# A STUDY ON THE SHALLOW-MARINE CULTURAL FACILITIES

# WATER CAPACITY OF THE CHANNEL CONSTRUCTED AT TANOURA FACILITY, KAGAWA PREFECTURE

Kiyoshi FUKUDA, Tadao MAEKAWA and Yoshihiro KONO

## Introrduction

According to the results of our practical research of the pisciculture facilities in Shikoku carried out in 1962 and 1963[1], the inflow and outflow of the sea water is presently the most important problem to be solved at the facilities.

The most important factor in pisciculture is to supply enough oxygen to the cultivating fish. At the shallow-marine pisciculture facilities, the oxygen is generally supply by replenishing fresh sea water and draining used sea water through the gates and the net-meshes of the facilities with the tide. Consequently, the degree of oxygen supplied to the facility depends upon the quantity of the sea water which flows in and out.

Because of the shortage of oxygen in the sea water at some of the facilities, there were several cases where all of the cultivating fishes died.

Channels or pipe lines were constructed through the side of the facilities to increase the inflow and outflow of the sea water to increase the oxygen level in the sea water. Since then, there has been no report of the fishes dying in great numbers at these facilities; although to what degree these structures have helped was unknown.

Consequently, we thought it was important to find out how much these structures actually contributed in increasing the amount of fresh sea water. With this objective, we carried out hydraulic observations on the flow of sea water coming through the channel constructed through the side of Tanoura Facility, Kagawa prefecture, during one spring tide and one nearp tide in August of 1963.

## Methods

Tanoura Facility, a typical net and float type facility, was built at Tanoura Bay facing the Gulf of Uchinomi, Shodo-Shima Island, Kagawa Prefecture in 1960.

The mouth of this bay is enclosed by a double netted wall with a number of floats. The length of this mouth is about 570 m. In this enclosed water area, about $28.5\times10^4$ "Hamachis" (The young of *Seriola quinqueradiata*) were cultivated in 1962.

As shown in FIG. 1, from the shape of the contour lines of the water depth, this facility is shallow on the east side and deep on the west side, and the maximum depth of about 20 m is near the northwest side of the double netted wall. To increase the inflow and outflow of the sea water, a concrete channel, 2 m in depth, 2 m in width, and 140 m

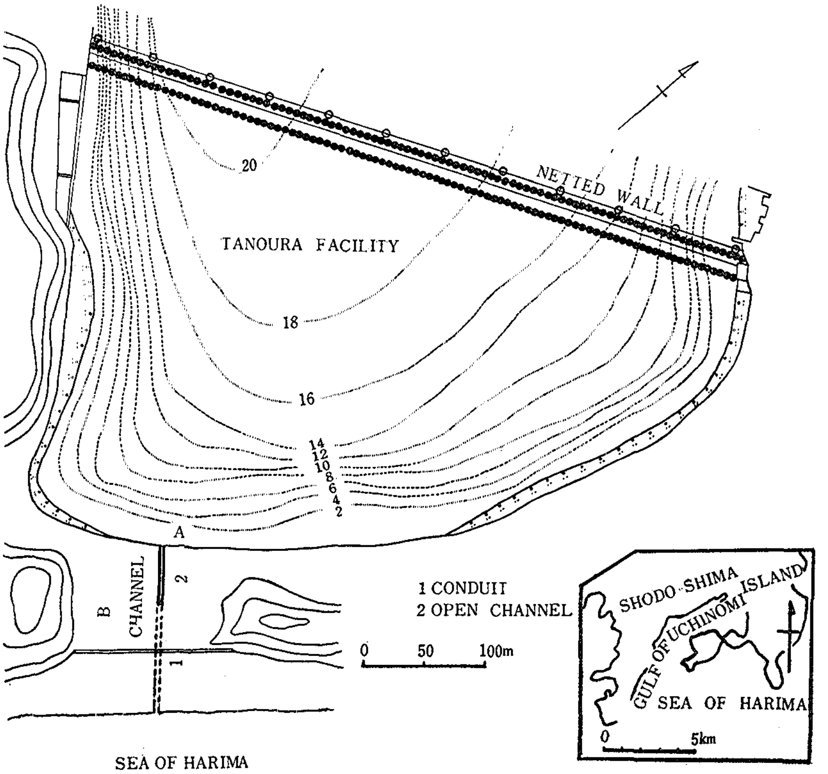


Fig. 1 Tanoura facility.

A : Observation Site. B : Channel 1. Conduit 2. Open Channel.
(We were permited to use this map with the courtesy of Mr.Yukichi Kume.)

in length, was built on the southeast side of the facility. The first 50 m from the bay is an open channel and the rest is a conduit. This channel connects Tanoura Bay with the Sea of Harima as shown in Fig. 1.

At the mouth of the open channel, point A, the velocity of the sea water running through this channel was measured by setting the current meter at the depth of 6/10 or 2/10 and 8/10 depending on the water depth at the time of measurement[(2)], and by counting the number of revolutions per minute with a stop watch and a counter. The tidal level was also measured by a water meter set near point A.

This observation was done during one spring tide from 16 : 00 on August 5 to 16 : 00 on August 6, and it was done during one nearp tide from 16 : 00 on August 12 to 19 : 00 on August 13.

## Findings and discussion

### The Water Area, the Water Volume and the Water Depth of the Facility

In Fig. 2, H-A curve shows the relationship between the water depth (H) and the

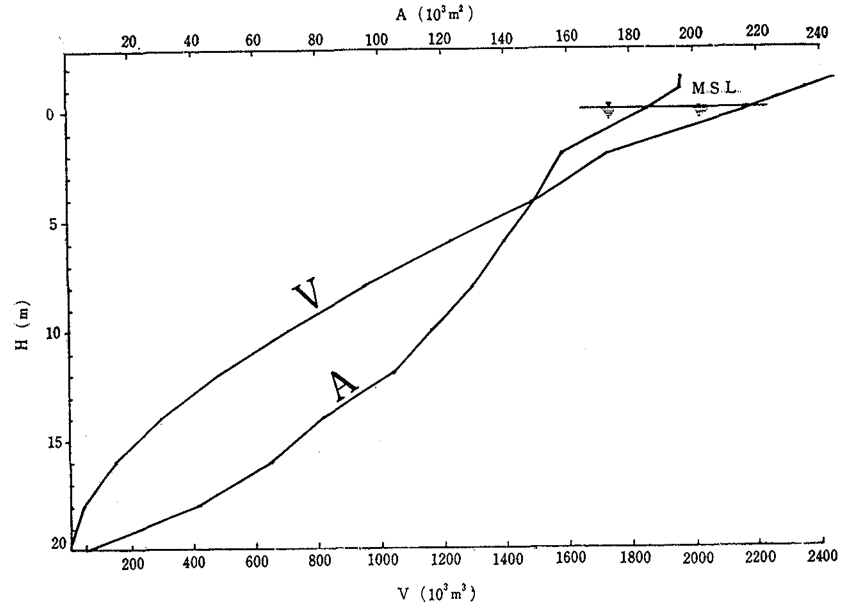


Fig. 2 H-A and H-V curves of Tanoura facility.

water area (A). H-V curve shows the relationship between the water depth and the water volume (V). The water depth was measured from the water level to the bottom of the bay. These curves were taken from the contour lines on Fig. 1.

From Fig. 2, A(water area) is about $185\times10^3m^2$ at M. S. L. (Mean Sea Level) and V (water volume) is about $2,166\times10^3m^3$ at M. S. L. According to the observation data on TABLE 1, the tidal range of the facility is within $\pm$ 1 m and H-A and H-V lines are roughly linear as shown in Fig.2.

### Sea Water Volume of the Facilty

The sea level varies with tide, as shown in Fig. 3, and this is listed in column (2) of Table 1. The sea level is calculated from the M. S. L. (Mean Sea Level). When the sea level is 0.83 m below M. S. L., the sea level is shown as −0.83 m. The water volume is obtained from Fig. 2 and it is listed in column (3) of the same table.

When the sea level is −0.83 m the water volume is $2,024\times10^3m^3$, and when the sea level is 0.83 m the water volume is $2,324\times10^3m^3$. The difference between the two is $300\times10^3m^3$ which is $\triangle V_{inc}$, the increased water vloume of the facility during flood tide. The increased water volume is listed in column (4) of Table 1. During spring tide, $\triangle V_{inc}$ varies from $89\times10^3m^3$ to $300\times10^3m^3$; and during nearp tide from $110\times10^3m^3$ to $220\times10^3m^3$.

Table 1 Water volume

| Date (Aug. '63) | (1) T | (2) H (m) | (3) V ($10^3 m^3$) | (4) $\triangle V_{inc}$ ($10^3 m^3$) | (5) $\triangle V_{dec}$ ($10^3 m^3$) | (6) Tide |
|---|---|---|---|---|---|---|
| | | | Spring Tide | | | |
| 5 th | 17:05 | -0.83 | 2024 | | | |
| | 23:48 | 0.83 | 2324 | 300 | - | flood |
| 6 th | 5:50 | -0.10 | 2149 | | 175 | ebb |
| | 10:00 | 0.38 | 2238 | 89 | - | flood |
| | 15:15 | -0.80 | 2029 | - | 209 | ebb |
| | | (Total) | | 389 | 384 | |
| | | | Nearp Tide | | | |
| 12 th | 16:45 | 0.60 | 2281 | | | |
| | 23:14 | -0.05 | 2158 | - | 123 | ebb |
| 13 th | 4:19 | 0.59 | 2268 | 110 | - | flood |
| | 10:10 | -0.60 | 2064 | - | 204 | ebb |
| | 16:30 | 0.51 | 2264 | 200 | - | flood |
| | | (Total) | | 310 | 327 | |

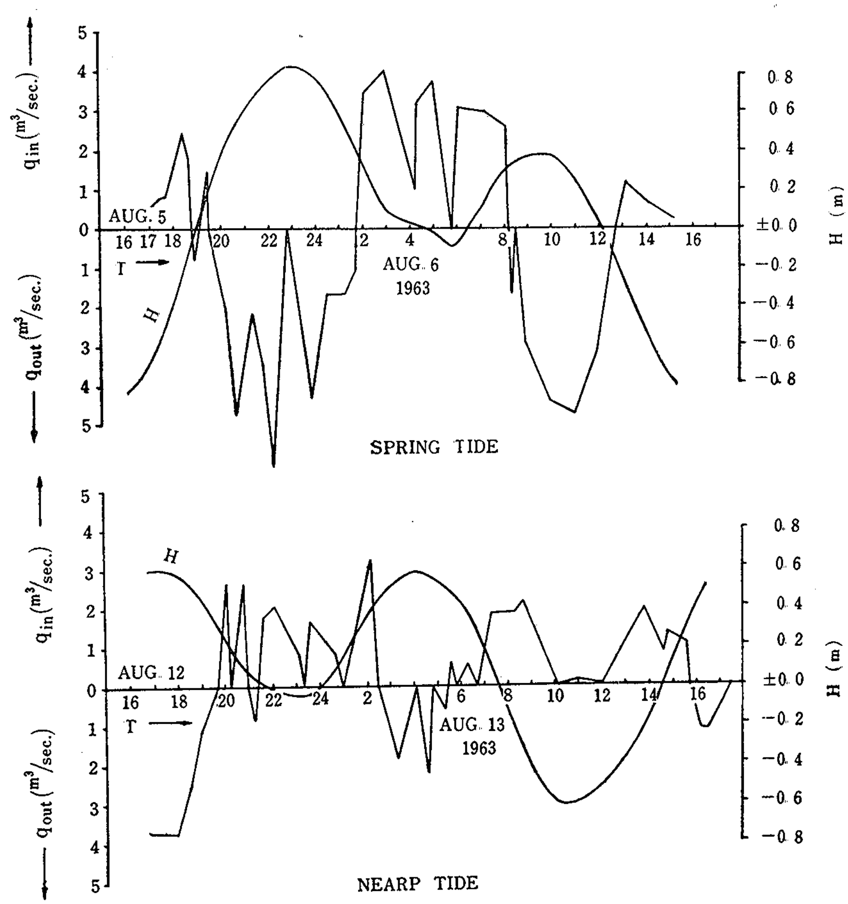


Fig. 3 The quantity of sea water running through the channel.

The decreased water volume $\triangle V_{dec}$ is listed in column (5) of Table 1. During spring tide, $\triangle V_{dec}$ varies from $175\times10^3m^3$ to $209\times10^3m^3$; and during nearp tide from $123\times10^3m^3$ to $204\times10^3m^3$.

## Sea Water Running Through the Channel and the Water Capacity of the Channel

The upper figure on Fig. 3 shows the inflow and outflow of the sea water through the channel during the spring tide. The lower figure shows the inflow and outflow during the nearp tide. The abscissa is T, the observation time. The positive direction of the axis of ordinate indicates the quantity of inflow $q_{in}$ ($m^3$/sec.) and the negative direction indicates the quantity of outflow $q_{out}$ ($m^3$/sec.). The tidal level H (m) is also shown on the same figure.

From this figure, sea water starts to flow out through this channel about 3 hours after the beginning of flood tide, and it starts to flow in about 3 hours after the beginning of ebb tide. Consequently, if the flood tide started at 12 : 00 the sea water would begin to flow out at about 3 : 00 and it would flow out untill about 9 : 00 which would be about 3 hours after the beginning of ebb tide which started at about 6 : 00.

From Fig. 3, the quantity of sea water through this channel was calculated and it is listed in Table 2. During spring tide from 20 : 32 on the 5th to 2 : 49 on the 6th of August 1963, $Q_{out}$ 5,381 $m^3$ of sea water flowed out of the facility throngh the channel. From 2 : 49 to 9 : 13 on the 6th of August, $Q_{in}$ 5, 229 of sea water flowed into the facility. From 9 : 13 to 14 : 00 on the 6th, $Q_{out}$ 5,136$m^3$ of sea water flowed out of the facility through the channel.

Table 2 The quantity of sea water running through the channel

| Date (Aug. '63) | T | | $Q_{out}$ ($m^3$) | $Q_{in}$ ($m^3$) | Date (Aug. '63) | T | | $Q_{out}$ ($m^3$) | $Q_{in}$ ($m^3$) |
|---|---|---|---|---|---|---|---|---|---|
| | Spring Tide | | | | | Nearp Tide | | | |
| 5 th | 20:32 to | 2:49 | 5,381 | - | 12 th | 19:50 to | 2:30 | - | 2,389 |
| 6 th | 2:49 | 9:13 | - | 5,229 | 13 th | 2:30 | 5:33 | 833 | - |
| | 9:13 | 14:00 | 5,136 | - | | 5:33 | 16:00 | - | 2,777 |

Table 3 Values $\triangle V$ and Q

| Tide | $\triangle V$ ($10^3m^3$) | Q ($10^3m^3$) |
|---|---|---|
| Spring | 386.5 | 11 |
| Nearp | 318.5 | 5 |

Thus, about $11\times10^3m^3$ of sea water flowed in and out during one spring tide. As for nearp tide, about $5\times10^3m^3$ of sea water flowed in and out.

## Contribution of the Channel

In order to find out the actual contribution of this channel, the quantity of sea water running through the channel, Q, was compared with $\triangle V$ and the results are listed in Table 3, where $\triangle V$ is the mean value of $\triangle V_{ino}$ and $\triangle V_{dec}$ or $\triangle V=(\triangle V_{inc}+\triangle V_{dec})/2$, and $Q=(Q_{in}+Q_{out})/2$.

From this table Q is a small per cent of $\triangle V$; thus, this channel does not help very much in increasing the inflow and outflow of the sea water of the facility.

With further investigation, we may be able to recommended a better channel site or other methods to increase the inflow and outflow of sea water.

## Summary

In order to find out how much the channel contributed to the inflow and outflow of sea water, we measured the water flowing through the Tanoura Facility Channel and its tidal level during one spring tide and one nearp tide. The findings of the observation are :

A) Facility

1) The sea water area of this facility is $185\times10^3 m^2$, 2) the sea water volume is $2{,}166\times10^3 m^3$, 3) the maximum depth is 20 m, 4) the amount and kind of fish cultivated is $28.5\times10^4$ "Hamachis".

B) Water Capacity of the Channel

1) Sea water starts to flow out through the channel about 3 hours after the beginning of flood tide and it starts to flow in about 3 hours after the starts of ebb tide.

2) The quantity of the outflow through the channel during one spring tide is estimated as $11\times10^3 m^3$; the inflow during one nearp tide is estimated as $5\times10^3 m^3$. On the other hand, during spring tide the water volume of the facility increased $389\times10^3 m^3$ in flood tide, and decreased $384\times10^3 m^3$ in the ebb tide. During nearp tide the water volume increased $310\times10^3 m^3$ and decreased $327\times10^3 m^3$.

Because the quantity of sea water running through the channel is only a small per cent of the increased and decreased volume of the sea water in the facility, the channel does not help a great deal in exchanging the sea water of the facility.

Further investigation is needed to improve the sea water condition of the facility.

## Acknowledgements

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# 浅海養殖施設に関する研究

## 田の浦養魚施設（香川県）に掘さくされている補助海水給・排水路の給・排水能力

福田　清，前川忠夫，河野義広

**要旨**　溶存酸素量の充分な海水を，絶えず放養魚に供給することは，浅海養魚において最も重要なことであろう。このことは，一般の浅海養魚施設では，水門や締切網の網目を通る海水の流入（給水）・流出（排水）によって行われている。しかし，これだけは充分でない場合に，水路を掘さくして外海水面と施設の海面を連結したり，パイプ・ラインを設けて，給・排水の増加を図っている施設がある。

これらの，補助給・排水施設が，どのくらい施設全体の給・排水に役立っているか，その給・排水能力を明らかにすることは，重要な意味を持つと考えられる。

ここにおいて，筆者たちは，田の浦養魚施設の南東側に掘さくされている補助給・排水路（断面 2×2 m，延長140m）の給・排水能力を，1963年8月の大潮・小潮について，24時間連続調査・計測した。

その結果，大潮・小潮を平均して，補助給・排水路の給・排水量は，約$0.8\times10^4m^3$であった。これに対し，潮差によって生ずる施設の水容積の増減量（すなわち施設の見かけの給・排水量）は，約$35.2\times10^4m^3$であった。したがって，この補助給・排水路は，給・排水の増進という役目を，ほとんど果していないことが，明らかになった。

なお，この研究は，文部省科学研究費（総合研究）の補助によった。こゝに記して謝意を表する。