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The British Oyster Industry and its Problems.

By

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Introduction.

The survey of the oyster beds on the coasts of England and Wales made by Bulstrode (1896), although primarily for the purpose of investigating the relation between oysters and disease, gives a good picture of the industry as it was at the close of the last century and forms a satisfactory basis for an examination of the causes of the great decline in the quantity of oysters marketed that occurred in the following fifty years. The problem to-day is, broadly speaking, to reverse this decline and to expand and cheapen production so that oysters may be removed from the luxury market and again become a food of general consumption. To elucidate the nature of this problem, or set of problems, it will be necessary to assess not only the contribution that can be made by scientific research but also, briefly, difficulties experienced in marketing, including the protection of the public from disease transmitted by polluted shellfish.

The Decline in Production.

The statistics of landings of oysters at British Ports (Table 1) do not give an accurate picture of the production from British beds for the following reasons:—

(a) In addition to British native oysters they include a variable proportion of foreign relaid oysters, principally French but, including also Portuguese (*Gryphaea angulata* Lamarck) and, up to 1939, American oysters (*Gryphaea virginica* Gmelin).

(b) Oysters landed at one port and sold for relaying and fattening elsewhere may appear twice in the statistics, on the second occasion when landed and sent to market. Since it is a regular practice to market the bulk of the oysters for relaying from certain beds, e. g., those in the River Crouch and the River Fal, the numbers involved may be substantial, although only those surviving to market size will appear twice in the figures.

(c) The statistics are not complete as they do not include landings from the Percuel River, St. Mawes, Falmouth and certain other beds of less importance. Further the figures for Falmouth do not include the production from the beds at Penryn nor oysters sold for direct consumption from layings in the Upper Fal. The figures for the Helford River appear only in the total landings and are not shown separately.

A detailed examination of these statistics would be out of place here, but it will be realised that while the recording of oysters sold for subsequent relaying tends to inflate the figures of total landings, the deficiencies listed under (c) above are serious, since the Falmouth district during the last few years has become one of the main sources of market oysters.

Reliable figures of production from certain beds are fortunately available in the Annual Returns made under certain Fishery Orders, which granted the sole right of fishing for oysters to certain bodies over defined areas of bottom. For example, since 1876 the Corporation of Truro has exercised control over the oyster fishery in the whole of the Upper Fal and reliable figures for the production from these beds are available (Table 2). Similarly the right of several fishery was granted in 1878 to the Tollesbury and Mersea Native Oyster Fishery Co. Ltd., over the greater part of the estuary of the Blackwater, Essex, and some of the creeks running into it. The fluctuations in the production from this estuary, which includes for the years 1936—1940 a proportion of relaid French oysters, are given in Table 3. These two fisheries have been selected since they present contrasting conditions, the Blackwater being infested with slipper limpets (*Crepidula fornicata* Say) and American whelk tingles (*Urosalpinx cinerea* Say) and being subject to severe frost, while the Fal is free of imported pests (although occasional slipper limpets have been found during the last two years) and hard frost is most unusual.

Tables 2 and 3 show that a most serious decline

in the production from these fisheries set in during 1920 and continued throughout the twenties and early thirties. Some improvement was evident in the late thirties, but in Essex the ground regained was lost during the exceptionally severe winters of 1939/40 and 1946/47, and has not been regained. In Cornwall these winters, although far more severe than those normally experienced, did not cause very substantial losses and were not sufficient to affect seriously the steady recovery of the Fal fishery.

Since 1939 the landings shown in Table 1 do not include American oysters, but the import of Portuguese oysters was continued on a reduced scale during the war years so as to keep the grounds in production. These oysters are laid principally at Brightlingsea and West Mersea and in certain creeks running into the River Roach, all in the County of Essex. Table 4 gives particulars of foreign oysters imported for relaying or breeding.

Principal Problems with a Discussion of Possible Remedies.

The principal causes of the decline in oyster production may be defined as:—repeated failures in spatfall, disease, prevalence of imported pests, industrial and sewage pollution, closure of beds and interruption of cultivation during war-time and exceptionally severe winters.

1. Spatfall Failures.

A thorough investigation of the factors controlling oyster spatfall on British beds is in progress, and sufficient has been done to enable us to reach certain conclusions. The subject is being dealt with in more detail by KNIGHT JONES and only the general conclusions will be stated here. It is clear that there are good and bad spatfall years which cannot be related simply to weather or the quantity of breeding oysters. Water temperature is important but summers which are generally described as "hot" or "cool" are not necessarily more and less favourable for the settlement of oyster spat. In 1946 for example, the summer in Essex and Kent was considered to be one of the poorest for many years yet there was a good settlement, and many instances have been recorded of hot dry summers with little spat. Our work has confirmed KORRINGA's view (1940) that good spatfalls cannot be expected on seriously understocked fisheries, despite the known fecundity of breeding oysters

Table 1.
Quantity and Value of Oysters landed in England and Wales.
(British Landings.)

Year	Oysters (Thousands) No.	£
1918	26,078	131
1919	31,111	201
1920	39,439	255
1921	31,027	208
1922	23,666	177
1923	18,102	152
1924	16,973	147
1925	16,740	151
1926	15,858	160
1927	9,712	101
1928	8,058	87
1929	7,377	60
1930	6,937	58
1931	7,045	62
1932	10,740	89
1933	10,719	96
1934	12,009	107
1935	15,799	140
1936	19,287	176
1937	16,583	142
1938	16,364	133
1939	12,193	101
1940	8,859	74
1941	9,800	94
1942	5,540	75
1943	4,946	67
1944	4,535	65
1945	5,651	108
1946	7,850	135
1947	6,675	110
1948	7,167	128

Table 2.
Oyster Production from the Upper Fal, Cornwall.
(Truro Port Fishery Orders, 1876 and 1936.)

Year	Natives (Thousands)
1918	ca. 11,500
1919	ca. 11,000
1920	ca. 14,000
1921	ca. 16,000
1922	ca. 9,000
1923	ca. 15,000
1924	ca. 8,000
1925	ca. 11,000
1926	ca. 3,500
1927	ca. 1,500
1928	ca. 600
1929	100
1930	750
1931	600
1932	400
1933	375
1934	225
1935	191
1936	103
1937	341
1938	546
1939	312
1940	590
1941	1,115
1942	1,358
1943	1,566
1944	1,637
1945	1,116
1946	1,732
1947	1,519
1948	1,782

Table 3.
Oyster Production from the River Blackwater, Essex.
(Tollesbury and Mersea Fishery Orders, 1878 and 1938.)

Year	Natives (Thousands)	French (Thousands)
1918	10,109	—
1919	2,281	—
1920	7,631	—
1921	3,688	—
1922	1,587	—
1923	901	—
1924	No record	—
1925	1,603	—
1926	1,499	—
1927	1,051	—
1928	661	—
1929	962	—
1930	123	—
1931	695	—
1932	295	—
1933	563	—
1934	335	—
1935	532	—
1936	268	800
1937	111	2,801
1938	922	6,140
1939	562	7,571
1940	—	3,551
1941	68	—
1942	187	—
1943	251	—
1944	167	—
1945	207	—
1946	227	—
1947	136	—
1948	131	—

Table 4. Imports of Oysters for Breeding or Relaying.

Year	Total (Thousands)	Value (Thousand £)	Percentage France	Netherlands	Portugal	U.S.A.
1922..	12,011	33	56·07	43·93	—	—
1923..	8,778	21	99·58	0·42	—	—
1924..	12,149	42	98·28	1·72	—	—
1925..	7,099	4	99·54	0·46	—	—
1926..	9,570	6	61·98	—	38·02	—
1927..	16,795	14	45·70	—	48·14	4·69
1928..	10,098	11	59·21	3·28	29·84	7·67
1929..	7,244	8	79·91	1·24	15·81	3·04
1930..	12,150	10	50·72	13·59	25·81	9·88
1931..	5,826	7	39·11	0·96	41·49	18·44
1932..	9,507	19	55·04	4·84	23·93	16·19
1933..	14,225	31	65·55	0·84	13·74	14·57
1934..	15,970	46	64·58	—	19·15	15·50
1935..	23,662	58	72·06	—	16·14	11·80
1936..	26,177	77	83·81	—	6·77	9·42
1937..	40,899	89	87·04	—	5·22	7·74
1938..	27,949	43	85·29	—	7·56	7·15
1939..	19,954	—	82·79	—	12·69	4·52
1940..	15,740	—	94·56	—	5·44	—
1941..	—	—	—	—	—	—
1942..	4,238	—	—	—	100·00	—
1943..	5,930	—	—	—	100·00	—
1944..	4,532	—	—	—	95·98	—
1945..	5,000	—	—	—	100·00	—
1946..	1,801	—	86·67	—	13·33	—
1947..	18,710	—	73·91	—	26·09	—

(Cole, 1941). A very dense concentration of oyster larvae is required to produce a good crop of spat under the relatively unfavourable conditions existing on the east coast, where large areas of once productive oyster ground are now derelict. The proportion of the larger fisheries, e. g., in the Blackwater and the Crouch, which is adequately cultivated and in a fit condition for the settlement of spat is now very small, the remainder being over-run with slipper limpets and mud and semi-derelict. On the Cornish beds conditions are more favourable and generally speaking the grounds are fairly well-cultivated, here spatfalls of commercial importance are more frequent, e. g., in the Helford River very good spatfalls occurred in both 1940 and 1947 and the intervening years were by no means unproductive.

Cole and Knight Jones (1949) have shown the importance of the gregarious habit in the settlement of oyster spat and there is no doubt that on seriously understocked grounds, with brood oysters from previous spatfalls sparsely scattered over the cultivated portions of the fishery, and with intervening stretches of derelict ground, settlement in concentrations of commercial magnitude only occurs in the proximity of other oysters. To restore the derelict portions of these fisheries to a condition where heavy settlement of spat can occur, it is not only necessary to remove pests and to cultivate intensively, to clean up the cultch and to expose fresh surfaces for attachment, but also to sow with spat-shells or brood oysters to provide the necessary focus for gregarious settlement. This fact has been imperfectly recognised in the past and had led to much wasted effort on restocking without provision for additional cultivation.

Considering the oyster fisheries in Essex, a serious degree of understocking is evident in the Rivers Colne, Blackwater, Crouch and Roach, and substantial spatfalls are unlikely to occur except in the most favourable seasons. In normal years only a scattering of spat can be expected and we have recently shown (unpublished work) that even where conditions are apparently favourable, in that major pests are absent, a very high proportion of the settled spat, probably exceeding 90%, die during the first autumn and winter after attachment. On beds where pests, particularly Urosalpinx, are abundant and where silting is serious, the losses may be expected to be even higher.

In Cornwall the degree of understocking in the Fal is less serious and normal years give a sufficiency of spat for replacement but not for expansion; given adequate cultivation, which has not yet been achieved, substantial spatfalls may be expected to occur in this river regularly. In the Helford River, Cornwall, alone of British oyster fisheries, is there sufficient stock to give regular spatfalls; it is somewhat ironical that in this river the fishery depends mainly upon relaid French oysters, which thrive exceptionally, and little attention is paid to the systematic collection and cultivation of home-grown spat.

We are unable, as yet, to recognize a favourable season for settlement until after the event. Water temperature is certainly important but not all important. Recent work has convinced us that the view expressed in 1939 (Cole), that both the quantity and the quality of the nannoplankton organisms available as food supply might be important, is correct, and there is some evidence that on occasion the quantity or quality of the food supply is insufficient to give good growth and survival of larvae. As Korringa (1940) has pointed out, any factor, e. g., low water temperature or inadequate food supply, which causes the free-swimming development period of the larvae to be prolonged, increases the risk of the larvae perishing from other causes and of their being dispersed to unfavourable localities for settlement.

The importance of predators—ctenophores, medusae, fish larvae, which may vary greatly in numbers from year to year—has not yet been assessed, but in cool seasons when larval development is prolonged the losses they cause may be serious.

As far as British oyster beds are concerned, therefore, we are unable as yet to give a clear indication of the relative importance of the various factors controlling spatfall, but research has progressed so far that we may confidently expect to be in a position to advise the planters effectively on this problem within, say, another five to ten years.

The use of artificial collectors, such as limed tiles, to improve the settlement of spat on British beds has been widely advocated (Orton, 1937) and some trials have taken place both in Essex and Cornwall. To use such collectors effectively very sheltered con-

ditions are desirable, but suitable grounds appear to exist in some of the quiet creeks of Essex and on the up-river grounds in the Fal and Helford rivers in Cornwall. Sedentary organisms competing with oyster spat for food and space on the tiles seem to be a more serious problem than in France or Holland, particularly *Elminius modestus*, the barnacle, and the ascidian, *Ascidiella aspersa*, in Essex, and the tube-worm *Pomatoceros triqueter* in Cornwall. Some trials made a few years ago in the Helford River showed that a good spatfall could be collected, equal to a "good year" (Dalido, 1948) in France, but competition from Pomatoceros was later very severe and the spat was stunted. Further work is needed, particularly in relation to the time of placing the tiles and the possibility of early detachment of spat before competition from sedentary organisms reaches a climax.

Tiles are relatively expensive to purchase and prepare, and the detachment of spat and its subsequent handling requires a lot of labour. In an effort to reduce these expenses it appears that the French planters are now beginning to experiment with coated egg-box partitions, as used successfully in Canada (Needler, 1941) and elsewhere. We have tried these collectors recently in Essex with moderate results and further investigations may reveal methods of checking the settlement of competitors, particularly Elminius.

All artificial collectors so far employed require a considerable amount of labour; in Britain, where all the major companies are dependent on hired rather than family labour, this objection is particularly serious. It is possible, however, that such collectors may have their uses on some British beds and experiments are being continued in Essex and will later be extended to Cornwall.

Tiles have been successfully used by the Fisheries Department to collect spat in large concrete tanks at Conway for subsequent rearing on sheltered grounds in the Menai Straits, and the commercial possibilities of this method have been clearly demonstrated. Unfortunately the abnormal costs and difficulties of major constructional works prevent the wider extension of this method at present.

2. Abnormally Severe Winters.

There is a great lack of precise information on the effect of low temperatures on oysters. It is usual to talk of oysters as being killed by severe frost, but in fact there is little evidence of direct killing of oysters by low temperature in circumstances which were otherwise favourable. When very heavy losses have occurred they appear usually with the melting of snow and ice and seem to be the result more of a prolonged run of fresh water in the estuaries than of low temperature by itself. It seems as though oysters, perhaps weakened by a long spell of very low water temperatures, are unable to protect themselves from the adverse effects of low salinity and succumb in very large numbers. The finding of shells still containing meat, but with much sand or mud in the mantle cavity, suggests inability to close the shells sufficiently tightly to prevent the entry of silt disturbed and brought down by melting snow and ice. The freezing of oysters within ice-sheets deposited on the shores by the receding tide has been witnessed on many occasions, and such oysters may be carried away in large numbers when the tide returns.

Oysters laid on the Ministry's beds in the Menai Straits, in North Wales, and exposed by spring tides for 2—3 hours appear to be extremely hardy. There is never any serious general or local reduction of salinity on these beds and it was observed in 1940 and again in 1947, both exceptionally severe winters in North Wales, that the winter mortality was little if at all above the normal. In both years the coldest spell occurred during a period of spring tides and the oysters were exposed for several days to air temperatures in the region of —11° C.; the sea temperature was about 4° C. on each occasion. In 1940 after a night during which the air temperature fell to —12° C. and the oysters were fully exposed, low water being at approx. 6 a. m., a careful search of spat, brood and adult oysters was made without finding any weak or recently dead. It appears then that oysters may be resistant to low temperature if conditions are otherwise favourable. There is evidence that strains from various localities may differ in their ability to withstand severe winters, e. g. the Brittany oysters laid down in Kent and Essex suffered much more severely in 1940 than the native stocks (Cole, 1940).

Whatever may be the precise cause of death during exceptionally severe winters, there is no doubt that these constitute a very serious menace to oyster culture, particularly on the east coast, and another winter of a similar severity to 1939/40 or 1946/47 would put many planters out of business. The losses experienced in 1940 were surveyed by Cole (1940) and on very few beds were they less than 50%. In 1941 the losses were even higher, approaching 100% on up-river grounds covered by a small depth of water, and particularly subject to a reduction in salinity. Losses everywhere on the east coast reached 50% and the general average was approximately 75%. These losses were particularly serious since the beds in this area were already gravely understocked. In 1940 the beds in Devon and Cornwall escaped but in 1947 losses were experienced of about 20%.

To find a winter of comparable severity to the two under discussion we have to go back to 1895 and the occurrence of the 1947 debacle so soon after 1940 profoundly shook the confidence of the east coast planters. It appeared as though exceptionally severe winters, talked of as "occurring once a lifetime" were becoming a regular feature of our climate. Whatever may be the mathematical probabilities, the reaction of the major oyster companies in Essex and Kent, or rather those not restricted to a trade in genuine "Natives", was to seek grounds in the S.W. where serious winter losses are not a major hazard. It thus came about that three major companies traditionally associated with the east coast transferred the bulk of their business to Devon and

Cornwall while still retaining their grounds in Essex and Kent, but with reduced staffs. While this arrangement has reacted to the benefit particularly of the industry in the Fal, it has slowed down the rate of recovery of the Essex and Kent grounds. It has reacted particularly heavily on Whitstable which no longer can claim to be the most important centre of the industry; the Fal Estuary (including the Penryn and Percuel Rivers), and the Helford River, each now carry larger stocks of oysters.

In former years it was the custom on the east coast to place all oysters dredged up during the autumn and winter into shallow pits excavated in the saltings fringing the rivers and creeks. Oysters of various sizes—brood, half-ware and market grades—were placed in separate pits and in these pits they remained throughout the winter months, unless sold, being laid down again on the beds in March or early April. The use of these pits was universal on the east coast and there are remains of many thousands, although comparatively few are still in usable condition. Some on the shores of the River Roach, which are still in use, were figured by BULSTRODE (1896, Plate No. 1) and the profusion of such pits alongside the Essex creeks is well shown by the aerial photograph of the creek mouths at West Mersea forming Plate XXIV of STAMP's (1946) "Britain's Structure and Scenery". This photograph shows the pits on Packing Marsh Island, to which reference is made below. Such wintering pits were never used extensively in Cornwall where losses by frost have never been serious.

It was the custom to take up all oysters each autumn from up-river grounds in Essex and Kent known to be subject to heavy losses during severe weather, but this practice fell into disuse as labour became more expensive and oysters less plentiful following the 1914—18 war, and the mortality which succeeded it. No doubt a succession of mild winters during the early twenties lulled the planters into a false sense of security. During the depression of the late twenties and early thirties the oyster trade was slack and expenses were cut, in consequence pits which were in need of repair were allowed to decay, the board sides rotted away or became dislodged and the tide broke down the walls of the pits and filled many in or demolished them altogether. Further, the technique of employing such pits to safeguard oysters in severe weather was lost and a new generation of oyster-men grew up without experience in their use. Small numbers of pits still remain in usable condition alongside most Essex rivers but they are now employed principally for the temporary storage of oysters before marketing. In the Blackwater some wintering pits are still employed by a few planters but there is much difference of opinion, and indeed uncertainty, regarding their proper management in severe weather. Some men attach great importance to the nature of the bottom, shram i. e. coarse shell gravel, or rammed chalk being most favoured, while concrete is held to be unsuitable. The proper depth of water to retain over the oysters, varying between little more than a foot and nearly three feet, is also in dispute, so too is the frequency with which the water should be changed. Formerly all pits were provided with a reservoir of water, either from another pit or from a "backwater" excavated in the marshes inshore of the pits, from which water could be obtained at neap tides or periodically changed, and this was used systematically, but most oyster-men are now at a loss when faced with questions regarding the technique of using such pits.

Recent experience with wintering pits has varied but on balance the oysters put into them have escaped with much smaller losses than on the neighbouring beds. Protected from serious falls in salinity and from heavy silting, oysters in pits are subject to low water temperature only, although deoxygenation may also be important. The temperature may fall to a minimum of —2° C. but the lower layer of water in the pit is sheltered by a layer of ice. It has been suggested that this ice should be broken "to allow the oysters to breathe", but more informed opinion suggests that the ice should not be disturbed. During the winter 1946/47 brood oysters placed in pits on Packing Marsh Island, West Mersea, referred to above, escaped with scarcely more than normal losses while similar oysters remaining in the creeks and main rivers suffered a minimum of 50% loss. On the other hand during the winter 1939/40 very heavy losses of larger oysters were experienced in pits on the River Roach, comparable with the mortality on the adjoining beds. Here it was alleged by some oyster-men that the treatment given was incorrect.

Careful research designed to elucidate the basic principles underlying the successful use of these pits, which are comparatively cheap to construct, is badly needed and forms part of the research programme of the Fisheries Department. Although the dredging up of oysters for pitting is rather a costly operation, it does incidentally enable such oysters to be concentrated later on good growing grounds, and ensures thorough cultivation. In the writer's opinion the successful reintroduction of the use of wintering pits on the east coast is essential to restore the confidence of the planters there in their ability to withstand the effect of severe winters; without such a technique at hand it is difficult to see how many of the shallow creek layings and the up-river beds, often extremely valuable as spatting grounds, can be restored permanently to a productive condition.

3. Imported Pests.

The two imported pests of major importance to British oystermen are the American Slipper Limpet (*Crepidula fornicata*) and the American Whelk Tingle (*Urosalpinx cinerea*). A third, the New Zealand and Australian barnacle *Elminius modestus* DARWIN, has recently been recognized (CRISP & CHIPPERFIELD 1948 and KNIGHT JONES 1948) and now occurs on all British oyster beds except those in the Menai Straits. It is dominant in the Essex rivers and constitutes a serious additional burden to the already handicapped

oyster planter in that area, since its settlement season coincides with that of the oyster. While it has been reported from Holland (BOSCHMA, 1948) there are at present no records from France, where its presence might seriously hinder the collection of spat on artificial collectors. In Cornwall it is not as yet very widespread or abundant, but it occurs both in the Fal and the Helford River. It is too early to judge whether it will become so abundant on the cultch in this area as it is in Essex.

No method of preventing the settlement of Elminius on cultch or tile collectors has yet been found but its biology is being intensively studied both at Burnham-on-Crouch, Essex (Fisheries Department) and in the newly established laboratory for anti-fouling research at Brixham, Devon (Imperial Chemical Industries).

The American slipper limpet was introduced into this country with American oysters probably about 70 years ago, but BULSTRODE (1896) when he surveyed the industry throughout the country did not allude to its presence. The first indication that it might become so abundant as to constitute a serious pest was given by COOPER (1905) and there is a record of law-suit at Burnham-on-Crouch in 1911 (Murie) in respect of alleged neglect of cultivation of an oyster bed based on the prevalence of slipper limpets on the ground in question. There seems no reasonable doubt that Crepidula was disseminated from Brightlingsea, Essex, and spread from there to the other centres of oyster culture in Essex. There has always been a considerable traffic in oysters between the Essex producing grounds and Whitstable and it would not be very long before Crepidula was transferred.

It was formerly the custom for some of the Essex and Kent planters to transfer oysters for wintering to the creeks around Hayling Island, Portsmouth and at this time (before the 1914—18 war) an Essex Company also held the rights in Bosham Creek, slightly further to the east, and it appears that slipper limpets were transferred to these creeks from Essex or Kent. They have since extended steadily along the south coast and have now reached the Torquay—Paignton—Brixham area in S. Devon. Small numbers have also been found during the last three years in the Fal and the Helford Rivers.

To the north, Crepidula has extended as far as Blyth, Northumberland, a few miles from the Scottish border (BULL, 1939) where there is definite evidence that large quantities were brought from the Blackwater on the bottom of a German vessel broken up in the yards. This evidence of transference on the bottom of a ship is of importance since KORRINGA (1942) states that it is never carried in this way.

It is very difficult to explain the occurrence of Crepidula in the Fal and Helford Rivers unless they can be transferred on ships, since none have been found between Brixham and Falmouth, a distance in a direct line of about 50 miles. Since the intervening stretch includes all the grounds worked from the Plymouth Laboratory of the Marine Biological Association, it is unlikely that Crepidula would pass undetected. Falmouth is a dock-yard town and a considerable number of ships pass through per annum and it is certainly possible that Crepidula may have been introduced in this manner. Oysters are relaid annually in the Helford River from the Fal and Crepidula may have been carried in this way from the Fal, although there is also the possibility that it may have been brought on American warships, which entered the mouth of the Helford River during the war period, or on a yacht laid up on the south or east coast.

Although Crepidula has been recognized as a serious hindrance to oyster culture for at least 30 years, very little work has been done on its biology or ecology; apart from the studies of feeding and sex change by ORTON (1912) and COE (1936) there is nothing on which to base research designed to elucidate methods of control. We have, however, now taken steps to remedy this defect and a comprehensive study of its growth, settlement, breeding and distribution in Essex is in progress.

It is claimed that in Holland a reasonable degree of control of Crepidula has been achieved, principally by the manufacture of a valuable product from the meat, thus making it worth while for the oyster-men to collect and bring ashore Crepidula. It is also said that where limpets are fairly thin and oysters have been taken up, the destruction of a high proportion of the remaining colonies can be arranged by temporarily leasing the ground to mussel cultivators, who plant it thickly with seed mussels, thus smothering most of the limpets.

Neither of these methods is at present feasible in Britain since all efforts to find a remunerative outlet for slipper limpets have failed and there is no interest in mussel culture in the areas where Crepidula is abundant, in fact mussels are regarded as a minor pest and are discouraged. It is possible that a market may eventually be built up for slipper limpets as a supplementary protein poultry food and effort along these lines is being continued.

The most hopeful method of control lies, however, in the development of mechanical dredging gear. At present one-man hand hauled dredges are used on all British oyster beds, although a hand operated winch of a very simple type is used in the river Fal, from rowing boats, and in this way the width of the scythe of the dredge can be increased to 3 feet from the normal 2 ft. 3 in.

Power-operated dredges have been used for many years in the Netherlands and also in America but have not been generally adopted in France. It must be remembered that the conditions under which these large dredges have been employed have no counterpart in England except perhaps at Whitstable. The Dutch and American oyster beds are extensive and situated in open waters where it is easy to manoeuvre comparatively large vessels. Further the bottoms are for the most part hard and shelly and well suited to withstand the adverse effects of heavy dredges. Many of the British beds lie in narrow somewhat

muddy creeks in which it is impossible to manoeuvre anything larger than a small launch and, indeed, some layings have not sufficient depth of water over them at low water of spring tides for motor vessels. The bottom in most of the creeks of Essex and Kent, and on the up-river layings in the Cornish estuaries, consists of mud with a small proportion of sand and variable quantities of shell cultch. It has yet to be proved that heavy power-hauled dredges can be safely used on such tender soils and the caution of the English planter, with a small area of cultivated ground, is understandable. The majority of British Oyster Companies, however, hold the rights over extensive areas of grounds, measured in hundreds of acres, and in the major rivers of the east coast, the Colne, the Blackwater, the Crouch and the Roach and on the Whitstable Flats it is reasonably certain that large dredges, perhaps of modified design, could be safely used; indeed there is no other way in which the vast areas of semi-derelict ground can be cleared of slipper limpets and rubbish and brought into a fit condition for replanting.

The Fisheries Department of the Ministry of Agriculture and Fisheries has recently equipped a motor dredger with a winch and gallows of experimental design and work has begun, with large dredges of the Dutch pattern, on the reclamation of derelict beds in the River Roach. If this work is successful, and first results are promising, it is hoped that the major oyster companies in Essex, Kent and Cornwall can be persuaded to fit the necessary winches and gallows, or davits, to tackle the large areas of limpet infested ground that they now hold. It is recognised that this task may be beyond the powers of the companies, unaided, since no returns would be obtained from the work during the first two or three years, that is unless a market can be found at a remunerative price for Crepidula, and this now seems unlikely. Some Government assistance may be needed, perhaps in the form of grants to assist in meeting the rather high initial cost of the mechanical equipment needed, or in the form of grants per acre for clearing and replanting oyster bottoms approved as suitable for reclamation. Our recent studies of the rate of re-establishment of slipper limpets on cleared ground suggest that, provided the initial clearing is done effectively, it should be possible to maintain the ground reasonably free from limpets by normal dredging, particularly if the system of clearing all grounds completely of oysters, and to a large extent of cultch, in rotation, is adopted. This implies culling the catch ashore, rather than on board as is now the usual practice, but this would in many ways be a desirable development as it would enable the cold and often rather unpleasant task of culling to be carried on effectively indoors independent of weather conditions.

The American whelk tingle, Urosalpinx, is in many respects a more serious pest than Crepidula, although the need for more active measures of control where it is prevalent is not as clearly appreciated as it should be. There is no doubt that despite warnings (Cole 1942) Urosalpinx is becoming more prevalent. It is confined so far as we know to Essex and Kent, but does not apparently thrive as well on the Whitstable Flats, which have a hard sandy and shelly bottom, as it does in the Essex rivers. Much of the damage that this pest does unfortunately passes unrecognized, since the shells of small spat up to thumb nail size, which are its chief prey along with barnacles, are easily swept off the cultch and broken up. Further there is evidence that Urosalpinx destroys annually very large numbers of tiny spat within a few weeks of settlement. In the Essex rivers 75% would probably not be an over estimate of the percentage of spat destroyed during the first year of life. Although Urosalpinx will on occasion attack adult oysters, both English and Portuguese, it is a serious pest only of spat and brood oysters up to 2 years of age. Urosalpinx was apparently introduced into this country with American oysters about 30 years ago but was confused with the native drill *Ocenebra erinacea* at first (Orton, 1927); the latter now seems to be extinct on the East Coast following the severe frosts of 1940 and 1947 (see Orton, 1931 & Cole, 1942).

At present control of Urosalpinx comprises removal of adults and spawn during dredging. Small tingles drop through the dredge rings and very few are collected. This is an inadequate measure of control and Urosalpinx is increasing in Essex. Traps such as have apparently been used successfully in America (Galtsoff, Prytherch and Engle (1937) and Federighi (1931)) have been found to be ineffective in Essex and also in Canada (Adams, 1947). The density of drills on the traps is not significantly higher than on the surrounding bottom as tested by dredging. Special dredges, releasing oysters, but retaining drills, may have some application but it will be necessary to develop a special pattern applicable to British conditions.

It is found that Urosalpinx does not occur in any significant quantity on stretches of clean muddy bottom without a top layer of cultch and, generally speaking, derelict grounds over-run with Crepidula—the "mud and limpets" of the Essex dredgermen—carry few tingles. The conditions that seem to favour Urosalpinx occur also on well cultivated creek layings. It is possible that by cultivating intensively patches of ground, surrounded by broad strips of clean mud, the migration into the cultivated areas of tingles from adjoining grounds might be prevented. Another possible method of control that is being investigated is the multiplication of final hosts of certain trematode parasites which cause castration.

This pest presents an intractable problem and it may well be that the most effective method of control will prove to be intensive dredging with special equipment during the early summer months when the drills are spawning. At this time a very high proportion of females is collected by the dredge (Cole, 1942), possibly due to the ease with which the male is detached from the cultch compared with the female,

resulting in the loss of males when the cultch is disturbed by the dredge. Spawn is usually deposited on cultch or other objects large enough to be retained by the dredge and intensive dredging of heavily infested ground during the period between spawning and hatching of the egg-capsules will always be an important measure of control.

4. Disease.

In the years 1920—21 there occurred in Europe a widespread and devastating mortality among oysters. The losses were exceptionally severe throughout Britain but more especially in Essex and Kent. A thorough investigation was made by ORTON (1924), who however suffered from the inevitable handicap of starting his investigations when the mortality was already on the decline. No causative organism was discovered but it was proved that the popular belief that the mortality was due to the dumping of unwanted explosives was without foundation. It has recently been suggested by GAARDER and ALVSAKER (1941) that the losses were due to exceptionally unfavourable environmental conditions persisting over several years, but this explanation cannot be accepted by anyone with memories of the vast quantities of dead oysters which appeared with relative suddenness on most British beds. The effect of this great mortality is evident in the returns from all British fisheries (see Tables 2 and 3) and the industry has never recovered the lost ground. Some recovery took place in the latter half of the inter-war period but this was more than wiped out, at least in the east, by the effects of the severe winters of 1940 and 1947. There is always the fear that a similar mortality, unheralded and equally devastating, may reappear on British beds and the knowledge that somewhat similar unexplained epidemics have occurred in Australia (ROUGHLEY, 1926) and Canada (NEEDLER, 1941) does not make for confidence. The devastated beds in Canada were however repopulated by apparently resistant strains and something of the sort may have occurred on British beds, since slightly abnormal losses are still occasionally experienced which are not easily explained except as the result of mild epidemics. The shell disease which is so prevalent in the Netherlands has never appeared in this country although Dutch oysters are regularly imported. They come, however, as ware oysters to be sold direct for consumption and are not now usually laid down on English beds.

5. Pollution.

The advance of industrialization and the spread of housing estates, accompanied as they are by increasing industrial and sewage pollution, have made it impossible to continue oyster culture on certain beds which were still productive at the beginning of the century. The spread of industry is particularly harmful in that it provides new sources of work to inshore fishermen, often at more remunerative rates. In this category we must include dockyards, both civil and naval. The once flourishing oyster beds in the Tamar at Saltash, Plymouth, have disappeared during the last 30 years, partly as a direct result of dredging to deepen the river for naval craft, and partly following great expansion of activity in the dockyards with accompanying pollution, but also by the absorption of the inshore fishermen into the industrial community. Some suitable oyster ground remains but the few inshore fishermen left are no longer interested in oyster dredging. In the neighbourhood of Portsmouth the position is much the same and the formerly much used beds in the creeks around Hayling Island ceased production after the 1914—18 war. The south coast oyster beds generally have suffered severely from the increasing sewage pollution which, combined with the prevalence of slipper limpets and the conversion of fishing ports into holiday centres, has resulted in the abandonment of once productive fisheries at Emsworth, Bosham, Chichester and Poole. There is now no major oyster fishery on the south coast east of Devon, the River Yealm, a few miles east of Plymouth, being the first. This should be compared with BULSTRODE's 1896 list of:—Southwick, Shoreham, Bosham (all in Sussex), Hayling Island, Emsworth Creek, Wooton Creek, Medina River, Hamble River, Beaulieu River (in Hampshire, including the Isle of Wight) and Poole and Wyke Regis (Dorset). Some of these fisheries are still capable of restoration—industrialization and housing development have not proceeded so far as to make them unsuitable for oysters—but in practically all cases provision would have to be made for the cleansing of the oysters from sewage pollution.

Sewage pollution is increasing and there is no doubt that the proportion of the population served by water carriage systems will rise steadily during the next ten years as the construction of new plants becomes possible. Unfortunately there is still a tendency on the part of coastal authorities to regard the discharge of crude sewage into estuarine waters as a reasonable practice and this is a matter which, in the interests of fisheries generally and shell fisheries in particular, should receive attention at the highest levels. The substitution of full treatment for crude discharge would bring about a positive improvement in the conditions of many estuaries and would help to redress the adverse effects of extended housing development. The sterilization of sewage is again receiving attention but most suggested methods would result in the discharge of a toxic effluent in some ways more dangerous to shellfish than the untreated sewage.

Fortunately there are still estuaries and inlets free from serious contamination in the remoter parts of East Anglia and the South West, and present-day planning powers seem to be sufficient to enable the fishery interests to resist any developments calculated to damage their interests.

The purification of oysters from sewage pollution has been successfully dealt with at Brightlingsea, Essex, by adapting the Conway technique to the

special needs of oysters. The principal adaptations are the slight warming of the water during the winter months to increase the rate of filtration by the oysters and a special hosing device to overcome the difficulty encountered in cleansing externally flattened instead of rounded shellfish. Unfortunately while this cleansing process seems to meet the needs of the planters of Portuguese oysters and is unassailable bacteriologically, there is an ineradicable prejudice against any process using chlorine, which has prevented the extension of this system to fisheries producing high quality natives. It is alleged that oysters are affected by the process, by the warming of the water, and that they taste of chlorine. Despite careful tests none of these alleged defects in the process have been substantiated; nevertheless the prejudice is no less strong now than it was 10 years ago and it would be unrealistic not to recognize its importance. The result has been the private development of an alternative method of purification based on a closed water system sterilized by the addition of ozone from a proprietary ozonizer. The system has not received official approval and cannot be used to cleanse oysters taken from a fishery officially closed on Public Health grounds under statutory powers, nevertheless a very substantial proportion of the oysters marketed in this country pass through plants of this type.

Such controlled bacteriological tests of the oysters passing through these plants, and physiological tests of functioning among the shellfish undergoing treatment, as have been made independently have not always been satisfactory and it is freely admitted that heavy losses may occur as the result of slight over-dosing with ozone. The lack of provision for slight warming of the water during very cold weather, or alternatively for extending the period of purification, does not inspire confidence in the functioning of these plants and the likelihood of their receiving official sanction is rather remote. A thorough investigation of the value of ozone in the cleansing of oysters is however overdue, since the commercial development of these small scale cleansing plants demonstrates the need for a cheap and effective system to deal with the output of an individual firm. Although the objections to the private operation of cleansing plants by oyster planters still remain as stated by DODGSON (1928), the provision of an adequate system of inspection and testing of private plants is by no means impossible. Where isolated fisheries occur, controlled by a single firm, and there are several of these, it is difficult to see how any independently controlled cleansing plant could be provided and in such cases the onus for the delivery of a clean product must rest on the oyster planters.

There is an urgent need for the provision of a simple, cheap and reliable method of purification for use on oyster fisheries where, although the risk of sewage contamination of oysters is small, it cannot be completely eliminated. This may be said to be the general condition of the majority of British beds not already closed on Public Health grounds. Sewage is present in many estuaries but is usually discharged many miles from the nearest beds, and is greatly diluted. Public Health authorities are naturally reluctant to give a "clean bill" to such fisheries and the provision of some extra safeguard in the form of a simple method of treatment would materially assist sales. Such a process must be cheap to run and low in capital cost, and experience with systems involving chlorination of water suggests that prejudice against them will not be easily overcome, and that some other method is required.

There is a good deal of evidence for the view that such slight pollution may be readily eliminated by the proper use of efficient storage pits, excavated on the shore out of reach of the tide, to a depth of about 2 feet, 6 inches, and filled by pumps at high water. Oysters retained in such pits for four days have been found to get rid of all contamination even at temperatures as low as 5° C. By siting the pits as far away from actual sewer outlets as is reasonably practicable, and by filling only at high water, recontamination with sewage organisms may be avoided. Using a series of such pits, in regular sequence, successive batches of oysters may be prepared for market. Under such conditions oysters remain healthy almost indefinitely during cool weather; the water may be changed weekly if desired, but a further two days should be allowed to elapse after renewal before any oysters are removed for market. The suggested period of cleansing—4 days—appears to offer a sufficient margin of safety even during the coldest weather when the rate of filtration of water by the oysters is reduced to a minimum. It is important to realise in assessing the performance of oysters in such cleansing pits, that the filtration of water by oysters does not cease at low temperatures but is merely gradually reduced as water temperature falls to freezing point. The final hosing of oysters before dispatch to market should be done either with fresh water, or if this is considered undesirable, with sea water drawn from a separate concrete tank in which it has been allowed to stand for several days; the partitioning of this tank would ensure a continuous supply.

I have dealt above in some detail with the problem of cleansing cheaply and simply, in a manner unobjectionable to the trade or public, of oysters subject to a risk of slight sewage pollution, because I regard the provision of such cheap and efficient cleansing facilities as a matter of great urgency. Without such plants, preferably independently operated, to give confidence to the consuming public, a large expansion of the British oyster industry is hardly possible.

Marketing.

It is impossible to give a comprehensive survey of the difficulties facing the British oyster planters without making some reference to problems of marketing, particularly as related to the importation of foreign oysters.

At present most firms market four grades of flat

oysters (*Ostrea edulis*) which differ widely in price; representative figures for the four grades during the 1948/49 season were 60/-, 52/-, 42/- and 30/- per 100. It may be said with some truth that all but the lowest grade were destined for what may be called the luxury market, comprising large restaurants, high grade hotels, oyster bars in large cities particularly London, Clubs and banquets. Only third and fourth grade oysters would be offered for sale in substantial quantities in retail shops and very few of the best grade oysters would be sold outside London and a few other large cities. The majority of the public do not see a flat oyster from one year's end to another but may eat small quantities of Portuguese at the popular holiday resorts.

The very highest grade genuine 'Native' oysters, i. e., those spatted and reared in Essex or Kent, at the moment very scarce, realise considerably higher prices, for example the Colne Fishery Board, in its accounts for the year 1947/48, claims to have sold 153,247 oysters at an average price of 89/- per 100. These oysters have a very high and jealously-guarded reputation which is generally considered to be thoroughly deserved and the stocks of natives of the particular type associated with the River Colne and Pyefleet have been kept pure from time immemorial; nevertheless it must be obvious to everyone that the market for oysters at such prices is severely limited and likely to remain so. There are one or two more beds on the Essex coast on which 'Natives' are cultivated exclusively, and to these planters and to the Colne Fishery Board the maintenance of very high prices is a matter of great interest, especially since genuine 'Natives' of good quality are exceedingly scarce. Since the majority of British oyster fisheries are very seriously understocked and there is no rich source of British brood oysters for replanting, the importation of foreign flat oysters for restocking cannot be avoided if the British beds are to recover. Brood oysters (flat) could only be safely obtained from France or Norway because of risks of disease or pest infestation from other sources. Spat might be available in fair quantities from Norway but the results of trials in progress in the Menai Straits are not encouraging; the spat is so small, light and thin-shelled on arrival that it needs protection both from strong tides, which may sweep spat away from the beds on which it has been laid, and particularly from American tingles. It is doubtful indeed whether any use can be made of this Norwegian spat until the American tingle problem has been solved, as the thin shells offer practically no protection and losses under present conditions would be very severe. We are therefore thrown back upon the importation of French brood oysters; these have done exceptionally well in the past in Devon and Cornwall and meet the requirements of all but the most select trade which still clings to the genuine 'Native'. On the east coast, experience with Brittany oysters has not been so happy, losses have frequently been severe and there is a very general complaint that they do not fatten so well as the native; this complaint has not yet been substantiated by controlled experiments. On the other hand there is little doubt that French oysters breed successfully on all British beds, and for restocking purposes I regard them as quite satisfactory. The fear that, by the introduction of French oysters for breeding on grounds formerly reserved for natives, the fine qualities of the latter will be diminished, is probably unfounded, since the produce of these imported oysters and the native stocks is likely to assume the characteristics of the locality. The subjects of race variation in oysters and resistance to frost and low salinity are however practically closed books and it would not be advisable to be too dogmatic.

It is doubtful whether the grounds in the River Colne and in the other haunts of the true native will recover without extensive restocking, and it appears that, to survive, the relaying of French oysters on these grounds too is now a necessity. This necessitates a revolutionary change of attitude, since no foreign oysters have ever been laid on these grounds, but the total production of the Colne Fishery Board, which controls probably about 1,000 acres of oyster bottom in the River Colne and Pyefleet, only amounted to 153,247 in 1947/48 and the immediate prospects are no brighter. Despite spectacular recoveries in the past, when stocks were low, it is not believed that this is possible now as there is a new factor tending to reduce the chances of a successful spatfall, viz. the universal prevalence of Crepidula on the east coast beds.

To guard against the possibility that the desirable characteristics of the true native may be lost, genetical research should be initiated as soon as possible with the aim of selecting and fixing quick growing, frost resistant strains of superior marketable quality.

Conclusion.

Some of the major problems of the oyster industry enumerated above, can be solved by the trade unaided. Among these we may include the necessity for substantial restocking with French oysters, and the achievement of a widespread increase in the intensity of cultivation of the beds. Others require the close co-operation of the scientist and the oyster planter. These include the development, and adoption where practicable, of mechanical methods of dredging and handling oysters; the employment of these methods in the reclamation of derelict ground and the re-introduction of the use of wintering pits so to avoid severe losses during hard winters on the east coast. A few, such as the elucidation of the causes of spatfall failures, the development of artificial collectors, the evolution of special methods of controlling pests and the development of new cleansing techniques, require extended research. To facilitate this research the Fisheries Department of the Ministry of Agriculture and Fisheries has recently established a new laboratory at Burnham-on-Crouch, Essex, in the centre of the oyster producing area, where the

major problems facing the trade are already receiving attention. This station will, in due course, undertake research on other inshore species of importance but at present attention is concentrated on oyster problems. For this purpose the station has been equipped with a motor-dredger and controls oyster layings of a representative character in the Rivers Crouch, Roach and Blackwater which together provide suitable conditions for an attack on all the major problems. The first results are now coming from this new venture and we may look forward confidently to further discoveries and developments of great interest to all associated with the oyster industry.

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