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Rocky shore distribution patterns along the Somerset coast

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Along the coast of Somerset, the numbers of animal and plant species progressively decline from west to east. Changes in zonation patterns thus reflect a decrease in species richness as well as the direct influences of increasing tidal range and turbidity. The patterns are also complicated by the differing rock types: quartzite to the west, limestone to the northeast with softer marls and shales inbetween. The overall appearance of some shores has changed in recent years as a result of fucoid responses to hot summers and cold winters. This has greatly influenced community structure. In contrast to the Quoddy Region (Bay of Fundy), *Ascophyllum nodosum* is confined to sheltered sites whilst *Nucella lapillus* (together with several other gastropods) becomes increasingly restricted to lower levels — especially where a fucoid canopy is present.

ADDITIONAL KEY WORDS:—Severn Estuary – Bay of Fundy – species richness – tidal range.

CONTENTS

THE INTERTIDAL ROCKY SHORE FAUNA AND FLORA

The county of Somerset offers three major types of rocky shore along the southern coast of the Bristol Channel/Severn Estuary (Fig. 1): steep exposed headlands formed from Old Red Sandstone quartzite (e.g. at Hurlstone Point); wave-cut platforms of ORS boulders overlying periglacial head (e.g. at Gore Point); and extensive wave-cut platforms cut into much softer Triassic and Jurassic (Blue Lias) rocks eastwards from Blue Anchor. Further north, in the county of Avon, Carboniferous Limestone outcrops provide more steep headlands (e.g. at Brean Down). On all, the sea, through its unusually-large tidal range, high current velocities (particularly over the lower shore), and turbid water imposes a controlling influence.

The macroscopic fauna is much richer, in terms of numbers of species than is the macroscopic flora. Boyden *et al.* (1977), augmented with subsequent records, record 457 species of invertebrates (Table 1), whereas we can only list 37 species of algae (Table 2). Such a preponderance of animals is not unusual. The

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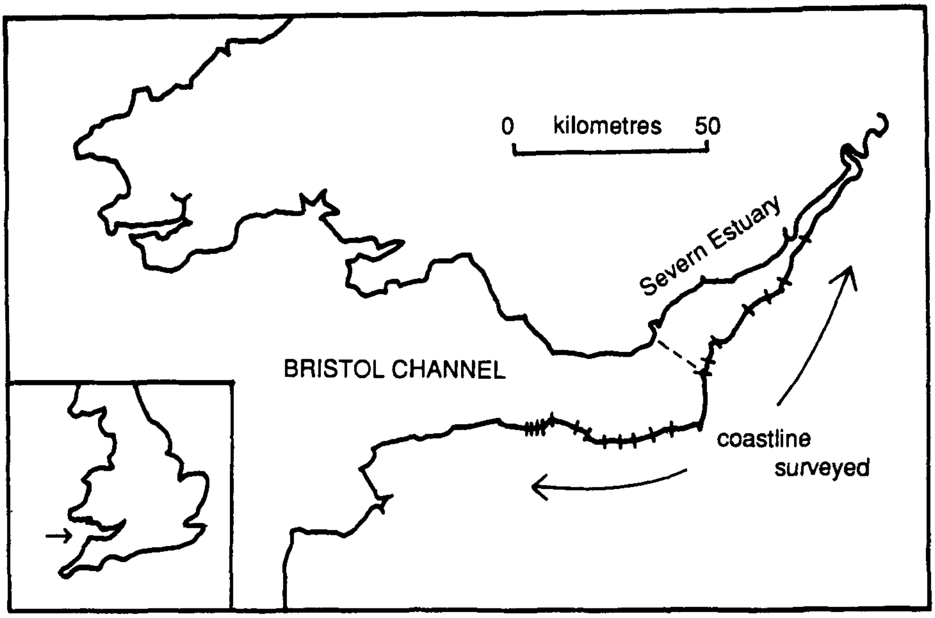

Figure 1. The Bristol Channel and Severn Estuary. Sampling sites on the southern shore (listed in Tables 1–3) are shown by lines perpendicular to the coastal outline. The line of the proposed barrage is shown by a pecked line.

equivalent figures for Dale (Milford Haven, S. Wales), at the mouth of the Bristol Channel, are 1,141 animals (Crothers, 1966) to 263 algae (Jones & Williams, 1966). Animals thus represent 81% of the combined species list in

TABLE 1. The number of species in the intertidal invertebrate fauna and the sites at which they appear to reach their eastern or northern limit along the English coast of the Severn Estuary. Key to columns: A = Arthropoda, B = Mollusca, C = Annelida, D = Bryozoa, E = Cnidaria, F = unsegmented worms, G = Porifera, H = Echinodermata, I = Ascidia

	A	B	C	D	E	F	G	H	I	Total	%
Porlock: First Rocks	2	1	1	2		1	2			9	2
Porlock: Gore Point	23	17	8	9	1	2		4	2	66	14
Porlock Bay	4	5	6	10	2	2	2		1	32	7
Hurlstone Point	2	6	3	1	2			2		16	4
Greenaleigh Bay	7	7	4	7		1	1	2	2	31	7
Minehead	9	9	8	2	5	1	3	2	1	40	9
Blue Anchor	8	9	5	4	2		3		1	32	7
Watchet	3	9	5	3	1			1		22	5
St Audries	1	1	1	1	2					6	1
Kilve	5	4	9		1	1				20	4
Hinkley Point	26	6	11	2	5	2		1		53	12
Burnham	4									4	1
Brean Down	3	2	2		2	3				12	3
Weston-super-Mare	6	2	1	1	1	1				12	3
Sand Point	3	2	1				1		1	8	2
Clevedon	7	3	1							11	2
Portishead	11	4	7		4					26	6
Avonmouth	1		1							2	0
Severn Bridge	3	2	1	4	5					15	3
above the bridge	24	8	1	3	3	1				40	9
Total	152	97	76	49	36	15	12	12	8	457	100

TABLE 2. The macroalgal flora at sites along the English coast of the Severn Estuary: Data from the sites from Brean Down to above the Severn Bridge were taken from Smith (1980).

	Phaeophyta	Chlorophyta	Rhodophyta	Total	%
Porlock: Yellow Rocks	7	7	23	37	100
Porlock: Gore Point	5	7	24	36	97
Hurlstone Point	4	6	13	23	62
Greenaleigh Point	2	5	7	14	38
Minehead	4	6	5	15	41
Blue Anchor	5	6	7	18	49
Watchet	5	6	8	19	51
St Audries	5	5	7	17	46
Kilve	6	5	8	19	51
Hinkley Point	4	4	6	14	38
Brean Down	6	2	7	15	41
Weston-super-Mare	6	2	8	16	43
Sand Point	6	2	6	14	38
Clevedon	6	2	6	14	38
Portishead	6	2	3	11	30
Severn Bridge	5	2	2	9	24
above the Bridge	5	2	2	9	24

Milford Haven and 86% in the Severn Estuary, which suggests that the flora is already proportionally more impoverished at Porlock than is the fauna.

Following the procedure adopted by Bassindale (1941), Table 3 displays the 'assumed marine fauna', comprising all species of *marine* invertebrate actually found at a site *plus* any others that have been recorded in similar habitats further up the Estuary, rather than the actual number of species recorded there. This is because the latter figure is influenced by the number of man/hours spent searching. The shore adjacent to the power station on Hinkley Point is a good

TABLE 3. The 'assumed' intertidal invertebrate fauna at sites along the English coast of the Severn Estuary: Data from Table 1. Key to columns: A = Arthropods, B = Mollusca, C = Annelida, D = Bryozoa, E = Cnidaria, F = unsegmented worms, G = Porifera, H = Echinodermata, I = Ascidia

	A	B	C	D	E	F	G	H	I	Total	%
Porlock: First Rocks	152	97	76	49	36	15	12	12	8	457	100
Porlock: Gore Point	150	96	75	47	36	14	10	11	8	447	98
Porlock Bay	127	79	67	38	35	12	10	8	6	382	84
Hurlstone Point	123	74	61	28	33	10	8	8	5	350	77
Greenaleigh Bay	121	68	58	27	31	10	8	6	5	334	73
Minehead	114	61	54	20	31	9	7	4	3	303	66
Blue Anchor	105	52	46	18	26	8	4	2	2	263	58
Watchet	97	43	41	14	24	8	1	2	1	231	51
St Audries	94	34	36	11	23	8	1	1	1	209	46
Kilve	93	33	35	10	21	8	1	1	1	203	44
Hinkley Point	88	29	26	10	20	7	1	1	1	183	40
Berrow	62	23	15	8	15	5	1	0	1	130	28
Brean Down	58	23	15	8	15	5	1	0	1	126	28
Weston	55	21	13	8	13	2	1	0	1	114	25
Sand Point	49	19	12	7	12	1	1	0	1	102	22
Clevedon	46	17	11	7	12	1	0	0	0	94	21
Portishead	39	14	10	7	12	1	0	0	0	83	18
Avonmouth	28	10	3	7	8	1	0	0	0	57	12
Severn Bridge	27	10	2	7	8	1	0	0	0	55	12
above the bridge	24	8	1	3	3	1	0	0	0	40	9

example. Much more attention has been paid to this site (e.g. Henderson, Holmes & Bamber, 1984; Bamber & Coughlan, 1987) than to adjacent stretches of similar shore and, not surprisingly, more species have been recorded. The equivalent procedure has not been applied for macroalgae, as the recording was carried out more systematically.

Comparatively few species — about 30% of the fauna and 40% of the flora — penetrate up the Estuary as far as the line of the proposed Barrage, which thus presents little threat to intertidal invertebrates or algae (Crothers, 1980). The fauna changes most in Porlock Bay and then between Hinkley Point and Brean Down. Algal species richness drops most signficantly immediately to the east of Hurlstone Point and there are only minor changes thereafter up the Estuary. None of these reductions is directly related to salinity. We have no information that suggests appreciable changes in that parameter between Porlock and Minehead, or in the vicinity of Hinkley Point. The decreases in species richness are more probably related to the increased load of suspended sediment in the water column, increased current velocities and the resultant scour — coupled with the absence of exposed bedrock between Hinkley Point and Brean Down.

DISTRIBUTION PATTERNS

Changes in the lithology and wave-exposure of rocky shores along the Estuary complicate the picture of species richness and species composition at the various sites. The shales, from Blue Anchor to Hinkley Point, are extensively bored by piddocks (*Pholas dactylus* and *Barnea parva*), but these animals are not seen east or west of those outcrops whilst several algal species are absent from some soft-rock sites only to reappear further on. For example, the two upper shore fucoids, *Pelvetia canaliculata* and *Fucus spiralis*, are present only when there is a sufficiently hard (and persistent) substrate for the plants to colonize successfully. Zones of these algae are well-developed on the north-facing wall inside Watchet harbour, but are absent from equivalent levels on the cliffs outside. Any attempt to colonize the natural face is doomed by the rate of erosion.

Zonation patterns are influenced by the changes in faunal and floral composition. On the steep headlands of West Somerset, fucoid and other macroscopic algae are virtually confined to the lower shore, except in rock pools. The most conspicuous species are *Fucus serratus*, *Mastocarpus stellatus*, and *Palmaria palmata*. A few years ago, we would have included *Laurencia pinnatifida*, especially on Hurlstone Point, but *P. palmata* has taken its place. The upper and middle shores are dominated by lichens (*Verrucaria* sp.), barnacles (mainly *Chthamalus* sp.) and limpets (*Patella vulgata*). *Chthamalus montagui* is also conspicuous on the boulder shores but here, edible winkles (*Littorina littorea*) and topshells (*Monodonta lineata* and *Gibbula umbilicalis*) are the dominant herbivores.

On the very low-angle, Lower Jurassic wave-cut platforms, the lower shore is usually bare rock (bored by piddocks). We presume that the shortage of light (due to the turbid water and high tidal range), plus the amount of mud deposited on the rock surface, prevents germination on the lower shore for there are no signs of young plants appearing and subsequently dying. The middle shore is fucoid-dominated with *Fucus serratus* extending upshore to HWNT. The up-shore extension of this alga appears to be a feature of flat shores. We have noticed this pattern from sites as far apart as Jersey, Handa and Orkney.

Other factors modify distribution patterns in the longer term. Prior to 1975, the extensive wave-cut platform at Watchet was dominated by fucoids — principally *Ascophyllum nodosum*, *Fucus vesiculosus* and *F. serratus* (Crothers, 1976) — and settlement of *Patella* was controlled by the whiplash effect: the process whereby algal fronds are swept over the rocks by wave swash, abrading away newly settled limpets and any other delicate organisms. The hot and dry conditions during 1975 and 1976 prevented settlement of young fucoids, as well as killing a number of the established plants. By the autumn of 1977 few of the latter remained, and any newly-settled plantlets were not yet visible. The young limpets which settled on the now-accessible shore, were not large enough to prevent initial recolonization by the seaweeds. By 1981, full fucoid cover was restored but, underneath, there were substantial numbers of limpets which grazed heavily on the next generations of the algae so that the shore became progressively denuded until about 1987, when that year class of limpets died out. By 1989, full cover was once again established.

A COMPARISON OF SEVERN SHORES WITH THOSE OF FUNDY

The Severn Estuary and the Bay of Fundy lie on opposite sides of the same ocean and have comparable (large) tidal ranges. Some areas, such as the south side of Minas Basin (Nova Scotia) and the eastern part of Blue Anchor Bay (West Somerset), show strikingly similar geomorphology. Yet details of zonation and other distribution patterns of intertidal organisms are, in many cases, quite different. The last part of this paper attempts to compare and contrast the two systems, seeking to establish those features which genuinely reflect a large tidal range. For ease of comparison with the zonation patterns of Fundy, described by Thomas (1983, 1994), we use his notation whereby height on the shore is expressed as a percentage of the tidal range: 0% is MLWST, 100% is MHWST.

Algal zonation, on the Somerset coast, changes with geographical location (Table 4). Around Porlock Weir, fucoids extend up the shore towards MHWNT (from 0–60% of the tidal range) but with maximum abundance — and presumed biomass — below mean tide level (50%). Eastwards, the fucoid belt

TABLE 4. The distribution of fucoid algae along the West Somerset coast between Porlock Weir and Hinkley Point. Heights are expressed as percentages of the tidal range (for easy comparison with Thomas, 1994); 0% is mean low water of spring tides, and 100% is mean high water of spring tides. In this part of the Bristol Channel, MHWST is a little less than 75% and MLWST a little more than 25%. Data mainly from Crothers, 1976.

Site	Lowest record	Highest record	Area of maximum biomass
Porlock Weir	0%	60%	< 50%
Hurlstone Point	0%	25%	c. 7%
Minehead: Harbour Wall	75%	115%	c. 90%
Blue Anchor	5%	95%	25–60%
Watchet	20%	75%	60–75%
Blue Ben	15%	100%	50–60%
Hinkley Point	25%	70%	60–70%

TABLE 5. The distribution of dogwhelks *Nucella lapillus* (L.), along the English coast of the Severn Estuary. Heights are expressed as percentages of the tidal range (for easy comparison with Thomas, 1994). Data from Crothers (1976) and unpublished. The species reaches its up-Channel limit halfway along the north coast of Middle Hope.

Site	Lowest record	Highest record	Area of maximum biomass
Porlock Weir	0%	75%	*c.* 50%
Hurlstone Point	0%	40%	10–25%
Greenaleigh	0%	30%	10–25%
Dunster Beach	0%	25%	0–10%
Blue Anchor	0%	20%	0–10%
Watchet	0%	20%	0–10%
Blue Ben	0%	20%	0–10%
Kilve	0%	15%	0–10%
Lilstock	0%	15%	0–10%
Hinkley Point	0%	15%	0–10%
Brean Down	0%	10%	5%
Steepholm	0%	10%	5%
Weston-super-Mare	0%	10%	5%
Middle Hope	0%	10%	5%

rises up the shore leaving the lower shore bare of macroalgal growth. *Ascophyllum nodosum* grows in much the same region of the shore as in Fundy (30–75% of the tidal range) but does not dominate the vegetation.

In the Quoddy Region (Thomas, 1983, 1994) and, indeed, on much of the eastern seaboard of the USA and Canada northwards from Massachusetts, rocky shores exposed to wave action are fucoid dominated, whilst some sheltered shores are comparatively free. In Britain, and elsewhere in Western Europe, the opposite pattern is seen. Here, fucoids are diagnostic of sheltered shores (Ballantine, 1961). Yet, apparently, they are the same species that grow on both sides of the Atlantic!

Differences in the marine fauna and flora appear to be due to the differential effects of winter cold, direct or indirect. Differences in the fucoid pattern are probably the result of selective grazing by the dominant herbivores which, in Europe, are usually limpets of the genus *Patella* — primarily, animals of the middle and upper zones on exposed shores. *Patella* is particularly vulnerable to icing (Crisp, 1964) and its absence from the Western Atlantic is readily explained by the winter temperatures. Sea ice extends south to Cape Cod. The dominant herbivores on those shores are the edible winkle *Littorina littorea*, and the green sea urchin *Strongylocentrotus droebachiensis*, primarily animals of the middle and lower zones on sheltered shores.

The ecological relationship is the same on both sides of the Atlantic: plants grow best in areas where grazing is least, but with strikingly different results. This cannot, however, be the whole explanation. *Ascophyllum nodosum*, regarded as a biological indicator of sheltered conditions in western Britain (e.g., Ballantine, 1961) is a principal component of the exposed-shore fucoid communities in Fundy (Thomas, 1983, 1994). Are these plants really members of the same species?

Another example of a strikingly different distribution pattern between Fundy and the Severn is provided by the dog-whelk *Nucella lapillus*. The favourite prey of this gastropod is the barnacle *Semibalanus balanoides* (see Crothers, 1985). In the Quoddy region (Thomas, 1994), these snails are found high on the shore. In the Severn, they become animals almost of the sub-littoral fringe (Crothers, 1976). In the former case, perhaps they are forced to live high up because they have eaten the lower barnacles. Similar patterns are known from Shetland and Norway (Crothers, 1985). This is not the explanation in Somerset; however, as *S. balanoides* (together with another palatable barnacle, *Elminius modestus*) extends much further upshore than the dogwhelk. Dogwhelks introduced onto this food supply have not persisted.

What features, then, are common to both areas and can be realistically attributed to the enhanced tidal range. We find only two. Firstly, there is a comparatively small splash zone in relation to the extent of the true littoral zone. Secondly, there is a blurring of the zonal boundaries that are so well-marked in places of small tidal range.

The comparatively small splash zone is a consequence of the physical distance of that region from the sea at low tide. With a 3 m tidal range, the upper rocks experience intermittent splashing throughout the tidal cycle: with a 10 m range, desiccation of the upper shore at low tide is significant. On the extensive wave-cut platforms between Blue Anchor and Hinkley Point (and in Minas Basin), with the tide line hundreds of metres away, conditions are extreme.

The blurring of zonal boundaries reflects the substantial differences in tidal heights on successive days. A glance at the tide tables will show what we mean; in places with a 3 or 4 m range (the average for open-coast British shores) many days of the month have the same predicted heights for high (and low) water. In both the Severn and Fundy, this occurs much less often. Zonal boundaries are sharp where conditions change significantly over a small vertical range. Where that change is more extended, the boundaries are comparatively diffuse.

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