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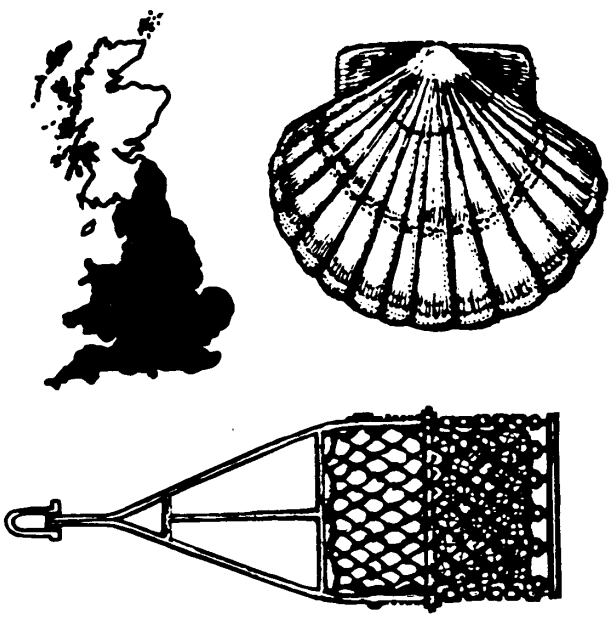
DIRECTORATE OF FISHERIES RESEARCH

THE SCALLOP

and its fishery in England and Wales



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CONTENTS

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THE SCALLOP AND ITS FISHERY IN ENGLAND AND WALES

by A. Franklin, G. D. Pickett and P. M. Connor

1. INTRODUCTION

Exploitation of the escallop, Pecten maximus, (in the U.K. commonly referred to simply as the 'scallop') has been important in Scotland and the Isle of Man for a number of years. In England and Wales, however, the fishery was of negligible size until the mid-1970s when there was a very great increase in landings as fishing effort intensified largely because of the development of overseas markets. Large, previously unexploited stocks were located and, by 1978, the annual landed value for scallops, at just over £2 million, was the second highest for any shellfish in England and Wales. The Ministry's research effort on scallops has intensified as the fishery has increased in importance and this leaflet briefly describes the information obtained to date. An outline is also given of the biology of the scallop, knowledge of which has improved considerably as a result of the recent interest shown in this shellfish by scientists in the U.K. and many other European countries.

2. BIOLOGY

2.1 Life history

The scallop (Pecten maximus) belongs to the pectinid group of bivalve molluscs whose European members also include the commercial queen scallop species, Chlamys opercularis and Chlamys varia, commonly called 'queens'. It is widely distributed from Norway to the Iberian Peninsula and is commercially exploited off the coasts of Iceland, Scotland, Ireland, England, Wales, France and Spain. It can be found in a range of depths, from very shallow water in some Scottish sea lochs to over 100 m off the Atlantic coasts of England and Ireland.

Scallops generally prefer clean, full salinity sea water but they are sometimes found in estuaries and inlets, especially on rocky coasts. They are found on a variety of bottom substrates, from rocks and stones to fine silty mud, but seem to occur most abundantly where there are rocky outcrops or boulders on a substrate of silty sand mixed with shell. Observations by underwater television (Franklin et al., 1980) and divers have indicated that scallops can be present in densities of 5-6/m^2 though a more normal density on a scallop bed would perhaps be 0.2/m^2. If the bottom is soft enough, scallops will excavate a depression or 'crater' in which to sit and they may be found with silt or gravel camouflaging the upper (flat) valve which lies at or below the level of the sea bottom.

Externally the bivalve scallop is almost saucer shaped (Figure 1). The lower (right) valve is cupped and is usually white, cream or pink; the upper (left) valve is

flat and is usually darker, orange or brick coloured sometimes streaked with darker brown. Albino specimens sometimes occur but are rare. Both valves have matching 'ears' at the hinge end of the shell. The valves are sculptured with 15-17 radiating ribs which give the margin of the shell a characteristic crenulate shape. The width of the shell in large specimens can be over 15 cm and individuals can weigh in excess of 350 g.

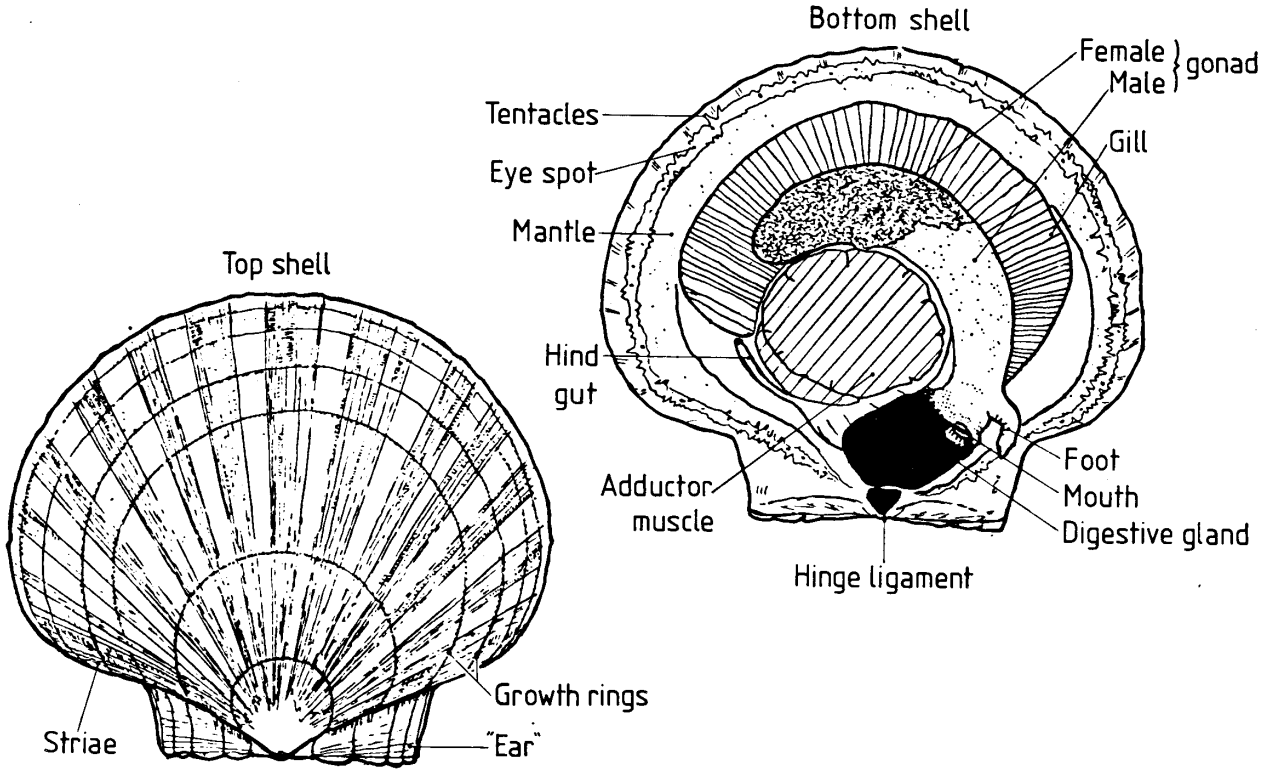

Figure 1 Structure of the scallop.

The two valves are joined by a rubbery ligament at the hinge and can open about 20^{o}. The valves are opened and closed by the large, white, adductor muscle which is powerful enough to make the live animal difficult to open, thus helping to protect it from predators. It is this muscle which gives the scallop its limited swimming ability, water being taken in round the shell edge and then expelled near the hinge by rapid contractions of the adductor, so resulting in a form of jet propulsion.

The scallop is a filter feeder, drawing in sea water which is filtered through the gills. Large particles are ejected; edible-sized ones (detritus, single-celled algae, diatoms, etc) are passed into the mouth and through the digestive system. At the base of the gonad is the 'foot' which in early life is used for locomotion. It is thought that this is used in the adult animal to help clear unwanted particles from inside the shell. The above organs are all enclosed in a thin membrane, the mantle. Around the edges of the mantle, along the edge of the shell opening, are rows of sensory tentacles and a number of bright eye spots (Figure 2). When the scallop is submerged and feeding, the mantle appears around the edges of the part-open shell like a curtain, hanging down from the upper valve and extending upwards from the lower valve. The tentacles can extend up to 50 mm in an adult and are used in detecting food, chemical changes, etc. The eye spots can detect changes in light intensity (Land, 1978) and possibly allow some warning of the approach of predators or fishing gear.

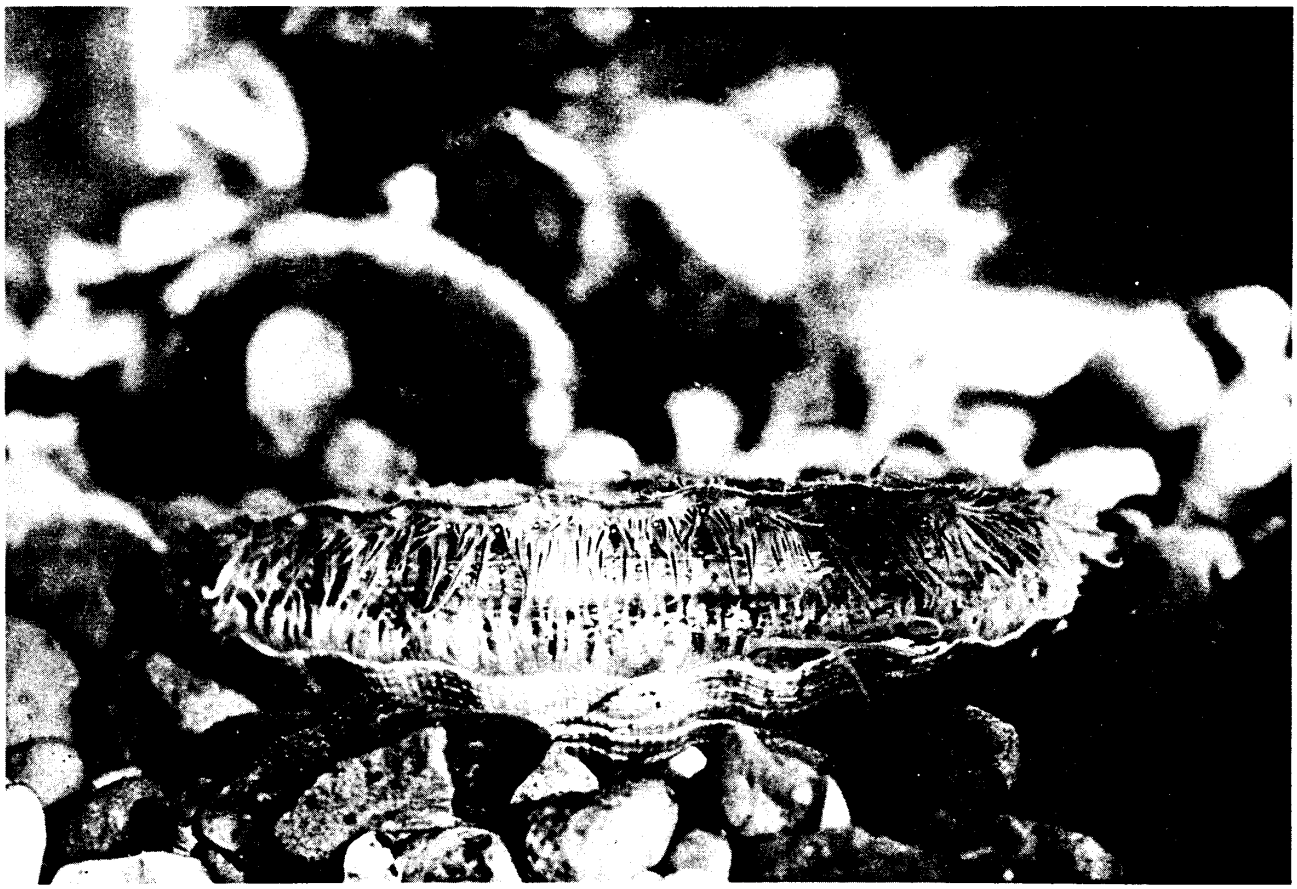

Figure 2 Scallop showing mantle, tentacles and eyespots.

Scallops are fully mature at about three years old. They are hermaphrodite, i.e. the gonad of each mature individual is made up of both female (ovary) and male (testis) parts (Figure 1). The former is pink, orange or red and the latter creamy-white; together these form the 'roe', normally an important constituent of the edible part of the scallop. Although scallops are hermaphrodite, cross-fertilisation with other individuals is the normal occurrence. The sexual products develop over a period of months and can be retained in a 'ripe' condition for several weeks. When spawning occurs, sperm is normally released first, followed several hours later by eggs and perhaps another sperm release within another few hours. The sex products are simply ejected into the surrounding water; the spawning of one scallop can stimulate other ripe individuals in the immediate vicinity to do likewise. Most spawning occurs in the warmer months (April-September), though the actual timing differs from region to region and also from year to year. In some populations there appears to be quite short, sharp spawning periods in spring, mid-summer and/or autumn, but in others a definite 'spawning' is difficult to observe. Where spawning occurs several times a year, the relative success of any one depends on the climatic conditions, food availability, etc. during that particular year.

The eggs are fertilised by sperm carried to them in the sea water. They remain on or near the sea bed for a number of days and then gradually develop as larvae which rise to the surface where for a time, the length of which is not accurately known, they are transported by water currents. During this period the larva develops a transparent pair of valves and a ring of hair-like cilia which are used for propulsion. As it grows denser, the larva sinks slowly to the sea bed where it moves around testing surfaces upon which to settle. This is called the 'pediveliger' stage and its size will be 0.25-0.30 mm shell length (shell length is

measured as the greatest dimension parallel to the hinge). The time from fertilisation to settlement is probably about 3-4 weeks (Comely, 1972). The pediveliger has two methods of locomotion: it can swim in an erratic fashion by flapping the two shell valves together, or it can pull itself around by means of its foot - an arm-like structure which can be extended from between the shells. When a suitable surface is found (e.g. certain seaweeds or hydroids) the scallop anchors itself by means of sticky threads (called byssus threads) from a gland at the base of the foot. It then feeds until the shell is thick and strong enough for the scallop to withstand life amongst the sand and gravel on the sea bed. This usually occurs at about 10 mm shell length. Once on the sea bed the young scallop partly covers itself with silt or sand. This process is facilitated by the concave shape of the upper valve at this stage (the upper valve only begins to 'flatten out' at about one year old).

2.2 Recruitment to stock

Scallops in their first year are called 'spat'. One characteristic of the scallop appears to be extremely irregular spat settlement and/or survival, so that certain age groups (or year-classes) are often entirely absent from a population. Scallops normally enter the fishery between 3 and 4 years old, generally becoming commercially acceptable at about 90 mm shell length; in some areas there is a market and fishery for scallops considerably smaller than this.

It has proved difficult to locate very small scallops (i.e. those less than 2 years old) and surveys to find out if these young animals occupy the same areas as the adult stock have usually met with little success. It is therefore not known

Figure 3 Recently-settled scallop, about 2 mm long.

whether separate nursery areas exist from where young scallops migrate on to commercial beds. Certainly active migration is not thought to take place to any great extent in older scallops (Franklin and Rolfe, 1976). One reason for this lack of information is that the standard dredges used by fishermen are very inefficient at catching small scallops, and even specially constructed research sampling dredges with fine meshes or small rings have met with only limited success. The location of populations of recently settled scallops (Figure 3) has proved especially difficult. At certain times of the year, in most years, large numbers of tiny queen scallops (Chlamys opercularis) can be found byssally attached to hydroids or bryozoans, but only the occasional Pecten spat is found with them. Mason (1958) has reported scallop spat attached to algae (Desmerestia and Laminaria) in Scotland and Minchin (1978) has found young scallops attached to a variety of algae in an Irish sea lough. Scallops of 20-30 mm shell length (around six months old) are found from time to time in sediment samples, usually associated with shells or gravels. Better information may be forthcoming from recent developments in the use of visual surveying techniques such as diver, photographic and television observations.

A recent development which may prove useful in assessing spatfall levels indirectly is the use of artificial collecting substrates, normally plastic netting stuffed inside fairly rigid netting bags (Figures 4 and 5); this technique is based on a system developed in Japan for cultivating scallops. Water bearing the larvae passes through the suspended bags and some of the pediveligers attach byssally to the stuffing. The spat usually settle in the bags in the summer and grow to 10-20 mm by

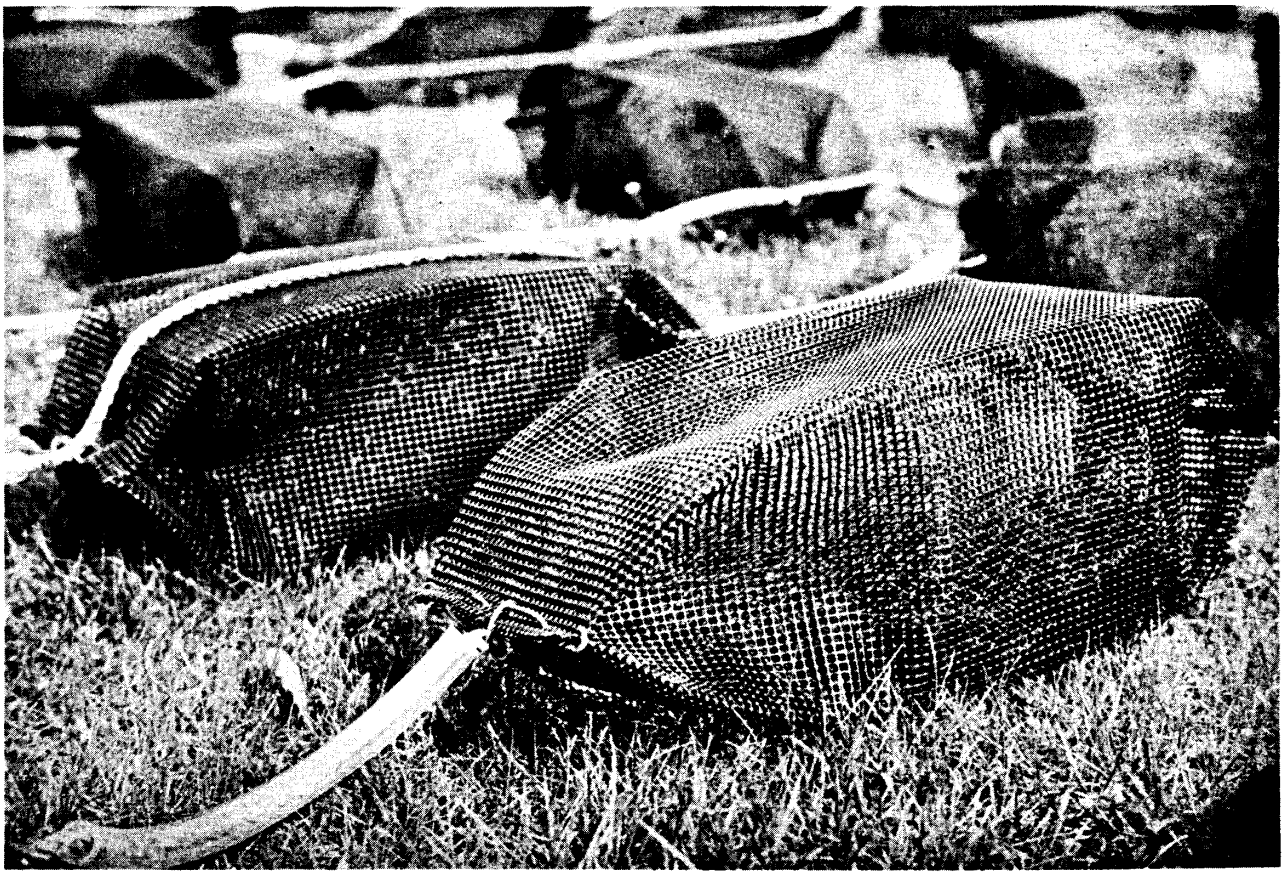

Figure 4 Close-up of artificial scallop spat collectors.

Figure 5 Artificial spat collectors showing rigged unit.

October of that year when the bags are retrieved and the scallops counted. (In England the scallop settlement is always outnumbered by queens which are between 10 and 100 times as numerous.) By comparing the relative numbers of scallops in the collectors from year to year, it is hoped to be able to assess the level of natural recruitment to the stocks at an early stage.

2.3 Mortality and predation

The characteristic irregular recruitment mentioned above indicates that, like most bivalves, scallop survival in the very early stages is dependent on a favourable combination of a number of factors which does not occur every year. Assuming conditions have allowed the adult scallops in a population to 'come into condition' and spawn, survival of larvae will depend on the presence of an adequate food supply, suitably high temperatures for growth, and the absence of excessive numbers of predatory zooplankton. In addition, scallops require the presence of suitable settling

surfaces such as algae, hydroids or bryozoans. Mortality up till the settling stage is likely, therefore, to be high and probably remains so until the young scallop finally descends to the sea bed when about 10 mm. These young individuals become less vulnerable to predation as they grow, but they are still a favoured prey of various fish such as plaice and turbot and are certainly susceptible to crab attack until the end of their first year (Minchin, 1978). The observed long lifespan indicates that once they reach this stage their natural mortality (i.e. deaths due to causes other than fishing) is fairly low. Results from tagging experiments in the Plymouth area showed that the annual natural death rate of adult scallops was of the order of 10%, though this greatly increased as the animals reached 14-15 years old, possibly indicating senescence at this stage (Franklin and Rolfe, 1976). The ability of the adult scallop to bury in the bottom and to camouflage the shell with silt and stones etc., together with its power to remain clamped tightly shut renders it difficult to locate and attack, though some predation still occurs from larger crabs and starfish. A further significant factor affecting the survival of the older scallop is of course fishing. Recent underwater television surveys carried out off Plymouth indicated that around 10% of the adult scallop population in this area was removed by fishing during 1976 (Franklin et al., 1980).

2.4 Growth

2.4.1 Shell

The scallop increases its shell size by the daily addition of bands called striae to all the shell margins. The shell material is mainly calcium carbonate secreted by the mantle. Normally growth is most rapid from April to June; it virtually ceases in the winter. If the animal is disturbed for a period, e.g. by fishing activity or bad weather, the daily growth may be reduced or non-existent. This leads to the appearance of 'disturbance bands' (irregular rings) on the shell. Under normal conditions a clear shell ring occurs where growth has ceased for the winter thus making ageing possible by counting the bands between rings (Figures 1 and 6). Accurate ageing of shellfish is important in studies of fisheries and the scallop is one of the few shellfish for which this is possible. Results have indicated that scallops have a relatively long lifespan. Individuals can live over twenty years, though on regularly worked commercial beds, few are likely to be found over ten years old. The growth rate of scallops varies greatly from area to area. By its first winter, in most areas, a scallop will reach 20-25 mm shell length and by its second winter 50-70 mm. In areas of poor growth, e.g. Whitesand Bay, Cornwall, a depression in growth rate becomes apparent in the second year and is very marked in the third and subsequent years so that over five years may be needed to reach 90 mm; in better conditions the same size can be attained in three years (Figure 7). The reason for the observed variations in growth rate in different areas is not clearly understood. Poor food supply due to limited water exchange seems a possibility, but it is likely that a number of factors are involved.

2.4.2 Soft tissue

The yield of animal tissue in scallops (commercially the meat yield is the weight of muscle and gonad) generally increases with shell size as shown in Figure 8. In the western English Channel the meat yield of a scallop of about 90 mm shell length has normally been acceptable commercially; scallops smaller than this are landed but fetch a very poor price. In the eastern Channel, where growth rates are very high, few scallops are landed under 110 mm.

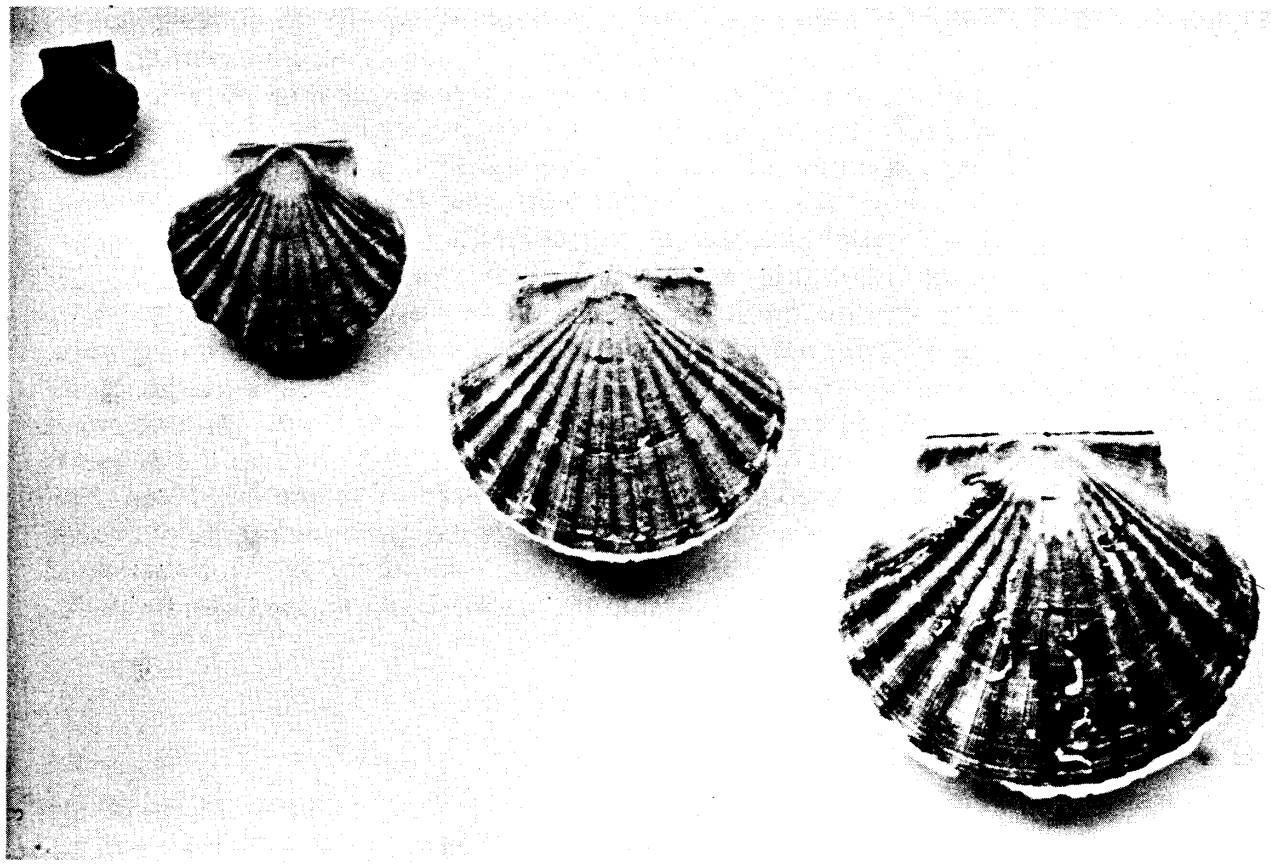

Figure 6 Scallops of varying ages showing shell bands.

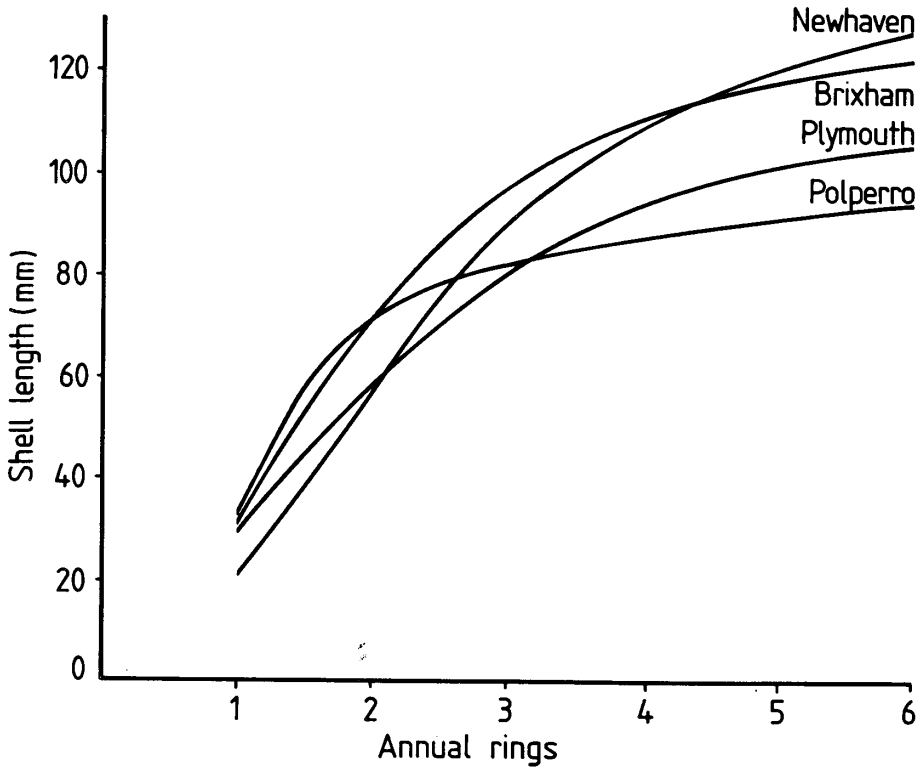

Figure 7 Scallop growth rates at four locations in the English Channel.

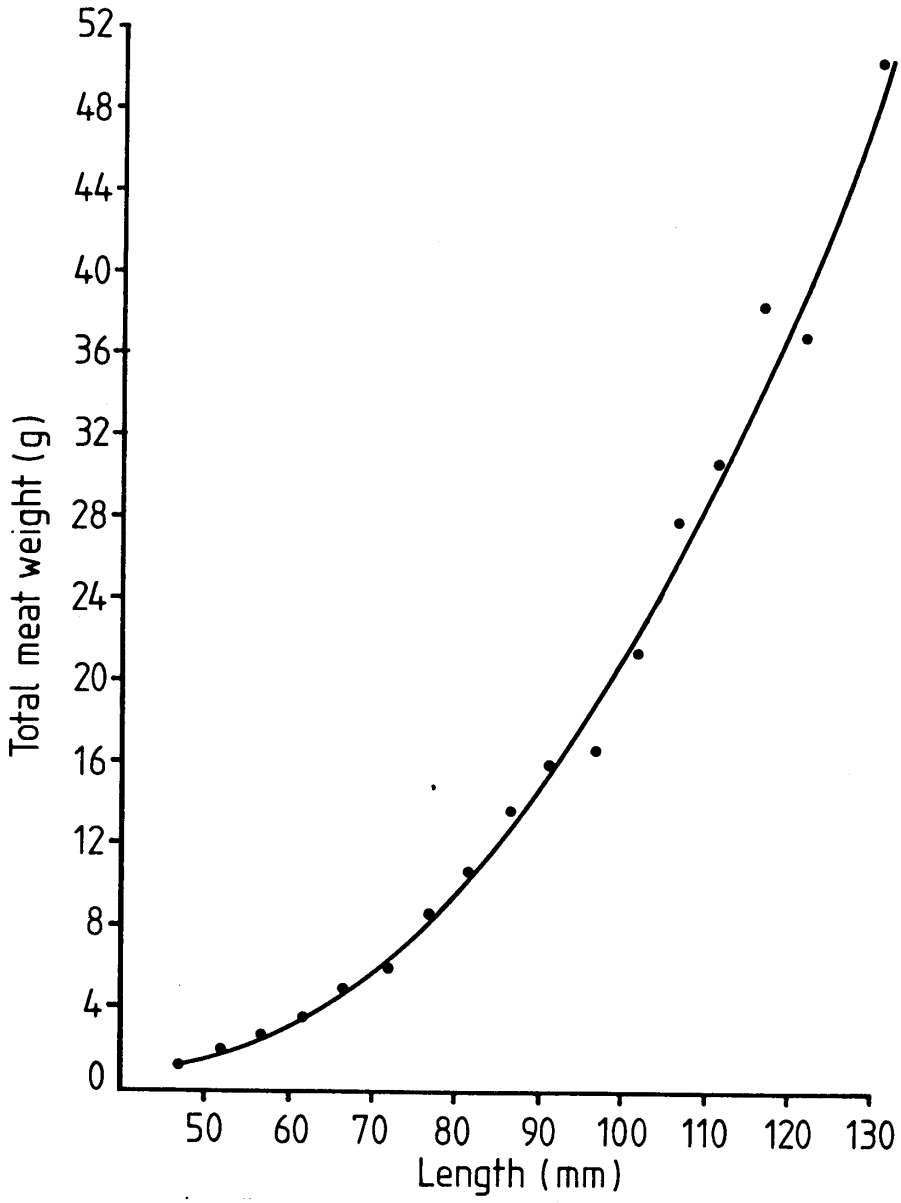

Figure 8 Relation between scallop meat yield and shell length (Plymouth sample).

The compounds of the soft tissue are affected by seasonal changes related to the scallop's breeding cycle. A study was made during 1977-78 of changes in the weight of both muscle and gonad from scallops on the Newhaven beds (Connor, 1978; Figure 9). As would be expected, the weight of the gonad was at its maximum in the spring prior to spawning. The weight gradually decreased from the start of spawning around May and reached a minimum in the autumn, when it rose steadily until the peak was again reached in the spring. The variation in the muscle weight was the inverse of this, with an increase during the summer months (possibly due to improved feeding conditions and higher temperatures) to a peak in the autumn; it then decreased from December onwards to a minimum in the spring. The result was that the total meat yield did not vary significantly throughout the sampling period. From a commercial point of view, however, the gonad is small and unattractive just after spawning so as to render the scallops unsuitable to some markets.

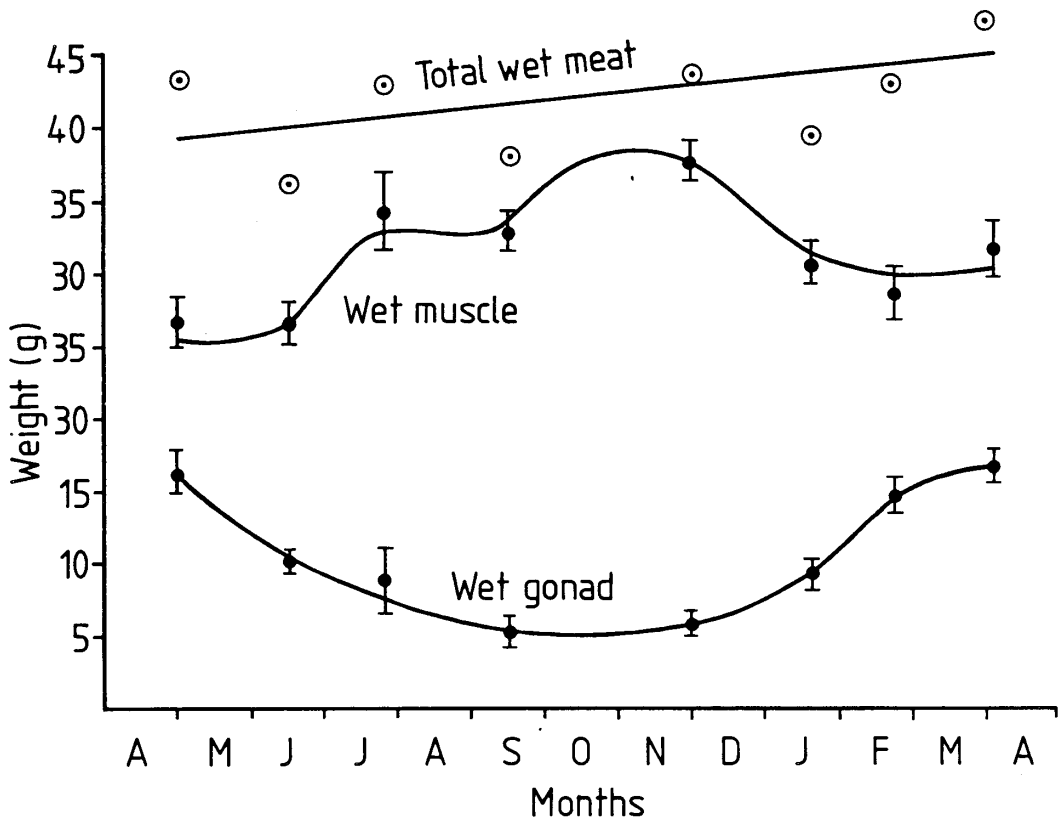

Figure 9 Seasonal variation in mean wet gonad, mean wet muscle and mean total wet meat weights (eastern English Channel).

3. THE FISHERY

Although scalloping has become a major fishing industry only in the last few years, records indicate that regular landings have been made for over a hundred years. At the turn of the century much of the catch, which was used for bait as well as for human consumption, was taken off the east and south coasts of England, but since the 1950s the greatest landings have been in south-west England, with Brixham a consistently important port of landing. The fishery remained of minor importance until 1975 (Figure 10) when exploitation increased extremely rapidly in both the western (Plymouth and Brixham) and eastern (Newhaven and Rye) Channel areas. These have remained the main fishing centres, but the vessels have tended to fish away from the home ports as new grounds have been located, so that, at the present time, scallops are exploited along much of the English side of the Channel (Figure 11). Further north, grounds have been located and fished in Cardigan Bay and off Anglesey and some interest is being shown in stocks off the north-east coast of England. (At the time of writing (spring 1980) fishing in Cardigan Bay had only just started, vessels from all round the British coast being attracted to the area by good catches of large, fast growing scallops.)

The most easterly Channel beds that have been exploited are those off Rye. Yields from these were high in 1976, but the vessels involved have engaged mainly in white-fish trawling since that time, though a number returned to scalloping early in 1979. The grounds exploited by Newhaven and Portsmouth vessels stretch in patches from Beachy Head to the Nab Tower, and up to twenty miles offshore. A number of beds in the Portland/Lyme Bay area support fisheries for several ports

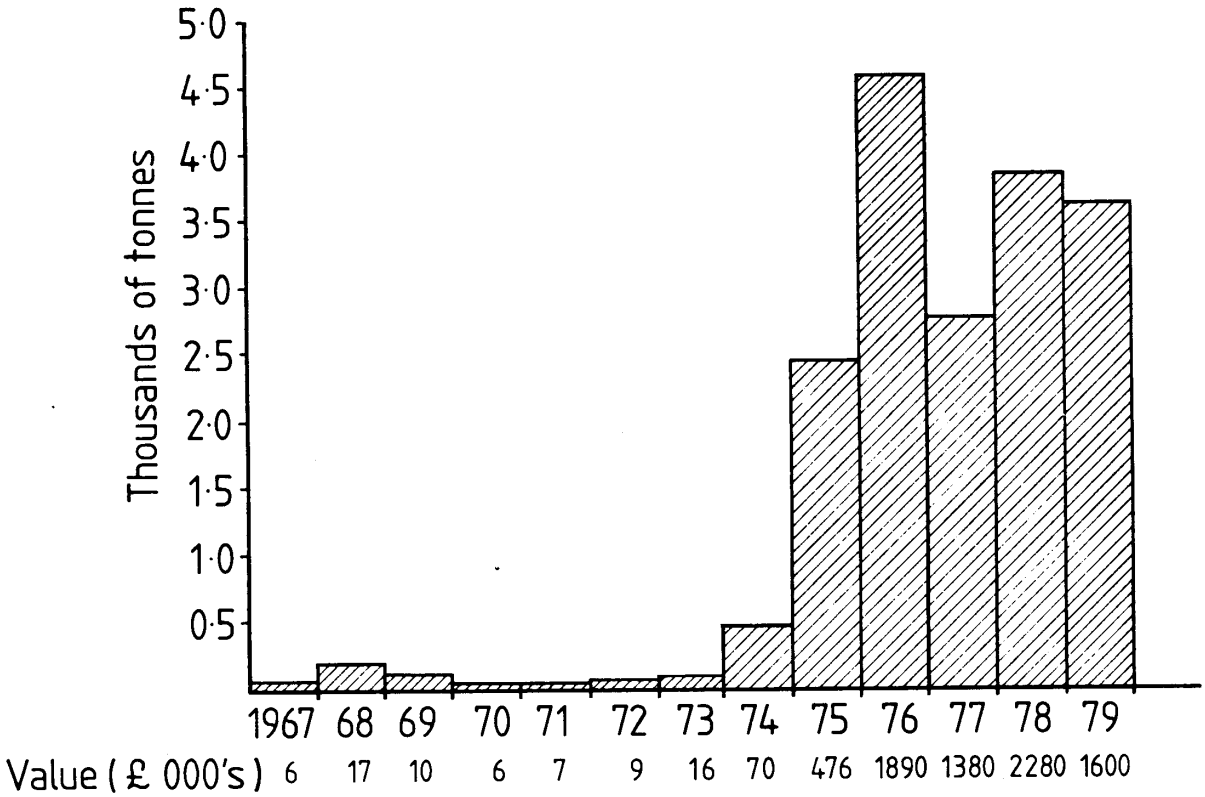

Figure 10 Annual landings and value of scallops in England and Wales, 1967-79.

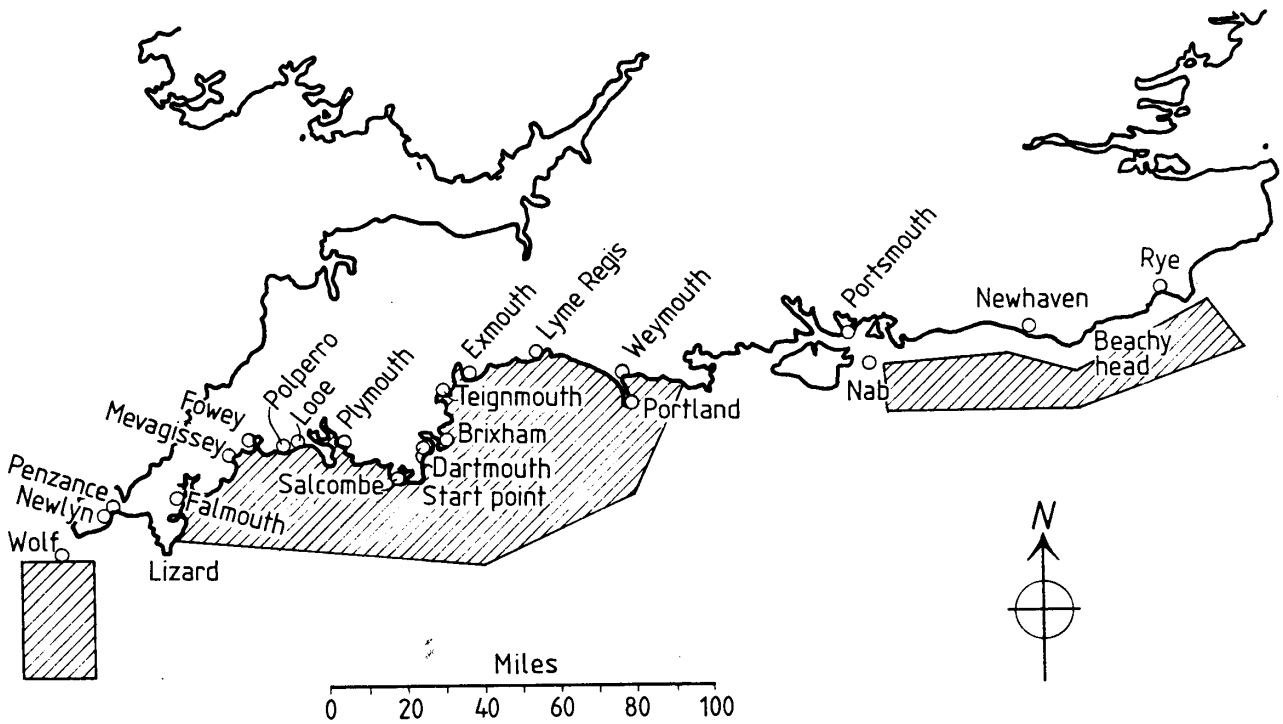

Figure 11 English Channel scallop ports and main fishing grounds (hatched areas).

in Dorset and Devon. Beds further offshore are exploited mainly by the larger vessels from Brixham. Some scallops also occur very close inshore around Brixham and these are fished by small local vessels. Many scallop beds exist between Start Point and the Lizard and these support vessels from a number of small ports as well as the large Plymouth fleet which normally includes numerous 'visiting' vessels at peak fishing times. Further west still are the more recently discovered offshore grounds around the Wolf Rock and Scilly Isles, exploited by the larger vessels from Brixham, Plymouth, Newlyn and Penzance.

Although some vessels fish for scallops all the year round the pattern of landings in the last few years has generally been affected by the seasonal availability of finfish species. For instance, in the western Channel maximum scallop landings have been made in the summer months, many boats switching to mackerel fishing in the winter, whereas in the eastern Channel the converse has been true, with boats scalloping in the winter and trawling for sole in the summer. The seasonal pattern of landings for the two main regions during the period 1974-78 is shown in Figure 12.

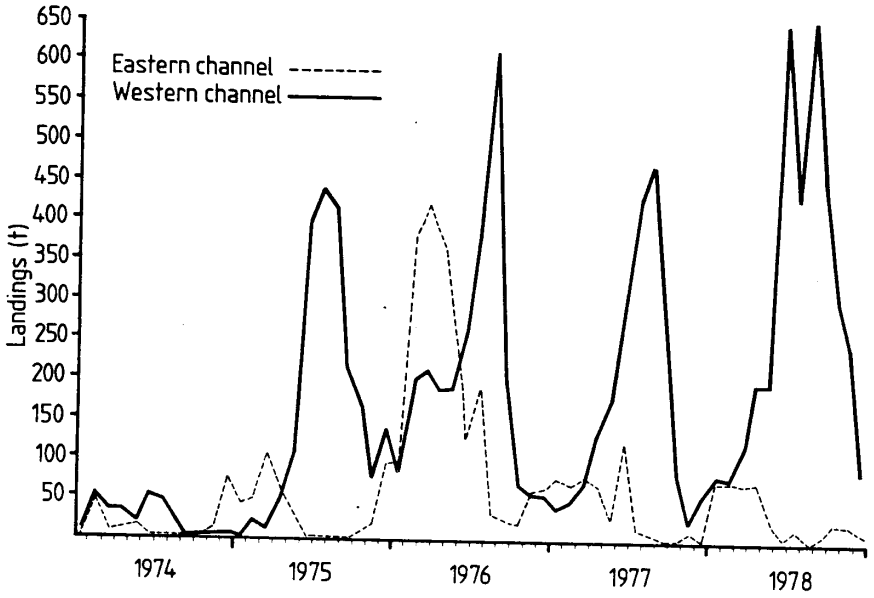

Figure 12 Monthly scallop landings in the eastern and western English Channel, 1974-78.

3.1 Fishing fleet

During 1978 a study of the size and distribution of the English and Welsh scallop fishing fleet was carried out. Approximately 130 vessels were found to have been engaged in scalloping for at least part of the year, all (except for a few boats working in the Irish Sea) exploiting beds in the English Channel. About 60% of the fleet had Plymouth or Brixham as their home ports, the remainder being distributed amongst the other ports indicated in Figure 11 (between one and eight vessels at each). The fleet was made up of vessels ranging in length from 25 ft (8 m) up to 100 ft (30 m); 65% of them were in the 40-60 ft (12-18 m) class, 25% were over 60 ft and the other 10% were less than 40 ft. The very small vessels usually fished from only their home ports, spending less than 24 hours at sea on

local beds; the same was probably true of about half the 40-60 ft class vessels. The remainder of the 40-60 ft boats made trips of up to 2-3 days duration and worked away from the home port if fishing seemed more profitable elsewhere, for example Newhaven vessels sometimes moved down the Channel to fish grounds off Plymouth. The large (over 60 ft) vessels were very wide-ranging, often exploiting scallop beds a considerable distance offshore and spending a number of days at sea; grounds in the Irish Sea have recently been fished by a few of the larger Plymouth-based vessels and, conversely, Manx, Northern Irish and Channel Island vessels have visited productive grounds off the south-west of England.

3.2 Fishing methods

Two types of dredge are currently in use in the fishery - the spring-toothed Newhaven dredge (Figure 13 and 14) and the heavier French dredge (Figures 15 and 16). These have over the past 10 years replaced the more traditional Manx and Baird dredges. The Newhaven dredge consists of a triangular steel frame bearing a spring-loaded plate to which the tooth-bar is bolted. When the dredge encounters rock or large stones, the springs allow the tooth-bar to swing back thus avoiding snagging and reducing the quantity of stones caught. The tooth bar is normally 0.8 m wide and bears about ten teeth up to 7 cm long. The bellies are constructed of approximately 80 mm diameter steel rings and the backs are of approximately 70 mm netting. Newhaven dredges are fished on a beam with a rubber bobbin wheel at each end. The number of dredges varies according to the size of the vessel; usually it is from three to six a side (Figure 17) but up to ten a side may be used.

Newhaven dredges are used almost exclusively by vessels in the eastern Channel, because of the stony nature of the grounds there. They are also used on rocky and stony areas in the western Channel; their introduction there a few years ago enabled good catches to be made in areas previously considered as too rough to be fished.

The French dredge (so named because if originated from Brittany) is considerably larger than the Newhaven dredge, being up to 2 m wide. A diving plate is incorporated which helps keep the dredge on the sea bed and allows it to dig more deeply into the bottom, thus increasing efficiency. Both the belly and the back are constructed of steel rings. Unlike the Newhaven dredge, which has to be inverted for emptying, the back end of the French dredge can be opened by means of interlocking steel bars. French dredges are used where the ground is relatively smooth. They are usually fished by larger vessel in the western Channel on offshore grounds and from two to four on beams on each side of the vessel are fished together.

In some areas, where the sea bed is sandy in nature, scallops can be fished by using beam trawls with tickler chains. Most trawled scallops are, however, taken as a by-catch in white-fish trawling.

On some inshore grounds the scallop populations are exploited by skin divers, but most beds in England and Wales are at depths too great for this to be practical. Overall, the numbers of scallops landed by divers are small compared with commercially dredged catches, but diving may have some local significance on beds off the south coasts of Dorset and Devon.

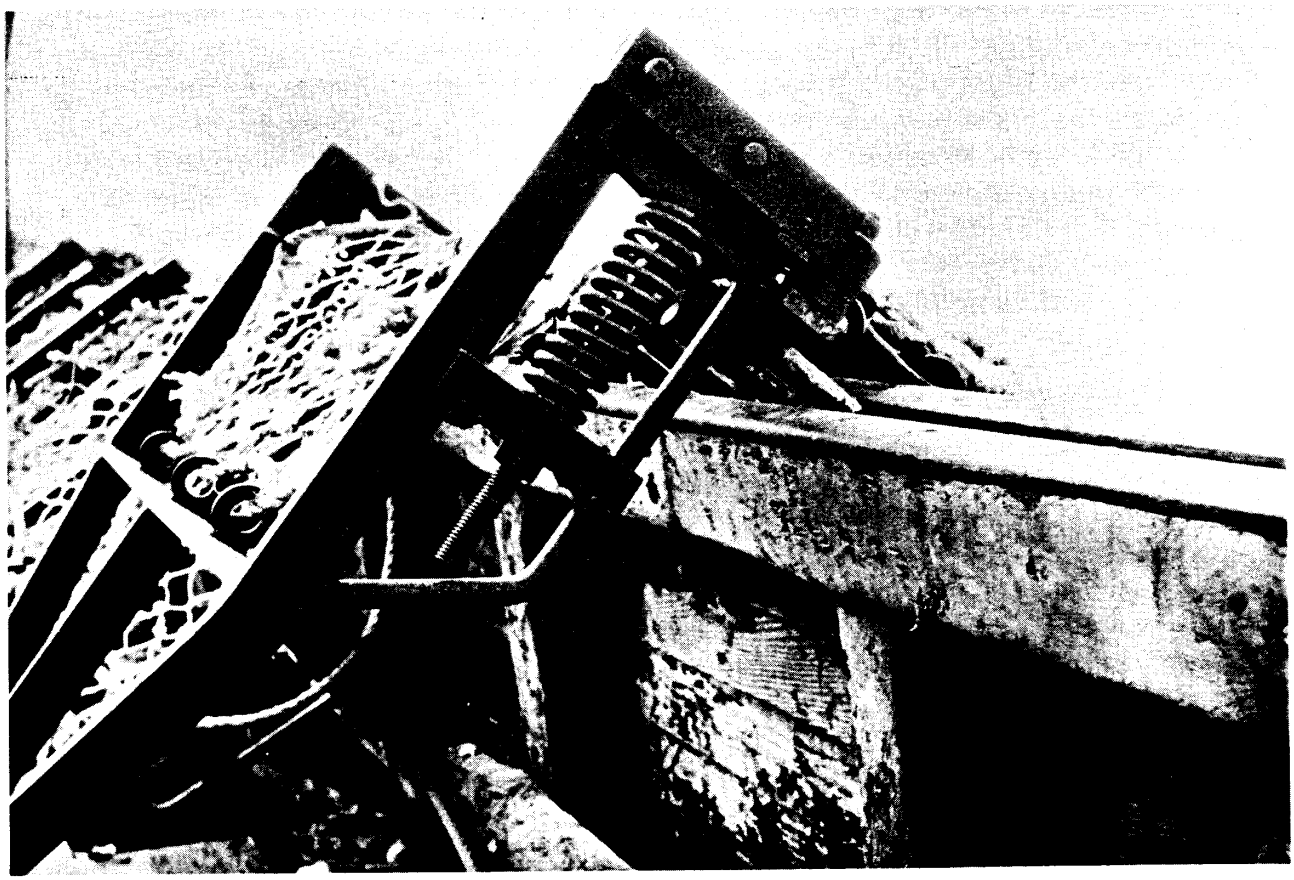

Figure 13 Close up on Newhaven dredge.

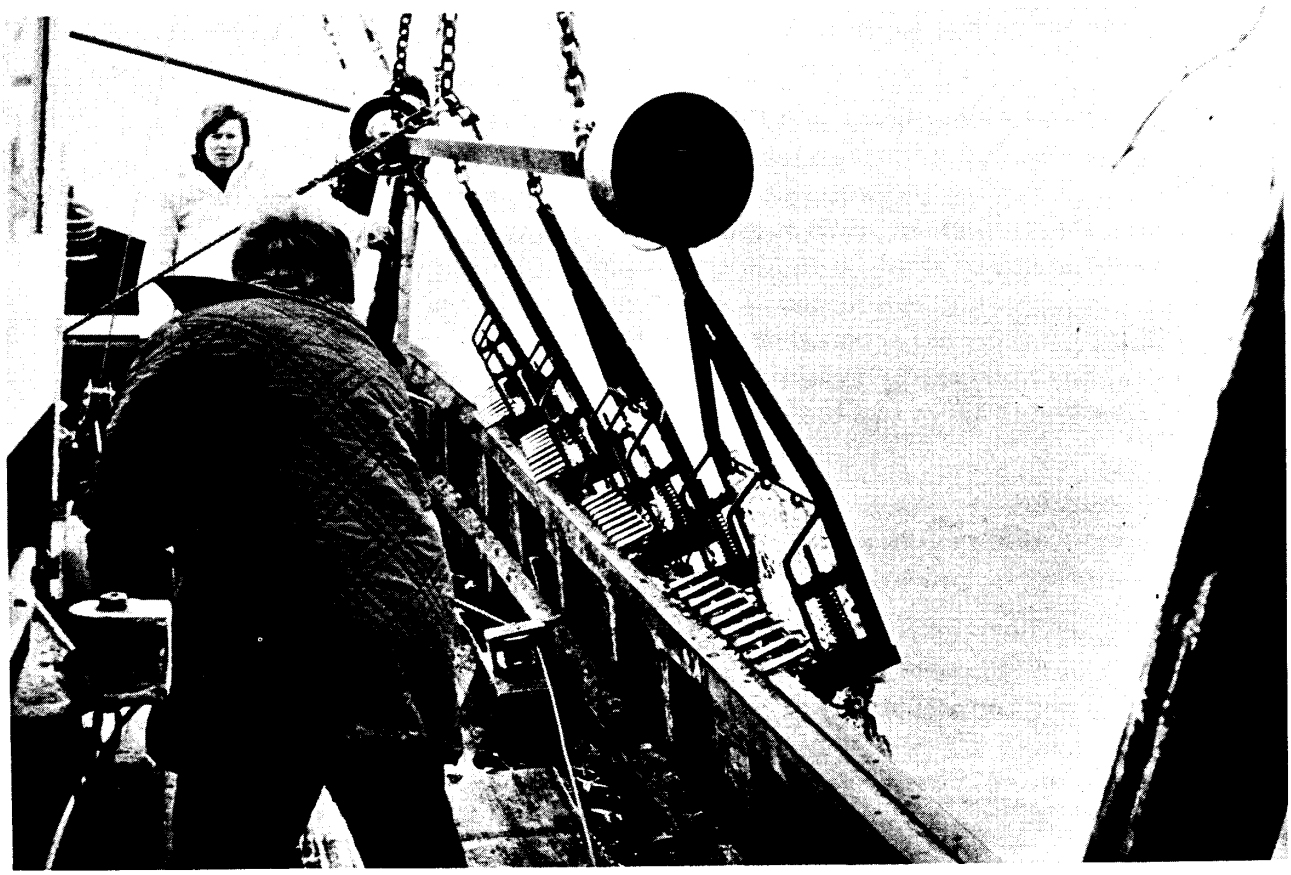

Figure 14 Newhaven dredges rigged on beam.

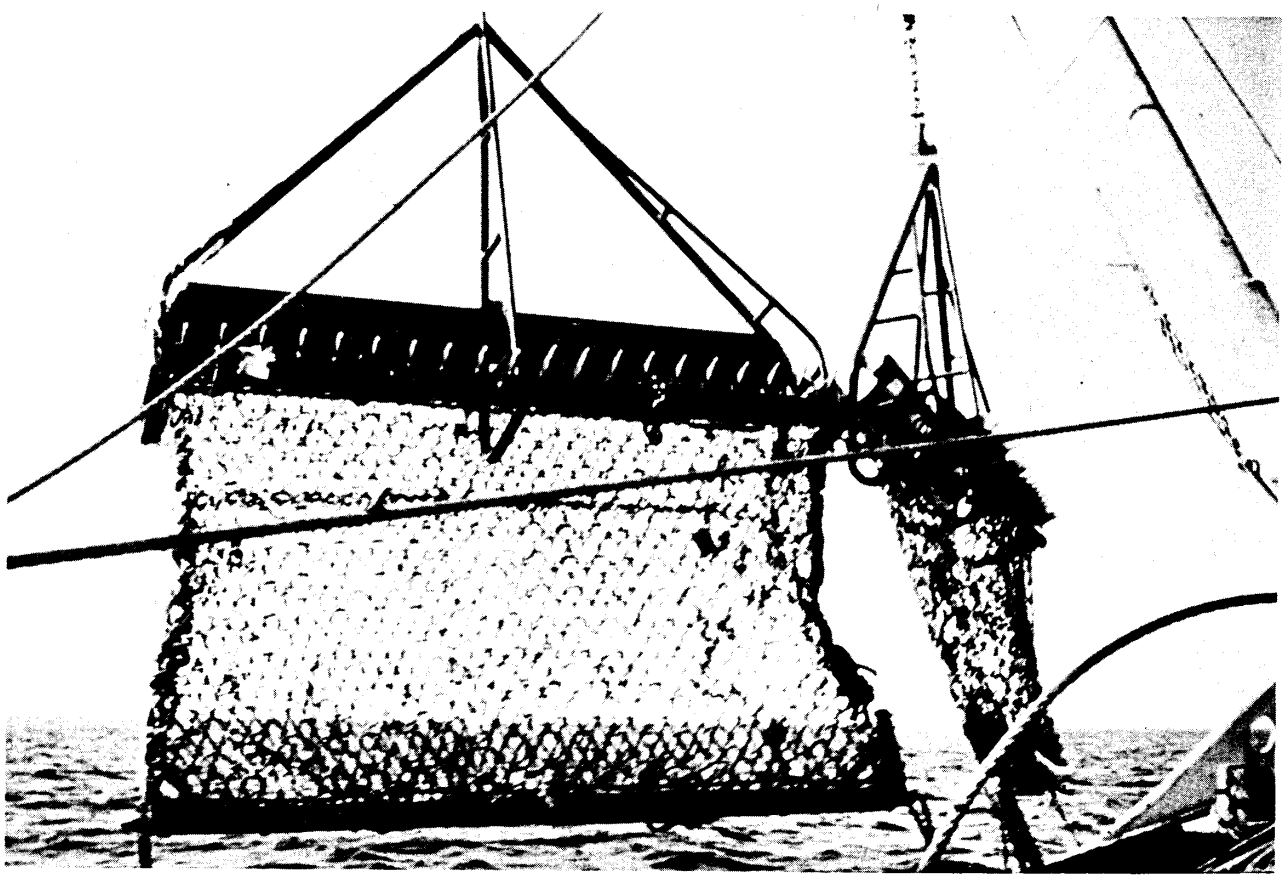

Figure 15 French dredges, underside and side view.

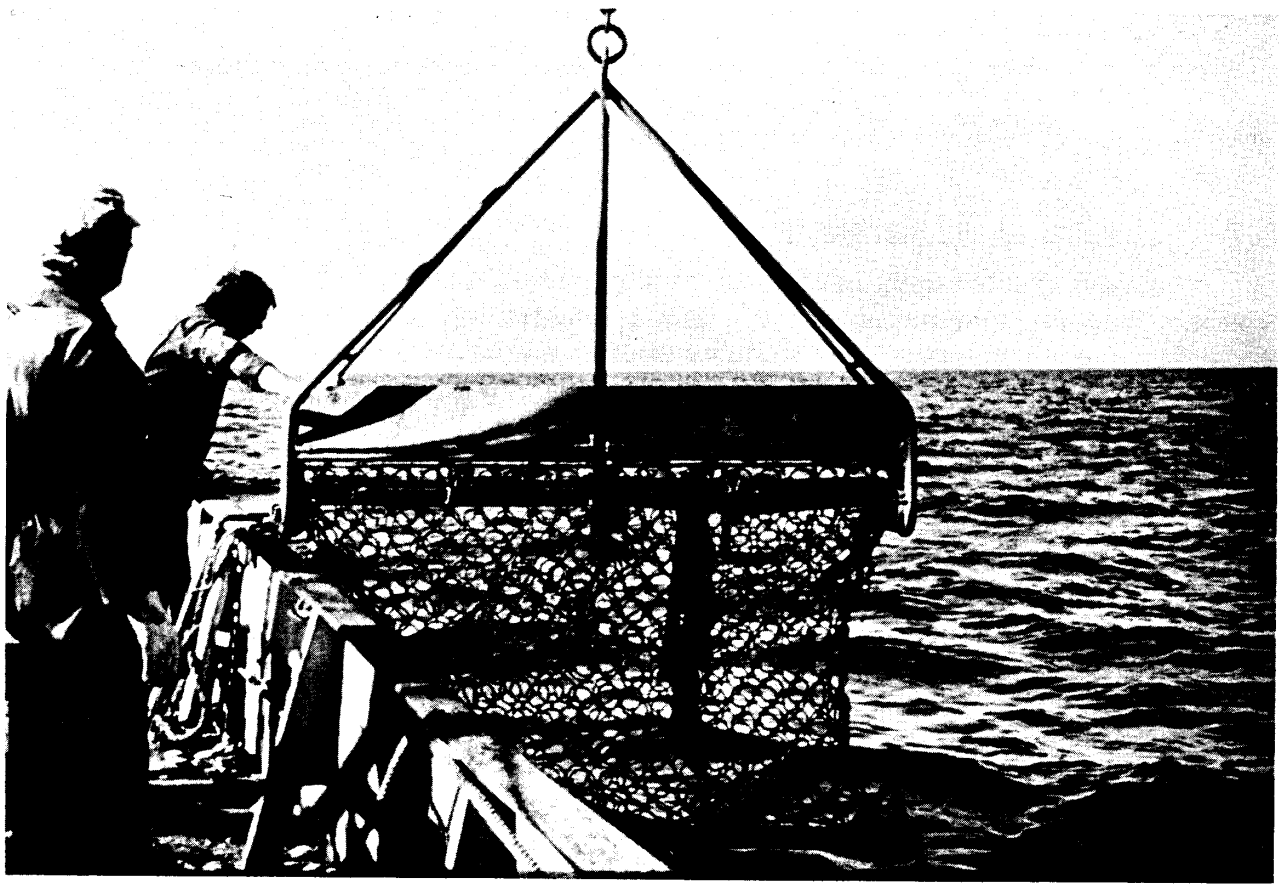

Figure 16 French dredge, top view.

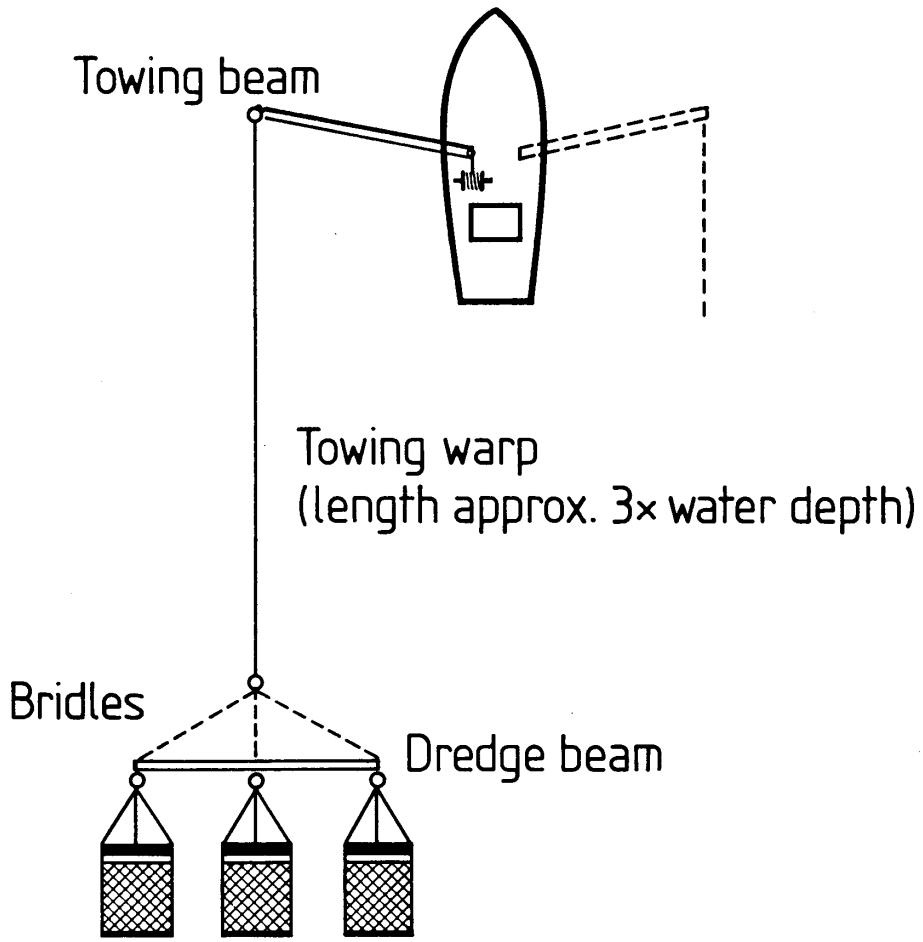

Figure 17 Diagrammatic representation of beam dredge rig (not to scale).

3.3 Processing and marketing

Considerable numbers of scallops are sold whole in the shell, fresh or deep frozen. Many are also processed. This is a relatively simple technique in which the scallops are shucked, either fresh or after a preliminary freezing, the muscle and gonad being cut free, and the meats then blast-frozen. Advice on handling, processing and storage of scallops is given in Torry Advisory Note, Number 46 (Hardy and Smith, 1970).

The rapid development of the English scallop fishery has largely resulted from improved markets for the species. The home market still remains relatively small, and most of the scallops landed are now exported to Europe (especially to France) and to America. Markets have been developed for whole scallops (to France and Spain, via the much improved cross-Channel ferry), frozen meats with or without roe, canned meats and breaded meats. The present range of products utilises scallops of many sizes, including those from slow-growing populations previously unsuitable for the 'on-the shell' trade. The landing in some areas of very young scallops gave rise to a relatively low-quality product, but the outlets for these are now becoming more restricted due to competition from suppliers

from outside Europe. Competition at the lower end of the market has become especially fierce recently, with the export from Japan of cheap, cultivated scallops and prices have been low. If these instabilities in sections of the export market continue they could lead to a considerable reduction in U.K. production.

3.4 Regulations and conservation

There is at present no national legislation specifically related to scallops and the only local byelaw is that covering the Devon Sea Fisheries District which sets a minimum size of 4 inches (102 mm). Some Sea Fisheries Committees also impose restrictions on the size of vessel permitted to fish in their waters (out to 3 miles) and this can limit fishing effort on scallops to some extent.

Research is being carried out into the likely effectiveness of various conservation measures which could be introduced should the increased fishing effort cause serious stock depletion. One problem is that any legislation implemented at the present time will have to apply to the whole of the U.K. and it will be difficult to have either one minimum size which would effectively protect young scallops in populations with widely varying growth rates (Figure 7), or one close season which would satisfactorily restrict fishing in all areas (Figure 12). Consideration is now being given to the introduction of a 95 mm national minimum size.

3.5 Prospects

Future prospects for the English Channel scallop fishery are uncertain. The high catch rates over the last few years have been partly the result of fishing previously unexploited beds where stock levels were initially high. It is unlikely that many of these will remain undiscovered in inshore Channel waters and scallop catch-rates will become increasingly dependent on natural recruitment to the stocks, which unfortunately tends to be very variable. It is also likely that the proportion of younger, smaller scallops in the catches will continue to increase. If prices, especially for smaller scallops, remain low, exploitation of the beds of slower-growing scallops in the western Channel could become economically unattractive. Thus in the immediate future, a downward trend in landings is expected.

4. CULTIVATION AND RESTOCKING

In Japan another species of scallop, the Pacific scallop Patinopecten yessoensis, has been farmed successfully for a number of years. Workers in Europe are now investigating the production of scallop (Pecten maximus) spat for farming or for re-seeding depleted areas. There are two main lines of research:

(1) the production of spat in hatcheries using similar techniques to those used for oysters;

(2) the use of collecting bags, as described above, to obtain 'seed' from coastal areas.

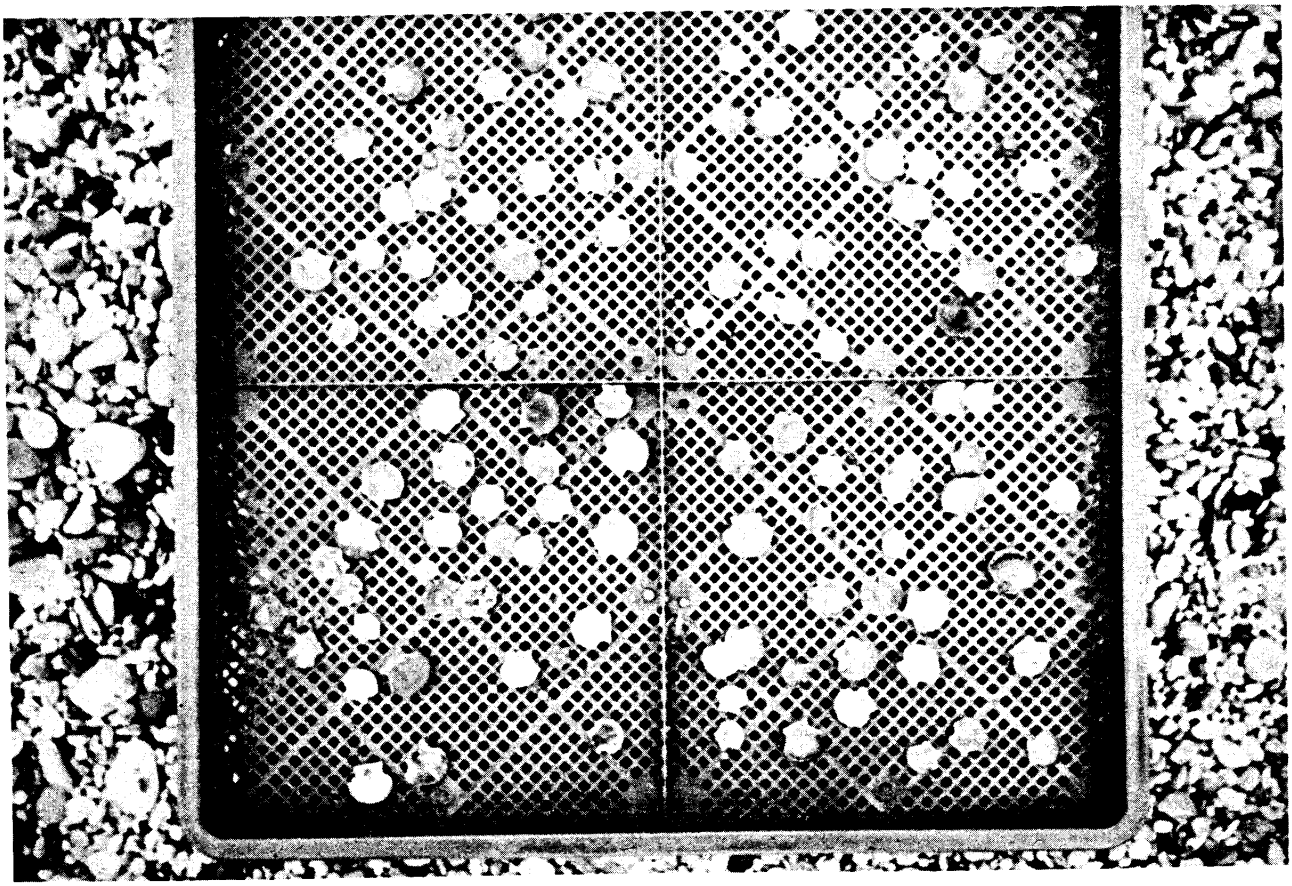

Figure 18 Scallops from collectors on tray.

Scallops obtained by both methods seem likely to require some form of intermediate culture e.g. growing-on in trays (Figure 18), whether they are to be grown to commercial size in captivity or released on to natural beds. Research on cultivation is still in its early stages and a number of problems have been encountered during the intermediate culture stage which is labour intensive. It is not yet known whether any form of cultivation of scallops in the relatively cold waters around U.K. coasts will be an economic proposition.

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