MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

OYSTER PESTS AND THEIR CONTROL

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BY D. A. HANCOCK
FISHERIES LABORATORY
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CONTENTS

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INTRODUCTION

One female oyster may produce a million larvae, but only a minute fraction of these usually survives to settlement. Many enemies of the larval stage have been identified - including free-swimming jellyfish, Noctiluca, and arrowworms, and bottom-living filter-feeding animals - but so many larvae die as a result of unfavourable environmental conditions that there is no guarantee that the control of these enemies will have any significant beneficial effect.

After settlement, the loss due to unfavourable environmental conditions becomes much reduced, so that control measures against enemies of the settled oyster may be of very great value. One aim of the Ministry's oyster research programme is to identify the enemies of the oyster, to evaluate the damage they cause, and to decide if control measures are possible or economically worth while. By studying the biology and habits of these enemies we hope to find (a) weak links in their life histories which will give a starting point for control measures, and (b) ways of modifying or adapting present methods of cultivation so as to reduce the damage by enemies to a minimum.

Enemies of the oyster fall into four main groups:

A. Direct enemies or predators - which kill and eat oysters, and include:

The American whelk tingle (Urosalpinx)
The European rough tingle (Ocenebra)
The starfish or fivefingers (Asterias and Marthasterias)
The shore crab (Carcinus)
The purple-tipped sea urchin or "burr" (Psammechinus)
The oystercatcher or sea pie (Haematopus)

B. Competitors - which take the food and space required by oysters, and include:

The American slipper limpet (Crepidula)
The New Zealand barnacle (Elminius)
The encrusting tube worm or "German writing" (Pomatoceros)
Sea squirts - "pock" (Dendrodoa)
- "blubber" (Ciona and Ascidiella)
Fan worms (Sabella)

C. Forms which attack the shell, including:

Shell disease fungus
Boring worm (Polydora)
Boring sponge (Cliona)

D. Parasites and diseases, including:

A parasitic snail (Odostomia)
Red parasite of the gut (Mytilicola)
Pea crabs (Pinnotheres)
Miscellaneous diseases.

GROUP A. DIRECT ENEMIES OR PREDATORS

The American whelk tingle (Urosalpinx) (Plate 1) is undoubtedly the most harmful enemy in this group. It is a snail which was first discovered in 1920, after it had been accidentally introduced into this country among American "Blue-point" oysters imported for relaying. In its native America, the tingle occurs in enormous numbers and does tremendous damage. The late Professor Nelson related how a large area of oyster bed had been completely cleaned using suction dredges, and then stocked with 60 tons of clam shell covered by oyster spat. A year later, instead of a harvest of brood oysters, the planters recovered only drilled shells. All the spat had been killed by American tingles, which had moved in from surrounding areas. The appearance of Urosalpinx on British oyster beds therefore gave cause for considerable alarm.

Plate 1 The American whelk tingle (Urosalpinx) with spawn capsules attached to an adult oyster (x 1). (P. J. Warren)

The American tingle is so far still confined to Essex and Kent (Plate 2). From the original centres of introduction, believed to be Brightlingsea and West Mersea, Essex, it has spread throughout the Rivers Colne and Blackwater, and along the coast to Frinton-on-Sea. It was transplanted with oysters to the Rivers Roach and Crouch, where it now occurs throughout their lengths, and to Whitstable. An example of how it has multiplied is shown by the observations of Dr H. A. Cole, who found that in the 1940s tingles occurred only sparingly in the River Crouch - now they exceed 10 000 to the acre in some places.

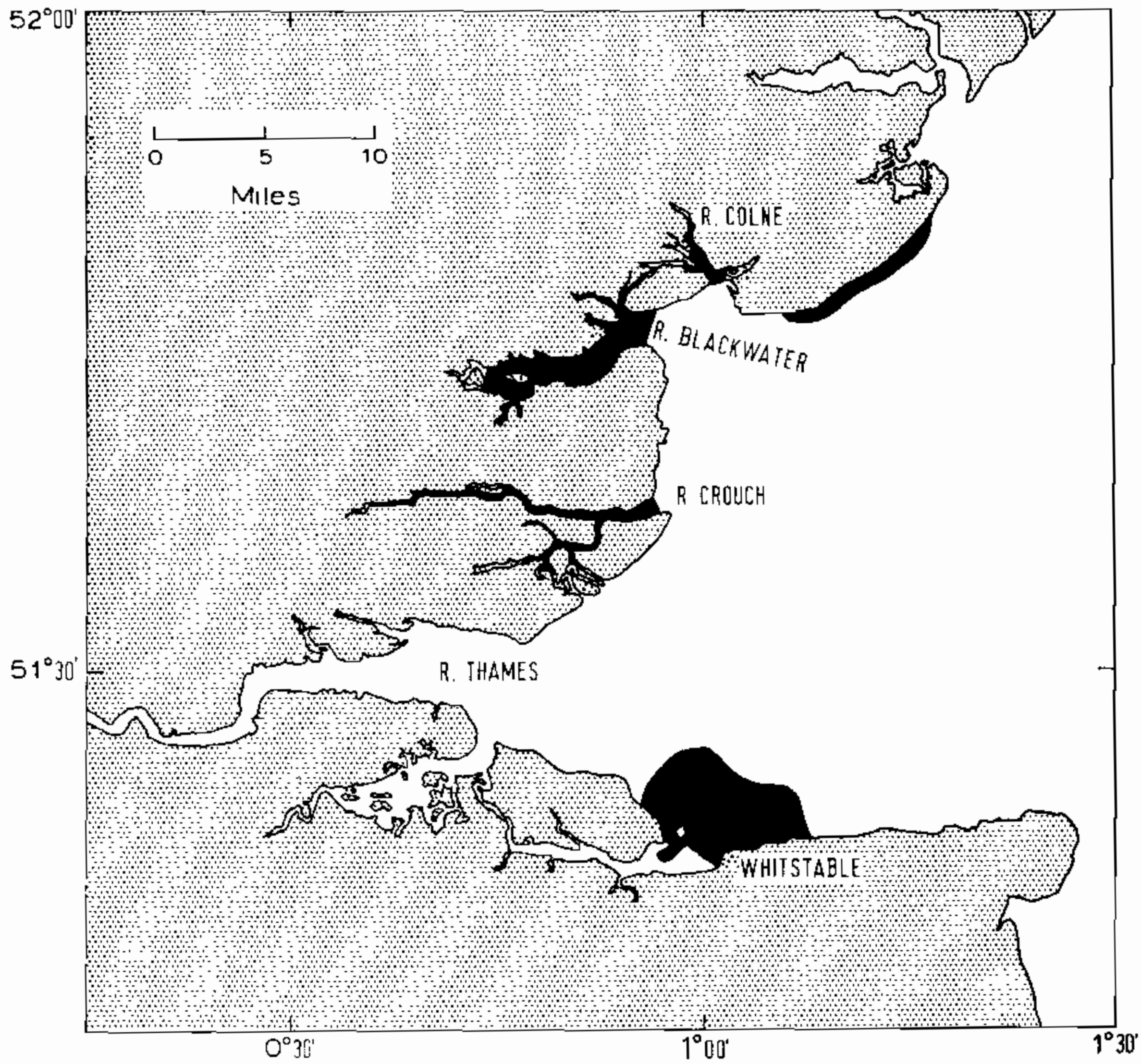

Plate 2 The distribution of the American tingle, which is confined to the Essex and north Kent shores.

The American tingle feeds on oysters by drilling a hole through the shell and sucking out the flesh, and it prefers oyster spat of thumbnail size to any other food. On one ground in the River Crouch, during only a few months, over 500 000 oyster spat were drilled. This represented over 50 per cent of spat of thumbnail size only, and did not include the many smaller ones in which drill holes are difficult to see. In the same year on another oyster laying on which there had been a poor spatfall, 25 000 three-year-old brood and 1 200 market-sized oysters had been drilled. Similar damage to oyster spat has been observed in recent years in the River Blackwater, and as long ago as 1937 the late Professor Orton suggested that 50 per cent of the spatfall in Essex rivers was lost to the American tingle.

American tingles and their damage are often overlooked. Tingles themselves fall through the rigging of the dredges, and newly-born tingles of little more than pinhead size are usually not detected. Drill holes may be difficult to see and the drilled valves of spat quickly disintegrate. In addition, newly-born tingles have been observed to move straight to tiny oyster spat to drill minute holes through their shells (Plate 3).

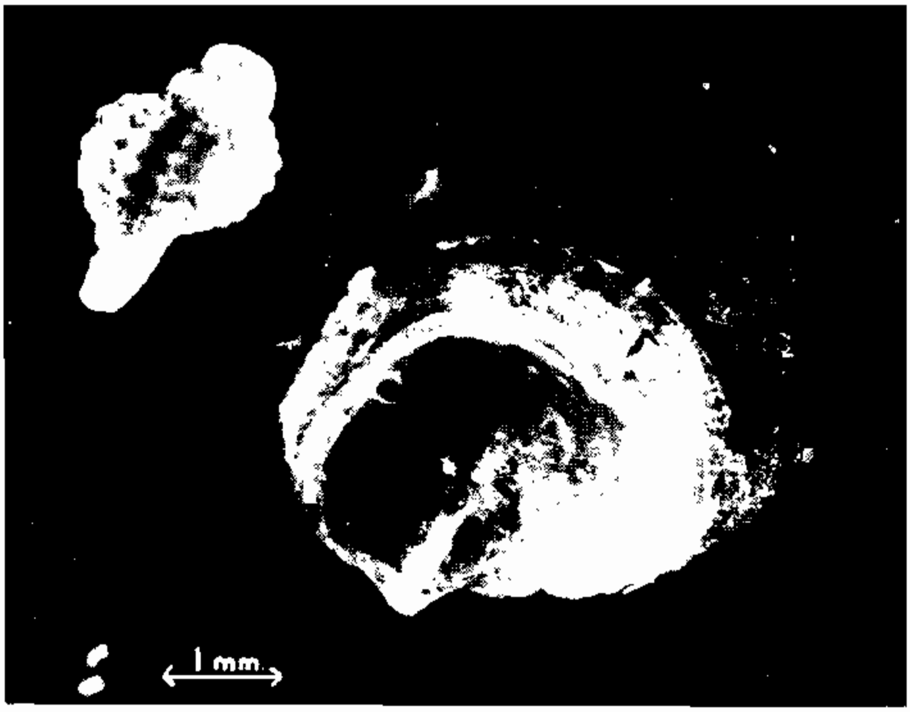

Plate 3 A tiny oyster spat drilled by a baby tingle which had only recently hatched from its spawn capsule (x 15).

One reason why the American tingle is confined to Essex and Kent is that it has no free-swimming stage in its life history. Baby tingles hatch from spawn capsules at the crawling stage, so that any migrations are limited to the tingle's own crawling movements. These are often restricted by barriers of mud or unfavourable conditions, which cannot be surmounted unless the tingle is transplanted with relaid oysters. Each female tingle lays at least 25 spawn capsules (Plate 1), each capsule producing about ten young. A single pair of transplanted tingles can therefore produce 250 young in the first year in a new area, which in subsequent years can increase with compound interest to form a population explosion if conditions suit them.

<u>What can be done about the American tingle?</u>

1. It is imperative that the oyster planter should recognize it, and be aware of the damage it does. To this end, the Ministry has published a leaflet (Laboratory Leaflet No. 2) describing the tingle, its damage, and our present knowledge of methods of control.

2. Oyster planters and others should ensure that American tingles are not transplanted accidentally to areas at present free from the pest. To date there is no sure method of disinfecting oysters for relaying, and it would be impossible to be sure that no tiny tingles were overlooked in crevices in the oysters' shells when inspecting the large number of oysters usually involved in relaying. In oyster-producing areas where the American tingle does not occur, national legislation (The Molluscan Shellfish (Control of Deposit) Order 1965) prohibits the relaying of oysters from Essex and Kent (see later) or from foreign beds infected by American tingles.

3. On oyster beds where American tingles already occur, measures for reducing their damage should be adopted. These include dredging, which, since the tingle hibernates during the winter months, is more effective during the summer, when large quantities of spawn capsules are also taken. In only four hours' dredging with the Ministry's research vessel WYSTRYS in the River Roach 250 tingles and 79 000 spawn capsules were taken. It is therefore well worth including dredging in the summer cultivation programme, possibly combining it with the "singling" of year-old brood. More tingles will be retained if the mesh of the rigging is reduced, and if catches are not "docked" or washed too vigorously. All spawn capsules caught should be scraped off, and, with the tingles, thrown on to the saltings or killed in hot water. A tingle can live out of water for at least eight days, so it is not enough to leave tingles on deck for a day or two and expect them to die.

In summer tingles move on to the shore, where they can be handpicked, but because they also lay their spawn in shaded positions, trapping is even more effective. Curved roofing tiles (Plate 4) are cheap, durable, easy to handle and catch tingles efficiently. They should be placed in a row, curved outer side uppermost, at low water of spring tides in spring and examined fortnightly at low tide.

Plate 4 One roofing tile which had trapped 10 American tingles and 1 500 spawn capsules (x 1/3). (P. J. Warren)

In the River Roach two men examined 225 tiles on eight occasions, taking half an hour each time, and collected 4 000 tingles and 30 000 egg capsules. This took eight man-hours and was therefore considerably more economical than dredging from a boat. However, the equivalent quantity of spawn caught on tiles is less than by dredging and a combination of dredging and trapping will be the most effective. One oysterman in the River Roach collected singlehanded 15 000 tingles and countless spawn capsules from only 100 tiles in two years. At a conservative estimate each tingle kills 1s. 0d. worth of young oysters each year, so that in only about eight hours' work this man had saved £750 worth of oysters, apart from the damage which would be done by the same tingles and their young for many years to come. It was also shown that the number of tingles moving on to the shore can be reduced by the regular use of tiles. The annual catches from one plot were:

Year	Tingles	Capsules
1954	3 750	16 000
1955	2 400	not counted
1956	1 100	5 000

If the shore is too muddy for tingles to move on to it, it is well worth making it firm with shram or shells. Alternatively, traps can be made from two tiers of tiles wired together or from larger roofing tiles. These can be roped together and used below low-water mark, and examined from a boat.

It is possible to kill spawn capsules fairly easily by dipping them in solutions of various chemicals, including a saturated solution of common salt, but so far there is no reliable method for killing adult tingles attached to oysters without harming the oysters. The difficulty lies in the close relationship between oysters and tingles. A team of American workers has been studying methods of chemical control with some encouraging results. These will be examined and careful experiments made before they are recommended for general use in this country.

The European rough tingle (*Ocenebra*) (Plate 5) is our native drill, which before 1939 occurred in all the major oyster-producing areas in this country, but was wiped out in east coast estuaries by a series of severe winters. It still occurs in the River Alde, and all along the south and west coasts of England and Wales. It appears to be less voracious than the American tingle, and usually occurs in smaller numbers, but in certain areas in the south-west it is known to do serious damage to oyster spat and can also drill market-sized oysters. Hand collection of the tingles and their spawn capsules, which are very like those of the American tingle, from rocks at and near low-water mark is practised there. The European tingle is so closely related to the American tingle that virtually the same control measures can and should be applied.

Plate 5 The European rough tingle (Ocenebra) attached to an oyster (x 1). (P. J. Warren)

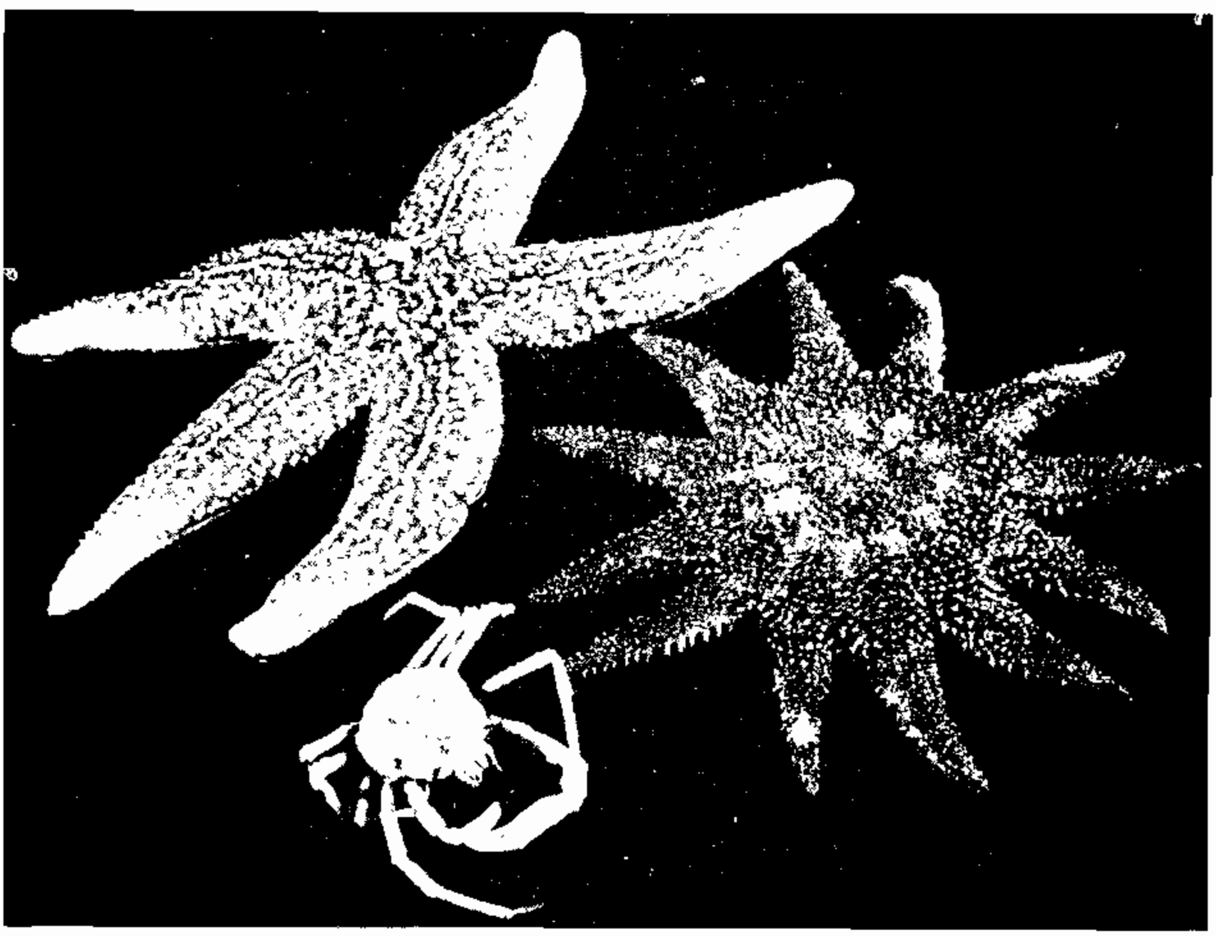

Plate 6 The common starfish or "fivefinger" (Asterias), the red sunstar (Solaster) and the stone crab (Hyas) (x 2/3). (P. J. Warren)

The starfish or fivefinger (Asterias) (Plate 6). In the United States and Canada a related species does tremendous damage to oyster beds, and scientists and oyster farmers there wage all-out war against them. The British species of starfish also can and will eat oysters. It grips the two shells with the sucker feet along its arms, pulls the shells slightly apart and sucks the flesh into its stomach. Opening the shell requires great force, and sometimes the edges of the valves are characteristically fractured. The appearance of such broken shells can sometimes be used to diagnose starfish attack (Plate 7).

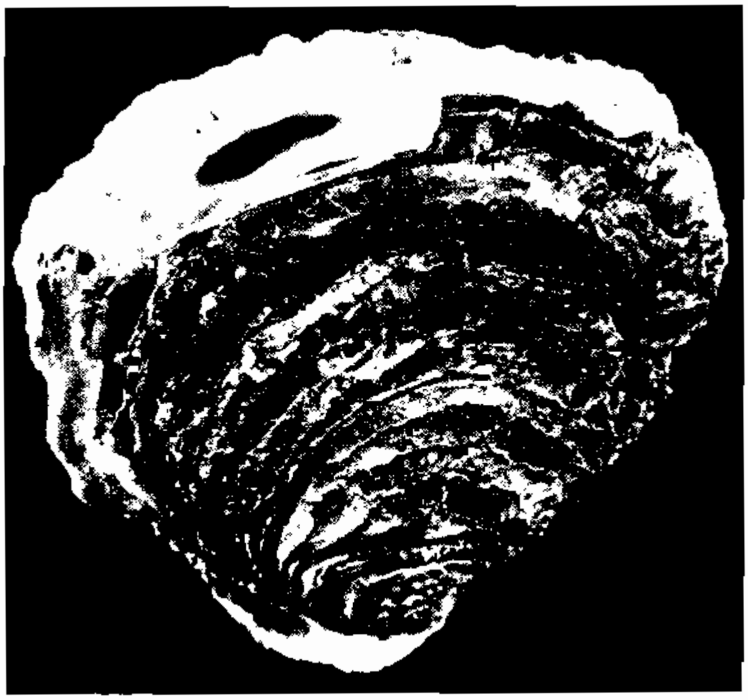

Plate 7 Adult oyster typically broken by the "fivefinger" (x 1). (P. J. Warren)

However, after repeated observations in the laboratory and on oyster beds, it was found that oysters are not the favourite food of starfish, at least on Essex oyster beds. They prefer mussels to any other food, and cause considerable damage to commercial mussel beds, but mussels usually occur only in small numbers on oyster grounds. On east coast oyster grounds where slipper limpets and oysters occur together, starfish seem much more likely to eat the slipper limpets. Since these are "weeds" of oyster beds the starfish, provided they do not eat any oysters, will then be doing some positive good. Young starfish were found to prefer barnacles to oyster spat, so they too can serve a useful purpose.

It was therefore concluded that it is unnecessary to engage on separate, and probably expensive, methods for starfish control outside of normal cultivation, and it was previously recommended that:

1. if starfish are dredged on derelict ground which is being cleaned, they should be thrown back to allow them to continue feeding on slipper limpets;

2. starfish dredged amongst oysters on clean ground should be either destroyed, or deposited on limpet-infested ground.

However, with the present shortage of oysters and oyster spat, their protection assumes more importance than the possibility of encouraging long-term changes in the environment in favour of the oyster, and though it is still not considered worth while embarking on a separate programme of control of starfish, it would be wise to destroy all those taken during normal cultivation. It is not enough to chop starfish up and throw them back, because portions of the central disc can regenerate new individuals. They should be dried, killed in fresh water or concentrated salt solution, or thrown on the saltings. Better still, starfish make excellent garden fertilizer.

If a plague of starfish is encountered on a cleaned, well-stocked ground, and normal methods of cultivation fail to reduce their numbers, it is advisable to consult this laboratory. There are several methods of control which may be appropriate, including special dredges, or even chemical methods under certain conditions.

The red sunstar (Solaster) and the stone crab (Hyas) (Plate 6) feed on the fivefinger, and when taken in dredges they should always be returned to the oyster beds.

Up to now, most research has been concentrated on the common starfish, Asterias. The larger, spiny starfish, Marthasterias, which is confined to the west and south-west coasts of Britain, has been reported to cause damage to oyster beds from time to time and must for the present be regarded as in the same category as Asterias.

Plate 8 The shore crab (Carcinus) with several New Zealand barnacles on its shell (x 2). (P. J. Warren)

The shore crab (Carcinus) (Plate 8). This occurs in very large numbers everywhere and is capable of eating small oysters by crunching the edges between its claws. It has a large appetite, but it eats such a variety of other things, including mussels, that it is difficult to decide on its exact role as an oyster enemy. In the United States, the green crab is a serious problem in the clam fisheries. In France, the problem of shore crabs is so acute, where small oysters are concentrated between low-water spring and low-water neap tides, that special fences are needed to protect intertidal oyster layings, and crabs are also captured in baited pots. It would therefore be a wise precaution to destroy crabs taken during dredging, and further research will be done to decide if other measures are necessary.

The purple-tipped sea urchin or "burr" (Psammechinus) (Plate 9). Burrs occur in very large numbers on or near certain oyster beds, for example in the River Alde and in some parts of Scotland. In 1920 the late Professor Orton found that a lot of oysters were being killed on Whitstable oyster beds by burrs.

Our investigations have shown that burrs can undoubtedly kill and eat oysters and other shellfish by grinding through the shell with their five powerful teeth. It was concluded, however, that the burrs were seeking other animals living on and in the shell of the oyster - barnacles, pock, boring worm and sponge - and that the flesh of the oyster was of secondary importance. Perforation and death of the oyster therefore appears to be accidental, but where burrs are numerous on oyster beds they may still cause noticeable damage. No special control measures are therefore recommended, but excessive numbers of burrs should be removed and crushed.

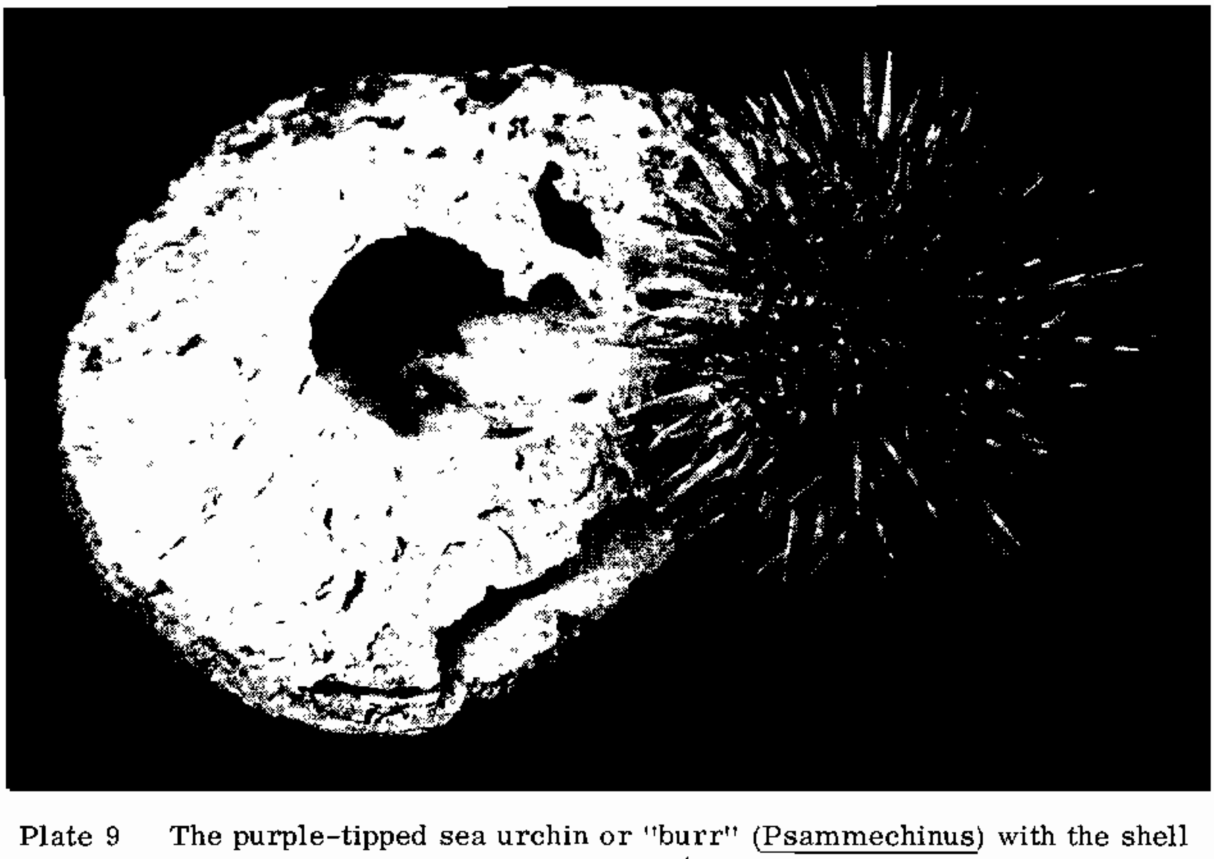

Plate 9 The purple-tipped sea urchin or "burr" (Psammechinus) with the shell of an oyster which it has eaten (x 4/3). (P. J. Warren)

Oystercatcher or sea pie (Plate 10). This bird is known to eat young oysters, particularly on hard ground in the intertidal zone, but is most often to be found eating other shellfish such as cockles and mussels. Less is known about feeding of oystercatchers on oysters, so any information should be sent to this laboratory. The oystercatcher is at present protected in most areas.

Plate 10 Oystercatcher. The plumage is black and white, the bill orange, and the legs pink (x about $\frac{1}{2}$). (J. G. Warner)

GROUP B. COMPETITORS

This group includes forms which compete with the oyster or its larvae for space and food and are literally the weeds of oyster beds.

The American slipper limpet (Crepidula) (Plate 11) is the most important competitor of the oyster. It is a snail which moves about only when young. Newly settled limpets attach themselves to older individuals to form chains or colonies which lie on the bottom, feeding like the oyster by filtering the water and extracting minute plants.

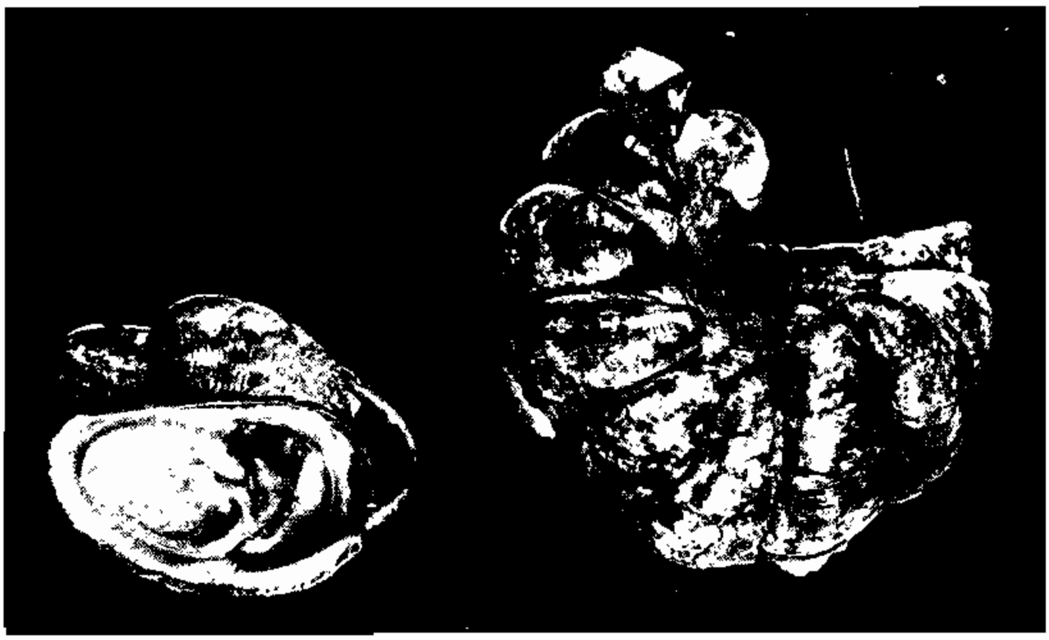

Plate 11 Typical chain of American slipper limpets, showing a detached snail (x 1). (P. J. Warren)

The slipper limpet was accidentally introduced into this country with oysters from America in about 1880. It has free-swimming larvae which have been dispersed rapidly round our coasts, and it is now found in most oyster-producing areas in England and Wales (Plate 12). In many Essex rivers slipper limpets form a carpet over areas of the bottom, where they effectively rob the oyster of food and space, and by their filtering action deposit soft mud and make the bottom unsuitable for oysters. Past surveys have revealed densities of up to 100 tons to the acre. In Cornwall, where the slipper limpet is not yet as firmly established as in Essex rivers, the payment in 1949 of a bounty of 5s. 0d. per limpet yielded only 25 specimens, but by 1953 nearly 2 000 were recovered during the year. Since then the numbers on the grounds have been increasing slowly, but nowhere does the problem approach the magnitude of that on the east coast.

Slipper limpets breed throughout the summer, and their larvae compete with those of the oyster for food and space in which to settle and grow. They thrive and breed most effectively on grounds which produce oysters of good quality, and their presence may be used as a guide to suitable conditions for oyster culture.

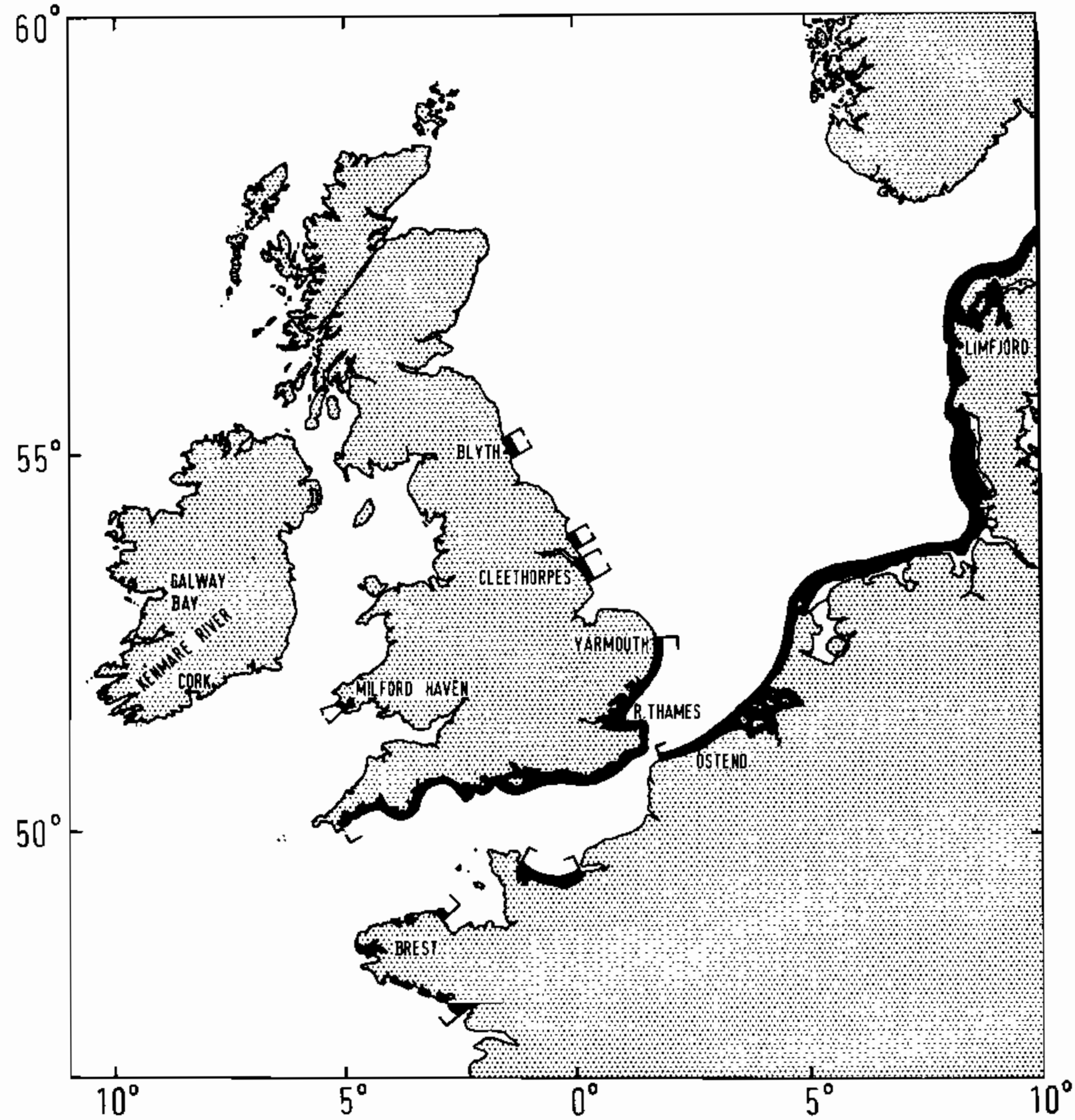

Plate 12 Northern Europe, showing the distribution of the slipper limpet.

Slipper limpets present three important problems:

their removal from grounds already cultivated;
their removal from derelict grounds scheduled for cultivation;
their removal from grounds not scheduled for cultivation.

From cultivated grounds, limpet chains should be removed by dredging and disposed of. Dense settlements of young newly-settled limpets may be killed by dipping infested cultch or oysters in solutions of various chemicals before relaying. Starfish, the spawn of the American tingle and various other pests can be killed at the same time. Dipping for a short time in a saturated solution of common salt is probably the cheapest, safest and most effective.

From a derelict ground, special dredging is necessary for the removal of limpets, and for this hand dredges are usually quite inadequate. Power dredges are essential for the vast quantity of material involved. Present research is directed towards finding the most economic methods and levels of removal and disposal. Limpets may be dumped on the shore well above low-water mark, where they eventually die and where they may also be useful for firming shores or making "hards". Better still, the chains should be separated by putting them through a crusher, and thrown back for the flesh to be eaten by scavenging animals on the bottom. On R. V. WYSTRYS a modified coke crusher was used to do this (Plate 13), and when required it would crush the shells to a suitable size for spat collection or reduce them to shram for hardening the bottom.

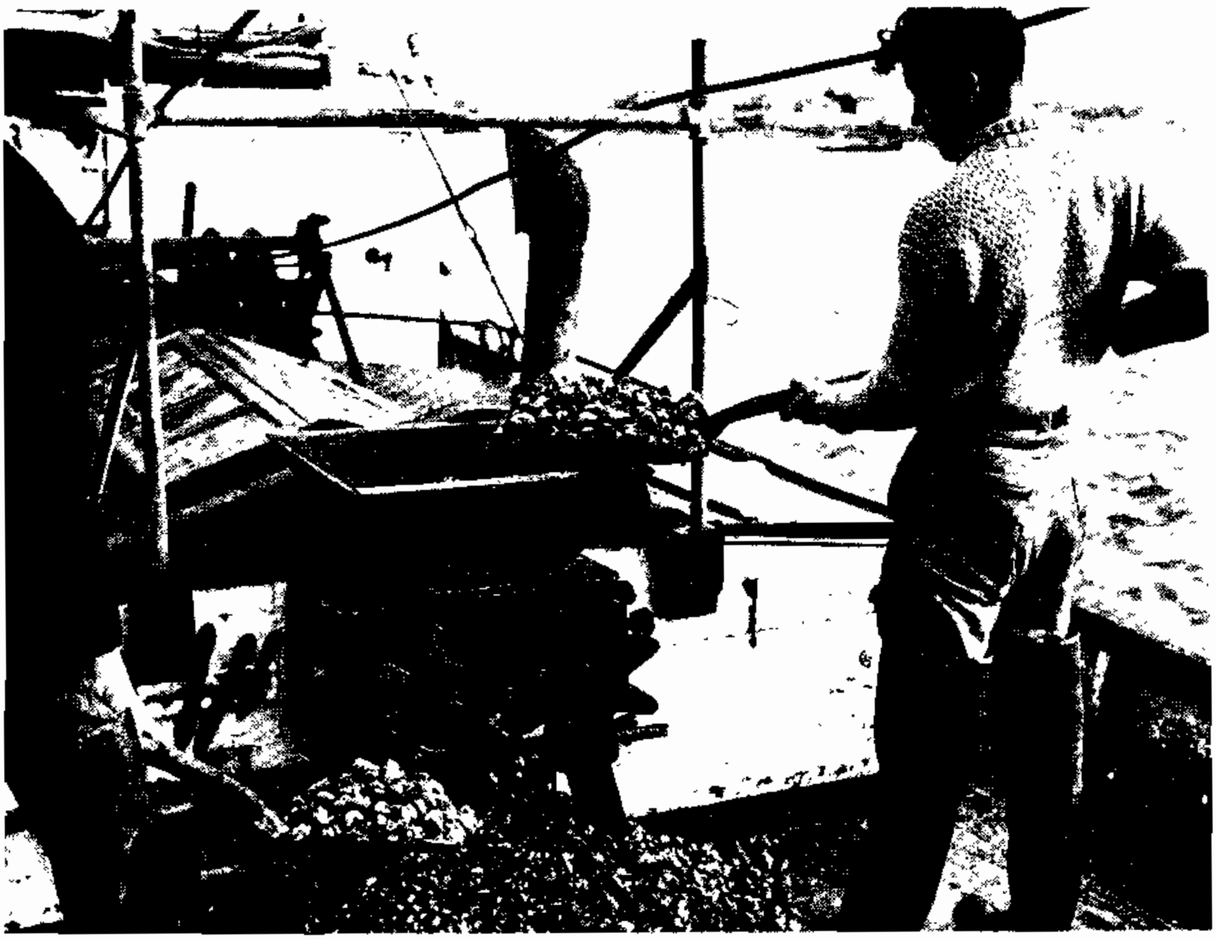

Plate 13 Crushing slipper limpets aboard the research vessel WYSTRYS at Burnham-on-Crouch. (P. J. Warren)

Various means have been suggested for destroying limpets *in situ* on grounds not scheduled for cultivation. These slipper limpets reduce the quantity of oyster food available in the water, and also provide a focus for limpet breeding. Methods include smothering the chains with silt by various devices, such as underwater ploughs. In the United States, slipper limpets and other pests have been effectively smothered by covering derelict grounds with heavy-duty polythene sheeting before relaying with oysters, but, except on intertidal plots, this proves somewhat difficult in practice. Limpet control will almost certainly involve high labour costs, and for this reason under the Sea Fish Industry Act of 1962 the Minister of Agriculture. Fisheries and Food will make grants towards the costs incurred in cleansing and restocking oyster beds rendered derelict by pests and diseases. The slipper limpet is one of the species cited in the Molluscan Shellfish (Control of Deposit) Order 1965 (see later).

The barnacle, nun or chitter (Plate 14). Until recent years barnacles presented no special problems, though of course they have always been responsible for fouling of oysters and cultch. In 1945, the introduction of the New Zealand barnacle (Elminius) into this country, possibly among ships' fouling, created special problems. The free-swimming larvae of this very vigorous species quickly spread and settled round much of our coasts, and it soon became the dominant barnacle on the east coast.

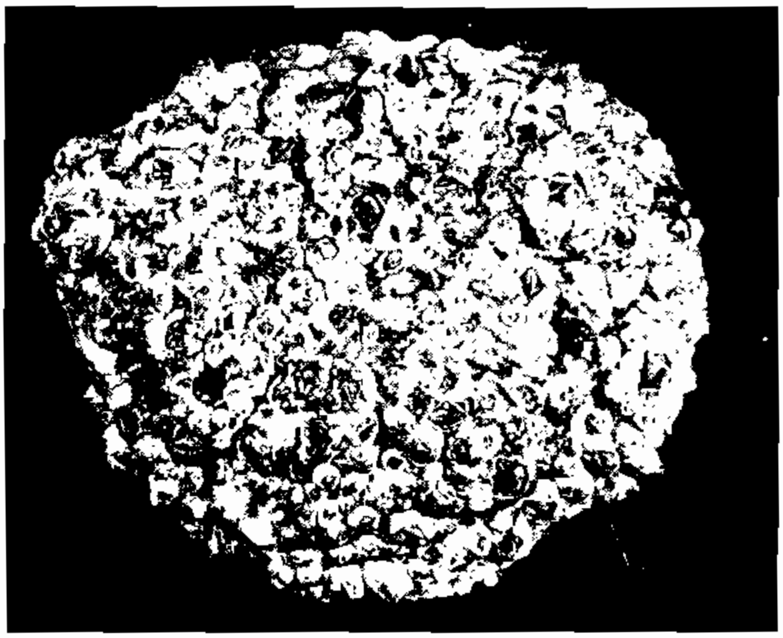

Plate 14 An oyster shell with a dense covering of barnacles (x 1). (P. J. Warren)

The barnacle competes with young oysters for space and food, but more seriously it interferes with the efficient laying of cultch for oyster spat collection. Native British species of barnacle have a breeding and larval settlement period which is completed before that of the oyster commences. The New Zealand barnacle, however, breeds throughout the period of settlement of oysters, so that the two are in constant competition for clean surfaces on which to settle. In the late 1940s this laboratory began a system of notifying planters of the predicted time of settlement of oysters. This was based on observations on the growth of oyster larvae in the plankton, and enabled planters to lay clean shell as nearly as possible to oyster settlement time. If this is done, oysters and barnacles can compete on equal terms for settlement space, but if shell is laid only a few days too soon it is almost certain to become smothered by barnacles. The system has been discontinued recently, since with such poor breeding stocks of oysters larval forecasts are proving to be less reliable. Barnacles also have a nuisance value because they smother the shells of market oysters, and many merchants prefer clean-shelled oysters. There is a need to develop a quick mechanical method of removing barnacles before despatch.

Encrusting worm or "German writing" (Pomatoceros) (Plate 15). This worm has white limy tubes which smother otherwise suitable settling surfaces. It is particularly abundant in the south and south-west and towards the mouth of the River Alde where it has been said to interfere with oyster cultivation. It competes with oyster spat, and like the barnacle presents a problem to planters wishing to send clean-shelled oysters to market.

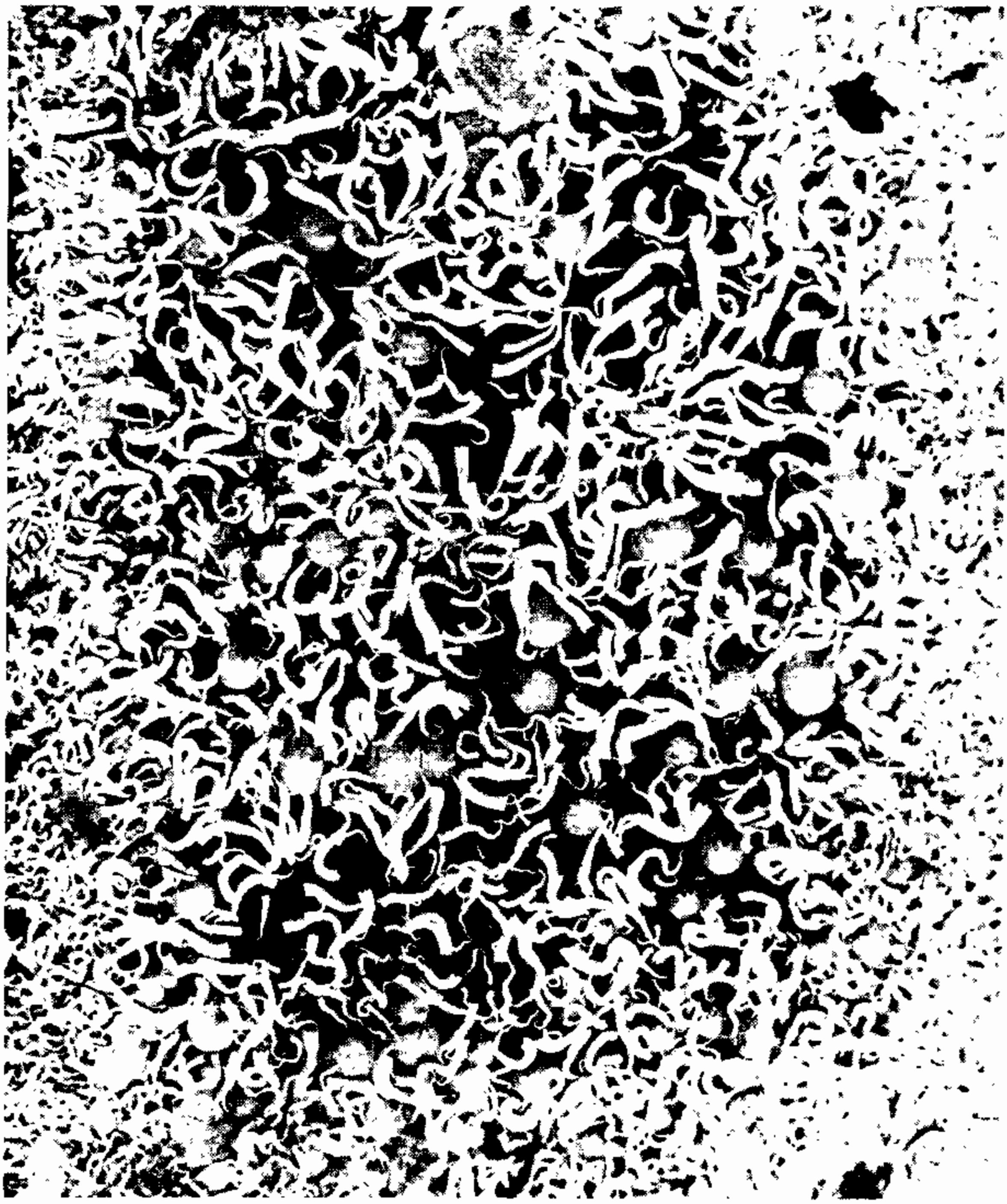

Plate 15 The encrusting worm or "German writing" (Pomatoceros) (x 5/4).
(J. Cruise)

Other competitors. There are other British species which feed by filtering the water and compete with the oyster for space and food, and which also accumulate mud, thereby producing conditions unsuitable for oysters. These include sea squirts, known as "pock" (small pink encrusting forms) (Plate 16) and "blubber" (erect, transparent and jelly-like forms often growing in large bunches) (Plate 17), fan worms or "hassocks" (Plate 18), and mussels. These should be removed by dredging during cultivation. Spiked harrows towed over the ground are particularly effective for ripping out worm tubes and puncturing sea squirts, which do not survive this disturbance. Smaller squirts or "pock", and other small competitors encrusting oysters and cultch may be killed by immersing them in chemical solutions such as saturated salt solution.

Plate 16 Oysters covered by "pock" - small sea squirts (Dendrodoa) (x 3/2).
(P. J. Warren)

Plate 17 "Blubber" - erect sea squirts Ascidiella and Ciona (x 2). (P. J. Warren)

Plate 18 Fan worms or "hassocks" (Sabella) (x 1). (P. J. Warren)

GROUP C. FORMS WHICH ATTACK THE SHELL

These include a fungus, a worm and a sponge.

Shell disease (Plate 19). This occurs widely in France, and in Holland where it causes epidemic mortalities among oysters during hot summers. The causative organism is a fungus, which first shows as white clear-centred spots on the inside of the shell, later spreading to form white clouds, then horny patches. In the final stages the shell margin becomes distorted, and when the disease reaches the adductor muscle attachment the oyster cannot close properly, it loses condition and dies.

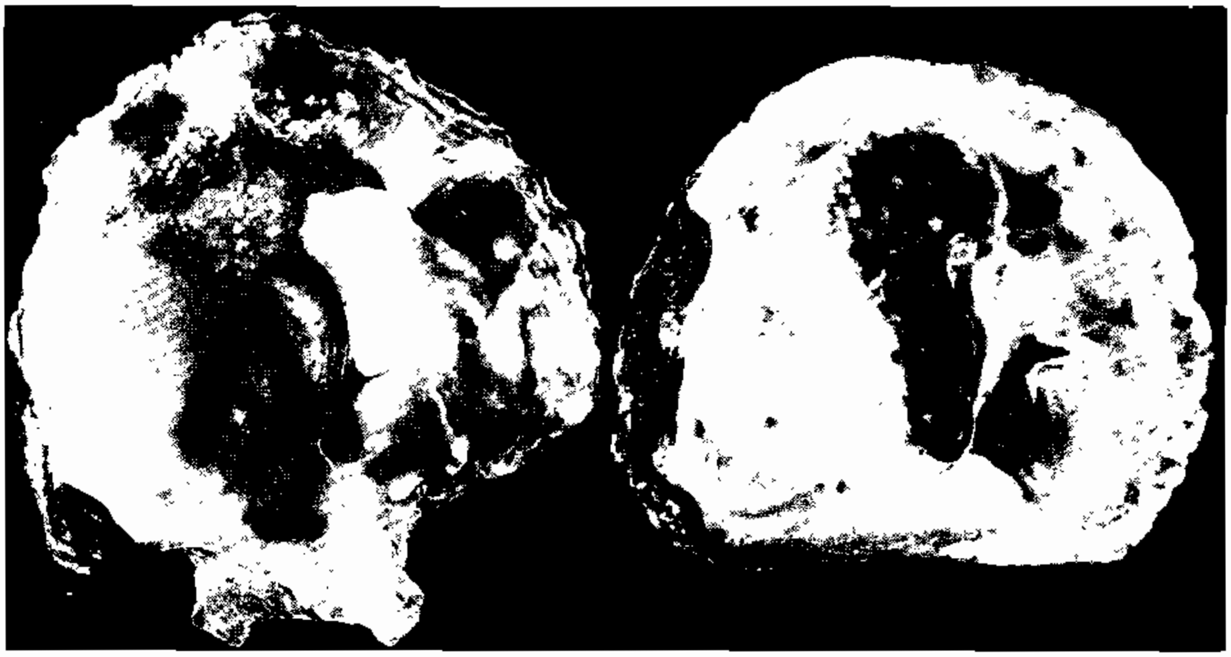

Plate 19 Inner surfaces of the cupped valves of oysters infected by shell disease. Left: White clouds indicating early stages of infection. Right: Severe infection showing discoloration and malformation of the shell, particularly at the point of attachment of the adductor muscle (x 5/4). (P. J. Warren)

Shell disease is believed to have been introduced into this country amongst relaid Brittany oysters. It is most prevalent on the east coast, where the conditions in shallow creeks are more suitable for its spread to native oysters. In Holland, it has been found that a water temperature of 19°C or more must persist for 10 days before epidemic conditions are produced. Such temperatures occur only rarely in south-western England, where, although Brittany oysters have been regularly relaid, the disease has not spread to native oysters.

Dutch scientists recommend dipping oysters in mercuric chloride solution. This is said to give protection to two-year-old oysters, and will kill shell disease already in them. The chemical does not however penetrate the shells of older oysters, and it should be remembered that it is corrosive sublimate, which is highly poisonous to man and requires careful handling. The fungus lives in old shells, so that the programme of cultivation should include not only the destruction of obviously infected oysters and shells, but also the removal of all cultch from infected areas. Exposure on the saltings may destroy the fungus in the shells, but where possible it is better not to re-use suspect shell on oyster beds.

The boring worm (Polydora) (Plate 20). The boring worm excavates burrows through the shell of the oyster, causing discoloration and mud blisters on the inside. Extensions of the burrows appear as tiny muddy tubes on the outside of the shell.

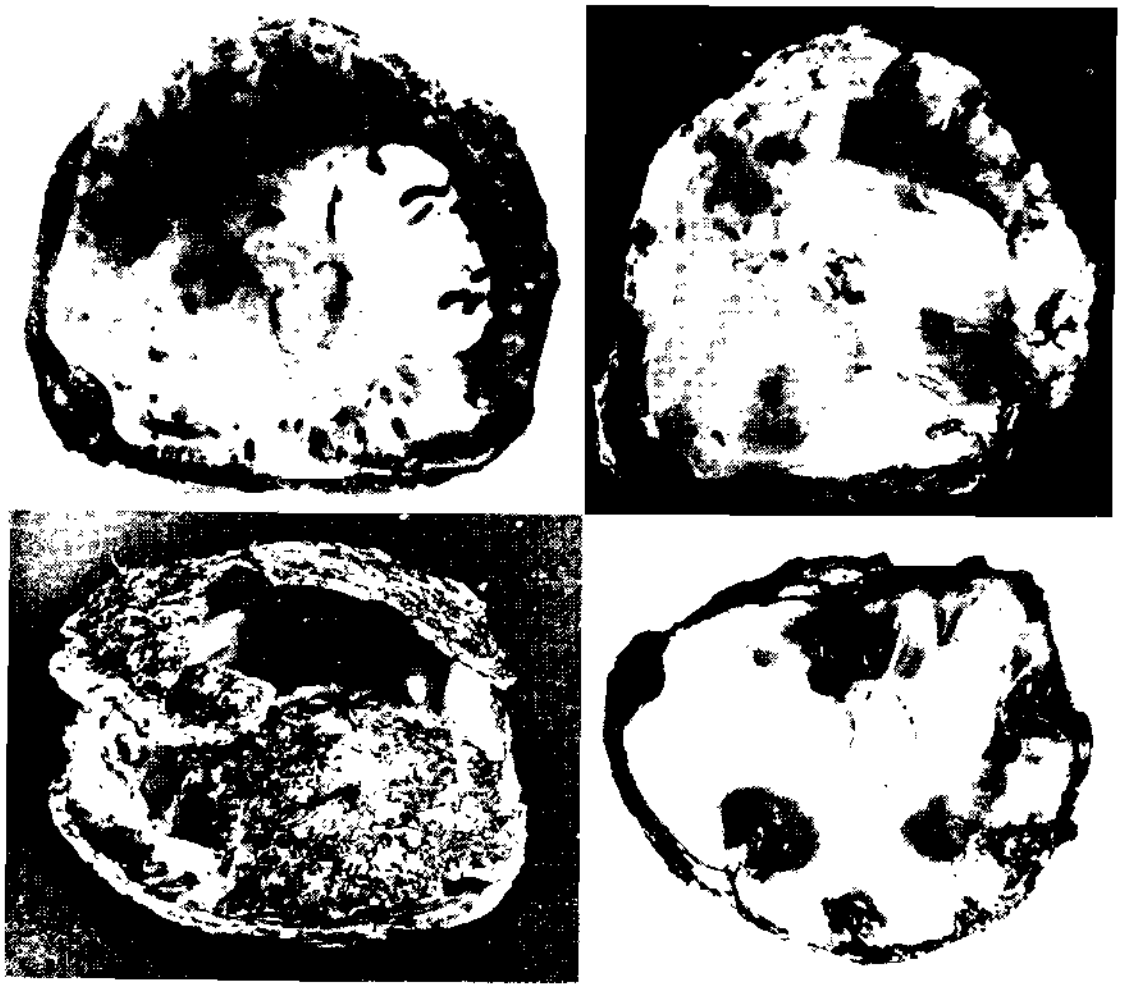

Plate 20 Oysters infected by boring worms (Polydora) (x 1)
Left: Infection by Polydora ciliata; in the lower oyster the shell was so badly eroded that it was fractured by a sudden contraction of the adductor muscle. Right: Characteristic U-shaped burrows and mud blisters caused by Polydora hoplura. (P. J. Warren)

Polydora hoplura is most serious in the south-west, and its characteristic U-shaped burrows and mud blisters show obviously on the inside of the shell. It thrives in oysters on soft ground in still, warm conditions, such as the headwaters of creeks and inlets. Polydora ciliata is more widespread, and is most prevalent on hard sandy or clay grounds, particularly in warm shallow water. Its burrows are smaller and give the inside of the shell a speckled appearance. Not only is the market value of these oysters reduced by their unsightly appearance, but the shells are weakened and difficult to open. In heavy infestations there may be loss of condition and reduction in shell growth.

The control of Polydora continues to be a problem, because although it is relatively easy to rid an infected oyster of worms, for example by dipping it in a solution of carbolic acid (phenol), so far there is no way of preventing reinfection, which takes place very quickly. Until this can be done, areas known to support heavy infections of Polydora should be avoided when relaying.

The boring sponge (Cliona) (Plate 21). This is easily recognized by the presence of yellow pustules of sponge on the outside of the shell. The sponge dissolves channels through the shell of the oyster, causing small brown spots and streaks, or networks of discoloration inside the shell. In heavy infections, the shells are easily crushed and unsightly, and are no good for market - the oysters are then called "rotten backs". The disease is most prevalent in the south and south-west. Control is simple, since dredged infected oysters may be relaid on the shore above low-water mark where the sponge soon dies. If the number of oysters infected is not sufficient to warrant this extra handling, yet sufficient to cause a substantial loss if destroyed, they may be dipped in various chemicals. American workers have suggested that dipping for only a few minutes in saturated salt solution would be effective. Sponge-infected cultch should be removed from dredged catches and thrown on to the saltings.

Plate 21 Above: Broken shell of oyster infected by boring sponge (*Cliona*).
Below: Yellow nodules of the sponge protruding through the surface of an infected oyster (x 3/2). (P. J. Warren)

GROUP D. PARASITES AND DISEASES

Fortunately in this country, as far as it is known, no major losses of oysters have been attributed to parasites and diseases, though in the USA and Canada a formidable number of identified diseases regularly cause great mortalities. Any widespread and major losses of oysters in Europe have usually been explained by extreme physical conditions such as severe winters, silting following floods, etc., the only exception being the mass death of 1920 which has never been properly understood and is now attributed by some to an epidemic disease.

Plate 22 (1) Typical "pockets" containing tiny Odostomia snails between the edges of oyster shells. (H. P. Sherwood)
(2) The edges of oysters badly affected by Odostomia. (P. J. Warren)
(3) Results of severe Odostomia attack in which the adductor muscle attachment was affected. (P. J. Warren)
(1) x 1; (2) and (3) x $\frac{3}{4}$.

Known parasites and diseases include:
Odostomia (Plate 22). This is a pinhead-sized snail which lives between the edges of the oyster's shells and feeds on the edge of the mantle. As a result of this irritation, the mantle of the oyster is withdrawn and unsightly pockets are formed (Plate 22, 1). Prolonged irritation by 6 or 7 snails can result in severe distortions in the inside of the shell of the oyster (Plate 22, 2 and 3), and eventually the oyster dies. The discovery of the serious effects which this parasite can have on oysters was as a direct result of the observations of Mr Jack Francis, one-time foreman of the Colne Fishery Board, who found some large oysters malformed and dying in a consignment for market, and sent some of them to this laboratory. Dr H. A. Cole had previously reported mild infections by this parasite amongst oysters from the River Roach, Essex, but this was the first time Odostomia had been found to cause such serious disturbances, leading to death. This was followed up by examining living oysters from the Rivers Colne, Roach and Crouch, and though cases of severe damage were fortunately rare, up to 30 per cent of oysters were found to be mildly infected. Only one infected specimen has been taken in south-western England, from Salcombe, while thousands of oysters from Cornwall have been examined at the laboratory without finding one.

Odostomia is therefore a parasite to be treated with suspicion, but so far it does not justify special control measures.

Mytilicola (Plate 23). This is a copepod parasite, like a small red worm, found usually in the gut of mussels; it can cause wasting and the death of enormous numbers of mussels. It has also been found in oysters in Essex and on the south coast, where up to 10 per cent of oysters in some places are infected, but so far the numbers of parasites found in one oyster have been small, and are believed unlikely to cause similar widespread losses to those experienced with mussels. The fact that oysters are infected by Mytilicola draws attention to the danger of relaying infected oysters in areas of mussel cultivation which are at present free from the pest, and this has been taken into consideration in the laws governing the relaying of infected shellfish (see later and Plate 24).

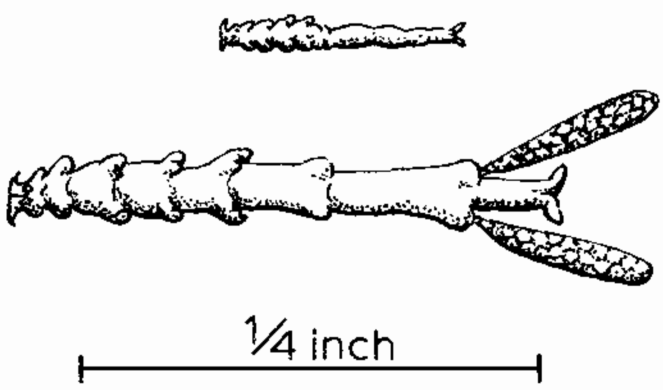

Plate 23 "Red worm" parasites (Mytilicola intestinalis) removed from the gut of a mussel. Above: male. Below: egg-carrying female.

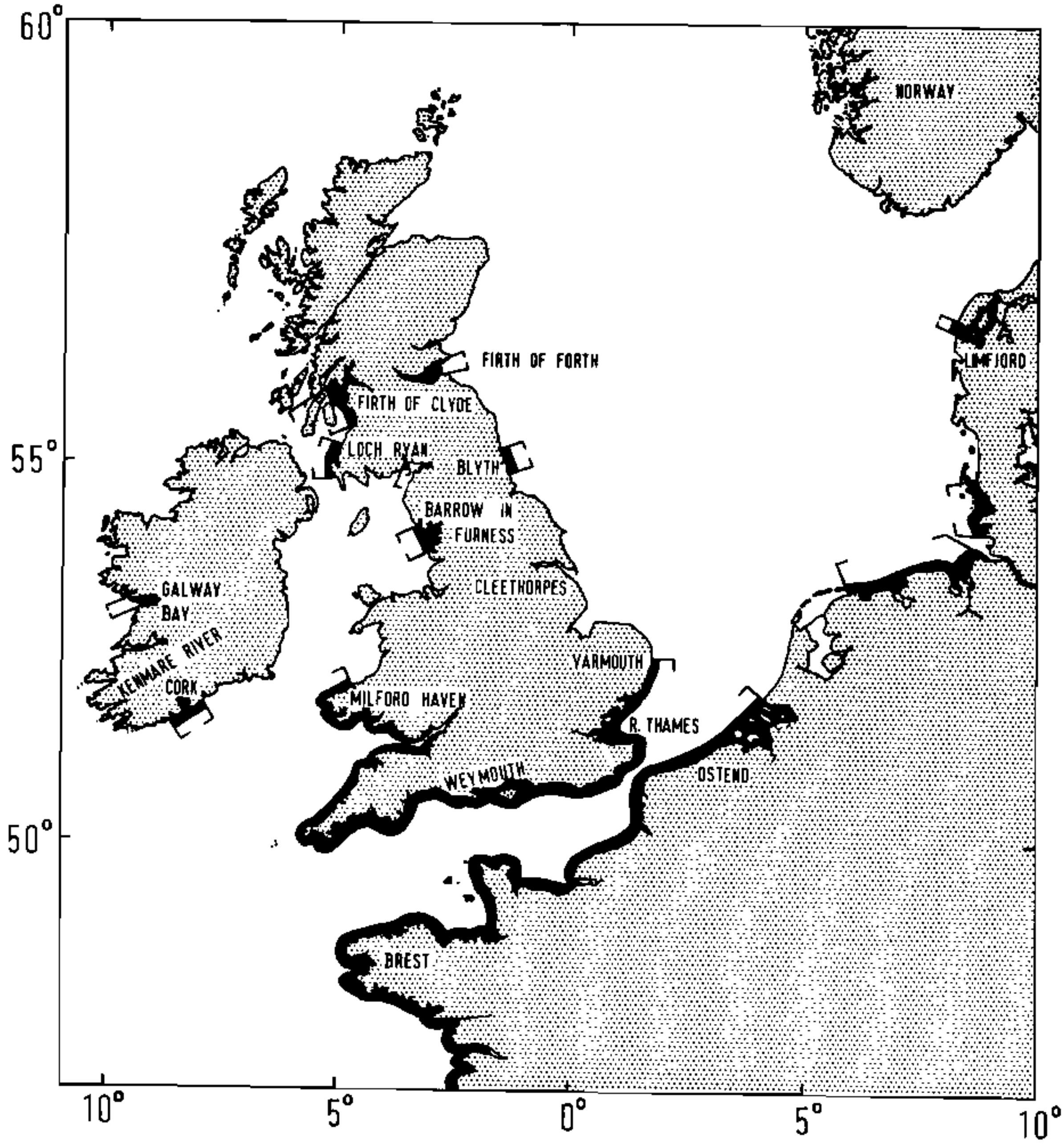

Plate 24 The distribution of Mytilicola intestinalis in northern Europe.

The pea crab (Pinnotheres) (Plate 25). This small parasitic crab is known to occur frequently in the mantle cavity of mussels and cockles. In the United States the pea crab occurs commonly in oysters, often causing serious damage. Any records of pea crabs in oysters, with specimens if possible, should be sent to this laboratory.

Plate 25 Pea crabs (Pinnotheres), male (smaller) and female, in the mantle cavity of a mussel (x 2). (P. J. Warren)

Gill disease. During 1967 and early 1968 heavy losses of Portuguese oysters relaid in France were attributed to an unidentified disease organism which caused characteristic damage to the gills. Similar symptoms were identified in Britain (Plate 26) in both Portuguese and native oysters but with severe gill damage only in Portuguese oysters. Nowhere were undue losses recorded, and the symptoms subsided during the summer of 1968. A careful watch is being kept for any recurrence and oyster growers are asked to report the occurrence of damaged gills and to send to this laboratory any oysters dying in suspicious circumstances.

Plate 26 Oyster gill affected by gill disease (x 3/2). (M. Rolfe)

CONCLUSIONS

The oyster has many enemies, and of these the ones which do most harm to the British oyster industry have been introduced from overseas. It is therefore clear that the uncontrolled importation of shellfish for relaying from abroad, or their transplantation between separate areas within this country, is extremely dangerous, and indeed, with our present knowledge of the damage caused by oyster pests, it would be irresponsible. This is true not only of relationships between oysters and the many enemies about which we know, but almost certainly true also of others as yet unknown to us.

In order to protect British shellfisheries, in particular the mussel and oyster fisheries, the Molluscan Shellfish (Control of Deposit) Order 1965 (Statutory Instrument No. 1971) came into operation on 1 January 1966 (obtainable from

H.M. Stationery Office, price 6d., and described in Laboratory Leaflet (New Series) No. 10). The Order is designed to prevent the introduction of foreign pests and diseases, and to limit the further spread of those which have already been introduced and become established on our coasts. Particular attention has been given to the American whelk tingle, the American slipper limpet and the "red worm" parasite Mytilicola, but during the past year the law was used to prohibit the introduction of relaying oysters from France, and to prevent the movement of oysters from an area known to have received French oysters, until the position regarding gill disease was better understood.

Another important law, the Sea Fish Industry Act of 1962, recognizes the fact that the cleansing of oyster beds from pests and diseases and subsequent restocking with oysters will be an expensive undertaking, but reclamation must be undertaken efficiently to succeed in improving oyster production. This process is being encouraged by the payment by the Ministry of Agriculture, Fisheries and Food, after a careful series of inspections, of a grant of £75 per acre towards reclamation costs and up to £150 per acre towards the cost of restocking.

Our knowledge of how to combat the enemies listed on the preceding pages is far from complete, but investigations into control measures are being continued. Available methods have been described only briefly in this leaflet, but full details of recommended mechanical and chemical control measures are available at this laboratory in response to specific enquiries. In view of recent findings on the manner in which marine organisms accumulate chemical substances, and the possibility of killing other useful animals in the water, or even endangering the health of man, chemical methods of controlling pests cannot be recommended without subjecting them to the most careful examination. An example of the complexity of the problem is that one of the chemicals, recommended in the United States for the protection of oysters from the American tingle, is not only intended to protect one mollusc from another mollusc, but it is also effective against crustacea such as crabs.

An alternative approach, which is likely to be particularly applicable during the present shortage of oysters, is to employ some form of direct protection from bottom pests, such as raising the oysters in covered trays or suspending the oysters from floats, in trays or attached to ropes, in the manner practised commercially in other countries. The possibilities for tray and rope cultivation are currently being examined at this laboratory.

Any information on cases of abnormally high mortalities among oysters, losses in unusual circumstances or outbreaks of pests - in fact, any problems worthy of attention - will be welcome. In this way, we hope to obtain as full a picture as possible of the enemies of oysters, and so increase the chances of effective control.

The dangers of introducing species from other parts of the world, or their transfer between different areas of the United Kingdom, cannot be over-emphasized and it would be a wise precaution to seek advice from this laboratory when considering such an action involving any marine species, including those not mentioned specifically in existing legislation.

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