# INFLUENCES OF RIVER CHANNEL PLANAR SHAPES ON CHARACTERISTICS OF FISH HABITAT IN SMALL-MIDDLE SIZED STREAMS

KAZUAKI OHTSUKI
*Aqua Restoration Research Center, Public Works Research Institute Japan, Gifu, Japan, k-ootsuki55@pwri.go.jp*

MORI TERUTAKA
*Aqua Restoration Research Center, Public Works Research Institute Japan, Gifu, Japan, t-mori@pwri.go.jp*

KEIGO NAKAMURA
*Aqua Restoration Research Center, Public Works Research Institute Japan, Gifu, Japan, nakamura-k573bs@pwri.go.jp*

YUICHI KAYABA
*Water Environment Research Group, Public Works Research Institute Japan, Ibaraki, Japan, kayaba@pwri.go.jp*

## ABSTRACT

Changes in planer shaped of river channel is affected on river environment. However, knowledge about relations between channel shapes and river environment including river morphology and fish assemblages is not enough so far. In this study, we provide some patterns of hydraulic environment and fish fauna in bending and partial widening reaches in point of comparing on straight reaches based on field survey data in small-middle sized rivers in Japan. As a result, from the viewpoint of the physical habitat properties, bending part typically provide high diversity in depth and velocity by creating pools, while the widened part was uncertain in giving habitat diversity. It strongly relates to invading plants. In point of fishes, there are some differences in dependence on each focused reach. Percentage of fish species found in bended area is larger as fish assemblage in the river is rich but that in widening reaches is opposite. It was suggested that there is a characteristic in the "positive effect" brought to the river channel by the planar shape of the river channel.

*Keywords*: River Channel Morphology, Small- and Medium-Sized River, Habitat formation, Fish Assemblage

## 1. INTRODUCTION

River channel shape consists of its horizontal position, vertical shape and cross-sectional shapes, which are planed for each other in river work. Although there is no clear standard has been set for horizontal shapes of river channel in Japan, it is important because of a great influence on river environment through formation various river morphology. Recent heavy rains have caused disasters with large amounts of sediment and driftwood (Chaithong et al., 2017, Miyazaki et al., 2018), and it has been discussed to actively adopt river channel widening as a buffer zone to reduce damage. Thus, it is thought that flood protection and environmental rehabilitation can be compatible with the design of the river channel. Several examples of local river widening for riverbed stabilization and environmental rehabilitation (Rohde et al., 2005). However, the relationship between the plane shape of the river channel and the river topography and river environment was not sufficiently investigated.

In this study, we investigated the relation between river topography, physical environment and fish fauna by conducting field surveys at multiple points of small and medium rivers and comparing them for each planar type such as straight section, curved section, and widened section.

## 2. MATERIALS AND METHODS

We selected study sites to compare straight section (STR), bended section (BND) and widened section (WDN) in each target rivers. The site length was approximately 200m. Finally, we conducted the surveys in 24 sites in 11 target rivers with a bed gradient of about 1/70 to 1/400 in Japan (Figure 1). In this survey, we investigated topography, flowing water environment and fish fauna in each site. Concretely, SfM-MVS analysis with UAV taken photos for morphological survey, distributed measurements of depth and velocity and fish sampling with kicking method. It required to complete the survey is about 90 minutes for four researchers.

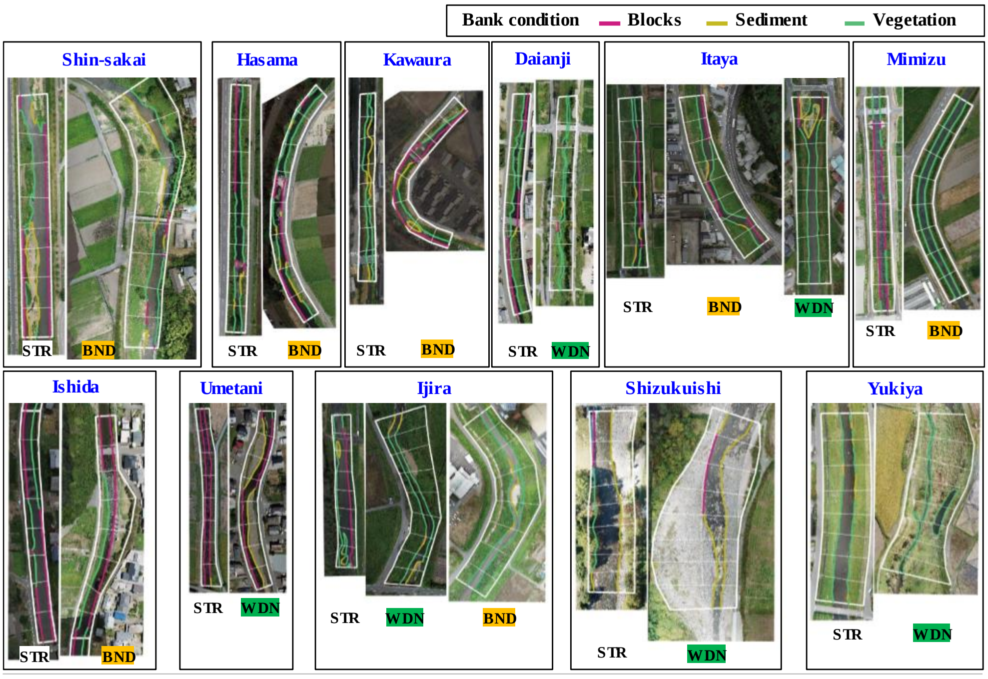

Figure 1 Study sites.

## 3. RESULTS AND DISCUSSIONS

### 3.1 Physical habitat formation and its diversity

Figure 2 show scatter diagrams of water depth and velocity observed in each plane shape type area in same river to overview the correspondence to flowing condition. Hatchings in these plots indicate ranges of depth and velocity in riffle and pool habitat as a guide as follows: The flow rate should be above 20cm/s. Compared with the straight section (gray plots) and the curve section (yellow plots) shows a part with a larger water depth which can be taken as pool than the straight section, however, this tendency is weak in bended part (green plots, lower part in Fig.2).

Bed scouring is occurred by alternate bars formation and curvature. It is known that the water depth of the pool observed in the local river has a linear relationship where the former is the intercept and the latter is the slope to B / r. The results of this study also correspond to this, and it is difficult to obtain a deep pool in the widened part because it is limited to alternate sand scouring, and it is easy to obtain a deep pool in the curved part even with the same river width. Figure 3 shows relations between sharpness of channel bend ($r/B$: ratio of curvature radius and channel width) and deepness of pool ($H_{max}/H_{maxs}$: ratio of maximum depth in straight part and all section). Red circles indicate that pool condition was obtained. The lines are the results obtained from model experiments and field data. The plots in condition of $r/B$ <10 in Fig.3 tend to be $H_{max}/H_{maxs}$ >= 1 indicating existence relatively deep part. However, the pool is not always formed at the bended part. In the Ishida River which represents gentle curve and narrow channel width, high velocity is also observed in deep part.

In the widened part, it tends to have a lower flow velocity and larger water depth than the straight part (Fig. 2, lower part). It means that flow environment could get diverse for channel widening if its condition is

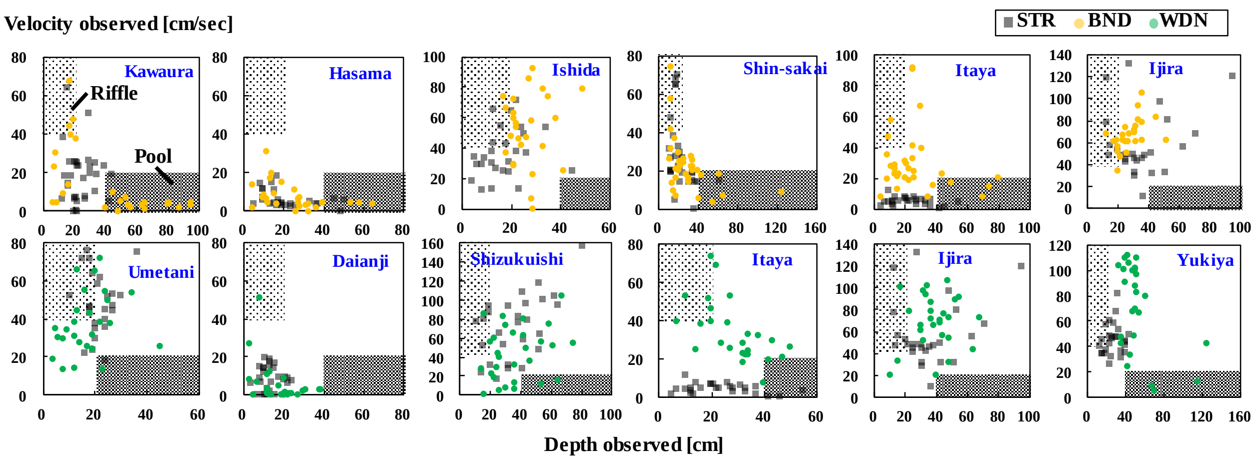

Figure 2 Relationship of water depth velocity by location. The black, yellow, and green plots show the data for the straight, bended and widened sections, respectively.

monotonous (Daianji and Itaya River, for example). However, the environment does not always diversify with respect to widening. In the Yukiya River, the deep and high velocity condition is dominant in the widened reach. It caused by channel shrinking for sediment trapping and plant invasion on it. Channel shrinkage is often triggered by fine sediment accumulation in large river channels (Formann and Habersack, 2007), but sand bar formation is also important for this in small and medium-sized rivers with steep slopes and large amounts of bed load. Thus, channel widening may not necessarily result in increased flow diversity or riffle and pool formation.

Figure 4 indicated correspondence between steepness of channel bending and change in flow diversity. Two axes ($\Delta CV$) represent normalized difference of standard deviation of depth and velocity calculated by comparing values in straight reach to another (bended or widened part) in same river. In the figure, A larger value means that the presence of a curved part or widened part has greater environmental variability than the case of a straight part alone. The plot size is $B/r$ (the larger the value, the steeper the bend). As results shown, many large plots can be found in the first quadrant where the variability of both depth and velocity increase, suggesting that bend can increase environmental variability.

On the other hand, we also found cases represent large $\Delta CV$ but small plot (mild curve) or small $\Delta CV$ but large plot. It means bend does not necessarily cause flow variability. As mentioned above, the bend promotes a specific environment like pool, however flow condition was affected by like sedimentation and vegetation, too. These factors also greatly depend on time from complete of river work. Although the elapsed time after the maintenance in the targets are deferent each other, these results like Fig. 4 suggest that the contingency of the response by channel bending to flow environment is greater than channel widening.

## 3.2 Changes in fish assemblage

A total of 32 species of pure freshwater fish including three domestic and foreign invasive species were caught in this study. We found more species in bended part or widened part than in straight part in 6 of 11 rivers, which indicate changing in channel planer shape does not always bring increasing diversity. Although it would be not enough data, we treat only native pure freshwater fish (29 species) in following analysis.

In the analysis, we count the number of species found in straight part ($N_1$) first. Next, we also pick up fish species only in bended and widened part ($N_2$). Using these numbers, we plot Fig.5 indicating relations between species richness (x-axis) and dependency on bended or widened part (y-axis) for each river. Figure 6 is the plot showing

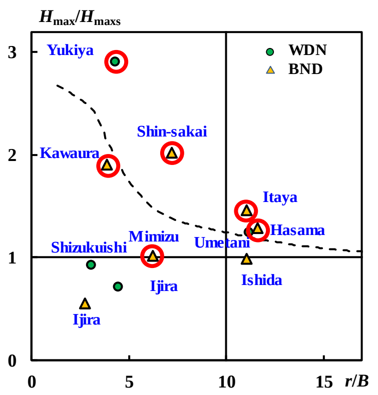


Figure 3 Relationship between ratio to maximum water depth of straight section ($H_{max}/H_{maxs}$) and $r/B$

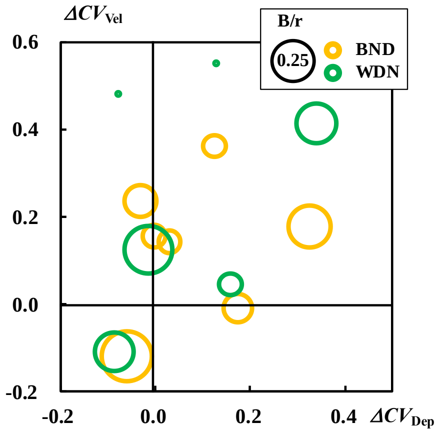


Figure 4 Relationship between $B/r$ and increase in diversity of water depth and velocity

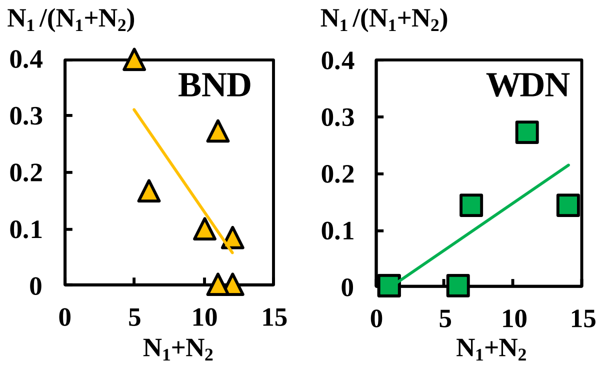


Figure 5 Percentage of species found only in river-plane changes in the appearance of straight and flat changes. (left: bended part, right: widened part)

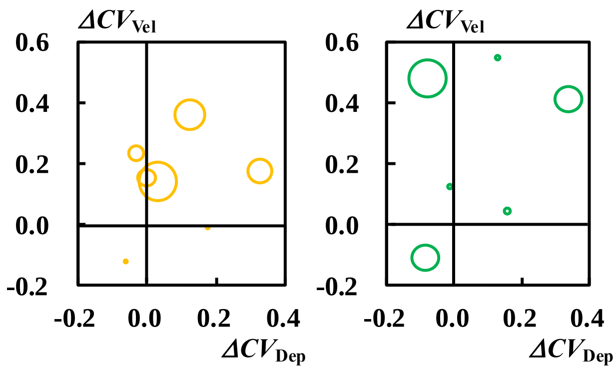


Figure 6 Relationship between diversity addition of water depth and velocity and specificity of confirmed fish species (left: bended part, right: widened part)

correspondence fish dependency (plot size, same as y-axis value in Fig.5) to increasing of flow condition variability (each axes).

As shown the Fig.5, tendency between richness and dependency are different for types of channel shapes. Concretely, ratio of species found only in bended part can be higher in poor river condition. On the other hand, that in widened part can be higher in rich river condition. In addition, the dependency on bended part suggest a relationship in increasing variability in flow velocity and water depth (Fig. 6, left), however we cannot find clear relation about it in widened part. We assume that these tendency in bended part is related to the high typicality of the formed habitat (eg, pool). In terms of widened part, it is likely that specific habitats (eg, eddy or sandy substrate) are likely to be formed under this condition. As mentioned, the response of change in channel form differs for bending and widening. The effects of diversification of flow velocity and water depth on fish assemblage due to changes in plane shape should be considered for each type of change given in river works.

## 4. CONCLUSIONS

In this study, we tried to understand the impact-response relationship of the physical environment and the inhabiting fish to the change of the plane shape of the channel in small and medium rivers. The results obtained are summarized below.

The widened part and the curved part were compared based on the straight part, and the relationship was evaluated by focusing on the formation of the pool. The pool is well formed in the curved part but not always in the wide part. The standard of the steepness of the curve where a pool with a characteristic depth is formed in the curved part is about $r/B$ <10.

If the original environment is monotonous in the widening area, the diversity of the flowing water environment will increase greatly. However, when the width is greatly widened, remarkable shrinkage of the streaks occurs due to sedimentation and plant invasion, and the target riffle-pool environment may not be formed.

Comparing the fish fauna between the straight part and the flat part, it was found that the habitat created differs between the curved part and the widened part, resulting in a difference in the reactivity of the inhabiting fish.

## REFERENCES


Anderson, R. J., Bledsoe, B. P., Hession, W. C. (2004). Width of streams and rivers in response to vegetation, bank material and other factors. J. American Water Resources Assoc., 40(5): 1159-1172.

Chaithong, T., Komori, D., Sukegawa, Y. (2017). Woody debris rectuitment caused by dizasters related to tropical strom NAMADOL (2017) in headwater of Asakura City , Fukuoka, Japan, 4th Int. Conf. Science, Engineering & Environment (SEE), Nagoya, Japan.

Miyazaki, T., Sawada, M., Matsuoka, N., Tachikawa, Y., Takashima, S., Yoshida, Y., Hayashi, S., Furuichi, T., Kasai, M., Osanai, N., (2018). Large sediment discharge caused by periglacial slope failures and erosion induced by Typhoon Lionrock (2016) in Pekerebetsu Creek, Hokkaido, Japan. J. Japan Society of Erosion Control Eng., 71(2): 22-33.

Rohde, S., Schütz, M., Kienast, F., Englmaier, P. (2005). River widening: an approach to restoring riparian habitats and plant species. River Research and Applications, 21(10): 1075-1094.