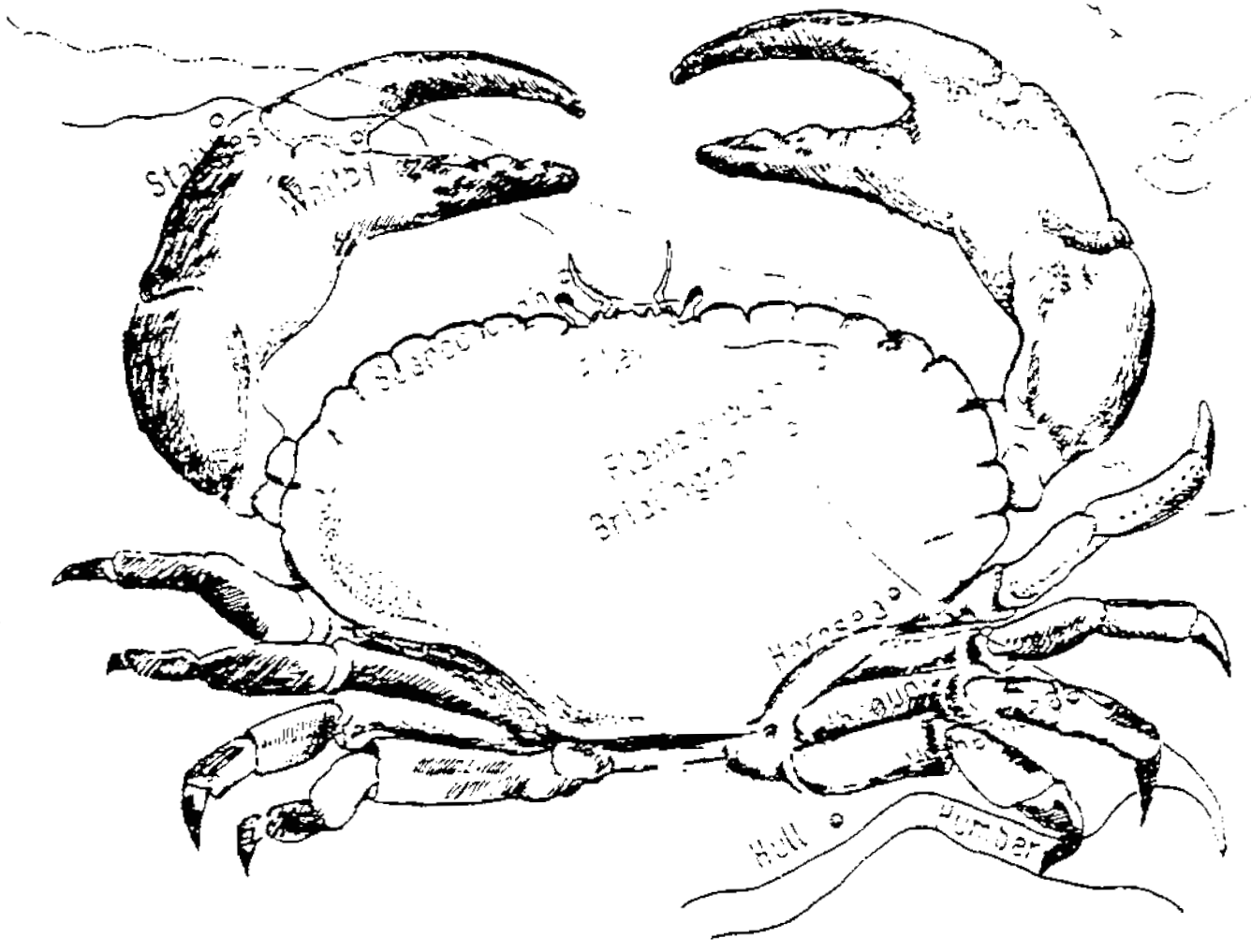
MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

YORKSHIRE CRAB STOCKS

ERIC EDWARDS



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RECOMMENDATION

On the basis of the information now available on this fishery, we have concluded that an increase in the legal minimum size to 5 inches is likely to result in, at best, only a small gain in the total weight landed, after the fishery has settled down to the new conditions. This conclusion, together with other biological evidence described in this leaflet, suggests that the present $4\frac{1}{2}$ inches minimum size limit is the most suitable for this district, and a change to 5 inches is not recommended. A preliminary report describing the conclusions upon which this recommendation was based was submitted to the North-Eastern Sea Fisheries Committee in May 1966, and the Members resolved that the report be accepted.

On 1 July 1966 the Sea-Fishing Industry (Crabs and Lobsters) Order 1951 was repealed and replaced by the Sea-Fishing Industry (Crabs and Lobsters) Order 1966. This new Order introduced certain changes concerning the national lobster legislation, but retained, on a national basis, the $4\frac{1}{2}$ inch legal size limit for the edible crab (Cancer pagurus).

THE FISHERY, 1961-66

The main crab fishing grounds are situated along the 80 mile length of Yorkshire coastline between Redcar and the Humber (Figure 1). Fishing is largely confined to shallow water of less than 20 fathoms and the main grounds are within 2 miles from the shore, although occasionally boats fish between 3 and 6 miles offshore and still catch considerable quantities of crabs.

Although crabs are found on a variety of different types of sea bottom they are usually only present in quantity in areas where the sea-bed is of a rugged nature, and it is likely that rocks and stones covered with seaweed provide shelter and protection from their enemies, particularly during their early life. In the northern part of the fishery, from Redcar to Flamborough Head, the sea-bed from the shore to about 2 miles offshore is a rocky continuation of the cliffs which fringe this coast. Further offshore the sea-bed becomes sandy with isolated outcrops of rocks and stones, and this mixed type of bottom extends offshore for 3 to 6 miles in most places. South of Flamborough Head there is a sandy region in the vicinity of Bridlington Bay where fewer crabs are found, but an uneven bottom composed of clay and stones, where crabs are numerous, continues from Hornsea to the mouth of the River Humber, extending to about 2 miles offshore.

The Yorkshire grounds also support a large population of lobsters and landings are considerable, particularly at the northern ports of Scarborough, Whitby and Staithes. Both crabs and lobsters are caught by baited traps, and

The three main ports in the area are Whitby (Plate 1), Scarborough and Bridlington. Harbour facilities are available at these ports, and fishing boats of 50 ft and over can be safely berthed and the catch landed at the quayside. Other smaller, but important, fishing centres are Redcar, Staithes, Filey and Flamborough, but at these stations the boats are launched off exposed beaches and are hauled above the tide level when not in use. Fishing from these ports is greatly affected by the sea conditions, which sometimes prevent launching. Grimsby, although a major deep-sea fishing port, has only a small inshore fleet, and boats engaged in crab fishing usually work off the Yorkshire coast but land their catches at Grimsby, which is in the county of Lincolnshire.

Boats

Boats between 20 and 55 ft in length and of a variety of design are used in the Yorkshire crab fishery. Various factors govern the types of vessels used from a particular port, the most important being the harbour facilities. Along the east coast of England between Holy Island in Northumberland and Flamborough Head, the cobie is widely used for crab and lobster fishing. The open boat, between 20 and 30 ft long and having a beam of around 5 ft, was primarily designed for launching off exposed beaches and has been used for centuries along the Yorkshire coast, where beaches and cliff clefts serve as havens.

The coble (Plate 2) has a high bow and a deep forefront which makes launching easier, whilst a flat bottom fitted with twin skids stabilizes the boat when landing through surf. Originally designed as an open sail and oar boat, the coble needed only slight modification before being motorized, and following the Great War (1914-18) petrol engines were installed. No sailing cobles now remain, and at the present time the majority are fitted with diesel engines of 20-40 h.p. Although the traditional open type of coble is still used at Flamborough Head, Filey and Redcar, where they are hauled out of the water, the harbour-based cobles of Whitby, Scarborough and Bridlington are often larger, with the fore part of the boat decked.

Cobles are manned by two or three men and work between 100 and 300 traps, which are hauled by a mechanical capstan worked off the main engine. During the period of the survey some 40 cobles were engaged in crab fishing on a full-time basis: on the Yorkshire coast the majority were at Filey (11), and Flamborough (10).

Although cobles have been used for centuries in the Yorkshire crab and lobster fisheries, larger craft of various designs have been used along this coast for trawling and drifting. In the 18th "five-man boats" were used for herring fishing but there is no record of these boats being used for crabbing. In 1803 the first yawl was built at Scarborough and this type of vessel gradual

Fishing methods

Traps, known locally as pots, are used to catch both crabs and lobsters for the commercial market (Figure 2). The pots are of the creel-type, being constructed of wood and netting with a base dimension of 24 x 18 inches and a height of 12 inches. Three half-hoops of hazel or cane support the netting of either sisal or twine or the now widely used synthetic fibres, such as nylon or "Courlene". The pot has two openings ("eyes") each constructed in the form of a short funnel and entering the pot from opposite sides, each "eye" having a diameter of about 5 inches at the narrowest part. Pieces of iron lashed to the wooden base are used to weight the pot. The catch is removed through a small "door", in one of the side panels. The bait is held between toggles in the single "bait band", which is a double length of stretched twine fitted from the roof to the wooden base. The pots are made by the fishermen at a cost of around 15 shillings each, excluding labour; the design varies little throughout the length of the Yorkshire fishery and is similar to the standard Scottish creel. It does however differ from the Norfolk pot, which has a cast iron base, two bait bands, and different openings. The number of pots worked by each boat is dependent upon the size of the vessel; for example, a 30 ft boat with a crew of two men can work about 200 pots, whilst a 50 ft keel-boat with a crew of five can handle up to 500.

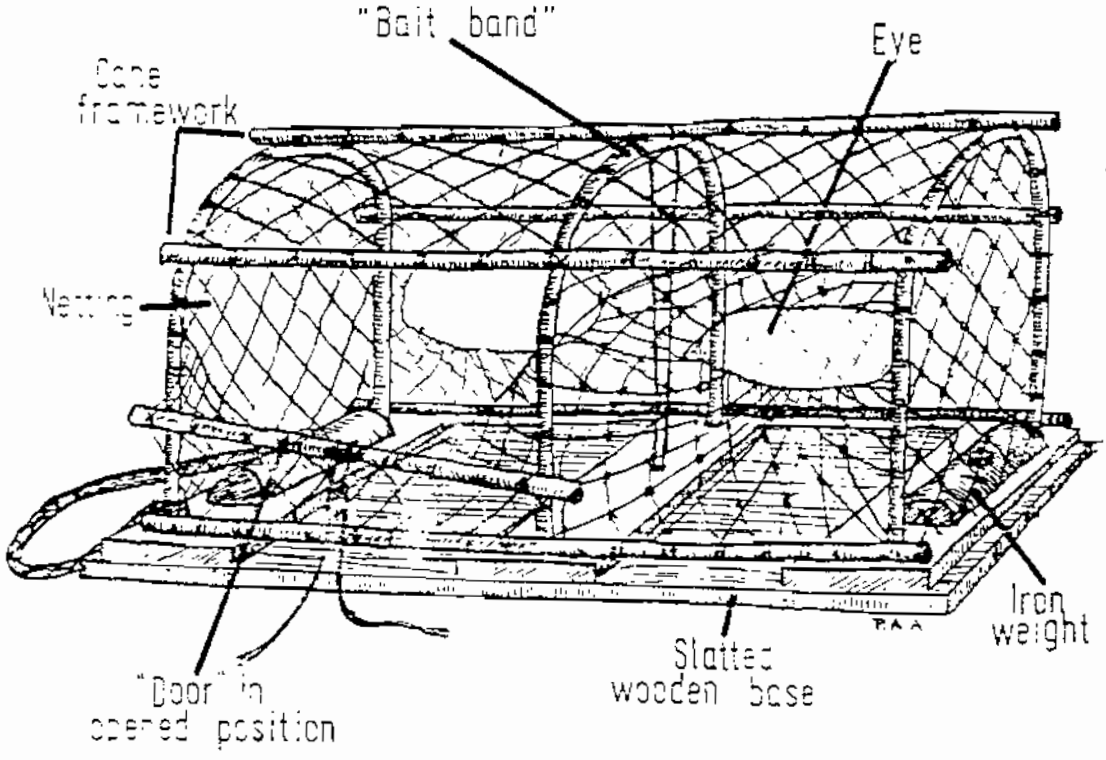

Figure 2 A Yorkshire crab and lobster pot

During the 1964 season about 22 450 pots were fished in Yorkshire waters by 100 boats, an average of 225 for each boat; they are fished in "fleets" of varying length, usually with between 20 to 70 pots attached to a single rope at 10 to 15 fathom intervals. The ends of each fleet are anchored and marked with a distinctive buoy. Mechanical haulers worked off the main engine are used to bring the pots to the surface, and a fleet of 50 can be hauled, the catch removed and sorted, and the pots rebaited and reset in about 40 minutes. Usually the pots are hauled once a day, but on occasions during rough weather some are not examined for several days. Loss of pots due to heavy seas buffeting and rolling them along the bottom does occur, particularly at the beginning of the season when the gear is dry and light. Losses are considerably greater when the pots are set in shallow water. During the severe gales of March 1964 at the start of fishing, around 3 000 pots were completely lost and another 1 500 damaged beyond repair.

Various kinds of fish are used for bait, and their price and availability will usually determine the choice. Most of the bait is caught locally and includes dabs, plaice and gurnard, the latter being particularly favoured because it has a hard skin and does not break up quickly. Fish offal such as cod heads and the backbones of skate are often used because of their relative cheapness. Redfish, landed at Hull and Grimsby by distant-water trawlers, are also used by Bridlington and Grimsby crabbers.

While the boats are on the fishing grounds the crabs are removed from the pots, and those with shell widths of less than the legal size limit of $4\frac{1}{2}$ inches are immediately returned to the sea. Recently moulted crabs known as "soft crabs" and females carrying eggs are protected by the 1877 (Oysters, Crabs and Lobsters) Act, and are also returned to the sea.

Commercial utilization

After being removed from the pots the day's catch is packed alive into boxes and sold by auction at the ports, or, by a pre-arranged agreement, to a shellfish merchant or processor. The crabs are sold by weight in units of stones (14 pounds) and prices fluctuate according to the supply and demand, the average price paid for one stone of crabs during this survey being between 8 and 13 shillings. Several firms in the area boil crabs and either sell them whole for the retail trade, or extract the meat and use it for the preparation of crab paste or for consumer and commercial frozen packs. Usually crabs with damaged limbs or with discoloured shells are considered unsuitable for the selected whole crab trade and are processed. At some ports, in particular Scarborough, some fishermen boil their own catches and have stalls on the seafront, where various types of shellfish are sold to the holiday-makers during the summer season.

Although no actual figures are available a large proportion of the Yorkshire catch is still sold in the shell as "boiled crabs". These are retailed locally in the coastal towns, which are all holiday centres, or sent to the populated areas in the industrial North and Midlands. The remainder of the catch is processed by removing the meat from the claws and body, usually by hand, but sometimes compressed air is used to assist in this task. During the period of the investigation, there were four major processing factories in operation - three at Bridlington and one at Hull. Supplies of crabs were transported by road to these factories from local ports, but on occasions when the local catches were low additional supplies were obtained from Northumberland or Scotland.

Manpower

The majority of men employed in the Yorkshire crab fishery are full-time professional fishermen, although they may spend only part of the year crabbing. Some fishermen, particularly the older ones, only work their pots during the spring and summer and lay their boats up for the remainder of the year; most of these men will however continue to work within the fishing industry during the winter, making or repairing pots or baiting long-lines. There was little change in the numbers of men employed in crab fishing during the period of the survey, the average being about 290 (Table 1).

Many men with full-time employment ashore outside the fishing industry also work a few pots in their spare time, and these men are classed as part-time fishermen. Although their boats are registered for fishing, these men generally own vessels of less than 40 ft in length and their catches are not always included in the published landing statistics for the area (see below). During the period of the survey there was no shortage of crews at any of the ports: many young men were joining the industry, and their numbers were just sufficient to replace those retiring. This recruitment was partly due to the relatively high level of unemployment along the north-east coast, although the majority of new entrants were the sons of fishermen who chose fishing from preference.

LANDINGS

Records of the annual Yorkshire crab landings are available from 1891. This information can be extracted from the Minutes of the Quarterly Meetings of the North-Eastern Sea Fisheries Committee, and from the Sea Fisheries Statistical Tables which are published by H. M. Stationery Office. Landings from 1891 to 1953 were recorded as numbers of crabs caught, but from 1954 onwards all figures given in the Statistical Tables are shown as weights landed - in units of hundredweights (112 pounds).

The weight of crabs landed annually from the Yorkshire fishery from 1925 to 1966 is shown in Figure 3. In common with other fisheries which were not exploited during the Second World War, there was an upward trend from 1946 to 1953, but landings from 1953 to 1965 have slowly declined, although the average catch during this period was still higher than before the War. Landings of crabs during 1966 were 3 790 cwt above the 1965 figure, an increase of 23 per cent.

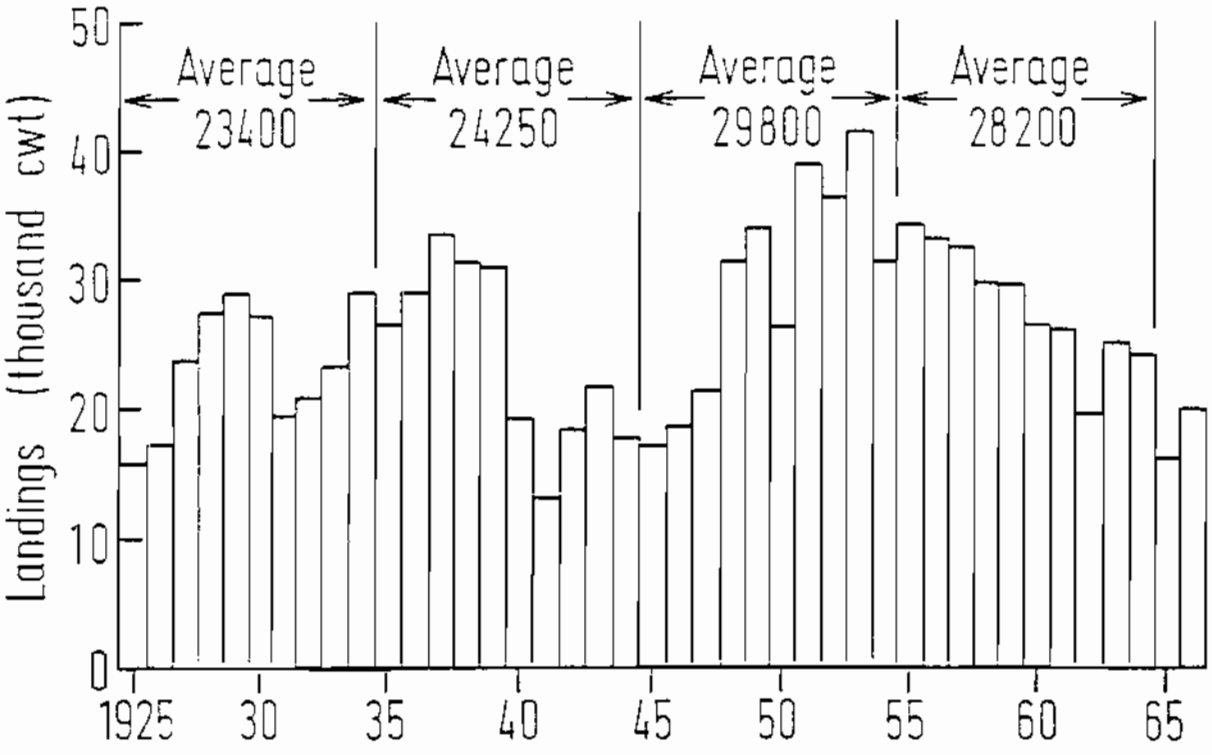

Figure 3 Annual recorded crab landings, Yorkshire coast, 1925-66

The weights of crabs landed at the various ports between 1955 and 1966 are shown in Table 2 and Figure 4. During this period there has been a continual decline in the annual catch for the whole fishery, amounting to a 30 per cent reduction between 1955 and 1964. The trend of landings at ports in the fishery (Figure 4) shows that those at Whitby, Grimsby and to a lesser extent Bridlington have fallen considerably, but those at Redcar, Staithes, Scarborough, Filey and Flamborough have remained fairly steady during this period. The landings at Grimsby have fallen from 6 886 cwt in 1955 to 2 134 cwt in 1964 - a decline of 4 752 cwt or 69 per cent; similarly the Whitby catch has declined by 4 742 cwt (41 per cent) during the same period. If the landings from Whitby and Grimsby are excluded from the annual landings for the Yorkshire coast it can be seen that although fluctuations did occur, they were only small and the landings over the 10-year period have been fairly steady.

Table 2 Crab landings (cwt) at Yorkshire ports, 1955-66

	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
MAJOR PORTS												
Whitby	11575	10315	9621	9392	8587	8007	7114	6538	6849	6833	4463	5553
Bridlington	7270	7891	6667	5991	7444	5737	5357	4557	6625	5933	3512	4066
Scarborough	3357	3559	3075	2715	3841	3021	3529	2370	3138	3283	2527	3097
Grimsby	6886	5544	7637	5646	3587	5368	4665	1493	2509	2131	2068	2776
MINOR PORTS												
Flamborough	2069	2955	2828	2671	2653	2278	2129	1661	3297	2987	2051	1911
Filey	1505	1390	1366	1345	1275	756	819	959	1512	1573	888	1579
Staithes	743	814	659	614	445	369	329	498	587	971	759	1066
Redcar	115	116	245	349	391	398	317	271	343	368	390	400
Total	33520	32584	32101	28723	28223	25934	24259	18347	24860	24082	16658	20448
Total excluding Whitby and Grimsby	15059	16725	14840	13685	16049	12559	12480	10316	15502	15115	10127	12119

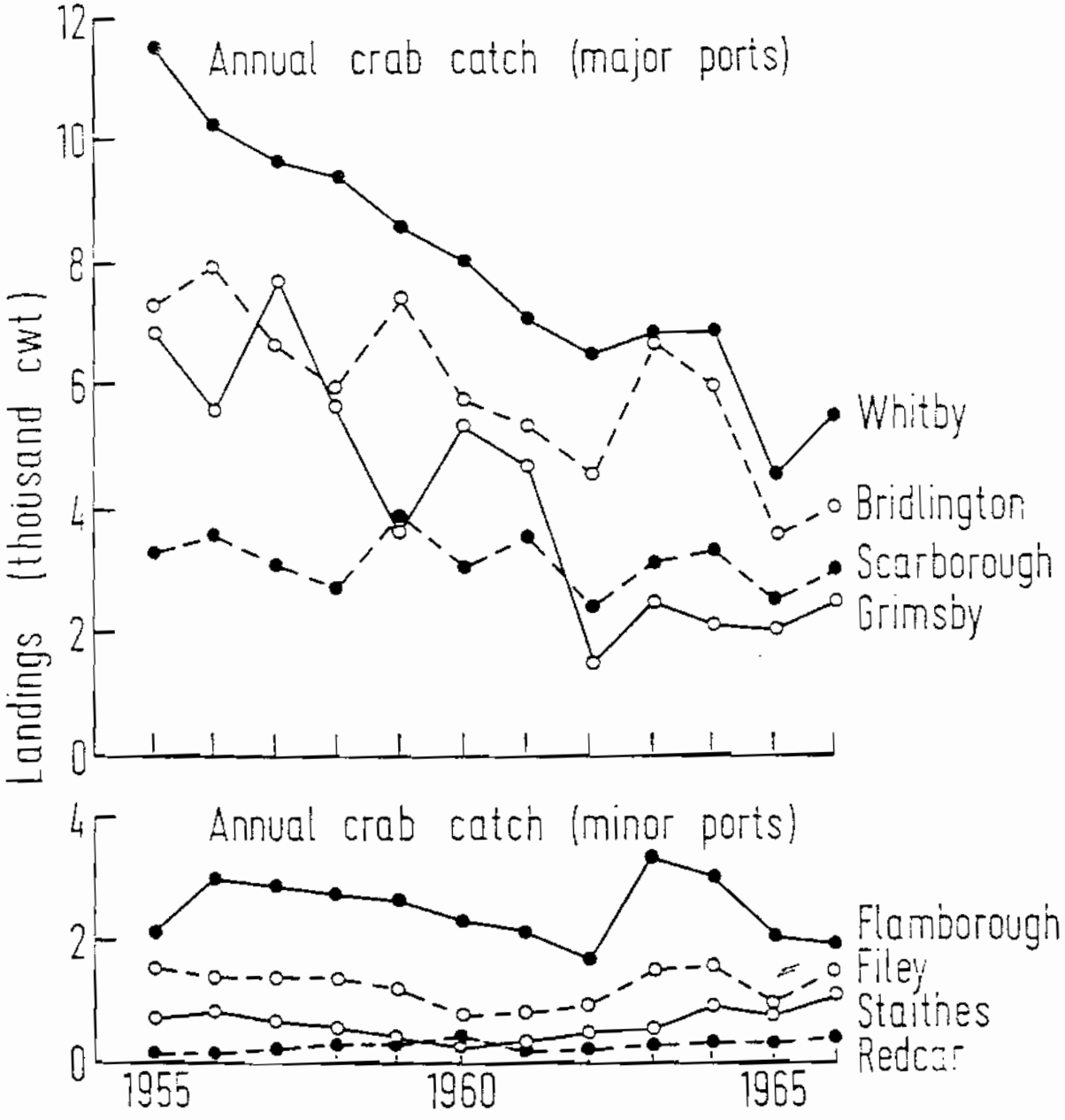

Figure 4 The weight of crabs landed annually at Yorkshire ports, 1955-66

It appears therefore that the continued decline in the annual crab landings from Yorkshire since 1955 can be attributed mainly to the substantial reduction in the landings at Grimsby and to a lesser extent at Whitby, due, it is believed, to a reduction in the crab-fishing effort at these ports during this period.

The reasons for the reduction in catch at Whitby and Grimsby would be better understood if the number of pots hauled during the year had been known. Unfortunately accurate data on the numbers of boats crabbing, together with the number of pots hauled each year, is only available from 1962 onwards, when

the Ministry introduced a scheme for the collection of this information. The number of boats crabbing in any year does not alone give the whole picture, because many boats continued to crab, but for only a short period of the yea

The overall reduction in the effort in the crab fishery is probably due mainly to this type of fishing becoming less profitable for the larger keel-bo The changeover to the more profitable types of fishing available in the area been accelerated by the development of an important trawl fishery, and many keel-boat crews have recently sold their pots and have fitted the more power engines and winches necessary for trawling. The coble fleet has remained fairly steady, and as this smaller vessel is a more economical unit it is like that this type of boat will assume a relatively greater importance in the futu of the crab fishery.

Table 3 Percentage of the annual Yorkshire crab catch landed at the variou Yorkshire ports, in the years 1955, 1960 and 1964

Port	1955	1960	1964	Port	1955	1960	1
Redcar	1	2	2	Filey	4	3	
Staithes	2	1	4	Flamborough	6	9	1
Whitby	35	31	27	Bridlington	22	22	2
Scarborough	10	12	14	Grimsby	20	20	

When the catches are expressed as the percentage contributed by each port it is seen that these have varied during the past 10 years, as shown in Table 3. The change has been very marked at Grimsby, where landings have followed a downward trend, from 20 per cent of the total Yorkshire catch in 1 to only 9 per cent in 1964; similarly, the proportion of the Yorkshire catch landed at Whitby has fallen from 35 per cent to 27 per cent. There has been gradual increase in the proportion of the catch landed at Flamborough, and th proportions landed at the other ports have remained fairly constant. Landing of crabs at the three major ports of Whitby, Scarborough and Bridlington rep sent about 60 per cent of the Yorkshire catch, and despite the downward trend in the landings at Whitby, this port has continued to land more crabs than any other in Yorkshire.

Information on the value of the crab catches at the various ports is sup plied in the North-Eastern Sea Fisheries Committee's Minutes of Quarterly Meetings. With the reduction in landings the value of the fishery has steadily declined by 14 per cent in 10 years, from £103 190 in 1955 to £88 848 in 1964 in spite of a 19 per cent increase in the average price paid per cwt, this bein £3 2s. 0d. in 1955 and £3 14s. 0d. in 1964.

Although some crabs are landed during the winter months the main crab fishing season is well defined: it usually commences in April and continues until the end of July (Figure 5). Catches reach a seasonal peak in May and June, and normally around 75 per cent of the annual catch is landed during the four months from April to July.

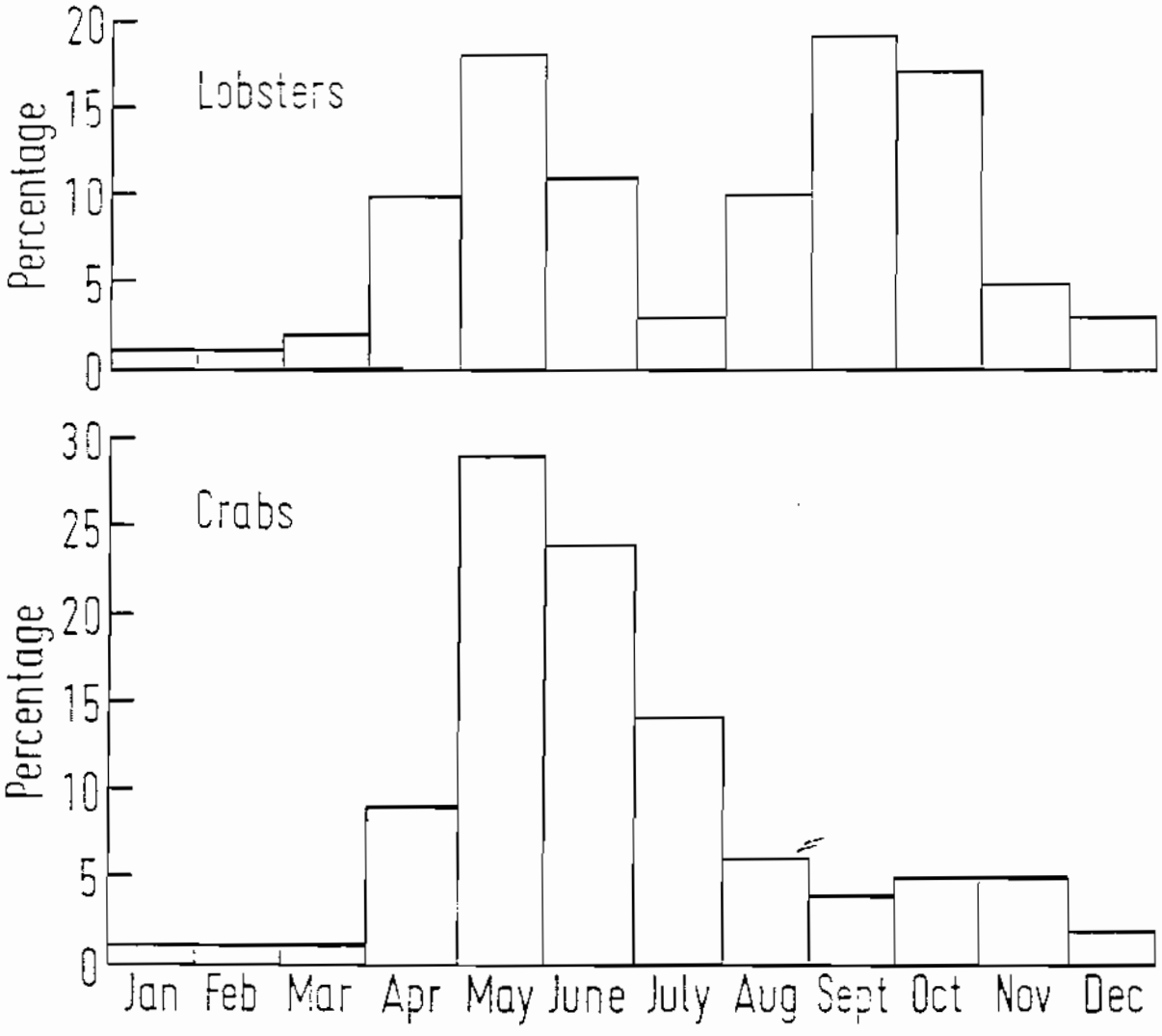

Figure 5 Proportions of the Yorkshire crab and lobster catches landed during each month of the year, based on catches for 1962-65

As mentioned earlier, pots used in the Yorkshire fishery catch both crabs and lobsters and there is often a seasonal emphasis on one species or the other. This is the cause of the increase of the lobster catch during August and September (Figure 5), when calm weather allows the pots to be set very close inshore on rich lobster grounds. In addition, at this time of year crabs are moulting and a larger proportion of the catch is soft-shelled and has to be rejected, and so fishermen will concentrate on lobsters and avoid the crab grounds.

CATCH IN RELATION TO EFFORT

In crab fisheries records of landings alone, although valuable, do not g a true guide to the abundance of the stocks, since landings are affected by su factors as weather, and by changes in fishing effort (both number of boats an pots hauled), as well as by variations in the abundance and feeding activity of crabs. Information on the changing abundance of crabs on the grounds can ho ever be obtained by relating the weight of the catch to the number of pots fish and expressing this as the catch from 100 pots hauled, i.e. the catch per unit effort. This is a more useful guide to the state of the stocks over a period, since it will not be affected by day-to-day changes in the number of boats fish

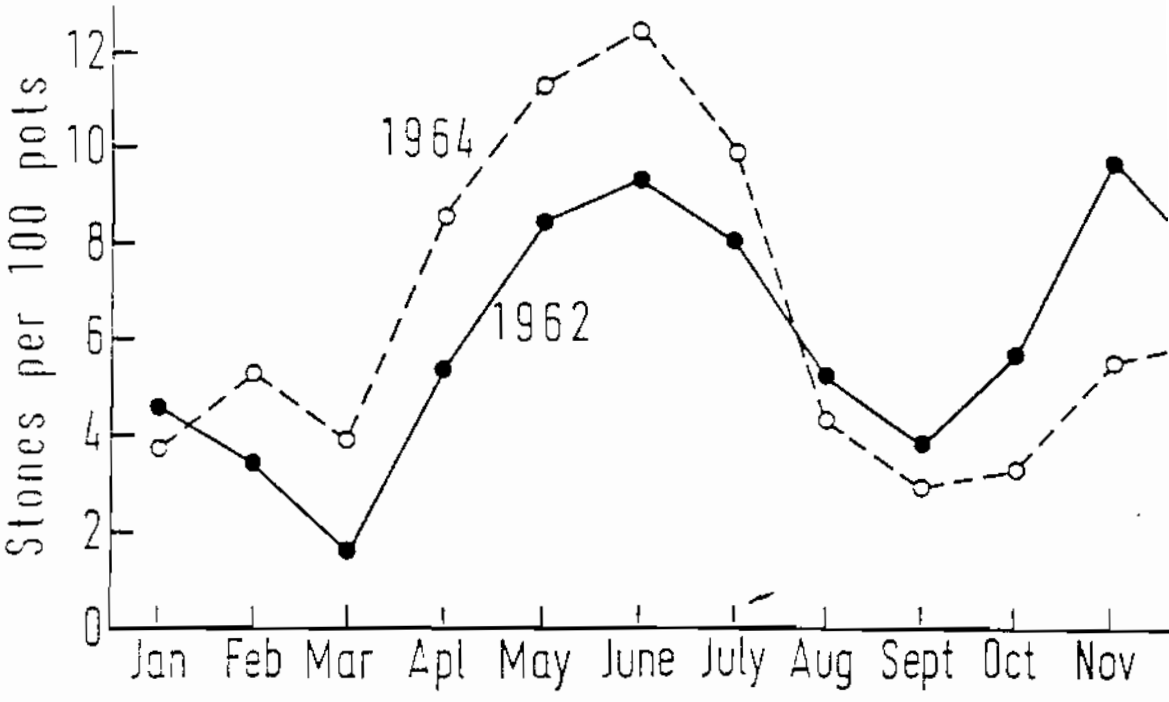

Figure 6 Monthly crab catch per unit of effort, Yorkshire. 1962 and 1964

Since 1962 Ministry Collectors of Statistics stationed around England have kep a weekly record of the number of boats employed in the crab and lobster fisheries, together with the number of pots hauled and the weight of shellfish caught. These figures have been used to show how the average catch from 100 pots varies throughout the season and from year to year. The records of the monthly crab catch per unit of effort for Yorkshire during 1962 and 1964 are shown in Figure 6, and both years show a similar pattern. Some boats were fishing during January, February and March, when catches were low, but there was a sudden increase in the catches in April, which could have been due either to a greater response to bait or a migration of crabs on to the fishing grounds. The period of highest catch per unit of effort in Yorkshire occurred

in June, and the average figure for 1964 was higher than that for 1962 (Table 4). The rapid decline in the catch per unit of effort later in each season is mainly due to moulting and mating, which takes place in the late summer.

Recent laboratory experiments have shown that variations in the amount of food eaten by crabs can be associated with changes in the water temperature: there is a rapid decline in feeding with a fall in water temperature, and below 4°C (39°F) feeding is negligible. It is therefore obvious that water temperature will affect the efficiency of baited pots, but other factors such as the abundance of natural food and the seasonal movements of crabs will also influence the catch per unit of effort during the year.

The average annual catch per unit of effort from 1962 to 1966 is shown in Table 4. Variations do occur between the ports, and consistently higher figures are obtained from the southern part of the fishery, which shows that crabs are more abundant in this area. However, despite the fluctuations at the ports there has been little variation in the average annual catch per unit of effort for the whole fishery, and therefore no evidence of any substantial changes in the stock of crabs on the grounds as a whole over the last few years.

Table 4 Average annual catch of crabs (stones) from 100 pots hauled

Port	1962	1963	1964	1965	1966
Whitby	7.4	8.0	8.1	6.3	8.1
Scarborough	4.3	6.6	5.7	7.7	7.6
Bridlington	10.5	14.2	17.5	14.4	16.1
Grimsby	12.2	21.0	20.0	19.6	21.2
Whole Yorkshire fishery	7.1	8.8	8.0	7.1	8.6
Thousands of pots hauled	1 933	2 042	2 227	1 667	1 626

Information on the fishing effort, as number of pots hauled, is now available for each season from 1962 to 1966. However, these data are composed of the effort in both the crab and lobster fisheries of Yorkshire, and cannot be separated into the two components. On average about 2 million pots were hauled during each year (Table 4) but there was a substantial reduction (25 per cent) in the effort between 1964 and 1965, which can be related mainly to the changeover to other types of fishing. There was little change in effort between 1965 and 1966 (a reduction of only 2 per cent). The collection of catch per unit of effort

data from Yorkshire ports is being continued and will be used in the future to give a guide to the state of the stocks.

CASTING - SOFT-SHELLED CRABS

The crab is covered by a hard rigid shell and so growth can only occur when this shell is cast. When casting (moulting) occurs, the shell cracks along a definite line, allowing the crab to clamber out of the old shell. Immediately after the moult the crab's body is soft and pliable and rapidly increases in size, due to the absorption of sea water. The new size is usually reached within two hours after moulting, and the shell then slowly thickens and hardens with the addition of layers of calcium salts, and no further growth will occur until the next moult. Newly moulted crabs can easily be recognized by the clean appearance and soft condition of the shell, which does not become completely hardened until two or three months after the moult.

On removal from the pots crabs in the soft-shelled condition are immediately returned to the sea because of their poor condition, and in accordance with the national regulation which protects them. It was therefore only possible to determine their abundance by accompanying commercial boats to the various grounds during each month of the season. In 1961 and 1962 this was done by members of the Ministry's staff: their records have shown that soft-shelled crabs were present in the catches during most months of the year (Figure 7),

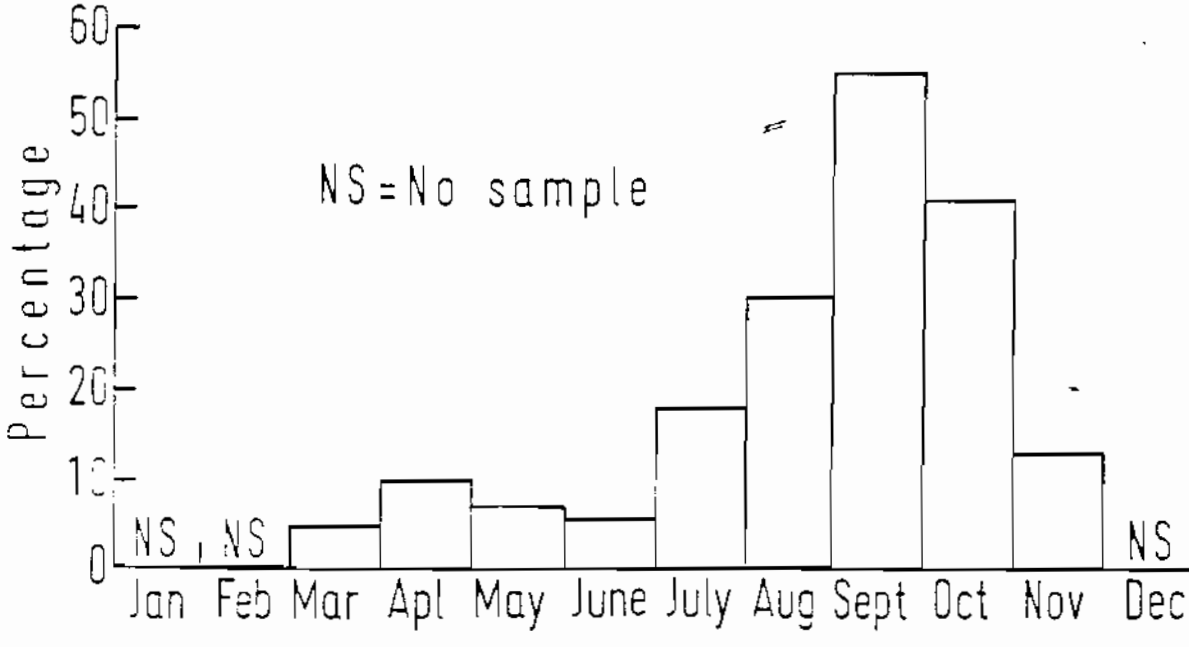

Figure 7 Proportions of soft-shelled crabs in the pots during the years 1961 and 1962

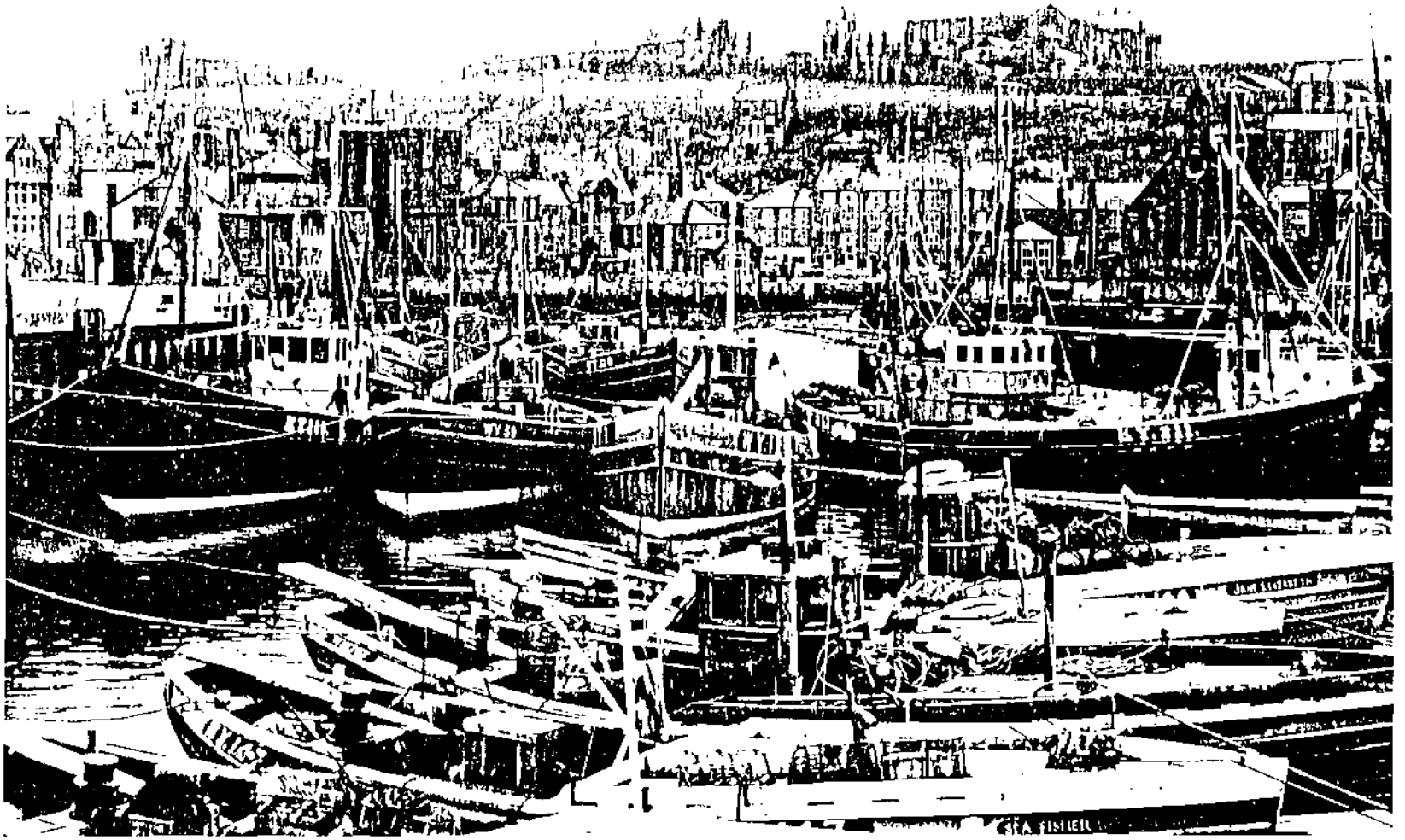

Plate 1 Part of the fishing fleet in the inner harbour, Whitby.

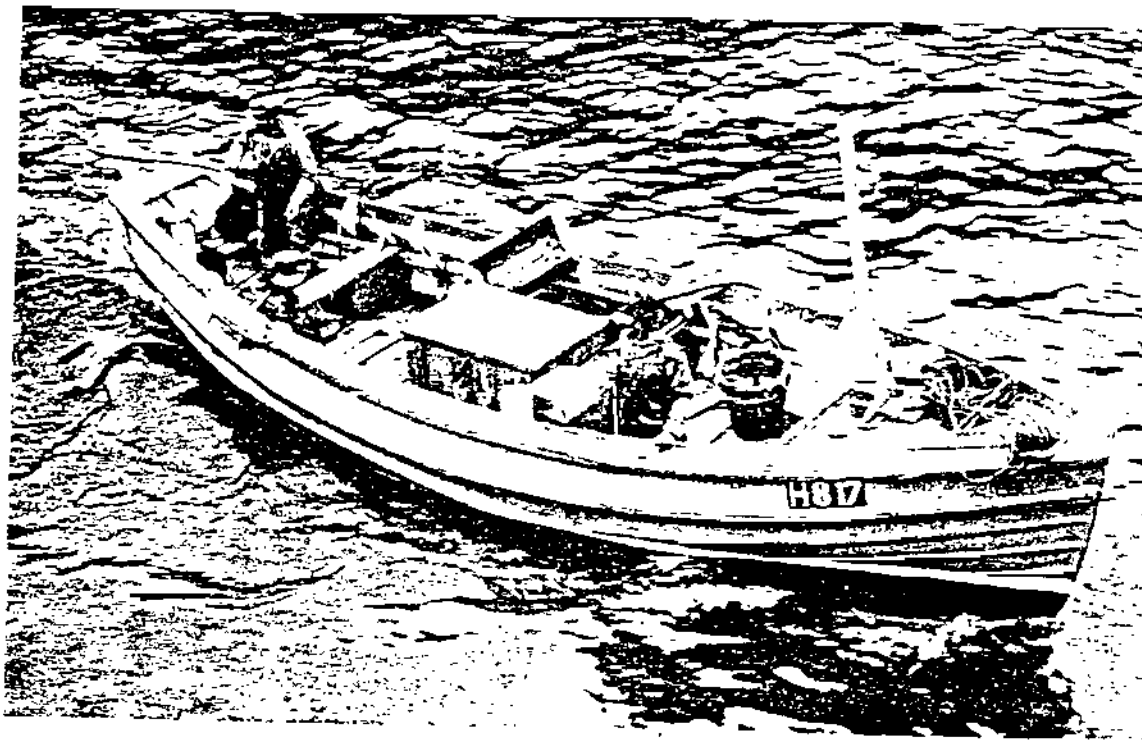

Plate 2 A typical Yorkshire coble.

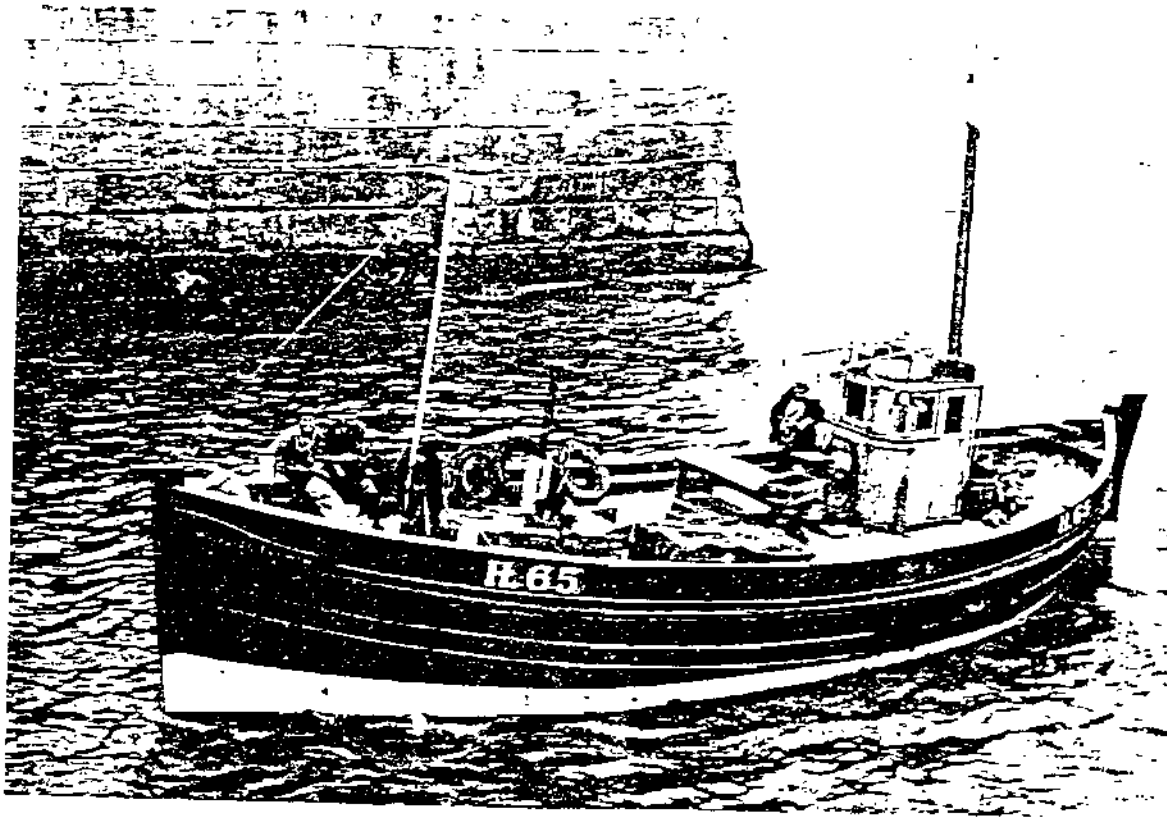

Plate 3 The Bridlington keel-boat WAYSIDE FLOWER.

Plate 4 A suture-tagged crab; the tag is attached by braided terylene, which is clamped with a lead seal.

Plate 5 A crab marked with a numbered plastic disc attached by wire to its claw.

Plate 6 Plugs visible in the two reproductive openings of a soft-shelled female c

Plate 7 A berried female crab.

but in the early part of the year the proportion never exceeded 10 per cent of the whole catch. The main moulting period was found to commence in July and to continue until October, although a few soft crabs were still found in November. During the moulting period the total numbers of soft crabs in the catches varied from 30-50 per cent, and this is one of the reasons why many boats discontinue crab fishing after July. Although the main moulting period was well defined there was some variation in the time of year when it started: in 1961 moulting commenced in early July, whilst in 1962 it occurred later in that month. Observations made in 1963 indicated that in that year moulting did not start until August, and this delay is believed to have been associated with the severe winter of 1962/63 and the low water temperature which prevailed until May.

It was also found that during July and August the recently moulted crabs of commercial size present in the catches consisted of more females than males. In September and October the number of soft-shelled males had increased, and the shells of most of the females had hardened. Although there was some overlap it does appear that the majority of females moulted before the males, and this difference in timing is related to the mating act, which occurs between hard-shelled males and recently moulted females.

GROWTH

When a crab moults any external marks or structures which could perhaps be used as a guide to its age are lost, and this has made it difficult to determine the rate of growth or the age of crabs. However the development of the suture-tag (Plate 4), which is not lost when the crab moults, has made it possible to determine the increase in size after moulting under natural conditions. During the 1962, 1963 and 1964 fishing seasons 2 600 crabs, ranging in size from $3\frac{1}{2}$ to 8 inches, were tagged by the suture-method and released off the Yorkshire coast. A reward of 3 shillings was offered for the return of each tagged crab together with full details of the position and date of recapture. Prior to release the size of each crab and the number on the tag were recorded, so that when they were recaptured they would provide information on the amount of growth which had occurred and give a record of their movement. (see page 19). Of the crabs released in these experiments 309 (12 per cent) were later recaptured, and since 119 of these had moulted it was possible to make an estimate of the growth of crabs in this fishery.

Measurements of the moulted crabs showed that the average increase in shell width after a single moult was about one fifth of their previous size, usually in the region of a one-inch increase. In Yorkshire the males were found to increase in width at the moult more than the females. The increase in weight after a moult was also found to differ between the sexes, a very important aspect of growth in the Yorkshire fishery, where crabs are sold by weight. On average,

female crabs nearly doubled their weight, whilst males became two and a half times as heavy. These results showed that, on average, after one moult a $4\frac{1}{2}$ inch male crab will reach a shell width of $5\frac{3}{4}$ inches, and its weight will increase by 110 per cent, from 9 to 19 oz: a $4\frac{1}{2}$ inch female, which on average weighs 8 oz, will reach a size of $5\frac{1}{2}$ inches and a weight of 14 oz. Mature male crabs are heavier than females of a similar size, due to their larger claws. Crabs of both sexes which have shell widths of about $3\frac{1}{2}$ inches will reach the legal size of $4\frac{1}{2}$ inches after a single moult.

It is more difficult to determine how often crabs of various sizes moult, but a method of analysis which used the recaptures from suture-tagging experiments, taken on yearly anniversaries after release, has made it possible to make some estimates of average annual growth and the annual frequency of moulting for various sizes of crabs of both sexes. The results from the 1962-64 suture-tagging experiments form the basis for Table 5. The figures are presented in units of millimetres because this unit was used to record the shell widths, and conversion to inches would reduce the value of the results.

Table 5 Calculated average annual increase in size, and the proportion of crabs which moult each year, from the data of suture-tagging experiments (1 inch = 25.4 mm)

Shell width groups (mm)	Equivalent shell width (inches)	Females		Males	
		Average annual increment (mm)	Estimated % of crabs which moult annually	Average annual increment (mm)	Estimated % of crabs which moult annually
90- 99	$3\frac{3}{4}$	26	100	26	100
100-109	4	27	100	27	91
110-119	$4\frac{1}{2}$	24	84	14	53
120-129	5	18	67	3	13
130-139	$5\frac{1}{2}$	13	50	1	7

Table 5 shows that the annual growth slows down in both sexes after a size of 4 inches is reached. This is not because the actual increase in size at each moult becomes smaller, but because fewer of the larger crabs moult. Furthermore, for males the proportion moulting annually decreases earlier than for females, and this results in a faster growth rate for females than for males of a similar size. This would affect any recommendation regarding an increase in the minimum size to 5 inches; for example, since only 50 per cent of the $4\frac{1}{2}$ inch male crabs moult each year, it would take two years for them all to grow to a fishable size, compared with only one year if all of them moulted each

year. In the case of the 4½ inch females, although more of them would moult in the year following the raising of the minimum size to 5 inches, many would have mated and are more likely to move out of the fishery (see below, under "Migrations"). All these factors need to be considered when drawing conclusions on the effects of raising the minimum size for crabs.

MIGRATIONS

At the start of this investigation only limited information was available regarding the pattern of migrations in the Yorkshire crab fishery, and so it was essential to determine the extent of any movements and to relate it to the question of changing the minimum legal size. In the growth studies described earlier in this leaflet crabs were marked with suture-tags and released at points along the Yorkshire coast. Recaptures from these tagging experiments also provided information on how far the crabs moved during their period of freedom.

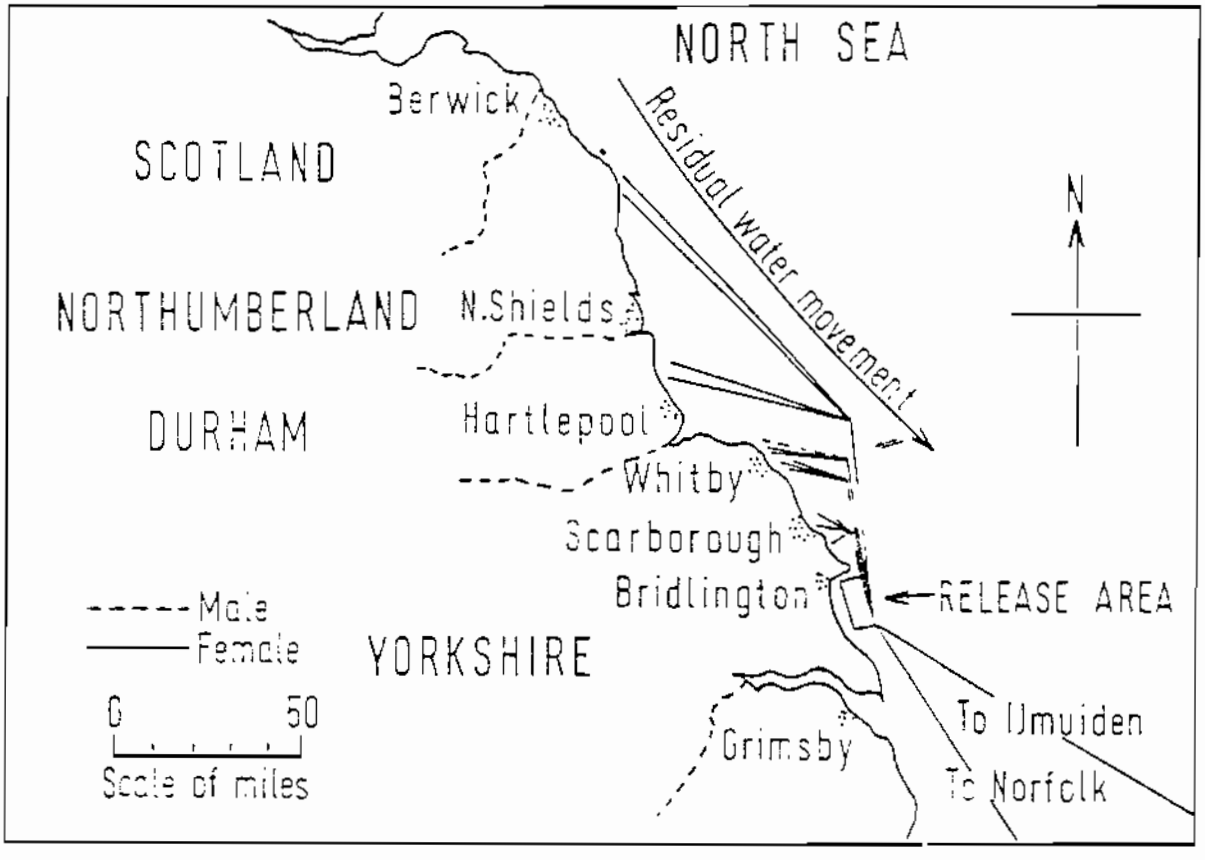

Figure 8 Migrations of recaptured suture-tagged crabs, released in the area Flamborough Head to Aldbrough in 1962 and 1963, which had moved more than 20 miles from their position of release

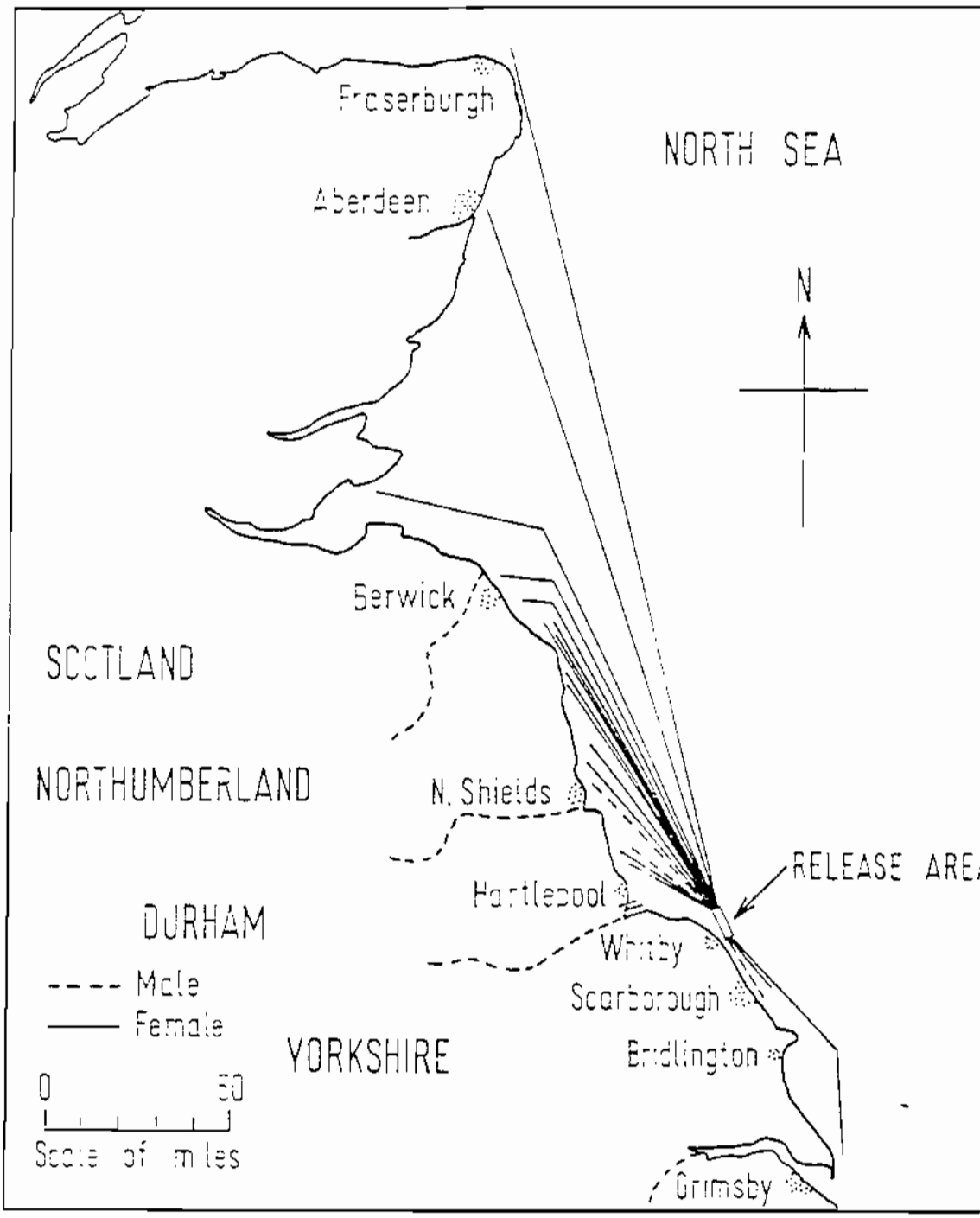

Figure 9 Migrations of recaptured suture-tagged crabs, released in the ar between Staithes and Robin Hood Bay in 1962 and 1963, which had moved more than 20 miles from their position of release

The results from the tagging experiments of 1962 and 1963 showed that tagged crabs released off Yorkshire travelled considerable distances from their original point of release. The migrations of 20 miles and over are shown in Figures 8 and 9, but as the movements plotted represent the shortest distance between the positions of release and recapture, the actual distance travelled may have been greater. Almost all the movements of more than 20 miles were made by female crabs, most of which moved in a northerly direction. Of the recaptured males 95 per cent had moved less than 5 miles from the point of release and only 3 had moved distances of more than 20 miles, compared with 40 of the recaptured females. The longest distance so far recorded was from Whitby to Fraserburgh, a direct distance of 230 miles, which was covered by a female crab in 52 weeks of freedom. All the crabs which took part in these migrations had shell widths of at least 5 inches: juvenile crabs of both sexes remained in the area of release.

Crabs recaptured during the year in which they were released had moved only short distances, and the majority of the long-distance movements were from female crabs recaptured in the year following release. The extensive migrations made by female crabs are believed to be a combination of an offshore movement during October and November to spawn, followed by a return to the inshore waters further north in the late spring, when the eggs hatch. Likewise, similar experiments off Norfolk during 1959 and 1960 showed that female crabs migrated out of this fishery to the Yorkshire coast, some being recaptured by fishermen working as far north as Whitby. As a follow-up to the 1962/63 experiments, in May 1965, 2 200 crabs marked with suture-tags were released off the Yorkshire coast. The recaptures during the 1966 season are shown in Figure 10, and these also indicate that there was a northerly migration of female crabs out of the Yorkshire fishery during these years. As long ago as 1906 J. R. Tosh of the North-Eastern Sea Fisheries Committee reported the results of his experiments along the Yorkshire coast and showed that, although the majority of crabs were recaptured within 10 miles of the place of liberation, some females travelled up to 120 miles northwards. Similar migrations have been recorded by other scientists whilst studying the Northumberland and Scottish crab fisheries.

In the North Sea the residual current drift is in a southerly direction, so that crabs moving north are walking against the current. When the larvae from these crabs are hatched in the late spring or early summer they are free floating and drift southwards with the current for about a month, before they finally settle to the sea bottom and assume the adult shape. The northerly migration of female crabs which occurs along the east coast of Britain is believed to be an instinctive behaviour pattern which results in the larvae settling in an area suitable for their survival.

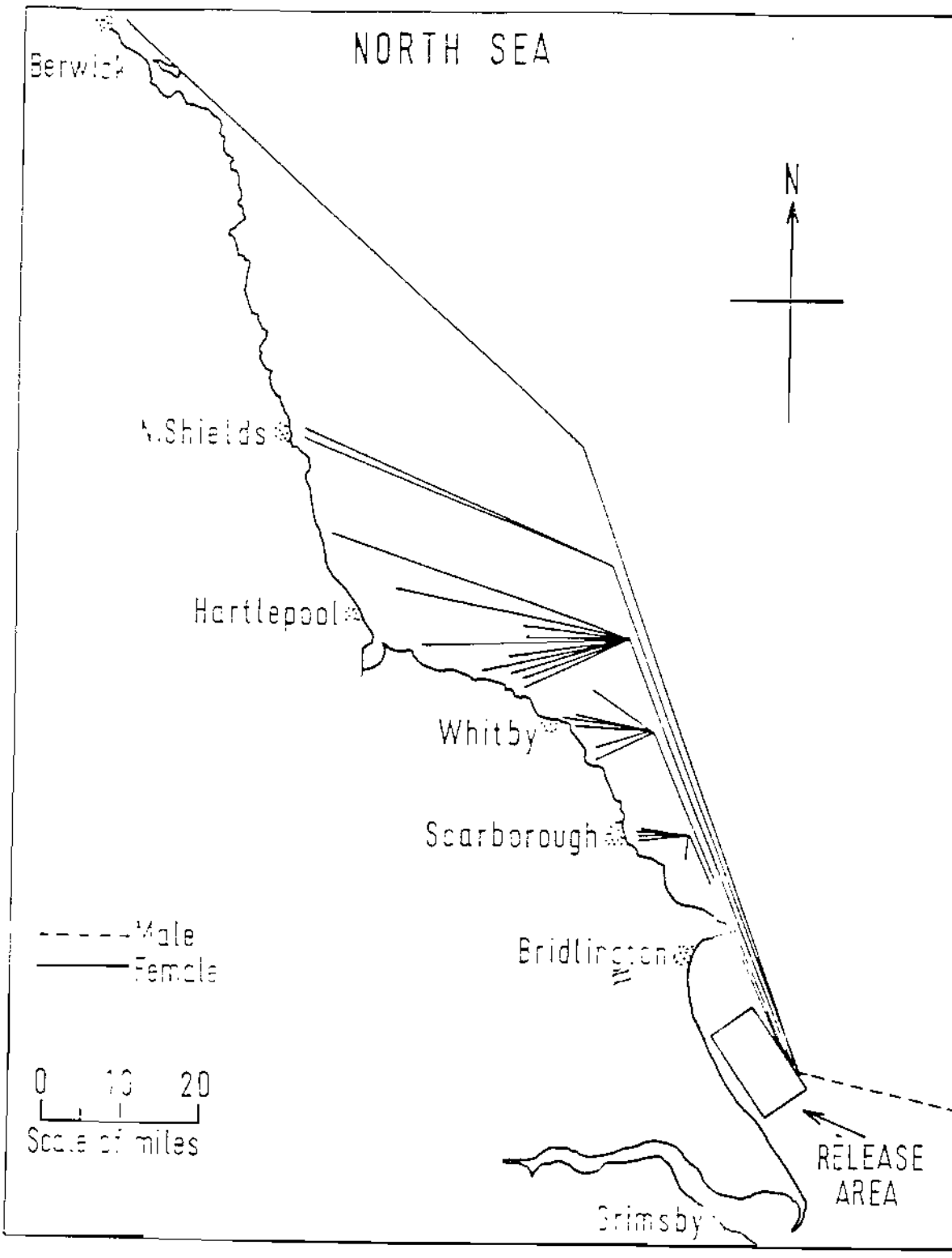

Figure 10 Migrations of suture-tagged crabs, released in May 1965 and recaptured during 1966, which had moved more than 5 miles from their position of release

It is difficult to determine accurately what proportion of the stock migrates, but 40 per cent of the females released off Whitby in 1962 and 1963 were recaptured outside the Yorkshire fishery in the following year, nearly all of them having moved in a northerly direction, into either Durham or Northumberland waters (Figure 9). Similarly 40 per cent of the recaptured female crabs released on the grounds between Bridlington and Aldbrough had moved north, 30 per cent of them into the area between Scarborough and Whitby and 10 per cent to the Durham and Northumberland areas (Figure 8). One female released off Hornsea, Yorkshire in 1962 was recaptured off Sheringham, Norfolk in the following year. This is the first record of a crab moving from Yorkshire to Norfolk, a distance of about 90 miles, and this is also one of the longest movements in a southerly direction. Another interesting recapture was made by a Dutch trawler fishing 40 miles north-west of IJmuiden in September 1965, which caught a female crab released off Flamborough Head in 1963. This 6½ inch crab, which had moved 170 miles, had not moulted during the 2½ years of freedom and is the first tagged crab to be recaptured from this area.

These recaptures show that there is a considerable movement of mature female crabs, mostly over 5 inches in shell width, from the southern to the northern part of the Yorkshire fishery, as well as completely out of the area.

Crabs are known to make seasonal migrations and to move offshore to the deeper water in the winter and return to the inshore waters in the spring. In April 1964 a tagging experiment was carried out in the area between Flamborough Head and Withernsea and, although the main purpose of this work was to determine the numbers recaught by the fishermen (see page 28), the experiment also yielded valuable additional information on local migrations in the early part of the season. In this experiment pots worked by a hired commercial boat were fished at distances of ½, 1½, 2½ and 3½ miles from the shore and were hauled and rebaited on four consecutive days. Each commercial-sized crab (4¼ inches and over) that was caught was marked by attaching a numbered plastic tag to one of the claws (Plate 5) and then liberated in the area of capture. The migrations of crabs released at the 2½ mile stations in April which were recaptured in the following 2 months of fishing are shown in Figure 11, indicating an inshore movement of both sexes at this time of year, although any offshore migrations would not have been traced because the majority of boats were fishing close inshore. This inshore migration is believed to be associated with the mixing of the sexes prior to moulting and pairing, which starts in July. A similar migration was found during the study of the Norfolk crab fishery.

The offshore migration commences in late September and is probably associated with falling sea temperatures. It has been difficult to determine the rate at which crabs migrate to the deeper water, because the majority of crab fishing takes place within 3 miles from the shore and therefore few tagged crabs are recovered outside the main fishing areas, although several have been caught by trawlers.

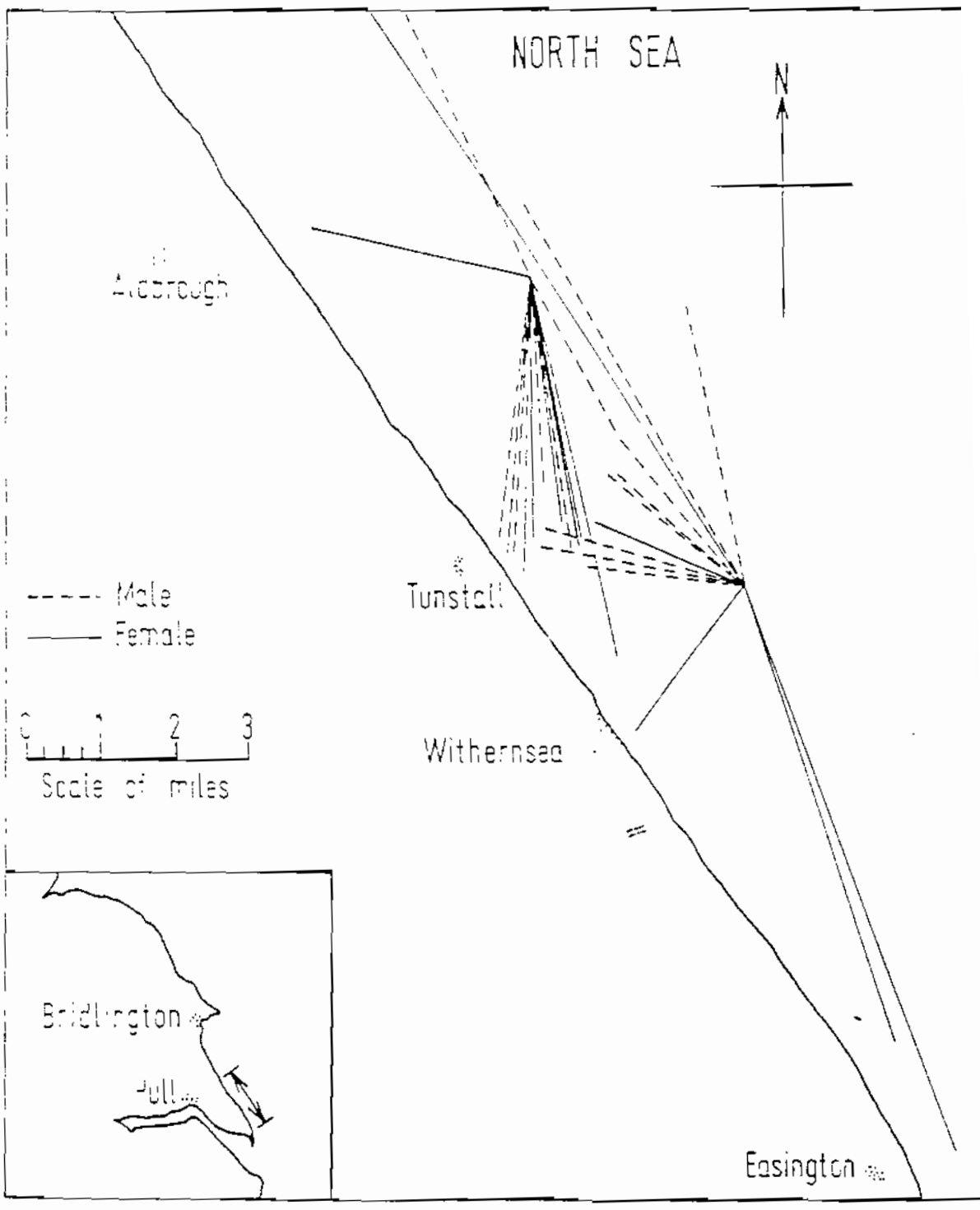

Figure 11 Local movements of crabs tagged and released 2½ miles offshore in April 1964 and recaptured during the following two months

LENGTH- AND WEIGHT-COMPOSITION OF THE PRESENT CATCHES

Estimates of the immediate loss to the Yorkshire crab fishery, which would follow any increase in the minimum landing size from 4½ to 5 inches, must be based on a knowledge of the composition of the catch by size and weight. Samples of the catches were measured at the ports each month and also whilst at sea with commercial fishing boats, from which the size range of crabs caught on the various grounds and landed at ports throughout the district could be compared.

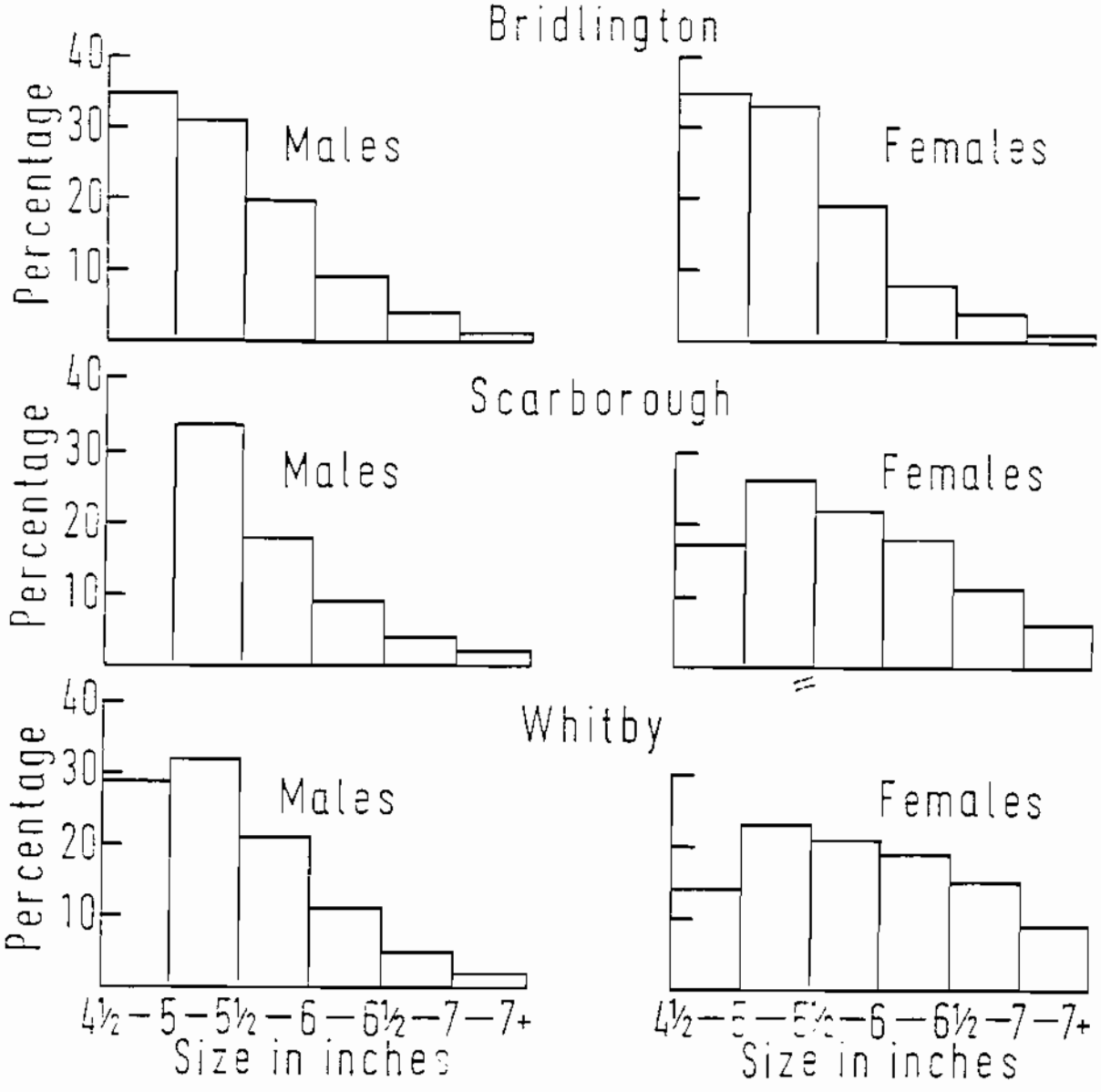

Figure 12 Proportions of the Yorkshire crab catch in the various size groups (1961-64)

During the survey some 40 000 crabs of commercial size ($4\frac{1}{2}$ inches and over) were measured. Information collected during 1961 and 1962 from samples taken at every port showed that for all practical purposes measuring could be confined to the three main ports of Whitby, Scarborough and Bridlington, which land the bulk of the crab catch, and in 1963 and 1964 sampling was confined to these three ports.

Shell width measurements collected since 1961 show that the average size of crabs landed increases from the southern part of the fishery (Grimsby-Bridlington) northwards (Whitby). When males and females are considered separately it is seen that the size range of male crabs caught varies little from south to north, but more small females are caught in the southern part of the fishery than further north (Figure 12 and Table 6). This is associated with the northerly migration of females larger than 5 inches, which has been found to occur along this coast, and which has been discussed earlier.

Table 6 The percentage of the crab catch landed between certain size limits for three Yorkshire ports (1961-64)

Port	Sex	Size-group (inches)						Percentage 6 inches and over
		$4\frac{1}{2}$-5	5-$5\frac{1}{2}$	$5\frac{1}{2}$-6	6-$6\frac{1}{2}$	$6\frac{1}{2}$-7	Over 7	
Bridlington	Male	35	31	20	9	4	1	14
	Female	35	33	19	8	4	1	13
Scarborough	Male	33	34	18	9	4	2	15
	Female	17	26	22	18	11	6	35
Whitby	Male	29	32	21	11	5	2	18
	Female	14	23	21	19	15	8	42

The fact that female crabs are larger at Scarborough and Whitby than at Bridlington, where both sexes are of similar average size, is also shown by the proportion of the catch of 6 inches and over (Table 6).

The relatively small proportion of the crabs just over $4\frac{1}{2}$ inches in the catches shows that, unlike the Norfolk fishery, this fishery is not based primarily upon crabs that have only become larger than $4\frac{1}{2}$ inches in the previous year. Furthermore the presence of quantities of large crabs, 6 inches and over, in the catches suggests that the fishery is not over-exploited. The figures of the proportion of crabs between $4\frac{1}{2}$ and 5 inches also represent the percentage reduction in the numbers of the landed catch which would inevitably occur during the first year following an increase in the minimum size to 5 inches. This loss would vary from port to port, but it would be greater at Bridlington and Grimsby than at northern ports.

In the Yorkshire fishery, where crabs are sold by weight, it is important to know the weight of the catch between $4\frac{1}{2}$ and 5 inches, since this would be lost following an increase in the minimum size. During the survey several thousand crabs were weighed individually, and a relationship between shell width and weight was obtained for each sex: from these data it was possible to calculate the proportion of the weight of the catch in the various size groups. The immediate loss in weight following a change in the minimum size to 5 inches would vary along the coast, but for the whole fishery it would be about 16 per cent (Table 7).

Table 7 Percentage weight loss which would have occurred during the first year if the minimum size had been increased to 5 inches in 1961, 1962 and 1963

Port	1962	1963	1964
Bridlington	24	26	17
Scarborough	16	17	11
Whitby	12	10	7
Whole fishery	18	18	12

The expected percentage loss for 1964 is smaller than in the previous two years, mainly due to the presence of fewer crabs in the small size groups. The immediate loss in weight of the catch at Whitby would be between 7 and 12 per cent, whilst in the Bridlington area, where crabs are smaller, the losses would vary between 17 and 26 per cent by weight.

The weight of crabs at various shell sizes is shown in Table 8. Below $4\frac{1}{2}$ inches the weight of males and females was the same, but above this males were heavier due to the development of larger claws. Samples taken at different times of the season showed that the average weight of a crab varied by only a small amount during a year, but there was greater variation between the samples taken in different years. The weight of a crab will be affected by its condition, but in many cases where there is a poor meat content the body is filled with fluid which has a similar weight to meat.

On average a stone (14 lb) of Yorkshire crabs will contain between 13-15 individuals. Because of the larger average size a stone of Whitby crabs will on average contain 12 crabs, whilst at Bridlington a stone will average 16 crabs.

Table 8 Average weight of crabs at various shell widths

Shell width (inches)	Weight (ounces)		Shell width (inches)	Weight (ounces)	
	Female	Male		Female	Male
4	6	6	6	19	22
4½	8	9	6½	24	29
5	11	12	7	30	37
5½	15	17			

INTENSITY OF FISHING ON THE CRAB STOCKS

By means of tagging experiments the effects of fishing have been calculate In these experiments we did not use the suture-tag but one attached to the claw (Plate 6), and although this tag is lost when the crab moults, important informa tion is gained on the proportion of the stock taken by fishing between the time of release and the onset of the moulting season. In experiments made during 1962 1963 and 1964, 3 038 tagged crabs were released on the inshore grounds at the beginning of the fishing seasons and a reward of 2 shillings was offered for the return of each tag. The proportion of the tagged crabs subsequently recaptured during the season gave a measure of the fraction of the stock removed by fishing

Table 9 Details of claw-tagging experiments, 1962-64

Period of experiment	Number released	Number recaptured	Percentage recaptured	Area
March-December 1962	800	200	25	Whole fishery
May-December 1963	1 300	692	53	Whole fishery
April-December 1964	938	241	26	Bridlington-Aldbrough
Total	3 038	1 133	37	

The numbers of tagged crabs released and the proportion later recaptured are shown in Table 9. On the basis of these recaptures it has been calculated that approximately 25 per cent of the stock was removed during each of the 1962 and 1964 seasons, but a higher figure of about 50 per cent was removed during 1963: this higher recapture rate is believed to have been brought about by the

conditions occurring after the severe winter of 1963. The overall annual fishing mortality during the period 1962-64 was in the region of 30 per cent. This figure is low when compared with the figure of 70 per cent of the stock removed by fishing during experiments in the Norfolk fishery in 1957-58. The fact that there is a high proportion of large crabs on the Yorkshire grounds can also be taken as an indication that the stock is not subjected to a high overall mortality. The reduced fishing effort since 1965 will probably have resulted in an even lower rate of exploitation.

BREEDING OF THE CRAB

Mating occurs in the inshore waters along the Yorkshire coast during the summer, immediately after the female has moulted and while she is still in the soft-shelled condition. Prior to the moult and for a period of up to a fortnight afterwards, the female is attended by a hard-shelled male. This attraction between mature crabs is believed to result from a chemical substance, as yet unidentified, produced by the female crab at the moulting time. Females which moulted in our laboratory tanks were each attended continuously by a single male for a period of between 3 and 20 days before moulting; after mating the males guarded the females for a further period of up to 12 days, until they began to harden and were not so defenceless.

Immediately mating has been completed the female secretes a fluid from her reproductive openings which hardens on contact with sea water and closes each of the two openings with a solid white plug (Plate 6). The tips of these plugs can easily be seen in soft-shelled females which have mated, although as the crab hardens they gradually disappear from sight and eventually break up. The presence of "plugs" in a soft-shelled female can therefore be used as an indication that mating has taken place. The majority of females which mate in July and August will spawn (i.e. become berried) in the November and December of the same year, although in some cases spawning is delayed until the next winter. Crabs usually select a soft sea-bed for spawning, often in deep water; afterwards the eggs remain attached to the fine hairs on the swimmerets of the abdomen (apron) for 7 to 8 months (Plate 7). Berried females are only occasionally caught in the Yorkshire fishery; our records show that although 20 000 females were examined by Ministry staff whilst accompanying commercial boats, only 200 of these were berried. The majority of berried crabs are caught in the pots during the early spring when they move inshore, but quantities are often caught by trawlers working in various parts of the North Sea during the winter, when these crabs are offshore. Although berried females are not caught in great numbers, crabs which have recently hatched their eggs are numerous in the pots, particularly from May to July. These crabs can easily be recognized by the presence of empty egg capsules on the swimmerets, and by the dirty and blackened condition of the shell, which is caused by the

crab's habit of partially burying itself in the sea-bed whilst carrying eggs. This observation suggests that once rid of their eggs the crabs enter the pots easily, and it is possible that the large egg mass of the berried females does hamper their ability to climb into the pots.

The majority of berried females examined during the survey were 6 to 8 inches in shell width (Table 10); the smallest we found was 5 inches in size, although fishermen have reported occasional ones of about $4\frac{1}{2}$ inches shell width.

Table 10 Percentage size distribution of 200 berried female crabs caught along the Yorkshire coast

	Size-group (inches)									
	$4\frac{1}{2}$-5	5-$5\frac{1}{2}$	$5\frac{1}{2}$-6	6-$6\frac{1}{2}$	$6\frac{1}{2}$-7	7-$7\frac{1}{2}$	$7\frac{1}{2}$-8	8-$8\frac{1}{2}$	$8\frac{1}{2}$-9	9-$9\frac{1}{2}$
Percentage berried	0	3	7	17	20	31	13	8	1	0

It is believed that most female crabs in the Yorkshire fishery are mature by the time they reach a size of 5 inches, whilst nearly all the males of $4\frac{1}{2}$ inches examined had mature sperm sacs containing ripe sperm.

Some information was obtained on the number of eggs carried by berried females of various sizes, caught in the Yorkshire fishery. The eggs were first removed from the swimmerets by drying and were then weighed. These weighed samples were counted, and from these the total number of eggs carried was calculated. The numbers of eggs carried by the females examined are given in Table 11, showing that crabs have a very high fecundity, with the larger crabs carrying more eggs than the smaller ones. The average number of eggs carried by a 7 inch crab was in the region of 2 million, although one female of this size had $2\frac{1}{2}$ million eggs.

Table 11 Number of eggs carried by berried females of various shell sizes

Shell width (inches)	Number of eggs carried	Shell width (inches)	Number of eggs carried
7.4	2 623 500	6.8	1 995 500
7.2	2 376 500	6.8	1 766 800
7.0	2 176 500	6.3	1 847 000
6.8	2 451 000	6.0	823 800
6.8	2 524 000	5.7	1 632 000

The eggs are about one-fiftieth of an inch in diameter, and in the spring and summer of the year after spawning they begin to hatch. The larvae which emerge look more like shrimps than crabs, and become part of the free-floating plankton (Figure 13). This planktonic period lasts for about a month, during which time the larvae is carried by the current to the area where it finally settles to the sea-bed and takes on the true crab shape, although at that stage it is still only about one-eighth of an inch in width. The critical period in the life history of most marine animals which produce a large number of eggs is during the planktonic stage, and fluctuations in the catches from year to year can often be associated with the conditions affecting the survival of larvae several years earlier. Although growth can be expected to vary in different years it is estimated that on the east coast of England it will normally take about 4 or 5 years for a young crab to reach a shell size of $4\frac{1}{2}$ inches.

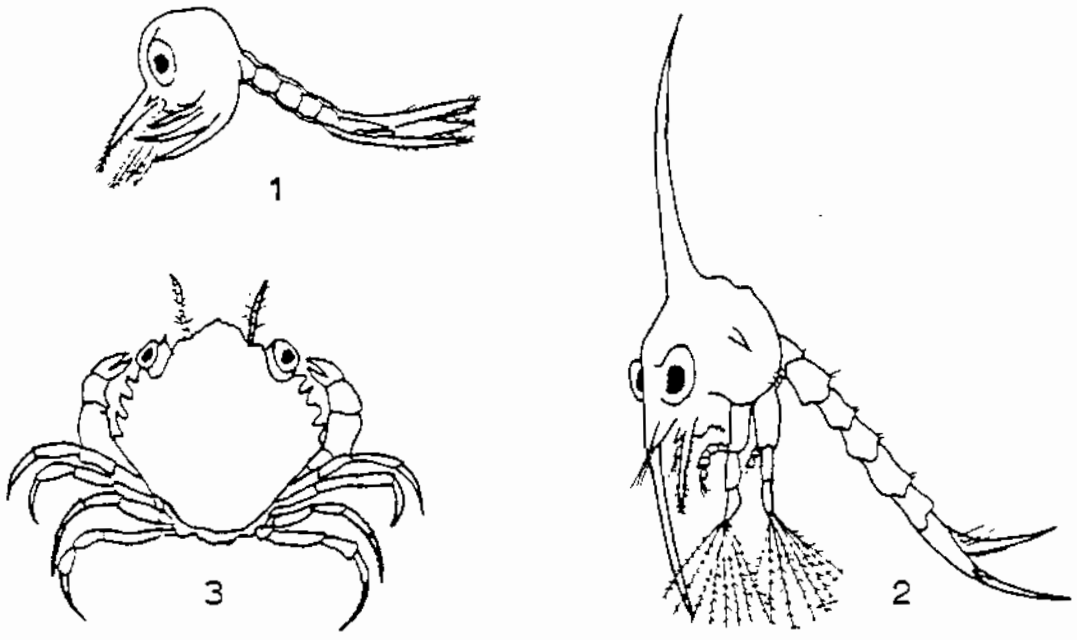

Figure 13 Stages in the development ... the young crab.

1 and 2 Planktonic stages (enlarged about 35 times). 3 First crab stage (enlarged about 10 times)

At present $4\frac{1}{2}$ inch minimum size				At new 5 inch minimum size			
Average size (inches)		Average weight (ounces)		Average size (inches)		Average weight (ounces	
Female	Male	Female	Male	Female	Male	Female	Male
5.8	5.5	16.7	16.0	6.0	5.8	18.3	19.0

5 An increase in the numbers of crabs which have to be returned to the sea following the new minimum size could result in increased competition for natural food, possibly leading to less favourable conditions for growth. The calculations made on weight gains are based on the present rate of growth.

6 Thus we can predict that there would be substantial losses in the first year and that it would take several years before this would be made up. Although it is definite that the average size of the crab caught would be larger the total weight yield is unlikely to increase by very much, if at all - especially in the northern part of the fishery.

CONCLUSIONS

The survey of the Yorkshire crab stock from 1961 to 1964 does not indicate any evidence of over-exploitation. Annual fluctuations in the catches due to natural causes can be expected to occur, but statistics collected since 1962 show that there has been little change in the stocks present on the grounds. Much of the decline in the recorded catch has been due to a reduction in the fishing effort, rather than to any failure of the fishery. It is therefore suggested that the future yield from this fishery would best be increased by attention to this factor and by efforts to promote a greater demand for crabs in order to make crab fishing more profitable, rather than to make changes in the minimum size at the present time.

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