A PLAN FOR THE DEVELOPMENT OF FISHERIES IN GUAM

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A PLAN FOR THE DEVELOPMENT OF FISHERIES
IN GUAM

Introduction
At the request of the Guam administration I have made a general investigation of fisheries in Guam from September 4 to September 11 and September 24 to September 26, 1955.

It was the desire of Governor Ford Q. Elvidge and of the members of the Guam legislature that this survey should lead to recommendations for the development of fisheries resources in Guam. Although the time allotted for this task was very short, I was able to obtain quite a good picture of present fisheries, thanks to the unfailing co-operation received from the officers of the Administration and in particular from the Secretary of Guam, the Director of Agriculture and his staff, as well as from private fishermen and businessmen.

I have set out very briefly the existing conditions regarding fisheries. For further details I refer to the following papers:

A Limnological Survey of Pena River Reservoir, Guam, Marianas Islands - Vernon E. Brock and Yoshio Yamaguchi - 1955.

I have read the five above-mentioned papers and made a number of trips on the island itself, over the neighbouring reefs and out at sea. I have further exchanged views with Dr. Vernon E. Brock in Hawaii and with Mr. George Taggart in Tokyo, both being fisheries experts familiar with the Pacific Ocean.

Although there is a shortage of fish in Guam there is fish in the ocean surrounding this island, and there are other possibilities for developing the fisheries resources. I therefore suggest that steps be taken as soon as possible to implement the recommendations contained in this report.

Fisheries investigations such as the survey recommended in this paper are normally undertaken at a high scientific level. However, the programme considered here was intended for a small area only and its cost should remain well within the possibilities of Guam.
Geographical Data

Guam is the largest and southernmost of the Marianas Islands. It is 30 miles long and tapers in width from 8½ miles in the north to 4 miles in the centre, widening again in the south to reach maximum width of 11½ miles from Orote Point in the west to Ylig Bay in the east. It has a land area, excluding the reefs, of 212 square miles. North of the narrow waist which extends from Agana to Pago Bay, the axis of the island is north-east-south west; south of the waist the axis is north and south. Twelve small islands are scattered along the reef, the largest being Ooos Island, off the southwest coast.

The north half of Guam is a broad, gently undulating limestone plateau bordered by steep cliffs. The plateau slopes generally south-westward from approximate elevations of 600 feet in the north to less than 100 feet at the narrow mid-section of the island. Three prominent peaks, rising above the level of the plateau, are Mount Santa Rosa (693 feet), Mataguac Hill (992 feet), both with underlying volcanic rocks; and the broad limestone dome of Mount Barrigada (650 feet). Along the shore the plateau is margined in places by a coastal plain, irregular in width, and fringed with a modern coral reef.

The southern half of Guam is a broad, ruggedly dissected upland chiefly with an underlay of volcanic rocks. The surface is weathered into peaks, rounded knobs, ridges and basin-like areas and is deeply channeled by numerous streams. A nearly continuous mountain ridge, with crests from 1 to 2 miles inland, parallels the west coast from the highland south of Piti to the southern tip of the island. The principal peaks from north to south of this backbone ridge are Mt. Alutom (1,076 ft.), Mt. Tenjo (1,014 ft.), Mt. Alifan (1,240 ft.), Mt. Islam (1,329 ft.), Mt. Jumullong Manglo (1,198 ft.), Mt. Bolanos (1,220 ft.), Mt. Schroeder (1,053 ft.) and Mt. Sasalaguam (1,110 ft.). The west coast is bordered by an emerged plain less than 300 feet high and less than a mile wide. Two prominent limestone masses, Cabras Island and Orote Point, project westward from the plain at Apra Harbour.

The dissected upland slopes gently eastward from the mountain ridge, and merges into a narrow limestone plateau from 100 to 350 feet above sea level which fringes the east side of the island from Pago to Inarajan.

The west coast of Guam borders on the Philippine sea and the east coast on the Pacific Ocean.

Climatological Data

Temperature

The average annual temperature is 80.7°F. The daily range which is roughly 10°F. is greater than the annual range of monthly mean temperatures - 3.5°F.
3.

A maximum of 95°F. and a minimum of 64°F. have been recorded, but
the temperature seldom rises over 90°F. or drops below 70°F.

**Humidity**

The relative humidity is generally over 60% in winter and over 70%
in summer. The average annual relative humidity is about 81%.

**Rainfall**

The highest rainfalls occur in August, September and October. Monthly
averages over 6 years will be found in Annex 6.

**Winds**

Easterly winds dominate with a strong northerly component from November
through March and a strong southerly component from April through June. From
July through October, winds are highly variable and calms are frequent. Strong
winds of 20 knots or more are nearly always associated with cyclonic distur-
bances.

High seas, destructive winds, and flooding rainfall are all associated
with typhoons that pass over or near Guam. Extremely destructive typhoons
have occurred about once every 8 to 10 years. About 20 damaging typhoons
(including the destructive ones) have been recorded in the period 1898–1954,
an average of about 2 in five years.

**Population**

In 1953, the population of Guam, including both U.S. citizens and
non-citizens and exclusive of military personnel, was 32,882. The population
is increasing. I do not know what numbers of Navy personnel are present on
the island and this factor is, of course, subject to variation.

**Food Supply**

The situation in regard to food supplies is different from what is
generally observed in other South Pacific islands. The presence of Navy
installations has elevated the living standard of the population and brought
them certain benefits so far.

However, Guam is not self-supporting as far as food is concerned and,
since about 60,000 people have to be fed every day, it has become necessary
to import great quantities of food.

A considerable amount of fish and fish products is imported. In the
last fiscal year, 869,855 lbs. of fresh frozen fish alone were imported from
Japan (70%), the United States (19%) and the Philippines (19%). In the
second quarter of 1955, the importations of canned fish products were: 1,568
cases from the United States, 44 cases from the Philippines and 412 cases from
Japan.
LOCAL FISHERIES

Local fisheries are under the responsibility of the Department of Agriculture. This department enforces fisheries legislation, looks after welfare problems, gives information and provides fry for stocking purposes. A Fish Warden is attached to the Department.

A development fund of $900,000 has been granted for the Island of Guam, and 40% of this is earmarked for agriculture, including fisheries. Loans have already been granted out of this fund for fisheries enterprises.

Active fishing takes place on the reef, on the ocean near the coast and in inland waters.

The reef

A narrow reef fringes the island, except for the northern half of the east coast. It reaches its greatest width in the south, near Moroio. Some parts are left dry at low tide.

In the course of my survey, I have recorded a temperature of 84°F. and a salinity of about 35 per mille in a depth of 10 feet, on the reef. The salinity is of course lower near rivermouths.

The growth of coral and algae is normal and in the south it is even prolific.

Many species of fish are present on the reef, but only in small numbers, due to overfishing.

The most common reef fish are: goatfish, parrot fish, snapper, mullet, surgeon fish, spinesfoot, leather jacket, eel, wrasse, trevally, reef cod, pike, garfish, half-beak, wolf herring, anchovy, ray and scad; squid and turtle are also present.

The most important fishing gear used is the fish weir or fish trap. These traps are made of 18 gauge, 2" mesh chicken wire held up by tanguntangan (Leucaena glauca) sticks. The shape of the trap varies but there is generally a wing, at least one fish room and two fish pockets. In some weirs, the pockets are 6 feet deep and in a few, 12 feet deep. A 6 feet weir of normal size requires at least $200 worth of chicken wire.

The length of the wing is limited to 100 yards, and the distance between two weirs may not be less than 150 yards. Weir owners are required to have a license. A total of 45 licenses have been issued. The catches I have seen taken from these weirs were small. On September 5, I have observed a catch of 67 lbs. of fish from a three pocket trap. On the following day, the combined catch from five weirs totalled 133 lbs. Catches of 300-400 lbs. are sometimes made.
Other types of gear used include cast nets, set nets and surrounding nets, hook and line, spear and rock traps. Fish are also attracted with lights.

Sea fisheries

This is mostly practised just beyond the reef with hook and line or nets. Lights are also used to attract the fish. The catch consists mainly of pelagic species - flying fish, mackerel, barracuda, Spanish mackerel and jacks; some snappers are caught just outside the reef. However, these activities are on a small scale.

There is some sport fishing, chiefly trolling, with motor boats.

A departure from the local trends can be observed in the establishment of a new fishing venture by Mr. Cruz of Agana. With the help of a loan of $15,000 which he received in 1954, he has purchased and fitted in Saipan an old Japanese fishing vessel, 53 feet long, which he has equipped with a 225 HP Gray marine diesel engine, giving a speed of 7 knots. The boat arrived in Guam on July 26, 1955. It is a bonito boat rigged for pole fishing with live bait.

Mr. Cruz brought with him from Saipan some fishermen skilled in bait and pole fishing. The rest of his crew is from Guam. Fishing is irregular since the Saipan fishermen have entry permits for one month only and it makes it very expensive for Mr. Cruz to send his crew back after they have worked only one month.

The maximum catch in one day was 1,700 pounds of fish worth 30 cents a pound. Mr. Cruz has repaid $3,000 on his loan but it seems that this money did not come from the sale of fish.

I went out once with this boat. Three and a half hours were spent fishing for bait near some rocks. The bait consisted mainly of "alotoce" (Anchovilula purnua). The quantity of bait caught was insufficient for a fishing trip. In the first place, there was not much bait around and in the second place the fishermen were clearly not used to driving the fish into the bait net.

We went out with the little bait we had and looked for tuna along the north west coast of Guam at distances of from 1 to 4 miles from the shore. We saw four schools of tuna this day, with sea birds flying over them. The first two were moving too fast, but the third one, a very large school of small yellowfin, came near the boat and two were caught with the poles. If we had had some more bait at that time we should have made a big catch. We ran out of bait just at the critical moment.
The schools sighted this day were small yellowfin tuna (Nerthusurus macropterus) and skipjack (Katsuwonus pelamis); flying fish were seen throughout the day. At the time this trip was made the sea water had a temperature of 84°F, and a salinity of about 35 per mille.

**Inland fisheries**

There are some small rivers in Guam but they are of little importance. In the centre of the southern half of Guam there is a body of water called the Fena reservoir. This is poor in fish. A limnological survey of this reservoir has been made this year by Dr. Vernon E. Brock and Mr. Yoshio Yamaguchi. They recommended stocking with Tilapia siliii and Tilapia mossambica in order to control the prevalent pond weed, bladderwort, and some algae. During my stay in Guam the second planting of *Tilapia mossambica* was made in this reservoir. In my opinion the introduced fish can only thrive near the banks, in shallow water.

The Department of Agriculture has a small concrete tank in which *Tilapia mossambica* are raised. These fish were introduced from the Philippines and have already spawned. Some of the fry went to small fish ponds and some to the Fena reservoir.

**POSSIBILITIES FOR IMPROVEMENT**

The improvement of fisheries will have to be considered in relation with three distinct zones:

1. The fringing reef
2. The sea
3. The inland waters.

**The reef**

Even a cursory examination of the reef showed that both flora and fauna are normal but that the fish population is below standard, or in other words, that the reef is over-fished.

Explosives and poisons have done much harm to the fish population. It is only on the slopes of the outer edge of the reef, just outside the surf, in depths from 3 to 20 fathoms, that a normal fish population is found.

Since the shallow parts of the reef are already overfished, I shall not waste time in recommending better fishing gear. The weirs already catch a number of fish and if we take into consideration the use made of nets, lines, spear, as well as the gathering done by hand, the fishing pressure is already sufficient for such a narrow strip of shallow reef.

One of the first steps to be taken should be closer supervision and
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an absolute ban on the taking of fish with explosives or poisons. Heavier fines would be advisable. Such measures would have to be taken at the earliest opportunity, otherwise the depopulation of the reef will go from bad to worse and weir fishery will become unprofitable.

Closed seasons - Reserves

Higher catches could be expected from the shallow reef by the establishment of a reserve or of closed seasons.

Such steps are generally not popular with fishermen, in spite of the fact that they are taken in their own interests. Nevertheless, it is the duty of every Government to protect the national food resources.

In the course of my investigation I observed one place which seems to be the only one in Guam where a reserve could be established with good results. That is the reef plateau in front of Merizo, which extends along the coast from Adjayan Point to Mile Bay. I realize that closing this area for two years as a reserve would seriously handicap the population of the adjacent coastal area. I would not be in favour of doing this, but must mention it as one of the most effective solutions.

Aside from the creation of a reserve there remains only the possibility of establishing closed seasons during the various spawning periods. So little is known of the reef fish of Guam that such a step could not be taken immediately. A simple survey of the reproductive habits of the most important economic species should be carried out over a period of one year. It would be better to have a biologist for this work, but as it would be very expensive to employ a qualified man, it might be possible to have the Fish Warden of Guam carry out a series of fortnightly observations. He knows all the fishermen and I feel certain that if he distributed specimen jars and formaline to owners of weirs, or other fishing gear at various points, the latter would co-operate and collect the ovaries of certain species of fish.

Forms would have to be prepared for each species and filled in, for example:

<table>
<thead>
<tr>
<th>Date of catch</th>
<th>Length</th>
<th>Place</th>
<th>Eggs</th>
<th>Particulars</th>
</tr>
</thead>
<tbody>
<tr>
<td>15/1/56</td>
<td>1'-1&quot;</td>
<td>Morizo</td>
<td>Empty</td>
<td>Few garfish are caught</td>
</tr>
<tr>
<td>1/2/56</td>
<td>1'-2&quot;</td>
<td>Inarajan</td>
<td>Eggs</td>
<td>&quot; &quot; &quot; &quot;</td>
</tr>
<tr>
<td>15/2/56</td>
<td>1'-2&quot;</td>
<td>&quot;</td>
<td>Ripe eggs</td>
<td>Many garfish caught</td>
</tr>
<tr>
<td>1/3/56</td>
<td>1'-3&quot;</td>
<td>&quot;</td>
<td>Very ripe eggs</td>
<td>&quot; &quot; &quot;</td>
</tr>
<tr>
<td>15/3/56</td>
<td>No garfish caught, bad weather</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14/56</td>
<td>1'-3&quot;</td>
<td>Morizo</td>
<td>Empty</td>
<td>Few garfish caught</td>
</tr>
</tbody>
</table>

NOTE: If for instance no fish are caught on the 15th on account of the weather and some are caught on the 17th or 18th, entries should be made for one of these dates.
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The survey should cover about 20 economic species of fish. After one year a decision could be made about which species should be considered for a closed season. This closed season could extend over a period of 3 months.

Once a closed season has been established for one particular species, any fish of that species caught in weirs or other gear during that period should be released. The South Pacific Commission could give advice on these matters. Such seasonal limitation on the taking of certain species is a normal procedure in other countries and I have indicated above the simplest way of dealing with this problem in the case of a small fishing area. I would recommend that an amount of $500 be set aside by the Department of Agriculture for the purchase of fish and jars, and to cover transport costs.

**Bottom traps**

On the sloping edge of the reef live some species (Lutjanidae, Serranidae, etc.), which never come on to the shallow reef. These fish can be caught in bottom traps made of split bamboo or chicken wire on a wooden frame. (See annex ?).

In depths of 8 to 20 fathoms, a line and a float are usually attached to the trap. In lesser depths the trap can be lifted with a grapnel hook and a line. An outrigger canoe would be suitable for handling these traps. They should be lifted every second day and can be replaced as soon as they have been emptied. During periods of bad weather, the traps can safely be left unvisited. Once a month they should be brought ashore for drying and cleaning. Traps are used commercially in many countries; they may be of many different shapes and may have several entrances. Traps are sometimes baited although this is not always necessary.

**Fish lure**

Schools of Carangidae swim along the deep outer reef shelf, in particular some "Atula". I saw two schools of these from Suapon Point just before sunset. Local fishermen told me that soon after the war a buoy was anchored just outside the reef opposite Agana. The anchor chain attracted many fish and it was a favorite fishing spot.

Such devices are used in Indonesia, Malaya and the Philippines for attracting fish. This type of gear is called a "rumpon". It consists of a float, an anchor line garnished with pieces of coconut leaves or bunches of long grass, and an anchor or stone. When I explained this to Guam fishermen, they understood the principle and related it to their experience with the Agana buoy.

These lurelines attract chiefly pelagic fish such as mackerel, sardines,
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trouvable, sand, dolphin, small tuna, herring, etc. I have had several years' experience with this type of gear. The fish are upstream of the "runon" and can be caught with deep sea seines, lampara, handlines or troll lines. If a strong light is used at night near the lure the fish will come to the light (see annex 2).

**Trochus niloticus, L.**

The trochus shell provides an important source of income for many Pacific islanders. There is no trochus in Guam, but as the reef and its sloping edge seem to offer good conditions for this shell, a transplantation from Saipan to Guam would be advisable.

Only trochus about 2 years old, with a base diameter of 2" to 2½" should be used for transplantation. Bigger specimens are often damaged by borers, while the smaller ones are at most slightly damaged. Many such borers are generally present on most tropical reefs, for instance boring clams (Lithophaga, Parapholas and Rosellaria), gastropods (Vermulus, Spondylus and Patella), and the boring sponge Ciona. These borers cause much damage, however, and it would not be advisable to introduce them together with the trochus.

Some trochus have already been brought from Saipan by Mr. Cruz on his bonito boat and put out on the reef near Agana. They were still alive a few days later. It seems also that a Mr. Bronson has been granted a loan to introduce trochus from Saipan. This, however, had not been carried out at the time of my visit.

I would advise that some care be exercised in the matter of this transplantation and I think that the simplest way would be to charter Mr. Cruz's boat. This boat has built-in wooden tanks for live bait. The trochus could be placed on chicken wire trays 4" high, 2 ft. long and 1½ ft. wide, and these trays could be stacked in the live bait tanks in such a way that the top ones remain covered with water. It would be possible to put about 30 trays in one tank, with an average of 30 trochus in each tray. Since the boat has two tanks it would then be possible to carry 1,800 trochus.

A plant of 900 trochus should be made in Tumon Bay and the rest should be put near Coco Island. The plants should be made in shallow water (1 to 5 fathoms). If the attempt is successful, the trochus will spread to other areas. If so the first trochus could be gathered after 5 years, at a minimum size of 3" across the base.

A second transplantation made now would undoubtedly make for a higher yield after the 5 years have elapsed. However, there is the question whether Saipan would be able to donate more than 1,800 trochus.
Trochus can live at least 2 days out of water, but dry transport would not be advisable as it could cause all kinds of disturbances and might, in particular, affect the reproductive capacity of the animals.

The sea

There is practically no deep sea fishing and there are no trained fishermen for such activities. Mr. Crus alone is trying to establish a commercial sea fishing venture with his bonito boat. I wish him success in his undertaking, but I have serious doubts, as his capital is insufficient to carry out experiments, his boat is very expensive to run and he is not an expert fisherman himself, but has to depend on foreign fishermen, with all the attendant difficulties. This man has very progressive ideas and is industrious. With all due respect to his qualities, however, I have to advise that the factors against this venture are so overwhelming that any development of sea fisheries in this difficult area would better be undertaken by the Government Authorities themselves or by some large private concerns.

If we study the problem as a whole we can perhaps come up with some definite conclusions.

1. There are yellowfin, skipjack, other tuna, flying fish, atule, mackerel, marlin, barracuda, dolphin, trevally, etc. in the area, and these are all edible species.

2. We know little, however, about the quantities of fish and the season during which they are available.

3. The Japanese have made good catches of skipjack, tuna, and flying fish during the war, but little is known of their fishing seasons and areas, of the bait they used and where it came from, etc.

4. I have myself seen good bait around Guam: Anchovia lina purpurea, locally called “Aleates”. This species is found along rocks and on the reefs as well as in the Navy Harbour, but little is known of quantities available and seasonal occurrence.

5. We must determine the periods of the year when the weather permits deep sea fishing.

6. We must find the best fishing methods for use around Guam.

7. We must find which of the species caught in Guam waters will be in demand locally and what prices they can command.

8. We must determine what is the best location in Guam for a commercial fisheries industry.

9. Local fishermen will have to be trained for deep sea fishing.

I shall leave points 1 to 5 and 7 to 9 for later discussion and set
11.

out first of all the various fishing methods which could be used in Guam.

1. Pole fishing with live bait for the various species of tuna.
2. Longlining with local bait or bait imported from Japan (Saury), or from the United States (herring) for tuna, marlin and shark,
3. Lampara with lamp attraction for pelagic fish,
4. Lift net with lamp attraction for pelagic fish,
5. Gillnet for flying fish
6. Gillnet for mackerel
7. Gillnet for atule.
8. Gillnet for largo fish
9. Trolling for Spanish mackerel, tuna, barracuda, dolphin, trevally, etc.
10. Handlining for trevally, dolphin, shark, etc.

Out of these 10 fishing methods, the most profitable must be selected.

From an examination of the 9 points set out earlier and the 10 methods above, it becomes clear that fisheries development is a task for the Government. Some big fishing concerns might be interested in one or the other of the above-mentioned methods, but this would probably lead to the employment of foreign fishermen.

Since the intention of the Government is to promote the development of fisheries for and by the local people in order to increase the supply of fish from local sources, I feel that the following plan is both the simplest and most logical that can be followed:

A two-year programme of fisheries development should be instituted under the supervision of the Department of Agriculture. This will involve the recruitment of a fisheries specialist for a period of two years.

This specialist should be a trained fisherman, able to navigate a fishing boat, experienced in tropical fisheries and having a good knowledge of nets and lines. Such a man could certainly be found in Hawaii, Okinawa or Manila. He should have a good command of English and be ready and even eager to train Guam fishermen; in other words he must become an instructor.

A motor fishing boat would have to be bought from Japan, Okinawa or the United States. I think Japan would be the most suitable place as the boat could be delivered in Guam within six months of ordering. Nets and lines could also be ordered from Japan. The question of where to order obviously rests with the Government of Guam and my suggestions in this regard are merely indications of what I think would be best.

The survey would have to be carried out on a semi-commercial basis so that 50% of the running costs, exclusive of the depreciation of the boat and
the salary of the instructor, could be covered by the sale of fish. Twenty per cent of the proceeds could be allotted for the crew (including trainees) and 5% to the instructor. This would be a bonus in addition to salary which would act as an incentive and ensure maximum diligence.

The boat

A rough sketch of a boat suitable for Guam waters will be found in Annex 3. Any fishing boat designer could produce suitable blueprints from this sketch. It should be taken into consideration that the fishing trips would not exceed five days, with a maximum crew of 8 and a maximum of 100 hours of Diesel fuel. The fore-deck should be raised and the foc'sle should contain 8 simple bunks. A line hauler should be placed on the starboard side for long line experiments. Ten removable water sprinklers should be placed outside the after rail. A water pump driven by the main engine would feed the sprinklers which would be used in attracting fish. The boat must be equipped with two bait wells. Each well should communicate with the sea through eight holes 4" in diameter, bored in the bottom of the boat and screened. The sides of the wells should be built at an angle of 20° from the vertical, the bottom of each well being wider than the top. Air spaces should be left to port and starboard of the wells. A fish hold with a capacity of 7,000 lbs. of frozen fish should be placed immediately before the engine room. A refrigerator unit capable of bringing the hold down to -10°C, at maximum load would be sufficient to keep the fish in good condition for some days.

An electric generator, a radio-phone with a range of 100 miles, three wooden outrigger poles 17 ft long and 5" in diameter, some simple navigation equipment, 2 anchors and 120 fathoms of Manila anchor rope (1 1/2" diameter) would be necessary.

Such a boat could be used for all kinds of fishing methods in Guam waters. It would be cheap to operate and the draught is such that the boat could find shelter in many places around Guam. The price would vary according to the place where it is built, but in Japan such a boat, built of good timber and equipped with a Yanmar Diesel engine would cost between 15,000 and 16,000 dollars according to information provided by the Fishing Boat Section of the Fisheries Agency in Tokyo.

Fishing gear

First Year

Ten fishing methods have been mentioned earlier. However, it would not be necessary to buy all the corresponding gear at once. The following items would be sufficient for the first year of operation.

1. Twenty bamboo poles with lines and hooks for bonito fishing. Also
13. a bait net 40 ft. by 60 ft. (See Annex 4). Estimated cost $200.

2. Thirty baskets of long line (see Annex 4). Each basket costs $22 in Japan. With some extra tools the cost would be around $750. A lift net (Annex 4), for use from the side of the boat to secure large bait for the long line. This net should be 26 ft. long and 17 ft. wide (measured along the edge ropes). It should be made of 30/12 cotton with 2" meshes. Some ropes for lifting, 3 kerosene pressure lamps of 500 candle power each, with the globe at the cotton, spare parts for the lamps. Estimated cost $200.

3. A nylon gillnet (see Annex 5) for flying fish and "atule" which would be used as bait for the long line. This net could also be used to catch fish for the market. It should be 600 yards long (mounted) 100 meshes deep, with 2½" meshes, made of dexter 250 x 2 x 2, or equivalent ½ mm. thread. Of this net, 120 yards should be dyed brown and the rest remain in its natural colour. It should be mounted with cork and lead lines. Three coils of 1½" manila rope of 120 fathoms each. Estimated cost $1,200.

4. Some hooks and lines for handlining and trolling. Estimated costs $100.

Second Year

The results of experiments carried out during the first year would show what kind of gear is necessary for the second year. Costs cannot be indicated since it would depend on the amount and type of gear to be used. However, this would not be high; the only expensive item would eventually be the lampara. Small lampara nets are available in the United States and in Japan.

If sufficient quantities of small bait can be caught, bonito and tuna fishing with poles stand a good chance of success. If sufficient quantities of large bait can be obtained long lining is likely to be profitable.

If it is possible to attract large numbers of fish with the lamps, it would become necessary to use a bigger lift net or a lampara. These two nets could be used to catch bait fish or fish for the market, since the species usually caught with them are generally popular food fishes.

The gillnet would give an indication of the species of fish which can be caught in Guam waters. The mesh width indicated is based on the fish I have observed. It is possible however that 2½" or 3½" mesh may be preferred in the light of experience. In any case, 2½" mesh would be approximately the right size.

This net will have to be tested, and that is why I suggested that 120
feet only be dyed. In the second year, the instructor will be in a position to say which part gives the best results.

The crew

A permanent paid crew should be maintained for two years. It would be made up as follows:

One instructor (foreign)
One engineer (local)
Two fishermen (local) able to dive and to mend nets.

These four men should have free board in the ship during working days. The rest of the crew would consist of four young apprentices fishermen from Guam, who would not be paid but would receive only equal share of the percentage allotted to the crew out of the sales of fish, plus free meals aboard the ship.

The future of local fisheries

Once this two-year programme has been carried out, some profitable method or methods of fishing would have emerged.

From this point on, development must be carried on by private enterprise. The experimental boat (if still in good condition) could be handed over to a fishing community or a private company formed by local inhabitants, to whom it could be sold at half price if they pay cash, or on a hire-purchase basis.

How much extension this fishery will take cannot be ascertained at the moment. It would be an important thing if enough fish could be caught to meet the needs of Guam. If it came to a point where more fish was caught than could be readily absorbed in the island, an outlet would have to be found for preserved fish. However, it would be premature to discuss such an eventuality at this early stage.

INLAND FISHERIES

Guam has a reasonable rainfall (see annex 6). The average over the last six years was 85.74 inches. From that point of view, there would be no great difficulty in raising fish in the inland waters, although there are no vast areas such as large lakes or big rivers suitable for fish culture, which could be stocked with fish. Nevertheless, it would be possible to make a contribution to the fish supply of the island, particularly appreciable in times of bad weather, when the supply from sea fisheries is non-existent or inadequate. It may also become an important item for people raising their own fish in backyard ponds.
Three species of fish would be suitable for pond culture in Guam: *Tilapia mosambica* Peters, *Trichogaster pectoralis* Pallas and *Ochropomus gonvani* Lacépède, better known respectively under their popular names of *Tilapia*, *Sapat* and *Gourami*.

**Tilapia**

This fish can grow in fresh or salt water ponds as well as in swamps and reservoirs. It is sexually mature at four months and spawning continues for several years. It is a mouth-breeder and a nest builder. Males grow bigger than females and reach a length of 10" or 12" under good conditions. It is more profitable to raise males in ponds and they are easy to select when they reach a length of 3".

Tilapia is omnivorous. It is easy to transplant and transport alive. It can give high yields, depending on the conditions under which it is raised. This fish has already been introduced into Guam from the Philippines.

**Sapat**

Sapat can grow in fresh water swamps, rivers, lakes and ponds. It matures at seven months and spawning continues for several years. A ripe female 7 months old is capable of laying 7,000 eggs and a 10" female can produce 82,000 eggs. It is a nest builder. It can reach a length of 10" and a weight of 230 grammes. It is a vegetarian and feeds mainly on aquatic plants.

This fish is easy to transplant and to transport alive. Yields can be very high under good conditions. Sapat is available in the Philippines.

**Gourami**

This fish will grow in ponds, swamps and shallow lakes. It will even grow in small backyard ponds. It is a first class table fish and therefore a high priced one. It matures in its third year and at this age it weighs approximately 3 kilograms. If kept in ponds for a longer period of time the gourami will grow indefinitely, so long as the environment is favourable. This fish can reach a length of 3 ft. It is omnivorous, taking at times frogs, insects, worms and many kinds of vegetables. However, it is essentially vegetarian and will eat potatoes, corn, arrowroot, bread and similar foods.

Gourami spawns throughout the year in the Philippines. On spawning they pair off, each pair selecting a suitable place wherein they construct a crude nest. When the nest is completed, the female deposits the eggs. A moderate size female may yield from 800 to 1,000 eggs. From the time the eggs are deposited and fecundated until they are hatched, the parents remain nearly, zealously guarding them. It is easy to transport this fish alive, but for a
transplantation it is advisable to select specimens at least 3" long. Gourami is available in the Philippines.

The introduction of fish is subject to Government authorization and the fish introduced should be covered by a health certificate. It would therefore be easier, in the case of fish being introduced from the Philippines, to obtain them from the Bureau of Fisheries, Manila. Upon arrival the authorities concerned should satisfy themselves that only those species for which permission has been granted are imported.

Fish ponds

Fish ponds can be built of any size. Many backyards or gardens will accommodate small ponds 30 ft. by 30 ft. for raising Tilapia or Gourami. Large ponds are best for commercial purposes.

In Annex 7 I have sketched the plan of a ½ ha. fish farm in which any of the three species mentioned above could be raised. The ponds in this sketch are designed for level ground and their number can be varied at will. On gently sloping ground, small elongated ponds are more suitable. In any case the soil should not be porous. The main or outer dikes must be stronger and somewhat higher than the inner or secondary dikes. Simple wooden gates or pipes can be used to regulate the water supply and the drainage of the ponds. All gates and pipes should be screened to prevent the entry of predators and the escape of fish from the ponds.

In a large fish farm, breeding and nursery ponds are necessary. The pH of the water should not be lower than 7. A slight acidity of the water can however be corrected by putting blocks of limestone in the ponds. The water surface should not be crowded with plants and the sunlight should penetrate freely so that algae and plankton can grow. However, if the ponds were stocked with the above-mentioned species the water surface would be kept clean of aquatic vegetation. The pond water should be stagnant, filling and drainage operations taking place only as necessary. Fertilization of the pond with organic manure is advisable and will promote higher yields.

The Dandang area seems to offer very good possibilities for fresh water pisciculture and I have already had the occasion to advise Mr. Jansen, manager for "Pedro Martinez" in this regard.
SUMMARY OF RECOMMENDATIONS

A. Reef and Deep Sea Fisheries

1. Closer control should be established on reef fisheries particularly in order to put a stop to the use of explosives and poisons for fishing. Heavier fines would be advisable.

2. Closed seasons should be declared for the protection of certain economic reef species during their spawning period. A survey will have to be made as a preliminary to these measures.

3. The use of bottom traps is recommended for bottom fishes on the outer slope of the reef.

4. The use of fish lures is recommended on the outer slope of the reef for pelagic fishes.

5. The introduction of Trochus niloticus from Saipan is recommended.

6. It is recommended that a two-year programme for the development of sea fisheries be instituted under the supervision of the Department of Agriculture. This programme should cover the following points:
   (a) a recruitment of a fisheries instructor for a period of 2 years;
   (b) purchase of a semi-commercial fisheries research boat;
   (c) training local fishermen in deep sea fisheries methods;
   (d) purchase of various types of fishing gear, possibly from Japan. This gear should be tried out in order to determine the most suitable types.
   (e) At the close of the 2 year research programme, the results should be assessed and it may be possible to start a commercial fishery under private enterprise.

B. Inland Fisheries

7. Three species of fish are recommended for introduction. Possibilities for fresh-water fish culture exist in the Dandan area and possibly in other areas as well. Small scale fish culture in backyard ponds is also advisable.

C. General

A local man should be sent to the SPC-FAO Fisheries Training Course which will be held in Nouméa late in 1956, to receive training as fisheries officer. A suitable man would be the Fish Warden.
**ANEX 1**

**TWO BOTTOM FISHTRAP**

- **A Entrance**
- **B Wooden frame**

Diagram: Bamboo Fish trap, Side, Front, Wire fishtrap, Side, Front.
A Rumpon or fishlure
B Canoe with light, fish from A move to B
C Boat has placed a net around B
DECK PLAN

A Linsenmayer
B Foc's'le hatchway
C Access to oil air tank
D Bait well
E Hatch, fish-hold
F Engine room
G Stove
H Hatch store hold
I Raised plank deck
J Insulated fish-hold with refrigeration
K Planks on baitwell
L Emergency sail
M Water sprinkler

SIDE VIEW

EXPERIMENTAL FISHING-BOAT

Annex 3

Scale 1/100
Length 50'
Beam 13'2"
Draught 5'4"
Engine 60 HP - Diesel
ANNEX 4

NET FOR SMALL BAIT

LIFTEST FOR BIG BAIT

Surface Ocean

Figures in fathoms

1 BASEUT OF LONGLINE
ANNEX 5

CJILLAMOT

A  Set near surface

B  Same net as A, but set in deep water, with main rope above net.
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SKETCH OF 1/4 HECTARE FRESH-WATER FISH FARM

PROFILE OF RESERVOIR AND REARING-POND

1 Reservoir  7 Supply canal
2 Breeding-pond  8 Drainage canal
3 Nursery pond  9 Main dike
4 Rearing-pond 10 Secondary dike
5 Canal  11 Supply and drainage pipe
6 Gate

ANNEX 7
Also mullets, shells, squids, and turtle in places.

1. Aletses
2. Flying fish
3. Yellowfin tuna
4. Skipjack
5. Mackarel
6. Barracuda
7. Tuna, marlin and sailfish
8. Many species of reef fishes are found in area inside dotted line.