Riverine Fisheries in Nineteenth Century Hida

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Distribution of fish yields are examined by altitude and stream order for four major river systems in the Hida region. The variety of freshwater food fauna includes fishes of many kinds, molluscs and amphibians, comprising 11 families, 19 genera and 25 species. It is important to note that the vertical distribution pattern of fish coincides to a large degree with that of the natural populations. This suggests that riverine fishing was practiced at every altitude within the region by those having easy access to the rivers.

However, distribution patterns of fish yields are quite diversified among the four river systems, as well as by altitude and stream order. In three of the four river systems specific patterns of yield distribution are observed; yield concentration is found at 800–900 m (Sho River system), at 400–500 m (Miya River system), and 200–500 m (Mashida River system), respectively, although conspicuous intensification of fishing efforts is seen in Takahara River system. Apparently, such tendencies have some correlates with fishing efforts and intensities on which yield is based. Those fish that were important both for subsistence and for commerical use were cyprinoid dace, ayu-fish, cherry salmon, and two kinds of landlocked salmon, among which cyprinoid dace was the most important in number and quantity. Those fish show high yields at different altitudes and in different stream orders. River fish provided the human population with sustainable yields of animal protein at different altitudes and according to different subsistence patterns (home consumption versus commercial use in nineteenth century Hida). [Riverine Fisheries, Yields, Vertical Distribution, Stream Order, Hida].

INTRODUCTION

Relatively recent development and alteration of river and lake environments have caused drastic changes in Japan, gradually resulting in "man-made ecosystems". The on-going effects caused by modification and change of river systems are enormous and complicated. The construction of dams, for example, to supply electricity and water for irrigation, and for flood and drought control, has contributed to the development of the local areas. Such construction has, in addition, caused various changes in biophysical and sociocultural environments. Dammed lakes gave birth to new hydrological systems, and were beneficially utilized for aquacultural operations of carp and cyprinoid fishes — that either increased naturally or were introduced from other rivers — as well as often providing space for human recreation. In the upper part of systems, dams have led to the decline of fishing for anadromous species like salmon, ayu-fish, and trout, leading to the ultimate abandonment of riverine settlements.

Modification of river systems has occurred quite extensively from the upper streams to the river mouths or brackish waters, radically altering the natural distribution of fish and artificially dividing rivers into several component sections. Such effects, as seen in dam construction, extend to almost every river and lake in Japan, and modifications are becoming more pronounced. The natural distribution of fish appears to have been irreversibly altered, and it is urgent that ichthyologists record the present distribution of freshwater fish before more environmental changes occur. Such research should concentrate on river systems which have suffered the least modification [KAWANABE 1978], thereby contributing toward understanding the relationship between freshwater fish and their use as resources.

This paper examines the distribution of fish yields, using data from the *Hidagofudoki* (the local geographical document on the Hida region of central Japan in the mid-nineteenth century; see KOYAMA, this volume). The ecological distribution of freshwater fish is first examined by altitude and river system. The distribution of fish yield in each river system is then described by altitude and stream order. Finally, a model is presented describing the human use of freshwater fish resources in Hida.

MATERIAL AND METHOD

Material

The *Hidagofudoki* describes local catch of fish and other freshwater organisms, in most cases village by village, as one of the items of "production of the village" (*sanbutsu*). These quantitative descriptions provide the basic material for the present study. Additional, generalized information on, *inter alia*, fish distribution, fishing methods, and the characteristics of particular fish are described or illustrated in sections of the *Hidagofudoki.*

Location and altitude of the village

Horizontal and vertical distribution maps of the Hida villages, based on geological maps drawn on a scale of 1 : 50,000, were prepared in order to investigate fish distribution relative to village location and altitude. The location of each village was plotted on the map and used for computer display. The altitude of the administrative center or geographical center of each village was used to approximate the altitude of the river at that point.

Stream order

Rivers are fed by many tributaries from a large number of sources, usually located below diverting ridges. These primary tributaries run down small valleys joining together in larger valleys to form major streams. The development of a river system can therefore be regarded as forming a series of dendritic interrelationships between tributaries and major streams.

Geological maps of 1: 50,000 scale were again used to determine stream order. Streams in the highest elevation of a river system are categorised as *primary*. A *secondary* stream starts from the confluence of primary streams. Orders up to the fifth are decided in the same way. A *tertiary* stream continues to be so classified until it joins with another tertiary stream, even if the primary or secondary stream joins the tertiary stream section (Fig. 1). Total length of each stream order by river system was measured from the 1 : 50,000 geological maps (Table 1).

Fish yield

The *Hidagofudoki* figures reflect nineteenth century fish yield and do not represent standing crop, standing stock, or biomass or biological production in biological fish terms [KAWANABE and HARADA 1964]. The major problem with the figures is the units of scale used. Traditional Japanese units of measurement were used in the

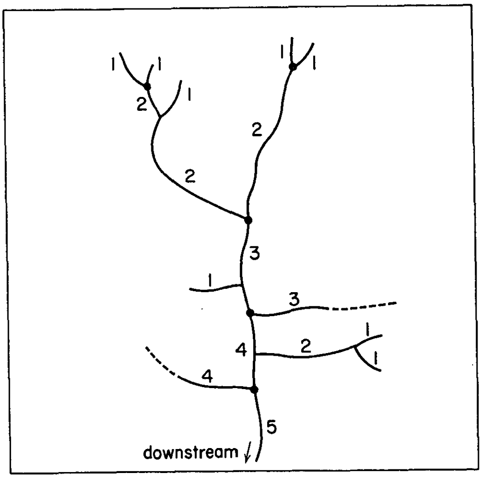

Fig. 1. Diagram to illustrate stream order.

Each number shows stream order: i.e., 1: primary, 2: secondary, 3: tertiary, 4: quadric, 5: fifth.

Table 1. Stream length by river system.

River system	Stream order 1	2	3	4	5	Total (km)
Sho	192.5	82.3	56.8	19.9	41.0	392.5
Miya	364.2	157.1	96.4	56.3	54.3	728.3
Takahara	217.2	123.6	38.0	37.6	27.1	443.5
Mashida	376.4	164.4	65.4	51.1	45.5	702.8

Hidagofudoki and secondary measures were also sometimes applied. Therefore, it was necessary to determine practical yields as follows:

1. Conversion of all figures by a centimeter/gram/second (cgs) scale system;
2. Conversion of figures from volume units to weight on the premise that all freshwater fish have specific gravity of 1.00;
3. Conversion of figures from numerical units to weight based on the estimated weight of each fish species; and
4. Inferences to determine maximum and minimum weight of individual fish species.

Identification of fish

It was not always possible to estimate and to identify fish from the historical documents alone, since the indigenous name often varies according to place, period, and even among inhabitants of the same village [SHIBUSAWA 1960]. A single species of fish may even be denoted by more than two names at successive stages of growth [AKIMICHI 1978].

Fish were identified in this paper with reference to the contemporary local fish names in Hida, and from ancillary historical documents supplemented by the author's field interviews. It is assumed that the local fish names have not changed significantly in the last century.

DISTRIBUTION OF RIVER FISH IN HIDA

Geographical Distribution of River Fish

Four river systems are evident in the Hida region. The Sho River, Takahara River, and Miya River flow into the Sea of Japan, and Mashida River flows into the Pacific Ocean. All of these river systems are composed of primary through fifth order streams, and topographic differences among them are briefly described below (Fig. 2):

1. Sho River system. The stream flows south to north between the Amo Mountains to the east and Hakusan to the west. A steep valley has been incised by the stream, the fastest flowing river in Hida. The total distance within Hida is about 60 km.
2. Miya River system. The stream starts from Mt. Kafuredake, one of the ridges of the north-south watershed of Hida. The flow passes through Takayama, running basically north, although there are occasional changes of direction to the northwest or northeast. Before it reaches the prefectural border it joins with several tributaries, like the Ohachiga, Kawakami, Kohachiga, and Odori Rivers. The topography along the stream becomes a flat basin between Takayama and Furukawa and a gorge is formed beyond Kadokawa. The total distance within Hida is about 76 km.
3. Takahara River system. The stream starts on the western slopes of the Japan Alps and joins with the Miya River at the prefectural border after

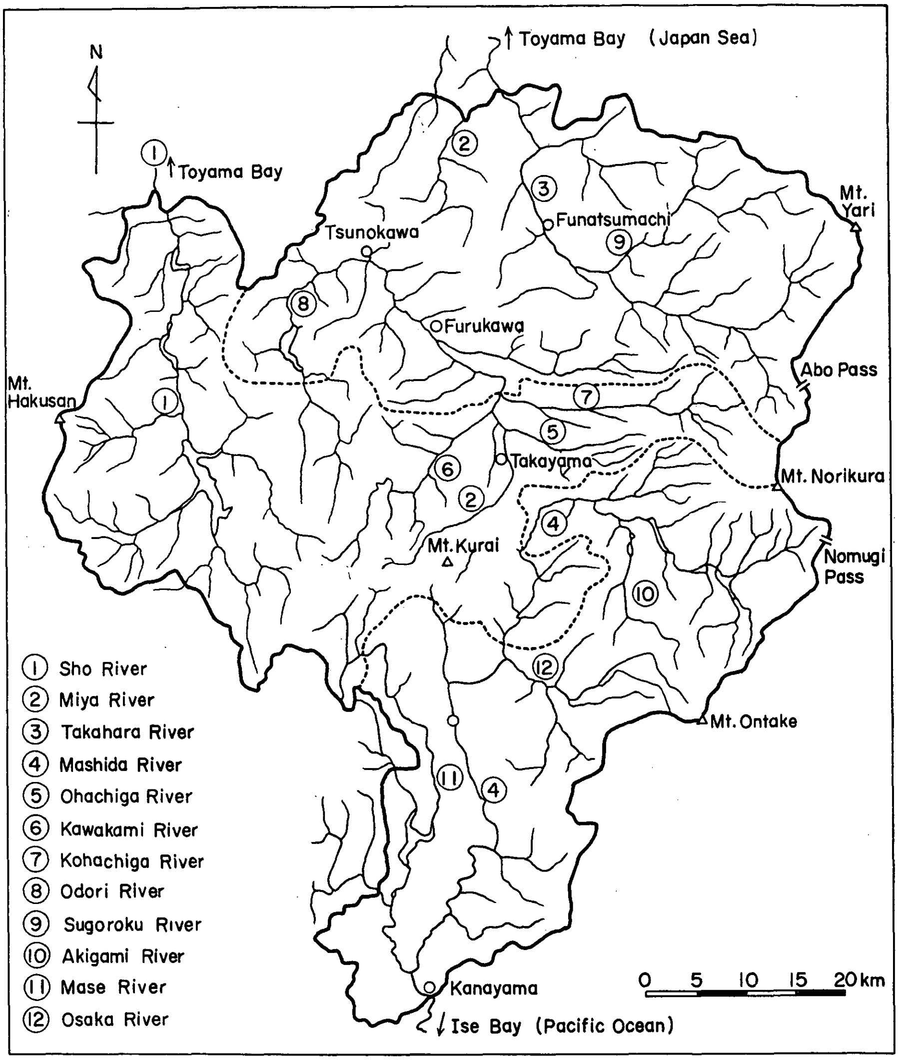

Fig. 2. River systems in Hida region.
················denotes district boundary

joining the Sugoroku River. Steep valleys are commonly formed along the stream owing to the great difference in elevation between its source and the point where it leaves Hida. The distance within Hida is about 54 km.

4. Mashida River system. The stream, starting from its source near Nomugi Pass, first flows west and is joined by the Akigami River running down from Mt. Ontake. The flow changes course tot he south, beyond Kuguno, and is joined by the Mase River, running south from its source in Mt. Kafuredake (after meeting the Osaka River at Osaka). Many gorges are found along

the stream, becoming steeper as the river nears the border of Hida. The distance within Hida is about 146 km.

Ichthyofauna in the River System

The results of identification of fish and ichthyofauna in each river system are summarized in Table 2.

Table 2. Identification of freshwater fish and other organisms described in the *Hidagofudoki*.

Described name	Common name	Scientific name
八目魚	Lamprey	*Lampetra* spp.
鰻	Eel	*Anguilla japonica*
石魚	Char	*Salvelinus leucomaenis*
鯈	Masu trout	*Salmo* (*Oncorhynchus*) *masou masou*
鱒	Masu salmon	*Salmo* (*Oncorhynchus*) *masou masou*
鱒，鯈，之末	Red-spotted masu trout	*Salmo* (*Oncorhynchus*) *masou macrostomus*
鮏	Chum salmon	*Salmo* (*Oncorhynchus*) *keta*
年魚	Ayu-fish	*Plecoglossus altivelis*
宇具比	Dace	*Leuciscus* (*Tribolodon*) *hakonensis*
アブラメ	Minnow	*Phoxinus* spp.
安可毛止，牟都鯈	Chub	*Zacco* spp.
七瀬走	Gudgeon	*Pseudogobio* spp.
川鯉，真鯉，緋鯉	Carp	*Cyprinus carpio*
川鯉	Steed barbel	*Hemibarbus labeo*
金魚児	Goldfish	*Carassius auratus*
鮒	Crucian carp	*Carassius* spp.
鰌，味女	Loach	*Cobitis* spp.
味女	Delicate loach	*Cobitis* (*Niwaella*) *delicata*
ザス	Bullhead	Bagridae spp.
鯰	Catfish	*Silurus* (*Parasilurus*) *asotus*
鱓	Swamp eel	*Monopterus albus*
鮔，川鹿，雑魚	Sculpin, Goby	*Rhinogobius* spp., *Cottus* spp.
鱅，雑魚，チリンコ	Common freshwater goby	*Rhinogobius* spp.
青貝	Freshwater pearl mussel	*Margaritifera laevis*
蜆	Freshwater clam	*Corbicula* (*Corbiculina*) *leana*
山椒魚	Salamander	Hynobiidae spp.
カワカメ	Soft-shelled turtle	Trionychidae spp.
田螺	River snail	Viviparidae spp.

Vertical Distribution of River Fish

Fish occupy certain key ecological niches in freshwater environments, some fish surviving only in the upstream areas whereas others range from the upper to the middle or even the lower reaches. Distribution of fish, therefore, can be ascertained

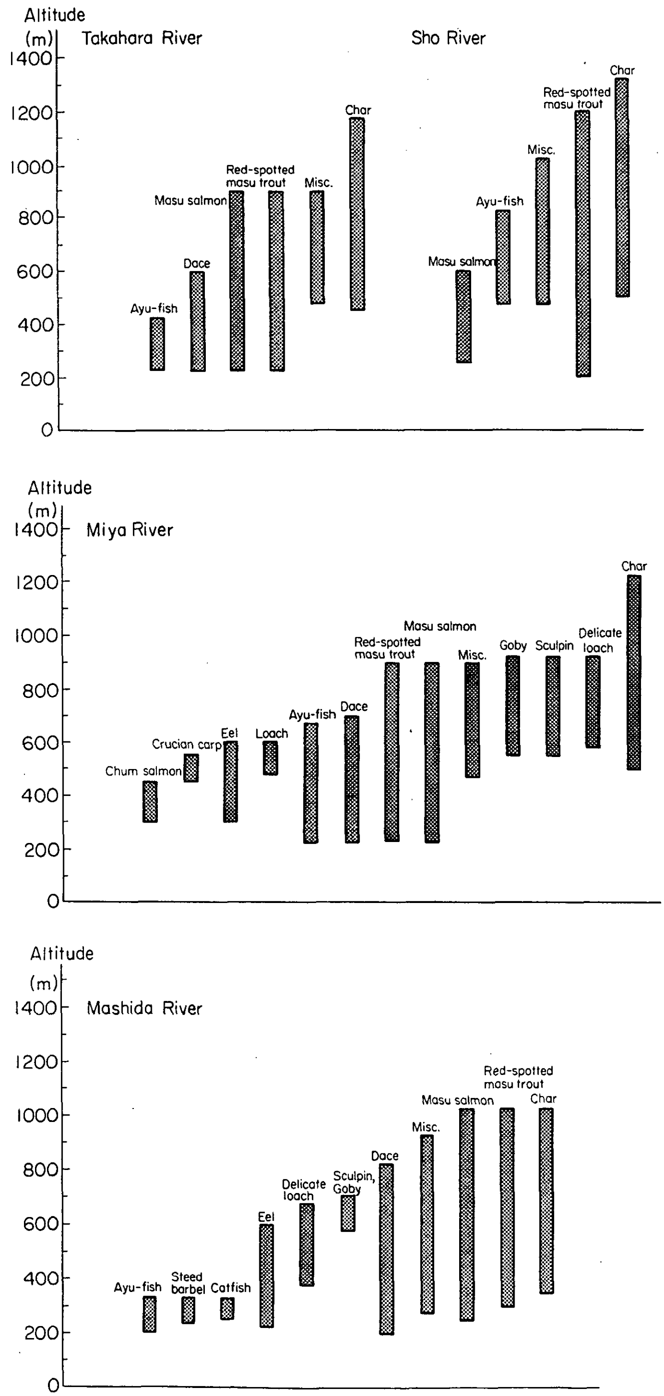

Fig. 3. Vertical distribution of fish by river system.
(Misc. are unidentified fish, described *en bloc* as *Zako* in the *Hidagofudoki*.)

in linear fashion, by altitude, in terms of the upper and lower limits of the range of each species.

Figure 3 indicates the vertical distribution of fish by river system. The upper limit of the distribution of species is well-defined, though it differs to some extent among river systems. The lowest point of the distribution is not accounted for in most cases, since the prefectural border of the Hida region is in the middle of the whole river system (from source to mouth).

There is a general tendency, particularly in the upper reaches, for several distribution types to be vertically arranged according to species; habitat segregation of fish from upper to lower streams can be observed, e.g., char–red-spotted masu trout–masu trout–delicate loach–goby–dace; ayu-fish–crucian carp–carp; and catfish–chum salmon.

This may well correspond to generally recognized fish habitat type, such as the char–area, masu trout–area, dace–area, chub–area, carp–area, and brackish water area. This last habitat type is not found in Hida, thus the *Hidagofudoki* includes no information on these species [MIYAJI *et al.* 1976].

Distribution of River Fish by Stream Order

Occurrence of fish was examined according to stream order, and is summarized below. Ranges and stream orders occupied by each species differ conspicuously according to river system.

Red-spotted masu trout, masu salmon, masu trout, and char occupy quite extensive zones whereas chum salmon, ayu-fish, catfish, and carp are limited within narrow zones of fourth or fifth order streams. It was also found that ayu-fish and chum salmon occur in fifth order streams and that these anadromous species sometimes reach quadric or even tertiary streams in periods of good catch, a fact confirmed by the *Hidagofudoki*. The distribution of masu salmon by stream order should be noted: Masu salmon in the Miya, Sho, and Takahara river systems ascend, like land-locked masu trout (the same species), to primary or secondary streams. Masu salmon are found in tertiary streams of the Mase River, one tributary of the Mashida River system, whereas they are confined within fifth order streams in the Mashida River itself.

DISTRIBUTION OF RIVER FISH YIELDS

Fish Yields

Calculation of total fish yield of Hida was based on a single sample weight of each species, giving production of somewhere between 159 and 341 t; this difference resulted from the use of both maximum and minimum weight of a single sample.

The Miya River system produces about 80 percent of the majority of the total yield. The Mashida River system has 17–18 percent of the yield and the Sho River system 1.5–1.8 percent, whereas the Takahara River system has only 0.4–0.5 percent. This difference of yield by river system is most pronounced.

By species, dace is the most popular fish representing 78.9–84.7 percent of the total yield. It is followed by red-spotted masu trout (10.1–16.7%), ayu-fish (1.9–2.0%), and masu trout (about 1%). Other popular species like goby, delicate loach, char, and eel occupy 0.1–0.7 percent each in the total.

Yield per species also differs according to river system, as follows. Char shows a high yield, following masu and red-spotted masu trout in the Sho River (though the ratio stays relatively low in other systems). Masu salmon is most important in the Sho River, constituting 40.7–54.1 percent of the river's total yield. This species is also popular in the Takahara River with 10 percent of the total yield, following red-spotted masu trout and dace. Yield of masu salmon in the Miya and Mashida rivers, on the other hand, remains low. Red-spotted masu trout shows the maximum ratio in the Takahara River, representing 60.1–69.7 percent of the total. The species also maintains high yields in the other river systems following either dace or masu salmon. Dace occupies the highest ratio of the yield both at the Miya and the Mashida rivers, representing 70–80 percent of the total. The species stands in second place, next to redspotted masu trout, in the Takahara River (12.6–16.3 percent of the total). No record of the species is mentioned, however, for the Sho River system. Ayu-fish occupies about 2 percent of the total yield in each river system except the Mashida, where the figure is only 0.4 percent.

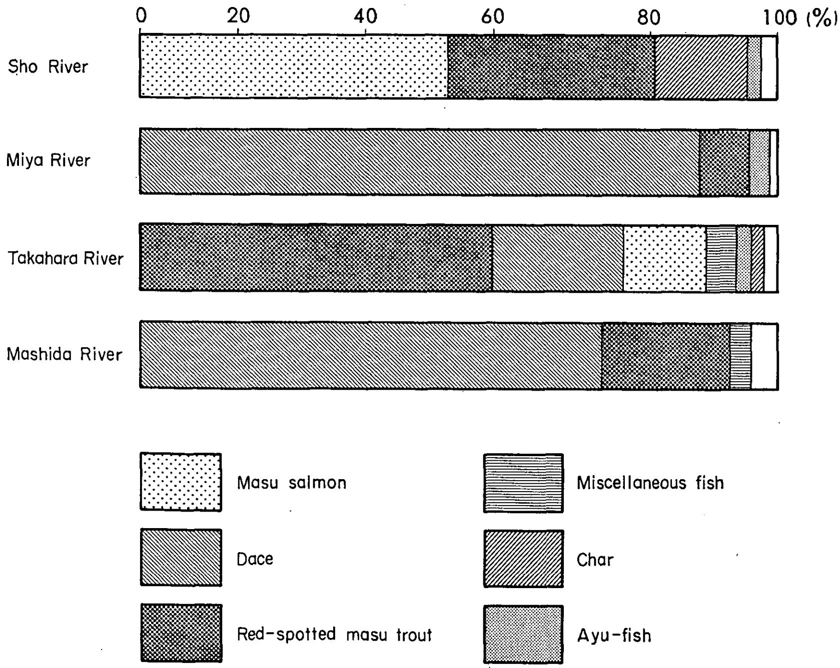

Fig. 4. Fish yield by weight according to four river systems. (Based on the estimated minimum weight of a single species sample).

Various unidentified fish, described as *Zako* in the *Hidagofudoki*, maintain higher proportions than ayu-fish in the Takahara and Mashida rivers, but the rank is reversed in the Sho and Miya rivers.

Vertical Distribution of Fish Yield

Both percentage and cumulative percentage of fish yield by altitude were computed. The concentration and dispersion in yield by altitude differs according to river system, as is shown clearly in the cumulative percentage graphs.

Figure 5 shows cumulative percentage of yield by altitude in each river system. The following facts become evident through comparison of the four graphs.

The significance of vertical distribution of yield can be seen between any two river systems by using the Kolmogorov-Smirnov Two-Sample Test (Table 3). The results indicate the existence of four different vertical distributions particular to each river system. No uniformity in yield distribution by altitude appears, as shown by a Kolmogorov-Smirnov One-Sample Test (Table 3), suggesting the existence of concentration or dispersion of yield at some specific altitude peculiar to each of four river systems.

The following four distribution types become apparent based on these findings:

1. Yield concentrates at low altitude, either decreasing or remaining constant as altitude increases. The Mashida River system exemplifies this type;
2. Prominent concentration of yield appears at middle altitude, declining

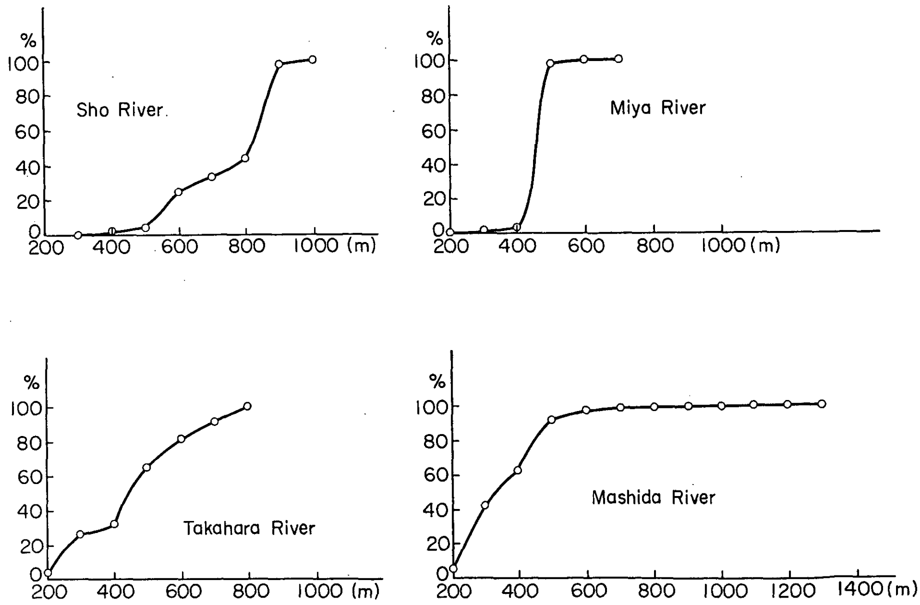

Fig. 5. Cumulative percentage graphs of fish yield by altitude in the four river systems.

drastically at both higher and lower altitudes. The Miya River system exemplifies this type;

3. Yield concentrates at high altitude, decreasing or remaining constant as altitude decreases. The Sho River system exemplifies this type; and
4. Yield is distributed uniformly regardless of altitude. The Takahara River system is the closest to this type, though significant variation appears.

The classification of the river systems into these distribution types can be clarified through analysis of the vertical distribution of yield by species. The following characteristics, summarized in Fig. 5, are specific to each river system:

1. *Miya River system.* All maximum yield figures by species, except chum salmon, are distributed at altitudes between 500 m and 600 m. Chum salmon peaks between 300 m and 400 m;
2. *Sho River system.* All maximum yield figures by species concentrate at altitudes higher than 600 m;
3. *Takahara River system.* Maximum yield figures by species disperse only slightly, compared to the other three river systems, according to altitude. The altitude of ayu-fish is between 200 m and 300 m. Dace and red-spotted masu trout are concentrated at altitudes between 500 m and 600 m whereas the char and masu trout peak between 600 m and 700 m; and
4. *Mashida River system.* All maximum yield figures by species, except char, are obtained at altitudes between 200 m and 300 m. The greatest yield of char is at 500 m.

Table 3. Kolmogorov-Smirnov Test on vertical distribution of Fish Yield.

	χ^2	$p<0.05$
Sho–Miya	0.970	*
Sho–Mashida	0.883	*
Miya–Mashida	0.567	*
Mashida–Takahara	0.310	*
Sho–Takahara	0.604	*
Miya–Takahara	0.366	*
d.f.=2	* significant	

	D	$p<0.05$
Sho River	0.346	*
Miya River	0.459	*
Takahara River	0.110	*
Mashida River	0.578	*
$D=\frac{1.36}{\sqrt{N}}$	* significant	

One important conclusion with respect to vertical distribution of yield becomes clear based on the above analysis: The yield distribution by species varies according to altitude and among the river systems. However, artificial factors also play an important role in the vertical distribution of yield in the case of intensive utilization of specific species at specific altitudes. This becomes clear in the case of ayu-fish in the Sho and Mashida rivers, red-spotted masu trout and dace in the Miya, and masu trout in the Sho River.

The strongest contrast found in vertical distribution of yield by river system appears between the Miya River system where most of the yields are concentrated at altitudes between 500 m and 600 m, and the Takahara River system with relatively uniform distribution throughout all altitude zones.

Yield Distribution by Stream Order

Tendencies of yield distribution in every stream order are studied in this section. The procedure starts by calculating yield per unit stream length (km) of each stream order. Table 4 indicates the yield ratio of each stream order, calculated on the premise that in a particular river system, yield ratio of the fifth order stream per unit stream length (kg/km) is 1.00.

Both primary and secondary streams show only 2×10^{-5}–7×10^{-2} of yield compared to the fifth order stream. A tertiary stream has 0.14–0.43 of the fifth order stream yield. Quartic streams, compared to the previous three orders, fluctuate greatly according to river system. The Sho River streams show three to five times the yield of the fifth order; Takahara streams have almost the same yield as the fifth order; but the streams of both Miya and Mashida rivers produce only 0.1 or 0.005 of the yield in the fifth order streams of each river system.

Generally speaking, yield per unit length in fifth order streams appears large in quantity, a tendency especially obvious in both Miya and Mashida rivers.

Fifth order streams also include all maximum yield figures by species except masu trout (for which 82% of the yield concentrates in quartic streams). It is further possible to determine the total proportional yield per species in primary, secondary, and tertiary streams (beginning with the highest): char, red-spotted masu trout, loach, dace, masu trout, and eel. These findings can be explained because the higher the yield ratio of a species becomes in primary, secondary, and tertiary streams, the more that species is distributed at higher altitude. Furthermore, yield by stream order is thought to reflect the vertical distribution of river fish, particularly considering the

Table 4. Proportion of fish yield per unit river length (kg/km) by stream order.

River system	Stream order 1	2	3	4	5
Sho	0.02	0.03	0.35～0.43	3.0～5.0	1.0
Miya	3×10^{-4}～4×10^{-4}	3×10^{-5}～5×10^{-5}	0.14	5×10^{-3}	1.0
Takahara	0	0.04～0.07	0	0.93～1.04	1.0
Mashida	2×10^{-5}～4×10^{-5}	0.001	0.14	0.12	1.0

fifth order distributions of catfish, steed barbel and crucian carp. The generally high ratios in fifth order streams implies the existence of some additional artificial factor, namely, the intensive efforts of people to increase yield in these situations.

CONCLUSION

The following points emerged through analysis of utilized river resources documented in the *Hidagofudoki*:

1. The vertical distribution of utilized fish resources coincides with the vertical distribution of freshwater fish (in general, i.e., habitat segregation of river fish by altitude);
2. Species identification of utilized fish is confirmed by the result of 1, above;
3. A clear correlation between distribution of species and specific stream order can be seen from the distribution mode by stream order; and
4. It has been verified quantitatively that the mode of yield distribution by both altitude and stream order is regulated by the vertical distribution mode of freshwater fish (natural phenomenon) and the concentration/dispersion of fishing effort (cultural phenomenon).

Model of Fish Yield Distribution

As already explained, yield distribution by river system varies markedly. The strongest contrast is the difference of yield distribution between the Miya and Takahara River systems. In the Miya River system, yield consists mainly of dace and concentrates at altitudes between 500 m and 600 m. Compared to other river systems in Hida, the yield at that altitude is extremely high. The Takahara River system, on the other hand, has a dispersed yield relative to altitude and, furthermore, the total yield is far less than that of the Miya River system.

These data from the *Hidagofudoki* strongly suggest that yield concentration in the Miya River system is connected with commercial utilization of river fish resources. The idea is reinforced by the pattern of land-use along the river at elevations between 500 and 600 m. Two densely populated areas identified as Furukawa (pop. 3,550) and Takayama (pop. 11,180) are located along the river, and these areas played a major role as big markets sustaining commercial fishery activities.

On the other hand, the high yields of specific species at specific altitudes are not evident in the Takahara River system, as noted above. But there is a slight concentration of yield at Funatsumachi village, the only village along the river with a population exceeding 1,000–1,300. Fish yield of the village is 152.5–691.5 kg, which is 22.3–41.4 percent of the total yield of that river system. Both population and yield at villages other than Funatsumachi are extremely small in comparison. Even in the Takahara River system, therefore, yield is higher in areas of greater population.

Yield of masu trout is highest at elevations between 900 and 1,000 m in the Sho River system, whereas highest yields of red-spotted masu trout and dace occur between 300 and 600 m in the Mashida River system. A common feature of both systems is that yield of some specific species concentrates at a specific altitude, though not as markedly as in the Miya River system.

Further detailed analysis will be necessary to clarify the relationship between use of resources and sociocultural factors like commercial production, population concentration, and urbanization. However, a general model for the use of river fish resources, based on above findings, can be proposed:

1. Uniformity in distribution of fish yield by altitude occurs under a self-sufficient economy, with the village taken as a living unit. The cumulative percentage graph of fish yield becomes like Stage I of Fig. 6;
2. Selective fishing activities aimed at specific species (at specific altitudes) occur as the result of the introduction and acceptance of the commercial economy. A skewing appears at a certain point on the graph corresponding to the concerned area/altitude, as in Stage II of Fig. 6;
3. Concentration and specialization of fish yield appears due to the acceptance of a commercial economy. In this case, the degree of skewness and its location (representing altitude) depends on the target species. Where anadromous fish like chum salmon are sought, for example, fish yield at lower altitudes increases as shown in Stage IIIa of Fig. 6; and
4. As the fishing efforts are directed at every species at all altitudes, fish yield continues to increase and thus eventually reaches a Stage IV, where it has a cumulative percentage graph similar to Stage I. But unlike Stage I, Stage IV involves the dangerous possibility of over-fishing by increasing the absolute quantity of yield.

It should be remembered, that this process rarely occurs exactly as described. Other factors such as dam construction, artificial hatching and release of available species, depopulation of fish species by pollution, and settlement pattern of riverine people, and the like, can affect or modify resource use patterns.

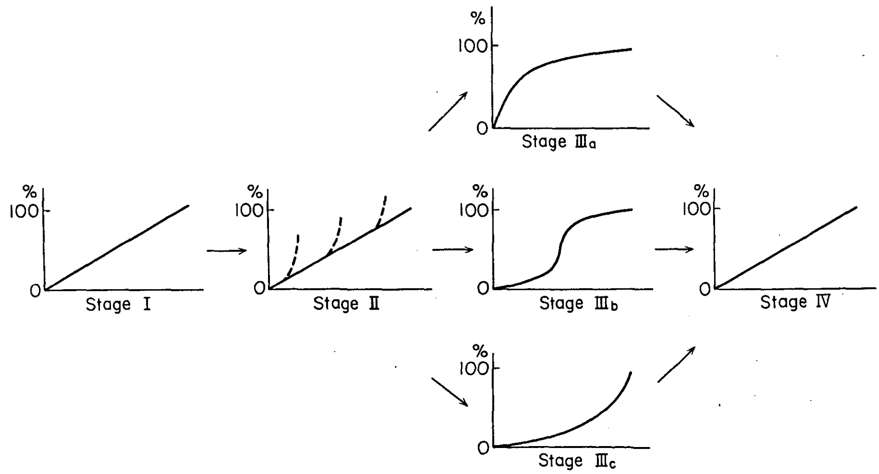

Fig. 6. A schematic model of fish yield

Species Distribution in Each River System (between the 1870's and the 1960's)

Fish species listed in the *Hidagofudoki* are limited to fish utilized and by no means comprise all species in the river systems. What kind of non-utilized species were in the river systems of Hida at that time? Precise consideration is impossible due to the lack of data, but inference based on present distribution is possible.

A brief comparison of fish distributions occurring in former times and at present in the four river systems follows, based on the data of the *Hidagofudoki* and distribution lists in *Gifu-ken no Dobutsu* ("Fauna in Gifu Prefecture").

1) Sho River System

Species confirmed as transferred or released artificially at the time of investigation in 1967 are red-spotted masu trout, rainbow trout, carp, brown trout, crucian carp, eel, chub, and ayu-fish. Among these eight species, ayu-fish is included in the *Hidagofudoki.* Some species whose distribution was confirmed in 1967, at Hatogaya village, are lamprey, chub, minnow, and bullhead, and no record of these exists in the *Hidagofudoki.* Other species, like sculpin fish, are quite possibly treated as *zako.*

2) Miya River System

Transferred species like gudgeon (ca. 1924), steed barbel (1923), piscivorous chub (ca. 1887), catfish (ca. 1887), and northern snakehead are recorded. Released species are red-spotted masu trout, rainbow trout, and especially ayu-fish. Seven species not recorded in the *Hidagofudoki*—bullhead, carp, chub, minnow, gudgeon, and rose bitterling—were confirmed in 1967; two fish mentioned in the *Hidagofudoki* —chum salmon and masu trout or cherry salmon—had disappeared by 1967.

3) Takahara River System

Six species—rainbow trout, ayu-fish, dace (partially), carp, crucian carp, and eel—are known as released species. Minnow and bullhead are found today but were not recorded in the *Hidagofudoki.*

4) Mashida River System

Ayu-fish, gudgeon, and carp are known as transferred/released species. Ayu-fish and carp are the dominant species. Four species—lamprey, smelt (found only in the artificial Asahi Reservoir), crucian carp, and loach are present today, though not mentioned in the *Hidagofudoki.*

All species mentioned in the *Hidagofudoki* as utilized fish were confirmed in 1967, except cherry salmon and chum salmon. Furthermore, there are probably more than twice as many species today as are recorded in the *Hidagofudoki*, even after excluding artificially transferred species.

Comparison of *Hidagofudoki* data with the results of the 1967 investigation reveals clearly contrasting pictures of fish distribution in Hida. In general, the family Cyprinidae (including carp, crucian carp, chub, and dace) has increased in variety and distribution owing to dam construction. Also, the decline of anadromous fish, like cherry salmon and chum salmon, gravely affected river fishing. As a result, a project to develop new species by hybridization between anadromous species like masu trout and land-locked species, like red-spotted masu trout and masu trout, was begun in 1924 [NIWA 1976].

Additionally, a new ecological cycle of crossing female masu trout to masu salmon in artificial dams (instead of at sea) was developed at Mihoro Dam in the Sho River [KANEKO 1974]. Change of ichthyofauna due to the introduction of foreign species, like rainbow trout, brown trout, and smelt, is also evident.

Species of Cyprinidae (like chub, minnow and gudgeon, confirmed in 1967) are quite possibly referred to as *Akamoto, Nanasehashiri*, and *Mutsubae* in the *Hidagofudoki*. But these names appear without any further descriptions, and are never referred in product classes of the *Hidagofudoki*.

Artificial selection was probably imposed to some degree on fish species mentioned in the *Hidagofudoki* as utilized species. Further analysis and consideration will be necessary on this matter.

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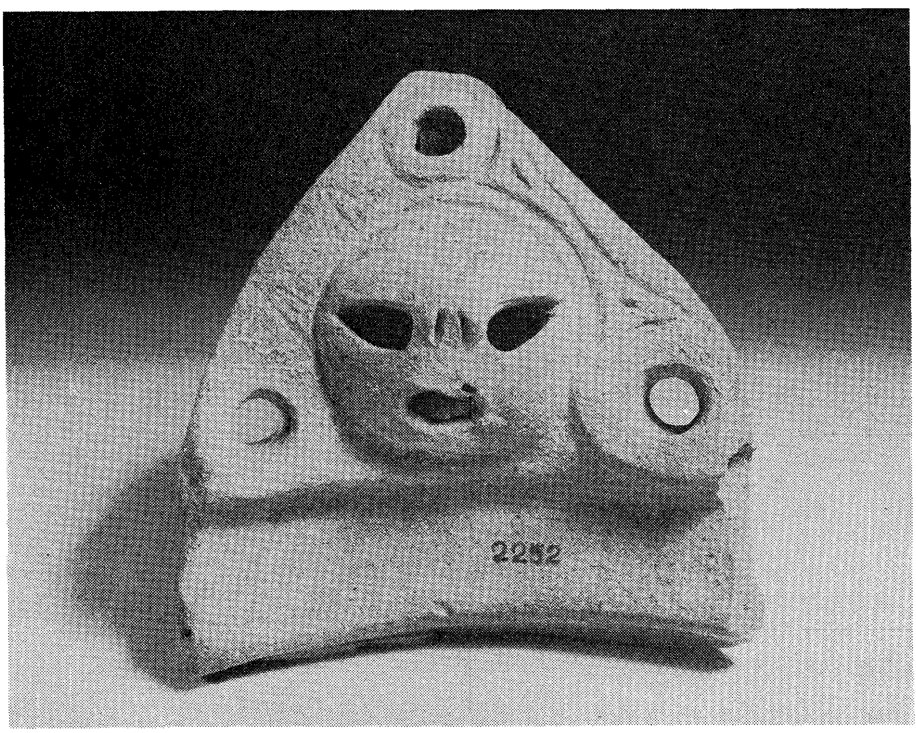
Part III

Foragers and Farmers of the Western Pacific



Rim Head from Jomon Pot
(Courtesy of University Museum, University of Tokyo)