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THE NORFOLK CRAB FISHERY

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INTRODUCTION

In Great Britain the only species of crab commercially exploited is the European edible crab Cancer pagurus. This crab is found in varying abundance around the British coast and is usually more plentiful where the sea bottom is rugged. Crabs form one of the most important sources of income to the shellfishermen of England and Wales, and although catches do fluctuate the average annual catch since 1960 has been around 60 000 cwt, valued at £265 000 and representing a quarter of the total value of shellfish landed in the country.

During recent years surveys have been made of the edible crab fishery of Norfolk by staff of the Fisheries Laboratory, Burnham-on-Crouch. Many problems associated with the regulation of this fishery have been studied, and a great deal of valuable information relating to the biology of this crab has been collected. Although much of this work has been published in scientific papers, the results have not yet been presented to the industry, and the aim of this leaflet is to summarize and discuss the main conclusions of this investigation.

A large proportion of the work described in this report was done under the supervision of Mr. M. N. Mistakidis, who is at present seconded to the service of the Food and Agriculture Organization in South America. The continued assistance of Mr. R. C. Rushmer and Mr. K. Pegg, Fishery Officers of the Eastern Sea Fisheries Joint Committee, is gratefully acknowledged; and we should like to express our appreciation of the support and interest of many local fishermen, who so willingly took us to sea in their boats, allowed us to examine their catches and answered our many questions.

THE FISHERY TODAY

The Norfolk crab fishing grounds occupy 15 miles of the coast from Salthouse to Mundesley, covering an area extending to about 2 miles off-shore (Figure 1). The grounds are mainly restricted to a sea bottom which is irregular and composed of chalk outcrops and large flints. Although the fishing grounds are relatively limited the fishery is an important one, and during the last five years crab landings from Norfolk have averaged 12% of the total catch of this species in England and Wales.

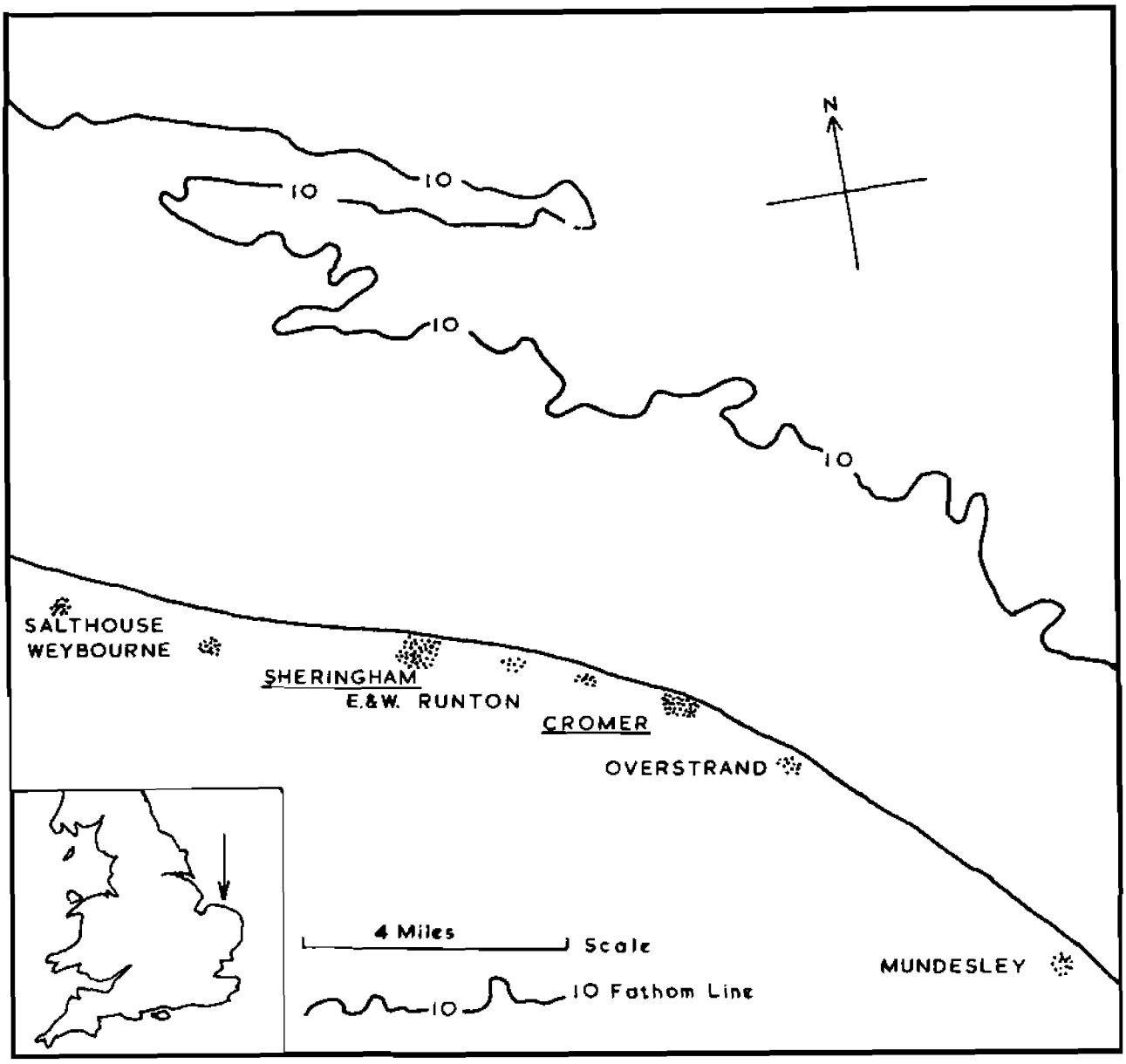

Figure 1 The Norfolk crab fishing area

The catches of crabs and lobsters from Norfolk for the years 1956-65 are given in Table 1. Although lobsters (Homarus vulgaris) are caught on these grounds in limited numbers only, the demand and high price paid for this shellfish adds considerably to the fishermen's incomes, particularly as lobster catches are highest during July and August, when crabs are moulting and are scarce. The main crab landings are made at Sheringham and Cromer, which between them land 80% of the

catch. Limited fishing either on a full-time or part-time basis also takes place from Mundesley, Bacton, Cley, Salthouse and the Runtons (Figure 1 and Table 2).

Table 1 Crab and lobster landings and their value at north Norfolk ports, 1956-65

Year	Crabs		Lobsters	
	Weight (cwt)	Value (£)	Weight (cwt)	Value (£)
1956	5 625	32 969	252	4 409
1957	5 401	33 812	327	3 842
1958	8 358	43 011	195	4 435
1959	10 021	57 347	285	5 271
1960	10 093	57 414	303	6 267
1961	9 102	55 586	401	8 975
1962	5 935	40 574	326	7 252
1963	3 584	34 051	333	10 213
1964	3 836	42 341	271	8 911
1965	7 360	62 211	158	5 936

Table 2 Number of boats and fishermen employed in the Norfolk crab fishery during recent years

Year	Salthouse		Sheringham		East and West Runton	
	Boats	Men	Boats	Men	Boats	Men
1959	1	2	16	35	5	10
1962	1	2	16	34	5	10
1965	1	2	10	22	4	9

Year	Cromer		Overstrand		Mundesley		Totals	
	Boats	Men	Boats	Men	Boats	Men	Boats	Men
1959	7	17	3	7	1	3	33	74
1962	7	17	3	7	2	4	34	74
1965	10	24	3	7	nil	-*	28	64

*Boats and crews now work from Cromer

Due to lack of harbour facilities the boats are launched off exposed beaches, either manually or with the aid of tractors. Winches or tractors are used to haul the boats back above the tide level (Plate 1). Open boats with an overall length of between 16 and 20 ft, and powered by petrol engines of about 10 h.p., are used in the fishery (Plate 2). These are crewed by two or three men, and are generally owned on a family basis.

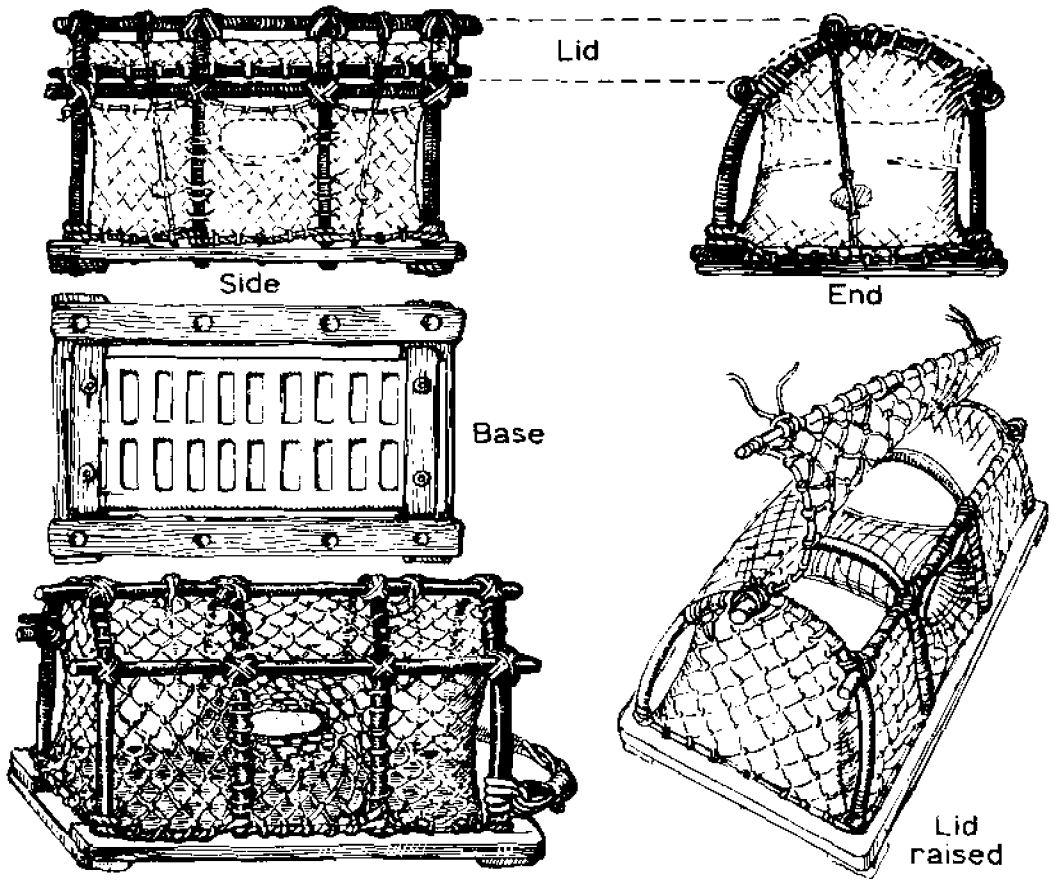

Figure 2 Construction of a Norfolk crab pot

The crabs are caught in baited pots (Figure 2) made by the fishermen; these are of the creel type having a base constructed of a rectangular wooden frame (24 x 18 inches) surrounding a cast-iron weight, known locally as a "music". The sisal or nylon netting is attached to hoops of hazel or cane. The pot has two opposite openings or "spouts", one at each side, joined by a single tunnel of netting, through which the crabs enter and fall through a hole into the pot. The bait is held between toggles in two "bait bands", which are double lengths of stretched twine fitted from the roof to the base of the pot. The catch is removed through the roof of the pot, which opens.

The pots are fished in strings or "shanks" of between 20 and 30; none of the boats are fitted with mechanical haulers and the gear is hauled by hand. The number of pots worked by each boat varies, but usually ranges from 120 to 200, and these are hauled, rebaited and set each day. Fish such as gurnard and plaice are used for bait, and this is sent from Lowestoft, a distance of 45 miles.

The main crab season commences in late March or early April and continues until late September or early October, when crabbing virtually ceases in Norfolk. Peak catches occur during May and June (Figure 3), but decline in July and August due to the increasing proportion of soft crabs on the grounds and the poor catches associated with the moulting period.

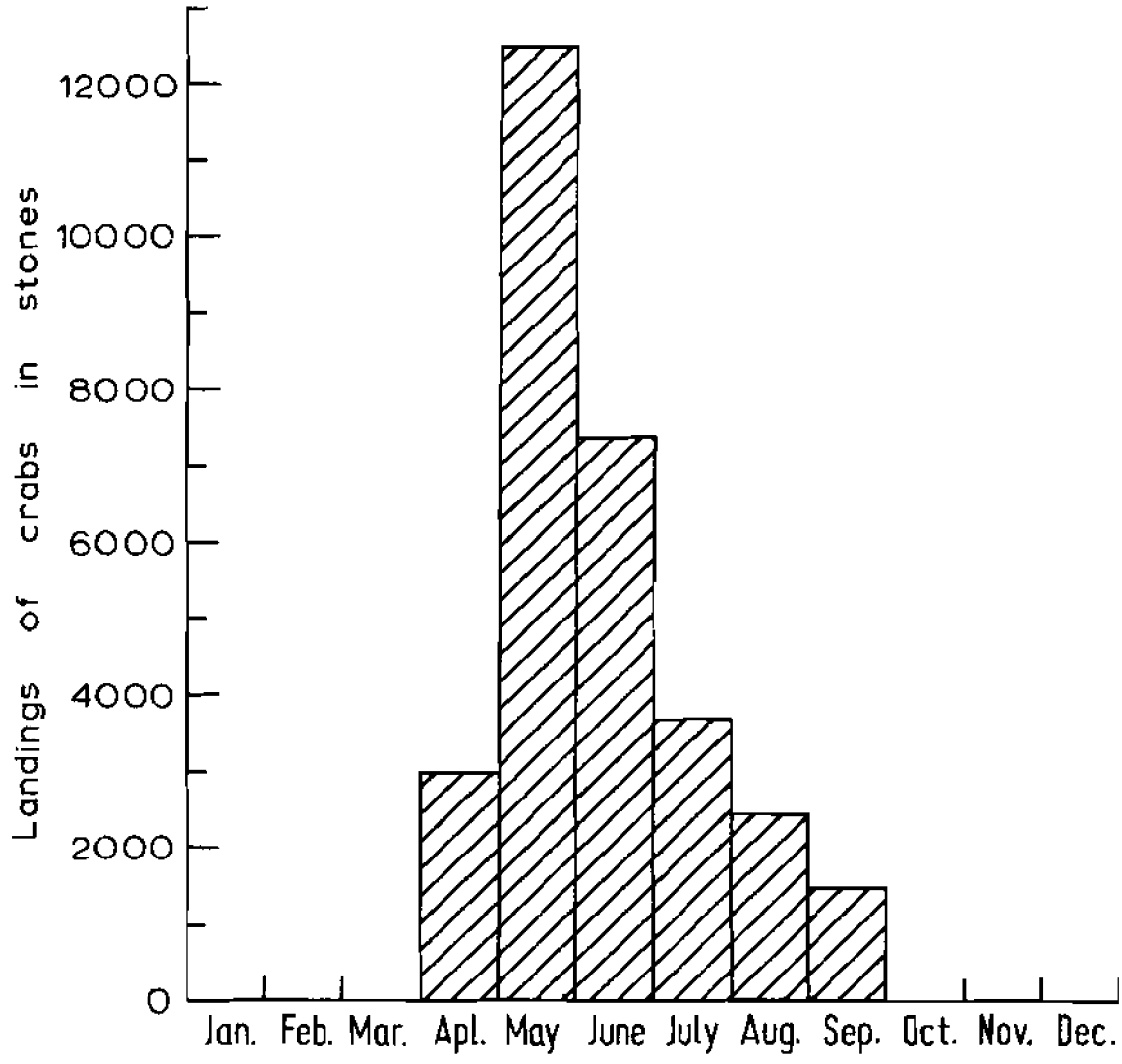

Figure 3 Monthly crab landings from the Norfolk fishery in 1964

Crabs are either sold locally or are sent to inland fishmongers, the crabs being despatched alive and cooked by the merchants. When landings are heavy, crabs are also sent to factories for the manufacture of processed meat. It is of interest to record that in this fishery crabs are sold by numbers, whereas in the remainder of the country they are usually sold by weight. In Norfolk crabs are counted in units of two, known as "casts", so that a daily catch of 180 crabs would be 90 "cast". A larger unit, "one long hundred", is 240 crabs or 120 "cast". This method of counting has been used over many years and was mentioned by Buckland in his Report on the Fisheries of Norfolk, which was published in 1875.

Although crab and lobster fishing is the main occupation of fishermen in the area, some also participate in the inshore herring fishing in September and October, or catch whelks during the winter. Certain fishermen also net for sea-trout during the summer. However, due to the lack of profitable fishing during the winter months many fishermen now take up temporary employment ashore, recommencing crab fishing in the following spring.

HISTORICAL BACKGROUND

There are no exact records of the earliest catches of crabs and lobsters from Norfolk ports, but it is likely that this fishery has existed since the early part of the 18th century. The earliest record is in "A Guide about Cromer", published in 1800 by Edmond Burtell, who states "Lobsters, crabs, whiting, cod-fish and herring are all caught here (Cromer) in the finest perfection". It is also recorded that at this time Cromer had a considerable trade in corn and crabs with London. In 1874 Holdsworth recorded that the crab season lasted from 1 April to 20 June, and that the population of Cromer at this time consisted of about 1 415 persons of which 120 were fishermen. In 1887 the populations of Sheringham and Cromer were 1 160 and 1 600 persons respectively, out of which 450 men and 94 boys were engaged in fishing. The activities of Norfolk fishermen at that time were more diverse than at present and included crab, lobster and whelk potting, drift netting for herrings, line fishing for cod, plaice and skate, and beam trawling for plaice and shrimps. In 1875 there were about 100 crab boats at Sheringham and 50 at Cromer, each boat crewed by two men. The boats used were similar in design to those in present use, being double-ended and broad-beamed but propelled by oars and sails. There is no record of the year when motor engines were first installed in crab boats, but most probably it was around 1905; by 1927, 40% of the boats were powered. Although Holdsworth described the boats used in this fishery around 1874, he did not mention the type of gear used to catch crabs.

During a visit to the fishery in 1875, Frank Buckland, the eminent marine scientist, recorded that in the past crabs and lobsters had been caught by hoop nets (Figure 4) which were sunk to the bottom and worked by hand. Buckland also mentioned that crab pots had been introduced about 12 years earlier, in 1862-63. After the introduction of pots the

number of hoop nets in use rapidly declined, but they were occasionally used for lobster fishing early in the season, and were used for this purpose until around 1930. They are not used in the present fishery but are still employed to take lobsters off the Suffolk and Essex coasts.

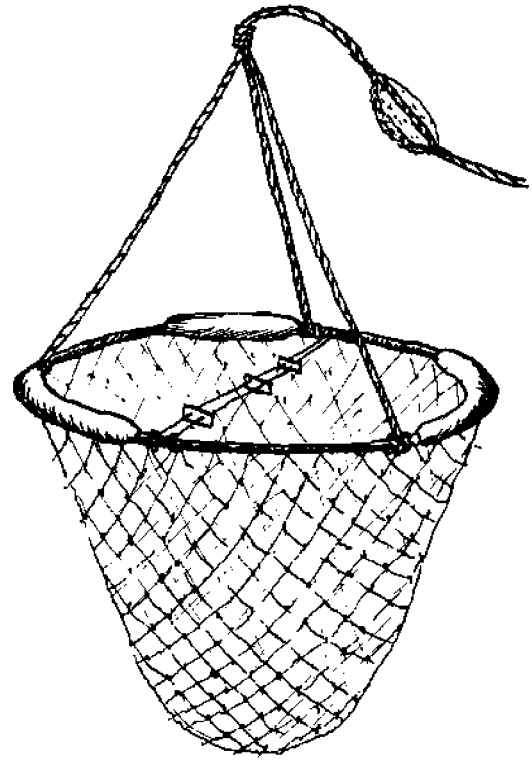

Figure 4 Hoop net used for crabbing in the 1800s

Buckland's description of the crab pot used in 1875 shows that it was similar to that in use today, except that it had a slightly larger base. Information on the number of pots used at this time is limited, but each boat worked around 20 to 35 pots. In 1875 the total number of pots used was around 4 000, but no reference was made to the number of hoop nets used. In 1909 the fishery employed 109 boats using around 8 000 pots. In 1924 a census was made of the fishermen and boats employed in England and Wales, and at that time 7 200 pots were used in Norfolk by 65 boats. At the present day around 4 000 pots are worked by some 30 boats, and the number of pots has remained steady during the period of the survey, 1960-65 (Table 3).

Table 3 Total number of pots fished in Norfolk during May, the main crabbing month

1960	4 073	1963	4 147
1961	4 070	1964	4 356
1962	4 382	1965	4 335

REGULATIONS

In his report published in 1875, Buckland described how a considerable decrease in crab landings had occurred in the previous few years. The cause was attributed to the wholesale destruction of small crabs, known locally as "toggs", and crabs carrying spawn. Crabs as small as $2\frac{1}{4}$ to 3 inches shell width were either sold for food at a price of between 4d and 6d for 20, or used as bait for lobster or whelk fishing. Buckland calculated that about 750 000 small crabs were brought ashore and sold every month. This must have affected the grounds considerably, because many fishermen left and took their boats and gear to settle at Wells, Mablethorpe and Grimsby, where a better living could be made. Buckland had previously reported that prior to 1863 the supply of crabs from Norfolk to the Billingsgate (London) fish market was considerable but after 1868 this supply had virtually ceased, again due, it was believed, to the destruction of small crabs.

Many fishermen were concerned about this, and desired an Act of Parliament to regulate their fishery; at Cromer, fishermen even imposed their own voluntary restriction to prohibit the destruction of small crabs less than $4\frac{1}{2}$ inches across. Following his enquiry into the fishery, Buckland made a recommendation to Parliament and in 1876 the Crab and Lobster Fisheries (Norfolk) Act was introduced. This imposed a restriction on the possession or offer for sale of crabs below $4\frac{1}{4}$ inches, and on the sale of crabs carrying spawn (berried crabs). The Norfolk fishermen were therefore instrumental in bringing about the introduction of the first statutory regulations for the management of a crab fishery. Following this, Parliament introduced the 1877 Fishery (Oysters, Crabs and Lobsters) Act, which replaced the Norfolk Act and introduced a minimum size for crabs of $4\frac{1}{4}$ inches and gave protection to berried and soft crabs for the whole of England and Wales.

In 1888, following the introduction of the Sea Fisheries Regulation Act, Sea Fisheries Committees were appointed with authority to make local by-laws for the protection of the fisheries within their district. The present area of the Eastern Sea Fisheries Joint Committee, created in 1893, extends from Donna Nook in Lincolnshire to Caister-on-Sea, just north of Great Yarmouth, and includes the Norfolk crab fishery.

One of the responsibilities of the Eastern Sea Fisheries Joint Committee is the enforcement of the national $4\frac{1}{2}$ inch minimum size regulation. A properly adjusted minimum size regulation ensures the best sustained yield from a fishery and its selection depends on a reliable knowledge of the fishery, including information on the amount of fishing and growth rates. One of the main purposes of the present investigation was to determine whether this fishery would benefit from an alteration in the minimum size, but following the four-year study the Ministry submitted to the Eastern Sea Fisheries Joint Committee a report which concluded that the $4\frac{1}{2}$ inch minimum size was still the most suitable for this particular fishery.

Present-day regulations affecting the Norfolk crab fishery

Statutory restrictions

Under Section 8 of the Fisheries (Oysters, Crabs and Lobsters) Act 1877, it is an offence for any person to take, have in his possession, sell, expose for sale, consign for sale, or buy for sale:-

(a) Any edible crab carrying any spawn attached to the tail or any other exterior part of the crab, whether known as "berried crab", "seed crab", "spawn crab" or "ran crab" or by any other name.

(b) Any edible crab which has recently cast its shell, whether known as "caster", "white crab", "whitefooted crab", "white livered crab", "soft crab", "glass crab", or by any other name.

Under the Sea Fishing Industry (Crabs and Lobsters) Orders 1951 and 1966, it is also an offence for any person to land, sell, expose, or offer for sale, or have in his possession for the purpose of sale:-

Any crab which measures less than four inches and a half across the broadest part of the back.

Local by-laws

Further restrictions relating to crabs have been imposed by the Eastern Sea Fisheries Joint Committee and confirmed by the Ministry of Agriculture, Fisheries and Food:-

No. 8 Crabs, whitefooted: close season (Confirmed 30 April 1959)

Between the 1st day of November and the 30th day of June (both days inclusive) in any year no person shall remove from a fishery any crab of the kind locally known as "whitefooted" crab.

No. 9 Crabs: undersized for bait (Confirmed 16 March 1965)

No person shall use any edible crab (*Cancer pagurus*), whatever its size or condition, or any part of such crab for the purpose of bait.

No. 10 Crabs: re-deposit of (Confirmed 30 April 1959)

Any person who takes any crab, the removal of which from a fishery is prohibited by a by-law of the Eastern Sea Fisheries Committee, or the possession or sale of which is prohibited by any Act of Parliament, shall forthwith re-deposit the same in the sea with the least possible injury, as nearly as may be in the place from which it was taken, or, under the written authority of the Clerk, on other suitable ground.

CRAB GROWTH

The crab is covered by a hard rigid shell, so that growth can only occur when this shell is cast. When moulting (as this casting process is known) commences the outer shell cracks along a definite line, allowing the upper and lower halves of the shell to gape (Plate 3); the crab then slowly backs out of the old shell, and is in the soft-shelled condition. A short time before and immediately after the moult has been completed the crab absorbs water and the new soft shell expands, the final size being reached about two hours after the moult has been completed. The shell then slowly thickens and hardens, with the addition of outer layers containing a high proportion of calcium carbonate, but does not reach the final hard-shelled condition for two to three months. No further increase in shell size occurs until the next moult.

In Norfolk the main moulting period commences in July and continues until October, the females moulting first, followed about a month later by the males. During this period soft crabs fill the pots, but are returned to the sea because of their poor quality and the regulations which protect them.

When a crab moults, any external marks or structures which could perhaps be used as a guide to age are lost, and this has made it difficult to determine the growth or the age of crabs. However, the development of the suture tag (Figure 5), which remains attached to the crab's body through the moult, has made it possible to determine the increase in size during moulting in the sea.

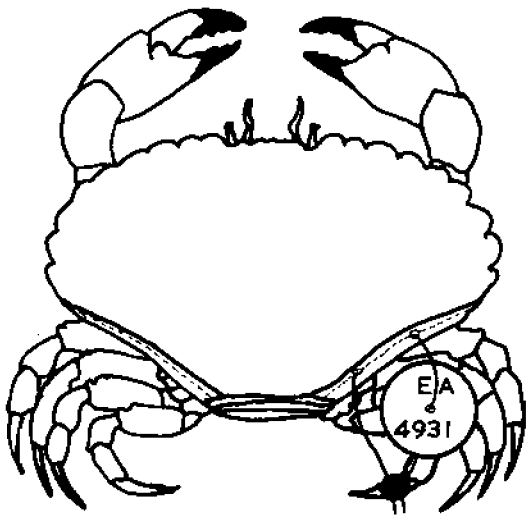

Figure 5 A suture-tagged crab

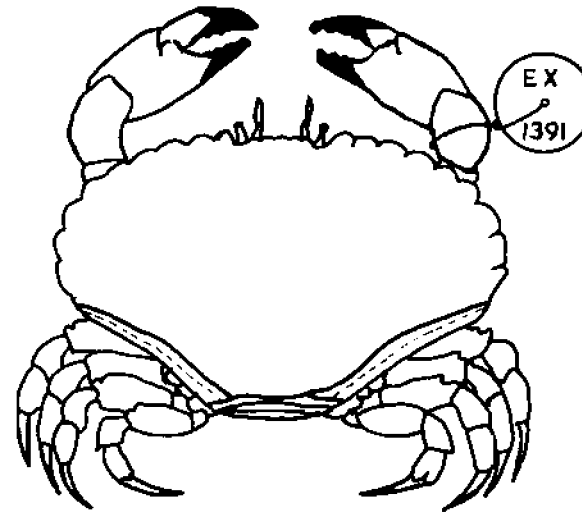

Figure 6 A claw-tagged crab

This method of tagging was originally developed in America, but after certain modifications was first used in this country in experiments in the Norfolk area during 1959 and 1960, when 1 228 crabs were tagged.

Prior to release the size of each crab was recorded, together with the number on the tag, and crabs later recaptured provided information on the amount of growth which had occurred during the period of freedom. Of the crabs released in these growth experiments, 440 (36%) were later recaptured, and since 45 of these had moulted it was possible to make some estimate of growth on the Norfolk crabbing grounds.

It is to be expected that the rate of growth will vary between individual crabs and from year to year, and it was found that the increase in shell width at a single moult varied between 20 and 30% of the original size. Males appear to grow slightly more at a moult than females, but moult less frequently after they reach $4\frac{1}{2}$ inches. On average a $3\frac{1}{2}$ inch crab will reach a size of $4\frac{1}{2}$ inches in one moult, and after a further moult could become $5\frac{3}{4}$ inches. It is not possible to state the age of any one individual crab with certainty, but on average a crab of $4\frac{1}{2}$ inches will be about 4 years old. The number of moults each year will vary according to the size of the crab; small crabs of $2\frac{1}{2}$ inches may moult twice in a season, but when they reach 4 inches the majority will moult only once a year. After about $4\frac{1}{2}$ inches, the frequency of moulting becomes less than once a year, and at 5 inches a crab will probably moult only in alternate years or even less frequently.

MIGRATIONS

Tagging experiments are being used to increase our knowledge of crab migrations, and fishermen have contributed to the success of this work by returning tagged crabs and reporting the position of recapture. The simplest method of tagging a crab is to attach a numbered disc by wire tied round a claw (Figure 6), but during moulting the tag is cast with the old shell and so this method can only be used in short-term experiments.

In claw-tagging experiments carried out during 1957 and 1958, when crabs were released early in the season, 70% of the crabs later recaptured had moved distances of less than 5 miles. These were not, however, at liberty for long because of the intensity of fishing; so it is likely that only local movements associated with feeding were recorded. Crabs released $1\frac{1}{2}$ to 2 miles offshore were usually recaptured close inshore and tended to move in a south-easterly direction (Figure 7).

Many fishermen around our coast are aware of these seasonal migrations of crabs, which move inshore to the shallow waters in the spring and summer, returning to the deeper water offshore in the autumn and winter. The Norfolk tagging experiments indicated that crabs moved inshore in the spring, but due to the absence of boats fishing offshore in the winter, it was not possible to establish positively how far the crabs had moved offshore.

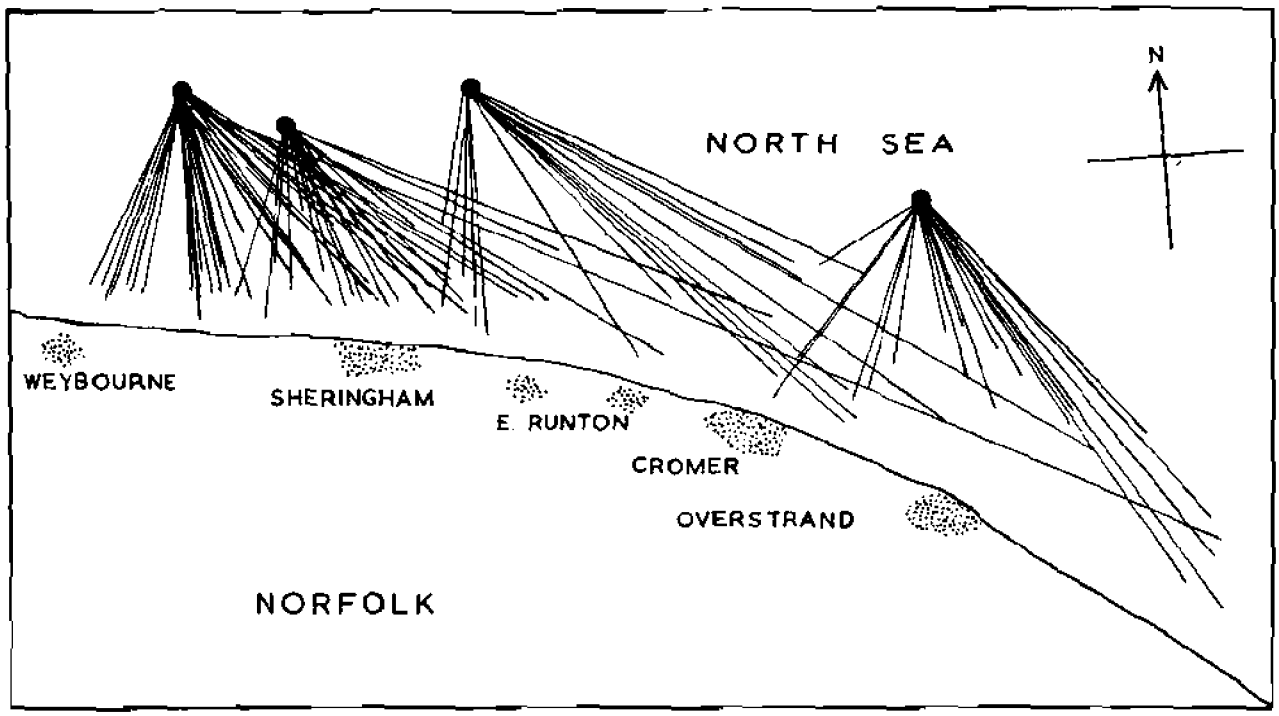

Figure 7 Positions of recapture of claw-tagged male crabs released at four points between 1½ and 2 miles offshore in May 1959

In 1910, H. Donnison, while employed by the Eastern Sea Fisheries Committee, made a study of the crab movements in this fishery by attaching numbered copper tags to the claws. Results from his experiments also showed that 60% of the tagged crabs were recaptured before they moved more than 2 miles, and that they moved in a south-easterly direction. He also recorded that one crab moved from Sheringham to Flamborough Head, 98 miles to the north. This migration was then believed to be an isolated case but, during our suture-tagging experiments in 1959 and 1960, 12 of the female crabs released off Norfolk were later recaptured by crab fishermen working along the Yorkshire coast, and another by a North Sea trawler, thus demonstrating that there is a movement of female crabs from the Norfolk crab grounds to the north (Figure 8 and Table 4).

The migration of crabs from Norfolk to northern grounds may be substantial but it appears that only mature females take part, and it is likely that these crabs had moved offshore to spawn and were recaptured on the inshore grounds off Yorkshire after hatching their eggs. All the tagged female crabs which were recaptured along the Yorkshire coast had shell widths of over 5½ inches, and this may be one of the factors which results in the small numbers of large female crabs in the Norfolk catches.

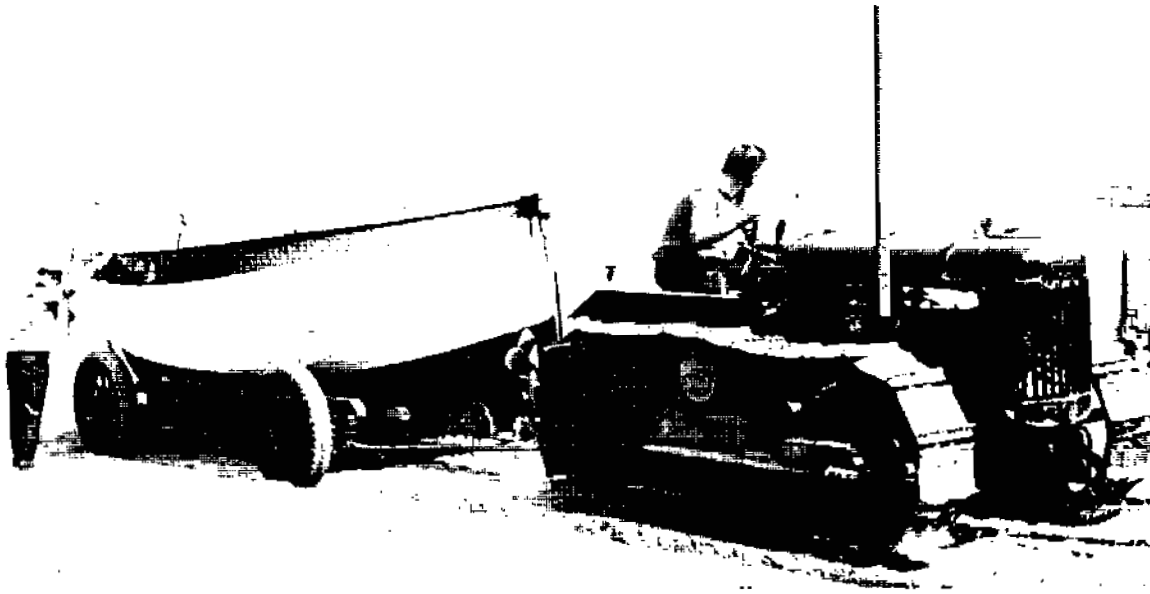

Plate 1. Tractors are used to haul the boats above the tide level.

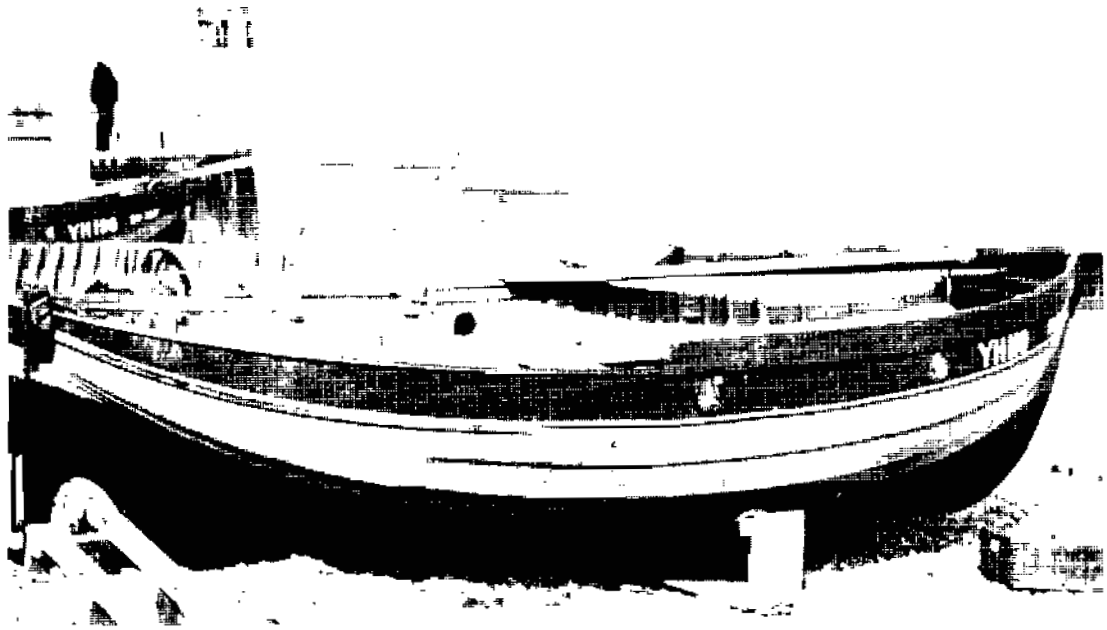

Plate 2. A Norfolk crab boat.

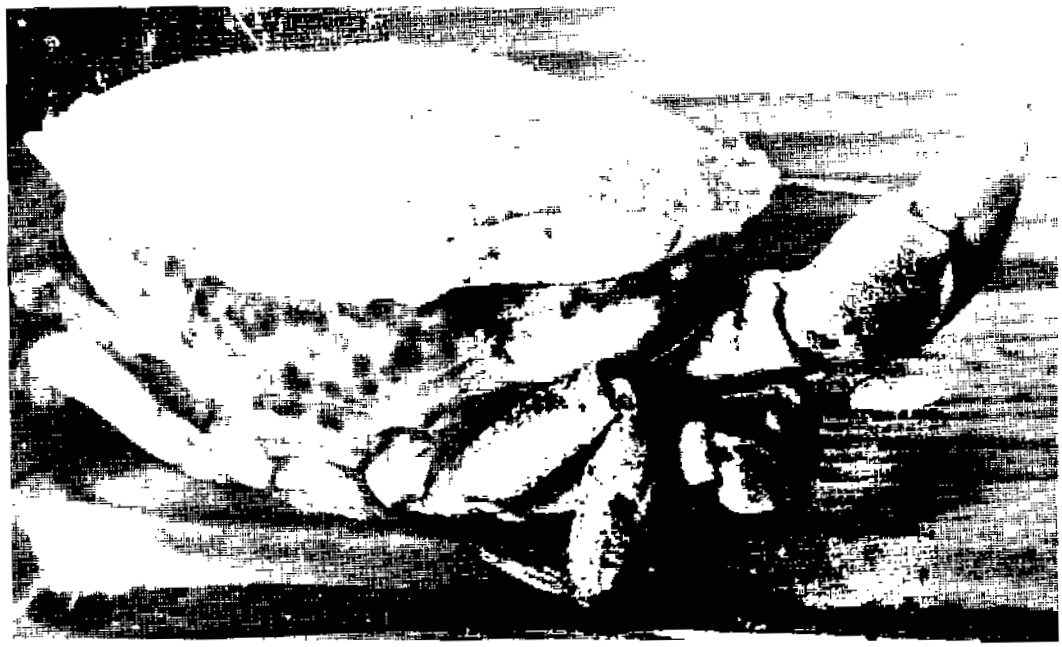

Plate 3. A crab commencing to moult.

Plate 4. A berried crab.

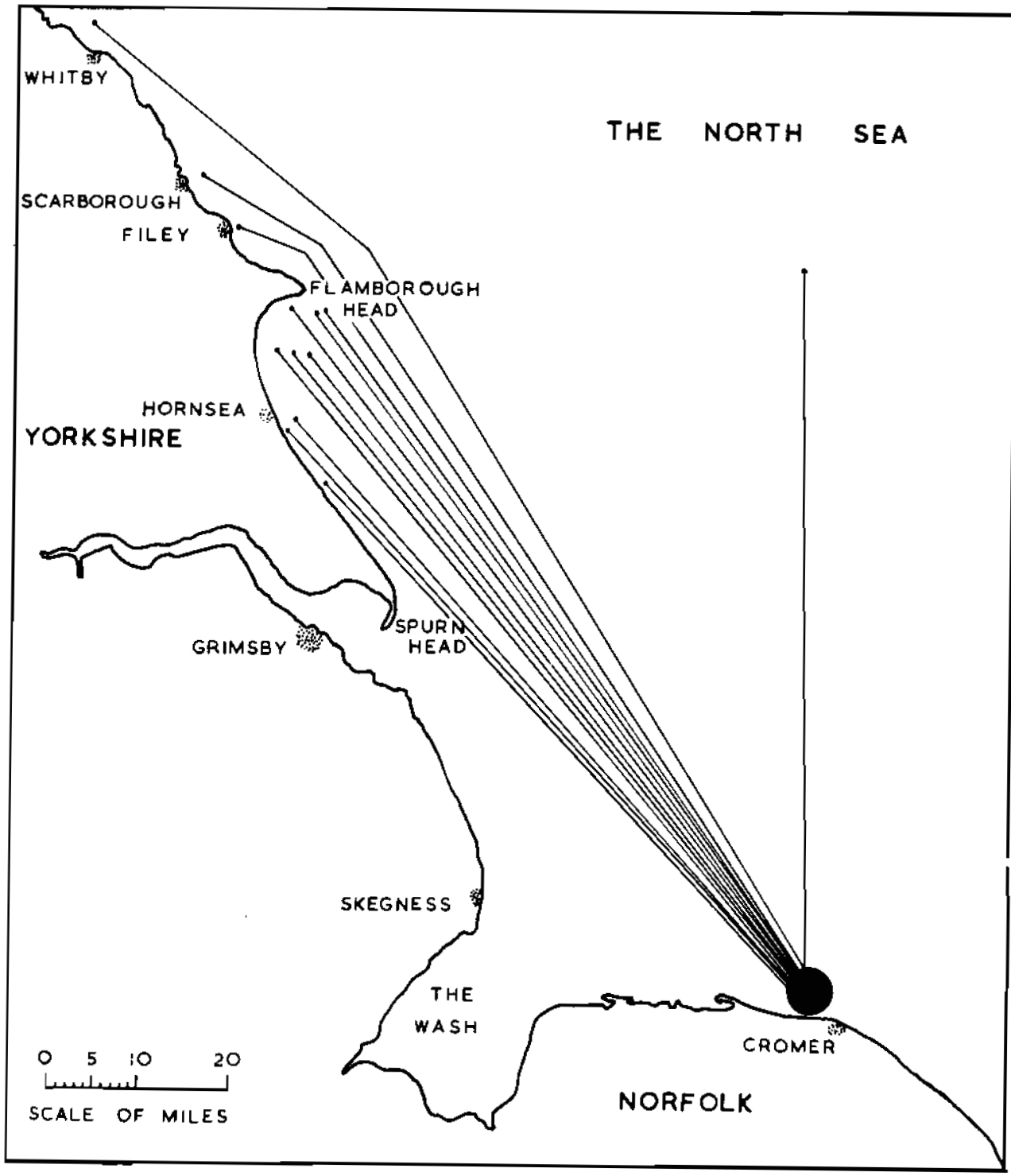

Figure 8 Northerly movement of thirteen suture-tagged female crabs released off Norfolk, 1959-60

Table 4 Details of suture-tagged crabs released off the Norfolk coast in May 1959 and 1960, which were later recaptured by Yorkshire fishermen

Number	Size (inches)		Position of recapture	Distance moved (miles)	Period before recapture	
	On release	On recapture			Years	Months
1	4.7	6.9	3 miles ENE of Scarborough	115	2	2
2	5.2	No details	1½ miles SE of Flamborough Head	98	3	2
3	5.0	6.7	1 mile off Flamborough Head	100	1	2
4	4.9	No details	1 mile off Flamborough Head	100	4	0
5	4.8	No details	6 miles N of Whitby	140	3	0
6	5.0	No details	¼ mile off Mappleton	85	3	2
7	4.5	6.8	Filey Bay	110	2	0
8	4.6	5.5	Flamborough Head	100	1	4
9	5.6	6.6	¼ mile off Hornsea	90	5	0
10	5.5	6.5	2 miles ESE of Flamborough Head	98	1	2
11	5.6	5.6	½ mile off Hornsea	90	-	11
12	4.7	6.9	60 miles NE of the Humber*	95	1	9
13	4.6	6.7	½ mile off Flamborough Head	100	4	1

*Recaptured by a Grimsby trawler

This northerly migration has also been found to occur along the Yorkshire, Northumberland and east Scottish coasts. Recaptures from these and more recent experiments show that, although females move great distances, males rarely move distances of over 20 miles and usually remain in the area of release.

One female crab released off Hornsea in Yorkshire in 1962 was recaptured off Sheringham the following year. This is the first record of a crab moving from the Yorkshire area to Norfolk.

THE LANDED CATCH

Size

The size of a crab is measured as the width of its shell (or carapace) at the broadest part. During the 1957-60 survey about 15 000 crabs of legal size ($4\frac{1}{2}$ inches and over) were measured, either at sea whilst aboard commercial boats or at the place of landing. These measurements showed that the majority of the Norfolk crab catch was between $4\frac{1}{2}$ and $5\frac{1}{2}$ inches shell width, and few crabs over 6 inches were found (Table 5). The size of the male and female crabs landed was similar, and there was no difference between the size of crabs landed at the various ports in the area. Later observations in 1964 have shown that the majority of the catch is still in the $4\frac{1}{2}$-5 inch range, but there were slightly more above $5\frac{1}{2}$ inches.

Table 5 Proportion of crabs in the various size groups landed at Norfolk ports, 1957-60 and 1964

	Shell width (inches)			
	$4\frac{1}{2}$-5	5-$5\frac{1}{2}$	$5\frac{1}{2}$-6	6-$6\frac{1}{2}$
1957-60	60%	32%	7%	1%
1964	51%	34%	12%	3%

In the trade, crabs from this fishery are well known for their small size, particularly when compared with crabs from the south coast, where specimens of between 8 and 12 inches are often caught. Norfolk crabs are however of excellent quality and fetch a price generally above that of crabs from other east coast fisheries.

Sex ratio

The ratio of female to male crabs in the catches varied during each month of the season. Generally females were slightly more abundant at the beginning of the season, but by July, when females commenced moulting, males formed the bulk of the catch and continued to do so

during August and September when the females were still in the soft-shelled condition (Table 6). In October a proportion of the females landed were "new" crabs, which had moulted in July but hardened sufficiently to satisfy the regulations relating to the soft-shelled condition.

Table 6 Proportion of females in the monthly landings, 1960

April	May	June	July	August	September/October
57%	49%	32%	18%	15%	33%

Weight

Observations on the weights of crabs of various sizes showed that up to a size of 4 inches the weights of males and females were the same, but above this males were heavier due to the development of larger claws (Table 7). On average a stone (14 lb) of Norfolk crabs will contain between 20 and 22 individuals.

Table 7 Average weight of crabs at the various shell widths

Shell width (inches)	Weight (ounces)	
	Females	Males
4	$6\frac{1}{4}$	$6\frac{1}{4}$
$4\frac{1}{2}$	9	$9\frac{1}{4}$
$4\frac{3}{4}$	$10\frac{1}{4}$	11
5	$11\frac{3}{4}$	13
$5\frac{1}{2}$	$15\frac{1}{2}$	$17\frac{3}{4}$

EFFECTS OF FISHING ON THE STOCKS

In the Norfolk fishery crabs rarely reach a large size, compared with those landed in other fisheries, and it was therefore important to determine whether the small size of the crabs landed was related to a heavy exploitation.

From the results of claw-tagging experiments the proportion of the stock caught during any period of fishing can be estimated. In experiments carried out during 1957 and 1958 tagged crabs were released over the main fishing grounds at the start of the season, and the number later recaptured gave a guide to the proportion of the stock removed by fishing. Since claw tags are lost on moulting, the results are only

valid until the moulting period commences, but this covers the most important part of the fishing season. Results from these experiments showed that between 35 and 50% of the tagged crabs were being recaptured per season, and from these figures it was calculated that around 70% of the legal-sized crabs present at the beginning of each season were being caught.

Despite this high rate of fishing, the evidence does not indicate that the stock is being overfished, i.e. that higher yields would be obtained with less fishing. Although fluctuations in annual landings have occurred (Figure 9), these appear to have been due more to natural causes than to any adverse effects of heavy fishing.

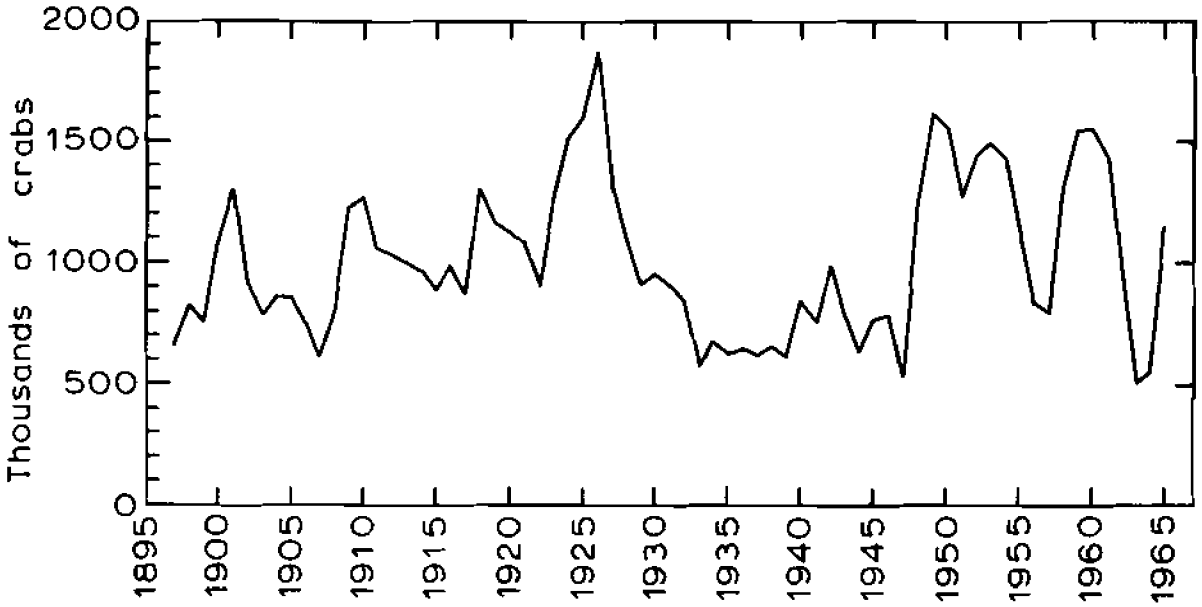

Figure 9 Annual recorded crab landings, 1895-1965

RECRUITMENT

During the years between 1960 and 1965 around one million crabs were landed annually at Norfolk ports. The success of each season depends largely on the "recruitment" to the fishable stock, i.e. the entry of new crabs to replace those caught; this can result both from the growth of small crabs to a size when they can be legally landed, and from a migration of crabs into the fishery from other grounds.

Recent tagging experiments conducted along the Yorkshire coast, which is the nearest area carrying large stocks of crabs, have shown no evidence of a southerly migration; and as far as is known stocks further south around East Anglia are small. It is however possible that there is a local inshore migration from a dispersed stock more than 3 miles off the Norfolk coast, which is the present limit of fishing activities.

It is therefore likely that any addition to the fishable stock comes mainly from the growth of small crabs to the legal minimum size. Growth studies have shown that all crabs of more than $3\frac{1}{2}$ inches will exceed the minimum size in only one moult. Since moulting at this size occurs at least once a year, the very large numbers of crabs in the $4\frac{1}{2}$ to $5\frac{1}{2}$ inch group, on which the fishery depends, will be derived from this source. The pattern of moulting during the summer and early autumn, and the subsequent delay in landing due to their soft-shelled condition, means however that the majority of these crabs are not fished until the year after moulting to fishable size.

Further evidence of the source of recruitment is given by the abundance of small crabs on the grounds, which make up half to three-quarters of the catch in the pots, but these are immediately returned to the sea with little or no ill effects. The number of small crabs caught varies over the grounds but, on average, for every legal-sized crab which is kept, 6 to 10 small crabs are rejected, although quite often 10 or 20 are removed from a single pot.

The presence of so many young crabs off Norfolk is somewhat surprising in view of the very few berried crabs (Plate 4) which are caught in this fishery. However, since the residual current drift along this coast during the summer is in a southerly direction, it seems likely that the young crabs are derived from berried females higher up the coast, possibly Yorkshire, where these occur in quantity.

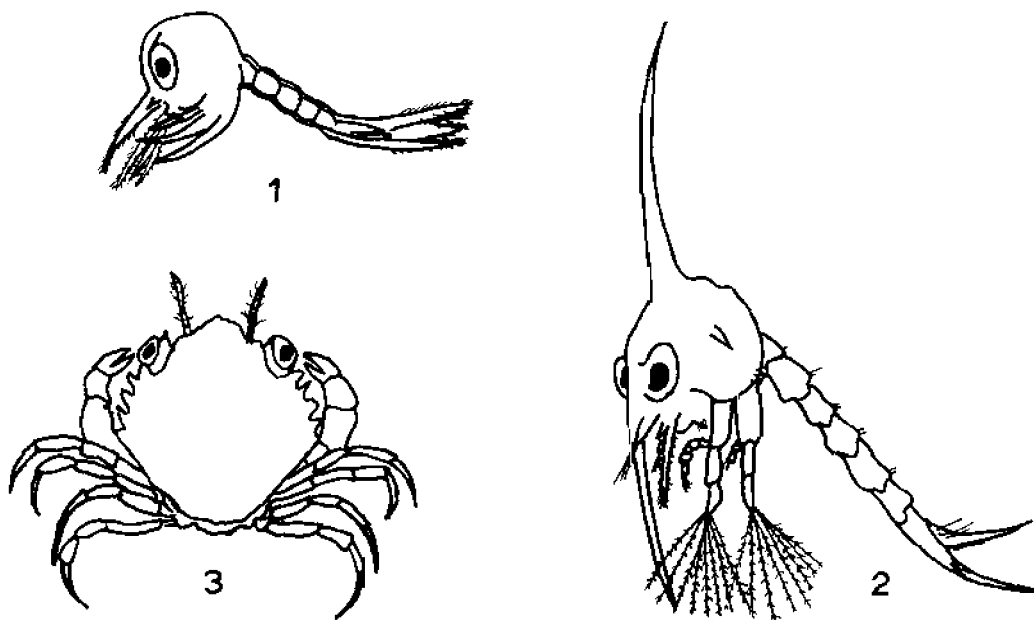

Figure 10 Stages in the development of the young crabs

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

Berried crabs carry eggs for 7 to 8 months, but move inshore in the spring for hatching. When the crab larva emerges from the egg it forms part of the plankton and for a period (reported to be about 30 days) it drifts with the current, gradually changing in shape and size until it finally settles to the sea bottom and assumes the adult shape (Figure 10).

The critical period in the life history of most marine animals with many eggs is during the planktonic stage, and fluctuations in the catches from year to year can often be associated with the conditions affecting survival of the larvae. Although growth rate varies it is estimated that it will normally take about 4 to 5 years for a young crab to reach $4\frac{1}{2}$ inches, and until this time it is protected by regulations which help to ensure the future of this fishery.

WHITEFOOTED CRABS

At the beginning of each season up to one fifth of the male crabs, but only a few females, caught on the Norfolk grounds are in the whitefooted condition. These crabs can easily be recognized by the colour of their claw pincers which are greyish white compared with the normal black colour, and by the speckled and clean appearance of their backs. The shells, although they appear hard, have not yet reached the final stage of calcification. The meat condition of whitefooted crabs is generally poor and a local by-law prohibits the landing of this type of crab until after 30 June, when their condition has improved. Before this date whitefooted crabs are normally rejected at sea, and any which have been overlooked and included in the landed catches are returned to the sea by the local Fishery Officers.

Observations made while accompanying local crabbing boats showed that whitefooted crabs were abundant on the grounds from April to July, but from then on their numbers declined, only occasional specimens being seen in September and October. Around 80% of the whitefooted crabs were males, and this condition appears to occur in crabs which have not moulted until the late autumn, with the result that their subsequent improvement in condition has been delayed until the next year, due to the reduction in feeding at the low winter sea temperatures. During recent surveys of other east coast crab fisheries only occasionally were whitefooted crabs ever found, and the abundance of this type of crab on the Norfolk grounds is believed to be associated with the shallow depth of the coastal waters in this area.

Laboratory observations

For some years it has been the general belief amongst Norfolk fishermen that whitefooted crabs remain permanently in this condition and never become normal. In May 1965, 50 crabs in the whitefooted condition, supplied by two Sheringham fishermen, were established in laboratory tanks at Burnham-on-Crouch. By early August 70% of them had

become normal crabs with black pincers and fully hardened dull-coloured shells, while in the remainder the pincers had become nearly black. Regular examination during the holding period showed that the claw pincers gradually changed in colour from white to light grey, and then to dark grey and black. In the Norfolk fishery crabs in the intermediate stage, with grey/black pincers, are known as "turntoe" crabs.

Meat yield observations showed that at the start of the experiment in May the meat in these whitefooted crabs was watery and low in yield. However in August, although the crabs had been held under artificial conditions, the meat was less watery and the yield had improved. It is to be expected that this improvement in condition would be greater under natural conditions, and since whitefooted crabs are accepted by merchants after 30 June their meat yield must then be reasonable. This experiment shows that whitefooted crabs held in laboratory tanks do eventually assume a normal appearance and improve in condition.

Observations under natural conditions

In order to find out whether the change from the whitefooted condition was a normal occurrence in the sea, 300 crabs classed as whitefooted were claw-tagged early in June 1965 and released on the inshore potting grounds. During the 1965 season, 186 (62%) were recaptured and the colour of their claw pincers was recorded by the Fishery Officers; many of those still whitefooted were returned to the sea and several have been caught a second time. The records show that by late June many of the recaptured crabs were changing in condition and were in the intermediate "turntoe" stage, whilst in early July a few were being recaptured in the normal black condition. During late July and early August most of the tagged crabs caught were recorded as having either black or nearly black pincers, and only the tag identified them as having been previously in the whitefooted condition. Recoveries did, however, show that even in September a small proportion of the crabs were still classed as whitefooted, and the speed with which the improvement in condition takes place appears to vary with individual crabs (Table 8).

Table 8 Proportion of whitefooted crabs tagged and released on 9-10 June 1965 that were recaptured in the various stages during the following three months of fishing

Month (a) 1st part (b) 2nd part	Condition of crabs on recapture		
	Percentage "whitefooted"	Percentage "turntoe"	Percentage "black"
June (a)	83	17	Nil
June (b)	51	49	Nil
July (a)	41	51	8
July (b)	29	62	9
August (a)	20	65	15
August (b)	7	60	33
September (a)	6	40	54
September (b)	Nil	30	70

SUMMARY AND CONCLUSIONS

During the last five years crab landings from Norfolk have amounted to 12% of the total catch for England and Wales, with an average weight of about 6 000 cwt and a value of £47 000.

A full scientific examination of this fishery was made from 1957 to 1960, and routine observations on the landings and fishing effort and the size range of crabs in the catch are being continued.

Regulations prohibiting the landing of crabs with shell widths of under $4\frac{1}{2}$ inches are at present in force. The results of scientific observations showed that this minimum size of $4\frac{1}{2}$ inches is the most suitable for this particular fishery.

Measurements of the landed catch showed that between 80 and 90% of the crabs were between $4\frac{1}{2}$ and $5\frac{1}{2}$ inches, and that the crabs caught on the Norfolk grounds were smaller than from other east coast fisheries.

The results of tagging experiments indicated that around 70% of the commercial stocks available at the start of fishing in 1957 and 1958 were caught during each season. There is however no evidence that the stock is being overfished, and landings have maintained a fairly steady average level over a period of years.

Growth studies have shown that all crabs of more than $3\frac{1}{2}$ inches will exceed the minimum size in only one moult, and it was concluded that this fishery is mainly dependent upon recruitment from the small crabs which are abundant in the area.

Tagging experiments using the suture tag have shown that there is a migration of mature females from Norfolk to the Yorkshire coast. This northerly movement of females has also been found to occur all along the east coast of Britain, but males usually remain in the area of release.

The variation in catches from year to year is believed to be associated with the conditions affecting the survival of the larvae - upon which will depend the recruitment to the fishable stock. Berried crabs are relatively scarce in the Norfolk fishery and the main supply of larvae is believed to be brought south by the tidal drift from grounds farther north, where berried crabs are known to be abundant.

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