Progress in Oyster Research in Britain 1949-1954, with Special Reference to the Control of Pests and Diseases

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Introduction

At the Special Shellfish Meeting of the International Council for the Exploration of the Sea, held in Edinburgh in 1949, the senior author gave an account (Cole 1951) of the British oyster industry and of the principal problems which had to be solved before production could be restored to pre-war levels. During the five years which have elapsed since the Edinburgh meeting, research has been proceeding at the laboratories of the Ministry of Agriculture and Fisheries at Burnham-on-Crouch and Conway and the purpose of this paper is to review the results achieved, especially in the control of pests and diseases.

In 1949 the problems reviewed included:- repeated failures in spatfall, disease, prevalence of imported pests, the effect of severe winters and industrial and sewage pollution. In the last-named field, progress has been substantial as new and simpler techniques have been evolved for the purification of oysters (Cole 1954) and mussels (Reynolds unpublished). It is not proposed, however, to consider the subject further in this review.

Factors Controlling Spatfall

The hope was expressed in 1949 (Cole 1951 p.9) that within ten years we should be able to advise oyster planters effectively on the relative importance of the various factors controlling spat production. After five years further experience the picture is a good deal clearer but little less gloomy than in 1949. During the intervening years oyster spatfall on the major producing grounds in the East of England has varied from excellent in 1950 to complete failure in 1951 (Waugh 1951). In the remaining three seasons it was insufficient to provide for replacement of stocks and the industry faces a shortage of native oysters which will continue until at least 1959. While it is clear that the maintenance of a high water temperature for a substantial period, such as occurs during warm summers, favours a heavy production of larvae and rapid growth to settling stage, it is becoming more certain that the percentage of larvae growing and settling is dependent to a very large extent upon the presence of an adequate number of nanoplankton algae (Waugh 1951 & 1952). It is evident too that only certain types of nanoplankton algae are capable of promoting good growth of larvae; others are ingested, if of suitable size, but are either indigestible or lacking in the required nutrients (see separate communication to the Paris meeting by P. R. Walne). Attempts have been made (Waugh, in the press) to stimulate the production of suitable food organisms by fertilization of the upper part of the estuary of the River Crouch, Essex, and some slight success has been obtained. These experiments are being continued.

Recent experience has confirmed the extent to which severe winters or highly adverse environmental conditions may influence the production and survival of oyster larvae in the summer following. It is generally agreed that good spatfalls are not to be expected after severe winters, notwithstanding the survival of a good stock of breeding oysters. A good example occurred in 1953 following the severe floods in January which killed many oysters in Essex and Kent (Waugh 1954); it was anticipated that the spatfall in 1953 would be poor and this was the case.

The relative infrequency of good spatting years in Essex, in comparison with 20 or 30 years ago, has led to speculation regarding the competitive effect of the vast accumulations of Crepidula on uncultivated ground in Essex estuaries. It has been suggested that the mass removal of these accumulations, if it were economically possible, might result in an all-round improvement in the rate of growth and survival of oyster larvae.

Survival of oyster spat after settlement is satisfactory in Cornwall but poor on the east coast. This is correlated with the dense settlement of the barnacle, Elminius, in Essex estuaries (Knight Jones 1952); the prevalence of the American oyster drill, Urosalpinx; and heavy silting. The settlement of Elminius on artificial collectors may be controlled by spraying with D.D.T. emulsions (Waugh, Hawes and Williams, 1952) but we are not satisfied that it can be applied economically to shell cultch, unless virgin shell is obtained from processing plants for mussels and cockles.

The control of Urosalpinx is discussed fully below; its attainment is one of the principal objectives of the Ministry's oyster research programme.

Silting is reported locally to be more severe in Essex than in the years before 1920 when production of oysters was much higher than at present. The water over the beds is usually turbid and light penetration must be greatly restricted. This is likely to reduce the rate of reproduction of the nanoplankton algae essential as food for oyster larvae, particularly during dull summers, and may at times act as a limiting factor on growth and survival. Moreover, the ingestion of silt in suspension may prevent the larvae from obtaining sufficient of the nutritive algae when these are present at a low concentration.

Survival of spat after settlement, and also the efficiency of collectors, is greatly influenced by rate of silting. The source of the excessive silt now present in Essex rivers is thought to be the extensive unrepaired breaks in the sea walls which exist in most areas and into which water from the river enters at each tide; as it leaves it may be seen, particularly at spring tides, to carry much clay in suspension. There is also the probability that the great reduction which has occurred in the quantity of new shell laid annually to catch oyster spat has increased the liability of the surface layers of the bottom to be disturbed and brought into suspension during rough weather.

The adverse effects of excessive silting was shown in 1953, following the flooding of the coastal lands of Essex and Kent following the great storm surge of 31st January. Very heavy losses of oysters were experienced (Waugh 1954), due to burying under debris from the land or to suffocation by suspended silt. Mortality from the second cause continued for several weeks after the inundation.

PESTS

Crepidula fornicata (The American Slipper Limpet)

During the period under review Crepidula has extended its range to include practically the whole of the south coast of England as far as Lands End (Cole 1952). Recently it has been discovered also in Milford Haven, Pembrokeshire (Cole & Baird 1953) to which it was undoubtedly conveyed on the bottoms of ships either laid up after the second World War or consigned to the ship-breaking yard in the Haven. In Cornwall Crepidula is not yet established generally, but a flourishing colony exists in the Helford River and smaller colonies in the Fal and Fowey estuaries. In its general spread westwards along the Channel, Crepidula has now reached the waters off Plymouth where it is now common.

Table 1

Quantity of Crepidula taken on the Helford River oyster fishery

1949	25
1950	65
1951	265
1952	1193
1953	1958

The rate of increase in the Helford River may be judged from Table 1, which shows the quantity of slipper limpets collected and paid for by the oyster company working the beds. At first five shillings was paid for each Crepidula collected but this has now been reduced to one penny; nevertheless the rate of increase has been slower than anticipated from experience on the east coast of England and it is possible that Crepidula is not so well suited by environmental conditions in Cornwall.

Detailed studies have been made of the distribution, density of occurrence, growth and breeding of Crepidula at selected points on the east and south coasts of England and the results will shortly be published. It has been found that Crepidula thrives and breeds most effectively on grounds which are capable of producing oysters of fine quality; the presence of an abundant stock of large Crepidula is a reliable guide to the suitability of the ground for the production of oysters. Similarly it has been found that crops of Crepidula spat are heavy in seasons when a good settlement of young oysters occurs and it is deduced that the larvae are dependent upon the same food organisms.

Careful observations of grounds cleared of slipper limpets during the severe winter of 1947 suggests that re-establishment of the population to the same level of density may occupy as long as 10 years.

The most intractable problem created by the presence of Crepidula on English oyster beds is the high cost of clearing and reclaiming ground which has gone out of cultivation. The necessity to remove 20 tons or more of Crepidula per acre from the worst infested, and, usually, the most valuable grounds, renders it impossible for any but the largest oyster companies to undertake reclamation on a large scale without assistance. In consequence the amount of derelict ground reclaimed during the period under review has been small. A new fishery has, however, been established at Fowey, Cornwall in an area almost free of Crepidula, and very small beginnings have been made with the rehabilitation of the once substantial fisheries in Poole Harbour and Milford Haven.

Urosalpinx cinerea (The American Whelk Tingle)

The American whelk tingle, Urosalpinx, continues to cause concern to oyster planters in the Essex rivers, and there is evidence that its numbers are still increasing in places which provide a favourable environment. Surveys in the Rivers Crouch and Roach have revealed concentrations of up to 10,000 Urosalpinx per acre. This should be compared with Cole's (1942) statement that Urosalpinx, in pre-war years, occurred sparingly in the River Crouch. There is no evidence that Urosalpinx has spread, or has been transported to, areas outside Essex and Kent. Surveys have failed to reveal the presence of Urosalpinx in the River Orwell (Suffolk), Orford River (Suffolk) or the Emsworth Channel (Hampshire), to which American and Essex oysters were taken in past years. Its distribution has extended slightly from the original centres and it is now known to have spread southwards at least as far as Herne Bay, along the Whitstable Flats, and northwards along the Essex coast from Brightlingsea to Frinton. It has been stated previously that such direct migrations must be greatly limited by the absence of free swimming larvae. Attention is being given to means of preventing the transport of oysters or oyster shell from infested to free areas. A few lots of oysters from Essex have been relaid in Devon, but so far no Urosalpinx have been found among the relaid stock. Investigations are being made of possible dipping techniques which would kill any spawn or young tingles adhering to the surface of oysters about to be relaid.

Observations in 1953 showed that on one oyster laying in the River Crouch, Essex, Urosalpinx had, by December, destroyed 58% of the oyster spat of 4-5 mm. diameter and larger which had settled during the summer, (Hancock, in the press). This represented 86 oyster spat per square metre destroyed by Urosalpinx. This estimate did not include the smallest spat, traces of which are more difficult to see, nor the spat rising one year old destroyed early in the spring following settlement. It is not, therefore, difficult to agree with Cole's (1942) estimate that in certain places in the Essex Rivers approximately 75% of the spat are destroyed before they reach one year of age. The discovery that on another ground in the River Crouch 10% of oysters aged 3 years and older had been drilled during the first half of the feeding period, indicates that Urosalpinx also causes a substantial mortality among oysters larger than spat.

Population studies have shown that normal dredging operations on the Southward Laying, River Crouch, between 1949 and 1952 inclusive, have accounted for some 10,000 Urosalpinx and a great deal of spawn. This figure represents only one-fifth of the present total population, and emphasizes the need for more vigorous control measures. Further trials using wire-bag traps of the type favoured in the United States, and other underwater traps, have met with little success. Extensive trials of drill dredges constructed on a pattern similar to those used in the United States have shown that, when compared with an ordinary power dredge of the same dimension, the drill dredge rarely catches more tingles than the power dredge, and catches none of the considerable quantity of spawn and other pests retained by the power dredge. It is possible, however, that lighter models of a hand dredge pattern, used incidentally to normal dredging, may have some application, and it must be remembered that the important feature of such drill dredges is that the contents need not be sorted, but can be taken ashore in bulk and dried.

Curved roofing tiles placed in lines along the lower shore, and inspected fortnightly at low water of spring tides, make useful traps for tingles, and utilise the habit of the tingle of crawling up and under objects during spawning. Three hundred tiles inspected on nine occasions throughout the summer of 1954 have yielded over 3,000 Urosalpinx and 16,000 of its capsules. This exceeds the expected yield of tingles from 50 hours intensive dredging in the summer.

The tiles provide an objective and quick method of inspecting the shore, on which tingles are usually obscured by mud. Only a short time is taken involving the use of the minimum number of men, and its efficency should be compared with the use of the boat and full crew required for dredging. A further advantage is that two thirds of the tingles taken are adult females. The tiles however have a limited application; they cannot be used on a bottom of pure mud, but a gradually sloping shore is found to increase their effectiveness. Experiments with improved methods of using tile traps for Urosalpinx are being continued.

The value of removing the spawn from oysters and shells during the height of the breeding season cannot be over-emphasized. The yield from four hours intensive dredging in the River Reach with one boat fitted with two four foot power dredges was estimated at nearly 80,000 capsules, each of which could have been expected to produce about 10 young tingles. A clearer picture of the biology and habits of these animals is being sought, with the object of shedding further light on methods of capture and control.

Starfish

Two species of starfish - Asterias rubens and Solaster papposus - are found in large numbers on the Essex coast. In Britain Asterias has always been regarded by fishermen as the traditional enemy of mussels and oysters. Laver (1916) regarded it as the most injurious of the direct enemies of the oyster in the Colchester oyster fishery, and Collard (1902) mentioned it as a deadly foe of the Whitstable oyster. Needler (1941) regards the starfish (Asterias vulgaris) as the worst enemy of oysters in Canadian Atlantic waters, while in the United States it has been estimated (Galtsoff & Loosanoff, 1939) that 500,000 bushels of oysters have been destroyed by Asterias forbesi annually since 1921. At present, local control measures in Essex comprise the collection and drying of starfish caught during normal dredging.

A series of experiments was designed to discover what part the oyster plays in the diet of the starfish, and to decide whether further control measures could be justified. Starfish (Asterias rubens)have been taken in the dredges from oyster grounds in the River Crouch in the act of feeding on brood and spat oysters. They have also, however, frequently been taken feeding on other forms such as Crepidula - a severe competitor of the oyster - which forms a considerable part of the fauna of the oyster beds.

As a result of long-continued laboratory experiments in which a choice of food was offered, it was found that although starfish occasionally ate spat and adult oysters, the greater part of their food was made up of shellfish and other forms which are the oyster's competitors for space and food. The smaller sizes of starfish ate large numbers of barnacles, with occasional spat of oysters and Crepidula. The larger ones ate oysters and oyster spat occasionally, but almost always exhibited a preference for mussels and, in the absence of these, for Crepidula and, occasionally, even for Urosalpinx. Asterias has been found to feed also on many other kinds of shellfish, but they exist in much fewer numbers on Essex oyster beds and are of considerably less importance than the oyster and its competitors, the slipper limpets and barnacles. The mussel appears to be a universal favourite of Asterias, but it occurs only sparingly on oyster grounds in the River Crouch.

Dredge surveys of an oyster ground in the River Crouch showed that there were very few starfish close inshore where the largest concentrations of oysters and their spat were found. The largest numbers of starfish were found further offshore, where oysters were either mixed with slipper limpets and barnacles or completely absent. 10,000 starfish were taken from the offshore part of this ground in the course of a few weeks' dredging from an area covered entirely by slipper limpets. Further confirmation of this feeding behaviour has been found in the River Colne, Essex, where starfish are found in largest numbers near the mouth of the river. Here oysters are virtually absent, but dredged starfish were found to be feeding on slipper limpets, the numbers of which are stated by the Foreman of the Colne Fishery Board to be decreasing, largely, he believes, as a result of the activities of starfish.

It seems likely, therefore, that on the east coast of England Asterias is less important as a pest of oysters than was previously supposed, and that under certain conditions its depredations on the competitors of oysters may be beneficial. The removal of starfish from clean grounds which are stocked with oysters and relatively free from pests and competitors is still to be highly recommended, but the destruction of all starfish, even on derelict or offshore grounds covered with barnacles and slipper limpets, seems to be an unnecessary, and even short-sighted, policy. The transplantation of starfish to help clear derelict grounds under controlled conditions might have some application.

The sunstar, Solaster papposus, and, to a certain extent, the stone crab, Hyas araneus, feed on Asterias rubens, and are considered to play a part in its natural control.

On oyster beds in Devon and Cornwall Marthasterias glacialis may occur, particularly in the lower parts of estuaries where salinity is rarely reduced. The feeding behaviour of this starfish has not been investigated. It is nowhere very abundant but is regarded by the oystermen as an enemy and is removed during dredging. It does not occur on the East coast of England.

Shell Disease

In 1949 shell disease of oysters had not been recorded in Britain, but in the year following it was found (Cole 1950) among relaid Brittany oysters in the East of England. Since 1950 detailed studies have been made of the occurrence and spread of shell disease in the British Isles and it has been revealed as a major cause of loss in certain shallow warm creeks in Essex.

Table 2. Shell disease in English native oysters

Date	Locality	Age of Oysters	No. Examined	No. with Shell disease	% Infected
26.1.52	River Crouch Essex (upper)	1 & 2 yrs.	105	25	23.8
2.2.52	River Crouch Essex (upper)	2 yrs.	98	11	11.2
3.11.53	River Crouch Essex (mid)	2 & 3 yrs.	35	9	26.0
14.1.52	River Crouch Essex (lower)	2 & 3 yrs.	120	nil	0.0.
10.1.52	River Roach Essex (upper)	2 & 3 yrs.	98	48	49.0
9.2.52	River Blackwater Essex (upper)	2 & 3 yrs.	140	22	15.7
11.6.52	River Blackwater Essex (lower)	2 & 3 yrs.	75	3	4.0
12.6.52	River Colne Essex	2 & 3 yrs.	58	5	8.6
25.1.52	Whitstable Kent	2 yrs.	102	nil	0.0
24.5.51	River Yealm Devon	2, 3 & 4 yrs.	54	5	9.3
20.6.51	River Fal (mid)	2 & 3 yrs.	105	nil	0.0
20.6.51	Penryn River Cornwall	2 & 3 yrs.	96	nil	0.0
21.2.52	Helford River Cornwall	3 yrs.	107	nil	0.0

Table 3. Shell disease in 3 year-old oysters from Brittany imported into Britain

Year Imported	Where Relaid	No. Examined	No. with Shell Disease	% Infected
1951	Menai Straits	50	4	8.0
1951	Whitstable	50	3	6.0
1951	River Roach	49	12	24.5
1951	Helford River	52	12	23.1
1951	River Shannon (Ireland)	25	4	16.0
1952	Menai Straits	50	4	8.0
1952	Helford River	27	nil	0.0
1952	River Fal	25	3	12.0

In Table 2 the results of examining a representative series of samples of native oysters from widely separated grounds are given. It will be seen that although the disease is present in oysters from nearly all the beds examined, the rate of infection is serious only in Essex. In Devon and Cornwall the disease is extremely rare in native oysters, although as shown below, heavily infected French oysters have been laid down at times on all oyster beds in the West of Britain and also in Ireland, (Table 3).

In Essex there appear to be two distinct forms of shell disease. The typical form as described by Korringa (1951), in which greenish rubber-like warts and knobs appear on the inside of the shell, particularly in the region of the muscle attachment, occurs commonly and as in the Netherlands, causes loss of condition and death of the oysters as soon as the muscle attachment is affected. In addition, in Essex, young oysters may be found in a very weak or dying condition without any deformation of the muscle attachment. In these oysters the cupped and, in some cases, also the flat valve, is much thickened throughout and densely covered with the "white clouds" which arise during the development of infection in the normal Dutch form of shell disease. Often the muscle scar and the division between the quick and catch components of the muscle are outlined by reddish brown pigment. Superficially these severely affected shells often do not appear abnormal and there is no doubt that the presence of this form of shell disease is easily overlooked by oyster planters.

The pattern of distribution of the disease in Essex and the low level of infection among native oysters in Devon and Cornwall is in good agreement with Korringa's (1951) hypothesis that a water temperature of 19°C. must be maintained over nearly two weeks before epidemic spread of the disease occurs. In Essex such a high level of water temperature is of frequent occurrence during normal summers, particularly in shallow creeks, but in Devon and Cornwall 17° - 10°C. is the normal summer maximum and temperatures above 19°C. very rarely occur.

Control of the disease in the rivers Crouch and Roach has been attempted, using the established Dutch method of dipping with mercuric chloride solution coupled with the removal of excessive accumulations of old green cultch. Little success has been achieved: the occurrence of very small crops of spat since the discovery of the disease has prevented any thorough trial of mercuric chloride on young oysters, and many of those dipped had too thick shells for the fungicide to penetrate. In consequence, an incomplete kill of the fungus was obtained and further it later invaded the shell. Removal of shell cultch has been adopted on some grounds and may have prevented epidemic spread of the disease; it has not, however, reduced its incidence. On one shallow water ground in the River Roach an infection rate of 60.4% was recorded in 1953, compared with 58.7% in 1952.

Marteil (1954) reports that the disease is confined to certain well-defined areas in Brittany and has not increased its range during the last five years. The examination of samples from nine separate Morbihan planters, received as part of a large consignment imported into England during 1952 led to a similar conclusion. The rate of infestation with shell disease amongst these samples of two year old oysters varied from 0.0% to 16.0%. Unfortunately, detailed information regarding the distribution of the disease in France has not been available to English oyster merchants. The lack of knowledge upon which selection of sound oysters could be based is a severe obstacle to the resumption of imports of oysters from Brittany.

Other Pests

During the period under review an intensive study has been made in America by Mackin and his colleagues of the causes of loss of condition and death in oysters. Several new parasites have been discovered, two of which, *Dermocystidium* (Mackin 1951) and *Hexamita* may be important. Hexamita has also been recorded in European oysters (Mackin, Korringa and Hopkins 1952) and it has been suggested that the unexplained mortality of 1920 which destroyed large stocks of oysters in Eastern England and on the Continent of Europe was due to infestation with *Hexamita inflata*. It is not possible to prove or disprove this contention as the material studied by Orton (1926) is no longer available. There are certain similarities in the conditions found by the latter in dead and dying oysters from British beds and the symptoms of Hexamitiasis, but it is worth while recording that in a personal communication received by the senior author from the late Professor J.H. Orton, shortly before the lamented death of this great zoologist, the opinion was expressed that the two conditions were not the same.

No recent search has been made for *Hexamita* or *Dermocystidium* or related conditions in British oysters, as substantial unexplained mortalities have not been recorded. This is not, however, to suggest that all the causes of death of oysters in Britain are known; this is certainly not the case but no *large* unexplained losses have occurred in recent years. A new parasite of oysters has, however, been recognized very recently; this is the pyramidellid gastropod *Odostomia*. *Odostomia eulimoides* was first found attacking young oysters in the river Roach, Essex (Cole 1951) but has since been found to be common and rather widespread in Essex (Cole & Hancock in the press). Moreover, it has been found that oysters may be greatly weakened and that some are killed by the simultaneous attacks of several parasites. It is remarkable that such a discovery should be made in connection with an animal so intensively studied as the European oyster, but no less remarkable is the very recent reporting of the damage done by a flat worm, *Stylochus frontalis*, to oysters on the American Pacific coast, (Woelke 1954).

Further attempts have been made to determine the importance of *Polydora* in relation to growth and fattening of oysters in Britain. In the Netherlands it seems that both *Polydora ciliata* and *Polydora hoplura* may cause stunting of oysters (Korringa 1951) but in Britain an evaluation of the effect of *Polydora* has been greatly hindered by an inability to devise a treatment which will keep oysters free from *Polydora* for long enough to give a satisfactory measure of their growth rate in comparison with untreated stock. The methods devised by Korringa have not proved to be adequate to free British oysters from *Polydora*. Phenol as used by Mackin (pers. com. to G.D. Waugh) is more satisfactory but very rapid re-infestation may occur under British conditions. It seems too, that further attention to the systematics of the genus *Polydora* may be needed as *Polydora ciliata* (as now defined) exists in two well-marked ecotypes which may on detailed examination prove to be separate species. The work that has been done in England is of a preliminary nature and no firm conclusions can be drawn, but the impression remains that heavy *Polydora* infestation may produce serious stunting and loss of condition.

A newly-recognised enemy of oysters in Britain, which however is only occasionally of any importance, is the oyster-catcher *Haematopus ostralegus*. Despite its popular name it was not considered that this bird damaged oysters; indeed it is rare in areas where oysters are cultivated and undoubtedly its main food is other lamellibranchs, principally cockles and mussels. However, in the autumn of 1949 substantial destruction of two-year-old oysters was observed on the Ministry's oyster ground in the Menai Straits, North Wales. The damage was confined to a patch of oysters laid on hard gravelly shore; ground not previously used for rearing oysters. The greater part of the stock laid on muddy sand was not attacked and it is to be supposed that the birds were only able to break the shells of the oysters when they were able to press them against the hard shore.

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