https://doi.org/10.26749/rstpp.108.1.93

FARMING THE SEA

by Trevor G. Dix

Fisheries Research Laboratory
Crayfish Point, Taroona, Tasmania.

(with three plates)

ABSTRACT

Within an encouraging prognosis of substantial increases in world aquaculture, conepts and practices of mariculture and factors affecting potentials are reviewed briefly.

Australian food-oriented mariculture centres principally on intertidal cultivation of the Sydney rock oyster in New South Wales. Experiments are underway with the raft cultivation of mussels, hatchery and pond rearing of prawns and oysters, midwater culture of oysters and laboratory rearing of scallops.

The introduced Pacific oyster supports a viable industry in Tasmania and production has risen from 9,500 dozens in 1968 to 185,000 dozens in 1973. The overall potential of mariculture, particularly oyster farming is considerable in Tasmania although a major constraint is seen in the conflict of interests for proposed lease areas.

INTRODUCTION

Aquaculture, the farming and husbandry of aquatic organisms, is an age-old practice, particularly in the Indo-Pacific region. Nevertheless, interest in aquaculture, including mariculture, the farming of marine organisms, has upsurged lately as evidenced in a recent series of review and journal publications (Iversen 1968; Bardach, Ryther and McLarney 1972; Pillay 1972; Idyll 1973; Neal 1973, and the journal publications FAO *Aquaculture Bulletin*, *Fish Farming International* and *Aquaculture*).

A factor probably providing most impetus to this upsurge has been the recent realisation that the harvesting of marine resources by traditional fishing methods will not give unlimited potential for food production and that the harvest of "familiar" species may increase only by an amount less than the present catch to 90-100 million tons (Gulland 1971; Moiseev 1973).

FAO estimated recently that the world's annual aquaculture production was just over 5 million tons, mostly from fresh and brackish water. Although aquaculture already contributes substantially to food production in a number of countries, possible 10-fold world production increase predicted for this century (Idyll 1973; Pillay 1973) suggest that food production from aquaculture should increase rapidly relative to traditional harvesting methods.

Aquatic organisms are cultured for a range of reasons including food, sport fish and bait production, improving natural stocks, stocking amateur and commercial aquaria, recycling organic wastes, production of animal feed, fish meal and fertilisers, and in the case of pearl oysters and related species, gem production (Pillay 1973). It is in the area of food production, however, that major developments are likely.

With this encouraging prognosis, the present paper seeks a brief review of aquacultural practices and concepts and also Australian mariculture with particular reference to Tasmania, outlining the present situation, problems and prospects.

PRACTICES AND CONCEPTS

Species at present under aquaculture include a wide variety of finfish, crustaceans, molluscs and algae. Much of the world's mariculture concerns shellfish, principally oysters and mussels.

Culture techniques vary markedly between and within countries and cultured species, but all aim to provide some degree of care for the organism under culture, often emphasising the vulnerable young stages. Several classifications of culture techniques have been proposed (Idyll 1973; Neal 1973; Bardach *et al.* 1972) and adapting these I prefer to classify techniques primarily on whether or not hatchery rearing forms their basis. The technology and sophistication of hatchery rearing methods generally differ greatly from those in culture not involving hatcheries.

The least intensive forms of hatchery culture involve raising young of a soecies and then releasing them into unmodified natural conditions, e.g. salmon culture in North America and abalone culture in Japan. To exert a greater degree of control over post-release survival, growth and harvesting, hatchery reared animals may be kept in special enclosures, or with sessile organisms such as oysters, attached to special structures in natural waters. The most intensive forms of hatchery culture involve maintenance of selected brood stock, production of progeny from these and care of the progeny in controlled environments (e.g. ponds, raceways) until harvesting. Although little practiced commercially at present, a large research effort centres on these intensive methods with species including finfish, prawns and oysters.

Culture operations not utilising hatcheries rely on capture or collection of stock from natural populations and then exerting varying degrees of control on subsequent growth and survival until harvesting. Collected stock may be placed in relatively unmodified natural conditions as with bottom growing oysters in North America where much culture effort centres only on predator/pest control. Paralleling the hatchery-based techniques outlined above, greater control may be exerted over culture stock by maintaining them in ponds or net enclosures, often with supplemental feeding (many forms of fish mariculture) or on fixed or suspended objects (oyster and mussel culture). To date most mariculture has involved variants of these non-hatchery based techniques.

A complex series of inter-related factors affects the practice and potential of mariculture to varying degrees depending primarily on which type of culture is under consideration. Examples of these factors are:-

biological: species productivity potential, pests and diseases, behaviour at different stocking densities, selective breeding, life cycles particularly of young stages;

technical: design of culture facilities, provision of skilled personnel;

social and legal: administration of lease areas, shore and waterway rights;

economic: commercial assessment of pilot and experimental operations, marketing;

environmental: pollution, hydrological factors.

Selected factors were discussed in Milne (1972), Wing (1972), Cole (1973), Neal (1973) and Webber (1973). My comments will be postponed until consideration of the mariculture examples in the following sections.

AUSTRALIAN MARICULTURE WITH SPECIAL REFERENCE TO TASMANIA

The Fisheries Division, Department of Primary Industry (now Australian Department of Agriculture) reviewed briefly Australian mariculture in 1970 (see Pillay 1972) and noted that "the only established form of coastal aquaculture in Australia is oyster farming." Passing reference only was made to pearl culture with *Pinctada* species in northern waters of Australia (see George 1966) and a number of commercial aquaria (e.g. Magnetic Island Marine Gardens, North Queensland) maintaining a wide range of fish and invertebrates were not mentioned.

At the time of the 1970 review, farming of the Sydney rock oyster, *Crassostrea commercialis* was the major mariculture industry. The non-hatchery based stick and tray culture methods were reviewed by Croft (1967, 1968) and by Medcof and Malcolm (1974). Production in recent years has reached 140,000 bags (about 798,000 kg meat weight, assuming 95 dozen 5 g oysters per bag) and currently 3000 leases occupying about 6400 ha of tidal waters produce oysters worth about $A5 million annually.

With the aim of increasing production in available areas and reducing disease problems, oyster research has been intensified in New South Wales with studies on pond and suspended culture techniques, hatchery rearing (Wisely 1973) and also diseases.

Concurrently at the State Fisheries Brackish Water Fish Culture Research Station at Port Stephens in New South Wales, research into hatchery productions and pond rearing of prawns is being attempted with some success. These and recent pilot commercial farming endeavours were reviewed by Pownell (1973).

Experimental raft culture of mussels (McLean 1972) is underway in New South Wales, Victoria, Tasmania, South Australia and West Australia in a programme being conducted by the University of New South Wales and that State's Fisheries Department. Further mention of mussel farming is made below.

TASMANIAN MARICULTURE

As with mainland Australia, most Tasmanian mariculture concerns oysters. However, experimental studies on mussels and scallops are underway and brackish water farming of trout has been attempted.

Oyster farming utilising the native mud oyster *Ostrea angasi* was practiced prior to the 20th century in Tasmania. In 1887 for example, 18 Government and private oyster farms were established in southern and eastern areas with the enthusiastic guidance of Mr. W. Saville-Kent (Sumner 1972). Oyster spat were collected on wooden slabs, tiles and stones and grown using bottom culture techniques until harvesting. For reasons unclear, production by farming and also dredging slumped soon after and consumption demand was satisfied by importation of New Zealand mud oysters *Ostrea lutaria*. Although this species was not cultured it was sometimes maintained alive in Tasmanian coastal waters after shipment prior to shucking. This practice apparently resulted in the introduction of a number of New Zealand marine invertebrates (Dartnall 1969), one a seastar predator of shellfish.

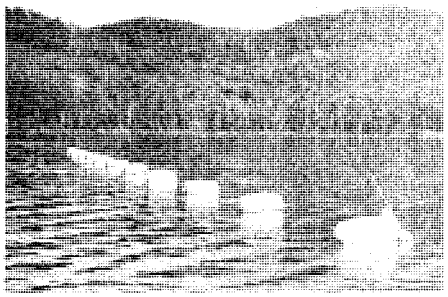
It is possible that remnant populations of *O. lutaria* still exist in Tasmania but few traces of these and the earlier oyster farms remain; native oysters are now not cultured or fished.

Oyster culture was revitalised in the late 1960's utilising the introduced Pacific oyster, *Crassostrea gigas*. After a series of spat introductions between 1947 and 1952 (Wolf and Medcof 1974) the oysters acclimatised and established populations in northern Tasmanian estuaries. Early Tasmanian Pacific oyster farming was reviewed by Wilson (1970) and later events by Sumner (1974).

1973 production was 185,000 dozens (18,500 kg meat weight) worth over $71,000 to oyster farmers compared with 9,500 dozens in 1968.

The main culture techniques are based on the stick and tray methods used for the Sydney rock oyster in New South Wales although commercial pilot operations using Japanese longline suspended culture techniques are beginning to assume significance.

Biologically, *C. gigas* is well suited to Tasmanian conditions and no Japanese pests or diseases appear to have been introduced with the spat. Growth is rapid and harvesting takes place only 16-18 months after spat are collected on sticks. Similar sizes are obtained in about a year using longline culture methods.



PL. 8. - Midwater culture of *Crassostrea gigas*, Row of buoys supporting longlines of oysters at Dover, August 1974.

Production rates compared favourably with those achieved elsewhere in Australia and also overseas. Mean annual production from actively farmed areas on 3-4 established stick and tray farms between 1970 and 1973 was 1220 kg meat weight/ha/yr. Suspended culture techniques are likely to achieve more than three times this rate.

Spat collection for subsequent culture is confined to the River Tamar and although regular, heavy summer spatfalls are usual, poor collections were made in 1973. Such occurrences obviously affect continuity and expansion of production. To enhance the chances of gaining good spat collections, larvae are now monitored by plankton sampling each breeding season in addition to noting temperature and salinity trends. An industry sector financed a Japanese expert to carry out this spat prediction work in 1974, Government assisted previously and co-operative efforts are envisaged now.

Apart from these biological and technical aspects, legal, social and environmental factors have been of major moment to the oyster farming industry. In the early stages, some leases were granted under clauses given in the Fisheries Act 1959. Possible health risks, amateur recreational activities, commercial fishing, navigational aspects and local council's views were and still are all considered prior to lease approval. In later years many leases or licences have not been granted because of conflicting interests in proposed oyster farming areas. Legislation designed to resolve such matters is now under consideration.

Environmental problems in the industry have arisen through the discovery of high heavy metal levels (particularly cadmium and zinc) near the cities of Hobart and Launceston in the Derwent and Tamar estuaries (Thrower and Eustace 1973). Highly productive oyster farms in these areas have been closed or are phasing out and it seems clear that the Tamar River will be used for spat collection only in the future. Unpublished heavy metal analyses presented to Tasmania's Working Committee on Oysters during 1972 and 1973 indicate that heavy metal problems are confined mainly to the Derwent Estuary and neighbouring coastal waters and to the Tamar Estuary.

Tasmanian Pacific oyster farming using stick and tray culture has proven a commercially viable industry. Local and interstate markets are bouyant and export markets seem likely to develop, suggesting that further expansion is assured from a marketing viewpoint provided high quality standards are maintained.

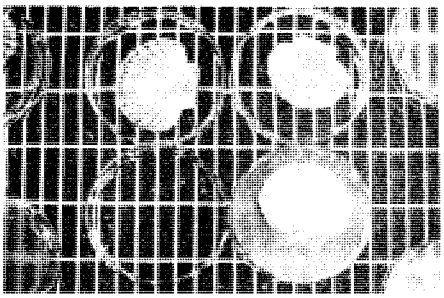
SCALLOPS

Since 1973 the Fisheries Division, Tasmanian Department of Agriculture has been conducting laboratory studies on scallop larvae (*Pecten meridionalis*) at the Research Laboratory, Taroona on the lower Derwent estuary.

The main aim of the studies is to assess biologically the species as a potential commercial hatchery shellfish. *P. meridionalis* can be induced to spawn readily when mature (pl. 9) and some progress on conditioning scallops for out of season spawning has been achieved by maintaining near mature scallops in cooled seawater.

The species has now been raised artificially through the larval period (Dix and Sjardin 1974) and current experiments are determining feeding regimes and treatments necessary to raise large numbers of larvae consistently to metamorphosis. Given success with this phase, studies on the care and maintenance of post-metamorphic juvenile

scallops are intended. The least intensive form of hatchery rearing, that of releasing the young into natural areas, is envisaged. Commercial viability will be assessed only after rearing procedures are clarified.



PL.9. - Hatchery experiments with *Pecten meridionalis*. Scallops spawning after temperature rise in the Fisheries Research Laboratory, Taroona.

One sideline of the investigations has been the elucidation of the morphology and size of the previously unknown *P. meridionalis* larvae. Should non-hatchery based Japanese scallop culture techniques (Sanders 1973) be considered in the future, essential spat prediction work using plankton collections will now be possible.

MUSSELS

Co-operating in a New South Wales University and State Fisheries programme, the Tasmanian Fisheries Division is assisting with feasibility studies of raft culture of edible mussels, *Mytilus edulis*.

Beginning in January 1973 a variety of synthetic, coir and combination ropes has been suspended from a raft in North West Bay and removed at regular intervals to determine fouling, spat settlement and growth of settled mussels (pl. 10). Ropes have also been tested for spat collection in the Tamar estuary.

A light spatfall was collected at North West Bay in the summer of 1973/74 but many of the young mussels were removed by predatory fish. Growth of the remaining mussels has proved good and market size should be reached less than 12 months from settlement.

PL.10. - Experimental *Mytilus edulis* culture. Inspecting ropes on a raft at North West Bay, August 1974.

Overall assessment of the mussel programme, including consideration of biological (growth, spat catching, pest and diseases) and economic factors will be carried out by the programme leaders in 1975.

TROUT

From a basis of successful freshwater trout farming for egg export and food production, Sevrup Fisheries Pty. Ltd. began experiments on the saltwater culture of rainbow trout (*Salmo gairdneri*) in the estuary of the Tamar River in 1970. Trout previously acclimatised to salt water at the company's Bridport hatchery were maintained with pelleted and fish foods in net enclosures in the estuary. Growth in the first year of trials was extremely good and acclimatised brown trout, *S. trutta* were added to the experiment. In the subsequent two years of trials results were less encouraging although brown trout showed more promise than rainbows.

Vandalism proved a major problem in these experiments and this was only partly overcome by tethering a guard dog to the structure supporting the net enclosures. Relatively poor growth and survival in the latter years of the experiments may have resulted from pollution and disease although the Company (Purves pers. comm.) considers the early results justify further trials in more southern waters of Tasmania in the future.

TASMANIAN PROSPECTS

From pilot experimental operations in the late 1960's Pacific oyster culture has grown rapidly as techniques to suit local conditions have been evolved by the oyster farmers assisted by research in the Tasmanian Fisheries Division.

Biologically, the potential of oyster mariculture is considerable. The Pacific oyster grows rapidly in Tasmania to produce meats suitable for the "half-shell" restaurant trade, and production per area cultured is comparable with that found with oysters elsewhere (Bardach *et al.* 1972).

When reviewed in 1970, the Fisheries Division, Department of Primary Industry (1972) estimated that 8000 ha of potential area as available for oyster farming in Tasmania. More recent examination of areas considered suitable for stick and tray culture alone (Sumner 1973, unpublished data) suggests that this figure may have been conservative. However, if only one-tenth of 8000 ha produced at rates similar to those found on actively farmed areas in 1970-73, 960,000 kg of oyster meat could be produced each year in Tasmania. At current prices this represents about $3.8 million to producers.

The areas available for longline culture have not been assessed in detail to date, but with production rates anticipated to be at least three times those achieved by stick and tray culture, the overall potential for Pacific oyster production in Tasmania clearly is considerable.

Several factors will limit the realisation of this potential, perhaps most significantly the conflict of interests for potential oyster culture areas. To quote Bardach *et al.* (1972):

> "It is necessary that the culturist exercise control through ownership, lease or other means of secure holding; this consideration is problematical for marine and brackish water aquaculture in many parts of the world .... where the traditional view is that the sea, its shores, and its resources are common property, available to all. Where this attitude prevails, aquaculture is effectively thwarted."

Some leases for oyster farming were granted in Tasmania, although a number have been refused in later years and the situation is under current review. Resolution of these considerations will provide a clearer prognosis for oyster farming in particular, and mariculture in general in Tasmania.

Neal (1973) considered that intensive aquaculture techniques involving hatcheries hold the most future for carnivorous and omnivorous species of apparent potential for economic culture. Direct initial costs may be high but these are outweighed by the indirect social costs, environmental and biological aspects in Neal's opinion.

Trout farming has been the only attempt at mariculture with a carnivorous species in Tasmania. Operations were semi-intensive as hatchery reared young were kept in enclosures in natural waters. Southern rock lobster (*Jasus novaehollandiae*) may be a potential omnivorous culture species in Tasmania as suggested for the western rock lobster (Chittleborough 1974) although intensive laboratory screening aimed firstly at improving growth would be essential.

The prognosis for hatchery rearing of molluscan species in Tasmania is unclear. Experimental scallop studies have shown encouraging progress but it is too early to assess the economics of such practices. However, should, reseeding of once prolific scallop beds in southern Tasmania be feasible, considerable social benefits could accrue as such beds established a strong tradition for scallops and scalloping in Tasmania. Hatchery rearing techniques, commercially viable overseas for oysters (Bardach *et al.* 1972; Anon 1973) could well provide a means of ensuring regular spat supplies for Tasmanian growers.

Whichever culture species and techniques are finally adopted, Tasmania has sufficient natural and acclimatised resources to share the expansion in aquaculture activities projected for the world in general.

ACKNOWLEDGEMENTS

Messrs. A.J. Harrison and J.H. Bradbury kindly reviewed the manuscript and Nancy Witherspoon helped assemble Tasmanian oyster production rate data.

REFERENCES

Anon, 1973: Oyster seed from modern hatchery in Scotland. *Fish Farming Int.*, 1, 60-1.

Bardach, J.E., Ryther, J.H. and McLarney, W.O., 1972: Aquaculture: THE FARMING AND HUSBANDRY OF FRESHWATER AND MARINE ORGANISMS. New York, Wiley Interscience. 868p.

Chittleborough, R.G., 1974: Review of prospects for rearing rock lobsters. *Australian Fisheries*, 33(4), 4-8.

Cole, H.A., 1973: Cultivation of marine fish and shellfish. *Fish Farming Int.*, 1, 16-26.

Croft, H.G., 1967: Stick cultivation of oysters in New South Wales. *The Fisherman*, 2(11), 12-15.

_____, 1968: Tray cultivation of oysters. *The Fisherman*, 3(1), 12-14.

Dartnall, A.J., 1969: New Zealand sea stars in Tasmania. *Pap. Proc. R. Soc. Tasm.*, 103, 53-5.

Dix, T.G. and Sjardin, M.J., 1974: Larvae of the commercial scallop, *Pecten meridionalis*, from Tasmania, Australia (in edit).

Fisheries Division, Department of Primary Industry, 1972: The status and problems of coastal aquaculture in Australia. pp 26-28 *In* Pillay T.V.R. (ed.) COASTAL AQUACULTURE IN THE INDO-PACIFIC REGION. London, Fishing News (Books) Ltd. 497pp.

George, C.D., 1966: The cultured pearl. Its history and development to the present day. *Australian Gemmologist*, 60-67.

Gulland, J.A., 1971: THE FISH RESOURCES OF THE OCEAN. London, Fishing News (Books) Ltd. 255p.

Idyll, C.P., 1973: Marine aquaculture: problems and prospects. *J. Fish. Res. Board Can.*, 30, 2178-83.

Iversen, E.S., 1968: FARMING THE EDGE OF THE SEA. London, Fishing News (Books) Ltd. 301pp.

MacLean, J.L., 1972: Mussel culture: methods and prospects. *Australian Fisheries Paper*, 20, 1-12.

Medcof, J.C. and Malcolm, W.B., 1974: Oyster culture in New South Wales. *The Fisherman*, 4(10), 1-2 and 22-3.

Milne, P.H., 1972: FISH AND SHELLFISH FARMING IN COASTAL WATERS. London, Fishing News (Books) Ltd. 208p.

Moiseev, P.A., 1973: Development of fisheries for traditionally exploited species. *J. Fish. Res. Board Can.*, 30, 2109-20.

Neal, R.A., 1973: Alternatives in aquaculture development: consideration of extensive versus intensive methods. *J. Fish. Res. Board Can.*, 30, 2118-22.

Pillay, T.V.R., (Ed.), 1972: COASTAL AQUACULTURE IN THE INDO-PACIFIC REGION. London. Fishing News (Books) Ltd. 497pp.

Pillay, T.V.R., 1973: The role of aquaculture in fishery development and management. *J. Fish. Res. Board Can.*, 30, 2202-17.

Pownell, P.C., 1973: Prawn farming prospects in Australia. *Australian Fisheries*, 32 (12), 2-5.

Sanders, M.J., 1973: Culture of the scallop, *Patinopecten yessoensis* (Jay) in Japan. *Fish. Contr. Fish. Wildlife Dept. Vict.*, 29, 1-24.

Sumner, C.E., 1972: Oysters and Tasmania, Part 1. *Tas. Fish. Res.*, 6(2), 1-15.

_____, 1974: Oysters and Tasmania, Part 2. *Tas. Fish. Res.*, 8(2), (in press).

Thrower, S.J. and Eustace, I.J., 1973: Heavy metals in Tasmanian oysters in 1972. *Australian Fisheries*, 32(10), 7-10.

Webber, H.H., 1973: Risks to the aquaculture enterprise. *Aquaculture*, 2(2), 157-72.

Wilson, R., 1970: Oyster farming spreads to Tasmania. *Australian Fisheries*, 29(1), 7-8.

Wing, S.W., 1972: A review of the status and problems of coastal aquaculture in the Indo-Pacific Region. Pp2-25 *In* Pillay, T.V.R. (ed.) COASTAL AQUACULTURE IN THE INDO-PACIFIC REGION. London, Fishing News (Books) Ltd. 497p.

Wisely, H.B., 1973: New methods of growing oysters in New South Wales. *Australian Fisheries*, 32(12), 6-8.

Wolf, P.H. and Medcof, J.C., 1974: Be on your guard against the Pacific oyster. *The Fisherman*, 4(10), 3-5 and 24-5.