

ON THE CONSISTENCY OF CONSERVATION OF FRESHWATER FISH
AND 'SABO' WORKS IN STREAMS.

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Goichiro Takahashi (1990) On the consistency of freshwater fish and "sabo" works in streams. *Bull. Inst. Zool., Academia Sinica* 29 (3, Supplement): 105-113. Fish habitat in streams is made worse by sabo works which are control of erosion and sedimentation, through two major processes: dams obstruct fish passage and channel works eliminate the environmental multifariousness of fish habitat. Although fishway is a means to solve the problem of fish passage, fishways attached to sabo dams involve many problems. Adoption of combination of the method of low dams series and simple pool-type fishway is recommended. Grasping nature of a stream and performing proper channel works in accordance with the nature possibly enables desirable channel works that satisfy both prevention of disaster and conservation of fish habitat. In order to avoid excessive sabo works, it is important to understand sabo works and proper treatment of watershed.

Key words: Conservation of fish habitat, Environmental multifariousness, Erosion control engineering, Fishway, Method of flow dams series

Sabo works, which are control of erosion and sedimentation for the sake of our lives and property, are undoubtedly necessary means for our safety. It is very common that sabo works threaten fish in streams. Keeping fish habitat in good condition is also important in terms of both biological aspects and an environmental issue to people. In this context, I emphasize that the both subjects, which are sabo works and conservation of fish habitat, must not exclude each other. They have been practically opposed to each other, however, we must aim to let the both subjects work out altogether.

The problem of consistency of conservation of freshwater fish and sabo

works in streams is composed of two levels. Level 1 is of technical issues: Are such sabo works possible that never give any damage to fish habitat? If possible, how are they? Since sabo works which are harmless to fish habitat do not materialize yet, to give precedence to protection of human beings from suffering natural disasters would bring great misery to fish, and if fish habitat is intended to be protected perfectly, sabo works must have great constrictions. Here, issues of level 2 arise: How these contradicting two problems would reach to a compromise under certain social circumstances and the natural environment. The issues of level 2 are rather social than those of level 1.

These two problems are not independent at all. Even if the consistency of

habitat conservation and disaster prevention is perfectly possible, the costs for them must be extraordinarily higher and much more space must be spared for stream section. Extra costs and more space are both very difficult problems which would not be easily accepted by citizens. In a stream that penetrates a developed area with dense population and in a stream that are subject to such natural events which very likely cause disasters, enough sabo works must take precedence over conservation of the natural environment. However, in many streams, especially in streams where rare species or races inhabit, conservation of the environment should be primarily considered. The most important thing is that conservation of fish habitat and prevention of disasters must be arranged within the technical limitations of stream management. From this point of view, the limitations must be discussed in detail.

CONTROL OF EROSION AND SEDIMENTATION IN STREAMS

Harmful events which may take place in a stream are as follows: debris flow, extraordinary deposition which may form a natural dam; change of channel course, both abrupt change and gradual change accompanied by lateral erosion; remarkable gradation and degradation of stream bed especially in a fan or a floodplain. In order to prevent disasters caused by these natural events, some works as below are usually combined and set to a watershed basin:

1) Hillside works to prevent landslide and collapse. To be concrete, they are stepping, grating crib works, soil retaining works, planting works and so on. These

works are usually constructed on a slope and hollow.

2) Dams in gullies to prevent erosion.

3) Dams streams to cut off all or part of debris flow and moving gravels. The dynamic type of flowing water and gravels is changed into more tranquil type by the expanse of depositional area which is formed behind a dam.

4) Ground sills and bed girdles to prevent degradation.

5) Levees and revetment works to fix channel course and to prevent overflowing.

The latter three works are constructed in streams, and they cause influences on freshwater fish. The influences are divided into two types. One is that dams do not enable fish passage. The other one is that the quality of fish habitat is devastated by channel works, straightening of channel course and excavation of channel section, construction of revetment works, etc. The channel works change rugged stream bed into flat terrain and chaotic water flow into monotonous regime (Fig. 1).

PROBLEMS CONCERNING DAMS

Basically the purpose of a sabo dam is to control bed load movement. Accumulation of sediments, which can be a means of controlling bed load movement, is not a primary purpose of a sabo dam. This matter does not necessarily mean that the bigger a dam is, the better it is. A well-known means that ensures fish passage is attachment of an efficient fishway to a dam. Concerning fishway, it is widely recognized that the higher a dam is, the more difficult and the more expensive to attach an efficient fishway is. Fishway

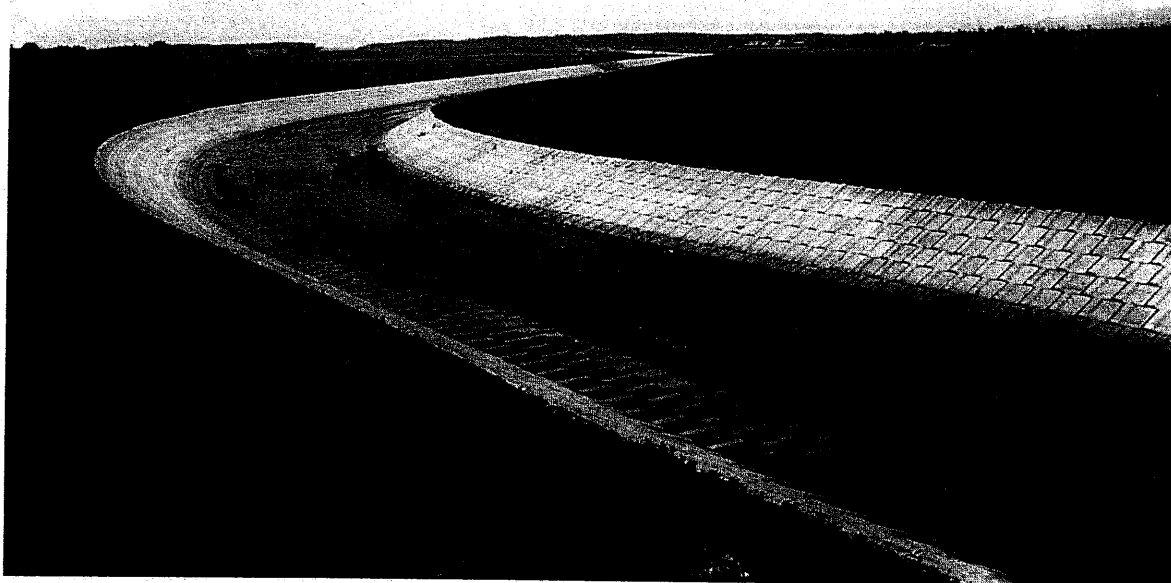


Fig. 1. A stream of which original microtopography and flow condition were changed into monotonous regime. These changes do fish habitat great harm.

attached to a sabo dam has technical disadvantages that the sabo dam is subject to attack of debris flow, logs and remarkable fluctuation of water level, and that it has lots of constraints in terms of location for the attachment (Tazawa et al., 1982). In addition, fishway attached to a sabo dam has not been studied enough and the technology of fishway is not established yet (Takahashi and Higashi, 1980). There is a law easily understood by both intuition and experience: the lower a dam is, the easier attachment of a fishway is.

It is said that dams with certain heights have three major purposes (Fig. 2). The first purpose is to keep sediments behind a dam not being eroded; here the sediments mean those gravels and soils existed where the dam was constructed. The second purpose is to accumulate sediments. And the last purpose is to regulate

bed load movement by reducing the bed gradient on sedimentation area behind the dam and by extending sedimentation area. The last function means regulation of bed load movement by the height of a dam. In contrast with this way, there is another idea that sedimentation is regulated by plane expanse around streams.

Stream geomorphology is not uniform. Concerning stream widths, they vary spatially. In some sites, stream widths are in narrow forming canyons. In other sites valley side slopes are set apart, and wide areas with relatively low gradients are formed. Major sediments are not deposited in canyons but in wide areas. In other words, canyon is an area where the sediments go through, while a wide area functions as storage of sediments and gravel source to downstream reaches (Fig. 3). Utilizing these characteristics of a wide area, a method of con-

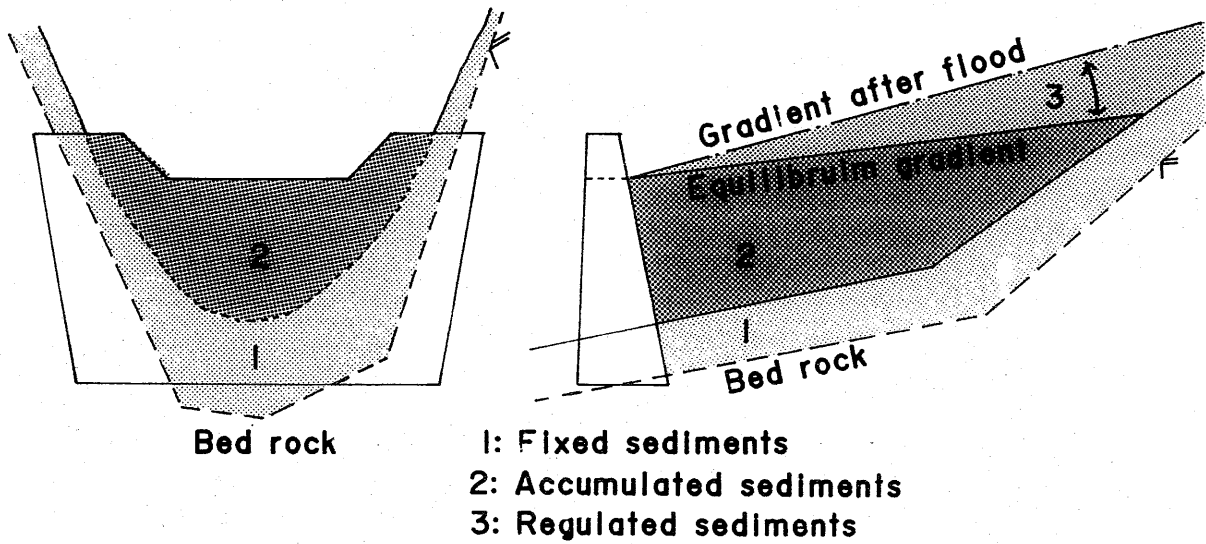


Fig. 2: Function of a sabo dam. A sabo dam prevent sediments which had already deposited from being eroded. It accumulates sediments behind itself, and it regulates bed load movement on the sedimentation area.

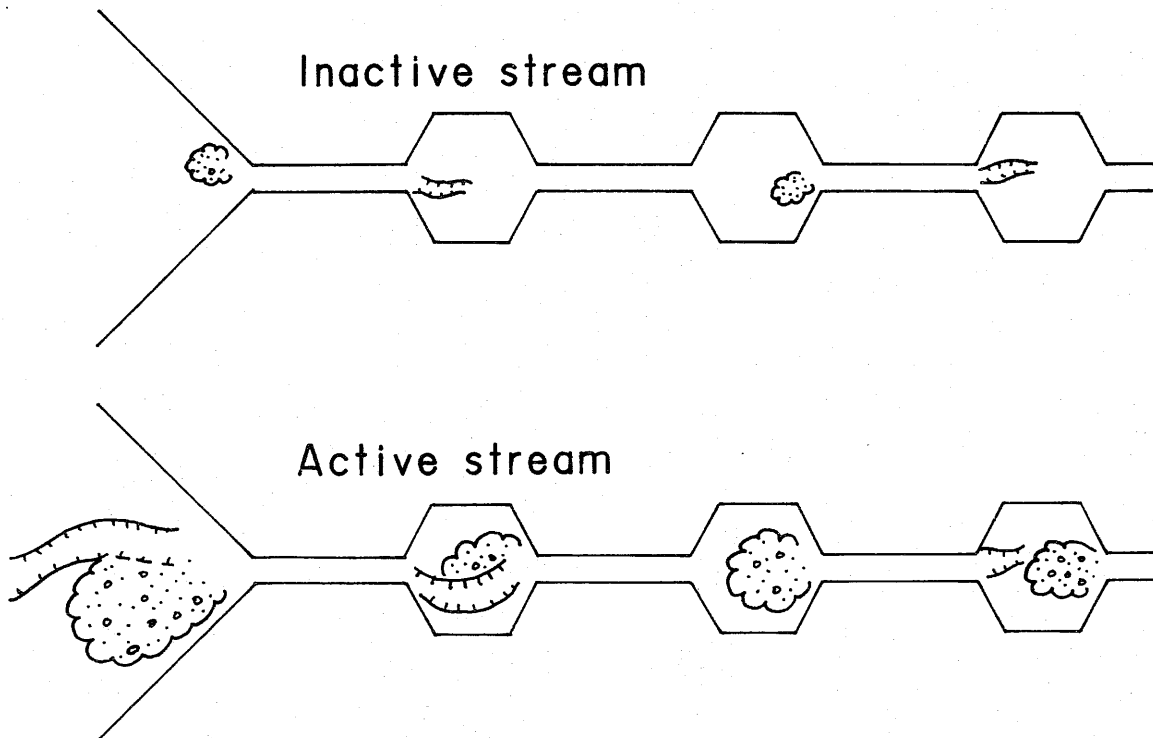


Fig. 3. Nature of natural streams. Difference between active and inactive streams in terms of bed load movement is shown in a schematic way.

trolling sedimentation without high dams has been developed (Higashi, 1982). By putting a combination of three or more dams into a wide area, sediments are prevented from being eroded, and at the same time debris flow or transported gravels from upstream are stimulated to deposit there by the spatial extent. Each dam is 1 to 2 meter high with enough width, to touch both valley side slopes. The distance between a dam and the next dam is about 50 meters. This way is called the method of low dams series. The low dams series is much advantageous in ensuring fish passage because of the low heights of the dams. Takahashi et al. (1986a, 1986b) designed a simple pool-

type fishway, which was attached to a low dams series (Fig. 4). And they made clear that pink slamon (*Oncorhynchus gorbusha*) could pass the dam series.

In order to settle debris flow down, the low dams series should be set first on a head part of a fan or floodplain where objects to be protected exist. According to the activity of bed load movement in a watershed, low dams series is to be installed in wide areas from downstream to upstream in order (Fig. 5). Installation of the low dams series must not be overdone in light of the activity of bed load movement to avoid providing extra obstacle to fish. As a matter of course, efficient fishway must be attached to each



Fig. 4. Combination of low dams series and a simple pool-type fishway. The fishway was attached to a low dam which was located downstream.

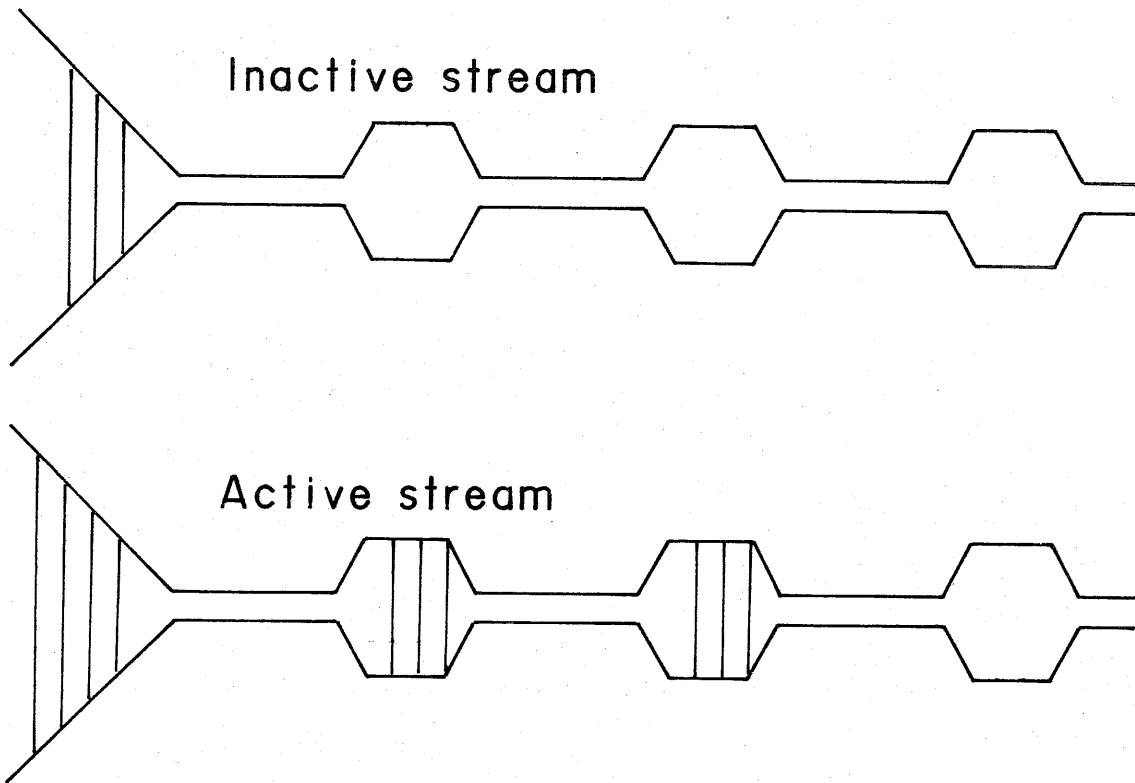


Fig. 5. Sabo plan with the method of low dams series. Scale of the plan must be decided in accordance with the activity of bed load movement in streams.

dam series. These arrangements attain efficient control of bed load movement ensuring fish passage.

PROBLEMS CONCERNING CHANNEL WORKS

Channel works are performed in a fan or floodplain to which inflow of sediments from upper reaches are small enough. The purposes of the channel works are to let floods pass quickly through areas that are to be protected safely. In order to fix channel courses and to prevent both scour to stream bed and lateral erosion of stream bank, channel courses are regulated and channel sections are often excavated into trapezoidal form,

ground sills and bed girdles are set and levees, reinforcement of banks are built. These works eliminate multiformity of stream microtopography, flowing condition is consequently changed into monotony. Sequence of riffles and pools is declined, thereby large extent of a stream is transformed into shallow and riffle-like regime. These changes mean devastation of environmental multifariousness, inducing decrease of fish population (Takahashi and Higashi, 1984).

Fish shares stream space in accordance with species of growth stages, in other words, preferences to the environment, and in accordance with competition. Consequently, for the sake of protection of fish habitat, it is the most basic principle

to make much of complex facets of environmental factors. With regard to channel works, variety of stream microtopography must be preserved both longitudinally and transversally as much as possible. Straightening of channel courses, which induces shortening of channel length and hence increase of bed gradient, must be particularly avoided, because ground sills are customarily set to prevent undesirable scour of stream bed caused by the increase of bed gradient and the sills would obstruct fish passage.

There are many problems in planning of plane form of channel courses where bed load movement is active. In a channel where the bed load movement is negligible, it is very easy to design proper form and to maintain it, on the other hand active movement of bed load makes upkeep of stable channel difficult; in actual design of channel works of a torrential stream plane form is decided through experiments using hydraulic models. Thus there is no simple way of channel form design, and straightening of channel courses do not have firm hydraulic basis but the straightening is thought to be assertive in connection with the advantage of congested land use. The more inactive a stream is, or the smaller a stream is so that the magnitude of flood is absolutely small, the more remarkably the stream is altered into straight form. Because, in such streams, power of flooding does not exceed the strength of artificial materials of channel works.

A key point to conserve the stream environment is that we must aim for development of such technology that can control flood safely, preserving original diversity of stream microtopography as much as possible. Researches on the

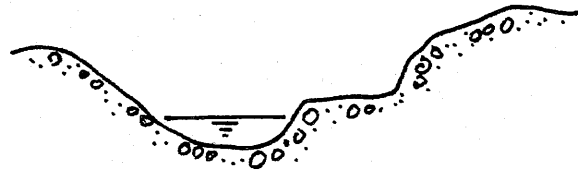
history of bed load movements and channel course changes can make clear some characteristics of a stream dynamics, and then some vulnerable points can be picked out (Takahashi and Sasa, 1985). Here, the vulnerable points mean that some violent events such as abrupt change of channel courses or extraordinary deposition are predictable there in the near future. By installing efficient works around the vulnerable points the channel course would be well fixed without straightening the channel too much.

Cross section of a stream also should not be excavated into trapezoidal form. Ikeya (1978) proposed a channel works design which makes much of the original shape of stream cross section (Fig. 6). In addition, if revetment works are constructed by rubble works using large boulders around the stream or by wickerwork using willow and alder, diversity of the natural environment is preserved and fish habitat is kept in good condition.

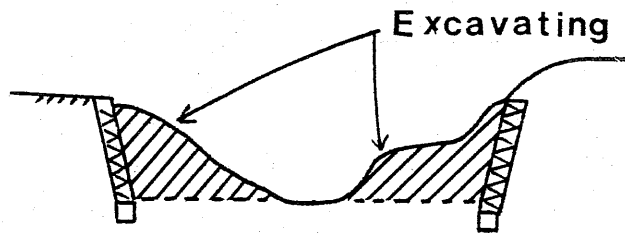
SOCIAL CONCERN TO STREAM MANAGEMENT

Concerning the issues of level 2, which are mentioned in the head part of this paper, I emphasize two important matters: One is proper treatment of drainage basin, and the other is restriction of land use in a fan and a floodplain.

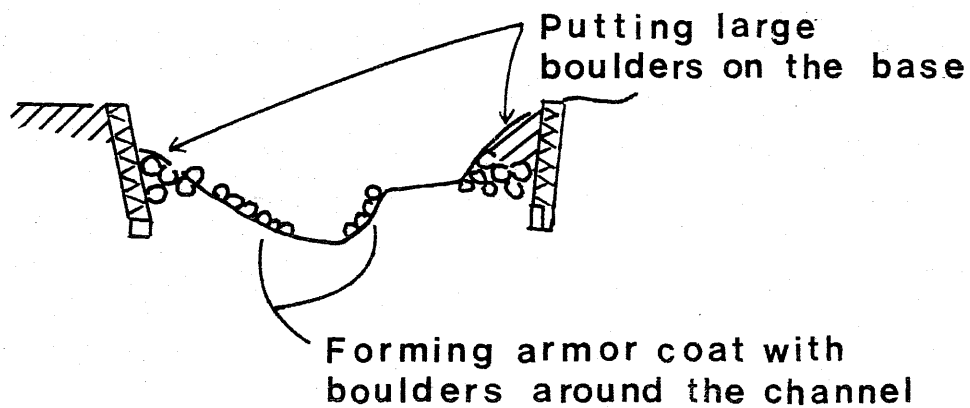
Improper cutting of timbers ignoring the nature of forests changes the hydrological regime of a watershed basin and also it may cause excessive hillslope failures. Crude and careless construction of mountain roads is a typical cause of increasing sediment yield. If extra sediments are supplied to a stream, the



a. Original channel section



b. Channel section of customary channel works



c. Channel section plan proposed by IKEYA

Fig. 6. Channel section plan which makes much of the original shape of stream bed (after Ikeya (1978)).

stream must be subject to more sabo dams. Imprudent land use also threatens the stream environment. Development of vulnerable areas, e.g. head part of a fan,

raises the necessity of sabo works.

Thus, not only the lack of understanding toward the stream dynamics and sabo works but also acceptance of improper

treatment of a drainage basin, even if the impropriety is beyond one's consciousness, lead fish habitat to devastation as a result. An important way is to change these circumstances. To be concrete, we should deepen the understanding toward them, and we should keep taking notice to watershed development.

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淡水魚保育和攔砂壩工程之相容性

高橋剛一郎

溪流中的攔砂壩是爲了要控制河川侵蝕及砂底之堆積作用而設的，但却使魚類棲地惡化。惡化的主要過程有二：水壩阻斷了魚類的通路，而引水溝渠（工程）則減少了魚類棲地環境的多樣性。

雖然魚道（fishway）原意是用來解決魚類通路（fish passage）的問題，但是要把魚道和攔砂壩結合在一起却牽涉了許多問題。因此，以一連串低壩結合簡單水塘狀魚道的方法是很值得採用的。執行適當的溝渠工程，並維持住溪流的自然狀況是可能的，也可同時滿足預防災害，以及保育魚類棲地的共同需要。此外，爲了要避免過多的攔砂壩工程，去了解攔砂壩工程，以及對集水區的適當處理是很重要的。

