Sustainable and Safe Dams Around the World – Tournier, Bennett & Bibeau (Eds)
© 2019 Canadian Dam Association, ISBN 978-0-367-33422-2

National census on river and dam environments in Japan and utilization for appropriate dam management using the results

T. Osugi, E. Akashi, K. Yamaguchi & H. Kanazawa
Water Resources Environment Center, Tokyo, Japan

M. Nishikawa
IDEA Consultants Inc. Kanagawa, Japan

ABSTRACT: National Census on River and Dam Environments in Japan is a periodical investigation for the purpose of collecting basic information about the environment of dam reservoirs and covers biological investigation and investigation on the number of tourists of the dam reservoir in Japan. This census targets at eight categories of plants and animals, such as fish, benthic animal, plankton, birds, etc. for the purpose of nationwide assaying the environment of a dam reservoir and its surrounding by accumulating data with keeping the survey accuracy. It has been carried out more than 20 years since 1990. In this paper, the objective species were selected and analyzed among the alien species expanding these population from the viewpoint of the dam and its lake management and environmental continuity of up- and downstream of the dam. For example, it has been found that Golden Mussel clogs water pipes and makes a great influence on hydroelectric power generation and that other alien species expanding its distribution makes a great influence on fishery activity. By utilizing this National Census Data we believe it is possible to upgrade dam management appropriately.

RÉSUMÉ: Le Recensement national de l'environnement des cours d'eau et des barrages au Japon est une étude réalisée de façon périodique dont le but est de recueillir des informations de base sur l'environnement des lacs de barrage. Il porte notamment sur l'aspect biologique et le nombre de touristes visitant ces réservoirs. Ce recensement vise sept espèces animales et végétales. (poissons, animaux benthiques, plancton, oiseaux, etc.) afin de pouvoir effectuer une évaluation nationale de l'environnement des réservoirs et de leurs environs. Il est en cours depuis une vingtaine d'année et a débuté en 1990.Dans cet article, nous avons sélectionné et analysé les espèces visées du point de vue de la continuité des cours d'eau en amont et en aval des barrages et de la propagation des espèces exotiques.Par exemple, nous avons constaté que la moule Limnoperna Fortunei, qui obstrue les conduits d'eau et a ainsi un impact important sur la génération hydraulique d'électricité et les activités de pêche, ne montre aucune tendance à se propager.Nous considérons que les données du Recensement national peuvent être mises à profit pour l'amélioration du fonctionnement des barrages.

1 INTRODUCTION

Japan consists of four large islands at the eastern end of East Asia, more than 1,000 small surrounding islands, and the Ryukyu Islands stretching to the south west. Japan's total land area is 377,837 km^2, which is about 1/25 of the land area of the United States and slightly larger than that of Germany. Japan is also extremely mountainous, with only 20% of its land area occupied by plains and the remaining area almost entirely covered with forested mountains and hills. As a result, 51% of Japan's population and 75% of its assets are concentrated on flood plains occupying no more than 10% of total national land area. As for its climate, it is located in the Asia Monsoon region that is one of the heaviest rainfall areas in the world, its

rainfall is concentrated in the summer rainy season (June, July), and the typhoon season (August to October) and is marked by considerable seasonal fluctuation. (Ministry of Land, Infrastructure, Transport and Tourism (MLIT) 2014)

The effect of the dam is demonstrated extremely effectively under such climatic and topographical natural condition and Japan's social conditions: the concentration of its population and assets on flood plains. In Japan, therefore, dams have been constructed since ancient times, are found throughout the country, and has demonstrated its effect as water supply and flood control infrastructure. (MLIT 2003)

Dam projects have been associated with various adverse effects on the natural environment as a direct result of their construction or due to the large-scale alterations in the terrain involved with the construction of the dam body, the building of alternative roads, and the creation of reservoirs. (Smith 1971, World Commission on Dams(WCD) 2000, Poff 2002) Examples of such adverse effects include the reduction or disappearance of habitats of fauna and flora due to the changing of forests and streams into reservoirs with the completion of the dam. Furthermore, structures such as the main dam body and the dam reservoir that cut through the habitats cause habitat fragmentation by blocking the upstream and downstream movement of fish and inhibiting the movement of land animals. (Mori 1999, Morita 2002)

In recent years, however, amidst growing interest in maintaining biodiversity and protecting the natural environment, in Japan too, the people have become to be extremely concerned with the environment of rivers and not only wish to not only boost the safety of flood control and water supply but are interested in preserving diverse ecosystems along rivers, and the MLIT has introduced measures to improve the environments of rivers. (MLIT 2018)

The government has also responded since 1990 by conducting the National Census on River Environments (Dam Reservoir Version) and taking measures to improve the environments around dams, mainly dams operated by the government and the Japan Water Agency. The National Census was introduced to clarify the life of living organisms in and around dam reservoirs by periodically, continually, and uniformly collecting basic information concerning dams from the perspective of the environments of dam reservoirs and of dams, it is being used for measures such as improvement of the environment around the dam and dam management.

The National Census of River Environments (Dam Reservoir Version) has included more than 110 dams managed by the MLIT and the Japan Water Agency in order to collect basic information about the environments of river regions.

The dams to be investigated are built after 1953 and are flooded throughout the year. It is located in 63 rivers throughout the country from the northernmost Hokkaido region to the southernmost Okinawa region. (Figure 1)

This has been done continuously for more than 20 years beginning in 1990, and five surveys were completed by 2015. The results of the surveys have been announced so they can be used by the general public using a database which has attracted international interest for its ability to permit comparisons with past data. Analyzing the survey results is beneficial in that it permits comparative study throughout Japan, and analyzing data obtained over a long period of more than 20 years permits researchers to trace change of the state of distribution of animals and vegetation over time. The same National Census is also conducted in 109 first-class rivers controlled by the governments, and it is possible to analyze the influence of the dam by comparing with Census data of the natural river section.

These dams are multipurpose dams intended for flood control, water supply, power generation, etc. It has discharge facilities for securing maintaining flow rate, preventing cold water discharge and turbid water discharge, and dam management is carried out in consideration of the downstream river environment. In recent years, the impact of invasive alien species on native ecosystem is concerned in Japan, and countermeasures against alien species in dams are also important issues.

This paper shows how the results of the National Census on River Environments are utilized to select object species from the perspective of links to dam management (continuity of interior of dam reservoirs – surrounding environments – river upstream and downstream from the dam), and species such as invasive species etc. which, having been distributed

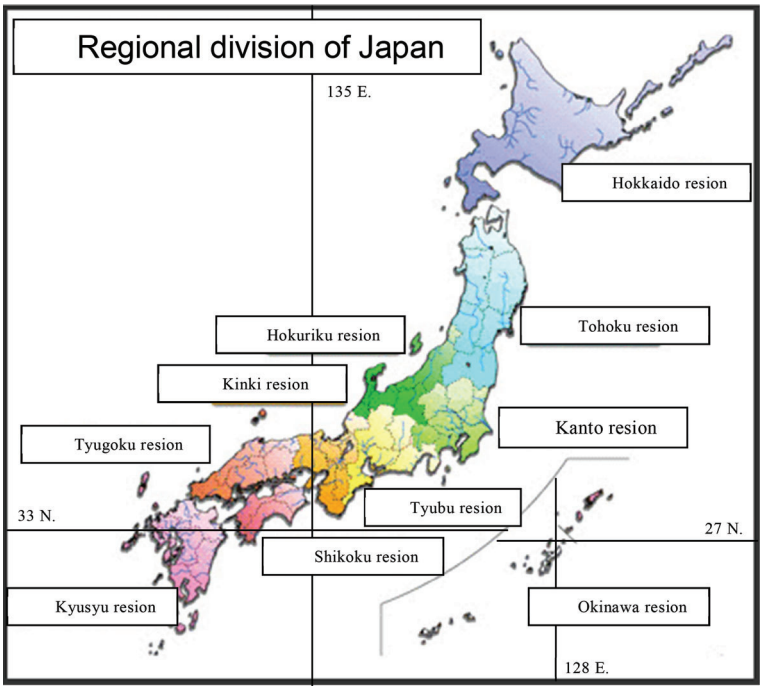

Figure 1. Regional division of Japan.

particularly widely in recent years, require special attention. The paper also presents the results of analysis of change of the environment by dams and methods of application to dam management.

2 METHOD OF CONDUCTING THE NATIONAL CENSUS ON RIVER ENVIRONMENTS

2.1 *Dams covered by the census*

The National Census on River Environments is conducted to appropriately promote river management and dam management at dams managed by the national government and the Japan River Agency in sections of 109 first class rivers directly managed by the MLIT. In 2015, the survey was done at approximately 120 dams. The survey is conducted once every five to ten years, and five investigations are conducted. (Table 1)

Table 1. State of performance of the National Census on River Environments.

Object	fish	Benthos	Plankton	Plants	Birds	Amphibians, reptiles, and mammals	Land insects	Basic chart of reservoir environment
First survey	81	80	80	81	81	80	80	-
Second survey	83	79	67	79	83	82	80	-
Third survey	94	96	83	97	96	96	96	-
Forth survey	107	107	100	111	111	109	112	102
Fifth survey	112	112	96	-	-	-	-	120

* Numbers in the table are dam counts

2.2 *Matters surveyed and survey method*

The National Survey on River Environments at Dam Reservoirs (Dam Reservoir Version) includes a biological survey of 8 items—fish benthic animals, zooplankton/phytoplankton, plants, birds, amphibians/reptiles/mammals, land inspects, and dam reservoir environment basic chart survey, and investigation of actual conditions of dam reservoir utilization, which is a survey conducted to count dam reservoir users.

The plan calls a biological survey of all items during the survey period to prepare the basic chart of the dam reservoir environment at every dam (including retarding basins and regulating ponds), by taking one sample every 5 years of the items, such as fish, benthic animal, zooplankton/phytoplankton, and vegetation etc., and one sample every 10 years of the items such as plants, birds, amphibians, reptiles, mammals, and land insects.

A standard survey method was planned to obtain similar survey data concerning each survey item at each dam and the surveys were conducted based on the Manual for the National Census on River Environments, Dam reservoir version: Biological Surveys. (Table 2)

The biological surveys are done by appointing academic experts with specialized knowledge of how to survey each item at each dam as National Census Survey on River Environments

Table 2. Items surveyed by the National Census on River Environments.

Item	Survey method
Fish	Done 2 or 3 times from spring to autumn. The survey is done in the reservoirs using a gill net, in shallow places and where the river flows into the reservoir and downstream using a casting net and a dip net.
Benthic animal	Done 2 or 3 times from spring to winter. The survey includes a quantitative survey that clarifies the quantity of benthic animals which exist and a qualitative survey that is done by sampling benthic animals in a variety of habitats. The quantitative survey is done in the reservoir by the fixed-point collection method using a bottom sampler, while at the inflow point and on the downstream river, by the quadrat method. The qualitative survey is done using a hand net of all living organisms at various locations.
Zooplankton/ Phytoplankton	Done 2 to 4 times from spring to winter. This survey defines and confirms the species of zooplankton and phytoplankton and performs quantitative analysis to clarify the quantity existing. Phytoplankton is collected by water sampling with a Van Dorn water sampler, and zooplankton is collected by water sampling methods using a Van Dorn or a Schindler trap.
Plants	Done about 3 times from spring to autumn when it is easy to confirm plants. A flora survey is done to clarify the flora.
Birds	Done 4 times from spring to winter. Within a range of 300 to 500 m around the reservoir, it is based on the line census method and the stereotaxic recording method plus surveys conducted from boats and nighttime surveys.
Amphibians, reptiles, and mammals	Done 2 or 3 times from spring to winter. Within a range of 300 to 500m around the reservoir, amphibians and reptiles are sampled mainly by the capture and confirmation method, and mammals by visual observation, confirmation of field signs, or by trapping.
Land insects	Done about 3 times from spring to autumn. Within a range of 300 to 500 m around the dam reservoir, either using a net or by hand, the light trap method or the pitfall trap method.
Basic chart of reservoir environment	A river survey done to investigate the material in rapids and pools and on riverbeds on the river downstream from the dam, plant distribution survey done divided into plant communities within a range of 500 m around the dam reservoir, and a plant community composition survey done to investigate the composition of each plant community.

advisors in order to be able to perform appropriate field surveys. The field surveys are done following their advice concerning survey planning, survey execution and survey results. National survey data were summarized by having academic experts with specialized knowledge by category in each field conduct screening committee meetings in order to guarantee precise identifications, and strive to ensure the precision of the results of the nationwide survey.

2.3 *Method of analyzing the survey results*

The survey results were analyzed to contribute to the analysis of change of operation of the dam reservoir and change of the environment caused by creation of the dam reservoir. Based on discussions by the National Census Survey on River Environments Screening Group Committee, the following four items were selected as the themes. (Figure. 2)

1. Links with dam management (environment inside and around the dam reservoir, continuity etc. of the river downstream and upstream from the dam)
2. Living organisms in and around the dam reservoir (species which are clearly related to ecological properties and the environment, invasive species)
3. Native species whose distribution is expanding
4. Species such as invasive species whose distribution has expanded in recent years which should be carefully observed.

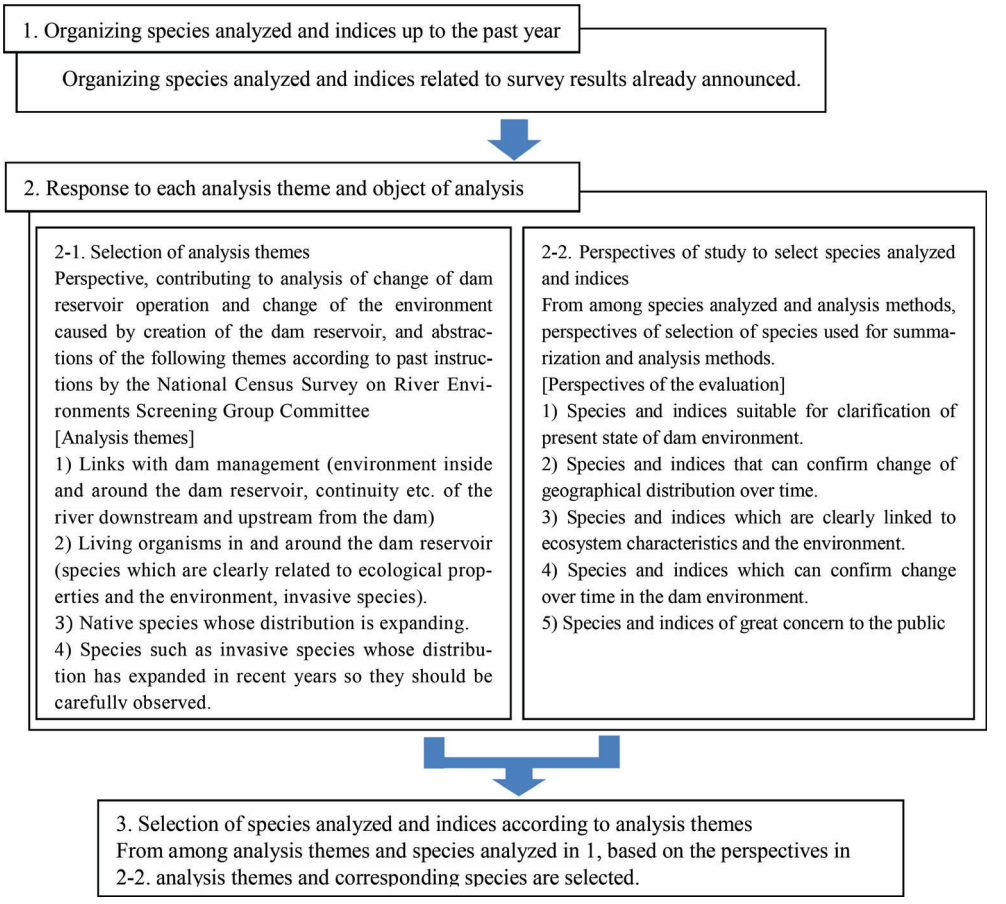

Figure 2. Analysis study flow chart.

All the species analyzed (indices) in the first to the fifth surveys were abstracted and analyzed from 5 perspectives based on the species analyzed by the overall past National Survey on River Environments. These are species and indices which "are suitable for clarification of present state of dam environment", "can confirm change of geographical distribution over time", "are clearly linked to ecosystem characteristics and the environment", "can confirm change over time in the dam reservoir environment" and "are of great concern to the public".

3 RESULTS

3.1 *Links with dam management*

3.1.1 *State of confirmation of diadromous fish in dam reservoirs*

A dam reservoir interrupts a river's flow, blocking the river. The species of fish that inhabit the river include diadromous fish that travel back and forth between the ocean and river during their lifetimes in order to spawn, but some have descended into the dam reservoir to end their life history (landlocked species). In order to confirm their landlocked state, the state of conformation inside the dam reservoir and river flowing into it about two fish of this kind, cherry salmon which is a salmonid specimen and triple-tooth goby (*Tridentiger trigonocephalus*) which is a Gobiidae species, were organized.

Looking at this trend by survey does not show an expanding trend in the cherry salmon from the first to the fifth surveys, but does confirm an increase of the number of dams where the goby was confirmed from the first to the fifth surveys. (Figure. 3)

The fifth survey which is the most recent survey confirmed cherry salmon in both the dam reservoir and the inflowing river at four dams in Hokkaido and Tohoku. They were confirmed in the dam reservoirs at only 14 dams from Tohoku to Kyushu.

Cherry salmon which are diadromous fish descend to the ocean while young then travel upstream in the river to spawn. But in cases where cherry salmon were confirmed in the dam reservoir and in the inflowing river, it is highly likely that a structure such as a dam blocked their descent to the ocean so they became a landlocked species that uses the dam reservoir as the ocean.

The fifth survey which is the most recent survey confirmed triple tooth goby in both the dam reservoir and inflowing river at 16 dams from Hokkaido to Kyushu. At many dams, they were confirmed in both the dam reservoir and inflowing river, and it is assumed that the these

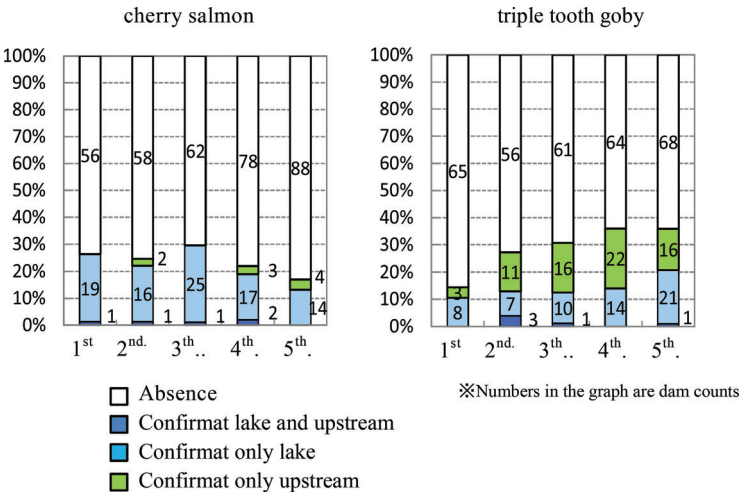

Figure 3. State of confirmation of diadromous fish.

triple tooth gobies are also a landlocked species. The triple-tooth goby which is an amphidromous fish inhabits originally brackish parts of the river and places in the middle river course where the flow is stopped or slowed, so it is possible that individual fish which entered the dam reservoir as bait when sweet fish or other species was released or as bait for bass fishing were confirmed.

3.1.2 *Comparison of river upstream and downstream from the dam (impact of dam on downstream river)*

Ephemeroptera, plecoptera, and trichopteran are aquatic insects typical of tributaries and other rivers with gravel beds. Many of these are susceptible to water contamination, so the total number of ephemeroptera (E), plecopteran (P), and trichopteran (T) (EPT) species are used as an index that represents the quality of the water. (Wallace et al. 1996)

At 112 dams included in the fifth survey, the number of EPT species in the inflowing river and in the downstream river were organized.

Although the number of EPT species is scattered between dams, nationally more EPT species were confirmed in the inflowing river than in the downstream river, suggesting that in many river environments, the water quality is better upstream than downstream.

Nutrient salts supplied from the river upstream from the dam are used by microorganisms or plankton inside the reservoir, although this depends on retention time or the state of dam operation, and are then often discharged downstream in a form different from that when they flowed into the reservoir. This is due not only to the possibility of deterioration of water quality in downstream rivers but also to monotony of the riverbed environment due to a decrease in the supply of soil and sedimentation, and the species diversity is reduced by the limited habitat of aquatic insects As a result, the possibility that the number of EPT types was lowered was considered.

Ephemeroptera, plecoptera, and trichopteran are used as indices which represent the good quality of the water, but on the other hand, they are species which adhere to the river environment, as bait or in habitat locations, and are easily impacted by environmental change such as the above. The species composition is, therefore, likely to be impacted physically by a dam. The results of this study found that the number of EPT species is high in the inflowing river while tending to be lower in the downstream river. This does not show that the water quality has deteriorated in the downstream river; rather that the impact of the dam could have homogenized the river environment, limiting habitats for aquatic inspect species, lowering diversity of species, resulting in a decline of the number of EPT species. (Figure. 4)

3.2 *State of distribution of invasive species*

In recent years, for leisure, aquaculture, as animal feed, landscaping or other purposes, foreign species which did not originally inhabit Japan were imported, released into rivers or dam reservoirs, then discharged from dams, or seeds mixed with feed grains escaped, so that in these and other ways, many became widely distributed throughout Japan. (The Ecological Society of Japan. 2002)

In response to this situation, the Act on the Prevention of Adverse Ecological Impacts Caused by Designated Invasive Alien Species (Designated Invasive Species Act) was enforced in 2006.

The species designated by this law include those said to have particularly great impact on the ecosystem, and the way the distributions of four species said to seriously impact agriculture, forestry, fisheries, and similar human activities—large-mouth bass, blue-gill (impact fisheries), golden mussels (impact hydropower and pipes), and racoons (impact farming)—have expanded in dam reservoir environments have been organized.

Large-mouth bass were confirmed over wide areas outside of Hokkaido, and blue gill were confirmed widely outside of Okinawa, Hokuriku and Hokkaido. From the first to the fifth surveys, the number of dams where they were confirmed did not increase very much, but there has been a tendency for them to continue to be found after being first confirmed. Golden

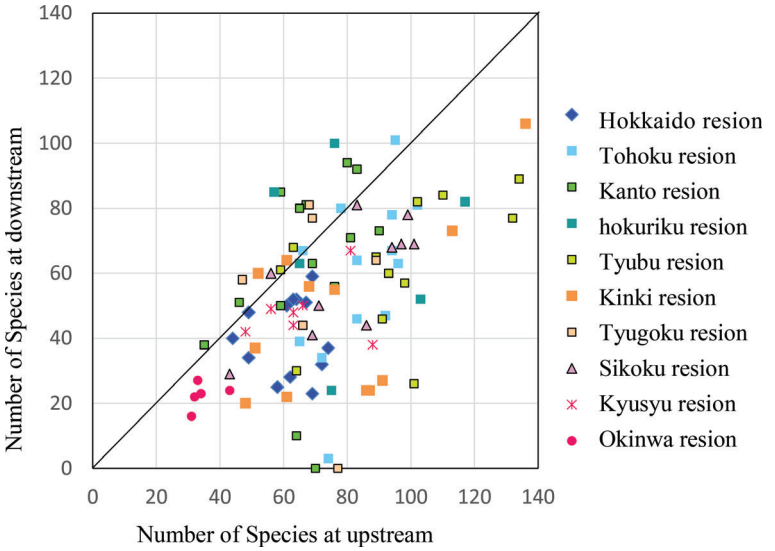

Figure 4. Comparison of number of EPT species in the inflowing rivers and downstream rivers by the fifth survey.

mussels were only confirmed at from 1 to 3 dams by the results of the first to fifth surveys, but their distribution has not particularly expanded. Racoons were confirmed only at river dams in Hokkaido by the first and second survey, but the third survey confirmed them at 9 dams and the fourth survey confirmed racoons at 24 dams. This shows that their distribution expanded rapidly to the environments of dam reservoirs according to the third to the fourth survey. (Figure. 5)

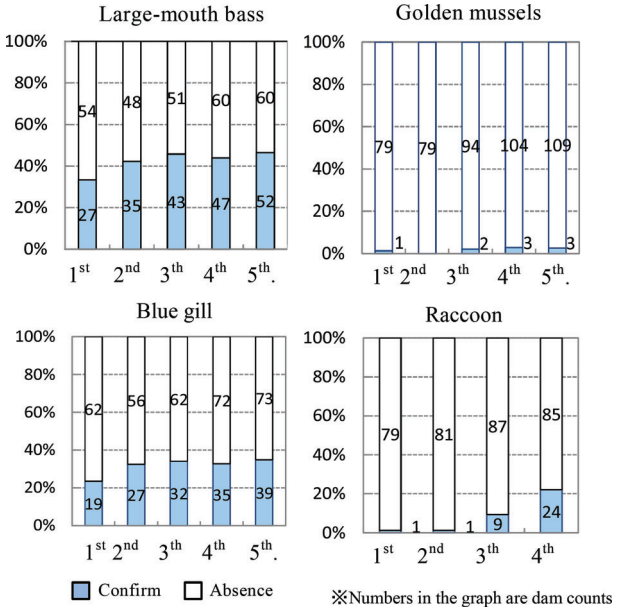

Figure 5. State of confirmation of large-mouth bass, blue gill, golden mussels and raccoons.

In addition, the trend of increase in the census results of the river is similar, but the confirmation rate in rivers is higher than dams, such like 67% for the large-mouth bass, 62% for the bluegill, 12% for the Golden mussels and 35% for the raccoon.(MLIT 2017) This is thought to be because the river flows also to the urban area of the downstream river whereas the Japanese dam is located far from the metropolitan area and located in a mountainous area with high naturalness. In order to conserve the native ecosystem in Japan, it is considered important to control invasion of alien species around the dam.

3.3 *Native species whose distribution is expanding*

3.3.1 *Raptors that use dam reservoirs (Osprey (Pandion haliaetus))*

Ospreys are designated as a near-threatened species in the Ministry of the Environment Red Data Book. Their range of activity is broad, they eat medium-size and small fish in the sea, rivers, and lakes etc., and build nests on large trees on rocky ledges, scarps, and near the seashore far from human habitations. Dam reservoirs where hunting ground, perches, and nesting areas are close together may be habitats suitable for ospreys. In recent years, it has been reported that ospreys nest inland, so it is possible that they are influenced by appearance of feeding areas on open water created inland by dams.

Thus, the way that the number of ospreys confirmed as raptors using dam reservoirs has changed was organized by the first to fourth surveys as river systems including rivers and dams. (Figure. 6)

At dams, as a result of the fourth survey, they were confirmed at a total of 84 dams.

Comparing the numbers of rivers and dams between the first and fourth surveys revealed a tendency for the number confirmed to rise. Looking at the places where they were confirmed shows that the first survey found many rivers where they were confirmed only at survey sites near the river mouth, but beginning with the second survey, they were confirmed at many inland river survey locations in particular, showing a tendency for osprey to expand inland from river mouths. This was particularly marked in the Tohoku and the Kanto regions.

The period when they came into use varied according to region, but in dam reservoir environments, it is highly likely that ospreys use dam reservoir environments as propagation locations.

3.3.2 *Bird species linked to inner water surface fisheries (great cormorant Phalacrocorax carbo)*

Great cormorants inhabit rivers, lakes, and marshes on deep bays or inland, form rookeries in nearby forests etc., and dive under the water to mainly eat fish and shellfish. From the 1960s until the last half of the 1970s, worsening of river environments reduced their numbers to a few thousand individuals, threatening them with extinction, but improvement of river environments by better water quality has increased their numbers in recent years, and in some regions,

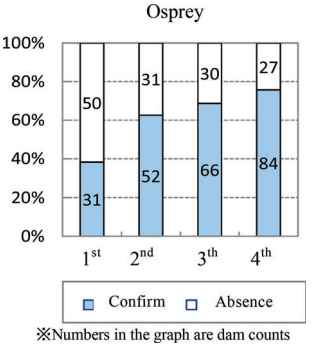

Figure 6. State of confirmation of ospreys from the first to fourth surveys.

they consume sweet fish, cherry salmon, and rainbow trout etc. which have been released, in some cases, harming the inner water fisheries. The following organization focuses on great cormorants from these perspectives.

As a result of the first to fourth surveys, the number of confirmed dams soared, and the fourth survey confirmed their existence at 89 dams. In Hokkaido and Hokuriku in particular, the number of dams confirmed increased. (Figure. 7)

And in dam environments, nests and rookeries of great cormorants were confirmed, while at some dams, great cormorant countermeasures have been taken in dam reservoir environments.

3.4 *Biota of the new environment*

At a dam, construction transforms the topography. And as compensation for the environment which was transformed or lost by dam bodies and surrounding roads etc., environments for the habitation and breeding of living organisms appear. Under the revised Manual for the National Census on River Environments, beginning with the fourth survey, locations of topographical change that forms new environments when a dam is constructed (reservoirs, dam bodies, gravel pits, places where soil for construction was obtained, large scale excavated slopes, and so on), or environment creation sites (Biotopes etc. provided in order to create environments for the habitation and breeding of living organisms) were set as survey locations, and the state of locations for the habitation or breeding of living organisms were confirmed in order to verify impacts on the environment or the dam's effects. So, environment creation sites and locations of topographical change at each dam were outlined and organized. (Figure. 8)

The National Census on River Environments surveyed 40 locations at about 32 dams that were surveyed for environment creation sites. Of these, Biotopes constructed mainly to create places for living organisms to breed were found at 21 locations on ponds and wetlands and at 4 places on canals. There were also 6 locations of environment creation sites intended mainly to form parks, and 10 environment creation sites intended to restore vegetation or form floating islands.

At environment creation sites, many species of Odonata, Hemiptera, Trichoptera, Diptera and other Insecta which breed in gently flowing or still water areas tended to appear. Breeding in a dam reservoir is difficult for these species, so it is assumed that they appeared as an effect of the creation of a Biotope.

Focusing on important species and invasive species which appeared at environment creation sites, it is found that important species of various kinds were collected at 8 out of the 10 environment creation sites. Bladder snails (*Physa acuta*), American ribbed fluke snails (*Pseudosuccinea columella*) and other invasive species that are highly fertile and have spread throughout Japan were confirmed, so these can be described as valuable breeding areas for living organisms that tend to decline in numbers or are in danger of declining in numbers.

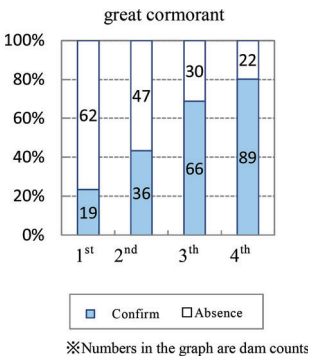

Figure 7. State of confirmation of great cormorants by the first to fourth surveys.

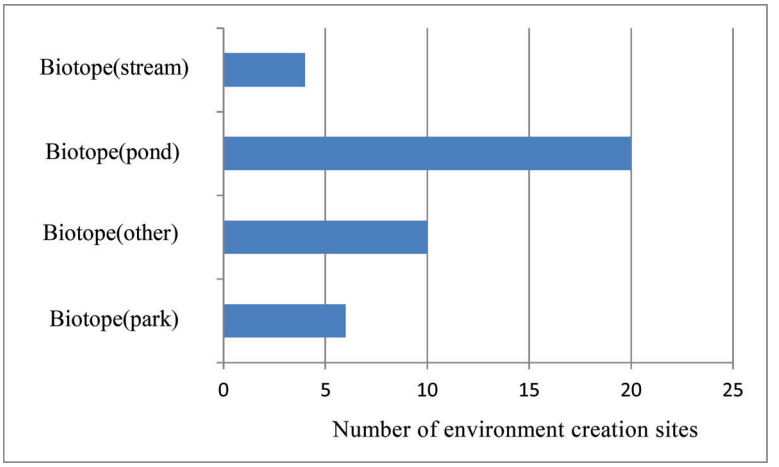

Figure 8. Breakdown of environment creation sites.

3.5 *Noteworthy species such as invasive species that have expanded their distribution particularly broadly in recent years*

3.5.1 *State of distribution of the designated invasive species, small-mouth bass, in river systems*

The designated invasive species, small-mouth bass, has expanded its distribution area through its release since it was confirmed to have invaded Lake Nojiri in Nagano Prefecture in 1991, and the National Census on River Environments (Dam Version) has shown that this species was confirmed at only 9 dams by the fifth survey, expanding its distribution since the third survey. (Committee on Effects and Measures against Foreign Species. 2001)

It is known that small-mouth bass prefer lower water temperature than large-mouth bass and their ability to adapt to a river is greater than that of large-mouth bass, and because they eat fish and benthic animals, their impact on native species is a problem.

Therefore, the state of distribution of small-mouth bass in rivers outside of dam reservoirs was confirmed, in order to clarify whether or not they had expanded their distribution from dam reservoirs. The state of confirmation in water systems including dams with many confirmed individuals (Tone River System for example) was organized along with the results of river surveys.

In the Tone River System, the third survey confirmed small-mouth bass in the dam reservoir of the Yagisawa Dam, and the fourth and later surveys confirmed them in the river downstream from that dam. The fifth survey on the other hand, did not confirm any in the dam reservoir, but continued to confirm them in the downstream river. Therefore, in the Tone River System, it is concerned that the distribution of invasive species is expanded by the existence of dams. (Figure. 9)

3.5.2 *Expansion of distribution of the designated invasive species, golden mussels (benthic animals)*

The designated invasive species, golden mussel, is a bivalve with shells up to 4cm in length which customarily attaches itself to the substrate with its byssi, harmfully impacting water use facilities such as pipelines or hydropower plants. Golden mussels are intermediate hosts of flukes which parasitize carps, so invasion by flukes accompanying invasion by golden mussels is a problem. On the Uji River, fish suffering from infectious diseases believed to be caused by the invasion of flukes along with golden mussels have been confirmed. (Committee on Effects and Measures against Foreign Species. 2003)

Therefore, the expansion and invasion of golden mussels around dam reservoirs have been confirmed.

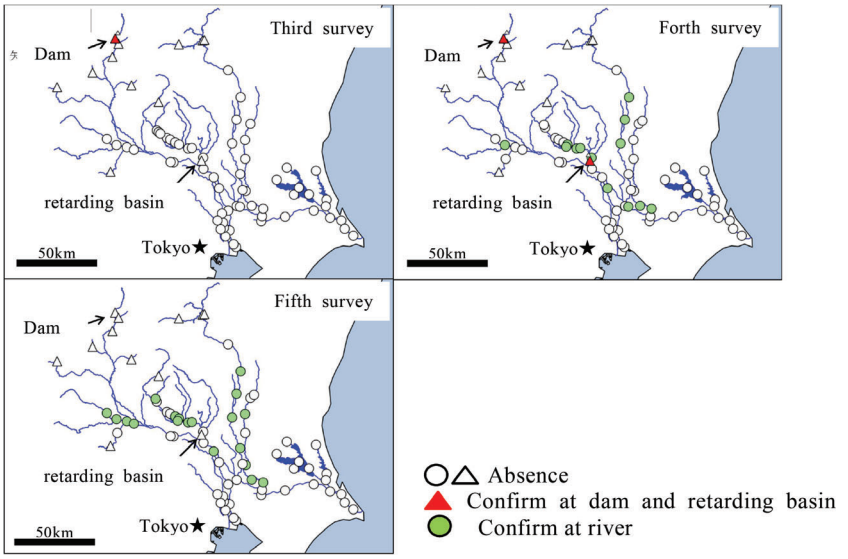

Figure 9. State of confirmation of small-mouth bass in the Tone River System (third survey to the fifth survey).

The first to the fifth surveys confirmed golden mussels at from 1 to 3 dams nationwide, but at this time, no particular national expanding distribution trend has been seen.

The 2015 survey confirmed golden mussels at the Yahagi Dam on the Yahagi River system from among the 32 dams surveyed. But once fish or benthic animals have invaded a body of water, it is possible for their distribution to expand upstream and downstream in the river system. So, on the Yahagi River, which has dams where golden mussels were confirmed in 2015, the results of confirmations by the National Census on River Environments (River Version) were also organized to examine distribution trends in the river systems.

On rivers, they were confirmed at 3 points downstream. At the Yahagi Dam, they were confirmed only at the downstream survey points while the invasion upstream from the dam body was not confirmed, but a tendency for their distribution to expand directly below the dam was confirmed. (Figure. 10)

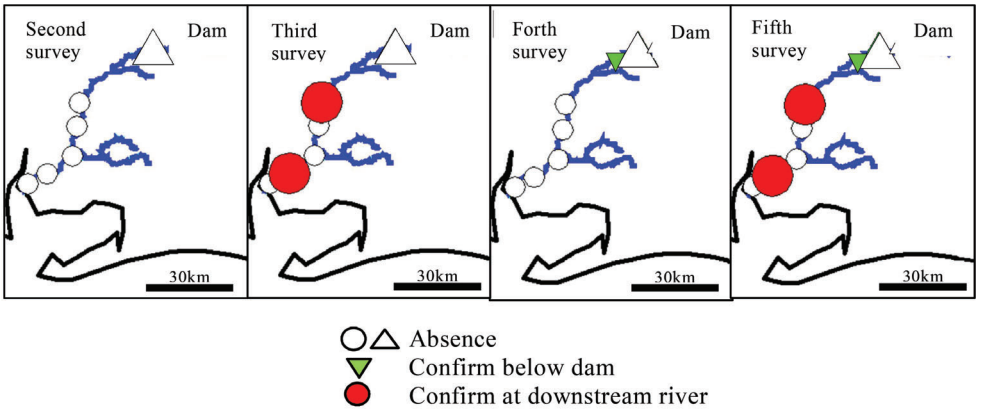

Figure 10. State of confirmation of golden mussels in the Yahagi River System.

At the present time, their distribution has not spread upstream, but downstream, presuming it is possible that they can breed over a wide range. Therefore, it is concerned that that there is fear that if their distribution expands in the future, water use facilities at the dam will also be impacted.

4 CONCLUSIONS

Biological data accumulated for more than 20 years is extremely valuable. Analyzing these data confirmed the present state and change from the past of ecosystems in and around dam reservoirs throughout Japan based on scientific data.

It is important that National Census on River Environment unify survey methods and be conducted periodically nationwide, and organizing the accumulated data permits such analyses. It is important to continue to accumulate basic survey data to contribute to analysis of climate change, and of change of the bodies of living organisms.

By accumulating and analyzing big data such as that obtained by this survey, the impacts of dams and present state of the environment around dams will be further clarified, permitting the clarification of future management problems, and also permitting further advance dam utilization using the results of these analyses.

REFERENCES

Committee on Effects and Measures against Foreign Species, 2001. *For Measures against Foreign Species in River* Environments *(draft)*. Foundation for Riverfront Improvement and Restoration. Tokyo. (In Japanese)

Committee on Effects and Measures against Foreign Species, 2003. *The view and its example of the measure against an introduced species in a river - The influence and the measure of the main aggressive introduced species* -. Foundation for Riverfront Improvement and Restoration. Tokyo. (In Japanese)

The Ecological Society of Japan, 2002. *Introduced species handbook*. chijin-syokan. Tokyo. (In Japanese)

MLIT, 2003. *FY 2001-2002. Program Evaluation: Dam Projects - Verification of the Various Regional Effects and Impacts*. (In Japanese)

MLIT, 2014. *Water Resources of Japan*, Social system. (In Japanese)

MLIT, 2017. *Summary of the results of the National Census on River and Dam Environments year 2016*. (In Japanese)

MLIT, 2018. *White Paper on Land, Infrastructure, and Transport in Japan*. (In Japanese)

Mori S. 1999. Dam and Fish Life-history – ecological perspectives in environmental conservation. *Ecology and Civil Engineering* vol.2 No.2: 165-177

Morita K. & Yamamoto S. 2002. Effects of Habitat Fragmentation by Damming on the Persistence of Stream-dwelling charr populations. *Conservation Biology* 16: 1-7.

Poff, N.L. & Hart, D.D. 2002. How dams vary and why it matters for the emerging science of dam removal. *BioScience* 52: 659-668.

Smith N. 1971. *A History of Dams*. London, Peter Davis.

Wallace J.B., Grubaugh J.W. & Whiles M.R. 1996. Biotic indices and stream ecosystem processes: results from an experimental study. *Ecological Applicatio*ns 6: 140-151.

WCD, 2000. *Dams and Development: A New Framework of decision-making*. London, Earthscan publications.