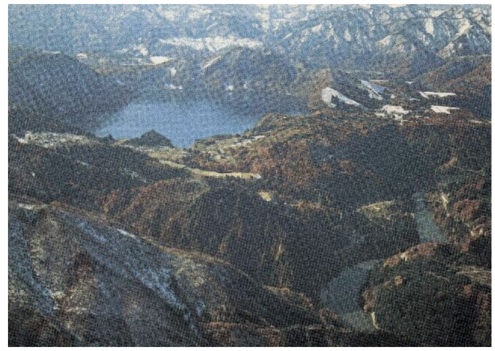


Key Issues:
3- Fish Migration and River Navigation

Climate Zone:
Cf: Temperate Humid Climate

Subjects:
- Acoustic Fish Straying Prevention Device

Effects:
- Maintenance of Fish Catches

Project Name: Daini Numazawa Power Plant
Country: Fukushima Prefecture, Japan (Asia) (N37°26′, E139°35′)

Implementing Party & Project
- Project: Tohoku Electric Power Co. Inc.
1977 (Commencement of construction) -
- Good Practices: Tohoku Electric Power Co. Inc
1981 (Commencement of operation) -

Key Words:
Fish Straying Prevention, Underwater Speaker and Fish Index

Abstract:
An acoustic fish straying prevention device was set up during the construction of a pumped storage power plant in order to prevent the straying of fishes in the upper reservoir from the intake, and the effect of the device was examined.

1. Outline of the Project

As shown in Fig.-1, the project site is a pumped storage power plant (effective head of about 220 m, discharge of 250 m^3 and maximum output of 460 MW), which uses, as the lower reservoir, the balancing reservoir of the Miyashita Power Plant in the midstream of the Tadamigawa River, a part of the Aganogawa River system that originates in Lake Oze located on the border between Fukushima, Gunma and Niigata Prefecture, and, as the upper reservoir, Lake Numazawa located on the right bank plateau (Fig.-3 and Table-1).

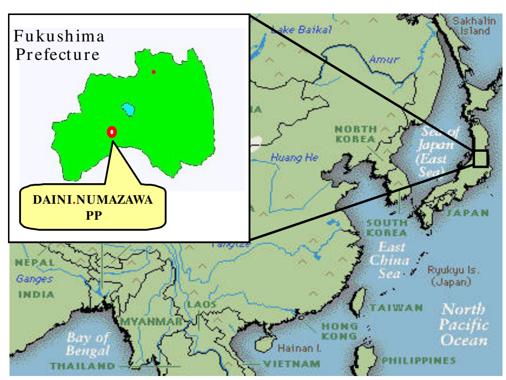


Fig.-1 Locations of Power Plants

As shown in Fig.-2, power source development started in the 1920's along the Tadamigawa

Table-1 Specifications for the Daini Numazawa Power Plant

Item		Specification
River system		Aganogawa River
Power plant	Name	Daini Numazawa Power Plant
	Maximum output	460 MW
	Maximum water	250 m^3/s
	Effective head	214 m
Upper reservoir	Total capacity	$193.8 \times 106\ m^3$
	Effective capacity	$44.7 \times 106\ m^3$
	Available depth	15.00 m
	Pooling area	3.10 km^2
Lower reservoir	Total capacity	$20.5 \times 106\ m^3$
	Effective capacity	$6.1 \times 106\ m^3$
	Available depth	5.00 m
	Pooling area	1.45 km^2

and Aganogawa River, and today, a group of power plants with a combined output of approximately 3,400 MW is clustered in steps. By making the maximum use of abundant water and large effective head, the region is regarded as one of the most important hydroelectric generating areas in Japan.

To meet the estimated increase of 1.8 times in electrical demand in our service area during the 1970's through to the 1980's, we started a program to diversify power sources to ensure stable and cost effective power supply; more specifically, the program involved the development of general hydroelectric, pumped storage and geothermal power, while using nuclear and thermal power as the base load source.

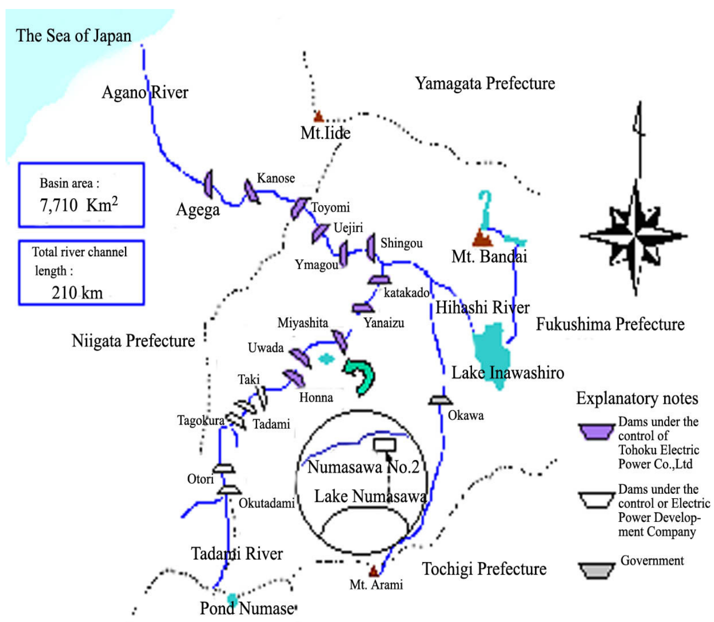


Fig.-2 Aganogawa River System

The Daini Numazawa Power Plant was constructed from the perspective of promoting more effective use of hydropower resources in a critical energy situation which necessitated a reduction of dependence on oil and the redevelopment of hydropower resources. The power plant was also designed to upgrade the daily, weekly or seasonal adjustment function for power supply.

This project site was completed over a period of 16 years; the geological survey was started in

1966, and the construction was started in 1977 and completed in 1982. Since the 1960's saw an increased tendency toward correcting mistakes made during the high economic growth period and problems associated with the environment and industrial development came under close scrutiny, a great deal of consideration went into establishing consensus with local communities and taking environmental measures during the construction of the project site.

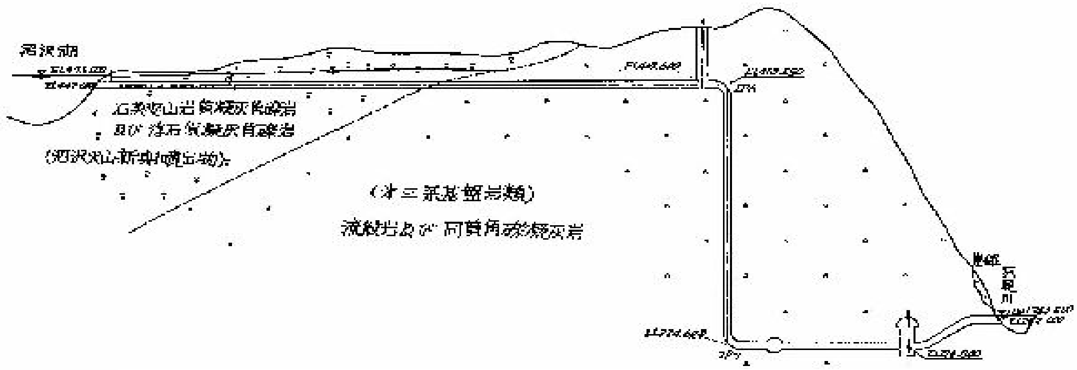


Fig.-3 Profile of the River Channel

2. Features of the Project Area

The Tadamigawa River, a part of the Aganogawa River system, originates in Lake Oze at the foot of Mt. Hiuchigatake, which marks the intersection between the Mikuni Mountain Range and the Taisyaku Mountain Range, and forms a watershed that ranges from the Echigo Mountain Range in the north, the Mikuni Mountain Range in the west, the Taisyaku Mountain Range in the south and the hills that stretch from Lake Numazawa to the west side of the Tajima Basin in the east. The river runs through the Ozegahara Marsh, flowing northward to the Oku-tadami Dam, the Tagokura Dam and five dams under the control of Tohoku Electric Power, merges with the Aganogawa River, which originates in Mt. Arakaizan in the northwest Aizu Basin, and then changes its course westward to six dams under the control of Tohoku Electric Power, and finally flows into the Sea of Japan.

With a total channel length of 210 km and catchment area of 7,710 km^2, the river is one of the largest in Japan. By taking advantage of abundant water and large effective head, a group of power plants is clustered in steps, and about 60%of hydroelectric power generated by Tohoku Electric Power is produced here.

With regard to the weather, since the region, also known as Oku Aizu (or Inner Aizu), is located on the east side of the Echigo Mountain Range, it has a typical Sea of Japan climate, meaning that it experiences a heavy snowfall brought by the northwestern seasonal wind during winter months. The region has, on an average, 131 snow covered days with snow depth reaching over 3 m at times, according to the data taken from neighboring meteorological stations.

The average annual temperature in the region is 10.8 ℃; the temperature falls below zero during the winter months of January and February as the effect of the northwestern seasonal wind that blows down from the Echigo Mountain Range and reaches a maximum of 36 ℃ in August. The region is also situated in a large rainfall area, with annual rainfall of between

1,800 and 2,000 mm and the average annual rainfall of 2,048 mm. Particularly between November and March, the northwestern seasonal wind brings rainfall (or snowfall) of about 200 mm each month, which is equivalent to the rainfall during the rainy season of June to the first half of July.

A large part of this project site is located in an area designated as the Tadamiyanaizu Prefectural Natural Park, and Lake Numazawa, which serves as the upper reservoir, in particular, is designated as third class special zone.

3. Major Impacts

Lake Numazawa, which serves as the upper reservoir, is a home to kokanee salmon, which are known to live in clean crater lakes in mountains. Crucian carp, carp, pond smelt and other fishes are also sporadically found in the lake. The Numazawa-numa Fisheries cooperative association stocks the lake with between 30,000 and 100,000 kokanee salmon each year, and catches about 50,000 three to four-year fishes each year. Since a large number of kokanee salmon is observed to make downstream migration once every few years, this raised the concern over the straying of fish into the intake.

The Fisheries cooperative association, therefore, requested the installation of fish straying prevention devices in the course of negotiations during the planning of the project and gave approval for construction in return for the acceptance of the request by Tohoku Electric Power.

4. Mitigation Measures

The fish straying prevention method had not been properly established technologically, and basic research in this area had been done only by a limited number of researchers. Instructions were therefore sought from Professor Kuroki of Tokyo University of Fisheries, who is regarded as the leading Japanese researcher in fish physiology, and the investigation and design were contracted out to Fuyo Ocean Development & Engineering Co., Ltd., which has proven performance record in fishery.

The fish straying prevention system, (Installed in July 1979 and, Starting operation in September 1981), as shown in Table-2, employs the acoustic, visual, electric, chemical or optical effect. In consideration of factors including effect, safety and influence on power generation, the acoustic system was selected.

Table-2 Fish Straying Prevention Method

Method	Detail
Acoustic system	Motor sounds and sounds similar to those emitted by predator fish
Visual system	Screens and air curtains
Electric system	Electric fences
Chemical system	Lime, copper sulfate and salt
Optical system	Variable lights

The acoustic system is comprised of a fish finder and underwater sound equipment (comprised of stereo speakers) that work in synchronization with the finder. The fish finder constantly emits ultrasonic waves, and when fish are detected, the underwater speaker emits continuous deterrent sounds of between 300 and 900 Hz (Fig.-5 and Fig.-6) to prevent fish straying. Once the fish are no longer detected, the speaker (Fig.-4) stops.
One fish finder was set up at the back of the intake facing forward and three sets of two underwater speakers were set up in the proximity of the intake.

Fig.-4 Underwater Speaker

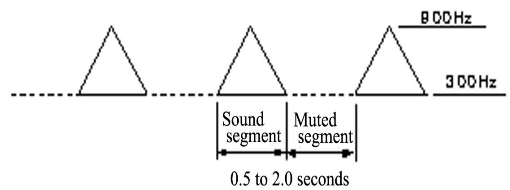


Fig.-5 Changes in Frequency

Table-3 Specifications for Fish straying Prevention Devices

Fish finder		Sound equipment	
System	Ultrasonic wave pulse	System	Underwater stereo system
Emitting frequency	3 times	Number of speakers	Three sets of two speakers connected in parallel
Finder frequency	50 kHz and 77.5 kHz	Sounding method	Intermittent sounding
Finder response range	30 m to 100 m	Sounding frequency	300 kHz to 900 kHz
Reflected wave monitoring	Electrosensitive recording paper	Sounding pressure	45 to 55 dB
Power supply	100VAC 50 Hz	Sounding time	Seconds, 4 steps (variable)

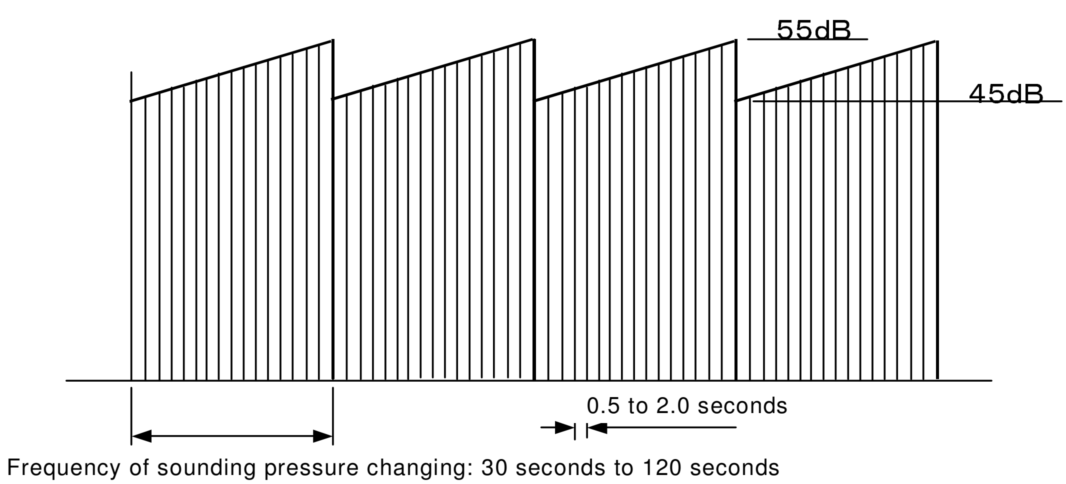


Fig.-6 Changes in Sounding Pressure

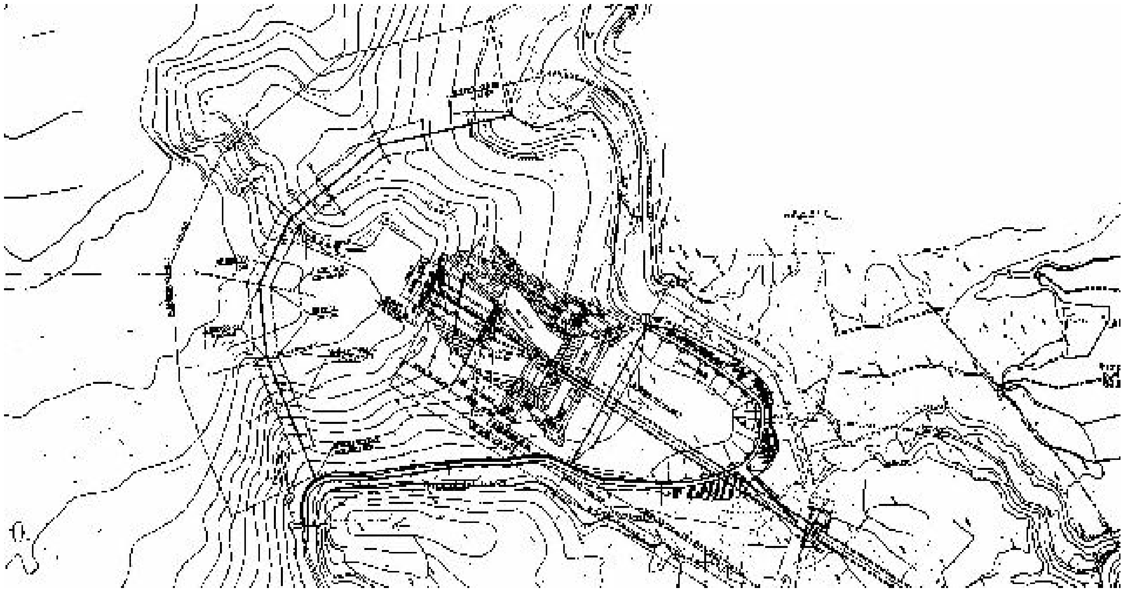


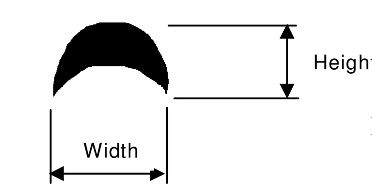
Fig.-7 Plane View of the Intake

5. Results of the Mitigation Measures

5.1 Measurement of the Effect and Results

In order to confirm the effect of the fish finder installed, a portable fish finder was used in the water around the intake to investigate the horizontal fish distribution when the underwater speaker is activated or muted, and using the results obtained, the fish index was made available.

The fish index is the quantitative representation of fish images recorded on the fish finder.



Fish index (mm^2) = Width (mm) X Height

Fig.-8, whose data were obtained from a location similar to that shown in Fig.-7, which shows the plane view of the intake, shows the coast in the proximity of the intake and the points for measuring the fish distribution.

The investigation of the horizontal fish distribution involved the measurement of the fish distribution using the fish finder installed on the research ship while passing through each measurement

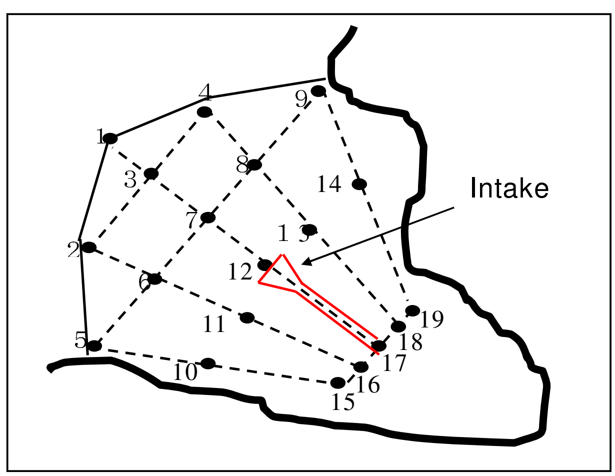


Fig.-8 Measurement of the Horizontal Fish Distribution point in the water around the intake shown in Fig.-8. The research ship, while performing measurements, passed through these measurement points in the following order: 1→17→19→9→5→15→18→8→6→16.

Each navigation took about 20 minutes. Seven measurements each were performed during a twenty-four hour period with the speakers muted and activated. Then, three additional measurements were performed with the speakers muted. This means that a total of 17 measurements were carried out.

The measurement results are shown in Fig.-9.

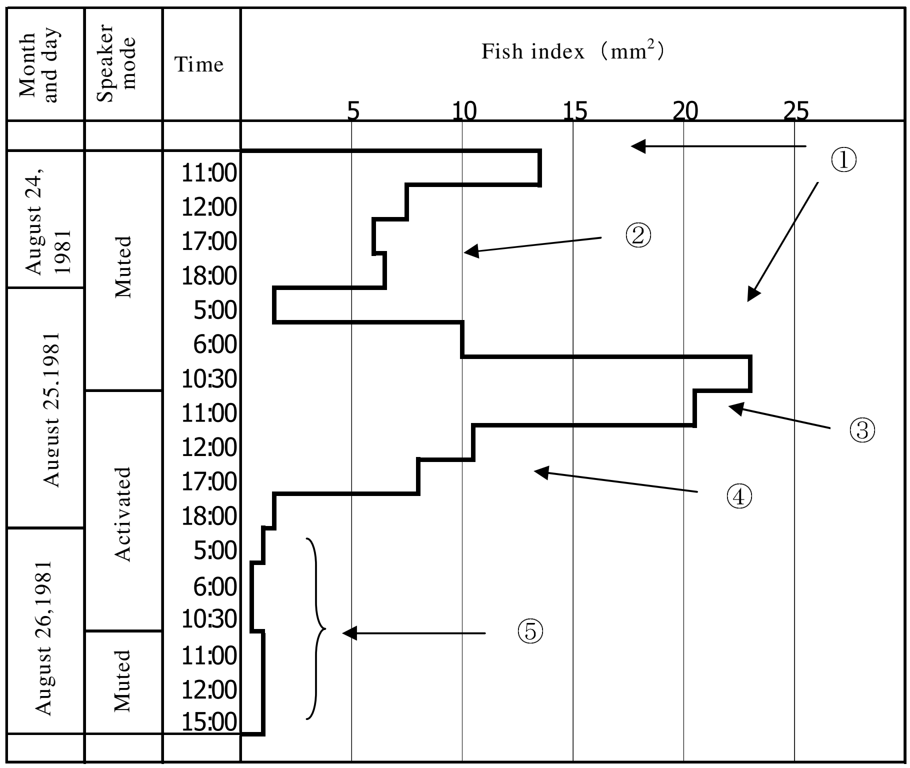


Fig.-9 Changes with Time in the Fish Index

5.2. Consideration

Fig.-9 shows the fish index in the water around the intake. A larger index is assumed to indicate a proportionally larger number of fish.

a) When the speakers are muted, the number of fish in the water around the intake tends to reach a maximum in the daytime particularly around 11 o'clock (①) and tends to be small in the nighttime (②).

b) No significant reduction in the number of fish is observed soon after the speakers produce sounds (③).

c) However, the number of fish gradually decreases when the sounds are played for a certain time period (④). This tendency was also reflected on the fish distribution observed at the same time (②) on the previous day when the speakers were muted.

d) No significant increase in the number of fish is observed even when the sounds are no longer played. In consideration of the fact that the number of fish reached a maximum around 11 o'clock on the previous day, the remaining effect of speaker playing on reducing the number of fish is observed (⑤).

What have been discussed above show that the device in question has, although not instantaneous, the effect of deterring the approach of fish to the target waters. The device is, therefore, considered satisfactory in preventing fish straying.

No reports have been so far received on the decline of the number of catches of kokanee salmon after the construction of the power plant.

6. Reasons for Success

The success of this project is considered to be the result of extensive investigation, research and examination. More specifically, the success is attributed to (1) prior implementation of research into fish and plankton as part of biological research on kokanee salmon that live in Lake Numazawa, and (2) the selection of the acoustic system for the fish straying prevention device, considered best in terms of effect, past performance and safety, based on basic research into the auditory sensitivity and behavior of fishes carried out under the guidance of experts including a university professor.

7. Further Information

7.1 References

1) Yoshiaki TORII and Tetsuo SASAKI, "Overview of the Location of the Daini Numazawa Power Plant and the Development Project", Japan Electric Power Civil Engineering Association, March 1978

7.2 Inquiries

Civil Engineering & Architecture Department,
Tohoku Electric Power Co., INC.
Tel: 022 - 799 - 6102
Fax: 022 - 262 - 5851
Email: w700181@tohoku-epco.co.jp