

Technical Series No. 5

**PATERSON INLET
MARINE BENTHIC ASSEMBLAGES**

Report of Coastal Investigations

by



**CONSERVATION
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**PATERSON INLET
MARINE BENTHIC ASSEMBLAGES**

Report of Coastal Investigations

by
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ABSTRACT

The marine algae and fauna living on the seafloor, rocky reefs and intertidal rocks of Paterson Inlet, Stewart Island are described. Data compiled over the past 22 years - in 11 sources including published and unpublished reports - is reviewed.

Assemblages identified range from semi-exposed reefs and sandy seafloor at the inlet's entrance to large exposed mudflat deltas at the mouths of the two main river catchments. Algal communities dominated by *Lenormandia* and *Rhodymenia* species grow on the muddy seafloor of the central inlet. Three species of brachiopod are widespread on mud, grit and gravel seafloor.

The catchment area of the inlet retains its natural vegetation cover; sedimentation rates are low. The stability of the inlet's sedimentation regime is hypothesised as being an important contributing factor in the maintenance of a marine community which is tolerant of a range of sediment types. A relationship between the presence of red algal communities and of brachiopods on soft-sediment seafloor areas is proposed. The diversity of marine algae is compared to other areas of New Zealand. The inlet supports a rich flora of algae, especially rhodophytes.

KEYWORDS: benthic assemblages, brachiopods, habitats, *Lenormandia*, marine algae, marine fauna, marine fish, *Neothyris*, Paterson Inlet, rhodophytes, *Rhodymenia*, Stewart Island, *Terebratella*

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PART I: INTRODUCTION

1 CONTEXT OF REPORT

This report comprises a review of investigations into marine benthic assemblages of Paterson Inlet undertaken over the last 22 years by a range of agencies, including work carried out by the Department of Conservation since 1987. These sources are described in Section 11.

Earliest studies of the inlet's marine biology highlighted several interesting features. An account of the soft-sediment biota in Glory Cove by Batham (1969) described the presence of large beds of the red alga *Lenormandia chauvinii* on mud and an unusual wealth of echinoderms.

The diversity of algae led to a compilation of a marine algal species list by Adams et al. (1974). Two cruises were sponsored by the National Geographic Society in 1977 and 1978 to study the brachiopod fauna of both the inlet and areas of Fiordland.

Because of the area's unusual features, and the continuing natural state of the inlet, the Department of Conservation (DOC) has promoted marine protection for Paterson Inlet since 1987. This followed similar suggestions in a public submission paper prepared by the Ministry of Agriculture and Fisheries, the government department previously responsible for marine reserves.

This report has an implicit purpose to support proposals for the protection of the natural features of Paterson Inlet, but not to say how, nor does it refer explicitly to threats to apparent conservation values. Rather it serves to further the scientific process by giving a "status report" of scientific knowledge and providing a basis from which to propose further investigation into benthic habitats, species and inlet processes. It is fundamental that successful marine protection has a scientific base; to provide information to determine what areas should be protected and a baseline against which to measure the effect of protection.

2 PATERSON INLET ENVIRONMENT

Paterson Inlet, on the east coast of Stewart Island, is 100km² in size (Figure 1) and is centred around latitude 46° 55' S, longitude 168° 5' E.

From a narrow entrance between two peninsulas, Ackers Point and The Neck, Paterson Inlet extends 16 kilometres westward to extensive intertidal mudflats around the mouth of two major rivers, the Freshwater and Rakeahua (Figure 2). Maximum depth in the inlet is 45 metres; over much of the mid-inlet depths vary between 18 and 25 metres.

Within the inlet are over 20 small islands. The largest, Ulva Island, is centrally located in the eastern reaches. Several smaller inlets and coves exist: Little Glory Cove and Big Glory Bay in the south east, and North Arm, Prices Inlet and Kaipipi on the northern shore. The

Rakeahua River flows into the long, open South West Arm. The natural forest cover around the inlet's shore is almost all intact. It descends from the hilltops to overhang the rocky shores.

The eastern reaches, including Ringaringa, Native Island, and the outer portion of the Neck, extending westward to include the eastern tip of Ulva Island, are referred to in this report as the entrance to Paterson Inlet or the outer inlet. Westward to the mudflat areas (Figure 2) is referred to as mid-inlet.

The inlet has a shoreline length of around 190 kilometres, comprised principally of granite shores, with limited areas of sandy beach and numerous small mudflats in bayheads. Below this the seafloor varies from sands swept clean by current, to scoured areas of shelly gravel, to extensive areas of mud little disturbed by current or wind driven waves. At the western end are large open mudflats.

Rocky intertidal habitats in the outer inlet range from the exposed platform rock and boulder reefs of the outer coast, to soft rock and numerous pools at Moses Nugget on Ringaringa Beach, and mobile sandy broken rock beaches with numerous pools as at Ringaringa Back Beach. In mid-inlet short steep platform rocks, and flatter beaches of broken rock are most common. Along the south shore, the rock cliffs are taller, and the shattered schist complex has numerous cracks, crevices and in places such as at Gentian Cove small intertidal rock pools occur. Large intertidal reefs of boulders and broken rock occur at Pipi Rocks and Bullers Point.

Except for the outer points of Paterson Inlet - Ackers Point and Bullers Point, and Ringaringa - the rocky shores are sheltered from wave swells from the ocean. The southern South Island coast and the offshore islands in eastern Foveaux Strait reduce the fetch of the majority of waves reaching the inlet to much less than 30 kilometres. Ringaringa is open to waves from across the Pacific Ocean, but only from a south easterly direction. The predominant winds are southwesterlies and westerlies. The Neck peninsula and two islands near the inlet entrance shelter the mid-inlet area from heavy seas.

The waters of Paterson Inlet are influenced by their exchange with the waters of southern New Zealand including Foveaux Strait to the north. To the south of the South Island (around Stewart Island) there are regions of strong gradients and mixing between cool subantarctic water and warmer, more saline tropical waters (Vincent et al., 1991). Periodically nutrient-rich saline water is introduced into the nearshore waters west and east of Stewart Island (Bradford et al., 1991). Tidal range at Stewart Island is estimated at 2.6m HWS (New Zealand Nautical Almanac 1973 in Adams et al., 1974).

3 AIMS OF REPORT

The aims of this report are threefold:

1. To summarise existing information on the composition of marine benthic assemblages on the shores and sea-bottom of Paterson Inlet;
2. To order these assemblages into three major and eight minor classes for the purpose of description, based on published data and on field survey undertaken for the purpose;
3. To review this material, highlighting: (a) the distribution of the assemblages; (b) the diversity of marine algae; and (c) the occurrence value of brachiopod and red algal assemblages on muddy seafloor; and proposing the importance of low rates of sedimentation in giving rise to this pattern.

Unlike in a conventional scientific report, factors of scientific significance are discussed before the "results" - the review of the various assemblage types in the inlet - are presented. The assemblages are described in section 10, following an outline of the methods used to delineate the different types in Section 9. The sources on which these assemblage descriptions have been based are summarised in Section 11. This order has been used to provide readers with a precis of the significant features of the inlet's marine ecology at the beginning of the report; the facts which support the reasoning and conclusions in Part II (Sections 5 - 8), are contained in section 10.

Appendix material gives greater detail on fish distribution (Appendix 2), fish count sites (Appendix 6), marine algae (Appendix 3), rocky shore communities (Appendix 4), fish species (Appendix 5); scientific and common names of plants and invertebrates are listed in Appendix 7.

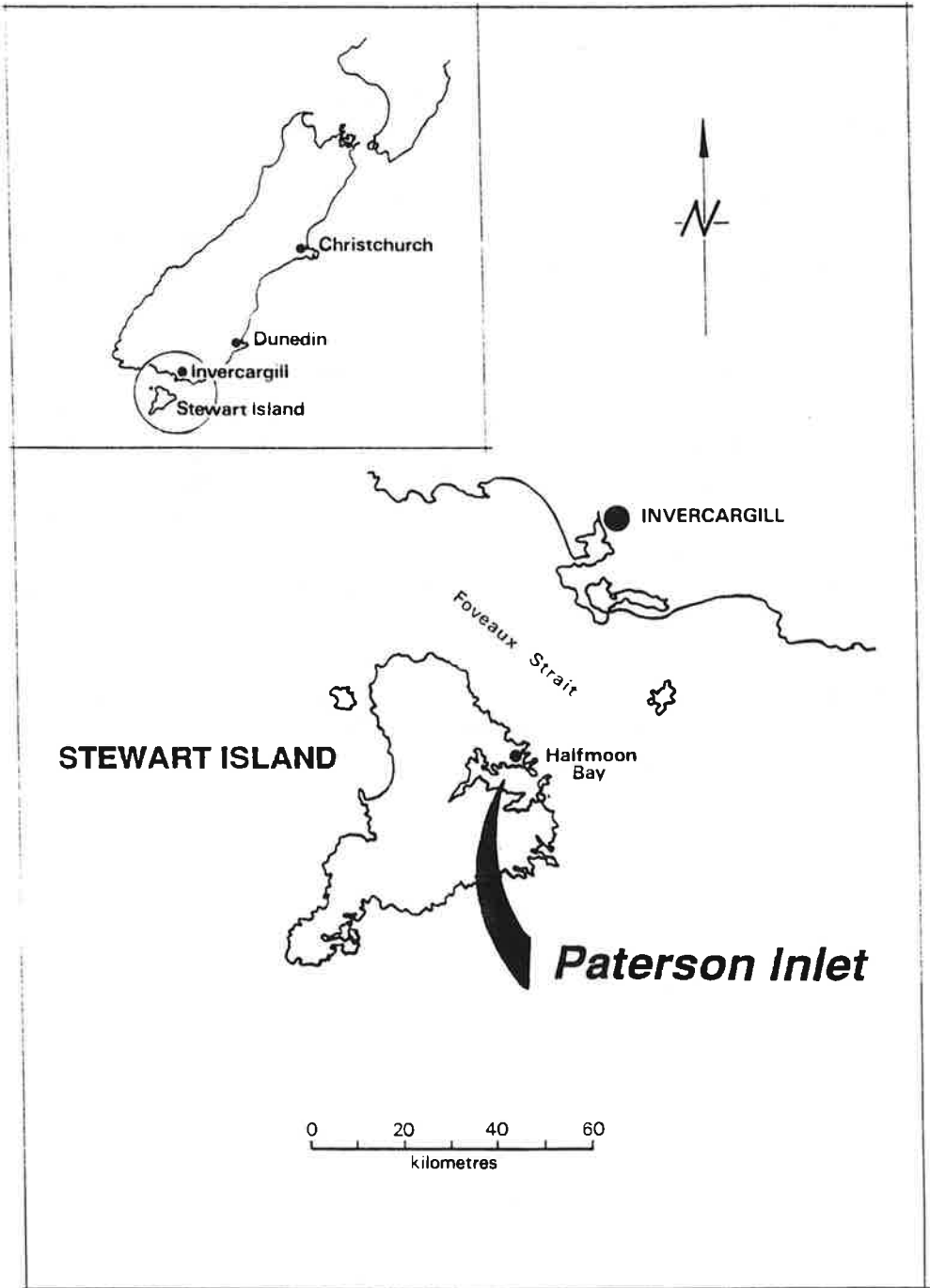
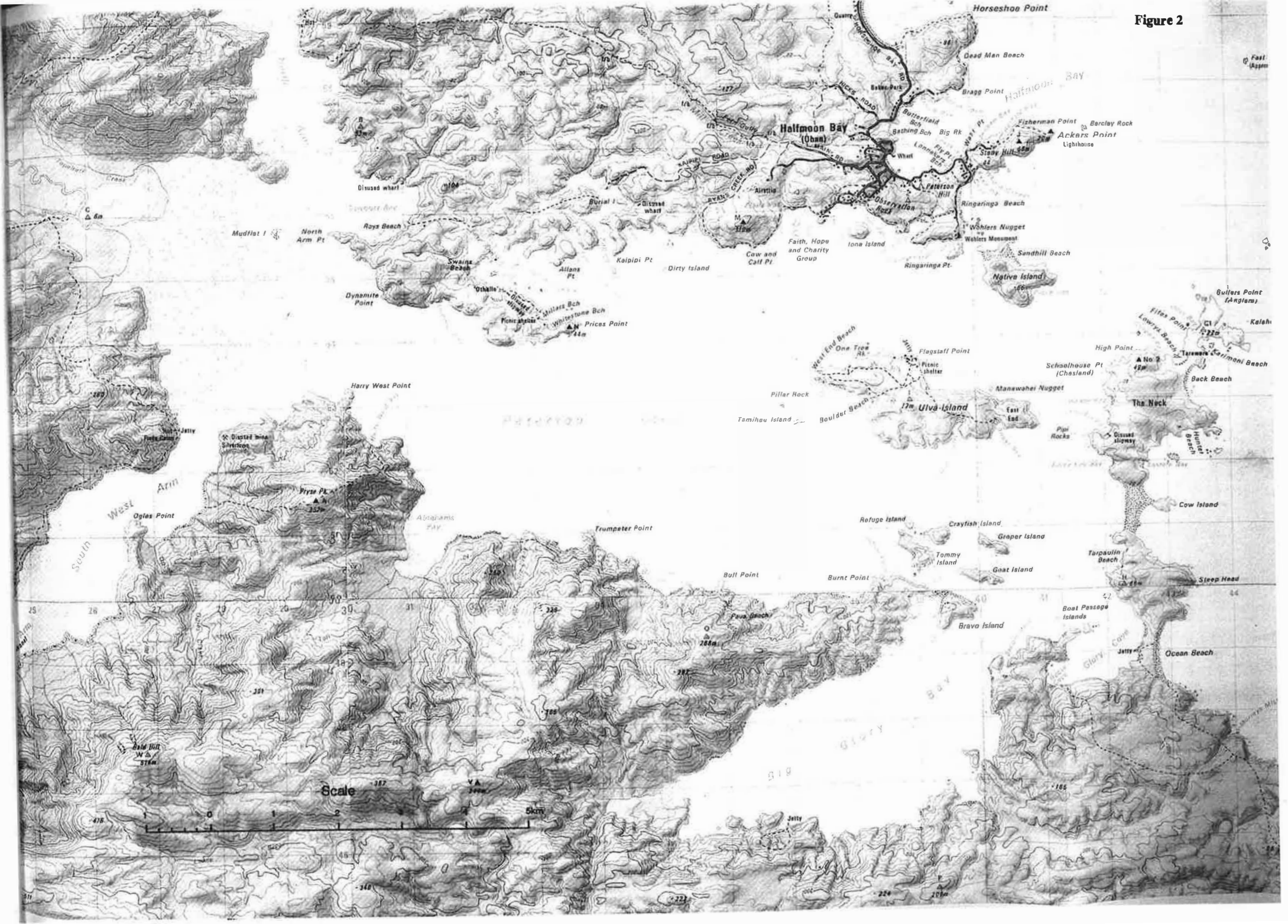


Figure 1: Location map of Paterson Inlet, Stewart Island

Figure 2



PART II: FACTORS CONTRIBUTING TO SCIENTIFIC SIGNIFICANCE

4 OVERVIEW

Paterson Inlet is one of the largest sheltered harbours in the south of New Zealand - comparable in size to Port Ross in the Auckland Islands or Port Pegasus on the southern side of Stewart Island - and one of the largest that is not a fiord. It has a unique combination of natural characteristics which have drawn scientific interest.

Biological characteristics of interest hinge on two principles: diversity (of habitats and species) and species of interest (e.g. uncommon, rare or endemic species).

The mixing of Subtropical Convergence and subantarctic waters in the currents around Stewart Island has resulted in the inlet having affinities with both the subantarctic region and areas of northern New Zealand. This, plus the natural diversity of topography and variety of habitat types within a relatively small area, is reflected in the variety of benthic assemblages - that is, collections of plants and animals co-existing in particular ways on the sea floor and the rocky coasts of Paterson Inlet. The diversity of marine life in Paterson Inlet (Sections 6 and 7) is shown by the range of distinct assemblages, also by the interrelatedness of the entire inlet ecosystem. The features common to several assemblages, outlined in the sections describing each (Section 10), point to this coherence.

The rivers flowing into Paterson Inlet are clear water (and come from relatively unmodified catchment areas); this along with the fact that the inlet is not a fiord or glacial valley but a drowned river valley, has resulted in an unusually low sedimentation rate on the floor of the inlet. This low sedimentation is a prime reason why the wide variety of brachiopods - double-shelled animals similar to some molluscs but of vastly older origin - are still found in Paterson Inlet. The brachiopods are found here in notably shallower waters than most other locations, and are accessible for in-situ research into this important phylum of 'marine fossils'. Species in Paterson Inlet which have been of greatest scientific interest to date have been the free-lying brachiopods *Neothyris lenticularis* and *Terebratella sanguinea*.

Another evident feature of Paterson Inlet's benthic ecology is that several faunal species - including brachiopods, echinoderm species such as sea cucumbers and brittle stars, and several fish species - occur at a majority of sites examined, despite obvious differences in sediment and exposure type between the sites. This is not common in New Zealand and may well be due to the very low sedimentation rate.

Stewart Island has the richest seaweed flora - especially red algae - relative to its coast length, in New Zealand, and Paterson Inlet supports populations of 70% of the types of seaweed found in Stewart Island. This alone has made the area worthy of major scientific study, as the diversity of species is greater than that found on the New Zealand subantarctic islands, the Chathams, or the Kaikoura coast. And the affinities of the Paterson Inlet marine algae also reflect its unique geographical position.

Of the other southern inlets with marine assemblages comparable to those in Paterson Inlet, Port Pegasus is most similar. But several distinct differences exist, not just in the topography and hydrology, but in the biota. In particular, the beds of free-lying brachiopods in Paterson Inlet (Sections 8 and 10.7) are not replicated at Port Pegasus. Much of the seafloor of Port Pegasus is too deep for algae communities to live.

Underpinning the physical and biological characteristics of an area is the ecotone, the transition zone between adjacent ecological systems, and their components - plant and animal communities, habitats and landscapes.

The state of an ecosystem and the associated ecotone, and the degree and manner in which it may have been modified by human influence, are causal elements of the combination of species, communities and processes now characterise an area. The less modified an ecosystem is, the more intact is its ecotone, and the closer it resembles a pristine state. This degree of naturalness is a criteria commonly used to determine areas that may merit protection from further modification.

The ecotone of Paterson Inlet extends from the highest slopes of the catchment down to the shores and continues through a diverse range of benthic assemblages on the seafloor and out into Foveaux Strait.

Compared to other deepwater inlets in the North and South Islands (with the exception of the fiords) Paterson Inlet is little modified. The catchment's natural vegetation cover is virtually intact. The largest influence on it has been introduced animals modifying the structure of the forest (NZ Forest Service et al., 1978). Fishing has impacted on Paterson Inlet; probably since the earliest Maori occupation (13th century at least (Otago Daily Times, 1961)). Localised destruction of the benthos from salmon and mussel farming has occurred in Big Glory Bay (see Appendix 1).

Accessibility - whilst a cultural factor - is of importance in determining the significance of the Paterson Inlet biota as a scientific resource. All the inlet is accessible to in-situ SCUBA study. Compared to the outer coast and Foveaux Strait the inlet waters are sheltered and safe for boating. The infrastructure provided by the nearby settlement permits scientific study to be more easily carried out than at the more southern inlets in Stewart Island or in the fiords.

5 SUBSTRATE TOLERANCE

One of the most evident features of Paterson Inlet's benthic ecology is that several faunal species occur at a majority of sites examined, despite obvious differences in sediment type and exposure to waves (Section 9.1) between these sites. The most common of these substrate-tolerant species are *Stichopus mollis* and *Terebratella sanguinea*. In addition many other faunal species which occur at lower densities exhibit tolerances to both sand/shell and mud sediments. These are listed in Table 1. Almost half these species also occur on rock substrates within the inlet.

Table 1: Faunal species present on/in a range of sediment types throughout Paterson Inlet

		Sand/shell	Mud	Rock
COELENTERATA	<i>"Cerianthus" sp.</i>	*	*	
ANNELIDA	<i>Brachiomma sp.</i>		*	*
	<i>Eunice australis</i>	*	*	
	<i>Filograna impexa</i>	*	*	*
CRUSTACEA	<i>Pagurus sp.</i>	*	*	*
BRACHIOPODA	<i>Terebratella sanguinea</i>	*	*	*
	<i>Neothyris lenticularis</i>	*	*	
	<i>Waltonia inconspicua</i>	*	*	*
MOLLUSCA	<i>Chlamys gemmulata forma suteri</i>	*	*	
	<i>Maoricolpus roseus</i>	*	*	
	<i>Nemocardium pulchellum</i>	*	*	
	<i>Tanea zelandica</i>	*	*	
	<i>Xymene ambiguus</i>	*	*	
ECHINODERMATA	<i>Amphicyclus thomsonii</i>		*	*
	<i>Chirodota nigra</i>	*	*	
	<i>Coscinasterias calamaria</i>	*	*	*
	<i>Echinocardium cordatum</i>	*	*	
	<i>Ophiopsammus maculata</i>	*	*	*
	<i>Ophiomyxa brevissima</i>	*	*	
	<i>Patiriella regularis</i>	*	*	*
	<i>Pentagonaster pulchellus</i>	*	*	*
<i>Stichopus mollis</i>	*	*	*	
ASCIDIACEA	<i>Cnemidocarpa bicornuata</i>	*	*	*

* Species found on both hard and soft substrates in Paterson Inlet

The majority of these species tolerant to all substrate types are echinoderms (including both holothurians and asteroids) and brachiopods. They include not only predatory starfish which commonly tolerate a wide range of sediments, but also a number of filter and deposit feeders (Willan, 1981).

Willan listed species occurring commonly at most stations within Paterson Inlet and shared by both communities that he identified - the sand-dwelling assemblage in the inlet's entrance and the mud assemblage of the central inlet. In Table 1 additional species have been added to Willan's list. They reflect the stations further west than those he examined (which are shown in Figure 3). The western stations occurred mainly on muddy sediments, with a few on inshore sandy areas.

Of the 35 species of algae recorded from soft substrates in the inlet (Tables 6 and 10) 32 are also found on rock substrates. Additionally, at least ten faunal species are found on both hard and soft substrates (Table 1). Although these species commonly occur throughout New Zealand, this tolerance to a broad range of sediment types is not usual (Ken Grange, NZOI Wellington, pers. comm.).

This may be due to the Paterson Inlet marine biota evolving in an environment of very low sedimentation. The catchment area of Paterson Inlet retains its natural vegetation cover. The inlet itself is relatively unmodified and would appear to have retained a low rate of marine sedimentation (infilling) for the last 5000 years.

The apparent stability of the inlet's sedimentation regime is hypothesised as also being an important contributing factor in the maintenance of the sediment-tolerant community.

If species are present on a range of sediment types, then this usually suggests that they can cope with environmental change. However in Paterson Inlet species live in mud as well as shell gravel and sand because sedimentation rates are low. In northern New Zealand inlets, the presence of mud usually indicates high rates of sedimentation that would smother immobile species. In Paterson Inlet, muddy areas may be accumulating sediment slowly enough that these species can survive on them (Grange pers. comm.).

"Sedimentation rates are low (in Paterson Inlet) and this is thought to have an important influence on the marine species in the inlet, the majority of which are not adapted to withstand high rates of sedimentation" (Grange and McKnight, 1987). As well as individual species, the structure of the marine community in Paterson Inlet as a whole is not adapted to withstand high rates of sedimentation. An increase in sedimentation in Paterson Inlet would alter the balance of dominance - some species may become more/less abundant but still survive. This change would also mean that food preferences of individual species - fish and starfish for instance - would alter, resulting in a new community structure (Grange pers. comm.).

Only in very recent time (in geological terms) have activities that might adversely affect sedimentation been introduced to Paterson Inlet. Salmon farming has been carried out in Big Glory Bay since 1981 and mussel farms are a recent introduction to the inlet. Small scale clearance of forest on the northern end of The Neck and at Ringaringa occurred during the last century. A trial harvesting of geoduc using seabed sluicing techniques occurred in

1990 and recreational dredging for scallops has occurred sporadically for years. The marine farming has modified the benthic communities under and around each farm (Gillespie, 1989; Roper et al., 1988). The impacts of these methods of scallop and geoduc harvesting have not been studied, nor the impact of land clearance.

6 SPECIES DIVERSITY

The rocky shores, both littoral and sublittoral, of the inlet entrance support a more diverse biota than that found in mid-inlet. There is a greater diversity of fish species (Section 11.5 and Appendix 2) and marine algae (Appendix 3 and Sections 10.1.1 and 10.1.2). Diversity of intertidal fauna appears to be correlated with the presence of broken rock substrate. Diversity at the 16 intertidal sites studied was highest at Thule Back Beach, Cow and Calf Point, and Pipi Rocks in mid-inlet and at Bullers Point in the inlet entrance (Appendix 4).

In the intertidal rocky shore fauna of Paterson Inlet, southern species form a more dominant portion of the biota than in the subtidal fauna. All the common soft substrate benthic species identified by Willan (1981) (those taken at 25% or more of stations) occur throughout New Zealand with only two exceptions (*Pentagonaster pulchellus* and *Felaniella rakiura*).

Within the inlet, species diversity is high amongst marine algae, echinoderms and fish. The diversity of marine algae is discussed below. The unusual abundance and diversity of echinoderm species reported by Batham (1969) from Glory Cove is also a typical feature of other areas in Paterson Inlet both *Lenormandia* meadows and other soft-sediment habitats as can be seen from the descriptions of species assemblages in Section 10. Comparisons of fish density and diversity have been made with areas of adjacent coast outside the inlet and islands in Foveaux Strait (Appendix 5). The number of fish species is higher in the inlet than at these adjacent coast and island sites; overall fish density is highest at shallow inlet sites.

7 MARINE ALGAL ASSOCIATIONS AND DIVERSITY

Few descriptions exist of algal communities in New Zealand to allow comparisons to be made. Communities comparable to those in Paterson Inlet occur on the Kaikoura coast. Relatively exposed sites on this coast at Fifth Bay and St Kildas Rocks contain sublittoral communities on rock (South and Adams, 1976) which are similar to those in the entrance to Paterson Inlet at Ringaringa and Bullers Point. The inlet assemblage contains several species of brown algae in the overstorey (compared to *Marginariella urvilliana* only at the Kaikoura sites). A diverse understorey of smaller red algae including *Hymenena* spp., *Schizoseris*, *Plocamium* spp., *Delisea elegans*, *Champia chathamensis*, *Spatoglossum chapmanii* and *Euptilota formosissima* is common to both the Kaikoura and Paterson Inlet sites.

The algal communities of Port Adventure and Port Pegasus both exhibit some similarities with those of Paterson Inlet. Port Adventure is much smaller (8.4 sq. km.) with less diversity of habitats. The algal communities on the soft sediments of Port Adventure have

yet to be studied but are of much more limited extent than these in Paterson Inlet. Much of the central mud areas of Port Pegasus are over 30 metres deep and probably beyond the limit of photosynthesis for algae.

Lenormandia meadows (Section 10.8.2) occur in sheltered shallow areas such as Islet Cove and North Arm of Port Pegasus. Another interesting association of algae living on the muddy seafloor occurs principally in the head of South and North Arms, Pegasus Passage, and the area between Noble Island and Islet Cove entrance. The brown algae *Ecklonia brevipes* and *Cystophora distenta* are widespread. *Lenormandia* occurs along with various other algae including *Champia chathamensis*, *Rhodomenia linearis*, *Griffithsia* sp., *Plocamium* sp., and *Ulva* sp. However it is not dominant in these mixed beds. Its distribution is again depth related; below 20 metres it occurs only occasionally in these mixed algal beds, whilst above 20 metres it is often the dominant species, as in North Arm (Hare, unpublished).

The extensive inshore sandy association of Paterson Inlet dominated by *Asparagopsis/Delisea/Brongniartella* and in places *Lenormandia* does not appear to occur at Port Pegasus where *Gracilaria truncata* dominates shallow sand/shell substrates.

Lenormandia beds are also widespread in Otago Harbour and occur to a small extent in Ranui Cove at the Auckland Islands. They may also be present in shallower areas of Fiordland such as in Preservation Inlet (Cameron Hay, DOC Wellington, pers. comm.).

No published accounts have been found of associations comparable to the *Lenormandia chauvinii/Asparagopsis armata/Brongniartella australis* community growing on soft sediments in Paterson Inlet (Sections 10.5 and 10.8.2). All algal species growing on sand and shell in these sandy inshore areas (see Table 3) also occur on rocky reefs in the inlet with the exception of *Gracilaria truncata*. This is in contrast to northern areas where it only grows on rock, and to the Marlborough Sounds where it grows in loose assemblages with other species (Wendy Nelson, National Museum Wellington, pers. comm.).

Currents in the areas of sandy sediments around the base of the rocky reefs in mid- Paterson Inlet are probably not strong enough to prevent the settlement and growth of algae. This has probably permitted the growth of this *Asparagopsis* dominated algal association on shell fragments anchored in the sand of these inshore locations. Whether these species reproduce sexually or from vegetative fragments in Paterson Inlet is as yet unstudied.

Records of all the Chlorophyceae (green seaweed), Phaeophyceae (brown seaweed) and Rhodophyceae (red seaweed) found in Paterson Inlet are given in Appendix 3. Adams et al. (1974) lists Cyanophyceae (blue-green algae) records. The total number of species recorded from Paterson Inlet is:

<i>Cyanophyceae</i>	8
<i>Chlorophyceae</i>	31
<i>Phaeophyceae</i>	56
<i>Rhodophyceae</i>	174
TOTAL	269

Rhodophytes growing in the inlet are primarily distributed among the orders Gigartinales (especially Gigartinales, Plocamiaceae and Rhodophyllidaceae), Rhodymeniales and Ceramiales. Species with large flat-bladed thalli, as well as those in the genus *Ceramium*, need further taxonomical investigation before their distribution within the inlet can be determined e.g. the Corallinales (particularly crustose species) in the inlet have been little investigated.

Adams et al. (1974) list 380 species of marine algae found on the coast of Stewart Island; a new record *Bangia fusco-purpurea* (Appendix 3), brings the total to 381. Thus, 70% of the algal species recorded for Stewart Island are found within Paterson Inlet.

The Paterson Inlet marine flora is a good representation of southern New Zealand flora, based on comparisons with other collections made. The diversity of algae, particularly of Rhodophyceae is a southern feature. Naylor's list of marine algae of the Dunedin District totals 223 confirmed records and 48 which remained unconfirmed (Naylor, 1954). The area covered by this list includes both Otago Harbour and the outer coast, a much wider area than Paterson Inlet, with a comparable diversity of algae species. The Dunedin list comprises 158 species of red algae; the Paterson Inlet one, 174 species; and Kaikoura 179 Rhodopyta (South and Adams, 1976).

The marine algae of the Wellington region exhibit a 40% similarity with Paterson Inlet species (calculation based on Adams, 1972). Species of the Kaikoura region exhibit a 50% similarity (based on South and Adams 1976) and there is a 56% similarity between species from the subantarctic islands and Paterson Inlet (based on Hay et al., 1985). There is a 46% similarity between Chatham Island and Paterson Inlet species (based on Nelson et al., 1991).

The level of diversity can only be compared with other New Zealand areas for which comprehensive collections have been made and species lists compiled. The number of species found within Paterson Inlet is greater than that recorded from the five New Zealand Subantarctic Islands which span 5° latitude and 13° longitude (225 species) (Hay et al. 1985). Collections from 34 stations along 65 kilometres of the Kaikoura coast (which does not contain sheltered inlets and estuaries) produced a total of 234 specimens of marine algae (South and Adams 1976). 235 species have been collected from the Chatham Islands (Nelson et al., 1991), which have a coastline of approximately 360 kilometres. The coastline of Paterson Inlet is 189 kilometres.

The number of algal species recorded from Paterson Inlet is greater than all of these three areas, two of which (Subantarctics and Chathams) are significantly larger than Paterson Inlet. Given the smaller area over which specimens from Kaikoura have been collected, diversity is probably comparable to, or lesser than that of the inlet.

Within the fiords of Fiordland, marine algae species are restricted in diversity and distribution. A low salinity surface layer reduces light levels below six metres depth to less than that necessary for most seaweeds to survive. Consequently large forests of seaweed are unable to develop where this layer is present (Grange, 1990). The algae biota from the outer coast of Fiordland and the fiord entrances is rich and diverse and similar to Stewart Island (Wendy Nelson, National Museum Wellington, pers. comm.).

The affinities of Paterson Inlet marine algae with both northern and subantarctic species probably reflect a mixing of waters from both the Subtropical Convergence and the Southland current (which itself is a mixture of both Subtropical Convergence and cooler subantarctic waters) around Stewart Island (Heath, 1975). Another factor which probably contributes to the diversity of algae within Paterson Inlet is the wide range of suitable habitats. This provides a wider range of opportunities for algae species to grow than is possible in other Stewart Island inlets.

8 BRACHIOPODS AND RED ALGAL BEDS ON MUD SEAFLOOR

Articulate species of brachiopod - those with shells held together by a pair of ball and socket joints that are part of the shells - are common around the South Island, frequently resting unattached on soft substrates. In the Palaeozoic era, when brachiopods were the dominant multicellular animals, many animals lived in this manner. At the end of the Palaeozoic era a major extinction eliminated many different animals and plants - up to 90% by some estimates, including many brachiopods species.

Usually *Neothyris* is found in areas where the current is fast enough to roll it along the bottom, thereby rolling it onto the top of any sediment that would otherwise bury it. But in Paterson Inlet *Neothyris lenticularis*, *Terebratella sanguinea* and *Waltonia inconspicua* are found on mud as well as sand and rubble areas (see Figures 3 and 4). As fossil brachiopods are found predominantly in what were originally soft sediments, the study of Paterson Inlet brachiopods has implications for the interpretation of fossil collections. Comparison of populations of brachiopods from hard and soft substrates in the same geographical area can also be undertaken in the inlet. Because of this, and because the inlet replicates conditions which existed in Palaeozoic times, it is an important site for the scientific study of brachiopods. The brachiopod beds on soft sediments in Paterson Inlet occur in depths where the species can easily be studied in-situ by scuba divers, unlike other southern areas such as Foveaux Strait where free-lying brachiopods occur.

Terebratella sanguinea and *Neothyris lenticularis* also occur on the mud of Port Pegasus, but not as a dominant component of the assemblage. At a total of 32 dredge stations on soft sediments, *Neothyris* were present at 10 and *Terebratella sanguinea* at five (Richardson, 1981a, b; Hare, unpublished). *Terebratella sanguinea* is a minor component of this Port Pegasus assemblage, unlike in Paterson Inlet where it occurred at almost every station at which *Neothyris* occurred.

"Apart from the southern fiords of South Island, Paterson Inlet probably represents one of the richest Recent brachiopod habitats in the world" (Grange and McKnight, 1987), but the free-lying habit of the majority of Paterson Inlet specimens is in contrast to the attached form of the majority of Fiordland brachiopods.

Attached brachiopods in Paterson Inlet are also of scientific interest. "Only two kinds of articulate brachiopods survive today: the terebratulids such as *Terebratella* species and rhynchonellid brachiopods of which the black ribbed species *Notosaria nigricans* is an example. Six genera of rhynchonellid brachiopods exist today, of which only one in each hemisphere is accessible by divers. The Northern Hemisphere one lives in deep water, often in dangerous currents (Thayer, 1990).

In the sheltered waters of Paterson Inlet *Notosaria* lives on rock walls as shallow as two metres. It is found on rubble substrates in several areas of Paterson Inlet including the major brachiopod beds east and south of Ulva Island, but is more commonly attached to rocky reefs.

Figure 4, which shows the distribution of *Terebratella sanguinea* and *Neothyris lenticularis*, has been prepared from data in Richardson 1981a and 1981b, Willan 1981, Roper et al. 1988 and DOC's bottom sampling programme 1989 (see section 11).

Within the inlet there appears to be a relationship between the nature of the red algal communities on mud (Section 9.8) and the presence of free-lying brachiopod species. The red algal communities may help stabilise the finer fractions of sediment sufficiently, by trapping them, to enable the brachiopods to live on these muds without being smothered or buried by sediment. As a phylum brachiopods are sensitive to increases in sedimentation (Ken Grange, NZOI Wellington, pers. comm.). Their sensitivity to smothering was demonstrated by studies of the effect of relocating salmon farms from Big Glory Bay to near Groper Island in January 1989. Within three weeks of the relocation of one farm all brachiopods under the sea cages were covered with a thin layer of sediment, and many were buried and had died. Brachiopods on the seafloor immediately adjacent to the area below the salmon sea cages appeared unaffected (Appendix 1). Salmon farming practices result in a large increase in sedimentation from fish faeces and fish food - this has been documented by Roper et al. (1988) for Big Glory Bay - with an associated increase in soluble nitrogen and phosphorous concentrations.

Batham's data from Glory Cove (1969) suggested that water currents were far less important than wind-wave action in controlling sediment distribution there. This is probably also a reasonable assumption for the mid-inlet where current levels are low, yet predominant westerly winds in gusty conditions create extremely choppy waters; circulation patterns are wind/wave driven.

The beds of red algae in mid-inlet lie upwind (in terms of the prevailing southwesterlies) from the main brachiopod beds which are associated with the shelly rubble substrate and brisker current areas around Ulva Island. In a study of the soft-bottom benthic communities in Otago Harbour and Blueskin Bay, Rainer (1981) concluded that the presence of macroscopic algae (principally *Lenormandia*) had affected sediment composition in some areas by favouring the deposition of silt and organic detritus, with resulting differences in

the fauna. The increased amounts of silt and organic detritus in the bottom deposit in an algal bed had affected the composition of the infauna with deposit- and mud-feeding species replacing those preferring a cleaner or coarser sediment (Rainer, 1981).

In Paterson Inlet the algal beds on soft sediments probably play an analogous role, permitting free-lying brachiopods to live on mud in areas of low current velocity. Free-lying brachiopods were found as far westward as the cover of red algae species extended. In the area near Freshwater mudflats neither red algae or brachiopods are common with the exception of one station at which *Terebratella sanguinea* was found. Only those dredge stations with red algae contained brachiopods.

Where red algal beds occurred on harbour mud communities in Otago, Rainer (1981) found that species diversity was higher than in comparable harbour mud communities with no algae. In general the number of brachiopod species in a sample increased with the amount of algae. Additionally, in the presence of a moderate amount of mud and fine sand in shallow areas without strong water movement (analogous to the areas of *Lenormandia* in Paterson Inlet), very coarse material such as whole or broken shell provided a substrate for both red and green (primarily *Ulva*) algae. Samples analysed from these areas of algae, had a high diversity of fauna species.

As a result of a Water Quality Centre study of Big Glory Bay, Roper et al. (1988) concluded that the *Lenormandia* meadows in Big Glory Bay "probably play an important role in stabilising the muddy bottom and provide a refuge for animals". This is consistent with Rainer's findings in Otago. It is hypothesised that the algal beds are an additional factor controlling sedimentation within the inlet.

PART III: BENTHIC ASSEMBLAGES IN PATERSON INLET

9 DELINEATION OF BENTHIC ASSEMBLAGES

9.1 Integration of survey data

Of the 11 studies on which this report has been based (Section 11), only Batham's (1969) study of Little Glory Cove systematically recorded all species, both flora and fauna, present in each given sample. The aim of the other field studies was principally to provide descriptive data on benthic associations present or to provide information on specific aspects of this such as algae (Adams et al., 1974) and brachiopod species (much of the data used by Willan (1981)). In almost all the field work (with the exception of Batham's) only "indicator species" able to be easily recognised in the field were surveyed. The recognition of marine associations on the basis of large indicator species is accepted as a standard technique (Thorson 1957, Hurley 1961, Erwin 1978, Grange 1979 in Willan 1981). Because of this, and because of the diverse methods used, it is not possible to describe the various benthic assemblages in Paterson Inlet from statistical analyses of the data available.

Whilst species of Foraminifera, Porifera, benthic Coelenterata, Bryozoa and Asciadicea are abundant and diverse in Paterson Inlet (Willan 1981), only very limited collection and description of these species were undertaken in the 22 studies considered. This was largely because of a lack of expertise in their field recognition and a consequent emphasis on larger more easily recognised species. Instead, the various surveys identified concentrated on Mollusca, Brachiopoda and Echinodermata and marine algae and used these to describe the various assemblages in Paterson Inlet.

Varied techniques helped remove bias in the detection of species: dredging, sediment sampling, trawling (in Glory Cove), use of a remote operated vehicle (in Big Glory Bay by Water Quality Centre staff), scuba diving transects, fish counts, spot dives plus shore surveys and collections were all carried out. Scuba diving techniques are biased towards the identification of epifaunal species which are easily visible. In contrast, dredging and trawling emphasise infaunal species from below the sand surface but pick up fewer subsurface, epifaunal ones (Baker and Woolf 1987), especially such mobile species as *Chlamys*.

In areas sampled during two or more surveys, similar data on community composition were obtained. This proved useful in developing lists of characteristic species from complementary results. For example, the soft sediment assemblages in the outer inlet were sampled by dive transect, NZOI dredges and dives, plus DOC dredges. Only in one instance did contradictory data result: none of the 16 infaunal bivalve species in Willan's mud assemblage were found at any of the DOC dredge stations in the same locality (Section 10.8).

9.2 Rocky shores

The biological communities present on any rocky shore represent an integration of several complex variables including the effect of a number of physical features principally fetch, the open sea angle and the nature of the seabed beyond the shore. These can be synthesised to provide a measure of wave exposure, and different rocky shore communities may be delineated by comparing relative wave exposures. Using such a biological "exposure" scale allows the ranking of shores according to this exposure based on the differential abundance of indicator species. This requires the development of abundance categories for individual species relative to their normal ecological species distribution (Baker and Woolf, 1987, Ballantine et al., 1973); the scale and categories developed for north-east New Zealand by Ballantine and colleagues were modified to include southern species and used to assess Paterson Inlet intertidal site data.

The abundance scales used are built around the concept of "normal" quantity for each species. "This normal quantity is that expected near the centre of the geographical and ecological range. This is then used to give the top of the "common" category. "Abundant" is more than this "normal" and the other divisions are arranged to give a geometrical scale reaching "rare", which is the lowest quantity which can reasonably be recorded quantitatively" (Ballantine et al., 1973). The scales are developed for single species or similar groups e.g. small barnacles or large brown seaweeds and are applied only at the appropriate level, where the organism is most abundant.

This enabled the identification of species judged abundant or common at each site - occurring within their normal geological/ecological range as dominants or codominants - depending on their size, density and degree of zone formation.

A comparison of the locations at which chosen intertidal indicator species were found showed that three rocky shore communities with different wave-exposures existed in Paterson Inlet: semi-exposed outer inlet shores, semi-sheltered mid-inlet shores and very sheltered shores at the heads of small bays.

Appendix 4 summarises the physical characteristics of 16 intertidal sites studied in Paterson Inlet. The relative frequency of nine indicator species was determined and from both sets of data an exposure ranking for each site was calculated (after Ballantine et al., 1973).

9.3 Substrate type, subtidal areas

The nature of substrates often determines the species living on them. Hard substrates, those that prevent entry except by specialised boring organisms (ie, all but the softer types of rocks), provide surfaces for organisms, algae and fauna, to live on. In contrast, on soft sediments there are few permanent firm surfaces for organisms to attach to, and species found there often live buried in the seabed.

This basic distinction was used to delineate two groups of subtidal assemblages - those living on rocky reefs and those on soft sediment habitats. Richardson (1981b) and Willan (1981) used sediment data collected by NZOI to differentiate stations recorded as having substrates

of sand (or gravel) from those on mud (Figure 3). Willan identified two subtidal associations occurring on the soft substrates of the inlet:

- a sand-dwelling assemblage in the outer inlet where the substrate is clean sand, current movement is brisk and scour material (often old shell gravel) present
- a mud assemblage in mid-inlet there is negligible current scour and the substrate is mud.

The stations on which Willan's analysis was based did not extend west of Kaipipi (with one exception) so the westward extent of the mud association was not determined. He suggests that the distinction between biological associations is not as sharply defined as the line between different sediment types would suggest (Figure 3). He noted that the two associations he described merged over a distance of half a kilometre in the region of the sediment line. At several stations, although the substrate was of mud, the fauna was transitional between assemblage types (eg., NZOI stations I651 - 654).

9.4 Mudflats

In the far west and southwest of the inlet, mudflat areas associated with the mouth of the Freshwater and Rakeahua Rivers are extensive and relatively exposed in nature. Also at the heads of several small bays there are limited areas of comparatively sheltered mudflat.

9.5 Further delineation

Further subdivision of these three rocky shore and three soft-sediment associations was made based on other recognisable biological features, principally differences in the dominant species, and also the range and type of other species present. This delineation was based on qualitative data.

10 PRINCIPAL ASSEMBLAGES

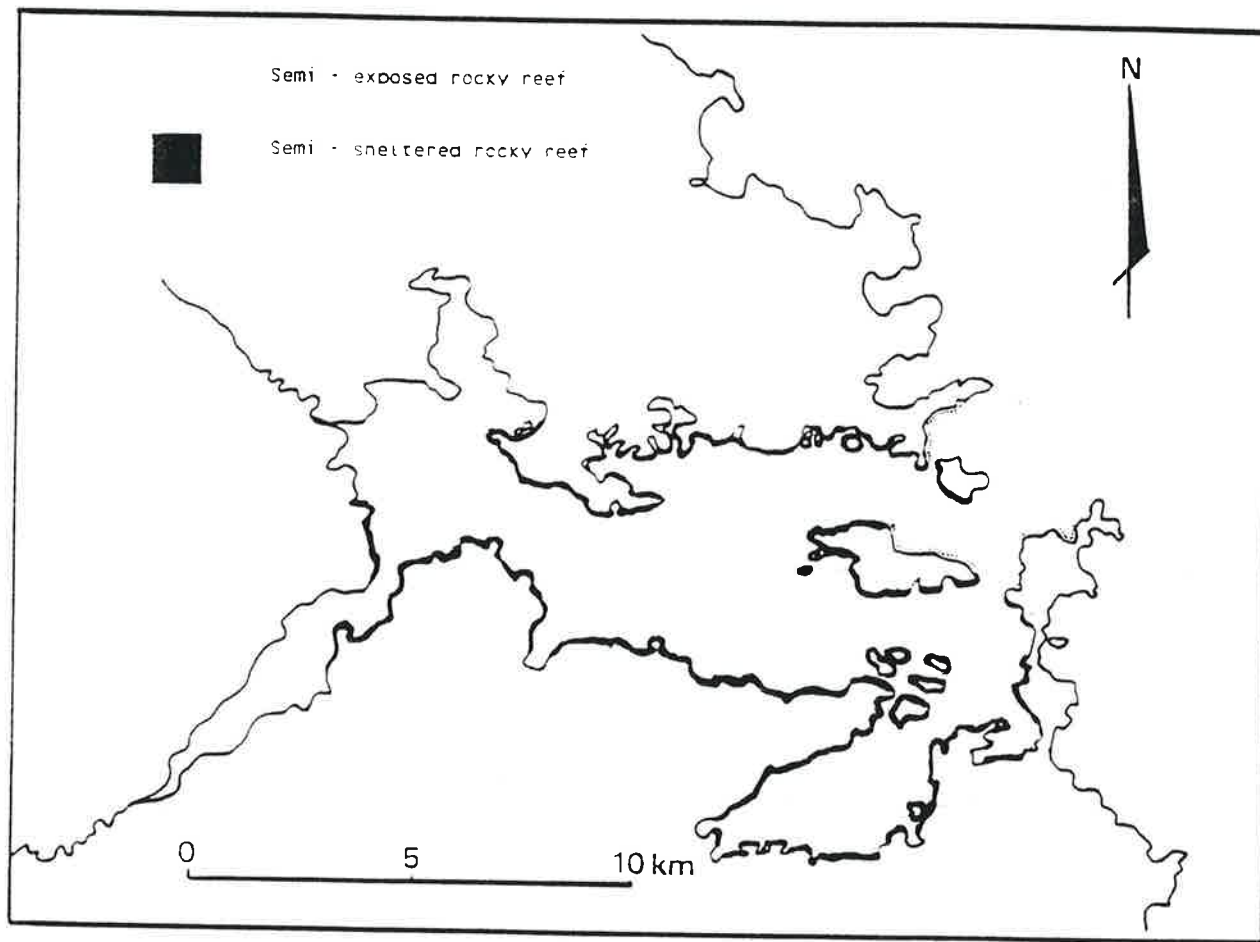
Eight principal assemblages within Paterson Inlet can be recognised, as well as local variations to them:

- 1 Semi-exposed rocky reefs
- 2 Semi-sheltered rocky reefs
- 3 Very sheltered rocky shores
- 4 Mudflats - both open and sheltered
- 5 Inshore sand/shell/algae assemblage
- 6 "Clean sand" assemblage
- 7 Brachiopod bed assemblage
 - bryozoan *Cinctipora elegans* mounds
- 8 Subtidal mud assemblage
 - shallow muddy habitat
 - *Lenormandia* meadows
 - *Rhodymenia*/mud

The distribution of plants and animals in these assemblages is shown on the diagrams following the descriptions of each type. Sites investigated are shown in Figure 5. Figure 3 showed the areas worked in 1977-79, as well as New Zealand Oceanographic stations used.

10.1 Semi-exposed rocky reefs

Along these shores the most consistent feature of the biota, noticeable from above the water, is the fringe of bladder kelp *Macrocystis pyrifera*.



10.1.1 Semi-exposed rocky intertidal shores

The semi-exposed nature of the rock reefs of the outer inlet is shown by the presence of southern bull kelp *Durvillaea antarctica* and *D. willana*, common on the intertidal shores. Bull kelp occurs only in this outer area of the inlet extending no further westward than Sydney Cove on Ulva Island. Of the two species, *D. antarctica* is more prevalent; at Ringaringa and outer areas of Native Island, the stalked and branched thalli of *D. willana* can also be seen.

A typical zonation pattern (*sensu* Stephenson and Stephenson, 1949) for rocky shore intertidal communities in the outer inlet, showing only abundant and common species, is depicted in Figure 6.

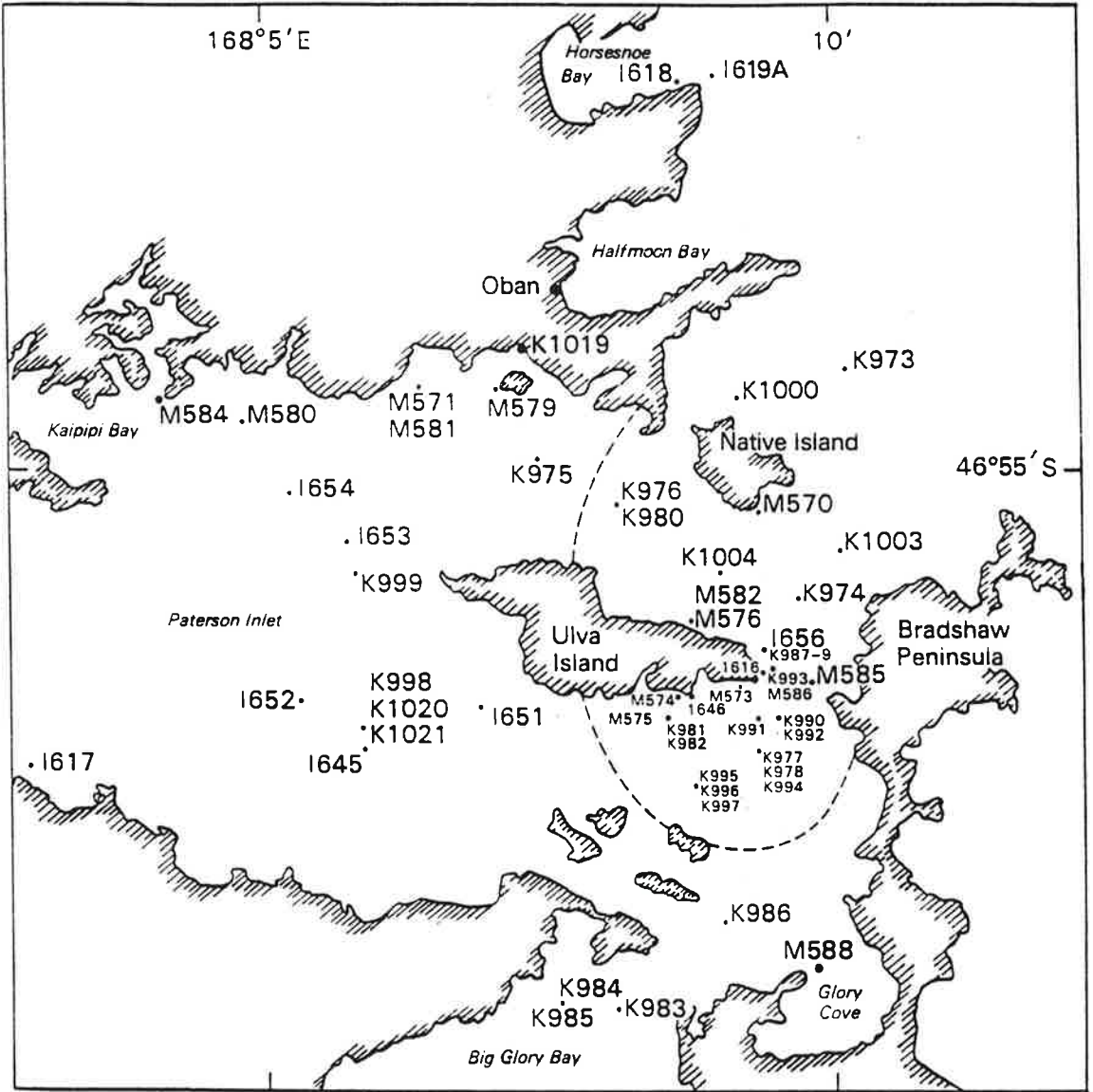


Figure 3: Location of NZOI stations; division between sand and mud sediments in Paterson Inlet.

The boundary between outer sand substrates and mid-inlet mud substrates of Paterson Inlet is shown by the dotted line. The map also shows the areas worked by brachiopod cruises of 1977-79 and NZOI stations of particular relevance to the biota studies of Willan (1981) (after Richardson 1981b).

Distribution of "freelying *Terebratella sanguinea*
and *Neothyris lenticularis* brachiopod species in
Paterson Inlet

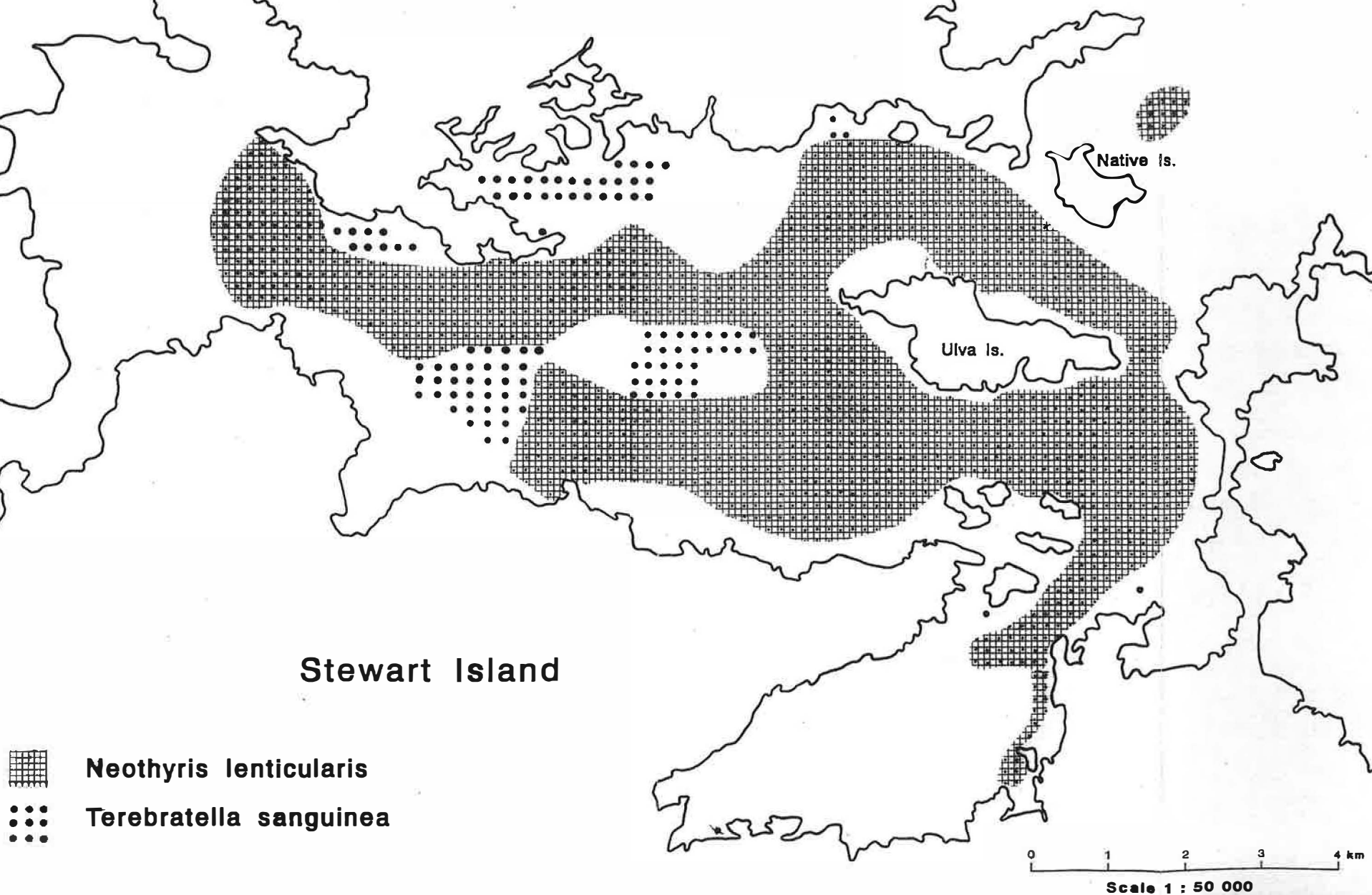
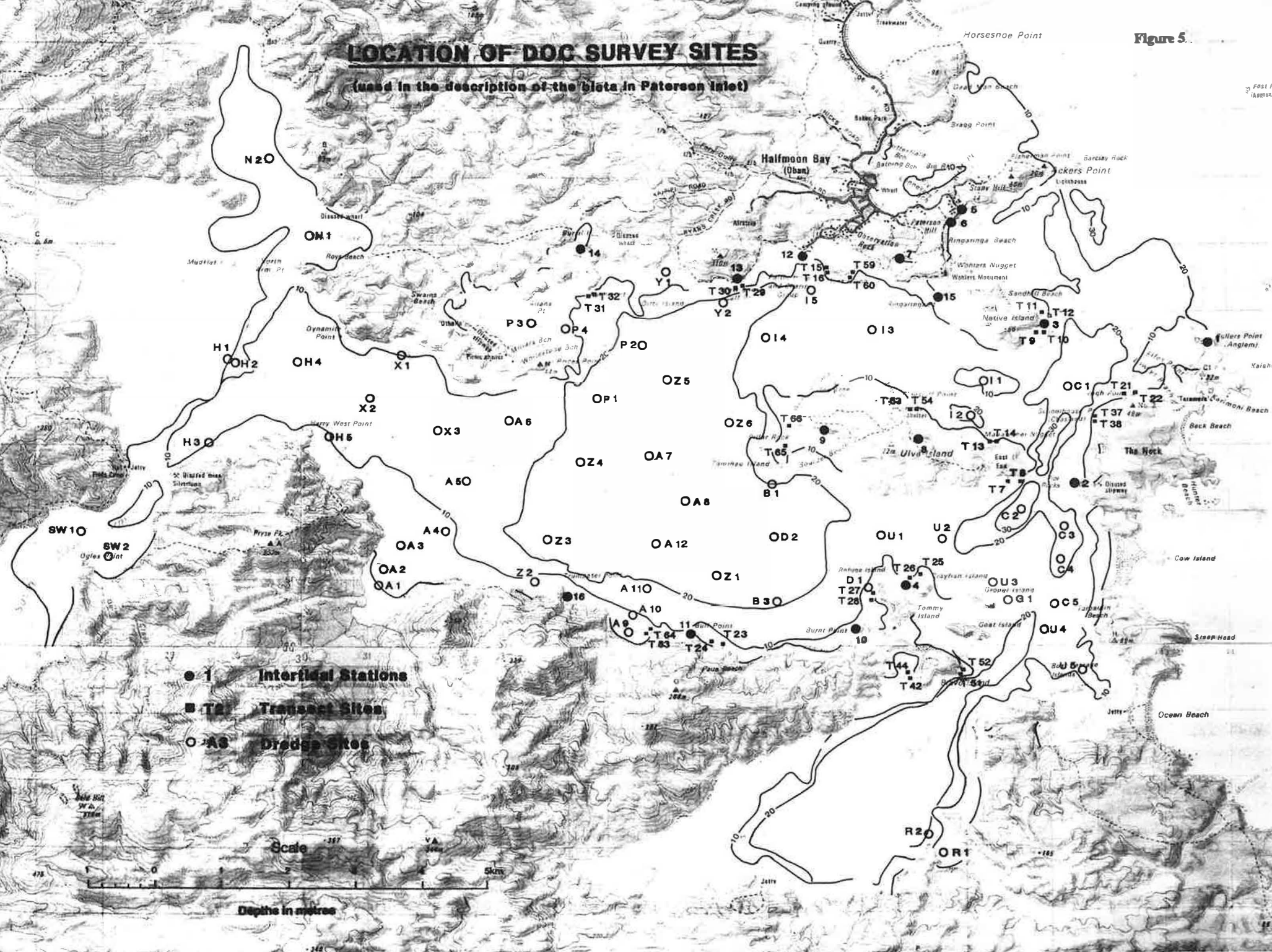


Figure 5

LOCATION OF DOC SURVEY SITES

(used in the description of the plots in Paterson Inlet)



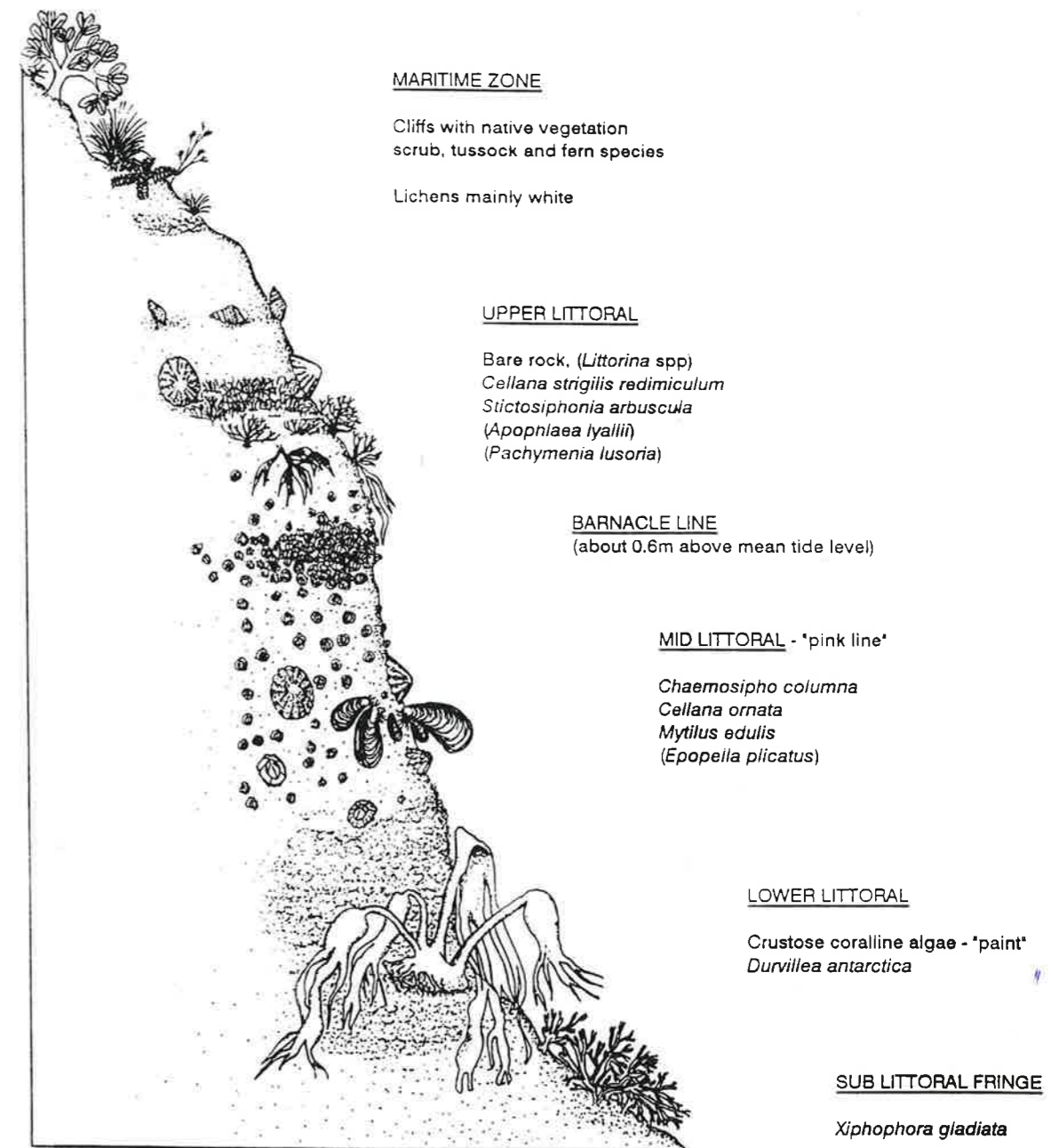
First R
Inset

Scale
Depths in metres

DOC Dive transects, Paterson Inlet

T#	LOCATION
7	Ulva Island - east end
8	Ulva Island - east end
9	Native Island - east end
10	Native Island
11	Native Island
12	Native Island - northeast
13	Ulva Island - northeast
14	Ulva Island - northeast
15	Iona Island
16	Iona Island
21	High Point, The Neck
22	High Point, The Neck
23	Paua Beach
24	Paua Beach
25	Crayfish Island
26	Crayfish Island
27	Tommy Island
28	Tommy Island
29	Cow and Calf Point
30	Cow and Calf Point
31	Ryans Creek
32	Kaipipi
37	Schoolhouse Point
38	Schoolhouse Point
41	Bravo Island - west
42	Bravo Island - west
51	Bravo Island - east
52	Bravo Island - east
53	Sydney Cove, Ulva Island
54	Sydney Cove, Ulva Island
59	Iona Island
60	Iona Island
63	Hapatuna
64	Hapatuna
65	Ulva Island - west
66	Ulva Island - west

Figure 6: Typical intertidal zonation on the rocky shores in the entrance to Paterson Inlet



Key () = a subdominant species
Only abundant and common species are depicted.

The relative frequency of each species was assessed using abundance scales as discussed above.

Sites which ranked as semi-exposed (Appendix 4) were: Bullers Point (site 1), northern end of Ringaringa beach (site 6), Native Island - an eastern site (site 3) and Evening Cove (site 5). The location of those sites investigated is shown in Figure 5.

Other species which are frequent on these semi-exposed shores are:

Adenocystis utricularis
Codium convolutum
Durvillaea willana
Crustose coralline algae
Splachnidium rugosum

Cellana radians
Haliotis iris (local, in sublittoral fringe)
Lepsiella scobina
Lepsithais lacunosus
Patelloida corticata
Siphonaria zelandica
Sypharochiton pelliserpentis
Xenostrobus pulex

The strap weed *Xiphophora gladiata* forms a near continuous sublittoral fringe in all but the most sheltered areas of the inlet.

Large reefs at Ringaringa, Bullers Point and Pipi Rocks appear to have a more diverse grazing fauna (chitons and gastropods such as limpets) in the intertidal and upper subtidal upper zone than other rocky shores in the inlet's entrance; this and the red algal assemblages discussed below both merit further study because of this diversity. The algae at Bullers Point are described in the following section.

The red algae communities of Paterson Inlet have long been the subject of scientific interest; for over 30 years Mrs Eileen Willa of Stewart Island undertook extensive collecting at Ringaringa, at Halfmoon Bay and later Port Pegasus. Many of her specimens are lodged at the National Museum in Wellington, University of Washington in Seattle and the Lindauer Herbarium, University of Auckland (Adams et al., 1974).

The shore at Ringaringa - the soft rock platform at Moses Nugget, the granite shores and the sandy tidal pools of Back Beach - is characterised by a diverse flora, including many seasonal species. Seventy percent of the species collected in Paterson Inlet were collected from Ringaringa (some species were found at two or more sites including Ringaringa): these were principally intertidal and drift and represent 48 families. Species of Gigartinales, Ceramiales and various large bladed, thallose Rhodophyceae are common (see Appendix 3).

Stations which occur at semi-exposed locations are Ringaringa, The Neck, Bullers Point, Evening Cove, Native Island and Manawahei Nugget at Ulva Island.

10.1.2 Subtidal rocky reefs, semi-exposed

All the inlet reefs exhibit a zonation of species from the shallows to the deepest areas (which are over 30 metres in a few places): temporal variation has not been measured. A band of macrophytes dominated by *Macrocystis*, with associated grazing fauna, provides canopy cover. Below this, boulder tops are commonly dominated by encrusting and fine "fuzzy" algae (principally Ceramiales); a variety of echinoderms are characteristically present. A dense association of encrusting fauna occurs in overhangs and crevices. Deepest areas are dominated by brachiopods (Grange and M^cKnight, 1987).

At offshore reefs, as at Native Island, Ringaringa and the rock off Schoolhouse Point at The Neck, this *Macrocystis* fringe broadens to form submarine forests which support a distinctive assemblage of reef fish and grazing fauna. Several species of brown algae provide both food and shelter for faunal species. Commonest are the fucoids *Cystophora scalaris*, *Carpophyllum flexuosum*, *Marginariella boryana*, *M. urvilliana* and *Sargassum sinclairii*. Occasionally *Sargassum verruculosum* and *Cystophora platylobium* are also present. Of the laminarian algae, *Ecklonia radiata* occurs sporadically, around Native Island and Ulva Island, and is generally deeper than *Macrocystis*. *Lessonia variegata* is confined to the most exposed headlands only as at Bullers Point. The depth of the *Macrocystis*/algal band varies from approximately 7-10 metres. Within the *Macrocystis* beds light levels are reduced, and there is a diverse understorey.

Sea tulips, *Pyura pachydermatina*, are common, attached to boulders. The Delesserian alga *Hymenena durvillei* is characteristically epiphytic on the stalks. Where the *Macrocystis* has been grazed - by the common kina *Evechinus chloroticus* for example - a band of green algae, *Ulva* and *Codium convolutum* grows (e.g. NZOI station K989 (Grange and M^cKnight, 1987)).

Crustose coralline algae are present covering rock in the lower littoral and sublittoral reef.

Some species have been reduced in number and extent by harvesting - particularly crayfish (*Jasus edwardsi*) and to a lesser degree paua (*Haliotis iris*) (pers. obs. and anecdotal evidence). The commoner faunal species characteristic of the upper *Macrocystis* zone of rock reefs in the semi-exposed outer sites of the inlet are listed in Table 2.

Table 2: Benthic fauna characteristic of *Macrocystis* zone, subtidal rock reefs in the entrance to Paterson Inlet.

COELENTERATA	<i>Actinothoe albocincta</i> <i>Corynactis huttoni</i>
ANNELIDA	<i>Galeolaria hystrix</i> <i>Pomatoceros terraenovae</i> <i>Spirobis</i> sp. - on <i>Macrocystis</i> fronds
MOLLUSCA	<i>Cellana stellifera</i> <i>Eudoxochiton nobilis</i> <i>Haliotis australis</i> <i>Haliotis iris</i> <i>Trochus viridis</i>
ECHINODERMATA	<i>Astrostole scabra</i> <i>Coscinasterias calamaria</i> <i>Evechinus chloroticus</i> <i>Ophiopsammus maculata</i> <i>Patiriella regularis</i> <i>Pentagonaster pulchellus</i> <i>Stichopus mollis</i>

Species of sponge (Porifera) and ascidians (Ascidacea) are present, but information gathered on these species during DOC surveys was not available for inclusion here. Specialised fauna are associated with *Macrocystis* plants (e.g. *Cantharidus purpuratus*, *Modelia granosa* and encrusting hydroid and polyzoa species and with bull kelp holdfasts (Morton and Miller, 1968)).

In places associations of red algae occur beneath the brown algae, with a large number of species clustered into small areas (e.g. NZOI stations K1000, K1002 and Bullers Point Reef).

At Bullers Point reef, four kilometres southeast of Ringaringa, a jumble of large granite boulders extends southeast from the point in a long reef, the upper part of which is exposed at low tide. Beneath the band of brown algae there is an extensive community of red algal species covering the tops and sides of the boulders down to 14 metres. The current is swift and the algae fronds swirl in it, creating the impression of a rich, red garden. The following red algae were collected; further collections should be made, as other species were present.

Asparagopsis armata
Ceramium sp.
Champia chathamensis
Craspedocarpus erosus
Dasya collabens
Delisea elegans
Echinothamnion hystrix
Echinothamnion lyallii

Hymenena dilabida
Hymenena palmata
Plocamium angustum
Polysiphonia sp.
Rhodophyllis gunnii
Schizoseris dichotoma
Streblacladia giomerata

Additionally specimens of small, red, flat bladed thalli (as yet unidentified) were collected.

This reef is tentatively suggested as the source of much of the drift red algae collected at Ringaringa. The reefs off Ringaringa beach do not support as diverse an assemblage of red algae: *Plocamium*, *Streblacladia* and *Hymenena* species mainly occur here.

Where these red algal communities are not present at depths below the brown algal band, the tops of boulders are commonly covered with a fine fuzz of red algae (Ceramiales) and hydroid species. Crustose coralline algae occurs more sporadically at these depths. A variety of gastropods and echinoderm species occur. The ophiuroid *Ophiopsammus maculata* is common. Various ascidian species including *Hypsistizoa* sp. and sponges are present. The richest life occurs under overhangs, in crevices and on vertical faces - in lower levels of light and out of strong current surge. Here there is a profusion of encrusting species - sponges and tunicates, bryozoans, tubeworms, hydroids and the brachiopods *Notosaria nigricans* and *Waltonia inconspicua*. Encrustations of coralline algae frequently cover the brachiopod shells.

At NZOI station I616, a transect down the rock wall at the eastern tip of Ulva Island (see Figure 3), the number of bryozoan species present were recorded and identified - 34 species in total (Willan 1981). Here too are specimens of a large tree-like branched hydroid (unidentified).

Four brachiopod species occur in Paterson Inlet: *N. nigricans*, *W. inconspicua*, *Terebratella sanguinea* and *Neothyris lenticularis*. Of these, *Notosaria* and *Waltonia* are common as attached specimens. The most prolific sources of *W. inconspicua* are crevices and overhangs between low water and ten metres depth. The maximum density of brachiopods recorded from any NZOI station was at K993, adjacent to I616, at the eastern tip of Ulva Island. From a 40 by 40 cm quadrat placed on a steep rock wall in less than 10 metres depth, 2894 *Waltonia* and 321 *Notosaria* were collected - a total brachiopod density of 20 000 per square metre. The deepest extent of rocky subtidal reef within the inlet occurs at this end of Ulva Island. At 30 metres brachiopods are dominant - *Terebratella sanguinea* and *Waltonia inconspicua* attached to the sides and tops of rocks whilst amongst the shell debris and rocks are aggregates of *Neothyris lenticularis* (NZOI station K988). *Terebratella sanguinea* is not common as an attached form in the subtidal area of Paterson Inlet. (See Stewart (1981) for a discussion of the brachiopod population structure).

Shell debris is a common feature of the interface of rock and softer sediments. *Maoricolpus roseus* is often present, and in areas of high water movement there are dense beds of the ribbed mussel *Aulacomya ater maoriana* preyed upon by reef starfish (NZOI station K1002)

(Grange and McKnight, 1987). In shallower areas an accumulation of drift algae (e.g. *Ulva* species) commonly accumulates at this interface.

The depths to which outer rocky inlet reefs extend, vary greatly. Probably shallowest in extent are areas of eastern Native Island and Evening Cove which grade into sand at around eight metres depth.

Compared to both adjacent coast and island sites and more sheltered mid-inlet sites there is a higher diversity of fish species in the outer inlet, in both shallow and deeper areas. Spotties, blue cod, banded wrasse and schools of oblique swimming triplefins were most abundant on shallow reef areas. Blue cod and spotty maintained high densities over the deep sections. Other less abundant species included scarlet wrasse, trumpeter and tarakihi; of interest is the appearance of greenbone at shallow exposed inlet sites (Walls 1989). (See Appendices 2, 5 and 6).

10.2 Semi-sheltered rocky reefs

The rocky subtidal reefs of mid-inlet can be characterised as semi-sheltered. They are short, steep and much shallower than those of the outer inlet and are generally under five metres deep. Medium and small boulders are common. The deepest rock reefs in mid-inlet occur around Ulva Island, for instance around the islets at the western end.

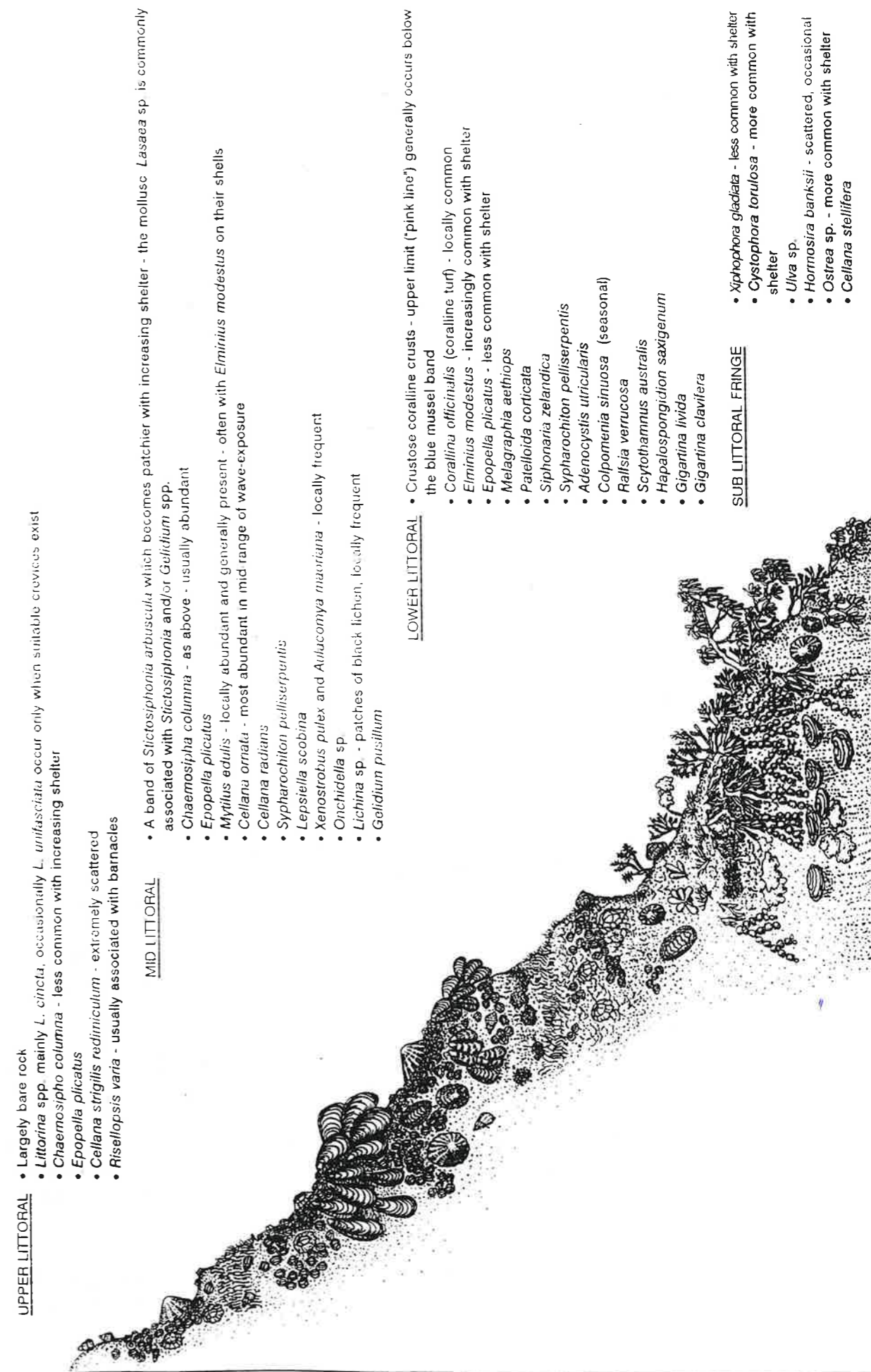
The band of macrophytes, principally large brown algae is restricted to the top three metres. Unlike the outer inlet, there are no *Durvillaea* species. Although *Macrocystis* is widespread as a fringe, it does not form large forests as around reefs in the inlet entrance. Both in this band and below it, faunal species are similar to those encountered on rocky reefs in the outer inlet; the same grazing herbivores and echinoderm species are present.

10.2.1 Semi-sheltered intertidal rocky shores of central Paterson Inlet

Characteristic species of the intertidal area are shown in Figure 7. Faunal species found only underneath boulders were not well investigated and have been omitted. Additional algal species, particularly those with a seasonal distribution, also occur. These are included in the list of marine algae for Paterson Inlet (Appendix 3) - see specimens collected at stations Cow and Calf Point, Deep Bay, Golden Bay, Hapuatuna, Prices Whaling Base, Ryans Creek, Thule, Tommy Island, and Vaila Voe.

Seasonally abundant species include *Chordaria cladosiphon* and *Porphyra columbina*. Further species live only in shaded situations - *Cladophora verticillata* and *Wittrockiella lyallii*. *Pilayella littoralis* is abundant in rock pools and shallows in spring and summer (Adams et al., 1974 and pers. obs.). The abundance of broken rock has resulted in a more diverse intertidal fauna than occurs on the platform rocks; and this assemblage of species merits further investigation of its diversity.

Figure 7: Typical zonation pattern for semi-sheltered intertidal rocky shore in mid-Paterson Inlet



10.2.2 Subtidal rocky reefs of central Paterson Inlet

The flat strap weed *Xiphophora gladiata* grows as a sublittoral fringe, occasionally with *Cystophora torulosa* or *Hormosira banksii*. Below this *Carpophyllum flexuosum* is commonest. Other species common in this algal band are *Cystophora scalaris*, *C. retroflexa*, *Codium convolutum*, *Ulva* sp. and *Adenocystis utricularis*. *Sargassum verruculosum* is occasionally present. Crustose coralline algae are a common feature on the rocks. Whilst widespread red algal associations of the large outer inlet reefs are not present, there may be a luxuriant but localised sublittoral fringe or understory of various Rhodophyceae (DOC transects T30, T65, T66).

Other algae species which frequently grow on these subtidal rocks are:

Asparagopsis armata
Asperococcus bullosus
Ceramium sp.
Chordaria cladosiphon
Codium fragile
Colpomenia sinuosa
Culteria multifida
Curdiea flabellata
Daysa collabens
Ectocarpus sp.

Glossophora kunthii
Halopteris sp.
Delisea elegans
Hymenena sp.
Plocamium spp.
Euptilota formosissima
Brongniartella australis
Anotrichium crinitum
Streblocladia glomerata

Amongst the band of macrophytes grazing faunal species are common; those species characteristic of the more exposed reefs towards the inlet entrance are common here too (see Table 3). These mid-inlet reefs do not appear as rich to the diver - the band of macrophytes is less diverse and, because of their limited depth, covers a smaller area. The colourful jewel anemones *Corynactis huttoni* occur sporadically. The ducks bill limpet *Scutus breviculus* occasionally occurs in high densities in the upper sublittoral (pers. obs.).

Beneath the algae band (below three metres depth), kina become more common. The tops of rocks have been well grazed and are generally covered with a fine red algal fuzz (Ceramiales species) and hydroid association as in the deeper areas of the outer inlet. The variety of echinoderms is greater than in the shallows. *Stichopus mollis*, *Ophiopsammus maculata* and *Pentagonaster pulchellus* are common. The starfish species *Allostichaster insignis* (commonest in crevices) and *Stichaster australis* are occasionally present.

Where the reefs extend below six metres, these echinoderm species still occur but encrusting fauna - sponges and ascidians - predominate. Crustose coralline algae also extend this deep. The brachiopod species *Terebratella sanguinea*, *Waltonia inconspicua* and *Notosaria nigricans* are frequently present.

Other frequent species are the sulphur sponge *Aplysilla sulphurea*, a black encrusting tunicate *Leptoclinoides* sp. and the tubeworms *Galeolaria hystrix* and *Filograna impexa*.

DOC dive transects which covered the mid-inlet reef were

T15 T16 T23 T24 T25 T26 T27 T28 T29 T30
T31 T32 T41 T42 T51 T52 T60 T63 T64 T65 (Figure 4)

Off Bravo Island an interesting association of drift algae, floating submerged but unanchored at around four to eight metres depth, was noted. The species present were *Carpophyllum flexuosum*, *Cystophora congesta*, *Macrocystis pyrifera* and *Sargassum sinclairii*.

The occurrence of crayfish *Jasus edwardsi* is also of interest. MAFFish have regularly surveyed levels of juvenile crayfish from a group of rocks off Thule Bay on the northern shore of Paterson Inlet (John Booth, MAFFish, pers. comm.). In the past crayfish have been found at several inlet locations including around Ulva Island, The Neck and along the northern shore as far west as Dynamite Point. At this latter area (nicknamed Crayfish Village by locals) a number of deep rock fissures have provided suitable habitat for a resident colony of crayfish (Ronald Tindal, Stewart Island, pers. comm.).

The variety of fish associated with mid-inlet rock reefs is less than in the outer inlet (Appendix 2). Around the rock reefs of the central inlet, spotties are the dominant species, occurring in higher density than in the outer inlet or adjacent coastal areas. Blue cod are very common, as are banded wrasse (but fewer). Cod are generally associated with the base of reefs or clusters of rocks in soft substrate areas. The densities of other species is generally low. Blue moki occur locally as do telescope fish. The number of fish species recorded over the deeper area of mid inlet reefs was lower than over the shallows (Walls, 1989).

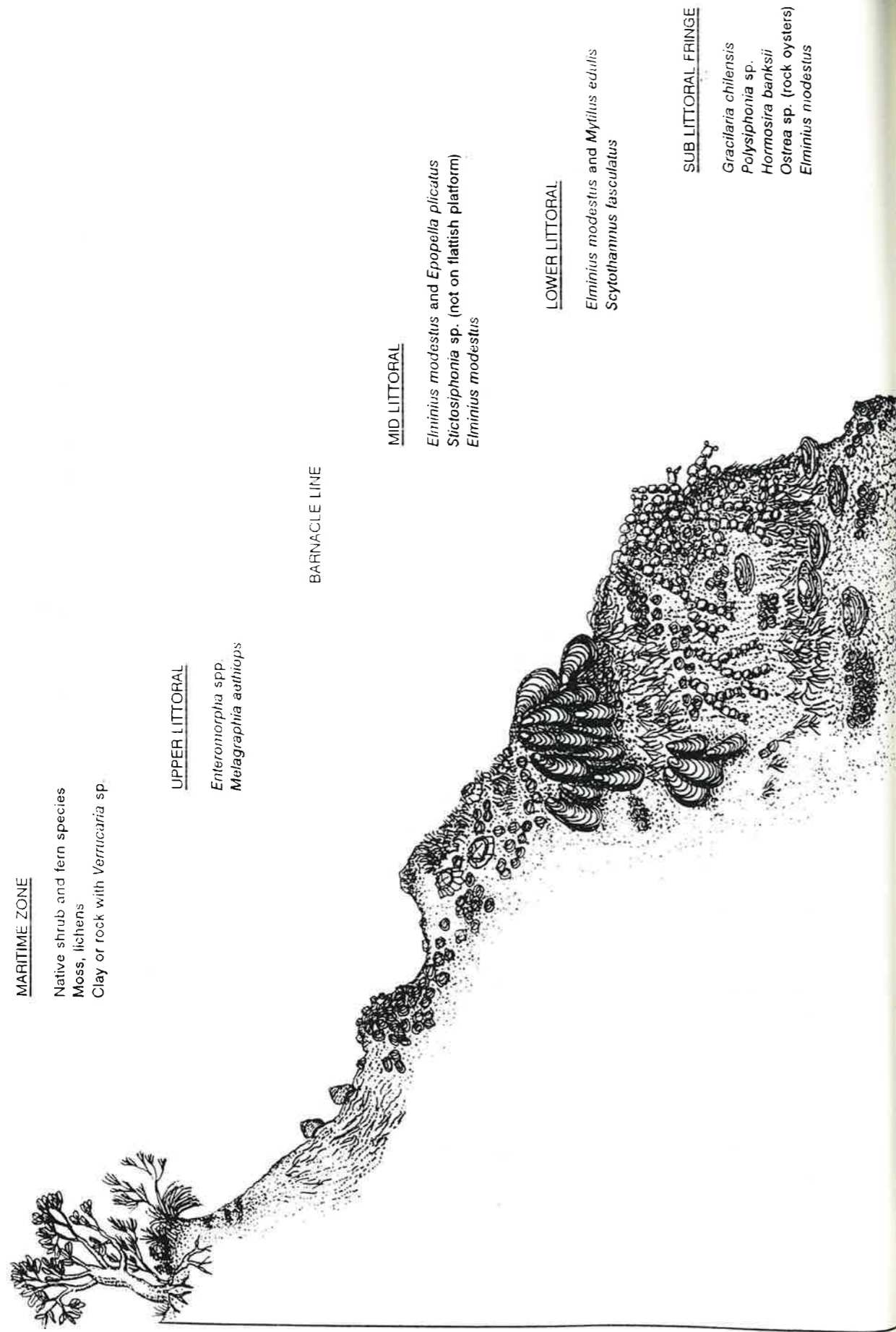
Octopus maorum the large octopus, is commonly found distributed through areas such as the *Lenormandia* meadows around Ulva and the Bravo Islands. They have been observed as far up the inlet as North Arm (Wayne Costello, DOC Invercargill, pers. comm.).

10.3 Very sheltered rocky shores

Rocky shores in the upper reaches of smaller sheltered inlets and bays in Paterson Inlet are typically composed of very small broken rocks with occasional platforms. They are low and relatively flat.

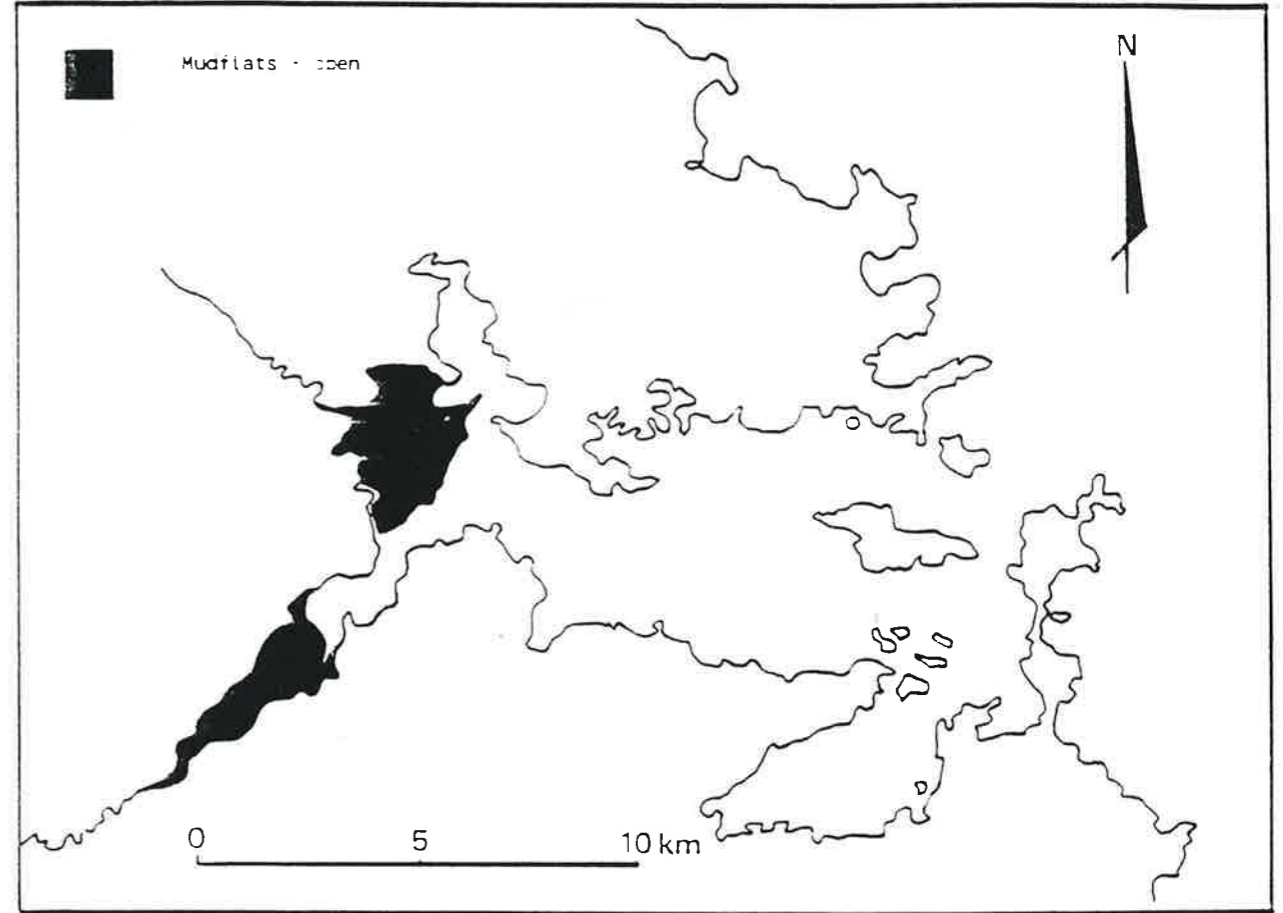
The sheltered inlet rocky shore assemblages are extensive, occurring in Big Glory Bay, North Arm, the Dundas Harbour area, Prices Inlet, Ryans Creek and Kaipipi along the northern shore and Abrahams Bay. At Kaipipi the shore zonation present is characteristic of these very sheltered shores; this is shown in Figure 8. Dominant species only are listed. Algae are listed in Appendix 3.

Figure 8: Zonation on intertidal rocky shore, Kaipipi, Paterson Inlet



10.4 Mudflats - both open and sheltered

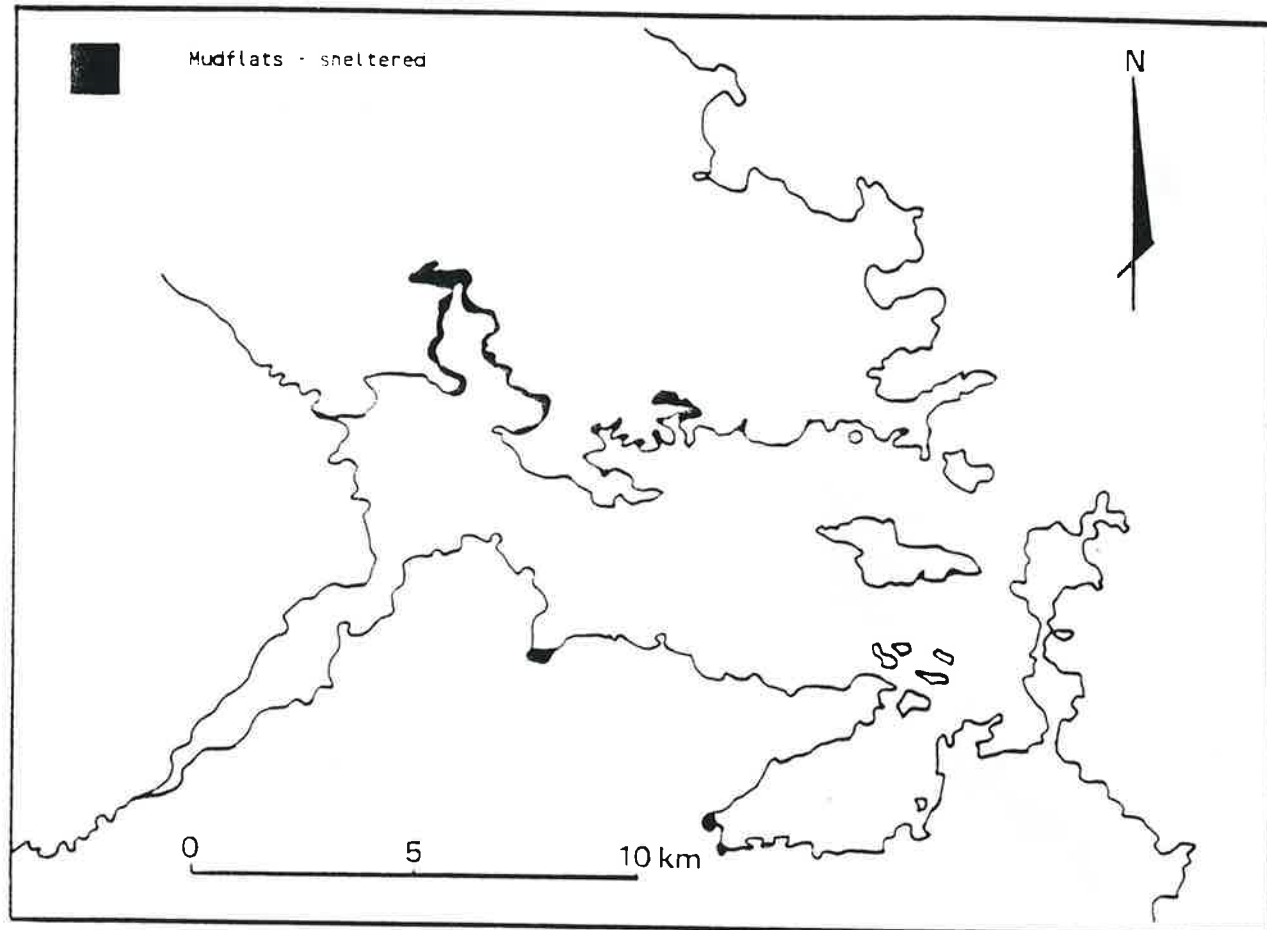
Extensive mudflats in Paterson Inlet are dominated by *Zostera* sp. (sea grass) and cockles *Chione stutchburyi*. The ecology of the open mudflats of South West Arm and the Freshwater are probably similar to those in more sheltered areas of the inlet; this has not been investigated. The open flats cover approximately 10 square kilometres.



Sheltered mudflat areas occur in the heads of several small bays in mid inlet - see Figure 2. On the most sheltered mudflats rafts of free-lying *Hormosira banksii* provide a refuge for numerous epifaunal species, crustacea and mollusca. These estuarine areas are possibly nurseries for species - flatfish and scallops in particular (various pers. comm. including Phred Dobbins, DOC, Stewart Island). This merits further investigation to identify nursery areas, to aid species management/ protection.

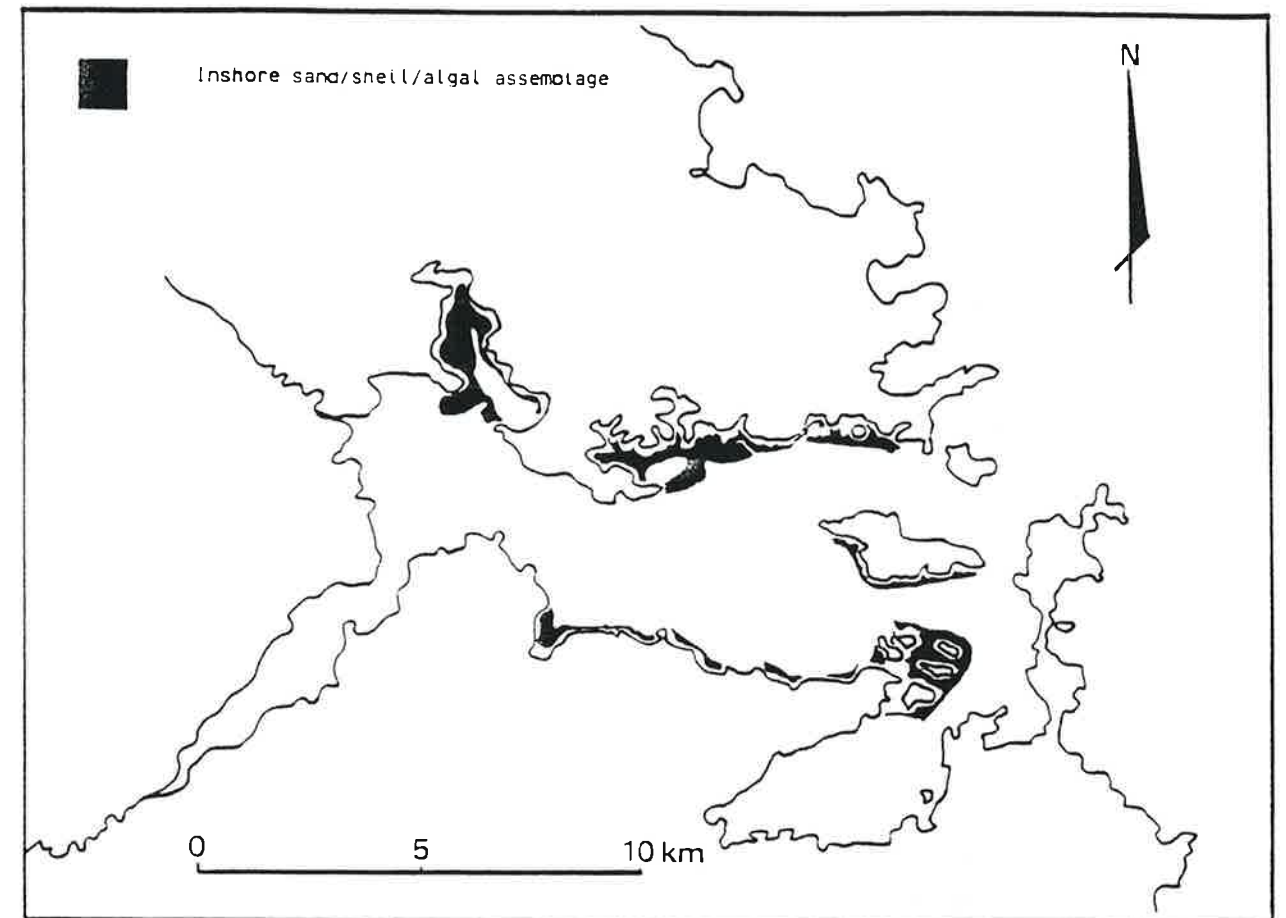
Of scientific interest but not sampled in the transects is a loose-lying form of *Macrocystis pyrifera* found in sheltered bays such as Kidney Fern Arm of Prices Inlet. This form consists of branched fronds with no basal meristems or holdfasts, found in clumps on the soft mud

bottom. The loose-lying forms probably originated from an attached population within Paterson Inlet and are possibly quite long-lived. Loose-lying forms of *Macrocystis pyrifera* have also been described from the Falkland Islands and from Port Pegasus at the southern end of Stewart Island (Moore 1943, Gerard and Kirkman 1984).



All these mudflats support high numbers of wader and waterfowl bird species which probably feed principally on the cockles, annelids and crustacea (Paterson Inlet Coastal Resource Inventory, Costello and Hare, Department of Conservation, in prep.). Although these sheltered rocky shores and intertidal mudflat areas are extensive, little is yet known as to whether their ecology differs from other such southern areas.

10.5 Inshore sand/shell/algal assemblage



Sublittoral sandy sediment areas with a high component of shell fragments are common between the base of rock reefs and deeper soft sediments, both sand and mud. These shallow areas in which the sediments are washed by waves and tide flow, occur in both outer and mid inlet areas: in the mouth of muddy bays in mid inlet as at Hapatuna, Ryans Creek, Abrahams Bay and Sawdust Bay, North Arm for example. (Note that the map may not show the full extent of this assemblage in the inlet as some mid-inlet, inshore areas were not surveyed). In some areas there is a tallus slope of dead shell - mussel, oysters and other bivalves at the base of the reef (Grange and McKnight, 1987).

An algal community occurs within this sand/shell zone, in the outer inlet. Cover varies from scattered plants to clumps and in places to dense forests with up to 95% cover, 0.3 metre high (DOC transects T7, T8, T10, T14: see Figure 5). These clumps appear to be loosely anchored to shell buried in the sand. *Asparagopsis armata* is commonly the dominant species and was found in 22 of 37 transects. *Brongiartella australis* was second most frequent (8

transects). Other algae species characteristic of this assemblage are listed in Table 3 and in Appendix 3.

Table 3 : Algal species characteristic of inshore sand/shell areas in the entrance to Paterson Inlet.

<i>Asparagopsis armata</i>	<i>Epymenia wilsonis</i>
<i>Bangia</i> sp.	<i>Gracilaria truncata</i>
<i>Brongniartella australis</i>	<i>Griffithsia antarctica</i>
<i>Bryopsis vestita</i>	<i>Iridea latissimum</i>
<i>Carpomitra costata</i>	<i>Laingia hookeri</i>
<i>Caulerpa brownii</i>	<i>Lenormandia chauvinii</i>
<i>Ceramium</i> spp.	<i>Pleonosporium</i> sp.
<i>Champia chathamensis</i>	<i>Plocamium</i> spp.
<i>Codium fragile</i>	<i>Polysiphonia</i> sp.
coralline algae on pebbles	<i>Scinaia australis</i>
<i>Delisea elegans</i>	<i>Sporochnus</i> spp.
<i>Delisea plumosa</i>	<i>Ulva</i> sp.

Some of these species are more commonly found in areas with brisker current towards the entrance: *Caulerpa brownii*, *Carpomitra costata*.

This algal association was found on sand predominantly in 6-13 metres; it may extend deeper. It was only recorded on dive transects (150 metres at most from any shore). Species of algae growing on sand were not recorded at any NZOI stations. In Willan's 1981 analysis of species characteristic of the sand-dwelling assemblage in the entrance to Paterson Inlet, almost all were infaunal (i.e. they lived beneath rather than on the surface of the sand). Dredge sites in this outer area of the inlet were 500 or more metres offshore and did not cover inshore sand/shell areas. Thus this algal assemblage is probably confined to areas close to rocky subtidal reefs only.

Mid-inlet areas of this habitat type were sampled by dredge so a description of the fauna could be compiled. These dredge stations were located at A1, A2, A9, N1, and Y1. Almost all dive transects located in mid-inlet crossed a zone of these coarse sediments. Epifaunal species, principally echinoderms and crustaceans, are commonest. Many of the faunal species found on these coarse sediment areas are also common in muddier areas. A burrowing bivalve fauna may be present but was not collected by the DOC survey dredge. Table 4 lists fauna species characteristic of both sandy substrates in the outer inlet entrance and of the inshore sand/shelly band where it occurs in central Paterson Inlet. (The latter are based on the DOC dredge sample records and are marked with an asterisk in the table). Species commonly found on the inshore sand/shell/algal areas of mid-inlet but not on clean sand in the entrance are *Cnemidocarpa bicornuata* and *Pentagonaster pulchellus*.

An unusual feature of the various soft sediments of mid-inlet is the occasional occurrence of reefs of polychaete tubeworms on soft substrates. These are colonised by many encrusting and nestling species, and it can be difficult for a diver to distinguish these from rocks, if viewing them from a distance. Four localities in which these have been noted are off the east side of Bravo (DOC transect T51), near Groper Island (Wayne Costello, DOC Invercargill, pers. comm.), off the western tip of Ulva Island (pers. obs.) and in Big Glory Bay (Roper et al., 1988). Tubeworm species appear to be principally *Filograna impexa*, but *Pomatoceros terranovae* was also noted.

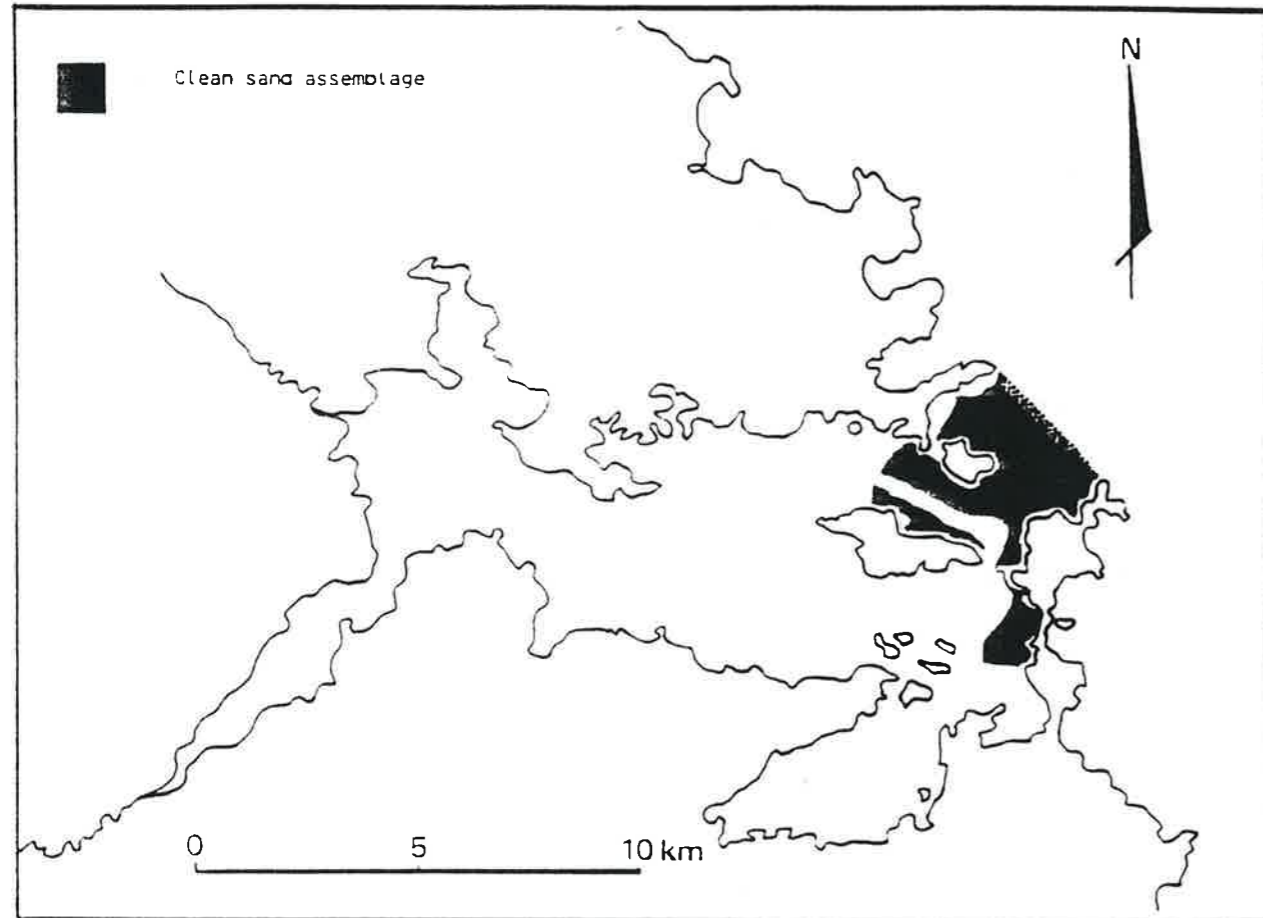
Table 4: Faunal species characteristic of sublittoral sandy sediments in Paterson Inlet.

COELENTERATA	* <i>Actina</i> sp. * <i>Cerianthus</i> sp.
ANNELIDA	* <i>Brachiomma</i> sp.
CRUSTACEA	<i>Lysiosquilla spinosa</i> * <i>Nectocarcinus antarcticus</i> * <i>Notomithrax peronii</i> * <i>Pagurus</i> sp. (in circular saw shells)
BRACHIOPODA	* <i>Terebratella sanguinea</i> (occasional)
MOLLUSCA	<i>Alcithoe arabica</i> forma <i>swainsoni</i> <i>Astrea heliotropium</i> <i>Cardita aoteana</i> <i>Chlamys gemmulata radiata</i> forma <i>suteri</i> <i>Chlamys zelandiae</i> forma <i>dieffenbachi</i> <i>Eataniella</i> sp. <i>Gari</i> sp. <i>Lima zelandica</i> <i>Maoricolpus roseus</i> <i>Pecten novaezealandiae</i> <i>Rissoina chathamensis</i> <i>Scalpomactra scalpellum</i> <i>Tanea zelandica</i> <i>Tawera spissa</i> <i>Thracia</i> sp. aff. <i>vitrea</i> <i>Xymene ambiguus</i>
ECHINODERMATA	* <i>Coscinasterias calamaria</i> * <i>Evechinus chloroticus</i> * <i>Patiriella regularis</i> * <i>Stichopus mollis</i>

* species found in inshore sand/shell band in central Paterson Inlet. This species list has been synthesised from Willan's (1981) assemblage description, from DOC dredge records and from diving transect data.

10.6 "Clean sand" assemblage

Further out from the shelly/sand band around the reef bases, the sea-floor of the inlet entrance is principally clean sand. Gastropods, bivalves and crustacean species predominate, most of them living beneath the surface of the sand.



In these areas currents are more substantial than in the mid-inlet, and the sands are kept clean by water currents. At NZOI station K1000 (Figure 3) off Ringaringa the mobility of the sediment surface is shown by the ripples in the sand bottom parallel to the beach; clumps of red algae were observed rolling along the bottom in the current and there was accumulation of drift weed at the rock/sand boundary (Grange and McKnight, 1987).

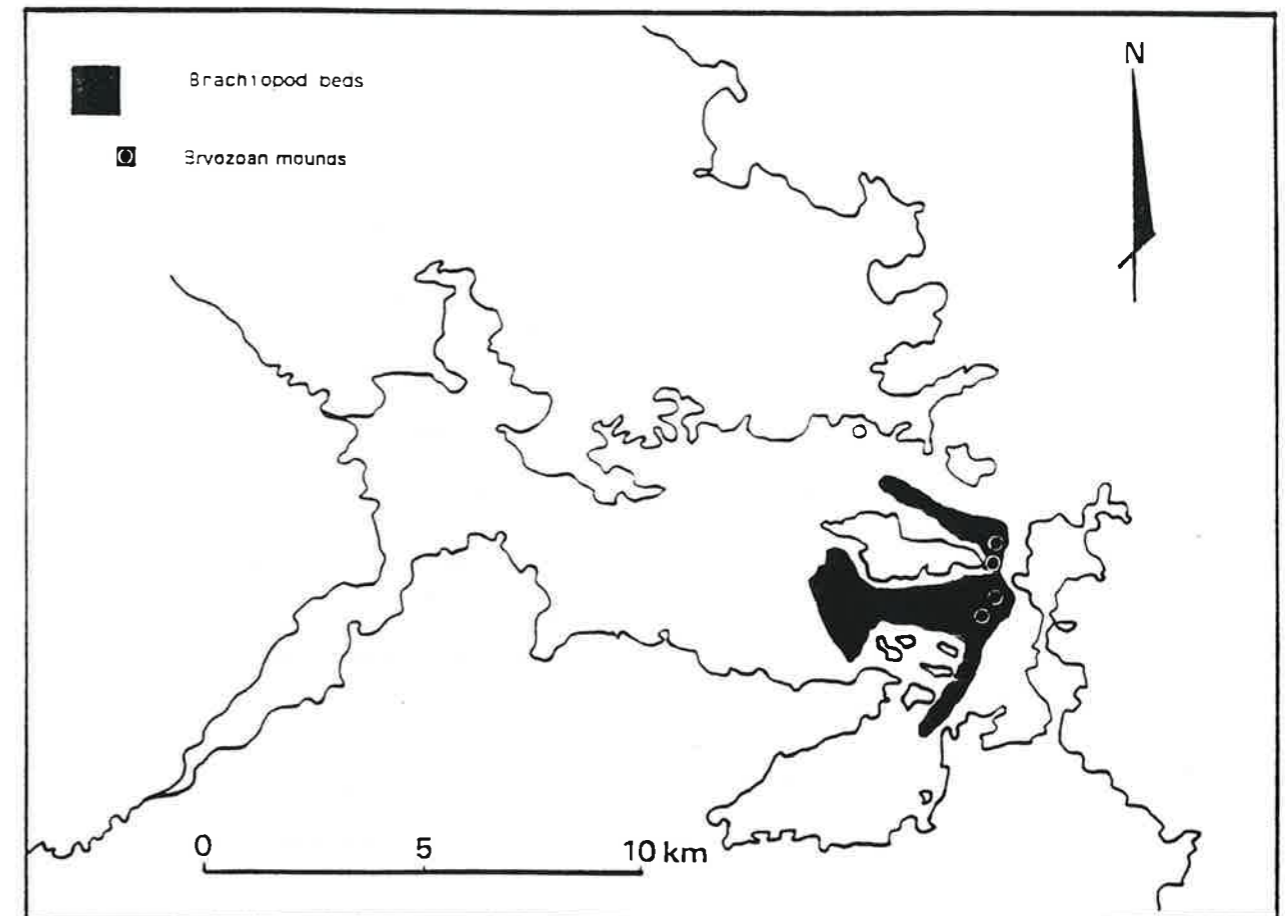
A list of faunal species characteristic of this area is in Table 4.

Many of the species listed, excepting the molluscs, are epifaunal; this reflects their larger size and ease of collection and identification. Deeper dredge sampling gear and finer sorting would probably have revealed other and smaller infaunal animals. Infaunal bivalves were

most diverse (Willan, 1981). The commonest epifaunal species present are scallops *Pecten novaezelandiae*, sea cucumber *Stichopus mollis* and the common kina *Evechinus chloroticus*. Kina commonly occur on sand only where there is a localised area of hard substrate such as a branch or horse mussel *Atrina zelandica* shell to sit on. Crustacea species, especially hermit crabs (*Pagurus* sp. in *Maoricolpus* and *Struthiolaria* shells), are common. A large white actinarian anemone, yet to be described but called "*Actina*" by Willan (1981), occurs occasionally in the sand. Its white fleshy tentacles are often tipped with colour; when prodded this anemone does not retract. Willan records the occurrence of transparent shrimps living commensally with it. Burrows in the sand are probably those of ghost shrimps *Callinassa filholi*, which are relatively common (e.g. on DOC transect T38).

10.7 Brachiopod beds assemblage

Within Paterson Inlet sea-floor areas of grit and gravel occur predominantly around the eastern end and southeast of Ulva Island where current scour is greatest. Bivalve shell material accumulates here. There is a more diverse infaunal polychaete and bivalve assemblage than occurs in the clean sandy areas nearer the entrance.



Tables 4 and 5, when considered together, list faunal species found on these brachiopod beds. The additional infaunal bivalve species in Table 4 were identified from DOC dredge stations C2, C3, G1, I2, U2 and U3 and from Willan's 1981 description of the soft-bottom assemblages in Paterson Inlet.

Table 5: Species found on the brachiopod beds - areas of shell/gravel and brisk current in the entrance to Paterson Inlet, additional to those in the sand dwelling assemblage in Table 4.

ANNELIDA	<i>Eunice australis</i> <i>Eunice tentaculata</i>
CRUSTACEA	<i>Ebalia laevis</i>
BRACHIOPODA	<i>Neothyris lenticularis</i> <i>Terebratella sanguinea</i> <i>Waltonia inconspicua</i>
MOLLUSCA	<i>Anisorbula zelandica</i> <i>Atrina zelandica</i> <i>Barbatia novaezelandiae</i> <i>Cominella nassoides</i> <i>Mesopeplum convexum</i> <i>Modiolarca impacta</i> <i>Myadora striata</i> <i>Nemocardium pulchellum</i> <i>Offadesma angasi</i> <i>Oxyperas elongata</i> <i>Venericardia purpurata</i> <i>Venerupis largillierti</i>
ECHINODERMATA	<i>Allostichaster insignis</i> <i>Amphicyclus thomsonii</i> <i>Astropecten polyacanthus</i> <i>Chirodota nigra</i> <i>Echinocardium cordatum</i> <i>Ophiopsammus maculata</i> <i>Ophiomyxa brevirima</i>
ASCIDIACEA	<i>Cnemidocarpa bicornuata</i>

The predominant feature of this area is the beds of brachiopods - areas of seabed on which *Neothyris lenticularis*, *Terebratella sanguinea* and *Waltonia inconspicua* are the dominant species. Both *N. lenticularis* and *T. sanguinea* on these beds possess a "free-lying" habit, living atop the sediment. *T. sanguinea* commonly has a remnant of dead shell to which the pedicle is attached. The smaller species *W. inconspicua* is frequently present attached to shells especially those of other brachiopods.

Both *Waltonia inconspicua* and *T. sanguinea* have the capacity to adopt free-lying (on soft substrates) and attached (on rock faces) ways of life, where both habitats are available. However *W. inconspicua* shows a preference for the attached habitat and *T. sanguinea* for a free-lying existence (Richardson, 1981a).

In Paterson Inlet maximum population densities of *T. sanguinea* occur on these unconsolidated substrates: this species does not occur intertidally and is uncommon attached to rock subtidally. *Neothyris lenticularis* occurs only on the soft sediments. Both species were most prevalent at NZOI station K989 on a muddy sand and shell seafloor at 22 metres (Stewart 1981).

This brachiopod assemblage - seabed on which brachiopods are dominant - extends from this sand/shell/rubble habitat onto muddier seafloor, into the entrance of Big Glory Bay for example (Roper et al., 1988). It also occurs in patches to the north of Ulva Island (dredge site U2) and southwest of Ulva where the sediments are mud with a large shell fraction. Further towards the head of the inlet past the western tip of Ulva Island, brachiopod abundance decreases and the assemblage merges into that of a mid inlet red algae/mud assemblage described in the following section. During the DOC dredge survey "free-lying" brachiopods were sampled over a 13 kilometre stretch extending from the main beds westward almost to the edge of the Freshwater mudflats (Figure 4).

Stewart (1981) calculated densities of brachiopods on unconsolidated sediments in Paterson Inlet based on samples at ten NZOI stations: the average was 213 m⁻². Highest density occurred at M574 - 506 m⁻² (*W. inconspicua* 320, *T. sanguinea* 170 and *N. lenticularis* 16). Stewart's population structure study showed a noteworthy absence of juveniles of *N. lenticularis* and *T. sanguinea*; few specimens < 20 mm were recorded. This absence was attributed to low mortality rates.

Richardson (1981a) concluded that *T. sanguinea* was commonest on mud. Because of the absence of quantitative data other than relative estimates of abundance for sites further west than Ulva Island covered during the DOC survey, it is not possible to draw any further conclusions on their distribution as related to sediment types. Both *Neothyris* and *Terebratella* are widespread and are commonly found together, although occasionally as along the northern shore *T. sanguinea* occurs with *W. inconspicua* or *Notosaria nigricans* instead (NZOI stations M584, M580) or alone as in M588 in Glory Cove.

Numerous echinoderms, both epifaunal and infaunal, also live within the area of the brachiopod beds. The commonest epifaunal species beside the brachiopods are *Echinocardium cordatum*, *Chirodota nigra*, *Ophiopsammus maculata*, *Cnemidocarpa bicornuta*, *Pagurus* sp. and *Chlamys gemmulata* forma *suteri*.

The composition of the assemblage is similar in biota whether it occurs on mud or on shelly sands. Other species of annelid worm are present but were not identified.

10.7.1 Bryozoan *Cinctipora elegans* mounds

A localised habitat occurs in areas of moderate to strong current near the eastern tip of Ulva Island. Accumulations of coarse material, particularly shell gravel, which appear conducive to colonisation by bryozoans, are described from this area by Willan (1981).

These bryozoans, of which *Cinctipora elegans* is commonest, grow to form large mounds up to 15 centimetres in height, with great lateral spread (half a metre).

Stations containing an association centred around these bryozoan clumps were K987, K989, K990, K994 and I616. *C. elegans* also occurs in smaller patches on areas of clean sand, as at Stn K991. After initial growth, the *C. elegans* patch becomes more hospitable than sand alone offering a microhabitat for colonisation by a great variety of encrusting and nesting species... Such secondary encrusting species tend to weld and stabilise the clumps. Species diversity is increased greatly with the incorporation of ascidians, sponges, and tubicolous polychaetes and the presence of nestling bivalves, chitons, and brachiopods in the interstices of the clumps.... Several of the species found in the bryozoan clumps are usually confined to hard substrates (e.g. *Pentagonaster pulchellus*, *Coscinasterias calamaria*). Silt trapped in the bryozoan mounds accounts for the presence there of nestling species usually found in muddier habitats (e.g. *Kellia cycladiformis*, *Felaniella rakiura*). (Willan, 1981).

Willan's list of species living in these mounds is reproduced in Table 6.

Table 6: Species living within bryozoan (*Cinctipora elegans*) mounds, as part of the sand-dwelling assemblage within the entrance to Paterson Inlet, Stewart Island (Willan 1981).

ANNELIDA	<i>Filograna impexa</i> <i>Galeolaria hystrix</i> <i>Pomatoceros terraenovae</i>
BRACHIOPODA	<i>Notosaria nigricans</i>
MOLLUSCA	<i>Astrea heliotropium</i> <i>Aulacomya ater maoriana</i> <i>Barbatia novaezelandiae</i> <i>Buccinulum</i> sp. cf. <i>linea</i> <i>Calliostoma forsteriana</i> <i>Calliostoma punctulata</i> <i>Cardita aoteana</i> <i>Chlamys zelandiae</i> forma <i>dieffenbachi</i> <i>Kellia cycladiformis</i> <i>Lima colorata zelandica</i> <i>Limatula strangei maoria</i> <i>Merelina maoriana</i> <i>Modelia granosa</i> <i>Modiolarca impacta</i> <i>Notosetia neozelanica</i> <i>Ostrea chilensis</i> (= <i>O. lutaria</i>) <i>Rhyssoplax stangeri</i> <i>Rissoina chathamensis</i> <i>Tugali stewartiana</i> <i>Zemitrella</i> sp.
ECHINODERMATA	<i>Coscinasterias calamaria</i> <i>Pentagonaster pulchellus</i>

This locality at the eastern tip of Ulva where both bryozoan clumps and brachiopod beds occur is the deepest portion of the inlet. The "hole" at 45 metres depth, is probably the result of scour (Richardson, 1981b).

The following stations were located on soft substrates in the areas of outer inlet described in the assemblages above (clean sand assemblage, brachiopod beds, and sand/shell/algal assemblage) :

DOC dredge stations	C1 C2 C3 G1 I1 I2 U2 U3
Dive transects	T7 T8 T9 T10 T11 T12 T13 T14 T21 T22 T37 T38 T53 T54
NZOI stations	I546 I656 K973 K974 K976 K977 K978 K980 K981 K982 K987 K988 K989 K990 K991 K992 K993 K994 K995 K996 K997 K1000 K1003 K1004 M570 M573 M574 M575 M576 M582 M586

10.8 Subtidal mud assemblage

The assemblage which covers the greatest area of Paterson Inlet occurs on mud substrates where there is negligible current scour. Mud bottom habitat covers approximately 60 square kilometres from the large mudflats of the Freshwater and Rakeahua Rivers to where it merges with coarser sandy sediments in the outer inlet as shown in Figure 3. Within this mid-inlet area are all of the smaller inlets within Paterson Inlet - Big Glory Bay, Glory Cove, Kaipipi, Kidney Fern and North Arm. There are also several island groups, the largest of which are Ulva Island and the Bravo Islands at the entrance to Big Glory Bay.

Willan (1981) noted that fewer bivalves are present in the mud assemblages than in the outer inlet. He lists 21 mollusc species as characteristic; of these, ten bivalve and six gastropods were not found in any of the DOC dredge stations, not even those in approximately the same localities as the NZOI stations. This may be attributable to the different dredge types used (section 11.3).

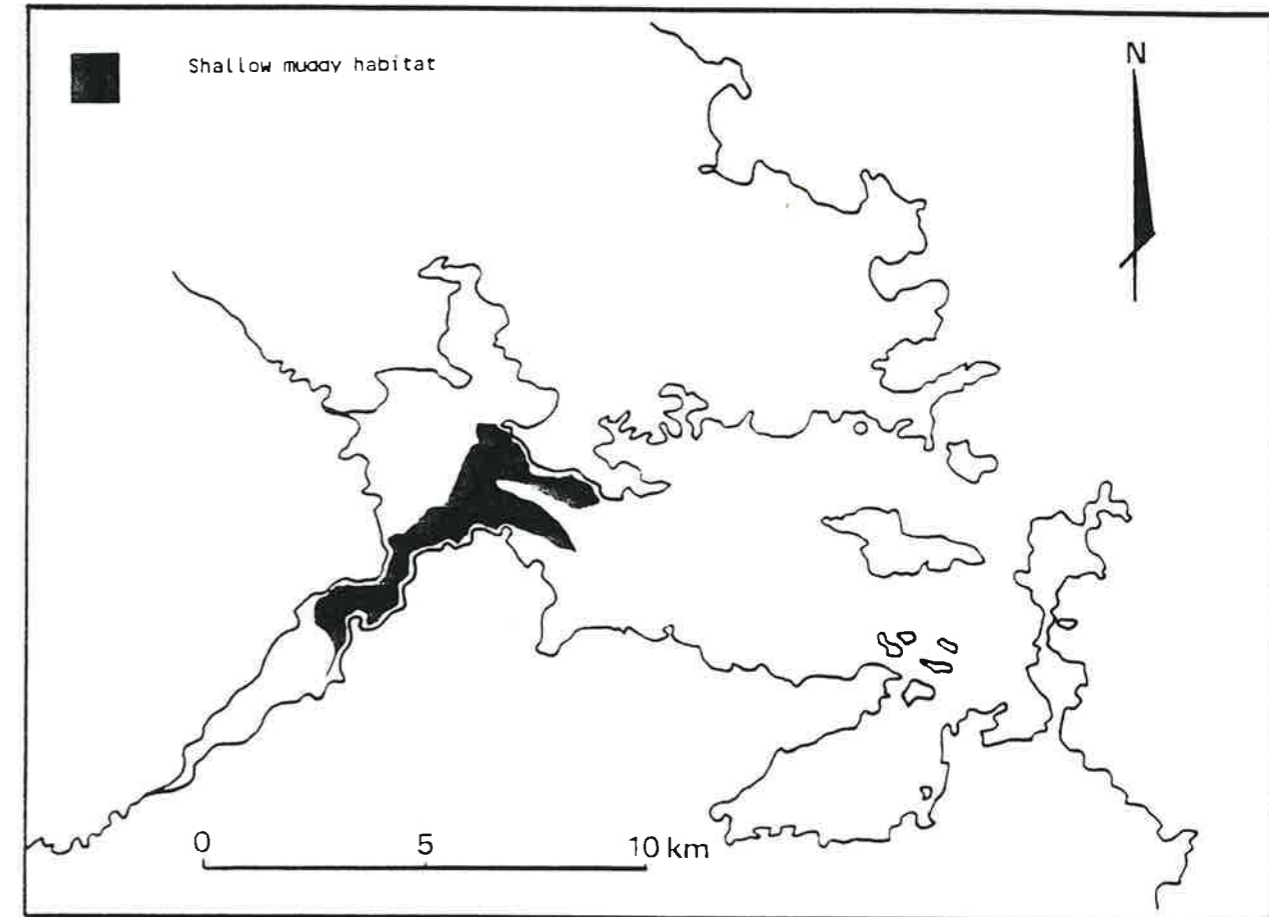
In comparison to soft substrate assemblages in the outer inlet, the abundance of epifaunal species is higher. The mid-inlet infauna is dominated by annelids and holothurians.

The different benthic assemblages on the mud of central Paterson Inlet - *Lenormandia* meadows, a *Rhodymenia* mud assemblage, brachiopod beds near Ulva Island and shallower areas near the western mudflats - are distinguished primarily by the different red algae rather than by faunal species; this in turn is partly related to depth. There is an indistinct boundary between the brachiopod beds around the south and west of Ulva Island (where those species are dominant) and the mud assemblages where brachiopods occur at lower densities (Figure 4).

Meadows of red algae in which *Lenormandia chauvinii* is present are widespread in 6-20 metres along the shores and in the bays of the mid-inlet. In deeper areas around 20-25 metres, an assemblage characterised by two species of *Rhodymenia* algae occurs.

10.8.1 Shallow muddy habitat

In the subtidal mud in South West Arm and adjacent to the Freshwater mudflats infaunal species - annelids and echinoderm species, especially holothurians - are commonest. The seabed adjacent to the mudflats of the Freshwater and Rakeahua Rivers is of fine anaerobic mud.



At dredge stations sampled in these locations (stations H1, H2, H3, H4, SW1, SW2, X1, and X2) species diversity and abundance appeared to decrease. Brachiopods are only occasionally present, in low numbers, as is the red algae *Rhodymenia linearis* which is very common in deeper areas. The heart urchin *Echinocardium cordatum*, holothurians *Chirodota nigra* and *Trochodota* species, along with various annelids, are commonest. The sampling method used may have failed to detect smaller or deeper living fauna living in these muds.

The commoner species which live in the various mud mid-inlet assemblages described above are listed in Table 7. This composite list has been synthesised from all the raw data available from the various studies, but principally from the DOC dredge sites.

Table 7: Species characteristic of the mid-inlet subtidal mud association of Paterson Inlet

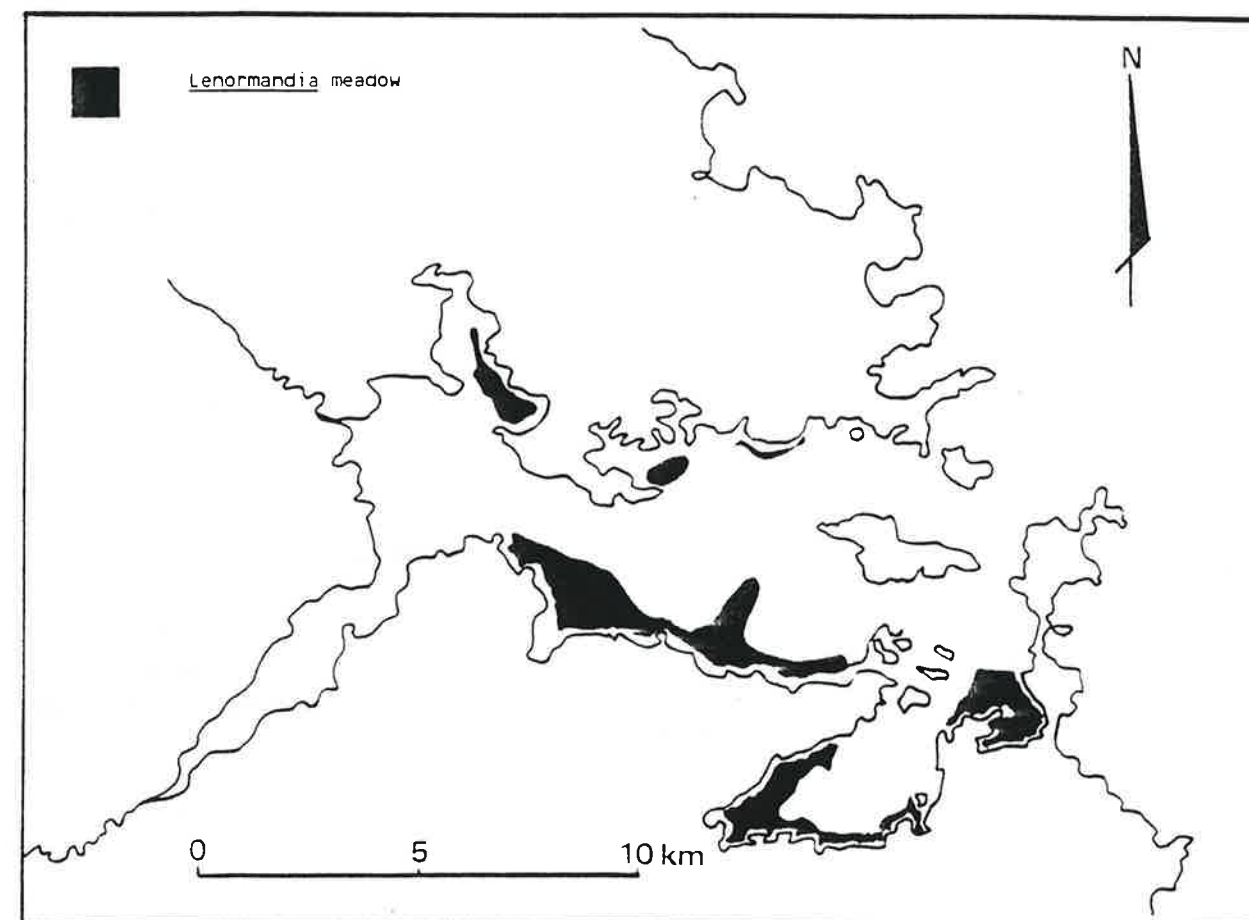
ALGAE	
Commonest	<i>Delisea elegans</i>
<i>Lenormandia chauvini</i>	<i>Delisea plumosa</i>
<i>Rhodymenia epimenioides</i>	<i>Epymenia wilsonii</i>
<i>Rhodymenia linearis</i>	<i>Hymenena</i> sp.
	<i>Gloiderma saccatum</i>
Present	<i>Gracilaria truncata</i>
<i>Asparagopsis armata</i>	<i>Griffithsia</i> sp.
<i>Brongniartella australis</i>	<i>Pleonosporium</i> sp.
<i>Ceramium</i> sp.	<i>Polysiphonia</i> sp.
<i>Codium dichotomum</i>	<i>Sarcodia flabellata</i>
<i>Codium fragile</i>	<i>Schizymenia novae-zelandiae</i>
<i>Craspedocarpus erosus</i>	<i>Sporochnus</i> sp.
<i>Cutleria multifida</i>	<i>Stenogramme interrupta</i>
<i>Dasya collabens</i>	<i>Ulva</i> sp.
FAUNA	
COELENTERATA	MOLLUSCA
▲ "Actina" sp.	▲ <i>Alcithoe swainsoni</i>
▲ "Cerianthus" sp.	▲ <i>Atrina novaezelandiae</i>
	▲ <i>Buccinum</i> sp. aff. <i>lineum</i>
ANNELIDA	▲▲ <i>Chlamys gemmulata</i> forma <i>suteri</i>
▲ <i>Aphrodite</i> sp.	▲ <i>Craspedochiton rubiginosus</i>
▲ <i>Brachiomma</i> sp.	▲ <i>Cuspidaria trailii</i>
▲ <i>Cerratulid</i> sp.	▲ <i>Diplodonta globus</i>
▲ <i>Eunice australis</i>	▲ <i>Felaniella rakiura</i>
▲ <i>Glycera</i> sp.	▲ <i>Gari strangeri</i>
▲ <i>Maera inaequires</i>	▲ <i>Glaphyrina</i> sp.
▲ <i>Pectinaria australis</i>	▲ <i>Leptomysa retiaris</i>
▲ <i>Phyllochaetopterus socialis</i>	▲ <i>Maoricolpus roseus</i>
▲ <i>Sipuncula</i> sp.	▲ <i>Maorithyas marama</i>
▲▲ <i>Thelepus</i> sp.	▲ <i>Micrelenchus caelatus</i>
	▲ <i>Micrelenchus micans</i>
CRUSTACEA	▲ <i>Myadora novaezelandiae</i>
▲ <i>Pagurus cooki</i>	▲ <i>Neilo australis</i>
▲ <i>Pagurus traversi</i>	▲ <i>Nemocardium pulchellum</i>
▲ <i>Palaemon affinis</i>	▲ <i>Nucula nitidula</i>
▲ <i>Notomithrax minor</i>	▲ <i>Pecten novaezelandiae</i>
	▲ <i>Phenatoma rosea</i>
BRACHIOPODA	▲ <i>Philina</i> sp.
▲ <i>Neothyris lenticularis</i>	▲ <i>Struthiolaria papulosa</i>
▲ <i>Terebratella sanguinea</i>	▲ <i>Tanea zelandica</i>
▲ <i>Waltonia inconspicua</i>	▲ <i>Tawera spissa</i>
	▲ <i>Tellina huttoni</i>
ECHINODERMATA	▲ <i>Terenochiton inquinatus</i>
▲ <i>Allostichaster insignis</i>	▲ <i>Thyasira peroniana peregrina</i>
▲ <i>Allostichaster polyplax</i>	▲ <i>Trochus tiaratus</i>
▲ <i>Amphicyclus thomsonii</i>	▲ <i>Venerupis largellenti</i>
▲ <i>Chirodota gigas</i>	▲ <i>Xymene ambiguus</i>
▲▲ <i>Chirodota nigra</i>	
▲▲ <i>Coscinasterias calamaria</i>	ASCIDIACEA
▲▲ <i>Echinocardium cordatum</i>	▲ <i>Hypsistozoa fasmerica</i>
▲ <i>Evechinus chloroticus</i>	▲▲ <i>Cnemidocarpa bicornuata</i>
▲ <i>Kolostenura</i> sp.	▲ <i>Astrocarpa</i> sp.
▲ <i>Ocnus brevidentis</i>	
▲ <i>Ophioceres huttoni</i>	
▲ <i>Ophiopsammus maculata</i>	
▲▲ <i>Ophiomyxa brevirima</i>	
▲ <i>Ophiuroida</i> sp.	
▲ <i>Patriella regularis</i>	
▲ <i>Pectinura gracilis</i>	
▲ <i>Pentagonaster pulchellus</i>	
▲▲ <i>Stichopus mollis</i>	
▲ <i>Trochodota dendyi</i>	
▲ <i>Trochodota dunedinensis</i>	

KEY:
 ▲ Epifaunal species found on *Lenormandia* meadows
 ▲ Fauna species characteristic of mud/*Rhodymenia* assemblage

Areas of seabed under the salmon farms in Big Glory Bay have been severely modified by the deposition of wastes. These effects are described in Roper et al. (1988).

10.8.2 *Lenormandia* meadows

Red algal meadows in which the dominant species (>50% cover) is *Lenormandia chauvini* are widespread around the subtidal shores of the central inlet. Their extent ranges from large beds covering the seafloor, to narrower fringes, both interspersed in places with "bare" patches. Generally the distribution of these *Lenormandia* meadows is depth related - occurring no shallower than six metres and extending out to about 20 metres depth, very occasionally to 25 metres (DOC dredge sites A8, A12).



Both patches and larger meadows occur on a variety of sediments - not only mud but often on sandy/shelly or gravel areas particularly at the base of rock; for example *Lenormandia* occurs on sandy sediments around the Bravo group of islands. *Lenormandia* is loosely attached to the substrate and can be rolled back. Atop the algae the active fan scallops *Chlamys gemmulata* forma *suteri* are common; the larger scallop *Pecten novaezealandiae* also occurs, both resting on the algae and on the mud patches between. Attached to the algal

fronds, a small orange ascidian *Hypsistizoa* sp. is common as are encrusting bryozoans (unidentified).

These meadows are a refuge for a diverse range of species buried in the algae or sheltering beneath it, from annelids and holothurian species such as *Chirodota nigra*, molluscs - *Maoricolpus roseus*, *Micrelenchus caelatus*, *Terenochiton inquinatus* - and the large solitary ascidian *Cnemidocarpa bicornuata*. The cream or red feeding frills of holothurian worms (*Trochodota* species) buried in the mud extend above the algae. Sponges, including flask shaped species and the golfball sponge *Tethya*, are frequently present.

Epifaunal species commonly found on or around these meadows are marked with an ▲ in Table 7.

The two free-lying brachiopods *Terebratella sanguinea* and *Neothyris lenticularis* occur frequently in deeper areas with scattered red algal cover. However they are sparse around areas of *Lenormandia* meadow. Exceptions to this were noted at the west end of Ulva (DOC transect T66) where both brachiopod species occur in shelly areas at 11-14 metres depth along with small patches of *Lenormandia*.

Elizabeth Batham's detailed 1969 study of the benthic ecology of Glory Cove showed that much of the seafloor in the cove was covered with *Lenormandia*.

Of animals, Echinodermata was the group represented unusually strongly in numbers of specimens, bulk of organisms, and numbers of species. Some 17 species were taken, many in considerable numbers... The particular impression gained... is one of an unusual wealth of echinoderms at Glory Cove (Batham, 1969, p.77 and p.80).

In Batham's samples *Chlamys gemmulata* form *suteri* and *Terebratella sanguinea* were poorly represented, probably because her survey relied on dredging and trawling only, which would emphasise infaunal species and under represent epifaunal ones. Mobile species like *Pecten* and *Chlamys* can actively swim out of the way of a small dredge. Scuba diving sampling and descriptions would detect this bias. The author has observed scallops present in the cove on several dives but this species was not recorded by Batham.

Lenormandia meadows in the shallower areas of Big Glory Bay were described by Roper et al. (1988).

Associated with the dominant *Lenormandia* there are generally up to six algal species also present, almost always in low densities. *Asparagopsis armata* is commonly present and the other algae species listed in Table 10 may also occur. An exception to the dominance of *Lenormandia* occurs in shallow areas along the northern shore eg. dredge site P4 at which *Lenormandia* presence can be as low as 50%, with similar amounts of *Craspedocarpus erosus*.

The occurrence of *Lenormandia* along the northern shore of Paterson Inlet is sparse and appears restricted to an inshore sand/shell zone comparable to that described earlier.

Asparagopsis armata is again associated with the *Lenormandia* and *Brongniartella australis* is frequently present (DOC transects T6, T15, T29, T30, T31, T32). In places *Lenormandia* meadows and the *Lenormandia/Asparagopsis/Brongniartella* association on sand and shell are not distinctly different assemblages. They grade into each other as sediment type changes from mud to sand/shell.

Lenormandia meadows were recorded at the following stations:

Dredge sites	A2 A3 A4 A5 A8 A10 A11 A12 C5 H5 P3 P4 R1 T1 U4 U5 Z2
Dive transects	T15 T23 T24 T25 T26 T27 T28 T29 T30 T31 T32 T41 T42 T52 T59 T60 T63 T66

and in papers on Glory Cove (Batham, 1969) and Big Glory Bay (Roper et al., 1988).

10.8.3 *Rhodymenia*/mud assemblage

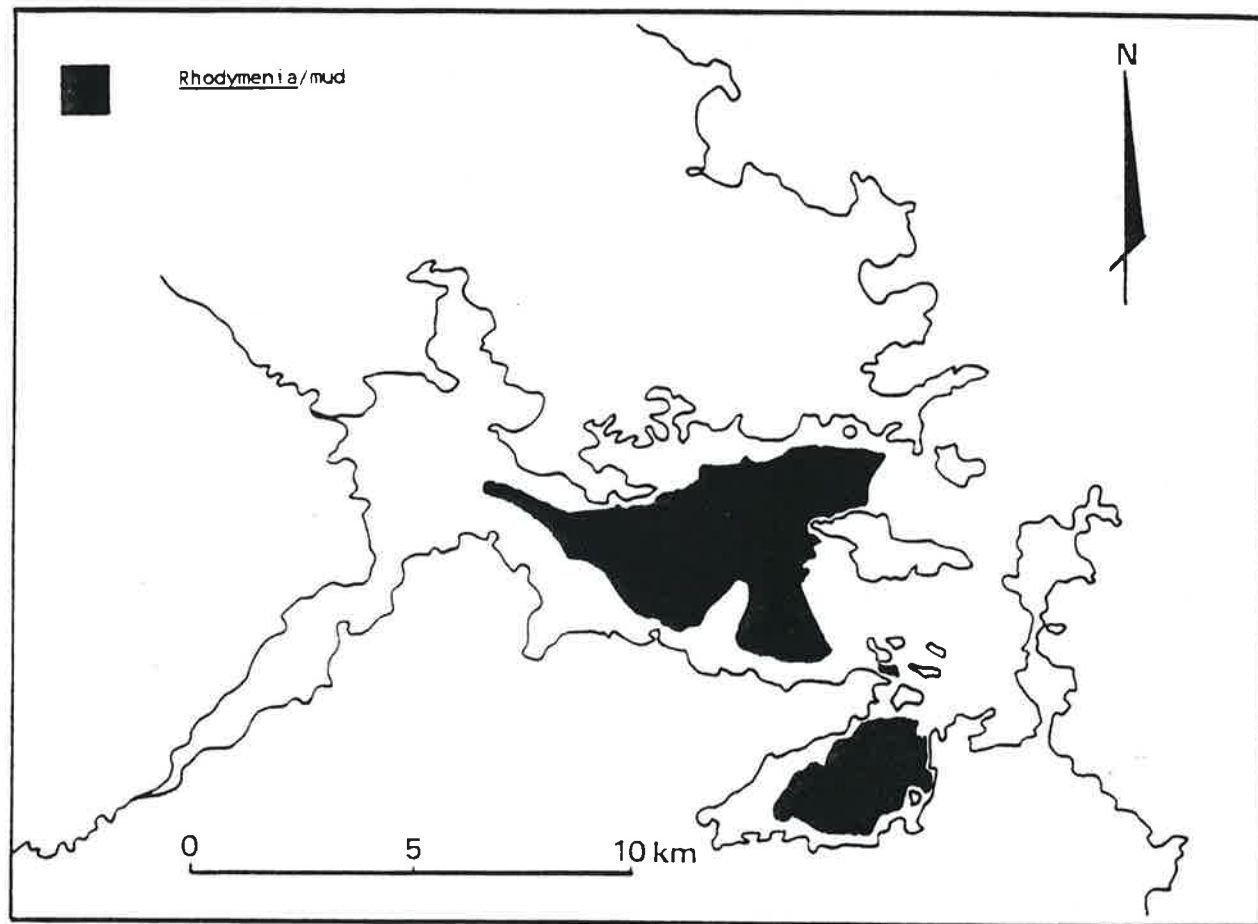
In depths over 20 metres *Lenormandia* is not generally present; instead other red algae species provide a scattered, less continuous cover over the mud. *Rhodymenia linearis* and *Rhodymenia epimenioides* still occur. The latter exhibits a variety of forms including acute apices and pinched fronds. A review of these *Rhodymenia* species is needed before any identification of further species which may be present can be made. Willan (1981) listed *Rhodymenia novaezealandica* as a species which lives on mud seafloor; however, this name has not been used in this paper as the original description was based on an infertile specimen - cystocarps unknown (Dawson 1941); all small narrow fronded *Rhodymenia* have been considered as *R. linearis*. A large red species with flat sheet-like thalli *Schizymenia novaezealandiae* occurs in a freeliving mode and is widespread. *Stenogramme interrupta* and *Gracilaria truncata* are also present.

At several adjacent DOC dredge sites on mud seafloor at depths of over 20 metres red algae species were not collected; these were principally in the northern/central area (DOC dredge stations B1,I5,P2,Y2). This apparent absence may have been related to random choice of dredge site rather than total absence of algae in these localities. The other species found at these localities were those also characteristic of the mud/*Rhodymenia* assemblage which are marked with an asterisk in Table 7.

A large white ascidian (not identified) was commonly found in Water Quality Centre study of Big Glory Bay (Roper et al., 1988).

DOC dredge stations at which this *Rhodymenia* association was recorded were:

A5 A6 A7 B3 H4 I4 P1 R2 X2 X3 Z1 Z3 Z4 Z6



PART IV: INFORMATION SOURCES

11. SOURCES

Benthic studies completed over the last 22 years have addressed a number of key aspects of the benthic ecology of Paterson Inlet. The key sources used in this report are identified below.

11.1 Batham's 1967 programme, Glory Cove

Batham E J (1969): Benthic ecology of Glory Cove, Stewart Island. *Transactions of the Royal Society of Royal New Zealand Biological Sciences* 11 (5): pp. 71-81

Elizabeth Batham of Portobello Marine Biological Station undertook an intensive bottom sampling programme in Glory Cove in 1967. Glory Cove is a sheltered bay, covering approximately one square kilometre in the south-east of Paterson Inlet.

The sampling comprised three trawls using a 4-foot wide Agassiz beam trawl and 1.5 foot wide dredge which obtained samples of the substrate and benthic species. Species lists were compiled for each haul. Eight sediment samples were analysed to determine grain size distribution (Batham, 1969).

11.2 Adams et al.'s algal species list, 1974

Adams N M; Conway E; Morris R E (1974): The marine algae of Stewart Island, a list of species. *Records of the Dominion Museum* pp. 185-245.

A species list for the marine algae of Stewart Island was compiled by Adams et al. (1974). As this details station numbers and locations at which each species had been collected, it proved possible to extract a list of all algae species recorded in Paterson Inlet (Appendix 3).

11.3 National Geographic brachiopod cruises

Willan R C (1981): Soft-bottom assemblages of Paterson Inlet, Stewart Island New Zealand. *New Zealand Journal of Zoology* Vol. 8 pp. 229-248.

Aldridge A E (1981): Intraspecific variation of shape and size in subtidal populations of two Recent New Zealand articulate brachiopods. *New Zealand Journal of Zoology* 8(2): pp. 169-174.

Richardson J R (1981a): Distribution and orientation of six articulate brachiopod species from New Zealand. *New Zealand Journal of Zoology* 8(2): pp. 189-196.

Richardson J R (1981b): Recent brachiopods from New Zealand - background to the study cruises of 1977-79. *New Zealand Journal of Zoology* 8(2): pp. 133-143.

Stewart I R (1981): Population structure of articulate brachiopod species from hard and soft substrates. *New Zealand Journal of Zoology* 8(2): pp. 197-305.

During the National Geographic brachiopod cruises carried out by New Zealand Oceanographic Institute (NZOI) in 1977 and 1979, data on the marine sediments and assemblages occurring in Paterson Inlet was collected. A description of the soft-bottom biota of subtidal areas in the outer half of the inlet was compiled by R. C. Willan (1981). Data on the presence of organisms had been recorded from direct observations made on dredge hauls, divers' debrief sheets and personal dive log records and from examining underwater photographs. The 53 stations used covered the portions of the inlet east of Kaipipi and were concentrated principally around Ulva Island (Richardson, 1981b); see Figure 3. The dredge used by NZOI was designed by Mr A J Black, the skipper of the chartered vessel *Munida*, and may have dug deeper and retained smaller molluscs than those picked up on the dredge used on the DOC survey (see section 10.8).

Richardson's studies showed that the water in the outer and mid inlet areas studied was similar in salinity and oxygen concentration to neighbouring oceanic waters (Richardson 1981b).

Data on brachiopod populations which were collected on the same cruises formed the basis of other studies. Intraspecific variation of shape and size in subtidal populations of *Terebratella sanguinea* and *Waltonia inconspicua* from sites including Paterson Inlet was documented by Aldridge (1981). Stewart (1981) studied the population structure of *T. sanguinea*, *W. inconspicua* and *Neothyris lenticularis* on both hard and soft substrates in Paterson Inlet. The distribution and orientation of these three species, also *Notosaria nigricans* and two other New Zealand species not found in Paterson Inlet (*Liothyrella neozelanica* and *Neothyris compressa*) were reported by Richardson (1981a).

11.4 New Zealand Oceanographic Institute summary

Grange K R and McKnight D G (1987): A summary of existing marine ecological information on Stewart Island of relevance to marine protected area proposals. NZOI Report prepared for the Department of Conservation.

In 1987 the Department of Conservation commissioned from NZOI a summary of the existing unpublished information on the marine ecology of Stewart Island held in its archives. This was to enable a comparison to be made of the habitats in Paterson Inlet with those of other areas around Stewart Island.

The report supplies summarised information held on Paterson Inlet, Port Adventure, Port Pegasus and other shallow (less than 50 metres deep) coastal areas around the island. It also gives a brief comparison of the overall similarities and differences between these areas.

Copies of dive register records for various stations are included in the report. Additional data on both rocky and soft substrates, generally in note form, is given.

11.5 DOC dive survey 1988

Unpublished survey data (1988) Department of Conservation, Wellington and Southland Conservancy (held by Kathy Walls and Cameron Hay, Head Office)

A DOC survey, organised by Kathy Walls, to collect descriptive information on the rocky reef areas of the inlet and its environs was conducted in February 1988. Assistance in the field was received from staff of NZOI, Department of Scientific and Industrial Research (DSIR) Water Quality Centre (WQC), and Ministry of Agriculture and Fisheries (MAF). The survey was completed in late 1988 by Stewart Island DOC staff.

Transect lines 100m long were located to cover a diverse range of topographical situations over the outer half of the inlet. Along these, dominant species (with the emphasis on macrophytes and other large easily recognised species) were recorded, as were substrate changes with depth and distance from the shore. In all instances where the transects extended across the rocky substrate onto soft sediments, epifaunal species observed on the latter were described.

A total of 36 transects were completed within the inlet; on 15 of these a detailed assessment of all algal species present, also their height and cover, was made in quadrats placed at five metres intervals along the transect line. This was undertaken by WQC staff led by Brian Coffey. Figure 5 shows the location of all transects.

All the transect data was studied during the compilation of this report including dive notes from Cameron Hay (then NZOI) and a database compiled by Coffey and his associates (formerly WQC). Malcolm Francis conducted visual fast counts of fish at 20 sites within the mid and outer inlet, at offshore islands and on the adjacent coast (Appendix 6). At each site counts were made over both the deeper part of the reef (12 - 15 m) and in the shallows (3 - 7 m). All fish species seen and their densities were recorded by a diver swimming along a 30 metre transect at a pre-calibrated rate. For analysis, replicate counts were pooled into six categories covering the mid and outer inlet and adjacent coast. A distinction was made between shallow and deep reefs and between sheltered and exposed sites (Walls, 1989).

11.6 Water Quality Centre studies, Big Glory Bay, 1988

Roper D S; Rutherford J C; Pridmore R D (1988): Salmon farming water right studies, Big Glory Bay, Stewart Island. Water Quality Centre, DSIR, Consultancy report No T7074/2.

In 1988 DSIR Water Quality Centre staff undertook studies in Big Glory Bay, a large bay opening onto the south-east corner of the inlet. These were aimed at formulating water right conditions appropriate to the operation of the salmon farms in this bay. As part of the studies a survey of the benthos in the bay was carried out.

During February observations of the seafloor were made with an underwater video camera attached to an Ocean Engineering Phantom 400 remotely operated vehicle (ROV) and by scuba divers. 41 sites were chosen to give a wide coverage of the bay. Two predominant

types of habitat were identified and the larger epifaunal animals which were characteristic of these were listed.

11.7 DOC bottom sampling programme 1989

Unpublished survey data (1989) held by Department of Conservation, Southland Conservancy

In May 1989 an extensive bottom sampling of the inlet was carried out by the Department of Conservation. 58 dredge stations were spaced to cover all the inlet and a rapid analysis was made of the dominant species and their relative abundance at each station.

The dredge used was of a letter box type, on the vessel "Munida" from Portobello Marine Laboratory. Sediment samples were taken at all stations. From the species sampled, 18 "indicator" species were chosen and their abundance charted for each station. The location of these sites is shown on Figure 5.

11.8 DOC intertidal and shoreline sampling programme 1989

Unpublished survey data (1989) held by Department of Conservation, Southland Conservancy

Sixteen intertidal sites in Paterson Inlet were examined during 1988/89. The sites were chosen to cover a range of exposures. For each site general physical characteristics were recorded and an abundance scale (*sensu* Ballantine et al., 1973) was used to assess the community pattern of plants and animals present. Zonation diagrams were compiled for each site; the intertidal study sites are shown on Figure 5.

Also during this period physical shore types within the inlet were surveyed and mapped. Systematic field coverage of all the shoreline (except around the Freshwater and South West Arm mudflats which is yet to be completed) was carried out by dinghy and the substrate topography mapped at 1:10,000.

11.9 DOC Stewart Island dive records 1989-90

Dive records (1988-1990) held by Department of Conservation, Southland Conservancy

During the two years the author and other DOC field staff on Stewart Island spent surveying the inlet, considerable information, other than from structured surveys, was gained about the biota and assemblages present. Spot dives made by Department of Conservation staff for other purposes (e.g. for examining the impact of salmon farms) helped interpret the survey data on assemblage structure and pattern.

12 ACKNOWLEDGEMENTS

This report is the result of field investigations in which many people were involved. My final role has been to coordinate the integration of all the available data and to synthesis it into a form that is useful for DOC's coastal programme.

The following scientific staff assisted with the DOC Surveys: 1988 survey: Kathy Walls, Malcolm Francis, Brian Coffey, Cameron Hay, Ken Grange, Sue Millar, Ann McCrone and other staff from WQC, MAF, and DSIR. Rakiura District surveys: Jane Hare, Sandy King, Wayne Costello, Travis Hughes. 1989 "Munida" survey: Wayne Costello, Anita Pillai, Glen Lauder. Others who assisted: Paul Johnson, Mark (Phred) Dobbins, Lindsay Chadderton, Richard Allibone, Ron Tindal and Alan Gray.

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Thanks too, to Wendy Nelson, Ken Grange, Anita Pillai, Simon Hayes and Phil Doole who commented on the text, to Wayne Costello for undertaking and collating the "Munida dredge" survey data, and to Kath Syme for typing. Editing was undertaken by Mary Cresswell and Phil Doole.

With the following exceptions the maps were prepared by Mark Day:

Figure 2 - Department of Survey and Land Information Map Authority 1991/104: Crown Copyright Reserved

Figure 3 - reproduced with permission of Science Information Division, DSIR, Wellington
Figures 6, 7 & 8 were prepared by Simon Hayes.

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PART V: APPENDICES

APPENDIX 1: EFFECT OF SALMON FARMING ON BRACHIOPOD BEDS IN PATERSON INLET

Department of Conservation Internal Report.

INTRODUCTION

In January 1989 five salmon companies relocated cages of salmon in Paterson Inlet, Stewart Island. This move, an illegal one, was the result of a large algal bloom in adjacent Big Glory Bay, the area of Stewart Island designated for marine farming by the Minister of Fisheries. The bloom was causing extensive fish kills and the cages were moved in an attempt to save remaining fish.

The sites occupied in Paterson Inlet lay between the Bravo Group of islands and Tarpaulin Beach on The Neck at approximately 46° 57.3'S, 168° 9.5'E.

Department of Conservation (DOC) staff decided that if the farms were to remain indefinitely at the new sites there would be an impact on the benthic life and water column such as has been observed and documented under the Big Glory farms⁽²⁾. There, anaerobic layers of sediment up to one metre or more deep completely smother the sediment under and adjacent to the cages; a large amount of biogas is generated by these wastes.

As the initial effects of siting a salmon farm over previously unmodified sea bottom had not been documented before on Stewart Island, visual monitoring of the benthos, using a combination of diver observations and underwater video filming, was undertaken by Department of Conservation divers.

OBSERVATIONS

To date a series of five dives have been made, all under one farm, that located in deepest water (24 metres).

Dives were made on 15 February, one month after relocation, 23 February, 7 March and 17-21 December. The farm was moved back into Big Glory in April 1989.

On the first dive, observation of the surrounding sea floor showed that the farm had been sited in an area in which brachiopods were the dominant benthic species - commonest were *Neothyris lenticularis* and *Terebratella sanguinea*, both lying atop fine muddy sediment. *Waltonia inconspicua* were also present in smaller numbers, attached to other shells. Scallops *Pecten novaezelandiae*, clumps of turret shells *Maoricolpus roseus* and patches of small red algae were also common. Sea cucumbers *Stichopus mollis* were frequent.

From the first dive, divers were able to pinpoint the position of the salmon cages above, from their shadow and from the layer of waste sediment covering the bottom substrate

directly under the farm. For approximately 15 metres out from the edge of this complete cover, there occurred a mosaic of patches of waste sediment and of natural substrate. This accumulation of waste sediment, a recognised feature of salmon farming, is a combination of fish faeces, uneaten fish food, dust from food handling, debris from nets etc.

Over the first 3 dives it was possible to recognise and record a sequence of the relative sensitivity of benthic fauna to smothering by the wastes.

On the first dive, one month after the farm's relocation, dead specimens of heart urchins *Echinocardium cordatum*, and cream coloured holothurian worms (unidentified) were commonly observed lying on the mud. Both species normally live below the surface of the substrate. Several dead specimens of a second holothurian *Chirodota nigra* were seen, as were *Terebratella sanguinea* and *Neothyris lenticularis*. Scallops *Pecten novae-zelandiae* and small orange fan scallops *Chlamys gemmulata form suteri* were apparently healthy. On the second dive one month later lesser numbers of the dead urchins and holothurians were present. Dead brachiopods were again observed. Still present and alive, although more sluggish were fan scallops and the larger scallops.

On the third dive on March 7, two and 3/4 months after the initial relocation, the diver's general impression was that the depth of waste had increased and there was even less live fauna than on the previous two visits. Dead scallops *Pecten novae-zelandiae* were now present and *Chlamys*, an active, mobile species were much less frequent.

Although the sea bottom under and around the farm could be described as a "brachiopod bed" brachiopod densities were observed to vary considerably within a 150 metre radius of the farm.

On all dives the brachiopods seen under the farm were covered by a thin layer of sediment. It was very difficult to search for specimens buried deeper than approximately 1/4 cm because stirring up the sediment reduced visibility to an unworkable level. However an overall low density of brachiopods under the farm compared to some adjacent areas suggested that more brachiopods could have been buried but unobserved.

The relative densities of alive and dead specimens were estimated on the second and third dives using replicate counts randomly located quadrats.

POTENTIAL CAUSES OF DEATH

All the dead brachiopods seen appeared to have died from smothering.

The free-lying *Neothyris* and *Terebratella sanguinea* specimens have been reported as being able to shake off excess sediment by a twisting motion, but presumably the amount of waste sediment was too much to deal with in this manner. Several other factors could possibly be implicated in the death of the brachiopods. Salmon farming practices result in a large increase in nutrient concentrations - in particular soluble nitrogen and phosphorous ⁽¹⁾.

Another possible lethal effect is an accumulation of mercury (present in the food fed to salmon) in the sediments under Big Glory Bay salmon farms ⁽³⁾. A reasonable estimate of

background level in marine and terrestrial sediments is 0.1mg kg⁻¹ Hg ⁽³⁾. More research is needed on the impact of accumulated mercury and particularly its toxic organic form methyl mercury, on benthic fauna.

The heavy oxygen consumption of the waste sediments is another possible factor. By March 1989 evidence of anaerobic conditions in the waste was noticeable. Under the lighter coloured surface (which itself is *Beggiatoa* a bacterium associated with sulphide producing sediments ⁽¹⁾) there occurred a black anaerobic layer. Under these conditions hydrogen sulphide could be generated; this is known to be toxic to fish life ⁽²⁾.

RECOLONISATION

Dives were made in December 1989 to try and relocate the farm site. Although the general position of the farm was still marked by buoys attached to the farm's anchor blocks, several dives, including two diagonal manta board runs through the site, failed to locate any sign of waste sediment.

A central area with an unusually high density of *Chlamys* was seen; this appeared to be the farm site which had since been recolonised by benthic species but not by brachiopods.

Video records have been kept of all the dives.

CONCLUSION

The site at which all the farms were relocated has since been identified as that most suitable for re-use as a refuge site, in the event of further blooms in Big Glory Bay. Methods of legalising this are currently being investigated.

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IJ HARE
22 January 1990

APPENDIX 2 FISH DISTRIBUTION

Paterson Inlet, adjacent outer coast and islands in Foveaux Strait

(Walls 1989)

X = mean SE = standard error

SHALLOW 3-7m	MID INLET				OUTER INLET				COASTAL				ISLANDS	
	exposed		sheltered		exposed		sheltered		headlands		embayments			
	n=18	n=18	n=18	n=18	n=18	n=18	n=12	n=12 shallow	n=12	n=12 shallow	n=12	n=12 shallow	n=24	n=24
Species	X	SE	X	SE	X	SE	X	SE	X	SE	X	SE	X	SE
<i>P. colias</i>	8.2	1.1	6.4	1.6	2.3	0.6	8.0	1.5	3.0	1.4	1.1	0.6	0.8	0.5
<i>N. fucicola</i>	1.6	0.5	0.4	0.2	5.8	0.9	7.4	1.4	2.7	0.6	4.4	1.6	5.5	0.7
<i>N. celidotus</i>	27.9	3.8	30.3	3.8	11.9	1.7	16.9	2.1	12.3	2.0	9.1	3.0	0.2	0.1
<i>N. cinctus</i>	0.2	0.2	0.0		0.7	0.1	0.2	0.1	0.0		0.0		0.6	0.3
<i>P. miles</i>	0.6	0.2	0.3	0.1	0.1	0.1	0.7	0.3	0.0		0.2	0.2	0.0	
<i>O. pullus</i>	0.0		0.0		0.9	0.4	0.0		0.2	0.1	0.8	0.3	5.6	1.7
<i>P. scaber</i>	0.1	0.1	0.0		0.2	0.1	0.7	0.2	0.5	0.1	3.2	3.1	0.2	0.1
<i>L. ciliaris</i>	1.6	0.5	0.3	0.2	0.9	0.3	4.4	1.5	0.9	0.2	0.8	0.4	1.1	0.4
<i>L. lineata</i>	0.4	0.4	0.0		2.1	1.9	0.1	0.1	0.0		0.1	0.1	0.3	0.2
<i>N. macropterus</i>	0.0		0.1	0.1	1.4	1.3	0.1	0.1	0.1	0.1	1.2	1.2	0.0	
<i>C. lepidoptera</i>	0.1	0.1	0.0		0.0		0.0		0.0		0.0		0.0	
<i>C. leucopaecilus</i>	0.0		0.1	0.1	0.0		0.1	0.1	0.0		0.1	0.1	0.0	
<i>R. plebeia</i>	0.0		0.0		0.0		0.0		0.0		0.0		0.0	
Oblique triplefin	0.4	0.2	0.2	0.1	1.2	0.3	3.5	0.8	1.8	0.6	1.3	0.3	2.1	0.4
Notothenid	0.0		0.0		0.0		0.0		0.1	0.1	0.0		0.0	
<i>H. abdominalis</i>	0.0		0.0		0.0		0.0		0.0		0.0		0.0	
<i>H. papillosus</i>	0.0		0.0		0.0		0.0		0.0		0.0		0.0	
<i>C. isabellum</i>	0.1	0.1	0.0		0.0		0.0		0.0		0.0		0.0	
<i>M. lineatum</i>	0.0		2.8	2.8	0.0		0.0		0.0		0.0		0.0	
No of species	11		9		11		11		9		11		9	
DEEP 12-15m														
Species	X	SE	X	SE	X	SE	X	SE	X	SE	X	SE	X	SE
<i>P. colias</i>	3.1	0.9	3.8	2.2	11.4	1.9	12.9	3.2	3.3	1.4	6.5	3.0	2.2	0.5
<i>N. fucicola</i>	0.1	0.1	0.0		2.3	0.8	0.9	0.3	0.8	0.8	0.7	0.3	2.5	0.6
<i>N. celidotus</i>	16.8	3.2	4.2	1.1	7.5	2.4	10.7	2.8	2.9	2.5	10.8	7.9	0.4	0.1
<i>N. cinctus</i>	0.0		0.0		0.8	0.4	0.0		0.0		0.0		0.4	0.2
<i>P. miles</i>	0.0		0.1	0.1	2.4	0.8	2.2	0.7	0.6	0.6	0.8	0.3	0.5	0.2
<i>O. pullus</i>	0.0		0.0		0.0		0.0		0.0		0.0		0.7	0.4
<i>P. scaber</i>	0.1	0.1	0.1	0.1	0.5	0.2	0.2	0.1	0.2	0.2	0.8	0.5	0.2	0.1
<i>L. ciliaris</i>	0.0		0.0		1.4	0.4	0.7	0.3	0.6	0.4	0.0		1.8	0.5
<i>L. lineata</i>	0.0		0.0		0.1	0.1	0.4	0.2	0.0		0.0		0.0	0.0
<i>N. macropterus</i>	0.0		0.1	0.1	2.3	1.7	1.2	1.2	0.1	0.1	0.0		0.0	
<i>C. lepidoptera</i>	0.0		0.0		0.3	0.3	0.4	0.3	0.0		0.0		0.0	
<i>C. leucopaecilus</i>	0.1	0.1	0.0		0.1	0.1	0.2	0.1	0.6	0.2	0.0		0.0	
<i>R. plebeia</i>	0.0		0.0		0.1	0.1	0.0		0.0		0.0		0.0	
Oblique triplefin	0.0		0.0		0.8	0.3	0.5	0.3	0.3	0.3	0.2	0.2	3.4	0.5
Notothenid	0.0		0.0		0.0		0.0		0.0		0.0		3.1	3.1
<i>H. abdominalis</i>	0.0		0.0		0.0		0.4	0.2	0.0		0.0		0.0	
<i>H. papillosus</i>	0.0		0.0		0.1	0.1	0.0		0.0		0.0		0.0	
<i>C. isabellum</i>	0.0		0.0		0.0		0.0		0.0		0.0		0.0	
<i>M. lineatum</i>	0.0		0.0		0.0		0.0		0.0		0.0		0.0	
No of species	5		5		14		12		9		6		11	
Total species	12		10		15		13		11		11		11	

APPENDIX 3: THE MARINE ALGAE OF PATERSON INLET

A list of species compiled from "The Marine Algae of Stewart Island" Adams et al. 1974, from specimens collected by Stewart Island field centre staff, Department of Conservation and by Cameron Hay and from a database of species recorded during the 1989 DOC survey by Brian Coffey.

A few records refer to sightings only - common species that have never been collected.

KEY

- * :specimen collected by Southland Conservancy, DOC
- AKU :Botany Dept, Auckland University (contains Lindauer herbarium)
- BC :Specimen recorded in Brian Coffey's database
- CHR :Botany Division, DSIR, Lincoln
- Laing CANU :Laing herbarium, Dept of Botany, University of Otago
- Lyall Fl NZ : specimens referred to in JD Hookers *Flora Novaezealandiae* Vol II
- OTA :Botany Dept, University of Otago
- MNC :specimen identified by Margaret Clayton, Monash University
- MP :specimen identified by Murray Parsons, DSIR, Lincoln
- Stn :Station
- T :transect on DOC survey (Figure 5)
- WELT :National Museum of New Zealand
- WTU :University of Washington, Seattle, USA

	Location	Locality/specimen #	Date
CHLOROPHYCEAE			
ULOTRICHALES			
ULOTRICHACEAE			
<i>Ulothrix subflaccida</i>	Ringaringa	Stn 319 OTA & WELT	Nov-71
MONOSTROMACEAE			
<i>Monostroma antarcticum</i>	Paterson Inlet	WTU 244 239	Apr-45
ULVALES			
ULVELLACEAE			
<i>Ulveilla lens</i>	Ringaringa	WTU 1488	Nov-58
ULVACEAE			
<i>Ulva lactuca</i>	Deep Bay	Stn 2 OTA & WELT	
<i>Ulva latissima</i>	Ringaringa	* lower littoral	Aug-88
<i>Ulva angustata</i>	Ringaringa	* rock platform (MNC)	Jul-88
<i>Ulva rigida sensu Womersley</i>	Deep Bay	Stn 7 OTA & WELT	May-71
<i>Enteromorpha compressa</i>	Kaipipi	WELT A7420	Nov-60
<i>Enteromorpha intestinalis</i>	Thule	* upper littoral	Aug-88
	Ringaringa	* rock platform	Nov-88
<i>Enteromorpha ramulosa</i>	Deep Bay	Stn 6 OTA & WELT	May-71
<i>Enteromorpha sp</i>	Moses Nugget	WELT A8008	Jan-73
SIPHONOCLADALES			
CHLADOPHORACEAE			
<i>Cladophorella marina</i>	Ringaringa	Stn 150 OTA & WELT	Nov-71
<i>Cladophora crinalis</i>	Ringaringa	Stn 317 OTA & WELT	Nov-71
<i>Cladophora daviesii</i>	Moses Nugget	Stn 3 16 OTA & WELT	Nov-71
<i>Cladophora feredayi</i>	Native Island	Moore CHR 47949	Dec-44
	Ringaringa	Stn 143 OTA & WELT	Nov-71
	Ringaringa	* subtidal	Dec-88
	Ringaringa	* pool	Jul-88
<i>Cladophora gracilis</i>	Native Island	CHR 47958	Dec-44
	Deep Bay	WELT A7712 on <i>Zostera</i>	Aug-72
<i>Cladophora verticillata</i>	Moses Nugget	Stn 14 OTA & WELT	May-71
	Evening Cove	* upper littoral	Jan-89
	Paterson Inlet	* T27, T29 BC	Feb-88
	Deep Bay	* drift	Jun-88
<i>Cladophora (tight ball)</i>	Moses Nugget	Stn 12 OTA & WELT	May-71
<i>Cladophoropsis herpestica</i>	Ulva Island	* intertidal C Hay	Feb-88
<i>Wittrockiella lyallii</i>	Paterson Inlet	Lindauer 253	Feb-47
	Cow & Calf Point	* upper littoral	Jul-88
<i>Chaetomorpha aerea</i>	Moses Nugget	Stn 9 OTA & WELT	May-71
	Ringaringa	* tidal pools	Jun-88
<i>Chaetomorpha coliformis</i>	Moses Nugget	Stn 10 OTA & WELT	May-71
	Ringaringa	*	Nov-88
<i>Chaetomorpha melagonium var novae-zelandiae</i>	Evening Cove	WTU 244048	Nov-58
<i>Lola litorea</i>	Native Island	CHR 47948	Dec-44
<i>Rhizoclonium sp</i>	Ringaringa	Stn 149 OTA & WELT	Nov-71
CAULERPALES			
BRYOPSISIDACEAE			
<i>Bryopsis vestita</i>	Pipi Rocks	*	Jan-89
	Ringaringa	* tidal pool	Jul-88
	West Ulva	* T65	Feb-89
	Evening Cove	* pools	Jan-89
CAULERPACEAE			
<i>Caulerpa brownii var selaginoides</i>	Ringaringa reef	* not collected	/89

CODIACEAE			
<i>Codium convolutum</i>	Paterson Inlet - widespread	not collected	
<i>Codium dimorphum</i>	Moses Nugget	Stn 21 OTA & WELT	May-71
<i>Codium fragile ssp. novae-zelandiae</i>	Deep Bay	Stn 20 OTA & WELT	May-71
	Ringaringa Back Beach	*	Aug-89
	Little Glory Cove	Batham - not collected	/69
	Kidney Fern Arm	* mudflats	Nov-88
<i>Codium dichotomum</i>	Little Glory Bay	Batham- not collected	/69
	Kaipipi	* T32 littoral C Hay	Feb-88
PHAEOPHYCEAE			
ECTOCARPALES			
ECTOCARPACEAE			
<i>Pilayella littoralis</i>	Deep Bay	Stn 24 OTA & WELT	May-71
	Moses Nugget	Stn 23 OTA & WELT	May-71
	Vaila Voe	WELT A7426	Feb-60
	Big Glory Bay	* subtidal	Feb-89
<i>Pilayella sp.</i>	Ringaringa	Stn 327 OTA & WELT	Dec-71
<i>Ectocarpus brachiolus</i>	Moses Nugget	Stn 25 OTA & WELT	May-71
<i>Ectocarpus chapmanii</i>	Ringaringa	WTU 244649	Nov-59
<i>Ectocarpus confervoides = E siliculosus</i>	Ringaringa	Stn 155,156 OTA & WELT	Nov-71
	Ringaringa	WTU 244640	Mar-63
<i>Hinksia granulosa</i>	Hapatuna	* T64	Feb-89
MYRIONEMATACEAE			
<i>Myrionema strangulans</i>	Deep Bay	Stn 29 OTA & WELT	May-71
	Ringaringa	Stn 168 OTA & WELT	Nov-71
	Pipi Rocks	* on <i>Ulva sp.</i>	Jan-89
<i>Myrionema sp</i>	Moses Nugget	Stn 30 OTA & WELT	May-71
<i>Herponema maculaeforme</i>	Ringaringa	WTU 244760	Dec-62
RALFSIACEAE			
<i>Ralfsia verrucosa</i>	Paterson Inlet	* T29 T41 BC	Feb-88
<i>Hapalospongidion sp</i>	Paterson Inlet	sighted	
ELACHISTACEAE			
<i>Elachista australis</i>	Ringaringa	* epiphyte on <i>Xiphophora</i>	Nov-88
LEATHESIACEAE			
<i>Leathesia difformis</i>	Ringaringa	* lower littoral	Dec-89
<i>Corynophlaea cystophorae</i>	Ringaringa	WELT A7450	Nov-59
CHORDARIACEAE			
<i>Myriogloia intestinalis</i>	Moses Nugget	Stn 32 OTA & WELT	May-71
	Moses Nugget	Stn 177 OTA & WELT	Nov-71
	Ringaringa (north end)	* lower littoral	Oct-88
<i>Papenfussiella lutea</i>	Moses Nugget	Stn 33 OTA & WELT	May-71
	Moses Nugget	Stn 178,179,181 OTA & WELT	Nov-71
	Ringaringa	* tidal pool	Nov-88
	Ringaringa	Stn 180 OTA & WELT	Nov-81
	Ringaringa	WTU 245108	Dec-58
<i>Tinocladia novae-zelandiae</i>	Moses Nugget	Stn 183 OTA & WELT	Nov-71
	Ringaringa	* littoral rocks in sand	Dec-89
	Deep Bay	WTU 244445	Nov-58
	Paterson Inlet	* T37 BC	Feb-88
	Bullers Point	* subtidal reef	Jan-89
	Ringaringa	* pool	Nov-88
SPLACHNIDIACEAE			
<i>Splachnidium rugosum</i>	Ringaringa	* pool	Aug-88

SCYTOTHAMNACEAE			
<i>Scytothamnus australis</i>	Moses Nugget Ringaringa Sydney Cove, Ulva Island	Stn 39 OTA & WELT * pool * mid littoral	May-71 Oct-88 Aug-88
<i>Scytothamnus fasciculatus</i>	Moses Nugget Ringaringa	Stn 40 OTA & WELT * pools	May-71 Jun-88
DICTYOSIPHONALES			
STRIARIAACEAE			
<i>Striaria attenuata</i>	Ringaringa Passage Deep Bay	Lindauer 340 WELT A7710 (ELWS)	Jan-50 Jul-72
PUNCTARIAACEAE			
<i>Adenocystis utricularis</i>	Moses Nugget Ulva Ringaringa	Stn 36 OTA & WELT OTA 000224 * pools	May-71 Apr-50 Jun-88
<i>Asperococcus bullosus</i>	Ringaringa	WTU 244404	Nov-58
SCYTOSIPHONALES			
SCYTOSIPHONACEAE			
<i>Petalonia fasciata</i>	Ringaringa Deep Bay	WELT A7467 Stn 35 OTA & WELT	no date May-71
<i>Scytosiphon lomentaria</i>	Ringaringa Trumpeter Beach Ringaringa (north end)	WTU 245033 * upper littoral * upper littoral	Jan-63 Oct-88 Oct-88
<i>Colpomenia peregrina</i>	Paterson Inlet Moses Nugget	* T11 BC Stn 40 OTA & WELT	Feb-88 May-71
SPHACELARIALES			
SPHACELARIAACEAE			
<i>Sphacelaria implicata</i>	Paterson Inlet Kaipipi	* T25 BC WTU 245061	Feb-88 Nov-60
<i>Spacelaria limicola</i>	Kaipipi Kidney Fern	WELT A6602 WTU 245071	Nov-61 Nov-61
<i>Sphacelaria tribuloides</i>	Sailors Rest	Lindauer 335	Jul-45
<i>Sphacelaria sp?</i>	Ulva Island	* T66 subtidal on shell	Feb-89
STYPOCAULACEAE			
<i>Halopteris congesta</i>	Moses Nugget	Stn 159 OTA & WELT	Nov-71
<i>Halopteris funicularis</i>	Moses Nugget Paterson Inlet Ringaringa	* rock pool * T21 BC * pool	Oct-88 Feb-88 Oct-88
<i>Ptilopogon botryocladus</i>	Ringaringa	Lindauer 337	Feb-47
CLADOSTEPHACEAE			
<i>Cladostephus spongiosus</i>	Big Glory Bay Ringaringa	* on ropes at NZ Salmon * driftweed	Aug-88 Jun-88
DICTYOTALES			
DICTYOTACEAE			
<i>Glossophora kunthii</i>	Ringaringa Ringaringa (north end) Moses Nugget	WTU 244711 * pool * rock pool	Dec-62 Oct-88 Dec-89
<i>Spatoglossum chapmanii</i>	Ringaringa Ringaringa Bullers Point	Stn 167 OTA & WELT WTU 245054 * subtidal	Nov-71 Nov-58 Jan-88
<i>Dictyota ocellata</i>	Paterson Inlet	* T13 BC	Feb-88
<i>Zonaria turneriana</i>	Paterson Inlet	* T13 BC	Feb-88

CUTLERIALES**CUTLERIACEAE**

<i>Cutleria multifida</i> var <i>pacifica</i>	Ringaringa	Lindauer 338	Jan-50
<i>Microzonia velutina</i>	Evening Cove Ringaringa Manawahehi Nugget Ulva	WELT A7440 WTU 244931 *	Dec-60 Nov-38 Dec-88

DESMARESTIALES**DESMARESTIACEAE**

<i>Desmarestia firma</i>	Ringaringa Ringaringa	WELT A7464 WTU 244554	Nov-60 Dec-62
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SPOROCHNACEAE

<i>Carpomitra costata</i>	Ringaringa Ringaringa Manawahehi Nugget Ulva	WTU 244413 WELT A7462 * subtidal	Dec-62 Oct-59 Dec-88
<i>Sporochnus elisiae</i>	Ulva Island	* T14 C Hay	Feb-88
<i>Sporochnus stylosus</i>	Moses Nugget Ringaringa Ringaringa Manawahehi Nugget Ulva	WELT A6928 WTU 245090 WTU 245088 * subtidal	Dec-71 Nov-59 Nov-60 /88

LAMINARIALES**LESSONIAACEAE**

<i>Lessonia variegata</i>	Bullers Point	* not collected	
<i>Macrocystis pyrifera</i>	Ringaringa Paterson Inlet Paterson Inlet Native Island	WTU 244840 Stn 190 OTA & WELT * not collected * subtidal C Hay	Dec-62 Dec-71 Feb-88
<i>Ecklonia radiata</i>			

FUCALES**FUCACEAE**

<i>Xiphophora gladiata</i>	Ringaringa rocks Moses Nugget Ringaringa Ringaringa Native Island	WTU 245123 Stn 44 OTA & WELT * WTU 244847 * sublittoral C Hay	Jan-63 May-71 Aug-88 Dec-62 Feb-88
<i>Marginariella boryana</i>			
<i>Marginariella urvilliana</i>			

CYTOSEIRACEAE

<i>Cystophora congesta</i>	Ringaringa Back Beach	WTU 244503 drift	Jan-46
<i>Cystophora distenta</i>	Prices Whaling Base	WTU 244505	Oct-46
<i>Cystophora platylobium</i>	Native Island Ringaringa Kidney Fern Arm	* sublittoral C Hay WELT A7494 drift WTU 244501	Feb-88 Mar-60 Jan-56
<i>Cystophora retroflexa</i>	Thule	WTU 244500	Feb-60
<i>Cystophora scalaris</i>	Ringaringa	* not collected	
<i>Cystophora torulosa</i>	Ringaringa	WTU 244509	Mar-63

SARGASSACEAE

<i>Carpophyllum flexuosum</i>	Ulva Island	OTA 000300	Apr-50
<i>Sargassum sinclairii</i>	Ulva Island Moses Nugget	OTA 001628 Stn 205 OTA & WELT	Feb-54 Nov-71
<i>Sargassum verruculosum</i>	Cow and Calf Point Native Island Ringaringa Back Beach	* sublittoral C Hay * sublittoral C Hay * drift	Feb-88 Feb-88 Jul-88
<i>Sargassum sp.</i>	Deep Bay	* drift	Jun-88

HORMOSIRACEAE

<i>Hormosira banksii</i>	Golden Bay Ryans Creek	WELT A3906 Stn 206 OTA & WELT freelying on <i>Zostera</i> flats	Dec-10 Dec-71
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DURVILLAEALES**DURVILLAEACEAE**

Durvillaea antarctica

Durvillaea willana

Moses Nugget	Stn 43 OTA & WELT	May-71
Bullers Point, Neck	WTU 244607	Jan-46
Ringaringa	Lindauer 6700 type	Oct-45
Ringaringa	WTU 244612	Jan-63
Moses Nugget	Stn 192 OTA & WELT	Nov-71
Ringaringa	* pool	Oct-88
Sydney Cove, Ulva Is.	* mid littoral	Aug-88

RHODOPHYCEAE**ERYTHROPELTIDALES****ERYTHROPELTIDACEAE**

Erythrotrichia carnea

Deep Bay Stn 7 OTA & WELT

BANGIALES**BANGIACEAE**

Bangia fuscopurpurea

Porphyra columbina

Paterson Inlet	* T31 BC	Feb-88
Ringaringa	WTU 255411	Nov-58
Moses Nugget	Stn 208 OTA & WELT	Nov-71
Ringaringa	* pools	Jun-88
Vaila Voe	* lower littoral	Jul-88
Ringaringa	Stn 211 OTA & WELT	May-71

Porphyra sp.

Porphyra subtumens

NEMALIALES**ARCHOCHAETIACEAE**

Acrochaetium densum

Acrochaetium porphyrae

Ringaringa	Norris No 6838 WTU	Jun-60
Moses Nugget	Stn 208 OTA & WELT on	Nov-71
	Diplocladia patersonis	
The Neck	WTU 245130 on Zostera	Mar-59

GALAXAURACEAE

Nothogenia fastigiata

Nothogenia pseudosaccata

Tommy Island	Lindauer 6000	Apr-45
The Neck	Lindauer 6988	Jan-46
Bullers Point	* upper littoral	Jan-89
Ringaringa	WELT A6610	Mar-63
Ulva Island	* subtidal on sand	Mar-89

HELMINTHOCLADIACEAE

Helminthocladia australis

Helminthocladia densa

Ringaringa	WTU 246886	Jan-60
Ringaringa	Stn 212 OTA & WELT	Nov-71
Ringaringa	WELT A7507 & WTU sn	Mar-63

BONNEMAISONIALES**BONNEMAISONIACEAE**

Asparagopsis armata

Tommy Island	OTA 000348	Apr-50
Ringaringa	Stn 214 OTA & WELT	Nov-71
Bullers Point	* subtidal	Jan-89
West Ulva	* T66 & * C4 dredge	Feb-89
Bullers Point reef	* subtidal	Jan-89
Ringaringa	WELT A7510	Jan-63
West Ulva Island	* T65	Feb-89
Iona Island	* T60	Dec-88

Falkenbergia rufolanosa

Delisea elegans

Ulva Nugget	* subtidal	
Ringaringa	OTA 000344	Apr-50
Paterson Inlet	* T25, T27, T37 BC	Feb-88
Moses Nugget	WELT A6922	Dec-71

Delisea plumosa

Ptilonia willana

GELIDIALES**GELIDIACEAE**

Gelidium pseudointricatum

Gelidium pusillum

Tommy Island	Lindauer 6001	Apr-45
Ringaringa Point	* mid littoral	Aug-88
Deep Bay	Stn 53 OTA & WELT	May-71

HILDENBRANDIALES**HILDENBRANDIACEAE**

Hildenbrandia lecanellieri

Apophlaea lyallii

Ringaringa	WELT A7520	Mar-63
Ringaringa	Stn 224 OTA & WELT	Nov-71
Cow and Calf Point	*	Jul-88

CORALLINALES**CORALLINACEAE**

Melobesia and other encrusting coralline spp

Lithophyllum sp

Haliptilon roseum

Corallina officinalis

Ringaringa	Norris 1958 WTU 254269	
Moses Nugget	Stn 73 OTA & WELT	May-71
Ringaringa	WELT A6605	Jun-60
Moses Nugget	Stn 61 OTA & WELT	May-71
Cow and Calf Point	* littoral	Jul-88
Ringaringa	* on Macrocystis drift	Jul-88
Ringaringa	* pool	Jul-88

GIGARTINALES**GIGARTINACEAE**

Gigartina cf. G. ancistroclada

= G. muelleriana?

Gigartina clavifera

Moses Nugget	Stn 74 OTA & WELT	May-71
Ringaringa	* lower littoral	Aug-88
Ringaringa	* rock pool	Aug-88
Thule Back Beach	* lower littoral	Jul-88
Watercress	* lower littoral	Jul-88
Ringaringa Point	* mid littoral	Aug-88
Ringaringa	Laing CANU	Jan-36
Moses Nugget	Stn 73	May-71
Ringaringa	WTU 246575	Jun-60
Thule	* lower littoral	Aug-88
Ringaringa	* rock pool	Jul-88
Kidney Fern	mid littoral	Nov-88
Thule Back Beach	lower littoral	Jul-88
The Neck	Stn 326 OTA & WELT	Dec-71
Ringaringa	Stn 247 OTA & WELT	Nov-71
Ringaringa	WTU 246651	Nov-58
Ringaringa	* lower littoral	Jun-88

Gigartina livida

Gigartina pachymeniodes

Gigartina tuberculosa

Ringaringa	WELT A 7546	Oct-59
Groper Island	* sublittoral drift	Feb-91
Paterson Inlet	* T15 BC	Feb-88
Ringaringa	WELT 7547	Jun-60
Ringaringa	*	Jul-88
Paterson Inlet	* T53 BC	Feb-88
Ringaringa	WELT A 7552 & A7548	Jun-60
Deep Bay	WELT A 6868	Jul-60
Bravo Island	* subtidal T52 C Hay	Feb-88
Ringaringa Cove	WTU 248173	Mar-47
Ringaringa	Norris 6971 WTU	Jan-63

Gigartina tuberculosa sensu Lindauer

Gigartina sp. = G. dilatata

Ringaringa	WELT A 7546	Oct-59
Groper Island	* sublittoral drift	Feb-91
Paterson Inlet	* T15 BC	Feb-88
Ringaringa	WELT 7547	Jun-60
Ringaringa	*	Jul-88
Paterson Inlet	* T53 BC	Feb-88
Ringaringa	WELT A 7552 & A7548	Jun-60
Deep Bay	WELT A 6868	Jul-60
Bravo Island	* subtidal T52 C Hay	Feb-88
Ringaringa Cove	WTU 248173	Mar-47
Ringaringa	Norris 6971 WTU	Jan-63

Gigartina lanceata

Iridea latissimum

Iridea undulosa

GRACILARIACEAE

Gracilaria chilensis

Curdiea flabellata

Gracilaria secundata

Gracilaria truncata

Kidney Fern	* mudflat	Nov-88
Kaipipi	WELT A7539	Nov-60
Moses Nugget	Stn 82 OTA & WELT	May-71
Paterson Inlet	* T41 BC	Feb-88
Ringaringa	* pools	Aug-88
Evening Cove	* in sand	Jan-89
Evening Cove	Norris No 1510 WTU	Nov-58
Big Glory Bay	* dredge N1	Feb-89

RHODOPHYLLIDACEAE

Rhodophyllis acanthocarpa

Ringaringa	WTU 248223	Nov-58
Paterson Inlet	* T63 on Lenormandia	Feb-89

Rhodophyllis lacerata	Ringaringa West Ulva Ringaringa	WTU 248237 T66 Norris sn	Nov-58 Feb-89 Dec-60
Rhodophyllis gunnii	Ringaringa Paterson Inlet Bullers Point reef Bullers Point reef Paterson Inlet Paterson Inlet	WTU 254 314 WELT A2980 * subtidal * subtidal * dredge Z2 * dredge P4, C4	Mar-45 Jan-70 Jan-89 Jan-89 Mar-00 /89
Craspedocarpus erosus			
PHYLLOPHORACEAE			
Gymnogrongus furcatus	Paterson Inlet	* T39 BC	Feb-88
Gymnogrongus humilis	Ringaringa Ringaringa	WELT A7555 WTU 246825	Jul-60 Nov-59
Gymnogrongus torulosus	Ringaringa Ringaringa	Norris sn WTU Walt A8193	Jul-60 Mar-63
Stenogramme interrupta	Paterson Inlet Big Glory Bay	* NI dredge sample * subtidal on mud	Feb-89 Feb-89
NEMASTOMACEAE			
Nemastoma laciniata	Ringaringa Ringaringa	WELT A6615 WTU 247541	Feb-48 Jan-60
Schizymenia novae-zelandiae	Ringaringa Nugget Paterson Inlet	Norris 6992 WTU * on mud at 70 ft	Dec-62 Apr-89
Platoma sp.	Ringaringa Ringaringa	WELT A7393 WTU 247524	Jan-72 Mar-47
PLOCAMIACEAE			
Plocamium angustum	Ringaringa Bullers Point reef Ringaringa	* drift * subtidal * intertidal pools	Jun-88 Jan-89 Apr-90
Plocamium cartilagineum	Paterson Inlet Dynamite Point	WELT A2966 * subtidal	Jan-70 Aug-88
Plocamium costatum	Ringaringa Ringaringa	WTU Norris sn WELT A6876	Mar-61 Mar-63
SARCODIACEAE			
Trematocarpus acicularis	Ringaringa	WELT A7558	Jul-60
Sarcodia flabellata	Ringaringa	WTU 248352	Nov-58
Sarcodia grandifolia	Ringaringa	Lindauer 5896	Mar-45
HALYMENIACEAE			
Grateloupia intestinalis	Moses Nugget Ringaringa Ringaringa Back Beach Ringaringa Ringaringa	Stn 58 OTA & WELT Norris sn * pool * * pool	May-71 Dec-63 Jul-90 Dec-89 Nov-88
Grateloupia stipitata	Ringaringa Ringaringa Ringaringa	WTU 246768 * pools * rocks in sand	Nov-58 Oct-88 Dec-89
Pachymenia lusoria	Ringaringa Moses Nugget Ringaringa Point	WTU 247640 Stn 60 Conway & Adams * mid littoral	Nov-58 May-71 Jul-88
Aeodes nitidissima	Ringaringa Ringaringa Thule Back Beach	WTU 245259 WTU sn Norris * intertidal	Dec-58 Dec-62 Jul-88
KALLYMENIACEAE			
Callophyllis hombroniana	Ringaringa Ringaringa Ringaringa Ringaringa	Stn 64, Stn 222 OTA & WELT Norris sn WTU * subtidal Norris sn WTU	May-71 Nov-71 Jul-88 Dec-62

Callophyllis calliblepharoides	Ringaringa	* intertidal pools	Apr-90
Callophyllis ornata	Ringaringa The Neck The Neck	WELT A7529 Lindauer 343 WELT A7531	Feb-60 Dec-48 Mar-59
Callophyllis stewartensis	Ringaringa	WTU 249024	Nov-58
Calloclax sp.	Ringaringa	Norris sn WTU	Jan-63
Thamnophyllis sp.	Evening Cove Ringaringa Ringaringa	WELT A7566 WTU 254 278 WELT A7380	Nov-60 Nov-58 Nov-71
Callophyllis depressa	Evening Cove	WTU 254286	Nov-58
Kallymenia sp	Evening Cove	WTU 254282	Nov-58
Pugetia delicatissima	Ringaringa Native Island	Norris 1411 WTU CHR 47997	Nov-58 Dec-44
RHODOMENIALES			
RHODYMENIACEAE			
Gloioderma saccatum	Ringaringa Ringaringa Ringaringa	WTU 246683 WELT A 6599 WELT A 6599	Jan-60 Apr-63 Apr-63
Gloiocolax novae-zelandiae	Ringaringa Ringaringa Ringaringa	WTU 246667 WTU 245323 WTU No 6857 Norris	Nov-58 Oct-59 Mar-63
Chrysymenia ornata	Ringaringa Ringaringa	Stn 253 OTA & WELT Norris sn WTU	Nov-71 Jan-63
Chrysymenia polydactyla	Ringaringa Ringaringa	* 14 R2 N2 Z3 Z1 I4 A5 WELT A 7568	/89 Feb-60
Rhodymenia epimenioides	Paterson Inlet Golden Bay	WELT A6596 & WTU sn * T60	Mar-63 Feb-89
Rhodymenia linearis	Ringaringa Iona Paterson Inlet Deep Bay	* A6 Z3 R1 R2 A5 dredge WELT 7571	Jul-60 Jul-60
Epymenia wilsonis	Bullers Point Ulva Island	Stn 248 OTA & WELT * subtidal C Hay	Nov-71 Feb-88
Hymenocladia sanguinea	Ringaringa Ringaringa Ringaringa	WTU 247047 Stn 248 OTA & WELT * intertidal pools	Nov-58 Nov-71 Apr-90
CHAMPIACEAE			
Champia affinis	Native Island Ringaringa Thule Cow and Calf Point	CHR 47924 Norris sn WTU * subtidal on Lenormandia lower littoral	Dec-44 Mar-63 Jul-88 Jul-88
Champia chathamensis	Bullers Point Reef	* subtidal	Jan-89
Champia novae-zelandiae	Ringaringa Ringaringa	Stn 308 WELT WELT A7572	Nov-71 Nov-59
CERAMIALES			
CERAMIACEAE			
Medeiothamnion lyallii	Ringaringa Hapatuna Paterson Inlet	WTU 248460 WELT A6875 WELT A2963	Nov-58 Oct ___ Jan-70
Aglaothamnion sp	Ringaringa Deep Bay Ringaringa	Norris No 1544 WTU WELT A7707 Norris sn WTU	Nov-58 Aug-72 Jan-60
Antithamnion ternifolium	Ringaringa	WTU 245292	Jun-60
Ballia callitricha	Ringaringa	Stn 100 OTA & WELT	May-71
Ballia hirsuta	Ringaringa	Norris sn WTU	Jan-60
Crouania mucosa	Ringaringa Ringaringa	WELT A7596 Stn 320 OTA & WELT	Apr-60 Nov-71
Platythamnion sp. = Wrangelia squarrolosa	Ringaringa Ringaringa Ringaringa Ringaringa Ringaringa	Norris sn WTU WELT A7716 WELT A8183 Norris No 1435 WTU	Jan-60 Dec-72 Jan-73 Nov-58

<i>Pleonosporium hirtum</i>	Ringaringa	WELT A6607	Nov-60
<i>Spongoclonium pastorale</i>	Ringaringa	Stn 307 OTA & WELT	Nov-71
	Ringaringa	* pools	Jun-88
<i>Anotrichium crinitum</i>	Ringaringa	WELT A7576	Mar-63
	Ringaringa	WTU 245987	Jan-60
<i>Griffithsia antarctica</i>	Ringaringa	Norris sn WTU	Dec-59
<i>Griffithsia traversii</i>	Ringaringa	Stn 102 OTA & WELT	May-71
<i>Griffithsia crassiuscula</i>	Ulva Island	* T66	Feb-89
	Ringaringa	WELT A6869	Dec-60
	Cow and Calf Point	* T30 C Hay	Feb-88
	Iona Island	* T16 C Hay	Feb-88
<i>Gymnothamnion elegans</i>	Ringaringa	Stn 259 & 301 OTA & WELT	Nov-71
<i>Euptilota formosissima</i>	Moses Nugget	Stn 264 OTA & WELT	Nov-71
	Ringaringa Back Beach	* drift	Jul-88
<i>Dasyptilon pellucidum</i>	Ringaringa	Stn 104 OTA & WELT	May-71
	Ringaringa	WELT A7593	Oct-59
	Ringaringa	WTU 246101	Nov-58
	Crayfish Island	*	Jan-89
<i>Ceramium</i> sp.	Bullers Point Reef	* subtidal	Jan-89
<i>Ceramium</i> sp.	Big Glory Bay	* NZ Salmon subtidal	Aug-88
<i>Ceramium</i> sp.	Ringaringa	* intertidal	/89
<i>Ceramium</i> sp.	Paterson Inlet	* T63	Feb-89
<i>Ceramium</i> sp.	Ringaringa	* on Lenormandia in pool	Dec-89
<i>Ceramium</i> sp.	Ringaringa	* lower littoral	Dec-89
<i>Ceramium</i> sp.	Big Glory Bay	* subtidal on mud	Dec-89
<i>Ceramium</i> sp.	Paterson Inlet	* P4 dredge	Feb-89
<i>Ceramium apiculatum</i>	Ringaringa	WELT A8004	Nov-71
	Ringaringa	Stn 266 OTA & WELT	Nov-71
<i>Ceramium</i> sp. cf. <i>C. fastigiatum</i>	Deep Bay	Stn 106 OTA & WELT	May-71
<i>Ceramium stichidiosum</i>	Ringaringa	Stn 267 OTA & WELT	Nov-71
<i>Ceramium vestitum</i>	Ringaringa	WELT A7579	Dec-60
<i>Ceramium</i> sp.	Moses Nugget	Stn 270 OTA & WELT	Nov-71
<i>Ceramium strictum</i>	Deep Bay	* drift	Jun-88
<i>Ceramium tasmanicum</i>	Deep Bay	* drift	Jun-88
<i>Microcladia novae-zelandiae</i>	Ringaringa	Stn 269 OTA & WELT	
<i>Microcladia pinnata</i>	Ringaringa	WTU 247382	Nov-58
DELESSERIAACEAE			
<i>Phitymophora linearis</i>	Ringaringa	WELT A6606	Mar-49
	The Neck	WTU 247675	Jan-48
	Evening Cove	Norris sn WTU	Nov-63
<i>Apoglossum oppositifolium</i>	Paterson Inlet	WELT A2983	Jan-70
<i>Delesseria crassinervia</i>	Ringaringa	WTU 246137	Nov-58
	Ringaringa	WELT A4395	Oct-65
	Moses Nugget	Stn 273 OTA & WELT	Nov-71
	Paterson Inlet	Lyll FI N2 p239	
<i>Delesseria laurifolia</i>	Ringaringa	WTU 246139	Jan-60
	Ringaringa	Stn 319	Nov-71
<i>Laingia hookeri</i>	Ringaringa	WTU 247188	Nov-58
<i>Marionella prolifera</i>	Evening Cove	WTU 247318	Dec-59
<i>Phycodrys quercifolia</i>	Deep Bay	WELT A7701	Aug-72
	Paterson Inlet	dredged WELT A2979	Jan-70
<i>Polycoryne</i> sp.	Paterson Inlet	WELT A2979	Jan-70
<i>Erythrogloussum laingii</i>	Deep Bay	WELT 7606	Jul-60
	Deep Bay	Norris sn WTU	Jul-60
	Paterson Inlet	WTU 246206	Aug-49
<i>Erythrogloussum undulatissimum</i>	Moses Nugget	WELT A6921	Dec-71
	Ringaringa	WELT A7705	Aug-72
<i>Myriogramme denticulata</i>	Ringaringa	WTU 247453	Nov-58

<i>Schizoseris davisii</i>	Ringaringa	WELT A7963	Jan-73
	Ringaringa	WTU 248 386	Oct-59
	Ringaringa	Norris sn WTU	Dec-62
	Moses Nugget	Stn 90, 91	May-71
	Ringaringa	* subtidal	Dec-88
<i>Schizoseris dichotoma</i>	Moses Nugget	Stn 92 OTA & WELT	May-71
	Ringaringa	WELT A7607	Nov-60
	Bullers Point	* reef subtidal	Jan-89
	Ringaringa	Stn 275 276 OTA & WELT	Nov-71
	Ringaringa	WTU 247456	Nov-58
<i>Acrosorium decumbens</i>	Moses Nugget	Stn 87 OTA & WELT	May-71
<i>Acrosorium uncinatum</i>	Paterson Inlet	WELT A2973 dredged	Jan-70
<i>Hymenena dilabida</i>	Ringaringa	Norris sn. WTU	Dec-63
	Bullers Point	* subtidal	Jan-89
	Dynamite Point	* subtidal	Aug-88
<i>Hymenena multipartita</i>	Ringaringa	WTU 247010	Nov-58
	Paterson Inlet	WELT A2975	Jan-70
<i>Hymenena palmata</i>	Ringaringa	WELT A7616	Feb-60
	Buller Point	* subtidal	Jan-89
<i>Hymenena durvillei</i>	Ringaringa	Stn 279 289 OTA & WELT	Nov-71
	Ringaringa	WTU 254 317	Nov-85
	Ringaringa	* pool	Feb-89
	West Ulva	* T66 T65	Feb-89
	Ringaringa	* pool	Oct-88
DASYACEAE			
<i>Dasya collabens</i>	Ringaringa	Norris sn WTU	May-60
	West Ulva	* T66	Feb-89
	Bullers Point	* subtidal	Jan-89
<i>Heterosiphonia concinna</i>	Ringaringa	Stn 283 OTA & WELT	Nov-71
	Ringaringa	* rock platform pools	Aug-88
	Bullers Point	* reef	Jan-89
	Ringaringa	* subtidal	Dec-88
	Ringaringa	* lower littoral	Dec-89
RHODOMELACEAE			
<i>Polysiphonia abscissoides</i>	Ringaringa	WELT A8568	Oct-71
	Ringaringa	OTA Stn 120, WELT A6805	Nov-71
	Paterson Harbour	Lyll FI NZ P227	ay 1850
	Ringaringa	Stn 294 OTA ,WELT A6794	Jan-60
<i>Polysiphonia adamsiae</i>	Ringaringa	WELT A11466	Jan-73
<i>Polysiphonia aterrima</i>	Watercress	* lower littoral	Jul-88
<i>Polysiphonia brodiaei</i>	Ringaringa	* drift	Jun-88
	Bullers Point	* lower littoral	Dec-89
<i>Polysiphonia decipiens</i>	Ringaringa	WELT A7625	Jun-60
	Kidney Fern Arm	WELT A16980	Dec-71
<i>Polysiphonia isogona</i>	Ringaringa	WELT A8218	Jun-60
<i>Polysiphonia muelleriana</i>	Ringaringa	* tidal pools	Jun-88
	Ringaringa	* lower littoral	Dec-89
	Ringaringa	WTU 248495	Nov-58
	Ringaringa	Stn 290 OTA , WELT A6790	Nov-71
	Ringaringa	* tidal pools	Aug-88
<i>Polysiphonia rhododactyla</i>	Ringaringa	WELT A6427, Stn 127	May-71
	West Ulva	* T66	Feb-89
	Ringaringa	WELT A6427, Stn 127	May-71
	Ringaringa	Stn 290 OTA, WELT A6790	Dec-74
	Deep Bay	WELT A7639	Jul-60
	Deep Bay	WELT A7708	Aug-72
	Ringaringa	WELT A7634	Nov-89
	Ringaringa	WELT A13570	Jan-83
	Deep Bay	Stn 124 OTA , WELT A6424	May-71
<i>Polysiphonia strictissima</i>	Kaipipi	WELT A7640	Nov-60

Lophosiphonia sp	Ringaringa	WELT A8221	Jan-73
Lophurella hookeriana	Ringaringa	WELT A7697	Nov-59
	Ringaringa	Norris sn WTU	Jan-60
Lophurella sp aff. L. pericladus	The Neck	WELT A7621 at 20 fathoms	Jan-45
	Ringaringa	WELT A7633	Dec-59
	Ringaringa	Norris sn WTU	
Lophurella pericladus	Ringaringa	* pools	Jun-88
Echinothamnion hystrix	Bullers Point	* reef	Jan-89
Echinothamnion lyallii	Ringaringa	WELT A7632	Oct-50
	Bullers Point	* reef	Jan-89
Diplocladia patersonis	Ringaringa	6838 WTU	Jun-60
Bryocladia ericoides	Ringaringa	WELT A7499	Dec-59
Bryocladia sp.	Moses Nugget	Stn 115 OTA & WELT	May-71
Bryocladia ericoides	Ringaringa	* pools	Jun-88
Brongniartella australis	Ringaringa	WTU 245497	Nov-58
	Deep Bay	Stn 117 OTA & WELT	May-71
	Iona Island	* T60 on sand/mud	Feb-89
	Hapatuna	* T64	Feb-89
	Deep Bay	*	Oct-89
	Watercress	lower littoral	Jul-89
Aphanocladia delicatula	Moses Nugget	Stn 114 OTA & WELT	May-71
	Ringaringa	* pool	Aug-88
Pterosiphonia pennata	Ringaringa	Lindæur 4478	Jul-44
Stictosiphonia arbuscula	Ringaringa	WELT A7618	Oct-59
	Deep Bay	Stn 119 OTA & WELT	May-71
	Cow and Calf Point	* littoral	Jul-89
Stictosiphonia scorpioides	Kaipipi	WELT A7620	Nov-60
	Paterson Harbour	Lyall FI N2 P226	
	Deep Bay	WTU 245440	Nov-58
	Paterson Inlet	* T25 BC	Feb-88
Stictosiphonia mixta	Ringaringa Nugget	Lindæur 349	Feb-47
Stictosiphonia vaga	Ringaringa	WELT A7619	Nov-59
	Moses Nugget	Stn 130 OTA & WELT	May-71
Strebloladia glomerulata	Ringaringa	WELT A7622	Nov-60
	Bullers Point	* reef	Jan-89
	Ringaringa Back Beach	* pool	Jul-89
	Bullers Point reef	* subtidal	Jan-89
Metamorphe colensoi	Ringaringa	Norris snWTU on C platylobium	Sep-63
	Evening Cove	WELT A7626	Dec-59
Dipterosiphonia heteroclada	Ringaringa	Stn 310 OTA & WELT	Nov-71
Herposiphonia heteroclada	Sydney Cove Ulva ls	* sublittoral fringe	Aug-88
Dasyclonium bipartitum	Evening Cove	WELT A7629	Dec-59
	Evening Cove	WTU 246085	
Dasyclonium cuneifolium	Ringaringa	Papenfuss	Mar-59
Dasyclonium incisum	Ringaringa	WTU 246090	Nov-56
	Ringaringa	WELT A7628	Nov-59
Chondria flagellaris	Paterson Harbour	Lyall FI NZ p224	
Chondria macrocarpa	Ringaringa	WTU 254307	Nov-58
Cladhymenia oblongifolia	Moses Nugget	Stn 134	May-71
	Ringaringa	Norris sn WTU	Dec-62
	Ringaringa	* mid littoral	Jul-88
	Ringaringa	* pool	Oct-88
Laurencia thyrsoifera	Ringaringa	Norris sn WTU	Jun-60
	Ringaringa Back Beach	* pool	Jul-88
	Ringaringa	* pool	Jul-88
Lenormandia angustifolia	Moses Nugget	Stn 131 OTA & WELT	May-71
	Ringaringa	* rocks in sand littoral	Dec-89
Lenormandia chauvinii	Paterson Inlet	WELT A2971 dredged	Jan-70

APPENDIX 4 ROCKY SHORE COMMUNITIES PATERSON INLET

LOCATION	#	TYPE	ASPECT	OPEN SEA ANGLE	MAX FETCH (KM)	OVERALL SLOPE	ROCK HARDNESS	STRUCTURE	LOOSE ROCKS	RUBBISH	SILT	EXPOSURE RANKING
BULLERS POINT	1	Reef	N	120	60	Low	Hard	Platform/pools	Mixed	Low	x	4
PIPI ROCKS	2	Reef	N	19	63	Low	Hard	Platform/pools	Few	x	x	3
NATIVE ISLAND	3	Headland	SE	60	1000	Med	Hard	Platform/fractured	x	x	x	4
CRAYFISH ISLAND	4	Headland	N	0	13	Med	Med - schist	Platform	Few	x	x	3
EVENING COVE	5	Indented coast	E	45	1000	High	Hard	Platform	x	x	Yes	4
RINGARINGA NORTH	6	Indented coast	SE	15	1000	High	Hard	Blocks	Large	Yes	Yes	4
DEEP BAY	7	Enclosed	SE	0	2.5	Low	Hard	Broken	Small	x	Yes	2
SYDNEY COVE	8	Semi-sheltered	N - NE	0	32	Med	Hard	Broken	Mixed	x	x	3
SW ULVA ISLAND	9	Guts present	S - SW	0	11	Med	Hard	Platform	x	x	Yes	3
BURNT POINT	10	Headland	NW	0	11	High	Hard	Platform/fiaky	Few	x	x	3
BULL POINT	11	Headland	N - NE	0	9	High	Hard	Platform	Few	Yes	x	3
THULE BACK BEACH	12	Semi-enclosed	W	0	6	High	Hard	Platform	Mixed	x	Yes	2 - 3
COW & CALF POINT	13	Headland	SE	0	6	Low	Hard & soft	Broken	Mixed	Yes	Yes	2 - 3
KAIPIPI	14	Enclosed	NW	0	0	Low-med	Hard	Platform	Small	Low	x	1
RINGARINGA POINT	15	Headland	S	0	9	Med	Hard	Platform	Mixed	Yes	x	7
TRUMPETER POINT	16	Indented coast	NE	0	7	Med	Med - schist	Fractured	Rare	x	x	3

KEY:
Slope (degrees)
Low 15
Med 15-25
High 26

Exposure
1 very sheltered
2 sheltered
3 mainly sheltered
4 semi-exposed
5 exposed

Med = medium
X = absent

INDICATOR SPECIES

LOCATION	#	# OF SPECIES	DURVILLAEA ANTARCTICA	PACHYMENIA LUSORIA	HORMOSIRA BANKSII	XIPHOPHORA GLADIATA	CYSTOPHORA TORULOSA	CARPOPHYLLUM FLEXUOSUM	CHAEMOSIPHO COLUMNNA	CELLANA ORNATA	OSTREA sp.
BULLERS POINT	1	34+	O-F	C	O-L	A	O-L	X	A	A	O
PIPI ROCKS	2	39	R	O	X	A	X	X	C-A	A	C7
NATIVE ISLAND	3	24	C	O	X	A	X	O	A	F	X
CRAYFISH ISLAND	4	34	X	R	O	F	F	F	A	O	F
EVENING COVE	5	24	A	X	X	A	X	X	A	A	X
RINGARINGA NORTH	6	NC	X	C-F	X	X	X	X	F	R	X
DEEP BAY	7	29	X	X	F	X	C	X	F	F	F
SYDNEY COVE	8	22	C	X	X	A	X	X	A	O7	R
SW ULVA ISLAND	9	30	X	O	C	C	C	A	A	C	O
BURNT POINT	10	27	X	X	R	C	C	R	A	C	O-F
BULL POINT	11	22	X	X	X	C-F	X	O	A	F	O
THULE BACK BEACH	12	41	X	X	O	F	O	A	O	O	F
COW & CALF POINT	13	37	X	O	F	A	F	X	F	C	X
KAIPIPI	14		X	X	O	X	X	X	X	O	F
RINGARINGA POINT	15	22	X-L	C-F	X	X	X	X	X	R	X
TRUMPETER POINT	16	20	X	X	O-F	F	F	X	A	F	O

Abundance

A abundant
C common
F frequent
O occasional
L local only
X absent

of species = # of species counted of the following

Barnacles
Molluscs
Crustacea
Echinoderms

NC not counted

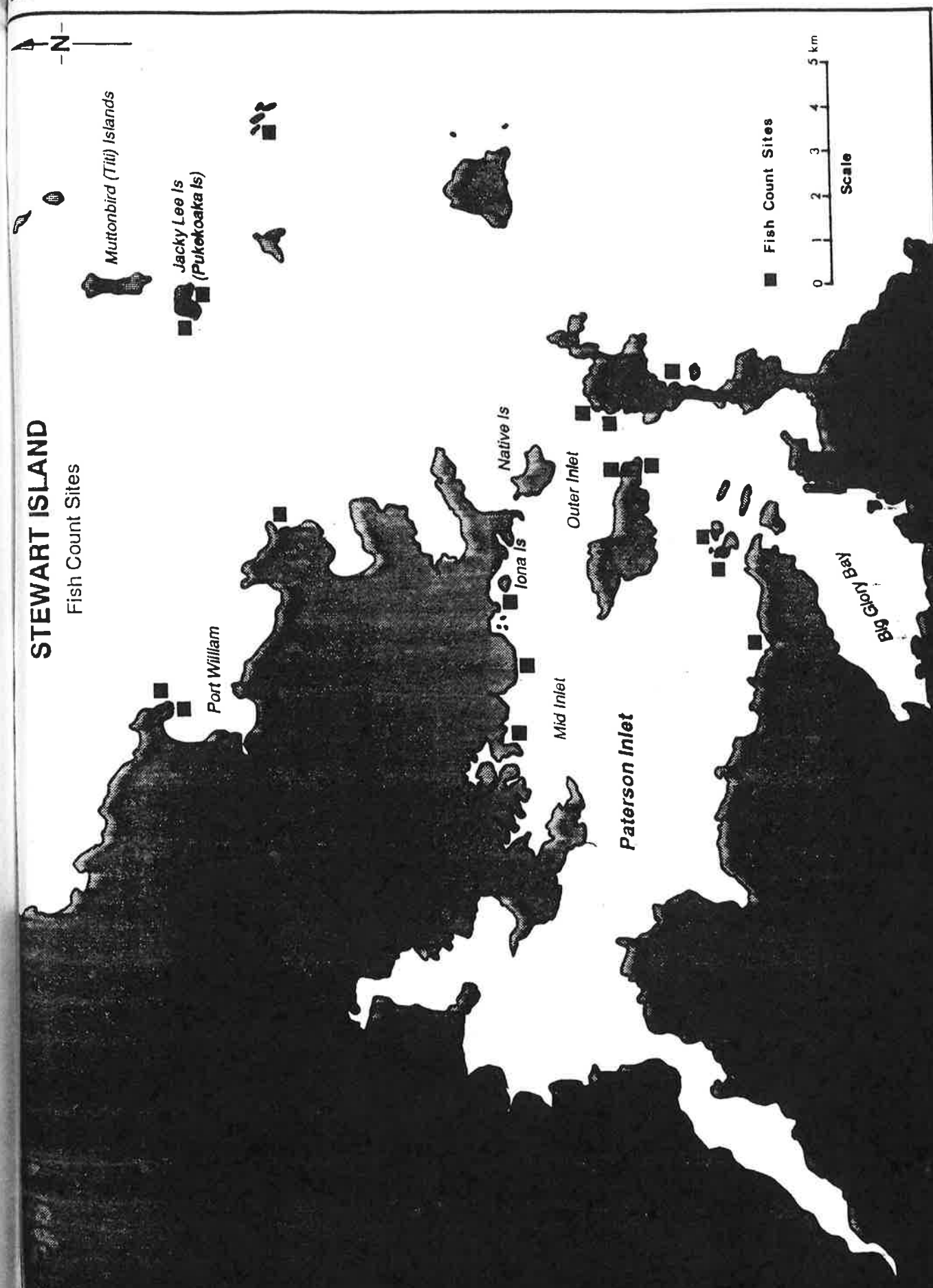
APPENDIX 5: PATERSON INLET FISH SPECIES LIST

Common name	Scientific name
(a rockfish)	<i>Acanthoclinus trilineatus</i>
(a pipefish)	<i>Syngnathus blainvillianus</i>
Banded wrasse	<i>Notolabrus fucicola</i>
Barracouta	<i>Thyrstites atun</i>
Basking shark	<i>Cetorhinus maximus</i>
Blue cod	<i>Parapercis colias</i>
Blue moki	<i>Latridopsis ciliaris</i>
Blue-eyed triplefin	<i>Notoclinops segmentatus</i>
Butterfly perch	<i>Caesioperca lepidoptera</i>
Carpet shark	<i>Cephaloscyllium isabellum</i>
Common roughy	<i>Paratrachichthys traillii</i>
Common triplefin	<i>Forsterygion lapillum</i>
Conger eel	<i>Conger verreauxi</i>
Electric ray	<i>Torpedo fairchildi</i>
Estuarine stargazer	<i>Leptoscopus macropygus</i>
Estuarine triplefin	(undetermined genus and species)
Giant stargazer	<i>Kathetostoma giganteum</i>
Girdled wrasse	<i>Notolabrus cinctus</i>
Great white shark	<i>Carcharodon carcharias</i>
Greenbone (butterfish)	<i>Odax pullus</i>
Leather jacket	<i>Parika scaber</i>
Lemon sole	<i>Pelotretis flavilatus</i>
Ling	<i>Genypterus blacodes</i>
Long snouted pipefish	<i>Stigmatophora longirostris</i>
Long finned eel	<i>Anguilla dieffenbachii</i>
Maori chief	<i>Notothenia angustata</i>
Marblefish	<i>Aplodactylus arctidens</i>
Mottled triplefin	<i>Tripterygion</i> sp.
Oblique swimming triplefin	<i>Obliquichthys maryannae</i>
Opal fish	<i>Hemerocoetes monopterygius</i>
Quinnat salmon	<i>Oncorhynchus tshawytscha</i>
Red cod	<i>Pseudophycis bachus</i>
Red gurnard	<i>Chelidonichthys kumu</i>
Rig (spotted dogfish)	<i>Mustelus lenticulatus</i>
Rockfish	<i>Acanthoclinus quadridactylus</i>
Rough skate	<i>Raja nasuta</i>
Sand flounder	<i>Rhombosolea plebeia</i>
Scarlet wrasse	<i>Pseudolabrus miles</i>
School shark	<i>Galeorhinus australis</i>
Sea perch (Jock Stewart)	<i>Helicolenus papillosus</i>
Sea horse	<i>Hippocampus abdominalis</i>
Seven gilled shark	<i>Heptranchias perlo</i>

Short finned eel	<i>Anguilla australis</i>
Southern pigfish	<i>Congiopodus leucopaecilis</i>
Spectacled triplefin	<i>Ruanoho whero</i>
Spotted spiny dogfish	<i>Squalus acanthias</i>
Spotted stargazer	<i>Genyagnus novaezealandiae</i>
Spotty	<i>Notolabrus celidotus</i>
Tarakihi	<i>Nemadactylus macropterus</i>
Telescope fish	<i>Mendosoma lineatum</i>
Topnot	<i>Notoclinops fenestratus</i>
Trumpeter	<i>Latris lineata</i>
Variable triplefin	<i>Forsterygion varium</i>
Warehou	<i>Seroilella brama</i>
Whitebait	<i>Galaxias sp.</i>
Yellow-black triplefin	<i>Forsterygion sp.</i>
Yellow-eyed mullet	<i>Aldrichetta forsteri</i>

Compiled by W Costello in 1989 from the sources below and from marine surveys as described in this document, also from personal observation by Stewart Island field centre staff, Department of Conservation

Sources: Batham 1969; Grange and McKnight 1987; Walls 1989.



APPENDIX 7: COMMON NAMES OF PLANTS AND INVERTEBRATES OF PATERSON INLET

Scientific name	Common name
<i>Adenocystis utricularis</i>	sea "bombs"/sea squirt seaweed
<i>Alcithoe arabica form swainsoni</i>	southern volute
<i>Allostichaster insignis</i>	dividing starfish
<i>Amphibola crenata</i>	mud snail
<i>Aphysilla sulphurea</i>	sulphur sponge
Ascidacea	sea squirts
<i>Asparagopsis armata</i>	"Moray wetsuit" seaweed (it sticks to it!)
<i>Astrea heliotropium</i>	circular saw shell
<i>Astrostole scabra</i>	seven armed starfish
<i>Atrina zelandica</i>	horse mussel
<i>Aulacomya ater maoriana</i>	ribbed mussel
<i>Barbartia novaezealandiae</i>	arc shell
Bryozoa	colonial animals forming hard, calcified growths
<i>Buccinulum sp.</i>	lined whelk
<i>Callianassa filholi</i>	ghost shrimp
<i>Cantharidus opalus</i>	opal top shell
<i>Cellana sp.</i>	limpet
<i>Cellana ornata</i>	ornate limpet
<i>Cellana strigilis redimiculum</i>	large Stewart Island limpet
" <i>Cerianthus</i> " sp.	large tube anemone
<i>Chaemosipho columna</i>	small fused plate barnacle
<i>Chirodota nigra</i>	purple holothurian worm
<i>Chlamys sp.</i>	fan scallop
<i>Cnemidocarpa bicornuata</i>	large wrinkly sea squirt
<i>Codium fragile</i>	sea velvet seaweed
<i>Codium convolutum</i>	pads of sea velvet
Coelenterata	phylum containing hydroids, jellyfish, anemones, corals
<i>Colpomenia sp.</i>	bubble like seaweed
Coralline paint	pink paint like algae on rocks
Coralline turf	small pink calcareous seaweed
<i>Coscinasterias calamaria</i>	eleven armed starfish
<i>Cystophora scalaris</i>	zig zag seaweed
<i>Durvillaea sp.</i>	bull kelp
Echinodermata	phylum containing urchins, cucumbers, starfish...
<i>Echinocardium cordata</i>	sea mouse/hearturchin
<i>Ecklonia radiata</i>	North Island kelp
<i>Elminius modestus</i>	small star shaped barnacle
<i>Epopella plicata</i>	larger barnacle with 4 plates
<i>Eudoxochiton nobilis</i>	a large hairy chiton
<i>Evechinus chloroticus</i>	common kina
Formanifera	one-celled animals forming calceous shells
<i>Gari sp.</i>	sunset shell
<i>Glycemeris laticostata</i>	dog cockle
<i>Haliotis australis</i>	yellow foot paua
<i>Haliotis iris</i>	common paua
<i>Hormosira banksii</i>	Neptunes necklace seaweed
<i>Jasus edwardsi</i>	crayfish/rock lobster
<i>Lima colorata zelandica</i>	file shell
<i>Macrocystis pyrifera</i>	bladder or butterfish kelp
<i>Maoricolpus roseus</i>	turret shell
<i>Marginariella sp.</i>	tooth combed seaweed
<i>Melagraphia aethiops</i>	small lined snail
<i>Modelia granosa</i>	granose turban shell
<i>Modiolarca impacta</i>	nesting mussel
<i>Munida sp.</i>	munida shrimp
<i>Mytilus edulis</i>	blue mussel
<i>Nectocarcinus antarcticus</i>	paddle crab
<i>Neilo australis</i>	small mallet shell
<i>Nemocardium pulchellum</i>	strawberry cockle
<i>Neothyris lenticularis</i>	large pink lampshell/brachiopod
<i>Notomithrax sp.</i>	camouflage crab
<i>Notosaria nigricans</i>	black toenail lampshell/brachiopod
<i>Octopus maorum</i>	common octopus
<i>Ophiopsammus maculata</i>	brittle starfish
<i>Ostrea sp.</i>	oyster
<i>Palaemen affinis</i>	shrimp
<i>Pagurus sp.</i>	hermit crab
<i>Patiriella regularis</i>	cushion starfish
<i>Pecten novaezealandiae</i>	scallop
<i>Pentagonaster pulchellus</i>	biscuit star fish
<i>Phyllochaetopterus socialis</i>	tubeworms like masses of sandy twigs
Polychaeta	tubeworms
Porifera	sponges
<i>Scutus breviculus</i>	black fleshy snail - ducks bill limpet
<i>Siphonaria zelandica</i>	a pulmonate limpet
<i>Sipuncula sp.</i>	a peanut worm
<i>Spirobis sp.</i>	very small coiled tubeworm
<i>Splachnidium rugosum</i>	"gummy" seaweed
<i>Stichopus mollis</i>	sea cucumber
<i>Struthiolaria papulosa</i>	ostrich foot shell
<i>Sypharochiton pelliserpentis</i>	snakeskin chiton
<i>Tanea zelandica</i>	necklace shell
<i>Tawera spissa</i>	morning star shell
<i>Terebratella sanguinea</i>	larger ribbed lampshell/brachiopod
<i>Trochus viridis</i>	a top shell
<i>Ulva sp.</i>	sea lettuce seaweed
<i>Venericardia purpurata</i>	purple cockle
<i>Waltonia inconspicua</i>	small red toenail lampshell/brachiopod

Xenostrobus pulex
Xiphophora gladiata
Zostera sp.

small black mussel
flat strapweed brown seaweed
sea grass

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