Fld Stud. (1970), 3, 263–274

THE DISTRIBUTION OF CRABS ON ROCKY SHORES AROUND THE DALE PENINSULA

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Crab distribution on rocky shores at low tide is comparable with that of the more sedentary animals described in earlier papers on the Dale Peninsula. All the six species examined increase in abundance with decreasing exposure but only *Carcinus maenas* L. reaches maximum abundance on the most sheltered shores; all other species reaching maximum abundance on shores of exposure five or six. The importance of considering differential crab distribution when investigating that of a possible prey species is emphasized.

STUDIES of zonation patterns on the rocky shores around the Pembrokeshire coast have occupied many pages in this Journal. But, whilst crabs are amongst the most conspicuous members of the fauna on these shores, their distribution patterns have, hitherto, received no attention. Dale, with its rich crab fauna and shores showing a wide range of exposure to wave action, has proved an excellent area for the study of possible relationships between distribution and exposure; and this paper describes a preliminary investigation carried out whilst the author was Assistant Warden of Dale Fort Field Centre. The paper is also, incidentally, one of a number of accounts describing distribution patterns in Milford Haven against which any changes associated with the industrialization of the area can be measured.

THE STUDY AREA

The essential character of the area is shown in Map 1—a small rocky headland, formed of Old Red Sandstone, jutting southwards into the Atlantic and closing the western end of Milford Haven. Its southern and western shores are exposed to the Atlantic swell whilst its northern and eastern shores are relatively sheltered. Descriptive accounts of the intertidal communities around the peninsula include Ballantine (1961), Bassindale and Clark (1960), Moyse (1958), and Moyse and Nelson-Smith (1963); whilst Crothers (1966) and Jones and Williams (1966) summarize the known information on fauna and flora respectively.

METHODS

The field data were collected during periods of spring tides in August and September 1964–1966. Sampling was confined to one season of the year because it was known (Naylor, 1962; Crothers, 1968) that *Carcinus maenas* exhibited seasonal changes in distribution.

Map 2 shows the 112 stations chosen at approximately regular intervals, in places where some cover made it seem likely that crabs might be found, and searched

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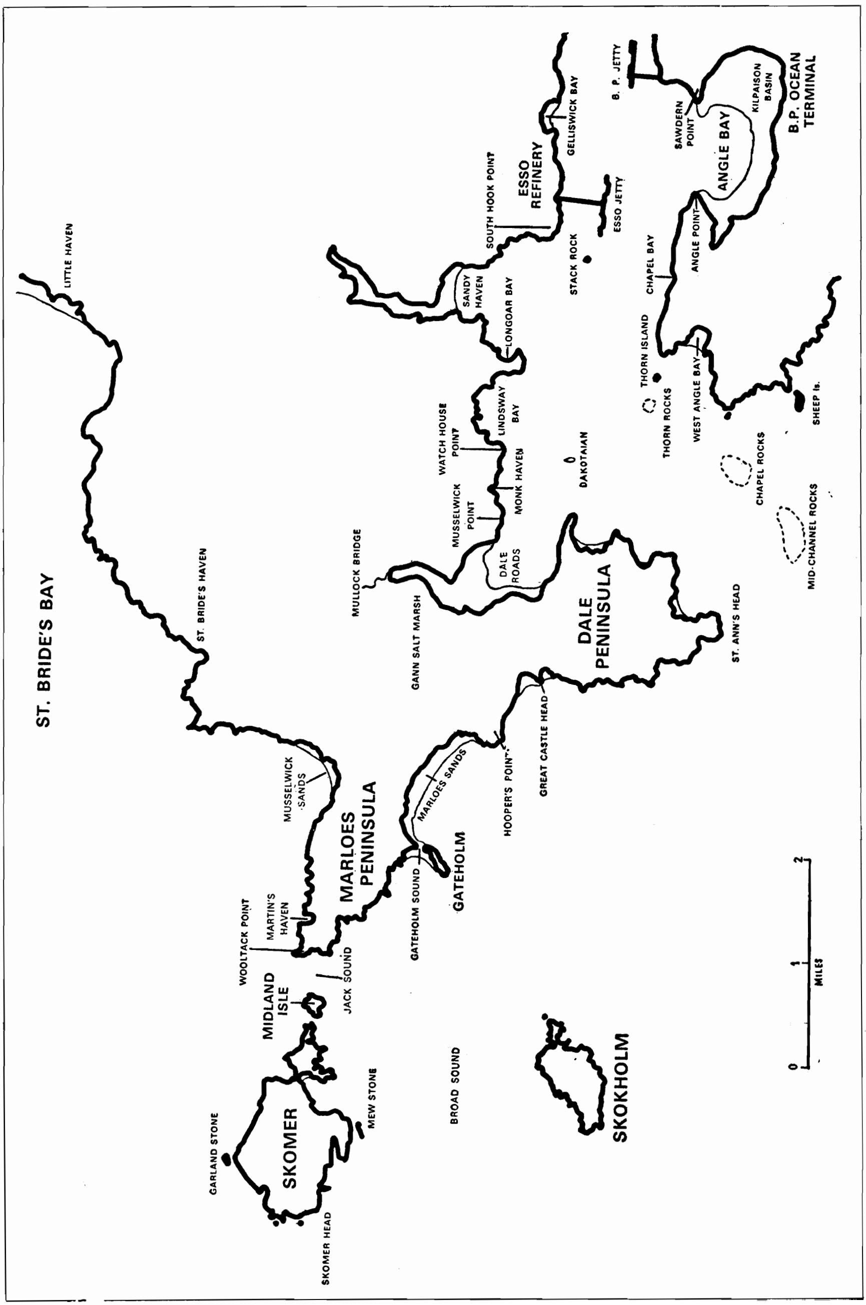


MAP 1.
The Dale peninsula at the western end of Milford Haven

intensively for 15 minutes each. No attempt was made, in this preliminary investigation, to estimate abundance; each species being recorded simply as present or absent. The shore between Short Point and St. Ann's Head was inaccessible to the author.

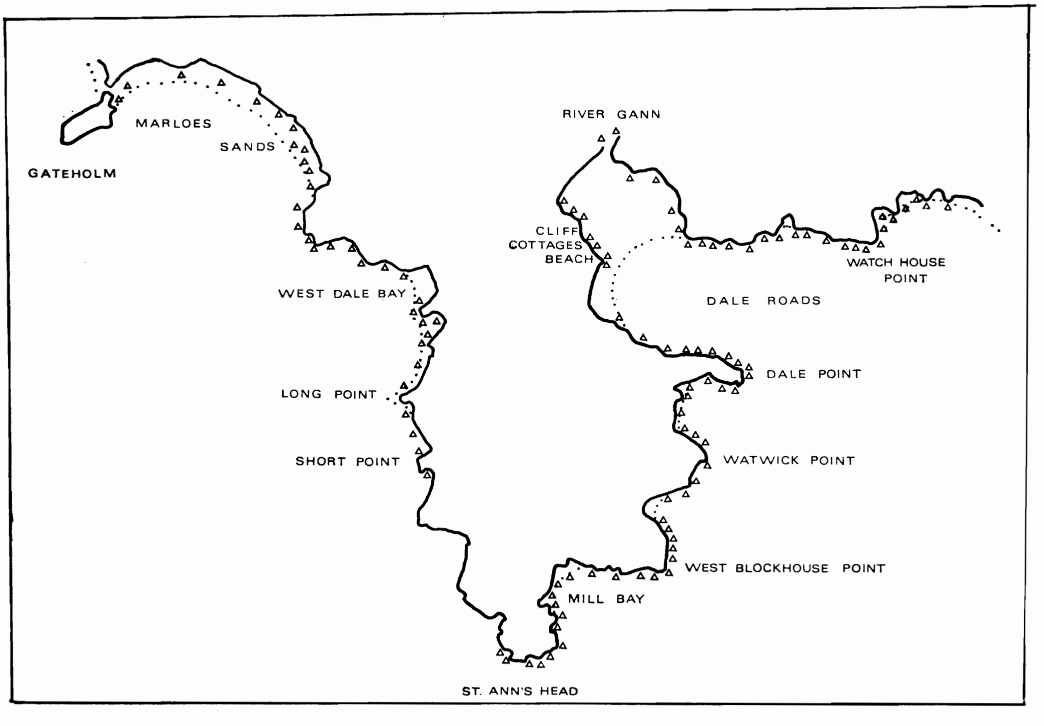
The exposure of each site was established from Ballantine's (1961) exposure scale. Ballantine used the Dale peninsula when devising his scale and thus any criticisms of its usefulness elsewhere in the British Isles (e.g. Lewis, 1964) are irrelevant to this study.

Results

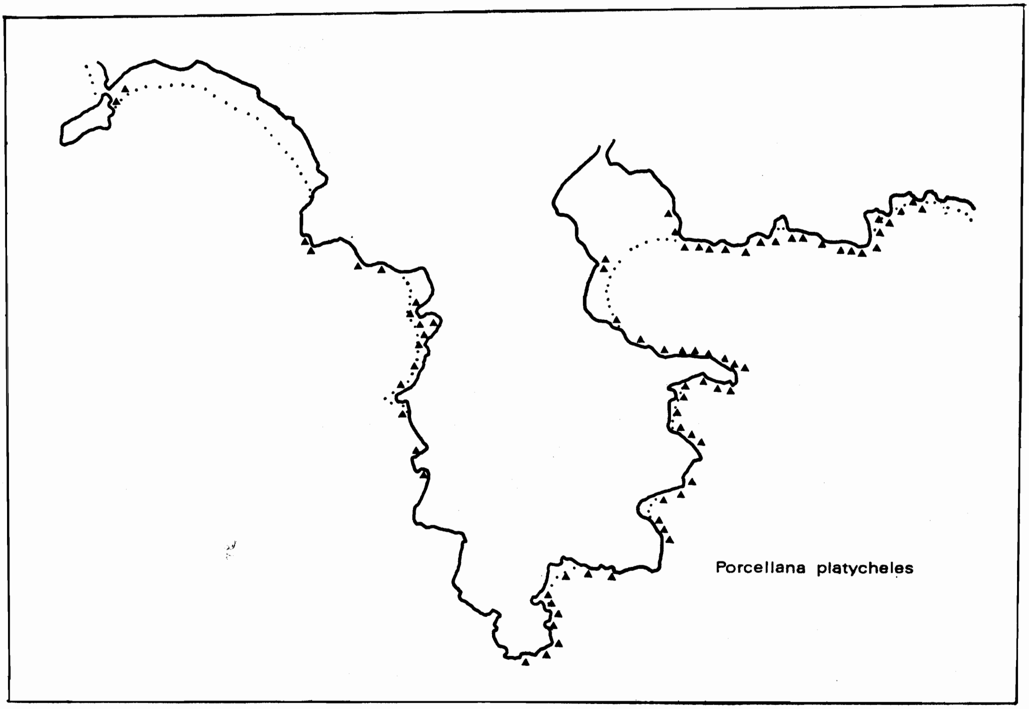
The Dale Fort Marine Fauna (Crothers, 1966) lists 20 species of brachyuran crabs plus two porcellanids that have been found on the shores of the Dale peninsula; but only six species were found to be common enough to be considered in this survey: *Cancer pagurus* (L.), *Carcinus maenas* (L.), *Macropipus puber* (L.), *Pilumnus hirtellus* (L.), *Porcellana platycheles* (Pennant) and *Xantho incisus* Leach.

Maps 3–9 show the distribution patterns for these species obtained during the survey and Map 10 shows the exposure values for the shores in question. Shores of exposure 1 and 8 do not occur around the Dale peninsula but shores of all exposures between 2 and 7 were included in the survey.

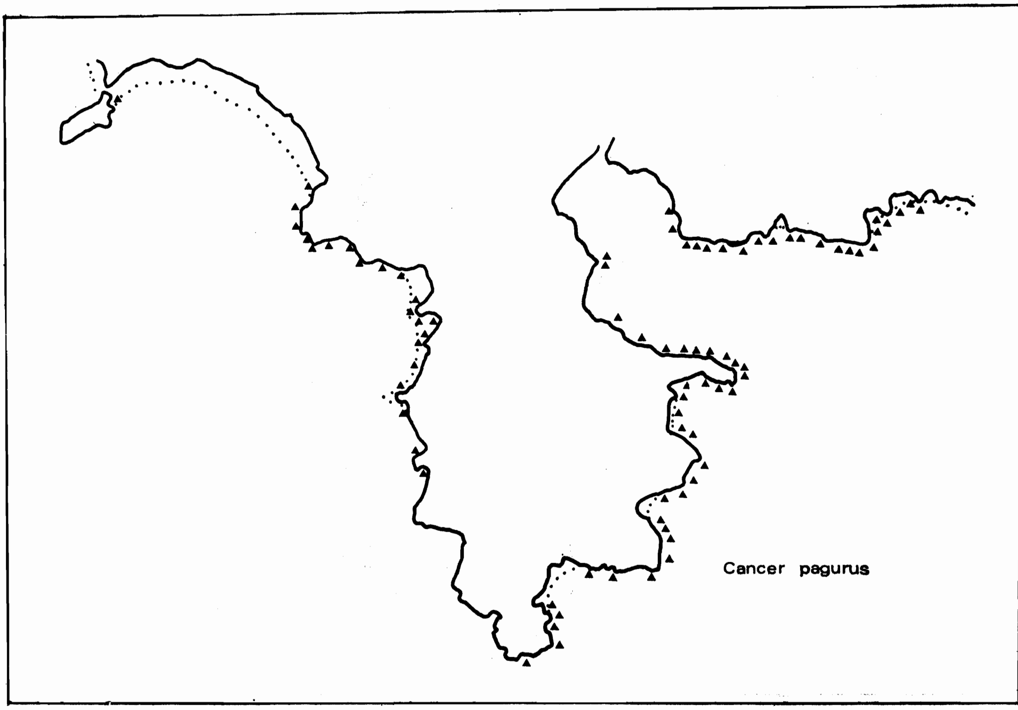
Table 1 summarizes the distribution patterns with respect to exposure grade. However, these figures are of course biased towards the most commonly occurring grades. This bias is removed in Table 2 by expressing the data as if 100 shores of each grade had been examined.



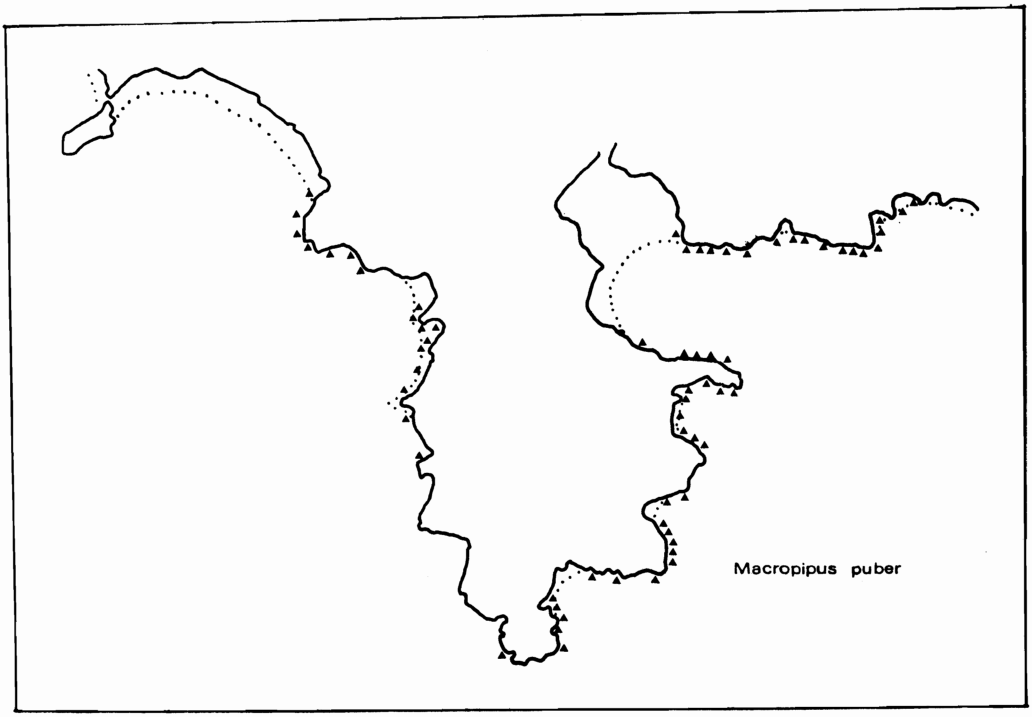
Map 2.
The area covered by this survey, showing the sites searched for crabs



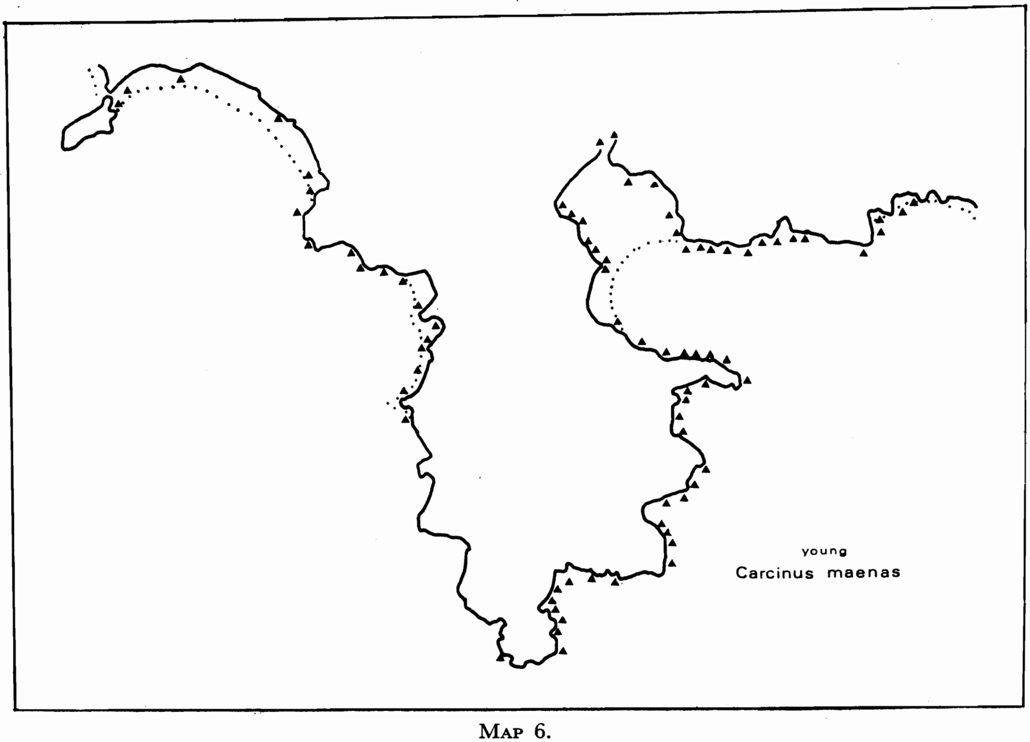
Map 3.
Positive records of *Porcellana platycheles*



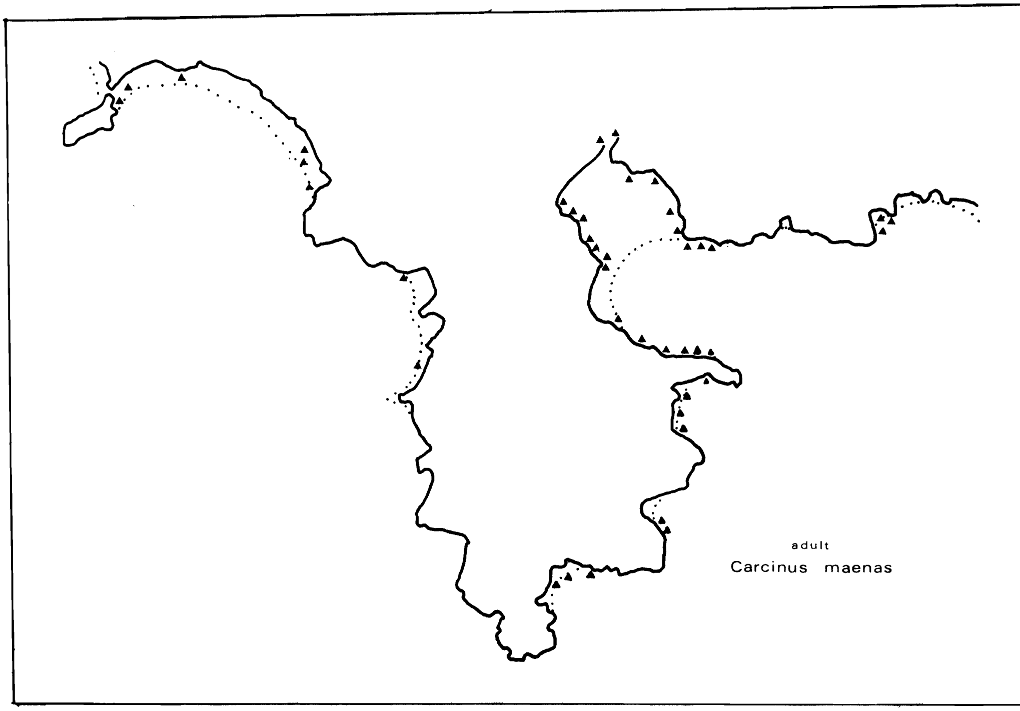
Map 4.
Positive records of *Cancer pagurus*



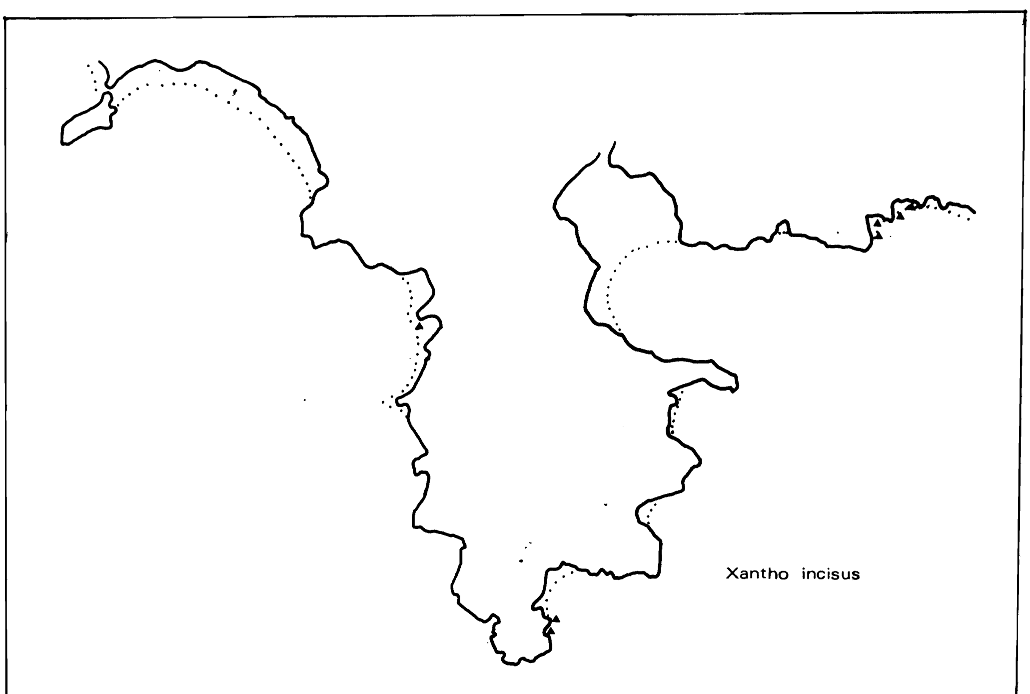
MAP 5.
Positive records of *Macropipus puber*



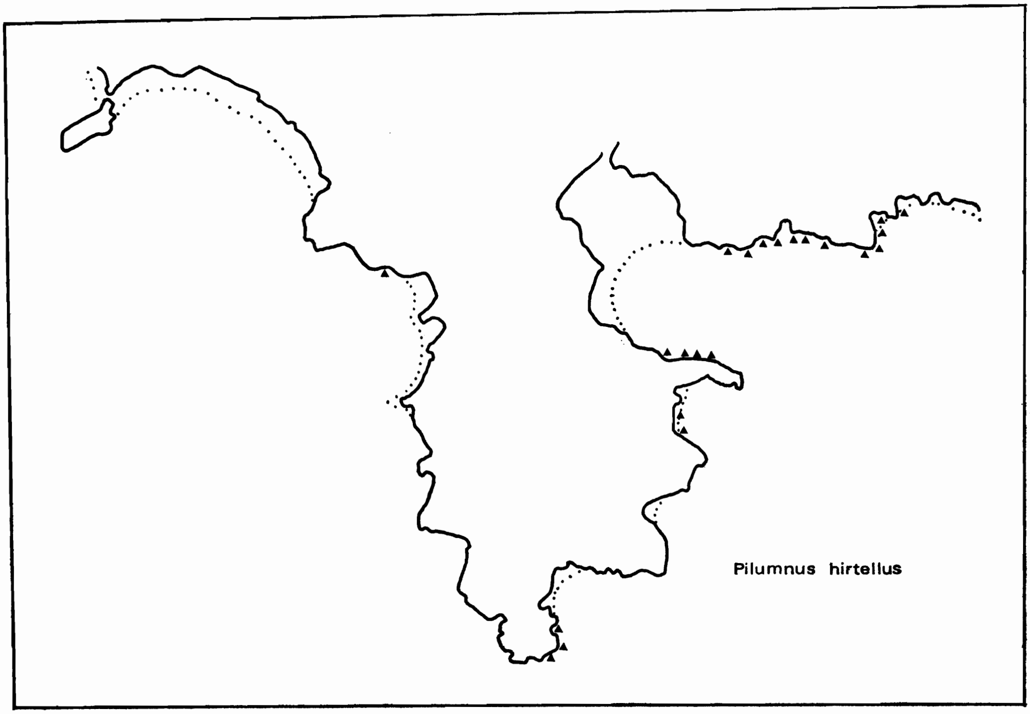
MAP 6.
Positive records of young *Carcinus maenas*



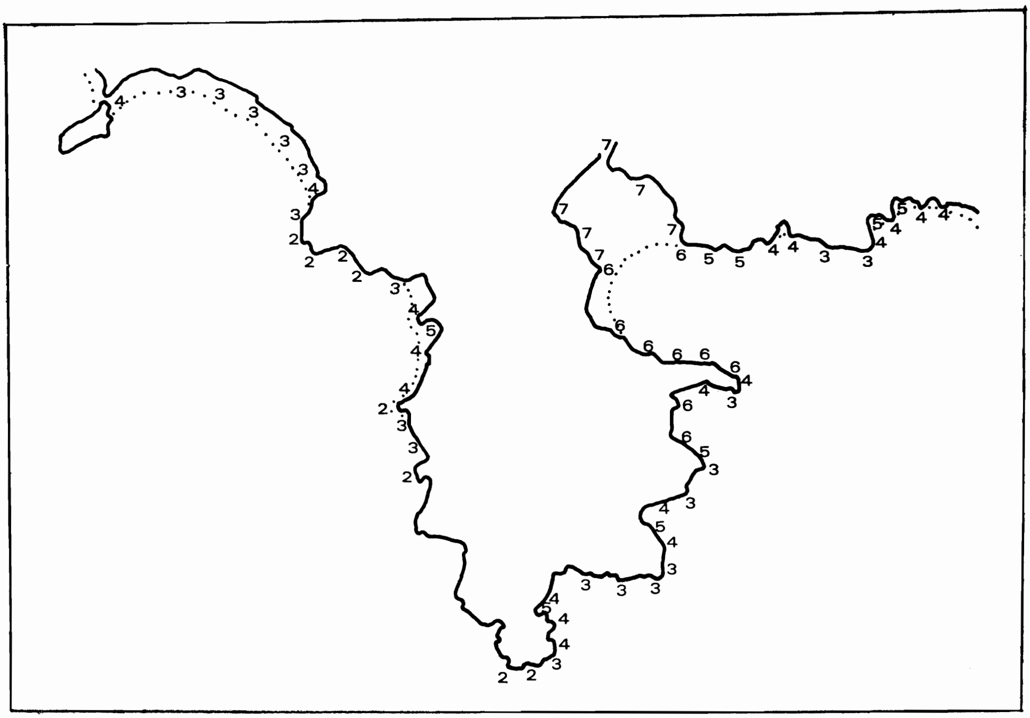
Map 7.
Positive records of adult *Carcinus maenas*



Map 8.
Positive records of *Xantho incisus*



MAP 9.
Positive records of *Pilumnus hirtellus*



MAP 10.
Exposure grades for the shores examined

Table 1. *A summary of the collections*

Exposure grade	No. of stations examined	Porcellana platycheles	Cancer pagurus	Macropipus puber	Carcinus maenas young	Carcinus maenas adult	Xantho incisus	Pilumnus hirtellus
2	11	5	8	6	5	0	0	0
3	33	21	22	20	14	3	1	5
4	30	22	23	21	25	12	3	9
5	12	10	10	12	10	6	4	3
6	14	14	14	12	12	11	0	7
7	12	3	3	1	100	100	0	0
Totals	112	75	80	72	78	44	8	24

Table 2. *The data from the shore collections (Table 1) expressed as though 100 shores of each exposure grade had been examined*

Exposure grade	Porcellana platycheles	Cancer pagurus	Macr opipuspuber	Carcinus maenas young	Carcinus maenas adult	Xantho incisus	Pilumnus hirtellus
2	45	73	55	45	0	0	0
3	64	67	61	42	9	3	15
4	73	77	70	83	40	10	30
5	84	84	100	84	50	33	25
6	100	100	92	92	85	0	54
7	25	25	8	100	100	0	0

The figures from Table 2 were plotted as histograms (Fig. 1). There is considerable similarity between the resulting patterns in that all species show increasing abundance with increasing shelter; but whereas the pattern for *Carcinus maenas* continues upwards to reach a maximum on the "very sheltered" shores of exposure 7, all the other species reach their maximum on shores of exposure 5 or 6 and drop to a minimum on shores of exposure 7.

Discussion

Unlike many common shore animals, crabs are sufficiently active to select their own habitat. Maps 3-9 represent their distribution at low tide but are not necessarily an indication of their feeding range at high tide. At low tide all the species considered in this paper hide in crevices or under stones and boulders and are only to be found on shores that offer them suitable cover. Thus their absence or scarcity on shores of

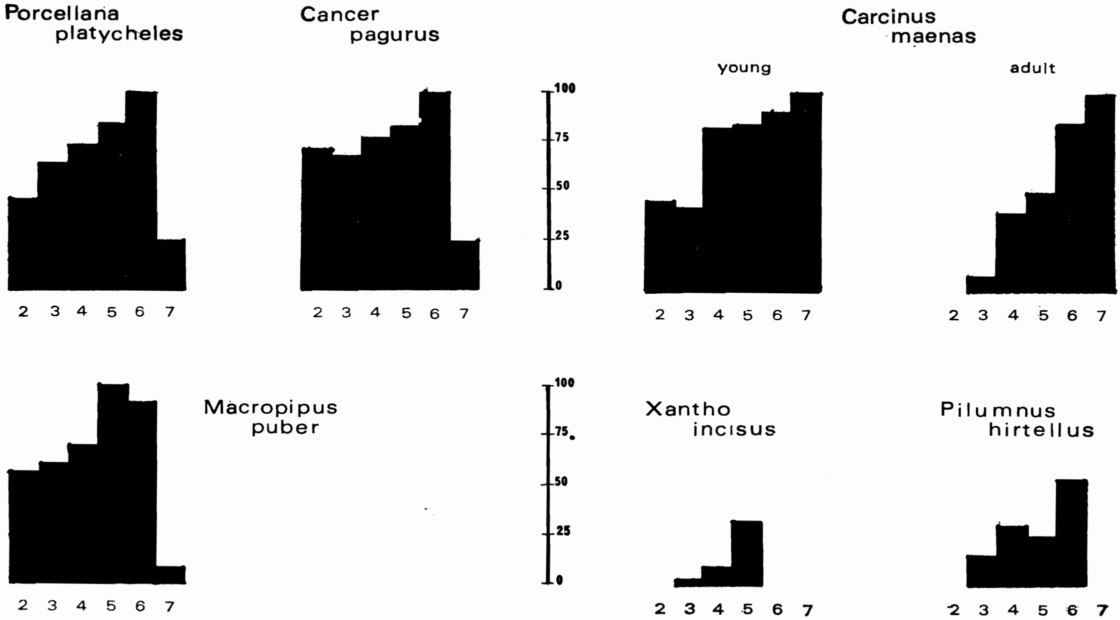


Fig. 1.
The occurrence of the common littoral crabs in relation to exposure. The data are plotted as though 100 shores of each exposure grade had been examined (Table 2). The numbers 2–7 refer to the grades on Ballantine's (1961) exposure scale

exposure 2 is easily explained by shortage of such cover if not by the direct effect of the wave action. Increasing abundance with increasing shelter presumably reflects the increasing number of stones and boulders on the shore. On the shores of the Dale peninsula this cover is maximal on shores of exposure 7 where a dense cover of fucoid algae is added to that provided by the boulders.

Yet only one species shows maximum abundance on the shores with maximum cover. I suggest that the fall-off of the other species is due to one or more of the following: (*a*) absence of a suitable habitat at the required tidal level; (*b*) accumulation of silt; (*c*) competition from *Carcinus maenas*.

(*a*) *Absence of a suitable habitat*

Whilst *C. maenas* is frequently a member of the mid-littoral component of the shore fauna (terminology from Moyse and Nelson-Smith, 1963), and almost never occurs (at Dale) amongst *Laminaria* holdfasts, the other species are predominately lower littoral or sub-littoral fringe animals. The most sheltered shores in the area are silted up at the lower levels and nowhere does the bedrock remain exposed down to chart datum on a shore of exposure 7. Thus it may be that the "very sheltered" shores of Dale do not provide suitable cover at the required tidal level.

(*b*) *Accumulation of silt*

Silt is deposited in quantity on the shores of Dale only at exposure 7, although it is noticeable on shores of exposure 5 and 6 as well. The presence of silt in the water may clog the crab's gills, restrict the settlement of larvae, or restrict in some way the availability of food.

(c) Competition from Carcinus maenas

C. maenas is clearly the most successful crab of sheltered rocky shores and the immediate sub-littoral. I suggested elsewhere (Crothers, 1969) that this species might restrict others from certain sub-littoral habitats and this might also be the case on shores where it is very numerous. Gaskell and Parr (1966) estimated a daily total of 250,000 *C. maenas* on the c. 500 × 70 yard stretch of Cliff Cottages Beach, Dale, in September 1966; and this density is certainly greater than that of any other species on any shore around Dale.

Porcellana platycheles is a filter feeder which may make it particularly susceptible to accumulation of silt, and also cause it to seek areas of considerable water movement. Its flattened form enables it to make use of small crevices and it reaches considerable abundance under stones on the lower shore at exposure 6. It is a truly intertidal animal and only rarely taken below the tidemarks.

The two Xanthid crabs, *Pilumnus hirtellus* and *Xantho incisus*, are sub-littoral fringe animals in this area and their absence from shores of exposure 7 was very possibly due to the lack of a suitable habitat. Both species appear essentially intertidal forms and have only rarely been recorded sub-littorally at Dale (Crothers, 1966) and elsewhere (Bruce *et al.*, 1963; Bouvier, 1940; Marine Biological Association, 1957; and Norman and Scott, 1906). At the time of this survey they both, but especially *X. incisus*, were much less widespread and common than earlier reports (Bassindale and Barrett, 1957; repeated by Crothers, 1966) had indicated. It may be that this was as a result of the cold winter 1962–1963, and, although the reports in Crisp (ed. 1964) show that this lusitanian species fared well, all the individuals found during this survey were relatively small (2–3 in. across). *P. hirtellus* was seriously affected by the cold elsewhere in south Wales but Bassindale (in Crisp, ed. 1964) considered the Dale population unaffected.

Carcinus maenas, *Cancer pagurus* and *Macropipus puber* are all common in the shallow sub-littoral zone as well as on the shore. They all apparently feed on much the same food (Muntz *et al.*, 1965) and so, potentially at any rate, can be expected to compete with each other. At low tide *M. puber* and *C. pagurus* are most abundant under boulders in the *Laminaria* zone whilst adult *C. maenas* favour boulders and fucoids in the mid-littoral zone, hardly ever (at Dale) appearing amongst *Laminaria*. But this apparent segregation into different habitats is misleading for adult *C. maenas* migrate up and down the shore with the tide, feeding at all levels (Naylor, 1962; Crothers, 1968). The other species do not apparently migrate upshore but may feed on shores that do not offer adequate low tide protection.

If competition with *C. maenas* restricts the range of the other species on shores of exposure 7 the question must arise as to why the abundance of this species falls off so rapidly with increasing exposure. The explanation may lie in the relative absence of cover in the mid-littoral zone on shores of exposure 5 and 6 coupled with the inability of *C. maenas* to wedge itself into crevices in the manner of *C. pagurus*; thus allowing the balance of competition to tip the other way.

When it became apparent early in the investigation that adult and young *C. maenas* had such dissimilar distribution patterns, it was possible to split the two because the size at which this species became adult was known (Broekhuysen, 1939, and others, see Crothers, 1967). This information was unfortunately not available for *M. puber*, although it now seems that the size at which they reach adulthood is similar. All the *C. pagurus* observed were immature, adults not usually moving onshore at all. It is clear for all species that the immature stages are much more widespread on the shore than the adults, a feature that may be common amongst littoral animals with planktonic larvae (cf. *Littorina littorea*, James, 1968). Immature distribution patterns presumably reflect the places where settlement and subsequent development are possible, whilst adult distribution reflects the selection of suitable conditions by the crab.

Conclusion

This paper has shown that crabs are not equally abundant on all shores; none is ubiquitous; and neither are they distributed at random. Rather they show distribution patterns comparable to those of more sedentary organisms that can be related to the degree of exposure to wave action. This presumably means that the predatory effect of the crabs is likewise more localized than might have been imagined. This effect on other shore animals needs further investigation particularly when explaining changes in distribution patterns with increasing shelter.

Acknowledgements

I am grateful to Mr. John Barrett, at that time Warden of Dale Fort Field Centre, for encouraging my work on crabs.

Summary

1. This paper describes the distribution patterns on the shore at low tide around the Dale peninsula of *Porcellana platycheles* (Pennant), *Cancer pagurus* (L.), *Macropipus puber* (L.), *Carcinus maenas* (L.), *Xantho incisus* Leach, and *Pilumnus hirtellus* (L.).

2. Data on presence or absence of these species were collected from 112 stations during spring tides in August and September 1964–1966.

3. The exposure of each station was established from Ballantine's (1961) exposure scale.

4. Crab distribution was shown to be related to the degree of exposure on the shore.

5. Up to a point all species show increasing abundance with decreasing exposure; all, except *Carcinus maenas*, reach maximum abundance on shores of exposure 5 or 6 falling to a minimum on shores of exposure 7.

6. *Carcinus maenas* reaches maximum abundance on shores of exposure 7. The reasons for these patterns are discussed.

7. Immature crabs were more widespread than adults.

8. The distribution patterns do not reveal the full extent of each species' range for only a proportion of individuals remain on the shore at low tide, and then only if the shore offers suitable cover.

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