THE SOUTH PACIFIC COMMISSION FISHERIES NEWSLETTER

Editors: J. Crossland (Fisheries Assistant) and
R. Grandperrin (Fisheries Adviser)
South Pacific Commission
P.O. Box D5, Noumea Cedex
New Caledonia

No. 17 December 1978

CONTENTS

1651/78

A MANGROVE OYSTER STUDY AT STAR HARBOUR, SOLOMON ISLANDS

Rich Braley
Fisheries Officer, Kira Kira
Solomon Islands

INTRODUCTION

A small pilot project involving mangrove oysters was begun in Namunga Harbour (Star Harbour area), San Cristobal Island, Solomon Islands during June 1977. The objective was to see what possibilities exist for culturing of local mangrove oyster species.

There are two main species at Star Harbour. They were identified by Dr P. Dinamani of the Fisheries Research Division, Ministry of Agriculture and Fisheries, Wellington, New Zealand. "Oysters of the genus Saccostrea growing intertidally on rocks and mangroves in tropical and sub-tropical areas have been relegated to a single species, S. cuccullata (Born 1778), by Stenzel (1971) who gives it the status of a superspecies. Oyster species identified formely as echinata, mordax, denticulata, tuberculata and glomerata may now be classified as semi or sub-species of cuccullata. The two Solomon Island types have been identified as echinata (black-lipped large oysters), and tuberculata (massive broad-hinged oysters with numerous chomata)." (Dinamani, personal communication). The latter sub-species is the more common of the two in Star Harbour, and also in Marovo and Roviana lagoons (Western Solomons). It is found on mangrove roots, landing barge skeletons and (in Marovo lagoon only) on intertidal rocks.

Basic information needed for mariculture of oysters is knowledge of the main spawning months, subsequent spatfall, and the growth rate in a culture compared with the rate in the wild.

PROCEDURE

A 15' x 10' raft made of timber and large bamboos, supported by four painted, empty 44-gallon drums was anchored in Namunga Harbour in June 1977. Net trays holding oysters hung from the raft, also wires and ropes holding spat collectors (made of fibrolite squares or natural oyster shell). Oysters should grow more rapidly hanging from a raft since they are feeding in the water 24 hours a day and not exposed at low tide as are wild oysters.

Weekly data were collected on temperature, salinity, secchi depth, tide, spatfall, etc. Plankton net tow samples were taken inside Namunga Harbour about every other week at a depth of 2-3 m using a 20 cm diameter net with a 50 micron mesh. Some samples were sent to Fisheries Research Division, Wellington, for identification of the bivalve larvae found in the late umbo stage at which they settle out as spat. Plankton samples have been taken in Marovo and Roviana lagoons, but not as regularly as in Star Harbour.

RESULTS

Collector plates were hung from the raft, under the wharf, and at a small island outside Namunga Harbour. Plates and shells were cleaned weekly to leave a good surface for spat to settle on. After about two months they were exchanged for new collector plates if no spatfall had occurred. Together the plankton sampling and collector plates gave a good picture of any major spatfalls that occurred. One spatfall was observed in the last week of July or first week of August 1977. It was sporadic; some collectors which had no spat were at the same depth and in close proximity to others that did. There were between 7-25 spat/10 cm^2 area on the fibrolite plates. The natural oyster shell, however, appeared to be a better collector, particularly on the part of the shell facing away from the sea surface. Mangrove wood collectors were made (no bark) but so far little spatfall has been observed on them.

A second spatfall occurred in early or mid-April and continued through most of May. There were from 6-12 spat/10 cm^2 area on fibrolite plates; again, the spatfall was sporadic. When this study was begun at the end of May 1977 it was noticed that mangrove roots and low branches were covered in a relatively heavy spatfall about one month old or less.

There appear to be three major spatfalls per year in the Star Harbour area: April-May, July-August, and December. Some spat are also found at other times. No investigations have been carried out in the Marovo and Roviana lagoons, the Russell Islands or the Florida Islands.[1]

Growth data: Samples of wild oysters were culled off mangrove roots and put in net trays for growth studies. Oysters collected on fibrolite plates, oyster shells and control groups each contained 20-50 oysters. One exception was tray 4 with only eight individuals. All measurements were made with a vernier caliper.

There was a significant difference in growth rates between the cultured oysters and the control group left in a natural situation. Oysters from new spatfalls in most cases showed more rapid growth for the first few months than subsequently (see Fig. 1).

Oysters in trays 1, 2 and 4 were all larger than marketable size (75 mm) and showed an overall growth rate of about 2.5 mm/month in one dimension. If the oysters from the late July-early August 1977 spatfall on the fibrolite plates and oyster shell continue to grow at no less than this rate (and all are showing a faster growth rate in both dimensions) it will take them about 10 months more to reach marketable size. It would be reasonable then to assume a growing period of 20 months or less to reach marketable size from new spat.

An article on tropical oyster farming by Mr Keith Bryson in the November 1977 issue of Australian Fisheries discussed several species he has worked with over the past 20 years in Queensland. *Saccostrea echinata*, which he calls the blacklip or mangrove oyster, is also found at Star Harbour. We have not been studying it because it is not as common among the mangroves as the *cucullata* sub-species. Bryson says most blacklips attain marketable size (75 mm) and shape in 18-24 months (that is a mean growth rate of 4.1 - 3.1 mm/month). Details of all growth measurements are shown in Table 1.

---

1. A recent communication from the author reported spatfalls in July 1978 at Star Harbour, Marovo Lagoon and Marau Sound (east Guadalcanal).

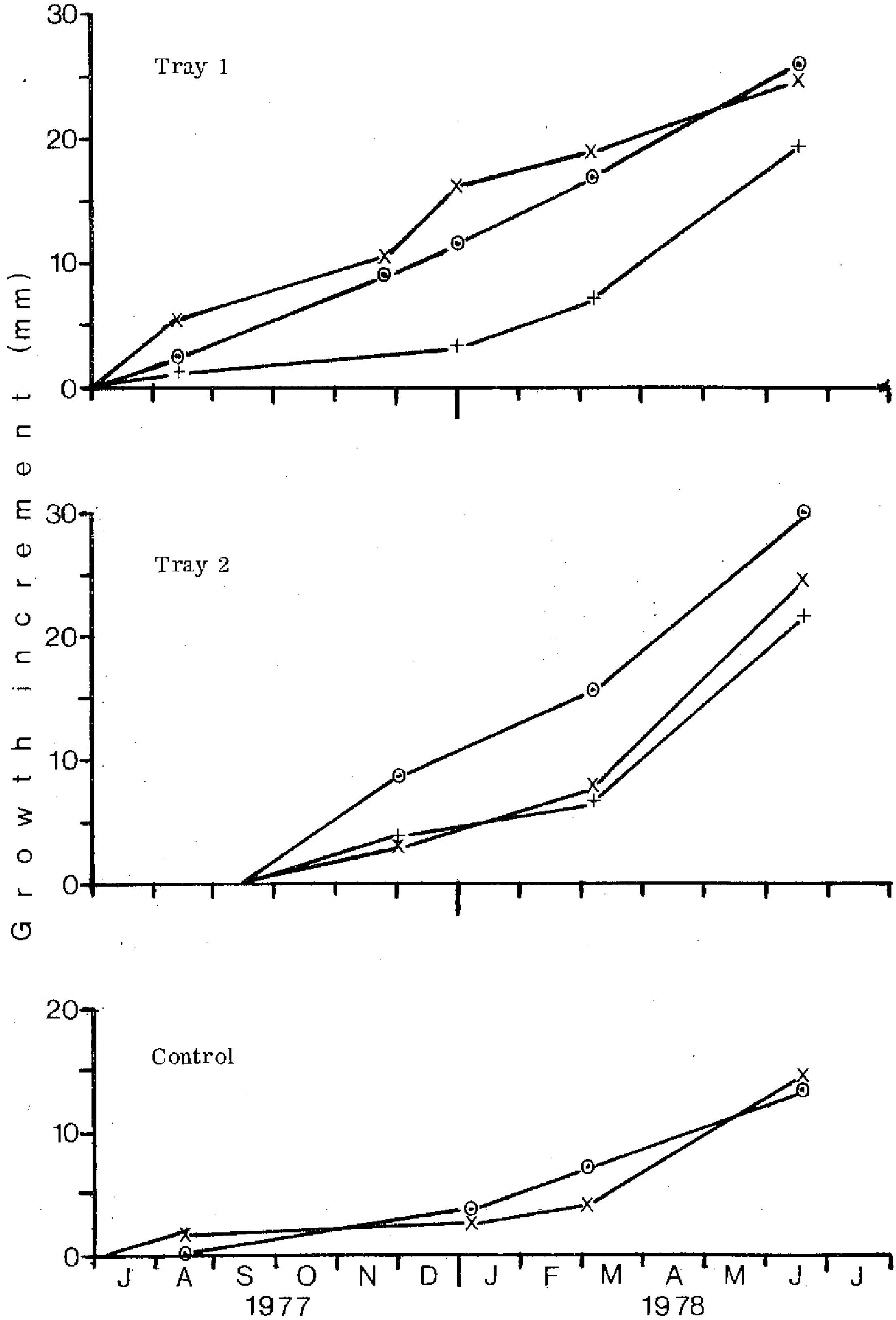


Fig. 1: Growth of mangrove oysters, Saccostrea cucullata tuberculata, at Namunga Harbour, Solomon Islands; X = length; O = width; + = depth; the initial sizes for each batch are given in Table 1.

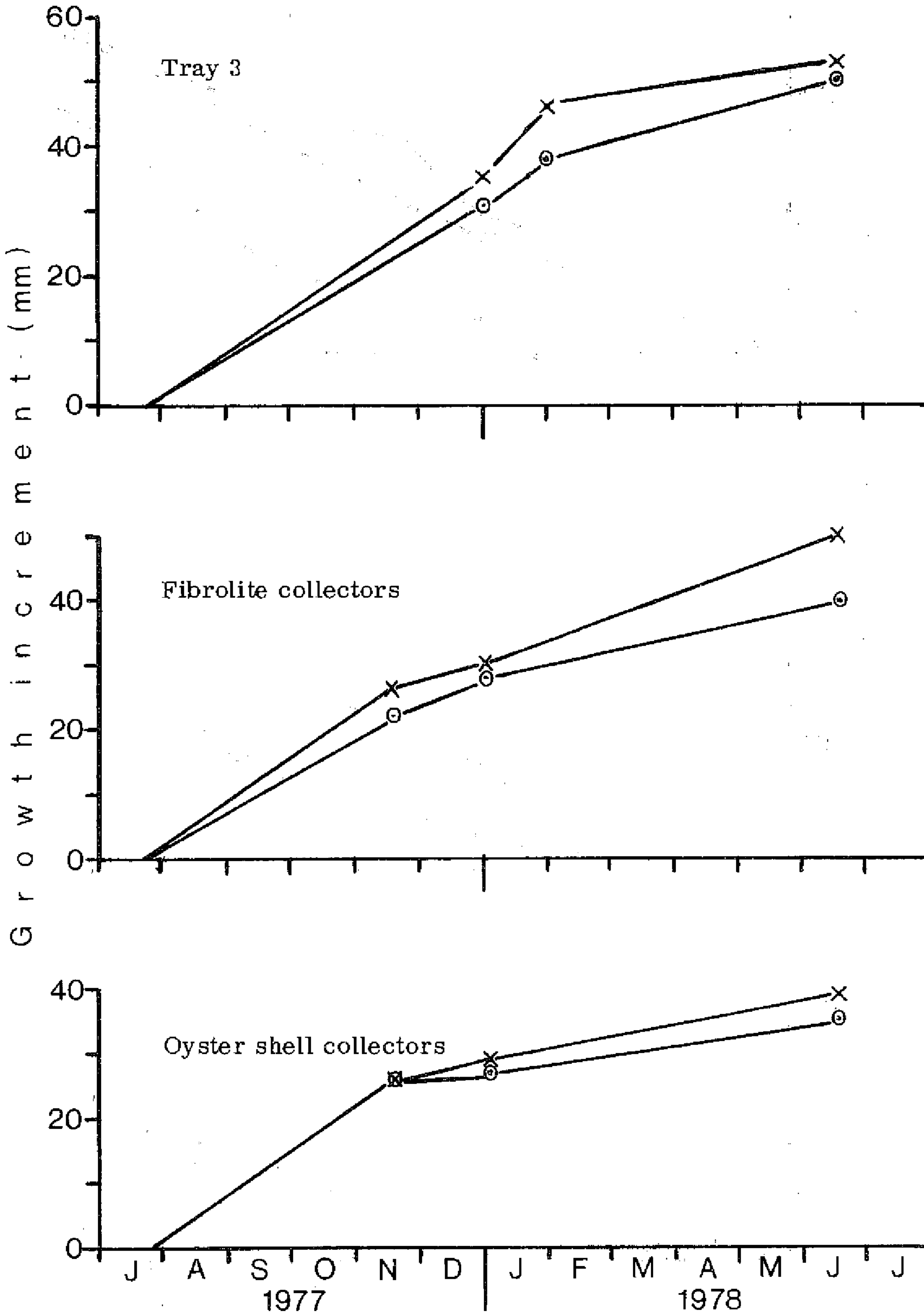


Fig. 1 (Continued)

Table 1: Growth rates of some mangrove oysters, <u>Saccostrea</u> <u>cucullata tuberculata</u>, at Namunga Harbour, Solomon Islands; l = length, w = width d = depth; * outside Namunga Harbour at Naone Islands ; - no data.

Batch	Stock and experimental conditions	Growth periods: Dates	Growth periods: Months	Initial mean sizes (mm) l	w	d	Mean growth rate (mm/month) l	w	d	Overall mean growth rate (mm/month) l	w	d
Tray 1	Wild oysters initially, then continually submerged from raft.	5/7/77-4/1/78	6.0	63	43	11	2.7	1.9	0.5	2.1	2.2	1.7
		4/1/78-22/6/78	5.6				1.5	2.6	2.9			
Tray 2	As for Tray 1	22/9/77-4/1/78	3.4	68	31	8	0.8	2.6	1.0	2.4	3.3	2.4
		4/1/78-22/6/78	5.6				3.8	3.8	3.2			
Control	Wild oysters on wharf piling; intertidal.	5/7/77-4/1/78	6.0	43	36	-	0.5	0.4	-	1.3	1.1	-
		4/1/78-22/6/78	5.6				2.1	1.9	-			
Tray 3	From late July 1977 spatfall on fibrolite pieces; continually submerged.	4/8/77-5/1/78	5.0	<1	-	-	6.9	6.3	-	5.0	5.0	-
		5/1/78-22/6/78	5.6				3.3	3.8	-			
Oyster shell collectors	From late July 1977 spatfall; continually submerged.	4/8/77-4/1/78	5.0	<1	-	-	6.0	5.6	-	3.8	3.4	-
		4/1/78-22/6/78	5.6				1.8	1.5	-			
Fibrolite collectors 1	From late July 1977 spatfall; continually submerged from raft.	4/8/77-4/1/78	5.0	<1	-	-	5.9	5.5	-	4.5	3.8	-
		4/1/78-22/6/78	5.6				3.3	2.2				
Tray 4	Large wild oysters; continually submerged.	9/2/78-22/6/78	4.4	91	67	29	2.6	2.2	2.3			
Fibrolite collectors 2	From late July 1977 spatfall; intertidal from wharf, but exposed short time.	4/8/77-22/6/78	10.6	<1	-	-	4.9	4.6	-			
Fibrolite collectors 3	*From April 1978 spatfall, intertidal from timber frame, but exposed short time.	15/4/78-22/6/78	2.2	<1	-	-	12.0	11.0	-			

Meat condition: Mr Bryson mentioned having some cultured blacklips which at 2.5 years old were 90-120 mm long. Meats of 12 individuals averaged 20g. At Star Harbour in late July 1977 some large, wild oysters were collected and taken to Honiara for measurements. The average shell length was 143 mm (range 100-156 mm). Meats of 10 individuals averaged 15.6g. This represents only 3.9 per cent of the total weight (shell, meat and water). On 20 January 1978 39 medium-large wild oysters, also from Star Harbour, were measured and weighed. The average shell length was 106 mm (range 84 - 138 mm) and the meats had a mean weight of 18g (3.8 per cent of total weight).[1] The scales were not as accurate as those in the laboratory at Honiara but sufficient for approximate weighing.

During April 1978 13 large wild oysters were collected from mangrove islands near Chuchulu village, Marovo lagoon. These were weighed and measured. Average shell length was 129 mm (range 102 - 143 mm). Meats averaged 16.3g (7.3 per cent of total weight). It is interesting that the shell is much thinner in the Marovo lagoon oyster than in those at Star Harbour. This may be a result of the true lagoon conditions in Marovo lagoon and the smaller tidal range than at Star Harbour. Most wild oysters examined at both Star Harbour and Marovo lagoon were not 'fat'. The taste of most wild oysters is good but some individuals have a somewhat strong flavour. This will hopefully be remedied with cultivation.

Mortality and predators: Mortality of the oysters over the study period was fairly low (Trays 1 and 2, zero; the highest were control, 33.9 per cent, and shell collectors, 66.6 per cent.) Predators on the oysters being cultured have not been a great problem. Few oyster borers (*Cymatium*) have been found, and although mudworm (*Polydora*) infestation is present, it is not common.

Plankton samples and other data: At the Namunga Harbour experimental raft secchi readings since July 1977 have averaged 5.7 m (range 3.2 - 10.0 m). Late August to late October was the longest consistent period of relatively clear water. All other periods were up and down in the second readings. These secchi readings indicate large amounts of plankton, which were sampled with a net used for only a few minutes; the results generally filled a 25ml vial about three quarters full of plankton. Bivalve samples contained many Teredines (shipworms), Mytilid larvae, Leptonaceans, flat oyster larvae (*Ostrea* sp.) and *Saccostrea* types. Other plankton included many chaetognaths and a wide variety and number of decapod and other crustacean larvae.

Temperature at the raft in Namunga Harbour averaged 28.2°C (range 26.0 - 29.5°C). Salinity averaged 31.7‰ (range 25.0 - 34.2 ‰).

CONCLUSIONS

Growth rates for the local mangrove oyster are extremely encouraging With marketable size attainable in 20 months or less, the prospects are good for cultivating this species. It is much better to develop the potential of a local species than to try and introduce a new species because it takes much time and effort to securely establish a species where it did not exist before, especially if it is to establish itself in the wild.

---

1. Meats of cultivated oysters measured in November 1978 averaged 8.9 per cent of total weight.

The three most important spatfall seasons of the year are known for Star Harbour; however, there need to be many more small collecting stations set up around Star Harbour so that large numbers of spat can be collected for culturing, and more thorough information acquired about spatfall (seasons, relative amounts of spat falling out in various areas of the harbour).

It would be helpful to conduct a comparative study in several areas of the Solomons at the same time, similar to this study but with even more emphasis spent on spat collection. Marovo or Roviana lagoons, Star Harbour and the Tulagi area would be excellent sites for such a study.

FUTURE PROSPECTS

Markets may exist for these oysters in countries within the region. These markets will have to be approached if oyster farming is initiated to pave the way for a local industry. Wild oysters have been kept out of sea water for up to eight days before they gape, so shipment live should not present a problem.

*   *

*

AMERICAN SAMOA BAITFISH PROJECT

J. Crossland

BACKGROUND

The American Samoa baitfish facility was originally sited at Coconut Point, a few miles from Pago Pago; it later moved to Taputimu agriculture station. Then in October 1976 construction of breeding enclosures was begun at a third site, a large pond at Tapuna airport. In April 1977 the Taputimu facility was closed, and all work was concentrated at the airport site. The present operation, jointly funded by the Office of Marine Resources and the National Marine Fisheries Service, employs a staff of six, energetically led by project manager, Pat Bryan.

THE FISH

Poecilia mexicana belongs to the family Poeciliidae or livebearers, members of which are widely distributed in fresh and brackish water in North and South America. Many species of this large family are well known to aquarists, including the world-famous guppy. The Mexican molly is a much plainer fish, but like other livebearers has the ability to withstand a wide range of temperature and salinity, and low oxygen levels. All these qualities make it an ideal fish, both for the conditions in the culture ponds and for bait wells of tuna boats. Although not a native species, *P. mexicana* was introduced to American Samoa at some time, and natural populations occur in many places there, including the present baitfish site.

THE SITE

The pond at Tapuna is located on the northern side of the runway, next to the sea. About 1.4 ha of the pond at the western end are shallow enough to be suitable for molly culture, and this area is now fully developed. Depths are about 80 cm for the most part, with a small shallow margin of 15 cm depth. The enclosure fences are made of fine nylon netting attached to wooden stakes driven into the bottom. There are several growing-on ponds, brood stock pens, and a leader system with four receivers for the fry. Through this leader system the females approach the weed covered margins to lay their fry. The newly born fry are able to pass through the fine mesh in the receivers and thus escape the cannibalistic attentions of their parents. This system has increased fry production by three to four times. Juveniles are also collected by hand nets along the pond margins. Access to the various enclosures is by a series of channels between them. Staff usually wade around to perform their daily tasks, but the channels are wide enough to take a small punt used for transporting materials about the ponds.

ENVIRONMENTAL CONDITIONS

Conditions in the pond cannot be controlled, and at times can be very severe. There are two small outlets to the sea through culverts, but these are partly blocked by debris. Consequently the pond is little affected by tidal movements. There is, however, a much greater effect from rainfall, which is accentuated by run off from the tarmac apron of the airport. For example, during one 10-day period in May 1977, about 750 mm of rain fell, causing the water level to rise above the top of the enclosures. Only hasty action to raise the entire enclosure system some 20 cm prevented all the fish being lost.

Diurnal temperature variations are usually in the range 28-36°C but maxima as high as 42°C have been recorded in the shallows. Algal blooms are quite common and dissolved oxygen often reaches saturation levels in the afternoons (around 14ppm), with a subsequent decrease to very low levels (2ppm) in the early hours of the morning.

PRODUCTION

Growth of the mollies and their reproduction is encouraged by supplementary feeding with fish meal three times daily. Fry production is apparently also dependent on water level. As the water level drops, fry production increases. Adult females migrate to the shallows in the western end to produce their young. About 40-50 thousand fry is the usual daily production, but it is sometimes double this. In its first nine months of full operation at Tapuna the project produced two million baitfish with an average weight of 1.3g. This represents a production of approximately 2.5 t/ha/yr.

PROBLEMS

Predators and disease have caused problems from time to time. An important predator is a species of cardinal fish, <u>Apogon lateralis</u>, which occurs naturally in the ponds. Many attempts have been made to eradicate it, but with limited success, as it is very difficult to catch.[1] However, it requires higher oxygen levels than the mollies, and its numbers have been reduced by mortality after periods of oxygen depletion. Reef herons also take a regular, heavy toll of the mollies. Disease problems have usually occurred at times when the fish are under stress from environmental conditions, or infestations of an external copepod parasite. This copepod sets up an irritation in the skin which provides a site for fungal and bacterial attack.

POSSIBILITIES FOR POLYCULTURE

An interesting sideline to the molly culture was the introduction into the pond of a number of juvenile rabbit fish, Siganus argenteus. About 8,000 were released on the outside of the pens and some 700 into one of the enclosures. These herbivorous fish completely cleaned off the algae covering the screening, and grew at a phenomenal rate. Unfortunately, they could not tolerate the low levels of dissolved oxygen sometimes occurring overnight. Nevertheless the results were sufficiently encouraging to warrant further trials under suitable conditions. Another attempt at mixed culture was made with a shipment of post-larval shrimps of the species Penaeus monodon, imported from Tahiti. These, too, showed encouraging growth rates.

SKIPJACK FISHING TRIALS

The first fishing trials with the mollies were aboard the 20 m vessel J. Ann. in January and February 1978. They were not very successful, probably because the vessel was not a local boat, nor did it have a proper spray system. Some encouraging facts emerged, however. The mollies did not dive, but tended to form schools, kept close to the boat, and jumped when chased. Later trials in June 1978, using the SPC charter vessel Hatsutori Maru, gave better results. This vessel is fitted with a proper spray system. A report on these trials has recently been published.[2]

THE FUTURE

At present the local fishing boats mainly troll for tuna. The aim of the baitfish project is to produce sufficient bait to enable some boats to take up pole-and-line fishing, and thus improve the tuna catches of American Samoa. Unfortunately this aim is likely to be delayed, because once again the project is faced with a change of site. The reason for the move is that the large numbers of herons which feed on the mollies are considered a potential hazard to aircraft movements.

---

1. There is interest in Tahiti in investigating the possibility of raising A. lateralis as a baitfish.

2. Bryan, P.G. (1978) On the efficiency of mollies (Poecilia mexicana) as live bait for pole-and-line skipjack fishing: fishing trials in the tropical central Pacific. Office of Marine Resources, American Samoa Government, Pago Pago, American Samoa. Technical report on project No. 4-35-D, 45 pp.

The project has until February 1979 to find a new site. It will probably move to Coconut Point on Pala Lagoon. Once again a lot of hard work will be necessary to get the project back into production. Not only will all the equipment and fencing have to be moved and the pond restocked, but the staff will have to overcome the additional problem of a site more exposed to the wind. Project manager Pat Bryan is philosophical about this, and confident that P. mexicana can make a significant contribution to pole-and-line tuna fishing in the South Pacific.

* * *

DEEP WATER POT FISHING IN NEW CALEDONIA AND ADJACENT ISLANDS: FIRST RESULTS

André Intes
Centre ORSTOM, Post Box A5,
Noumea Cedex
New Caledonia

INTRODUCTION

The study of possible new fisheries resources led ORSTOM to undertake a fishing programme on the banks around New Caledonia and the Loyalty Islands. These depths are not accessible to trawling, so potting was used to make a survey of the deep water crustaceans of commercial importance.

New Caledonia consumes an appreciable amount of sea foods, of which crustaceans, and particularly shrimps, are an important part. The territory imports about 150 t annually, mostly Penaeus spp. The exploitation of a possible stock of crabs or shrimps could therefore be quite lucrative.

METHODS

Depths investigated: The first surveys took place to the south of New Caledonia and around the Loyalty Islands. Some sets were also made around the northern islands of the New Hebrides. The depths investigated were 200, 400, 600, 800 and 1,000 m; in a few cases intermediate depths were also sampled. Sets were made along the chosen depth range whenever the slope of the banks allowed this. Ninety-seven sets were made.

Pots: Three types of pots were tried. The most frequently used was the truncated cone model recommended for deep-water red crab fishing (Le Loeuff et al, 1974). The netting used during these trials (20 mm mesh) resulted in a considerable loss of shrimps during retrieval. The second type was made to the design of Struhsaker and Aasted (1974) for a collapsible pot. The entrance mouth was fixed at 5 cm, and did not permit the capture of large individuals of the genus Heterocarpus.

To get around the limiting factor of the size of the entrance, a large rectangular trap with wide entrances (15 x 40 cm) was also used. It achieved some interesting catches, particularly of large shrimps.

Fishing method: The pots were joined to a line at 25 m intervals. They were baited with shark flesh and soaked for approximately 20 h, including the whole of the night. The line could be located by means of a rope and a buoy with flag attached.

RESULTS

Catch composition: the frequency of the species and their possible economic interest enabled them to be put into three groups.

1) Occasional captures

All fishes came into this group. These comprised eels of the families Muraenidae and Congridae (the species not yet identified), and the following species: Cephaloscyllium umbratile Jordan and Fowler, Epinephelus septem fasciatus Thunberg, Physiculus peregrinus Gunther, and Etelis oculatus Cuvier.

Three species of crustaceans also came into this category: a few specimens of Linuparus sp. were taken at 400 m off the Loyalty Islands; Plesiopenaeus sp. was captured in several sets at 800 and 900 m, but only a few individuals were recorded each time; a few individuals of Lithodes turritus Ortmann were also taken.

2) Regular captures of no economic value

Molluscs: Nautilus macromphalus Sowerby, an exclusively New Caledonia species, was captured in appreciable quantities (up to 26 per pot). The best catches were taken in the 400 m zone.

Crustaceans: Eurythenes gryllus Lichtenstein, a large amphipod (4 cm long), was taken between 700 and 1,000 m.

Bathynomus affinis Richardson was only caught to the south of Noumea, with best catches in 600 m. It is a large isopod sometimes reaching a length of 22 cm. Large numbers entered the pots and devoured all the available bait.

Paralomis sp. was captured most frequently at 600 m.

Acanthodes armatus de Haan occured between 100 and 400 m. This crab was never abundant. The quality of its meat and its appearance make it of little potential value.

3) Regular captures of potential economic value

Crustaceans: Several species of Parapandalus all taken at similar depths, are grouped together. Best catches (about 2 kg/pot) occurred in the 200-400 m range. These species are of medium size (up to 14 cm total length), and have an attractive meat of good flavour.

Heterocarpus ensifer Milne Edwards was caught between 200 and 800 m, most abundantly between 400 and 600 m.

Heterocarpus laevigatus Bate occurred between 600 and 1,000 m with best catches in the 800 m zone. This species attains a large size (22 cm) and is probably the one with the best potential for commercial exploitation.

Geryon quinquedeus Smith, the deepwater red crab, was caught between 600 and 1,000 m. Individuals were all of a commercial size (mean weight 0.8 kg). However, the catch rate was insufficient to make this an important economic species on its own although it may be a useful by-catch for a fishery in these depths.

Catches by areas

1) Southern New Caledonia. Two locations investigated, near Noumea and off the Isle of Pines, gave low catches of shrimps (all species combined). The catches varied from 0.2 to 1.5 kg per four pots. On the other hand catches of G. quinquedeus were quite good, with 46 individuals caught for 40 pots fished.

2) Loyalty Islands. In the 200-400 m depth range up to 2 kg/pot of Parapandalus spp. were taken; between 400 and 600 m catches of H. ensifer were up to 3 kg/pot, and at 800 m H. laevigatus amounted to 2 kg/pot, despite losses on hauling. Catches of G. quinquedeus were also good, as 80 kg were taken in 18 sets in their favoured depth range.

Catches compared with other studies

Trials made in Hawaii by Struhsaker and Aasted (1974) resulted in higher catches than the best obtained in this study. Their results ranged from 0.9 to 11.5 kg/pot for Heterocarpus shrimps. On the other hand catches recorded here are comparable to those of Wilder (1977) around Guam during 1975-77 (1.45 kg for H. ensifer and 0.9 kg for H. laevigatus).

The first results of this study suggest that commercial exploitation is possible and would be profitable for small units, particularly around the Loyalty Islands.

References

Clark, T.A. (1972): Exploration for deep benthic fish and crustacean resources in Hawaii. Hawaii Institute of Marine Biology Technical Report 29: 1-18.

Intes, A. (1978): Pêche profonde aux casiers en Nouvelle-Calédonie et îles adjacentes. Premiers résultats. Documents Scientifiques et Océanographiques de l'ORSTOM, Nouméa, No. 2.

Le Loeuff, P., Intes, A. and Le Guen, J.C. (1974): Note sur les premiers essais de capture du crabe profond Geryon quinquedeus en Côte d'Ivoire. Documents Scientifiques du Centre de Recherches Océanographiques d' Abidjan 5 (1, 2): 73-84.

Struhsaker, P. and Aasted, D.C. (1974): Deep-water shrimp trapping in the Hawaiian Islands. Marine Fisheries Review 36 (10): 24-30.

Wilder, M.J. (1977): Biological aspects and fisheries potential of two deep-water shrimps Heterocarpus ensifer and H. laevigatus in waters surrounding Guam. Thesis, University of Guam.

GROWTH TRIALS WITH GREEN MUSSELS IN TONGA

A New Zealand Aid-Project

P. Dinamani and J. Illingworth
Fisheries Research Division
Ministry of Agriculture and Fisheries
Wellington, New Zealand

At the SPC technical meeting on fisheries held in Tonga in 1974, it was agreed that species of shellfish with potential for commercial production be considered for introduction to the South Pacific island member countries. Two species in this category were the Philippine green mussel, Perna viridis (erroneously referred to as Mytilus smaragdinus in many publications) and the tropical oyster, Crassostrea iredalei. The Tongan Fisheries Department accepted these recommendations and sought New Zealand aid in procuring seed mussels and oysters, and also assistance in establishing proper trials for scientific evaluation. The New Zealand Government responded to this request and two members of the Fisheries Research Division in Wellington undertook to supervise the trials and to help in training Tongan staff in carrying out the experiments.

The first lot of experimental material obtained by the Tongan fisheries officials in March 1976 was unfortunately composed of mussels of a large size (40 mm and over), did not travel well and suffered heavy mortality. Histological examination in Wellington revealed that most of the mussels were in post-spawned condition when collected in the Philippines. They had obviously been under physiological stress during the prolonged transport time to Tonga and had not recovered. It was therefore decided to restart the experiments with fresh, smallsize seed, preferably obtained from a direct source so that travel time was kept to a minimum. Help came from the Singapore Fisheries staff who had access to seed-size mussels and promised to collect and transport them to Auckland. A trial shipment of P. viridis seed was flown out from Singapore and when this showed good survival, more seed was air-freighted in November 1976 and introduced into Tonga without delay. Some of the mussels were still larger than desired (20 mm) but this time prospects for their survival in Tongan waters looked more encouraging.

Three sites were chosen for these trials: (1) open but protected deep water (outer reef); (2) sheltered medium depth harbour sites; (3) sheltered shallow water sites within lagoons at Tongatapu and Vava'u Islands. The mussels were held in suspended culture from rafts in three different ways: (A) in small-mesh plastic covered trays at standard depths; (B) in "sausages" of Norwegian netting on ropes at two depths; (C) in plastic lantern-type baskets at four depths. At the end of a 3-month period (March 1977), it was found that mussels in both the tray and lantern-type experiments had experienced high mortalities, and a growth in length of only about 10 mm. Mortalities were higher at the Tongatapu sites, and much of the experimental material was destroyed and lost due to unknown causes. Inside the lagoon itself there was heavy predation by swimming crabs on mussels held in lantern containers. About nine months after the experiments had been in progress (August 1977), the following facts became obvious: (1) mussels in open situations (outer reef) tended to show poor growth and high mortality, especially when temperatures began to drop during May-July; (2) growth and survival improved with depth at sheltered sites, for example in the lagoon; (3) holding mussels in loose netting till they attached securely proved to be superior to other handling methods, the netting being slit afterwards to help mussels grow out; (4) mussels showed a tendency to detach themselves actively from the rope when they were at a size of 20-30 mm.

The mussels' tendency to detach themselves accounted for the heavy losses, with the sudden disappearance of quantities of mussels from experimental ropes. The main reason was found to be weak byssal attachment; it is also possible that the mussels were seeking to migrate to a firmer substrate. However, mussels that grew out of the critical stage and survived in the lagoon showed an acceptable growth rate of about 5 mm/month and attained a mean length of 50 mm at the end of the first year (November 1977). All the mussels showed maturing gonads as well as a few spawned stages, which indicated that conditions in the lagoon may also be suitable for ripening and spawning.

Growth during the next six months (December 1977 to June 1978) was much faster, with the mussels reaching a mean length of 80 mm. This acceptable market size, achieved in 18 months, holds some promise for mussel farming at selected sites in Tonga. More trials are planned and will be combined with a New Zealand sponsored research study on the problems of feeble byssal attachment and migration of small mussels from ropes.

* * *

INFLUENCE OF CURRENTS ON THE PRODUCTION OF TROPICAL SEAS: CONSEQUENCES FOR FISHERIES

R. Grandperrin

INTRODUCTION

In recent decades many oceanographical studies have tried to establish simple relationships between the physico-chemical environment of the open sea and its living communities. From these researches, which are too numerous to list, only a few definite results have emerged. These have usually concerned cases when there are marked changes, such as the spectacular spring plankton blooms in the high latitudes. Generally, however, the effect of environmental conditions on the development of phytoplankton and zooplankton is very difficult to understand, and its effect on the commercially exploited species more so.

The situation in the tropical Pacific Ocean is still largely indeterminate. The analysis of the parameters determining production is therefore complex. The tropical character of these waters has important effects on their production and through this on the oceanic fisheries which have developed there, or may develop in the future. What is this situation? To understand it well, it is advisable to describe the processes of enrichment which have their origin in the oceanic currents. Several very schematic models, essential for the understanding of these phenomena, will be developed.

INFLUENCE OF CURRENTS ON VERTICAL MOVEMENTS OF WATER MASSES

Let us consider an imaginary ocean (Fig. 1a) with the water mass stratified. At the surface there is a layer of low density water, strongly warmed by the sun. At the bottom is cold water, dense and rich in nutritive elements. Between the two is a narrow layer of rapid temperature change, the thermocline. In the surface layer, called the isothermal layer, there is no primary production, despite the abundance of illumination, for the nutritive salts have long ago been exhausted. Without photosynthesis the living cycle is blocked, there is sterilisation of the isothermal layer and the ocean becomes a desert, This is what happens, in a less marked fashion, in many parts of the tropics. These waters are marvellously transparent, and therefore blue[1]. Blue is to the sea what yellow is to land - an index of sterility. Despite a great faunal diversity[2], often mistaken for great richness, production[3] is low compared to temperate waters.

Let us now consider the case, in the northern hemisphere, of a zone influenced by two currents, one nearer the equator setting east and the other west, as shown in Fig. 1b. Because of the direction of rotation of the earth, the Coriolis force[4], acting perpendicularly to the direction of the liquid particles, causes them to deviate to the right relative to the current direction as shown in Fig. 1b and also 1c (to the left in the southern hemisphere, see Fig 1d, e). Between the two currents the surface waters tend to be displaced, creating a deficit, and this is filled by water from the underlying cold layer. This is a divergence.

Still in the northern hemisphere, let us again consider east-and-west-flowing currents, but this time with the west-setting current nearer the equator (Fig. 1c). Between the two currents the surface waters accumulate; the excess water then sinks under the force of gravity. This is a convergence.

Finally let us take two currents, both setting to the west along either side of the equator (Fig. 1f). Due to the Coriolis force the waters are deviated to the left in the southern hemisphere, and to the right in the northern hemisphere. This results in a divergence. This is, in fact, the situation which obtains along the equator. Thus, where a series of currents flow side by side in opposite directions along the parallels[5] (except at the equator) one will encounter from north to south a succession of convergences and divergences. These are very important in determining the productivity of the sea and the location of fishing areas. One such situation is shown schematically in Fig. 2, which corresponds to a north-south section along 170^{0} E.

---

1. The colours making up sunlight are absorbed in varying degrees by sea water. Red, orange and yellow are absorbed in the first few metres, violet and blue penetrate deeper.

2. Species diversity expressed in Shannon's index is greatest when the number of species is high and the numbers of individuals of each are equal: in this case there is no dominant species.

3. Quantity of living material produced in a given period.

4. The theorem of Coriolis (1825) states:"At any instant the total acceleration of the motion of a moving object is the resultant of the acceleration at that instant of the relative motion of the given object, of that of the movement of the geometric point where the moving object lies, and of a third, complementary acceleration". This last is called the Coriolis force.

5. The currents which flow along the parallels follow a "zonal circulation", different from the "meridional circulation" north-south or south-north, which has a different origin.

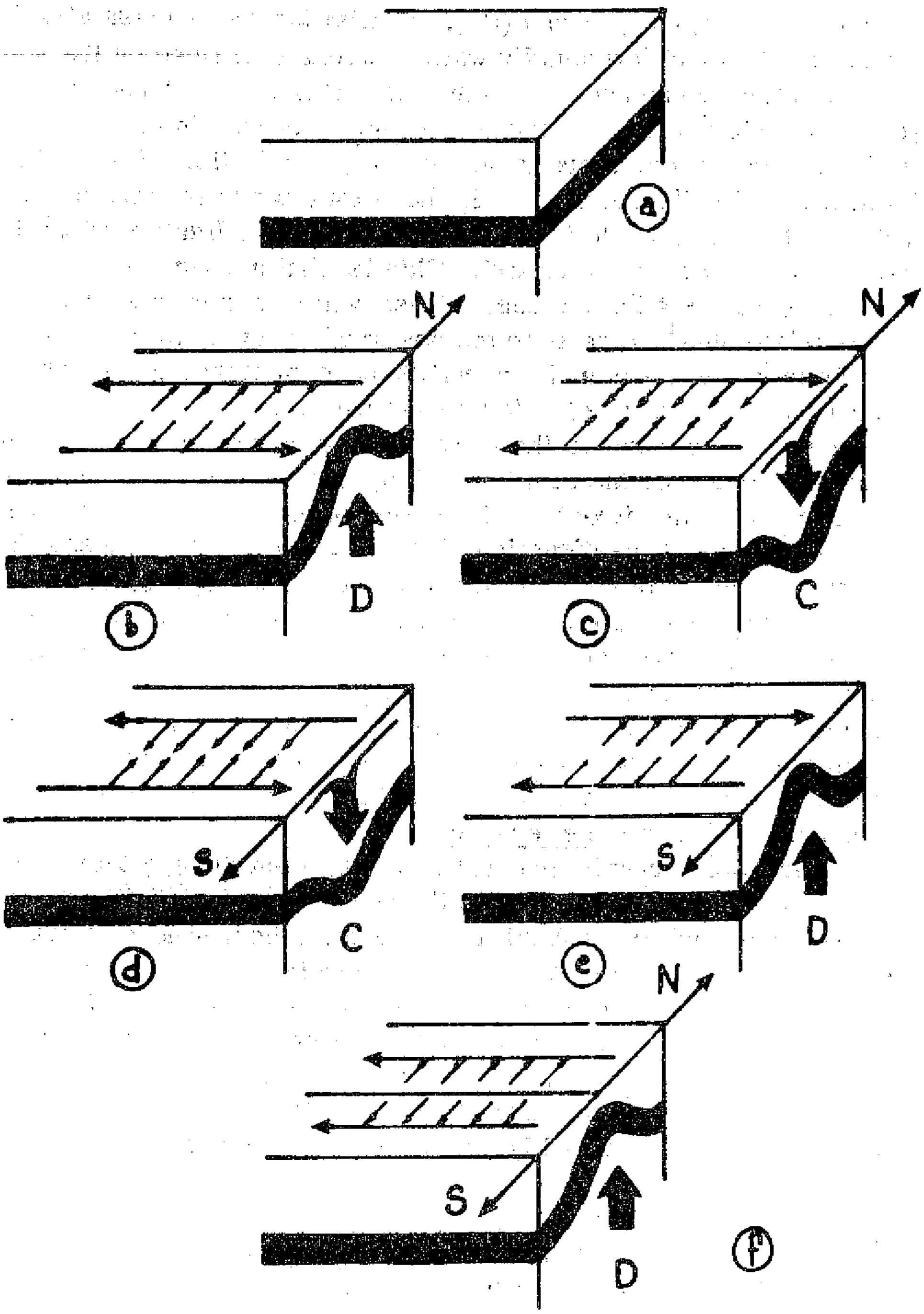


Fig. 1: Ocean currents and the movement of water masses;

a: no current	D: divergence
b and c: northern hemisphere	C: convergence
d and e: southern hemisphere	N: north
f: at the equator	S: south

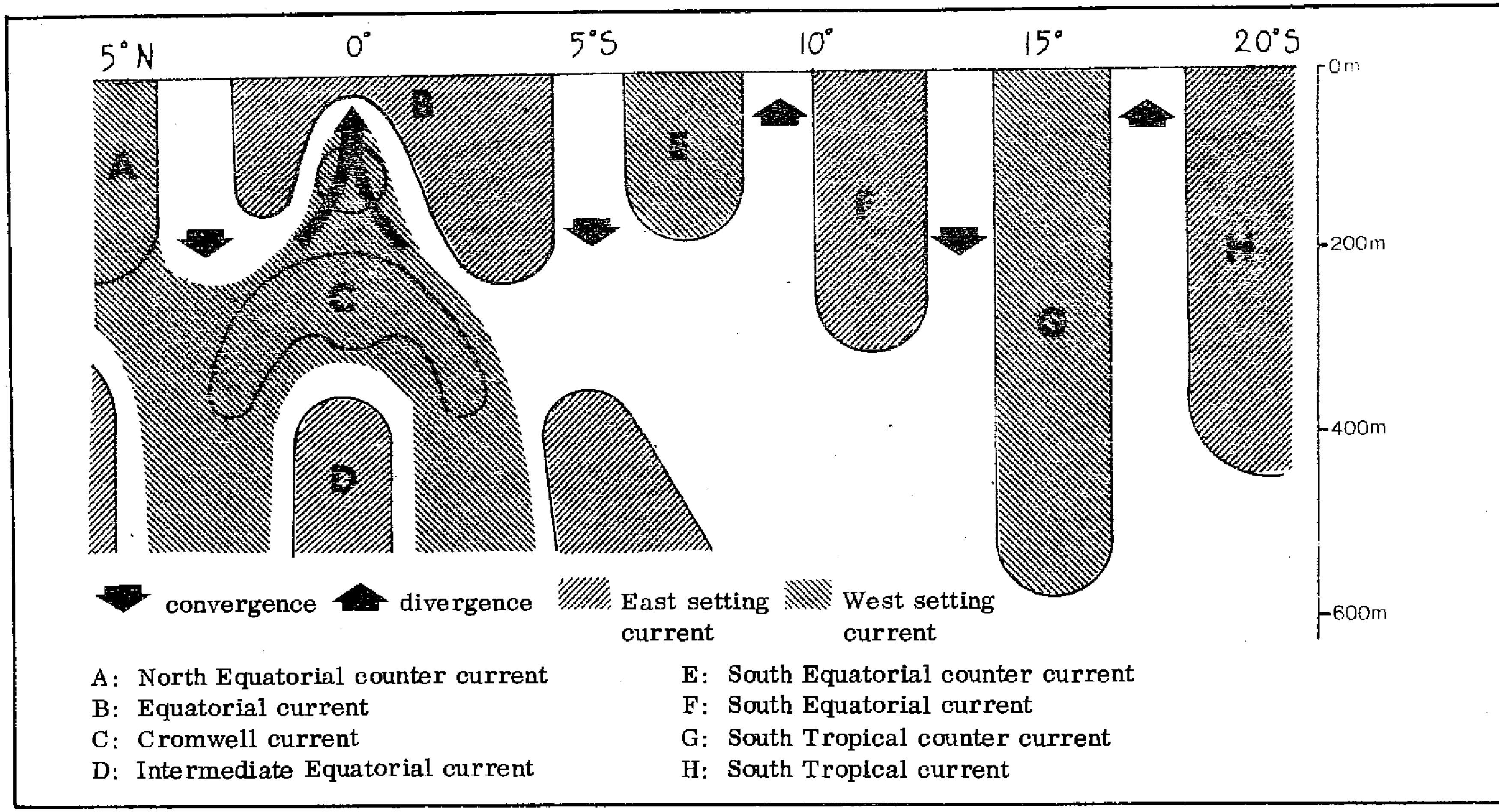


Fig. 2: Zonal circulation along the longitude of 170°E.

THE INFLUENCE OF DIVERGENCES AND CONVERGENCES ON FISHERIES

As we have seen, around convergences there is a concentration of surface waters, poor in nutritive elements. Despite strong insolation, phytoplankton develops poorly and primary productivity is limited. By contrast there is high primary production in the rich divergence zones. One would therefore expect that the process of enrichment would would pass step by step through the successive "meshes" of the food web[6], and that total production not only of plants but also of herbivores, primary, secondary and tertiary carnivores etc. would be high in the region of divergences. In fact it is not; and it can be shown, paradoxically, that the best fishing areas most often occur near convergences (Fig. 3). This is due firstly to the length of the response time of the primary producers to conditions which are suitable for them, secondly to the successive time lags between the different meshes of the food web, and finally to the vertical and horizontal movements which the organisms undergo in the water masses. All this is translated into important displacements in time and space between the causes and their effects, and the relationships are very often impossible to unravel. However, to explain it in a simple manner, let us consider the following hypothesis.

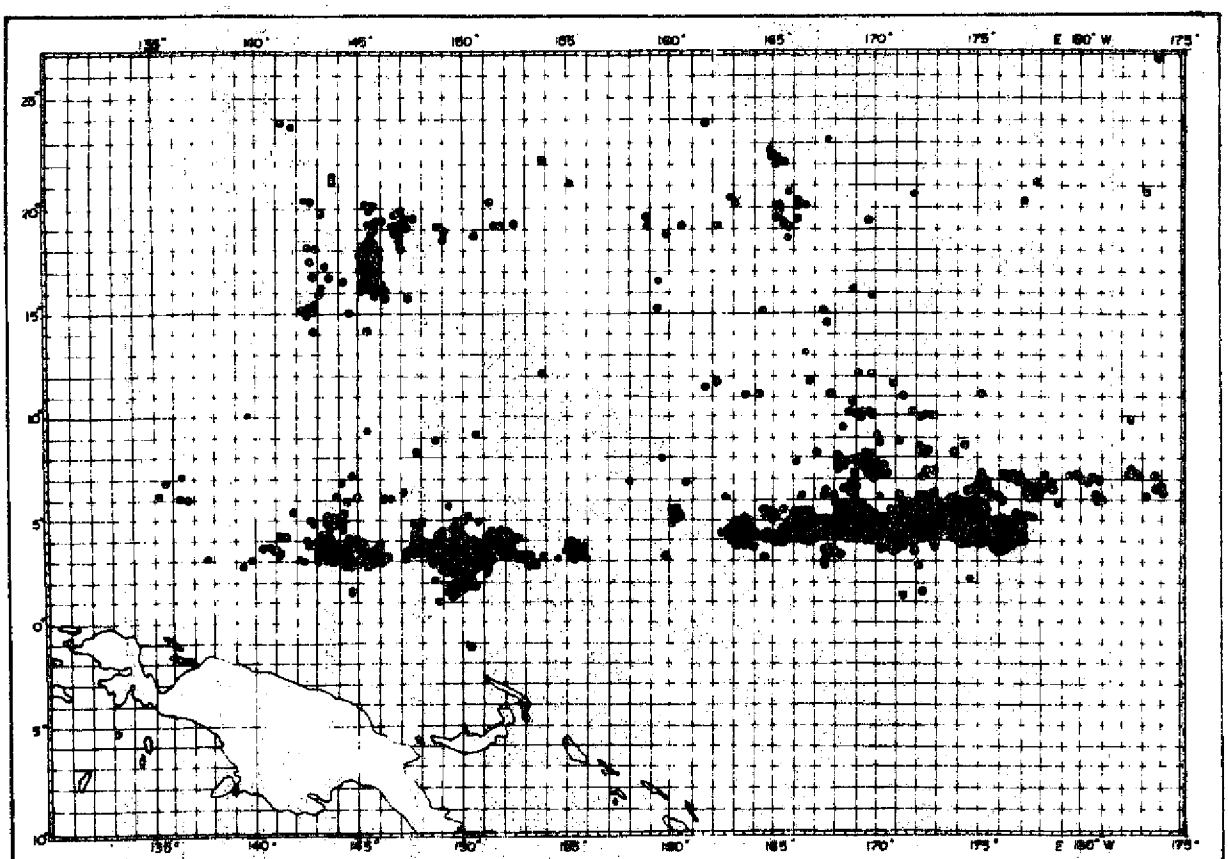


Fig. 3: Positions of Japanese pole-and-line vessels in August 1975 (reproduced from "Atlas of skipjack tuna fishing grounds in southern waters, 1975 fishing season" by Tamotsu Tanaka). The fleet is markedly concentrated along the convergence between 3°N and 5°N.

---

6. The term "food chain" has been superseded by "food web", which better expresses the complex trophic relationship within the pelagic ecosystem.

Let us take a theoretical north-south section for the case of a convergence lying between two divergences (Fig. 4). The supply of water coming from the divergences constitutes an excess which spreads out on both sides to the north and to the south (meridional circulation). These waters are rich to begin with and thus an abundance of phytoplankton develops; they become progressively poorer as their nutritive elements are used up by the phytoplankton. When they finally reach the region of the convergence, their supply of salts and minerals is low. However, because of the time lag between the biological cycles of the different constituents of the pelagic fauna, there is a succession of zooplankton types, progressively higher in the food web, as one moves away from the divergence zones towards the convergence. In the region of the convergence itself are found mixed concentrations of large zooplankton and small nekton.[7] It is on these intermediate constituents of the food web that the top level predators that is, those species (mainly tunas) on which oceanic fisheries are based, feed.

To this process of succession in the food web is added a phenomenon of trapping of organic wastes, which in fact makes the convergence a vast "dustbin". In addition, the frequent presence in this region of frontal zones with strongly marked temperature gradients favours the concentration of populations of the commercially-exploited species.

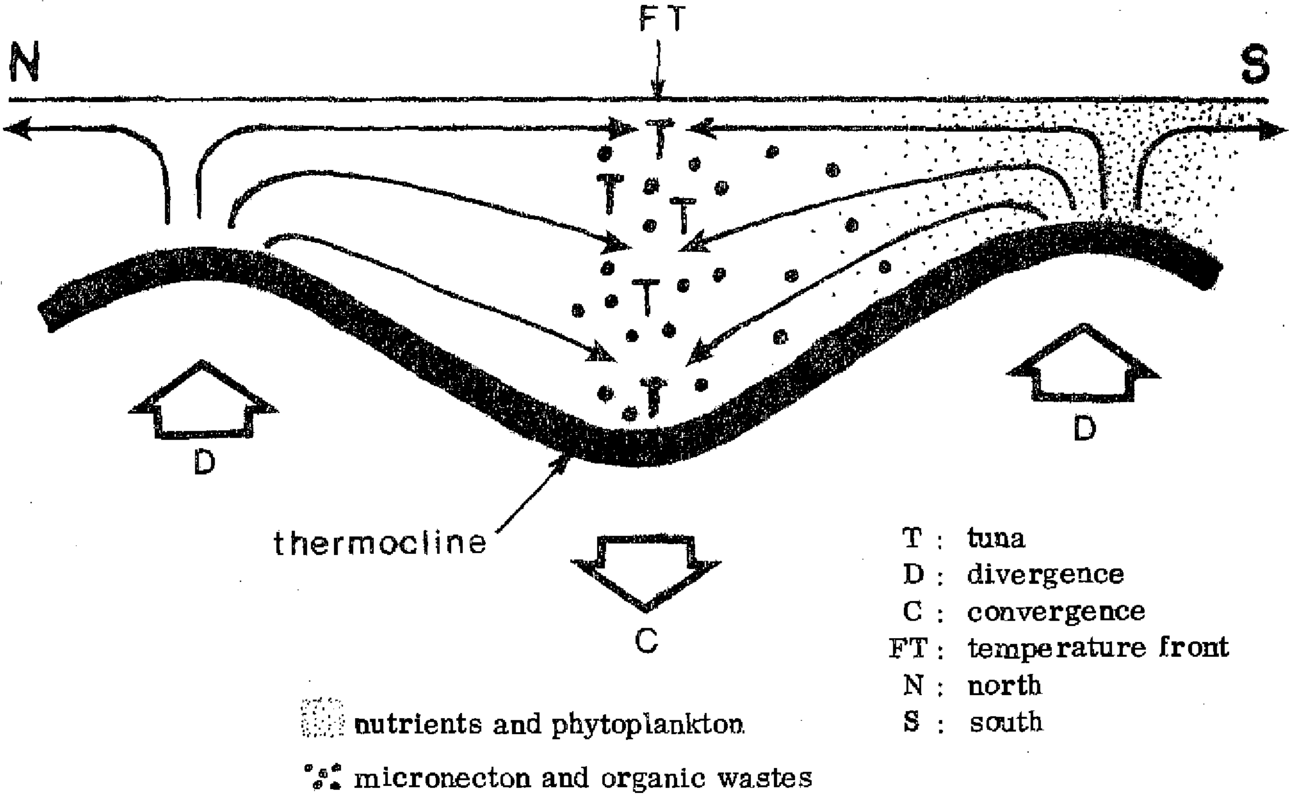


Fig. 4: The effect of divergences and convergences on production.

INFLUENCE OF ISLANDS ON FISHERIES: THE WAKE EFFECT

Fishermen have always known that waters near the points of islands are often richer in yellow-fin tuna and skipjack than the windward or leeward zones. This is the result of the "wake effect" of islands. This phenomenon has become the object of increasingly detailed hydrological studies. On an oceanic scale, an

7. Also known as "micronekton".

island is like a stone placed in the current of a stream; it causes turbulence. In the ocean this turbulence is a function of several factors: the shape and size of the island, the depth of the waters around it, the strength and constancy of the prevailing winds and currents, and of the tidal streams which may either reinforce or lessen its effect. This turbulence creates a considerable disturbance which can result in the rupture of the thermocline, and the bringing to the surface of deep, cold water - rich water. We then have an upwelling which brings an enrichment in nutritive materials and stimulates the process of production.

Also contributing to production in other places are the islands' silt-laden drainage flows, from run-off and rivers, and in a similar way the permanent diffusion from reefs towards the open sea of a fauna of wandering benthic larvae which provides an abundant food source. If one adds to this the frequent occurrence of thermal fronts, favourable conditions exist for the concentration of pelagic species such as tunas.

CONCLUSIONS

We have seen that currents were the origin of convergences and divergences and that these are determining factors in the enrichment process of the different meshes of the food web ending in those species exploited by man. Since currents are directly linked with the winds, the study of the latter is also essential. Winds have a complex origin situated in the region of the exchanges occurring at the ocean-atmosphere interface. The study of these exchanges, which is becoming increasingly important in oceanography, is the key to meteorological forecasts in the short and middle term, and thus indirectly to fisheries.

In this field co-operation towards the establishment of a world-wide organisation is increasing. The resources to be employed, ships, planes and satellites, will use teledetection to detect the different radiations emitted by the sea surface, thus enabling maps to be made whose interpretation will aim at predicting the most likely areas of concentration of commercial species. Such work has already led to real success in certain places, particularly where the thermal front is strongly marked. In the tropical region of the Pacific, however, it has not yet been shown whether the methods of measurement are sufficiently sensitive to detect frontal zones favourable to tuna concentrations.

* *

*

AGGREGATION SYSTEMS FOR SKIPJACK TUNA

W.A. Wilkinson
Fisheries Officer
Nuku'alofa
Kingdom of Tonga

For some time it has been well known that pelagic species in tropical waters are attracted to flotsam such as floating logs and other marine debris. The Japanese have capitalised on this natural phenomenon and have used logs on their commercial live bait pole-and-line fishing boats for some time. With the recently improved techniques in purse-seining for skipjack and yellow-fin tuna in the South Pacific, logs have also been used with considerable success. The logs are released from the fishing boat and are fitted with a small transmitter emitting radio signals which the fishing boat can track and follow for weeks at a time. Skipjack concentrate in the vicinity of the floating logs and are easily identified and caught.

The United States National Marine Fisheries Service in Honolulu, Hawaii, have been very active in a series of experiments to determine whether the pelagic tunas can be equally attracted by suitably designed anchored objects. The objects are sited in areas where these species are known to pass in their seasonal movements. The tuna are held in the vicinity until they can be caught by fishermen. The results of these experiments have been extremely successful and fishermen have substantially increased their catches.

Skippers of fishing boats have enthused on the value of knowing exactly where to proceed, thus cutting down scouting for schools, which consumes valuable time and fuel. As news of the excellent fishing in the vicinity of the objects spread throughout Hawaii, requests for similar aggregation systems were received. Fishermen have even offered to contribute to the cost of constructing and maintaining the systems, indeed an indication of their success. Apart from the commercial fishing boats, local sports fishermen have also benefited and the local tuna fishing industry has received an unprecedented boost. These initial successes have prompted moves to establish a series of anchored objects in strategic locations round the Hawaiian island group. Other islands in the Pacific are looking at the feasibility of establishing similar systems.

The National Marine Fisheries Service has indicated that to be successful, the objects should be no closer than 20 miles from each other. Too many objects placed too close together could scatter the schools instead of aggregating them, and make fishing more difficult. Ideally placement should be in the 300-450 fathom depth range; extremely deep anchorages to beyond 1000 fathoms should be avoided because of the greater cost involved, the greatest component being the large amount of 5/8 inch anchoring rope required.

Two designs for the objects have been tried off Hawaii:

1. Two 55 gallon steel drums filled with polyurethane foam are held side by side in a frame of angle iron. A 4 ft canopy built of angle iron and plywood houses the battery pack, which provides power for a warning navigational light on top of a 10 ft pipe. A radar reflector is also attached to assist location and for navigational safety; a 45 ft section of netting is suspended from the buoy to act as principal fish attractant. The buoy is anchored to the sea floor by a 1,200 lb concrete block. The anchor line consists of 50 ft chain lengths at the top and bottom and 5/8 inch polypropylene rope in between. Because this rope is buoyant, a weight sufficiently heavy to keep it submerged during slack tide is attached about one third of the distance from the surface.

2. The second design consists of a foam-filled platform on which are mounted sections of piping suitably bracketed; again a radar reflector and light are attached. The anchoring method is the same.

Cost for the construction of one floating object would be approximately 1,100 US dollars. Maintenance, of course, would be a recurrent expenditure which could be met from a small levy on fishermen using the objects.

The National Marine Fisheries Service is fully convinced that a network of objects strategically placed will give the declining tuna fishery off Hawaii a much needed boost. Other Pacific islands must certainly follow suit and the aggregation systems may soon be an accepted feature of fisheries development in tropical seas.

Editors' note: Fisheries Newsletter No. 15, p. 14 contains the project summary of the Pacific Tuna Development Foundation study on aggregation of skipjack to floating objects.

* *

*

PAPUA NEW GUINEA'S SEPIK RIVER SALT FISH INDUSTRY*

Joe Glucksman
27 Spring Creek Village
Bonita Springs, Florida
U.S.A. 33923.

ABSTRACT

After the inadvertent introduction of tilapia, Sarotherodon mossambica, to the mighty Sepik River, it became evident that a tremendous amount of fish surplus to subsistence requirements there, but badly needed elsewhere in Papua New Guinea, was being produced. Subsequent investigation indicated that the fishery could only be exploited economically by means of "intermediate technology", and a small successful industry was set up. An Asian Development Bank loan has made it possible to begin the rapid expansion of this fishery, although the recent introduction of the aquatic fern Salvinia molesta may present serious problems.

The Sepik River may be classed among the great tropical rivers of the world such as the Amazon and Mekong. During floods it can discharge over 8,500 m^3/sec. For most of its 1,200 km course it flows from west to east, draining a flood plain of 500,000 ha which supports a population of 80,000 people. It enters the sea between the provincial capitals of Wewak and Madang (Figs. 1 & 2).

---

* This is the reprint of a paper presented to the IPFC 18th Session Symposium on Fish Utilization Technology and Marketing in the Indo-Pacific Region held in Manila, Philippines, 8-11 March 1978. The proceedings of the symposium are being printed by the Indo-Pacific Fishery Commission Secretariat, FAO Regional Office for Asia and the Far East, Bangkok 2, Thailand, with the kind assistance of the Philippine Bureau of Fisheries and Aquatic Resources.

FIG.1 MAINLAND PAPUA NEW GUINEA

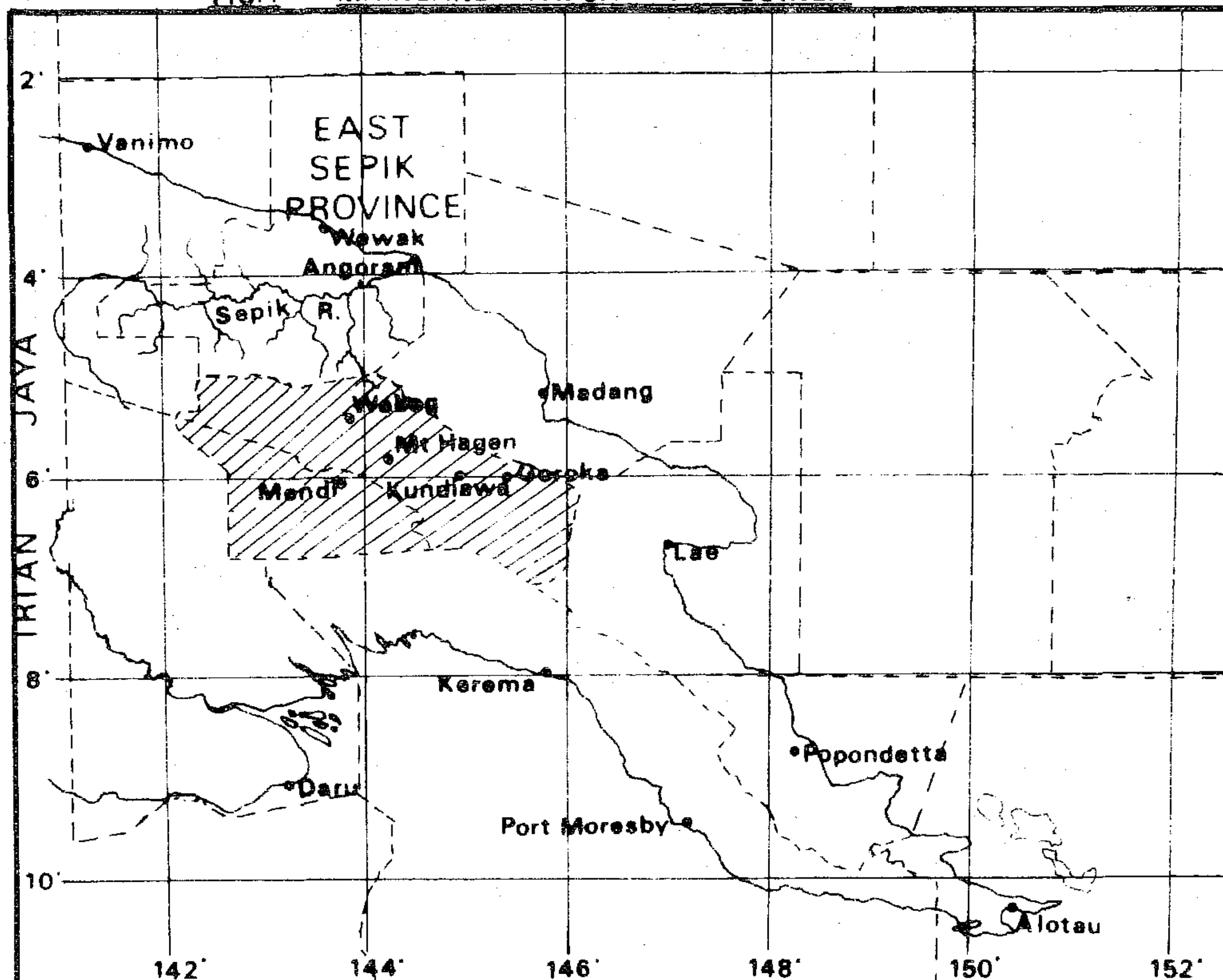
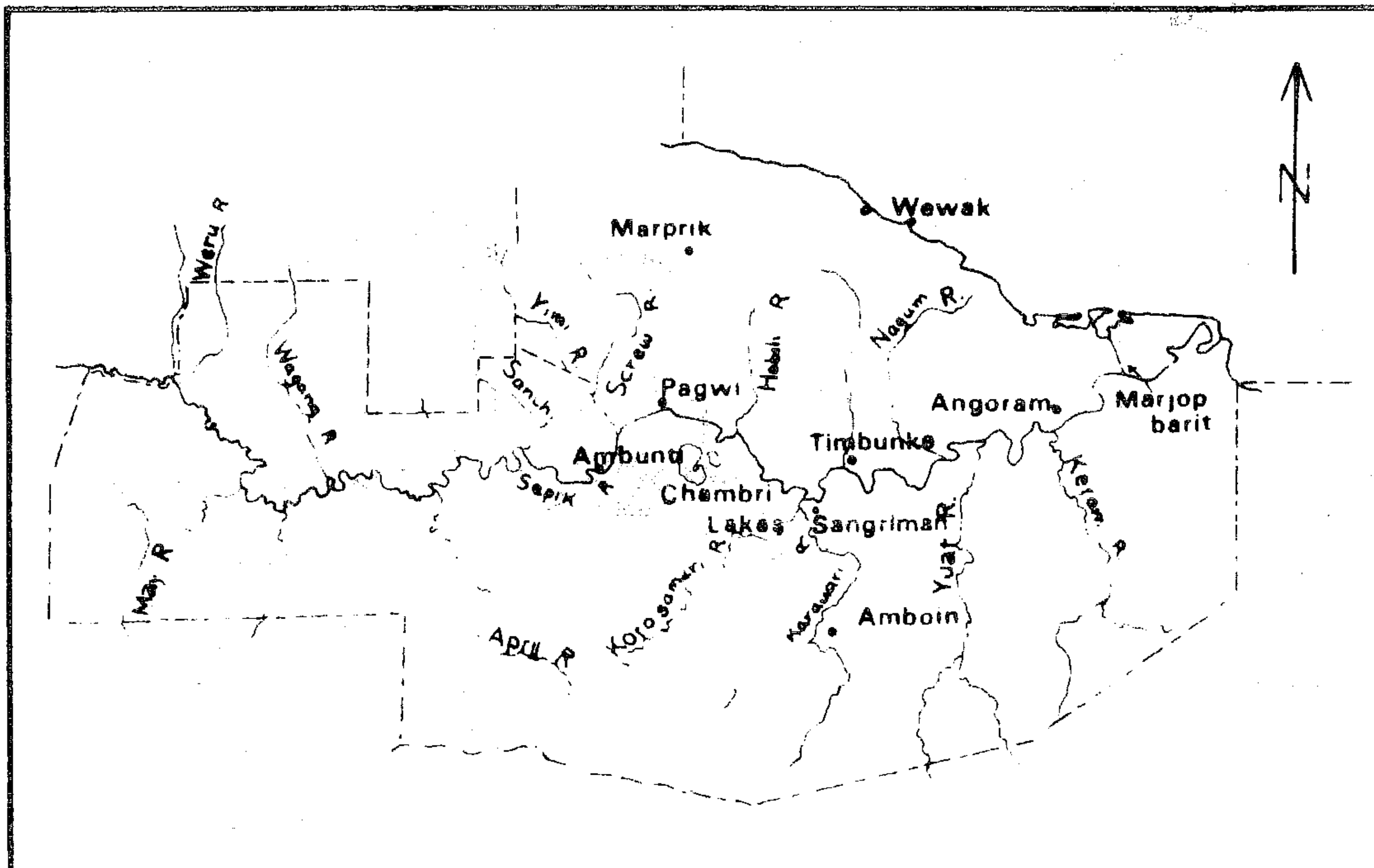


FIG. 2 EAST SEPIK PROVINCE



Traditionally most of the day-to-day fishing on the Sepik is done by women with woven cane traps. There has always been a surplus fish catch on the river, traded as far into the interior as practicable. The people of the flood plain, themselves, derive an unusually high amount of their energy requirements from fish, the lack of arable land making carbohydrates relatively scarce (Korte, unpublished).

Nowadays many men own gill nets, the preferred size being 10.16 mm mesh by 50 meshes deep by 100 m. The mean annual daily catch (dusk to dawn set) of these nets would be approximately 40 kg, 28 kg of which would be tilapia, Sarotheradon mossambica, the type of fish used in the salt fish industry. The bulk of the remainder is forktailed catfish (Fam. Ariidae) plus approximately two per cent gudgeons (Fam. Eleotridae) (Glucksman, unpublished).

Estimates of the annual fish production of the Sepik flood plain are between 30,000 and 40,000 t/yr. Of this, approximately 8,000 t are consumed for subsistence. This leaves a considerable tonnage, over half of which is tilapia (Anon. 1976).

The potential for a Sepik tilapia fishery was first recognised in 1950, when a visiting fisheries specialist noted that fish production was below the potential indicated by primary production due to the paucity of native plankton-eating species (Schuster, 1951). However, the introduction of tilapia to the Sepik was unintentional, They were washed out of ponds at Maprik in 1959 and entered the Sepik via the Screw River. By 1966 they had reached their present distribution from the May River to the Marjop Barat. They were immediately adopted into the subsistence fishery and called "makau" in Melanesian Pidgin, the lingua franca along the river (West and Glucksman, 1976).

By 1970 reports of extensive fish (tilapia) kills, due to natural anoxia (Wirthrington, personal communication), at Chambri Lakes indicated that numbers were greatly in excess of subsistence requirements. Agricultural officers began to encourage the increased production of traditionally smoked (non-brined) fish. These fish were marketed as far away as Maprik and Wewak, despite their rather short shelf life.

The then member for the House of Assembly, Jim McKinnon, constructed a large smokehouse with brine tanks and a freezer at Angoram. He produced extremely palatable lightly-brined smoked tilapia, as well as frozen tilapia fillets for export to the Highlands and Inland Sepik areas, but his operation soon failed, because his centralised plant could not be supplied properly and the facilities for the distribution of frozen fish were inadequate.

The Sepik fishery, like other tropical riverine fisheries, has characteristics which make its development a very different matter from fisheries in more temperate climates. Topography, lack of motorised, refrigerated vessels and ambient temperature combine to make the servicing of any large centralised processing plant impossible. Social factors such as fishing rights strictly defined on a spatial basis and lack of incentive to enter a purely cash economy also conspire against centralised fish processing (Glucksman, in press).

If the processing is to be decentralised it most certainly cannot employ the conventional western methods of icing, canning or freezing since neither the energy, clean water, expertise, nor the capital to create them exist even in the administrative centres, much less in outlying areas of the Sepik province.

In 1972 the Department of Agriculture, Stock and Fisheries (now Department of Primary Industry) conducted an extensive investigation of the potential fishery, which revealed the factors mentioned above. The search for alternative methods of development then began. After an examination of the development of other tropical riverine fisheries, it became evident that processing by some simple means of dehydration would be the most suitable method, and that a large part of it would have to be done either chemically (salting), physically (pressure), or with fuelled driers because of the high rainfall.

After considerable experimentation a process combining brine salting, pressure and sun drying was developed. It consisted of heading, scaling and splitting the fish down the back, leaving the belly flap intact. The body cavity was then scrubbed clean and the fish placed between layers of salt in the polyethylene drum. A plank and stone were placed on top of the fish to assist the salt's osmotic drawing of water with physical pressure and to keep the fish completely submerged in the brine which formed. After 48 hours of this treatment the fish "struck" (all flesh in equilibrium with a saturated salt solution). They were then sun-dried, but they could be returned to a saturated brine solution during bad weather and re-dried later. With this method individual fishermen could preserve their fish at the point of catch and transport them to a central market at their leisure.

In mid-1975 this method was introduced to a river village and by mid-1976, 25 villages were producing 6.5 t of salted tilapia per month, which represents a catch of about 20 t. These salted fish were then transported to packing centres at Angoram and Pagwi where the fishermen received Kina 0.40 per kg (US$1.00 = Kina 0.80). The fish were then sealed in 10 kg plastic bags (with cooking instructions), four of which were sewn up in a hessian (copra) bag for shipment to the Highlands and other inland areas.

Initially, they received a good reception in most areas where people were properly instructed in their preparation (prior to this exercise salt fish was completely alien to inland diets). Soon, however several important drawbacks became evident:

1. The bones and spines of the split fish punctured the plastic bags during transit, allowing the entrance of humid air which shortened the shelf life considerably.
2. There is a very large market for deep fried fish in batter, which requires fillets.
3. Inland people were familiar only with the pre-cooked bones of tinned fish and the inedible bones of the split tilapia were a health hazard.

All these problems were solved at a stroke by processing fillets rather than split fish, in the manner described above. This method has the added advantages of reducing the time it takes for the fish to "strike"; being easier for the processor (scrubbing the body cavity of a split fish clean is a laborious process); providing a more attractive offal for pig and crocodile farm use; and removing the bones which served as reservoirs for oil which readily oxidised or became rancid.

At the collection centres the fisherman now receives Kina 0.50 per kg for the sun dried fillets which are then kiln dried for a uniform moisture content and packed in 250 g, 500 g, 1 kg and 5 kg polyethylene bags displaying the brand name, "SOLPIS", and cooking instructions. The bags are shipped in 10 kg cardboard boxes. Production of this product is presently 2.5 t/month representing a catch of 15 t.

In 1976 the Asian Development Bank investigated the feasibility of and finally granted a loan for the development of five integrated projects in the East Sepik Province. The "SOLPIS" project described above was one of them. The fisheries sub-project share of the loan is Kina 770,000 to be spent over a 15-year period, after which it is hoped that enough capital will be amassed on the river to form a co-operative.

The fisheries sub-project will encompass the Sepik and its tributaries from Ambunti to Angoram. This production target is 500 t of "SOLPIS" per year (3,000t catch by year five, 1983) There will be two main collection, extension and packaging centres at Pagwi and Angoram and six primary collection, extension and salt distribution points (see Fig. 3). A training centre will be constructed at Angoram where fishermen will be taught those skills necessary for protracted commercial fishing and where in-service courses will be held for personnel. A biological research centre will also be constructed at Angoram.

From the two main packaging centres the fish will be sold to large food wholesale/retail companies with outlets in the Highlands and inland Sepik areas. If target production is reached at the end of year five the retail value of the product, based on the present recommended retail price of Kina 1.40/kg, will be Kina 700,000; of this the primary producer will receive Kina 250,000. This "SOLPIS" will be equivalent in nutritional value to 1,500 t of imported tinned mackerel, which presently retails at more than Kina 1,000/t. The import and consumer savings which will actually occur in the future will almost certainly be far greater, as the production costs of "SOLPIS" will rise along normal inflationary lines while the price of tinned mackerel will be affected by political factors such as the 200-mile exclusive economic zones.

The fisheries sub-project will also entail credit and supply facilities. Such items as salting vessels, salt, and filleting knives will be distributed from extension centres. The main item for which long term credit will be extended is nets. Although the limitations of gill nets have been recognised, and considerable research has already been done on alternative gear, a floating set with the 10.16 mm mesh gill nets described above remains the best gear discovered to date.

Sometime between 1972 and the present the noxious water fern Salvinia molesta was introduced to the Sepik. As the weed reproduces almost exclusively vegetatively, it is usually considered to have been spread by hand over long distances for "ornamental" purposes and then by navigation and drift within a river system. Salvinia had reached epidemic proportions in some parts of the Sepik by December 1977, interfering with navigation and the setting of nets.

None of the chemical, physical, or biological controls employed with only marginal success elsewhere seem feasible for the Sepik, primarily because of topography. It is thought that the extreme fluctuations in water level in Salvinia's original South American habitat prevent it from causing too much damage there. Normally there are similar fluctuations in the Sepik, but in 1977, the first year Salvinia became detrimental, these fluctuations did not occur. It is hoped that when the Sepik returns to its normal high and low water regime the Salvinia population will fall below the point where it interferes with the fishery (Johnstone, unpublished). Meanwhile the search for methods of control applicable to the Sepik continues.

References

Anon. (1976): Report on Asian Development Bank East Sepik Development Project: Chapter V, fish production and processing sub-project. Asian Development Bank, 234-288.

Glucksman, J. (1972) (Unpublished): Journal of Sepik River System Investigations May 1-30, 1972. Department of Primary Industry, Papua New Guinea, 50 pp.

Glucksman, J. (In press): The role of intermediate technology (cottage industry) in the development of some of Papua New Guinea's fisheries. Proceedings of the University of Papua New Guinea 1976 Waigani Seminar, Lae, 3-7 May 1976.

Johnstone, I. M. (Unpublished): Report to J. Glucksman (DPI Fisheries) on the trip to the Sepik by I. M. Johnstone (Biology Dept., UPNG) to investigate the Salvinia problem.

Korte, R. (1975) (Unpublished): Comments and recommendations; Duty Tour 20 October - 2 November, Madang and Sepik Districts. Department of Public Health, Nutrition Section, Papua New Guinea, 7pp.

Schuster, W. H. (1951): A survey of the inland fisheries of the Territory of New Guinea and Papua. Australian Journal of Marine and Freshwater Research, 2 (2): 226-236.

West, G. J. and Glucksman J. (1976): Introduction and distribution of exotic fish in Papua New Guinea. Papua New Guinea Agriculture Journal 27 (1 & 2): 19-48.

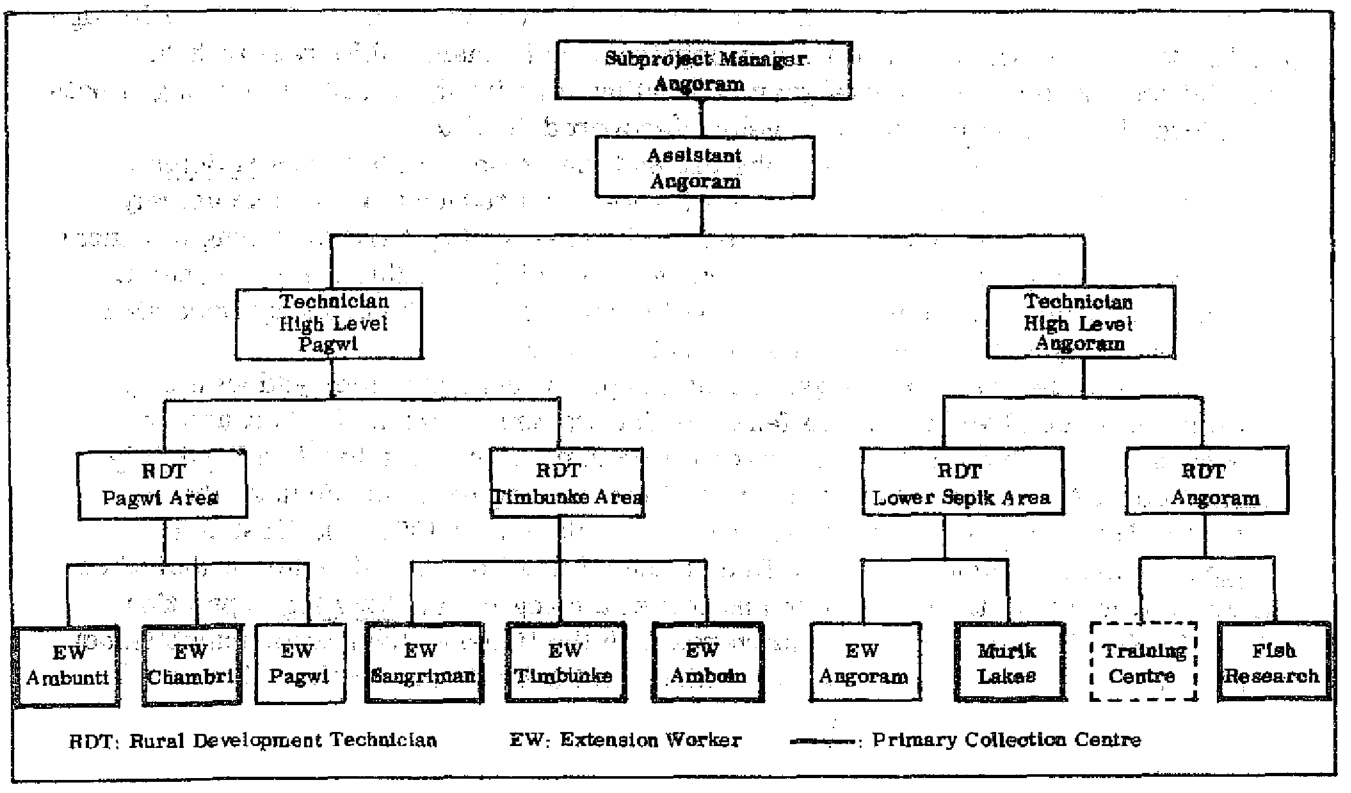


Fig. 3: Organization of Asian Development Bank fish production and processing sub-project, East Sepik Province.

MINI POT HAULER DRIVEN BY AN OUTBOARD ENGINE*

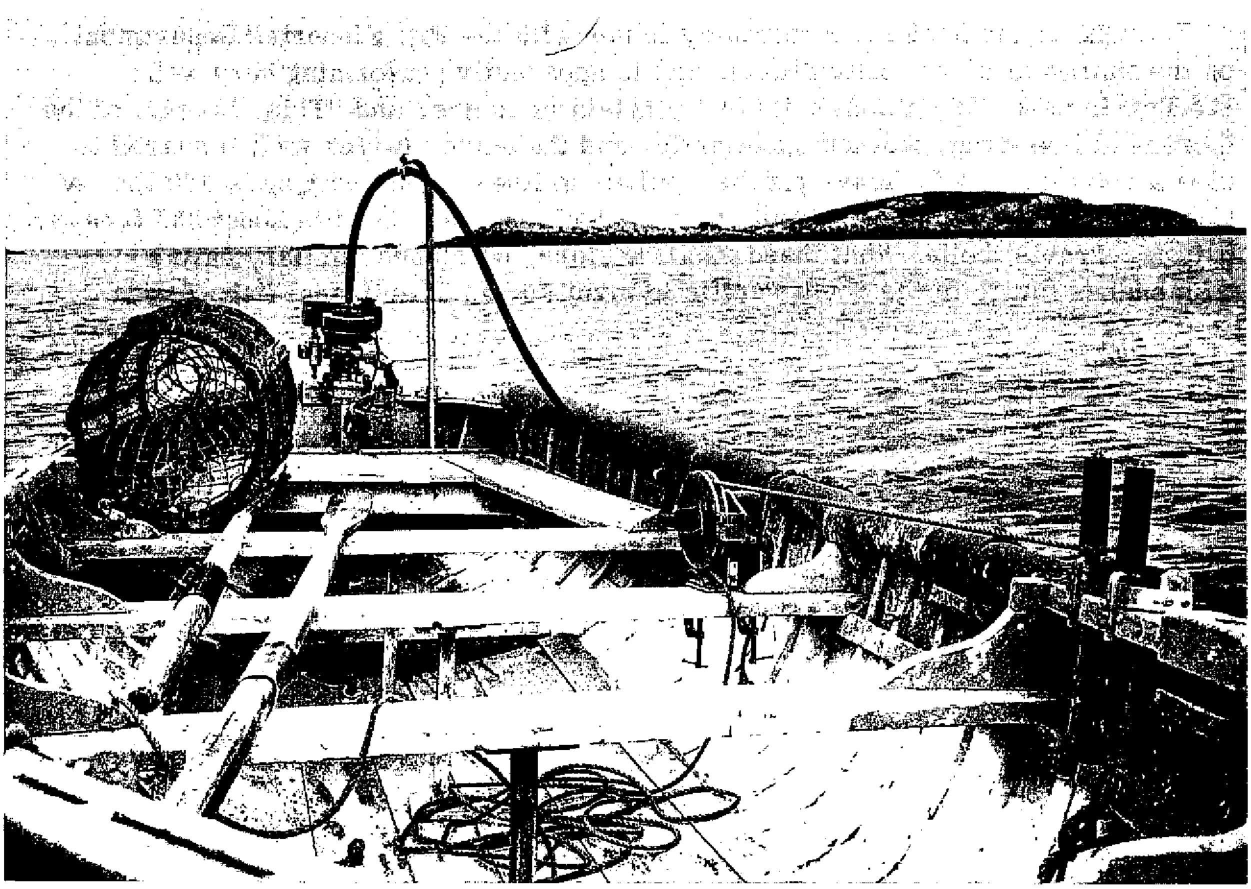
"The simplest, safest, most reliable, cheapest trap hauler in the world" are the strong claims made for a new outboard-driven mini pot hauler recently introduced by Trap Fishing Ltd. in Ireland. The new hauler, which can be powered by most makes of outboard-engine from 1.5 hp upwards, was seen for the first time at the Scottish Fisheries Exhibition which closed at the port of Ayr last month.

It is suitable for boats of between 12 ft and 25 ft (3.7 and 7.6 m) in length. Priced at only £120, is it almost certain to create a lot of interest among small-scale fishermen - especially in developing countries.

Managing director of Trap Fishing Ltd., Mr William Kingston, told Fishing News International that he sees a big potential for the hauler in countries where the outboard is used extensively by small fishing craft. The simple hauler could in thousands, he said. The hauler could sell well in developed fisheries, too. In the USA, for example, where more and more trap fishermen are scaling down their operations, it is seen as a potential winner. Within weeks of its introduction, more than 20 haulers have been sold in Scotland, and about the same number in Ireland where it is under test by the Irish Sea Fisheries Board (BIM). It has also sold in the Caribbean.

---

* Reprinted from the June 1976 issue of Fishing News International



"We realised", says Mr Kingston, "from the time we sold our first hauler in Puerto Rico, where pots are hauled by hand at present but still weigh about 100 lb. in air, that we would have to develop a more powerful version. This will be coming out next month, and will have a maximum pull of 200 lb., though still capable of being run off any outboard."

The small hauler is connected to the outboard by a flexible drive and operates through its own gearbox which is supplied to suit the power source. It clamps securely to the gunwale, and can be worked over the bow or stern by merely moving the outboard. Sheave width is adjustable, and the sheave cuts out if the line or the trap becomes fast. Worldwide patents are held in ten countries, with others pending.

Further information can be obtained from Trap Fishing Ltd., 47 Mespil Road, Dublin 4, Ireland.

Editors' Note: Since the original introduction of the line hauler, both its performance and versatility have been improved. A connector is now available with which it is easy to take the drive from almost any inboard engine.

The hauler was originally designed for pots, but can also be used to haul lines. The quoted speed for pot hauling (100 ft/min for a 200 lb pull) is too slow for drop lines, but according to advice recently received from the makers, much higher speeds can be achieved... "There is of course a trade-off between speed and pull. The quoted speed is related to the heavy pull that a trap fisherman needs, and is from an outboard running moderately slowly, at 2,000 r.p.m. At full revs., outboards go over 5,000 r.p.m., so we could go up to 250 ft/min. simply by running the power plant faster, with no change at all to our hauler".

One of the haulers is currently in use with the Fiji Fisheries Department on the initiative of Mr Bill Travis, and is apparently performing very well. Mr Travis used 300-fathom coils of 7 mm laid nylon line, and "This, in spite of the increased line-drag, worked excellently, and the hauler (which we had geared to give a rotation of 200 sheave r.p.m.) pulled up lines loaded with up to 120 lbs of fish without any slip, or apparent strain." This hauling speed is about 330 ft/min. It is Mr Travis' belief "that these small haulers, or others similar, have a tremendous future in the South Pacific in many forms of artisanal fisheries".

*   *

*

OVERFISHING A MIGRATORY SPECIES

Study of the history of whaling shows how the various species of whales have been successively overexploited in all the oceans of the world. In the early days the contest between whales and whalers was much more even than it is today. Modern technology - fast chasers, harpoon guns, and the introduction of factory ships - has ensured that whales are no longer safe anywhere. Even the last stocks in the Antarctic Ocean have been depleted far below the optimum level.

For the two remaining nations, Japan and the USSR, who fish for whales on an industrial scale, whaling makes only a tiny contribution to their large economies. However, for small communities like the one at Ha'apai in Tonga (see the article below), whaling is still a very important contributor to the local economy. If this subsistence fishery for the humpback whale is banned for conservation reasons the Tongans cannot replace it, but the whaling giants responsible for the original stock depletion can continue their operations elsewhere, on other whale species. Although fishes are not so vulnerable to overexploitation as whales, this example should be borne in mind when the management of migratory fish species in the South Pacific is considered.

WHY TONGA STILL NEEDS WHALES*

The humpback whale's South Pacific breeding ground off Tonga could soon be empty, according to conservation experts. Already several sub-populations of the species are dangerously low. The main damage has been due to heavy fishing by Russian and Japanese fleets in the 1950s. Now, even the small numbers taken by local Tongan boats may be threatening the humpback's survival. But for the Tongans, this small fishery (four to six whales are caught each year) provides an important local source of protein[1]. Now, local boats cannot replace the 20 tons or so of meat required each year.

Alternative jobs

The whaling families need compensation - if not in cash then at least in alternative jobs. In Tonga's subsistence society, where income per head is only about 500 pa'anga a year, a family can earn as much as 1,000 pa'anga from one adult whale. There is a ready demand for whale meat. As soon as a carcass is beached, hundreds of Tongans gather to buy their share.

The fishery can be traced back to the middle of the last century when a young sailor named Cook deserted his whaler for the Friendly Islands. His descendants now work the fishery. The traditional method of hunting the humpback from 35 ft double-ended, gaff-rigged sailing boats, armed only with a hand-harpoon, is spectacular. Great skill is needed to move in close enough. When struck, a whale sometimes sounds and tows the whale boat for six to eight hours before dying from

---

* Reprinted from Fishing News International, March 1978 issue.

1. During the first eight months of 1978 four females and one calf were killed, all from around Ha'apai.

exhaustion and loss of blood.

During the breeding season from July to October, the lactating females and calves move into shallower water where they are most vulnerable. It is from these stocks that the Tongan whales are taken. A ban on whaling for a specified period may be the only way to save the fishery. At least scientists would have the chance of assessing the remaining stocks and of imposing quotas.

* * *

FISHERIES DIRECTORY OF THE SOUTH PACIFIC

"The meeting recommended that the South Pacific Commission be responsible for the compilation, distribution and maintenance of a detailed directory of the status of fisheries in each country and territory of the region as an aid to reviewing fisheries progress and status and identifying development needs." Recommendation No. 12 of the Ninth Technical Meeting on Fisheries, Noumea, January 1977.

Work has started on compiling this directory. A questionnaire has been sent to all principal fisheries officers of the SPC area. Information has been requested on the size and budget of the different government fisheries departments; fisheries regulations; the numbers and kinds of fishing boats; the fishing methods used; numbers of fishermen; the catches of the artisanal fisheries, weights and values; industrial fisheries catches; aquaculture; commercial fishing and fish processing companies; joint ventures; the types of fishery products produced; exports; imports; fishing facilities, harbours, slipways, storage facilities etc.

We intend to include as much detail as possible in the directory without making it an elaborate, lengthy document. It is planned to be in two sections; country profiles, and subject summaries. Also included will be information on non-governmental institutions and organizations whose fields of activity include fisheries. Groups or individuals who have not been approached, but who feel they have useful information for the directory, are invited to forward this to the SPC Fisheries Adviser.

RECENT SOUTH PACIFIC COMMISSION FISHERIES PUBLICATIONS

KEARNEY, R.E. (1978): Skipjack survey and assessment programme. Annual report for the year ending 31 December, 1977, 18 pp.

KEARNEY, R.E. and LEWIS, A.D. (1978): Interim report of the activities of the skipjack survey and assessment programme in the waters of the Solomon Islands (1 November - 4 December 1977). Preliminary Country Report No. 2, 14 pp.

KEARNEY, R.E. and HALLIER, J.P. (1978): Interim report of the activities of the skipjack survey and assessment programme in the waters of New Caledonia (13 December 1977 - 19 January 1978). Preliminary Country Report No. 3, 20pp.

KEARNEY, R.E., LEWIS, A.D. and HALLIER, J.P., (1978): Interim report of the activities of the skipjack survey and assessment programme in the waters of the New Hebrides (5 - 13 December 1977 and 20 - 23 January 1978). Preliminary Country Report No. 4, 16 pp.

KEARNEY, R.E. (1978): Interim report of the activities of the skipjack survey and assessment programme in the waters of Fiji (26 January - 18 February, 28 March - 10 April 1978). Preliminary Country Report No. 5, 13 pp.

KEARNEY, R.E. and GILLETT, R.D. (1978): Interim report of the activities of the skipjack survey and assessment programme in the waters of the Kingdom of Tonga (11 April - 3 May 1978). Preliminary Country Report No. 6, 13 pp.

KEARNEY, R.E. (1978): Some hypotheses on skipjack (*Katsuwonus pelamis*) in the Pacific Ocean. Occasional Paper No. 7. 23 pp.

KLAWE, W.L. (1978): Estimates of catches of tunas and billfishes by the Japanese, Korean and Taiwanese longliners from within the 200 mile economic zone of the member countries of the South Pacific Commission. Occasional Paper No. 10, 41 pp.

EGINTON, R. and MEAD, P. (1978): Report on the South Pacific Commission outer-reef fisheries project in Funafuti (Tuvalu). 21 September 1976 - 28 March 1977, 19 pp.

GUIDE TO JAPANESE ORGANIZATIONS HAVING COURSES FOR OVERSEAS TRAINEES*

These organizations listed below, have training courses for foreigners in order to cultivate men of talent with the additional aim of promoting friendship and mutual understanding between nations.

Name of Organization	Japan International Cooperation Agency	Association For Overseas Technical Scholarship	International Skill Co-operation Center, ILO Association of Japan	Overseas Fishery Cooperation Foundation	OISCA international
1. Application Procedures	In case of Group(s): When Japanese Government makes an offer of training course, your Government makes an application by nominating official representative and applicants. Decision shall be made by Japanese Government after due consideration. Individual application may be acceptable.	* Formal application papers available. * Application papers shall be submitted at least one month and a half prior to the beginning of training course. Decision shall be made by the Screening Commission.	With the formal forms duly filled-in, application shall be made to this Association through those of ILO Association or joint-ventures in each nation, or through Japanese corporations contracting technical tie-ups.	In case of Group(s): When Japanese Government makes an offer of training course, your Government makes an application by nominating official representative and applicants. Decision shall be made by Japanese Government after due consideration. Individual application may be acceptable.	Application shall be made to the OISCA International in each nation. Decision shall be made by OISCA of Japan.
2. Training Place	Fishery: at Nagai Kanagawa Prefecture	Training Centers in Tokyo, Nagoya, Osaka, Yokohama	Mainly at the training center in Chiba City, conducting training courses classified by types of industry.	Classified by types of industry or by corporations.	At each center located in Toyama, Aichi, Kagawa, Fukuoka.
3. Training Programme	Lessons and practices of fishery in general	1. Lessons in Japanese language 2. Knowledge in general for further understanding of Japan and Japanese 3. Introduction of various Japanese industries 4. Lessons of professional courses 5. Inspection tours	Orientation including Japanese language and basic business training. Practical training at each corporation.	Lessons and practices of fishery in general	Practical training in industrial plants, farms, etc.
4. Training Period	Coastal fishing: 11 months Fishery cooperatives: 6 months	As a basis: More than 3 months, less than 2 years. Provided that training of less than 3 months may be acceptable, depending on particular circumstances.	As a basis: 9 months including 3 months for orientation.	5 months including 1 month for orientation. 4 months at universities or laboratories.	2 years in total: 3 months for basic training. 21 months for practical training.
5. Scholarship Provisions	Travel expenses to and from Japan. Living expenses while in Japan. (Food & lodging, etc.) Medical expenses. Accident insurance premium.	Travel expenses to and from Japan. Preparation expenses. Living exp. while in Japan Shipping exp. for unaccompanied materials when leaving Japan. Domestic transportation expenses. Medical expenses. Practical training expenses including materials for training. Accident insurance premium.	Travel expenses. Preparation expenses. Living expenses while in Japan. Medical expenses. Deposit funds for practical training. Accident insurance premium.	Travel expenses. Preparation expenses. Living expenses while in Japan. Medical expenses. Deposit funds for practical training. Accident insurance premium.	Travel expenses. Preparation expenses. Living expenses while in Japan. Medical expenses. Deposit funds for practical training. Accident insurance premium.
6. Enquiries Addressed to:	Shinjuku Mitsui Building, 2-1, Nishi-Shinjuku, Shinjuku-ku, Tokyo	2-12-13, Hon-komagome, Bunkyo-ku, Tokyo	Satomi Building, 6-19, Shimbashi, Minato-ku, Tokyo	Sankaido Building, 1-9-13, Akasaka, Minato-ku, Tokyo	3-6-12, Izumi, Suginami-ku, Tokyo

Anyone wishing to make further enquiries should write direct to Japan to the appropriate address listed above.

* Reprinted from the Yamaha Motor Co., Ltd. publication "Technical Service School Guide".