SHELLY BEACHES ON THE VICTORIAN COAST

By ROBERT A. GELL*

ABSTRACT: The accumulation of biogenic sediment on the Victorian coast to form shelly beaches depends upon the availability of shelly debris and therefore on the ecology and local population densities of contributing species (Table 1). Shallow marine embayments and estuaries, shore platforms and offshore reefs are areas where shelly beaches are often found.

Shelly beaches exist either as a veneer over sandy material or as a thick deposit consisting solely of shells and shell debris. As the shells are usually fragmented and worn, species identification is difficult. Shelly beaches are deposited by constructive wave energy, and are often concentrated locally by wave refraction, or by storm waves at higher water levels; they are often associated with accumulation forms such as spits, tombolos, cheniers and swash bars.

INTRODUCTION

Shelly beaches are infrequent on the coast of Victoria (Fig. 1). Littoral sediments are composed of quartz with a variable concentration of sand-sized biogenic material which may account for more than 50 percent of the sediment on beaches west of Wilsons Promontory. Shepard (1973, p.132) states that shelly beaches are rare in high latitudes, except where terrigenous material is scarce; in general temperate beaches are of quartz. Raymond and Stetson (1932) attributed the development of a shelly beach on the coast of Maine to a lack of terrigenous mineral sand; and similarly on the Melbourne coast, beaches are becoming progressively more calcareous after construction of sea walls has reduced cliff erosion and diminished the terrigenous sand supply to the beaches (Bird 1970). Leontiev and Khalilov (1976) report that the carbonate content in sediments of the eastern shore of the Caspian Sea is 80 to 90 percent, and that shelly material on the western coast varies from 10 to 50 percent and sometimes reaches 80 to 90 percent. Mamykina and Khrustalev (1976) report that in the Sea of Azov, four million tons of shelly material were delivered to the shoreline annually: shell productivity is related to the volume of dissolved calcium carbonate entering from the Don and Kuban rivers. As a result, beach bars at river mouths composed of sands had 70 to 80 percent shell content. Other descriptions of shelly beaches in extra-tropical areas include Zenkovich (1976, p.115), Watson (1971) and Keary (1968) who correlates biogenic carbonate content with degree of exposure to prevailing winds and consequently to waves.

MORPHOLOGY AND FORMATION

The components of beach deposits on the Victorian coast depend upon the availability of various kinds of source material. Beach material may be derived from eroding coastlines, from rivers that deposit sediment at the coast, from alongshore by lateral beach drifting, or from the sea floor, swept landward by wave action. At a number of localities along the Victorian coast, calcareous remains of marine organisms, both modern and fossil have accumulated to form shelly beaches (Pl. 23, (1), (2)). Description of a beach as 'shelly' has been a subjective classification because of variations in beach morphology and composition, but in this paper the term refers to beaches visibly dominated by broken or entire shell material greater than sand-size diameter. Zenkovich (1967, p.76) uses the term shell debris to describe organic elements such as shells and shell fragments and the remains of other organisms in beach material, and shell gravel to describe material which is broken, graded and sometimes rounded. Some shelly beaches are only a veneer of shells on a quartzose or calcareous sandy beach; others are composed almost entirely of shells and shelly debris, as in Bridgewater Bay (Pl. 24 (3), (4)), and along the muddy shorelines on the northern side of Westernport Bay.

Because of the high permeability of coarse

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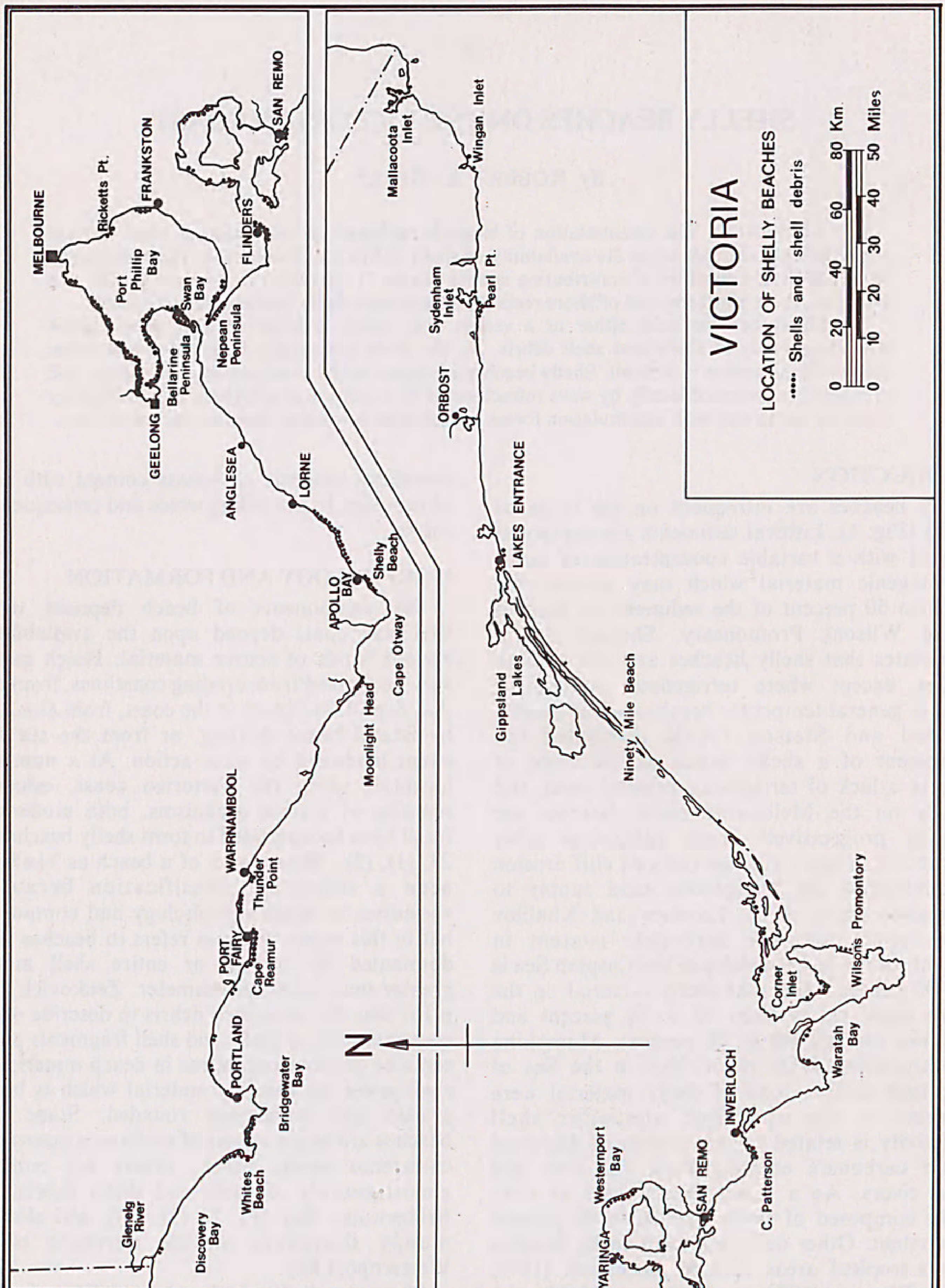

FIG. 1 — Location of Shelly Beaches on the Victorian Coast.

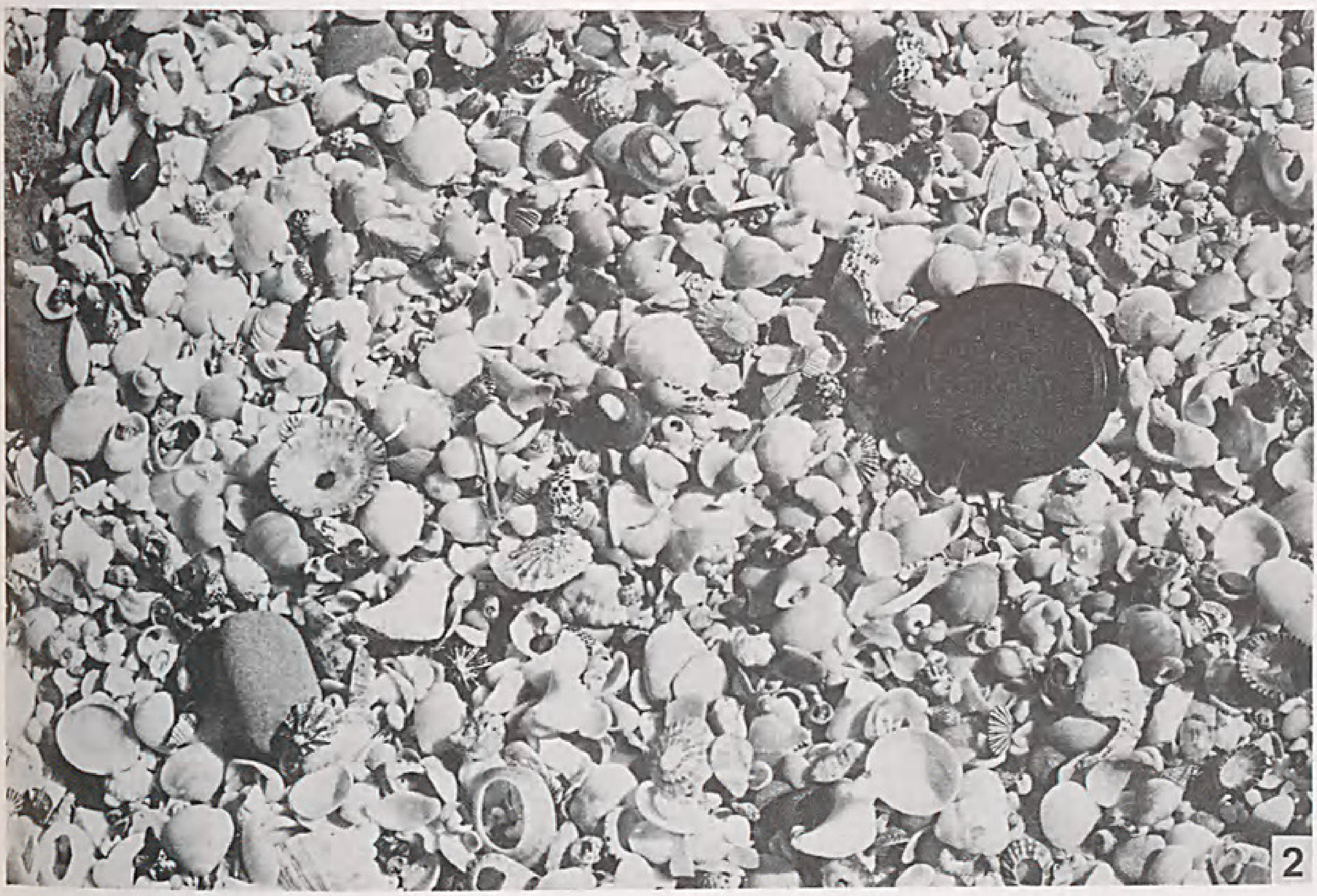

PLATE 23
(1) 'Shelly Beach' near Elliott River, Otway Coast, showing deep shell drifts behind arkosic shore platform.
(2) Shell debris and pebble accumulation at 'Shelly Beach' near Elliott River, Otway Coast.

PLATE 24
(3) 'Shelly Beach', Bridgewater Bay near Portland.
(4) Shells and shell debris at 'Shelly Beach', Bridgewater Bay.

material, shelly beaches are more affected by wave swash than by backwash. Shells are moved up the beach by the swash but the backwash is rarely strong enough to move them back down the beach face, and so they accumulate. Backwash is effective in sorting shelly sediment so that the largest shells remain on the surface overlying the smaller fragments. Shelly beaches are also sorted across the beach as waves move the large particles up the shore to accumulate on the upper beach, and the smaller particles are displaced down the slope by the backwash. This further enhances the concavity of the beach profile. Aeolian deflation is effective in sorting shell material from sand on Padre Island, Texas (Watson 1971), and is evidence that large carbonate accumulations can occur in areas of great terrigenous sediment supply; in most cases a large terrigenous sediment supply causes reduced carbonate content. Rusnak *et al.* (1966), working on the Florida coast showed that low concentrations of shell material near Jacksonville were attributable to erosion of carbonate-poor 'older' dune sands whilst beaches of south Florida which receive little quartz sand from northern flood plains have higher values.

Shelly beaches are found only where there has been a sustained supply of shells on the shoreline. The available habitat for marine molluscs at different localities along the shoreline and offshore regulates the population density of contributing species available for incorporation in beaches (Table 1). Extensive molluscan populations supply nearby beaches with a large volume of shells. In the southern United States the carbonate content of beach and dune sediments is controlled by the availability of materials and also by wave energy, with the carbonate fraction small on the low wave energy coast of Georgia, increasing to the north where energy is higher, and greatly to the south where large amounts of biogenic carbonate material are available (Giles & Pilkey 1965).

Where shelly material is exposed to high wave energy disintegration and comminution to calcareous sand occur (Davies 1972, p.113). This is the case at Whites Beach near Cape Duquesne where the beach consists entirely of shell fragments of coarse sand size, 1.0 — 2.0 mm. Shells at Thunder Beach, Warrnambool, are fragmented and worn; the fragile shells have been reduced to sand-sized particles, and only the stronger segments of gastropods, such as the columellas and operculums of *Subninella undulata* (Solander 1786) remain as large recognisable fragments of molluscs. These fragments are mixed with sand and sandstone pebbles by waves breaking on the beach. By contrast the low wave energy shores of Westernport Bay have shelly beaches on which delicate shells such as *Pholas australasiae* (Sowerby 1849) remain intact. They have been swept onshore by waves to accumulate as a veneer of whole shells, either on the wave-cut clay platforms or over the existing beach material of coarse quartz sand, so that the shelly zone remains a separate entity.

Shelly beaches are frequently found on cuspate spits and tombolos, where reduction of wave energy by refraction enhances sediment accumulation. For example, on the Otway coast where rocky shorelines provide suitable habitats for a wide variety of molluscs, small cuspate spits and tombolos are often found in the lee of offshore reefs, consisting of shells or shelly veneers on sand or gravel. Wave refraction in Kitty Miller Bay on the south coast of Phillip Island reduces wave height at each end of the beach, and the resulting waves cause the accumulation of shelly material from nearby rocky shores along the limit of swash at high tide. Bridgewater Bay near Portland in western Victoria is a shallow sandy bay which contains numerous offshore reefs with associated algal growth. These provide a habitat for a large number of pelecypods and some gastropods. Constructive wave action moves shells on to the shoreline, and extensive shelly deposits have formed. These are frequently associated with calcarenite headlands like those which occur at 'Shelly Beach', where wave refraction around reefs causes the construction of deep shell drifts in sectors adjacent to shoreline, and headland features where wave height is reduced (Pl. 24 (3)).

There are a variety of structural traps in the coastal zone which retain sediment, particularly shells. Irregularities within a shore platform may be sites of accumulation of shelly debris. The arkosic shore platforms of the Otway coast have a rectangular jointing pattern, with joints often marked out as ridges as a result of ferruginization along the joint planes. These ridges form an effective shell trap. Shore platforms in the aeolian calcarenite of the Nepean Peninsula have surface features such as lapiës and potholes which trap shells migrating across the platform, and large rock pools provide a sink for all debris including shells. At Pearl Point, near Sydenham Inlet, the shore platform is cut in steeply dipping Ordovician sandstones which strike north/south, and differential erosion has produced a series of parallel strike ridges with channels almost at right angles to the wave crests. Shells and pebbles are trapped within these channels, and large gastropods accumulate to depths of 20 cm. On similar high wave energy coasts shells may be moved on to the backshore in large volumes where a cleft in the shore platform constricts waves and produces strong currents which can lift material from the sea floor onto the beach behind.

Beaches at Cape Reamur and Killarney near Port Fairy are built behind extensive and intricate shore platforms and offshore reefs of Newer Basalt. The platform and reefs absorb wave energy and provide suitable habitats for a variety of small gastropods. The columnar morphology of the basalt platforms intercepts shells in basins between the joint planes, and these shells are later distributed on to the beaches behind. Columnar jointing of basalt in shore platforms at Cat Bay on Phillip Island traps shells in the same manner. Artificial structures such as groynes and jetties influence wave refraction and the longshore drifting of sediment, and can also act as shell traps.

The low wave energy coasts of Port Phillip and Westernport Bays have numerous shelly sectors. Swan Bay and Corio Bay are sheltered areas with shallow, muddy floors which support large populations of molluscs. Most of the beach deposits on the northern shore of Corio Bay consist entirely of small shells (Pl. 25 (5)); at Avalon the shells are mixed with a fine white quartz sand, and along the whole northwest coast of Port Phillip Bay shelly strand lines of large shells may accumulate after storms to heights up to 25 cm above the former beach surface. Other accumulation forms in the area, such as the paired spits at the mouth of Limeburners Bay, 'The Island' and 'The Sand Hummocks' (Pl. 26 (7)), and the Point Henry spit, are composed almost entirely of shells, and the shallow depositional shores of Mud Islands have extensive accumulations of shelly debris. The northern part of Westernport Bay is another low wave energy mudflat habitat. Parts of the shore here are scalloped in plan, and longshore drift has concentrated shells and coarse sand from local rivers in pockets along the coast. The shells are easily transported shoreward from the bay floor to form a veneer on the muddy shoreline at the limit of wave swash. Frequently two parallel strand lines are found on one beach, the result of reworking by waves at higher high tide and lower high tide during a twenty-four hour period (Gell 1974), (Pl. 25(6)). In the Sea of Azov, Zenkovich (1967, p.115) observed shoreward movement of shells from the muddy bottom after the bottom material had been stirred up, and the author has observed that accumulation rates are accelerated at periods of higher wave energy during storms. Shelly strand lines up to 15 cm in height may be built at the rear of a bay and shells swept into the salt marsh during storms at high spring tide form cheniers (Pl. 26(8)). Van Straaten (1952) explains that shell beds intercalated between marsh deposits in the Dutch Wadden Sea formed in this way during gales, when the water level rises well above mean high tide and mollusc valves are washed on to the marsh surface. These shell beds are typical elements of sea built levees in the area and lens out over a few metres when traced landward.

The importance of estuaries and other shallow marine areas as a sheltered habitat for molluscs is evident on the East Gippsland coast. There are few local concentrations of shells on the ocean beaches apart from beaches adjacent to large estuaries. Mallacoota, Wingan and Sydenham Inlets provide a more sheltered muddy habitat for the shells which have accumulated along the shores of these estuaries and a local source for shell accumulations on ocean beaches. On the Florida coast widely divergent values of average shell content are attributable to carbonate-rich inlet areas which have a high standing crop of shell forms and contribute a higher percentage of shell than a normal beach (Rusnak *et al.* 1966).

Accumulations of shelly material at the shoreline need not necessarily be derived from recently living molluscs. Fossil marine shell beds of the kind exposed in Swan Bay are locally a plentiful source of shelly beach material similar in origin to calcareous beaches in Scotland (Raymond & Hutchins 1932). Much of the shell material behind the basalt boulders at Cape Reamur may be material reworked from emerged shell grit terraces (Gill 1973). Aboriginal kitchen middens, common on the Victorian coast, are another source of shells, delivered to the shoreline where dune middens have been exposed by wave attack. Gill (1951) has established criteria for distinguishing between marine shell beds and coastal kitchen middens *in situ*, but the distinction may be less obvious once the shell material is incorporated into a shelly beach: the reworking of southern New South Wales coastal midden deposits by storm waves has been described by Hughes and Sullivan (1974). Some of the shells delivered to the northern shoreline of Westernport Bay appear to have been eroded out by currents from a marine shellbed which extends beneath the inter-tidal and sub-tidal mud-flats, and is locally exposed in meandering tidal channels (Miles 1976).

DISTRIBUTION AND SPECIES CONTENT

The distribution and relative abundance of extant molluscs found in Victorian shelly beaches is

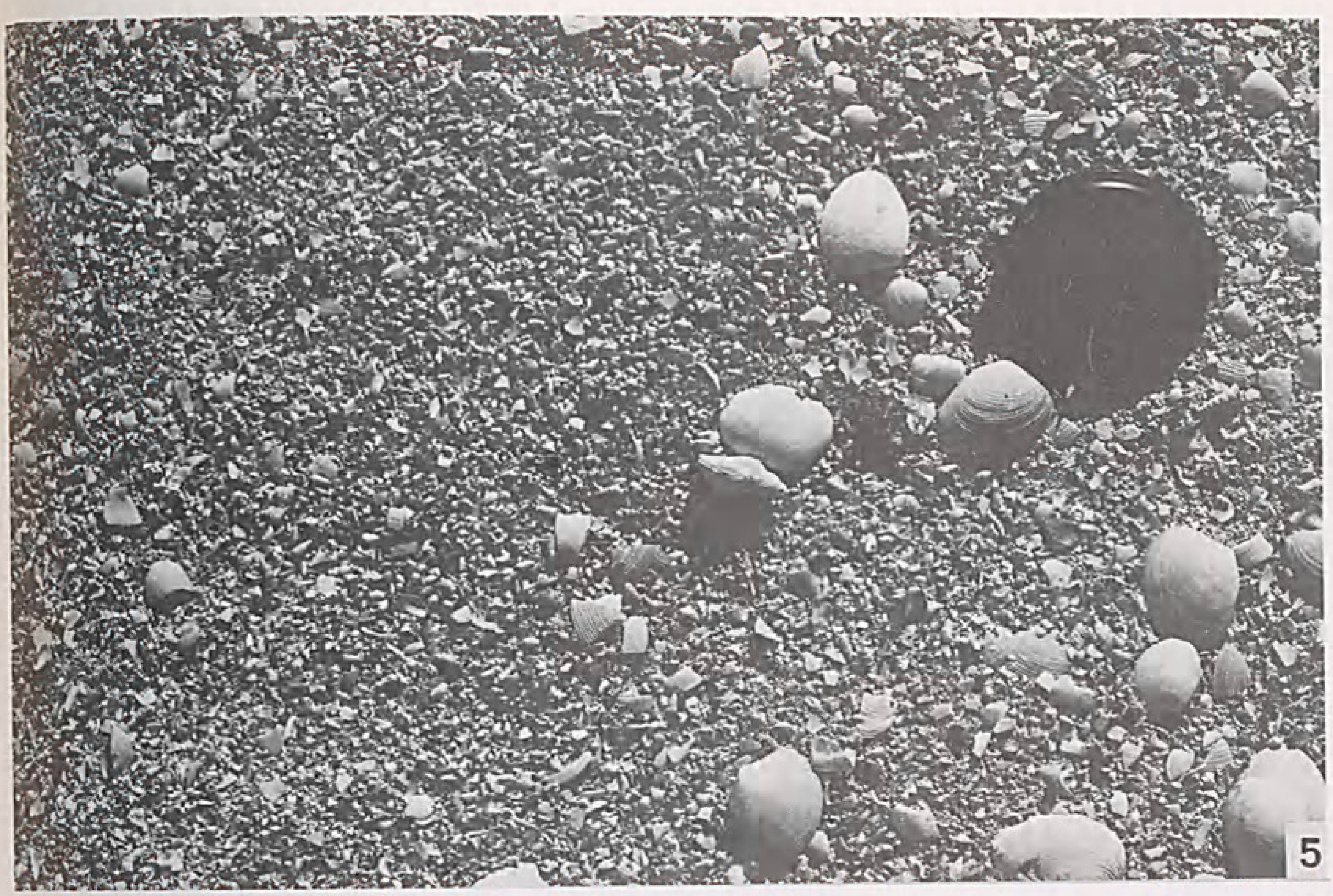

PLATE 25

(5) Accumulation of small shells at 'The Island' on the northwestern shore of Port Phillip Bay.

(6) Strandlines at the higher tide mark and lower high tide mark, northeastern Westernport Bay. Shelly cheniers are evident on the salt marsh surface behind bays.

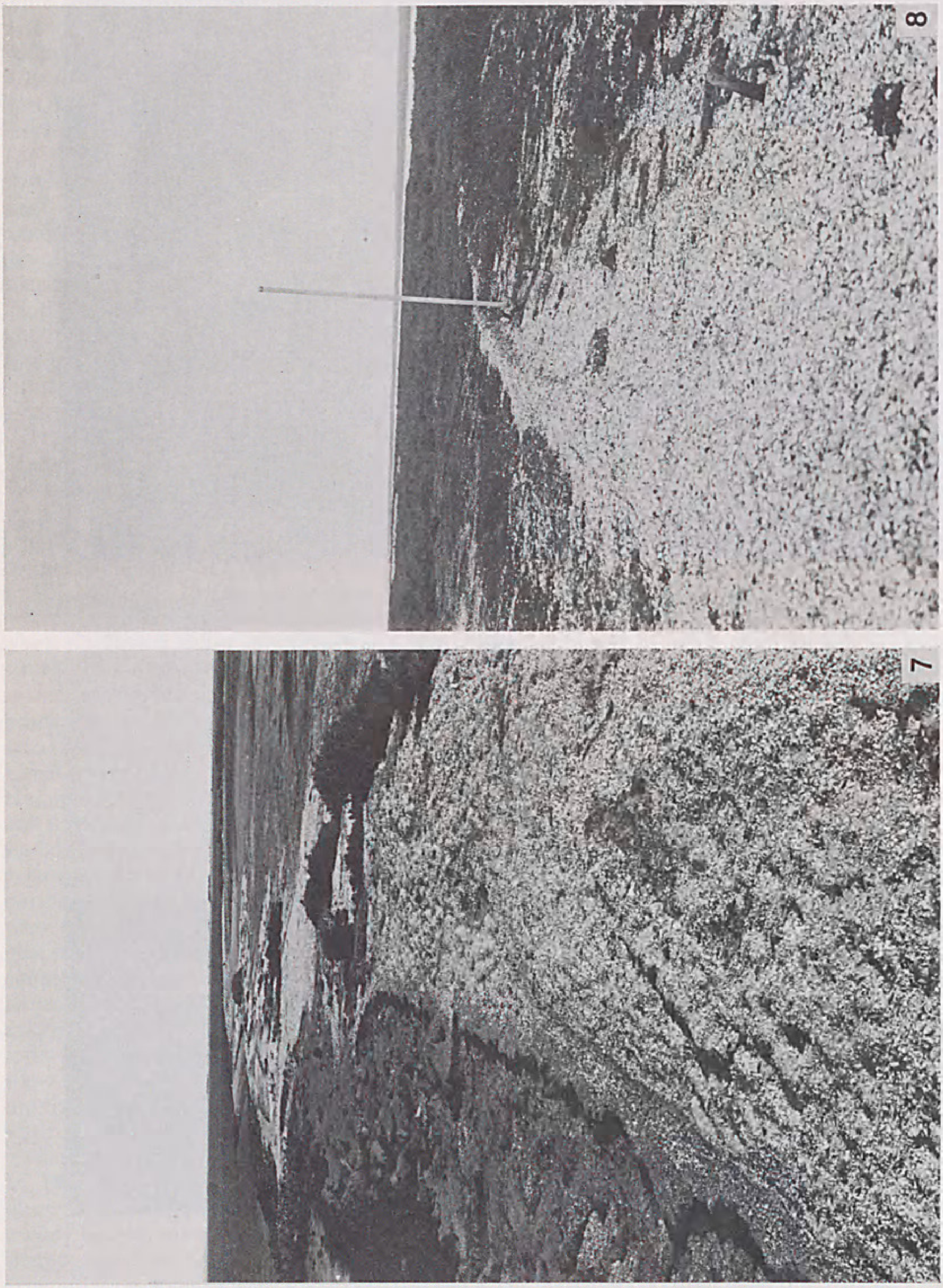

PLATE 26
(7) Shelly shore of 'The Island' on the northwestern shore of Port Phillip Bay.
(8) Shell strand on northeastern Westernport Bay shore.

TABLE 1

DISTRIBUTION AND RELATIVE ABUNDANCE OF SHELL SPECIES IN SHELLY BEACHES ON THE VICTORIAN COAST.

Amphineura | ← Gastropoda →

SAMPLE LOCATIONS	MOPALIIDAE Poneroplax sp.	ISCHNOCHITONIDAE Ischnochiton sp.	HALIOTIDAE Haliotis ruber *	Haliotis emmae *	Haliotis roei *	Haliotis laevigata *	FISSURELLIDAE Scutus antipodes	Notomella candida	Montfortula rugosa	Hemitoma subemarginata	Amblychilepas javanicensis	Amblychilepas nigrita	Macroschisma tasmaniae	Macroschisma producta	Elegidion audax
HABITAT	Ri	Ri	Rs	Rs	Rs	Rs	Rs	Rs	Ri	Rs	Ri	Ri	Ri	Ri	Ri
DISCOVERY BAY															
WHITES BEACH							•								
BRIDGEWATER BAY	·										●				
SHELLY BEACH (BRIDGEWATER)	·										●				
PORTLAND BAY			●	·	·										
CAPE REAMUR - PORT FAIRY		·	●					·	·						
THUNDER BEACH		·	⬤												
MOONLIGHT HEAD															•
SHELLY BEACH (OTWAYS)		·									•	·		•	
APOLLO BAY - SKENES CK.	•	•	•				•								
KENNETT RIV - LORNE	·	·	•				•								
SWAN BAY & ENVIRONS															
BELLARINE PENINSULA															
NORTHWEST PORT PHILLIP BAY															
RICKETTS POINT - BEAUMARIS			●												
FRANKSTON - LONG ISLAND															
DROMANA - McCRAE															
TYRONE FORESHORE															
COLLINS BAY			●	·		·								•	
MUD ISLANDS															
NEPEAN OCEAN COAST	·		●	·		•	·				•			·	
FLINDERS	·		●												
SHOREHAM															
STONY POINT - YARINGA															
NORTHEAST WESTERNPORT															
WESTERN PHILLIP ISLAND			•							•			·		
SHELLY BEACH (SAN REMO)	·	·	•												
CAPE PATTERSON			•												
INVERLOCH		·													
WARATAH BAY															
WILSON'S PROMONTORY															
CORNER INLET															
NINETY MILE BEACH			·												
LAKES ENTRANCE															
PEARL POINT															
WINGAN INLET & ENVIRONS			•												
MALLACOOTA INLET & ENVIRONS															

SAMPLE LOCATIONS	PATELLIDAE Patellanax peroni	Patellanax chapmani	Cellana tramoserica	ACMAEIDAE Patelloida alticostata	Patelloida victoriana	Notoacmea sp.	TROCHIDAE Herpetoma aspersa	Stomatella imbricata	Calliostoma spp.	Cantharidus spp.	Phasianotrochus sp.	Bankivia fasciata	Austrocochlea spp.	Clanculus spp.
HABITAT	Ri	Ri	Ri	Ri	Ri	Ri	Rs	Rs	Rs	Rs	Rs	Rs	Ri	Rs
DISCOVERY BAY					•									
WHITES BEACH			●	•										
BRIDGEWATER BAY												⬤		
SHELLY BEACH (BRIDGEWATER)					•	·						●	·	
PORTLAND BAY			•			•					·			
CAPE REAMUR - PORT FAIRY	·		●			•	·			•	•		•	•
THUNDER BEACH			•		•	·							•	
MOONLIGHT HEAD	•		●	•	●								•	
SHELLY BEACH (OTWAYS)		·	•	·	●					·			•	
APOLLO BAY - SKENES CK.			•	·	•				·				●	
KENNETT RIV - LORNE			●		•					•	·		●	
SWAN BAY & ENVIRONS														
BELLARINE PENINSULA														
NORTHWEST PORT PHILLIP BAY													•	
RICKETTS POINT - BEAUMARIS			•										•	
FRANKSTON - LONG ISLAND														
DROMANA - McCRAE														
TYRONE FORESHORE			•											
COLLINS BAY										•	•		●	
MUD ISLANDS														
NEPEAN OCEAN COAST			●	•						•	•		●	
FLINDERS			●						·	●	•	•	●	
SHOREHAM			•										●	
STONY POINT - YARINGA														
NORTHEAST WESTERNPORT									•	•			•	•
WESTERN PHILLIP ISLAND			●	•			•	·		•			⬤	·
SHELLY BEACH (SAN REMO)			●	·						•	·		●	
CAPE PATTERSON			•		·				•	•			●	·
INVERLOCH			·											
WARATAH BAY														
WILSON'S PROMONTORY			·											
CORNER INLET														
NINETY MILE BEACH			·	·								●		
LAKES ENTRANCE														
PEARL POINT														
WINGAN INLET & ENVIRONS			·			·						•	•	
MALLACOOTA INLET & ENVIRONS													·	

SAMPLE LOCATIONS	TURBINIDAE Subninella undulata	Phasianella australis	Phasianella ventricosa	Phasianella variegata	NERITIDAE Nerita atramentosa +	LITTORINIDAE Littorina unifasciata +	Littorina praetermissa +	Bembicium nanum	Bembicium auratum	TURRITELLIDAE Ctenocolpus australis	Gazameda gunni	POTAMIDIDAE Pyrazus ebininus	Velacumantus australis	Zeacumantus diemenensis	CERITHIIDAE Diala monile	SCALIDAE Granuliscala granosa	Opalia australis	STILIFERIDAE Stilifer sp.
HABITAT	Rs	Rs	Rs	Rs	Ri	Ri	Ri	Ri	Ri	Rs	Ss	Si	Si	Si	Si	Ri	Ri	Ss
DISCOVERY BAY																		
WHITES BEACH																		
BRIDGEWATER BAY																		
SHELLY BEACH (BRIDGEWATER)																		
PORTLAND BAY	●	•	•	•														
CAPE REAMUR - PORT FAIRY	●			•	●	•	·	·						•		•	●	
THUNDER BEACH	⬤																	
MOONLIGHT HEAD	●																	
SHELLY BEACH (OTWAYS)	●		·					·									•	
APOLLO BAY - SKENES CK.	●		•														•	
KENNETT RIV - LORNE	●																	
SWAN BAY & ENVIRONS														⬤				
BELLARINE PENINSULA													⬤	●	●			
NORTHWEST PORT PHILLIP BAY													●	●	·			
RICKETTS POINT - BEAUMARIS	●																	
FRANKSTON - LONG ISLAND																		
DROMANA - McCRAE																		
TYRONE FORESHORE																		
COLLINS BAY	●	•	·	•														
MUD ISLANDS		·	·											·				
NEPEAN OCEAN COAST	●					•			•									
FLINDERS		·	·	·	•				●									
SHOREHAM									⬤									
STONY POINT - YARINGA																		
NORTHEAST WESTERNPORT														●				·
WESTERN PHILLIP ISLAND			•		•				•					•				
SHELLY BEACH (SAN REMO)	•		·	·	·												·	
CAPE PATTERSON	•				●									·				
INVERLOCH																		
WARATAH BAY											·							
WILSON'S PROMONTORY											•							
CORNER INLET										·				•				
NINETY MILE BEACH											·							
LAKES ENTRANCE											●	•						
PEARL POINT																		
WINGAN INLET & ENVIRONS											•	⬤						
MALLACOOTA INLET & ENVIRONS	•								•		•	●		●				

NB. Taxonomy follows that of Macpherson and Gabriel (1962) except where indicated * Shepard, S.A. 1973
+ Underwood, A.J. (1974).

KEY TO SCALE OF RELATIVE ABUNDANCE

Rare	1%	·
Occasional	1-10%	•
Frequent	10-45%	●
Very frequent	45%	⬤

KEY TO HABITAT TYPE OF EXTANT SPECIES

Rocky substrate:	intertidal	Ri
	subtidal	Rs
Soft substrate:	intertidal	Si
	subtidal	Ss
Free swimming:		F

TABLE 1 (Continued)

DISTRIBUTION AND RELATIVE ABUNDANCE OF SHELL

Gastropoda

SAMPLE LOCATIONS	CALYPTRAEIDAE	NATICIDAE				CYPRAEIDAE		CASSIDIDAE			CYMATIIDAE					MURICIDAE			THAIDAE				COLUMBELLIDAE		BUCCINIDAE					NASSIDAE			FASCIOLARIIDAE				MITRIDAE				VOLUTIDAE			CANCELLARIIDAE			TURRIDAE	CONIDAE	
	Sigapatella calyptraeformis	Polinices conicus	Polinices sordidus	Mammilla melastoma	Sigaretotrema umbilicata	Notocypraea spp.	Ellatrivia merces	Antephalium semigranosum	Xenogalea spectabilis	Xenogalea nivea	Cymatiella spp.	Mayena australasia	Cabestana spengleri	Monoplex australasiae	Charonia rubicunda	Pterynotus triformis	Bedeva paivae	Maculotriton australis	Lepsiella reticulata	Lepsiella vinosa	Agnewia tritoniformis	Dicathais spp.	Dentimitrella semiconvexa	Dentimitrella pulla	Austrosipho grandis	Austrosipho waitei	Cominella eburnea	Cominella lineolata	Tasmeuthria clarkei	Parcanassa pauperata	Parcanassa burchardi	Niotha pyrrhus	Dolicholatirus spiceri	Pleuroploca australasia	Fusus novae-hollandiae	Fusus australis	Austromitra tasmanica	Eumitra australis	Eumitra badia	Bamitra glabra	Lyria mitraeformis	Mamillana mamilla	Amorena undulata	Sydaphera lactea	Sydaphera undulata	Nevia spirata	Epidirona quoyi	Floraconus anemone	Parviconus rutilus
HABITAT	Rs	Si	Si	Si	Si	Rs	Rs	Ss	Ss	Ss	Ss	Ri	Rs	Rs	Ri	Rs	Rs	Rs	Ri	Ri	Rs	Ri	Ss	Rs	Ss	Ss	Si	Rs	Rs	Si	Si	Si	Ss	Ss	Ss	Ss	Ss	Si	Si	Ss	Si	Ss	Ss	Si	Si	Si	Rs	Rs	Rs
DISCOVERY BAY										•												●																											
WHITES BEACH																						⬤																											
BRIDGEWATER BAY																						●																											
SHELLY BEACH (BRIDGEWATER)		●																										●																•	•				
PORTLAND BAY													●																																			●	
CAPE REAMUR - PORT FAIRY						●					●							•	•	•		●	•					⬤											•	•				•				⬤	
THUNDER BEACH											•											●						●										•		•								●	
MOONLIGHT HEAD																						●																											
SHELLY BEACH (OTWAYS)		•				●					●		●						•		•	⬤						⬤										●	●						●			●	
APOLLO BAY - SKENES CK.	●						●				●		●							●		●						⬤																			•	⬤	
KENNETT RIV - LORNE	•										●		●							●		●						⬤															•					●	
SWAN BAY & ENVIRONS			⬤														•		●		•								●					●									●						
BELLARINE PENINSULA		●			•												●				●				•			●																					
NORTHWEST PORT PHILLIP BAY			●													•	●								•		●																						
RICKETTS POINT - BEAUMARIS																												●																					
FRANKSTON - LONG ISLAND																																																	
DROMANA - McCRAE																																																	
TYRONE FORESHORE																																																●	
COLLINS BAY			●			●	•				•		●			•						•						•		•		•		●							•		●			•		⬤	
MUD ISLANDS						●		●					●				●								●									●												●			
NEPEAN OCEAN COAST						•	•				•		●									●						●				●						●										⬤	
FLINDERS	•					•	•				●								•	•								●		●		●						⬤										⬤	
SHOREHAM						•					●						●											●																				•	
STONY POINT - YARINGA																																																	
NORTHEAST WESTERNPORT			●																●				•				●				•	•																	
WESTERN PHILLIP ISLAND						•	•				●		●						●				●	•			●	⬤									•			•						●		⬤	
SHELLY BEACH (SAN REMO)		•				•					●											●	●				●	⬤											●									⬤	
CAPE PATTERSON						•					•									•		●	●					●					•					⬤	•										
INVERLOCH																																																	
WARATAH BAY																																											●						
WILSON'S PROMONTORY																																											●						
CORNER INLET			⬤																																•														
NINETY MILE BEACH									•			●	●																						•	●							●						
LAKES ENTRANCE													●														•	●			●					•							•						
PEARL POINT						•						●	⬤	●	●				•	•		●				●									●					●			⬤						
WINGAN INLET & ENVIRONS				⬤					•													•													•	●						•							
MALLACOOTA INLET & ENVIRONS		⬤				●			•								●					●						⬤							●					⬤			⬤						•

KEY TO SCALE OF RELATIVE ABUNDANCE

Rare	1%	•
Occasional	1-10%	●
Frequent	10-45%	⬤
Very frequent	45%	⬤

TABLE 1 (Continued)

SPECIES IN SHELLY BEACHES ON THE VICTORIAN COAST.

					Pelecypoda																																											Cephalopoda	
	TEREBRIDAE	BULLARIIDAE	SIPHONARIIDAE		LEDIDAE	ARCIDAE		GLYCIMERIDAE		MYTILIDAE			PTERIIDAE	PINNIDAE	PECTINIDAE			ANOMIIDAE	OSTREIDAE		TRIGONIIDAE	CRASSATELLIDAE	CARDITIDAE	CARDIIDAE	VENERIDAE												DONACILLIDAE	MACTRIDAE				DONACIDAE	SANGUINOLARIIDAE	TELLINIDAE		SOLENIDAE	PHOLADIDAE	SEPIIDAE	ARGONAUTIDAE
	Nototerebra albida	Bullaria botanica	Siphonaria diemenensis	Siphonaria tasmanica	Scaeoleda crassa	Anadara trapezia	Barbatia pistachia	Glycimeris flammeus	Tucetilla striatularis	Modiolus albicostus	Brachidontes rostratus	Mytilus planulatus	Electroma georgiana	Atrina tasmanica	Pecten alba	Camptonectes famigerator	Chlamys asperrimus	Monia ione	Ostrea angasi	Crassostrea commercialis	Neotrigonia margaritacea	Eucrassatella kingicola	Venericardia sp.	Fulvia tenuicostata	Phacosoma circinaria	Notocallista kingii	Sunemeroe aliciae	Tawera gallinula	Placamen placida	Bassina pachyphylla	Callanaitis disjecta	Gomphina undulosa	Eumarcia fumigata	Katelysia rhytiphora	Katelysia peronii	Pullastra galactites	Donacilla nitida	Notospisula parva	Mactra rufescens	Mactra australis	Mactra pura	Plebidonax deltoides	Soletellina biradiata	Pseudarcopagia victoriae	Homalina deltoidalis	Solen vaginoides	Pholas australasiae	Amplisepia apama	Argonauta nodosa
HABITAT	Ss	Ss	Ri	Ri	Ss	Ss	Rs	Ss	Ss	Rs	Ri	Ri	Ss	Ss	Ss	Ss	Ss	Rs	Si	Ri	Ss	Ss	Ss	Ss	Ss	Ss	Ss	Ss	Ss	Ss	Ss	Ss	Ss	Ss	Ss	Ss	Si	Si	Ss	Si	Si	Ss	Ss	Ss	Ss	Ss	Ss	F	F
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NB. Taxonomy follows that of Macpherson and Gabriel (1962).

KEY TO HABITAT TYPE
OF EXTANT SPECIES

Rocky substrate:	intertidal	Ri
	subtidal	Rs
Soft substrate:	intertidal	Si
	subtidal	Ss
Free swimming:		F

summarized in Table 1. The shells have been classified by family and genus, and to species level wherever possible. It should be noted that speciation of fragmented and worn shell fragments is often difficult; in cases where it was difficult to identify shell species because of minor variations in shell sculpture, colour, and form these have been classified to genus level only. The data presented in Table 1 should not be taken as an exhaustive guide to the distribution of molluscs on the Victorian coast, but rather as data representative of the typical collections and major components of shelly beaches at specific localities.

The species content of shelly beaches is variable along the coast; some of the common assemblages and distribution trends can be obtained from the Table. Generally the shorelines west of Wilsons Promontory have more rocky habitats and more shelly beaches. Shell accumulations on the east coast, particularly of large pelecypods, are localized. The tendency for gastropods to be found on high wave energy rocky shorelines and pelecypods in sheltered areas and on sandy beaches is common.

Gastropod species such as *Haliotis ruber* (Shepard 1973) and *Cellana tramoserica* (Sowerby 1825) are commonly distributed on high wave energy rocky shorelines, as are members of the families Cymatidae, Thaidae and Buccinidae. The families Trochidae and Turbinidae are abundant in two areas: the rocky shorelines between Cape Bridgewater and Lorne, and the Nepean Peninsula, Phillip Island and Cape Patterson. In comparison the Potamididae are frequent in sheltered low wave energy areas such as the western shores of Port Phillip Bay, northeastern Westernport Bay and East Gippsland estuaries, while the Scalidae are more frequent on the western Victorian coast.

Pelecypods often accumulate in high concentrations. The Mactridae are very frequent in shelly beaches on high wave energy sandy shorelines on the far west coast; this family is replaced by the Glycimeridae in similar environments on Gippsland shores. The Mytilidae are most frequent in the west on both rocky open coasts and sheltered shorelines; the Veneridae are centred on low wave energy environments of Port Phillip Bay and Westernport Bay.

The free swimming Cephalopods of which *Amplisepia apama* (Gray 1849) and *Argonauta nodosa* (Solander 1786) are the most common, are distributed along most of the Victorian coastline.

CONCLUSION

Although infrequent, shelly beaches are present on the Victorian coast in sectors where sufficient quantities of biogenic material are available for incorporation in beaches. The availability of shell material is related to the population density of contributing species. The nature of the material depends on the molluscan faunal assemblage present, which is in turn determined by the types of habitat available in the area, and the degree of fragmentation and abrasion of the shells. Shelly material accumulates on beaches in response to a variety of wave conditions; reduced wave height after refraction produces the swash which often causes accumulation of shelly debris. In some environments, particularly estuaries and shallow embayments, storm waves cause accelerated accumulation, and pile shell material in deep strands.

ACKNOWLEDGMENTS

I am grateful to Dr. E. C. F. Bird, Geography Department, Melbourne University, for constructive criticism of drafts of this paper and to Mr. R. N. Synnot, Zoology Department, Melbourne University, for information on recent changes in gastropod taxonomy and assistance with fieldwork. I would like to thank Mr. N. E. Green for photographic printing and scale reduction of figures and tables and Miss J. R. Miller for typing the manuscript.

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