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SCAD IN THE NORTH-EAST ATLANTIC

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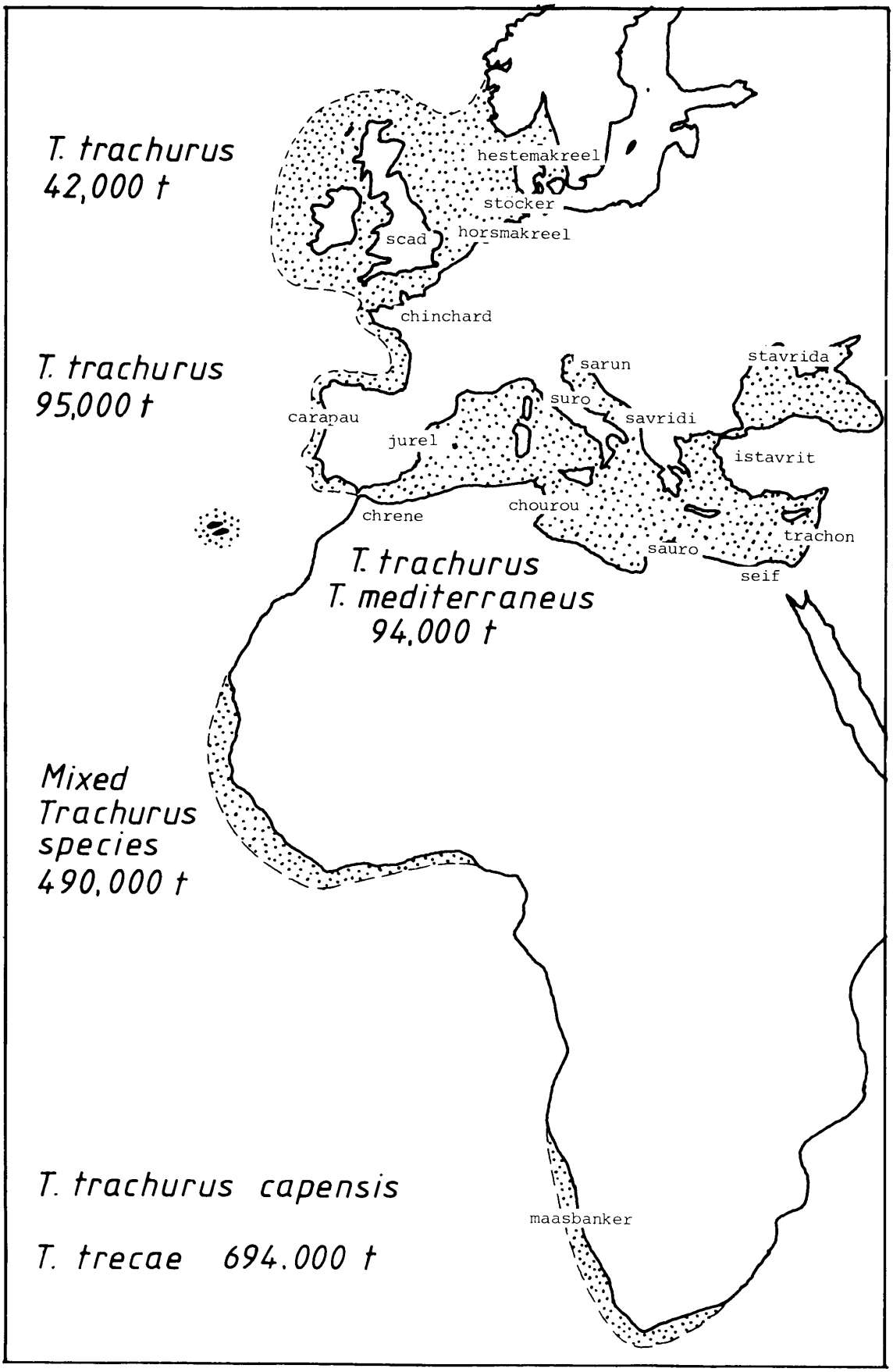

Figure 1 Major fisheries for scad and closely-related species in the eastern Atlantic in 1980.

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SCAD IN THE NORTH-EAST ATLANTIC

by D. R. Eaton

1. INTRODUCTION

Over the past decade catching opportunities for fish traditionally sought by UK vessels have remained unchanged or have been reduced, especially for pelagic species. At the same time imports of fish and fish products have increased, and there has been a greater incentive to utilise species previously ignored by the fishing industry. Laboratory Leaflet Number 38 'Horse mackerel' by S. J. Lockwood and P. O. Johnson, was produced in 1977 in the expectation that one of these species, scad (or horse-mackerel, Trachurus trachurus L.), would be fished as a possible alternative to mackerel (Scomber scombrus L.) in UK waters, a fishery which is coming under increasing pressure. That leaflet summarised the available information about the biology, distribution and potential catch rates of scad in British waters, but information was very limited due to the unimportance of scad as a commercial species at that time.

In anticipation of a greater interest there has been an increased research effort on both the biology of scad and the way that scad might best be utilised by the trade. The purpose of this leaflet is to update the 1977 publication by presenting new data and by indicating to the reader alternative sources of information which are available.

2. THE BIOLOGY OF SCAD

2.1 The fish and its distribution

The scad is a member of a large family of fish known as the carangids which include many important commercial species world-wide. The alternative name of horse mackerel is misleading as the true mackerel-like fishes, e.g., tunnys, bonitos, etc., belong to the scombrid family, and therefore the English vernacular name 'scad' is preferable. The species commonly found in British waters, Trachurus trachurus, is the most northerly representative of the trachurid family which is widely distributed in the world's seas and often supports important fisheries (Figure 1). The scad is found from the waters around the Cape Verde islands north to Iceland and the Norwegian coast, and also in the Mediterranean and Black Seas. The large fishery off the South African and Namibian coasts also exploits this fish, although it might be a subspecies Trachurus trachurus capensis (the Cape horse mackerel or maasbanker).

Within the home operating range of British fishing vessels the scad is likely to be confused only with two other species, both commonly referred to as Mediterranean scad, and both found occasionally in the Bay of Biscay and southern Celtic Sea. These are Trachurus mediterraneus (Steindachner) and Trachurus picturatus (Bowditch), both of which grow to much greater lengths (up to 65 cm) than the scad of the North-east

Atlantic (maximum length 45-50 cm). All three species show typical trachurid characteristics; a row of bony scutes or raised scales along the lateral line which has a conspicuous slope above the paired anal spines, and a forward-pointing spine in front of the first dorsal fin. The differences between the species, which are not immediately obvious, are illustrated in Figure 2. Common names for these three species of scad in various countries are listed on page 20 of this leaflet.

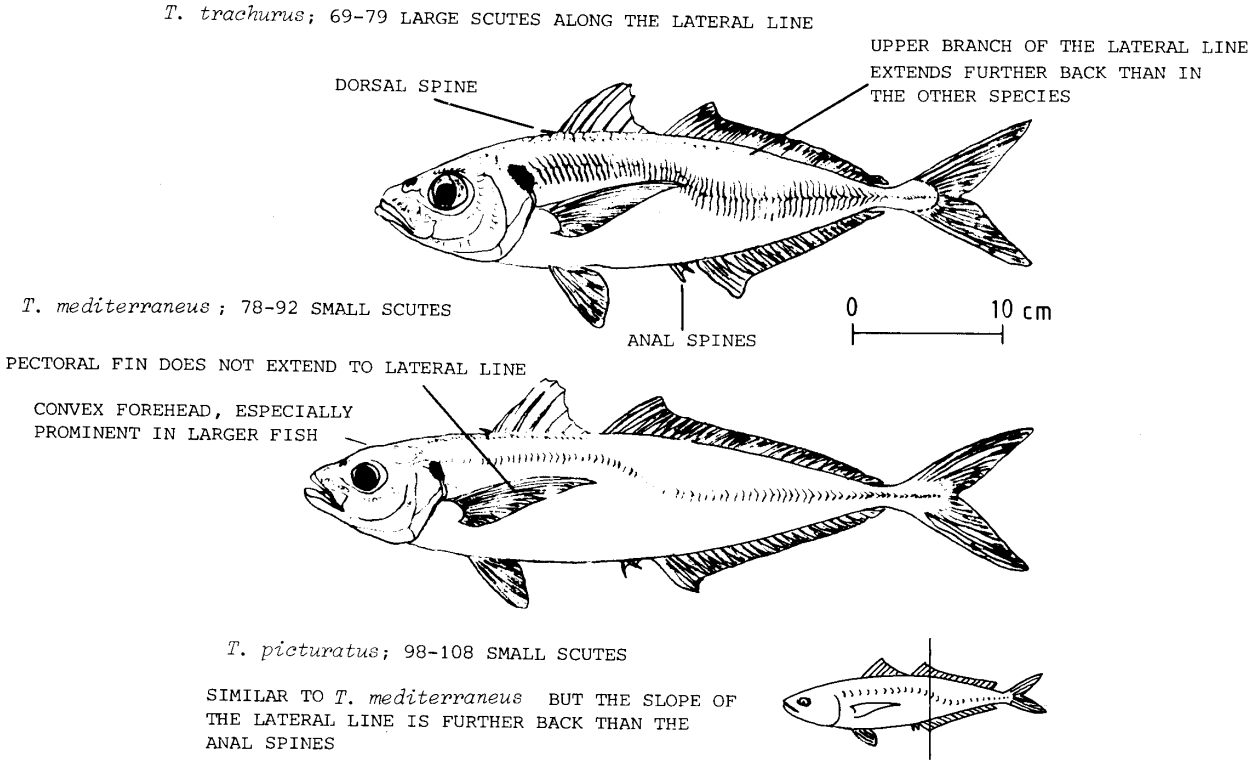
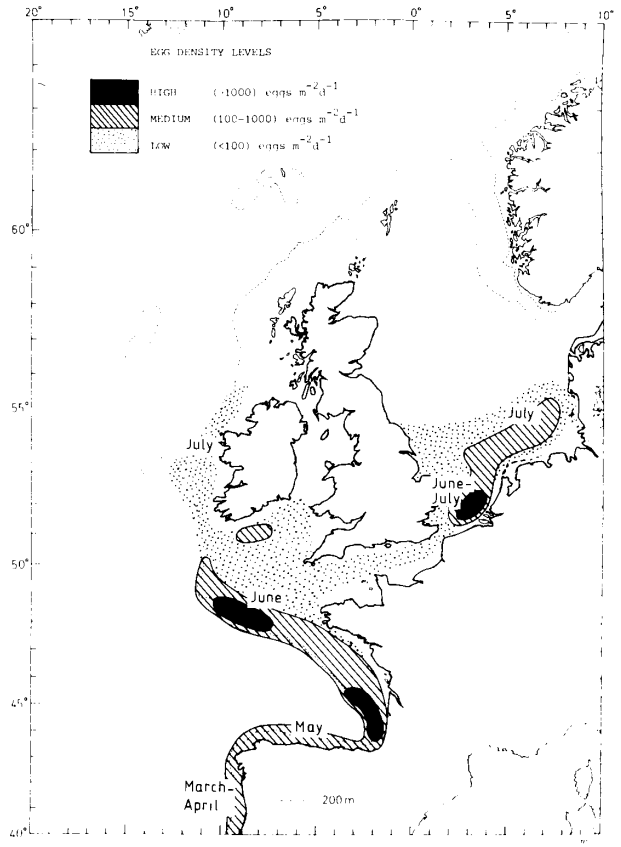


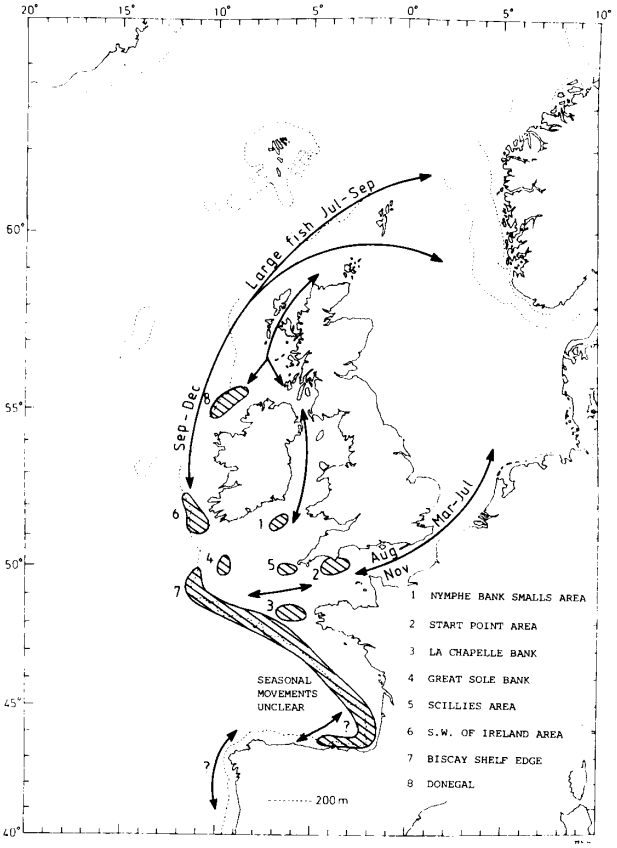
Figure 2 Identification characteristics of Trachurus species in the North-east Atlantic.

Although still not fully understood, a clearer picture is now emerging of the movements of the scad populations during the year. It is generally accepted that there are at least two distinct spawning populations, one to the west of the British Isles along the continental shelf edge extending as far north as the Donegal and Tory Island grounds off north-west Ireland, and the other mostly restricted to the central and southern North Sea and English Channel. There is also the possibility of other populations in south Biscay and off the Portuguese coast (Figure 3A).

The western population spawns along the shelf edge, starting earlier in the south than in the north of the area, with the larger, usually older, fish tending to spawn earlier than smaller fish. During the spawning season the fish tend to be scattered as individuals or small groups and are at their most difficult to catch. Age and length distributions from around the British Isles suggest that, as for mackerel, the largest fish tend to travel furthest and may reach areas around the Shetland Islands, Norwegian coast and northern North Sea by September.



A. Spawning grounds and peak spawning periods.



B. Migration routes and main wintering grounds.

Figure 3 Scad in the North-east Atlantic.

As yet we are uncertain that their migrations are on the same scale as found in Western mackerel, although occasionally good catches of large scad have been taken in the Minches and to the west of the Shetland Islands. The smaller, younger fish do not travel as far, and immature fish also tend to stay within the Celtic Sea area with some extension into the English Channel.

During the autumn, from September onwards the fish return to and congregate in their overwintering areas (Figure 3B). The larger fish tend to favour the deeper water along the shelf edge. Relatively few large fish join the big shoals found in the Start Point area which are composed mainly of small and immature fish (possibly including those from the North Sea spawning). Larger fish from the North Sea population are caught less often in the Start Point fishery and possibly move further west. The shoals sometimes encountered in the eastern English Channel in late summer-early autumn might well be North Sea fish migrating westwards to the wintering grounds. The age and length compositions of scad shoals wintering in the English Channel show a greater range and complexity than those found at other times in the North Sea and Celtic Sea, suggesting that there is some mixing of fish from different areas.

The western English Channel is not only a wintering ground for scad but also a nursery area for juvenile fish which, when mature, will make spawning migrations, mostly back to the North Sea. There are indications from research vessel cruises that other nursery grounds probably exist in the south and east German Bight and in the middle Biscay area.

Overwintering shoals usually form by mid-November and begin to disperse again by mid-March. The diurnal behaviour patterns of the winter shoals, described in the 1977 leaflet, have since been verified on many occasions in all areas where the shoals have been located. The scad tend to be in separate compact shoals close to the bottom during daylight, then rise a few metres off the seabed and spread out laterally to form less discrete layers during darkness. The lateral dispersion and lift are not usually as marked as in other pelagic species such as mackerel, sprat and pilchard, and the scad remain vulnerable to capture by both midwater and high headline bottom trawls.

2.2 Life cycle

In the area between the Strait of Gibraltar and Cape St. Vincent spawning commences as early as January, with a peak during March-April in Portuguese and western Spanish waters. Further north peak spawning becomes progressively later, and the last appreciable spawnings finish in July to the west of Ireland and in the North Sea.

In the laboratory scad eggs developed only in the temperature range 10° to 22°C. Heaviest spawning appears to coincide with a mean sea surface temperature around 13°C, a temperature observed to be conducive to higher rates of survival to hatching stage in laboratory development experiments. Within the temperature range stated the eggs take between 2 and 5 days to hatch as planktonic larvae about 2.5 mm long.

By the end of the year the young fish will have grown to about 10 cm total length and will be of the typical scad shape. At this age they are wholly pelagic in lifestyle, staying high in the water column in shoals separate from larger fish, and feeding mainly on zooplankton. They are often found associating with jellyfish and salps in the mid-water layer, especially when very small. During their second year the fish grow

to a length around 16-20 cm and become increasingly demersal (sea-bed living) in habit, joining shoals of larger scad and taking an increasing proportion of small fish in their diet. In their second year up to 50% of the fish spawn for the first time, this proportion rising in subsequent years until 100% maturity is attained in the fourth or fifth year of life.

2.3 Growth

Three measurements are commonly used when referring to fish length: (i) total length, from the tip of the snout to the tip of the closed tail fork; (ii) fork length, from the tip of the snout to the base of the fork in the open tail; (iii) standard length, from the tip of the snout to the base of caudal peduncle. The first is always used for pelagic species in British and European scientific establishments which operate within the framework of the International Council for the Exploration of the Sea (ICES). The other two are widely used in commerce, and by some other foreign scientific organisations. There are simple relationships between total length and the alternative length measurements which are illustrated in Figure 4. For all practical purposes, fork and standard lengths are respectively 85% and 80% of the total length. All further references to length in this leaflet are to total length.

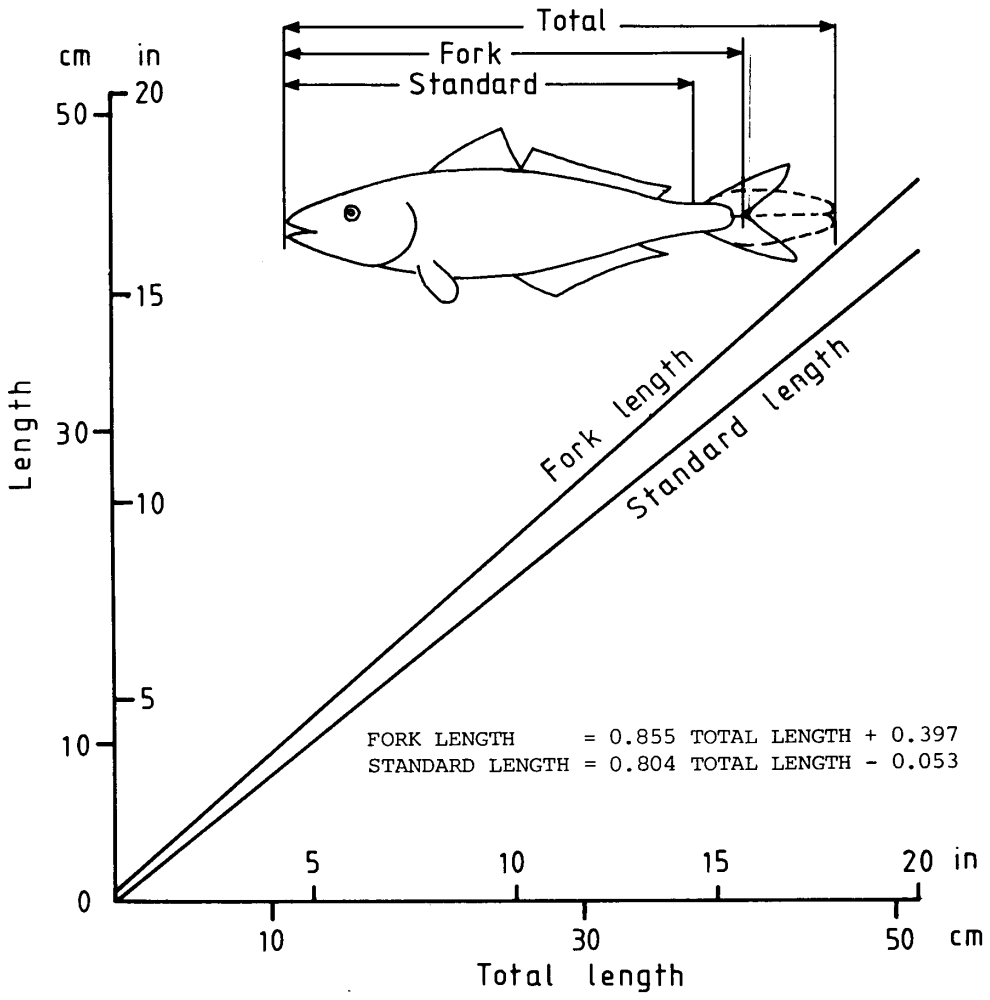


Figure 4 Relationship between total, fork and standard lengths of scad.

Using the otoliths (or ear stones), it is possible to age scad without difficulty up to at least 7 years. Thereafter it becomes increasingly difficult, but it is apparent that they are at least as long-lived as mackerel, 15 years or more. During the first few years of life the fish grow rapidly in length, but this rapid growth slows dramatically as the fish approach sexual maturity. Most scad caught in UK waters are in the length range 20–35 cm. Larger fish, up to about 45 cm, are found mainly along the continental shelf edge to the north and west of Ireland, but are never as common as, for example, large 'jumbo' mackerel are in the Minch autumn fishery.

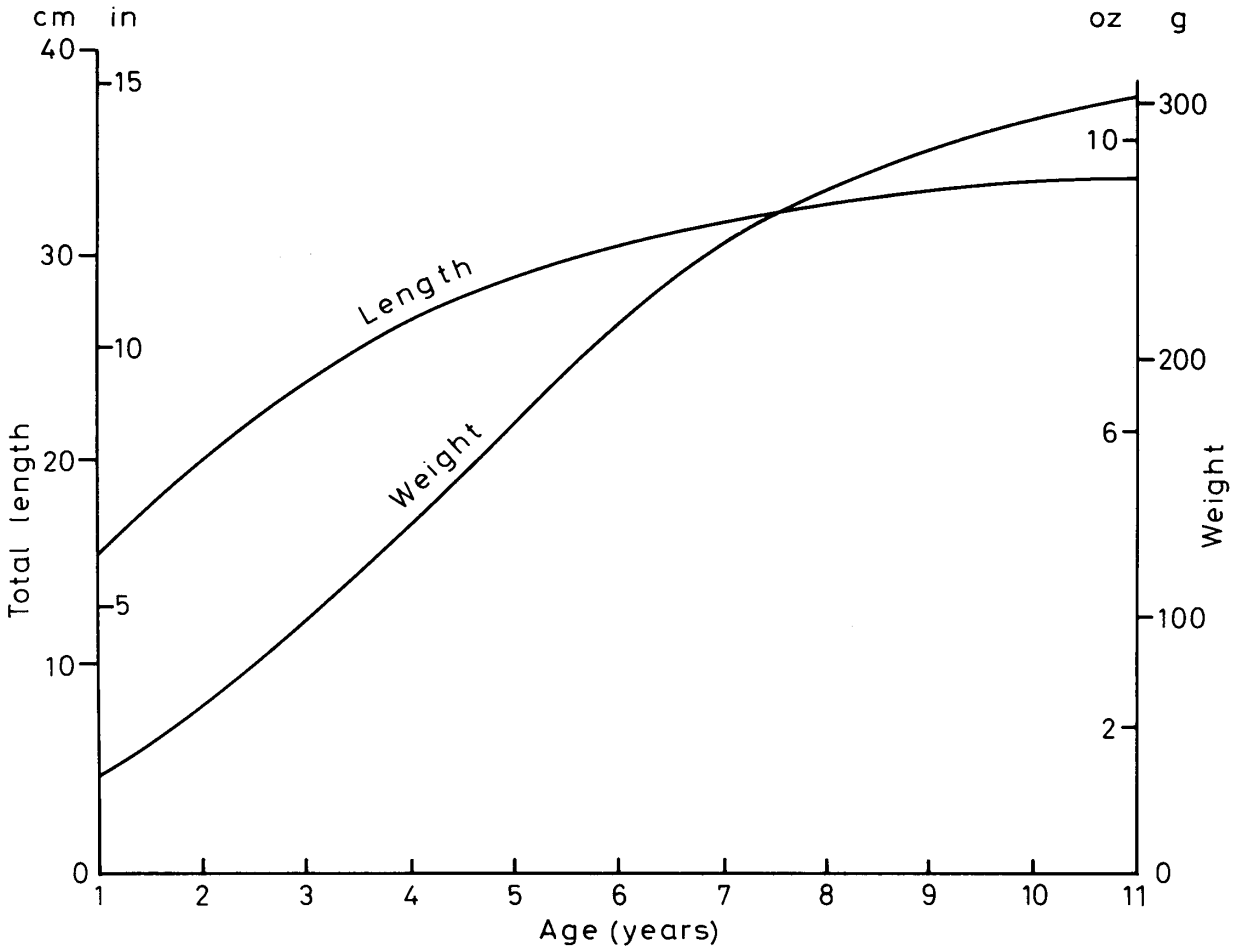


Figure 5 Relationship between mean body length, mean whole body weight and age.

The relationship between length and weight at age is shown in Figure 5. The rate of growth in length starts to slow down when the fish are about 26 cm long and weigh around 140 g in winter, which is usually in their fourth or fifth year. By this time the weight of the fish is normally increasing rapidly. For example, a fish which might typically weigh about 220 g at 30 cm, would more than double that weight to around 530 g (about 1.25 lb) by the time it has grown to 40 cm long.

2.4 Annual fat cycle

In common with other pelagic species, the scad shows an annual cycle of fat content (Table 1) which is linked to its feeding and spawning activity, and is inversely related to its moisture content. (The fat plus moisture content together form a stable 80% of the fish weight throughout

the year.) Fat content is at its highest in October-November when levels around 16% by weight are recorded in the flesh. These levels then decline throughout the winter when the fish do not feed, and by early spring, when the fish recommence feeding, minimum levels of 4-7% are recorded. After spawning the fish are generally in a poor condition and begin feeding intensively ready for the next overwintering period, building up fat stores not only in the flesh but also in the liver and as fat tissue around the gut.

Table 1 Fat content of scad: analyses of skinned fillets from individual fish and/or batches of minced flesh from at least 100 fish. Most of the observations were on fish from ICES division VIIe.

Month	Number of analyses	Length range (cm)	Fat content range (%)	Mean fat content
January	41	27-33	2.3-13.7	9.1, 6.7
February	32	33-39	2.9-10.5	6.3
March	80	15-38	3.6- 9.4	7.1, 4.8
April	>104	15-37	2.4-12.0	11.3, 5.6, 4.3
May	> 38	25-34	2.1-13.5	11.3, 6.9
June	>112	20-39	2.2-13.5	9.3, 8.0. 5.4
July	32	Not known	5.7-20.2	11.9
August	Not known	25-34	4.8-10.3	7.6
September	Not known	25-34	6.4- 7.3	6.7
October	> 82	17-39	5.5-16.2	15.2, 11.9, 11.4, 7.0
November	Not known	25-39	9.4-16.7	15,7, 11.6
November/ December	16	20-37	6.6-20.4	11.6
December	32	26-34	2.5-14.8	6.3

Although the fat cycle has this general pattern, it has been found that the fat content of individual fish at any time can vary immensely. The difference between individual fish in a sample can be greater than the variation between sample mean values throughout the year. This can cause problems when processing and marketing the fish, especially if specific fat levels are required.

3. SPAWNING STOCK SIZE ESTIMATES

The size of the scad stock spawning in shelf edge waters to the west and south of the British Isles has been estimated twice by pelagic egg survey using the method described by S. J. Lockwood in Laboratory Leaflet Number 44 (1978) 'Mackerel - a problem in fish stock assessment'. In 1977 the Bay of Biscay, Celtic Sea and west of Ireland was surveyed during the period March to July and the scad spawning stock biomass in this area was estimated to be 1.1 million tonnes. The same area was sampled again in 1980 when the provisional spawning stock biomass estimate obtained was fractionally over 1 million t. Both surveys probably under-estimated the stock size because the policy adopted when working up the results was to 'err on the side of safety' and only the main spawning area was covered. Only partial coverage of this area was achieved in some months during the 1977 survey. It is possible, therefore, that the biomass then was much underestimated and that there had been a decline in the spawning stock size over the period 1977-80. A declining trend in the catch per unit of effort (an index of stock abundance) over the same period in the large Portuguese and Spanish scad fisheries further south might point to the

same conclusion. However, it is still far from clear what the relationship is between scad caught off the Iberian coast and those spawning further north. Some scientists consider the south Biscay and Portuguese coast fish to be a separate stock from those in north Biscay and the Celtic Sea. The Portuguese and Spanish coastal areas were not covered by the surveys, and consequently the stock estimates did not include the fish in these areas.

The only other estimates of stock size to the west of the British Isles were made by Russian fisheries scientists using mathematical models of the scad population (see page 19). They calculated that there were 1.5 million t of mature scad (older than 2 years) in the Celtic Sea/Biscay area in 1970, with an average stock weight of 1.2 million t for the period 1970-75. For the same period they estimated the weight of the exploited stock in the North Sea and English Channel to be in the range 375-457 thousand t with a mean weight of 412 000 t, and English egg survey data for the period 1962-68 gave effectively the same value, 433 000 t.

4. FISHERIES

Table 2 shows the scale of fisheries for scad and closely related species around the Atlantic basin. By far the most important are those off the South African and Namibian coasts (the maasbanker fishery, FAO area 47, the south-east Atlantic) and the coastal waters of western central Africa from the Gulf of Guinea north to the Canary Islands (FAO area 34, central eastern Atlantic). The sharp fall from 1977 to 1978 in the north-east Atlantic (223 695 t down to 146 433 t) is largely due to the exclusion of Eastern bloc fleets from European Community (EC) waters, since when the catch has stabilised at a much lower level, around 140 000 t per year.

Table 2 Catches (tonnes) of *Trachurus* species in the Atlantic (Source FAO Yearbook of Fishery Statistics, Vol. 50 1980)

FAO Fishing area (code) and species	1976	1977	1978	1979	1980
NE ATLANTIC (27)					
Trachurus trachurus	381 747	223 695	146 433	143 654	136 903
E CENTRAL ATLANTIC (34)					
Mixed *Trachurus* species	430 365	492 345	330 262	250 072	490 390
SE ATLANTIC (47)					
T. trachurus capensis	547 854	688 456	551 831	465 136	326 361
*Trachurus trecae**	31 298	33 764	378 255	272 390	347 899
Other *Trachurus* species	30 329	28 997	35 612	29 693	19 951
MEDITERRANEAN AND BLACK SEAS (37)					
Trachurus trachurus	272	5 605	13 191	18 479	9 720
Mediterranean scads‡	23 616	18 008	30 747	66 266	52 473
Other *Trachurus* species	53 659	39 561	31 902	34 086	31 684

*Known as the 'Cunene' horse-mackerel
‡Mostly *Trachurus mediterraneus*

Figure 6 shows the disposition of catches in European waters by nation and ICES fishing area. Portugal and Spain remain the major European catchers of scad despite falling catch rates in recent years. However, other nations are taking a greater interest in the stock, most noticeably the Netherlands whose catch of scad has risen from 2 000 t in 1977 to more than 40 000 t in 1981, of which about 25 000 t were taken in the English Channel (ICES divisions VIId and e).

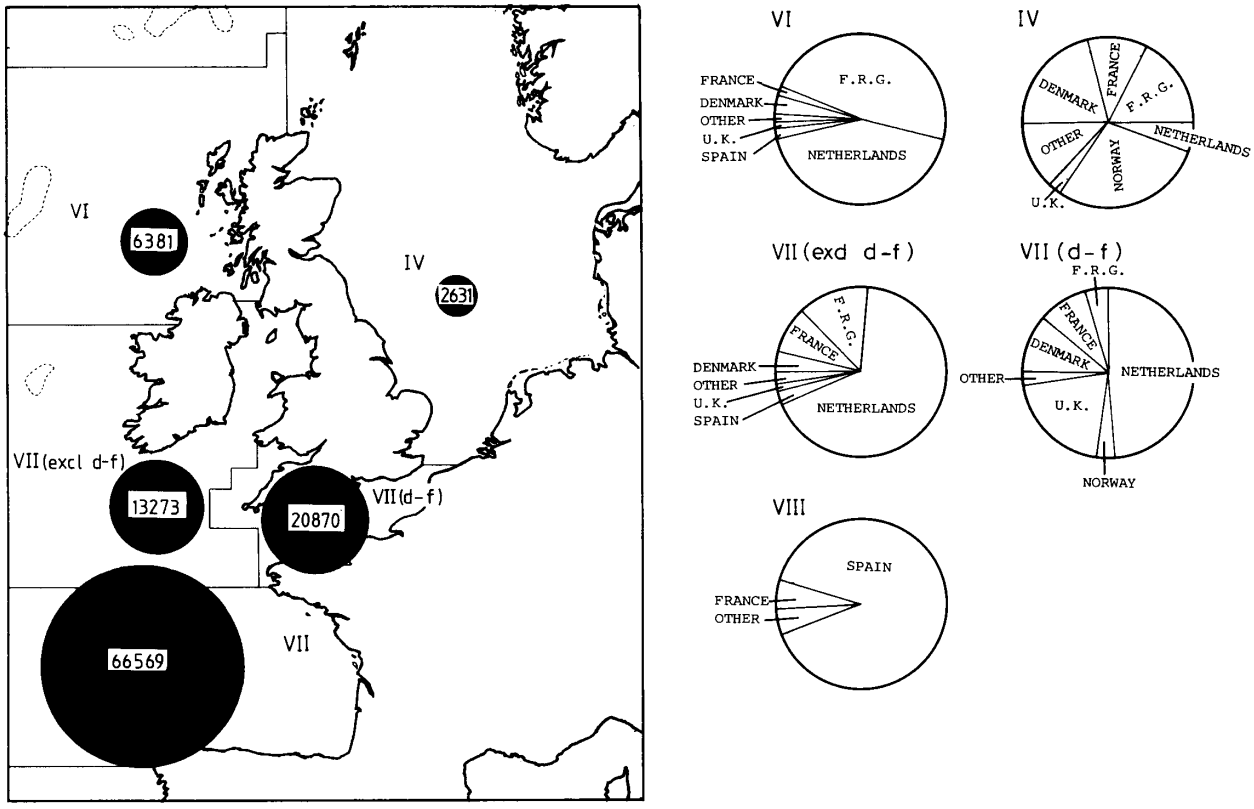


Figure 6 Mean annual catch (tonnes) of scad by ICES sub-areas or divisions, 1977-81, and proportions of total taken by nations.

Following a 13 000 t English catch in 1980, an attempt was made in the winter of 1981/82 to establish a directed fishery for scad in division VIIe around Start Point. Because of several factors, in particular the very bad weather experienced that winter, the venture was not wholly successful. Despite this, interest has been maintained within the British fishing industry, and Dutch vessels also seem prepared for another major effort in the area. It is possible that an operation based on fish caught along the shelf edge to the west of Ireland might also be tried in 1983.

5. LENGTH COMPOSITIONS

The combined length data from January 1977 to May 1982 are summarised by quarter years, as length groupings for each ICES division and type of gear used, in Table 3 and Figure 7. The distributions show that throughout the length range different gears tended to take different

components of the stock, and in some cases well defined stock components could be associated with specific areas at certain times of the year. In general it can be said that, if there is a wide length distribution in an area, (i) Granton type bottom trawls will tend to catch larger scad; (ii) midwater trawls will take a larger proportion of small fish; (iii) high headline bottom trawls will tend to catch a wider range of sizes than other gears. These differences are probably due to the changing behaviour of the fish as it increases in size, as described earlier, and could imply layering of fish by size groups in the shoals.

Table 3 Size of scad caught in various ICES divisions, quarterly, as percentage frequency by length groups, 1977-82

ICES Division	Gear	Length group (cm)															
		January-March				April-June				July-September				October-December			
		<16	16-25	26-35	>35	<16	16-25	26-35	>35	<16	16-25	26-35	>35	<16	16-25	26-35	>35
N & Mid-Biscay	HLBT	17.9	64.7	16.6	0.7	46.0	19.0	33.3	1.7			NO DATA					
VIIIa & b	BT	92.0	0.9	6.3	0.8	0	6.1	78.6	15.3	0	0	26.1	73.9			NO DATA	
	MT	89.0	5.3	5.7	0.1			NO DATA				NO DATA					
N Spanish coast	HLBT	0	1.5	90.2	8.4	0	12.0	82.1	6.0			NO DATA				NO DATA	
Mid & S North Sea	HLBT			NO DATA		0	6.9	72.2	20.9			NO DATA				NO DATA	
IVb & c	BT							NO DATA		12.2	1.7	85.2	0.9	0.3	0	99.1	0.6
N North Sea IVa	BT			NO DATA				NO DATA		0	0	26.0	74.0			NO DATA	
W of Scotland and	HLBT			NO DATA		0	0	11.5	88.5	0	0	53.1	46.9	0	+	33.2	66.8
Ireland VIa +	BT					0	0	63.2	36.8	0	0	94.9	5.1			NO DATA	
VIIb, c																	
Celtic Sea -	HLBT			NO DATA		+	0.1	75.3	24.6					0	0.2	42.9	56.9
Shelf edge	BT					0	0.1	86.6	13.3			NO DATA				NO DATA	
VIIj	MT	0	0	58.2	41.8			NO DATA									
E Celtic Sea &	HLBT	0.4	0.4	69.0	30.2	0.4	63.8	35.1	0.7	0	0	99.8	0.2	6.1	6.9	54.7	32.3
Bristol Channel	MT			NO DATA				NO DATA				NO DATA		99.9	0	0.1	+
VIIf, g, h																	
W English Channel	HLBT	0.2	41.3	58.1	0.4	3.4	95.6	1.0	+	0	0	99.4	0.5	12.1	64.9	21.8	1.0
VIIe	PMT & BT	0.6	50.6	47.0	1.8			NO DATA						0.5	74.5	24.9	0.2
	MT	36.9	29.4	33.5	0.2	0	45.2	54.8	0			NO DATA		71.4	25.5	3.2	0
	PS	0	14.5	84.9	0.5			NO DATA						0	12.3	86.3	1.3

* HLBT - high lift bottom trawl; BT - bottom trawl; MT - midwater trawl; PMT - pair midwater trawl; PS - purse seine.

A basic pattern of movement is discernible from the length distributions shown in Figure 7. The component of large fish (30 cm or longer) seen in the middle and southern North Sea appear only briefly in the Start Point area during the autumn. These fish probably pass through the area to over-winter further west, the main winter fishery being based on smaller, younger fish as can be seen from the length distributions. This lends credence to the idea that this area is a nursery ground. Immature scad have been seen in other areas but usually only in the post-spawning period, July-October, and only in middle and north Biscay have they been caught in any quantity. These areas may also be nursery grounds, as has been suggested by Russian scientists. In all areas along the shelf edge, from the southern Celtic Sea to the northern North Sea, the smaller components of the stock (less than 25 cm) have seldom been taken, even by research vessels using small mesh cod-end liners, although scad less than one year old were found widely distributed in the Celtic Sea and English Channel in December 1982.

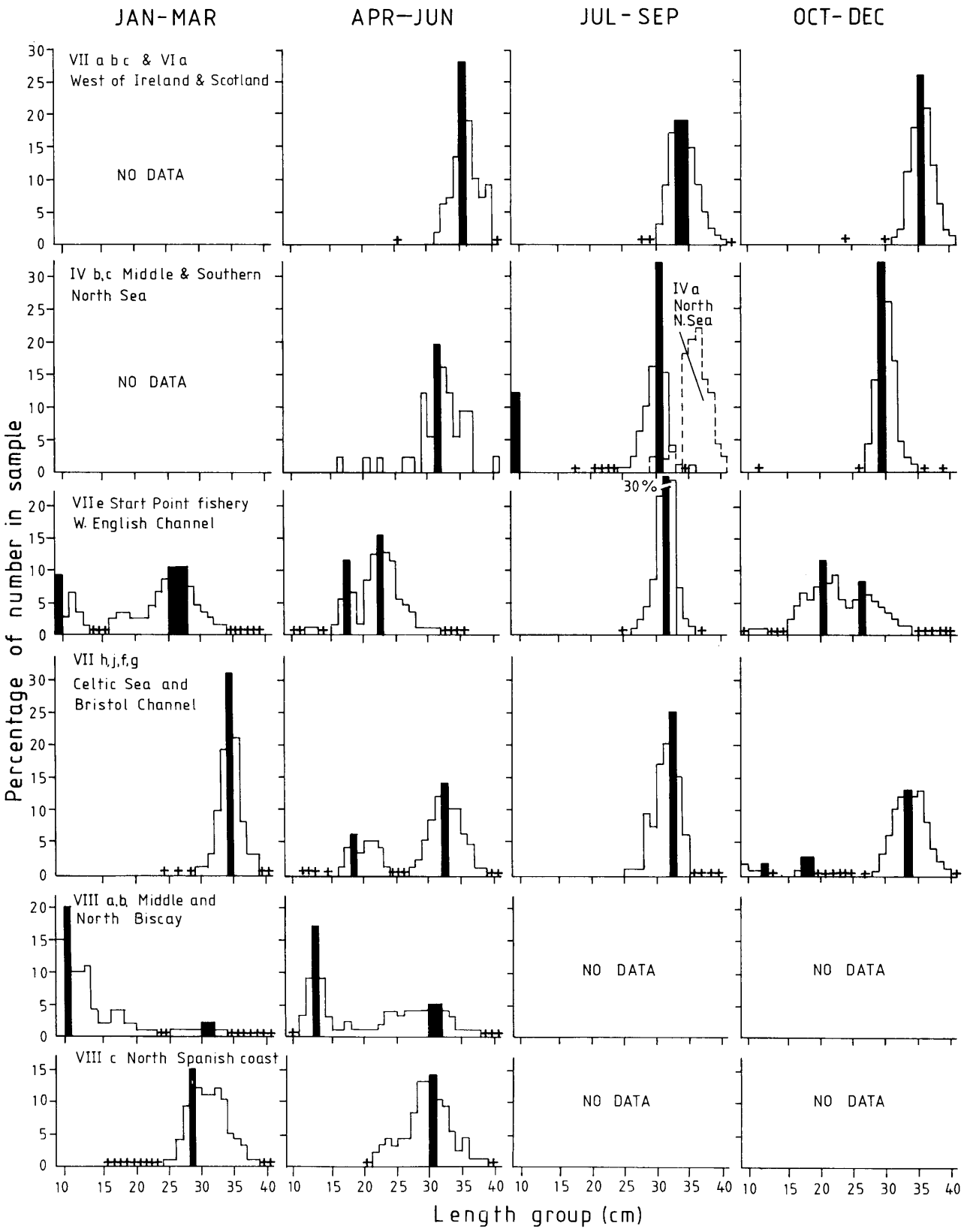


Figure 7 Percentage length frequency distributions of scad by ICES divisions, quarterly in the period 1977-82, by all trawls; + = less than 1%; solid bars shows the predominant length groups

6. CATCH RATES

Information on commercial catch rates, detailed or otherwise, apart from USSR records, is lacking. Although not truly representative because of the nature of the work, the catch rates achieved by commercial vessels chartered by the Ministry of Agriculture, Fisheries and Food and the White Fish Authority (now the Sea Fish Industry Authority) for exploratory scad voyages do give an indication of what might be possible. Summaries of these voyages, are given below, and the results from the 1980 exploratory voyages are summarised in Table 4.

Table 4 Catch rate (kg/hour) summary of exploratory voyages, 1980

	Mackerel		Scad		Grounds	Trawl
	Pelagic	Demersal	Pelagic	Demersal		
CIROLANA	0	0	0	520	La Chapelle Bank	Engel midwater
4-17 Jan	0	0	0	39	Biscay, Shelf edge	1 600x20 cm;
	626	-	40	-	Devon/Cornish waters	Granton
SWANELLA	0	-	3 981	-	La Chapelle Bank	Engel midwater
11-31 Jan	0	0	0	0	Biscay, Shelf edge	398x80 cm;
	0	-	4 616	-)		Portugese high
	26 073	-	0	-)	Devon/Cornish waters	lift bottom
		-	115	-)		
KELT	0	-	0	-	La Chapelle Bank	Engel 2 000x20 cm
21 Jan-10 Feb	0	-	0	-	Biscay, Shelf edge	
	0	-	0	-	Celtic Sea	
	12 459	-	0	-	Devon/Cornish waters	
CORDELLA	36 324	3 341	0	0	W of Ireland	Boris midwater
1-21 Feb	-	3 529	-	0	Gt Sole Bank	400x80 cm;
	149	-	2 902	-	Devon/Cornish waters	Portugese high lift bottom
PRINCESS ANNE	0	-	0	-	La Chapelle Bank	Midwater;
11 Feb-2 Mar	1 076	358	0	0	W of Ireland	
	14 487	-	0	-	S of Scillies	
	0	0	2 693	87	SW of Gt Sole Bank	Granton
	0	-	83	-	Biscay, Shelf edge	
	3 775	-	394	-	Devon/Cornish waters	
G A REAY	0	-	0	-	Sole Bank	DAFS midwater
1-23 Mar	0	-	177	-	La Chapelle Bank	
	0	-	253	-	S Biscay	
	33	-	391	-	Devon/Cornish waters	
JUNELLA	-	0	-	0	W of Scotland	Portugese high lift bottom
9-30 Jun	-	44	-	45	W of Ireland	
	-	19	-	361	SW of Hurd Bank	
	-	0	-	951	E of Sth Hake Ground	
	-	0	-	0	SSW of Scillies	
	-	9	-	49	Devon/Cornish waters	
ARCTIC GALLIARD	0	-	0	-	Western Approaches	Ijmuiden Stores
4-16 Jul	235	-	141	-	W of Ireland	Engel midwater P47C
	465	-	22	-	Celtic Sea	
ST JEROME	-	0	-	0	Sole/Melville Bank	Engel high lift bottom
15 Aug-25 Sep	-	0	-	1 011	N of Scillies	
	-	0	-	26	W of Ireland	
	-	0	-	39	W of Scotland	
	-	0	-	0	Labadie Bank	

6.1 St Jasper; 1-10 February 1978

Fishing was carried out in the Start Point/Eddystone area using a Cosalt-single boat rectangular midwater trawl. An overall mean catch rate of 7.4 t/hour was achieved, with night tows when the fish were off the bottom proving to be more productive (9.5 t/hour) than tows in daylight when the fish tended to be hard down (1.25 t/hour). The best catch rates were achieved when towing at higher speeds than normally used when fishing for mackerel, a technique also used by the Russian fleets. There were no obvious differences in catch rates towing with or against the tide, but the shape and alignment of the scad shoals appeared to be influenced by wind and tide conditions. The shoals tended to be long and

narrow, with the long axis aligned with the tidal currents, and moved around in response to changes in the wind direction (usually against it), breaking up and scattering when the weather turned bad. These responses are all similar to those observed in mackerel shoals.

Despite the spiny nature of the fish, no problems were experienced with meshing in either the main part of the trawl or in the cod-end (50 mm herring/mackerel liner), but because of the scutes the fish tended not to run or spread themselves evenly when emptied down the ramp hatch into the pounds, and consequently large hauls had to be dealt with in batches to allow time for pile-ups to be cleared. Countering this disadvantage was the fact that because scad, unlike mackerel, have a gas filled swim-bladder, the bags floated and could be held alongside if necessary.

Catches were clean and scad were found to have excellent storage qualities. It was felt that better catch rates could have been achieved by using a high-lift bottom trawl. Lengths of the fish ranged from 17 to 39 cm, with modes at 28 and 31 cm. The lengths were distributed as follows: 6.5% < 22 cm, 12.9% between 22 and 24 cm, 80.6% > 24 cm.

6.2 Cordella; 3-16 August 1979

This voyage was to search for scad on the Irish, Malin and Hebrides shelf areas to the west of the British Isles. At the time of the survey scad were fetching around £220 per tonne from West African and Japanese buyers.

Gears carried were an Engel 2000 x 20 cm midwater trawl, a Portugese high headline bottom trawl (3.6 m lift) and a French high headline bottom trawl (5 m lift). Of these, the French trawl gave the better (albeit low) catch rates, 0.5-2 t/hour, but it was felt that these rates could have been significantly improved by using a higher opening trawl and by concentrating more on working up catch rates in promising areas rather than adopting the 'fish and move' strategy normally used on surveys of this type.

Scad were found in 130-200 m of water within 12 m of the sea bed. The largest concentrations were off Bell Rock and the Skelligs to the SW of Ireland, and off Tory Island in the north-west. The amount of scad caught fell markedly north of 50°30'N. All fish caught were in the length range 32-42 cm. In addition to scad, good concentrations of white fish were also found, mostly haddock with smaller amounts of cod and hake.

For fuller accounts of these voyages see WFA Industrial Development Unit Field reports, Nos 591 (February 1978) and 767 (August 1979).

6.3 Exploratory voyages programme, 1980

During 1980, two research vessels and thirteen chartered commercial vessels spent a total of 221 days at sea between January and September in search of commercial quantities of scad. During the winter (January-March), the area searched extended from south Biscay to the Tory Island grounds, including the Celtic Sea and Cornish and Devon coastal waters. Some vessels took scad and/or mackerel in reasonable quantities. During the summer (June-August) the area along the shelf edge from La Chapelle Bank to the Shetlands was covered but virtually no commercially viable hauls were made (see Figure 8).

Apart from catches taken in the already well known English Channel area, most of the successful hauls were made in 180-200 m close to the

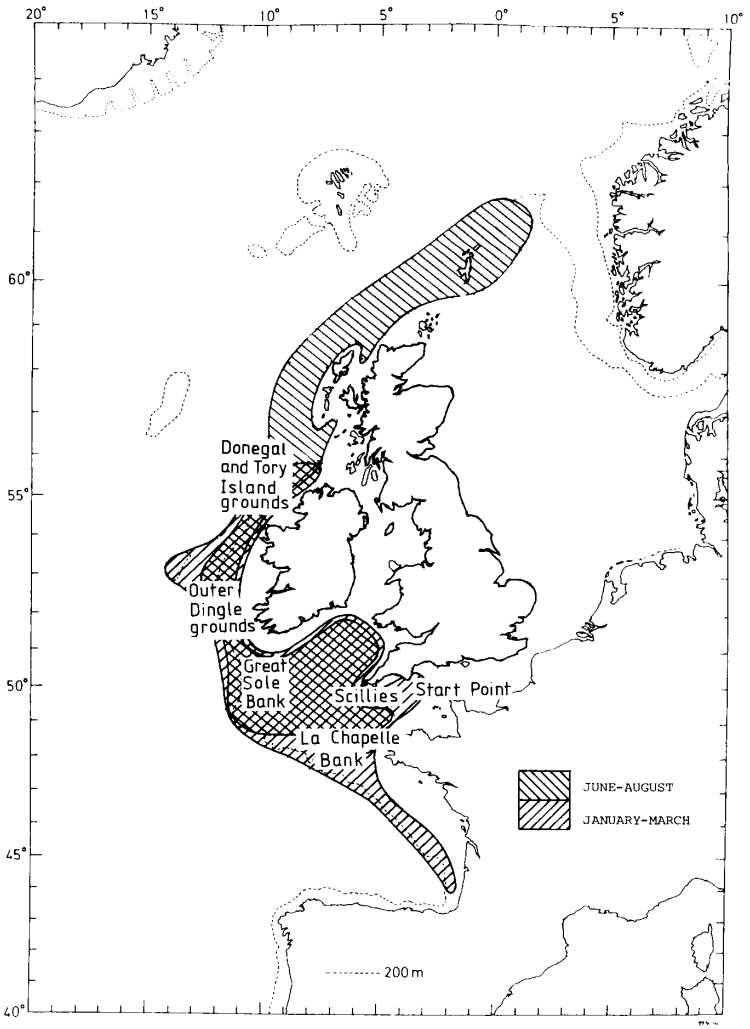


Figure 8 Survey areas of exploratory voyages, 1980. Named grounds are those on which scad and/or mackerel catch rates exceeded 2.5 t per hour.

shelf edge. The scad and mackerel caught were consistently larger than those taken in the English Channel.

Using a midwater trawl, scad catch rates of more than 2 t/hour were achieved off Start Point, but along the shelf edge the mean catch rate was less than 1 t/hour. However, in two localities, the Great Sole and La Chapelle Banks, between 3 and 4 t/hour were taken on some hauls. There were also some good catches of large mackerel taken in February to the west and north-west of Ireland.

6.4 USSR fishery

It is interesting to compare the exploratory voyage catch rates with those of Russian fleets in previous years. Detailed information on Russian fishing activity in the survey areas during 1976 show overall catch rates higher than those reported above, even allowing for the possibility that some catches might have been misreported (e.g., some catches reported from Biscay in the winter may have been from the Azores or even further south). Nevertheless, mean catch rates throughout the year of 23.7 t/day (midwater trawl) and 19.6 t/day (bottom trawl) were reported from the grounds south of Ireland (ICES divisions VII g, h, j and k). These catch rates were for mixed scad and mackerel in the approximate ratio 5:3 respectively, and peak catches of scad were taken in January,

Table 5 Russian fishing pattern and average daily catches (tonnes) of scad and mackerel to the south and west of the British Isles in 1976

Month	Trawl	Species	ICES sub-area or division					
			VIa	VIIb,c	VIId,e	VIIf	VIIg-k	VIII
Jan	Midwater	Scad					19	22
Feb	"	Scad					15	18
Mar	"	Scad			12		7	8
		Mackerel			29		19	16
Apr	"	Scad					2	18
		Mackerel					21	0
	Bottom	Scad					2	*
		Mackerel					22	*
May	Midwater	Scad		0.4			8	
		Mackerel		25			16	
Jun	"	Scad		0.8			9	
		Mackerel		19			16	
Jul	"	Scad	2	16			14	
		Mackerel	9	7			10	
	Bottom	Scad	3	20			19	
		Mackerel	17	4			2	
Aug	Midwater	Scad			17	16	13	
		Mackerel			5	9	12	
	Bottom	Scad	6				10	
		Mackerel	12				6	
Sep	Midwater	Scad			10	5	8	
		Mackerel			12	17	15	
Oct	"	Scad			11	4	9	
		Mackerel			13	17	15	
Nov	"	Scad			14		5	13
		Mackerel			9		15	9
Dec	"	Scad			22		11	18
		Mackerel			1		6	4

*No catch rate estimate made: reported catches probably included fish from sub-areas other than VIII.

February and December using midwater trawls. Table 5 gives a summary of the Russian fishing pattern and catch rates (where more than 50 days fishing was completed in a given ICES sub-area or division) in 1976.

Although the Eastern Bloc fleets have been excluded from fishing within EC waters since 1977 their catch data do indicate that the fish should have been present in the areas covered in 1980 by the exploratory voyages. However, the exploratory voyages failed to discover, by and large, adequate quantities of scad, other than in the English Channel, whereas the Russian vessels had averaged around 21 t/day. Assuming that the exploratory voyages surveyed the right areas at the right time, it is reasonable to ask why our vessels did not achieve comparable catch rates. The probable answer is that they were not able to cover such a vast sea area adequately. There were never more than two vessels at sea at any one time, whereas it has been calculated that in 1976 the Russian fleet never had less than 26 vessels searching for scad and mackerel in EC waters, and this number rose to nearly 100 during September. A properly coordinated fleeting exercise of that magnitude would stand a much better chance of locating such fish as were there.

7. MESH SELECTION

In December 1981 trawl mesh selection trials were carried out on mackerel and scad by Dutch scientists working off Devon and Cornwall. These trials, the results of which are as yet unpublished, showed that for cod-end mesh sizes of 40 and 70 mm (mean mesh size ranged between 34 and 67 mm) there was only selection of fish at very low catch rates. Under these low catch conditions at least half of the scad larger than 16 cm were retained in a net with a 40 mm mesh cod-end; but with a 70 mm mesh the 50% retention length increased to 28 cm. However, it was concluded that in practice there was no selection of scad within the cod-end when fish were caught in commercial quantities (10 t or more per tow).

8. MARKETING

Despite the UK controls on mackerel fishing in the ICES area, there has been relatively little diversion of effort onto scad by the British fleet, even though it is available to capture at the same time and in the same area as the mackerel winter fishery. This may be because the first sale price for scad is often significantly less than that offered for mackerel for human consumption. However, if the right product is presented there are marketing prospects for scad. Brief outlines of three possible outlets with this potential are given below.

8.1 Japan:

In the first six months of 1982, 11 214 t of scad from all sources were imported by Japan with a mean value of £490 (222 936 yen) per tonne, compared with 9 682 t during the same period in 1981, i.e., about four times the total UK catch for the whole of 1981. The fish are used mainly to manufacture a minced, raw fish dish known as surimi and there are strict product requirements. Only small fish (approximately 17-22 cm) are wanted, and these must have a minimum fat/oil content around 10 or 11%. This immediately restricts a British Fishery to autumn/winter fish as the fat/oil content is usually too low by the end of January. Traditional resistance by Japanese buyers to frozen produce is now less strong than hitherto.

8.2 Africa and the Middle East:

There is a demand in west Africa, Iraq and Egypt for cheap protein which can in part be filled by pelagic fish. The local preference is for mackerel or scad. Large fish are required, either whole or as 'steaks', and a high oil content is preferred, although as low as 7% may be acceptable. The greatest demand is normally between November and March, and consignments of 1000 t or more are often required with some guarantees of regular supply. The WFA Fisheries Economics Research Unit Occasional Paper Series No. 3 (1980) entitled 'The potential of West Africa and Egypt as direct markets for UK produced fish and fish products' by I. Scott (obtainable from Sea Fish Industry Authority, 10 Young Street, Edinburgh EH2 4JQ) contains a great deal of invaluable information on this subject.

8.3 Fish meal and oil:

Since 1977-78 UK production of fish meal and oil has fallen dramatically. During the six-year period 1974-79 fish meal imports into the UK averaged 225 000 t/year, with a mean value of £46.9 million/year (£208/t), and the equivalent figures for fish oil were 192 000 t valued at £42.0 million/year (£219/t). In the same period fish meal production in the UK averaged 71 771 t/year. The potential output for all UK plants in 1980 was about 214 000 t, just slightly less than the amount of meal imported in that year. Assuming a conversion ratio for fresh fish to meal of 4.5:1, then in 1980 the total landings of industrial and pelagic species, plus fish offal, for reduction left a shortfall of 448 000 t of fish on possible full capacity operation.

Further information on the potential of scad and other fish stocks for industrial uses is given in Laboratory Leaflet No. 53, (1981) 'Prospects for fuller utilisation of UK fish meal capacity' by P. O. Johnson and R. S. Bailey.

It is understandable that skippers and owners may be put off by the low first sale value of scad for all uses compared with that of some other pelagic species. Scad from ICES sub-area VII attracted a mean first sale price in 1981 of £69.65/t although prices did range as high as £350/t. Equivalent figures for other pelagic species were mackerel £93.80/t, sprat £74.32/t, pilchard £74.39/t and herring £267.96/t.

In 1981 the EC Commission proposed advisory 'quotas' for scad of which the UK share was 27 800 t for all areas. Less than one tenth of this was taken and there is obviously the potential to increase catches. This could most readily be achieved in the south-west winter fishery.

9. PROCESSING

Scad is an oily, dark-fleshed species, less rich than mackerel. It has proved suitable for use in a range of products which have been well received by tasting panels who often compare it to herring in flavour. The products tried were hot and cold smoked fish, paté prepared from hot-smoked fish, various recipes of canned fish using skinned fillets, and fish fingers prepared from minced fish or fillets.

The spiny, hooked scutes which are prominent along the lateral line towards the tail have presented problems in handling and processing the

fish. They tend to snag on one another, and on other surfaces, interfering with smooth flow along conveyors and the operating channels of machines. These scutes interfere with machine skinning of larger fish but small single fillets suitable for canning can be skinned reasonably well. However, both alkali treatment, as in the lye-peel process, and heat treatment with steam, enable the scutes to be removed. The fish can also be 'nobbed' (headed and gutted) by machine with yields as high as those achieved by hand-nobbing.

Fresh fish should be chilled quickly after catching by stowage in ice or in chilled or refrigerated sea water, because long delays at ambient temperature cause the fish to soften and reduce filleting yields. As assessed by tasting, scad loses quality after storage of 6-10 days in ice or chilled sea water, which is considerably longer than expected for herring or mackerel. Seasonal differences do not seem to affect spoilage rates. Belly bursting, a feature of spoilage in other pelagic species, was not observed and the thick, tough skin of scad may possibly protect it against spoilage.

Despite the problems in marketing frozen blocks, caused by disputes over the quantities of ice and fish they contain, preservation of fresh scad by freezing is best carried out using the vertical plate freezer to freeze whole fish in blocks, in plastic lined paper sacks topped up with water. Storage in this form at -30°C provides at least one year of shelf life as oxidation changes, the development of rancid flavours, and dehydration processes are reduced to a minimum. Storage life at -30°C does not seem to be affected by seasonal differences. Recovered scad flesh (minced fish), frozen in 7.4 kg blocks, protected by waxed card cartons in typical commercial fashion, has a shelf life of 6-9 months at -30°C, depending on how quickly the fish is processed after catching.

Development of rancidity in frozen scad products is easily controlled by vacuum packaging. Useful protection is also afforded by breaded coatings set by flash frying.

Further information on handling, processing, preservation and development of product ideas for the consumer market can be obtained from: Ministry of Agriculture, Fisheries and Food, Torry Research Station, PO Box 31, 135 Abbey Road, Aberdeen AB9 8DG.

10. FISHING RESTRICTIONS

At present there are no restrictions on fishing for or the landing of scad, except for by-catch regulations affecting other protected species. Although the EC Commission proposed quotas for member countries in 1981, these were advisory in nature, intended as a precautionary measure because there were no available data at that time on which to base a scientific assessment. The advisory TAC covering ICES sub-areas IV, VI, VII and VIII was 244 000 t apportioned as follows:

> Belgium 550 t; Denmark 10 800 t; France 116 000 t; Federal Republic of Germany 32 000 t; Ireland 13 350 t; Netherlands 42 500 t; UK 27 800 t.

The combined catch by these nations in 1981 was 103 000 t. Even when the Spanish catch of 36 362 t was included, the total catch never approached the recommended TAC. In 1980 Russian scientists calculated that a yield of 260 000 t could be safely taken from a scad fishery in the Celtic Sea

and North Biscay areas. Whilst the data base is rapidly improving, it is still not sufficient for a full assessment, but such data as are available suggest that the advisory TAC is not unrealistic. It seems then that there is still scope for considerable expansion of the scad fishery to the south and west of the British Isles.

Acknowledgements

I am indebted to my ex-colleague J. P. Bridger for the information from the 1980 exploratory voyages and for the worked-up information about the Russian fishery for scad in the Atlantic. Also to K. Whittle and J. Smith of the Torry Research Station, Aberdeen, for the information on scad processing.

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12. NOMENCLATURE

Nation	Trachurus trachurus	Trachurus mediterraneus	Trachurus picturatus
UK	Scad Horse mackerel	Mediterranean scad	Mediterranean scad
Egypt (Arabic)	Seif	Seif	Seif
Tunisia (Arabic)	Chourou	Chbouka	Chourou
Spain	Jurel	Chicharro	Chicharro
France	Saurel Chinchard	Saurel	Saurel
Greece	Savrídi	Savrídi	Mauras áfrido
Israel (Hebrew)	Trakhon gedol-magen	Samur	Trakhon
Malta	Saurella (kaħla)	Saurella	-
Italy	Suro	Sugarello (maggiore)	Sugarello pittato
Morocco	Chrène	Chrène	Chrène
Monaco	Cagnassum	Cagnassum	Cagnassum
Turkey	Istavrit	Karagöz istavrit	Karagöz istavrit
Yugoslavia	Šarun	Šarun	Snjur golemi
Portugal	Carapau		
Denmark	Hestemakrel		
Holland	Horsmakreel		
Republic of South Africa	Maasbanker		
Germany	Stöcker Bastardmakreel		
Norway	Taggmakreel		
USSR	Stavrida		

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