer season. In addition to assisting with defining status and trends in watershed conditions. To assess biological condition of surface waters utilizes a multi metric approach commonly known as the Fish Biological Health Index (FBHI). This index is a scientifically validated tool that uses attributes of biological communities to assess aquatic health. We used the scientific literature and expertise from regional fish researcher to provide a comprehensive functional description of the Fish Biological Health Index. This FBHI index developed empirically for a region of interest and allow each species to be characterized according to its unique relation with the environment (place), behavior, substrate preference, and life history included spawning (substrate, vegetation, or various). Inter-regional variation in fish community, life history type, swimming layer, suitable flowing type and spawning ecology type. Fourteen metrics/criteria were screened to compare the conditions of the sampling stations for the fish ecological evaluation process: (1) native species, (2) diadromous species, (3) swimming species, (4) muddy bottom-dwelling species, (5) sand bottom-dwelling species, (6) gravel bottom-dwelling species, (7) cobble bottom-dwelling species, (8) species that live usually in flow areas, (9) species that live usually in slow flow areas, (10) floodplain species, (11) species that spawn in aquatic vegetation, (12) species that spawn on muddy bottoms, (13) species that spawn on gravel bottoms, and (14) species that spawn on rocky (cobble and bolder) bottoms. These metrics are typically evaluated with respect to criteria such as the environmental significance of the site and data availability.

Data on fish communities from 5 sites, were used to develop expectations and scoring criteria for each metric. The index value for a site was the sum of the scores for the 14 metrics. This Environmental Assessment (EA) has been prepared to evaluate the potential environmental of Muromi River. River healthiness in each reach could be explained by the counting the number of appeared fish species in research spot.

We calculated and evaluated spatial and temporal patterns of the Fish Biological Health Index (FBHI) as:

$$\mathrm{FBHI}_{ij} = 10 \times N_{\mathrm{k}ij}/N_{\mathrm{s}j} \quad (1)$$

where i is reach number (1–5), j is metric number (1–14), $N_{\mathrm{k}ij}$ is the number of species in metric j at the reach i, and $N_{\mathrm{s}j}$ is the number of species in metric j at all reaches combined. The FBHI scores represent characteristics of river health and can be used to determine which rivers (or segments/reaches) warrant restoration, and the appropriate methods. The overall FBHI was calculated in three steps: (1) each FBHI_{ij} was calculated, (2) the mean of each metric was calculated ($\frac{\sum_{k=1}^{5}\mathrm{FBHI}kj}{5}$), and (3) the FBHI_j of each metric was averaged to give the FBHI_{ij} of each reach.

We also used partly of habitat assessment by Barbour et.al, 1999. The actual habitat assessment process involves rating the nine parameters as excellent, good, fair, or poor based on the criteria included on the Habitat assessment field data sheet in Table 1.

Table1. Habitat assessment field data sheet (Harbour,et.al,1999).

Habitat Parameter	*Excellent*	*Good*	*Fair*	*Poor*
Bottom substrate available cover	Greater than 50% rubble gravel, submerged logs undercut banks or other stable habitat (16-20)	30- 50% rubble gravel, or other stable habitat adequate habitat (11-15)	10- 30% rubble gravel, or other stable habitat habitat availability less than desirable (6-10)	less than 10% rubble gravel, or other stable habitat Lack of habitat is obvious (1-5)

RESULTS AND DISCUSSION

We collected 269 fish of 7 species from the Muromi River. All species are native to the Muromi River in Japan. The Classification of fish assemblages encountered during the research in terms of Japanese common name and site groups (Tabel 2) and the data processing for FBHI model and the calculation of FBHI model metric values (Tables 3, 4).

Tabel 2. The Classification of fish assemblages encountered during the research and site groups

Species	*Hanaide Weir*	*Hashimoto Bridge*	*Otoide Weir*	*Hanadate Weir*	*Tochigowora Weir*
Plecoglossus altivelis	1	10	1	1	5
Zacco Platypus		95		13	98
Pseudogobio ecosinus		15		2	
Hydrolagus puspurences		5		1	
Rhinogobius Sp OR		3			
Carrasius auratus langdorfii		2	1		
Zacco temmincki	13		3		
Total species	2	6	3	4	2
Population	14	130	5	17	103

Tables 3. Data processing for FBHI model

Species	Axis 1 native	Axis 2 diadromous	Axis 3 swimming	Axis 4 muddy	Axis 5 sand	Axis 6 gravel	Axis 7 cobble	Axis 8 flow area	Axis 9 slow flow area	Axis 10 flood plain	Axis 11 spawning plantrow	Axis 12 spawning muddy bottom	Axis 13 spawning gravel bottom	Axis 14 spawning rock bottom
Plecoglossus altivelis	0	0	0					0					0	
Zacco Platypus	0		0					0					0	
Pseudogobio ecosinus	0				0			0					0	
Hydrolagus puspurences	0		0					0						
Rhinogobius Sp OR	0	0		0		0	0	0	0	0				0
Corrasius ouratus longdorfii	0		0					0	0	0	0			0
Zacco temmincki	0		0					0					0	

Table 4. Calculation of FBHI model metric values

Metric	indicator	Total in Muromi River	Hamaide Weir	Hashimoto Bridge	Otoide Weir	Hanadate Weir	Tochigawara Weir	Average
Metric 1	native	7	2.9	8.6	5.7	5.7	2.9	5.1
Metric 2	diadromous	2	5.0	10.0	5.0	5.0	5.0	6.0
Metric 3	swimming	5	4.0	8.0	6.0	6.0	4.0	5.6
Metric 4	muddy bottom	1	0.0	0.0	0.0	0.0	0.0	0.0
Metric 5	sand bottom	1	0.0	10.0	10.0	10.0	0.0	6.0
Metric 6	gravel bottom	1	0.0	10.0	0.0	0.0	0.0	2.0
Metric 7	cobble bottom	1	0.0	10.0	0.0	0.0	0.0	2.0
Metric 8	moving flow	7	2.9	8.6	5.7	5.7	2.9	5.1
Metric 9	slow flow	2	0.0	10.0	0.0	0.0	0.0	2.0
Metric 10	floodplain	2	0.0	10.0	0.0	0.0	0.0	2.0
Metric 11	spawning plantrow	1	0.0	10.0	0.0	0.0	0.0	2.0
Metric 12	spawning muddy bottom	0	0.0	0.0	0.0	0.0	0.0	0.0
Metric 13	spawning gravel bottom	4	2.5	7.5	7.5	7.5	5.0	6.0
Metric 14	spawning rock bottom	2	0.0	10.0	0.0	5.0	0.0	3.0

1. Hamaide Weir. This location consisted predominantly (80%) of fast-current shallow habitats (2 riffles/rapids, 4 runs, 4 glides) and very few slow-current habitats (pools) about 10 cm in mean depth. Some vegetation occurred in approximately 10% of the channel. We found only 2 species at this location: *Plecoglossus altivelis* (1 individuals) and *Zacco temmincki* (13 individuals). This location was considered to be in poor condition, as all metrics were well below the average (Figure 2).

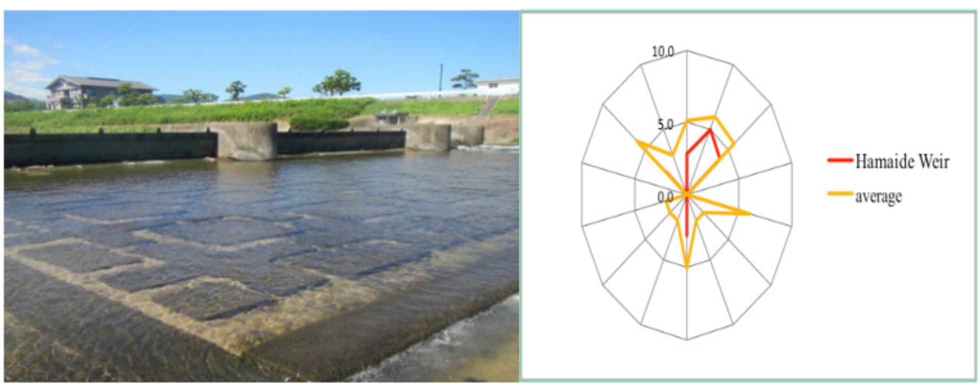

Figure 2. Spider plot of Hamaide Weir.

The state of Hamaide Weir site was poor too based on habitat assessment by Harbour, which is the bottom substrate available cover less than 10% rubble gravel.

2. Hashimoto Bridge. This location consisted predominantly (91%) of fast-current shallow habitats (2 riffles/rapids, 4 runs, 6 glides) and very few slow-current habitats (pools) about 18 cm in mean depth. Some vegetation occurred in approximately 80% of the channel. We found 6 species at this location: *Plecoglossus altivelis* (10 individuals), *Zacco platypus* (95), *Pseudogobio esocinus (15), Hydrolagus puspurescens* (5), *Rhinogobius* Sp. OR (3), *Carassius auratus langsdorfii* (2). This location was considered to be in good condition, as all metrics exceeded the average values (Figure 3), with the exception of metrics 4 (muddy bottom species) and 12 (species that spawn in muddy bottom).

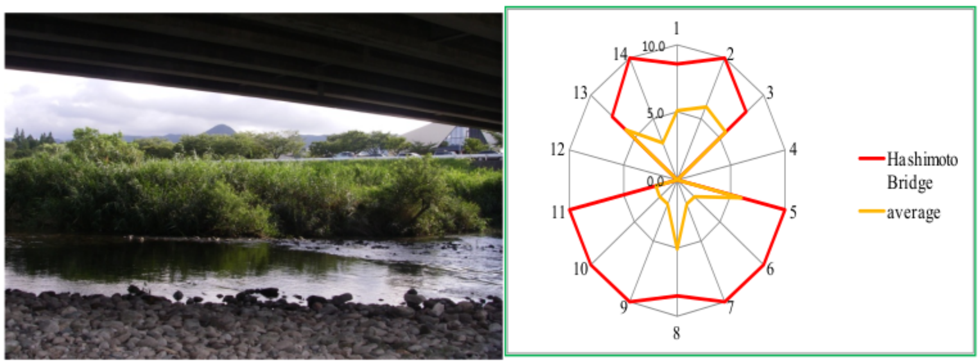

Figure 3. Spider plot of Hashimoto Bridge

The state of Hamaide Weir site was poor too based on habitat assessment by Harbour, which is the bottom substrate available cover.

3. Otoide Weir. This location consisted predominantly (91%) of fast-current shallow habitats (6 riffles/rapids, 4 runs, 6 glides) and very few slow-current habitats (pools) about 12 cm in mean depth. Some vegetation occurred in approximately 90% of the middle channel. We found 3 species at this location: *Plecoglossus altivelis* (1 individual), *Carassius auratus langsdorfii* (1) and *Zacco temmincki* (3). As a result, the index scores for Otoide Weir partly were lower than average and partly were higher than average, and it was considered to be in moderate condition, Figure 4.

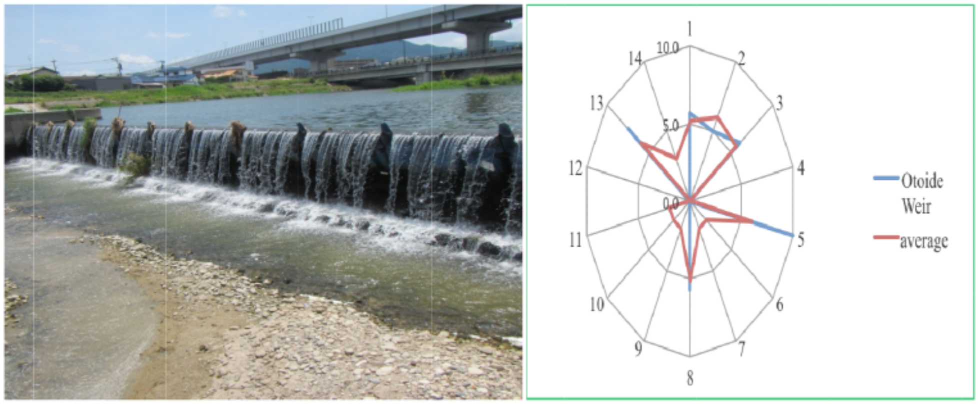

Figure 4. Spider plot of Otoide Weir.

4. Hanadate Weir. This location consisted predominantly (80%) of fast-current shallow habitats (2 riffles/rapids, 4 runs, 6 glides) and very few slow-current habitats (pools) about 12 cm in mean depth. Some vegetation occurred in approximately 10% of the channel. We found 4 species at this location: *Plecoglossus altivelis* (1 individual), *Zacco platypus* (13), *Pseudogobio esocinus (2),* and *Hydrolagus puspurescens* (1). As a result, the index scores for Hanatate Weir were low, and it was considered to be in poor condition, Figure 5.

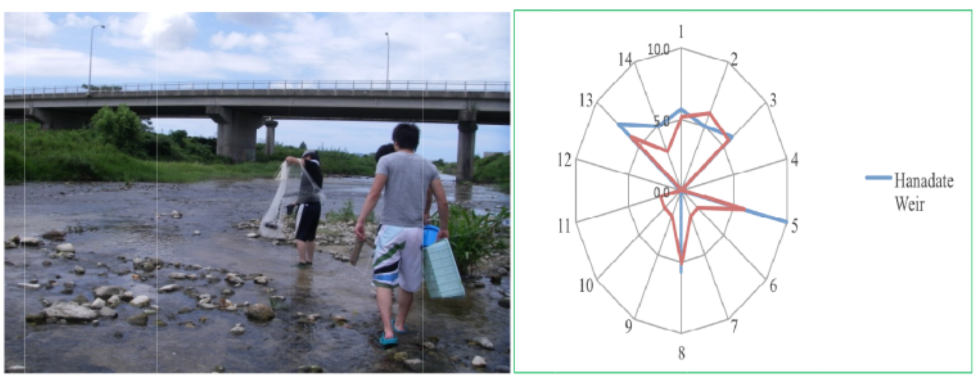

Figure 5. Spider plot of Hanadate Weir.

5. Tochigawara Weir. This location consisted predominantly (90%) of fast-current habitats (8 riffles/rapids, 4 runs, 6 glides) and very few slow-current habitats (pools) about 25 cm in mean depth. Some vegetation occurred in approximately 85% of the channel. We found 2 species at this location: *Plecoglossus altivelis* (5 individuals) and *Zacco platypus* (98). This location was considered to be in poor condition, as all metrics were well below the average, Figure 6.

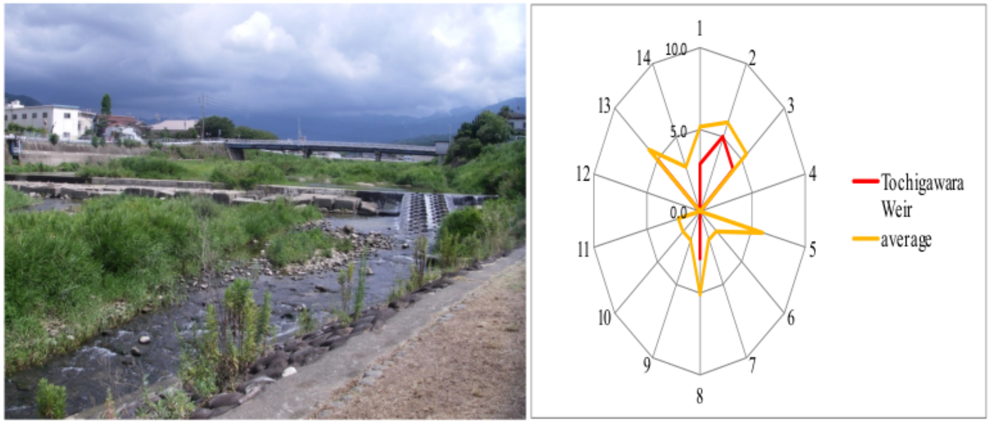

Figure 6. Spider plot of Tochigawara Weir.

From the comparison, evaluation using the fish index explained field environment well, and it was confirmed to be an available method to understand the present environment of the Muromi river. From the result of the evaluation, it is identified that quality of the environment is widely different from site to site and lacking habitat at each site is also verified.

It is expected that, with appropriate management, the ecological health of the Muromi River in this region can be restored and that the Muromi River can become a healthy river that both restricts sand movement further downstream while providing stock watering requirements for the community.

CONCLUSION

Hashimoto Bridge was in much better condition than the other four locations, as the area around it exhibited a diversity of habitat types. Hamaide Weir, Hanadate Weir and Tochigawara Weir were all in poor condition, meanwhile Otoide Weir were in moderate condition. This assessment will allow us to determine which indicators are particularly weak at specific locations throughout the river. According to these results, we suggest some detail design planning to the each site referring to the lacking habitat: To construct floodplain, to make a variety of flow velocity using, and to install some spawning vegetation. Our results support the value of the fish biological integrity index for making preliminary diagnoses of ecological quality, thus through the use of this index and the characterization of the flow ecology, improvement programs can be established at the exact locations.

Acknowledgements

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REFERENCES

Barbour (1999). "Habitat Assessment Field Data Sheet – High Gradient Streams".

Cam Stevens and Trevor Council (2008). "A fish based index of biological integrity for assessing river condition in central Alberta". Technical Report, the Alberta Conservation Association, Sherwood Park and Lethbridge, Alberta, Canada. 29 pp. + App

David Neils (2012). "Biological Index Development: Start to Finish". New Hampshire Department of Environmental Services.

Jun Nakajima, Yukihiro Shimatani, Rei Itsukushima and Norio Onikura(2010). "Assessing riverine environments for biological integrity on the basis of ecological features of fish". Advanced in river engineering, Vol.16, p. 449-454.

Rita Lopa (2012). "An evaluation of river restoration effectiveness in a housing land development area". The University of Kyushu, Japan, Dissertation.

The Trust for Public Land (2010). "Return on the Investment from the Land and Water Conservation Fund".

Yukihiro Shimatani (2000). "Ecological Health; Evaluation and Restoration of River Ecosystems", Japan.

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