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VICTORIAN MARICULTURE SITE ASSESSMENT STUDY

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VICTORIAN MARICULTURE SITE ASSESSMENT STUDY

SECTION 1

A. INTRODUCTION

Aquaculture, the farming of aquatic species, has a history which goes back at least to 475BC when descriptions of carp culture were published by the Chinese (Dill 1967). In general however, aquaculture has lagged behind the spectacular advances made in agriculture particularly over the last century. Many authors believe that aquaculture yet has enormous unrealised potential which will be made good increasingly rapidly over the next century. In particular, mariculture, that branch of aquaculture to do with the farming of marine and estuarine species, is thought to have great potential. A look at the highly successful mariculture industry in Japan together with developments in technologies now being applied in agriculture such as genetic engineering suggest such views of the future are not unrealistic. On a world wide basis, the contribution which aquaculture makes to the total fish production is rapidly rising; from 8% in 1975 to 12% in 1981). This trend is expected to continue, encouraged by international bodies such as the Food and Agricultural Organisation of the United Nations and many national governments particularly in tropical areas. It is recognised that aquaculture can make a significant contribution to world nutrition both because very high levels of productivity can be achieved in many cases and because the products are protein rich.

In Australia at present, the potential of mariculture lies largely in the production of high priced luxuary foods. The long standing oyster industry in NSW serves as a good example of a successful industry although other examples are hard to find.

In Victoria, mariculture has been largely ignored in the past by industry and government alike for many complex reasons. Very recently however, experiments and developments in a number of fields have taken place which promise to lead to the establishment of viable industries. Over the last decade a small 'extensive eel culture'industry has developed in Victoria's western districts. In 1983 a potentially large mussel farming industry has been encouraged in Port Phillip Bay. The number of enquiries about other forms of mariculture being received by the Fisheries and Wildlife Division is rapidly growing and early experiments are being conducted in areas such as culture of salmon and rainbow trout in seawater, the farming of native oysters and abalone culture. Now is the ideal time to develop policies and persue strategies for the development of mariculture industries in Victoria.

Study Objectives

At this time, the Government and the community at large should be asking questions about what future direction a Victorian mariculture industry should take.

1. Is a mariculture industry desirable and should Government be encouraging its development?

2. If so, how is development best encouraged? Some possible ways are through simplified administration, government backed research,positive incentive schemes and the nurturing of industries during the early stages of development.

3. Where are the sites of most potential located and what species have potential for culture? Who presently administers suitable sites for mariculture and what are their policies in relation to mariculture?

4. What conflicts exist with the use of suitable sites and how should public land or water bodies be assigned?

5. What are the other likely problems associated with development of a mariculture industry? For example, what Government agencies need to be involved, what are their present policies and how should they best be co-ordinated? Is it necessary to ammend present fisheries legislation?

It is these questions which the present study sets out to address.

B. SITE SELECTION

It is undoubtedly true that selection of the site of farming operations is the most critical factor in any mariculture project since it largely presets the economic viability of the enterprise. It is therefore critical that a great deal of effort be made to choose the best available site.

The site must initially have certain natural attributes specifically compatable with the species being cultured. These are water of suitable quality and quantity and of suitable temperature, salinity and productivity. Some of these attributes can be modified (e.g. water temperature through the use of waste heat from power stations).

It is useful to clasify sites according to where they lie in relation to the shore. Several categories can thus be distinguished.

i) Land based mariculture

ii) Intertidal mariculture

iii) Offshore mariculture which may further be subdivided into surface floating, midwater and seabed (or sublittoral) farms.

Farming techniques for each type are briefly described below.

(i) Land Based Mariculture

The culture of organisms in land based ponds or similar structures enables most environmental control. Consequently the most intensive farms producing the highest yields are land based.

The main environmental factors that may be controlled in land based farms are:

1) Temperature: temperature manipulation allows optimised growing conditions for each species. Two commonly employed methods are passive solar heating in semi extensive farms and gas/oil/electric heaters in intensive farms.

2) Oxygen Supply: supplemental oxygenation maintains a high dissolved oxygen content in the water and removes the danger of oxygen stresses. In such systems the limiting factor on stocking density is often space.

3) Supplemental feeding: optimal rates of feeding either indirectly through pond fertilization or prepared food addition can be calculated since pond volume and water exchange rates are known.

4) Disease Control: control of water input enables monitoring of potentially hazardous diseases and water treatment (eg chlorine addition) to reduce the likelyhood of disease outbreak. Also, as ponds are independent of the environment and each other it is possible to isolate disease outbreaks.

5) Predator/Competitor Screening: control of water input enables the screening and removal of predators/competitors. Adults may be removed by simple screens and juveniles/larvae by chemical treatment. Periodic draining and drying of ponds eliminates unwanted organisms which may have become established.

Semi intensive land based farms generally have earth ponds. Prior to their construction it is necessary to consider soil characteristics, of which water retention and fertility are the two most important. If the cultured species feeds on the algae which grow in the pond, then fertile soil will enhance productivity and reduce the need for pond fertilization. If the cultured species requires direct feeding e.g. is carnivorous, soil fertility is of less importance.

Water retention is important as a well sealed pond will require less addition of water. Soils with high clay content are most suitable (Bardach, Ryther & McLarney 1972). If the soil has poor sealing qualities, it may be possible to proof the pond by chemical means or by utilizing heavy duty plastics.

Two types of pond construction can be recognised, dugout and levee ponds. In dugout ponds the base lies below the ground surface. These are cheaper as material used to construct the walls is taken from the pond base. However, levee ponds are preferable as they may be completely drained without pumping. The cost of levee ponds is high as non porous soil needs to be transported to the pond site.

The method of harvesting should be considered in the pond design. A slope of about 2% toward the outlet is advisable to facilitate water drainage. Harvesting basins are incorporated into many ponds and may consist of a concrete ditch or a furrow along one wall. As the pond is drained, animals are concentrated in the basin. Outlets should be designed so that the pond may be drained within 48 hours. The relative advantages of smaller and larger ponds are given below (Bardach et al 1972).

Smaller ponds:

1) Easier and quicker to harvest
2) Can be drained and refilled more quickly
3) Easier to treat disease and parasites
4) If for any reason all or part of the stock in one pond is lost, it represents less of a financial loss.
5) Less subject to dam and levee erosion by wind.

Larger ponds:

1) Less construction cost per hectare of water
2) Take up less space per hecatre of water
3) More susceptible to wind action, therefore less susceptible to oxygen deficiency.

Pond depth depends primarily on the species to be cultured. Oysters require a minimum depth of about 400mm whereas snapper, whiting and other cold water fish would require a minimum depth of approximately 2m. Shallow ponds gain and loose heat more rapidly while deeper ponds have a more stable temperature regime.

Intensive farms are generally more compact than the larger semi intensive farms. They are widely used for the culture of such fish as trout, flatfish (flounder, sole, turbot), salmon and shellfish such as oysters.

Essentially they are extentions of hatcheries, however instead of releasing juveniles to the environment they are ongrown to market size. High water exchange rates are used and the compact nature of the farms permits artificial heating of the water to maximise growth rates. One such intensive farm in England produces 500 tonnes of flatfish per annum in a 2.5 hectare area (FFI July 1982). This farm utilises water treatment, high exchange rates, supplementary oxygenation and a pellet diet for the fish.

Ponds used in intensive farms are generally small and are above ground structures of either concrete or fibreglass coated metal. Their shape may be circular, rectangular or square. The advantages of small ponds are that disease can be readily isolated and cleaning and handling are simplified. Water circulation and aeration is also more efficient in small ponds. Temperature control is enhanced as they may be easily heated and insulated from temperature variations.

Water treatment in intensive farms may involve filtration of particulate matter which affects pumps and piping, treatment with chlorine or ultra violet light to remove bacteria, predators and competitors and chemical filtering to adjust ionic composition (eg, salts, trace metals and pH) to suitable levels. Water heating to optimal growth temperature may be achieved by heaters or by locating the farm near a hot water source where heat exchangers may be used.

The high cost of running such farms requires a high yield of product to be obtained.

ii) Intertidal Mariculture

The culture of Sydney rock oysters in New South Wales is a typical example of intertidal mariculture. The spat are collected on sticks, and later transferred to areas with natural high productivity for on-growth to commercial size. Off bottom growing techniques were developed since oysters located on the seabed are soon covered by a thin layer of mud in which a burrowing mud worm Polydora sp. thrives.

It is possible to construct ponds in the intertidal zone. Using one way operating sluice gates, tidal water enters such ponds and water exchange is achieved by slow release back flow sluice gates.

iii) Offshore Mariculture

(a) Surface floating

The developing mussel culture industry in Port Phillip Bay provides a good example of a surface floating culture technique. The system consists of a 100 m long-line moored to the seabed. From this long line, at 0.5m intervals, 5 - 7m long ropes are suspended which hold the growing mussels. Oysters and scallops may also be grown under long lines; in some cases lantern nets (a series of trays within a net) are used to confine the culture organisms.

Fish are commonly cultured in floating cages, which consist of pontoons from which nets are suspended to enclose the body of water beneath the pontoon. The mesh size of the nets can be varied so stocks at various stages of growth may be held. Often two nets are used, the inner to hold fish and the outer to keep predators out. Cages can be designed so that they fit together in series.

Net cage systems are moored to the seabed using anchors or concrete blocks. Supplementary feeding is widely practiced, either by hand feeding or utilising automatic feeders. In general, the use of net cages is restricted to relatively sheltered waters.

b) Midwater

It is possible to farm both shellfish and fish in the midwater zone. In the case of shellfish a cage system with trays on which oysters, mussels or scallops are placed is utilized.

Fish are cultured in large rigid framed cages. Such systems are anchored to the seabed and surfaced marked with buoys. The disadvantages associated with midwater farming are that cages must be raised to the surface for feeding, harvesting and cleaning.

c) Seabed

It is possible to construct artificial reefs on the sea bed for the culture of such species as abalone and rock lobsters. The building of artificial reefs as fish habitats is a commonly used technique.

SECTION 2

CRITERIA FOR SITE SELECTION

The major criteria to be considered in selecting a suitable mariculture site are outlined below.

(A) Physical Factors

(i) Wave action is the most destructive of all physical forces to offshore and intertidal mariculture. Two categories of waves can be distinguished; oceanic swells of long wavelength and wind induced waves of short wavelength. As there are few sites on the exposed coast of Victoria suitable for mariculture at this time, the former type will not be discussed here.

The nature of wind induced waves is determined by wind strength, direction and duration, the distance of water over which the wind blows (fetch) and the water depth. In general terms, as wind strength and fetch increase and water depth decreases, wave height increases so that by reference to appropriate weather statistics along with the detailed description of the site, wave action can be predicted.

Obviously, in areas of high wave action the construction standards of offshore or intertidal structures need to be high and maintenance costs will be higher. Flexible systems such as long lines are less prone to damage. Farming may be carried out below the surface since wave energy decreases rapidly with increasing depth. Farms may even be designed to be lowered during storms. In other cases baffle fences or floating barriers are built to reduce wave energy reaching the farm.

Wave action may also have beneficial effects such as removal of waste products from floating cages, aeration of water or movement of food to filter feeders. In some cases large volumes of water may be moved by 'wave pumps'.

(ii) Wind may cause direct damage to farm equipment although may be used to advantage in generating power or pumping water.

(iii) Currents once again have both positive and negative aspects. If too strong, they may damage farming structures and it is advisable not to site operations in areas where the current exceeds three knots. However, currents may be very useful in removing waste products and uneaten food thus preventing localised oxygen depletion and spread of disease or in moving food past filter feeding culture species.

(iv) Water depth should be such as to allow a surface floating farm to be located well clear of the seabed. This allows wastes to fall clear, lessens the likelihood of benthic predators reaching the cultured species (e.g. starfish reaching mussel stocks) and avoids damage to equipment due to contact with the sea bed.

(v) Water temperature must obviously be within the tolerance range of the species being cultured. However, within this range, higher temperatures will generally lead to faster growth rates which in some cases means the difference between operations being viable or not.

(vi) Site geography may be such that periodic flooding occurs, estuaries may be subject to periodic closure or silting etc. or operations may be subject to undue human interference (pollution, theft etc). A general assessment of locality is therefore important.

(B) Chemical factors

(i) Salinity The salinity tolerance range of the cultured species should be matched with the known salinity range at the site. Points that need to be considered, particularly for estuarine sites are seasonal salinity variation, history of variation (or flooding if information is available) and the degree of salinity stratification. This last point is significant as extended periods of stratification may lead to deoxygentation of the bottom water which will affect sedentary culture species.

Spawning in some shellfish and fish is regulated by salinity variation and once spawned some organisms are unsuitable for sale and may take many months to recover to marketable condition.

(ii) Dissolved oxygen As salinity and/or water temperature increases, the dissolved oxygen content of the water decreases. Oxygen deficiency will cause mass mortality.

Environmental factors that assist in maintaining high oxygen levels are currents, waves and winds. The likelyhood of low oxygen levels may be estimated to some degree by observing the above factors at the proposed site. Another method of estimating local oxygen conditions is to investigate the sediment. If it is composed of black mud and produce hydrogen sulphide (rotten egg gas) when disturbed, it is likely that low oxygen conditions occur in bottom waters.

(iii)Contaminants Terrestrially derived contaminants are generally localised in effect in Victorian waters. The Environment Protection Authority regularly monitors areas of concern and data from these sites are availabe. Information on other areas is scarce, however, contaminant levels in these waters are low and unlikely to have any effect on mariculture.

a) Heavy Metals There are two sources of heavy metals which accumulate in marine organisms. They may enter the estuarine and marine environment through industrial and domestic discharges. In such cases, localised areas of heavy metal pollution occur. The other mechanism leading to heavy metal build up is bioaccumulation operating through the food chain from naturally occuring metals. This mechanism accounts for the high levels of mercury in school shark.

The Victorian EPA has prepared criteria for heavy metal levels in water and edible fish, crustaceans and shellfish. The recommended minimal risk levels for various heavy metals are:

Metal	Criterion level in water mgL^{-1}	Criterion level in edible tissue (wet wt) ppm
Mercury	0.15	0.5
Antimony	45000	1.5
Cadmium	10.0	2.0
Chromium	50.0	5.5
Copper	--	30.0
Cyanide	200.0	--
Lead	50.0	5.5
Nickel	100.0	--
Zinc	--	1000.0
Selenium	10.0	2.0
Silver	50.0	5.5
Beryllium	0.6	5.5
Thallium	48.0	5.5
Uranium	100.0	5.5
Arsenic	0.175	1.5

In relation to the protection of shellfish growing areas, the EPA has recommended minor changes to the water criteria in the above list. Revised minimal risk concentrations for the protection of shellfish growing areas are:

Metal	Criterian level in water mg L^{-1}
Chromium	10.0
Lead	<10.0
Copper	3.5

The above recommended criteria should be used in selecting a suitable site. If information is not available for the relevant area, it is advisable to have a chemical analysis conducted.

(b) Organic Compounds The effects of organic compounds on marine organisms are less well understood than those of heavy metals. Some break down into relatively harmless compounds in a short period of time but may cause localised pollution problems around coastal towns and industrial sites. Others are remarkably stable and may be concentrated through the food chain.

The EPA has prepared recommended criteria for organic compounds to protect human consumers of fish, shellfish and crustaceans. Only one group of compounds, polychlorinated biphenyls, have been given an edible tissue level, the recommended minimal risk level being 0.1 ppm (wet weight in edible tissue).

(c) Tainting Substances Tainting substances are likely to be localised in effect, again around drainage outfalls. Away from such areas, the most likely cause of tainting would be from fuel spills from ships and boats.

(d) Bacteria and Viruses The presence of bacteria and viruses in seawater poses a risk, generally not for the cultured organism, but for the human consumer. Bivalve molluscs, because of their feeding mode, accumulate bacteria and since they are often consumed raw, can cause considerable health problems.

Inputs of bacteria and viruses into the marine environment generally occur during periods of freshwater runoff via drains or streams. The proximity of such inputs should be noted when selecting sites. The problem of bacterial pollution is short term as most are killed by salt water within a few days.

Once the bacterial input has ceased, shellfish are capable of cleansing themselves. Modern depuration facilities work on the principle of placing shellfish from bacterially polluted waters into clean water and allowing time for the cleansing process to occur. If bacterial pollution occurs and depuration facilities are unavailable, it is advisable not to harvest for at least three days after freshwater runoff has ceased.

The Environment Protection Authority has prepared guidelines for the protection of human consumers from bacteria in shellfish growing waters. These are:

> Total Bacterial Coliforms The total coliform median (most probable number) in the water should not exceed 70 per 100 ml, based on not less than 5 water samples taken within a 42 day period. Nor shall more than 20 per cent of those samples exceed a total coliform median of 230 per 100 ml for a 5 tube decimal dilution test.
>
> Faecal Coliforms The faecal coliform median in the water should not exceed 14 per 100 ml based on a minimum of 5 water samples taken within a 42 day period. Nor shall more than 10 per cent of those samples exceed a median of 43 per 100 ml.

The protection of human consumers of shellfish is considered in the 1978 amendment to the Health Act, Food and Drug Standard Regulations, though at this stage the amendment only refers to oysters. The regulation states that bacterial levels in oysters (including frozen ones) should not exceed the following:

> *E.coli count not to exceed 2.3 E.coli per gram of oyster flesh.
>
> *Aerobic plate count should not exceed 100,000 microorganisms per gram.

Although these regulations apply only to oysters, they could be used successfully to monitor other shellfish and in the future be broadened to include other shellfish species.

(e) Pesticides/Herbicides The effect of pesticides and herbicides are generally localised in areas of high water runoff from adjacent land. There are no coastal areas of Victoria seriously polluted by such compounds although they are of more concern to freshwater aquaculturists.

(f) Mutagens In general, as the pollutant load of bays, estuaries and rivers increases so does the incidence of mutagenic activity. It is reasonable to assume that the areas of significant matagenic activity are adjacent to industrial and domestic inputs. The effect of mutagens on organisms is to increase the incidence of cancers and genetically based diseases. As yet, mutagens in the marine environment have not been shown to affect human consumers.

The EPA lists all potentially troublesome toxicants and provides recommended minimal risks concentrations in its publication "Water Quality Management Criteria." If the proposed site is regarded as marginal it would be wise to refer to this publication and obtain water analyses for the relevant chemicals.

(iv) Suspended Solids Suspended solids in the marine environment can be classified into two types; particulate matter re-suspended in the water column through current and tidal action and flocculent material permanently suspended in the water column.

Primary productivity may be reduced in turbid areas as suspended solids absorb and scatter light that would otherwise be used by phytoplankton. The feeding of some animals, particularly filter feeders, can be impaired by suspended solids. Sendentary organisms may be smothered by settling suspended solids.

An estimate of suspended solid load in potential waters may be derived by measuring light penetration with a secchi disk or similar instrument.

(C) Biological factors

(i) Primary Productivity Many species which have potential for mariculture feed directly on algae growing in the water body being farmed. This is applicable to the filter feeding shellfish such as oysters and mussels and the omnivorous grazers such as prawns, abalone and crayfish.

In the culture of filter feeders it is advantageous to use a water body with a reasonably high level of productivity. The most accurate method of estimating primary productivity is by measurement of chlorophyll, the

concentration of photosynthetic material in a given volume. Such information is available for a number of Victorian coastal areas. Where such information is not available an analyses can be conducted or an approximate estimate can be made by observing the degree of green in the water. Water of a soft green nature is ideal for culture of filter feeders as food is plentiful. There is considerable seasonal variation in primary productivity in coastal waters, generally peaking in spring/autumn and being least during winter. Water of lower productivity may also support adequate growth, however such areas rely on greater water exchange to maintain the food supply.

Land based farms have the advantage that primary productivity can be directly controlled. Pond fertilization using standard terrestrial chemicals such as superphosphate and sulphate of ammonia is commonly practised throughout the world. Fertilization rates are generally 100kg/Ha at two weekly intervals until light penetration is down to approximately 30 cm. At this stage, fertilization may be reduced to a lower level determined by practical experience.

(ii) Marine Fouling Fouling by plants and animals is a major problem for mariculture at many sites and is expensive in terms of both equipment and manpower. The mariculture structures most affected by fouling are permanently immersed nets such as floating cages and longline structures used in mollusc farming. Mesh, pontoons and ropes act as settling substrates for a host of marine organisms ranging from algae to ascidians. In addition, nets collect and retain drift weed brought by currents. The maintenance of adequate water circulation through these structures requires regular diving to physically remove the fouling organisms or if the culture species allows, removal of the structure from the water for two to three days.

Gauging the likely effect of fouling at a potential mariculture site is somewhat subjective. Inspection of pier piles and solid substrates in the vicinity of the potential site will enable estimation of the degree of fouling and the likely fouling species to be encountered.

Land based farms are less likely to have major problems with fouling as regular maintenance of pumps, equipment and ponds will minimise the fouling effect.

(iii) Predation In order to maximise yield it is necessary to control or remove predator access to the cultured species. There are many types of predators, for example seabed organisms such as crabs, starfish and molluscs, pelagic animals such as fish and squid and terrestral animals such as birds and water rats.

The following table associates potential predators with the culture method and species.

Mariculture Species	Culture Method	Predation
Oysters, scallops mussels.	Longline Culture, ropes and suspended trays.	Location of culture structures off the seabed restricts access of crabs, starfish and molluscs. Use of covered trays restricts fish predation. Problems may result from larval settlement of predators amongst culture organisms.
Oysters	Intertidal Stick/Tray Culture	Predator access from seabed is facilitated as structures are attached to seabed.
Finfish	Net Cage Culture	Double net system is advisable. The outer net functions as a barrier to predators and prevents damage to the inner culture net. Bird predation restricted by suspended nets or wires drawn between sides of cage above the waterline.
Finfish Crustaceans, Shellfish	Lagoon/pond Culture	Predation restricted by screening of inflow water and regular inspection of ponds. Bird predation restricted by nets or wires. Water rats etc. difficult to control.

Predation in any mariculture system is potentially greater than that occurring naturally, due to the concentration of the cultured animals. The degree to which predators can be controlled depends on the culture system and land-based mariculture will be easiest to control in this regard.

(iv) Competition Competition for food between undesirable species and the cultured organisms can significantly affect growth, particularly in the case of filter feeders and hence affect the economics of the operation. Again the influence of competition depends on the cultured species and the culture method.

Species	Culture Method	Comments
Fish and Crustaceans (carnivorous)	Land Based Culture	In a well managed pond system there should be a minimal competition effect. Drainage of ponds once per year for treatment and drying removes undesirable species. Organisms which require feeding (pellets or trash fish) have less competition problems.
Fish and Crustaceans (omnivorous)	Land Based Culture	Organisms in this category consume the naturally produced food of the pond with only supplementary feeding. Drainage of ponds and adequate input water screening reduces competitors.
Fish	Net Cage Culture	Competition for food sources is reduced by the nets restricting entry of the larger competitors. Juveniles of other species which enter the cage are often eaten by culture species.

Molluscs	Longline/Raft/ Intertidal Culture	The competition effect by other filter feeding organisms is minimal as an adequate food supply is usually available. Competition for space on culture ropes and trays may cause problems which can be overcome by regular maintenance, thinning and redeployment of stock.

(v) Disease The basic premise of any aquaculture operation, be it in freshwater or the sea, is the maintenance of high stocking densities. Under such conditions, disease transmission is facilitated. The problem cannot usually be overcome by the simple flushing of ponds or the relocation of offshore culture; it is most often necessary to utilise specific preventative or curative measures.

In ponds it is possible to control disease by fallowing and treating the bed with appropriate chemicals. If disease occurs in net culture or longline systems it may be difficult to control and if it has spread to wild stocks, almost impossible. Chemicals are available for the treatment of many diseases. It is quite common, especially in pond culture, to add antibiotics to the water or food. In addition to disease control, there is now considerable emphasis being placed on the selective breeding of disease resistant stock.

(vi) Ecosystem Response to Mariculture The effect of pond mariculture systems on the adjacent environment should be minimal. If the pond culture system is intensive, treatment of waste waters to remove accumulated toxic metabolites and waste materials may be necessary. In general, filter systems incorporating shell, gravel and sand components are sufficient to clean the waste water. As the culture system becomes more intensive, water treatment requirements also become more complex. The dangers of polluting the environment with farm wastes should not be overlooked.

The establishment of net cage or long-line culture systems, may, in areas of limited water flow, have a deleterious effect on the benthic environment in the vicinity of the farm. Accumulation of waste products beneath the farm may harbour disease and larvae of predators and lead to localised water quality deterioration. Observations beneath and within structures should be conducted regularly to avoid future problems. Inspection within farm structures should concentrate on the degree of waste material build up within the habitat of the cultured organisms. Selection of a mariculture site in an area of adequate water circulation should ensure few problems from accummulation of farm waste products.

(ii) Availability of potential culture organisms. Currently, the species most suitable for mariculture in Victoria are those endemic to the State. The basis for this statement is current Government regulations, biological knowledge and to a lesser extent, economic potential.

Species cultured successfully elsewhere, could in many cases also be cultured successfully here. Policy on the importation of exotic species for mariculture will depend upon their likely impact on the local environment.

(D) Social factors

In choosing a farm site careful account of the social effects should be made. Land based farms will have least effect on community coastal usage unless the farm borders a sensitive area. The farming methods most likely to affect the community are intertidal and offshore operations. The likely objections range from aethetics to restriction of water usage.

(i) Distance of farm from base Applying only to intertidal and offshore farms, this criterion is important for a number of reasons. In exposed areas, operators should be in close proximity to the farm to enable rapid access. Following rough weather it should be possible to make rapid repairs to lessen the chance of the farm fouling and interfering with others nearby. Permanent observation is advisable as it aids detection of damage and human interference.

(ii) Visual Impact of the farm The development of mariculture, by its nature, draws public attention to this industry to a greater extent than most others. Visual impact of the farm should be minimised so it blends into the general scenery. Public acceptance of the industry will be based on first impressions which undoubtedly will be the general appearance.

(iii) Conflicting Interests Conflicting interests occur mostly in offshore and intertidal situations although are also a potential problem to land-based operations. Conflicts may occur with commercial activities and increasingly with recreational activities.

a) Commercial Fishing Commercial fishing in the proposed mariculture area is one use which is considered prior to the issue of a Fish Culture Permit. It is advisable for the proposer of a mariculture scheme to contact the local Fisheries and Wildlife Officer or the Fishermens' Co-operative to ascertain traditional fishing activities in the proposed area. This will enable the selection of a site acceptable to both the mariculturist and fishermen. The identification of a number of alternate sites will provide greater flexibility for the final selection process. The likely areas of conflict with commercial fishermen are the alienation of waters previously used for commercial netting and the restriction of access to seabed for dreding operations.

b) Commercial Shipping Mariculture operations will not be approved in areas used for commercial shipping.

c) Amateur Fishing The extent of amateur fishing pressure in Victorian coastal waters is largely unknown. The selection of a suitable mariculture site should take into account local fishing sites, as far as possible avoiding the most popular ones. Strong opposition from amateur fishermen is unlikely as there is now strong evidence that suggests offshore structures act as artificial reefs and enhance fish life. If amateur fishermen are allowed to fish near such structures, opposition is likely to be reduced.

d) Leisure Boating Leisure boating is a rapidly growing activity on Victorian coastal waters. Boating can be divided into a number of classes, each of which can have an influence on mariculture development.

Yachting is an extremely popular past-time in many areas during the summer months. Consideration of yacht club locations should be made when choosing a farm site. Sufficient space between the farm and yacht club should remain for yacht access under the most adverse conditions. It is also wise to take into account the commonly used yacht racing circuits.

There are many diverse recreational activities associated with power boating. In inshore areas, water sking is popular. Other activities include leisure cruising, fishing and SCUBA diving/snorkeling.

e) Other Activities Activities in nearshore waters which may influence site selection are surfing, windsurfing and swimming. Location of the farm near heavily utilised areas should be avoided.

Passive use of coastal land and water is increasing as more and more people appreciate the aesthetic qualities of the coast. Potential developers should consider the impact of their proposals on such qualities.

E) Economic Considerations

The major consideration in any commercial development proposal is its economic viability. It is imperative that any project be completely thought out financially and a realistic cost/return analysis constructed.

In the cost of establishing and operating the project the following should be considered.

1) Licence costs.- relevant to all controlling bodies in the proposed area

2) Construction costs.

a) land based - costs of pond construction, channels, pumps, piping, pond liners, hatchery, power, heating, aeration, stock, feed, waste water treatment, maintenance etc.

b) offshore/intertidal - costs of longlines/rafts, moorings, ropes, nets, cages, buoys, navigational marks, boats, transport containers, diving equipment, fuel, maintenance etc.

3) Stock loss - an estimate of anticipated stock loss should be made and included in the cost/return analysis.

4) Anticipated return - allowing for stock loss estimates it is possible using current market prices to estimate farm return. Such estimates should be made at the lower and upper yearly market prices for the product. This will aid in the selection of the appropriate farming intensity.

F) Legal Considerations

Anyone establishing a mariculture operation must obtain either a Fish Culture Permit or an Experimental Permit from the Fisheries and Wildlife Service. Other licensing/legal requirements vary according to location. Offshore mariculture would require approval from the Ports and Harbours Division and the Land Protection Service. Depending upon location, other authorities may be involved, eg Port Phillip Authority, Port Authorities. Land based farming will require approval from Local Government and if on Crown Land, the Land Protection Service.

SECTION 3

POTENTIAL MARICULTURE SPECIES IN VICTORIA

There are many species native to Victoria which are potentially suitable for culture (McLean 1975). Some of these are cultivated in other parts of the world (eg. the blue mussel, Mytilus edulis) or are biologically very similar to species being cultivated elsewhere (e.g. the native oyster Ostrea angasi is very similar to the European flat oyster Ostrea edulis). Such species have immediate prospects as culture organisms. Other species such as the black bream Acanthopagrus butcheri offer good potential although more information on their biological characteristics is necessary.

There are also a number of exotic species which offer good culture prospects although their introduction would need to be carefully controlled both because of the potential ecological damage to the environment and the possible introduction of exotic diseases. Such species include the pacific oyster Crassostrea gigas and the chinook salmon Oncorhynchus tshawytscha.

Each species has its own problems in relation to culture so that no overall statements can be made. This section lists several species which offer potential and presents a summary of their biology, suitable cultivation techniques and a broad economic outlook.

1. Molluscs

(i) The blue mussel - Mytilus edulis

This species occurs world-wide and in Victoria is particularly common in the bays and estuaries.

Following the pioneering experiments of several mussel farmers and research conducted at the Victorian Marine Science Laboratories, a mussel farming industry was started in Port Phillip Bay in 1983 where there is an abundant and reliable source of spat and where growth rates are good.

Habitat:- Mussels occur commonly in all Victorian bays, inlets and estuaries, both in intertidal and subtidal zones.

Reproduction:- In Port Phillip Bay, spawning occurs in mid to late winter. The larvae are planktonic for 10-14 days after which they settle onto a solid substrate.

Growth Rate:- Mussels reach a marketable size of 70-90 m.m shell length in 14-18 months from spat settlement.

Food Requirements:- Mussels are filter feeders on phytoplankton which occurs naturally in the water.

Cultivation Techniques:- In Australia, culture consists of hanging ropes vertically in the sea under surface or sub-surface floating long lines at least one month prior to spat settlement. Ropes develop a fauna which is suitable for mussel spat to settle upon. Approximately 4-5 months after settlement the young mussels are thinned in a process known as mussocking to an on-growing density of 200-400 mussels/meter. These mussels can be harvested 10-12 months later.

Economics:- The economics of mussel farming in Victoria appear favourable if a price of $1.50 per kilogram for fresh mussels can be maintained. However, since the industry is yet very young, little detailed economic information is available.

Legal Considerations:- At present there are twenty fish farming permits issued for mussel farming in Port Phillip Bay and a further three experimental permits.

Government policy is not to issue any further permits for mussel farming in Victoria at least until January 1986. This is to protect the existing industry while growing techniques and markets are developed.

ii) Scallop - Pecten alba

The scallop occurs in large numbers in Victorian waters and is the basis of a commercial industry in Port Phillip Bay and Bass Strait. Scallop farming began in Japan in the early 1970's and is still undergoing development. Scallops are cultivated in Europe, Japan and on a limited scale North America and New Zealand.

Habitat:- Marine, sedentary on sandy substrates. Depth range is from approximately 7m to deeper offshore waters. Rapid pumping of water through the shell allows limited movement.

Reproduction:- In Victoria, spawning occurs between August and October. Free swimming larval stages are present until December-January. In the hatchery, spawning may be induced throughout the year by means of temperature manipulation.

Growth Rate:- Under natural conditions, growth rate is moderate with commercial size being reached in 2-3 years. Port Phillip Bay Scallops average the following lengths with age.

Age (years)	1	2	3	4	5
Length (mm)	42	65	78	85	89

Growth rate of cultivated scallops overseas is substancially faster than that of wild stock and this would be expected to apply to Pecten alba.

Food:- Filter feeders on phytoplankton.

Cultivation Methods:- Suitable for offshore cultivation using longline/raft systems. Scallops are held in suspended cages (lantern nets) for ongrowing.

Suitable areas for culture are bays and inlets with limited freshwater input such as Port Phillip Bay, Westernport Bay and Corner Inlet.

Economics:- Current wholesale prices are $4 to $5 per kilo flesh weight. Operational expenses are high due to the labour intensive nature of cage culture techniques and this has retarded development of scallop culture overseas.

Legal Considerations:- Fisheries and Wildlife has no definite policy on collection of wild spat.

iii) Sydney Rock Oyster - Crassostrea commercialis

Sydney Rock oysters occur naturally in Victoria in the far east of the State, from the N.S.W border to Wingan Inlet. One small farm currently operates in Mallacoota Inlet. Ongrowing experiments have been conducted at Lakes Entrance, Shallow Inlet, Westernport Bay and Port Phillip Bay but have largely been unsuccessful. Victoria is the southern limit of the species and extensive mortalities (associated with low temperatures) occur in winter. This species has potential in Victoria in situations where water temperature can be controlled or for ongrowing over the summer period when water temperatures are suitable.

Habitat:- Estuaries and tidal creeks.

Reproduction:- In the wild, major spawnings occur in early summer through to autumn, coinciding with a salinity decrease and a temperature increase. Larvae are free swimming for up to 10 days prior to metamorphosis and settlement. Hatchery production involves induction of spawning through temperature and salinity manipulation and larvae are fed on cultured algal diets. Settlement is induced onto shell fragments to produce "cultchless" spat.

Hardiness:- Can withstand exposure to sunlight and dessication. In cool conditions can survive for up to 10 days out of water.

Growth Rate:- Slow and reach market size (60-70mm) in 2.5-3 years.

Food:- Filter feeders on phytoplankton.

Culture Method:- Intertidal/subtidal trays or longline cage culture. Due to their hardiness, Sydney Rock Oysters are ideally suited to intertidal farming.

Economics:- As survival of this species is marginal in Victoria and the outlook for cultivation is not good. The most logical areas for ongrowing would be within the natural range (east of Wingan Inlet). Other areas would require considerable experimentation to overcome the problem of winter mortality. Market wholesale prices vary between $1.50-$2.00 per dozen. Spat (≈ 15mm shell length) and seconds (≈ 25 to 30 mm shell length) may be purchased from New South Wales growers.

Legal Considerations:- The approval of the Director of Fisheries and Wildlife is required for importation of stock into Victoria.

iv) Native Oyster - Ostrea angasi

The native oyster was the basis of a large dredge fishing industry in Port Phillip Bay, Westernport Bay and Shoal Inlet/Corner Inlet between the 1890's and mid 1950's. This species is closely related to Ostrea edulis, the flat oyster widely cultivated in Europe and North America.

Habitat:- Inlets and bays, sand and mud substrates.

Reproduction:- In natural conditions spawning occurs from October through to March. The eggs are incubated on the gills for a period ranging from 15-22 days.

Hardiness:- Subtidal, not tolerant to prolonged exposure.

Growth Rate:- In Tasmania a shell length of greater than 75 mm is reached in two years. (Dix 1980.)

Food:- Filter feeders on phytoplankton

Culture Method:- Subtidal trays or longline cage culture.

Economics:- As water temperatures are generally warmer in Victoria than Tasmania, a more rapid growth rate could be expected here. This species would be suitable for cultivation in most Victorian waters, particularly those areas where a dredge industry was once located. Current market prices are unavailable for this species, however, expected wholesale price would be approximately $1.50 per dozen.

Legal Considerations:- There are no regulations concerning the farming or collection of this species.

v) Pacific Oyster - Crassostrea gigas

The Pacific Oyster, native to Japan, is now the most widely cultivated species in the world. A culture industry is being developed in Tasmania and South Australia and the species is being experimentally cultivated in salt works adjacent to Port Phillip Bay.

Habitat:- Estuaries, bays and open coastal areas.

Reproduction:- In subtropical areas, spawning may occur when water temperatures exceed 20°C. Two hatcheries operate in Australia, one at Dry Creek, Adelaide and the other at Bicheno, Tasmania. Hatchery production involves temperature and salinity manipulation. The larval period is 10-14 days after which metamorphosis occurs and the spat are induced to settle on shell fragments.

Hardiness:- In cool conditions, animals will survive 2-3 days out of water. Shells are characteristically thin and fragile. The species cannot withstand prolonged dessication.

Growth Rate:- Reach marketable size of 60-70 mm in 14 to 18 months.

Food:- Filter feeders on phytoplankton.

Culture Method:- Intertidal/subtidal trays or longline cage culture.

Economics:- This species has more potential than any other oyster for culture in Victoria. It is fast growing, has a low mortality rate and Victorian environmental conditions are well suited. Suitable areas for cultivation include all sheltered coastal waters. Wholesale market prices vary between $1.50-$2.00/dozen.

Legal Considerations:- Fisheries & Wildlife policy is not to allow the introduction of this species into open waters in Victoria since there is a possibility that it will become established and cause an environmental problem. This policy may change in the future.

vi) Abalone - Greenlip (Haliotis Laevigata), Blacklip (Haliotis ruber)

Both species are found on rocky reefs in coastal Victorian waters. The blacklip abalone is more widespread than the greenlip abalone. A large fishery is based on these species. Almost the total cutch is exported to Japan, S.E. Asia and the U.S.A.

Habitat:- Generally subtidal,on rocky reefs.

Reproduction:- Spawning takes place in late summer/early autumn. Larvae are planktonic for 6-11 days after which they metamorphose and settle.

Hatchery production involves thermal conditioning of parent stock. Spawning is induced using ultra violet light. Juveniles are raised on prepared algal diets, primarily diatoms.

Hardiness:- Tolerate short periods of exposure only.

Growth Rate:- Slow growing, taking 5 years to reach 12 cm. Animals mature at approximately 7 cm. shell length. Hatchery produced stock reach 3-5 cm in the second year. (Bardach et al 1972).

Food:- Planktonic larvae do not feed and following settlement, juveniles feed on benthic diatoms. Adults feed at night on macroalgae, particularly leafy seaweeds.

Culture method:- In Japan, hatchery produced juveniles are ongrown in races until they are of sufficient size to transfer to natural reefs, which are "owned" by Fishermens 'Co-operatives. It is also possible to construct artificial reefs which can be designed to maximise space and food for abalone.

Economics:- Price of abalone to fishermen is currently approximately $3.60 per kilo. There is a considerable potential market for small abalone in Asia which cannot be supplied due to legal minimum size regulations. This market could be readily supplied with cultivated abalone.

Legal Consideration:- Minimum legal sizes in Victoria vary according to area, with the smallest size permitted for harvesting being 10 cm in Port Phillip Bay. As collection of juveniles is prohibited, any development of an abalone farming industry would be dependent on hatchery production. Difficulties could be expected in leasing natural reefs for farming and such leasing is unlikely to be possible, except in isolated and presently little utilised areas. Construction of artificial reefs is one likely way in which abalone farming will proceed. Approval would be required from the Fisheries and Wildlife division and the Ports and Harbours Branch to establish such reefs.

vii) Clams and Cockles - Anadara sp, Kalelysia sp and Mactra sp.

Species of these three genera occur widely in Victorian waters, particularly on the mudflats and sandy regions of the large bays and inlets. They are extensively cultivated in Asia and considerable quantities are canned and imported into Australia. In Australia they are harvested on a small scale to supply the angling bait market.

Habitat:- Shallow mudflat areas and soft subtidal substrates.

Reproduction:- In all genera, spawning occurs throughout the year, peaking in spring and summer. Planktonic larvae are present in the water column all year.

Hardiness:- Can withstand fluctuating salinities and temperatures.

Growth Rate:- In Malaysia, growth rate (of Anadara Sp) is rapid; 2.5 cm reached in 6-12 months. Growth rates in Victoria would be expected to be slower due to lower temperatures.

	Average sizes, (mm)		
	Length	Height	Section
Anadara	60	50	55
Katelysia	45	40	25
Mactra	40	30	20

Commercial size for all species, both for human consumption and bait, would be reached in 12-24 months.

Food:- Filter feeders on phytoplankton and small particles of organic detritus.

Culture Method:- Traditional methods overseas rely upon harvesting of natural seed stock which are transplanted to growing areas. In Victoria, hatcheries would be required to produce spat.

Economics:- The market potential of these species is presently low, particularly for the domestic market. Production costs in comparison with Asia would be high. The bait market is generally well supplied by species harvested interstate.

Legal considerations:- Government policy would preclude any form of bottom culture on the environmentally important mud flat areas in Victoria. The only suitable culture method available is off bottom, involving hatchery produced spat and cage and pontoon on-growing systems.

2) CRUSTACEA

i) Prawns:
- Western King - *Penaeus latisucatus*
- Eastern King - *Penaeus plebejus*
- Tiger - *Penaeus esculentus*
- Banana - *Penaeus merguiensis*
- School - *Metapenaeus bennettae*

Prawns are by far the largest component of Australian fish exports. The 1981-82 catch is estimated at 21,000 tonnes liveweight. Demand for prawns is such that wholesale prices range from $5.50 per kg for the smaller School Prawns to in excess of $10.00 per kg for the larger King Prawns.

Cultivation of prawns was originally developed in Asia and is now practiced throughout the world. Prawns lend themselves to both extensive and intensive farming; the latter method is applied in the more industrialized nations. Intensive farming with associated temperature control would be appropriate in Victoria as natural conditions preclude extensive cultivation here. Currently only one commercial farm operates in Australia, cultivating the Western King prawn in South Australia. Experiments are also being conducted in N.S.W.

Habitat:- Estuarine and shallow coastal areas on mud, silt and sand, depending on the species.

Reproduction:- One species, the greentail prawn, breeds in estuaries and all others migrate to offshore areas for breeding. Spawning in greentail prawns occurs during the full moon from November to March in lakes, estuaries and the sea to a depth of 14 metres. Other species breed offshore primarily in Spring and again in Autumn. The larval period from fertilised egg to juvenile prawn is approximately 40 days. Males transfere sperm to females in spermatophores following moulting and the sperm is then released by the female to fertilize the eggs when environmental conditions are suitable. Intensive farming of prawns involves collection of mature females and manipulating environmental conditions to induce spawning. Larvae are fed on algae specifically cultured for each stage.

Hardiness:- Estuarine prawns can tolerate large fluctuation in salinity and temperature although offshore species are more vulnerable to such changes. Temperature tolerance varys, though all species become torpid below 12^{o}C.

Growth rate:- In the juvenile stages moulting occurs about every two weeks. Growth rate is directly dependent upon temperature and is at a maximum between 25^{o}C and 30^{o}C. School prawns reach a length of 100-120 mm after seven months.

Food:- Prawn larvae feed on phytoplankton, juveniles on organic detritus and adults are omnivorous.

Culture Method:- As saleable size is reached in approximately seven months, at least one crop per year could be achieved in shallow ponds. There are two possible farming strategies; shallow (approximately 1m) earth ponds can produce one crop a year and small ponds with temperature control can support continual cropping year round. Stocking densities may be kept high with supplementary aeration and additional feeding of specially prepared diets.

Economics:- The wholesale price of prawns (fresh) in 1981-82 varied between $5.50 per kg and $10.50 per kg. Such prices would need to be maintained in order to cover the costs of establishing a land based pond farm, with temperature control and supplementary feeding facilities. Price is dependent on the species and king prawns have the highest price. In Victoria, continuity of juvenile supply could only be guaranteed if a hatchery was available. Currently the only supply of juveniles is the Port Broughton Prawn Farm which produces Western King Prawns. Until production of other species is undertaken, Western King prawns offer the best prospects for culture in Victoria.

Legal Considerations:- There are no specific regulations with regard to prawn farming in Victoria although it would be necessary to obtain a fish culture permit and the consent of the Director of Fisheries and Wildlife to import parent stock from elsewhere.

ii) Southern Rock Lobster: Jasus lalandei

The Southern Rock Lobster is the basis of a considerable commercial fishery in Victoria. Artificial propagation of rock lobsters has been recently achieved experimentally in Japan, however the long larval period has precluded any major commercial development. Furthermore, the slow growth rate lessens the economic potential for farming the species.

Habitat:- Fully marine, inhabits rocky reef areas.

Reproduction:- In the natural environment spawning occurs from early winter to early summer. The female carries the eggs for approximately 150 days when they hatch. Larvae are pelagic for about 6 to 9 months.

Growth Rate:- After the larvae reach the juvenile stage, growth to legal size of 11cm carapace length takes about 8 years.

Food:- Shellfish and crustaceans. Larvae feed on phytoplankton.

Cultivation Method:- Though rock lobsters have yet to be cultivated past the juvenile stage,on-growing would require pond systems or leased seabed areas with supplemental feeding. Habitat enhancement utilising artificial reefs is also possible.

Economics:- Wholesale prices for Southern Rock Lobsters were between $8.00 and $10.00 per kg in 1981-82. Demand is high and as natural supplies are declining their potential as a mariculture species could improve. Biological difficulties in rearing larval stages and slow growth rates preclude any commercial development at this time and it is unlikely that any technical break throughs will be made in the near future.

Legal Considerations:- The minimum legal size for Southern Rock Lobsters in Victoria is 11cm carapace length. It is further illegal to take egg carrying females. These regulations preclude the collection of wild juveniles for restocking in mariculture operations. Opposition to such stocking methods would come from commercial fishermen and to a lesser extent sport divers and conservationists as natural populations seem to be in a state of decline.

3) FISHES

i) Mullet - Sea Mullet - Mugil cephalus
Yellow Eye Mullet - Aldrichetta forsteri

The mullet family is one of the most widely cultivated of all fish groups. It is represented in tropical and subtropical waters world wide and in all Australian states. The sea mullet is of considerable importance in New South Wales and Queensland where it is the basis of a large fishery. Yellow Eye mullet is commonly caught in Victoria and is used for both human consumption and pet food.

Habitat:- Estuaries both in freshwater and sea water and all coastal areas.

Reproduction:- Sea mullet spawn during the winter in shallow coastal waters. Fry then migrate to estuaries and inlets where they further develop to the juvenile stage. The Yellow Eye mullet spawns in summer in brackish water areas.

Artificial propagation of mullets is possible using hormone induction based on carp pituitary extract. This method permits breeding at any time of the year.

Hardiness:- Larvae are delicate, however juveniles and adults tolerate large environmental fluctuations. Salinity tolerance is from freshwater through to two times the salinity of seawater and temperature tolerance is from 6 to 25°C.

Growth Rate:- Sea mullet have the following average lengths at age.

Years	1	2	3
Length mm	14-15	23-25	31-35

The optimum temperature for mullet growing is 20-25°C. Sea mullet reach a maximum length of at least 75 cm. The yellow eye mullet grows to about 40 cm.

Food:- Both species of mullet are omnivorous and will feed on algae, detritus and fish.

Economics:- The wholesale price of sea mullet is 50c to $1.50 per kg and yellow eye mullet is 60c to $1.00 per kg. The viability of culture of these species would depend on high turnover rates and stocking densities.

Legal Considerations:- The only regulation governing mullet is the legal minimum length for capture. This would preclude capture of juveniles for stocking unless special approval from the Fisheries and Wildlife Division is obtained.

ii) Australian Salmon - Arripes trutta esper
Ruff - Arripes georgianus

These species are common in Victorian waters. The Ruff has better quality flesh and is preferred. Both fish are taken commercially in Victoria.

Habitat:- Shallow coastal waters, inlets and embayments.

Reproduction:- Little is known of the reproductive biology of these species. As yet, they have not been artificially propagated.

Hardiness:- Tolerate fluctuating salinities and temperatures.

Growth Rates:- Australian salmon reach sizes of up to 80-90 cm and Ruff up to 40 cm.

Food:- Carnivorous on other, smaller fish.

Cultivation Method:- These species are suited for both cage and pond culture. They school strongly and are capable of high stocking densities. Supplemental feeding would be required.

Economics:- Wholesale prices for Australian salmon vary between 80^{c} and $1.50 per kg.

Legal Considerations:- Minimum size regulations apply to these fish. A permit to collect juveniles would be required.

iii) Black Bream: Acanthopagrus butcheri

The Black Bream is common in estuarine waters in Victoria. It forms the basis of a large commercial fishery in the Gippsland Lakes and is also a popular angling fish. Research conducted by the Fisheries and Wildlife Division has shown the species can be bred under controlled laboratory conditions. Further research is needed before hatchery production can be routinely carried out.

Habitat:- Coastal areas, occurring commonly in estuaries.

Reproduction:- In Victoria, generally spawn in late October and November in freshwater sections of estuaries. Has been propagated in the laboratory.

Hardiness:- High tolerance to varying salinity, temperature and oxygen levels.

Growth Rate:- In the Gippsland Lakes, Black Bream reach 6.0 cm in one year and 13.5 cm in two years.

Food:- Molluscs, crustaceans, worms and some algae.

Cultivation Methods:- Highly suited to brackish water farming, either cage culture in areas of suitable water flow or intensive pond culture. Supplemental feeding would be required. Schooling behavior is strong therefore the species is well suited to high density culture.

Economics:- Wholesale prices vary between $2.00 and $3.00 per kilo. Demand for bream is moderate to high.

Legal considerations:- Minimum legal size regulations apply for Black Bream and approval to collect juveniles for farm stocking would therefore be required.

iv) Yellowtail Kingfish: Seriola grandis

The yellowtail kingfish is common in Victorian waters and enters the bays, particularly Port Phillip Bay, during early summer. It is a popular angling fish and is commercially marketed in small numbers during early summer.

Habitat:- Pelagic, offshore marine fish.

Reproduction:- The Japanese species has not been bred in captivity and it would be expected the local species would also not lend itself to hatchery production. In the wild the species breeds in open waters and in Japan, fry from the wild are captured and reared.

Hardiness:- Require seawater salinities at all stages and cannot tolerate low oxygen levels. Susceptible to bacterial infection.

Growth Rate:- Reach lengths of up to 2.5 metres and weights of 65 kg. The Japanese species grows from 15 mm to 60 mm in 4 to 6 weeks and further to 400 mm in 6 months.

Food:- Ongrowing requires supplemental feeding of minced fish at a rate of 10% of body weight per day. Fish require food with low oil content as they cannot digest fatty acids.

Cultivation Method:- Cage culture in areas with good water flow.

Economics:- Yellowtail kingfish have rarely been marketed in Victoria and are only cultivated in Japan where there is strong demand. It is therefore expected their economic potential is low and considerable market development would be required. Costs of running the farm would be high as large amounts of feed would be required and due to these high costs a high price would be required to break even.

Legal considerations:- Approval to collect fry from the wild would be required from the Fisheries and Wildlife Division.

v) Whiting - Spotted (King George) Whiting - Sillaginodes punctatus
School Whiting - Sillago bassensis

Whiting are a significant component of the Victorian fish catch, occuring throughout the State. The spotted whiting is less common than the school whiting. Both species are endemic to Australia.

Habitat:- Coastal waters, bays and estuaries.

Reproduction:- Spawn in coastal waters in autumn and eggs and larvae are pelagic. Whiting have so far not been artificially propagated.

Hardiness:- Tolerate a wide range of salinities and temperatures.

Growth Rate:- Spotted whiting average 50cm maximum length whilst school whiting are smaller, averaging 30-35 cm. The growth of spotted whiting in South Australia has been shown to be 10-14 cm in the first year, 20-26 cm in the second and 27-35 cm in the third.

Food:- Worms, crustaceans, molluscs and fish.

Cultivation Method: Suitable for both cage and pond culture. Schooling behavior enables high stocking densities. Supplemental feeding would be required.

Economics:- The potential for cultivation of the spotted whiting is good as its market price is high; $4.50-$7.00/kg. The outlook for school whiting is low as prices are generally less than $1.00/kg. The spotted whiting price would need to be obtained to cover feeding and operating costs for any mariculture venture.

Legal considerations:- The sole source of supply of fry is by wild capture methods and Fisheries and Wildlife Division approval for this would be required. As these fish are taken commercially there would be considerable pressure to restrict collection of fry. Collection is likely to be permitted on an experimental basis, however long term production would require development of hatchery techniques.

vi) Flounder: Greenback - Rhombosolea tapirina
Long snouted - Ammotretis rostratus

These species are commonly taken by commercial fishermen in coastal Victorian waters. They have excellent quality flesh and demand is high, often exceeding supply. Intensive culture techniques have been developed in England for very similar species. Some research is being undertaken at Universities in Victoria and Tasmania which is directly applicable to commercial mariculture of these species.

Habitat:- Coastal waters and embayments and move to deeper water during summer.

Reproduction:- Spawn in shallow coastal waters in winter/spring. Hatchery techniques are to collect fertilized eggs from naturally spawning stock held in tanks. Hatching of eggs takes approximately 3 weeks and metamorphosis of larvae to benthic juveniles occurs in a further 6-7 weeks. Larvae and juveniles feed on brine shrimp and rotifers.

Hardiness:- Larvae quite delicate and do not tolerate rapid salinity or temperature changes. In high stocking densities fish are suceptible to bacterial infections.

Growth Rate:- In England under controlled conditions, plate sized fish can be grown in 12 to 24 months. Similar growth rates could be expected in Victoria.

Food:- Larvae and juveniles feed on brine shrimp and rotifers. Adults feed on crustaceans, molluscs and worms.

Cultivation Methods:- Hatchery production is required to obtain a supply of juveniles. On growing is possible in both extensive or intensive land based ponds. This species can tolerate very high density stocking (10 adults per square meter) if water circulation is sufficient to maintain high oxygen levels.

High density stocking allows small ponds with limited temperature control facilities to be used economically. Farms in England operating on a total water area of 5 ha produce 500 tonnes of whole fish per annum. These farms use above ground pools of approximately 3 m diameter by 1m deep. Small ponds allow close monitoring of feeding rates and better disease control.

Economics:- Wholesale prices vary between $4.50 to $7.00 per kg. In Australia, demand usually exceeds supply, particularly during the winter months. Costs of operating an intensive farm would be high, considering in particular initial construction, pumping, temperature control and feeding costs. The prices given above would need to be maintained to make farming viable.

Legal considerations:- The only regulation currently relevent to mariculture is the legal minimum size for harvesting from the wild. Any collection of juveniles for farm stocking would require a permit from the Fisheries and Wildlife Division.

vii) Snapper: Chrysophrys auratus

Snapper are commonly taken by commercial fishermen in coastal Victorian waters and embayments, particularly Port Phillip Bay. They are also an exceptionally significant angling fish. A closely related species, the Red Sea Bream is cultivated in Japan, Asia and the Mediterranean. Culture techniques for the Victorian species would be very similar to those applied in Japan and little further basic research would be required in Victoria. Research is also currently being conducted in New Zealand (Smith and Taylor 1982).

Habitat:- Coastal waters and embayments.

Reproduction:- Spawn in shallow coastal waters and the eggs are pelagic. Hatchery production of Red Sea Bream involves collection of suitable brood stock from the wild. These are held in tanks for spawning. The fertilized floating eggs are caught on filters and transferred to hatching tanks. The fry are fed a diet of rotifers and copepods until they reach a length of 15 mm when it is changed to minced fish and shrimp.

Hardiness:- Tolerate a wide range of temperatures. Juvenile fish can withstand small salinity variations, however salinities below 16‰ impair growth. In crowded culture conditions, all stages are susceptible to bacterial disease.

Growth Rate:- In Japan, cultured fish reach 1kg in 20-24 months. Optimum growth is achieved at temperatures between 20^{o} and 28^{o}C. Growth rates in Victoria are likely to be slower.

Food:- Adults feed on crustaceans, molluscs and small fish. In hatcheries, larvae are fed on plankton, particularly rotifers. Juveniles feed particularly on amphipods and brine shrimp. Commercial farms use minced fish with vitamin additives as food.

Cultivation Method:- Snapper fry are transfered to offshore cages when they reach 30 mm. The cages are situated in areas where current flow is 5-15 cm/sec.

Economics:- The wholesale price of snapper varies between $3.00 and $5.00 per kg. Demand for snapper is high and considerable quantities are imported from New Zealand as the Victorian production is insufficient to meet demand. Costs of feeding snapper may vary. They will readily consume cheap trash fish combined with vitamins, minerals and carbohydrates. With some research pelletized foods could also be developed.

Legal Characteristics:- The only current regulation relevant to mariculture is the legal minimum size. In order to establish an operation a permit would be required to collect a suitable quantity of juveniles. From the initial stocking suitable future breeding stock could be selected.

viii) Trout - Rainbow - Salmo gairdneri, Brown - Salmo trutta

Both species were introduced to Australia from America and England. Although normally confined to freshwater, sometimes migrate to the sea and later return to the freshwater to spawn. Growth rates are rapid and growth is faster in seawater than in freshwater.

Habitat:- Freshwater streams and lakes.

Reproduction:- Hatchery production techniques are well developed and juvenile trout are available from many hatcheries in Victoria. Spawning in the wild occurs on stream gravel beds. The female digs a nest and lays eggs which are fertilized by one or more males.

Hardiness:- Adults tolerate moderate temperature variations and considerable salinity changes from freshwater to sea water. Not tolerant to reduced dissolved oxygen levels. Susceptible to bacterial infection at temperatures in excess of 20^{o}C and this is also commonly associated with high stocking densities.

Growth Rate:- In seawater, fingerlings grow to plate size in less than 12 months.

Food:- Molluscs, small fish, crustaceans and insects. Take well to pellet food.

Cultivation Methods:- Hatchery reared fingerlings can be grown in cages or land based ponds. Sufficient water movement is required to maintain high oxygen levels.

Economics:- Table sized trout wholesale for approximately $3.00 each or $4.00 each smoked. Trout are presently cultivated commercially in freshwater and are usually fed palletized food. The economics of freshwater farming are favourable and as growth rates are faster in the sea, farming in such areas should be equally economic.

Legal Considerations:- Approval for fingerling purchase and translocation is required.

ix) Salmon - Chinook - Oncorhynchus tshawytscha

Chinook salmon were introduced to Victoria from North America. The species is propagated at the Government fish hatchery at Snobs Creek, Eildon and fingerlings are used to stock lakes in Western Victoria. Research on the mariculture prospects of this species has recently been started.

Habitat:- Adults live in offshore and coastal waters and return to freshwater streams to spawn.

Reproduction:- Spawn in gravel beds of rivers. Females dig a pit in the gravel and deposit eggs which are fertilized by one or more males. Hatchery production involves stripping eggs and sperm from adults and incubating the fertilized eggs. Fry are fed fine particles of formula food.

Hardiness:- Adults tolerate a wide range of salinities. Fish are stressed at temperatures in excess of 20°C. All stages require high dissolved oxygen levels. Bacterial infection often results from overcrowding.

Growth Rate:- Chinook salmon grow to commercial size of 50-75 cm in 12-24 months, depending on average temperatures. Optimal temperatures are from 12°C to 18°C (Bardach et al. 1972).

Food:- Molluscs, small fishes and crustaceans. Will take pelletized food.

Cultivation Method:- Fingerlings can be ongrown in net cages.

Economics:- Salmon are not commercially marketed in Victoria. Smoked salmon wholesales at about $20 per kilo. Development of a smoked salmon industry has great potential in the light of recent import restrictions on cold smoked salmon.

Legal considerations:- Approval for fingerling purchase is required and at present the only source of supply in Australia is the Snobs Creek Hatchery, operated by the Fisheries and Wildlife Service, Victoria.

SECTION 4:

POTENTIAL MARICULTURE SITES IN VICTORIA

Introduction

Potential sites for mariculture along the Victorian coast were investigated using the site selection criteria outlined in SECTION 2 and with potential culture species in mind. As well as geographical and physico-chemical criteria, potentially conflicting uses were considered. Attempts were made to define the policies of responsible authorities although in most cases, not surprisingly, no such policies existed. The study is by nature somewhat subjective and the findings should be used as a guide only.

A) MALLACOOTA INLET

Mallacoota Inlet covers an area of 2650 ha and into it flow two significant rivers, the Genoa and Wallagaraugh. The inlet is almostly entirely surrounded by the Croajingolong National Park. In 1971, the township of Mallacoota had a resident population of 296 although seasonal tourist influxes often raise the population to over 1000. Mallacoota's main industries are fishing (primarily abalone) and tourism.

The inlet is divided into two areas, the upper and lower lakes. The entrance is wide, shallow and permanently open. A number of sand islands have formed inside the entrance. The lower lake is predominantly marine while the upper lake is estuarine.

GENERAL CHARACTERISTICS

Rainfall Annual rainfall averages between 900 and 1000 mm.

Temperature Range - (Gabo Island)

Monthly Average	J	F	M	A	M	J	J	A	S	O	N	D
^{o}C	18.3	18.7	18.1	16.2	13.9	10.5	11.0	11.5	12.7	14.1	15.4	17.0

River Discharge (Genoa River upstream of confluence with Wallagaraugh River).

Annual Discharge (ML)			Minimum Monthly Discharge
Max	Min	Mean	
190,000	14,100	96,400	173

Salinity The salinity of Mallacoota Inlet varies directly with the inflow of freshwater. Under a normal flow regime, the upper lake is brackish whilst the lower lake is marine as it is primarily governed by tidal exchange from the sea. Flooding occurs during winter and salinities in the lower lake may drop to below 15‰. Major flooding of the system is less frequent and on average, salinities in the lower lake drop to 0‰ every 4-5 years.

Winds The predominant wind regime is from the south west with secondary winds from the south east and north east. The depth and area of the inlet do not allow significant wind induced waves to form.

Land Use The flats of the Genoa and Wallagaraugh Rivers are partly used for cattle grazing. The majority of land bordering the inlet is forested and forms part of the Croajingolong National Park.

Contaminants - No major inputs of contaminants occur in the Mallacoota Inlet system. Bacterial pollution adjacent to Mallacoota township has been evident in the past, though this should cease on completion of the town sewerage system.

Commercial Fishing Abalone, taken along the ocean coast, is the main species landed at Mallacoota. A factory owned by a co-operative of fishermen processes the catch.

A small net fishery operates in the inlet, taking black bream, flathead, whiting and mullet. A Sydney rock oyster farm is located in the lower lake.

Recreational Fishing Recreational fishing is a major and growing component of tourism in Mallacoota Inlet. The more popular fishing locations are marked on the accompanying map. Fish commonly taken are black bream, flathead, garfish, whiting, mullet, bass, australian salmon and snapper.

Other Water Uses In addition to commercial and recreational fishing, Mallacoota Inlet is used for water skiing, sailing (predominantly lower lake) and general sightseeing (all areas).

Social considerations Considerable opposition to commercial development of any sort taking place in Mallacoota Inlet can be expected from a number of quarters. Tourism is very important and one of the main features of the inlet is its undeveloped nature. The inlet is surrounded by a national park and development occuring within it obviously will affect the aesthetics of the area in general. Consequently, any mariculture development would need to be located, built and operated to minimise visual impact. In particular, mariculture sites should be located away from the township of Mallacoota and the channels connecting the two lakes, where boat traffic is heaviest.

MARICULTURE PROSPECTS

The development potential of the upper lake is low due to wide and frequent salinity variations and shallow water depths. The lower lake is more suited to development due to its size, depth range and relatively stable salinity.

Though potential sites are few, the mariculture potential of Mallacoota Inlet is high.

POTENTIAL MARICULTURE SITES

Goat Island, Horse Island, TiTree Point This site is located in shallow water adjacent to the above islands. Water depth averages 0.5 m and is suited to the tray culture of oysters. Tidal exchange with the ocean is excellent and water quality is high. Bottom sediments are firm and consist of coarse grained sands. The existing oyster lease is located on the east side of Horse Island. The area is not commonly utilised commercially or recreationally.

The oyster species most suitable for culture is the Sydney rock oyster which occurs naturally in the inlet. Pacific oysters were introduced during the 1950's, however this species has not become established.

Some conflict between competitive uses could be expected due to the proximity of Mallacoota, though the existing oyster lease has caused few complaints. Prospects - good

Howe Bight The shallow water in the Howe Bight region is suitable for tray oyster culture. Areas close to the shore average 0.5m in depth and sediments are predominantly sand. Water movement is adequate as a consequence of both tidal currents and wind induced currents. This area is not widely utilised by commercial and recreational interests. Oyster species suitable for culture are those mentioned previously.

Lease development in this area should not be continuous and at least 100 m separation between leases should be provided to enable public access to the shoreline. Conflict between competitive uses is low. Prospects - very good.

Goodwin Sands The shallow water north of the sand islands on the Goodwin Sands is ideally suited to oyster culture. Average water depth is 0.5 m and sediments are coarse grained sand. This area is not widely utilised by commercial or recreational interests. Water movement is primarily tidal. Oyster species suitable for culture are those mentioned previously. Conflict between competitive uses is low. Environmental conditions excellent. Prospects - very good.

Eight Foot Bank The deeper water, which averages 7 m., east of Eight Foot Bank is a suitable site for deep water culture of a number of species of shellfish and fish. Longline suspension culture of molluscs and floating cage culture of fish could be undertaken in this area. Tidal currents are such that sea water reaches the site directly from the inlet entrance.

The proposed site is adjacent to a popular recreational fishing area. It is seaward from the commercial netting areas. The site is sufficiently far from Mallacoota to have minimal impact on recreational boating.

It is recommended that an average lease size of 3ha apply to this site.

Suggested species for culture in this area are mussels and oysters (longline culture) and bream, trout, chinook salmon, whiting and snapper (floating cage).

Potential conflict between competitive uses is moderate. Likely opposition will arise over the visual impact. Prospects - good.

Bass Strait The Mallacoota Abalone Divers Co-operative is in the unique position of being the only abalone supplier in far eastern Victoria. As such, this group has great potential for the development of lease areas on offshore reef for the on-growing of small abalone. A hatchery could be developed on the coast near Mallacoota.

Initial reefs for leasing could be those commercially exploited offshore, such as Tullaburga Island, where little amateur activity occurs. Conflict with other uses would be minimal. Prospects - very good.

GOVERNMENT POLICY

National Parks The National Parks Service controls land use to the high water mark in areas under its control. Its policy is not to support land based mariculture. The Service has no control over water use and a permit is not required from this body for mariculture in the inlet.

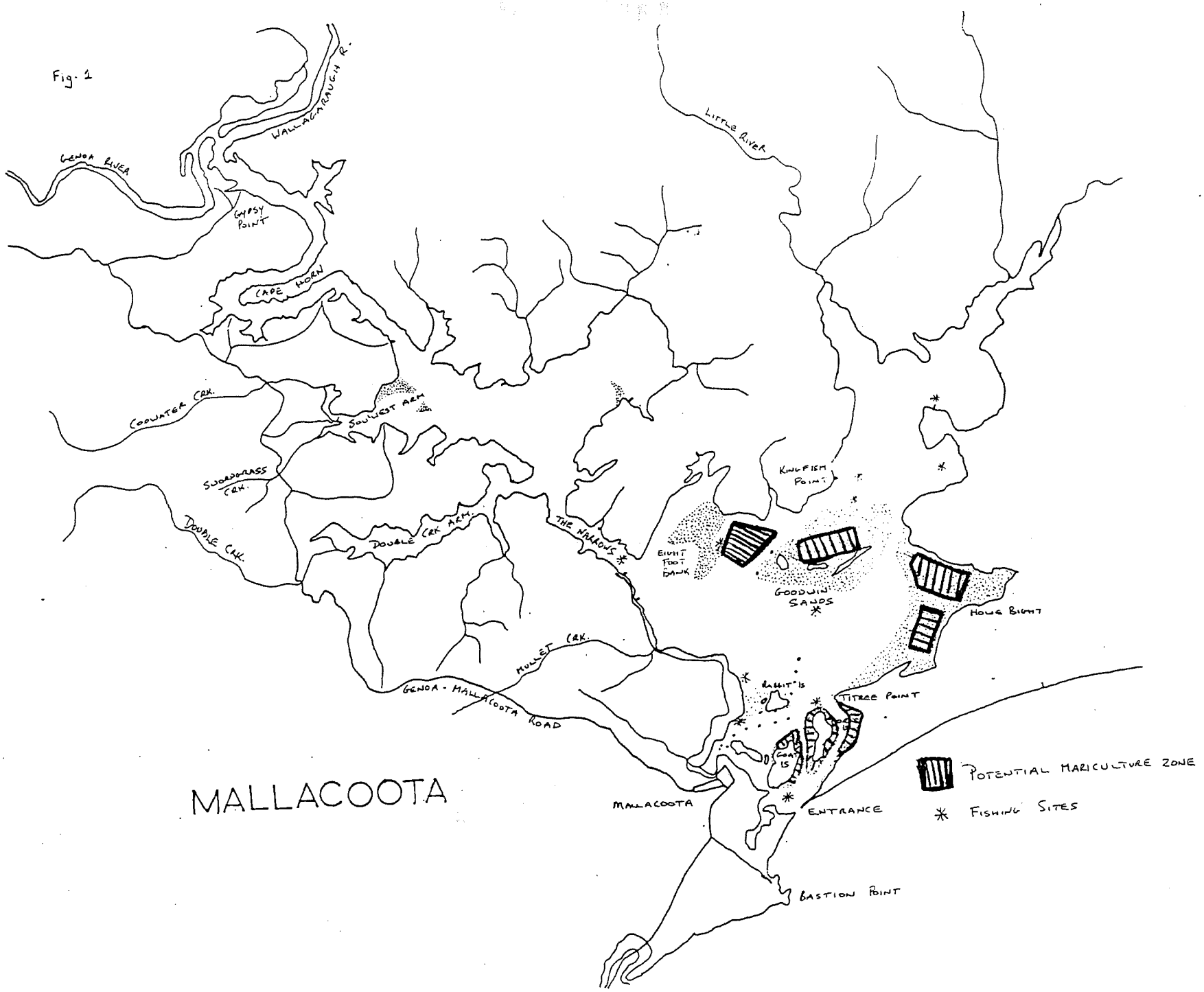
Environment Protection Authority The EPA considers the water quality of Mallacoota Inlet is suitable for shellfish culture (EPA 1981).

Ports and Harbours Division Mallacoota Inlet is a designated port and approval to establish a lease is requirecd from the Ports and Harbours Division. Approval should be sought in conjuction with approval from the Fisheries and Wildlife Service.

Land Protection Service The Service has no formal policy on mariculture in Mallacoota Inlet, however, approval is required for any moorings on the seabed. Approval should be sought in conjunction with a Fisheries and Wildlife Service permit.

Shire of Orbost The Shire approves in principle mariculture in the inlet.

Fig. 1


WALLAGARAUGH R.
GENOA RIVER
GYPSY POINT
CAPE HORN
LITTLE RIVER
COOLATER CRK.
SOUWEST ARM
SUGARGRASS CRK.
DOUBLE CRK.
DOUBLE CRK ARM
THE NARROWS
KNUCKLE POINT
EIGHT FOOT BANK
GOODWIN SANDS
HOUSE BIGHT
MULLET CRK.
GENOA - MALLACOOTA ROAD
RABBIT IS
TITREE POINT
GOAT IS
MALLACOOTA
ENTRANCE
BASTION POINT
MALLACOOTA
POTENTIAL MARICULTURE ZONE
FISHING SITES

B) SYDENHAM INLET

Sydenham Inlet is located at the mouth of the Bemm River. The entrance leading to Bass Strait is often closed and water conditions in the inlet are generally brackish. The small township of Bemm River, located on the north west shore, is tourist oriented and has a caravan park, hotel and boat launching facilities. The eastern shore of the inlet is bordered by the Croajingolong National Park. To the west of the inlet there is low swampy ground behind foredunes which extend westwards towards Pearl Point. This region is included in the Corringle Creek to Sydenham Inlet Coastal Reserve.

GENERAL CHARACTERISTICS

Rainfall yearly average is 900 - 1000 mm
Temperature Range not recorded. The nearest recording stations are Gabe Island (see Mallacoota Inlet) and Orbost (see Marlo).
River Discharge (Bemm River upstream of township) in ML.

Max	Min	Mean	Minimum Monthly Discharge
304,000	105,200	172,200	3293

Salinity The salinity in the inlet is variable and depends a great deal on the condition of the opening to Bass Strait. Maximum salinity recorded in the channel to the sea is 35‰, minimum recording at this site is 13‰. The minimum recorded salinity at the Bemm River mouth in the inlet is 6‰. Under heavy flooding however, the entire inlet would become fresh.

Depth Average depth varies between 2 and 3 metres.

Winds The predominant wind regime is from the south west with secondary winds from the south, southeast and northwest. The small area (1000 ha) of the inlet is insufficient for the build up of significant wind waves.

Land Use Land use in the vicinity of Sydenham Inlet and upstream along the Bemm River is predominantly timber production and limited forest grazing of cattle.

Contaminants No significant contaminant inputs occur in this system. Some septic sullage may enter the inlet during the summer months from Bemm River township (EPA 1981).

Commercial Fishing The inlet was closed to commercial fishing in 1967 to protect the spawning of black bream and flounder.

Recreational Fishing The main fish caught by recreational anglers are black bream, garfish, whiting, Australian bass, Australian salmon and luderick. Boat fishing is the most popular method in the inlet; pier and shore fishing, to a lesser extent.

Other Water Uses Sydenham Inlet is used to a small extent for small yacht sailing and water skiing. Swimming is more popular on the ocean beaches, though some swimming is done in the inlet near Bemm River township.

Social Considerations Sydenham Inlet is primarily used by recreational fishermen. Bemm River township caters predominantly for tourists. The annual average growth rate in caravan park use at Bemm River during the early 1970's was 35% and shows the increasing popularity of Sydenham Inlet with tourists.

People also visit the inlet for its aesthetic qualities. The significance of this was recognised when the Croajingolong National Park and Corringle Creek to Sydenham Inlet Coastal Reserve were created.

POTENTIAL MARICULTURE SITES

Mariculture in the inlet is restricted by the shallow depth and frequency of closure to the sea. Water chemistry in the inlet is highly variable and few species are able to tolerate such large changes.

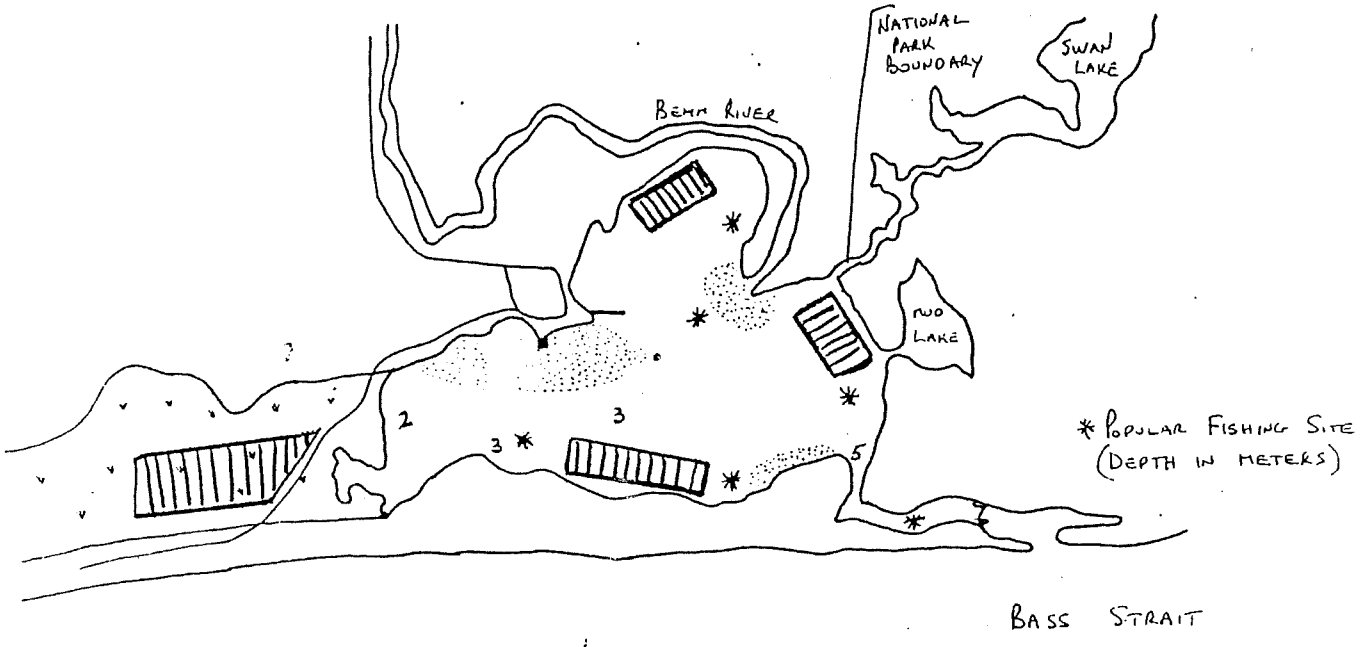
The shallow water limits sites for floating cage culture or longline techniques. The inlet is most suited to tray culture of molluscs. Suitable species are the Sydney and pacific rock oysters.

Area opposite boat ramp at Bemm River The area opposite the boat ramp is between 3-4 metres deep and is suited to tray culture of oysters. The depth would allow multiple level culture in some areas. Bottom sediments are silty sand. Water circulation in this area is good and salinities are at the higher end of the range near the level of seawater. Potential salinity variations cast doubts or the suitability of this area for long term oyster culture. Prospects - low to good.

Area off Mud Lake This area is approximately 3 metres deep and is suited to tray oyster cultivation. Bottom sediments are silty sand. Salinities in the area would be generally higher than average for the inlet as a whole. Prospects - low to good.

Fig. 2.

SYDENHAM INLET



Bob's Bay Water depth in this area is approximately 1 metre and hence suited to tray oyster cultivation. Bottom sediments are predominantly silt and fine sands. Salinities are variable, depending on river discharge and would be generally lower than at the other sites. Prospects - low.

Land Based Site A potential land based site is located immediately to the west of the inlet. Low swampy ground in this area is suitable for the excavation of ponds. Ponds would require clay or synthetic lining as soil in the area is sandy. Species suitable for cultivation would be most brackish water fish such as black bream and mullet. Black bream would be ideally suited for cultivation as they breed naturally in the Bemm River. Road access and power are available to this site. Suitable water for the ponds is available from the inlet. The characteristics of the inlet are highly suited to brackish water fish farming and the shallow depth makes land based farming the only viable method in the area. Prospects - good.

GOVERNMENT POLICY

National Parks Service This group controls land usage to the waterline in Croajingolong National Park. Land based facilities would not be approved in this area.

Environment Protection Authority The EPA considers water quality of Sydenham Inlet is suitable for the harvesting of fish and crustaceans. It is EPA policy to maintain such water standards. Land based farms would require a permit from the EPA to discharge waste water.

Land Protection Service This Service controls land use along the coastline in the area. Its policy considers land based farming along the coastline in the reserve to be inappropriate, although such farming has not been considered in the past and may after an environmental impact study be compatible. Approval is required from the Service for any development in the inlet and on adjacent crown land.

Shire of Orbost The Shire approves of the development of mariculture in the inlet.

C) SNOWY RIVER - MARLO

The Snowy River is the largest river in East Gippsland and has a relatively small estuary at its entrance to Bass Strait. The township of Marlo is located at the entrance. To the east of the estuary, high cliffs and sand dunes predominate. To the west, low stable foredunes are backed by low marsh formed by sedimentation in the inlet. Associated with the inlet are two large shallow lakes, Lake Corringle and Lake Curlip.

GENERAL CHARACTERISTICS

Rainfall Marlo; average monthly. (Yearly average is 780 mm)

Month:	J	F	M	A	M	J	J	A	S	O	N	D
mm:	64	58	69	68	76	68	62	55	65	73	61	61

Temperature Range Orbost (mean)

Month:	J	F	M	A	M	J	J	A	S	O	N	D
^{o}C	18.9	19.0	17.7	14.8	12.0	9.9	9.2	10.0	11.7	13.7	15.5	17.4

River Discharge (Buchan, upstream from Orbost).

Annual Discharge (ML)			Minimum Monthly Average (ML)
Max	Min	Mean	
4,647,500	280,000	1,750,300	2220

Major flooding of the Snowy River occurs at about five year intervals.

Salinity The estuarine system of the Snowy River can be considered brackish as salt water penetration is limited. The high volume flow of the river combined with the small estuarine area account for this. Salinity at the mouth would generally be 35‰ and would decline rapidly to Lake Corringle where salinities are around 10‰.

Depth Water depth in the channels varies between 3 and 5 metres. The entrance itself is shallow. Lake Corringle and Lake Curlip are less than 1 metre deep.

Winds Winds are predominately from the south during summer and the north during winter.

Land Use The Snowy River flats are extensively used for agricultural purposes. Over 1000 ha of river flats in the area between Orbost and Marlo are devoted to vegetable production. Other farming on the river flats includes cattle, dairy and sheep production. Forestry is a major activity in the hinterland.

The town of Orbost, (population 3000) is located on the Snowy River and has a dairy factory and a number of sawmills. Marlo, at the river entrance has a permanent population of approximately 500. The main industry of Marlo is tourism and during summer the population grows to over 2000.

Contaminants No measurements of contaminants in Snowy River water are available and there is no evidence to suggest significant pollution occurs. (Some runoff of pesticides and herbicides from agricultural land may occur as many of the farms are irrigated).

Commercial Fishing The only commercial fishing activity based at Marlo is abalone diving. These fishermen either use the entrance of the Snowy River to reach offshore reefs or travel to Cape Conran to launch their boats.

Recreational fishing Angling is a major activity for tourists who visit Marlo. Beach fishing is popular and commonly caught species are australian salmon, shark, flathead and ruff. Estuarine and river fishing are most popular and two boat ramps have been provided. Shore fishing along the river and estuary is also popular. Species most commonly caught include black bream, garfish, flounder and flathead.

Other Water Uses The ocean beach is generally isolated and most people prefer to swim in the estuary, particularly in the lagoon downstream from the Marlo jetty. Small boat sailing is uncommon in the estuary as size and depth limit this activity.

Social Considerations The Snowy River is largely modified by commercial exploitation along its shoreline until the estuarine portion is reached. The lakes and estuarine areas have been little developed. The size of the estuary restricts any large increase in recreational use of the area.

The area to the west of the estuary is marshland and is noted as a habitat for wading birds. Some use of this area is made by bird watchers and naturalists.

The primary existing use of the estuary is recreation.

MARICULTURE PROSPECTS

The potential of mariculture in the estuary is low. Current recreational use of the area precludes development as space is limited. Environmental conditions do not favour mariculture as flooding is common and consequent salinity variations are large.

Land based mariculture has a high potential on sections of the marshland west of the Snowy River and there is sufficient area availible here. Access is good and existing use of the area is negligable. The culture of both marine and brackish water species would be possible as suitable water may be drawn from both Bass Strait and the estuary. Clay soils here are suitable for the building of ponds. Levee banks would be required to reduce the possibility of flooding.

Species suitable for culture are all oyster species, mussels, prawn, flounder, whiting, snapper, Australian salmon and in brackish conditions black bream and mullet. Potential - good.

GOVERNMENT POLICY

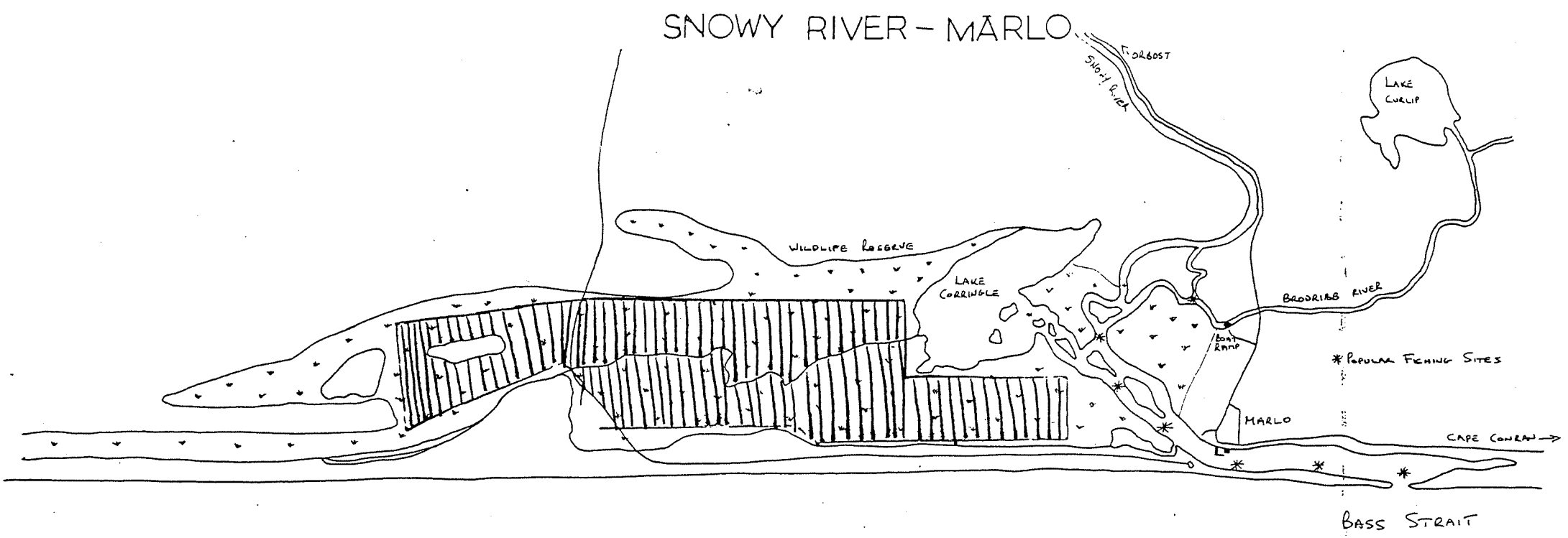
Environment Protection Authority Approval from this Authority for discharge of farm waste water would be required. Water quality of the estuary and Bass Strait are regarded as suitable for harvest of fish, crustaceans and shellfish and policy is to maintain such conditions.

Ports and Harbours Division The Snowy River at Marlo is recognised as a port and as such any mariculture use in this area will require approval of the Division.

Land Protection Service Potential sites on the marshland area are on crown land and approval for mariculture here would be required from the Service. Though no formal policy applies to this area, general departmental policy is that such areas should remain undeveloped unless potential developers can prove that degradation of the environment will not occur.

Shire of Orbost The Shire supports mariculture development in principal.

Fig 3


SNOWY RIVER – MARLO
← ORBOST
Snowy River
LAKE CURLIP
WILDLIFE RESERVE
LAKE CORRINGLE
BADDAIBB RIVER
Boat Ramp
* POPULAR FISHING SITES
MARLO
CAPE CONRAN →
BASS STRAIT

D) LAKE TYERS

Lake Tyers was formed by the submergence of Boggy River and Stony Creek valleys, which are now the major components of the lake, the Nowa Nowa Arm and Toorloo Arm respectively. These arms extend seawards and form a lower lake of approximately two square kilometers. The entrance to the sea is normally closed by drift sand which has built up to form a large sand island system immediately inside. The lake breaks out naturally only during heavy flooding or severe storms. As the lake system is normally closed and seawater exchange is limited the lake can be considered brackish. Water depth varies considerably; in the bottom lake it is 6 to 8 metres.

GENERAL CHARACTERISTICS

Rainfall - Bruthen - average monthly rainfall. (mm)

Month:	J	F	M	A	M	J	J	A	S	O	N	D	Total
Rainfall:	65	58	60	64	62	66	54	54	61	77	68	76	763

Temperature Range - Bairnsdale

Mean monthly maximum/minimum ^{o}C.

Month:	J	F	M	A	M	J	J	A	S	O	N	D
Max:	25.1	25.4	23.6	21.1	16.9	15.5	14.3	15.4	17.2	19.6	21.6	22.9
Min:	13.0	13.2	12.0	8.9	6.6	5.0	4.3	4.8	6.2	8.4	9.9	11.8

River Discharge The drainage basin of Lake Tyers is small and hence freshwater input via the rivers is also small in comparison with the size of the lake. Significant inflow only occurs during heavy flood periods. Inflow to the lake is not gauged.

Salinity The salinity of Lake Tyers is normally brackish. During 1980, it was in the range of 20-25‰ and during the drought of 1982-83 approached 40‰.

Winds The winds in the area are predominately southerly in winter and northerly in summer, however, as the lake is well sheltered and as there is limited fetch the wind effect on mariculture structures is likely to be small.

Land Use The catchment area of Lake Tyers is predominately forested and approximately 70% of the shoreline is enclosed in the Lake Tyers Forest Park which is not logged. An aboriginal farm reserve is located on the peninsula between Toorloo Arm and Nowa Nowa Arm. Farms are located on the eastern shore in the vicinity of the lower lake and Nowa Nowa arm. The village of Lake Tyers is located on the western shore of the entrance.

Contaminants Flow of contaminants into lake Tyers is minimal. The only source of pollution which may be of concern is septic sullage from Lake Tyers village and the timber milling operations at Nowa Nowa.

Commercial Fisheries Fishing endorsements for the Gippsland Lakes also include Lake Tyers. Fishing in the lake is seasonal and methods commonly employed are gill netting and seine netting. Species commercially caught are sea mullet, dusky flathead, luderick, tailor and black bream.

Recreational Fishing Lake Tyers is a popular angling site. Species mainly caught in the lake are sea mullet (the most common species in the lake), dusky flathead, luderick, tailor, bream and estuary perch. The more popular fishing locations are marked on the accompanying map. These locations are the deeper holes in each arm and areas in the lower lake. Fishing tours operate in the lower lake and seaward reaches of both arms.

Other Water Uses Recreational use of Lake Tyers is heavy, particularly in the lower lake. Small boat sailing and windsurfing are popular in this area. The area inside the barrier near Lake Tyers township is a popular sheltered swimming area. Popular activities in both arms, apart from fishing, are water skiing and boat touring.

Social Considerations The area around Lake Tyers and the lake itself are heavily used for tourism and recreational activities. Visits to the Lake Tyers Forest Reserve are high (between 20,000 to 25,000 people per annum) and the reserve has a large number of picnic areas and walking tracks which border the lake. As the lake is close to the Gippsland Lakes, a considerable number of tourists visit Lake Tyers during their stay in the Gippsland Lakes area. Visits to the area are increasing each year.

The aborigines of Lake Tyers obtained freehold of 1600 ha of the reserve in 1971. This is now operated as a farm.

Lake Tyers has considerable potential as a recreational resource as it is enclosed, sheltered and is largely surrounded by natural forest.

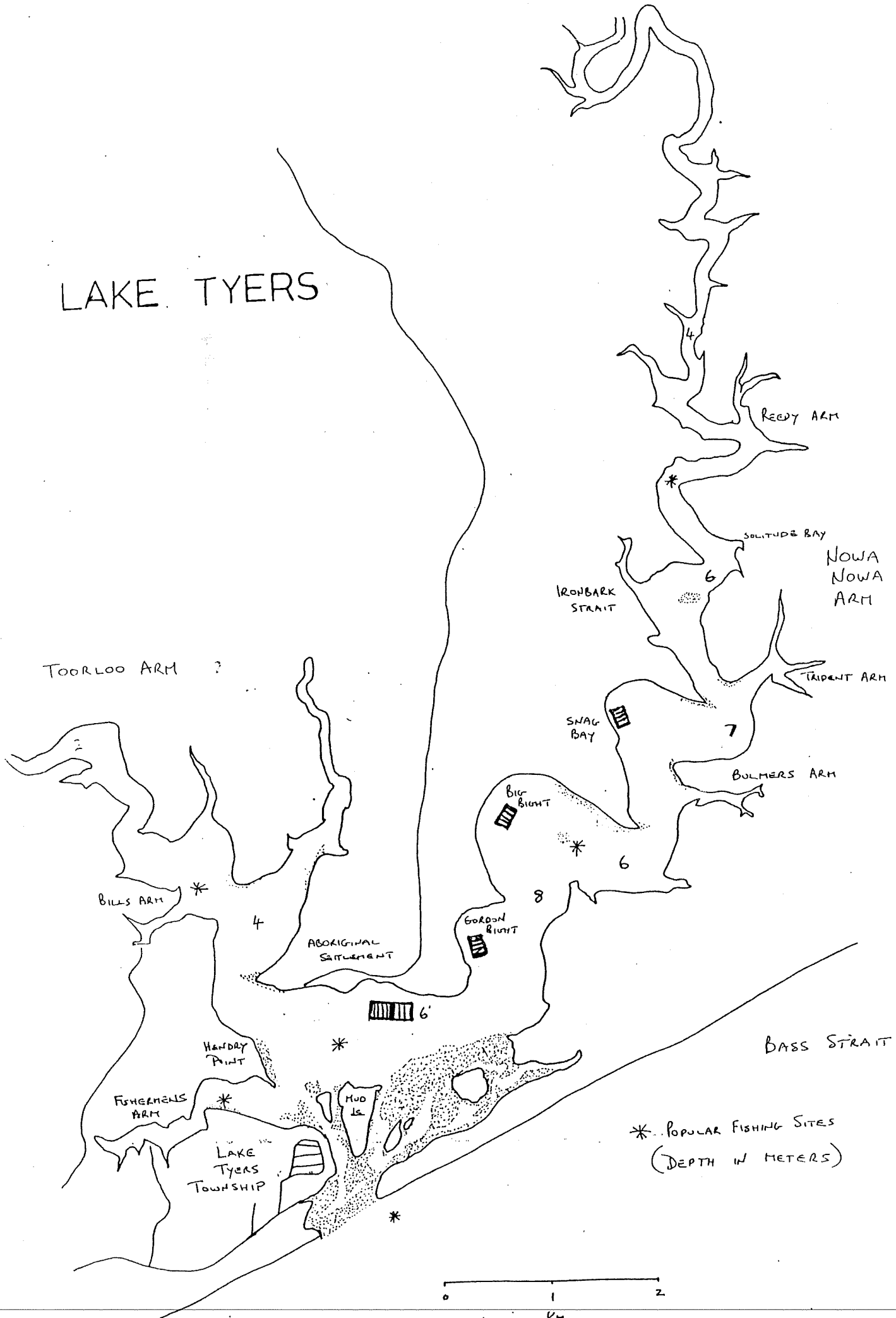
MARICULTURE PROSPECTS

Though the recreational use of Lake Tyers is quite high, the lake has good potential for mariculture. The range of suitable species is however restricted by the prevailing environmental conditions i.e. no tidal exchange through the barrier and low salinities.

The two most common species found in the lake, mullet and black bream, have the greatest potential for mariculture. These species are tolerant to wide salinity fluctuations and juvenile supply for stocking farms would be available. Floating cage culture in the deeper parts of the lake could be used for farming these species.

Mussels are plentiful in the lower reaches and in deeper water, longline suspension mussel culture would be possible. It should also be possible to grow oysters in this region. Lake Tyers would be most suitable for pacific oysters as it is landlocked and the species would not be able to establish itself outside the lake system. Mollusc culture in the lake would however suffer from the rapid salinity changes due to periodic flooding. Shoreline mollusc culture is unsuited here as water level changes can be significant and fixed structures may be exposed for considerable periods.

Fig 4.


LAKE TYERS
REEDY ARM
SOLITUDE BAY
NOWA NOWA ARM
IRONBARK STRAIT
TRIDENT ARM
SNAG BAY
BULMERS ARM
TOORLOO ARM ?
BIG BIGHT
BILLS ARM
GORDON BIGHT
ABORIGINAL SETTLEMENT
HENDRY POINT
FISHERMENS ARM
MUD IS
LAKE TYERS TOWNSHIP
BASS STRAIT
POPULAR FISHING SITES (DEPTH IN METERS)
0
1
2

POTENTIAL MARICULTURE SITES

Lower lake adjacent to aboriginal farm The average water depth in this region is 6 metres, so the area is suitable for longline suspension culture of molluscs and cage culture of fish. Recreational use of the area is high, both for angling and watersports and it is also fished commercially by seine fishermen.

The most suited location for mariculture is near the point adjacent to Nowa Nowa Arm, away from the most heavily utilised areas (see accompanying map). A reasonable development level would be 2 by 3 ha lease units in one group. Species suitable for culture would be mussels, pacific oysters, Sydney rock oysters, mullet, bream and salmon. Potential - good.

Nowa Nowa Arm The lower reaches of Nowa Nowa Arm are deep (between 6-8 m) and moderately wide (500 to 1000 m). These areas are suited to long line suspension culture and floating cage culture. Recreational use of the immediate area is moderate, though it is heavily utilised by boating traffic moving to other parts of the arm. The area is also fished commercially by seine fishermen.

Mariculture development in this arm is restricted by width but there is potential for a limited number of 3 ha lease sites.

Recommended are one lease in Gordon Bight, one lease in Big Bight and one lease in Snag Bay (see map). Suitable species are the same as for the previous site. Potential - good.

GOVERNMENT POLICY

Environment Protection Authority The EPA has yet to determine a policy on the water quality of Lake Tyers, though in terms of fisheries, the Authority is likely to classify the waters as suitable for harvest of fish, shellfish and crustaceans. The water of the lake should therefore also be considered suitable for mariculture.

Land Protection Service The Land Conservation Council recommendation for the Lakes Tyers area is that it should be used largely for recreation. Proposals for land based farming on crown land are unlikely to be supported by the Service. The Service has no formulated policy on mariculture development in the lake and is likely to accept recommendations made by the Fisheries and Wildlife Service.

Shire of Tambo The Shire supports the development of mariculture.

E) GIPPSLAND LAKES

The Gippsland Lakes is the largest estuarine lake system in Victoria and was formed during sea level rises during the quaternary period. Accretion of sand barriers along the coast, the 90 mile beach, led to the development of a sheltered estuarine environment. Prior to the construction of the entrance to Bass Strait in the 1880's, the lakes only opened during flooding or after severe coastal storms. Since the system has been permanently opened, it has become increasingly more saline.

The major components of the system are;

- Lakes Entrance Region - major water bodies are Cunningham Arm, Reeve Channel, North Arm and Hopetoun Channel.
- Lake King - the Tambo and Mitchell River enter here.
- Lake Victoria
- Lake Wellington - the LaTrobe, Avon and Perry Rivers enter here.
- Lake Reeve.

The lakes are in general shallow and are transected by deeper channels. They are reasonably sheltered environments with both sediment deposition and erosion occurring at different locations. Lake bed sediments are predominantly silt with increasingly more coarse sand towards the entrance. The river mouths are characterised by delta formations, the most notable of which is the "silt jetty" at the mouth of the Mitchell River.

The Gippsland Lakes area is one of the most important recreational regions in Victoria and has the largest number of motels and caravan park/camping areas of any coastal location in Victoria. Recreational use of the area is mainly during the summer months and the school vacation periods. Major towns in the region are Lakes Entrance, Bairnsdale, Stratford and Sale. Smaller towns located on the lakes are Nungurner, Metung, Swan Reach, Nicholson and Paynesville.

GENERAL CHARACTERISTICS

Rainfall - Lakes Entrance (Average monthly rainfall, mm)

Month:	J	F	M	A	M	J	J	A	S	O	N	D	Total
Rainfall:	63	49	65	61	60	62	53	49	59	73	65	69	734
Bairnsdale													
	61	52	64	51	55	57	50	51	57	69	66	69	702
East Sale													
	47	46	57	46	59	46	38	53	51	66	64	59	633

Temperature Range - (Average minimum/maximum ^{o}C)

Month:	J	F	M	A	M	J	J	A	S	O	N	D
Lakes Entrance												
Max:	23.8	23.8	21.6	20.3	16.4	14.5	14.4	15.0	16.7	18.9	19.5	21.4
Min:	14.2	14.9	13.0	10.9	8.2	6.1	5.3	5.8	7.1	9.1	10.4	12.2
Bairnsdale												
Max:	25.1	25.4	23.6	21.1	16.9	15.5	14.3	15.4	17.2	19.6	21.6	22.9
Min:	13.0	13.2	12.0	8.9	6.6	5.0	4.3	4.8	6.2	8.4	9.9	11.8
East Sale												
Max:	25.4	25.3	23.4	20.6	16.3	14.3	13.5	14.6	16.6	19.0	21.1	23.0
Min:	12.9	13.3	11.5	8.5	6.1	4.1	3.3	4.3	5.6	7.8	9.4	11.4

River Discharge - Major Streams

River	Gauging Point	Mean Discharge (MLx1000)	Maximum Flow (MLx1000)
Latrobe	Rosedale	942	3253
Thomson	Downstream of Macalister	948	2273
Avon	Valencia Creek Bridge	143	758
Mitchell	Bairnsdale	847	1620
Tambo	Bruthen	216	680

The catchment area of the Gippsland Lakes is approximately 20,000 km^2 and extends to the Great Dividing Range. An estimate of the annual input of freshwater to the Gippsland Lakes is 3.6 x 10^6 ML of which approximately 3.37 x 10^6 ML is discharged to the sea. Approximate percentage input from each river is, Latrobe/Thomson 60%, Avon 3%, Mitchell 28%, Nicholson 1% and Tambo 7%.

Morphology of Gippsland Lakes - (from Bek and Bruton, 1979)

Compartment	Length (mean) km	Width (mean) km	Surface Area km^2	Mean Depth m	Max Depth m	Shore Length km	%Surface area Shallower than 2m
Lake Wellington	17.8	9.7	148	2.6	6	60	30
Mc Lennons Strait	9.7	0.2	1.9	5	8	19	
Lake Victoria (West of Pt. Wilson)	27.4	3.2	75	4.8	9	100	20
Lake King	12.9	6.5	98	5.4	10	160	20
Jones Bay	8	2	18	1.5	3	23	90
Lake Reeve (usually dry)	53	1	53	1	--	120	95
Bunga Arm	14	0.2	2.8	1	--	30	80
Reeve Channel (Metung to Entrance)	13	0.75	15	3	18	36	50
Cunningham Arm	--	--	1.3	2	--	--	--
North Arm	--	--	1.4	2	--	--	--

Hydrochemistry Bek and Bruton (1979), divide the Gippsland Lakes inflowing waters into three chemically distinct groups, the eastern and western catchment sectors and the ocean sector. The lakes themselves are divided into three arms: the Lakes Wellington and Victoria/South King Arm receiving discharge from the western catchment, the Jones Bay, north Lake King arm receiving discharge from the eastern catchment, and, the Reeve Channel arm, receiving at its western end the combined outflow from the other arms, and at its eastern end, sea water from Bass Strait.

The chemical compositions of water in the three sectors are distinct and have a significant bearing on potential mariculture development.

Salinity The salinity of the Gippsland Lakes system varies significantly with the volume of freshwater inflow. During flooding, surface salinities of the entire system can decline to zero. This last occurred during the winter floods of 1978. On the other hand, during droughts, salinity levels increase throughout the lakes. There is a general horizontal salinity gradiant through the lakes with the lowest readings in Lake Wellington and the highest immediately inside the entrance.

Average salinity values for each lake area under differing freshwater input regimes are as follows:

Lake Salinity Values (‰)

Lake System	Water Input Regime		
	Drought	Average	Flood
Lake Wellington	5-10	1-5	0
Mc Lennans Strait	12-18	5-10	0
Lake Victoria	18-24	10-16	0-2
Lake King South	24-26	15-16	0-2
Jones Bay	15-24	4-16	0-1
Lake King North	24-26	15-16	0-2
Reeve Channel	26-35	16-26	0-5

Water Temperature Average water temperatures in all lakes are similar, though they may vary locally due to flow conditions, wind, salinity stratification and solar radiation.

Temperature ranges for surface and bottom water at selected sites and the yearly means are given below.

	Site					
Temperature Range	Lake Wellington	Lake Victoria	Lake King South	Jones Bay	Lake King North	Reeve Channel
Surface	7.6-22.6	9.0-22.5	7.5-22.8	7.0-23.9	7.8-23.1	8.2-22.9
mean	15.5	16.1	15.9	16.4	15.9	16.1
bottom	7.4-20.0	11.5-20.1	9.5-22.5	8.5-23.8	8.8-22.2	10.2-21.5
mean	14.6	14.8	16.6	17.5	16.5	16.7

As can be seen from the table, little temperature stratification is evident. Temperature stratification is generally associated with floods and consequent salinity stratification.

Dissolved Oxygen During the study of Bek and Bruton (1979), surface dissolved oxygen levels were above 80% saturation at all sampling stations. Vertical stratifation was evident in all the deeper waters except east of Shaving Point where seawater inflow replenishes oxygen supplies.

Oxygen depletion of deeper water is associated with high river flows and salinity stratification.

Surface and bottom means for representative locations are:

	(% saturation)	
	Surface	Bottom
Lake Wellington	97	95
Lake Victoria (West)	97	61
Lake Victoria (East)	96	24
Lake King (North)	92	47
Jones Bay	96	93
Lake King (South)	91	42
Bunga Arm Mouth	94	75
Shaving Point	91	77
Reeve Channel (Narrows)	86	89

Chlorophyll a The measure of chlorophyll a concentration in the lakes shows phytoplankton production is affected by nutrient inputs from freshwater inflows. Chlorophyll a concentrations peak in Lake Wellington and decline towards the entrance where oceanic chlorophyll levels are recorded.

Seasonal variations in chlorophyll a concentrations for selected sites are as follows:

		Chlorophyll a concentrations - $mg/^{M3}$		
Flow Period		Lake Wellington	Lake Victoria	Lake King South
Wet (Spring)	Surface	23.3	18.2	12.5
	Bottom	14.5	11.8	5.0
Drought (Summer)	S	5.2	1.7	0.7
	B	4.2	1.5	1.6
Flood (Winter)	S	1.3	1.3	0.9
	B	1.7	1.2	0.1
Study Period	S	11.9	5.0	2.9
Mean	Range	0.4-41.0	0.2-23.0	0.3-26.0
	B	11.5	4.7	2.2
	Range	0.4-50	0.5-2.0	0.1-7.0
		Jones Bay	Lake King North	Reeve Channel
Wet	S	50	9.9	5.8
	B			1.7
Drought	S	1.1	1.6	0.6
	B			1.0
Flood	S	12.0	0.7	0.9
	B			1.4
Study Period	S	3.4	2.4	1.9
Mean	Range	0.3-23.0	0.3-42.0	0.2-11.0
	B		2.2	1.8

As can be seen from the table, chlorophyll a concentrations and resultant primary production is seasonally variable. The least variable regions are the marine sectors of the lakes but concentrations in these areas are low. These areas are the most suitable for mollusc culture and the stable chlorophyll levels suggest adequate food supply year round.

Currents Tidal currents are strongest at the entrance and decline further into the lake system. Currents at the entrance may reach five knots during king tides. Current speed declines in Lake King where larger areas of water are encountered.

Winds The predominant wind regime in the Gippsland Lakes region is south to south-westerly during the summer and north to north-westerly during winter. The only lakes on which there is sufficient fetch to induce significant chop are Lake King and Lake Wellington.

Land Use and Contaminants Land use in the western catchment area is more intense than it is in the east, which is mostly forested.

Land use in the catchments of each river flowing into the Gippsland Lakes is as follows:

Avon River :	Predominantly forested. Borders the eastern edge of the Maffra - Sale irrigation area.
Latrobe River :	Drains central highlands and southern uplands. Head waters are forested and dairying predominates in the valley. The river borders the southern edge of the Maffra - Sale irrigation area. Water is utilised for heavy industry based on brown coal, pulp and paper mills and by a large urban area with a population in excess of 80,000.
Mitchell River :	Most of the catchment is forested. The lower reaches are used for agriculture such as market gardening, beef, dairy cattle and sheep.
Nicholson River:	The upper reaches are forested and some agriculture is conducted along the lower reaches.
Perry River :	Drains the lowlands and is bordered by dairy farms.
Tambo River :	The upper reaches are forested and the lower reaches support grain crops and market gardening.
Thomson/ Macalister Rivers:	The upper reaches are forested and there is a significant water use in the Maffra - Sale Irrigation Area (60,000ha). Dairying and fat lamb growing are also conducted.

As land use affects water quality of inflowing streams and ultimately the lakes, the river of most interest is the Latrobe. This is the major river of the system and drains the western catchment into Lake Wellington. Any contaminants entering via the Latrobe River are deposited into Lake Wellington and to date have not had any affect on the general ecosystem.

Land use on the shores of the lakes, particularly in the urbanised areas, may contribute to localised problems in water quality. This could occur during peak use of the area (holiday periods) and is associated with septic/sewage overflows and stormwater runoff.

On the south western shore of Lake Wellington is the Dutson Downs Sewerage Farm operated by the Latrobe Valley Water and Sewerage Board. This receives industrial and domestic effluent from the Latrobe Valley and discharges into Bass Strait. During times of flood however some effluent may wash into Lake Wellington.

Commercial Fishing The two major fishing ports in the Gippsland Lakes are Lakes Entrance and Paynesville. Estuarine fishermen operating in the lakes use either mesh nets or beach seines. All waters are fished, the location depending on the availability of fish.

The main commercial species taken in the lakes in order of importance are black bream, yellow eye mullet, snapper, european carp, luderick, flathead, tailor, sea garfish and silver trevally.

Recreational Fishing The Gippsland Lakes are the second most important recreational fishing location on the Victorian coast. An estimate of 149,000 angler days per annum are spent in the Gippsland Lakes (Beinssen 1978). A breakdown by fishing method shows 63% fish from boats, 26% from the shoreline and 12% from piers. The number of fish caught per hour fished from boat and shoreline is similar, 0.43 and 0.41 respectively. Fishing success from piers is considerably lower at 0.13 fish per hour.

The principal species caught by anglers in the Gippsland Lakes are black bream, estuary perch, mullet, luderick, snapper, flathead and garfish.

Other Water Uses In addition to angling, the Gippsland Lakes are widely utilised for recreational boating. Large marinas are located at both Metung and Paynesville. Boat ramps and jetties are located at many points around the shoreline. These are shown on the map if they are relevant to suitable mariculture sites. Commercially operated hire boats are extensively used on the lakes, these being cruisers, yachts and house boats. House boats are popular on Lake King, Lake Victoria and the entrance region.

Yachting is extremely popular on the lakes and clubs exist at Lakes Entrance, Metung and Paynesville. All the lakes, excepting Lake Willington, are sufficiently deep to enable the use of small keel yachts. Regattas and competitions are commonly held during the summer months.

Water skiing and windsurfing are popular adjacent to the major tourist areas. Swimming and surfing are restricted mainly to the ocean beaches.

Social Considerations The growth rate in recreational use of the Gippsland Lakes is the highest of any coastal Victorian area. Consequently mariculture development in the lakes would require considerable consultation to determine suitable locations which will have minimal impact on existing uses. The size of the recreational industry is such that in the future it is likely to reduce the areas available for commercial fishing. Recreational considerations are also likely to restrict the extent of mariculture development in certain areas.

There is moreover a growing awareness for the need for shoreline management in the lakes region. Urbanisation is being restricted to existing towns, primarily Lakes Entrance, Metung and Paynesville in order to maintain existing shoreline qualities.

One previous land development scheme near Loch Sport was located on the foredunes of the Ninety Mile Beach and caused considerable concern. This development did not proceed beyond the subdivision stage.

Areas of aesthetic interest are plentiful and a number of sites are of botanical and zoological interest. The most notable of these is the "Lakes National Park" which includes Sperm Whale Head. The coastline between Lakes Entrance and Metung is particularly beautiful being cliffs overlooking Reeves Channel and associated islands.

The Boole Poole Peninsula located on the southern shore of Lake King and extending to the entrance is only accessible by boat. This penisula, still heavily forested, has extensive swamps noted for their bird life. The area is extremely popular with boaters and walkers.

The remainder of the coastline, save for isolated areas of swamp and forest, is generally farmland used for grazing cattle and sheep. The swamp areas, particularly the larger ones, are important as habitats for water birds.

Mariculture development in the Gippsland Lakes will be restricted to areas not widely utilised for recreation.

MARICULTURE POTENTIAL

The major factor determining the suitability of the Gippsland Lakes for mariculture development is salinity. Salinity variation is greatest in the lakes above Metung and this point can be used to divide the lakes into two segments, the marine and the estuarine segment.

i) Marine Segment

This segment includes all waters from the entrance to Shaving Point, Metung. Water is shallow, generally less than 4 metres except for Reeves Channel and Bancroft Bay. The salinity is stable except during heavy flooding which occurs on average every 5 years. As such these waters are suitable for cultivation of marine species. Suitable species are mussels, oysters (pacific and to a lesser degree Sydney rock), snapper, whiting, bream, trout and salmon.

Water use in this area is heavy and this will place considerable restrictions on mariculture development. Considerable boating occurs in Bancroft Bay and Reeves, Hopetoun and South Channels. Conflict would occur between potential finfish cage sites in Reeves Channel and commercial fishermen who seine fish in the channel.

The following sites are recommended and will have least impact on existing uses while utilising to the fullest the potential of the region for aquaculture.

Nungurner Approximately 500 m east of Nungurner jetty, it is deeper than 4 m. and possible to locate two 3 ha leases without impairing navigation through Reeves Channel. This area is suited to net cage culture of all previously mentioned fish species and longline culture of mussels. Water circulation through the channel is good as the current is strong. The area is shelted from high winds. Access to the site is available from Nungurner Jetty for light craft and Metung for work boats. Conflicting uses in this area are moderate and most opposition could be expected to come from anglers and commercial net fishermen. Potential - good.

Bancroft Bay In water deeper than 4 m between Chinaman Creek and Box Creek there is sufficient area to support two 3 ha lease sites. This location will not impair navigation and will conflict only moderatly with other water uses. The location is sufficiently far offshore to enable smaller yachts which race in the bay to pass around the lease sites without difficulty. Some conflict with anglers could be expected. The bay receives adequate water exchange from current action and is well sheltered from wind effects. This area is suited to net cage culture of all previously mentioned fish species and longline culture of mussels. Potential - good.

Hopetoun and Reeves Channel The shallow areas adjacent to Rigby, Fraser and Flannagan Islands and Boole Poole Penisula are suited to tray cultivation of pacific and Sydney rock oysters. The latter species may not be very successful since preliminary trials in this area have yielded poor results.

This region is not as heavily utilised as Reeves Channel. Shallow water is used primarily by anglers and pleasure boaters whilst the deeper water is used by water skiers.

Water quality is good and current and tidal action would ensure adequate water exchange to provide sufficient food for oysters. Access to the shoreline would need to be maintained and lease areas should be separated to enable this. Shore facilities are available at Metung and Lakes Entrance. Potential - very good.

ii) Estuarine Segment

This segment includes Lakes King, Victoria, Reeve and Wellington and is the most variable in terms of salinity. Lake King and Jones Bay are also significantly affected by winds in excess of 25 km/h which can induce large short wave-length chop.

Water use in all these areas is great, with angling, waterskiing, pleasure boating and commercial fishing all being significant. Usage is highest around Paynesville, the river mouths, Eagle Point and Hollands Landing. Jetties and landing points are located in many places around the lakes.

Mariculture development is somewhat restricted in these lakes by the number of species suitable for cultivation in such estuarine conditions. The most promising species are bream, trout and salmon. Bream has potential for cultivation in all areas whereas trout and salmon need water where oxygen concentration remains high during the warmer months. The latter two species are most suited to shore based cultivation in these areas.

In the lakes proper, floating cage culture techniques would be required for the cultivation of fish. Particularly in Lake King, such structures need to be located in sheltered waters where wave effects are minimal. However, this is difficult, as waters of sufficient depth are generally well offshore.

The following offshore sites are recommended for floating cage culture.

Lake King The predominant wind regime (from the south west) indicates that significant waves will commonly occur on the eastern shoreline. Areas with sufficient shelter and water depth occur offshore from Point King (Raymond Island) near the 2m marker pile and Point Fullarton.

The Point King site will have only a moderate effect on navigation as most boats pass to the south of Raymond Island to reach Paynesville from Metung. Access from Metung to northern Lake King will not be affected by leases located at this site.

Lease areas of 3 ha would be appropriate to this form of mariculture and the area off Point King has potential for four such leases in one group. Such a grouping should minimise the impact on existing recreational and commercial uses. This area has considerable potential for expansion of offshore farming and could eventually harbour about 16 such leases. However, further development would depend upon the economic viability of leases granted earlier.

Water quality at this point is excellent and circulation patterns would ensure good water exchange through the farms. Access to the site is available from both Paynesville and Metung. Potential - very good.

The Point Fullarton site is approximately 1 km offshore in water 5-7 m deep. The site is only moderately sheltered, however this is compensated for by the distance offshore which places the area outside the major commercial fishing grounds and major boating areas. Access to the site is available from both Paynesville and Eagle Point.

The site has potential for four 3 ha lease units in a single group. This area also has potential for expansion though on a smaller scale than Point King. Expansion is dependent on the same factors as Point King and the area could ultimately support up to 12 leases.

Water quality at the site is good and circulation is adequate. The site would be susceptible to short term salinity fluctuations due to its proximity to the Mitchell River mouth. The major drawback is the exposed nature of the site. Potential - good.

Lake Victoria Prospects for mariculture in Lake Victoria are good as deep water occurs close to the shoreline and the narrowness of the lake ensures shelter.

Suitable areas for cage culture include Lady Bay, the coastline between Banksia Peninsula and Steel Bay and the coastline of Sperm Whale Head.

The Lady Bay site has suitable water in excess of 6m deep and has potential for four, 3 ha lease sites. Development of this area is restricted primarily by boating access to Paynesville and Duck Arm. The lease site is sheltered from all but easterly winds which are infrequent. Water quality and circulation are good. Potential - very good.

The area between Banksia Peninsula and Steel Bay has considerable potential for mariculture. A water depth of between 6 and 8 metres occurs in this area approxomately 1 km offshore. Here the farms would be seaward of the major commercial fishing areas and inshore from the major boating channel.

There is potential here for up to forty leases, however initially eight sites could be considered. One group of four should be located east of Steel Bay and the second group of four should be located west of Banksia Peninsula. Further leases could be issued between these sites if developments warrant this.

Water quality in the area is very good and access to the sites is available from Paynesville. Potential - very good.

The area adjacent to Sperm Whale Head, opposite Steel Bay and Wattle Point have sufficient depth to enable development of a maximum of twelve 3 ha lease units in three groups of 4 leases. Development at this site is limited due to the proximity of the National Park and the need for boating access to the shoreline. The lease areas are inshore from major boating channels and hence would not restrict boating operations.

Water quality is good and the area is well shelterd from prevailing winds. Initially four leases could be considered at this site. Potential - very good.

There is potential for further development of offshore mariculture in Lake Victoria in the vicinity of Loch Sport. However, the area is less sheltered and water of suitable depth occurs further offshore.

Water quality is good and circulation is adequate. A zone of suitable water for development has been marked on the map. This area should be considered for development if an industry develops elsewhere or if any of the other recommended areas prove unsuitable on biological, physical or social grounds. Potential - good.

In discussing the Gippsland Lakes region, a large number of potential offshore mariculture sites have been proposed. In the short to medium term it would be expected that few of these sites would be taken up and in the longer term, significant changes to domestic and/or export markets would be required to enable any large scale mariculture development in the lakes. The wide distribution of potential sites should enable development to occur without undue conflict with other water uses.

Lake Wellington has been omitted from the discussion as it is not considered suitable for mariculture. Three factors lead to this conclusion. The average range of salinity from 1-5‰ places the lake into the freshwater category. Such water is unsuited for cultivation of marine/estuarine fishes although trout and salmon cultivation may be possible. The mean depth of 2.6 m indicates most of the lake is not deep enough for floating cage culture. The high water turbidity which occurs in the lake would reduce growth of cultured species.

iii) Land Based Mariculture

Although the shoreline boardering the lakes is long, there is only a small number of potential land based mariculture sites. Large areas of the shoreline are incorporated into reserves or are freehold farms. The largest area is part of the Gippsland Lakes Coastal Park which extends from Lakes Entrance to the western end of Lake Reeve. Most of the southern shoreline of Lake Victoria and the lake bed of Lake Reeve are included in the park. In terms of mariculture, the southern shore of Lake Victoria is generally unsuitable as the terrain is irregular. The bed of Lake Reeve is unsuited to landbased mariculture as this use is not compatible with the coastal park.

Land based farming on the northern shores of Lakes Victoria and King is suited predominantly to brackish water culture of bream, mullet, trout and salmon. Intensive culture techniques would be required for trout and salmon as high summer water temperatures would require high volume water turnovers, supplementary aeration and/or water cooling. The space requirements for intensive farms would be small. Culture of bream and mullet could be conducted on both an extensive and intensive scale. Water treatment would be required for waste water returning to the lake.

Lake Victoria The northern shore of Lake Victoria is undulating and as such is not suited to extensive mariculture methods. Most land in this area is freehold and crown land is generally restricted to a narrow strip along the foreshore.

Freehold land suitable for land based farming is available westwards from Banksia Peninsula to McLennans Strait. The sites of greatest potential are those with existing road access to the shoreline, notably Banksia Peninsula, Wattle Point, Steele Bay and Storm Point. Potential - very good.

Lake King The northern shore of Lake King between Jones Bay and the Tambo River is most suited to extensive land based farming as it is relatively level and is of low agricultural quality. Road access to the area is good. Intensive farming is suited to this area and also to the shoreline between the Mitchell River and Point Pelican. Potential - very good.

There are no suitable sites for land based farming between Metung and Lakes Entrance.

GOVERNMENT POLICY

There is yet no recognised Government Policy concerning mariculture in the Gippsland Lakes, however, discussions with relevant groups to obtain opinions on such development is proceeding.

Environment Protection Authority The EPA considers water quality in Gippsland Lakes is suitable for the cultivation of crustaceans, molluscs and fish.

Ports and Harbours Division The Ports and Harbours Division supports in principle development of offshore mariculture if the sites do not represent navigational hazards. It requires that the leases be suitably marked during both day and night. The proposed sites have been located away from recognised boating areas to minimise any boating conflicts.

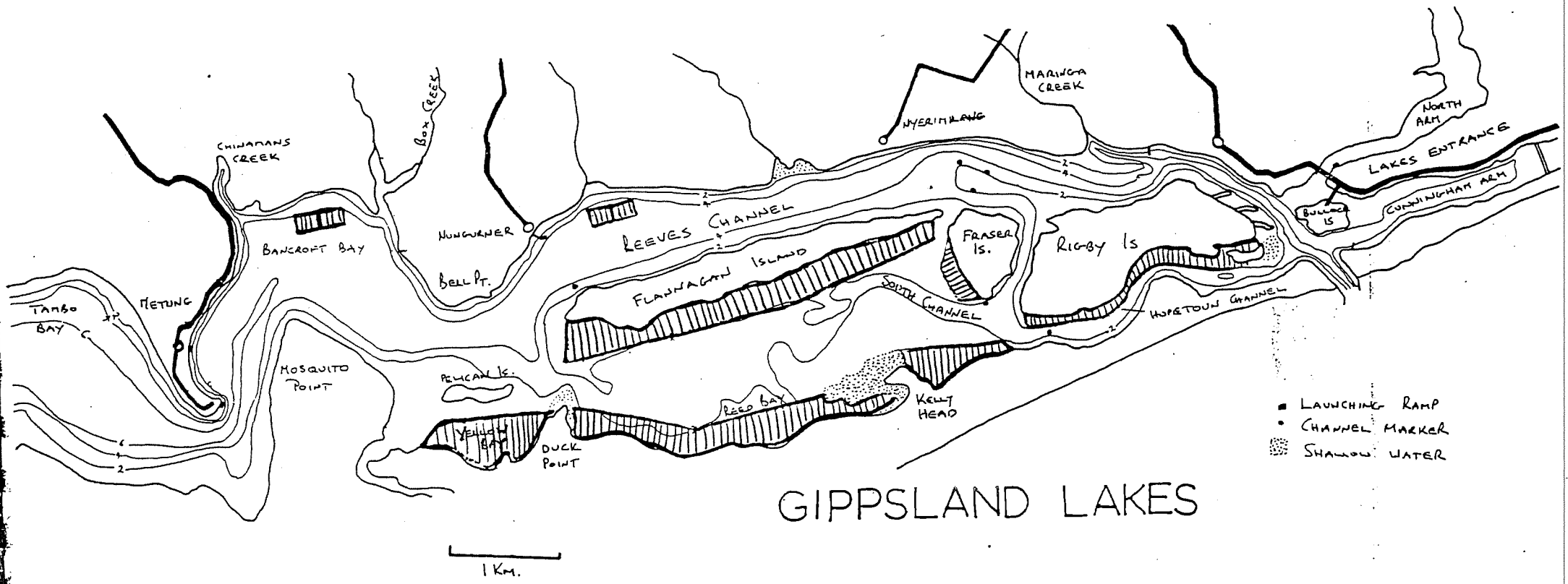
Land Protection Service The Service considers mariculture is a legitimate 'coast dependent' industry and would support proposals which did not compromise existing uses, in particular national parks and coastal reserves.

Shire of Tambo The Shire supports the development of mariculture.

Shire of Bairnsdale The Shire supports the development of mariculture in principle.

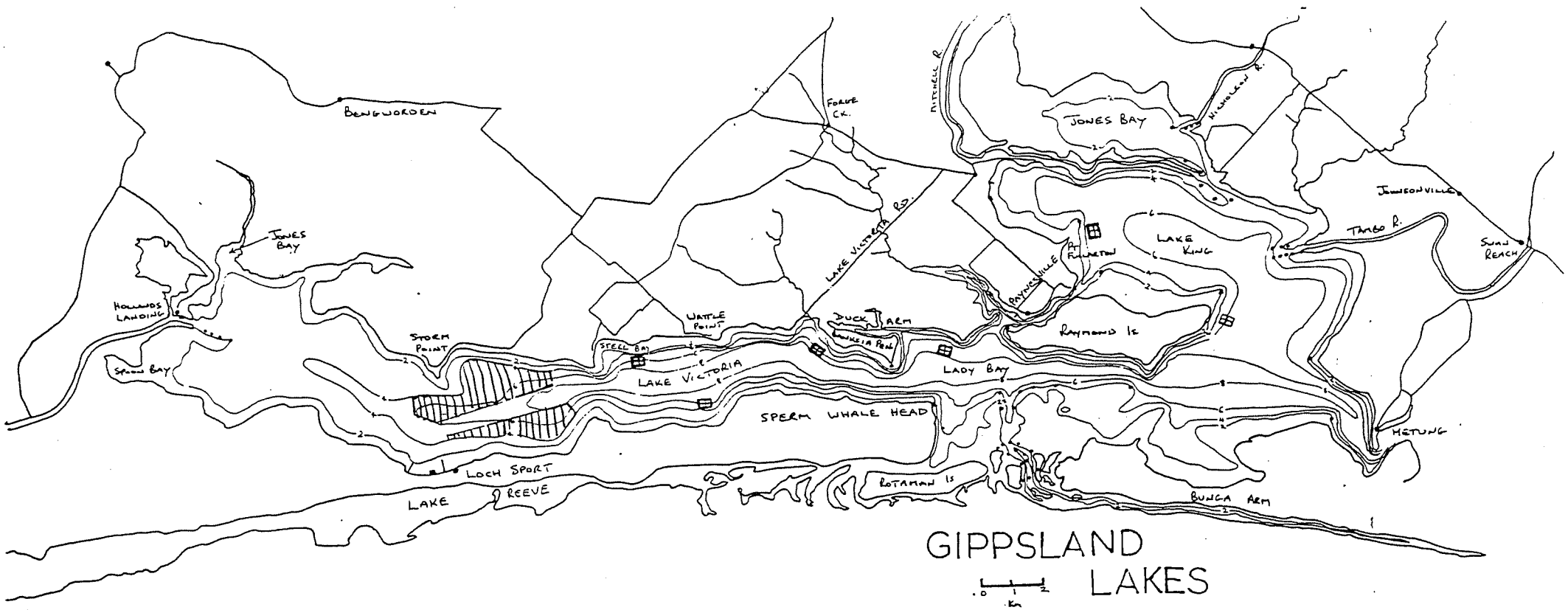
Shire of Rosedale The Shire supports the development of mariculture in principle.

Fig. 5.



GIPPSLAND LAKES

Fig. 6.



⊞ Potential mariculture sites

F) SEASPRAY

Areas of the coastline in the vicinity of Seaspray are suited to land-based mariculture. Seaspray itself is a small village located on the Ninety Mile Beach and is predominantly a holiday resort. The population peaks during the summer months with the influx of holiday residents.

Access to the area is good, with a number of connecting roads from the South Gippsland Highway. Merriman's Creek enters Bass Strait at Seaspray and on occasions, floodwaters have entered Lake Denison and flowed southwards. The coast along the Ninety Mile Beach consists of well vegetated stable dunes inland from a line of foredunes. The stable dunes extend approximately 500 m inland from the beach. Behind these dunes a considerable area is available for development of land based mariculture. The suitability of these sites is improved by natural creeks entering Bass Strait through which inlet/ outlet pipe systems could be run more economically.

GENERAL CHARACTERISTICS

Rainfall - Seaspray (Average Monthly - mm)

J	F	M	A	M	J	J	A	S	O	N	D
43	41	55	48	49	50	42	46	47	55	55	54

The rainfall at Seaspray is relatively stable throughout the year and is unlikely to have any effect on land based mariculture. On the other hand, rainfall in the catchment of Marrimans Creek is considerably higher than at the coast and occasional flooding of land behind the dunes should be allowed for in planning.

Wind The predominant year round wind along the Ninety Mile Beach is west with east, northwest and southwest winds being less common.

River Flow Merrimans Creek is gauged at Gormandale, inland from the South Gippsland Highway. The mean annual discharge is 16,650 ML. Creek flow is intermittent with virtually nil flow during summer at the mouth.

Land Status Most public land in this region of the coast is in a 30 m wide strip along Ninety Mile Beach. Reserves are located at Jack Smith Lake (2500 ha) and north of Seaspray, where the Gippsland Lakes Coastal Reserve begins at Lake Reeve. The proposed mariculture zones are located on uncommitted crown land and represent the areas most likely to be approved for mariculture by the Department of Crown Lands and Survey.

MARICULTURE POTENTIAL

Land based mariculture is the only suitable form at this location and there are likely to be few conflicts of use at the proposed sites.

There are two areas which are suitable for land based mariculture located behind the line of stable dunes on relatively level ground. Soil type is mainly sand and earthern pond construction would require importation of sealing clay. The two areas are north and south of Lake Denison. The Lake Denison North Zone has approximately 250 ha of suitable land and the Lake Denison South Zone, approximately 750 ha.

Mariculture at Seaspray could employ either intensive or extensive methods. The major cost of providing seawater to the farms will be reduced since creek outlets and in one case a road, pass through the dunes. Pipes for an offshore water intake could be laid through the creek opening at a lower cost than directly through the dunes. These four locations are marked on the map. As at all locations on the coast, pipes to land based farms would need to be buried and the area returned to its previous quality as a condition of any permit.

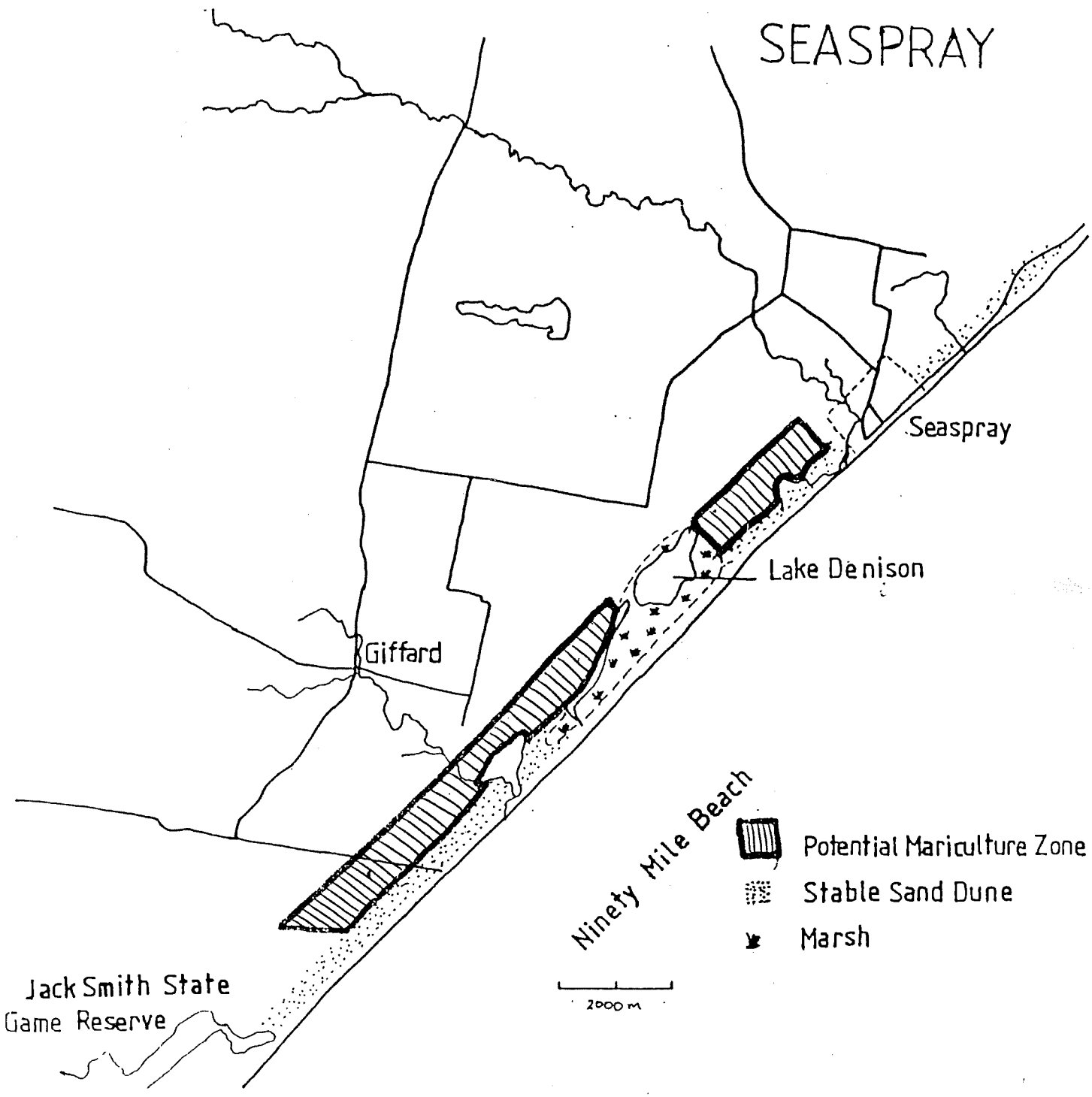
Water quality in Bass Strait is high and the temperatures are not subjected to the variations found in shallow estuarine systems. Therefore in winter it would be possible to maintain relatively high temperatures in the farm. High water temperatures in summer are likely to be uncommon and if oceanic temperatures of 18-19°C are maintained, farms at this site would be well suited to the culture of salmon and trout. Development potential here depends on the economics of providing water to the sites. Potential - good.

GOVERNMENT POLICY

Land Protection Service The proposed sites are located on either uncommitted crown land or on freehold land. The Service will consider applications for use of the land for mariculture on merit. Pipes laid through the coastal strip would need to have a minimal impact on the dunes.

Shire of Rosedale The Shire supports the development of mariculture in principle.

Fig. 7.


SEASPRAY
Seaspray
Lake Denison
Giffard
Ninety Mile Beach
Potential Mariculture Zone
Stable Sand Dune
Marsh
2000 m
Jack Smith State
Game Reserve

G) WOODSIDE BEACH

The area of coastline extending from a point south of Jack Smith State Game Reserve to the mouth of Bruthen Creek is well suited to land based mariculture.

Access to this portion of the coast is fair with roads extending to the coast at Woodside Beach and further south towards the mouth of Bruthen Creek. The stable dunes along this coast extend approximately 200-300 metres inland and the proposed zone is on level and somewhat marshy land. Large areas of uncommitted crown land and freehold land suitable for land based farming are available here.

GENERAL CHARACTERISTICS

Rainfall The nearest recording station is Seaspray. Average monthly rainfall (mm) is:

J	F	M	A	M	J	J	A	S	O	N	D
43	41	55	48	49	50	42	46	47	55	55	54

Wind The predominant wind all year is from the west with east, northwest and southwest less common.

Creek Flow Freshwater flow in this region is not recorded. Creek flow is intermittent and flooding is generally minor.

Land Status Public land along this region of the coast consists mainly of a 30 m strip along Ninety Mile Beach. The southern boarder of Jack Smith State Game Reserve adjoins the proposed site. The site is located on both crown and freehold land, the crown land being adjacent to the two roads.

MARICULTURE POTENTIAL

There are likely to be few conflicts of interest at this location as the only form of mariculture with potential is land-based. The only source of conflict would arise over the limited recreational use of the land, e.g. duck shooting.

The proposed zone is continuous and covers approximately 950 ha. Initial development would be near existing access points. The land is generally marshy and as such is of poor quality for existing uses. The soil type is mainly sand and extensive pond construction would require importation of impervious soils. Suitable mariculture methods include both extensive and intensive farming.

The economics of the proposed site depend on establishment costs, a large component of which is the cost of supplying seawater to the farm. Farms located in the southern region may obtain water at low pumping costs from the inlet near the mouth of Bruthen Creek. Development of this portion of the zone would be considerably cheaper than at other places.

A creek flows out through the dunes at the site and pipes could be layed through this opening. Areas north of Woodside Beach would require a water input cut through the dunes. Therefore, the southern area would be the most economic to establish.

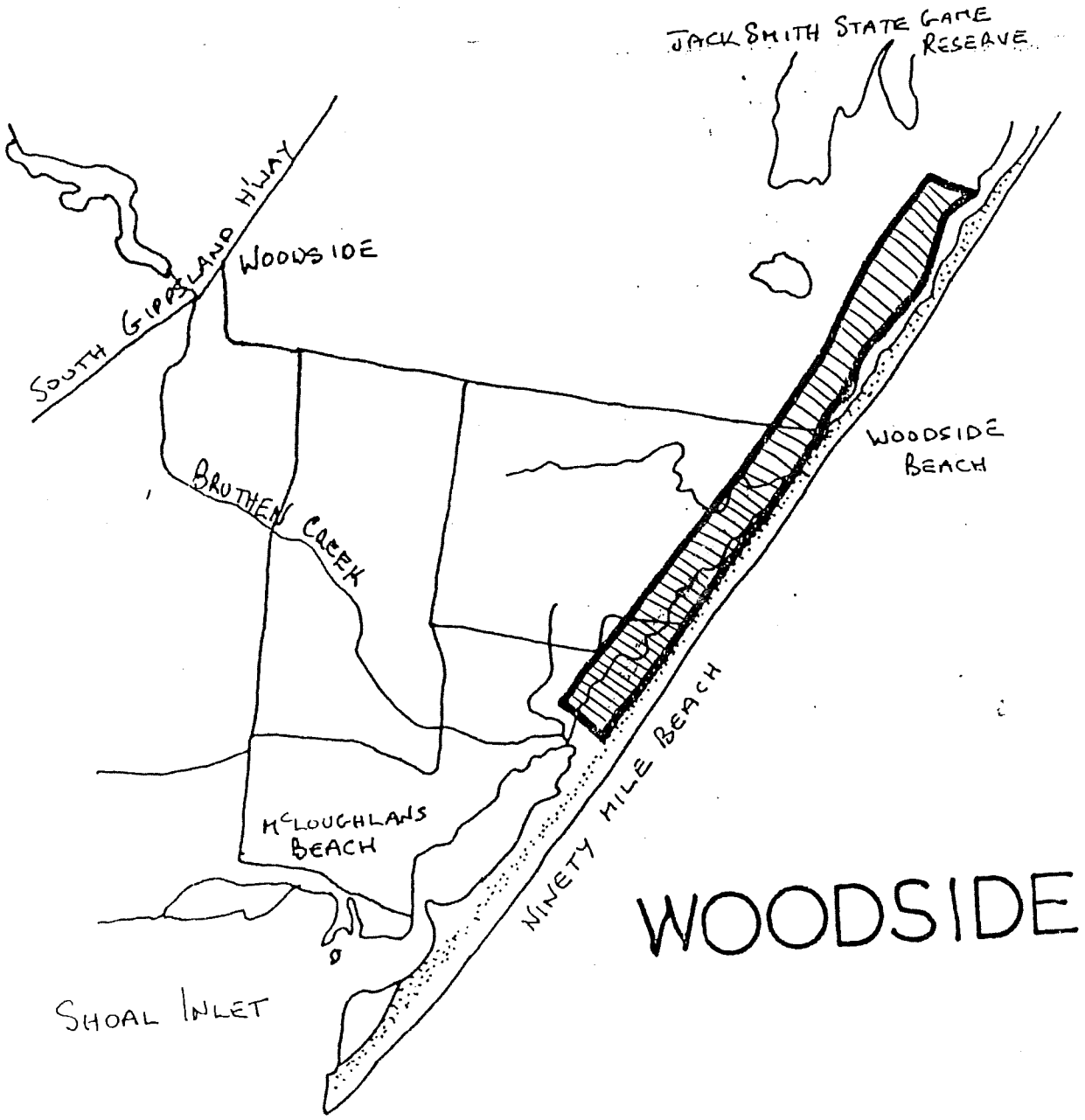
Water quality is high and for the same reasons as those given for the Seaspray site, water temperatures would be suitable for salmon and trout culture. An exception to the above would be farms drawing water from the McLaughlin Beach Inlet during summer. Temperature here is higher than in Bass Strait. Potential - good.

GOVERNMENT POLICY

Land Protection Service The proposed zone is located on uncommitted crown or freehold land. The Service will consider proposals for mariculture on crown land in the zone. Approval would be required to lay pipes through the coastal zone and, if issued, would be conditional upon dune restoration.

Shire of Rosedale The Shire supports the development of mariculture in principle.

Fig 8.


JACK SMITH STATE GAME RESERVE
SOUTH GIPPSLAND HWAY
WOODSIDE
BRUTHEN CREEK
WOODSIDE BEACH
NINETY MILE BEACH
McLOUGHLANS BEACH
SHOAL INLET
WOODSIDE

H) SHOAL INLET

The Shoal Inlet system covers a considerable area of coastline extending from McLaughlin's Beach to Port Welshpool, a distance of approximately 45 kilometers.

The inlet differs from others on the Victorian coast as intertidal mudflats predominate. Barrier islands form the seaward margin of the inlet and five entrances permit water exchange from Bass Strait.

Only one of the entrances, Snake Island/Drum Channel, is navigable by small boat and the remaining four are shallow, narrow and have strong tidal currents. Between the barrier islands and mainland, the inlet has a number of small islands and large areas of mudflat transected by narrow channels. The main source of freshwater inflow to the inlet is through the Albert and Tarra Rivers, both of which enter near Port Albert. The mainland shore of the inlet is predominantly marshland, mangrove and scrubland.

The environment of Shoal Inlet is one of the most diverse and least modified of all Victorian coastal areas. The shallow mudbanks provide ideal habitats for large populations of birds. The inlet itself represents a significant nursery area for both offshore and inlet fishes. The mangrove stands are significant in that, with those in Corner Inlet, they are the southernmost stands in Australia. The islands in the inlet are mostly undeveloped and the inlet as a whole is basically unmodified and may shortly be declared a marine reserve.

In comparison to the Gippsland Lakes, commercial development and other uses of the inlet are minor. There are two major towns on the inlet, Port Albert and Port Welshpool, both of which are fishing ports. The remaining townships of Mann's, McLaughlin's and Robertson's Beaches are primarily holiday resorts. Until the late nineteenth century, Port Albert was the principal port for Gippsland, however increased competition from the Gippsland Lakes ports as well as channel siltation, caused a decline in trade and the town is now primarily a fishing port.

Fishing operations in the inlet are based on seine fishing methods. In the past a sizeable industry was based on the native oyster, Ostrea angasi. This industry commenced when the area was first settled and lasted until the late 1940's. The industry was characterised by variable breeding success of the oysters and overfishing. Statistics show peaks in catches lasting up to five years followed by long periods of very low production.

As mudflats predominate in the inlet, there are few available areas for floating forms of mariculture. Channels are utilised by boat traffic and their narrowness precludes use of floating structures. The forms of mariculture most suitable for the inlet are intertidal mollusc culture and land based culture.

GENERAL CHARACTERISTICS

Rainfall, average monthly, mm

	J	F	M	A	M	J	J	A	S	O	N	D	Total
Alberton:	46	47	62	56	58	62	57	62	65	68	59	55	697
Port Albert:	47	44	58	59	65	66	59	61	66	68	61	55	709

The rainfall pattern for the hinterland, including the drainage basins of the rivers, is largely dictated by the topography of the area. Rapid flooding of the coastal rivers can occur. Yarram, only 20 km inland from Alberton, receives 50 mm more rain per annum than does Alberton.

River Discharge

	Mean ML	Annual Max ML	Annual Min ML	Recorded Max Flow/Day ML
Albert*	31000	72000	13000	5200
Tarra	47000	141000	8000	6800
Bruthen Ck	6000	14000	1000	1200

*Albert figures addition of Albert and Jack Rivers.

Bruthen Creek enters Shoal Inlet at McLaughlin's Beach. Although the rivers are relatively small and flows are generally of low volume, the maximum daily flow figures show that in excess of 50% of average annual flow can occur in a single day. During times of such flooding salinity within the inlet would drop significantly.

Wind In winter, winds are most frequently from the west and less frequently from the northwest and east. Summer winds are mainly from the east and west with southwest winds less common.

Waves The barrier islands prevent oceanic swells from entering the inlet. Wind induced waves within the inlet are quite significant as there is a large fetch and the shallow water causes the generation of short wavelength chop.

Salinity Salinities within the inlet are stable, except during significant flooding. Tidal exchange is good and areas adjacent to the outer channels have near oceanic salinities. During the summer period salinities may reach 40‰ in the upper reaches of the inlet.

Land Use The plains leading to the foothills of the Strzelecki Ranges are heavily utilised for dairy farming. Farms in the Strzelecki ranges predominantly produce cattle and sheep.

Land on the shore of the inlet is mostly saltbush marshland grading to some areas of scrubland and dairy farming land. Road access to the coast is generally poor.

Contaminants Contamination of the inlet is limited to agricultural runoff of fertilizers and pesticides/herticides. There is no industrial discharge into the inlet.

There are no documented records of any fish kills traced to man made contamination. Petrol and oil spillages from boats may occur near the boat ramps. Water quality in the inlet is good since freshwater inflow is low and there is considerable tidal exchange. The Environment Protection Authority has yet to issue a policy statement on water quality in Shoal Inlet and quality is likely to remain high into the foreseeable future.

Commercial Fishing Corner Inlet and Shoal Inlet have been managed as restricted fisheries since 1970 with currently approximately 40 fishermen licensed to fish here. The main methods employed are mesh and seine netting with limited trolling and long lining. Fish caught by commercial fishermen in declining order of importance are king george whiting, rock flathead, flounder, australian salmon, pike and yellow-eye mullet. The two major fishing ports on the inlet are Port Albert and Port Welshpool, the latter being the larger. Fishing takes place in all parts of the inlet but in the main within the channels and on the edges of the mudflats at high tide.

Recreational Fishing Recreational fishing is the major water use within Shoal Inlet. Boat ramps are available at all towns boardering the inlet where facilities to service anglers can also be found. The most popular fishing locations are in the numerous channels or the mudbank edge of the channels. Some little fishing occurs over mudbanks at high tide. Shore and pier fishing is limited to port areas or where channels reach the coast. Estuary fishing is popular in both the Albert and Tarra Rivers.

Black bream are caught in the estuaries but in the inlet proper, the most commonly caught species are king george whiting, flathead, pike, flounder, mullet, and estuary perch.

Other Water Uses The shallowness of the inlet precludes extensive use for more active recreational boating activities. Watersking and deep draft yachting are restricted by the narrowness of the channels and are limited to the areas adjacent to Port Welshpool and Port Albert. Small boat yachting is also restricted to waters adjacent to towns by the strong currents within the inlet.

Social Considerations Shoal Inlet has not been developed to any great extent. Existing commercial fishing operations are stable. Recreational activities are predominantly passive and have no significant effect on the environment.

A considerable portion of the inlet is incorporated in the Nooramunga State Faunal Reserve managed by the Fisheries and Wildlife Service. Areas incorporated in the Faunal Reserve include St. Margaret, Clonmell, Snake, Dog and Scrubby Islands. Sunday Island is privately owned by the Para Park Game Reserve Co-op Ltd. Significant sites for bird populations occur in the inlet.

The significance of the existing reserve, the bird habitats on the mudbanks and the nursery areas for fish in the inlet has led to a proposal to proclaim the inlet a marine reserve. This proposal is currently receiving submissions prior to drafting of legislation. Mariculture within the inlet will be required to comply with certain guidelines.

MARICULTURE POTENTIAL

The inlet has potential for only two forms of mariculture, intertidal shellfish farming and land based pond culture.

1) Intertidal Shellfish Farming

The mudflats of the inlet are ideally suited to shellfish farming which could become a large industry here. Factors to be considered when locating zones for development include access to the site, existing habitat in relation to significant sites of the marine reserve and the degree of commercial/recreational fishing at the site.

Species suitable for intertidal culture are the pacific oyster (Crassostrea gigas) and the Sydney Rock oyster (Crassostrea commercialis). Oyster farming in the inlet could be very successful as the native oyster, Ostrea augasi, is abundant and formed the basis of a dredge industry lasting until the late 1940's. Native oyster culture would be restricted to subtidal areas.

The temperature range of all Victorian waters is suitable for cultivation of pacific oysters and they would be expected to grow well in the inlet. A further point for consideration is the stable salinity of the inlet in the oceanic range which may preclude successful reproduction of the pacific oyster.

The potential for the Sydney rock oyster is not good as low water temperatures are likely to cause high winter mortalities.

The area away from the coast near the barrier islands and inner islands contains the most significant biological habitats and has limited access from the mainland. Potential for development in this area is limited and may be considered undesirable if the inlet becomes a marine reserve. The areas of most potential for oyster farming are adjacent to channels near the mainland and sufficient space is available for considerable development without affecting sensitive wildlife habitats.

Description of potential areas are based on the nearest access point and are marked on the map.

McLaughlins Beach Conservatively, there are five square kilometers of suitable mudflat available for oyster culture here. Suitable areas are located to the west of McLaughlin's Beach, south side of St Margaret Island including both sides of the channel and south of the channel opposite McLaughlin's Beach. There are no bird breeding habitats of significance in the area though wading birds frequent the mudflats and swamps. Substrate in the area is predominantly firm silty sand. Potential - very good.

Mann's Beach Suitable mudflat areas in the vicinity of Mann's Beach are limited as tidal channels pass close to the shoreline. Substrate in the area is a mixture of silt, sand and some clay. Suitable areas are north of Pelican Channel, on the south shore of St Margaret Island, south of Mann's Beach and the western bank of Farmer's Channel. Potential - very good.

Port Albert/Robertson's Beach There is a large expanse of mudflat extending from Robertson's Beach to the west of the Old Port Channel. Beyond the area marked on the map access is difficult both from sea and land. Access to the mudflats in the area marked is excellent from Port Albert and facilities at the port include an all weather launching ramp, harbour facilities and fish processing facilities. Both Dog and Scrubby Island and adjacent mudflats are significant breeding habitats for terns and consequently have been omitted. Recommended areas include the mudflat between Port Albert and Robertson's Beach and mudflats adjacent to Old Port Channel, Sheep Island and both north and south of Clump's Channel. Potential - very good.

Port Welshpool is the major harbour facility on the inlet and provides extensive areas of suitable mudflat extending both east and west of the town. The available area to the east of the town is restricted by the channel which is only navigable at high tide. Sediment in the area is silt/sand, a very firm substrate created by the tidal currents which often exceed four knots. There are no significant wildlife or botanical habitats adjacent to Port Welshpool. Potential - very good.

ii) Land Based Culture

The majority of the coastline is highly suited to land based farming utilising both extensive and intensive pond farming as it is predominantly lowlying scrub/marshland. The economics of pond construction and costs of obtaining water in such conditions are good in comparison with other areas on the Victorian coast. Costs of pumping water depends directly on the height to be pumped and along this coast costs would be relatively low. However a major drawback to land based farming here is the day round availability of water. Except at a few locations, water is available only at high tide and then only for a relatively short period. Land based farming will generally require a suitable water source throughout most of the day and farms will be limited to areas where this condition can be met.

Land based mariculture of molluscs, crustaceans and fishes has potential here. Species most suited for culture are the fishes, particularly salmon and trout which require cool water and flounder which abound in the inlet. Water treatment would be required for waste water re-entering the inlet.

McLaughlin's Beach The area suited to land based farming outside the defined urban area is marshland/saltbush with suitable water supply for most of the day. The land is uncommitted crown land and is not considered significant habitat. The available area for such development is approximately three square kilometers.

Soil type in the area is a mixture of sand and clay. Intensive farming methods are ideally suited to the area and power is readily available. Potential - good.

Mann's Beach The area suited to land based farming outside the defined urban area is scrubland and saltbush fringe with suitable water supply from Farmers Channel. Land status is uncommitted crown land and the site is not considered an important wildlife habitat. The crown land area boarders freehold grazing land. Available area for development is approximately one square kilometer.

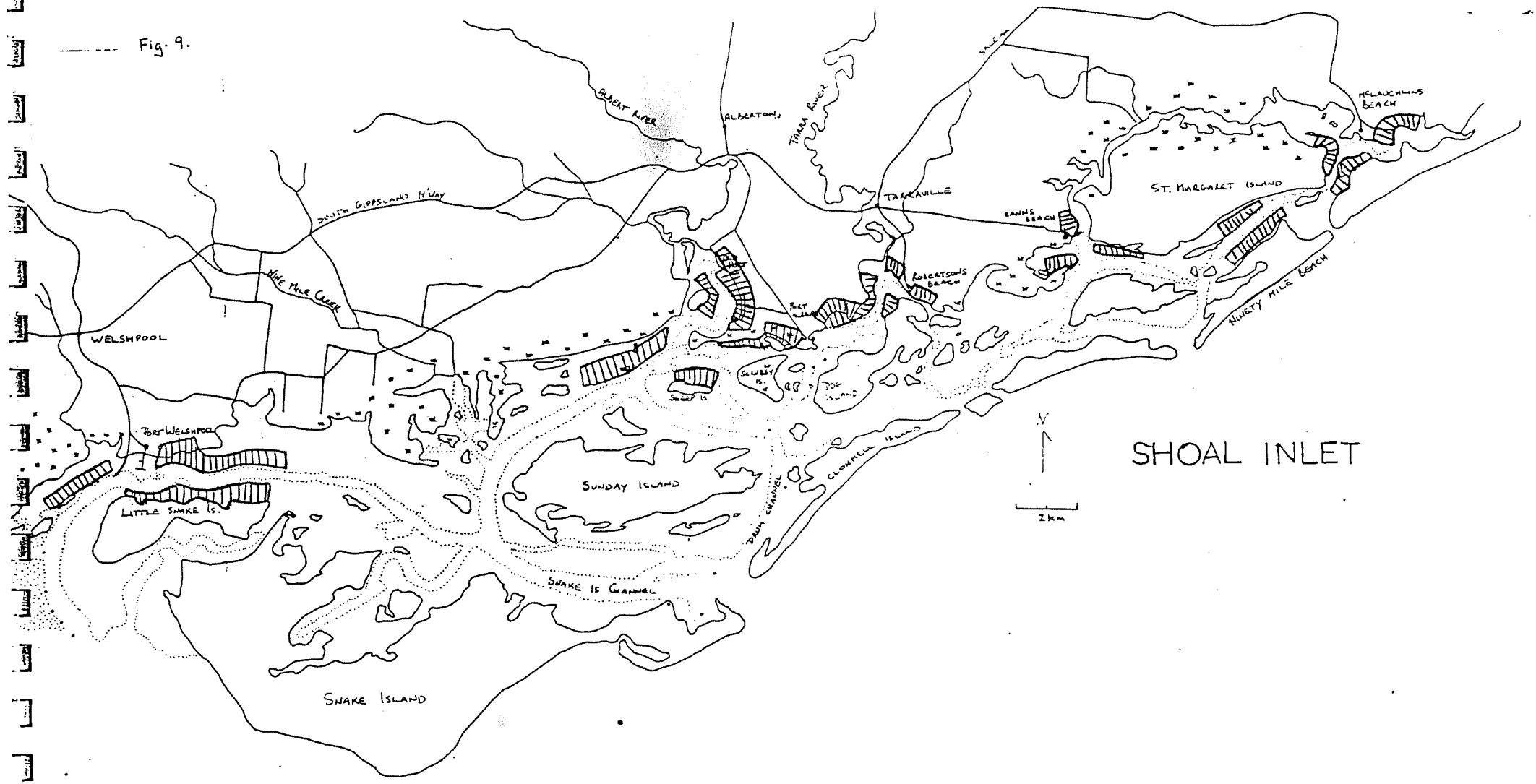
Soil type in the area is a mixture of sand and clay and earthen ponds would require sealing. Intensive farming methods are most suited to the area. Potential - very good.

Robertson's Beach The area suited to land based mariculture outside the urban area is predominantly scrubland and a small area of saltbush fringe. The extent of scrubland restricts the available area and indicates intensive farming in small areas is most suited to Robertson's Beach. Land is uncommitted crown land, however, approval for clearing is unlikely to be given. Water is available for the greater period of the day from the channel adjacent to the foreshore. Available land is approximately two square kilometers. Potential - good.

Port Albert There is a large area of suitable land extending from the east of Port Albert to the mouth of the Albert River. Status of the land is uncommitted crown land and it is scrubland, marshland and saltbush flats. None of the land included in this area is considered significant habitat for flora and fauna.

Soil type in the area is predominantly sand with some clay. Water is available from the Port Albert Channel and the Old Port Channel. Area available is approximately six square kilometers. Power and reticulated freshwater are readily available in the area. Potential - very good

Fig. 9.


ALBERT RIVER
ALBERTON
TARRA RIVER
SALE
TARRAVILLE
MELALEUCA BEACH
ST. MARGARET ISLAND
SANDS BEACH
ROBERTSONS BEACH
SOUTH GIPPSLAND H'WAY
NINE MILE CREEK
WELSHPOOL
PORT WELSHPOOL
NINETY MILE BEACH
LITTLE SNAKE Is.
SUNDAY ISLAND
SNAKE Is CHANNEL
SNAKE ISLAND
DARBY CHANNEL
CLONMELL ISLAND
N
SHOAL INLET
2km

Port Welshpool A small area of land to the east of the town is the only area available for land based culture. The primary factor influencing suitability of this area is availability of water close to the shoreline. Except for an area near the existing piers the tidal channels occur offshore and obtaining adequate water supplies would be difficult. The land available is uncommitted crown land to the east of an existing crown land reserve adjacent to Port Welshpool. Soil type is predominantly sand. Available land is approximately one to two square kilometers. Potential - good/very good.

GOVERNMENT POLICY

Environment Protection Authority The EPA has no formal policy on the water quality of Shoal Inlet but consider it to be suitable for culture of molluscs, crustaceans and fishes.

Ports and Harbours Division The Ports and Harbours Division supports in principal development of mariculture provided such development does not interfere with navigation or other water uses. All intertidal areas proposed here for mariculture are located out of recognised shipping areas.

Land Protection Service The Service does not consider land based mariculture highly suited to the greater part of this coastline due to the presence of a number of significant fauna and flora habitats. Proposed land based mariculture areas have been located to avoid conflict where possible. The Service considers mariculture to be a suitable use on some uncommitted crown lands.

Shire of Alberton The Shire supports the development of mariculture in principle.

I) CORNER INLET

Corner Inlet is a tidal embayment of approximately 250 square kilometers of which intertidal mudflat accounts for approximately 140 square kilometers. Freshwater inflow through the two major streams, the Agnes and Franklin Rivers, is minor in comparison with tidal exchange through the entrance. The single entrance is approximately 2.5 kilometers wide with depths up to 40 m. The main channel branches into seven principle channels which are up to 20 m deep. Most of the shoreline is low lying marshland and about 30% is incorporated into the Wilson's Promontory National Park. Land use in the catchment is principally grazing. Excepting the small fishing village of Port Franklin and the oil maintenance facility at Barrys Beach, no large towns or industrial facilities boarder the inlet.

As with Shoal Inlet, intertidal mudflats predominate. These are extensive and are noted as habitats for wading birds and as a nursery area for many commercial fish species. The shoreline is fringed by stands of white mangrove, the most southern of the species. The mudflats are extensively covered by a number of species of seagrass.

Commercial fishing in Corner Inlet is more significant than in Shoal Inlet and methods employed include gill netting, beach seining and some long-lining. Recreational use of the inlet is predominantly fishing with limited sailing and cruising. The main channel to Barrys Beach and Port Welshpool is extensively used by ships.

Mariculture prospects for the inlet are mainly for intertidal and landbased farming with limited scope for offshore mariculture. A vast area of intertidal mudflats is available for shellfish farming and significant areas of land behind the foreshore are suitable for land based farming. The prospects of offshore mariculture are limited by the availability of deep water.

GENERAL CHARACTERISTICS

Rainfall - Average monthly (mm)

	Fish Creek											
J	F	M	A	M	J	J	A	S	O	N	D	Total
54	60	69	95	102	104	99	114	90	97	86	69	1039
	Foster											
62	62	79	102	107	107	106	119	111	108	86	97	1145

Rainfall along the coastline is lower on average than at the above two towns. Yanakie, near the coast has an annual average rainfall of 808 mm. The high rainfall in the catchment can lead to short term flooding of rivers draining into Corner Inlet.

River Discharge The two major sources of freshwater inflow into Corner Inlet are the Agnes and Franklin Rivers. Annual maximum, mean and minimum discharge and peak flows are as follows.

	Annual (ML)			
	Mean	Max	Min	Max flow/day (ML)
Agnes:	26,000	45,000	7,000	2,100
Franklin:	24,000	49,000	5,500	5,700

Freshwater inflow during flooding is moderate and in comparison with tidal exchange has little effect on salinity within the inlet. Flooding is generally short term as the river catchments are small and the salinity effects of flooding are localised at the river mouths.

Winds Winds during the winter are mainly from the west and northwest. During summer they are mainly from the south, south east and to a lesser extent the north east.

The available fetch from all direction is large, however the effect of wind induced waves is largely tide dependent. At low tide large areas of mudbank are exposed effectively reducing the available fetch. At high tide large, short wavelength waves can be generated as the water is very shallow.

Salinity The high volume of water exchange from Bass Strait ensures salinities are very close to 35‰.

Land Use Land use in the catchment is mainly grazing and dairy farming. Light industry is restricted to Foster, Toora and the Barrys Beach oil maintenance terminal. Over the past century the hinterland has been considerably modified and only a few areas of untouched native vegetation remain. The northern shore of Wilsons Promontory had for a considerable time been used for cattle grazing but this has now ceased.

The shoreline of the inlet excluding the National Park is mainly low marshland in varying states of modification. Some areas of coastal woodland/marshland still exist. In other areas coastal pasture (mainly leased crown land) extends to the shoreline. Many significant stands of coastal vegetation are currently recommended for incorporation into the proposed reserve.

Contaminants Treated waste water enter Corner Inlet from the Foster and Toora Sewerage Authorities works. Effluent from both is secondarily treated and tidal exchange ensures rapid dispersal and dilution of the effluent. There are no known accumulations of toxins in Corner Inlet and water quality is of high standard.

Contamination from Barrys Beach is likely to be caused by hydrocarbon spills but to date no such spills have occurred. Limited pesticide/herbicide/fertiliser discharge can be expected through the Agnes and Franklin Rivers though such discharges are likely to be insignificant.

Commercial Fishing Thirty eight professional fishermen are currently licenced to operate in Corner Inlet. Methods commonly used are gill netting and seine netting. The fish catch in order of importance (tonnage) is king george whiting, rock flathead, flounder, australian salmon, pike and yellow eye mullet.

The two principal fishing ports are Port Franklin and Port Welshpool with a limited number of boats operating from Toora Bight. The annual catch is relatively stable and is in the vicinity of 140 tonnes.

As in Shoal Inlet, the major fishing grounds are in or adjacent to the channels and over the deeper areas of the mudbanks. All areas of the inlet are fished to some degree.

Recreational Fishing Boat fishing is the most popular form of angling in Corner Inlet. Launching facilities are located at Port Franklin, Toora Bight and Port Welshpool. Pier and beach fishing is very limited and is often restricted by the tide.

The most popular fishing sites are located over the mudflats at high tide. Long-nosed flathead and sand flathead are most commonly caught on sandy bottoms whereas king george whiting are caught over seagrass beds.

The popularity of boating and angling in Corner Inlet is increasing annually and an aerial survey conducted over the summer of 1983/84 detected up to 203 boats in Corner Inlet/Shoal Inlet at the one time.

Other Water Uses Other uses of the waters of Corner Inlet are limited by the extensive mudflats. The main channels and the entrance are heavily used by commercial shipping and pleasure boats for access to the inlet ports and Bass Strait. The volume of such traffic in the limited space restricts any development of offshore mariculture. The Franklin, Toora and Lewis Channels are most heavily used. Most recreational boating activity, water skiing and yachting are confined to the main channels and the port areas. These activities are likely to have limited effect on mariculture development. The majority of the intertidal flat area is little used by commercial and recreational interests.

Social Considerations The environmental importance of the inlet is considerable and a major portion has been recommended for incorporation into a marine reserve. Areas of the shore are also to be included in this reserve.

Four principal factors contributing to the environmental significance of the inlet are as follows:

1) Its significance for feeding and roosting of migratory wading birds of international importance.
2) The extensive mudflats which support seagrass communities sensitive to human influence.
3) The extensive stands of mangrove, salt marsh, intertidal flats, and the only extensive beds of broad-leafed seagrass, Posidonia australis in Victoria.
4) Spectacular scenery provided by the backdrop of Wilson's Promontory.

The aesthetic value of Corner Inlet is high and Local and State Government policy is to maintain this quality.

Current commercial use of the inlet has a minimal environmental impact and further major expansion of existing operations is unlikely particularly as the Bass Strait oil fields decline in importance over the next two decades. Commercial fishing within the inlet is presently stable and is unlikely to increase in the future.

The expansion of use of the inlet is likely to come from two directions; recreational fishing (known to be increasing) and passive recreation. The proposal for a Marine Reserve stems from the increasing interest in the inlet system for passive recreation. Mariculture is considered an acceptable use for the inlet and regulations will permit development on condition that existing environmental attributes are not affected.

MARICULTURE POTENTIAL

The inlet has potential for predominantly two forms of mariculture, intertidal shellfish farming and land based pond culture. Offshore mariculture on a limited scale would also be possible.

i) Intertidal Shellfish Farming

The mudflats of the inlet are ideally suited to this form of mariculture. The large areas available for development indicate shellfish farming could become a large industry here. Significant factors in selecting shellfish culture zones in Corner Inlet include ease of access, zoning plans for the marine reserve, existing uses and habitat suitability.

Species suitable for cultivation include the Pacific oyster (Crassostrea gigas) and the Sydney rock oyster (Crassostrea commercialis). The native oyster occurs naturally in abundance in the inlet and this species has high potential for subtidal culture. It has as yet not been commercially cultivated in Australia and some experimentation would be required prior to commercialisation. A species of the same genus is cultivated intertidally in Europe.

Environmental conditions in the inlet are also suitable for cultivation of pacific oysters and this species could form the basis of a large industry. The potential for the Sydney rock oyster is not good as low water temperatures are likely to cause high winter mortalities.

Access to lease sites is a considerable problem within Corner Inlet. Intertidal areas in the Northern and North-western area are the most suited for cultivation as the majority of access points are in this area. The proposed marine reserve incorporates areas to the west and south west of the inlet and access to these areas is poor. The most logical sites for intertidal culture are on the large areas of mudflat away from the proposed marine reserve. Selection of suitable sites within the proposed zones is dependent on tidal range.

Descriptions of potential areas are classified by their nearest access point. Potential zones are shown on the accompanying map.

Barrys Beach Two areas adjacent to Barrys Beach are suitable for shellfish culture. One is located on the southern side of Barrys Point north of the Toora Channel. Available area at this site is approximately 4.5 square kilometers. Sediment conditions are stable being mostly sand. Tidal exchange is excellent as the site boarders the main channel.

The second site is north of the Barrys Beach terminal in the area between the Toora Channel and Barrys Beach Channel. Available area is approximately 4 square kilometers. Tidal exchange at this point is also excellent. Potential - very good.

Toora Bight North of Little Toora Island and to the east of Toora Channel an area of approximately 1.5 square kilometers is suitable for shellfish culture. Access from Toora Bight and tidal exchange are excellent. South of Toora Channel two sites are suitable for shellfish culture. On the northern side of Big Toora Island the available area is aproximately 1.5 square kilometers. To the south of Big Toora Island available area is approximately 3 square kilometers. All these sites have good access from Toora Channel and the latter also has access from Barrys Beach. Potential- very good.

Port Franklin East of the Franklin Channel adjacent to Mangrove Island there is a suitable area of approximately 3 square kilometers. The area may be continuous with the Toora Bight area described above but this is dependent on tidal range. Access is excellent from the Franklin Channel. Another suitable area is located to the south of Franklin Island. This area is located within the proposed marine reserve. Available area is aproximately four square kilometers. Potential - very good.

The potential zones recommended in this report are located on environmentally sensitive mudflats. Mariculture permits would be issued with the requirement of minimal disturbance to these mudflats.

All other potentially suitable areas for shellfish farming located within the proposed marine reserve are considered unsuitable. The entire coastline is recommended as a conservation zone which is incompatible with shore facilities for shellfish farming. Access to the inlet from this section of coastline is poor and only limited areas have suitable access. As access is poor and the conditions on permits will be severe, it is considered shellfish farming in this portion of the inlet is incompatible with the aims of the marine reserve.

ii) Land Based Mariculture

The coast which boarders the marine reserve is predominantly unsuitable for land based mariculture. The entire shoreline is tidal and no channels containing water at all stages of the tide, reach the shore. Secondly, and more importantly, a licence to discharge waste water from landbased ponds to the inlet is unlikely to be granted.

The areas where water is continuously available are where channels reach the shoreline. These occur at Port Franklin, Toora Bight and Barrys Beach. The coastline at these points is low scrub/marshland ideally suited to land based mariculture. Species with most potential for culture are salmon, trout and flounder. Water treatment will be required for waste water discharged into the inlet.

Port Franklin The channel to Port Franklin provides a suitable source of water for land based farming east of the township. The land is marsh/scrubland and is predominantly freehold and uncommitted crown land. Available land area is approximately 3 square kilometers. Access to the area is excellent and power is readily available. Water pumping costs would be low as pumping height is small. Both extensive and intensive farming methods would be applicable to this area. Potential - good.

Toora Bight Toora Channel provides a suitable source of water for land based farming in Toora Bight. A coastal reserve is located on the shoreline, however, suitable uncommitted crown land is located further inland. A permit to run pipes under the coastal reserve would be required from the Land Protection Service.

Inland from the uncommitted crown land there is suitable freehold land. The available area is approximately two square kilometers and is presently low marsh and scrubland. Access to the site is excellent and power is available. Both extensive and intensive farming methods are applicable to the site. Water pumping costs would be low as pumping height is small. Potential - good.

Barrys Beach Water could be drawn from the dredged channel to the marine terminal at Barrys Beach. The area around Barrys Beach is freehold industrial land which could be used for land based farming and to the north and south uncommitted crown land is available. A narrow strip of coastal reserve boarders the shore and a permit would be required to lay pipes across this. Further inland from the uncommitted crown land there are some areas of suitable freehold land. Total area available is approximately three square kilometers. Access to the area is excellent and power is available. Both extensive and intensive culture methods are applicable to these sites. Potential - good.

iii) Offshore Maricultre

The potential of offshore mariculture is limited by the small area of available water. All the tidal channels are heavily utilised. Suitable sites exist at the entrance to Franklin Channel and adjacent to Chinaman's Beach, Wilsons Promontory. The entrance to Franklin Channel is approximately two kilometers wide and water depth is 10 to 20 m. Tidal currents are strong and preclude most suspension culture except longline mollusc culture. Mussels (Mytilus edulis) are common in the entrance and are most suited to culture at this site. Spat may possibly be caught locally or could be transported from Port Phillip Bay. Access to the site is adequate from both Port Franklin and Barrys Beach. Area available is limited, perhaps two 3 ha lease areas. The second site is in Bennison Channel near Chinaman Beach. The potential area is adjacent to the shoreline with a depth of about 10 m. Shelter is good and access is available from Port Franklin and Barrys Beach. Tidal currents are of moderate strength and (as well as longline culture) net cage culture has some potential. The area is within the proposed marine reserve. Few conflicting interests occur at this site. Potential - good.

GOVERNMENT POLICY

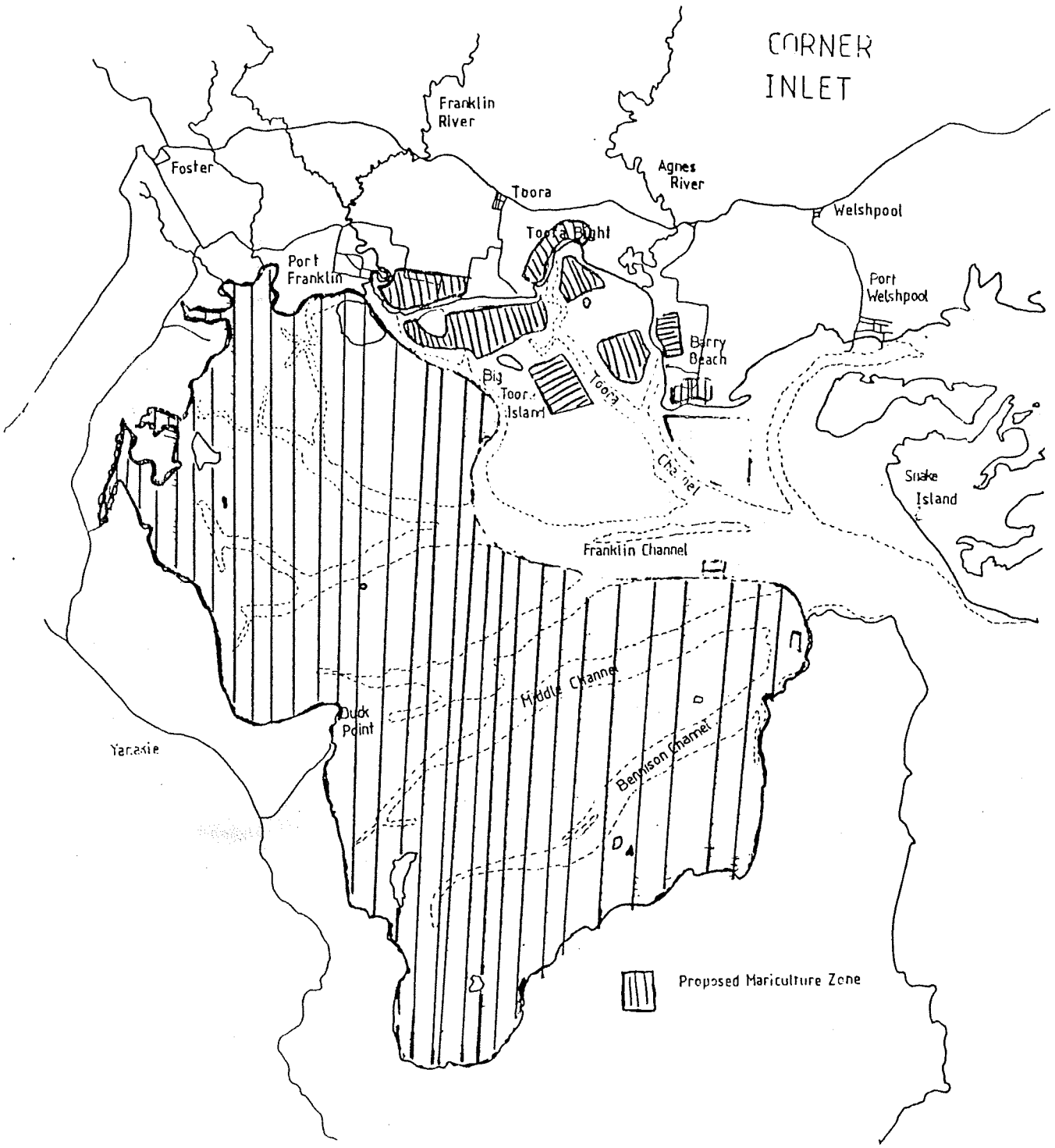
Environment Protection Authority The EPA has no formal policy on water quality in Corner Inlet although it is considered suitable for the culture of molluscs, crustaceans and fishes.

Ports and Harbours Division The Ports and Harbours Division supports in principle the development of mariculture provided any such development does not interfere with navigation.

Land Protection Service The Service considers mariculture to be a suitable use on some uncommitted coastal crown land. In Corner Inlet, special approval would be required to construct shore facilities or lay pipes across the coastal reserve.

Shire of South Gippsland The Shire of South Gippsland supports mariculture development in Corner Inlet provided such development does not interfere with established fishing grounds or navigation.

Fig 10.


CORNER
INLET
Franklin
River
Foster
Toora
Agnes
River
Welshpool
Toora Bight
Port
Franklin
Port
Welshpool
Barry
Beach
Big
Toora
Island
Toora
Channel
Snake
Island
Franklin Channel
Middle Channel
Duck
Point
Yanakie
Bennison Channel
D
D4
Proposed Mariculture Zone

J) SHALLOW INLET

Shallow Inlet is a small tidal inlet covering about twenty square kilometers. Extensive intertidal sand and mudflats occur within the inlet, covering up to 70% of its area. The entrance is permanently open and tidal movement maintains a single channel system up to five metres deep. Fresh water input is small from a number intermittently flowing creeks.

On the west the inlet is bounded by extensive marshland which leads to undulating grazing land. The eastern shore is boarded by a ridge of sandstone sediments. A large area of unstable dune boarders the western side of the entrance. The eastern shore at the entrance is part of the Wilson's Promontary National Park. The small village of Sandy Point is located adjacent to the western shore of the inlet and a caravan park is located on the eastern shore. Current land use patterns have minimal impact on the inlet.

The inlet is fished by commercial and recreational fishermen. It is also used by small boat sailers, wind surfers and water skiers. It is a significant wildlife habitat and is being considered as a marine reserve.

Mariculture prospects are limited to intertidal shellfish farming and land based farming. Mariculture is compatible with the marine reserve provided operations do not interfere with the general ecology, scenic qualities or current uses of the inlet.

GENERAL CHARACTERISTICS

Rainfall The nearest rainfall recording station is at Foster, some distance from the inlet. As the catchment is small, rainfall is unlikely to have a significant effect on salinity.

Foster (average monthly in m.m.)

J	F	M	A	M	J	J	A	S	O	N	D
62	62	79	102	107	107	106	119	111	108	86	97

Winds The small area of the inlet does not allow significant build up of wind induced waves. Winds from the north west and the south east can cause significant wave chop at times of high tide. Such winds are uncommon. Wind induced waves in Shallow Inlet will therefore not cause significant problems for intertidal mariculture.

Salinity Water in the inlet is basically marine. Changes in salinity will only occur during prolonged heavy rainfall, however such variations will be short lived as tidal flushing causes a fast water turnover.

Land Use Land use in the area surrounding the inlet is predominantly grazing and dairy farming. The village of Sandy Point is a seasonal holiday resort and has few facilities.

Contaminants The only likely source of contaminants to Shallow Inlet is from small boat petrol spills and a limited input from herbicides, pesticides or fertilizers from the hinterland. The degree of contamination is likely to be insignificant and have no effect on mariculture.

Commercial Fishing The commercial fish catch rarely exceeds 10 tonnes per annum. Fishing methods employed are mainly beach seining and gill netting. Six fishermen are currently licenced to fish in Shallow Inlet. Commonly caught species include whiting, Australian salmon, flathead, flounder and some trevally. Fishing is mainly conducted in the channel.

Recreational Fishing Shallow Inlet is a popular angling site. Boat fishing and shore fishing in the channel at low tide are favoured methods. An aerial survey conducted over the summer of 1983/84 detected up to 36 boats in the inlet. Summer is the period of peak usage and boating activity would be lower for other times of the year. During summer, commonly caught species are whiting, australian salmon, flathead, trevally, flounder and occasionally gummy shark and snapper. Australian salmon is most commonly caught in winter.

Other Water Uses Small yacht sailing is popular during the summer months utilising the channel at low tide and the entire inlet at high tide. Boats are launched off the beach at Sandy Point and adjacent to the caravan park on the eastern shore. Some conflict between mariculture and yachting may occur. Windsurfing is increasing in popularity but is limited to the channel near the entrance.

Power boating other than recreational fishing is limited to the main channel. Water skiing is infrequently conducted.

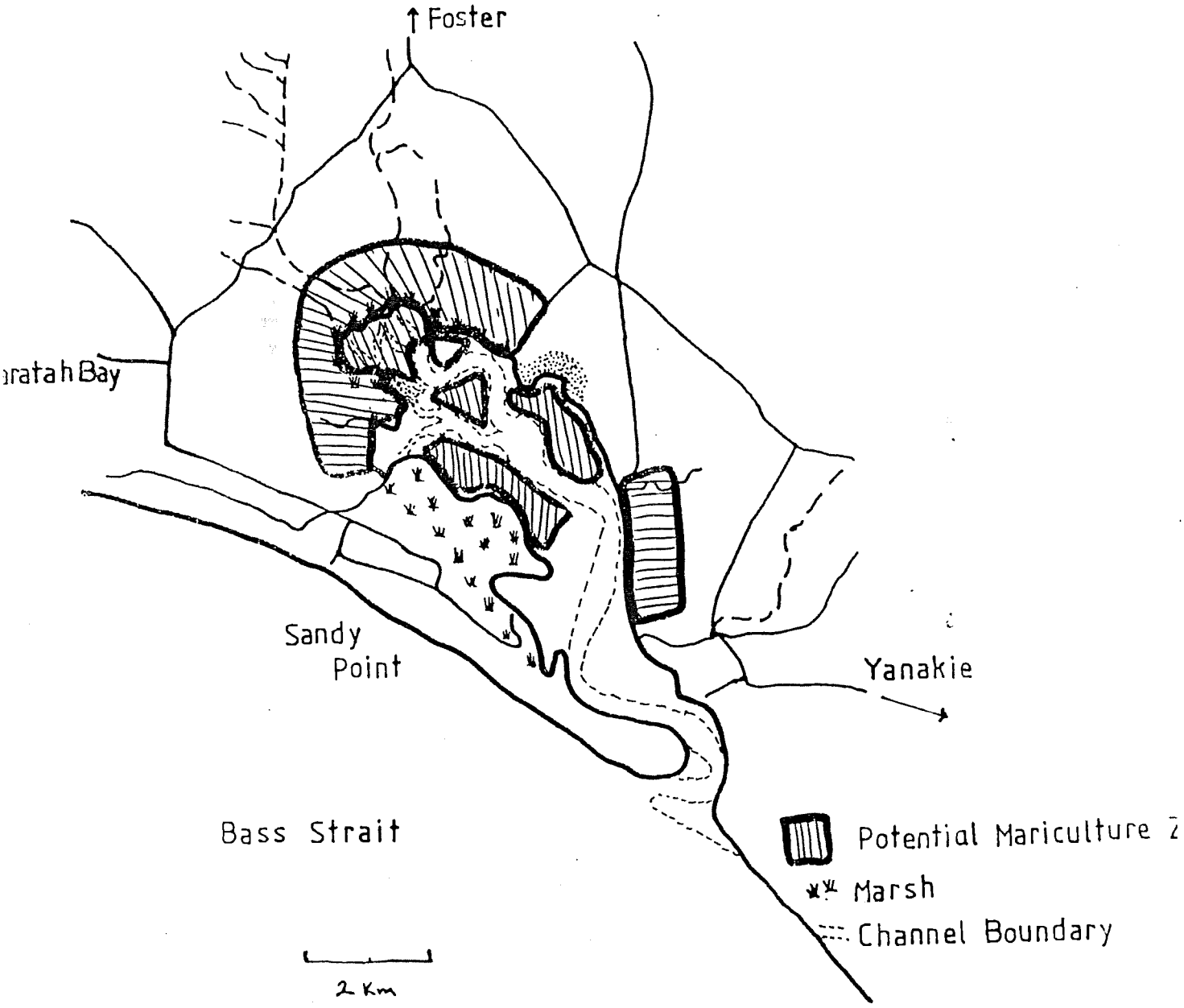
Social Considerations The predominant use of the inlet is for recreational fishing. Land use has minimal impact on the inlet. The mudflats are biologically significant as they support large areas of seagrass and are utilised by wading birds. At high tide the flats are also utilised by juvenile fish as feeding grounds. For these reasons the inlet has been proposed as a marine and wildlife reserve. Mariculture would be a compatible use in the reserve, provided operations do not interfere with the general mudflat ecology. Conflicts with other uses are expected to be minimal as the mudflats are little used by existing recreational or commercial interests.

MARICULTURE PROSPECTS

The inlet has considerable potential for intertidal shellfish farming and land based farming. There are no suitable sites for offshore culture. Shellfish suitable for culture are the native oyster (*Ostrea angasi*), the Pacific oyster (*Crassostrea gigas*) and the Sydney Rock oyster (*Crassostrea commercialis*).

SHALLOW INLET

Fig 11.



An experimental intertidal oyster farm operated in the inlet on an area of mudflat near the caravan park during the early 1970's. This was based on the Sydney rock oyster and the operators claimed growth and survival rates were good. The venture was discontinued although no information as to why is available.

i) Intertidal Shellfish Farming

The stable mud/sand flats of the inlet are suitable for shellfish farming. Access to all areas of the inlet is excellent at all states of tide. The most suitable areas are on the western and northern sides away from the entrance. The entrance region is most heavily used and mariculture here would conflict significantly with other uses. The area suitable for intertidal shellfish culture is approximately three square kilometers, as shown on the accompanying map. Potential - very good.

ii) Land Based Mariculture

Land bordering the inlet is suited to both extensive and intensive mariculture. The crown land fringe around the lake is proposed as a wildlife reserve and mariculture in this area will not be permitted. However, suitable freehold land exists behind the crown land in the north west and north and mariculture is appropriate here provided the operation does not affect the ecology of the reserve. Soil type is predominantly sandy loam and importation of suitable soil would be required for construction of ponds.

The available area is approximately six square kilometers. This suggests intensive farming is most suited. Water treatment would be necessary for all water re-entering the inlet. Access via existing roads is good and power is available. Water supply would require pumping across the wildlife reserve. Potential - very good.

GOVERNMENT POLICY

Environment Protection Authority The EPA has no formal policy on the water quality of Shallow Inlet. A permit to discharge into the inlet would be required.

Ports and Harbours Division Although the inlet is not a recognised port, the Ports and Harbours Division require that mariculture structure do not affect navigation in recognised waterways and that structures be suitably marked.

Land Protection Service The Service does not consider mariculture to be a suitable use for the crown land presently being considered for the wildlife reserve. This policy is also held by the Fisheries and Wildlife Service and National Parks Service which will manage the proposed reserve. A special permit would be required to run water supply pipes across crown land.

Shire of South Gippsland The Shire supports mariculture development provided such development does not significantly interfere with existing uses of the inlet.

') ANDERSONS INLET

Andersons Inlet covers approximately 24.5 square kilometers. It is characterised by large areas of sand and mud flat exposed at low tide and a single channel of varying depth leading to the mouth of the Tarwin River. The mixing of water in the inlet is complex and is dependent on wind, storm surge and flooding. The entrance is permanently open though a shallow sand bar extends across it. The channel depth varies between 3 and 6 metres. The Tarwin River enters the inlet in the south eastern corner and is the major freshwater input. A number of small creeks and drains enter the inlet from the farmed hinterland though flow is generally insignificant.

The catchment area of the inlet is large, extending to Leongatha in the north and Fish Creek in the east. The hinterland is considerably modified and land use is dairying in the hills and cattle and sheep grazing in the coastal region. The town of Inverloch is located on the north side of the entrance and has a considerable residential area and some light industry. There is a large influx of seasonal residents during holiday periods. The small village of Tarwin Lower is located at the mouth of the Tarwin River and has a small permanent population and a large number of seasonal residents.

The inlet is moderately exploited by commercial fishermen and heavily used by recreational fishermen. A number of offshore fishing vessels moor at Inverloch as well as some inlet fishing boats. Methods used by fishermen in the inlet are beach seining and gill netting. Commercial fishing is concentrated in the channel region. Recreational fishing is extremely popular in the inlet and is conducted in the channel at low tide and all waters at high tide. Boats can be launched at both Inverloch and Tarwin Lower. Small boat sailing and water skiing are extremely popular in the vicinity of Inverloch. Wind surfing is increasing in popularity and is mainly done in the Inverloch area. Swimming is popular in the entrance area. The intertidal flats are used by anglers to collect bait and by fossickers. The inlet area has been modified over the past century. The entrance has been dredged and an exotic grass species, Spartina, was introduced on the shoreline to control erosion. Spartina is now well established in the inlet and is transforming some intertidal areas to saltmarsh.

Maricultue prospects in the inlet are limited to intertidal shellfish farming and landbased farming as there are no areas deep enough for offshore culture. Large areas of sand and mud flat are suitable for shellfish farming. The inlet is fringed by a narrow belt of crown land and behind this to the north there are areas of freehold land suitable for mariculture.

GENERAL CHARACTERISTICS

Rainfall

Tarwin Lower (monthly average in mm)

J	F	M	A	M	J	J	A	S	O	N	D	Total
54	44	72	94	93	106	93	95	104	91	67	70	983
	Inverloch											
51	45	68	100	87	120	92	101	87	96	74	55	976

Heavy localised falls contribute to minor flooding in the surrounding creeks. Rainfall in the catchment is considerably higher than on the coast and the large catchment of the Tarwin River results in regular flooding.

River Discharge The Tarwin River, at Meeniyan has the following characteristics.

Annual Flow (ML)			
Mean	Max	Min	Max Flow/Day (ML)
275,000	467,000	73,000	18,200

Salinity Under normal conditions, stratification of the channel is pronounced. At low tide a salt wedge forms, with freshwater influence extending to approximately three kilometers from the entrance. At this point surface salinity in the channel can be as low as 25‰ while bottom salinity approximates 30‰. Midway along the inlet surface salinity is about 20‰ with bottom salinity of 27-28‰. At the mouth of the Tarwin River, surface salinity averages 5‰. At high tide, salinity is 35‰ in the lower half of the inlet. Approaching the mouth of the Tarwin River salinities decline to approximately 10‰. During flooding, the upper half of the inlet is 0-10‰.

Winds Winds are mostly westerly, with easterlies and north westerlies occuring less frequently in winter. During summer, westerlies and easterlies predominate with south westerlies less common, though they are characteristically the strongest winds. South westerly winds induce storm surge in Bass Strait which strengthens the tidal effect in the inlet. At high tide, south-west winds generate a short wavelength chop which increases suspended solids, particularly in the mudflat area. However, the physical effect of waves would have a minimal effect on intertidal mariculture.

Land Use Land use in the area surrounding the inlet is farming, primarily cattle and sheep grazing. Light industry is based at Inverloch. The town has residential housing boardering the inlet and a caravan park on the foreshore to the east. The northern shore is undulating grazing land. A number of small creeks enter the inlet in this region. Except for Townsends Bluff and Nolans Bluff, the land is generally low and sandy beaches form the coastline. At the mouth of one of the small creeks there is a large mangrove stand.

The mouth of the Tarwin River is characterised by low marshland. The town of Tarwin Lower borders the southern bank of the river and only few houses boarder the southern shore of the inlet. Part of the southern shoreline of the inlet has of a levee bank which restricts king tide inundation of the marshland. The southern shore is stable sand dune and is little used. Most of the land on the southern shore is incorporated in a coastal reserve.

Contaminants Tidal exchange ensures rapid turnover of inlet water and therefore water quality is high.

Some input of fertilisers, herbicides and pesticides would occur through the Tarwin River though to date no significant concentrations have been recorded. Some septic seepage from Tarwin Lower and Inverloch would be expected though tidal exchange would rapidly dilute and disperse any contamination from this source.

Commercial Fishing Use of the inlet for commercial fishing is moderate with the main fishing methods being seine netting and gill netting. Commonly caught species are australian salmon, ruff and yellow eye mullet.

Recreationl Fishing Amateur angling is very popular in Andersons Inlet. Launching facilities are available at Inverloch and Tarwin Lower. Inverloch is also a launching point for many offshore anglers. Boat fishing is the most common as shore access to most of the inlet is difficult. At low tide, fishing is restricted to the channel but at high tide mudflats are also fished. Fish commonly caught are whiting, australian salmon, flathead, trevally and flounder.

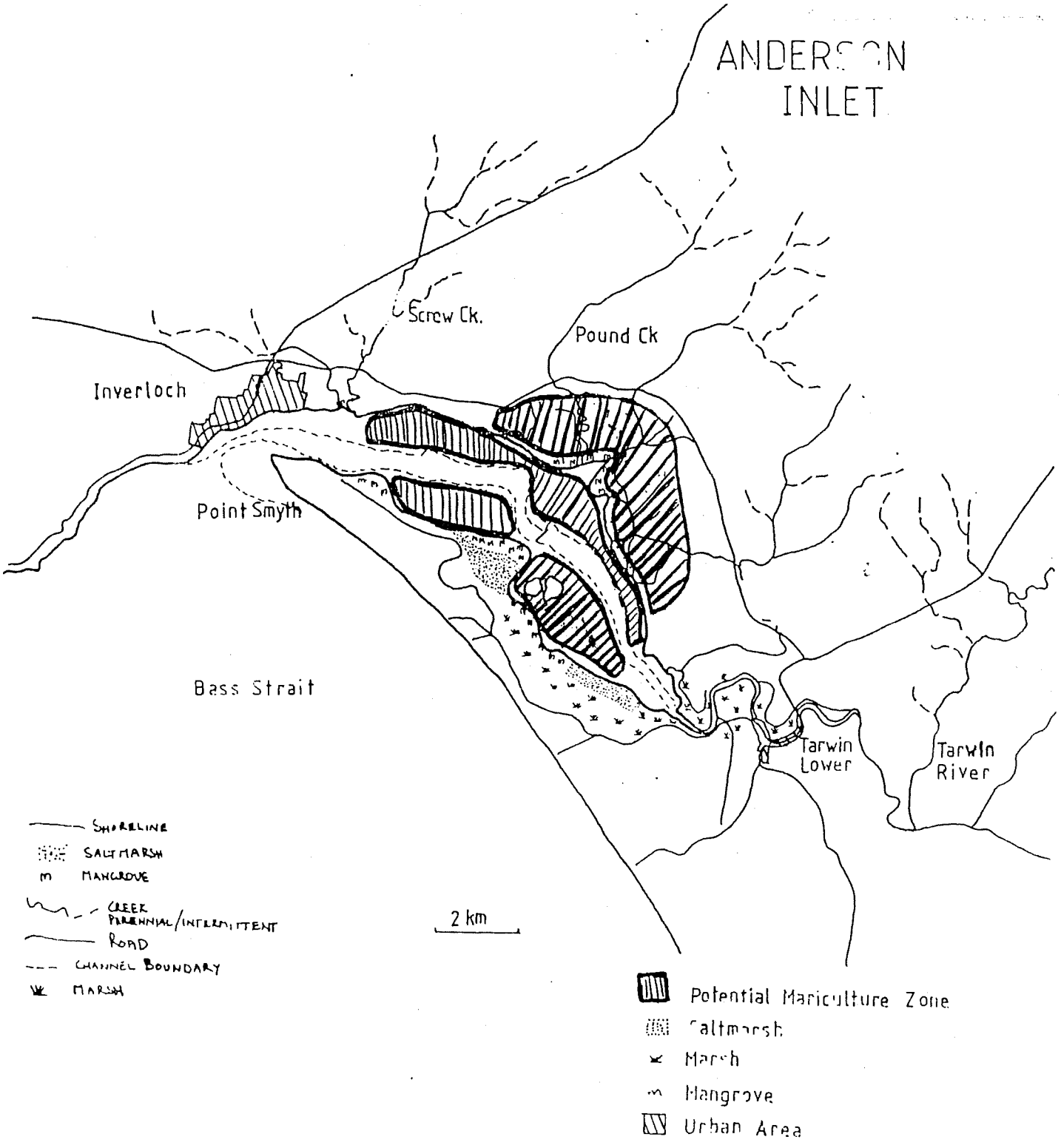
Other Water Uses Small yacht sailing is popular during the summer months utilising the seaward reaches of the inlet at high tide and the wider channel areas at low tide. Some larger yachts are moored in the channel. Windsurfing is increasing in popularity near Inverloch. Power boating, other than recreational fishing, is limited predominantly to the small channel area. Swimming is popular near Inverloch as the inlet beach is sheltered. Fossicking and bait collecting is common on the sand flats near populated areas.

Social Considerations Anderson's Inlet is a significant biological habitat as its mangroves and intertidal flats support many forms of life. Many fish species such as bass and estuary perch breed in the area and it supports migratory waders and other water birds. Anderson's Inlet has therefore been declared a Wildlife Management Co-operative Area, managed by the Fisheries and Wildlife Service in consultation with other Government agencies. The aim is to protect existing wildlife while permitting suitable uses which have minimal effect on the environment. Interdidal mariculture is compatible with this aim.

MARICULTURE PROSPECTS

Only two forms of mariculture, intertidal shellfish farming and land based mariculture, have potential in Anderson's Inlet. Species suitable for intertidal shellfish farming are the Sydney rock oyster (*Crassostrea commercialis*) and the pacific oyster (*Crassostrea gigas*). The native oyster is unsuited to the inlet as it does not grow in estuarine conditions.

Fig 12.


ANDERSON INLET
Screw Ck.
Pound Ck
Inverloch
Point Smyth
Bass Strait
Tarwin Lower
Tarwin River
2 km
SHORELINE
SALTMARSH
MANGROVE
CREEK PERENNIAL/INTERMITTENT
ROAD
CHANNEL BOUNDARY
MARSH
Potential Mariculture Zone
Saltmarsh
Marsh
Mangrove
Urban Area

i) Intertidal Shellfish Farming

The stable sand and mud flats offer a suitable environment for oyster culture.

Access to all areas of the inlet is excellent from the channel at all tides. Suitable sand flat areas exist both north and south of the channel. The transition point from sand flat to mud flat is approximately mid way along the estuary and also represents the point where a significant salinity change occurs. Sydney rock oysters have the greatest potential for culture on the mudflat region. Both this species and the pacific oyster are suitable for culture in the sand flat zone. Suitable areas for culture are shown on the attached map. Potential sites around the entrance are omitted due to the considerable existing and conflicting uses in this area. Potential area is approximately nine square kilometres. Potential - very good.

ii) Land Based Mariculture

Land bordering the southern shore is unsuited to land based mariculture as it is predominantly stable sand dune. This land forms part of a coastal reserve.

The northern shoreline has a narrow coastal strip of crown land behind which there are large areas of suitable freehold land. The zone between Townsend and Nolan Bluff is most suited as it is low lying, has a number of small channels extending from the shore to the main channel and the soil is suitable for pond construction. Potential area available is approximately 5 square kilometers. Access to the area is excellent and power is readily available. Water supply to farms here would require pumping across crown land reserve. Potential - good.

GOVERNMENT POLICY

Environment Protection Authority The Environment Protection Authority considers water quality to be suitable for production of mulluscs, crustaceans and fishes for human consumption. A licence to discharge water into the inlet would be required from the EPA.

Ports and Harbours Division Inverloch is a designated port and the Ports and Harbours Division has control over structures located within the inlet. A permit is required to erect intertidal structures. The Division does not favour development adjacent to the entrance where there is heavy recreational use.

Land Protection Sevice The Service considers land based mariculture to be a suitable use for some of the uncommitted crown land on the northern shore of the inlet. A permit will be required for any pumping or piping structures that are located on or traverse crown land. Land based farming is not considered compatable with the oceanic shoreline which is largely committed as coastal reserve.

Shire of Woorayl The Shire supports the development of mariculture in principle subject to suitable environmental standards being maintained.

L) WESTERNPORT BAY

Westernport Bay is the second largest embayment on the Victorian coastline. The water surface area is 680km^2 of which 270km^2 is intertidal mudflat. French and Phillip Islands are located within the Bay. There are two entrances, the western one between the town of Flinders and Phillip Island, having most tidal exchange. The eastern entrance is small and tidal flow through it reaches only the south east corner of the bay. The net circulation of water in the bay is clockwise around French and Phillip Islands. Tidal heights increase progressively from 1.6 m to 2.2 m. The general sediment characteristic is sand at the entrances grading to fine silt and clay/mud in the northern portion. Intertidal mudflats predominate in the northern portion. The channel through the western entrance divides into an eastern channel passing between French and Phillip Islands and along the eastern shore of the former and a northern channel passing to the west and north of French Island. From these channels run a large number of smaller channels. Tidal currents in the channels are strong, at times exceeding five knots (Westernport Bay Environmental Study 1973).

Industrial development has occured on the western shore in the Shire of Hastings. This area now supports oil refining, gas fractionation, steel processing and many light industries. Related to the industrial activity, port facilities have been established and are regularly used by large commercial ships. Channels are dredged regularly. Land use in the greater part of the catchment is agricultural (68%), while forests cover a further 20% of the area. Urban areas occupy approximately 2% of the catchment. Industrial development is generally associated with the coast and covers approximately 20 kilometers of coastline in the vicinity of Hastings.

Land use on Phillip Island is predominantly agricultural though there is a considerable permanent population and seasonal influx of tourists. French Island is predominantly forested crown land with some freehold farms. The permanent population of the island is small.

The shore has extensive areas of saltmarsh and mangroves. The intertidal mudflats are covered with seagrasses, though these have declined over the past five years. The intertidal area is suffering from increased erosion caused by loss of the stabilising seagrasses and water turbidity is increasing. Mudflat areas are significant as habitats for juvenile fishes and many wading bird species. The commercial and recreational fisheries in the bay are important with the commercial component stable and the recreational component increasing. Native oysters are abundant in the bay and in the past were exploited commercially.

Prospects in the bay are very good for both intertidal and land based mariculture. Offshore culture potential is limited to a small number of sites.

GENERAL CHARACTERISTICS

Rainfall The average yearly rainfall over the bay and the immediate coastline is 800 mm. Average monthly rainfall (mm) at Cowes is as follows:

Month:	J	F	M	A	M	J	J	A	S	O	N	D	Total
Rainfall(mm)	44	44	57	69	76	78	75	74	69	68	58	52	764

Rainfall in the outer area of the catchment to the north and east is considerably higher , varying between 1000 and 1400 mm.

The catchment to the north includes the Great Dividing Range and that to the east includes the Strzelecki Ranges.

River Discharge The catchment areas of the major rivers are large and generally extend to the heavy rainfall belts of the mountains. Flows are generally low, however high rainfall can lead to significant flooding.

River	Seasonal Flow Total Flow ML				MEAN DAILY FLOW ML				YEARLY MEAN	
	Summer	Autumn	Winter	Spring	S	A	W	S	Flow	Daily
Bass	811	7794	32595	13375	9	78	354	147	54575	150
Lang Lang	1473	8056	35917	23184	16	87	390	252	68630	187
Bunyip	6961	12346	33803	47608	77	134	367	523	100718	274
Cardinia	354	3140	9048	5033	4	23	98	55	17575	49
Langwarrin	5	1166	2815	2120	<.1	13	31	23	5106	14
Stony Creek	73	494	1320	503	0.8	5.5	14.4	5.5	2390	6.4

Lang Lang and Bunyip Rivers therefore contribute most freshwater to the bay.

Temperature Range Mimimum and Maximum means at Cowes are as follows:

Month	J	F	M	A	M	J	J	A	S	O	N	D
Mean Max^{o}C	24.1	24.4	22.7	19.3	16.4	13.7	13.2	14.3	16.4	18.4	20.1	22.6
Mean Min^{o}C	13.3	14.1	13.8	11.2	9.5	7.8	7.0	7.3	8.4	9.4	10.6	12.3

Water Quality of River Inflows The Westernport Bay Environmental Study (1973/74) examined quality of input from a number of drains. The overall quality was good though inputs from a number of drains off the Koo-Wee-Rup plains have bacterial levels occasionally exceeding 1000 E.coli cells/100 ml water. Bacterial levels are considerably lower in the bay and fall within health limits. Heavy metal concentrations are well within EPA ranges. Herbicide and pesticide concentrations in the water are low, the former being non detectable and the latter in the order of 0.02 kg/day.

Physical characteristcs Net water movement through the bay is complex with most water entering and discharging through the western entrance. A net circulation from west to east of 24×10^6 m^3 per tidal cycle flows in through the western entrance around Phillip Island and out through the eastern entrance at San Remo. A weaker net clockwise flow of 4×10^6 m^3 flows around the top of French Island.

The morphology of the bay is complex and a number of zones are evident. On the landward edge there is the beach/cliff/rock platform and saltmarsh zone. Proceeding seaward are the mangrove zone, the inshore marginal sandy zone, the intertidal flats and banks, the offshore banks and shoals, the embayment plains and the tidal channel system. The mangrove zone is extensive, though generally narrow and lies just below the high water level. The inshore marginal sandy zone is a narrow band around the bay sloping gently outwards to the tidal flats. The intertidal flats and banks is the biggest zone in the bay, occupying 35% of the area. Three morphological types occur, elongate flats along channel margins, small isolated flats and extensive embayment head flats. The seaward margin of the flats generally descends steeply into channels. The offshore banks and shoals are mostly subtidal and relatively grass free. The embayment plains are subtidal and have a low irregular relief and slope gently towards the tidal channels. The tidal channel system comprises the minor channels of the embayment head and isolated tidal flats and the main channel trunk systems.

Sediment characteristics of the bay are determined by tidal currents. The major channels are predominantly sand with a gradation of particle size related to current strength, coarser sands being common in areas of high velocity. The sediments of the intertidal flats vary with area. In the west between Stony Point and Hastings Bight sediments are predominantly sandy clay. Between Hastings Bight and Warneet they are mainly silty sand and clay sands. East of Warneet to Corinella sediments vary between clay, silty clay and clay sands. The area near the east entrance north of San Remo is a mixture of clay sands, silty sand and clays.

Salinity Freshwater inflow to the bay is insufficient to establish a normal estuarine regime and the bay's circulation is dominated by tidal exchange.

During all seasons except summer, the salinity steadily decreases further up the bay from the entrance. Salinity is lowest in the north east and eastern regions. Dilution is low and salinity seldom falls below 30‰. Maximum and minimum salinities at various locations are listed below.

Location	Maximum Salinity ‰	Minimum Salinity ‰
Stony Point	36.5	34.8
Hastings Channel	35.5	35.0
East of Crawfish Rock	37.3	32.5
Channel West of Lang Lang	37.5	31.5
Main Channel North East of Corinella	38.5	29.5
North of Churchill Island	37.0	33.0

Lower slainities will occur at the mouths of rivers at low tides and during floods.

Temperatures Water temperatures vary with depth and area. The yearly temperature range at the entrance is similar to Bass Strait temperatures of 13°C to 19.6°C. In the shallow intertidal areas, temperatures range between 9.9°C and 22.4°C.

Contaminants The presence of contaminants, heavy metals and organic compounds in Westernport Bay biota are below the National Health and Medical Research Council's guidelines for shellfish for human consumption. Water and sediment concentrations of contaminants are also below health limits. Areas of higher than average heavy metal concentrations are confined to some industrial outputs and river inflows. Hydrocarbon concentrations are low and are within health limits.

Nutrients Nutrients are important as they are necessary for phytoplankton growth which provides food for filter feeding organisms.

Silica concentrations in the bay are highest in the intertidal areas (interstitial waters of the sediments have concentrations 60 times higher than Bass Strait seawater). The sources of silica are sediments and freshwater inputs. The range of dissolved silicates occurring in Westernport Bay is from 31 to 700 mg m^{-3}, considerably higher than coastal waters which vary between 0 and 20mgm^{-3}.

Phosphorus concentrations in the bay, as orthophosphate and total phosphorus vary considerably. Total phosphorus varies between 8.7 and 29.3 ug/l. The intertidal areas in the northern reaches of the bay have higher concentrations than seawater. Orthophosphate concentrations range between 2.5 and 9.9 ug/l over all parts of the bay.

Inorganic nitrogen as ammonium, nitrite and nitrate in varying quantities enter the bay from Bass Strait, stream discharge, seepage from interstitial water and the decay of biological material. Ammonium is the predominant form and there is little variation within the bay. Seasonal variation is from 15 to 25 ug/l. Nitrate levels in the bay are variable between 2 and 6 ug/l. The source is mostly from freshwater streams.

Dissolved Oxygen Dissolved oxygen concentrations are generally close to saturation in most parts. Oxygen levels can decline over the mudflat areas and this drop is associated with decay of plant material.

Productivity Chlorophyll a concentration is an index of phytoplankton production within the bay. The observed range is from 0.03 to 5.5 mg/m^3 with the lower values occuring near the entrance. The figures indicate that there is a good food supply for filter feeding organisms.

Peripheral Vegetation The coast of Westernport Bay is significant as the peripheral vegetation is largely unmodified. Large areas of saltmarsh, melaleuca scrub and mangrove fringe the shoreline. Some areas of existing coastal vegetation are incorporated into wildlife and crown land reserves. The significance of these habitats, particularly the saltmarsh fringe, precludes their use for land based farming.

Seagrass and Macrophytic Algae These groups, growing on the mud and sand banks, have a large biomass and high primary productivity. Most common species are Zostera muelleri, Heterozostera tasmanica and Amphibolus antarctica (seagrasses) and Caulerpa cactoides (algae). The area covered by these species has declined over the past years though the cause for this is unclear. Seagrasses maintain the stability of mudflats and an increase in water turbidity has been associated with erosion of mudflats which have lost their seagrass cover. The location and operational managment of any intertidal shellfish farms will need to consider the sensitivity of the seagrass beds.

Zooplankton The zooplankton of Westernport Bay is dominated by two species of copepod, Acartia clausi and Paracalanus parvus. Zooplankton standing crop is low in Bass Strait and increases further into the bay. Population densities are highest in spring/early summer and reach a low point during winter. The value of naturally produced zooplankton as a food source for cultured fishes is low for part of the year and an alternate source of food would be required.

Benthos The benthos of Westernport Bay is very diverse, indicating an unstressed environment. Benthic grab surveys showed the dominant groups to be the polychaeta and crustacea. They accounted for 80% of collected individuals whilst the next most abundant group was the mollusca. Difference in the distribution of the benthos correlates with sediment type, some species being common on sand or mud and other species ubiquitous. The native oyster Ostrea angasi and a number of cockles including Anadara sp are commonly found in the bay. The native oyster formed the basis of an important fishery in past years.

Fishes The bay is an important spawning and nursery area for many fishes including a number of commercially important species. Additionally many species seasonally migrate into the bay. A feeding analysis of some commercial species, noting important food sources, is given below.

Species	Food source. (decreasing importance)
Garfish	Seagrass, amphipods, detritus, polychaetes.
Mullet	Algal macrophytes, amphipods, plankton, polychaetes.
Leatherjacket	Algal macrophytes, detritus, amphipods, other crustaceans, seagrass.
Whiting (K.G.)	Crustacea, polychaetes, detritus, amphipods.
Flounder	Polychaetes, crustacea, seagrass, detritus, amphipoda.
Rock Flathead	Molluscs, crustacea, polychaetes, amphipods.
Blue Sprat	Plankton, detritus, amphipods.

Commercial Fishing Westernport Bay supports a large commercial fishing industry. Fishing ports in order of importance are Hastings/Stony Point 30%, San Remo 20%, Corinella 15%, Tooradin 12%, Cowes/Rhyll 10% and Newhaven 10%. (These figures include production from Bass Strait).

Fishing methods used in the bay are mainly gill netting, seine netting and longlining. Fish contributing to the commercial catch are king george whiting, sea garfish, rock flathead and yellow eye mullet. Annual catch varies between 200 and 300 tonnes.

Recreational Fishing Recreational fishing is a major activity in Westernport Bay. A breakdown fo fishing type shows 83% of fishermen use boats, 1% fish from shore and 16% from jetties (Beinssen 1978). Target fish species for anglers in Westernport are king george whiting, rock flathead, and snapper. The available figures of number of fish caught per hour fished shows boat fishing is the most successful returning 0.34, jetty fishing follows with 0.17 and shore fishing near zero. During the four month study period a total of 256,000 fishing hours and a catch of 80,000 fish were estimated.

The most favoured fishing sites in the bay are in the channels and at high tide fishing extends over the shoals and tidal flats. King george whiting are caught most often over the seagrass beds. Launching facilities for boats are available at Flinders, Stony Point, Crib Point, Hastings, Warneet, Cannons Creek, Tooradin, Corinella, San Remo, Newhaven, Rhyll and Cowes. All points of the bay can be reached from these ramps. Recreational fishing is increasing and the bay's proximity to Melbourne suggests this trend will continue.

Other Water Uses Westernport Bay provides port facilities for deep draught shipping at Crib Point and Long Island. A swing basin for shipping waiting for berth space is sited between Stony Point and Cowes. Deep draught shipping is restricted to the western entrance and north arm as far as Long Island point. A ferry service operates between Stony Point, Tankerton and Cowes and a vehicular barge operates between Corinella and French Island.

Nine yacht clubs operate within the bay and are located at Warneet, Hastings, Balnarring Beach, Somers, Cowes, Merricks, Rhyll, Newhaven and Point Leo. An extensive marina complex, Westhaven, is currently being constructed on the tidal flats at Hastings. "Off beach" sailing is extremely popular at Somers, Merricks and Balnarring beaches. Power boating within the bay is also popular.

The most popular recreation beaches lie between Shoreham and Somers and Cowes and Ventnor. These beaches are sheltered, safe and are popularly used by family groups. Swimming is popular as is windsurfing. The beaches of Point Leo and Shoreham are also suited to surfing. The coastline north of Stony Point to Warneet, east to Lang Lang and South to San Remo is predominantly mud and is little used for swimming. Small areas of sandy beach, both natural and man made are located in this zone.

Land Use The dominant use for the catchment is agriculture 68%, of which industries in order of importance are dairying, orcharding, grazing and market gardening. The next largest use is forestry (20%).

The coastline between Flinders and Stony Point supports grazing and a number of holiday towns are located here.

Between Stony Point and Long Island Point there are industrial and urban areas. Industry includes oil refining, gas fractionation and steel milling. Hastings has considerable light industry. The remainding coast is predominantly used for agriculture. French Island has agricultural land and some scrub forest on crown land. Phillip Island is predominantly agricultural land with some urban areas.

Social Considerations During the 1960's when industrial development was rapid, little consideration was given to the environmental quality and significance of the bay. During the late 1960's and early 1970's policy changed and the environmental implications of development were examined.

Environmentally sensitive areas have been identified and protected as Crown Land Reserve or Wildlife Reserve. The most sensitive areas are Rhyll swamp and mudflats, Tortoise Head and surrounding mudflat on French Island, the natural scrubland on the north shore of French Island and the mudflats from Barriliar Island to the mainland at Lang Lang jetty, the area around Quail Island and the scrubland and mudflats of Sandy Point/Hanns Inlet. Most of these sites (and others) have been declared Wildlife Management Co-operative areas managed by the Fisheries and Wildlife Service and the Ports and Harbours Division. Within these areas development is allowed provided the wildlife value of the area is protected. Much of the coastal crown land is gazetted coastal reserve, state park or flora and fauna reserve. Most of the crown land of French Island is State Park and the Bass River estuary is a fauna reserve.

Preservation of most of the bay area is of paramount importance as it supports a large nursery area for fishes, is a significant wildlife habitat particularly for wading birds and is of high aesthetic value.

MARICULTURE PROSPECTS

The mariculture prospects of Westernport Bay are very good, particularly for land based and intertidal mariculture. Prospects for offshore mariculture are limited by available area and unfavourable physical conditions. Intertidal mariculture is limited in scope by sediment condition, however a considerable area is suitable. Land based mariculture is restricted by availability of suitable crown land with access to water, however a considerable area is suitable.

i) Intertidal Shellfish Farming

Species suitable for shellfish farming are the native oyster, Ostrea angasi, the pacific oyster, Crassostrea gigas and the Sydney rock oyster, Crassostrea commercialis. Of these, the Pacific oyster is highly suited as environmental conditions are ideal. Salinities are probably too high for successful reproduction of the species. The native oyster commonly occurs in the bay and would be well suited to cultivation. The Sydney rock oyster would suffer from winter mortalities at this latitude, however if a cold tolerant strain is developed, it would be well suited for cultivation here.

The selection of potential zones for intertidal shellfish farming is based on the suitability of sediments to support structures, avoidance of environmentally sensitive intertidal flats and ease of access.

West Coast Suitable areas of intertidal mudflat begin north of Stony Point extending to Crib Point. Sediments are a clayey sand or sandy clay. Existing uses of the intertidal zone here are few and the area is not considered a significant habitat. Available area is approximately 1.5 km^2. Potential - good.

Sediments in Hastings Bight are sandy clay and are suitable substrate for supportive structures. Conflict with existing uses are few as boating access to Hastings is via a well marked channel. The development of the Westhaven marina will increase boating activity in the area and much of the intertidal area to the south of the existing channel has been dredged. The recommended zone for mariculture in Hastings Bight is an area to the east of Sandstone Island and the intertidal area to the north of the existing channel. Potential area is approximately 2 km^2. Potential - good.

The most suited area on the west coast is the intertidal flat between Lysaght Jetty and Watsons Inlet. Sediments in this region are suitable for supporting mariculture structures as they are a mix of silty sand and clayey sand. Access is available from Hastings or Yaringa. Suitable area is approximately 2.5 km^2. Potential - very good.

North Coast Most intertidal areas here are included in the Wildlife Management Co-operative Area.

Watsons Inlet is well suited to intertidal shellfish culture as the sediment type is predominantly sand and silty sand. Access is available from Yaringa and the channel extending into the inlet. The construction of shore based facilities will be restricted to the Yaringa area as the foreshore in Watsons Inlet is a reserve. Suitable sites are located on both sides of the channel and the potential area is approximately 1.5 km^2. Potential - very good.

Sediment type in Rutherford Inlet is predominantly sand and is well suited to intertidal shellfish culture. Warneet and Cannons Creek provide good access to the intertidal zone. Suitable potential sites exist on both sides of the well defined channel and approximate area is 1.5 km^2. Potential- - good.

Sediment type in Tooradin Inlet and westwards is predominantly sand and is well suited to intertidal culture. The sandy strip in this area borders the coastline and transitions to clayey sand and clay further offshore. The width of the sandy strip varys between 500 and 1000 metres. Access to this zone is available from Tooradin and from the shore where a number of roads reach the coast. Extensive mudflats lie further offshore, however their suitability is low both because sediments are mainly clay and because they are significant wildlife habitats. The suitable potential area is approximately 3 km^2. Potential - very good.

East of Tooradin, sandy sediments boarder the coastline as far as the mouth of Yallock Creek. Offshore the sediments are silty clay and clay which are unsuited to intertidal culture. Furthermore, these flats are significant wildlife habitats. The coastal sand strip is well suited to intertidal culture however access from the land is limited and upgrading of land access is unlikely to be permitted under the guidelines of the coastal management policy. Potential area is approximately 7 km^2. Potential - very good.

East Coast The sediment types on the east coast are predominantly finer than those on the west, being mainly clay. However, sand sediments do occur in a number of areas. The area with greatest potential is the zone from Lang Lang Jetty to Stockyard Point. Access is excellent as a shoreline road connects these two points. Water access is limited as launching facilities at Lang Lang are tide dependent. Potential area is approximately 3 km^2. Potential - very good.

The remainder of the east coast is largely unsuited as sediment type is predominantly clay, water access is poor and existing land access is restricted. Small potential areas, approximately 1 km^2 at Corinella, approximately 2 km^2 at Cobbs Bluff and 1 km^2 at San Remo are the only remaining suitable areas. Sediment type at all these sites is clayey sand. Potential - good.

Phillip Island Intertidal shellfish culture on Phillip Island is possible on a narrow strip of clayey sand bordering the coast at Swan Corner. The coast is incorporated into a Wildlife Management Co-operative Area and is a significant habitat for wading birds. The strip of suitable sediment varies between 200 and 500 metres in width and makes up approximatiely 2% of the intertidal area. Shellfish culture should have a minimal impact on existing wildlife. Road access is good, however access from the sea is poor. Suitable available area is approximately 2 km^2. Potential - good.

French Island Areas suitable for intertidal shellfish culture are dependent on access from the mainland. Road access on French Island is very limited.

On the west coast the intertidal flats are predominantly sand sediments. They vary between 500 to 800 metres in width and are a significant habitat for wading birds. Access is available from Stony Point, Crib Point and Hastings. Utilisation of the inner tidal flat near the access points at Tankerton will have minimal impact on the wading bird populations. Potential area is approximately 3 km^2. Potential - very good.

On the north coast of the island, east of Bariliar Island, the sediments are predominantly sand and the flats are extensive. These flats are included in the Wildlife Management Co-operative Area. Access to the area is available from Hastings, Tooradin and Warneet. Potential available area is approximately 3 km^2. Potential - very good.

On the south east coast suitable sites exist opposite Corinella between Peck Point and the old Prison Pier. Sediment is a mixture of clayey sand and sand. Access is excellent from Corinella and the land in the vicinity of the barge landing at Peck Point, Red Bluff and the old Prison farm. Potential area is approximately 10 km^2. Potential - good.

The flats adjacent to Elizabeth Island are suitable for intertidal shellfish farming. Sediment type is clayey sand suitable for supporting mariculture structures. The area is included in the Wildlife Management Co-operative Area, however the larger wading bird populations are found to the west. Potential area at this site is approximately 1 km^2. Potential - good.

ii) Offshore Mariculture

Offshore mariculture prospects are limited by available space. Spatial conflicts occur at most sites and high current velocities restrict many suitable areas. The two suitable forms of mariculture are longline culture of shellfish and net cage culture of fishes. In addition to the three oyster species, Mytilus edulis is a suitable species. The species has been experimentally cultivated here in the past and growth rates were found to be very good. The experimental farm was abandoned when mussel culture leases became available in Port Phillip Bay. Fish species suitable for culture include chinook salmon, trout, snapper, whiting, flounder and mullet.

No sites are available in the west channel as current speeds are excessive and the channel is heavily utilised by shipping.

The northern side of French Island, in the lee of Bariliar Island and Crawfish Rock has an extensive area of deep sheltered water, little utilised commercially or recreationally. Water depth varies between 5 and 15 metres and bottom sediments are predominantly sand. Water exchange from the west channel is excellent and accumulation of waste materials under the farms would be minimal. There is available space for eight, 3ha lease sites in two groups of four. Potential - good.

Most of the eastern channel area is unsuited to offshore mariculture as currents are excessive. Spacial conflicts would be high near Corinella and Cowes/Rhyll and low in other areas. The major use of water in the area is recreational and commercial fishing. There is an expanse of deep water north of Rhyll and to the south of French Island which is well suited to offshore mariculture. Water depth averages 5-8 metres and shelter is good as the longest fetch is 5 kilometers. Oceanic swells do not reach this area of the bay. There is available space for a minimum of twelve, 3ha lease sites in three groups of four. Potential - good.

A small suitable area exists in the Western entrance adjacent to Flinders. Here the available area is limited by the oceanic swells. However, the small bay at Flinders is sheltered from most oceanic swells and water depth is about 6 metres. A suitable area for offshore mariculture occurs to the west of the pier where conflict with power boats, yachts and commercial craft is low. Sediment type is sand which would provide good anchorage for mariculture structures. There is sufficient space for four, 3ha leases in a single group. Potential - good.

iii) Land Based Mariculture

The low lying areas of coast with water access at all tides are economically most suited to land based mariculture as pumping costs are low and can be carried out around the clock. In all cases, a licence to discharge water into the bay would be required from the Environment Protection Authority.

Species suitable for land based culture are oysters, prawns, chinook salmon, trout, snapper, whiting, flounder and mullet. Both intensive and extensive culture methods are applicable to the area.

Flinders to Somers There is some potential for landbased farming along this section of coast. Land cost in this area is high as land is sought for residential and hobby farm development. A narrow crown land reserve exists along the coastline at this point and a permit would be required to run pipes across it. Water quality is high. Soil type is a mixture of sand and clays so ponds would require sealing. Intensive farming methods are most suited as land required for extensive farming would be very costly.

There are no sites available between Somers and Stony Point as this area is occupied by the navy. Potential - low.

Stony Point to Long Island Point Potential sites in this area are limited as it is largely urban or industrial and undeveloped land is mostly zoned coastal reserve. One area with development potential may be the site of the BP oil refinery following its shutdown in the near future. Water supply to the coast will be partly tide dependent, though there is an established seawater intake for the refinery which could be adapted to supply land based farms. Much of the land is zoned industrial and would be suitable for intensive mariculture. Potential - low.

Long Island Point to Warneet Most of the land in this area is zoned industrial and excepting a narrow coastal Crown Land Reserve is mainly freehold. The area zoned industrial is south of Yaringa. North of Yaringa the land is part of the Quail Island Faunal Reserve and is unsuited to land based mariculture. South of Yaringa the coast is fringed by scrubland and behind this fringe there is grazing land. Water supply to the coast is partly tide dependent. Soil type is mostly clay and is suited to both extensive and intensive farming. Water quality in the west channel is excellent. Potential - good.

Warneet to Tooradin A small area of coastline to the east of Warneet is suitable for intensive land based farming. The area is mostly uncommitted crown land, fringed by scrubland. Access is good via a foreshore road and water supply is tide dependent. The soil is predominantly sand and ponds would require sealing. The area is suitable for both extensive and intensive mariculture. Potential - good.

Tooradin to Lang Lang Jetty Extensive areas of uncommitted crown land suitable for mariculture exist in this region. The nature of the land is lowlying grassland behind a fringing saltmarsh transected by tidal channels linked to the creeks and drains of the Koo-Wee-Rup swamp. Water supply to the shore depends on the state of the tide, though water is always available in the creeks and drains. Access to this area is good from the South Gippsland Highway. Soil type is clay or sandy loam. The area is suited to both extensive and intensive mariculture and sealing of extensive ponds would be required. This area is the largest expanse of suitable land in the entire Westernport region. Potential - good.

Stockyard Point to Corinella To the east of Stockyard Point there is a narrow strip of uncommitted crown land which is suitable for land based mariculture. The available land area is narrow, so intensive farming has the greatest potential. Water supply is tide dependent. Soil type is a mixture of clay and sand and ponds would need sealing. The foreshore consists of salt flats transitioning to grassland. Potential - low.

Corinella to San Remo Potential land based culture sites are available on uncommitted crown land from south of Cobb Bluff to Stony Point. Access to this section of coast is excellent. Water supply is tide dependent. The land is low lying and is fringed by salt marsh. Soil types are sand and clay, indicating pond sealing would be required. The crown land strip is narrow and behind this strip there is extensive freehold land.

The remainder of the mainland coast is unsuited, generally by topography or existing uses. To the south of Stony Point, the Bass River estuary is a fauna reserve and the remainder of the coast undulates with little flat space suitable for ponds. Potential - good.

Phillip Island There are few suitable on-land sites on Phillip Island. The ocean shore is either cliff or sandy beach. The coast between Cowes and Cat Bay is physically suited though most of the land behind the shore reserve is zoned residential.

South of McHaffie Reef, suitable land exists. This land is mostly freehold and slopes gently so is well suited to intensive culture methods. Water quality is excellent and the intake area is sheltered. Some conflicts over land use would occur, predominantly between residential and mariculture uses. Potential - low.

The coastline from Rhyll to Churchill Island is lowlying marshland which has been mostly undeveloped. Adjacent to Rhyll, conflict exists as the swamp and scrubland is a significant wildlife habitat being a breeding site for ibis, spoonbills and cormarants. Swans and herons are common on the intertidal flats but are not common on the shore. Apart from the scrub and marshland in the north the land is poor quality freehold farmland. Soil type is sandy clay and would require sealing. Water quality is good however supply is tide dependent. The coast has a narrow band of crown land. Conflicting interests at this point are few, however development would be conditional upon operations having minimal impact on the existing environment. The potential area is small and intensive farms are most suited. Potential - moderate.

French Island Prospects for land based farming on French Island are moderate since access to the shoreline over most of the island is poor. Approximately 50% of the land is crown land which is soon to be designated as State Wildlife Reserve. The remaining 50% is freehold farmland which is mainly used for grazing.

The most suitable location is the area of freehold land on the north western corner where a constant water supply is available from the channel in the lee of Bariliar Island. Land access is also good at this point as the coast road connects Tankerton with the barge loading point on the far side of the island. The land gently slopes and soil type is sand or clayey loam. Additional sealing of earthen ponds would be required. This area is also the only one on the island where the crown land foreshore reserve does not extend to the waterline. Competitive interests are few and there are no significant wildlife habitats on this freehold land. Suitable area is approximately 2 km^2. Potential - good.

The east and northern coasts are considered unsuitable as the former is fringed by thick scrubland and the latter is crown land forming part of a proposed wildlife reserve.

A small area of suitable land exists on the south coast, to the east of Tortoise head. The status of the land is freehold with a narrow fringing strip of coastal crown land. Water access is good and is not tide dependent since a channel extends to the coast here. Topography is lowlying extending to undulating farmland and soil type is sand and clay. Additional sealing would be required for earthen ponds to prevent seepage. Road access to the site is good. There are no sites of biological significance in the immediate area. Suitable area is approximately 2 km^2. Potential - good.

On the east coast there are two sites with limited potential for land based farming. The first site covers approximately 2km^2 around the bay near Elizabeth Island. Water supply is good with channels reaching the shoreline and road access is also good. Land is freehold inshore from the narrow crown land coastal strip. Topography is low undulating cleared land with soil composition being clay and sand. Earthen ponds would require sealing. Conflicting interests are few as only the intertidal flats are significant wildlife habitats. Potential - good.

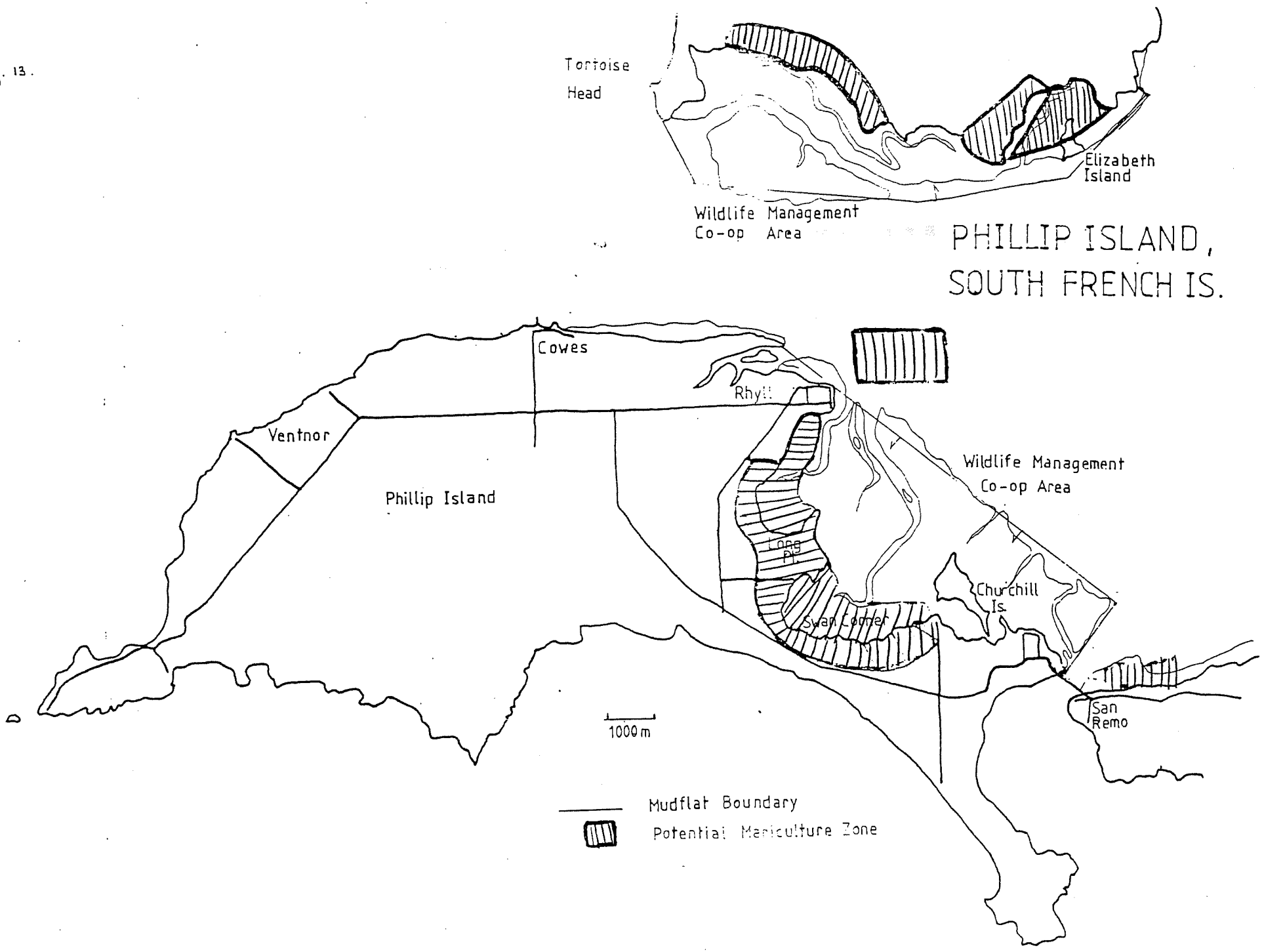
The second site on the east coast also covers approximately 2 km^2 between the former prison farm and the barge landing point. Water supply is fair, being tide dependent. Road access is good. The entire available area is crown land boardering the State Park. Soil type is clay/sand and topography is undulating. The land is only partly cleared and significant scrub stands remain. This area is presently uncommitted and mariculture may be permitted. Potential - low.

GOVERNMENT POLICY

Environment Protection Austhority The Environment Protection Authority considers water quality in Westernport to be suitable for cultivation of crustaceans, molluscs and fish. Mariculture is considered a relevant use in all waters of the bay.

Ports and Harbours Division The Ports and Harbours Division manage the waters of the bay as the Port of Westernport. The Division supports in principle the development of mariculture provided the sites do not significantly interfere with existing uses or pose navigational hazards.

Fig. 13.


Tortoise Head
Elizabeth Island
Wildlife Management Co-op Area
PHILLIP ISLAND, SOUTH FRENCH IS.
Cowes
Rhyll
Ventnor
Phillip Island
Wildlife Management Co-op Area
Long Pt
Churchill Is.
Swan Corner
San Remo
1000 m
Mudflat Boundary
Potential Mariculture Zone

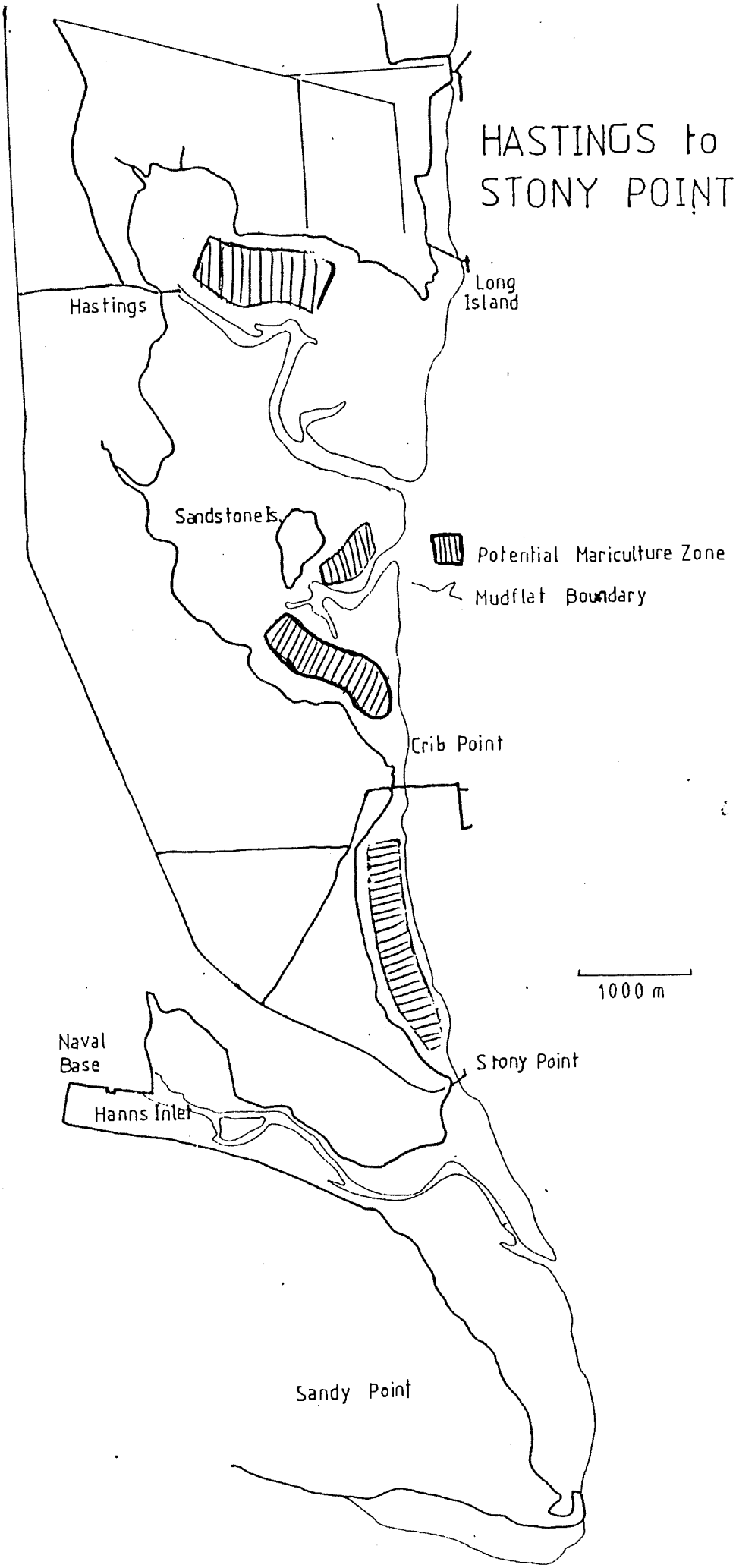

HASTINGS to
STONY POINT
Long
Island
Hastings
Sandstone Is.
Potential Mariculture Zone
Mudflat Boundary
Crib Point
1000 m
Naval
Base
Hanns Inlet
Stony Point
Sandy Point

Fig. 15.

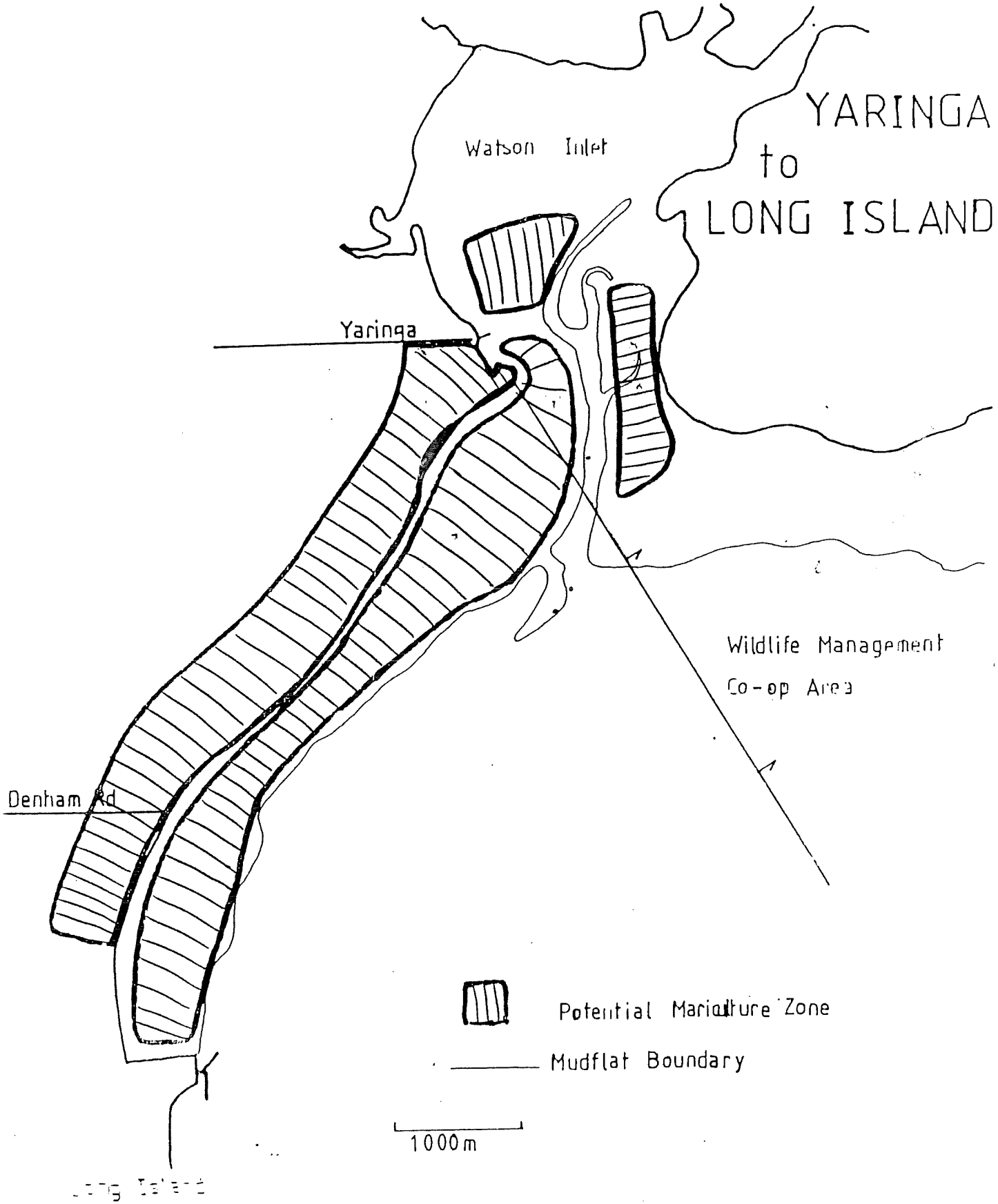

YARINGA
to
LONG ISLAND
Watson Inlet
Yaringa
Wildlife Management
Co-op Area
Denham Rd
Potential Mariculture Zone
Mudflat Boundary
1000m

Fig. 16.

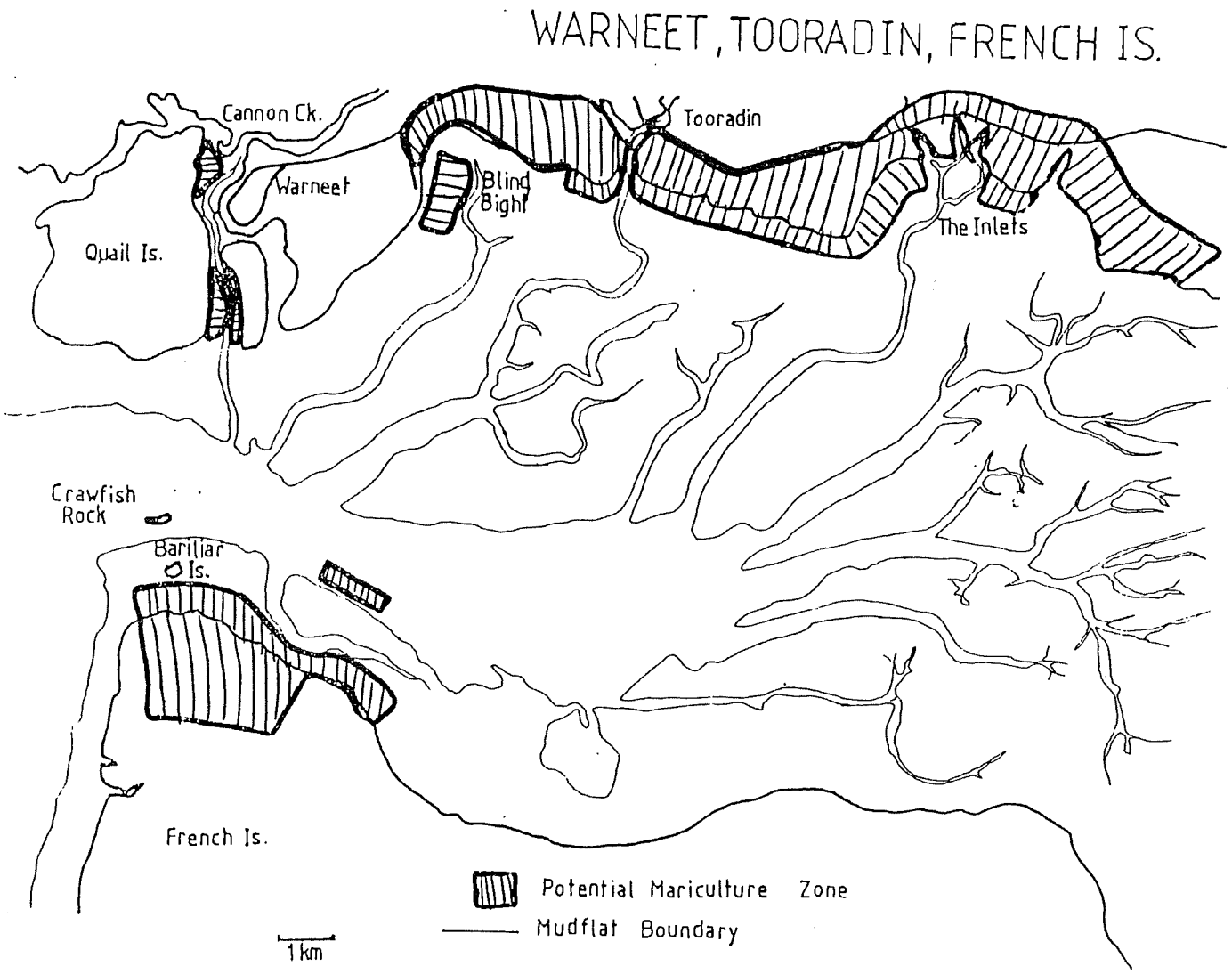
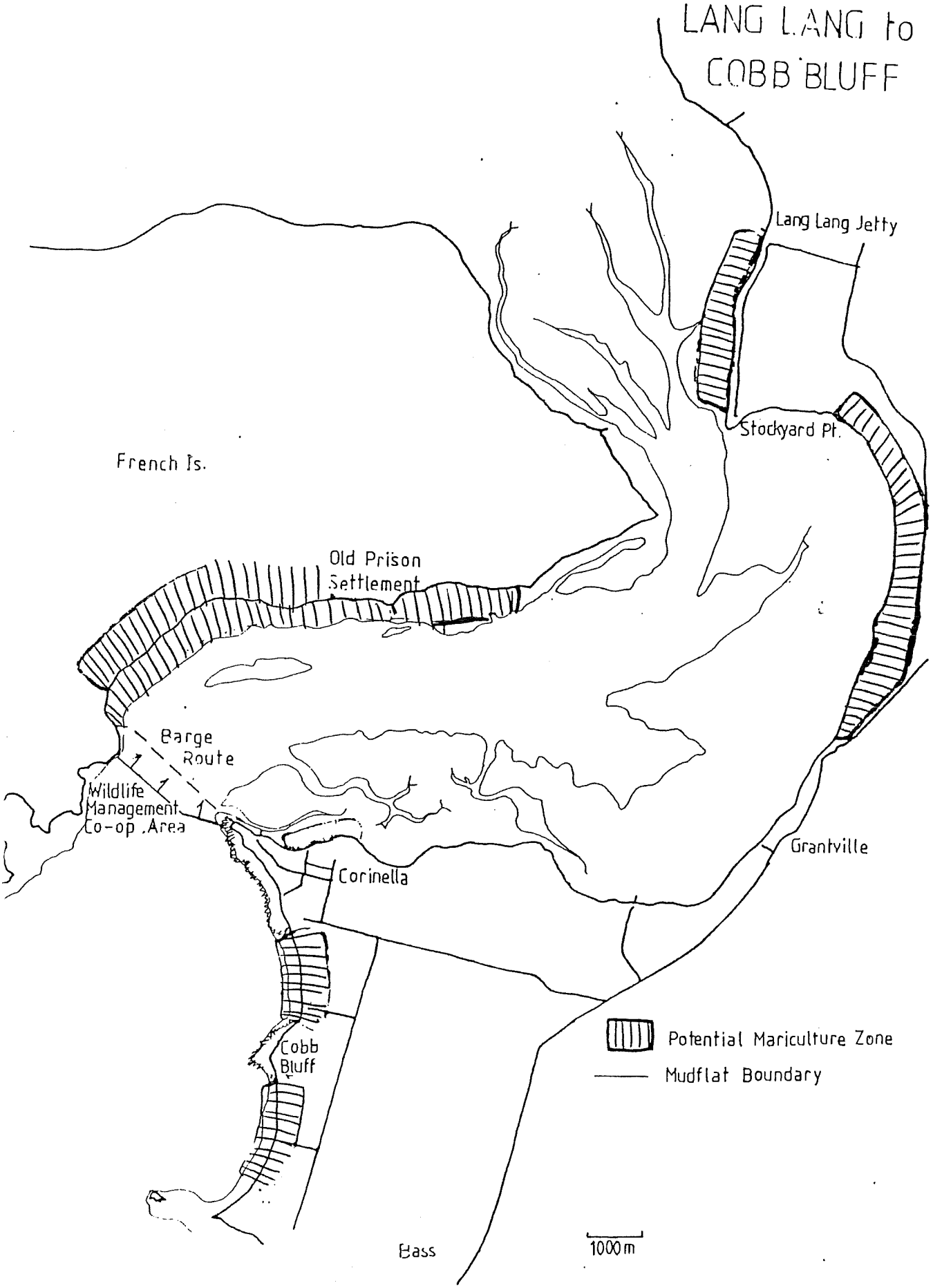

WARNEET, TOORADIN, FRENCH IS.
Cannon Ck.
Warneet
Quail Is.
Blind Bight
Tooradin
The Inlets
Crawfish Rock
Bariliar Is.
French Is.
Potential Mariculture Zone
Mudflat Boundary
1 km

Fig. 17.


LANG LANG to
COBB BLUFF
Lang Lang Jetty
Stockyard Pt.
French Is.
Old Prison
Settlement
Barge
Route
Wildlife
Management
Co-op Area
Corinella
Grantville
Cobb
Bluff
Bass
Potential Mariculture Zone
Mudflat Boundary
1000m

Land Protection Service A permit is required from the Service to traverse the coastal strip with pipelines. Land based mariculture sites have been recommended here bearing in mind the Service's policies.

Shire of Flinders This Shire supports the development of mariculture in principle.

Shire of Hastings This Shire supports mariculture development subject to maintenance of environmental standards.

Shire of Cranbourne This Shire supports the development of mariculture in principle.

Shire of Bass This Shire supports the development of mariculture in principle.

Shire of Phillip Island This Shire supports mariculture development subject to maintenance of environmental standards.

M) PORT PHILLIP BAY

Port Phillip Bay is the largest and most heavily utilised water body in Victoria. Its surface area is approximately 1950 km^2 and average water depth is 12 metres. The two largest cities in the state, Melbourne and Geelong, are both located on the bay and urban areas cover approximately 40% of the shoreline. Associated with these two cities are many industries which discharge effluents into the bay, port activities associated with the Port of Melbourne, the largest in Australia, commercial fishing and a considerable diversity of recreational uses (Port Phillip Bay Environmental Study 1969).

The entrance to the bay is narrow, deep and has strong tidal currents. Freshwater inflow is approximately equal to evaporation creating a basically marine environment with estuarine areas in the lower reaches of rivers. Salinities in the south are close to 35‰ and increase going northward. Salinity in Corio and Hobsons Bay averages 38‰ but at the latter site may be as low as 25‰ when the Yarra and Maribyrnong Rivers are in flood. Apart from these two rivers, remaining freshwater inflows are Hovells Creek, Little River, the M.M.B.W. farm, Skeleton Creek, Kororoit Creek, Mordialloc Creek, Patterson River and Kananook Creek. The shoreline is predominantly sandy beach with some cliffs. Sediment types are coarse sands at the entrance and the sand banks around Mud Island, finer sands around the shoreline and clay in the centre. Tidal range is 1m at the entance and is less than 0.5m in Corio and Hobsons Bay.

Major ports are located at Melbourne and Geelong. Channels are marked from the entrance through the shallower waters; the central portion of the bay is unmarked as water depth is suitable for most shipping. The commercial fishing industry in the bay is the State's largest inshore fishery, major ports being Melbourne, Geelong, Portarlington, St Leonards, Queenscliff, Mornington and Mordialloc. Species most commonly caught are snapper, flathead, flounder, whiting, australian salmon, pilchards, anchovies, scallops, mussels and abalone. Methods employed are longlining, mesh netting, seining and dredging. Recreational use of the bay is high; it supports Victorias largest recreational fishery, many yacht clubs, is used for recreational boating including water skiing and the beaches are extensively used for swimming.

Land around the bay is used predominantly for urban residential purposes. The entire east coast from Melbourne to Portsea is urbanised. The west coast between Melbourne and Geelong is less used for housing. The Melbourne and Metropolitan Board of Works Farm at Werribee has a beach frontage of more than 15 kilometers and south of the farm area the land is partly zoned industrial and partly Commonwealth reserve. Salt production on coastal land occurs at Altona, Lara and Geelong. The Bellarine Peninsula coastline is both farmland (along the Geelong Arm) and residential. The small embayment of Swan Bay is a marine reserve and the associated coastline is farmland.

Prospects for mariculture in the bay are very good, the greatest potential being offshore culture. There is limited potential for land based farming and very little potential for intertidal farming. Land based oyster cultivation is undertaken in the salt ponds at Lara and offshore mussel cultivation has been established at Beaumaris Bay, Clifton Springs and Portarlington. Prospects along the east coast are restricted by existing water uses and the heavily urbanised coastline. The greatest prospects occur along the west coast and Geelong Arm where conflicting uses are considerably lower.

GENERAL CHARACTERISTICS

Rainfall The general rainfall over the bay and catchment is variable being lower in the west than in the east. Total rainfall over the bay does not exceed yearly evaporation, therefore there is only a slight direct effect on bay salinities with the associated flooding of input streams.

Average monthly rainfall (mm) and yearly averages (mm) for a number of localities are listed below.

Locality Month	J	F	M	A	M	J	J	A	S	O	N	D	Total
Queenscliff	33	38	45	47	57	57	55	59	57	57	49	43	597
Geelong	27	36	40	43	48	45	47	49	50	51	45	42	521
Werribee	35	42	39	43	44	40	41	43	49	57	49	44	523
Melbourne	47	48	52	58	55	50	48	48	59	67	58	58	649
Whittlesea	45	55	51	56	57	55	54	60	63	77	63	59	692
Healsville	63	70	62	90	92	84	87	70	70	106	91	83	1007
Frankston	43	44	49	58	66	69	66	70	68	69	59	47	706
Dromana	43	39	58	63	76	85	80	74	70	69	57	51	763

Temperature Range Air temperature variation over the bay area is small. Maximum and minimum means of monthly air temperatures for a number of bayside locations are listed below.

Locality		J	F	M	A	M	J	J	A	S	O	N	D
Queenscliff	Max	22.3	22.4	21.1	18.3	15.7	13.3	12.8	13.8	15.7	17.5	19.2	21.0
	Min	14.1	14.7	13.6	11.6	9.6	7.7	6.8	7.3	8.5	9.9	11.3	12.9
Geelong	Max	24.9	24.9	23.2	19.7	16.5	14.0	13.5	13.7	16.9	19.2	21.3	23.0
	Min	13.2	13.8	12.7	10.3	8.1	6.2	5.4	5.9	7.1	8.6	10.2	12.0
Melbourne	Max	25.8	25.6	23.7	20.1	16.5	13.8	13.2	14.8	17.2	19.5	21.9	24.2
	Min	13.8	14.1	12.7	10.4	8.2	6.6	5.6	6.3	7.6	9.1	10.7	12.5
Mornington	Max	24.6	24.6	23.1	19.2	16.1	13.3	12.6	13.6	16.1	17.9	20.2	22.9
	Min	13.1	13.5	12.7	10.6	8.9	7.2	6.3	6.7	7.9	9.4	10.7	12.0

River Discharge Most of the river gauging points are located upstream from urban and industrial areas and thus do not provide a true reading of total inflow into the bay. The average annual inflows to Port Phillip Bay for each catchment area are shown below.

Approximate seasonal distribution of inflows are summer 22%, autumn 24%, winter 26% and Spring 28%.

Catchment	Inflow ($MLx10^3$)
South Bellarine	16.4
North Bellarine	10.5
Geelong	6.6
Hovell Creek	25.5
Little River	43.2
Werribee River	157.2
Skeleton Creek	14.5
Kororoit Creek	38.3
Total Yarra River	890.6
North East Coast	51.4
Patterson River	77.4
Kananook Creek	26.2
Mt Martha	22.8
Nepean Peninsula	11.4

The principle sources of inflow in order of significance are therefore the Yarra River, Werribee River, Patterson River and the North East Coast. The latter is significant in that a large proportion of inflow from this area is from storm water drainage. During flooding the plume of the Yarra River may extend down the east coast to Beaumaris. Flooding of the Werribee River usually creates a fan like plume off the river mouth. Bay water salinities decline during periods of heavy flooding (EPA 1979a).

Water Quality - Inputs The EPA has monitored water quality of the input streams. Those most intensively sampled were in the north east segment from the Yarra/Maribyrnong to Patterson River and in Corio Bay. Water quality of the input streams is generally poorer in the urban areas.

Concentrations and loads of total nitrogen (N) and total phosphorus (P) in a number of input streams are as follows (EPA 1979a).

Stream	Concentration mg/l		Loads kg/day	
	N	P	N	P
Yarra	0.8	0.13	1962	318
Maribyrnong	1.0	---	2469	406
Mordialloc	5.7	2.2	---	---
Patterson	3.1	0.8	626	162
Kororoit	10.7-20.0	0.8-4.0	1059-1980	79-396
Werribee	0.7	0.1	305	44
Werribee Sewerage Farm	---	---	16358	3716
Werribee Irrigation District	6.0	1.6	114	30

These data indicate the principal sources of nitrogen and phosphorus are the Werribee Sewerage Farm and the Yarra/Maribyrnong Rivers.

Heavy metal input sources to the bay are mainly associated with industrial activity. The load of summed heavy metals (Pb, Zn, Cd, Cu, Ni, As, Cr) per district is as follows.

Region	Load Metals kg/day
N.E Catchment	39
Mordialloc Creek/Patterson River	94
Kororoit Creek and western suburbs	7
Werribee River, Little River, Howell Creek	<1
Sewerage Inputs (Braeside, Werribee)	235
Geelong Region	6

These data indicate the major heavy metal inputs to the bay are through the Werribee Sewerage Farm and the North East Segment of the coastline.

Input levels are variable and except in a few instances are not high.

All input streams are contaminated with faecal coliform bacteria originating both from farmland and urban land. Levels are generally low and peak during periods of flooding. Sewerage connections in the catchment areas are increasing and this trend has reduced E.coli levels in the input streams.

Physical Bay Characteristics The entrance to the bay is approximately three kilometers wide between Point Nepean in the east and Point Lonsdale in the west. The entrance has a 94 meter deep scour hole which extends a short distance inside the entrance. The Port Phillip Sands, lying north-east of the entrance, are a triangular area of shallow sand flats with depths between 0.5 to 3 metres. There are six principle channels through the sands of which the West and South Channels are dredged to allow shipping access. From the entrance the bay opens to a wide basin extending 60 kilometers northward to the port of Melbourne. Overall width of the bay between Indented Head and Seaford is about 32 kilometers. The Geelong Arm is about 8 kilometers wide and extends westward about 28 kilometers to Geelong.

There is an even depth grading from the shoreline to the deeper central portion of the bay. Of the total area, approximately 50% is less than 15 metres deep. Sediment type is sand in the shallower waters grading to sandy mud and muds in the central portion of the bay.

Two tidal cycles per day occur in the bay. Tidal amplitude declines with distance from the entrance. Average amplitude is 1 metre at the entrance and declines to about 0.4 metres at Williamstown. The Port Phillip Sands significantly affect the volume of water exchange between Bass Strait and the bay. The effect of the sands on tidal flow is such that the time lag between tides at the entrance and Williamstown is approximately 3 hours. Tidal heights and times are also significantly affected by wind speed, direction and duration. Strong winds blowing for a period of several days from a given direction tend to raise water levels in down-wind areas.

The predominant wind is south and south-west from October to March and west to north from April to September.

Except at the entrance, waves in the bay are the result of local winds. Waves are characterised by a short wavelength and seas rise and abate quickly. Wave height is generally moderate, however in periods of strong winds damaging short wavelength waves up to three metres high may be generated.

Currents in the bay are generally tidal with superimposed wind effects. Tidal currents dominate at the entrance reaching speeds of 5 knots. Over the Port Phillip Sands currents are 2 knots and beyond the sands are weak and are largely wind determined. Current speed between Point Lillias and Point Henry across the shallow sand banks is fast. Water circulation in the bay is clockwise, modified by wind effects. Residence time of water entering the internal circulation is between 3 and 6 months.

Salinity Salinity in the bay is closest to Bass Strait in the south and increases to the north and west. Variations are due to freshwater inflow and summer evaporation. Observed ranges are listed below:

Segment	Salinity g/L
Exchange	31.0-37.8
Geelong	31.7-37.5
South Eastern	32.5-37.5
Corio Bay	31.6-37.9
Central	31.1-37.4
Werribee	31.7-37.6
North Eastern	30.5-36.2
Altona	31.2-37.2
Hobsons Bay	28.3-36.8

The lower limit of these salinity readings corresponds with heavy flooding which occurred in late 1976 (EPA 1979b).

Water Temperature Yearly temperature range is as follows.

Segment	Temperature Range. ^{o}C
Exchange	10.4-21.4
Geelong	9.9-21.5
South Eastern	10.2-22.1
Corio Bay	10.0-22.4
Central	9.6-22.5
Werribee	9.7-22.8
North Eastern	9.8-21.8
Altona	10.1-22.2
Hobsons Bay	10.0-23.3

Temperature variations in shallow coastal water and intertidal areas are greater (EPA 1979b).

Nutrients Generally, the highest concentrations of nutrients occur in the northern and western sections of the bay associated with inflows from Werribee Sewerage farm.

Nutrient ranges are as follows (EPA 1979b)

Segment	Silica (ug/l)	Total Nitrogen (ug/l)	Total Phosphates(mg/l)
Exchange	20-221	2.5-31.5	16-60
Geelong	11-143	3.0-35.0	63-110
South Eastern	31-112	3.5-19.0	36-60
Corio Bay	8-95	5.5-27.0	73-105
Central	8-260	5.0-19.0	60-76
Werribee	11-81	15-282	70-145
North Eastern	6-308	6.0-33.0	65-88
Altona	45-123	4.0-30.0	62-92
Hobsons Bay	0-213	8.0-74.0	72-98

The largest variation of nutrients occurs in the Werribee area.

Dissolved oxygen concentrations are generally close to saturation though may decline with depth after prolonged periods of still weather. Except in extreme cases, oxygen supply to caged fish would be sufficient to maintain high stocking densities.

Oxygen concentrations are sufficient to support offshore mollusc culture.

Ranges of minimum dissolved oxygen concentrations and % saturation for each segment are listed below. (EPA 1979b)

Segment	Mean Dissolved Oxygen (mg/l)	% Saturation
Exchange	6.6	85-112
Geelong	6.2	88-128
South Eastern	6.7	85-123
Corio Bay	5.8	88-125
Central	6.5	82-140
Werribee	6.2	82-122
North Eastern	6.4	90-130
Altona	6.6	86-123
Hobsons Bay	4.9	87-128

Contaminants Port Phillip Bay is most significantly affected by heavy metals and organic compounds. The EPA has set safe threshold levels for heavy metals in seawater. These levels are:

Zinc	20 ug/l
Lead	10 ug/l
Mercury	0.1 ug/l
Copper	10 ug/l
Chromium	50 ug/l
Cadmium	0.2 ug/l
Nickel	2 ug/l

Heavy metal levels in Port Phillip Bay exceed the above values on occasions. Higher levels for mercury, cadmium and nickel have been recorded in all EPA sampling segments. The exchange segment has also exceeded the level for lead and zinc levels have been exceeded in the Corio, North Eastern, Altona, Central and Werribee segments.

The Victorian Health Commission has classified shellfish from both Hobsons Bay and Corio Bay as being unfit for human consumption since here the major inputs of heavy metals are found. Levels are tabulated below.

	Metal mg/L						
Segment	Zn	Pb	Hg	Cu	Cr	Cd	Ni
Threshold level	20	10	0.1	10	50	0.2	2.0
Exchange	<18	<12	<0.4	<4	<12	<1.4	<6
Geelong	<13	<10	<0.4	<8	<10	<0.8	<5
South Eastern	<17	<9	<0.4	<5	<7	<0.6	<8
Corio	<23	<10	<0.4	<10	<20	<0.9	<10
Central	<36	<4	<0.4	<10	<12	<1.1	<7
Werribee	<22	<10	<0.4	<6	<8	<2	<15
North Eastern	<25	<12	<0.4	<7	<13	<0.7	<8
Altona	<22	<6	<0.4	<6	<3	<0.6	<6
Hobsons	<12	<5	<0.4	<5	<15	<0.6	<8

Recorded concentrations of organic contaminants in water and sediments are generally low; localised higher concentrations occur at drains on the north east coast.

Productivity Primary production in the bay correlates closely with the higher nutrient areas. Chlorophyll a concentration is highest in the north and west of the bay and measurements are presented below for each bay segment. Productivity is important for mariculture as it provides an index of potential food for filter feeding organisms.

Segment	Chlorophyll a (mg/l max/min)
Exchange	0 - 2.2
Geelong	0.2 -14.4
South Eastern	0.1 - 8.3
Corio	0.3 - 6.2
Central	0.2 - 4.8
Werribee	0 -16.5
North Eastern	0.2 -19.0
Altona	0.4 -10.8
Hobsons	0.2 -16.5

Seagrass and Macrophytic Algae The seabed in the bay is predominantly free of floral cover. Macrophytes are limited to the small number of subtidal reef areas. Seagrass areas are limited in size being narrow strips in the shallow coastal waters of Swan Bay, Geelong Arm, Corio Bay, the west coast and the southern Mornington Peninsula. Algal growth on structures in the bay is prolific and substancial fouling of offshore mariculture structures particularly net cages can be expected.

Zooplankton The zooplankton of the bay is dominated by two species of copepod, Acartia clausii and Paracalanus parvus which make up about 67% of total crustacean standing crop. There is a seasonal dominance between the two species, the former being dominant between spring and autumn and the latter dominant between autumn and spring. Cladocerans and Malacostacans represent the two other most common crustacean groups. The total standing crop of zooplankton is high during spring and summer and declines during autumn.

Zoobenthos Potential mariculture species are the blue mussel, Mytilus edulis, the native oyster, Ostrea angasi and the scallop, Pecten alba. The mussel occurs widely in the bay on rocky reefs, and on man made structures below the low tide mark. The native oyster occurs commonly on the finer sediments in the bay and is particularly common in Corio Bay and the Geelong Arm region. The scallop occurs commonly on the coarser sediments and is usually most common along the east coast and part of the Geelong Arm. Both mussels and scallops are commercially exploited.

Other organisms of interest to mariculture include the mudworm, Polydora which causes significant problems to the oyster industry in New South Wales. This species infests oysters in the bay, causing mud blisters to form internally on the shell. The presence of such mud blisters lowers the marketability of oysters.

Fouling organisms are prevalent in the bay and species likely to cause problems to offshore mariculture are tube worms, barnacles and a number of molluscs. The blue mussel is likely to be a significant fouling organism on offshore cage fish culture structures.

Fishes The most common fishes in the bay are sand flathead, tiger flathead, longnose flathead, stingarees, gurnard, snapper and flounder. Of most interest to mariculture are the snapper and flounder.

The flounder breeds only in the bay whilst the snapper also breeds in offshore waters. Also of interest to mariculture are the australian salmon, mullet and king george whiting.

Commercial Fishing Port Phillip Bay is the largest coastal fishery in Victoria. The most important commercial species are anchovy, pilchard, flathead, snapper, flounder, king george whiting, australian salmon, shark, mullet, scallop, mussel and abalone.

The main commercial fishing methods are as follows:

Purse seine, lampara net, bait net, hoop net - anchovy and pilchard.
Garfish seine - garfish, anchovy and pilchard.
Beach seine - mullet, king george whiting, flathead, snapper.
Troll line - snook and australian salmon.
Hand line - snapper, flathead and king george whiting.
Drop line - snapper
Long line - snapper and shark.
Meshnet - snapper, snook, flathead, king george whiting, shark and flounder.
Dredge - scallop, mussel.
Diving - abalone.

The major fishing ports are Williamstown, Port Melbourne, Geelong, Portarlington, Black Rock, Dromana, Queenscliff, St Kilda, Mordialloc, Sorrento, Mornington, Chelsea and Frankston.

The most important scallop ports are Port Melbourne, Geelong, Portarlington, Mornington, Queenscliff, St Leondards and Mordialloc.

Annual catch of fin fish in Port Phillip Bay in 1981 was approximately 1,450 tonnes.

Recreational Fishing is a major pastime in the bay. Beinssen (1978) recorded 976000 fishing hours over a four month study period of which boat fishing was the major type (73%) followed by jetty fishing (23%) and shore (4%). Target fish are mainly snapper, flathead and whiting from boats and flathead and squid from jetties. Flounder are mainly caught by hand spear at night.

The major recreational fishing grounds are the east coast between Melbourne and Portsea. Recreational fishing on the north east coast is evenly spread over the year whilst fishing in the south is mainly seasonal, peaking over the summer periods. Apart from the Werribee area, the west coast is comparatively little fished. Fishing in Geelong Arm is heavy particularly around Point Lillias, Portarlington and Corio Bay. Fishing pressure near Queenscliff and the entrance is also high particularly in summer. Boat ramps are located around the bay to provide access to all coastal areas. Fishing is concentrated on reef areas in particular.

Commercial Shipping The Port of Melbourne is the largest port complex in Australia with Geelong being the second largest port in Victoria. In the southern area of the bay and Geelong Arm shipping is restricted by water depth. The south channel extends from the entrance to South Channel Pile off Rosebud and the West Channel extends from Queenscliff to the West Channel Pile off St Leonards. The channel in Geelong Arm starts at Portarlington and runs through to Corio Bay. Shipping movements use the deeper water central section of the bay to travel from the south channel to Melbourne, the west channel to Melbourne, the west channel to Geelong and from Geelong Arm Channel to Melbourne. Offshore shipping anchorages are located off Corio Bay, Point Wilson, Point Cook and Williamstown. Any mariculture development adjacent to areas used for commercial shipping should allow approximately 300 metres leeway.

Yachting There are over thirty yacht clubs based in Port Phillip Bay. Most are on the east coast from Williamstown to Portsea and in the Geelong region. Racing series through all seasons are conducted by the larger clubs. The east coast from Melbourne to Frankston and from Dromana to Portsea are most heavily utilised and this is a significant conflict for offshore mariculture. Yachting on the west coast is mainly found on Corio Bay and near Portarlington, St Leonards and Queenscliff.

Other Water Uses Power boating is popular though again is concentrated on the east coast and near towns on the west coast. Power boating is in conflict with offshore mariculture on the east coast. On the west coast, few spatial conflicts arise.

Beaches around the bay are extremely heavily used by residents of Melbourne and Geelong. The entire east coast from Melbourne to Portsea is important for recreation, particularly in the summer months. Popular activities include swimming, snorkeling/diving, windsurfing and canoeing. On the west coast heavy utilisation of the beaches occurs between Queenscliff and Point Lonsdale, St. Leonards and Portarlington, Geelong and Werribee. The remaining section of coast is little utilised for recreation. The heavily utilised coastline is unsuited to any form of mariculture in the nearshore zone.

Land Use Land use on the shore of the bay is complex. The entire coast from Altona to Portsea is basically urban with some industrial areas. Industrial areas are found at Williamstown, along the Yarra and Maribyrnong Rivers and Port Melbourne. Excepting some cliffy areas, scrubland at Mornington and Mt Martha and Commonwealth land at Portsea the east coast is urban. On the Mornington Peninsula, the urban strip is usually narrow and behind this area there is grazing land.

Land use southwards from Altona is as follows; Laverton (salt production), Point Cook (coastal reserve and Commonwealth land, Werribee South (farmland and urban area) and Werribee River to about three kilometers north of Point Wilson (sewerage works). Point Wilson is a Commonwealth explosive reserve and the farmland adjacent to this area is zoned industrial. Gravel extraction and salt production occur between Point Wilson and Point Lillias. A small section of farming land borders the east and north coast of the bay. The shoreline of Corio Bay is predominantly industrial and has port facilities. An oil refinery, fertiliser production plant and wheat terminal are located here. East of Geelong is another salt production field and an aluminium smelter at Point Henry. The Bellarine Peninsula to Portarlington is predominantly farming. A large marina and resort complex is currently being developed at Point Richards adjacent to Portarlington. Portarlington to St Leonards is residential and farm land. Bordering Swan Bay is farmland and between Queenscliff and Point Lonsdale is residential area.

The only areas in Port Phillip Bay which may be suitable for land based mariculture are the west coast and northern Bellarine Peninsula.

Social considerations A number of areas in Port Phillip Bay are significant wildlife habitats. The salt production field at Laverton is a sanctuary for water birds as is Mud Island. Marine reserves exist at Point Cook and at the southern end of the bay. These latter reserves collectively called the Harold Holt Reserves include Swan Bay which has the largest area of intertidal flats in Port Phillip, reefs at Point Nepean, Point Lonsdale and Popes Eye and the area around Mud Island.

The aesthetics of mariculture operations, particularly on the eastern side of the bay, are an important consideration. In particular, people whose houses overlook the site of proposed operations are likely to object and this should be taken into account when choosing sites.

MARICULTURE POTENTIAL

The selection of potential sites for mariculture has taken into account all potential conflicts as well as physical, chemical and social considerations. Port Phillip Bay is large and there appears to be sufficient space to accomodate significant numbers of farms.

Offshore mariculture has the greatest potential followed by land based farming, however intertidal farming has low potential. Species suitable for cultivation include trout, chinook salmon, snapper, flounder, whiting, Australian salmon, mullet, mussels, oysters (native, pacific, Sydney rock) scallops and prawns.

i) Intertidal Shellfish Farming

There is only one suitable site for intertidal shellfish farming, this being the marine reserve area of Swan Bay. As the area is marine reserve, intertidal mariculture should be limited to the coastal fringe area where other uses are permitted. The offshore mud banks are clay sediments and mainly unsuited to supporting mariculture structures. They are also significant seagrass areas and wading bird habitats.

Suitable areas for cultivation include the intertidal zone adjacent to Queenscliff extending to Swan Bay Jetty Rd. Access to the bay north of this site is limited. Species suitable for cultivation are the native oyster, Ostrea angasi, the pacific oyster, Crassostrea gigas and the Sydney rock oyster, Crassostrea commercialis. The native oyster occurs naturally in the bay and the potential of the pacific oyster is excellent. The Sydney rock oyster suffers from winter mortality but may be suitable if a cold tolerant strain is developed. Potential area suitable for cultivation in Swan Bay is approximately 3 km^2. Potential - low.

ii) Land Based Mariculture Development of this form of mariculture would be restricted by the availability of suitable land. Most of the coastal area is already taken up with residential, industrial or reserve development.

Queenscliff Ponds between Swan Bay and Lake Victoria are well suited to land based mariculture. The extraction of shellgrit has left ponds which receive tidal exchange from Swan Bay. More ponds are being excavated by further extraction of shell grit. To establish an enclosed pond system, tidal gates at the Swan Bay entrance and at a yet to be constructed outlet channel would be required. Available area is approximately 4 km^2. Species with potential are oysters, flounder, whiting, trout, chinook salmon, Australian salmon and mullet. Intensive cultivation at this site is possible, however, water discharge to the marine reserve would require treatment to remove metabolites. Potential - very good.

Swan Bay The shoreline on the west coast of Swan Bay is fringed by a narrow crown land strip and large areas of freehold farmland. The land is undulating with sandy soils which are unsuited to extensive pond culture. Therefore intensive farming methods would be most suitable for this area. Access is excellent and power supplies are available. Available area is approximately 8 km^2. Potential - good.

North Bellarine Peninsula Going east from Point Henry to where cliffs commence there is approximately 10 kilometers of coast suited to intensive land based mariculture. Land is freehold used for farming and gently rises inland. Beaches in this area are little used and the Port Phillip Authority coastal management plan has not classified the area. Access and power are available. All species named earlier except mussels and scallops are suited for cultivation. Potential - good.
good.

Point Wilson to Kirk Point The coast here has a narrow strip of crown land behind which there is suitable freehold land currently zoned industrial. The area is low lying and is suited to both extensive and intensive mariculture. Access and power are available.

The coastal strip here is a significant habitat for water birds and the orange bellied parrot. The significance of this latter endangered species is sufficient to restrict development of the immediate foreshore.

The suitable coast is approximately 8 km long and water is available at all tides. Potential - good.

Point Cook Located between the Cheetham Salt works at Laverton and the coastal reserve at Point Cook there is a small area of suitable land for intensive land based culture. Soil type is sandy clay with high seepage characteristics. The coastal fringe is crown land behind which there is freehold farmland. Conflicting interests are few at this location and relate mainly to beach use. Suitable coastline is approximately 2 km long, access and power supplies are reasonable and water is available continuously. Potential - good.

Newport Power Station Cooling water from power stations for cultivation of marine fishes and molluscs is used in Europe and Japan. The Newport Power station draws water from the mouth of the Yarra River and discharges warmer water into Hobsons Bay. Peak use of the power station is in winter and discharge water is 5-8^{o}C warmer than ambient temperature. There is approximatley 5 ha of crown land available in the grounds of the power station suitable for intensive cultivation. Access and power availability are excellent.

One drawback with this site is the variable salinity which occurs in the estuary. Variations occurring randomly throughout the year would effectively preclude species such as snapper, flounder and whiting. Suitable species would be mullet, black bream, trout and chinook salmon. The contaminant load of the water would require study prior to any development. Potential - good.

iii) Offshore mariculture

The potential of offshore mariculture in the bay is excellent. Water deeper than 8 metres occurs close to the shore at most points, incidence of heavy seas is generally low, and currents would ensure regular water movement. The greatest restriction to development of offshore mariculture is conflict with other uses particularly on the east coast and the west coast near Geelong.

Two main forms of offshore mariculture are possible in the bay; the longline cultivation of molluscs and floating cage culture of fishes.

Mollusc cultivation could be rope culture of mussels or suspended tray culture of oysters and scallops. Cage fish culture involves anchoring a series of floating cages to a common mooring line. Species suitable for cultivation in this way are trout, chinook salmon, australian salmon, snapper, whiting and mullet.

Mussel cultivation is already underway at three sites; Beaumaris Bay, Clifton Springs and Portarlington. The last two sites are amongst the most suitable in the bay for offshore mariculture. The initial results of mussel culture indicate seed collection at these sites is excellent and growth rate is rapid (approximately 14-16 months to market size).

Grassy Point - Portarlington The proposed Grassy Point to Portarlington zone is located in water averaging 8-10 metres deep immediately to the north of the Prince George Bank. This area is free of commercial shipping as from the Prince George Beacon movements occur in a WNW direction to the entrance of the Point Richards Channel. Scallop beds do not occur in this area although some commercial fishing is done on the edge of the bank. Recreational angling is an existing use of the area though fishing pressure is not high. Recreational boating is low and is mainly near Portarlington. Yachtsmen avoid the area because of its proximity to the shallow Prince George Bank.

Eight 3 ha lease sites have been issued here for mussel cultivation. Public response to these has been favourable with no serious conflicts arising.

This site has potential for the issue of more multipurpose 3 ha lease units to the east and west of the existing leases. Space should be left between new areas and the existing leases to enable boating access to the shore.

Boating access to the site is excellent and full mooring facilities are available at Portarlington. Crane facilities on and vehicle access to the wharf are provided. Potential - very good.

Point Henry - Clifton Springs The area south of Wilson Spit Channel between Clifton Springs and Point Henry is well suited to offshore mariculture. Ten 3 ha lease units have been issued off Clifton Springs and are currently used for mussel cultivation.

Access to the area is excellent from both Geelong and Portarlington though it is limited from Clifton Springs. Commercial shipping in this area is restricted by depth to the channel. Recreational use of the area is primarily for angling which is mainly carried out in the shipping channels or over shoals. Two spoil grounds are located in the area though they have not been used since 1958 when the channel was last dredged. The spoil areas cannot be used for mariculture development. Shelter from the prevailing SW winds is excellent. Commercial fishermen use the inshore area for beach seining.

Further leases in this area should be groupings of four, leaving enough room between each grouping for boats to pass through. A recommended grouping pattern is shown on the accompanying map. Potential -very good.

Outer Harbour Average water depth is 7 metres and the site is well protected from prevailing south westerly winds. Access to the site is good from Geelong harbour. The area is little used by commercial fishermen, anglers or recreational interests. The shoreline is used for salt production in evaporation ponds and gravel extraction. An outer harbour for the Port of Geelong is proposed here to be completed by the year 2010. Potential - good.

Kirk Point Off Kirk Point between Arthur the Great Beacon and the Port of Geelong Authority Boundary there is sufficient deep water for limited development of offshore mariculture. Leases would need to be located inshore of the shipping lane from Point Wilson to Melbourne. The inshore waters of Kirk Point are infrequently used as spoil grounds for dredging operations. Recreational fishing in the area is low and commercial fishing is mainly confined to inshore seining. Shelter from the prevailing southwest winds is good at this point.

Access to this area is possible from Portarlington which has well established port facilities. Potential - very good.

Wedge Spit to Point Cook This section of coast has a limited potential for offshore mariculture. Water less than 5 metres deep extends up to 1000 metres offshore and the shipping passage zone comes within 2 km of the coast at some points. Located between the shallows and the shipping lane there is a narrow strip sufficiently deep for mariculture. Conflict with other uses is low in this area as commercial fishing and angling pressures are low. The Werribee Sewerage Farm discharges to the south of Wedge Spit but as the potential culture zone is about 1.5 km offshore, the effects of the discharge should be low.

Access to the potential culture zone is from Werribee which has mooring sites and lauching facilities. Shelter from winds from the south west to north east is poor and heavy seas occur along this portion of coastline. Potential - fair.

Atlona Bay The potential area for cultivation in Altona Bay is small as the bay is moderately used by commercial shipping and commercial fishing and extensively used by anglers. The southern area is an explosives anchorage and is unavailable. Yachting is also an important use of the area. The bay is moderately sheltered from the southwest, however shelter from the south and south east is poor. Access to the area is excellent from Altona and Williamstown.

There is space for eight 3 ha lease units without significantly affecting existing uses. Potential - good.

Beaumaris Bay Beaumaris Bay is a small sheltered bay boardering the southeastern suburbs of Melbourne. Two mariculture leases have been issued for mussel culture in the bay and it is considered there is insufficient space for further development here. The two leases are well sheltered from the south west winds and any further leases would be more exposed. There is considerable conflict in the bay with power boating, recreational fishing and yachting. The site has good access from Mordialloc and Sandringham and good shelter. Potential - good.

Mornington The coast in the Mornington region is predominantly cliff with small beaches in a series of coves. Two sites have potential for offshore culture, one to the north west and the other to the south west of Mornington away from the areas of heaviest water use.

The north western area is located about equidistant between Mornington and Canadian Bay. Deep water occurs within 500 metres of the shore. Heaviest use occurs around Mornington and Canadian Bay. Access from Mornington is excellent. Shelter from the north west, north and north east is poor though the deep water close to the coast generally reduces wave effects. Allowances for heavy conditions should be made when establishing farms in this area.

The south western site is located in Balcombe Bay. Water deeper than 10 metres occurs 1 km offshore. Water use is predominantly angling and recreational boating and potential conflicts are moderate. Access from Mornington is excellent. Shelter from the north west, north and north east is poor.

The potential of these sites is moderate as present mariculture technology has yet to be proved in such exposed areas.

Dromana Dromana Bay is a moderately sheltered embayment which has limited potential for offshore mariculture. Water of suitable depth occurs close to the coast and conflicting water uses are moderate. Existing uses in the area are confined mainly to angling and power boating. The bay is being considered for a marina development which will lower its potential for mariculture.

SWAN BAY

Fig. 18.

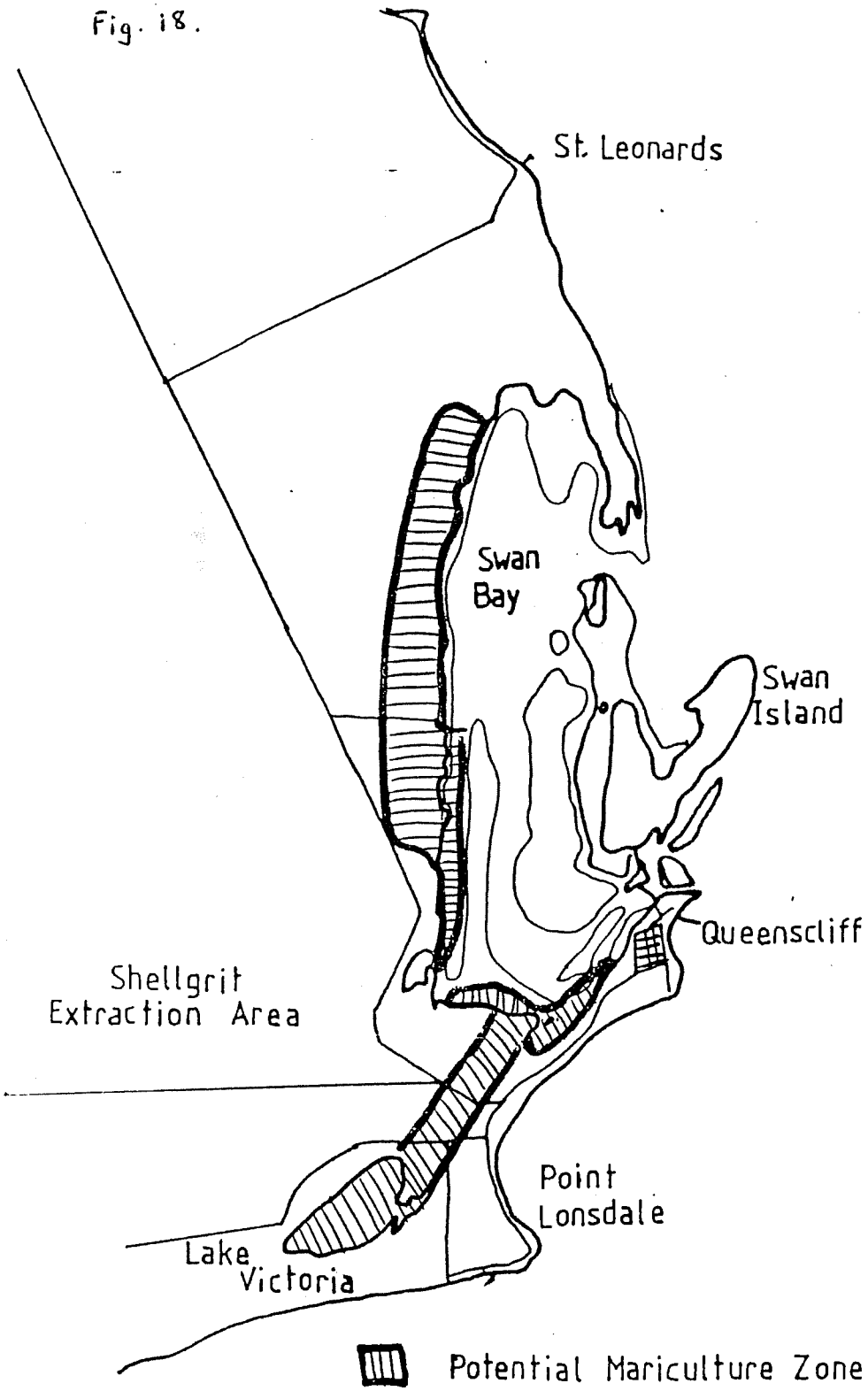


Fig. 19.

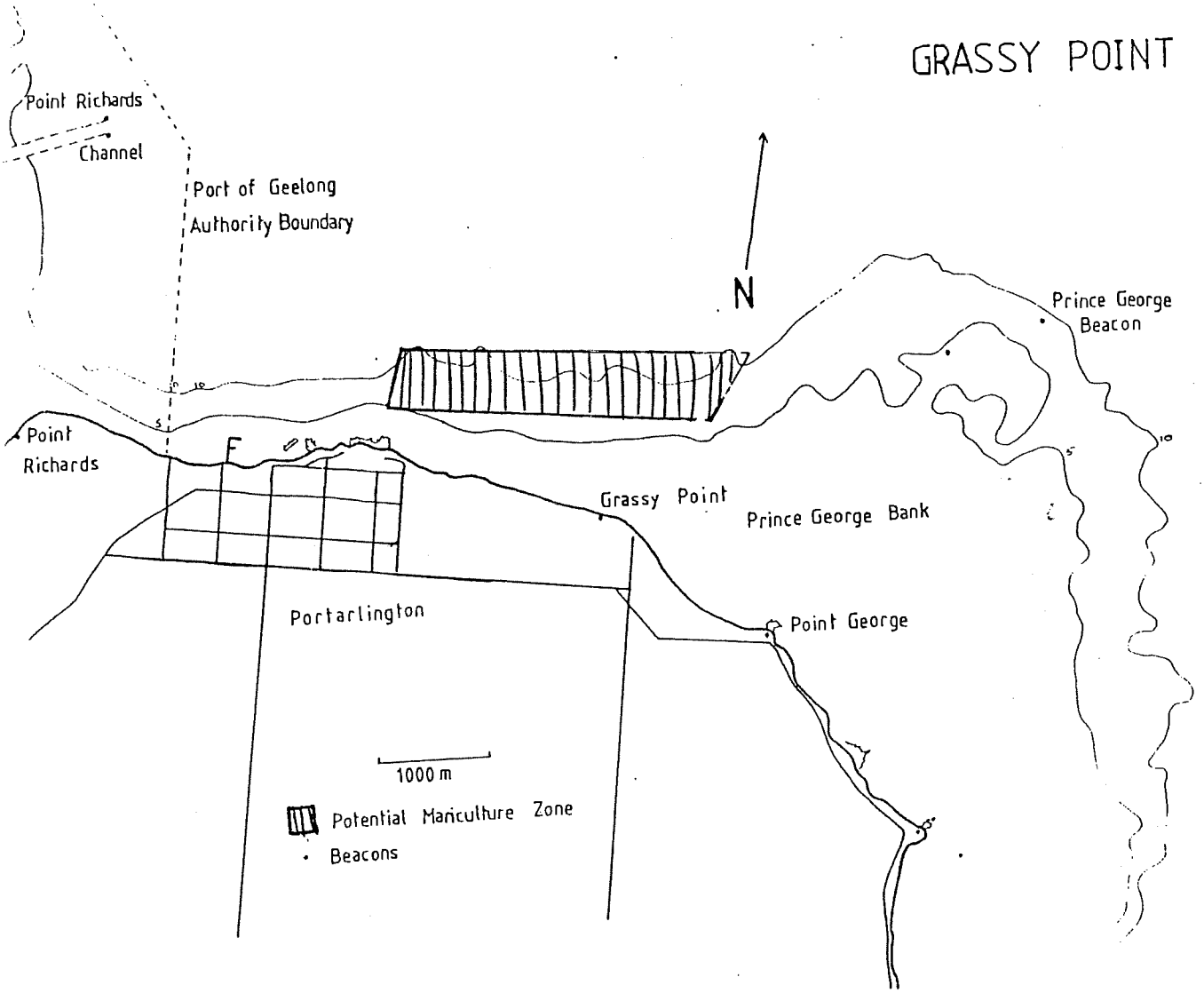

GRASSY POINT
Point Richards
Channel
Port of Geelong
Authority Boundary
N
Prince George
Beacon
Point
Richards
Grassy Point
Prince George Bank
Portarlington
Point George
1000 m
Potential Mariculture Zone
Beacons

Fig. 20.

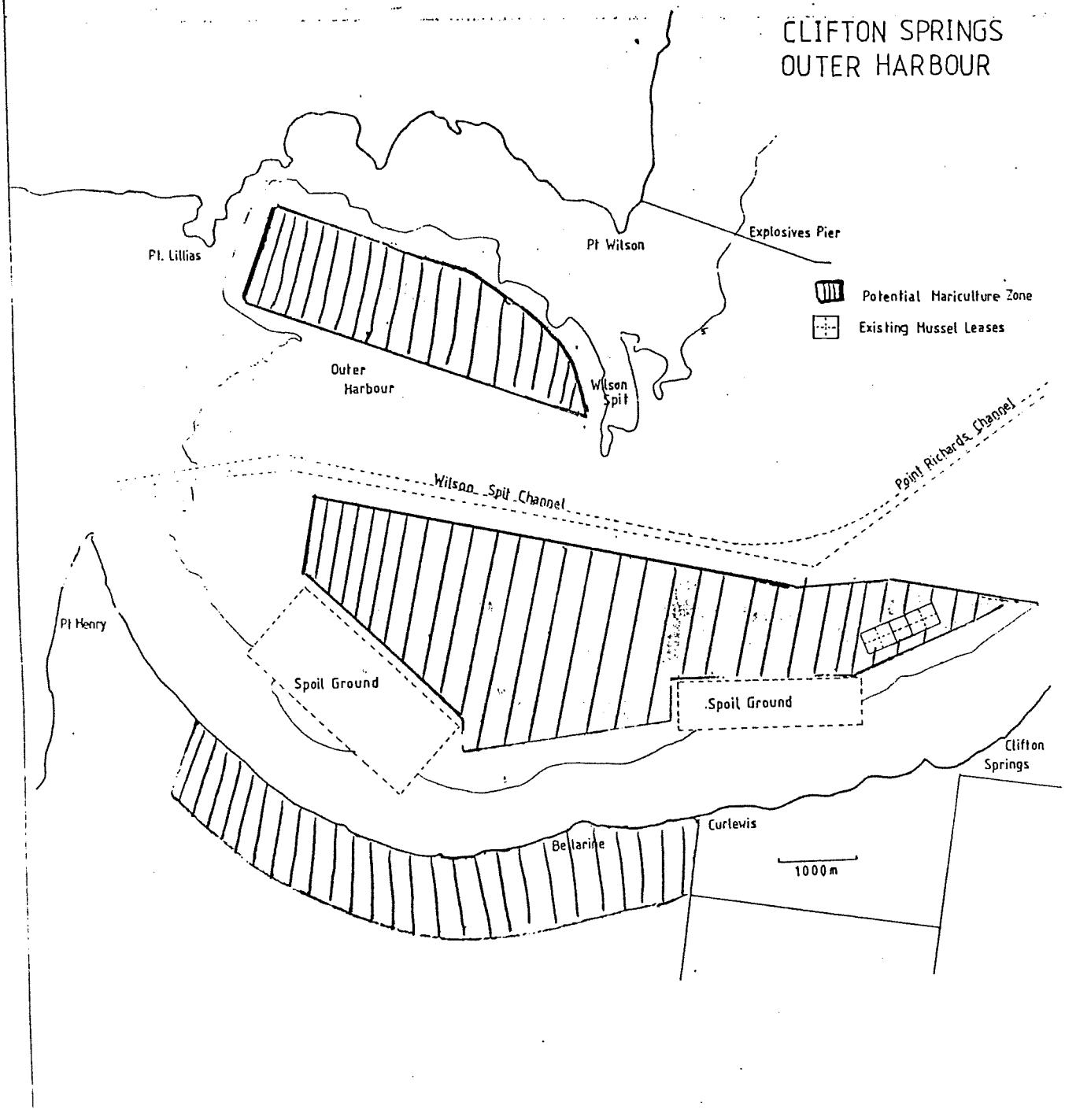

CLIFTON SPRINGS
OUTER HARBOUR
Pt. Lillias
Pt Wilson
Explosives Pier
Potential Mariculture Zone
Existing Mussel Leases
Outer
Harbour
Wilson
Spit
Point Richards Channel
Wilson Spit Channel
Pt Henry
Spoil Ground
Spoil Ground
Clifton
Springs
Curlewis
Bellarine
1000 m

Fig 21.

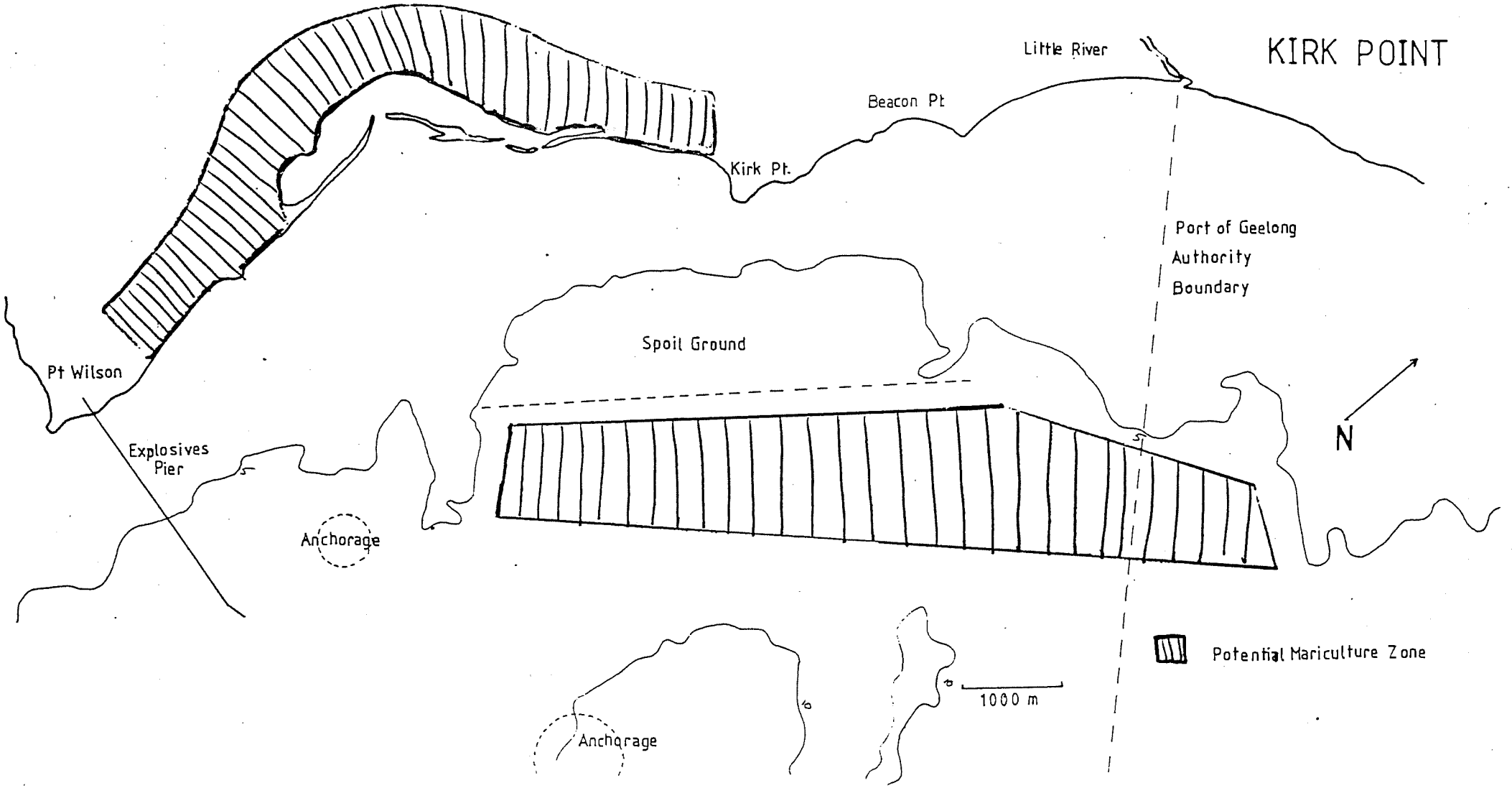

KIRK POINT
Little River
Beacon Pt
Kirk Pt.
Port of Geelong
Authority
Boundary
Spoil Ground
Pt Wilson
Explosives
Pier
Anchorage
N
Anchorage
1000 m
Potential Mariculture Zone

Fig. 22.

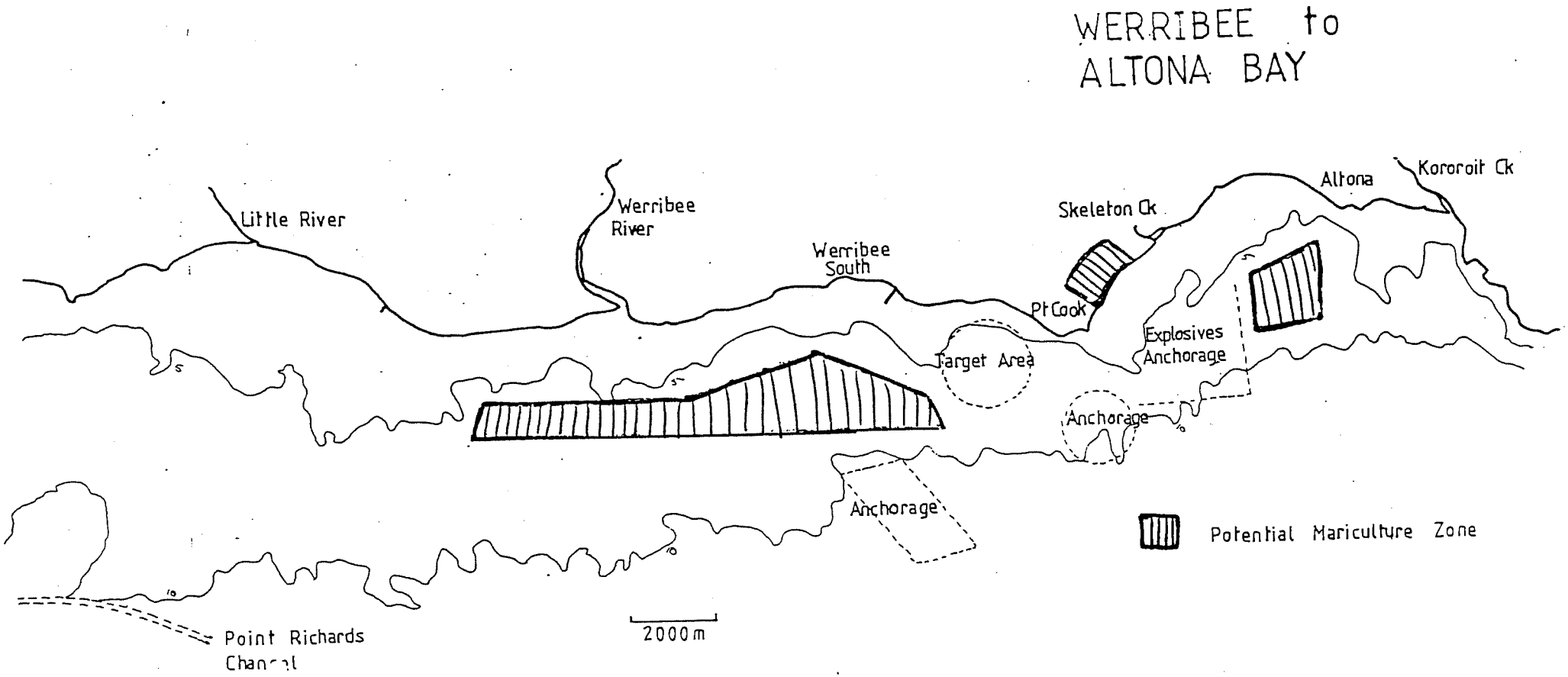
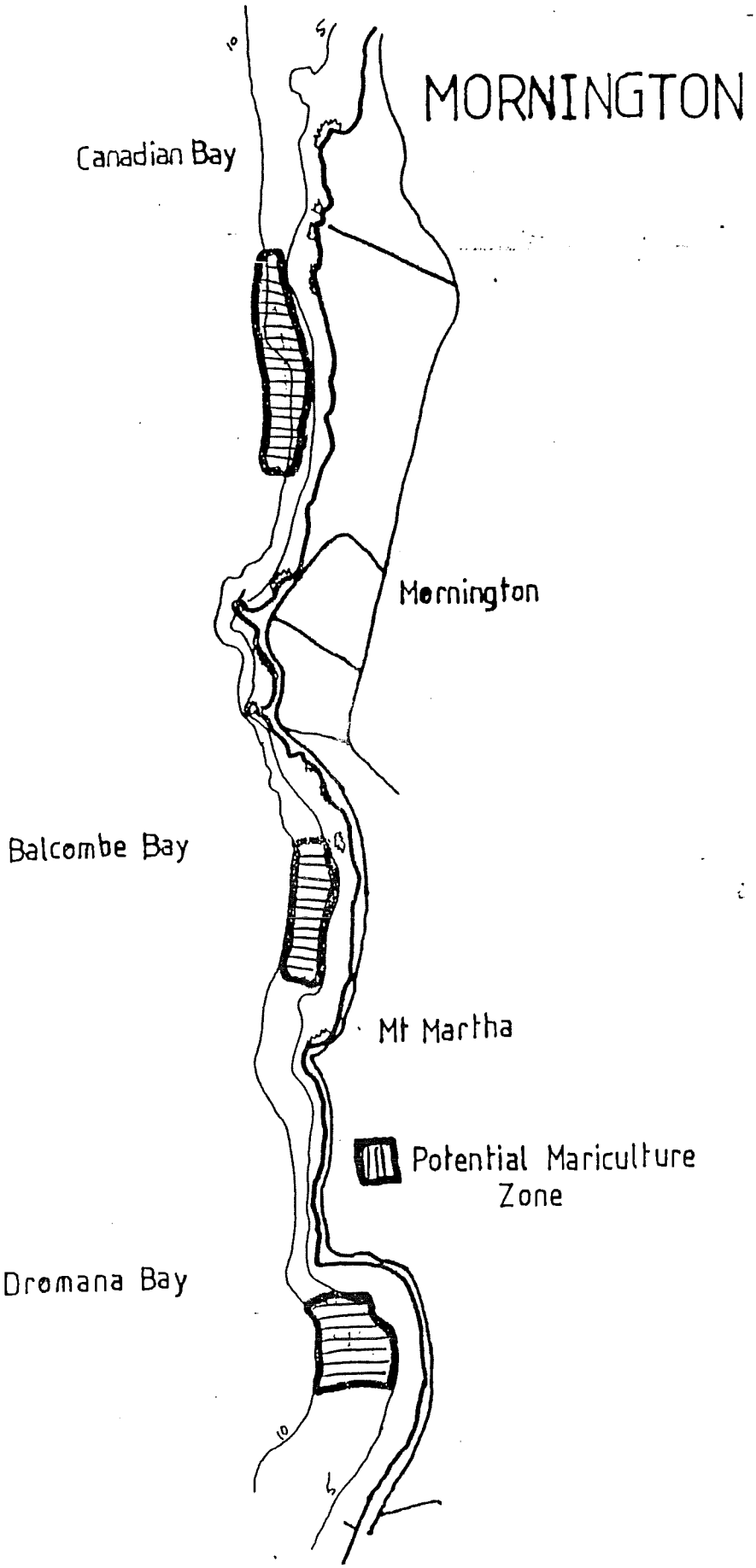

WERRIBEE to
ALTONA BAY
Little River
Werribee
River
Werribee
South
Skeleton Ck
Altona
Kororoit Ck
Pt Cook
Explosives
Anchorage
Target Area
Anchorage
Anchorage
Potential Mariculture Zone
2000 m
Point Richards
Channel

Fig. 23.


MORNINGTON
Canadian Bay
Mornington
Balcombe Bay
Mt Martha
Potential Mariculture Zone
Dromana Bay

The bay has potential for at least four 3 ha leases and possibly more without increasing conflict. The site is sheltered, being only exposed to winds from the north west. Potential - good.

iv) Seabed Mariculture

Port Phillip Bay is well suited to abalone culture on artificially constructed reefs. The bay presently supports a considerable abalone fishery, however, mariculture could open a new market for small abalone which, due to legal restrictions, cannot be collected from the wild. Negotiations by individuals for reef design and location would be required with Port Authorities and the Fisheries and Wildlife Service. Sandy substrates away from existing fishing grounds would be favoured as enforcement problems would be minimised. Suitable coast for artificial reef development are Dromana Bay to Frankston, Brighton to Beaumaris and Altona Bay where course sandy substrates predominate. In other areas of the bay water of sufficient depth is a considerable distance offshore where sediments are fine and unsuited to abalone culture.

GOVERNMENT POLICY

Ports and Harbours Division This Division supports the development of offshore mariculture provided it does not interfere with commercial shipping or unduely affect other existing uses. In conjunction with the Fisheries and Wildlife Service, the Division has issued leases for Grassy Point, Clifton Springs and Beaumaris Bay and granted a number of experimental leases. A permit is required from the Division for any offshore structure and the structure must be adequately marked by day and lit by night.

Land Protection Service A permit and lease is required from the Service to either use coastal crown land for land based mariculture or to traverse the coastal strip with pipelines. Recommendations for land based mariculture have taken into account the coastal policy of this Service.

Port Phillip Authority The Port Phillip Authority controls use of the zone extending 200 metres inland and 600 metres offshore from the coast. The Authority has no formal policy regarding mariculture though it regards intertidal culture incompatible with coastal management. Recommended areas for land based culture comply with Port Phillip Authority coastal management policy. A permit will be required from the Authority for any mariculture operation within its area of pervue.

Health Commission of Victoria The Health Commission of Victoria prohibits the taking of shellfish for human consumption from Corio Bay and Hobsons Bay. The Commission considers mariculture to be a compatible use within all other bay waters.

Environment Protection Authority The EPA considers bay water suitable for production of fish, shellfish and crustaceans for human consumption except mollusc production in Hobsons and Corio Bays.

Port of Geelong Authority The Port of Geelong Authority considers mariculture to be a compatible use within its area provided it does not compromise commercial shipping. A permit is required for any offshore mariculture development within the port boundry.

Shire of Queenscliff The Queenscliff Shire Council supports the development of mariculture.

Bellarine Shire Council The Bellarine Shire Council supports the development of mariculture.

Corio Shire Council This council has no formal policy on mariculture development.

Shire of Werribee This Shire has no formal policy on mariculture development.

City of Altona The city of Altona supports mariculture provided there is no effect on existing water uses.

City of Sandringham This council considers the development of two leases in Beaumaris Bay to be adequate and will not support further expansion at this site.

Shire of Mornington The Shire of Mornington considers mariculture to be acceptable provided existing water uses are not affected.

N) BARWON RIVER ESTUARY

The Barwon River has its source in the Otway Ranges and flows eastwards to its discharge point south of Geelong. At the entrance, the estuary is narrow and is fringed by sand flats and mangoves. Tidal influence is marked although salt water intrusion upstream is not great. Sand flats only occur in the lower estuary and approximately two kilometers from the entrance the flats become marshland and the main channel cuts a meandering path to the large brackish Lake Connewarre. Lake Connewarre is a State Game Reserve and conservation area. It is shallow and unsuited to mariculture development both because of low salinity and its reserve status.

The lower estuary is of most interest to mariculture. Ocean Grove is located to the east and Barwon Heads to the west. Both towns have extensive residential areas and some septic tanks wastes seep into the estuary. A rubbish tip is also located in the mangroves on the west coast of the estuary, 2 kilometers upstream from the entrance. Land use upstream is predominantly farming with the major urban area located at Geelong. Some industrial run off enters the river. Ocean Grove and Barwon Heads are resorts used mainly during the summer months. The estuary below the road bridge is extensively used for swimming, fishing, sailing, windsurfing and canoeing.

Flooding of the river often occurs during late winter and spring. At these times salinity in the lower estuary drops to zero and a large plume of brackish water extends into the ocean.

Prospects for mariculture in the lower estuary are limited to intertidal shellfish farming. Land based mariculture is unsuited here as it conflicts with existing land uses such as the State Game Reserve.

Below the bridge the entire area is significantly utilised for recreation. Upstream of the bridge there are a number of existing uses, however intertidal farming is compatible with most. Sailing and windsurfing are only carried out in the lower estuary near the bridge. Suitable mariculture sites are located to the north of this area. The potential areas are sand substrates and are fringed by a mangrove boarder in the higher tidal zone. Behind the mangroves are extensive areas of saltbush.

Species suitable for cultivation are the pacific oyster, Crassostrea gigas, the native oyster, Ostrea angasi and the Sydney rock oyster, Crassostrea commercialis. Experiments will be required to determine their suitability and factors requiring consideration are the tolerance of the native oyster to intertidal farming and periods of zero salinity, relationship between times of low salinity and the spawning season of the pacific oyster, the susceptibility of the Sydney rock oyster to winter mortality and the likelyhood of development of a cold tolerant strain of this latter species.

Overall potential for the estuary is low but may improve with some research.

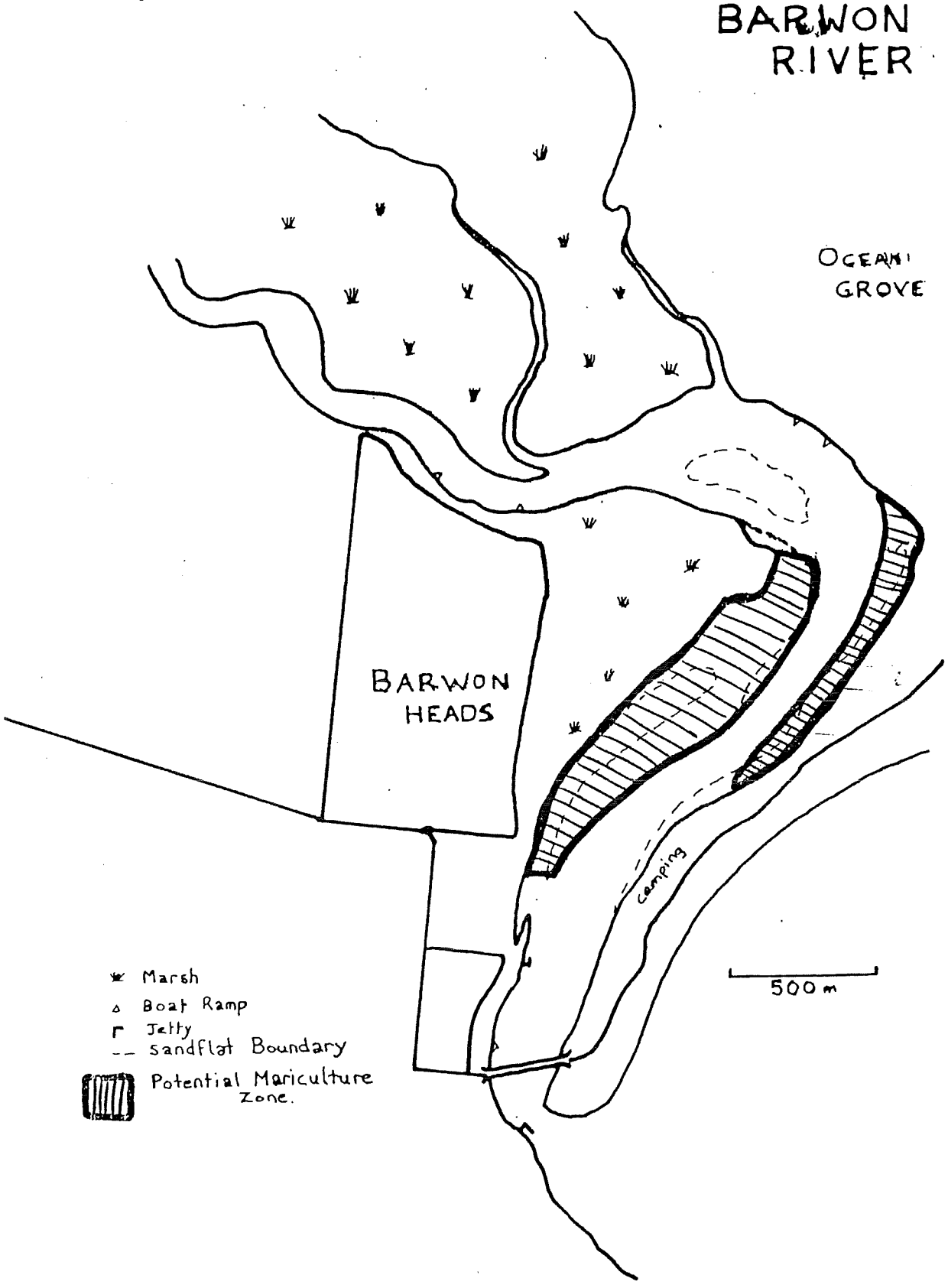
GOVERNMENT POLICY

Land Protection Service A permit is required from the Service for developments on crown lands.

Shire of Bellarine The Shire supports the development of mariculture.

Shire of South Barwon The Shire supports the development of mariculture in principle.

Fig. 24.


BARWON RIVER
OCEAN GROVE
BARWON HEADS
camping
500 m
Marsh
Boat Ramp
Jetty
sandflat Boundary
Potential Mariculture Zone.

O) BREAMLEA

The area of coast around the mouth of Thompsons Creek at Breamlea is well suited to landbased mariculture. Access to this area is excellent. The shore consists of stabilised sand dunes with some outcrops of rocky reef. Thompsons Creek is generally permanently open to the sea as the mouth is sheltered by rocky outcrops on its western side. The proposed mariculture zone is located on marshland which is uncommitted crown land.

GENERAL CHARACTERISTICS

Rainfall Data are not available for Breamlea. Data for Geelong, the nearest recording station are presented in the section concerning Port Phillip Bay.

Winds Predominant winds are south westerly from spring to autumn and north westerly from late autumn to early spring.

Creek Flow is not recorded. It is low during summer and peaks during winter and spring. Flooding of the lowlying land occurs irregularly.
Land Status The land being considered for land based mariculture is uncommitted crown land, though part of the proposed area has been recommended as wildlife reserve. Behind the crown land there is poor quality freehold land.

Existing Uses Breamlea is a small holiday resort with a very small permanent population. The town also has a caravan park which is occupied mostly during summer. The creek mouth is a popular surfing location and the beaches are used for swimming.

MARICULTURE POTENTIAL.

Intensive land based mariculture has most potential at this site as available space is limited. Land topography is lowlying, rising inland and soil type is predominantly sand indicating any pond development would require sealing. Conflicts for space are not great as the land is not used for any commercial purpose. Water for the operation may be drawn from the creek or if supply is insufficient here, an offshore intake could be built. Deep water occurs close to the shore. Power is readily available at Breamlea and may be easily extended to the area near the creek mouth. Suitable area is approximately 3 km^2. Potential - very good.

GOVERNMENT POLICY

Land Protection Service The crown land in this area is uncommitted and as such mariculture is a relevant use. A permit would be required to use the land and to pipe across the coastal reserve to draw water from Bass Strait.

Environment Protection Authority A permit would be required to discharge waste water into Bass Strait.

Shire of South Barwon The Shire supports the development of mariculture in principle.

P) APOLLO BAY - MARENGO

Prospects here are limited to land based culture and abalone culture on artificial reefs.

Two sites are suitable for land based culture, one being north of Apollo Bay, on the landward side of the Great Ocean Road and the other being between Apollo Bay and Marengo on the flats of the Barham River. The shore is sandy beach with a line of low dunes. The Barham River opens to the sea intermittently.

GENERAL CHARACTERISTICS

Rainfall Average rainfall at Apollo Bay is in the range of 1000-1200 mm per annum. In the headwaters of the Barham River rainfall exceeds 1400 mm per annum.

Temperature Range Temperatures at Cape Otway are from 11°C in winter to 18°C in Summer

Wind The predominant winds on this section of coast are from the south and south east.

River Discharge River flow in the Barham River peaks in July and August. The small steep catchment area leads to short term flooding fairly often. The catchment area is 32 km^2 and annual recorded maximum, mean and minimum discharges (ML) are as follows:

Maximum	Mean	Minimum
28172	18712	4983

Land Status Crown land forms a coastal reserve along the foreshore between the Great Ocean Road and the shoreline. Behind this is freehold land, partly zoned residential though mostly rural.

MARICULTURE POTENTIAL

Land based mariculture potential is limited by the small amount of suitable land which indicates intensive culture methods are most suited.

Water quality along this coast is excellent. Water intake structures will need to be well designed as wave action is high. An alternate source of water can be found at the harbour and drawing water here may in the long term be cheaper than erecting and maintaining an offshore intake system.

Facilities at Apollo Bay are excellent as road access and power are readily available at the proposed sites. Apollo Bay also has a fish processing works which could handle the farmed product.

The only form of offshore mariculture with potential in this area is production of small abalone on artificial reefs. The seabed north east of the harbour at Apollo Bay is sand and is suitable for artificial reef construction. The high energy coastline is well suited to the growth of small blacklip and greenlip abalone.

The potential of land based farming is low because of the small available area. Potential of offshore abalone farming is moderate.

Fig. 25.

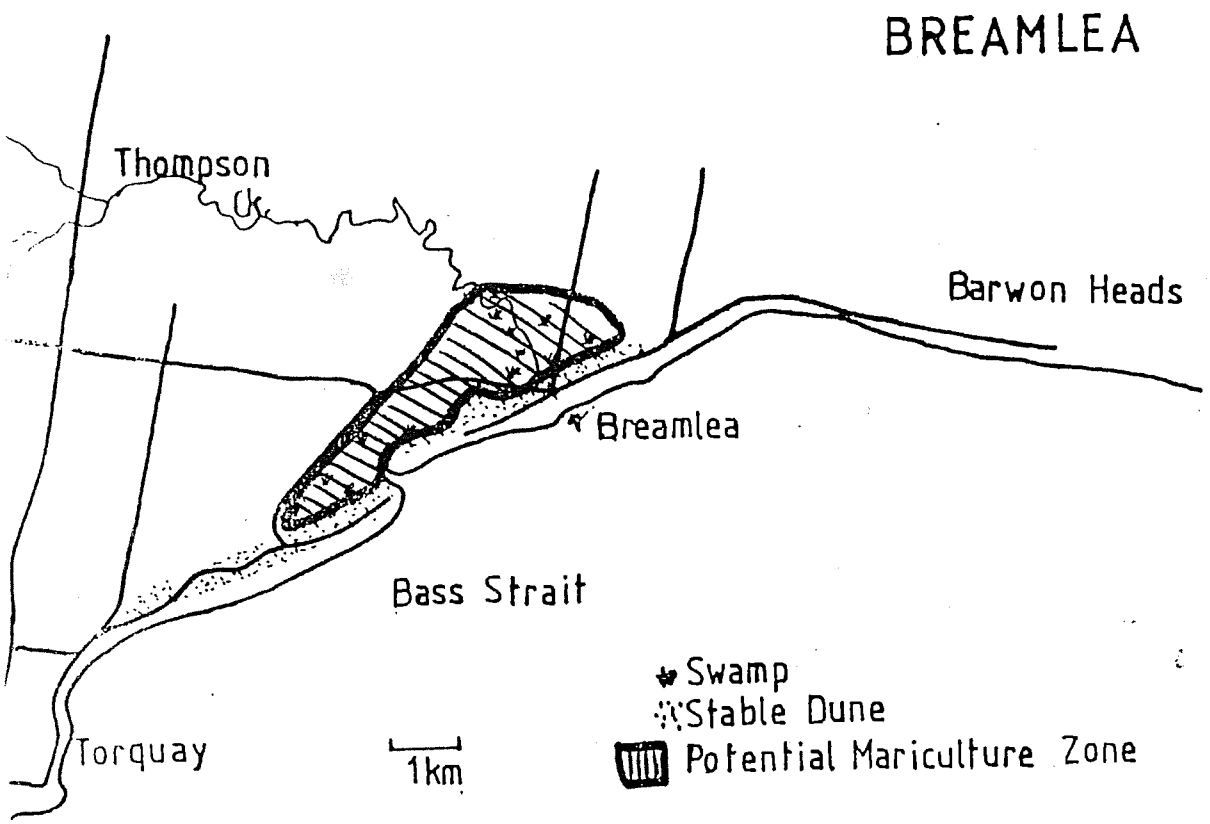
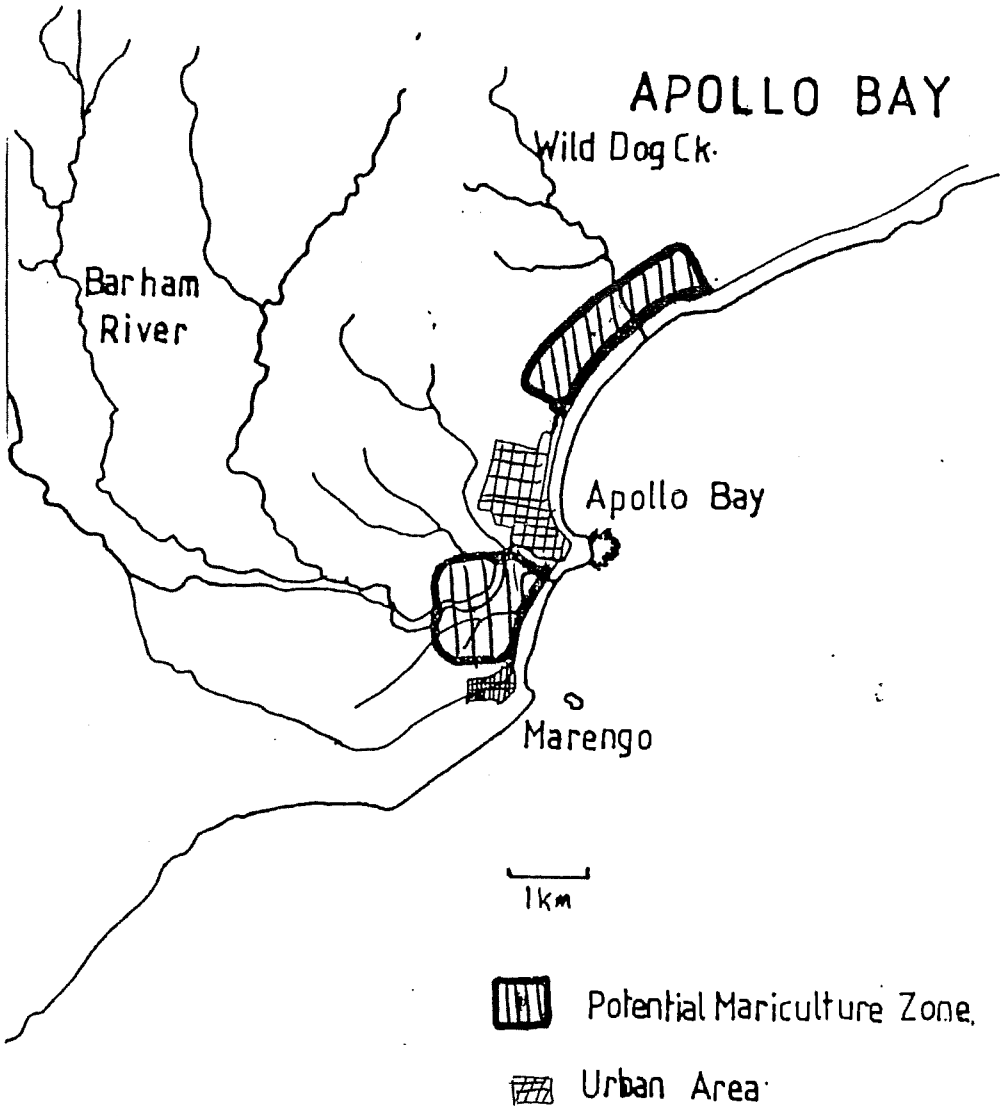

BREAMLEA
Thompson
Barwon Heads
Breamlea
Bass Strait
Swamp
Stable Dune
Potential Mariculture Zone
Torquay
1km

Fig. 26.


APOLLO BAY
Wild Dog Ck.
Barham River
Apollo Bay
Marengo
1km
Potential Mariculture Zone.
Urban Area

GOVERNMENT POLICY

Land Protection Service A permit will be required to traverse the coastal strip with water intake facilities.

Shire of Otway The Shire supports the development of mariculture in principle.

Q) CURDIES INLET

Curdies Inlet is located at the mouth of the Curdies River and is three kilometers long and a maximum of one kilometer wide. The entrance is usually closed for a few months each year. When open, salinity in the inlet is generally close to that of seawater however, it declines significantly during flooding. The inlet has some potential for shellfish farming and land based mariculture.

GENERAL CHARACTERISTICS

Rainfall Rainfall over the inlet area is in excess of 900 mm per annum. Further north, in the catchment of the Curdies River, rainfall is approximately 700 mm.

Temperature Range Temperatures at Warrnambool average 9.5°C in winter and 18°C in summer.

Wind Predominant winds are southwest with a higher incidence of north west during winter.

River Discharge Discharge peaks in late winter/spring and is least during summer. The catchment area is 790 km^2 and mean, maximum and minimum annual discharges (ML) are as follows.

Maximum	Mean	Minimum
277,600	127,100	5,218

Salinity Salinity of the inlet is dependent upon season and closure of the inlet. During flooding salinity is less than 1‰ at the entrance and during droughts, may rise to approximately 32‰. Species cultivated will need to be salinity tolerant.

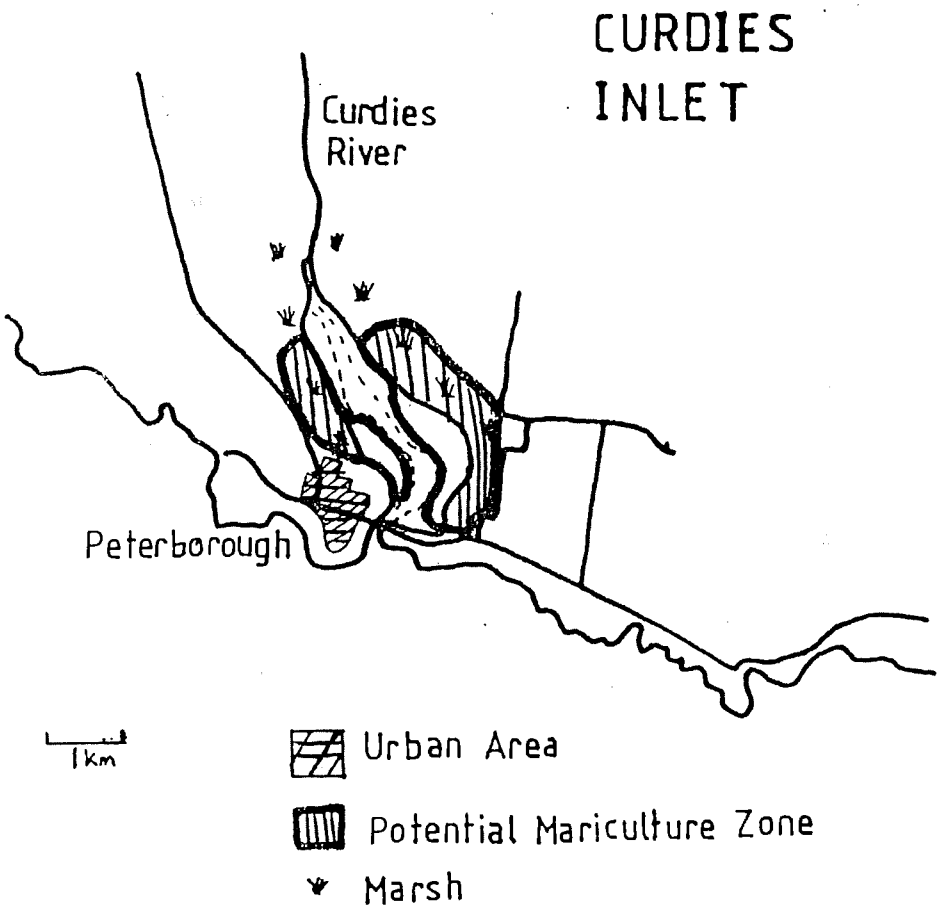
Land Status The bed of Curdies Inlet is crown land and is incorporated into the coastal reserve. Land on the east side of the entrance, south of the Great Ocean Road is crown land. The remaining land boardering the inlet is freehold.

Land Use Land use in the catchment is dairying and sheep/cattle grazing. Most of the catchment is cleared land. The only major town on the river is Cobden.

Peterborough is located on the western shore of the southern portion of the inlet and land here is zoned residential. Most of the remaining land around the inlet is marshland or used for grazing.

Water Uses The main water use in the inlet is amateur angling. Black bream, estuary perch and mullet are the main target species. The inlet is not commercially fished. Other water uses are small yacht sailing, windsurfing and canoeing.

Fig. 27.


CURDIES
INLET
Curdies
River
Peterborough
1km
Urban Area
Potential Mariculture Zone
Marsh

MARICULTURE POTENTIAL

There is some potential for intertidal shellfish farming within the inlet, though this is low because of variable salinities. The mudflats are suitable for culture and it is recommended only the lower half of the inlet be utilised to maximise salinity. Access to the western and eastern shore of the inlet is good. Species suitable for cultivation are the pacific oyster, native oyster and Sydney rock oyster. Suitable land area is less than 1 km^2. Potential - poor.

Land based cultivation has greater potential than intertidal farming, since water can be recycled until conditions in the inlet are suitable. Land on the west and east coast is suitable. Power and access to either coast are readily available. Conflicts with existing land uses will be small. Species suitable for cultivation include brackish water fish species, e.g. black bream, trout, chinook salmon and mullet. Suitable land area is approximately 2 km^2. Potential - good.

GOVERNMENT POLICY

Land Protection Service A permit will be required to establish mariculture operations on crown land and to establish water intake facilities across the coastal strip.

Shire of Warrnambool The Shire has no policy concerning mariculture development.

R) HOPKINS RIVER

The Hopkins River enters the sea at Warrnambool. The river entrance is permanently open and considerable water exchange occurs with tidal influence extending ten kilometers upstream. The entrance is predominantly marine, though during significant flooding salinity at the mouth declines.

Prospects for mariculture are limited by the extent of urban development along the estuary and its small area at the mouth.

GENERAL CHARACTERISTICS

Rainfall Monthly average rainfall figures for Warrnambool are as follows.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall (mm)	31	35	46	60	77	73	84	83	70	64	55	44

Temperature Range Mean monthly temperatures at Warrnambool are as follows:

Month	J	F	M	A	M	J	J	A	S	O	N	D
Temperature ^{o}C	17.6	18.8	16.5	14.2	11.5	10.5	9.8	10.4	11.0	13.2	14.4	16.4

River Discharge peaks during late winter/spring and declines during summer. The drainage area of the Hopkins River is in excess of 8355 km^2 and maximum, mean and minimum annual discharges are as follows.

Maximum	Mean	Minimum
984000 ML	318730 ML	14185 ML

Winds The prevailing winds are south, south westerly and north westerly.

Land Status The eastern shore of the estuary is freehold land. The western coastal strip at the entrance is crown land reserve.

Land Use in the catchment is predominantly farming, dairying in the south and sheep and cattle grazing and grain production in the headwaters. Warrnambool and Allansford are the only major towns on the river system. Large urban areas border both sides of the estuary, particularly at the river mouth.

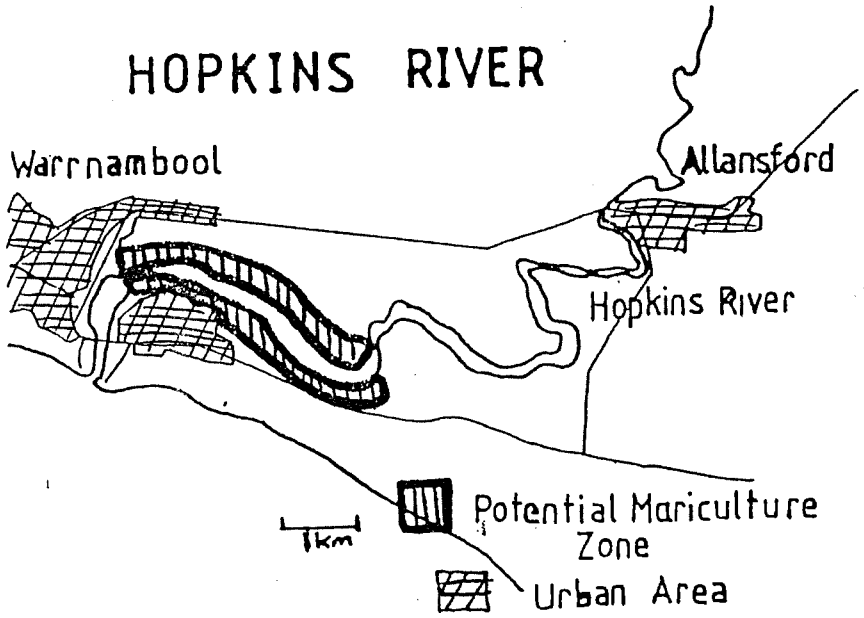
MARICULTURE PROSPECTS

Physical and social constraints limit the mariculture potential of the inlet to intensive land based mariculture.

Brackish water species are recommended for culture on the north and south banks of the estuary, upstream of the Warrnambool residential areas. Access and power are available to both banks. The land is currently zoned residential and would require rezoning for land based mariculture development.

Species suitable for culture are black bream, mullet, trout and chinook salmon. Potential for this area is low as rezoning of land is required, salinity of the estuary is variable and spatial conflicts are considerable.

Fig. 28.


HOPKINS RIVER
Warrnambool
Allansford
Hopkins River
1km
Potential Mariculture Zone
Urban Area

GOVERNMENT POLICY

City of Warrnambool and Shire of Warrnambool Neither group has any formal policy regarding mariculture development.

S) KILLARNEY BEACH, BELFAST LOUGH

This area of coast is suitable for intensive land based mariculture. The coastal strip here is mainly stable sand dune interspersed with rocky outcrops and offshore reefs. The offshore reefs are often continuous and at Killarney Beach they break the oceanic swell, sheltering the beach. Behind the stable dunes are marshlands and low quality grazing land.

The area is mostly crown land which along the foreshore is coastal reserve. The remaining crown land is uncommitted, though the marshland is significant as wading bird and water fowl habitat. Land use on the immediate coastal strip is dairy farming. A recreation reserve and picnic area is located at Killarney Beach and this sheltered beach is heavily utilised in the warmer months. The marshland areas are used for passive recreation by bird watchers and walkers.

Belfast Lough and its associated marshland is also significant as a wildlife habitat. Recreational use is confined to fishing and canoeing. The town of Port Fairy is located on the southern shore.

Water inflow from the Moyne River which enters Belfast Lough is as follows:

Drainage area - 570 km^2
Maximum annual inflow: 95,600 ML
Mean annual inflow: 39,878 ML
Minimum annual inflow: 2,393 ML

Inflow is maximum during late winter/spring and declines over summer. The narrow exit channel from the lough to the ocean ensures tidal exchange is limited and for much of the year the Belfast Lough has a low salinity. Of interest in this area is the underlying hot water artesian basin which could be tapped to enable temperature manipulation in intensive farms.

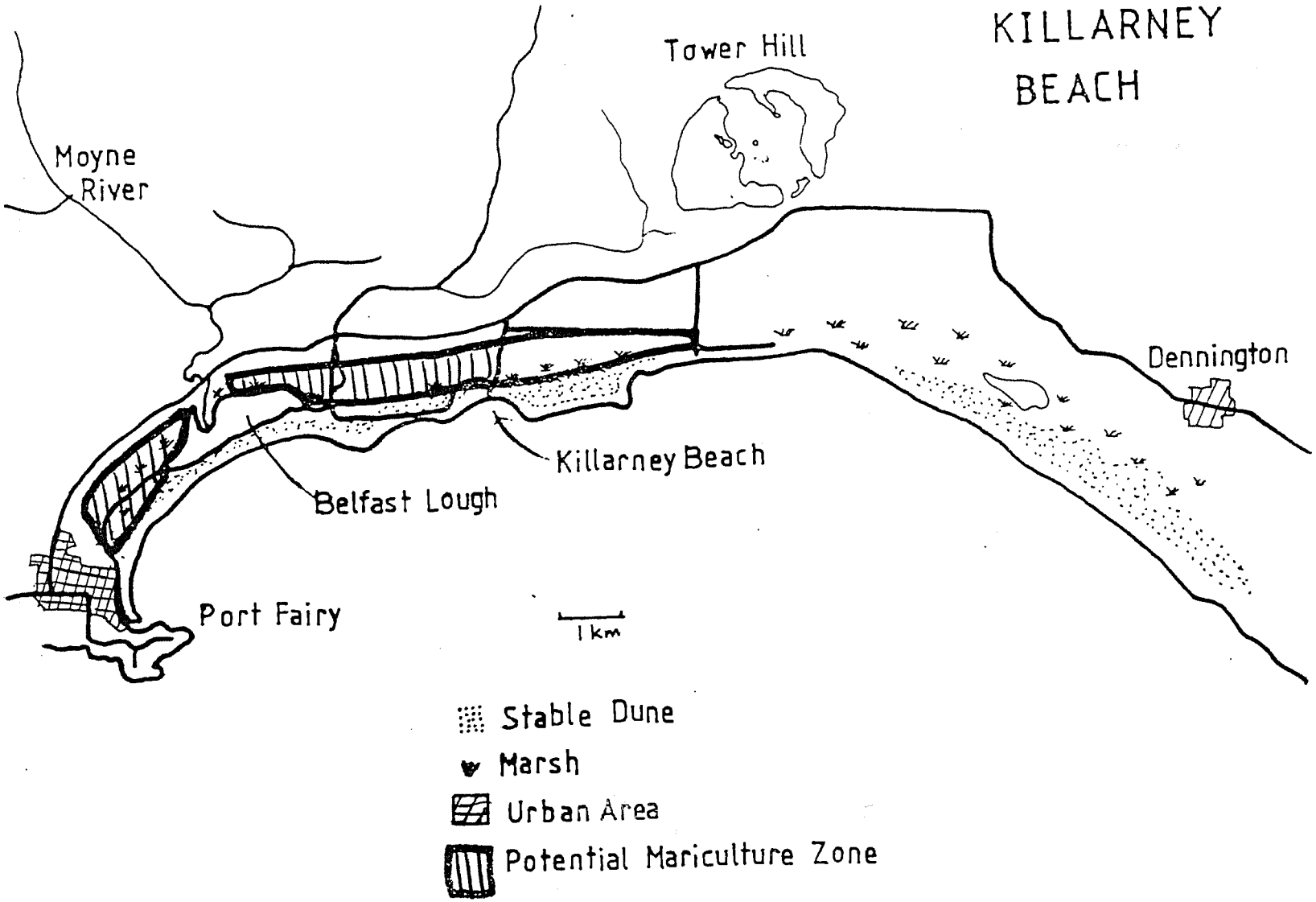
MARICULTURE PROSPECTS

The extensive marshlands near Dennington are unsuited to land based cultivation as they provide a significant habitat for migrating wading birds and waterfowl. The preservation of this habitat is not incompatable with limited development at Killarney Beach and Belfast Lough.

Killarney Beach water is high quality and the sheltered conditions are ideal for drawing seawater from this bay. The dunes have been modified for car parking and pipes could be laid through them with minimum risk to dune stability. The coastal marshland is narrow and is fringed by extensive areas of poor quality grazing land which are well suited to development. Artesian bores are located nearby. Conflicting uses are high on the coast but low elsewhere. Road access and power are available to the beach. Area available is 3 km^2. Potential - good

The area at Belfast Lough suitable for mariculture adjoins the above area. However, ocean conditions here are more exposed and water intake would be more difficult than at Killarney. The two most promising locations are to the south and north east of the lough. Potential area is marginally less than 2 km^2, of which half is uncommitted crown land. Potential - good.

Fig. 29.


KILLARNEY
BEACH
Tower Hill
Moyne
River
Dennington
Killarney Beach
Belfast Lough
Port Fairy
1 km
Stable Dune
Marsh
Urban Area
Potential Mariculture Zone

GOVERNMENT POLICY

Land Protection Service Most of the crown land on the coast is committed as Coastal Reserve. Some marshlands are uncommitted and currently, mariculture is considered a suitable use in these areas.

Shire of Warrnambool The Shire currently has no policy concerning mariculture.

Shire of Belfast The Shire supports the development of land based mariculture along the coast.

T) PORT FAIRY WEST

Small sheltered, reef enclosed beach areas extend westward from Port Fairy for approximately eight kilometers. Relative costs of drawing water from these embayments are considerably lower than high energy coasts making these sites emanently suitable for land based culture. Behind the beachfront there is a thin strip of stable dune, approximately 200 metres in width behind which there are suitable areas of freehold farmland. Conflicting interests are few as access to the beach is limited. Beaches are used for swimming, diving and fishing. There is no conflict with land use behind the dunes as the land is freehold and presently used for farming. Power and access to the sites could be provided from the Princes Highway which is approximately one kilometer inland.

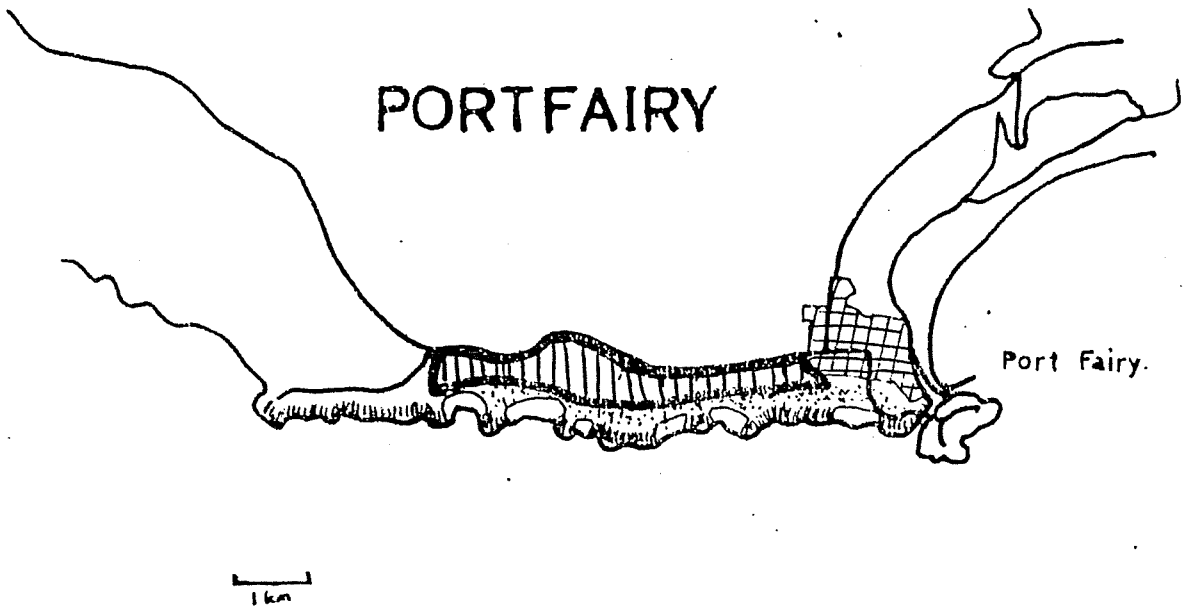
MARICULTURE PROSPECTS

Water quality is excellent. Intensive culture methods are most applicable because of land availability. Approximate area available is 3 km^2. Potential - good.

GOVERNMENT POLICY

Shire of Belfast The Shire of Belfast supports in principle the development of mariculture.

Fig. 30.


PORTFAIRY
Port Fairy.
1km
Track
Beach
Reef
Urban Area
Potential Mariculture Zone

U) LAKE YAMBUK

Lake Yambuk is located at the mouth or the Eumeralla River where there is a small area suitable for land based mariculture. The lake is basically estuarine, however, during winter and spring floods salinity is low for considerable periods. The entrance often closes. The Eumeralla River catchment is farming land, mainly dairy farming and sheep/cattle grazing. Adjacent to Lake Yambuk is the small township of Yambuk.

Lake Yambuk is used significantly for water sports such as water and jet skiing and swimming. The marshland on the west of the lake is a significant habitat for wading birds. Picnic facilities are provided at the mouth of the lake.

MARICULTURE POTENTIAL

The only site with landbased mariculture potential is marshland to the south east of the lake. This land is close to the entrance where seawater is available.

Supply of sea water to the site would require an offshore water intake as the inlet is closed for part of the year. Location of water pipes through the entrance would lower construction costs and would not affect the existing sand dunes. There is a crown land reserve between the coast and the proposed mariculture zone through which any water supply pipes would need to pass. Conflicts with use of this area for land based farming are few. Potential area available is 3 km^2. Potential - good.

GOVERNMENT POLICY

Land Protection Service A permit would be required from this Service to run water pipes across the foreshore.

Shire of Belfast The Shire in principle supports the development of mariculture.

Y) FITZROY RIVER

The Fitzroy River is a small stream entering the ocean east of Portland. The entrance is often closed and salinities are variable ranging from freshwater during floods to seawater when the estuary is open during the summer months. Catchment use is predominantly grazing and dairy farming. Surrounding the estuary is lowlying poor quality grazing land interspersed with saline marshland. The coastal strip between the sea and estuary is stabilised sand dune. The land to the north of the estuary is freehold farmland whilst the entrance and coastal zone is incorporated into a crown land coastal reserve.

The estuary is used for amateur fishing and swimming near the mouth. Conflicts with mariculture at this site are few.

MARICULTURE PROSPECTS

The prospects of land based mariculture are made more difficult by the cost of establishing and maintaining a water intake system on this high energy coastline. Access points to the sea are limited to the estuary mouth as costs of laying pipes through the sandunes would be prohibitive. Intensive mariculture is most suited here as soil type is mainly sand and there is insufficient space for extensive land based ponds. Access to the site is excellent with power supplies being located nearby. Conflicts with other uses are low as farming is the only significant use. Potential suitable area is approximately 2 km^2 located to the east of the access road. Potential - good.

GOVERNMENT POLICY

Land Protection Service A permit would be required from the Service to traverse coastal crown land with a water intake system.

Shire of Portland The Shire has no formal policy concerning mariculture development.

Fig. 31.

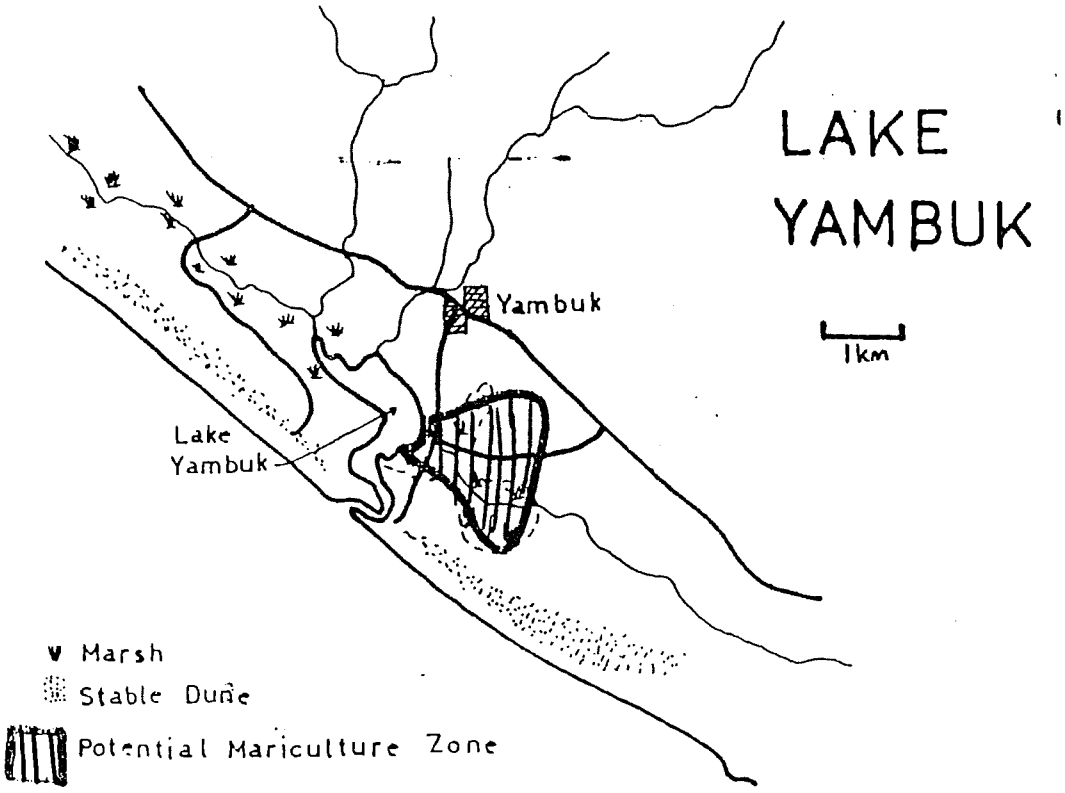

LAKE
YAMBUK
Yambuk
1km
Lake
Yambuk
Marsh
Stable Dune
Potential Mariculture Zone

Fig. 32.

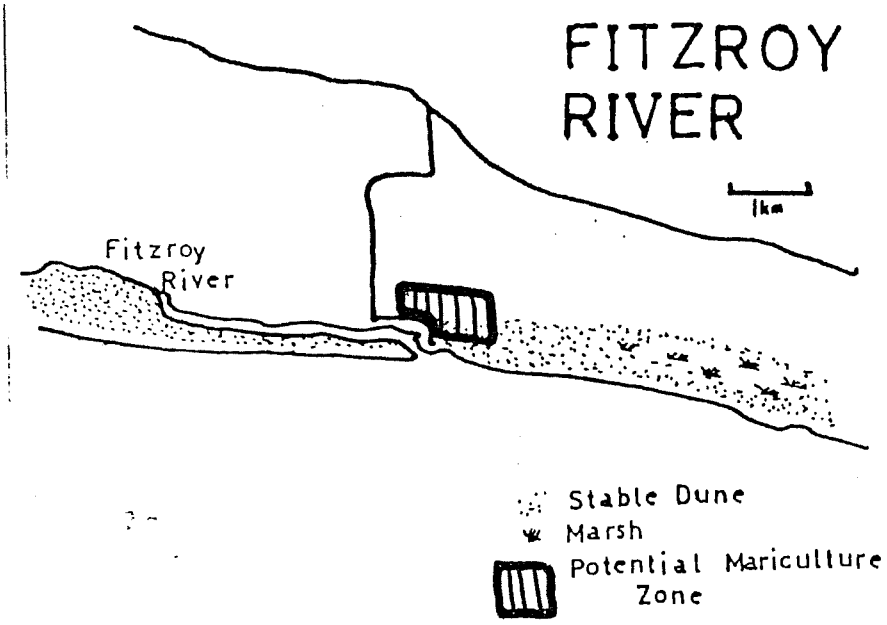
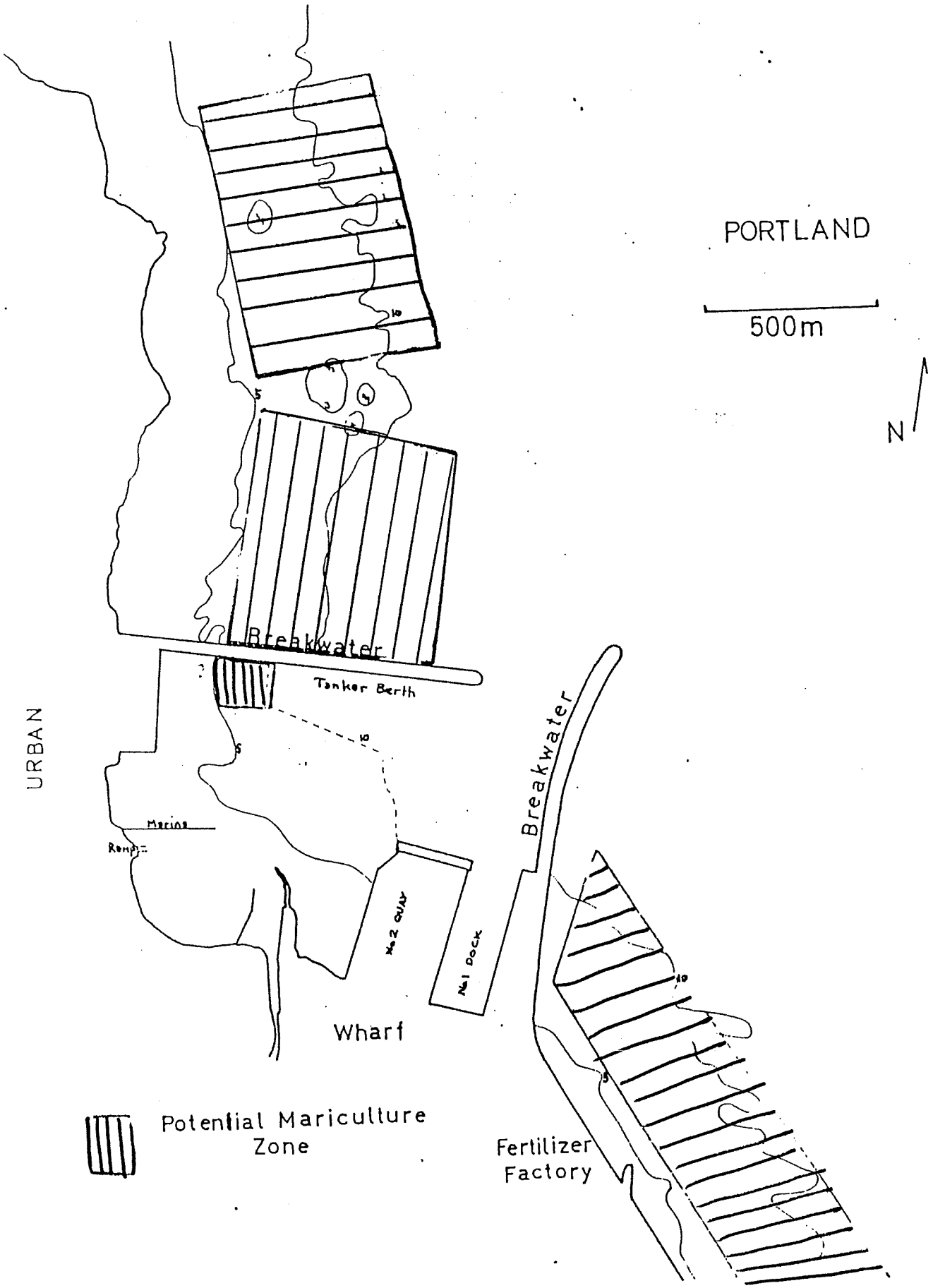

FITZROY
RIVER
1km
Fitzroy
River
Stable Dune
Marsh
Potential Mariculture
Zone

Fig. 33.


PORTLAND
500m
N
Breakwater
Tanker Berth
URBAN
Marina
Ramp
No 2 QUAY
No 1 DOCK
Breakwater
Wharf
Potential Mariculture Zone
Fertilizer Factory

W) PORTLAND

Three areas at Portland are suitable for offshore mariculture these being within the sheltered waters of the harbour, in the lee of the harbour near Whalers Point and in the lee of Blacknose Point.

Portland is the fourth largest Port in Victoria and its use as a grain terminal is growing. It is also the site of a developing aluminium smelting industry. A large fishing fleet is based in Portland which includes deepwater offshore trawling, rock lobster fishing, abalone fishing and inshore mesh netting. Portland Harbour is heavily used by anglers, yachtsmen and other recreational interests. Angling is either inshore reef fishing or offshore game fishing. Water quality of the bay and the harbour is excellent as tidal exchange regularly flushes the harbour. Portland is sewered and only stormwater runoff enters the bay. Access to all the potential areas is excellent in most weather conditions. Mooring and launching facilities are available within the harbour. Prevailing winds are from the south west, south and north west. The lee of Point Danger is well sheltered and suitable for offshore mariculture.

MARICULTURE POTENTIAL

Mariculture potential within the harbour is low because of spatial conflicts with existing commercial shipping, the fishing fleet's requirements and boating in general. These sheltered waters however provide a suitable site for limited scale floating cage culture of fishes. There is sufficient space for perhaps one lease area which would have minimal effect on existing uses. The water quality of the harbour is excellent. Management would be simple as access to the harbour is available at all times.

There is a small area adjacent to the harbour which is suited to longline culture of molluscs and floating cage culture of fishes. Conflicting uses in the area are moderate with angling and yachting being most common. There is potential for at least two x 3 hectare lease sites. Shelter at this site is good with heavy seas being uncommon. Access to the lease site is excellent.

The largest area suitable for offshore culture is located between Blacknose Point and the harbour breakwater. Water depth is greater than 10 metres and the area is well sheltered from all directions except the south east. The area is suitable for floating cage culture of fish and longline culture of molluscs. Conflicting uses of the area are few, angling being the principle one. There is potential for a minimum of four x 3 hectare leases with room for four more. Access from the harbour is excellent.

GOVERNMENT POLICY

Port of Portland Authority The Authority has in the past rejected an application for mariculture within the harbour and does not support the use of the harbour for mariculture.

Town of Portland The Town supports development of mariculture outside the harbour area in principle.

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