PAP. & PROC. ROY. SOC. TASMANIA, VOL. 86 (15TH SEPTEMBER, 1952)

The Nature of Intertidal Zonation in Tasmania

By

ERIC R. GUILER

Zoology Department, University of Tasmania

SUMMARY

The various types of zonation found on the different coasts of Tasmania are described and compared. The zones to be seen in Tasmania are compared with the zones found on the Mainland of Australia and the terminology used by several authors is also compared. The geographical affinities of the Tasmanian intertidal region are discussed and it is shown that Tasmania lies within the southern region of large brown seaweeds. This region exhibits other very similar ecological features on the continents in which it occurs. Some parts of the coasts of Victoria are ecologically very similar to Tasmanian shores and there are also close similarities with Kangaroo Island.

INTRODUCTION

The types of shore which have been described are as follows:—

Oceanic with heavy wave action at Eaglehawk Neck, Sleepy Bay, Remarkable Cave, Point Puer, Betsy Island. (Guiler, 1951*a*, 1951*b*, 1951*c*).

Semi-exposed coast with moderate wave action at Blackman's Bay, Betsy Island and Port Arthur (Guiler, 1950, 1951*c*, 1951*a*).

Sheltered coast with very little wave action at Coles Bay, Barnes Bay, Dover, Oyster Cove, Kettering and Dodges Ferry (Guiler, 1951*a*, 1951*d*).

Lagoon with virtually no wave action at Pipe Clay Lagoon (Guiler, 1951*e*).

All types of zonation are to be found on these different coasts. In some cases there are species which are found both on exposed and sheltered shores. Some of these species are not of very much use as indicator species, but others are found in abundance on one type of coast and can be used as indicators of that type of coast. A few species are found on only one type of shore and are therefore characteristic of such shores. A list of the indicator species and the type of shore on which they are found is given in Table 1.

TABLE I.

Indicator species and the type of shore on which they are to be found.

(a) Characteristic of one type of coast

Sarcophycus potatorum (Labill.) Kutz	Exposed coasts.
Lithophyllum hyperellum Foslie	Exposed coasts.
Jania sps.	Exposed coasts.
Ecklonia radiata (Turn.) S. Ag.	Oceanic sheltered.
Zostera sps.	Sheltered.
Assimania brazieri (Ten.-woods)	Lagoons and semi-lagoons.
Austrocochlea obtusa (Dillwyn)	Sheltered and lagoon.
Cymodocea antarctica	Sheltered.
Anapella cycladea (Lam.)	Lagoons and sheltered.
Bittium lawleyanum Crosse	Lagoons.
Pyrazus diemenensis	Sheltered and Lagoons.

(b) Found on several types of coast but dominant on one shore

Melaraphe unifasciata (Gray)	Most coasts in Tasmania, but its absence is characteristic of sheltered shores.
Bembicium nanum (Lam.)	Semi-exposed and sheltered.
Bembicium melanostoma (Gmelin)	Sheltered and Lagoon.
Pyura praeputialis (Heller)	Sheltered, semi-exposed and exposed.
Xiphophora sps.	Semi-exposed to nearly exposed, but best developed at three-quarters exposed.
Lessonia corrugata Lucas	Semi-exposed to exposed. Best developed on nearly exposed shores.
Cystophora spartioides (Turn.) J. Ag.	Semi-exposed to nearly sheltered. Best developed at a quarter exposed.
Cystophora uvifera (Ag.) J. Ag.	Semi-exposed to sheltered. Best developed on sheltered coasts.
Cystophora torulosa (R. Br.) J. Ag.	Semi-exposed to sheltered. Best developed on sheltered coasts.
Catophragmus polymerus Darwin	Semi-exposed to exposed. Best developed at more than semi-exposure with surf.
Galeolaria caespitosa (Lam.)	Sheltered to semi-exposed. Absent on exposed coasts. Best developed on sheltered shores.
Mytilus planulatus (Lam.)	Semi-exposed to sheltered. Best developed on semi-exposed coasts.
Hormosira banksii (Turn.) Decaisne	Semi-exposed to sheltered. Best developed on sheltered shores.
Brachyodontes rostratus (Dunker)	Exposed to sheltered. Best developed on three-quarters exposed coasts.
Corallina cuvieri Lamour.	Exposed to semi-exposed. Best developed on semi-exposed shores.

(c) Ubiquitous on rock shores

Lichina confinis
Cancer novae-zealandiae Jacquinot & Lucas
Ulva lactuca (L.)
Petrolisthes sp.

It must be noted that the species living in the pool environment are not included in the above. *Melanerita melanotragus* Smith is a very common organism in ponds on the exposed east coast but it is confined to ponds and does not have any value as a zonal organism.

It is proposed to discuss the zones seen in the major divisions of the intertidal region and compare these zones with their equivalents on various types of shore. For reasons outlined in Guiler, 1951*e*, the lagoon will be compared separately with the other types of shore. (Table 2).

EXPOSED									SEMI-EXPOSED								
SLEEPY B. PT. PUER	BETSY IS. W.	BETSY IS. E.	SLEEPY B. V. EXPOSED	FOSSIL IS.		REMARK'LE CAVE	PIRATES' BAY		BLACKMAN'S BAY AREA			OPOSSUM BAY	LADY BAY	FOSSIL IS.	FRYING PAN IS.	N.E. BETSY IS	EXPOSURE
BARE LICH.			LICH. BARE														
MEL.	MEL.		MEL.	MEL.		MEL.	MEL.		MEL.			LICHENS + MEL.	LICHEN + MEL.	MEL.		MEL.	70-100 %.
BARN.	BARN.		BARN.	BARN.		BARN.	BARN. GAL. + BRA.		BEMB. BARN. GAL.	BARN. BRA.	BARN.	SIPHO. + TETRA. GAL.	BARN. RIV. GAL.	BARN.	BARN.	? BARN. GAL.	27-88 %. 18-70 %.
PAT.	CATO.	PAT	CATO.	PAT. + RIV.	PAT. + ACT.	BRA.	BRA.	BRA.	PAT.	MYT.	MYT.	GAL. + HOR.	GAL. + HOR.	PAT. + HOR.	CATO. + MYT.	COD. +/or MYT.	7-60 %.
COR.	CATO.	CATO.	COR.	COR. COR.	COR. + ULVA	COR.		LAUR.	MYT. LAUR.		CATO.	HOR. + CYST.		COR.	CATO.		0-26 %.
SAR.	LESS.		SAR.	SAR.	XIP. + SAR.	PYURA + SAR.	PYURA +/or SAR.		LESS.			CYST.	CYST.	CYST.	XIPH.	LESS.	0-2 %.

TABLE II.—*continued on next page.*

SHELTERED											LAGOON	TERMINOLOGY	
COLES BAY	BARNE'S BAY			DODGE'S FERRY	DOVER	GRANGE	PT. PUER	JETTY AT FOSSIL IS.	KETTERING	OYSTER COVE	PIPE CLAY	LAGOON	S. & S., 1949.
											ARTHROCNEMON	UPPER SHORE	SUPRALITT.
MEL.	MEL.			MEL.		MEL.	·	MEL.	BRA.	LICH.	ARTHROCNEMON + SALINATOR		S-L. FRINGE
BARN.	BEMB BARN. AUST.	BARN. AUST.	BEMB. AUST. OR BARN.	BARN.	BEMB AUST.		BARN.	AUST.	AUST.	SIPHO.	BEMB. BITTIUM ANAPELLA	SUPRA	MID
GAL.	GAL.	GAL.	GAL. + SYP. OR MYT.	GAL.	GAL.	GAL.			GAL. + MYT.	GAL.		ZOSTERA	
HOR.	BRA	HOR. + MYT.		MYT.	HOR.	MYT.	HOR	PAT.		HOR.	(ANTHO.)		LITTORAL
											ZOSTERA	ZOSTERA	
COR.	MYT.		GAL + MYT.					COR.	MIXED		MARCIA	INFRA	
CYST.	CYST.		PYURA &/OR MYT.	PYURA	CYST.	CYST.	CYST.	CYST. + ECK.	CYST.	CYST.	AUST.	ZOSTERA	INFRALITT. FRINGE

TABLE II.—Comparison of the zonation seen on various types of coast in Tasmania. These zones are compared with the terminology of Stephenson & Stephenson (1949) and also with the proposed lagoon terminology.

Abbreviations used are: LICH.—Lichens; MEL.—Melaraphe; BARN.—Barnacles; PAT.—Patelloids; COR.—Corallines; SAR.—Sarcophycus; CATO.—*Catophragmus*; LESS.—*Lessonia*; RIV.—*Rivularia*; ACT.—*Actinia*; XIP.—*Xiphophora*; BRA.—*Brachyodontes*; GAL.—*Galcolaria*; LAUR.—*Laurencia*; BEMB.—*Bembicium*; MYT.—*Mytilus*; SIPHO.—*Siphonaria*; TETRA.—*Tetraclita*; HOR.—*Hormosira*; CYST.—*Cystophora*; COD.—*Codium*; SYP.—*Sypharochiton*; AUST.—*Austrocochleia*; ECK.—*Ecklonia*.

The striking feature of the intertidal region in Tasmania is the bareness of most of the shore. This bareness becomes evident very sharply at a level which experiences about 30 per cent exposure. The forms inhabiting the shore below this "Lethal" level according to the different types of coast. Above this lethal level the species are few in number and individuals.

TABLE III

The number of species on the shore at certain levels at six places in Tasmania.

Height R.D. at Blackman's Bay	Sleepy Bay	Coles Bay	Blackman's Bay	Betsy Island	Oyster Cove	Pipe Clay
8′ 6″	24 +	33 +	31 +	?	20 +	17
10′ 6″	10	10	7	9	7	7
11′ 3″	8	7	4	5	5	3

The number of species above the lethal level is fairly uniform on the different types of coast although the species composition may be different. Table III. also shows the very small number of species encountered on the shore, though there is a great difference in the numbers of individuals found on the different types of coast. The upper shore is most bare in appearance on sheltered coasts. Exposed coasts, with one or two exceptions, are very nearly as bare. The exceptions noted are at Betsy Island and Remarkable Cave. The former locality has a very dense growth of *Chthamalus* covering most of the Midlittoral and at Remarkable Cave there is a barnacle—*Brachyodontes* growth over a large area of the Midlittoral. The semi-exposed coasts show the greatest development of intertidal life. Although the number of species is not any greater than on other coasts there are a great many more individuals of these species. As examples, we have the Hormosiretum at Point Puer and the more dense barnacle population at Blackman's Bay. It is not valid to compare the numbers of the fauna of a lagoon with those seen on other types of coast as the lagoon habitat is very specialised, most of the forms occupying a burrowing niche.

On an exposed coast the zones are very much wider than those seen on sheltered shores. This is, of course, a universal feature of the intertidal region.

There is a great difference between the dominant species found on wave exposed coasts and those encountered on sheltered shores. This difference is greater than that noted between the dominant species of semi-exposed and exposed or sheltered coasts. This is only what might be expected. The dominant species on lagoons are entirely different from those found on any rocky shore. As noted previously, ocean surf beaches have not been examined.

(1) *The Supralittoral Zone*

The Supralittoral region is usually bare but in some places, for example, at Pierson's Point and Sleepy Bay, orange and grey lichens form very prominent bands around the shore. These two localities are semi-exposed and exposed coasts respectively but on sheltered shores the Supralittoral is usually bare, with such plants as *Mesembryanthemum* at the upper limits. In lagoons the Supralittoral is occupied by some form of salt marsh or brackish water marsh. At Pipe Clay Lagoon there is an *Arthrocnemon* scrub while at Boomer Marsh there is a saltings (Curtis & Somerville, 1947). A similar association to that found at Boomer is to be seen at Moulting Lagoon near Freycinet Peninsula.

(2) *The Supralittoral Fringe*

(a) The Melaraphe Belt

This belt is found on all coasts in Tasmania with the exception of very sheltered rocky shores, beaches and lagoons. There is usually one species found in the belt, namely *Melaraphe unifasciata,* though in places where there is intense spray *Melaraphe praetermissa* may also be found in the Supralittoral Fringe. In certain localities another Littorinid, *Bembicium nanum,* is found immediately below the *Melaraphe* belt. At Blackman's Bay *Bembicium* is locally developed into a prominent band, but in places where wave action is strong the species is absent. *Bembicium melanostoma* is found in lagoons and also on some very sheltered shores. The two *Bembicium* species probably represent the upper limit of the Midlittoral. Bearing in mind the accepted Littorinid zone in British waters with *Littorina saxatilis* and *L. neritoides* as the dominant species, it appears that *Littorina neritoides* is represented in Australia by *Melaraphe unifasciata* and *L. saxatilis* by *Nodilittorina tuberculata.* The latter species is absent from Tasmania. The *Bembicium* species probably represent British species which are found further down the shore, perhaps *Littorina littoralis* or *L. littorea.* This hypothesis is substantiated by the occurrence of many *Bembicium* in the Midlittoral and by the presence of the belt dominated by that genus below the barnacles at Dover.

(3) *The Midlittoral Zone*

(a) The Barnacle Belt

The distribution of barnacles in Tasmania will be discussed fully below. It may be noted here that the belt is only rarely well developed and in no sense can be compared to the *Tetraclita rosea* belt on the New South Wales coast. The species are very few both in number and individuals.

The belt is wide spread on the coast of Tasmania. In some places, due to the small numbers of the barnacles, *Siphonaria* replaces them as the dominant organism, for example, at Oyster Cove and locally at Opossum Bay. In places where there is no substratum suitable for barnacle attachment the zone may be absent, for example, at Pipe Clay Lagoon and at the head of Barnes Bay. The shore at Kettering where there is shelter from the sun and little wave action the barnacle belt is replaced by *Austrocochlea* + *Mytilus* and/or *Galeolaria.* Similarly, at the Grange where the reef is below the barnacle level and there is no suitable substratum, the barnacle belt is absent.

(b) Patelloid Belt

On wave exposed coasts the presence of a Patelloid belt below the barnacles is an interesting feature. This belt is characteristic of some shores in South Africa (Bright, 1938*a*) and it is a significant geographical parallel to find a similar feature in Tasmania. Pope (1951*b*) observed that there was a tendency to a Patelloid belt in southern Victoria.

The Patelloid belt is obvious on all coasts having heavy wave exposure. The species composition of the belt is remarkably constant.

Patelloida alticostata, P. conoidea, Cellana limbata, C. variegata, Siphonaria diemenensis and *S. zonata* are the most common species found. In places the Patelloids may have *Rivularia* growing in the same belt. This is seen at Fossil Island and is probably indicative of broken water resulting from surf being formed by boulders, &c. If *Brachyodontes rostratus* is present in sheets covering large areas of rock, the Patelloid belt is eliminiated by the mussels. This condition is seen on the reefs in Pirates Bay and at Remarkable Cave. Blackman's Bay probably represents the minimum wave action required by the Patelloids to permit them to form a belt.

All grades of mixing with other belts are to be seen at different places on this coast. In some areas for example Eaglehawk Neck, the Patelloids become mixed with other species not usually found forming a belt, e.g., *Actinia equina*. The Patelloid belt is absent from sheltered coasts and lagoons, though the individual species that compose the belt may all be found in the more sheltered situations.

In some places where there is heavy surf the Patelloid belt may be suppressed entirely or in its lower parts there may be a well developed *Catophragmus* belt, e.g., on the west side of Betsy Island and Frying Pan Island or on parts of the Blow Hole platform at Eaglehawk Neck and also at Sleepy Bay. *Catophragmus* is best developed where there is constant surf, oceanic water but not intense wave action. The barnacles at Eaglehawk Neck are smaller than those at Frying Pan Island and fewer in numbers.

The west coast of Tasmania has not been examined but I have had the opportunity of examining some photographs taken by Mr. A. Hewer near the Duck River. These show the Patelloid belt extending without a break as far down the shore as the *Sarcophycus*. The suppression of the *Coralline* belt in this region of very heavy surf is most interesting, but detailed examination is necessary before conclusions can be drawn.

On sheltered coasts the Patelloid belt is replaced by *Hormosira*, e.g., Point Puer and Coles Bay. At the area where the change from one species to another takes place, e.g., Fossil Island, the *Hormosira* is found lower down the shore and extends up to replace the Patelloids. *Hormosira* is best developed on sheltered shores and does not grow on exposed places. This is different from the condition at Long Reef, Sydney, where the weed forms a continuous covering to the rocks (Pope, 1943). On exposed or semi-exposed shores the species is confined to the rock pool environment.

In some areas, e.g., North-eastern Betsy Island, *Galeolaria* replaces the Patelloids and at Opossum Bay both *Galeolaria* and *Hormosira* replace the limpets. At Barnes Bay the Patelloid belt is replaced by a *Brachyodontes* belt. This feature theoretically resembles that seen at Pirates Bay but at the latter locality the mussels are in sheets whereas at Barnes Bay they are in thin clusters. In other places *Mytilus planulatus* replaces the Patelloid belt. All combinations of these species can be found on the sheltered coasts, depending on the degree of wave exposure at the place examined.

(c) Corallines

The Coralline belt is also characteristic of exposed coasts. The species composition of the belt is not fully known as the Corallines are a very poorly worked group in Australia.

The Coralline belt includes a *Jania* sp., *Corallina cuvieri, C. officinalis* and *Lithophyllum hyperellum.* This latter species is indicative of heavy wave action. It is very poorly developed on Betsy Island. The belt is usually very thickly populated by the calcareous algae and other forms are prevented from successfully colonizing the rocks. The belt is never great in vertical height but at the appropriate tidal levels may be some feet wide on a horizontal shelf. It is absent from the semi-exposed shore at Blackman's Bay and even from some exposed places such as Betsy Island. The belt is well developed on the sheltered side of the Freycinet Peninsula at Coles Bay and also on the sheltered side of Fossil Island, though the coral-like *Lithophyllum* is not present in either of the localities.

The Coralline belt is found on all of the coasts in Tasmania which are washed by oceanic waters. On the eastern shoreline the Corallines are present as a continuous band, irrespective of wave action. At Blackman's Bay there is no Coralline belt. This area does not suffer from any marked degree of fresh water pollution but true oceanic water does not always occur there. The belt appears at Lucas Point, nearer the mouth of the estuary but is absent from Betsy Island. The reason for the absence of the Corallines from Betsy Island is not known.

In sheltered places the Corallines are usually replaced by *Hormosira*, though in the exceptional conditions seen at Kettering and Barnes Bay, *Mytilus* and *Galeolaria* are dominant on most of the shore above the Infralittoral Fringe. The mussels replace the Corallines on semi-exposed coasts, e.g., between Blackman's Bay and Kingston. In places of heavy surf suitable to the growth of *Catophragmus* the barnacle replaced the Corallines. In some places the *Catophragmus* belt extends from the barnacles to the Infralittoral Fringe, e.g., on the western shore of Betsy Island and at Frying Pan Island. The Corallines are absent from lagoons and their place is largely taken by a belt dominated by *Marcia corrugata.*

(d) Galeolaria

This serpulid is found on nearly all types of coast, usually forming a belt on exposed and semi-exposed shores. The species is absent from extremely exposed places but it is found in sheltered clefts on an exposed coast line. The species does not like surf, being absent from Frying Pan Island. The worms are found in lagoons and sheltered places, where they form dense masses on stone on the lower shore.

On exposed shores the *Galeolaria* belt is replaced in part by the *Patelloids* but mostly by a downward extension of the barnacles. If there is heavy surf the *Catophragmus* belt replaces the *Galeolaria.*

Galeolaria frequently forms mixed belts, particularly with mussels. In the sheltered places there are several such mixed belts to be seen, e.g., at Barnes Bay (with *Mytilus planulatus*), at Pirates Bay (with *Brachyodontes rostratus*). Less commonly it is found with *Hormosira* (Lady Bay) or *Sypharochiton pellis-serpentis* (at Barnes Bay).

The worm tubes have been found in various places forming masses up to six inches thick on rocks, e.g., Dodges Ferry. These masses have a dense fauna dwelling within them. In particular the interesting form of the barnacle *Ibla quadrivalvis* has been noted (Guiler, 1951*d*). The small lamellibranch, *Lasaea australis,* is also extremely plentiful in the tube masses along with numerous species of polychaetes, *Leptolana australis* and isopods and amphipods.

(e) Mytilus planulatus

The beds formed by this species are only found in restricted areas of southern Australia, e.g., the south coast of Victoria (Pope, 1951*a*), but they are a feature of Tasmanian coasts. The species is widespread occurring on all but exposed coasts. The beds are characteristic of semi-exposed places.

On sheltered shores the mussel beds are replaced by *Hormosira.* In places with surf the mussels are found in fairly large numbers, e.g., at Frying Pan Island and Betsy Island, but they are not the dominant species as they are replaced by *Catophragmus.* The mussel beds form an important ecological habitat as large numbers of animals live both on and below the mussels.

The distribution of mussels in Tasmania is discussed below.

(f) Catophragmus polymerus

This barnacle is only dominant where there is heavy surf. *Catophragmus* is present but not dominant in regions where the waves pound directly on the shore, but if the shore is swept by broken water or surf the barnacle is extremely numerous and the individuals are of a large size. The eastern shore of Betsy Island is the outstanding example of this type of coast with a resulting dense *Catophragmus* population. On exposed shores *Catophragmus* is replaced by the *Corallina* belt and on sheltered shores *Hormosira* and *Mytilus* replace the barnacle.

(g) Austrocochlea obtusa

As noted in Guiler, 1951*e* there are three ecological varieties of this species. A strongly ribbed white variety, formerly called *A. constricta,* which is found on exposed coasts on the mainland (Macpherson, 1950), a normal *Austrocochlea obtusa* and a small estuarine form. None of these forms is found on exposed coasts in Tasmania but the ribbed form is most common in sheltered places. The small estuarine variety is found in the hypersaline Pipe Clay Lagoon. The normal variety is found on sheltered shores, and may occur with the var. *constricta.*

(h) Semi-cryptic species

On all coasts there are some species which are confined to cryptic or semi-cryptic places. These species are often found as indicators at a lower level on the shore, being forced to seek sheltered places at levels higher than that at which they experience their optimum exposure. The chiton, *Sypharochiton pellis-serpentis,* is often found in cracks in rocks in the barnacle belt but is not found as a dominant. In some restricted sheltered areas it achieves a co-dominance, living in exceptionally large numbers among the dominant species, the latter forming a shelter necessary for the chiton. The barnacle *Chthamalus antennatus* is also found in a semi-cryptic habitat at a higher level on the shore than is usual for the species. It does not form a zonal band at the higher level, the dominant species at this level being *Melaraphe unifasciata.*

Lagoon Conditions

The fauna of a lagoon differs very considerably from that found on any other type of shore in Tasmania. Not only are the dominant species different from those on more exposed coasts but the majority of the animals found in the lagoon are also different. A few species, e.g., *Elminius modestus* are found in lagoons as well as on other types of shore. These species are of great value for correlating tidal levels and are listed in Table IV.

Table IV

Species which are found in Pipe Clay Lagoon as well as on other types of coast.

SPECIES	ALSO FOUND ON
Brachyodontes rostratus	Sheltered to exposed coasts.
Mytilus planulatus	Semi-exposed to sheltered coasts.
Pyura praeputialis	Sheltered to nearly exposed coasts.
Elminius modestus	Semi-exposed to sheltered coasts.
Bembicium melanostoma	Sheltered coasts.
Patelloida conoidea	Rocky coasts.

Some species such as *Mictyris platycheles* do not form suitable indicators for comparing faunal levels on different types of shore as they are of a roving habit. This species is found on several surf beaches as well as in the lagoon.

The upper shore of the lagoon is composed of two parts, the *Arthrocnemon* scrub and *Arthrocnemon* with *Salinator*. The *Arthrocnemon* scrub is represented on more exposed coasts by either a lichen belt or bare rock. Where *Salinator* is present the scrub is the equivalent of the *Melaraphe* belt, i.e., it forms the Supralittoral Fringe. The presence of *Bembicium* in the belt below that jointly occupied by *Arthrocnemon* and *Salinator* is the indicator which make it possible to correlate the Supralittoral Fringe and the Midlittoral of rocky shores with the lagoon. On rocky coasts *Bembicium* follows immediately below the *Melaraphe* belt and forms the top strip of the Midlittoral zone.

The barnacle belt is absent from lagoons and is replaced by the gastropod-lamellibranch belts of the Supra Zostera zone. The *Bembicium* and *Bittium* belts cover a smaller area of the shore than the *Anapella* belt, the latter species being dominant over most of the Supra Zostera Zone.

The *Bembicium melanostoma* belt of the lagoon is represented on sheltered coasts by the belt occupied by *Bembicium nanum*. Some doubt exists as to the validity of these two species. It is probable that the two species are ecological varieties as specimens of *B. nanum* found at Dover are very similar to small individuals of *B. melanostoma*. On semi-exposed and exposed coasts the *Bembicium* belt is absent and is represented by the barnacle belt or by *Siphonaria* (e.g., at Opossum Bay and Port Arthur).

The *Bittium* belt is represented on semi-exposed or exposed coasts by a part of the barnacle belt. The *Anapella* belt is the widest belt found on the shore and is represented on semi-exposed coasts by the *Galeolaria, Brachyodontes, Hormosira* and part of the *Mytilus* belt. On exposed coasts it is represented by the *Patelloid* and *Catophragmus* belts.

The lamellibranchs are found burrowing in the immediate sub-surface sand. In the upper part of the *Anapella* belt the lamellibranchs are not utilised as a substratum by the anemone *Anthopleura aureo-radiata,* but in the lower part of the belt the anemone attaches itself to many of the lamellibranchs. Although there may be as many as twenty anemones per square foot, the lamellibranchs are still the dominant species as they number as many as 35 per square foot in the same part of the lagoon. It is possible to consider the *Anthopleura* as forming a sub-belt in the *Anapella* belt at about the same level as would be occupied on other types of coast by *Brachyodontes, Hormosira* and Patelloids.

The Zostera beds are found at three different tidal levels on the lagoon. The beds Z_1, Z_2, and Z_5 all occur at the level which approximates to that occupied by *Mytilus planulatus* on semi-exposed coasts. (Guiler, 1951*a*). This species is found in the lagoon and is common in the *Zostera* beds. The *Zostera* at Z_3 and Z_4 is found at a higher level on the shore than at any other place. As noted earlier these two latter beds are found at a higher level on account of the effect of the wind. The level at which *Zostera* occurs can also be shown by direct observation of tidal levels to be about the same as that of the upper *Mytilus* belt. A ' low high ' tide just exposes the *Zostera* in the lagoon and also just exposes the mussel beds at Blackman's Bay.

The belt occupied by *Marcia corrugata* corresponds to that occupied by the lower part of the mussel beds, *Catophragmus* or the *Corallines*. A few clusters of *Mytilus* are found in this belt and are useful species for the correlation of faunal levels on the different types of shore.

The Infralittoral Fringe is represented by a belt dominated by *Austrocochlea obtusa* var. *constricta*. This species occurs over most of the lagoon shore but is dominant only on the lower parts of the intertidal region. The species is also found at various levels on rocky shores but does not form a belt at such a lower tidal level as at Pipe Clay Lagoon. A possible reason for this is to be found in the density of algal population on rocky coasts. The seaweeds of the Infralittoral Fringe on coasts which experience oceanic water are particularly well developed.

The Infralittoral is dominated by clusters of *Pyura, Mytilus, Ostrea* and several smaller species. The majority of the *Pyura* clusters are never exposed at low water. A few clusters of the ascidians are exposed but these are small in size and have been moved by wind and waves to a higher level than normal. In Barnes Bay there are similar Infralittoral clusters of *Pyura*.

(4) *The Infralittoral Fringe*

The very sharp change in dominant takes place in the Infralittoral Fringe. In practically all of the places visited the dominant forms on this part of the shore are algae. The exceptions are *Pyura* at Dodges Ferry, *Pyura* and *Mytilus* at Barnes Bay, *Sarcophycus* and *Pyura* at Pirates Bay and *Austrocochlea* at Pipe Clay Lagoon.

The salient feature of the Infralittoral Fringe of wave exposed coasts is the presence of the bull-kelp, *Sarcophycus potatorum*. Due to the prevalent swell encountered on these coasts this species is always to be seen, irrespective of the state of the tide. It does not form a habitat for other large organisms. Some hydroids, *Spirorbis* sp. and other small organisms are occasionally found on the kelp. The holdfast is a large sucker-like structure and it does not lend itself to the activities of errant polychaetes, molluscs, ascidians and bryozoans as do the holdfasts of *Macrocystis* or *Laminaria*. There is no mollusc filling the niche occupied by *Patina pellucida* (L.) on British coasts. The continual thrashing of the fronds of the weed does not permit dense hydroid or bryzoan growths.

The strap-like algae are a feature of all grades of exposure with the exception of sheltered and lagoon shores. *Phyllosphora, Lessonia, Xiphophora billardieri* and *X. chondrophylla* and *Sarcophycus* are all species with straplike fronds and the presence of any of these species is indicative of fairly strong wave action. The sheltered coasts are characterised by the presence of the less robust species. These species are also smaller in size than the strap-like algae but this is not a general rule. The brown algae of sheltered coasts are usually either of the genera *Cystophora, Hormosira* or *Sargassum* and are frequently accompanied by the green *Caulerpa* sps.

The normal habitat of these algae is the Infralittoral Fringe. Some of these species are found higher up the shore when the wave action is above their optimum (e.g., *Hormosira* and *Lessonia* at the northern end of Fossil Island at Eaglehawk Neck). Species such as *Sarcophycus* which favour the most intense wave action are not found further up the shore than the Infralittoral Fringe.

When the wave action is below the optimum required for a species, there are two possible effects on the algal composition of the Infralittoral Fringe. The species seeks deeper water, i.e., it inhabits the immediate Infralittoral zone, or if the wave action continues to decrease, the species becomes absent from that coast. Due to the topography of Tasmanian coasts this change usually takes place within a very short distance. Between Blackman's Bay and The Grange the exposure is just below the optimum required for *Lessonia* to thrive in the Infralittoral Fringe and this alga is found in the Infralittoral zone immediately below the Infralittoral Fringe.

It is possible that in many cases the retreat into deeper water is prevented by the usually dense growth of Infralittoral forms. At the best the Infralittoral is only a substitute habitat for Infralittoral Fringe algae and the species, which are indigenous to the former habitat and maintain a permanent breeding stock in it, will certainly dominate the environment. The result of this is that the algae of the Infralittoral Fringe will only be able to find occasional opportunities for retreat into deeper water.

In other places the nature of the substratum may change at or below the level of ' low low ' water. If the change of the substratum is very marked profound floral and faunal changes will also take place. In sheltered bays, such as Oyster Cove, the rocks of the intertidal region are suddenly replaced at ' low low ' water by a sandy mud. This results in an immediate biological change. The algae are eliminated and replaced by *Zostera* (on the eastern seaboard there is also *Cymodocea*) and the fauna becomes either fossorial in nature or is confined to mollusc or ascidian clusters. In such an area the Infralittoral Fringe is extremely well defined.

There is a third type of alga found in the Infralittoral Fringe. The two types discussed above are the species which are characteristic of the Fringe at the wave action experienced in that area and the species that may have retreated into deeper water because of diminishing wave action. The third type is the species which is reaching the end of its geographical range and is found in deeper and/or more sheltered water than its normal habitat. Such a species is *Ecklonia radiata*. This species is very plentiful in New South Wales on exposed coasts in the Infralittoral Fringe (Dakin, Bennett and Pope, 1948). In Tasmania the species is rare and is found in places where it is only partially exposed (if at all) at low water and where the wave action is slight, e.g., Lady Bay and the Old Jetty at Fossil Island. Pope (1951*a*) found a similar distribution for this species on the Victorian coast but with the exception that the species did not favour such sheltered places. Pope (1951*b*) pointed out that the distribution of *Ecklonia* in Tasmania was exactly what might have been expected in view of Victorian conditions.

The dominant algae of the Infralittoral Fringe may be summarised in terms of decreasing wave action as *Sarcophycus, Phyllospora, Lessonia, Xiphophora* sps., *Cystophora spartioides, C. torulosa, C. uvifera* with local *Caulerpa brownii. Hormosira* may be dominant in the Infralittoral in restricted areas but it is more usually characteristic of the lower Midlittoral. If dominant in the Infralittoral Fringe it has a wave action toleration about the same as that of *Cystophora torulosa*. Eaglehawk Neck is the most important area for algal zonation as controlled by wave action, the algae being arranged in the series as listed above.

(5) *The Infralittoral*

No attempts have been made to systematically examine the Infralittoral region. In certain areas the Infralittoral has been examined as far as possible at low tide either by wading or from a boat. The purpose of these examinations was to ascertain if there was any significant difference between the Infralittoral and the Infralittoral Fringe.

At Coles Bay the Infralittoral is composed of the same dominant algal species as the Infralittoral Fringe, but there is a great difference in the fauna of the two zones. Intensive collection in the Infralittoral Fringe failed to reveal as many forms as were collected or observed in the Infralittoral. No examination of the Infralittoral was possible on wave-exposed coasts. The difference between the Infralittoral and the Infralittoral Fringe in sheltered bays has been noted above where *Zostera* replaces the *Cystophoras* on the muddy bay bottom. On a sandy bottom the *Zostera* is frequently replaced by *Cymodocea*. Although no detailed examinations have been undertaken it is possible to state that there is a very pronounced faunal, and often floral, change between the Infralittoral Fringe and the Infralittoral.

Discussion

On the shores of Tasmania, as in all other parts of the world, there is a definite vertical zonation of the dominant species. Animals are usually dominant over all types of the coast but at the Infralittoral Fringe a very sharp change occurs and algae become the dominant species. The algae are of more use than the animals as wave exposure indicators. The presence of *Zostera* indicates lagoon or very sheltered conditions.

It is possible to estimate the relative degree of wave exposure experienced on any coast by the forms found on that shore, especially by the algae of the Infralittoral Fringe. The animals of the Midlittoral may be confusing in this respect as one species may be found on several types of shore. The Infralittoral Fringe algae are characteristic and in terms of decreasing wave action the species are *Sarcophycus, Phyllospora, Xiphophora, Cystophora spartioides, Cystophora torulosa, C. uvifera* and finally in very sheltered places the phanerogam, *Zostera*.

Comparison of Tasmanian Intertidal Features With Those seen on the Mainland

Literature describing the intertidal features on the southern and eastern coasts of Australia has been reviewed in Guiler, 1950. The principal descriptive works are those of Hedley (1915), Pope (1943), Dakin, Bennett and Pope, 1948, all dealing with New South Wales. Two papers by Womersley (1947, 1948), describe the features of the algal ecology of Kangaroo Island in South Australia and Edmonds (1948) describes the animal ecology of the same island. Fischer (1940) gives a comparative account of the littoral animals of Australia as a whole.

It is possible only to compare the exposed rocky coasts as other types of shore on the Mainland have not been fully described. The pool habitat has not been considered in Tasmania. Due to the lack of tidal data from other parts of Australia it is not possible to compare the exposure suffered by intertidal organisms in Tasmania with similar data for the same species on the Mainland.

It is proposed to consider each zone in Tasmania and its equivalent on the Mainland and then to draw an overall comparison between the shores of Tasmania and those of Australia.

The Supralittoral Zone

The Supralittoral in Tasmania is either bare or occupied by lichens. Pope (1943) and Dakin, Bennett and Pope (1948) do not mention the presence of lichens on the New South Wales coast but these plants are to be found on exposed coasts in that State. Edmonds (1948) records a *Lichina* sp. from Kangaroo Island. The common Tasmanian lichens found in this belt are a bright orange coloured *Telostichistes parietinus* (L.) Norm., and orange *Candelariella vitellina* (Ehrn.) Müll. and a white *Lecanora* sp. I am indebted to Mr. Cribb of the University of Queensland for this information. No work has yet been attempted on the distribution of the Tasmanian lichens.

The Supralittoral Fringe

There are two species found in this belt in Tasmania. These are *Melaraphe unifasciata* and *M. praetermissa.* Of these two species *M. praetermissa* is found at lower levels than *M. unifasciata,* though at one restricted area near Roaring Beach, Dover, the small *M. praetermissa* occurs above the larger *M. unifasciata.*

On the coast of New South Wales the Supralittoral Fringe is occupied by *Nodilittorina tuberculata* (Menke), *Melaraphe unifasciata, Melanerita melanotragus* (Smith) and *Notoacmaea petterdi* (Ten.-Woods). *Nodilittorina* and *Notoacmaea* do not occur in Tasmania. *Melanerita* is found in rock pools on the east coast, particularly in the northern parts. It is also found on the north coast where it is more generally distributed than on the east coast. The crabs found in this belt on the New South Wales coast are the same as those found in Tasmania, namely *Cyclograpsus audouinii* (M-Edw.) and *Leptograpsus variegatus* (Fabr.). Both from the literature and from personal observations at Harbord, Vaucluse and Long Reef, the Supralittoral Fringe in New South Wales is very similar to that seen in Tasmania with the exception of the absence of *Nodilittorina* and *Notoacmaea* from the latter place. Pope (1943) observes that most of the Supralittoral Fringe species inhabit cracks and so there is little apparent difference between the upper shore of the Sydney region and that of Tasmania. On a cursory examination the Supralittoral Fringe of both countries appears to be very poorly populated by *Melaraphe unifasciata*.

In South Australia the Supralittoral Fringe bears a very close resemblance to Tasmanian conditions. Edmonds found *Melaraphe unifasciata* and *Ligia australiensis* at Kangaroo Island, while Womersley found a well developed winter growth of *Prasiola* at the same place. This algal growth is well developed in places where there are penguin tracks. I have not found any Tasmanian algae living as high on the shore. Apart from this local algal growth the Supralittoral Fringe in South Australia is very similar, if not identical to the same zone in Tasmania.

The Midlittoral Zone

(a) Barnacles

The barnacle belt in Tasmania is not at all well developed. It is populated by five species of barnacle, namely, *Elminius modestus* Darwin *Elminius simplex* Darwin, *Chthamalus antennatus* Darwin, *Chamaesipho columna* (Spengler) and rarely, *Tetraclita purpurascens* (Wood). These barnacles are not all found living on the same type of coast. Also found in the belt are *Bembicium nanum* Lam. and/or *B. melanostoma* (Gmelin), *Austrocochlea obtusa* (Dillwyn), *Lichina officinalis, Verrucaria microsporoides* Nyl. and *Lasaea australis* Lam. In local areas *Actinia tenebrosa* (Farq.) and *Austrocochlea concamerata* also occur in this belt.

In New South Wales the belt is populated by eleven species of barnacles, namely, *Tetraclita rosea* Darwin, *T. purpurascens, Chamaesipho columna, Chthamalus antennatus, Elminius modestus, E. simplex, Balanus amphitrite, B. imperator* Darwin, *B. nigrescens* Lam., *B. algicola* Pilsbry and *Catophragmus polymerus* Darwin. The latter four species are found on lower parts of the shore and do not reach the upper Midlittoral. Associated with these species are numerous gastropods, a few lamellibranchs, and some echinoderms. The density of population of the Sydney barnacle belt is uniformly greater than that seen in Tasmania with the possible exception of Betsy Island.

In Tasmania, *Hormosira* is the dominant alga of the Midlittoral. At certain seasons of the year other species may appear on the shore, but these evanescent growths are usually of short duration. The genera involved are *Porphyra, Ulva* and *Scytosiphon* (Guiler, MS.). *Hormosira* is nearly always found in rock pools and does not form a complete covering over the shore except in restricted localities such as Point Puer. This is in contrast to the well developed growth of *Hormosira* at Long Reef described by Pope (1943). Both Womersley and Edmonds note the well developed growth of *Hormosira* at Kangaroo Island. The latter locality shows very well developed Midlittoral algae, Womersley describing thirteen associations in the Littoral zone. From the descriptions and photographs made by these authors Edmonds describes Patelloid and mussel zones below the barnacles.

(b) Galeolaria

The *Galeolaria* belt is found throughout the temperate Eastern seaboard of Australia. Fischer (1940*b*) notes that this zone at Sydney is comparable with that of Hobart, but with population differences. *Galeolaria* is also prominent on certain parts of Kangaroo Island (Edmonds, 1948). Dakin, Bennett and Pope give a list of species closely associated with the *Galeolaria* encrustations. This list is of interest as so few of the species recorded are found in the Tasmanian worm masses. *Actinia tenebrosa* is found in New South Wales near the *Galeolaria* tubes but in Tasmania this species is not found in the *Galeolaria* belt. *Ibla quadrivalvis* and *Lasaea australis* are found both in Tasmania and New South Wales. *Ibla* forms an interesting variety in thick worm tube masses in Tasmania. The serpulid is frequently found forming an encrustation six inches thick on the rocks. The barnacles, which must have settled at about the same time as the worm larvae, have developed a very long peduncle to enable them to feed and successfully survive among the worm tubes.

In South Australia the *Galeolaria* belt is well developed. Edmonds notes that the species is most plentiful on the sheltered shores of Kangaroo Island. This is in full agreement with the distribution of the species in Tasmania.

(c) The Patelloid Belt

This belt is found on exposed coasts and is one of the features of the Tasmanian region. Pope (1951*b*) found an indication of the presence of a Patelloid belt in the Wilson's Promontory area of Victoria. In New South Wales this belt is possibly represented by the upper part of the Infralittoral Fringe. The lower band is characterised by a *Pyura* with *Ecklonia* and *Phyllospora* and has a smaller algae such as *Sargassum, Colpomenia* and *Padina*. Living in the *Pyura* belt are some Patelloid molluscs, e.g., *Patelloida angasi, Montfortula conoidea* (Reeve), *Patellanax squamifera, P. perplexa* and *Cellana tramoserica*. The first named of these species is common in Tasmania, although it is usually higher on the shore than the ascidian but it also extends as far down the shore as the Infralittoral Fringe. The presence of a *Cellana* sp. and three other Patelloids in the *Pyura* belt, is an indication that the upper *Pyura* belt of New South Wales is the equivalent of the Patelloid belt in Tasmania. There is stronger evidence that the New South Wales equivalent of the Patelloid belt is found higher than *Pyura* because of the presence of a *Sargassum-Colpomenia Padina* band. This band is probably the equivalent of the Tasmanian *Laurencia* belt which is found below the Patelloids at the lower limit of the Midlittoral. It is probable that the Patelloid belt of Tasmanian coasts is not replaced by a well defined belt in New South Wales but is represented by an extension of the lower part of the *Galeolaria* belt, which is much wider in New South Wales than in Tasmania.

Edmonds (1948) describes a *Notoacmaea-Siphonaria* band below the barnacle band at Kangaroo Island.

The species composition of the South Australian band is different from that of the Tasmanian Patelloid belt, *Siphonaria diemenensis* being the only species common to both coasts.

From personal observations in Queensland it seems as if the Patelloid belt is replaced by an oyster-barnacle belt.

New South Wales		Queensland.	S. Australia.	S. Tasmania.	Universal.
Hedley, 1915.	D., B. & P., 1948.	Johnston, 1917.	Edmonds, 1948.	Guiler, 1949.	S. & S. 1949.
Upper Zone with Tectarius Chthamalus Melaraphe Tetraclita.	Supralitt. with Melaraphe	Tectarius & Upper Melaraphe Zones.	Supralitt. with Melaraphe.	Supralitt. Fringe with Melaraphe.	Supralitt. Fringe with Littorinids.
	Upperlitt. with Barnacles	Lower Mel. or Chthamalus.	Barnacles.	Barnacles.	Mid. Littoral.
Median Zone with Galeolaria.	Midlitt. with Galeolaria	Tetraclita.	Molluscs & Galeolaria.	Galeolaria Patelloid. Mytilus.	
Lower Zone with Cynthia.	Litt.-Sublitt. Fringe with Pyura.	Sargassum.	Sublitt. Fringe with Cystophora.	Infralitt. Fringe with Laurencia &c.	Infralitt. Fringe with Laminaria &c.

FIG. 1.—The relation of intertidal zones recognised by Australian authors to those proposed by Stephenson & Stephenson (1949). (From Guiler, 1950). The abbreviations used are INFRALITT. Infralittoral; LITT. SUBLITT. Littoral sublittoral Fringe; MEL. Melaraphe; SUPRALITT. Supralittoral; UPPERLITT. Upperlittoral. Fischer (1940) followed the classification of Hedley.

(d) The mussel beds

Mussel beds are found forming extensive sheets on semi-exposed coasts. The beds are formed of one or two species but only one of the species is dominant on the shore at one tidal level. *Brachyodontes rostratus* is dominant on higher parts of the shore and also on more exposed coasts while *Mytilus planulatus* is dominant on semi-exposed or sheltered shores. As noted above, the mussel beds are a feature of the Tasmanian coast. The Wilson's Promontory area of Victoria is very similar to Tasmanian shores as mussel beds are found on the coast around the Promontory.

Mussel beds occur in sheltered parts of Sydney harbour but, according to Hedley (1915), they do not form an important feature of the intertidal region.

Edmonds describes the *Brachyodontes rostratus* band at Kangaroo Island. It is found immediately above the *Hormosira-Actinia* band. Although the latter combination of species does not occur in Tasmania it can be seen from Table II. that such a faunal level would correspond to that occupied by *Brachyodontes* at Blackman's Bay. (In his paper, Edmonds refers to the mussels as *Modiolus pulex* (p. 171), but in a footnote he states that this is probably *B. rostratus*.).

(e) Sarcophycus

This seaweed is found in the lowest part of the Tasmanian intertidal region. The species also occurs on the southern coasts of New South Wales where it joins the *Ecklonia-Phyllospora* association. It is also found in Victoria. *Sarcophycus* reaches its maximum development in Tasmania. On Macquarie Island, which lies 600 miles to the south of

Tasmania, there is a very similar band but the alga is *Durvillea antartica* (Cham.) Hariot. (Kenny, 1951). This latter species is rare in Tasmania, the only records being from drift weed found at high water mark.

In New South Wales the *Ecklonia-Phyllospora* association of Dakin, Bennett and Pope is the equivalent of *Sarcophycus* in Tasmania. In sheltered places in Tasmania *Sarcophycus* is replaced by *Cystophora* and *Sargassum* sps. These two genera are found in similar situations in New South Wales. In South Australia the Infralittoral Fringe, occupied by *Ecklonia, Cystophora* and *Sargassum* closely resembles that of New South Wales.

General Discussion

It is not possible to take a detailed comparison of all the zones found on Tasmanian shores with their equivalent zones on the Mainland. In most cases the workers on the Mainland have either confined their efforts to exposed coasts or they have examined very small areas and given brief notes on the zoning encountered in these places. It is possible to draw certain general conclusions about the comparative appearance of the shores of Tasmania and those of Australia. The major zones on exposed coasts in various parts of the Mainland and Tasmania are shown in Fig. 1.

(a) Queensland

There is very little information available from Queensland. The Queensland coasts can be divided into the coral reef areas and the semi-tropical areas of southern Queensland. The latter may have a zoanthid fauna and when they have been fully investigated it is probable that there will be a close similarity between the zones seen on these shores and those seen on the coasts of Natal as described by Eyre & Stephenson (1938).

The mangrove swamps of Queensland are not represented in Tasmania. There is no similar formation, with the possible exception of *Melaleuca* on some brackish water streams. The fauna of mangroves, as described by Fischer (1940*b*), is similar to that of the Supralittoral Fringe in Tasmania and species which are normally found living on rocks are to be found living on the roots, &c., of mangroves, e.g., *Bembicium melanostoma*. On a tropical rocky coast the species found living above the oysters are similar in appearance to species found on a similar shore in Tasmania. The fauna is composed of barnacles and littorinids. The species composition of the barnacle belt in Queensland is different from that in Tasmania, though some species are the same in both places. One interesting feature is that a considerable part of the shore is bare in both places, the fauna of the barnacle belt being largely confined to cracks in both places.

The oyster band, which forms a prominent feature of the coasts of Queensland, probably represents the *Galeolaria* belt in Tasmania. The oysters, *Ostrea mordax*, are found on semi-exposed and sheltered coasts and are visible from a considerable distance off-shore as a white band. Below the oyster band is a thin strip of large barnacles and oysters, e.g., on West Molle Island, and this is followed by a bare belt which often has a deposit of mud and silt on it. The muddy area continues as far down the shore as the lowest part of the Midlittoral. This latter area is occupied by the Alcyonarians, *Sarcophytum* sp. and *Lobophytum* sp. (? *palmatum*). The hard corals follow below the Alcyonarians and extend far down into the Infralittoral Region. The upper part of the hard coral belt is exposed at low tides, especially at springs and thus forms the Infralittoral Fringe. The species composition of the Infralittoral Fringe differs from that of the Infralittoral mainly in the absence of the typical 'stags horn' from the former zone. On a sheltered shore the barnacle belt is often absent and is replaced by a muddy shore with coral fragments and *Halimeda*. This in turn is replaced by a *Favia* belt which is above the Alcyonarian band. The *Favia* band corresponds to the lower parts of the Midlittoral in Tasmania, possibly the Patelloid belt. The Alcyonarian band corresponds to the mussel beds in Tasmania. Due to the greater tidal range in Queensland all the belts on the shore are wider than in Tasmania. This feature is especially noticeable in the Infralittoral Fringe where the corals form a strip up to 20 yards or more in width from the Alcyonarian belt. This is of course partly a feature of the reef forming corals which build up colonies from the substratum and only stop this growth when killed by excess exposure to the air.

It is interesting to note that animals are dominant over nearly all of a rocky shore in tropical Queensland, with the exception of a *Halimeda* belt on sheltered, muddy shores.

In semi-temperate Queensland, Johnston (1917) recognised at Caloundra Upper *Melaraphe, Chthamalus, Tetraclita rosea-Liolophasa* and *Sargassum-Ornithochiton zones*. This follows fairly closely the type of zonation found in New South Wales. The two upper zones resemble Tasmanian conditions but the lower parts of the shore have a closer affinity with New South Wales than Tasmania. In sheltered bays, e.g., Moreton Bay, the zoning is very similar to what might be encountered on a similar shore in Tasmania, i.e., *Melaraphe, Bembicium,* barnacles. There is frequently a *Nodilittorina* band above the *Melaraphe*. The lower parts of the shore are muddy, e.g., at Manly, and there is a tendency for lagoon conditions to appear with species such as *Zostera* and *Mictyris longicarpus*. The latter species frequents muddier places in Queensland than the Tasmanian *M. platycheles*.

On exposed coasts in semi-temperate Queensland, e.g., near Coolangatta, the shore superficially resembles Tasmanian conditions but the species composition is very different. The algae of the Infralittoral Fringe are mainly *Sargassum sps*. A Coralline band is well developed but is composed of encrusting *Lithothamnion*-like species. The *Jania* sps. are not as evident as in Tasmania, though this may be a matter of relative wave exposure.

In conclusion it can be said that the coastal conditions of Queensland do not resemble very closely those seen in Tasmania. In coral areas the shore at and below the oyster belt is very different from any shore to be seen in Tasmania. Oysters, Alcyonarians and hard corals replacing the *Galeolaria,* Patelloid, mussel and algal belts of Tasmania.

Temperate exposed coasts show a similarity of zones but the species composition is different. The degree of wave action experienced on the coasts of Queensland not protected by the Barrier Reef is probably greater than that encountered in any part of Tasmania with the exception of the West Coast.

The only resemblance between Tasmanian coasts and those of Queensland lies in the fauna of the upper part of the shore. The barnacle and littorinid belts show a marked similarity, if not in species at least in appearance and general poverty of population. Some Tasmanian species are found in the upper part of the shore in Queensland, e.g., *Melaraphe unifasciata, Bembicium melanostoma* and *Chthamalus antennatus.* Barnacle and littorinid zones are found on nearly all types of coast found in both States with the exception of very sheltered places in Tasmania. Mangrove swamps are absent from Tasmania but the amphibious element of the mangrove fauna corresponds to the fauna of the Supralittoral Fringe in Tasmania.

(b) New South Wales

The upper parts of the shore resemble the conditions seen in Tasmania. The fauna is poor in numbers and is dominated by Littorinids. *Nodilittorina tuberculata* forms a band above *Melaraphe unifasciata.* The former species is absent from Tasmania.

The exposed coasts of New South Wales differ very considerably from those of Tasmania. The salient feature of the New South Wales coast is the wealth of the barnacle fauna. Although there are not many more species than in Tasmania the density of population is very much greater, particularly in places with extreme wave exposure. Betsy Island is the only Tasmanian locality in which the numbers of the barnacle fauna compare favourably with the conditions seen in New South Wales, though on Betsy Island there is only one species forming a dense covering to the above. The species is *Chamaesipho columna.* In New South Wales there are 9 common species of barnacle, namely, *Tetraclita purpurascens, T. rosea, Chthamalus antennatus, Chamaesipho columna, Catophragmus polymerus, Elminius simplex, Balanus nigrescens, B. imperator* and *B. algicola.* The three last named species are largely restricted to the Infralittoral Fringe. In Tasmania there are only five species on wave exposed coasts, namely, *Catophragmus polymerus, Chthamalus antennatus, Chamaesipho columna, Elminius simplex* and *Tetraclita purpurascens. Elminius modestus* and *E. simplex* usually prefer more sheltered conditions. *Balanus trigonus* is rare in Tasmania. When it occurs, it is usually in the Infralittoral Fringe. If we compare the density of population of a species in Tasmania with that of the same species in New South Wales, it is seen that only *Catophragmus polymerus* reaches a similar density in both States. In this connection it is interesting to compare the plates of Dakin with those in my earlier papers on Tasmanian ecology.

The lower Midlittoral of a sheltered coast in New South Wales usually has a very well developed oyster band. This feature is absent from Tasmanian shores. Mangroves are found in estuaries in New South Wales but they are absent from Tasmania.

There is a very interesting inversion of two of the zones in New South Wales and Tasmania. In Tasmania *Galeolaria* occurs above the *Catophragmus* belt, but in New South Wales the reverse is true. The only possible reason offered for this alteration of habitat is that as the barnacle is approaching the end of its geographical range, it is forced to seek a less rigorous environment. *Catophragmus* being the relic of a tropical fauna (Fischer, 1940) would have to seek less exposure in order to be able to survive the cold of the winter nights to which it is exposed (Guiler, 1950).

The *Galeolaria* belt reaches its best development on sheltered coasts in both States. It is absent from exposed coasts in Tasmania but Dakin, Bennett & Pope describe the species as occurring on exposed shores in New South Wales. Conversation with Miss Pope revealed that their description of an exposed position would correspond to my description of an area with modified exposure. In spite of this difference in nomenclature it is obvious that the worm colonies in New South Wales reach a better degree of development in more exposed places than in Tasmania. In Tasmania the worm colonies are best developed on sheltered coasts where the incrustations are often up to 6 inches in thickness. In New South Wales these incrustations are found in more exposed places, e.g., Merewether. The greater exposure at Merewether is illustrated by a comparison of Dakin, Bennett & Pope, Plate V, Figure 2 (1948) with Plate I of Guiler 1951*d*. The formation and density of population of the worm tubes is remarkably similar in both places.

There is no Patelloid belt in New South Wales.

In many places in New South Wales the dominant form in the Infralittoral Fringe is *Pyura*. *Ecklonia* is dominant in other places with *Sarcophycus* appearing near the southern border of that State. In Tasmania *Pyura* is only rarely dominant being replaced by the *Coralline* and *Sarcophycus* belts. *Pyura* does not form a prominent feature of the shores of Tasmania. In places where the species is dominant it is usually found forming a series of clusters around the holdfast of *Sarcophycus*. The latter species forms the obvious feature of the shore.

It is not possible to compare sheltered coasts in Tasmania with similar shores in New South Wales, as very little work has been carried out describing the ecology of sheltered conditions in the latter State.

In conclusion, the Supralittoral Fringe of New South Wales closely resembles that of Tasmania in its general bareness. The presence of *Nodilittorina* of the coasts of New South Wales is a feature not found in Tasmania. The barnacle population of the Midlittoral in New South Wales is more dense than in Tasmania. Not only are there more species found on the Mainland but the density of population is very much greater than in Tasmania, where the cirripedes are frequently confined to semi-cryptic places. On sheltered coasts of New South Wales the presence of an oyster belt is a feature which is absent from Tasmania. The Infralittoral Fringe of exposed coasts in New South Wales is dominated by *Pyura-Ecklonia,* whereas in Tasmania the species are entirely algal, namely the Corallines and *Sarcophycus*. There is no Patelloid belt in New South Wales.

(c) Victoria

There is no literature describing Victorian intertidal conditions and it is not possible to make a detailed comparison of the Tasmanian and Victorian coasts. Pope (1951*b*) states that the Victorian coast shows conditions which are intermediate between those of New South Wales and Tasmania.

(d) South Australia

The only comprehensive information on the intertidal zones of South Australia is contained in the publications of Womersley and Edmonds. Johnston and Mawson (1946) give a very brief outline of the fauna of the Adelaide beaches. Womersley and Edmonds have both worked extensively on Kangaroo Island.

The salient feature of Kangaroo Island is that the algae are the dominant forms over most of the shore. Edmonds (1948, p. 175) states that the algae are the dominant species of the rock platforms but there are certain animal belts to be recognised. These belts are *Melaraphe, Chthamalus, Galeolaria,* Patelloid and mussel bands. *Catophragmus* is present in places with strong wave action, also a few *Balanus nigrescens.* The Infralittoral Fringe is populated by algae, of which *Cystophora, Sargassum* and *Ecklonia* are the dominant genera. *Pyura praeputialis* is not found in South Australia but *Boltenia australis* is present in the Infralittoral Fringe.

The fauna of Kangaroo Island intertidal region closely resembles that of a semi-exposed coast in Tasmania but the animal zonation may be obscured by an algal zoning. The presence of mussel beds in Kangaroo Island (*Brachyodontes rostratus*) as well as in Tasmania is of considerable importance. Similarly the presence of a Patelloid band in both States is of importance in assessing certain geographical affinities. *Sarcophycus* is confined to Tasmania as is the coral-like *Lithophyllum.* The Corallines are well developed in both areas.

Conclusion

Figure 1 shows the relation between the intertidal zones on an exposed coast in the various States of Australia with the exception of Western Australia and Victoria. This zonation is correlated with that of Stephenson & Stephenson (1949). It can be seen from the text and this table that with the exception of the barnacle and littorinid belts, the zones seen on the coasts of Tasmania and tropical Queensland are very different. These two belts are a universal feature of intertidal life. The coasts of the Mainland show greater affinity with Tasmania the nearer they are to that State, but probably the greatest resemblance is to be found in South Australia where the animal belts are the same as in Tasmania. It is possible that recent work in Victoria will show that the coasts of Victoria are ecologically similar to Tasmanian shores. The presence of mussel beds and *Sarcophycus* in Victoria shows that there is a considerable resemblance between the intertidal life of these two States.

Problems relating to the distribution of some species and some geographical considerations

(a) Barnacles

As noted in several parts of this paper the barnacle fauna of Tasmania is poor both in numbers and species. The only common species are *Chthamalus antennatus, Chamaesipho columna, Elminius modestus, E. simplex* and *Catophragmus polymerus. Tetraclita purpurascens* is found less frequently.

The barnacle fauna is found at its maximum development on semi-exposed coasts, where *Chamaesipho* and *Chthamalus* are plentiful. Fully exposed coasts do not support a prolific barnacle fauna but *Catophragmus* may be very numerous in a belt in the lower part of the Midlittoral. On sheltered coasts there as usually very few barnacles and these are often confined to semi-cryptic places. Some sheltered coasts are virtually devoid of cirripede belt, e.g., Oyster Cove.

A shore on which there is extensive but not heavy surf supports a good barnacle fauna. To experience such a surf a coast should be exposed to moderate action and the shore profile be a gentle slope which allows the waves to rush for some distance up the rocks. The dense barnacle growths at Betsy Island and Frying Pan Island have been described above.

Sun exposure does not seem to be one of the factors which limit the barnacle population. At Betsy Island the dense population of *Chthamalus* is on the sun-exposed side of the island and the barnacles experience the full effect of the sun, though this may be considerably modified by the amount of splash and spray received by the animals. At Sleepy Bay the barnacles live in small clusters which are often found on sun-exposed rocks, though at Blackman's Bay the barnacle population is most dense in places where there is some shelter from the sun. The principal evidence against sun exposure as a controlling factor in Tasmania lies in the fact that the same species of barnacles are found on the shores of New South Wales or Queensland where the sun exposure is greater than any encountered in Tasmania. In general in Tasmania barnacles do not seek shade from the sun except in half sheltered situations such as Triabunna, Oyster Cove and parts of Blackman's Bay.

Fischer (1940) suggests that the Australian littoral fauna is primarily tropical in its affinities and has been slowly acclimatized to cooler conditions by a gradual recession of the warmer water over a period of geological time. Further evidence for this is seen in the " inlier " of molluscs with New South Wales affinities in the Great Australian Bight as quoted by Hedley (1915). The summer on-shore flow of the warm Notonectian Current would help to maintain a warm water element in temperate seas by raising the sea temperature to a breeding temperature and also by bringing down larvae and/or adults from a warmer climate breeding stock. The plankton of Tasmania is warm water in nature and receives little cold water reinforcement (Fairbridge, 1949) which further supports Fischer's theory.

Further support for the tropical recession theory of Fischer is found in a statement by Kenny (1950) who says that there are no barnacles on Macquarie Island. This island is 600 miles south of Tasmania and situated well away from the influence of the warm tropical currents. The Southern Drift passes the island and effectively cuts it off from any Australian hydrological or biological influences. At some time in the past Macquarie Island may have had a barnacle fauna composed of Australian warm water elements. If such a fauna once existed there it failed to adapt itself to the cold conditions of the Southern Ocean and has become extinct. No reinforcements of Australian barnacle larvae can reach the island and a " barnacle vacuum " has been created. The vacuum cannot be filled by other species on account of the distance from other breeding stocks, possibly Heard Island, Kerguelen Island or Cape Horn. Because of this vacuum it seems possible that Macquarie Island once supported an Australian fauna. It might be pointed out that Macquarie Island is neither ice bound nor frozen over in winter so that ice action cannot affect the intertidal fauna.

It is noticeable that barnacles on the northern coast of Tasmania, e.g., at Burnie and Boat Harbour, are not only much larger but also more numerous than in the south and east of the island. The barnacles on the western coast are similar in size to those found in the south.

It has been inferred that the effect of cold winter nights combined with tidal effects is more harmful to intertidal animals than exposure to the summer sun. The persistent failure of barnacles to colonize rocks after successful spatfalls points to an unsuitable environment and has been attributed to cold winter nights.

It is suggested that Tasmania is at about the limit of cold toleration of the barnacles which are the relics of a warm water fauna. Warm waters wash the shores of Tasmania and it is the presence of this warm water than enables the barnacles to survive in Tasmania. Australian barnacles do not occur on Macquarie Island because the water is too cold. If the habitat were suitable it is probable that colonization would have been effected by larvae liberated from ships visiting the island, once an important sealing station. The barnacle vacuum on Macquarie Island may have been caused by the recession of warm water or by the recent geological appearance of the island, either of these factors combined with the distance of the island from a permanent barnacle breeding stock.

(b) Pyura

Pyura praeputialis is very plentiful on the exposed coasts of New South Wales, where it forms dense aggregations of individuals at the lower levels of the shore. Hedley (1915) recorded the species as being very common wave exposed places but Dakin, Bennett and Pope (1948) have modified Hedley's statement and found the species in oceanic waters with some wave action. Other workers have found related species of *Pyura* on wave exposed places in South Africa and New Zealand. Similarly, *Pyura chilensis* is common on the coasts of Chile.

There is little disagreement between any of the results from the above countries, but the distribution of *Pyura praeputialis* in Tasmania does not fully conform to any of the above conclusions. On most of the wave exposed coasts of Tasmania the species is rare. At the Freycinet Peninsula for example, there are about 2 ascidians on every 40 yards of shore. At Point Seymour the species is slightly more abundant. At both these places the density of population does not vary with the wave exposure. At Pirates Bay in South-Eastern Tasmania the species forms beds along the shore at the lowest tidal levels, but these beds are not in a position where they are exposed to heavy wave action. The wave action which they experience might be considerable but it would not be as much as they would experience on the ocean coast. It is probable that the distribution here agrees with that noted by Dakin, Bennett and Pope.

The species is rarely found forming beds in Tasmania on exposed coasts. Mr. Cribb tells me that it is found on the eastern shores of Port Arthur and I have found it forming beds on the exposed shore at Remarkable

Cave. These are the only two places where I know of the species being found on exposed coasts in large numbers.

In Tasmania the species is most common in places where there is sheltered water. We find it forming masses on the sheltered side of the Freycinet Peninsula, in Dunalley Canal, at Dodges Ferry, Carlton, on piles at Pittwater and on jetties throughout D'Entrecasteaux Channel. At the Freycinet Peninsula and possibly D'Entrecasteaux Channel the water is oceanic in character. Some parts of the Channel experience estuarine conditions and the ascidians are found in large numbers in such positions. At Pittwater there is considerable dilution of the water after rain and Dodges Ferry and Carlton experience a lesser degree of dilution. At Pipe Clay Lagoon the species lives in hypersaline water in the summer as the salinity has been recorded as high as 37 grs./mille.

Apart from one or two exceptions the largest beds of the ascidians are found in the more sheltered situations, most of them being without oceanic water. The ascidians are rare on exposed coasts.

In some exposed places the ascidian and *Sarcophycus* are in competition for space. The absence of this alga from the New South Wales coast may leave more space for colonization by the ascidian, but this does not explain the obvious preference of the species for sheltered places. Mr. R. Endean has suggested that the ascidian may have two ecological varieties, one found on a sheltered coast and the other living on exposed places. This possibility is being investigated at present.

Is the species reaching the end of its geographical range and seeking a more sheltered habitat in a similar fashion to *Ecklonia*?

(c) Mytilus

A salient feature of semi-exposed coasts in Tasmania is the presence of large beds of the mussel *Mytilus planulatus*. The beds are usually found in the lowest part of the Midlittoral. In South Africa *Mytilus perna* is a feature of exposed coasts but in Sydney, Hedley states that mussels do not form an important part of the intertidal region.

In Tasmania, if the mussels are found in beds, the species is very rarely found in the upper levels of the shore. If beds are not present, then mussels may or may not be found at high shore levels.

In wave sheltered places the mussels are found at various levels on the shore and do not usually form beds. In Barnes Bay the species is found at various levels on the shore as high as the upper limit of the tides. The mussels in this place are sheltered from the sun by high trees, but in other places in nearby inlets the mussels are found nearly as far up the shore but they are not sheltered from the sun.

If the mussels are capable of living at such high tidal levels, why are the mussel beds characterised by a sharp upper limit? Also, why are there no clusters of mussels on the shore at a higher level than the beds? On semi-exposed coasts the presence of a certain amount of spray would tend to assist the mussels to live at higher levels but the species is found furthest up the shore in sheltered places.

Similarly, why is there such a sharp limit to the lower level of the mussel beds? It has been suggested by Newcombe (1935) that starfish and carnivorous gastropods are responsible for the sharp lower limit of the beds of an American species of mussel. In Tasmania I doubt if there are a sufficient number of active intertidal predators to cause such a limit. The answer more probably lies in a modification of the conclusion of Kitching that slow growing perennials eventually dominate over large species.

GEOGRAPHICAL CONCLUSIONS

It is possible briefly to compare the intertidal region of Tasmania with that of New Zealand, South Africa and Chile. In making any such comparisons it is advisable for the worker to have seen the features of the countries being compared as there is a considerable difference in the interpretation of wave exposure by authors. The value of talks and personal visits has been shown in the conversation with Miss Pope noted previously. These conclusions must be treated with a certain amount of reservation but in the main, I think that certain features can be compared with accuracy.

(a) New Zealand

The most important literature describing the coasts of New Zealand is the works of Oliver (1923), Cranwell and Moore (1938), Beveridge and Chapman (1950), Ambler and Chapman (1950), Dellow (1950) and Chapman (1950). Several of these papers are confined to the algal communities but Oliver, Cranwell and Moore and Dellow give a picture of the animal zonation as well as that of the plants.

In many respects the shores of New Zealand closely resemble those of Tasmania. The Supralittoral Fringe in New Zealand is populated by lichens and Cyanophyceae with *Melaraphe* in the lower limits of the region. This is very similar to the conditions noted in Tasmania but is not the only resemblance as there is a *Chthamalus* belt which has *Actinia tenebrosa,* a Patelloid and *Porphyra* living in it (Cranwell & Moore). In other places *Chamaesipho columna* replaces *Chthamalus* and the algae are of greater importance (Dellow). *Hormosira* and the Corallines are both present in New Zealand. *Mytilus planulatus* and *M. canaliculatus* form beds in New Zealand with *Ulva, Pinnotheres, Plaxiphora, Turbo, Elminius plicatus* and *E. modestus, Cellana,* and *Sypharochiton pellis-serpentis,* e.g., at Taylor's Mistake (Oliver, 1923). These mussel beds in their generic and even their species composition closely resemble those of Tasmania.

It is interesting to note that there is also a *Modiolus pulex* association which is very similar to the Tasmanian *Brachyodontes rostratus* beds. These New Zealand mussels are found near high water mark, which is much higher than is the case with the Tasmanian species.

Under certain conditions of shelter from wave action there are oyster beds in New Zealand composed of *Ostrea cucullata.* This is the same species as is found at Sydney.

The *Galeolaria* beds of Tasmania are replaced by the *Hermella-Vermilia* associations as described by Oliver (1923) and Dellow (1950). Plate 48, Figure 2 of Oliver closely resembles the conditions found on Pipe Clay Lagoon.

Corallina, Hormosira, Xiphophora and the Patelloids are all found in New Zealand and form prominent bands on the shore. The genus *Sarcophycus* is absent from New Zealand but is replaced by *Durvillea* which looks very similar in appearance. *Durvillea* is found on the wave exposed coasts and occupies a similar niche to *Sarcophycus.*

From the accompanying table (Table V.) it can be seen that there are very close affinities between not only the appearance of the belts comprising the intertidal belts of Tasmania and New Zealand but in many cases the species are identical. There are some elements of the Sydney fauna and flora found in New Zealand, namely the Oyster belt and *Ecklonia*. *Ecklonia* appears to be better developed in New Zealand than in Tasmania as it is found in restricted areas in Tasmania. The oyster belt is absent from all coasts of Tasmania.

TABLE V

Zone forming species found on various types of coast in Tasmania and New Zealand.

(a) Tasmania	(b) New Zealand
Lichens	Lichens
Melaraphe	*Melaraphe*
Chamaesipho columna	*Chamaesipho columna*
Chthamalus antennatus	*Chthamalus antennatus*
Elminius modestus & *E. simplex*	*Elminius modestus* & *E. simplex*
Hormosira banksii	*Hormosira banksii*
Patelloids	Patelloids
Mytilus planulatus	*M. planulatus* & *M. canaliculata*
Brachyodontes rostratus	*Modiolus pulex*
Galeolaria	*Hermella*
—	*Ostrea*
Pyura	*Pyura*
Corallines	Corallines
Sarcophycus	*Durvillea*
Xiphophora	*Xiphophora*
Lessonia	*Lessonia* (in Sublittoral, Moore).
Ecklonia	*Carpophyllum-Lessonia* (Oliver)
	Carpophyllum-Ecklonia (Dellow)
Cystophora	?
Zostera	*Zostera*
Macrocystis	*Macrocystis*
Amphidesma (surf beaches)	*Amphidesma* (surf beaches)

The presence of the southern alga Durvillea in New Zealand is a feature which is not found in Tasmania, though *Sarcophycus* looks very much the same in both external appearance and habitat. *Durvillea* is only recorded from Tasmania as driftweed.

(b) South Africa

The most important literature dealing with the South African intertidal region is that published by a team of workers under the direction of Prof. T. A. Stephenson. These publications are Stephenson, Stephenson & duToit (1937); Bright (1938*a*-*b*); Stephenson, Stephenson & Bright (1938); Eyre & Stephenson (1938); Eyre, Broekhuysen & Crichton (1938); Eyre (1939) and Stephenson, Stephenson & Day (1940). This important survey is summarized in three papers by Stephenson (1939, 1944 and 1948). There are also several other papers on special topics connected with this survey but they do not directly concern this general comparison.

The *Littorina* and barnacle zones in South Africa have a very wide range, extending from Natal to the West Coast. This is similar to Australian conditions.

The temperate Indian Ocean coast and the East London area resemble New South Wales more than Tasmania because of the prevalence of *Pyura* in the Infralittoral Fringe. The occurrence of a widespread Patelloid zone in South Africa is more a Tasmanian feature than one with Mainland affinities. In view of the mixing of Patelloids and *Pyura* it is possible that this part of South Africa resembles the southern coasts of Victoria, where a mixing of Tasmanian and New South Wales features is found. It is also possible that False Bay (Eyre, 1939) has an equivalent area on the coast of New South Wales.

The Durban area resembles Queensland and does not come into the scope of this comparison.

The West Coast of South Africa (Bright, 1938*a*-*b*) & Stephenson, Stephenson and Day (1940), shows the greatest resemblance to Tasmanian conditions. *Macrocystis* is found off-shore and the algae of the Infralittoral Fringe are *Laminaria* and *Ecklonia*. The former occupies almost the same niche is *Sarcophycus,* but differs in the nature of the holdfast which is not sucker as in *Sarcophycus*. The presence of large amounts of *Ecklonia* is not a feature which can be shared with Tasmania because of the restricted distribution of that alga in Tasmania. In South West Africa there is a very well developed *Cochlear-Argenvillei* belt. This is the equivalent of the Patelloid belt in Tasmania.

Pyura is found in some places on the S.W. African coast. This might be a similar feature to that seen in Tasmania where the species is not widespread but is restricted to patches on exposed coasts. As noted above, it is very common in sheltered places in Tasmania.

Bright (1938*b*) reports that where there is heavy surf the mussels *Mytilus meridionalis* are encountered. This is a different habitat from that occupied by mussel beds in Tasmania but it is important to note that mussels form beds in S.W. Africa.

Oysters do not form a band in either S.W. Africa or Tasmania. The barnacles and littorinid belts are found in both countries though it appears from the literature that the barnacle belt in Africa is more densely populated than its Tasmanian equivalent.

(c) Chile

Macrocystis pyrifera is common off-shore on the west coast of Chile. *Durvillea* is widespread from Coquimbo around Cape Horn to the Atlantic Ocean (Etcheverry, personal communication). The genus *Lessonia* is also very common in Chile but is more sublittoral in nature. The zonation on an exposed Chilean coast is:—

Littorina peruviana or *L. araucana*
Barnacles
Corallines
Pyura chilensis
Durvillea antarctica

The resemblance between this type of zonation and that encountered in Tasmania is very close.

CONCLUSION

It can be seen from the above brief comparison that the intertidal zones of Tasmania, New Zealand, Chile and South-West Africa closely resemble each other in appearance. In several instances the species are the same, e.g., *Macrocystis pyrifera* is common to all countries, *Durvillea antarctica* is found in two countries. In other cases the genera are the same, e.g., *Mytilus*. There are other common features such as the presence of serpulid masses in sheltered waters and the distribution of *Ecklonia*. The presence of an oyster belt in New Zealand is the only character of that country not found in Tasmania.

There is a cold water flora and fauna of the character listed above extending round the southern end of the great continental masses of the Southern Hemisphere, and including the subantartic islands and New Zealand. In S. America, the Chilean coast falls into this belt, the South West African coast, New Zealand and Tasmania also fall into this belt. Ecologically the Tasmanian coasts have a greater affinity with New Zealand or Chile than with the shores of South Australia, though Tasmania and S. Australia are both in the Flindersian Region. This belt can conveniently be called the southern region of giant brown weeds and is characterised by the presence of large Phaeophytes, Patelloids, mussel beds and Corallines. The belt follows the distribution of *Durvillea* as shows by Fritsch (1945, Map 2).

The flora and fauna of the coasts of Tasmania, New Zealand, Chile and S.W. Africa are all cold water in nature. The low temperature of the waters of Tasmania and New Zealand are maintained by the colder seas while S.W. African seas are kept cold by an upwelling of cold water much in the same fashion as the Chilean coast is also kept cold. In South America the cold Humboldt Current enables the large brown weeds to survive as far north as California (Chapman, 1950). The presence of *Ecklonia* in New Zealand and S.W. Africa indicates that those waters may be slightly warmer than the seas round Chile and Tasmania. The following table illustrates the similarity in the zones to be seen on exposed coasts in the giant brown weed belt.

TABLE VI

Correlation of intertidal zones on nearly exposed coasts in Chile, Tasmania, S.W. Africa and New Zealand. The Chilean zonation is based on communications from Dr. Bahamande, Prof. Riveros-Zuñega, Dr. Etcheverry and Prof. H. Brattstrom.

Tasmania	*New Zealand*	*S.W. Africa*	*Chile*
Littorinids	Littorinids	Littorinids	Littorinids
Chamaesipho & Chthamalus	Chamaesipho & Chthamalus	Balanus	Chamaesipho & Balanus
Galeolaria	Hermilla	Pomatoleios	Serpulids
Corallines	Corallines	Corallines	Corallines
Sarcophycus	Durvillea	Laminaria	Durvillea
Macrocystis	Macrocystis	Macrocystis	Macrocystis

Acknowledgments

I am indebted to Professor V. V. Hickman for checking the typescript of this paper and for his interest throughout its preparation. I am also grateful to Prof. Riveros-Zuñega and Dr. Etcheverry of the University of Chile for information on the conditions on the coasts of that country and to Dr. Bahamande of the National Museum of Natural History of Santiago and Prof. Brattstrom of the University of Bergen for further information on Chilean conditions.

References

Ambler, M. P. & Chapman, V. J., 1950.—A quantitative study of some factors affecting tide pools. *Trans. Roy. Soc. N.Z.*, 78, 4, 1950, pp. 394-409

Beveridge, W. A. & Chapman, V. J., 1950.—The zonation of marine algae at Piha. *Pac. Sci.* 4, 3, 1950, pp. 188-201

Bright, K. M. F., 1938*a*.—The South African intertidal zone and its relation to ocean currents. II.—An area of the West Coast. *Trans. Roy. Soc. S. Afr.*, XXVI. 1, 1938, pp. 49-65.

————————, 1938*b*.—The South African intertidal zone and its relation to ocean currents. III.—An area on the northern part of the west coast. *Trans. Roy. Soc. S. Afr.* XXVI, 1, 1938, pp. 67-88.

Chapman, V. J., 1950.—Marine algal communities of Stanmore Bay. *Pac. Sci.* IV, 1, 1950, pp. 63-68.

————————, 1950*b*.—Seaweeds and their uses. London, 1950.

Cranwell, L. M. & Moore, L. B., 1938.—Intertidal communities of Poor Knight's Island. *Trans. Roy. Soc. N.Z.*, 67, 1938, pp. 375-406.

Curtis, W. M. & Somerville, J., 1947.—Boomer Marsh—a preliminary botanical and historical survey. *Pap. Roy. Soc. Tasm.*, 1947, pp. 151-157.

Dakin, W. J., Bennett, I. & Pope, E. C., 1948.—Some aspects of the ecology of the intertidal zone of the N.S.W. coast. *Austr. J. Sci. Res. Ser. B.* 1, 2, 1948, pp. 176-231.

Dellow, V., 1950.—Intertidal ecology at Narrow Neck. *Pac. Sci.* IV, 4, 1950, pp. 355-74.

Edmonds, S. J., 1948.—The commoner species of animals and their distribution on an intertidal platform at Pennington Bay, Kangaroo Island, South Australia. *Trans. Roy. Soc. S. Austr.*, 72, 1, 1948, pp. 167-177.

Eyre, J., 1939.—The South African intertidal zone and its relation to ocean currents. VII.—An area in False Bay. *Ann. Natal. Mus.*, 9, 2, 1939, pp. 283-306.

Eyre, J., Broekhuysen, G. J., & Crichton, M. I., 1938.—The South African intertidal zone and its relation to ocean currents. VI. The East London district. *Ann. Natal. Mus.*, 9, 1, 1938, pp. 83-112.

Eyre, J., & Stephenson, T. A., 1938.—The South African intertidal zone and its relation to ocean currents. V.—A subtropical Indian Ocean shore. *Ann. Natal Mus.*, 9, 1, 1938, pp. 21-46.

Fairbridge, W. S., 1949.—Fisheries in the *Handbook to Tasmania*, Hobart Meeting of *A.N.Z.A.A.S.*, 1949, pp. 67-76.

Fischer, P. H., 1940.—Notes sur les peuplements littoraux d'Australie. *Soc. de Biogeogr. Mem.* 7, 1940, pp. 279-329.

Fritsch, F. E., 1945.—The structure and reproduction of the algae. Vol. 2. 1945. *C.U.P.*

Guiler, E. R., 1950.—The intertidal ecology of Tasmania. *Pap. Roy. Soc. Tasm.* 1949 (1950), pp. 135-201.

————————, 1951*a*.—Notes on the intertidal ecology of the Freycinet Peninsula. *Pap. Roy. Soc. Tasm.*, 1950 (1951), pp. 53-70.

————————, 1951b.—Notes on the intertidal ecology of Eaglehawk Neck. *Pap. Roy Soc. Tasm.*, 1951.

————————, 1951*c*.—Marine life on Betsy Island. *Tasm. Nat.*, 2, 2, 1951, pp. 8-9.

————————, 1951*d*,—The intertidal ecology of certain sheltered areas in Southern Tasmania. *Pap. Roy. Soc. Tasm.*, 1951.

————————, 1951*e*.—The intertidal ecology of Pipe Clay Lagoon. *Pap. Roy. Soc. Tasm.*, 1950 (1951), pp. 29-52.

Hedley, C., 1915.—An ecological sketch of the Sydney beaches. *Proc. Roy. Soc. N.S.W.*, 49, 1915, pp. 15-77.

Johnston, T. H., & Mawson, P. M., 1946.—A zoological survey of Adelaide beaches. Handbook of South Australia, Adelaide Meeting, *A.N.Z.A.A.S.*, 1946, pp. 42-47.

Kenny, R., 1951.—The fauna of Macquarie Island. Lecture delivered at *A.N.Z.A.A.S.*, Brisbane meeting, 1951.

Macpherson, J. H., 1950.—Personal communication.

Newcombe, C. L., 1935.—A study of the community relations of the sea mussel, *Mytilus edulis* L. *Ecol.*, 16, 1935, pp. 234-243.

OLIVER, W. R. B., 1923.—Marine littoral and plant communities of New Zealand. *Trans. N.Z. Inst.*, 54, 1923, pp. 496-545.

POPE, E. C., 1943.—Animal and plant communities of the coastal rock platform at Long Reef, N.S.W. *Proc. Linn. Soc. N.S.W.*, 68, 1943, pp. 221-54.

——————, 1951*a*.—Lecture delivered before the Brisbane Meeting of *A.N.Z.A.A.S.*, 1951.

——————, 1951*b*.—Conversation at the Brisbane Meeting of *A.N.Z.A.A.S.*, 1951.

STEPHENSON, T. A., 1939.—The constitution of the intertidal fauna and flora of South Africa. Part 1. *J. Linn. Soc.* XL, 273, 1939, pp. 487-536.

——————, 1944.—The constitution of the intertidal fauna and flora of South Africa. Part 2. *Ann. Natal Mus.*, 10, 3, 1944, pp. 261-357.

——————, 1948.—The constitution of the intertidal fauna and flora of South Africa, Part 3. *Ann. Natal Mus.*, 11, 2, 1948, pp. 207-324.

STEPHENSON, T. A., & STEPHENSON, A., 1949.—The universal features of zonation between tide marks on rocky coasts. *J. Ecol.*, 37, 2, 1949, pp. 289-305.

STEPHENSON, T. A., STEPHENSON, A., & DAY, J. H., 1940.—The South African intertidal zone and its its relation to ocean currents. IV.—The Port Elizabeth district. *Ann. Natal Mus.*, 9, 1, 1938, pp. 1-19.

STEPHENSON, T. A., STEPHENSON, A., & DAY, J. H., 1940.—The South African intertidal zone and its relation to ocean currents. VIII.—Lambert's Bay and the West coast. *Ann. Natal Mus.*, 9, 3, 1940, pp. 345-80.

STEPHENSON, T. A., STEPHENSON, A., & DU TOIT, C. A., 1937.—The South African intertidal zone and its relation to ocean currents. I.—A temperate Indian Ocean shore. *Trans. Roy. Soc. S. Afr.*, 24, 4, 1937, pp. 341-382.

WOMERSLEY, H. B. S., 1947.—The marine algae of Kangaroo Island. I.—A general account of the algal ecology. *Trans. Roy. Soc. S. Austr.*, 71, 2, 1947, pp. 228-252.

——————, 1948.—The marine algae of Kangaroo Island. II.—The Pennington Bay region. *Trans. Roy. Soc. S. Austr.*, 72, 1, 1948, pp. 143-166.