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# BRIEF DESCRIPTION OF FISH MARICULTURE FACILITIES IN KOCHI PREFECTURE, JAPAN

by

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ABSTRACT

The annual mariculture production of Japan was 114,991 tons in 1976. The species raised by mariculture are yellowtail, red sea bream, mackerel, etc. The production of yelowtail accounts for 97% of total.

The facilities for fish culture are divided into three types; embayment, outer bay and offshore types depending on geographical and meteorological conditions. In this paper the structure of these facilities and damage caused by typhoon are described in detail.

In order to make the layout of a unit resistant to strong waves some conditions are discussed basing on the experiments.

# BREVE DESCRIPTION DES INSTALLATIONS D'AQUACULTURE A LA PREFECTURE DE KOCHI, JAPON

La production annuelle par aquaculture au Japon a été de 114 991 tonnes en 1976. Les espèces élevées sont la sériole, la daurade rose, le maquereau, etc. La production de sériole représente 97% du total.

Les installations pour élevage du poisson sont de trois types : endiguées, abritées en baies et au large, selon les conditions géographiques et météorologiques. Dans ce papier, la structure de ces installations et les dommages causés par les typhons sont décrits en détail.

Dans le but d'esquisser une unité résistante aux grosses vagues, quelques conditions sont discutées, basées sur ces expérimentations.

KEY WORDS : Mariculture - technology - coastal - offshore - Japan.

MOTS CLES : Aquaculture - technologie - côte - large - Japon.

## INTRODUCTION

The number of all types of mariculture units in Japan was 5530 and annual mariculture production was 114,991 tons in 1976 according to the government statistics. The species raised by mariculture are yellowtail, red sea bream, mackerel, etc. The production of yellowtail accounts for 93 % of total. Mariculture of yellowtail has become increasingly important since 1958. After that year the crop increased rapidly and taking the 1960 crop of 1524 tons as 1. The crop increased 33 times by 1970 and 75 times by 1976.

The initial mariculture facilities for yellowtail employed dikes or were enclosed inlets, but at the present time the productivity of these fish farming grounds has decreased. Then net cages began to be commonly used. This paper focuses on the practical construction of cage net facilities commonly used by fishermen in Kochi and some trials for improving their resistance to storms.

## I. PRESENT STATUS OF NET CAGE CULTURE

Net cage culture has been carried on along the coasts of the southern part of Honshu, the island of Shikoku and Kyushu. There three basic types of net cages used depending the geographical location and oceanographical conditions.

A. Embaymental farming ground

This type of farming is common to protected bays, inlets and water protected by island. In these areas the currents are very slow, the current velosity being less than 25 cm/sec. And the bottom is composed of mud or mixture of sand and mud. The water depth is less than 25 m and usually the village is nearby. In these areas the facilities are usually floating on the surface. The size of the net cages is 9-10m square with a frame made of bamboo or iron and the net is synthetic fiber or wire netting.

B. Outer bay farming ground

The current velocity is higher than inside the bay with a maximum velosity of 50 cm/sec. and maximum wave length is 2 m. The wave length is 22-30 m and the depth of water is 30-50 m. These areas are protected from typhoons and storms. In suche areas the facilities do not employ an iron frame but groups of nets are attached to ropes fixed to long lines which are anchored to the bottom. The size of the net cages as the same as for A.

C. Offshore farming ground

This type of farming ground is better than B. from a physiological point of view but it is susceptible to typhoons, storms and strong tidal currents, etc... In such places the maximum tidal current is 100 cm/sec., wave height is 4-5 m and wave length 150-200 m.

Storms can last from 4-5 hours in the case of typhoons. There are employed two types of net cages for culture off Shikoku Is. which have such conditions. In one case, an elevator type net cage is employed which can be lowered below the surface. Another case, instead of fixing the net cages to long lines in groups, they are each anchored individually and their shape is circular instead of square, 6 m deep and made of wire netting.

## II. STRUCTURE OF NET CAGE FACILITIES

A. This is very similar throughout Japan as far as shape and materials are concerned. In Fig. 1 an example of this type used in Kochi area is shown. The size is 7.5 x 7.5 x 7.5 m and five of these cages are fixed in a line. The frame of the cage is bamboo or iron. Bamboo frames have a diameter of 7-12 cm and a length of 10 m and 12-16 lengths are needed for one line of five cages. The buoyancy employed

for one line or cages is 270 kg and is provided by floats made of styrol. In the case of iron frames, SGP 500 mm iron pipe is used in a ladder shape. The netting used is made of polyethylene fiber, 40-46 fibers, 400$^{d}$ and the mesh size is 5-6 cm, non knotted seine. Wire netting is 32 mm in diameter and has a mesh size of 5-7 cm and is zinc plated.

The cages made of wire netting have a rigid structure but those made with synthetic fiber netting are flexible and their shape is distorted by their resistance to the water flow. Therefore to prevent too much distortion 12 sand bags are attached to the bottom edges each weighing 7-8 kg. Four 50 kg anchors are used for one line of cages and diameter of the anchor ropes is 24 mm made of polyethylene. Two buoys are attached to the anchor ropes with a buoyancy of 200 kg each.

The synthetic fiber nets changed 10-15 times a year when there is a large build up of attached organisms. Total life of these nets is 3 or 4 years. In the case of wire netting, they are not changed and have a life of only 1 or 2 years.

B. Outer bay type structure

This type started to be widely used since 1970, as a method of using fresh grounds outside crowed embayments. One such structure is shown in Fig. 2. One unit is made up of ten cages fixed in two parallel lines of five cages each. The cages are about 3 meters below the surface with the opening for feeding in the top net just on the surface. The size of the cages is 9 x 9 x 9 m. The netting is 400d polyethylene, 60-80 fibers, mesh size 5-6 m nonknotted. 12-16 sand bags weighing 15-20 kg each are attached to the bottom edges. The nets are changed 3-4 times a year as with the embayment type. Iron anchors weighing 75 kg are used or concrete blocks weighing 2.5 tons. The anchor ropes are 24 mm diameter polyethylene ropes having a length equal to twice the depth. The buoys used for this system are styrol with buoyancy of 270 kg. These materials have a life of 3-4 years.

C. Offshore type structure

One example of this type of structure is given in Fig. 3. In this case a stronger type of structure is needed. It has a circular shape with a diameter of 12 m and a depth of 6 m and made with wire netting to prevent distortion of shape by strong currents and to protect the fish from sharks and puffers.

This shape is very suitable for minimizing damage from storms in the season from July- October, and these cages were designed to be kept up without surplus buoyancy so that there is no excessive twisting of the wire netting due to rough conditions. The maximum surplus recommended is 0.86 tons giving a buoyancy of 2.54 kg/m of wire netting. The buoyancy on the mooring lines should be as far from net cage as possible. In the case of using polyethylene net, the structure, method of feeding and changing nets are almost the same as in the outer bay type, but heavier sand bags must be used.

## III STUDY OF RESISTANCE TO ROUGH WATER OF OFFSHORE TYPE STRUCTURE

A. Resistance of synthetic fiber net facilities to typhoons

One example of a typhoon is described below :

a. Scale of typhoon and strength of wind and wave

Typhoon No. 10 origin NE 300 km of Saipan Island on August 15th 1970. This typhoon landed on the prefecture of Kochi on the morning of August 21st. This typhoon caused a record breaking amount of damage. The total damage was estimated at 4,300 million and 1,602 culture units were destroyed costing 500 million. The culture fish escaped were worth 900 million. Fig. 4 shows the maximum velocity of wind distribution of this typhoon and the duration of winds with a strength greater than 20m/sec.

b. Damage to culture facilities

At this time culture using elevator type net cages was being carried on at Iburi, Kaminoe, and Tei on the Pacific coast of Kochi Pref. At Iburi net cages were located 2000 m offshore in waters about 31 m deep containing 20,000 pieces of yellowtail and 15,000 red sea bream ; at Kaminoe the culture site was 200 m offshore in water about 20 m deep and 15,000 red sea bream were being cultured. At Tei net cages were 3,000 m offshore in waters 31 m deep and Held 15,000 red sea bream. All three sites had cages made of synthetic fiber net. The fishermen lowered their nets

below the surface on hearing typhoon warnings. At Iburi and Tei they lowered their nets 15 m and at Kamonoe 11 m.

At Iburi there was no damage to the yellowtail but nets containing red sea bream brust open on several places and all the fish escaped. On the other hand, the normal type of yellowtqil set nets used for fishing just next to the net cages were completely destroyed. At Tei the net cages were dragged to a site 4 km away bu the strength of the storm and it was found 5 of the 8 anchor ropes had been broken. The floats remained attached but the net has broken at places at the joints and the red sea bream escaped. At Kaminoe the anchor ropes were not broken but three of the anchors dragged and the net shape was distorted. The net was broken about in at the joint and the fish escaped.

In each case the ratio of the total mooring force (W) to the total byoyancy (F) of the Facilities (F/W) was 0.21 and the safety ratio ($\beta$) was 2.74. From the results at these places it is clear that this type of facility can withstand the worst storms having a wave height of 4 m if the mooring force is somewhat increased and the breaking stress is improved.

B. Resistance of wire netting facilities to typhoons

In Sukumo Bay, Kochi Pref., the wire netting used for the experiments was of the ploating type. The frame was 10 x 10 m made of square section pipe 50 x 50 mm, 7.2 floars were attached giving total buoyancy of 270 kg. The total weight of one unit was 1.9 ton. Surplus buoyancy was 1.5 ton. The net cage was held 12 lines which were attached to an outer rope frame 15 x 15 m. This outer frame was attached at the four corners to four anchors.

After analyzing the meteological data, it was clear that the metal can withstand waves of 1.3 m in hight and 30 m in length for a period of 24 hours, but is destroyed by waves of 1.7 m in height in 10 hours.

At the same location, the same type net cage having surplus buoyancy of 0.7 tons was held by only 2 lines to the outer rope frame. In this case the facility was able to withstand the same conditions as the previous case.

## CONCLUSION

The facilities for fish culture in Japan are divided into 3 types, embayment, outer bay and offshore types depending on geographical and meteorological conditions. In this paper, the structure of these facilities and damage caused by typhoons were described in detail.

The results of experiments show that in order to make the layout of a unit resistant to strong waves the following points should be considered.

a) The lines of net cages should be set up parallel to the direction of the waves.
b) The mooring line floats should be placed as far from the net cages as possible.
c) Buoyancy of mooring line floats and the buoyancy on the net cages should be the minimum necessary, as the floats have a buffer action.
d) Anchor ropes should be especially strong at the front of the line as they take most of the strain of wind and current. The rear anchor ropes need not be so thick.
e) The length of the anchor ropes should be twice the depth of water.
f) Ballast using sand bages or iron weights should be used to prevent distortion of the net in offshore areas.

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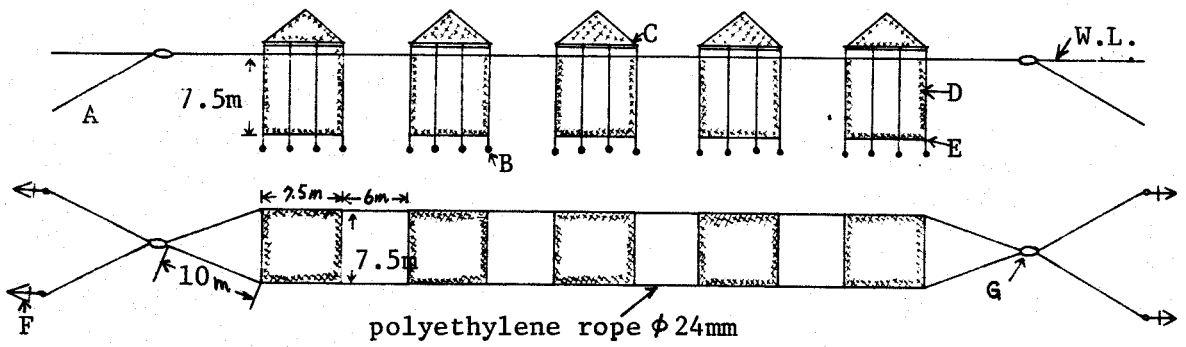


Fig. 1. The yellowtail mariculture facilities in embaymental farming ground. A, polyethylene rope, ϕ 24 mm, n 3; B,stone, 7-8 kg; C, baboo frame; polyethylene fiber, 400$^{d}$ n 40, 7 knot, E, side seine, ϕ 10 mm; F, anchor50 kg; G, stylol float ϕ 56 cm, l 90cm, buoyancy 200kg

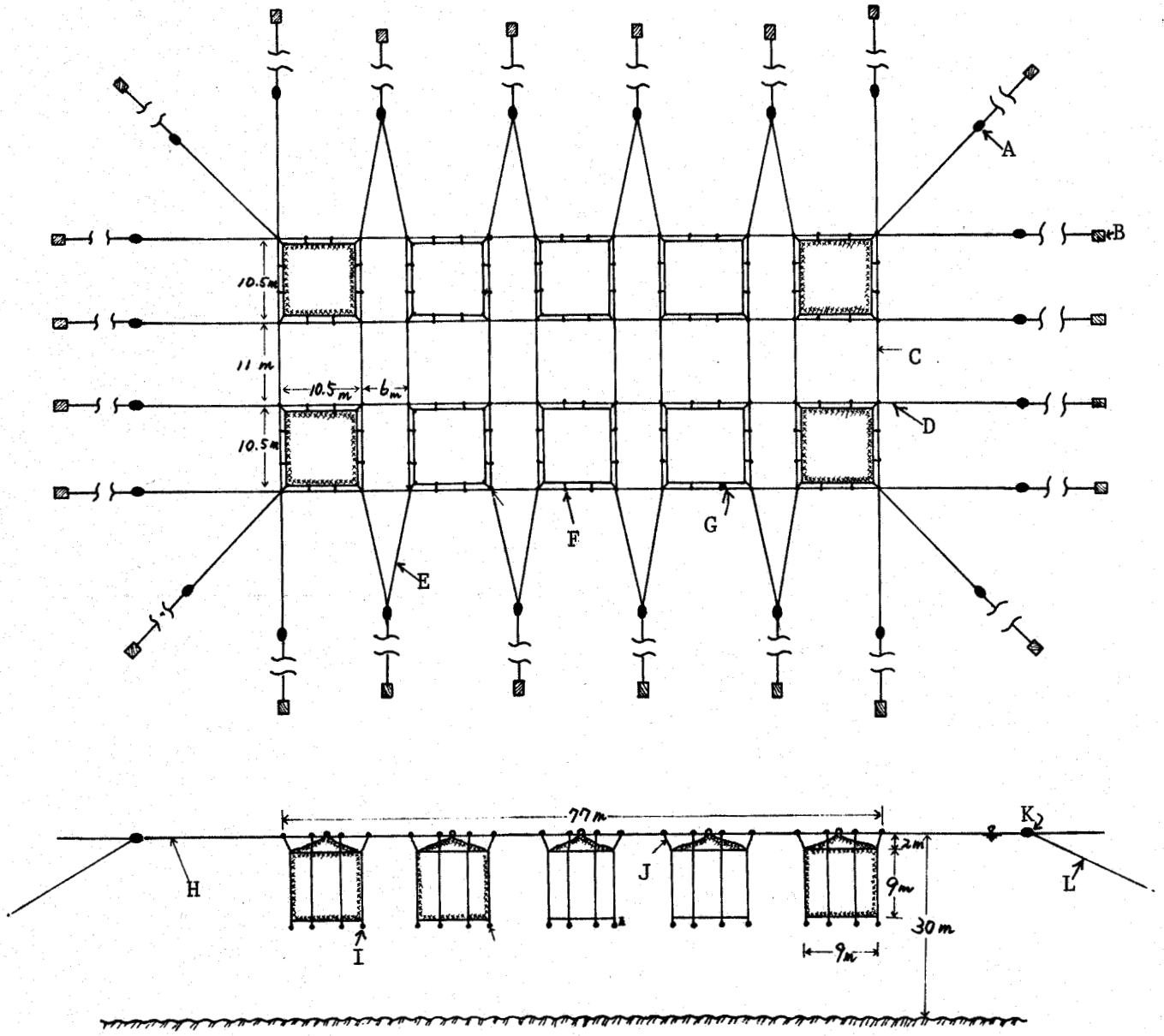


Fig. 2. Structure of outer bay type mariculture facilities. A, styrol float, Buoyancy 200kg; B, Concrete block 2.5 t; C, polyethylene rope φ25mm; D, polyethylene rope φ30mm, length 20m; E, polyethylene rope φ25mm, length 15m; F, small float, Buoyancy 1.5Kg; G. polyethylene rope φ16mm; H, polyethylene rope φ 30mm, length 20m; I, sand bag, 20 Kg; J, polyethylene rope 16mm; K, mooring buoy; L, polyethylene rope φ 25mm, length 90m.

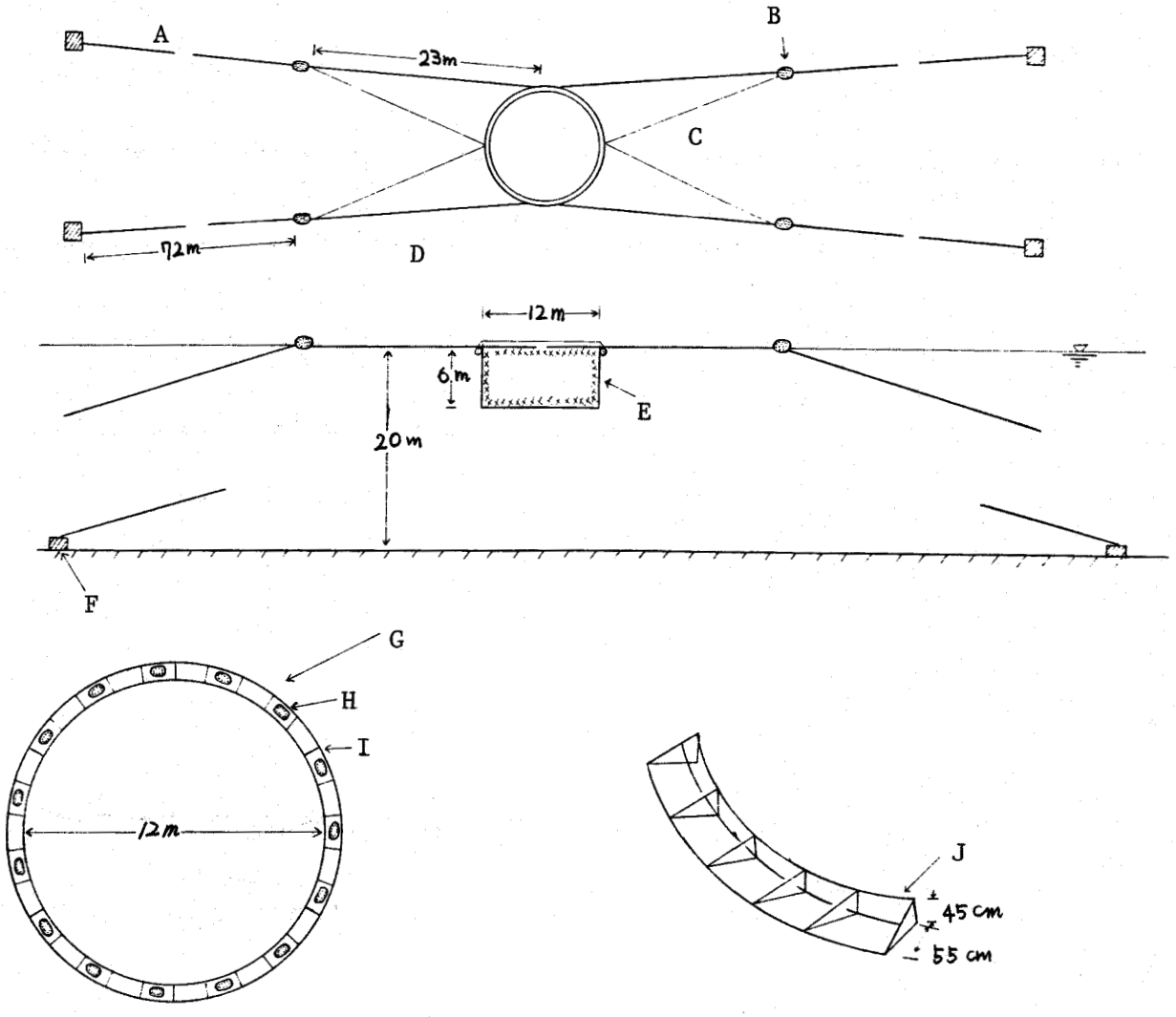


Fig. 3. Structure of offshore type mariculture facilities. A, polyethylene po rope ϕ 65mm; B. stylol float buoyancy 200Kg; C, polyethylene rope ϕ 24mm D, polyethylene rope ϕ 48mm; E, wire net ϕ 4.2mm, length 6.5cm; F, concrete block 7t; G, iron frame ( six set combinated ); H, stylol float buoyancy 200Kg; I, welded part; J, SGP ϕ50mm.

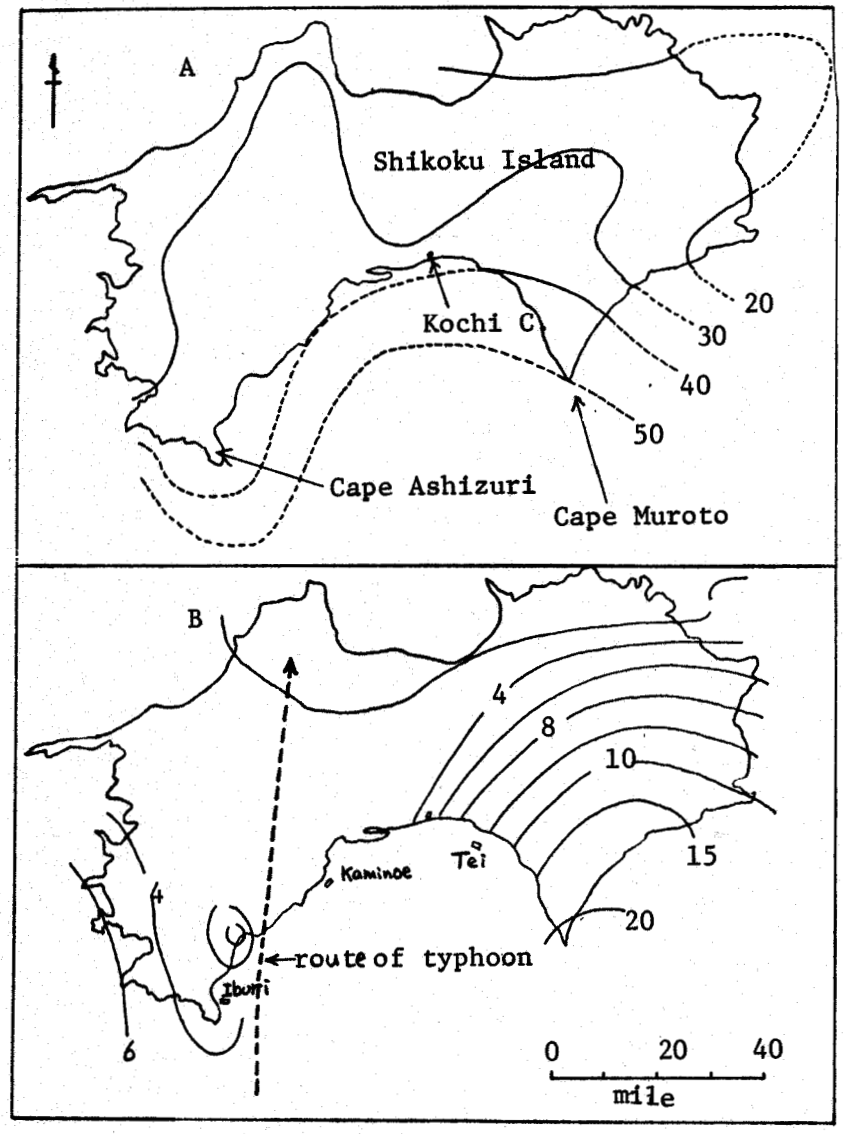


Fig. 4 Distribution of Maximum strength of wind (A) and duration of winds ( hour, B ) more than 20m/sec. in average velosity of wind during typhoon No. 10.