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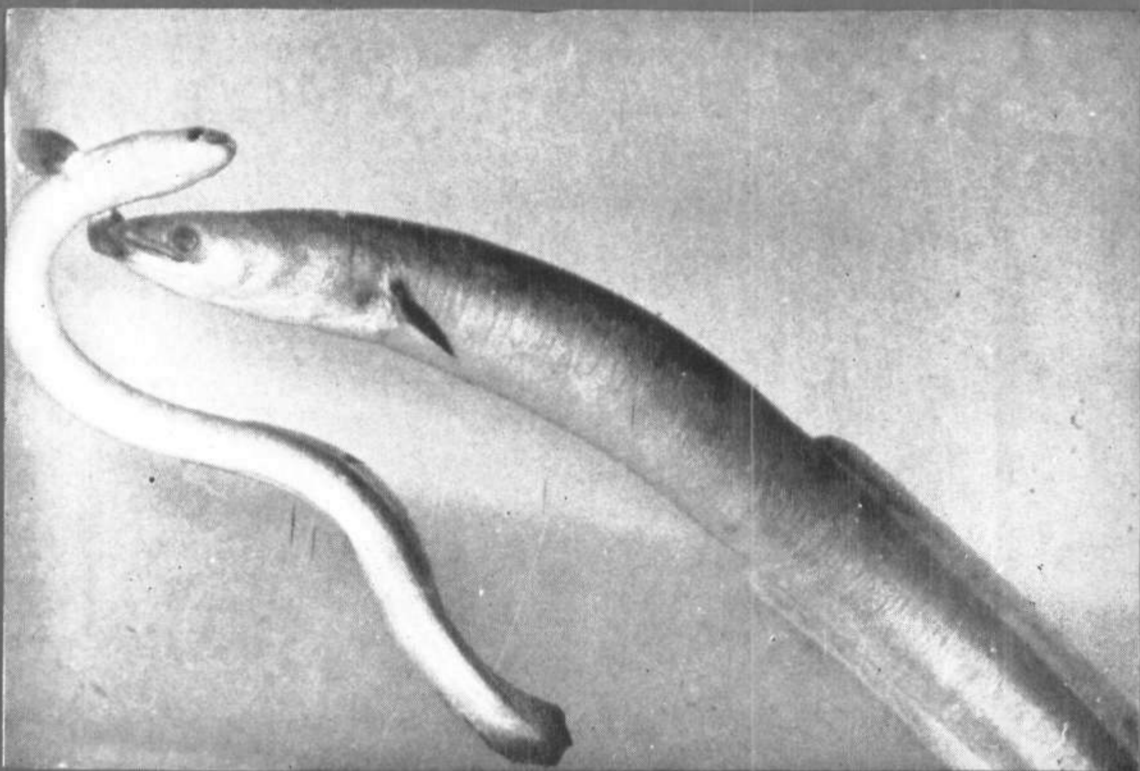

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THE MARINE FISHERIES INFORMATION SERVICE: Technical and Extension Series envisages the rapid dissemination of information on marine and brackish water fishery resources and allied data available with the Fishery Data Centre and the Research Divisions of the Institute, results of proven researches for transfer of technology to the fish farmers and industry and of other relevant information needed for Research and Development efforts in the marine fisheries sector.

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1. Eel culture in India

2. Culture of blood clam at Kakinada

3. Workshop on mussel farming

4. News—India and Overseas

Cover photo: Hormone-injected male and female short finned eels in an aquarium tank

EEL CULTURE IN INDIA*

Introduction

In recent years great strides have been made in fish farming in many countries, augmenting fish production substantially. Eventhough the main objective of fish culture is to produce more protein-rich food, there has been an emphasis, particularly in the developing countries, on the culture of luxury table fish to step up exports. Eels *(Anguilla* spp) are considered as a luxury food and consumed as a delicacy in several Asian and European countries. The Japanese eel *(Anguilla japonica)* is cultured commercially in Japan, Taiwan, and South Korea and the European eel *(Anguilla anguilla)* in Italy, Denmark, West Germany, France, Holland, etc. For the first time in India, experimental culture of short-finned eel *(Anguilla bicolor bicolor)* was undertaken in 1971 by the Central Marine Fisheries Research Institute at its Regional Centre at Mandapam Camp. Following the encouraging results obtained in the preliminary experiment, a regular project work on the culture of eels was undertaken by the Institute in 1974 and since then experiments are being conducted to develop and perfect the techniques for the culture of the short-finned eels in running fresh water and in re-cycled running water. Since elvers are the starting point for eel culture, an investigation was undertaken in December 1975 to survey the rivers of the Tamil Nadu coast for elver resources. Besides, induced breeding experiments in eel, the first of its kind in India, was initiated in this Institute in 1980. The present report highlights some of the basic information on the Indian eels and their culture, based on the results of the experiments conducted during the period 1974–1980.

The eel and its life cycle

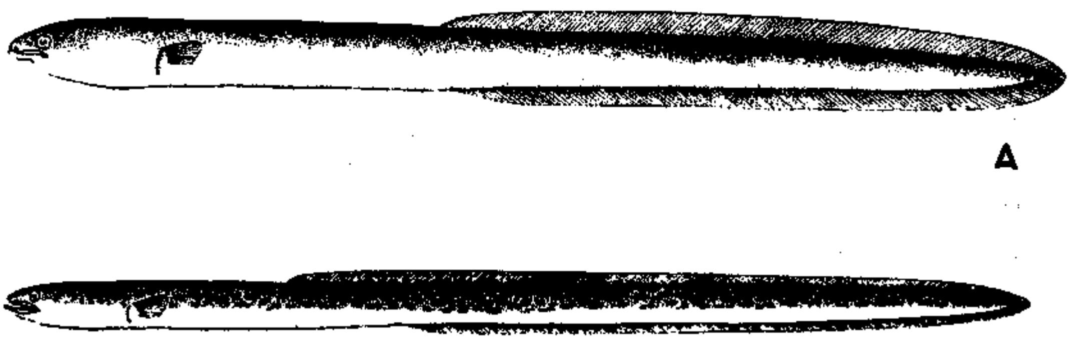
Most of the eels spend their entire life in the sea, but the species of *Anguilla* spend their life both in marine and freshwater environments. The freshwater phase of the eel is taken advantage of and exploited in eel culture. There are 17 valid species of *Anguilla* distributed throughout the world. In India two species namely the short-finned eel *(Anguilla bicolor bicolor)* and the long-finned eel *(A. nebulosa nebulosa)* commonly occur in estuarine and fresh waters (Fig. 1).

The important features of field identification of the two Indian species are as follows:

Anguilla bicolor bicolor: Head shorter; snout broad, lower jaw not prominent. Vomerine teeth reaching as far backwards as those on maxilla. Dorsal fin commences above vent. Colouration: Dark olive dorsally and yellowish ventrally.

Anguilla nebulosa nebulosa: Head longer; snout not broad, lower jaw prominent. Vomerine teeth do not extend as far as the maxillary teeth. Dorsal fin commences far in front of vent. Colouration: brownish

*Prepared by K. Dorairaj in collaboration with R. Soundararajan and D. Kandasami



A

B

Fig. 1. A. The Short-finned eel, ***Anguilla bicolor bicolor***
B. The Long-finned eel, ***Anguilla nebulosa nebulosa***

dorsally, with black spots and blotches, some of which are continued on to the dorsal fin, and yellowish on the sides and ventrally.

As the life cycles of the different species under the genus *Anguilla* are more or less similar a general account of the same is given (Fig. 2). *Anguilla* spp. bread in the open sea at a depth of 400–500 m. After fertilization the egg hatches into a tiny larva, pre-leptocephalus and later becomes leptocephalus. The leptocephalus is transparent, leaflike with large number of myotomes and small, pointed head. The leptocephali are weak swimmers and their transport/drift from the open sea to the nearshore regions is effected by oceanic and coastal currents. The duration of the larval life in different species varies from three months to two and a half years. The leptocephali metamorphose into glass eels which are thread like and transparent (Fig. 3). On getting pigmentation the glass eels become elvers (Fig. 4) and approach the coasts. On entering brackish and freshwaters the metamorphosis is completed and the elvers in a few months become young eels. The latter grow in the brackish or freshwaters for some years and at this phase of life they are called yellow eels. On nearing sexual maturity the adult yellow eels cease to feed, acquire a silver colouration, leave the fresh and brackish waters and migrate to their spawning ground in the open sea where they breed. After spawning the silver eels are believed to die.

Thus, in the life history of the eel there are three phases viz., 1) marine larval phase (Letocephalus, glass eels, elvers), 2) freshwater phase of growth (yellow eel) and 3) adult marine phase of reproduction (silver eel).

The techniques of eel culture

It is necessary to adopt suitable techniques based on scientific study at all stages of eel culture as it will not only enable smooth and efficient management of eel farms but also will ensure high production and profits. Elvers are the starting point for eel culture. The seed elvers measure 55–100 mm in size and about 0.16–2.0 g in weight. They are collected from close to the banks of the rivers during night time with the help of suitable nets, when they ascend the rivers immediately after a freshet during October–March period. Very early stage elvers, known as glass eels, are completely transparent and thread like whereas the late stage elvers are pigmented and slightly thicker in size. The live elvers are transported in conventional fish tin carriers, specially made wooden boxes and in styroform boxes. In the initial phase of eel culture, elvers are stocked and reared in small indoor ponds which are known as elver

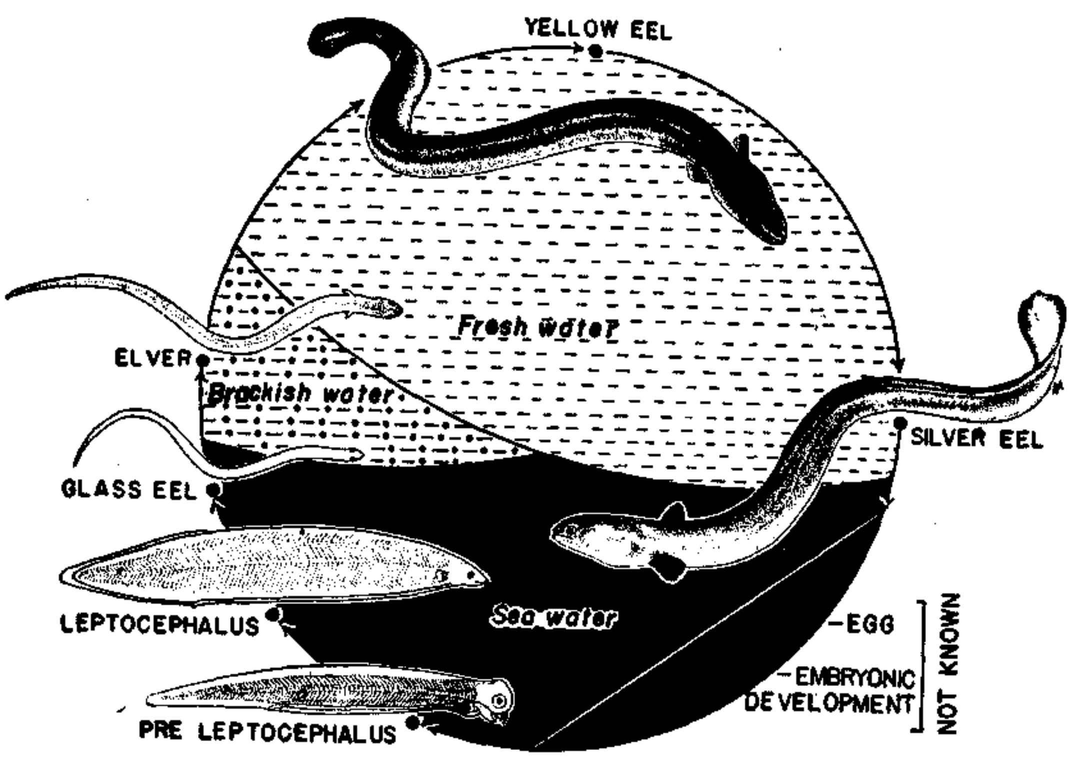


Fig. 2. Life cycle of eel

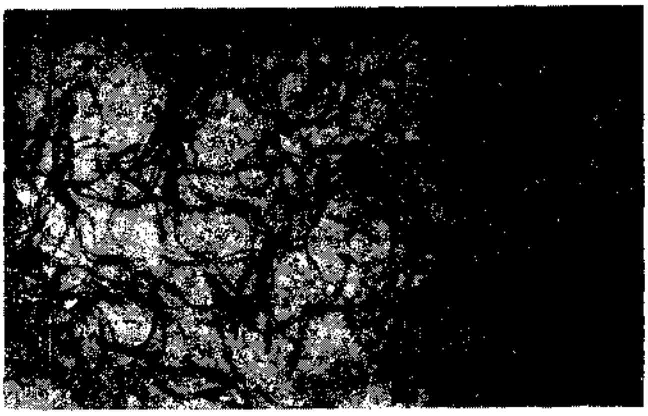


Fig. 3. Glass eels of short-finned eel

ponds. After about three months the grown up elvers are reared in bigger outdoor ponds known as fattening ponds. The optimum stocking density is 30 elvers, each weighing 0.16–0.2 g or 20 young eels of about 15 g per sq. m.

Artificial feeding is an important aspect in eel culture. Elvers do not take food for the first few days after their capture and they have to be slowly acclimatised to a regular feeding habit. Crushed earth worms are to be given to the elvers when they begin to feed and after about fifteen days a mixed feed of

Fig. 4. Pigmented elvers of short-finned eel

earthworms and fish meat. After about one month the growing elvers may be exclusively fed with fish meat. Elvers and eels prefer to feed in a dark place. Therefore the feeding place should be provided with a shelter. The feed is placed in a wire basket or tray and suspended just above the water surface to prevent contamination of water (Fig. 5). The elvers are given feed at a ration of about 30% of their body weight and the growing eels about 10% of their body weight Growth rate in eels is observed to be very rapid during April–October period. Therefore, it is advisable to give as much food as possible during the above period.

The success of eel culture also depends upon the proper maintenance of the culture tanks. The tanks should have a minimum water depth of about 60 cm. Even under optimum conditions of water supply, temperature, stocking density, food supply and maintenance, cultured eels exhibit a wide range in growth both in terms of size and weight. Therefore, at periodical intervals, in all stages of culture culling should be done which will ensure uniform size of eels at the time of harvest. Detection and eradication of diseases

Fig. 5. Cultured eels feeding in suspended tray

of the eel is another important aspect in eel culture. A general method of eradication of these diseases is to disinfect the water by chemicals or by completely flushing the tanks with large quantity of water. The introduction of concentrated dry feed facilitate mixing of drugs in eel food to control certain diseases.

The cultured eels (Fig. 6) are harvested when they reach marketable size which varies according to species and market demand in different countries. In Japan, the Japanese eel (*A. japonica)* is harvested when it reaches a weight of about 100 to 200 g which is attained in about two years from elver stage. The Taiwanese prefer comparatively larger sized eels than the Japanese and harvest when eels attain a weight of over 200 g. In Germany, the European eel *(A. anguilla)* is harvested when the male attains 150 g and the female 500–600 g. The production of eels per hectare varies with the type of culture method. In running water culture, eel

Fig. 6. Cultured adult short-finned eels

production is found to be about 4 times higher than that obtained in still water culture. The average yields realised from running water and still water eel farms in Japan are 26, 360 kg/ha and 6,120 kg/ha respectvely.

Culture methods

Eels are cultured in five different methods viz. 1) Still water method, 2) Running water method, 3) Recycled running water method, 4) Net preserve method and 5) Tunnel method. The first three methods only are commonly followed. In still water method the pond water will be more or less static and only about 5% of the total volume of the pond water is changed daily. The still water of the pond enables quick propagation and luxurient production of phytoplankton which in turn will increase the oxygen content of the pond by photosynthesis and thus provide a suitable condition for the eels to strive well. In the running water method, there will be a continuous flow of freshwater to the ponds and simultaneously an equal amount of water will be drained to keep the water level in the pond constant. In this method the eels are supplied with more oxygen through the constant flow of freshwater. In the re-cycled running water method, the same water in the pond is re-used again and again after filtration, sedimentation and oxygenation. The carrying capacity of the filter bed should be determined and the water quality checked at periodic intervals. The basic principle in eel culture methods is to rear eels in high densities in a confined area by providing extra oxygen and more suitable food to achieve maximum production in a short period of time. Depending on the facilities and quantity of water available, any one of the three methods could be employed in eel farming.

Elver resources survey

One of the pre-requisites for the eel farming is the availability of seed elvers. In India elvers of the short-finned eel and the long-finned eel are known to ascend the rivers Hooghly, Godavari and Tambraparni. The availability of elvers in the other rivers is not clearly known. Therefore, the Central Marine Fisheries Research Institute has undertaken a survey to assess the resources of the glass eels and elvers and in the first phase of the survey programme, the entire Tamil Nadu coast was surveyed during December, 1975 to December 1978.

During the survey three types of nets viz. scoop net, drag net and elver net were used for collection of glass eels and elvers. The survey was conducted in 81 centres between Cape Comorin and Pulicat lake. Fiftytwo centres were found suitable for elver collection and in 23 centres either glass eels or elvers were collected during the survey. The tail end shutters and/or the first anicut across the river from the sea side are found to be the most suitable place for the collection of elvers. In most of the rivers in Tamil Nadu the immigration of glass eels and elvers takes place in the month of November after the onset of the north east monsoon. The survey had brought to light for the first time the immigration of glass eels and elvers of *Anguilla* spp. in Rivers Vaigai, Vellar, Gadilam, Penniyar, Coleroon, Vembar, Tambraparni, in the creeks of Ervadi and Pillaimadam, in several seashore pools on the Gulf of Mannar side at Mandapam, Vedalai and Seeniyappa Dharga, in Kaliveli tank near the regulator at Marakkanam and Kadharshapad backwaters near Pamban. Based on the extensive enquiries made and the results obtained in the preliminary survey, the following centres are considered potentially rich grounds either for glass eels or for elvers: 1) Srivaikundam Anicut and Maruthur Anicut on the River Tamraparni, 2) Lower Anicut on the River Coleroon 3) Melayur Anicut on the River Cauvery, 4) Sethiyathoppu Anicut on Vellar river, 5) Thiruvendipuram Anicut on the Gadilam river, 6) Vallur Anicut on Karattalaiyar river, 7) Lakshmipuram Anicut on the Arni river, 8) Several seashore pools on the Gulf of Mannar side at Mandapam, Vedalai and Seeniyappa Dharga and 9) Kadharshapad backwaters near Pamban. By employing the most suitable net at right time and at right place it is possible to collect large quantities of elvers.

Running water culture of eels

At the Regional Centre of Central Marine Fisheries Research Institute, Mandapam Camp experimental eel culture was conducted during 1974-1976. The short-finned eel (*A. bicolor bicolor*) was cultured in running fresh water in fibreglass tanks. The average size of the elvers at the beginning of the experiment was 13 cm in length and 3 g in weight. The elvers were stocked at a density ranging from 330 g to 1500 g per sq. m. At the end of eleven months the elver had reached an average size of 27.8 cm and 43 g. Monthly growth rate works out to 13.4 mm in length and 3.6 g in weight. The maximum size at the end of eleven months was 38.9 cm and 115 g. The overall survival rate for the first year was 87%. At the end of second year the average size was 38 cm and 119 g. The Monthly growth rate during the second year was 8.5 mm and 6.4 g. The maximum size of eel at the end of second year was 51.4 cm in length and 275 g in weight. The average size of the eel at the end of third year was 41.9 cm in length and 177 g in weight. During the third year the monthly growth rate was 3 mm in length and 4.5 g in weight. The maximum sized eel at the end of the third year measured 68 cm in length and 726 g in weight. It was observed that the length increase was faster in the first year and slower during the second and third years while the weight increase was more in the second year as compared to first and third years.

Food Conversion: Experiments were conducted to study the conversion efficiency of seven animal feeds that were compounded locally. Silverbelly and prawn flesh were found to give better conversion ratio (7 : 1) than the other feeds. The next best conversion ratio of 7.38 : 1 was for a mixed feed made of sardine and clam meat. The sardine alone gave the lowest conversion rate. Though silverbelly and prawn were found to give more or less a similar conversion rate, the former is considered to be the more suitable feed for the eel culture because of its cheap price and easy availability.

Production: In March 1974, 7.28 kg of elvers were stocked in fibreglass tanks having a total surface area of 6.65 sq. m. At the end of one year the total weight of eels was 22.22 kg with a net increase of 14.94 kg. At the end of second year the total weight of cultured eel was 34.61 kg. The net increase in two years from initial stocking weight was 27.33 kg. The net production in one year works out to 2.2 kg/sq.m and in two years 4.1 kg/sq.m. The eel production in outdoor tanks is likely to be higher than those obtained in this study. This is well reflected in the re-cycled running water eel culture, an outdoor culture experiment conducted in 1978.

Re-cycled running water culture of eels

The experiment was conducted in an outdoor cement tank (6 m x 3 m x 1 m size) with natural mud bottom. By sluice gate arrangement the bottom water in the culture tank was gravitationally drained out and passed through a biological filter. The filtered water was allowed to settle in a settling tank. The clear water in the settling tank was made to overflow to the oxidation tank. From the oxidation tank the water was pumped into a small over head tank and from there the water was fed to the culture tank. Thus, the same water was re-used again and again after filteration, sedimentation and oxidation. Weekly once about 1/3 of the water in the culture tank was drained out and replenished with new fresh water. Water level in the culture tank was maintained at 75 cm depth.

An effective feeding method was adopted in this experiment. A sheltered feeding area was provided on one side of the culture tank in the form of a wooden platform with a small door in the middle. The eel feed in the form of a paste, made of minced silver-bellies, broken rice powder and ground nut oil cake powder mixed in 2 : 1 : 1 proportion with 0.2% multi-vitamin, was placed in a plastic tray and suspended through the door at water level. The eels in the culture tank would immediately congregate near the tray, climb over it, dart to the feed, take a mouthful and slip back into the water. After gulping the feed, the eel would again climb the tray and take another mouthful of food. This process is repeated until satiation when the eels would settle down at the bottom of the tank. The tray with left over food would then be lifted out through the door. By this method contamination of water by food was effectively reduced. The eels were fed at a daily ration of 5 to 10% of their body weight.

In the re-cycled running water culture tank, 9 kg of young eels (208 in numbers, ranging in size from 20 g to 65 g with an average weight of 43 g), was stocked at a stocking density of 500 g per sq.m. in August 1978. The average weight of the eel had increased from 43 g to 84 g in 31 days, 132 g in 61 days, 203 g in 122 days and 232.8 g in 163 days. The eels were harvested after 163 days and the total production was 47.8 kg which shows a net increase of 430% of the initial stocking weight. The survival rate was 98.56%. The net production rate works out to 2.15 kg/sq.m in about 5 months.

When 43 g size eels were reared indoor in fibreglass tanks they reached only to 76 g in about 5 months, whereas in an outdoor mud bottom tank, similar sized eel attained a weight of 233 g in the same period. This clearly shows that nearly three times higher production than those obtained in the experimental culture in the laboratory could be obtained, if the eels are cultured in the mud bottom outdoor tanks.

The results obtained in the experimental outdoor tank in re-cycled running water culture system have been found to be very high as compared to the results obtained in experimental eel culture in Europe. In channel system 30 g weight European eel had reached only to 160 g in 12 months, and in river ponds 49 g weight eel reached to 109 g in six months. In Japan, the Japanese eel of 60 g weight attained marketable size of 150–200 g in about 12 months.

Disease

It is a known fact that as the intensity of fish culture operation increases there is greater chance of problems from fish disease. In eel culture about 20 types of diseases are reported from Japan. During the experimental culture of the short-finned eel in running water, seven kinds of eel diseases viz., fungus disease, tail-fin rot disease, gas disease, red pest and blotches disease, swollen intestine disease, gill disease and cripple body disease were identified. The fungus disease was observed in elvers on their body as an outgrowth of whitish grey mass spreading from the affected region. The tail-fin rot disease was noticed both in elvers and in growing eels. Mostly the glass eels were affected by the gas disease, when the O_2 or N level in the water was too high. By bringing down the temperature of the water by adding ice blocks the gas disease could be effectively controlled. The red pest and blotches disease was observed in elvers as well as in grown up eels; the visible symptoms of this disease are rash-like reddening of the body musculature, particularly near the abdominal and anal regions. The swollen intestine disease has been found to attack both the elvers and the growing eels whereas the gill disease and cripple body disease were observed only in grown-up eels. The incidence of eel diseases met with in the present experiments was insignificant. However, further intensive research work is necessary in order to develop suitable diagnosis and control measures of the diseases in large scale culture practices.

Export value of elvers and cultured eels

Elvers and cultured eels have a great export potential as there is a high demand for the same in Japanese market. Faced with short supply of elvers for culture purpose, Japan imports large quantities of elvers from many Asian and European countries. In 1971 Japan imported elvers worth $ 10 million. The wholesale price in Japanese market in that year ranged from $ 66 to $ 88/lb for elvers, from $ 35 to $ 50/lb for juveniles and from $ 2.5 to $ 3.0/lb for adult eels. Realising the export value of elvers and cultured eels, the Marine Products Export Development Authority of India came forward to finance a sponsored project on 'Elver Resources Survey and Eel Culture'. The project functioned from 15–11–1978 to 31–3–1980 at Mandapam Camp and Madras with the technical expertise of Central Marine Fisheries Research Institute. During the tenure of the first phase of the Project the entire Tamil Nadu coast was surveyed more intensively for elver resources, live elver and cultured eel transportation experiments were conducted and a sample consignment of 10 kg of cultured eels air lifted to Japan. Although India has fairly good elver resources they are practically unutilised at present either for culture or for export purposes.

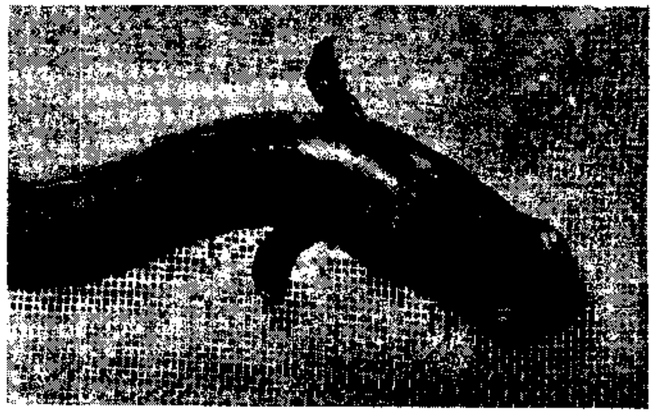


Fig. 7. Head portion of hormone-injected male

Fig. 8. Hormone-injected female

Induced breeding in eels

Experiments on induced breeding in the short-finned eel (*A. bicolor bicolor*) were initiated in August 1980, with the adult eels of about 6½ years old, cultured in the laboratory in running water from elver stage. The male and female eels were gradually transferred from fresh water medium to sea water in three days period and later on maintained in sea water aquarium tanks for 75 days to get acclimatised to the marine environment. The Carp pituitary and two hormones viz., Gonadotrophin F.S.H (Follicle Stimulating Hormone) and Gonadotrophin L.H. (Lutinizing Hormone) are used in this work. These are administered in different dosage and in combinations to the eels to stimulate the maturation process. The eels are favourably responding to the injections and the secondary sexual characters like enlargement of eyes, darkening of the pectorals and silver colouration of the body have appeared in them (Figs. 7 & 8). The experiments are being continued.

Prospects

The survey conducted by the Central Marine Fisheries Research Institute has brought to light many promising centres for large scale collection of elvers. The techniques of live elver collection and their transportation have been developed. A suitable culture technology for the Indian short-finned eel have also been developed by the Institute. Based on the results of the experimental culture of eels it has been possible to establish the possibility of increasing the production by undertaking commercial eel culture in recycled running water. In addition to eel culture, collection and export of elvers could also be taken up as a profitable enterprise with the development of export market. Apart from earning foreign exchange for the country, this would offer employment opportunities to a large number of marginal fishermen.

CULTURE OF BLOOD CLAM AT KAKINADA*

Many species of clams occur abundantly along Indian coast, particularly in the estuaries and backwaters, forming sustenance fisheries. The clams are rich in protein, glycogen and minerals and are easily digestible. They are sessile, feed low in the food chain and are admirably suited to 'on-bottom' farming. *Anadara granosa* (L) belongs to the family Arcidae and it is popularly known as blood clam owing to the red colour of its flesh which is due to the presence of haemoglobin in the blood. It is also called ark shell or cockle, the latter name due to its superficial resemblence to the European cockle, *Cardium*. The blood clams are regularly fished in the Kakinada Bay and about 1000 tonnes of clams are landed annually. This clam meat is eaten locally to a limited extent and the shells are used in producing lime. This species is traditionally cultured for its food value in Malaysia, Thailand, Vietnam, Taiwan and the Philippines.

The Central Marine Fisheries Research Institute has given priority for developing appropriate techniques for the culture of suitable marine animals and plants for augmenting the seafood production. As a part of this programme experiments on the culture of the blood clam were initiated at the Kakinada Research Centre of the Institute in 1979. The results obtained during 1979–80 are given in this account.

The farm

The farm site was selected in close proximity to the natural clam bed but sparsely populated by clams. It is about 300 m from the shore, north of Yetimoga fishing village and is located within the Kakinada Bay. The farm is in the subtidal region and elevated in such a way that a minimum of 25 cm water level is maintained at low tides. It was cleared of dead shells, debris etc. and casuarina poles were planted to mark the boundaries of the farm (Fig. 1). The bottom is muddy with 64% clay, 25% silt and the rest sand and dead shells. Split bamboo screens (Fig. 2) interlaced with hemp twine were used in constructing pen enclosure. Each screen measured 5 m long, 0.3 m high and interspaced with 6 numbers of 1 m long bamboo sticks driven upto 0.75 m into the mud to hold the screen vertically. In the farm the monthly average water temperature varied from 28.9 to 33.5°C, salinity

*Prepared by Shri K. A. Narasimham

from 22.29 to 34.4‰ and dissolved oxygen from 4.98 to 7.00 ml/l.

Seed availability and stocking

The spawning period of the blood clam in the Kakinada Bay is prolonged and it spawns for the major part of the year, attaining peak activity in January–April period. Heavy settlement of seed on the natural bed takes place from February to May which is the ideal period for collection. The collection sites are about 1 km east of the farm in the Kakinada Bay where the depth is about 1 m at low tide. The seed were collected at low tide by scooping the muddy substratum

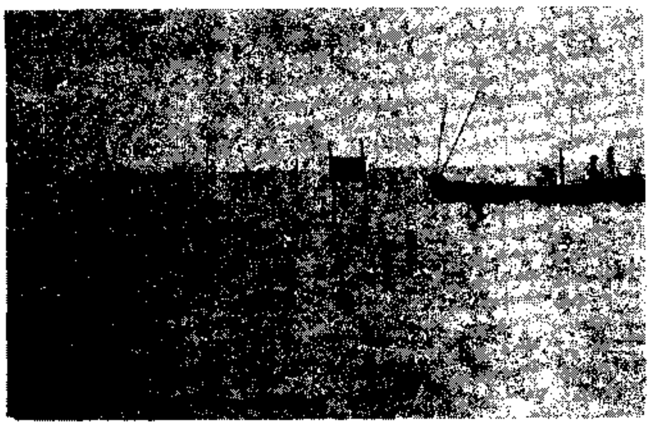


Fig. 1. Part of the clam farm

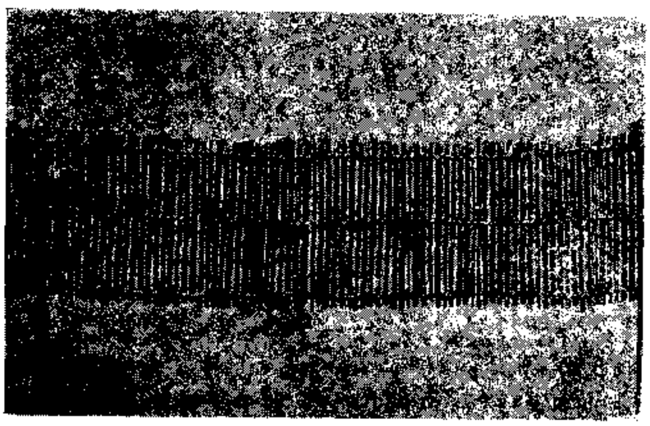


Fig. 2 Part of the split bamboo screen used in pen construction

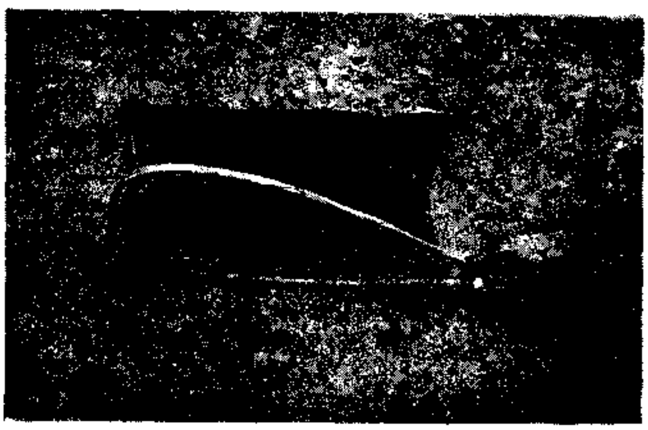


Fig. 3 *Nathudu vala*, a small bag shaped hand net used in the collection of clam seed in mud flats

Fig. 4 After washing the clams are ready for emptying into the boat

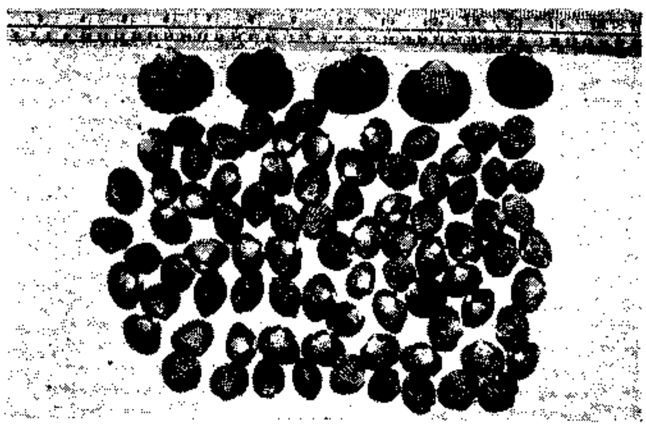


Fig. 5 Numerous small clams and at the top 5 large clams indicate the lengths at stocking and harvesting respectively

Fig. 6 Part of the harvest

with a small bag shaped hand net called *Nathudu vala* (Fig. 3) or by hand picking. In the culture experiment in May 1979 seed clams (Fig. 5) with an average length of 24.3 mm (average weight 5.53 g) were stocked in a 100 m^2 pen at a density of 140/m^2 (Table 1). In April 1980 seed of 23.0 mm average length (average weight 5.53 g) were stocked in a 625 m^2 pen at a density of 175/m^2. The stocking was done at high tide from a plank built boat by sowing the seed on the bottom, ensuring an even dispersal as far as possible.

Growth and production

During the culture experiments artificial feeding was avoided as they feed on the plankton and detritus which are abundantly available in the natural waters circulated by the tides. Except for watch and ward work, no other maintenance job was necessary during the period of culture. The clams were harvested in October by hand picking (Fig. 4) and washed in bamboo baskets to rid them of mud. In the experiment in 1979, at harvest they had attained an average length of 40.6 mm (Fig. 5) and an average weight of 31.06 g. The growth rate was 3.3 mm/month (Table). The survival of the clams was 88.6% and a production of 385.3 kg/100 m^2/5 months was obtained. In 1980 they showed a growth of up to an average length of 39.2 mm (average weight 28.5 g and the monthly growth rate 2.9 mm). The common marketable size is 30-35 mm length. The survival of the clams was 83.4% and production 2.6 tonnes/625 m^2 in 5½ months (Fig. 6). The ratio of flesh weight to total weight of clams was about 20%. Proximate analysis showed that protein formed about 10% and fat 1.6% on wet flesh weight basis. In both experiments the results on the growth, production and survival were consistent and comparable.

Prospects

In shellfish culture it is well known that the environmental conditions required for profuse spat settlement differ from conditions needed for optimal growth and fattening. With this in view transplantation of seed clams to areas suitable for growth was carried out so that production can be maximised, In Malaysia, blood clam production by cultivation is 46,423 tonnes and the yield is 20.7 tonnes/ha/year. In the experiments at Kakinada, a very high production, nearly double the yield in Malaysia, was obtained per unit area in a relatively shorter period of culture operations. The yield could be further increased by enhancing the stocking density to 240 clams/m^2 since experiments showed that at this level the growth of the clams did not appear to be affected. The Kakinada Bay has a spread of about 130 km^2 and is mostly shallow. It is sheltered and several hundred hectares are suitable for blood clam culture. Clam culture is low intensive—both in capital and labour and has a tremendous potential.

During these experiments two important aspects have emerged for further studies. The clams burrow in the mud and their movements are very much restricted. So it would be worthwhile to investigate whether the pen is necessary. Another point for consideration is better utilisation of the ecosystem by way of poly-culture such as the on-bottom culture of the windowpane oyster and off-bottom stake culture of the edible oyster in association with the blood clams. Both these oysters are regularly fished in the Kakinada Bay. Further work on these aspects and also on the economics of clam culture are in progress at the Kakinada Research Centre of the Institute.

Table 1. *Stocking and harvesting details of blood clam cultured at Kakinada*

	Stocking	Harvesting
Experiment 1		
Area of pen	100 m^2	100 m^2
Date	23 & 24–5–1979	23–10–1979
Numbers	14,000	12,406
Size range	19–29 mm	34-49 mm
Average length	24.3 mm	40.6 mm
Average weight	6.7 g	31.06 g
Density	140/m^2	—
Survival rate	—	88.6%
Production	—	385.3 kg
Rate of production – 385.3 kg/100 m^2/5 months		
Experiment 2		
Area of pen	625 m^2	—
Date	28 & 29–4–'80	12 & 13–10–'80
Numbers	1,09,584	91,439
Size range	20-28 mm	34-50 mm
Average length	23.0 mm	39.2 mm
Average weight	5.53 g	28.50 g
Density	175/m^2	—
Survival rate	—	88.6%
Production	—	2.6 tonnes
Rate of production – 2.6 tonnes/625 m^2/5½ months		

WORKSHOP ON MUSSEL FARMING - AN ACTION PLAN FOR R & D PROGRAMMES*

A 3-day Workshop on "Mussel Farming" was held at Madras in September, 1980 under the auspices of the Centre of Advanced Studies in Mariculture, Central Marine Fisheries Research Institute (CMFRI). The intention of the workshop was to encounter and exchange information/views on the present status of research and development and to identify the lacunae and constraints in advancing the mussel culture technology in India. Against this background, the Workshop considered the ways and means of enhancing the production, transfer of technology and establishment of a viable industry for mussel culture fisheries in the country.

The Workshop was organised under eight Technical Sessions and a Plenary Session. It was attended by 46 participants representing the National and State Fisheries Organisations, Agricultural Universities and Fisheries Development Corporations.

The Technical Sessions covered specific subjects on biology, physiology and genetics of mussels; culture technology; production and economics; diseases of mussels and their control; post-harvest technology and marketing, besides the general areas on the present status of mussel culture, its socio-economic and legal aspects, training and extension. Twenty-three background papers prepared and presented by the experts in the concerned fields formed the lead material for discussion. Besides, the CMFRI bulletin (No.29) entitled "*Mussel Farming: progress and prospects*" which contained the results of research carried out so far by the Scientists of the Institute also served as reference material. The discussions were mainly directed/lead by Prof. P. N. Ganapati, Dr. R. Raghu Prasad, Dr. R. Natarajan, Dr. E. G. Silas, Dr. H.P.C. Shetty, Shri K. Virabhadra Rao, Shri M. R. Nair and Shri K. Nagappan Nayar. The Workshop brought out a wealth of information on mussel farming carried out at different centres along our coasts during the last decade.

Following the deliberations on both technical and non-technical aspects on mussel farming and the field visit to open sea mussel farming site at Kovalam near Madras, the participants noted in the Plenary Session several areas which need increased research inputs to solve the basic as well as applied problems in mussel culture and indicated many gaps where R & D efforts have to go in. Outlining an 'Action Plan' the Workshop identified the following areas for organising intensive research as well as joint programmes for the accelerated development of mussel culture in India.

I. AREAS WHICH NEED BASIC RESEARCH

The areas identified for basic research pertain to mussel culture environment, biology, nutrition, physiology and genetics of mussels.

1. Environment

Detailed studies for the physico-chemical sea conditions, bottom contour, sedimentation, movements of water and light penetration in the farm sites are essential to evolve appropriate methods of farming in different eco-systems. Similarly, information on productivity of water, distribution pattern of suspended materials, organic detritus and their nutritional value, availability of nutrients and trace elements at stratified depth levels should be obtained for sustained mussel culture.

There is also need for understanding the mechanism of the formation, growth and dissipation of blooms of plankton, the effects of blooms on the crop; monitoring of heavy metals, pollutants and also bacterial load particularly in respect of coliforms and *Vibrio*.

2. Biology

An important aspect of mussel biology which is directly relevant to culture operations is the repro-

* Prepared by E. G. Silas and P. Vedavyasa Rao, CMFRI, Cochin

ductive behaviour of the mussel. Size at first maturity, maturation, spawning, reproductive potential in different environments, factors accelerating/inhibiting spawning, and environmental and neurosecretory/endocrine control of spawning are some of the areas which need detailed studies (studies in progress).

It is also necessary to have information on the growth of mussels under different conditions and their longevity (in progress).

3. Nutrition

One of the priority areas for research in mussel culture is larval nutrition and growth efficiency. It is also necessary to have information on the food and feeding habits of the adult mussels.

4. Physiology

In rope culture of mussels, byssus formation plays an important role in attachment and there is need for understanding the mechanism of secretion of byssus under different environmental conditions. Tolerance limits to environmental parameters such as temperature, salinity and oxygen should be understood. Protein, lipid and carbohydrate metabolism and their interrelationship at different conditions of culture should be studied.

5. Genetics

Very little information is available on the genetics of bivalves in general, and mussels in particular. The areas which need attention are cytotaxonomy, karyological studies, biochemical genetics and population genetics.

II. AREAS WHICH NEED APPLIED RESEARCH

The applied aspects of mussel culture where considerable research inputs are required relate mainly to design and construction of the farm base; seed collection, transport and conditioning; hatchery production of seed optimal conditions of mussel for harvest, production, biofouling; predation and control; parasites and diseases; possibilities of polyculture; harvesting technology; post-harvest technology and product development; utilisation of by-products and market research/survey.

1. Design and construction of farm base

Considerable experimental work involving engineering aspects, and selection and treatment of material is necessary to develop standard system designs for mussel culture suitable for different eco-systems and scale of operations. Optimal size of raft or other structures, anchoring devices in open sea for rafts, carrying capacity of ropes on rafts and production capacity will have to be investigated under different sea conditions.

2. Seed collection, transport and conditioning

A major constraint for large scale mussel farming would be the availability of good quality seed for culture. It is necessary to identify the seed resources, and study the conditions favouring or inhibiting spatfall in the wild beds as well as culture farms, methods of transportation, conditioning of seed and seeding operations in relation to production. All or any one of the above factors could play a vital role in mussel production.

3. Hatchery production of seed

Taking into account the limitations of seed availability for large-scale culture operations, priority should be given for developing a low-cost technology for hatchery production of mussel seed.

4. Optimal conditions of mussel for harvesting

It has been established that on the east and west coast of India, both the green and the brown mussels, reach harvestable size under culture conditions in about five months time. However, the meat content and quality of mussels, vary from centre to centre at the end of the above period. It is necessary to study the optimal conditions of the mussel in terms of quality and value of meat at different periods of culture to take advantage of the meat weight and value factors at harvest. This should also take into account the size and meat content requirement for the diversified product use.

5. Production

The data available on mussel production show variations at different centres and also variations in different years at the same centre. While this could be expected as there is no control of environmental factors in the mussel farms, it would be necessary to obtain more reliable data on average production rates (in progress).

6. Biofouling, predation and control

These factors affect production in the culture farms. Fouling also poses problems at post-harvest treatments. Experimental work is required for the control of predators and pests (in progress).

7. Parasites and diseases

Very little information is available on these aspects. In intensive culture we are bound to face disease problems which would affect the production and consumption. It is, therefore, necessary to work on these problems (in progress).

8. Possibilities of polyculture

The farming infrastructure should also be made use of for rearing other organisms such as quality finfishes and lobsters as a step towards developing polyculture technology for maximum economic advantage.

9. Harvesting technology

Harvesting mussels from the rafts is a labour intensive and time consuming work. It is necessary to develop methods for mechanical harvest of mussels with a view to reducing the cost of operation.

10. Post-harvest technology and product development

As at present, mussel has only a limited market potential. In order to take care of the anticipated increased production and for enlarging the consumer sector appropriate post-harvest technology should be developed for processing and product development (work under way). The purification of mussels is also an important component of this aspect and a low-cost process within the reach of the farmer should be followed.

11. Utilisation of byproducts

Large scale production of mussels would lead to accumulation of enormous quantities of shells. It is necessary to develop processes for by-product development from the mussel shells.

12. Market research and survey

There is an urgent need for carrying out a study on the market potential both within and outside the country to ensure the marketing of mussels and mussel products. This is one of the important constraints of mussel culture and would need concerted efforts of the Fisheries Departments, Corporations and the Marine Products Export Development Authority.

III. EXTENSION AND TRANSFER OF TECHNOLOGY

Besides the basic and applied aspects of research mentioned above, the Workshop also considered the requirement for extension and transfer of technology. It was felt that the CMFRI may intensify its efforts for training scientists, technical and operative personnel, and farmers in mussel culture as the Institute has the necessary infrastructure for the purpose.

Extension proper of mussel culture may be done by the Fisheries Departments of the maritime states with necessary technical assistance for the transfer of technology from the CMFRI.

Wherever transfer of technology and large-scale mussel culture operations are to be taken up, the desirability of carrying out benchmark surveys for later socio-economic impact analysis was stressed.

A streamlining of the distribution and marketing system within the country combined with massive extension programmes for enlarging the acceptability of mussels as food by the Central and State Extension wings was suggested.

Large-scale extension programmes, as the one envisaged in Kerala, may be adequately supported by research and training along with proper post-harvest technology and marketing programmes.

IV. SOCIO-ECONOMIC AND LEGAL ASPECTS

The Workshop also discussed certain fundamental issues such as legal aspects involved in mussel farming and socio-economics in relation to large scale adoption of mussel farming by the coastal fishermen, and enlargement of acceptability of mussel as food.

As regards the legal aspects in sea farming, it was felt that suitable areas may be demarcated for culture operations taking into account navigational and water use problems.

In conclusion, the Workshop appreciated the achievements and continuing efforts of the Central Marine Fisheries Research Institute on mussel culture, and the steps taken on transfer of technology through training programmes, Operational Research Project and Lab-to-Land Programme. Although the lacunae in the R & D base for large-scale mussel culture have been identified, the Workshop felt that there must be simultaneous production-oriented development programmes which would also provide the necessary feedback to the research system. Further, it was also appreciated that a single Institute will not be able to discharge all the responsibilities related to R & D programme in mussel farming. There are several areas which will have to be dealt with at inter-institutional levels and through a multidisciplinary approach.

The Workshop desired that the necessary development support may come from the Government of India as well as the State Governments for mussel culture which possesses great potential for increasing production and for providing employment opportunities in the coastal sector.

NEWS—INDIA AND OVERSEAS

Seminar on exploitation of sun, sea and shore—retrospect and prospect

A seminar on "Exploitation of sun, sea and shore-retrospect and prospect" is scheduled to be conducted in the Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavanagar, a national laboratory under the Council of Scientific and Industrial Research (CSIR) on 30th and 31st December, 1980. It is being organised in order to take stock of the accomplishments and to gear-up research and development efforts in the exploitation of the inexhaustible source of energy, the sun, the tremendous wealth bearing sea and the long sea shores offering land for cultivation of economic crops. The main topics for consideration will be salt, marine and inorganic chemicals, desalination, marine algae, sea water irriculture and solar energy utilisation. The seminar will terminate with a felcitation session arranged for Dr. D. J. Mehta, Director of the Institute on the eve of his retirement.

Experiments in Israel on duck manure feed for fish

Encouraging results have been shown in experiments in feeding fish on duck manure at the Dor Fish and Aquaculture Research Station of the Israeli Ministry of Agriculture. Ducks are kept on raised platforms directly over the fish ponds. Nourished by duck droppings only and with no extra input of feed, fish yields of 38–39 kg per ha per day have been achieved. The manure enriches the water and results in high yields of fish. With the ducks directly above the ponds fresh manure is in continuous supply. Added advantages are that the manure does not have to be gathered and transported to the pond and the operation is easy and simple.

World Fishing 29 (5): May 1980.

Fishery Publications in microfiche

Updata Publications Inc., Los Angeles has announced forthcoming microfiche publications that will encompass the complete collection of the U.S. National Marine Fisheries Service (NMFS) and its predecessors from 1871.

The first publication will be the Fisheries Bulletins of the US Bureau of Fisheries, 1881–1978. The bulletin contain scientific papers on various subjects related to fisheries including biology, economics, technology, fish physiology, pathology and oceanography All material will be reproduced on 4 x 6 inch black Diazo microfiche at a 24:1 reduction ratio.

World Fishing 29 (5) May 1980

Money for old rope

A Norweigian insurance company, Tromstrygd, is making its own contribution to the effort to clear the seas of fishing lines and nets which have been lost or discarded. Modern synthetic fibres do not rot as the old natural fibre ropes and twines did and so remain in the water entangling propellers and rudders and fouling gear.

Laws forbidding deliberate discarding of such lines and nets have had little effect. Therefore, Tromstrygd is trying another line. It will pay fishermen to bring in remnants they find floating or caught up in their own gear.

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Compiled and prepared by M. J. George, S. K. Dharmaraja and G. Subbaraju. Published by Dr. M. J. George, Senior Scientist on behalf of the Director, Central Marine Fisheries Research Institute, Cochin-682 018 and printed at PAICO, Cochin-31