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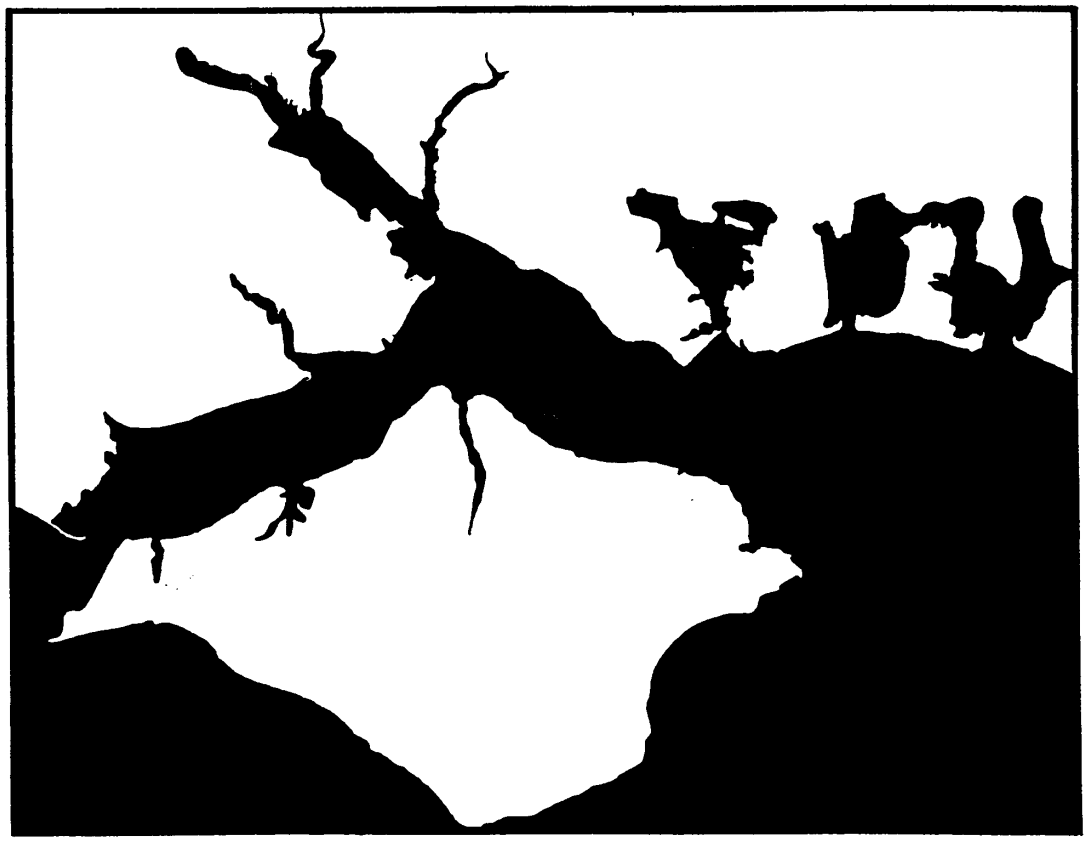
DIRECTORATE OF FISHERIES RESEARCH

A Review of Development of the Solent Oyster Fishery, 1972-80



D. Key and P. E. Davidson

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Laboratory Leaflet Number 52

A REVIEW OF DEVELOPMENT OF THE SOLENT OYSTER FISHERY, 1972-80

by D. Key and P. E. Davidson

1. INTRODUCTION

Until the 1970s the Solent had not featured significantly as part of our national fishery for native oysters (Ostrea edulis) for a great many years. An extensive report prepared in 1865 by the Commissioners appointed to enquire into the sea fisheries of the United Kingdom made no mention of an oyster fishery in the Solent although references were made to other fisheries now extinct e.g. at Shoreham, Brighton and Weymouth.

However, in an 1876 report prepared by a Parliamentary Select Committee an account of oyster growing activities in the Solent area was given by Captain Edward Johnson who had charge of the Isle of Wight Oyster Fisheries from 1866. This Company bred oysters in ponds constructed on the Newtown and Medina rivers on the north shore of the Isle of Wight and also bought oysters for relaying from fishermen working the public grounds in the Solent. Captain Johnson stated that between 1866 and 1876 there was a spatfall every year in the Solent and in 1862 and 1864 large quantities of oysters could be taken, "four or five bushels before breakfast". He also stated that many of the grounds were in his opinion overworked, oysters, spat and shell cultch having been taken off the grounds for relaying elsewhere. Mention is also made of the devastation of some grounds from the effects of "borers" or oyster drills. In some years 90% of the spatfall from the previous year was found to have been killed.

Some further references to the taking of oysters from the Solent are made in the Annual Report on Sea Fisheries, England and Wales, 1910-38 (Anon.,1912-40). These reports give details about the source of oysters used for relaying on the Emsworth and Bosham several order fisheries; a summary is given in Table 1.

In the period 1910-18 the Solent was supplying stocks to the local Bosham Fishery. The quantities were relatively small as compared with those purchased from Essex 1915-17 and it may be concluded that supplies from the Solent were limited at this time. Following the mass mortality of oysters throughout Europe in the early 1920s it appears that all the oyster fisheries on this part of the south coast collapsed and no recovery was evident up to 1938. No substantial landings were recorded from any Solent area from the 1920s to the 1970s. In the early 1970s it became apparent that Stanswood Bay in the Solent had received a considerable natural settlement of oysters. Since that time, grounds in the Solent and adjoining harbours have developed into extensive natural oyster producing areas with recent recorded annual landings in the region of 650-850 tonnes, worth approximately £1 million at first sale by 1979-80. This development has resulted in a very

significant increase in the size of the inshore fishing fleet in the Solent area and has given considerable impetus to the development of the English oyster industry as a whole.

Table 1 Numbers and source of oysters relaid on the Bosham and Emsworth several order fisheries 1910-1938 (from Annual Report on Sea Fisheries, England and Wales, 1910-1938) (Anon, 1912-1940)

Year	Bosham Fishery		Emsworth Fishery	
	Quantity relaid (000)	Source	Quantity relaid (000)	Source
1910	0	-	4	Emsworth
1911	995	Solent and Langston	14	Hayling
			12	Emsworth
1912	1 210	Solent and Langston	15	Emsworth
1913	989	Solent and Langston	50	Emsworth
1914	609	Solent and Langston		
1915	544	Langston	No data	
	269	Solent, Thorney and Langston		
	7 311	Essex		
1916	420	Solent and Langston	40	Emsworth
	1 116	Essex		
1917	3 104	Essex and Solent		
1918				
	No data		No data	
1922				
1923				
1924				
1925	No oysters relaid			
	Fishery terminated 1934			
1934			No fishing took place on the fishery	
1938				

It was appreciated from the outset that danger to this fishery from over-exploitation of the stocks could occur and surveys of the Solent oyster grounds have been carried out by Ministry scientists each year since 1972 and reports have been made on the level of the stocks found (Key, 1972, 1974, 1975, 1976, 1977, 1978). The authorities with Sea Fishery Committee responsibilities for the area, i.e. The British Transport Docks Board (Southampton Water and Stanswood Bay), the Southern Sea Fisheries Committee and the Sussex Sea Fisheries Committee (Figure 1), have made modifications to the byelaws controlling fishing activities including reductions in the length of fishing season and, in 1976, an increase from 50 mm to 63 mm in the minimum size of oysters legally permitted to be removed from the fishery.

The purposes of this report are to review the information which has been obtained concerning this fishery in the past few years, to draw attention to the major problems in achieving a rational management of the stock, and above all, to highlight the constant possibility of overexploitation.

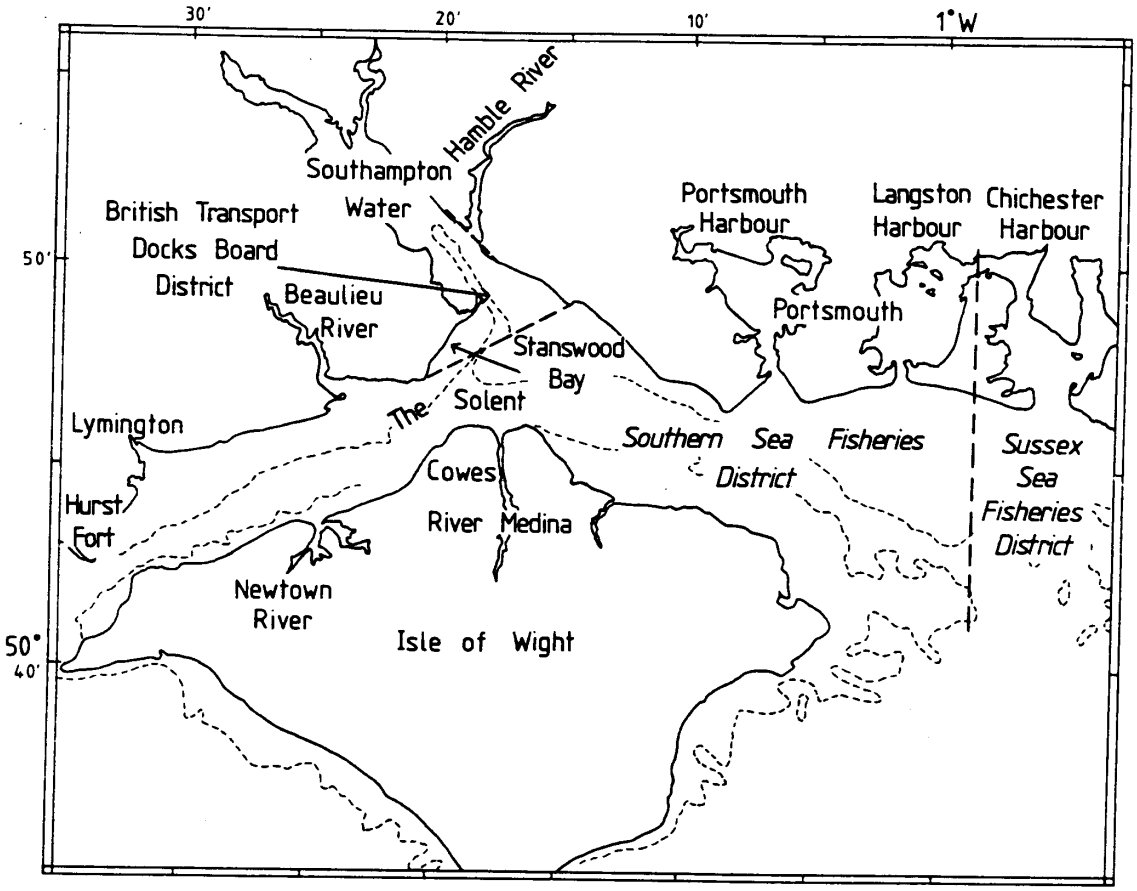

Figure 1 Positions of the boundaries of the Sea Fisheries Committee districts in the Solent area.

2. BACKGROUND TO OYSTER PRODUCTION IN ENGLAND

At the beginning of the 19th Century the coasts of the British Isles were surrounded by fishing grounds containing underexploited stocks of native oysters, both in estuaries and in deeper waters further offshore. In a few decades this situation was changed with the advent of easier transport of fish to wider markets on the new railway systems and consequent development of more intensive fishing. By 1860 considerable concern was being expressed by both the industry and Government regarding the depletion of stocks in most fisheries. A parliamentary committee was appointed and an extensive enquiry was carried out to investigate the situation. This resulted in new and far reaching legislation in 1868, including governmental power to remove or limit public rights of fishing by the granting of Several and Regulating Orders for oyster and mussel fishing. These measures did not result in any marked improvement in the situation and output from the oyster fisheries continued to dwindle.

Over the past forty years considerable research effort has been directed into the study of methods of revitalising the oyster industry and increasing stocks by both natural and artificial means. Some considerable successes have been achieved but the large, stable industry which has for so long been sought has not yet materialised.

Supplies of seed oysters in quantity are an essential basis for the growth of the oyster industry in this country. Hatcheries producing seed oysters by artificial means have been developed, initially by Ministry of Agriculture, Fisheries and Food scientists, to the stage where many of the problems of large-scale production

have been solved and there is little doubt that vast numbers of young oysters will be produced economically from commercially run hatcheries in the near future. Nonetheless, natural production of seed oysters in fisheries such as occur in the Solent will continue to play an important part in the redevelopment of many of the shellfish beds where the mature oysters are grown to market size.

For a successful settlement of spat to occur in natural conditions a number of factors must combine:

(i) sufficient parent stock must be available in the area to inject large quantities of larvae into the water system at a point where the majority will not be dispersed too widely by tidal currents and lost to the open sea during the course of their pelagic life;

(ii) water temperature must reach a sufficiently high level for the parent oysters to breed and this level must be maintained for the 7-14 day period necessary for the larvae to grow to the settlement stage;

(iii) adequate food must be available for the larvae during the period of their growth;

(iv) suitable settlement surfaces must be available in the area where the mature larvae are about to settle;

(v) conditions in the area of settlement must subsequently remain suitable for spat to survive (unsuitable conditions for survival may occur through physical or biological factors).

There is consequently a very large element of chance attached to obtaining regular natural settlements in U.K. waters, particularly as in many of our coastal regions water temperatures are not certain to reach a high enough level every year to enable the English native oyster to breed successfully.

3. THE SOLENT FISHERY

3.1 Recent development of the fishery

The reasons for the revival and development of the oyster fishery in the Solent in recent years are not entirely clear. There were importations of native oyster stocks from Brittany for relaying in 1958 in Newtown River on the Isle of Wight and Beaulieu River on the mainland (Figure 1). In Newtown River most of the oysters were lost due to unknown causes, before becoming marketable and a large proportion of the stocks in Beaulieu River died during the severe winter of 1962-63. However, the survivors produced a series of spatfalls in Beaulieu River during the following years and a substantial population was established. It is most likely that these stocks produced the larvae which resulted in the spatfalls in 1969 and later years which formed the nucleus of the population in Stanswood Bay. Thereafter, as the quantity of stock and the areas in which good spatfalls occur have increased, it has become more difficult to determine where the important breeding stocks are situated. Nonetheless, it seems significant that Stanswood Bay receives good spatfalls more consistently than any other ground in the Solent and the maintenance of high levels of parent stock in Beaulieu River probably contributes substantially to this continuity.

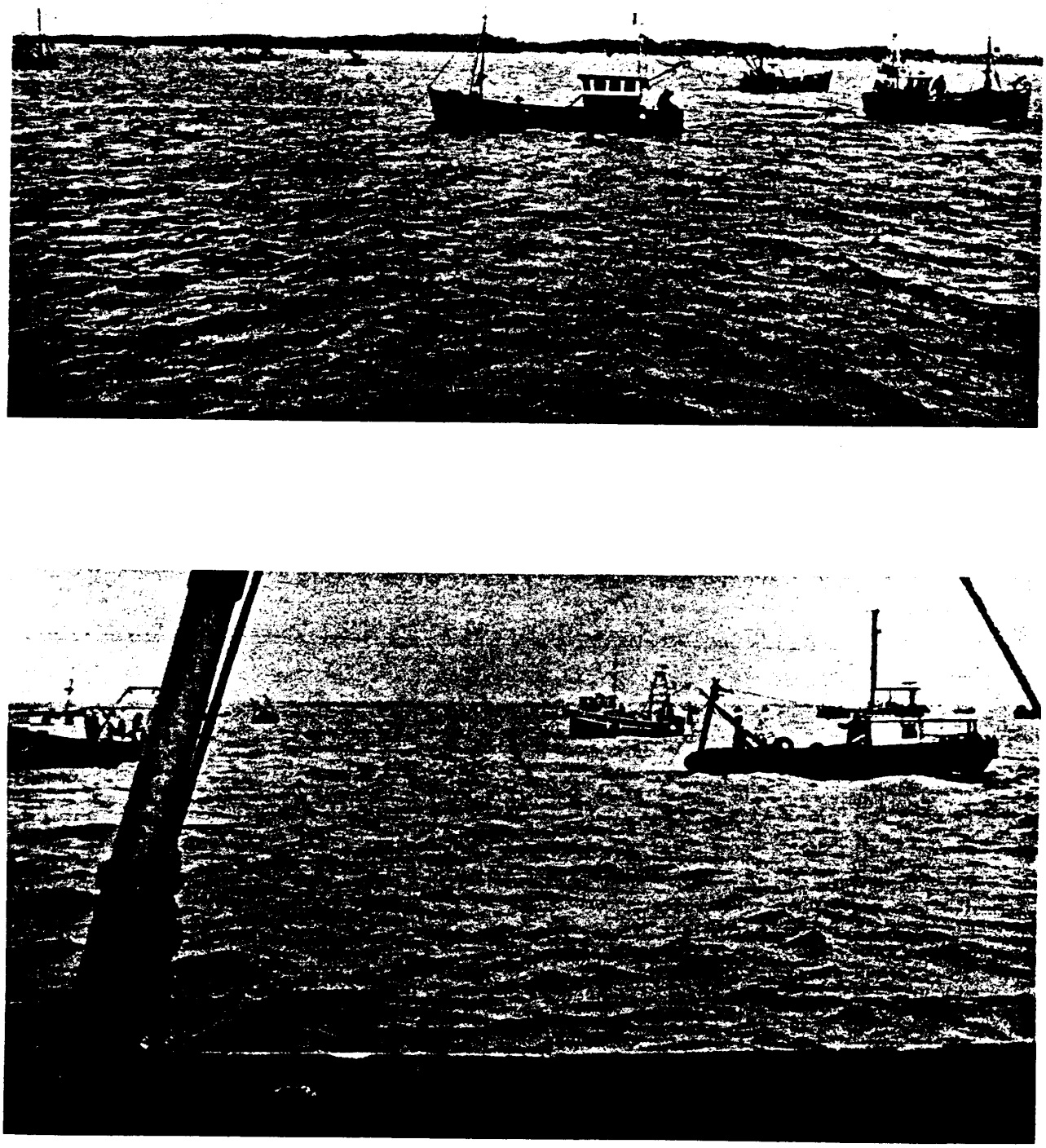

Figure 2 Oyster dredgers working the Calshot fishery, March 1980.

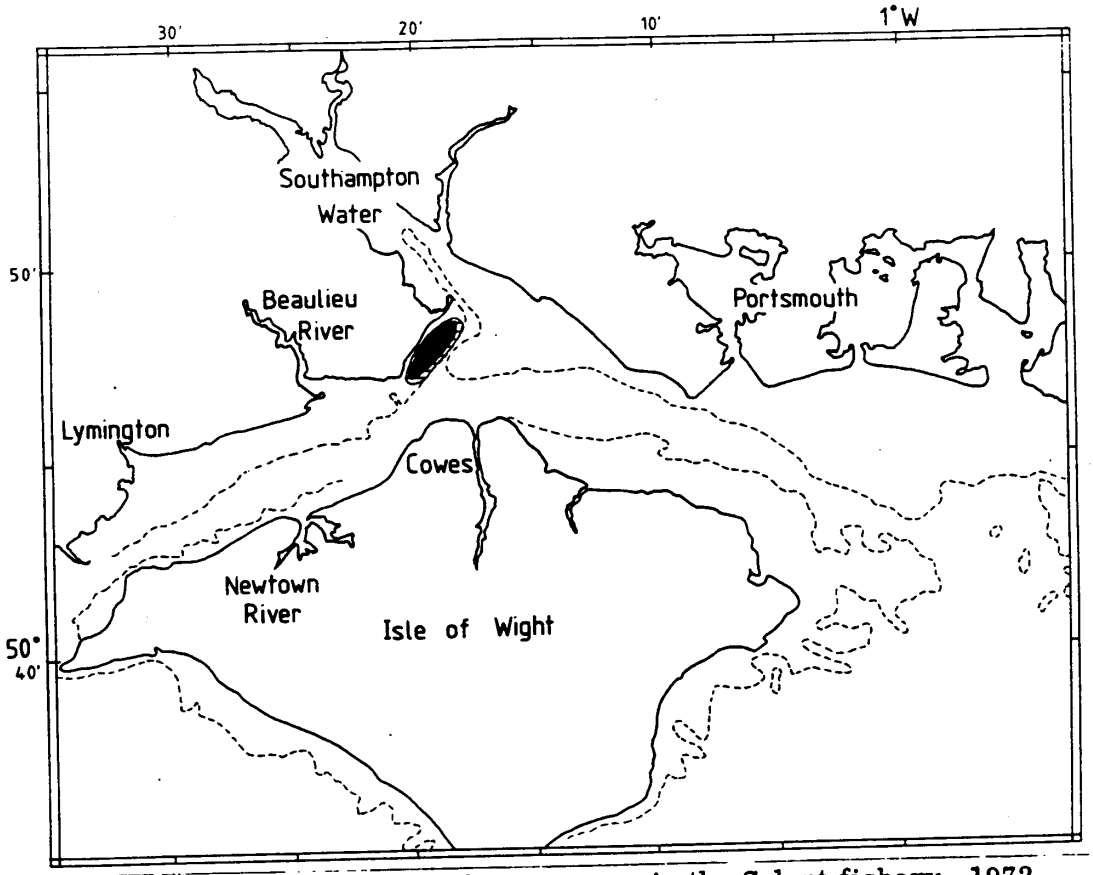

Figure 3 The main oyster producing areas in the Solent fishery, 1972. 1-15 oysters per dredge haul ⊜; greater than 15 oysters per dredge haul ●.

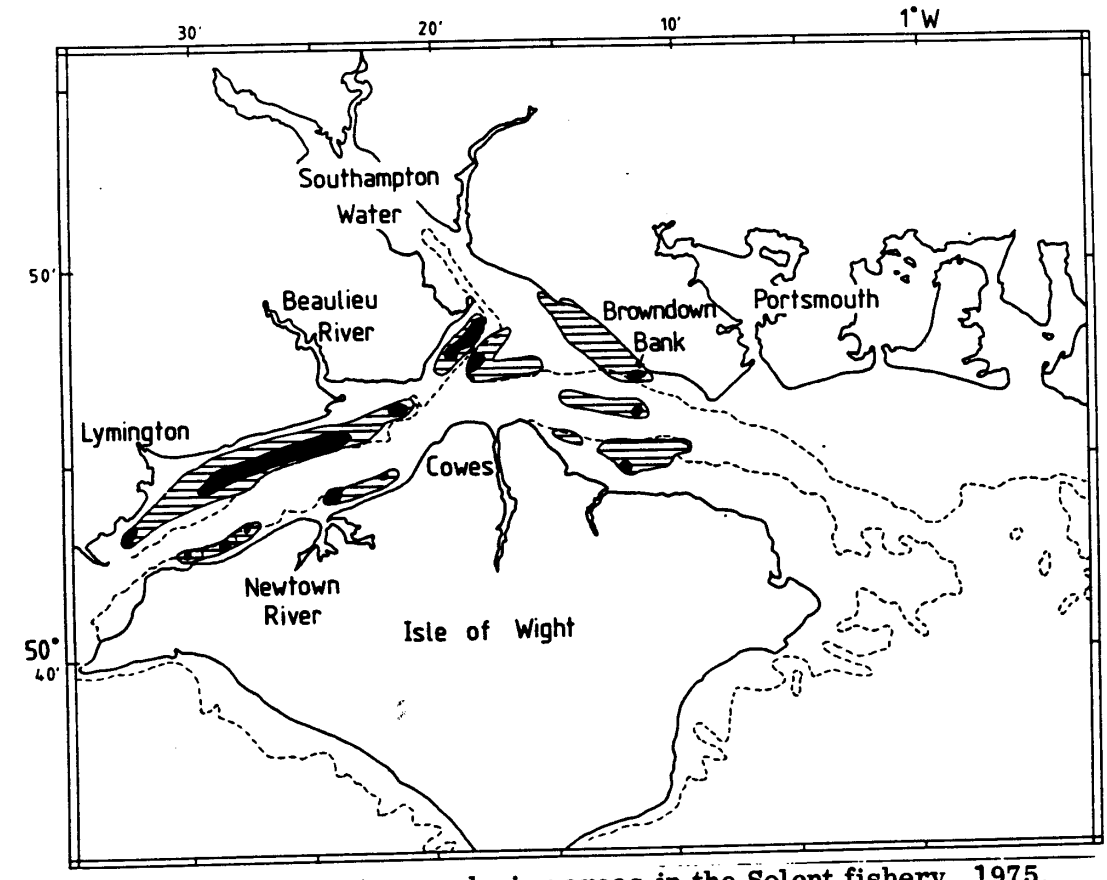

Figure 4 The main oyster producing areas in the Solent fishery, 1975. 1-15 oysters per dredge haul ⊜; greater than 15 oysters per dredge haul ●.

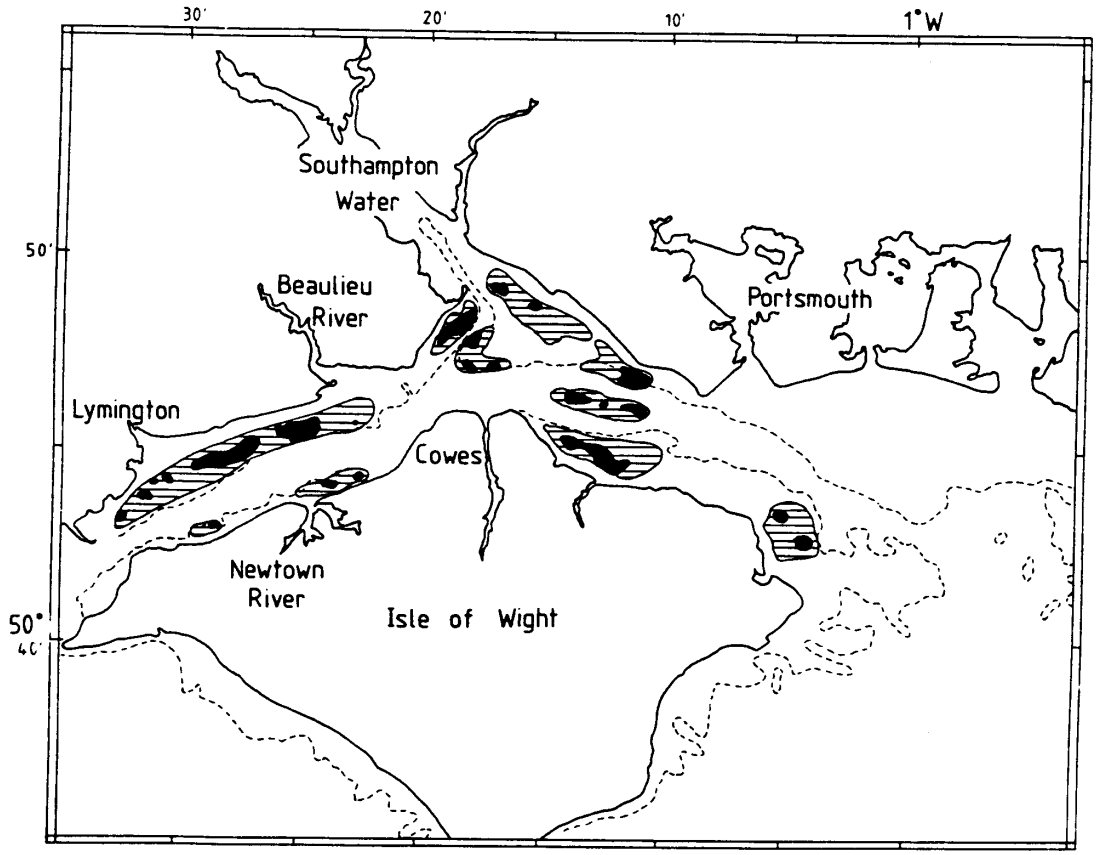

Figure 5 The main oyster producing areas in the Solent fishery, 1977. 1-15 oysters per dredge haul ; greater than 15 oysters per dredge haul .

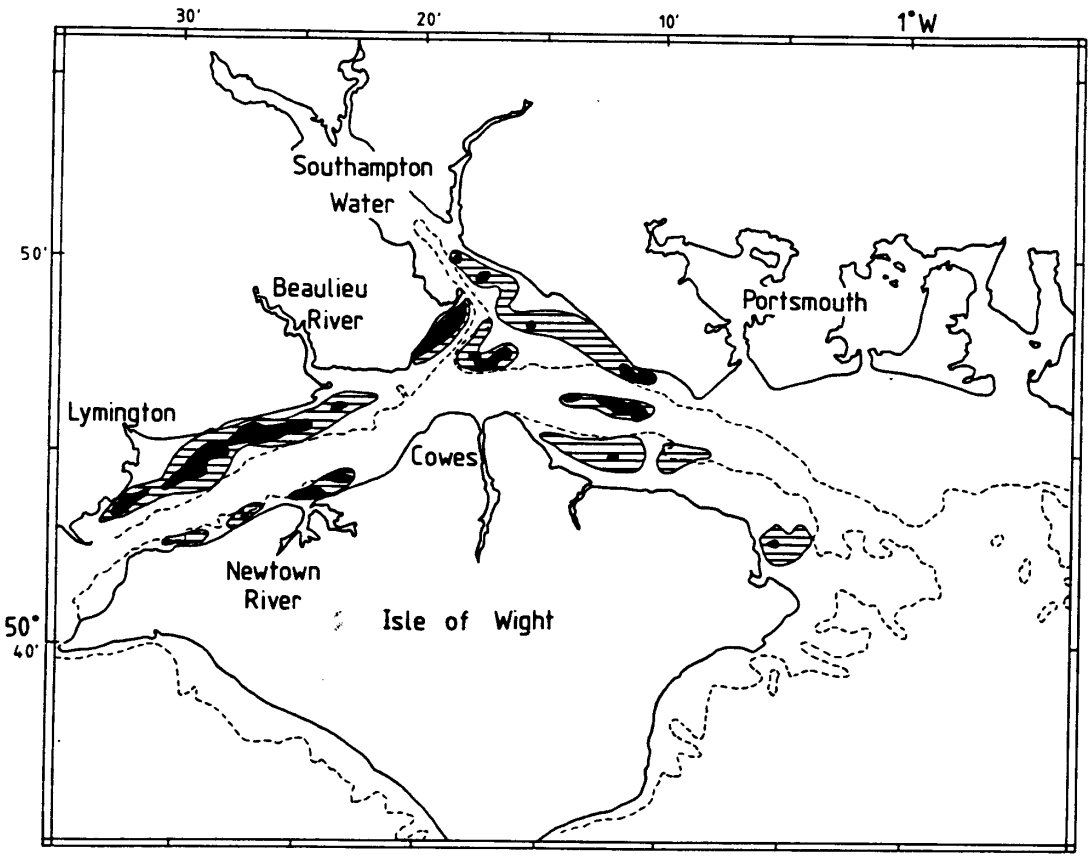

Figure 6 The main oyster producing areas in the Solent fishery, 1979. 1-15 oysters per dredge haul ; greater than 15 oysters per dredge haul .

The production of stock from more grounds over a wider area during these years has resulted in an increase in the size of the oyster fishing fleet. In 1972 there were approximately 40 full-time and part-time fishermen (17 boats) interested in joining the Stanswood Bay Fishermen's Cooperative. By 1978 some 450 vessels were involved in oyster fishing in the Solent, based between Weymouth and Chichester, with at least 700 men obtaining a substantial part of their earned income from this source (Figure 2). However, a proportion of these vessels are occupied with oyster dredging for only a relatively short period at the beginning of the dredging season; some will not fish for oysters throughout the winter but may dredge again for a limited period when the public ground on the Calshot Fishery opens in mid-March.

3.2 Distribution of oysters

The conditions in the Solent during the past few years have clearly favoured settlements of young oysters on a fairly regular basis. In the course of the annual surveys changes in the distribution of major concentrations of stock have been detected. Comparisons of oyster densities at intervals through the period 1972-79 (Figures 3-6) illustrate that while the original major settlement area for oysters in Stanswood Bay has been maintained in spite of extremely heavy dredging activity, other areas throughout the Solent have also become highly productive. In 1973 high concentrations of oysters (32 per square metre) were found in a small area off Lee-on-the-Solent (Browndown Bank) and lower concentrations were to be found over wide areas in the western Solent (Key, 1974). By 1975 it was clear that considerable settlements of spat were occurring in many areas. The warm summers of 1975 and 1976 probably assisted these recruitments (see Section 3.4).

Some of the factors controlling recruitments are extremely difficult to monitor, for example, whether adequate phytoplankton, which forms the food for the larvae, is present in the water when larvae are released, or whether unproductive areas of sea bed would be suitable for survival of spat. Surveys have therefore been concentrated on monitoring the distribution and relative levels of stock on the grounds from year to year by dredging. In one of the most productive areas (Stanswood Bay) periodic detailed examinations have been made by grabbing techniques.

3.3 Topography and bottom deposits caught by dredges

The Solent extends for approximately 20 miles along the south coast of England, protected to the south by the Isle of Wight (Figure 1). There is a relatively narrow entrance at the western end, near Hurst Fort and a complicated system of channels and shallow banks at the eastern end between the Isle of Wight, Portsmouth and the entrance to Southampton Water. Leading into the main part of the Solent, both from the mainland to the north and from the Isle of Wight to the south, are a number of rivers, notably Beaulieu River, Newtown River, Southampton Water and the harbours of Portsmouth, Langstone and Chichester. Figures 7 and 8 show the eastern and western Solent with the main types of bottom deposits caught by dredges and indicate the main channels and shallow water areas. The convenient division between these two parts occurs where a number of gas pipes and telephone and electric cables cross from the mainland to Egypt Point on the Isle of Wight. Fishing and anchoring is restricted in this area (delimited by pecked lines in the Figures). The area where concessions for commercial gravel extraction have been granted is also indicated.

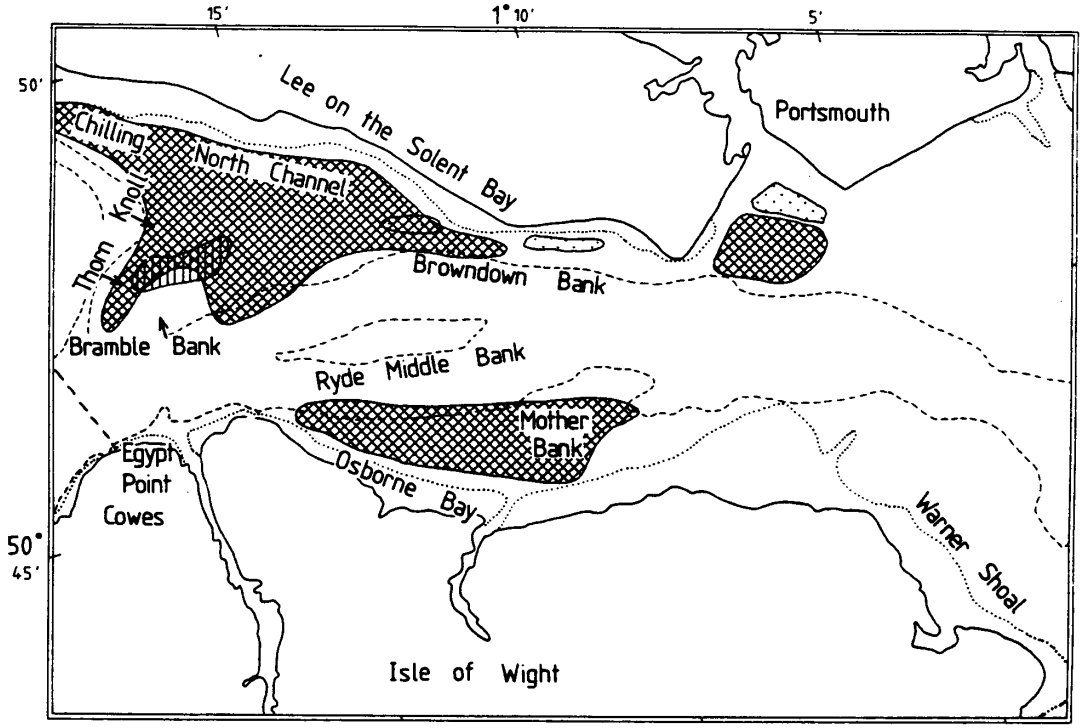

Figure 7 The eastern Solent showing positions of mud, sand and gravel deposits caught by dredges. Mud ; sand ; gravel .

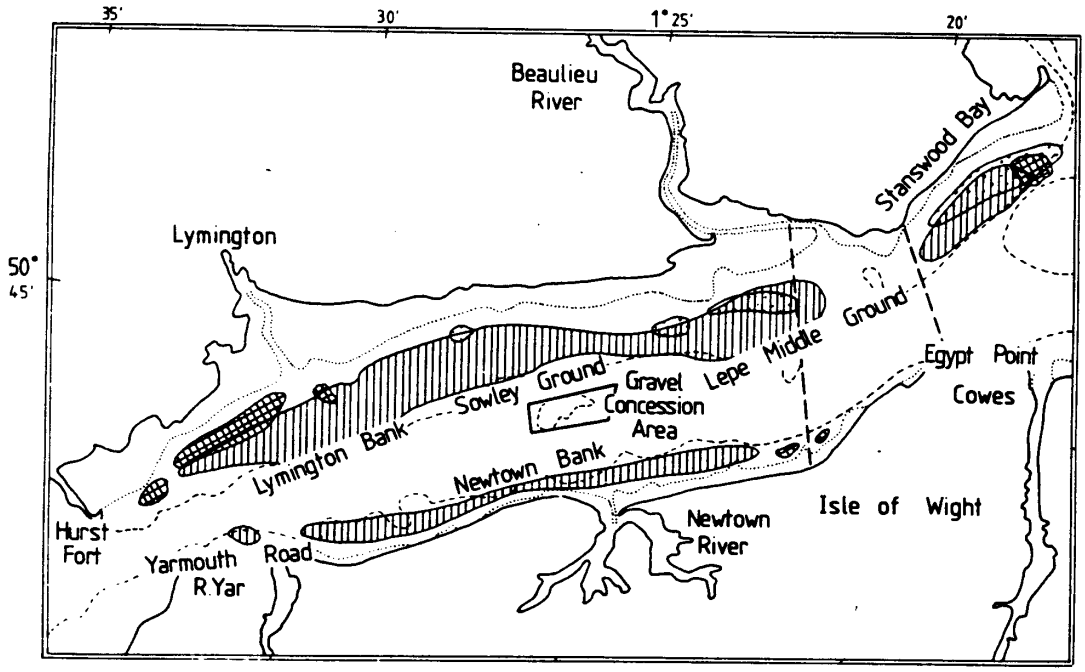

Figure 8 The western Solent and Stanswood Bay showing positions of mud, sand and gravel deposits caught by dredges. Mud ; sand ; gravel .

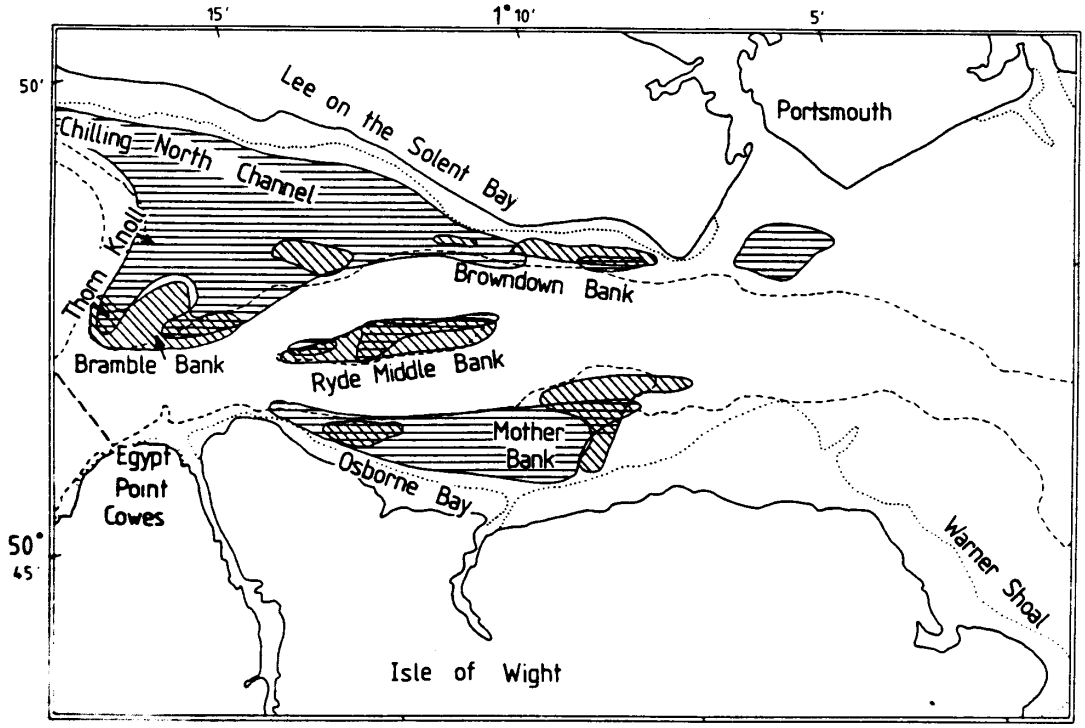

Figure 9 The eastern Solent showing positions of Crepidula banks and old oyster shell deposits caught by dredges. Crepidula ; oyster shell .

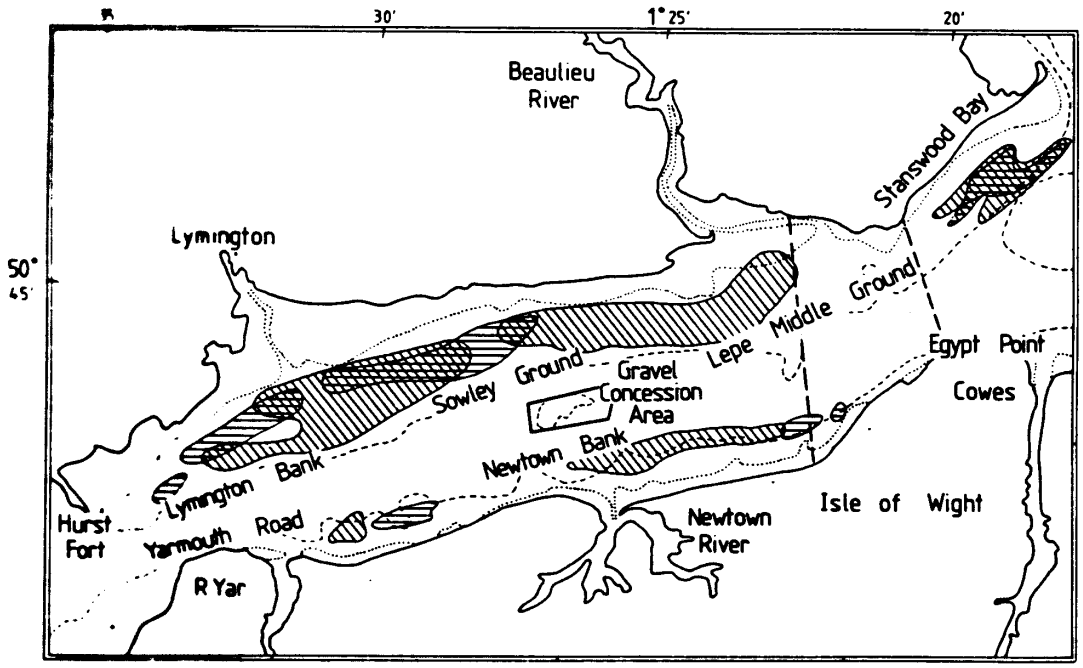

Figure 10 The western Solent and Stanswood Bay showing positions of Crepidula banks and old oyster shell deposits caught by dredges. Crepidula ; oyster shell .

Figures 9 and 10 show the distribution of the dominant shell materials recorded in each area of the sea bed during the series of dredge surveys for oysters from 1972 to 1978. From these results it can be seen that a very wide range of materials exist on the sea bed and that many of them are quite suitable for oysters to settle on. Oysters are commonly found on shells of live and dead oysters or slipper limpets and occasionally on other types of shellfish. Stones and gravel collect large numbers of spat in some areas. However, it is clear that there are quite large areas where suitable material exists but which the oyster larvae either do not reach or where conditions prove unsuitable for any large-scale settlement or subsequent spat survival. Patches of gravel near the entrance to Beaulieu River and in other areas where there are strong tides, can become unstable and in these circumstances it is to be expected that survival of small oyster spat would be poor. Less easily explained are areas of high slipper limpet density where few, if any, oysters have been found in the surveys. If conditions are suitable for the settlement and survival of slipper limpets it would be expected that oysters would also be able to settle and thrive. From this evidence it may be deduced that oyster larvae ready to settle are not evenly distributed in the water in the Solent but tend to be aggregated in specific areas on a fairly regular basis.

3.4 Water movements and temperatures

Both tidal movements and water temperatures have a profound effect on the success of recruitments of young oysters. The oyster larvae are discharged into the water when water temperatures reach about 18°C and develop further for a period of 7 to 14 days while being carried by the tides before settling to the sea bed to search for a clean surface on which to attach themselves. It is therefore evident that in areas where water exchanges and tidal excursion are limited, conditions will favour the retention of larvae in the general area of the parent stock. Where large exchanges of water occur it is less likely that larvae would be retained in the same area for many days.

In many of the channels throughout the Solent strong tides occur, 2 knots at neap tides and $3\frac{1}{2}$ knots on spring tides being commonly found. At the narrow western entrance, not only are ebb tides travelling in excess of $4\frac{1}{2}$ knots recorded, but also there are areas of even faster flow where turbulence occurs. However, in the shallower regions tides are not always strong and in considerable areas such as the banks off Lymington and Osborne Bay, relatively slack tidal flow prevails. Over many of the inshore banks large eddies tend to recirculate water during part of the tidal cycle. Reference is made to these conditions in the nautical almanacs. Work carried out by the MAFF Fisheries Laboratory, Lowestoft has produced further details of these conditions. Talbot and Talbot (1976) describe their mathematical model of the Solent following investigations with moored current meters and dye releases. This model was produced with particular regard to the dispersal of oyster larvae in the central part of the Solent and used a grid size (1 km) which is too large to permit detailed representation of some parts of the coastline. In particular the narrow channel between Hurst Fort and the Isle of Wight is not accurately reproduced and the model does not give a detailed prediction of the water movements in this area. However the predictions for mid-ebb tide, Figure 11, do correspond reasonably well with other information and give a useful idea of the water movements over the area as a whole. In particular many of the known oyster producing areas can be identified as having relatively slow or recirculating water movements, e.g. Stanswood Bay, Sowley Ground, Osborne Bay and Warner Shoal.

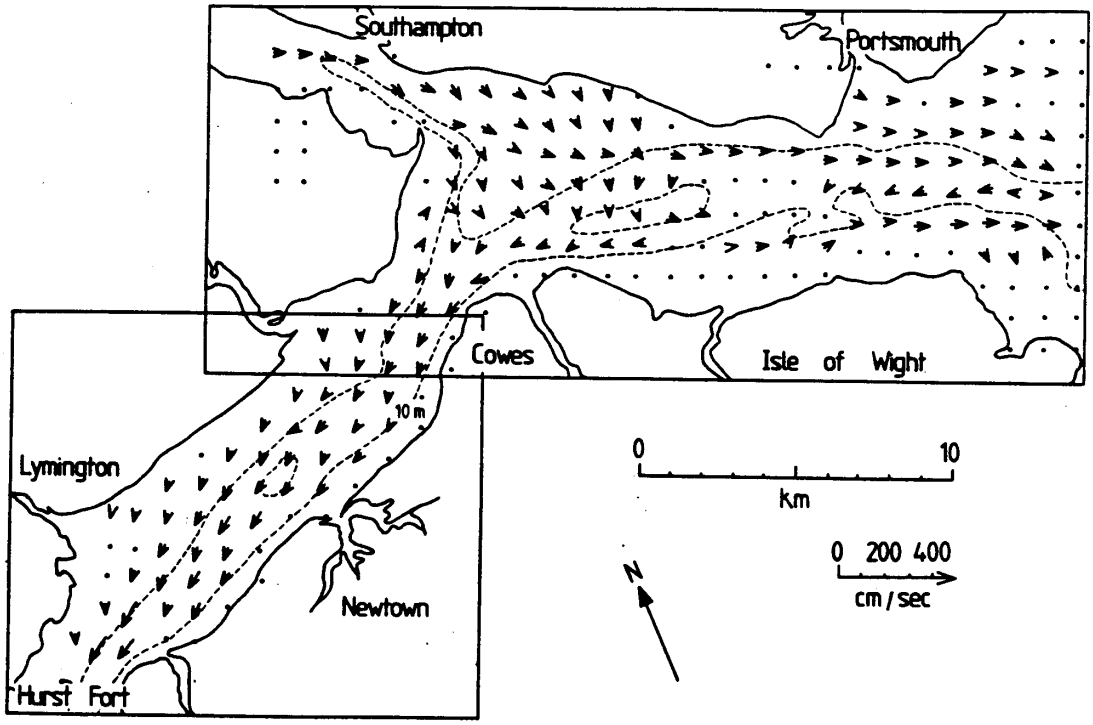

Figure 11 Water flow directions and velocities predicted for the Solent at about mid-ebb tide (after Talbot and Talbot, 1976).

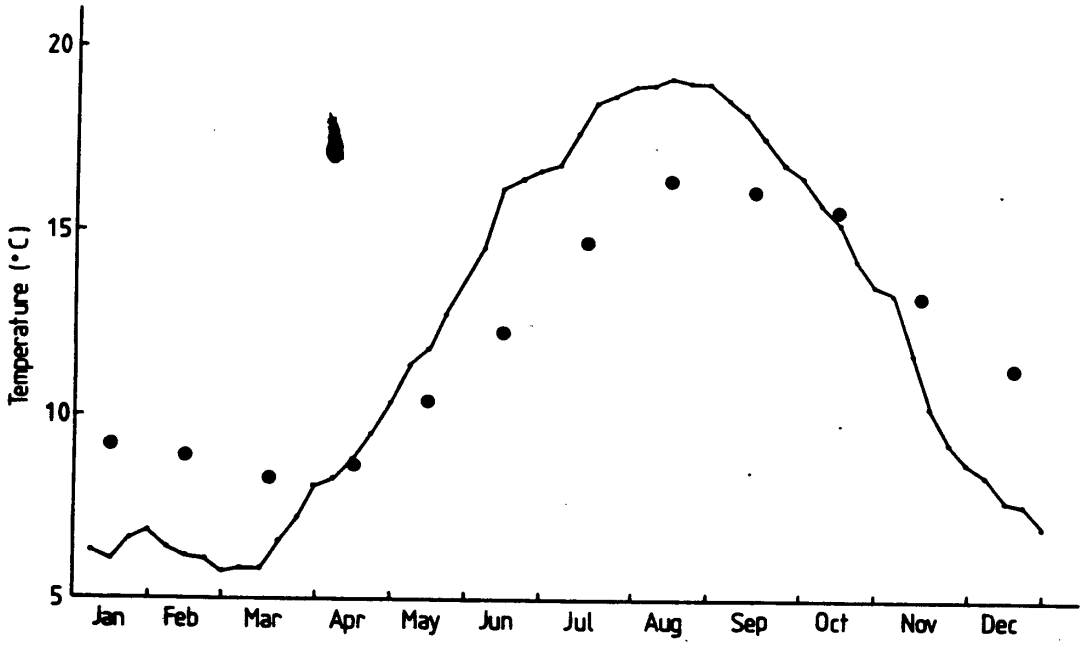

Figure 12 Mean weekly water temperatures from Calshot Jetty for the years 1968-73 (•——•), and monthly mean water temperatures for the English Channel for the years 1968-73 (●). (Source of Calshot Jetty data: British Transport Docks Board, personal communication. Source of English Channel data: ICES, Service Hydrographique, 1975-79.)

Water temperature records for the period 1968-79 inclusive shown in Table 2 are derived from the mean of the weekly maxima and minima taken at Calshot Jetty. These records give some useful general indications regarding the years when good spatfalls have occurred. Years when the temperatures exceed the average by 1-2°C for a prolonged period in July or August are generally the years of exceptionally good spatfalls. Conversely, those years with temperatures lower than average in the summer months often prove to be years of poor recruitment. Thus, 1969, 1975 and 1976 were years with very good recruitments, 1968, 1974, 1977 and 1978 were poor years and the remainder gave mediocre results. Even in good years, settlements of spat do not always occur uniformly over the fishery, for instance in 1975 the grounds in the western Solent benefited most from the spat recruitment.

Table 2 Mean weekly sea temperature (°C) at Calshot Jetty in July and August, 1968-1979 and yearly deviations from 10 year mean. (Data provided by British Transport Docks Board, Southampton)

Week	Mean 1968/77	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
26	17.1	-1.2	+0.2	+0.4	-0.9	-1.8	+1.7	-0.7	+0.1	+2.6	-0.5	-1.4	-0.7
27	18.0	-	-	-0.7	-0.2	-2.0	+1.4	-1.5	-0.5	+3.4	+0.4	-2.3	+0.3
28	18.6	-1.0	-	-0.7	+1.1	-0.8	+0.9	-1.8	-0.7	+3.4	-0.4	-1.5	+0.1
29	18.7	-1.3	+2.0	-1.5	+1.2	+0.4	-0.0	-1.5	-1.1	+3.3	-1.3	-1.8	-0.2
30	18.8	-1.1	+2.6	-1.8	+0.8	+0.8	-0.2	-1.6	-1.4	+2.1	-0.9	-0.7	+0.2
31	19.0	-1.0	+1.0	+0.1	-	-0.4	-0.0	-1.5	+0.9	+1.3	-0.4	-1.1	+0.1
32	19.3	-1.5	+1.0	+0.3	-0.2	-1.1	-0.4	-1.7	+1.0	+0.9	-0.2	-0.7	-1.0
33	19.1	-1.9	+1.7	-0.8	-0.3	-0.3	+2.0	-1.2	+0.4	+1.7	-0.9	-0.1	-1.3
34	19.0	-0.6	+1.0	-1.6	+0.1	+0.1	+1.5	-1.0	-0.4	+2.1	-1.4	-0.8	-1.7
35	18.9	-0.4	-0.2	-0.6	-0.0	-0.7	+0.2	-	+2.1	+1.6	-1.8	-0.7	-1.2

- = No data available.

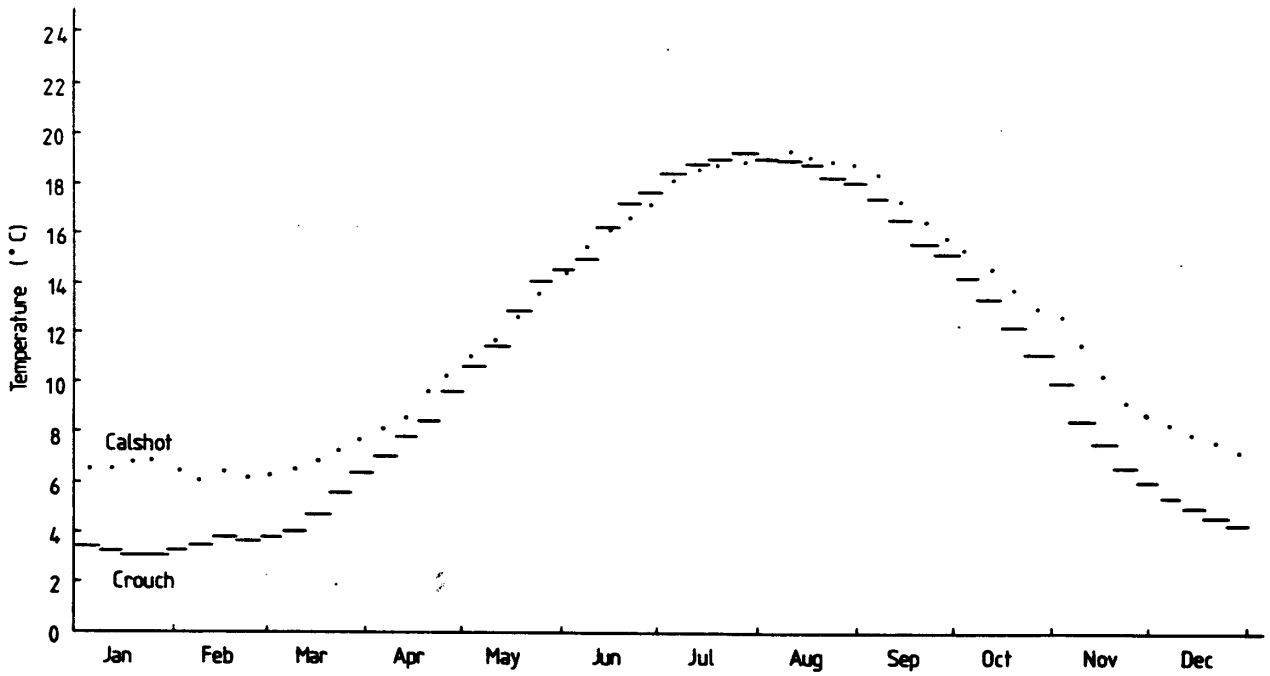

Figure 13 Mean weekly water temperatures for the River Crouch, 1948-77, and for Calshot Jetty, 1968-77.

Comparison of the 1968-73 average monthly surface water temperatures taken at Calshot Jetty with those from the English Channel area off the Isle of Wight (Figure 12) shows that there is a tendency for water temperatures within the Solent in winter to be about 2-3°C below the mean of 9°C in the English Channel and in early summer to be 3-4°C higher than the 16.5°C in the English Channel. On the Essex coast in the east of England, water temperatures are on average about 3°C in mid-winter and reach an average summer peak of about 19°C in late July (Figure 13). It can therefore be seen that the average winter temperatures in the Solent are some 3°C above those in Essex estuaries but that peak summer temperatures of approximately 19°C occur in both areas.

3.5 Landings and catch-per-effort

The collection of statistics for landings of oysters from the Solent oyster fishery (Table 3) has been a difficult task, especially in the early years. It is believed that more accurate figures were obtained in recent years, but anomalies still occur because the fishing season takes place during the winter months and the official statistical returns are compiled for the calendar year, thus including the end of one season and the beginning of the next. The restriction of the fishing season for the Calshot public fishing grounds to the two months of mid-March to mid-May as from April 1974 resulted in no major fishing on this ground between January and December 1974 the productive fishing having been at the start of the season in Autumn-winter 1973. This artificially depressed the figures for 1974 and gave a corresponding increase for 1975 in the official statistics.

Table 3 Landings (tonnes) of oysters at all Solent ports, 1972-78

Year	Official statistics (Jan-Dec)	Export certificates (Sept-May)	
1972	13.7	1972-73	282.8
1973	265	1973-74	262.6
1974	12.7	1974-75	195.6
1975	183	1975-76	415.5
1976	665	1976-77	564.4
1977	740	1977-78	562.8
1978	337	1978-79	637.0
		1979-80	828.4

An additional source of information for each season's catch is the certificates issued from the Burnham-on-Crouch Laboratory for export purposes. In Table 3 both the official landings and export certificate data are presented. It is considered that from 1972 to 1975 the figures from export certificates may represent about 20% less than the total catch, as a number of boats came to the fishery from areas outside the Solent to gather stocks for relaying on fisheries in other parts of England and a proportion was being sold to other growers in the United Kingdom. For 1976 and 1977 the difference between exports and the recorded landings may represent this home trade more accurately.

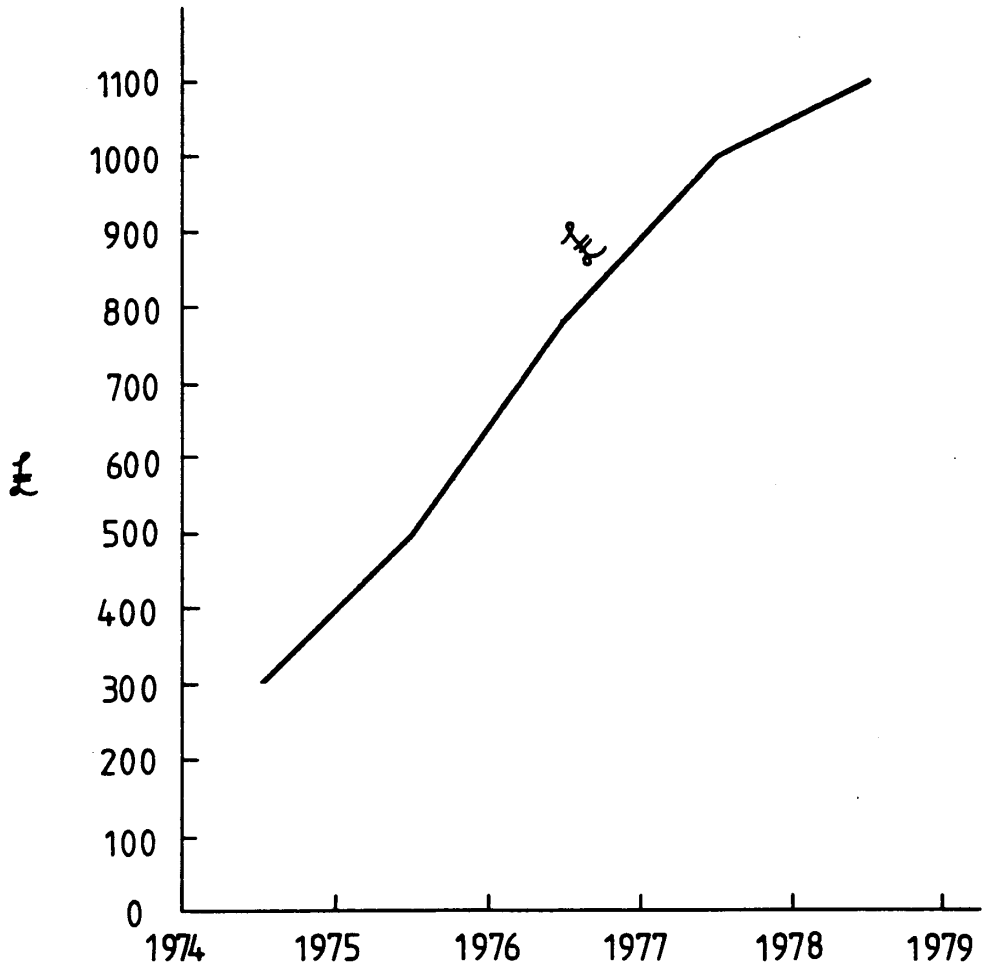

Figure 14 Value per tonne of Solent oysters, 1974-79.

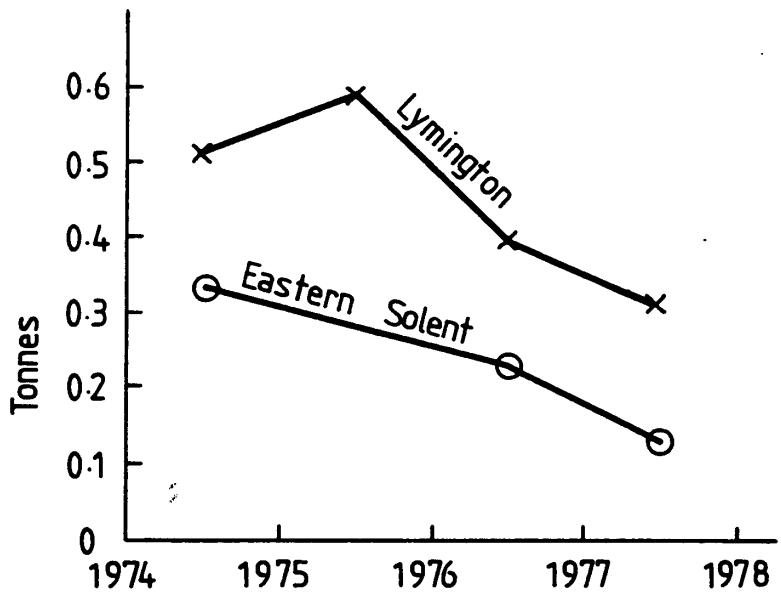

Figure 15 Average catch of oysters per week by seven top Lymington dredgers, and per day by an eastern Solent dredger, 1974-78.

Over the past three years total catches have been consistently high. Our surveys have shown however, that there has been considerable fluctuation of fishable stocks from individual grounds over the past five years. Sowley Ground in particular yielded extremely high catches in 1976-77 and a very large contribution was made from grounds in Langstone Harbour in 1977-78 although to date this area has not featured in our survey reports on the level of stocks.

While the total landings of Solent oysters have markedly increased since 1974, the sharp rise in value realised for the catches since that time (Figure 14) has made it possible for vessels to profitably land smaller quantities per week. At Lymington, in the western Solent, where several vessels have worked consistently over a number of years, it is possible to calculate that in the 1975-76 season the average weekly catch from the seven vessels with top landings was 0.6 tonnes per week. By 1977-78 average weekly landings over a similar period for the same vessels had fallen to 0.3 tonnes per week (Figure 15). Data for a single vessel landing in the eastern Solent given in the same Figure, shows a similar trend, although in this case the boat fishes oysters only when catches are relatively high and at other times is employed on alternative fishing. Taken together these figures indicate that between the 1974-75 and 1977-78 fishing seasons the total catch in the Solent fishery increased about three-fold, while the average catch-per-unit-effort decreased by about 50%, i.e. the total fishing effort increased by a factor of six over these four seasons.

There are now nine times as many vessels fishing for oysters in the Solent as there were in 1972. However, it is quite clear that a proportion of these vessels dredge for oysters only for a relatively short period during each season and that many which do fish for oysters through the winter are now landing very small quantities for a great part of the season.

3.6 Report of the surveys made in 1978, 1979 and 1980

The surveys of the Calshot fishery and Stanswood Bay several order fishery were carried out in 1978 by the same grabbing technique as used in 1972, 1973 and 1976 (Key, 1972). This method was used in preference to the dredging technique as it gives a more accurate and quantitive result. Both these areas were also dredged in 1978 by the standard technique used for examination of all other grounds each year since 1972. Most areas in the western Solent, Lymington Banks and Sowley ground, were surveyed during June using the MAFF Research Vessel NUCELLA. The remaining grounds were examined during August and September from a commercial fishing vessel. In 1979 and 1980 all the major grounds were surveyed by dredging from a hired vessel during September.

The figures obtained from the dredge surveys carried out each year in the Solent are not quantitatively accurate and cannot be used for estimating absolute numbers of stock on the ground. However, provided that the method remains reasonably constant, major changes in stock density can be detected by comparing the results from one year with another.

In this report the figures for average catches of oysters of the various size groups have been calculated using only hauls where at least one oyster was obtained in the dredge. This method has been adopted because the surveys have all been partly exploratory, and often ground of a type totally unsuitable for oyster settlement was dredged. Other areas have been located which carry large populations of slipper limpets or other cultch and these areas are re-examined from time to time

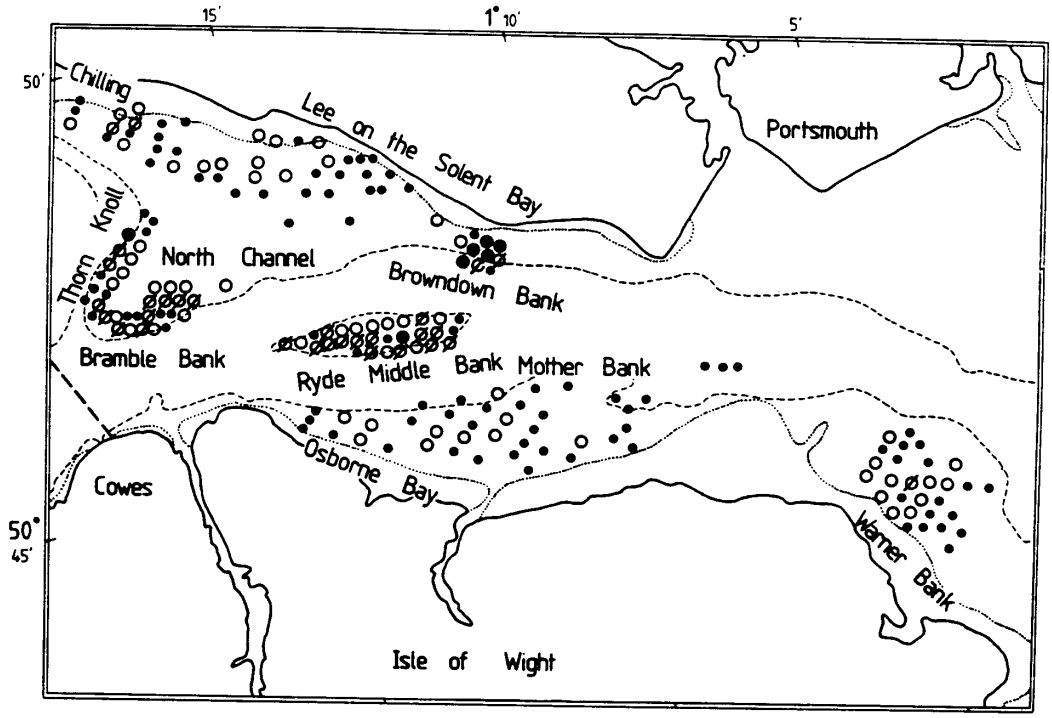

Figure 16 Numbers of oysters per dredge haul in the 1980 survey of the eastern Solent. 1-5 oysters • ; 6-14 oysters o ; 15-49 oysters ϕ ; greater than 49 oysters ● .

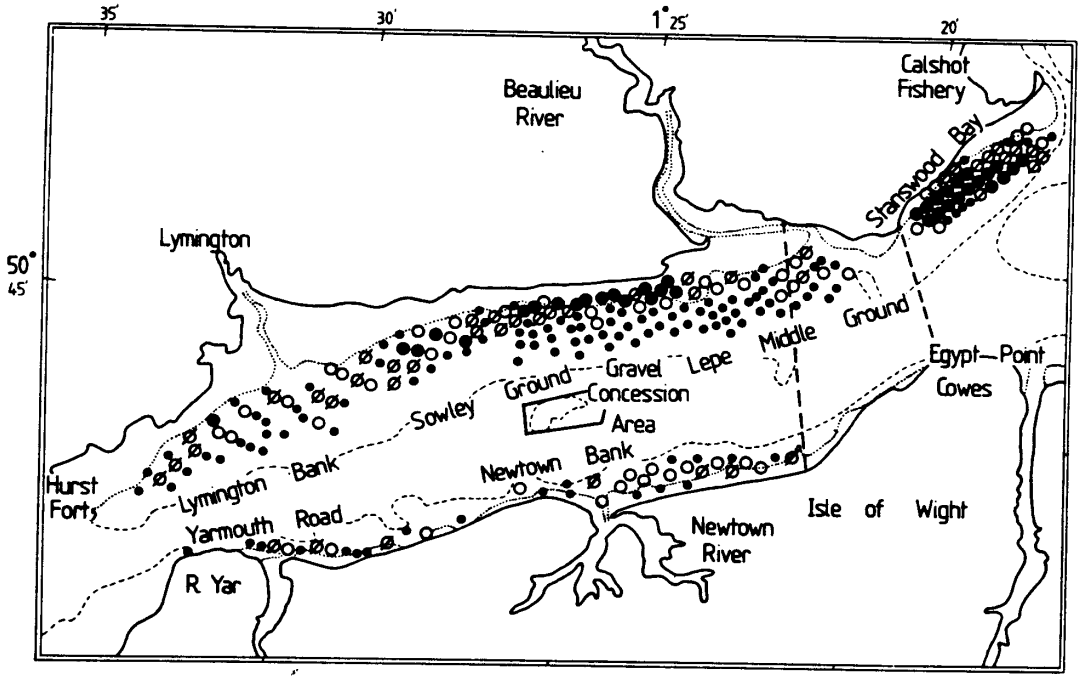

Figure 17 Numbers of oysters per dredge haul in the 1980 survey of the western Solent and Stanswood Bay. 1-5 oysters • ; 6-14 oysters o ; 15-49 oysters ϕ ; greater than 49 oysters ● .

to determine whether a spatfall has occurred. Also in these tables an extra size category is shown for the surveys which followed the change in the size limit for removal of oysters in 1976. Thus from 1976 the two larger size categories must be added to compare with figures for earlier years.

The area within the Stanswood Bay several order fishery is granted to the Stanswood Bay Fishermen's Cooperative for their exclusive use as a shellfishery and the public are not permitted to fish oysters from these grounds. Data in this report includes information obtained about this private fishery with the permission of the Stanswood Bay Fishermen's Cooperative.

3.6.1 Methods

The numbers of grab stations worked during 1978 were 44 on the Calshot Public Fishery and 79 on the Stanswood Bay several order fishery. At each station four grab samples were obtained using a half metre square Baird grab.

In the dredge surveys a standard Baird dredge fitted with a blade 1 m wide and $1\frac{1}{2}$ inch (38 mm) chain link mesh was towed for approximately 90 m at each station. On hard ground a diving plate was fitted to the dredge but, where extensive areas of soft mud were to be surveyed, this plate was removed to prevent the dredge digging in excessively. Positions of the hauls and densities of stocks from the 1980 dredge survey are shown in Figures 16 and 17. The efficiency of dredges may alter with the type of ground being worked. Areas of reasonably firm ground are usually fished more efficiently than soft, muddy or weedy sites, and areas where massive quantities of shell cultch occur are often difficult to dredge effectively.

3.6.2 Results

The dredge survey results show the areas where stocks have occurred and have been maintained from year to year, and comparisons can be made with other areas, where recruitments are more variable. Comparison of average catches of oysters in the 1980 survey with those for earlier years shows that generally, the grounds in the western Solent have improved levels of stock and those in the eastern Solent have rather poorer levels.

It should be appreciated that the dredge survey figures quoted for spat and small oysters (below 35 mm in size) are not always a reliable guide for future prospects on many grounds. When surveys have been made in late summer, spatfalls from spawnings earlier the same year may have been just detectable. However, several surveys were made, or partially made in June or July before a spatfall had occurred. Comparing yields of 2-year-old oysters in the surveys with counts of spat from 2 years before, therefore, gives inconsistent results. This problem was underlined during experiments in 1978 where the predation effects of oyster drills on small oysters was estimated. In spite of careful selection of sizes of oysters (30-40 mm maximum shell diameter initially) at the end of the experiment two months later several small oysters between 25-30 mm were found attached to the original stock. The only explanation for this is that some small spat were already present on the shells of the live oysters when they were selected, but these were too small to be easily detected when the trial was set up. It must therefore be concluded that estimates of oysters below 35 mm in size are unreliable for the purposes of accurate predictions of yields for future years and especially when surveys have been made in mid-summer.

Overall, the Solent fishery has maintained a high level of output of oysters over the past few years. This has mainly been sustained from fishing the extensive grounds in the Sowley and Lymington areas. However, the downward trend in the number of smaller oysters taken on the dredge surveys was evident in the western Solent as elsewhere, thus confirming that there were generally poor recruitments of spat in the period 1977-79.

(i) Calshot fishery

Substrate type: mainly muddy sand with patches of mud and limpets. Toward Calshot spit there are areas of gravel and large stones. Inshore more sand overlies the mud. There is much buried old shell, both oyster and limpet.

This fishery was one of the first areas to be worked commercially and a stock of about 2 million oysters was estimated to have been present in 1973 (Key, 1974). Intensive fishing reduced this stock by about two thirds by 1974 (Key, 1975) and the 8-month fishing season was subsequently reduced to 2 months (mid-March to mid-May) from 1974. Good spat settlements in 1975 and 1976 led to increased catches in 1977 and 1978 but by 1980 a decline in numbers of all sizes of oysters on this ground was apparent, due to poor recruitments in recent years.

A summary of grab catches for the Calshot fishery is compared with those from previous years in Table 4. The average density of oysters greater than 35 mm was approximately 50% higher in 1978 than that found during the 1976 survey but the average density of spat (less than 35 mm) was about 30% lower. Although prospects for the 1978-79 and 1979-80 seasons were therefore good the outlook for sustained output in future years depends upon better settlements of spat in the coming seasons than has occurred in 1977 and 1978.

Table 4 Results from grab surveys on the Calshot fishery in 1972, 1973, 1976 and 1978

Year	No. of stations worked	Average catches (number per m^2)			% reduction of limpet chains since 1972
		Oysters*	Spat*	Limpet chains	
1978	44	2.6	0.59	10.3	67
1976	39	1.58	0.86	12.2	61
1973	45	1.72	0.04	18.7	41
1972	21	4.66	0.53	31.5	

* Oysters are distinguished as 35 mm or greater and spat as smaller than 35 mm, measured across the largest diameter.

The dredge surveys in 1976 and 1978 (Table 5) gave results which appear to conflict with those of the grab surveys. (Table 4). The latter indicated total stocks to be higher in 1978 than in 1976 while the dredge surveys indicated stocks in 1978 to be reduced by 27% from those recorded in 1976. As both the 1976 and 1978 dredge hauls were taken from a rather restricted area, the results of the grab survey

Table 5 Dredge survey results, Calshot fishery

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	15	15	16.5	18.0	5.6	1.0
1979	15	15	36.2	32.5	11.8	6.8
1978	28	28	78.3	57.7	14.4	10.3
1977	6	6	41.2	78.2	62.5	16.2
1976	3	3	69.3	40.0	67.3	43.3
1975	13	13		9.2	11.3	6.5
1974	11	11		17.2	7.4	3.3
1973	7	7		37.0	21.1*	-*

* Includes all oysters below 49 mm.

are a more reliable indication of the true stock position over the whole fishery. Although this ground continues to yield large numbers of oysters of all sizes, the trend in the past two seasons has been for a general decline in catches in the dredge survey. In 1978 about 78% of the stock comprised oysters over 50 mm and the majority would have been fished by the end of the spring of 1979. The survey in 1979 indicated that catches in March 1980 would only be about half of those obtained in 1979. Since recruitment of young oysters to this ground in 1978 has been poor compared to 1976, output may also be expected to decline for the 1981 season.

The number of live chains of slipper limpets has been reduced steadily on the Calshot fishery by the intensive dredging which has taken place over the past years (Key, 1976). It is not possible to say what effect, if any, this is having on recruitment of spat as the availability of single limpet shells and other material on the ground may provide adequate settlement surfaces. It appears that the occurrence of limpet chains may now be stabilising at around 10 chains per square metre as there has been only a small loss in numbers since 1976. It is also understood that the intensity of dredging over the area may be somewhat less than formerly, as catching has become more efficient and the available oyster stocks are removed with less fishing effort.

(ii) Stanswood Bay several order fishery

Substrate type: generally sandy inshore becoming more muddy towards the middle of the ground. There are clay outcrops towards the western end of the bay with sand and gravel patches. The ground tends to have more shells towards the eastern boundary and becomes less muddy in the southern deeper water areas.

The 1978 grab survey in the northern part of the fishery showed a 25% increase in numbers of oysters greater than 35 mm over the previous highest

Table 6 Results from the grab surveys on the Stanswood Bay fishery in 1972, 1973, 1976 and 1978

Year	No. of stations worked	Average catches (number per m^2)			% reduction of limpet chains since 1972
		Oysters*	Spat*	Limpet chains	
1978	54+	4.25	0.3	3.3	71.0
1976	55+	2.36	1.52	5.9	47.8
1973	52	1.49	0.24	10.8	4.4
1972	26	3.02	0.33	11.3	

* Oysters and spat are distinguished respectively 35 mm and over or smaller than 35 mm, measured across the largest diameter.

+ These stations correspond to those in the area of the previous surveys; a further 26 stations were worked in 1976 in the southern half of the several order area and 25 in 1978.

Table 7 Dredge survey results, Stanswood Bay several order fishery

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
Northern part						
1980	30	27	25.4	37.1	21.0	5.4
1979	22	22	53.0	44.9	19.8	14.5
1978	6	6	57.3	74.2	52.8	15.8
1977	12	12	25.5	76.1	73.2	32.7
1976	3	3	72.6	62.7	73.7	55.7
1975	6	6		32.5	50.0	37.0
1974	6	6		33.0	18.3	8.0
1973	7	7		37.0	21.1*	
Southern part						
1978	30	23	11.4	20.4	14.9	0.8
1977	24	20	9.0	8.6	6.7	3.4
1975	18	18		8.5	2.8	1.4

* Includes all oysters below 49 mm.

recorded in 1972, but spat were fewer than in 1976 and about the same as found in 1972 (Table 6). Slipper limpet chains in the northern area were reduced in number by 71% in 1978 when compared with 1972, but, there was no evidence that spatfall had, as yet, been reduced by shortage of cultch.

The southern part of the several order fishery, which was first examined by dredging in 1975 and by grabbing in 1976, was surveyed by both techniques in 1978. The latest grab survey showed that the average number of oysters larger than 35 mm had remained at about the same density as found in 1976 (0.70 oysters per square metre in 1978 and 0.73 oysters per square metre in 1976). It was also evident from the grab survey that the density of oysters has remained on average substantially less than that found on the northern part of the several order area.

The numbers of oysters obtained from the dredge samples in 1979 (Table 7) were extremely high in the northern part of this ground when compared with most other grounds in the Solent but did show an overall reduction when compared with the previous two years. There were fewer oysters below 35 mm than in any other year since 1974. By 1980 the downward trend of numbers of all sizes of oysters was similar to that occurring on the Calshot fishery, but numbers of oysters per haul remained higher overall. In the southern part, although densities of oysters of all sizes were lower than in the northern part, when the dredge catches are compared with those from grounds elsewhere it is clear that good commercial catches can be obtained from an extensive area of sea bed.

(iii) Thorn Knoll

Substrate type: mainly muddy ground with limpet banks. Up to 1978 this area of the fishery continued to show slow improvement with reasonable catches of oysters in one or two dredge hauls indicating limited areas of moderate density (Table 8). In 1978 and 1979 numbers of spat in the catches declined, but in 1980 some improvement was evident. Although considerable quantities of limpets are present to provide settlement surfaces this area compares poorly with those on the opposite side of the shipping channel in Stanswood Bay.

Table 8 Dredge survey results, Thorn Knoll

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	17	14	4.5	2.5	1.8	1.1
1979	16	13	2.1	1.5	0.8	0.4
1978	15	12	3.6	4.1	3.7	0.9
1977	17	10	2.6	2.7	4.3	1.5
1976	13	9	1.2	2.2	1.1	1.0
1975	19	14		3.5	1.6	1.9
1974	21	13		3.0	0.3	1.0

(iv) Bramble Bank

Substrate type: to the south-west where oysters are found, mainly old, clean oyster shells. To the east it gradually becomes more muddy with banks of limpets. The South Bramble area continues to produce considerable numbers of oysters (Table 9) but these are distributed over a rather larger area than in previous years, with the high concentrations either fished out or scattered by fishing activities. The number of spat found in this area in 1978 was one of the highest recorded in the survey that year, but this situation was not repeated in 1979 or 1980. Little change is apparent in the substrate type despite the amount of dredging which has taken place on the ground.

Table 9 Dredge survey results, Bramble Bank

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	31	23	8.2	4.5	1.2	0.4
1979	30	27	7.1	4.9	2.4	0.6
1978	40	32	4.5	3.6	3.4	1.5
1977	18	13	7.2	3.6	3.6	4.6
1976	10	8	7.6	7.6	5.2	7.6
1975	37	18		2.0	0.7	1.0

(v) North Channel

Substrate type: tends to be muddy with considerable numbers of limpets.

Table 10 Dredge survey results, North Channel

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	22	18	2.3	1.7	1.2	0.3
1979	14	10	2.3	0.9	0.6	1.0
1978	19	15	2.9	1.5	1.0	0.3
1977	18	13	3.9	3.1	1.6	0.8
1976	23	17	2.6	3.4	4.1	1.7
1975	93	42		2.0	1.0	0.6

This is an extensive area where in spite of considerable patches of limpet cultch few areas are found where oysters occur at high densities. Stock levels appeared to be generally lower in 1979 and 1980 than in the previous two years (Table 10).

(vi) Lee-on-the-Solent Bay

Substrate type: generally muddy with considerable numbers of limpets in places. A few areas with large boulders occur inshore where good oyster catches may be obtained. Weed can be a problem for dredging in some of the more shallow areas. This ground maintains a fairly low level of production from areas which have sufficient cultch and which remain relatively free from mud. Elsewhere soft sediments seem to prevent more oysters surviving on the ground. Fewer oysters were found in this area in 1979 and 1980 than in the previous three or four years (Table 11). Small oysters were also scarce and there appears to be little prospect of an improvement in catches in the immediate future.

Table 11 Dredge survey results, Lee-on-the-Solent Bay

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	24	15	2.9	0.7	0.4	0.2
1979	25	14	2.3	0.5	0.2	0.7
1978	6	4	2.5	1.5	0.25	0.5
1977	20	9	4.8	1.3	0.9	0
1976	12	9	1.6	2.0	2.1	0.6
1975	26	14		3.0	2.2	0.7
1974	16	10		3.9	0.3	0.6

(vii) Chilling

Substrate type: generally soft mud and limpets with a few isolated patches of shell, and becoming more stony towards Hamble. This is one of the few areas now available for dredging from 4 August. By the time our survey had been carried out in September each year the ground had been dredged by 12 boats for nearly 2 months. Stock levels were low at the time of the survey (Table 12). As commercial dredging was still continuing at the time this illustrates how grounds can now be worked commercially at a very low stock density. The extensive working has probably cleared the ground by removing mud and weed so that clean shell surfaces are available for spatfalls; dredging has become progressively easier and more efficient.

Table 12 Dredge survey results, Chilling

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	23	17	2.5	2.6	1.2	0.1
1979	23	18	2.8	3.2	1.3	1.2
1978	40	28	2.4	3.3	1.7	0.4
1977	30	24	3.0	4.3	3.9	0.5
1976	33	27	2.2	2.5	4.1	1.4

(viii) Browndown Bank

Substrate type: mud and limpets with occasional large stones, much weed inshore. Distribution of oysters is rather uneven on this ground which makes accurate sampling difficult. Catches of commercial sized oysters in 1979 were, as anticipated, considerably lower than in 1978 (Table 13), but catches of spat in 1979 were better than previously recorded, indicating that an improvement in yield could be expected in future years. Between the 1979 and 1980 surveys, the number of oysters larger than 50 mm increased by about 78%. However, a marked fall in numbers of oysters below 35 mm to the lowest level recorded since 1975, indicated that the improvement will not be sustained.

Table 13 Dredge survey results, Browndown Bank

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	10	10	26.1	21.3	6.5	1.4
1979	8	8	17.2	9.3	5.7	4.9
1978	10	9	26.6	27.2	16.1	2.8
1977	17	16	6.7	10.8	10.3	2.6
1976	8	7	7.0	9.9	15.5	3.2
1975	12	7		5.3	2.0	1.4

(ix) Ryde Middle Bank

Substrate type: graduates slowly from an area almost entirely composed of old oyster shell on the south-west corner to a mixture of old oyster shell and limpets at the eastern end; very little silt or weed is found. This bank continues to hold considerable stocks of oysters (Table 14), particularly toward the eastern end. The fact that many of the oysters are settled on and between large oyster shells rather than on smaller limpets tends to render dredging less efficient than on some other grounds because large quantities of shell are caught. This affords some protection against the stock being fished out.

Table 14 Dredge survey results, Ryde Middle Bank

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	30	29	10.9	5.0	1.8	0.6
1979	36	32	9.8	7.3	2.8	1.5
1978	47	38	5.1	5.7	4.5	1.5
1977	23	23	8.8	6.1	6.0	3.6
1976	22	21	5.4	3.1	1.8	2.5
1975	23	21		4.4	1.4	0.6

(x) Mother Bank and Osborne Bay

Table 15 Dredge survey results, Mother Bank and Osborne Bay

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	62	41	2.5	0.9	0.2	0.05
1979	64	42	3.7	1.1	0.4	0.1
1978	75	63	2.6	1.1	0.4	0.1
1977	33	33	4.4	4.7	2.5	0.2
1976	18	15	3.2	1.5	2.7	0.2
1975	55	35		3.0	0.7	0.4
1974	32	14		4.2	0.3	0.1
1973	33	18		1.5	0.7	0.1

Substrate type: mud with limpets and a good deal of weed in the shallower areas; good patches of shell cultch in some localities. For the first time since commercial dredging commenced on this ground in 1972 there are indications of a decline in stock in the past two years (Table 15). The lack of substantial spatfall in recent years is disappointing on a ground which had shown signs of considerable development during the previous years. This area tends to be muddy and needs to be worked to provide clean cultch for spat to settle on.

(xi) Warner Shoal

Substrate type: stones and boulders on hard ground with small patches of softer mud, fine shell and limpets. This ground has improved with working and catches up to 1979 rose somewhat (Table 16). The higher densities of oysters are associated with the limpet banks. Spatfall has been light since 1976 and it seems unlikely that intensive fishing could be sustained in this area.

Table 16 Dredge survey results, Warner Shoal

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	36	30	2.7	1.2	0.9	0.2
1979	37	28	4.5	1.7	0.7	0.2
1978	29	18	4.4	2.7	2.0	0.5
1977	22	17	4.0	1.4	1.6	1.8
1976	29	23	4.4	1.2	0.6	0.7

(xii) Newtown Bank

Substrate type: variable with stones and gravel patches interspersed with limpets and shell overlaying firm clay. A great improvement is recorded here with numbers of large oysters in 1978 and 1979 being double those in the previous two years; oysters smaller than 50 mm were however, less abundant in 1980 than in previous years (Table 17). This is a fairly small area containing reasonable commercial densities of oysters with a few patches of ground containing stocks at high density.

Table 17 Dredge survey results, Newtown Bank

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	32	27	9.2	4.6	1.3	0.3
1979	21	18	10.8	6.1	1.7	0.8
1978	20	20	7.4	6.6	3.8	1.1
1977	15	14	3.8	4.8	4.8	1.4
1976	16	16	5.0	3.4	2.1	0.6
1975	14	14		7.1	1.9	1.4
1974	12	12		12.6	4.3	0.7
1973	11	10		13.0	3.9	0.6

(xiii) Lepe Middle ground

Substrate type: stones and gravel and a few shells. Somewhat reduced catches of larger sizes of oysters were obtained from this ground in 1979 when compared with most previous surveys but some improvement was evident in 1980 (Table 18). The numbers of small oysters (less than 50 mm) in 1979 and 1980 were the lowest recorded since surveying started in 1973.

Table 18 Dredge survey results, Lepe Middle ground

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	36	23	3.9	2.7	0.8	0.1
1979	26	21	3.3	2.3	0.6	0.1
1978	16	11	4.3	3.9	1.1	0.4
1977	20	18	3.1	2.4	0.4	0.4
1976	25	22	4.3	7.5	2.7	0.3
1975	41	27		6.6	1.7	1.9
1974	14	14		8.0	1.2	1.0
1973	10	8		12.7	2.5	0.1

(xiv) Sowley ground

Substrate type: large areas of clean gravel with smaller areas of slipper limpet banks; larger stones on the outer edge of the bank, heavily encrusted with barnacles. Very good catches of oysters larger than 50 mm were obtained from this area in the 1979 and 1980 surveys (Table 19). It was expected that a large proportion of those oysters would exceed the ring size of 63 mm before the end of the fishing season and the catches from this ground should be extremely good. Numbers of smaller oysters declined in 1979 and 1980, indicating that catches may decrease again after the 1980-81 fishing season.

Table 19 Dredge survey results, Sowley ground

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	79	56	15.3	15.6	2.5	2.0
1979	54	42	12.3	18.4	4.8	2.1
1978	58	42	3.5	12.4	8.1	1.9
1977	48	45	7.6	12.6	6.7	2.9
1976	58	58	4.5	15.3	10.7	2.3
1975	58	52		13.8	9.8	7.0
1974	26	23		9.0	4.0	2.4
1973	23	22		8.8	2.8	0.3

(xv) Lymington Bank

Substrate type: the outer edge similar to Sowley, with gravel and larger stones; inshore, large stones and shell overlaying black mud and peat with a great deal of weed. The 1980 survey results indicated that this ground should continue to yield good catches comparable with those in the previous four years (Table 20). Numbers of smaller oysters dredged were less than obtained for several years, indicating a probable decline in catches following the 1980-81 season.

Table 20 Dredge survey results, Lymington Bank

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	41	30	7.9	5.0	1.6	0.4
1979	46	36	7.0	7.2	2.9	0.7
1978	62	53	4.3	6.0	3.2	0.7
1977	34	30	3.6	7.0	4.4	3.0
1976	70	59	4.9	8.9	4.4	1.4
1975	43	37		4.6	2.5	2.0
1974	37	30		4.9	1.3	2.0
1973	32	25		4.2	1.1	0.1

(xvi) Yarmouth Road

Substrate type: large stones and old shell overlaying firm clay and peat. In this area, where small patches of stock can be found from time to time, the last two surveys have shown none of the high densities of oysters such as were found previously. Somewhat better catches were obtained in the 1980 survey than in the previous two years but, in general, the total numbers of oysters were considerably lower than in the period 1976-77. Spatfall appears to have been poor for the past two seasons on this ground.

Table 21 Dredge survey results, Yarmouth Road

Year	No. of hauls made	No. of hauls with oysters	Average catch from hauls with oysters			
			Greater than 64 mm	64-50 mm (1976-80) Greater than 49 mm (1973-75)	49-35 mm	Less than 35 mm
1980	19	12	6.3	4.5	0.8	0.1
1979	15	10	4.1	1.7	0.8	0.3
1978	12	9	2.8	0.6	0.7	0.2
1977	6	4	4.0	5.1	6.5	3.0
1976	8	6	7.3	9.6	7.3	2.2
1975	20	16		7.2	1.4	1.9

3.7 Oyster drills

The European rough tingle (Ocenebra erinacea) occurred commonly in all the major oyster-producing areas in this country prior to 1939. Since that time it has been almost wiped out in east coast estuaries by a series of severe winters and has largely been replaced in Essex and Kent by the American tingle (Urosalpinx cinerea). The American tingle has proved to be more damaging to oyster spat than the European rough tingle and much time and effort has been devoted to minimising the damage caused by this animal by collecting and destroying its egg capsules and by trapping the adults (Hancock, 1974).

Following the substantial spatfall on Sowley ground in the western Solent in 1975, considerable numbers of European tingles were found in this area. It is not known whether an exceptionally successful recruitment of tingles just happened to coincide with increasing numbers of these predators in the area, whether the increase in tingles was an effect of additional food being available in the form of young oysters, or whether an already existing large resident population of tingles had not been recognised. By 1976 it was estimated that there were at least 3 million tingles on the Sowley and Lymington grounds. Calculation of the population number was based on the catching efficiency of the survey dredge being 20% (Key, 1977). In the light of further work in 1977 it became clear that oyster dredges caught only about 2% of the tingles over which they passed, and the population of tingles on these two oyster grounds was therefore probably in the region of 30 millions.

Tingles are most active in the summer when they slowly crawl over hard shell or stone materials in search of food. Each female lays about 24 egg capsules per year and approximately 10 eggs develop within each capsule. The eggs hatch directly into minute snails, about 2 mm in size, without there being a free-swimming stage. Newly hatched juvenile drills are capable of boring holes and feeding on small oyster spat. Although the natural rate of spread of these pests is very slow if they are left undisturbed, any trawling or dredging on ground where they occur can quickly scatter them into new areas. Further, unless extreme care is taken, tingles and their egg capsules may easily be transferred from one part of the coast to another attached to oysters being transported in commercial consignments.

Experiments carried out in 1978 to measure the mortality of oysters caused by drills were only partially successful because two of the three sets of gear were lost. Each set of gear comprised five 0.5 x 1 m netting bags containing oysters, anchored and marked by dans. Results from the one set of gear recovered showed that oysters between 30 and 45 mm laid on the ground in late June suffered 11% loss by being drilled in the following two months. All sizes of the trial stock were equally affected and an additional 20% of the live oysters showed one or more unsuccessful drill attempts to penetrate the shell. From the five mesh bags of the one set of gear together containing 730 live oysters, 122 tingles were recovered in July and 197 in September at the end of the experiment.

A method of controlling the drills on small oyster beds in creeks in Essex was developed some years ago. Special tile traps are set out on the edge of oyster layings just above the level of low water spring tides. By visiting the traps every two weeks through the summer to remove adult tingles and egg capsules the population of tingles can be substantially reduced in the course of a few years. However, it is thought that such techniques could not be effectively worked or make a significant reduction in the

population of tingles on the very large areas of oyster ground in the Solent, where the tingles do not move onto the exposed parts of the foreshore and where an enormous background population of the pest occurs. Even placing collecting surfaces on the sea bed in this area is difficult due to strong currents and other activities such as trawling.

Spreading quicklime on the sea bed is said to be effective in killing the American tingle and its spawn on oyster grounds in the USA. Where conditions allow it can be economically feasible to lay sufficient material to dose large areas of ground (6.75 tonnes per hectare or 2.7 tons per acre is the minimum requirement), but the quicklime must carpet the sea bed for several days if it is to be effective, and the tidal conditions in the Solent are unlikely to allow this. No method for controlling this pest in the Solent can yet be suggested that would be both economically possible and decrease the mortality of oysters.

In 1977 the estimates of tingles on Sowley ground were 49-89 per square metre and the numbers found in the 1978 work tended to confirm these figures. However, during the 1979 dredge survey for oysters there were indications that numbers of tingles on the ground were reduced. Thirty-seven stations on Sowley ground where tingles were found in 1977, 1979 or both years have been compared. In 1977, twenty-three stations yielded 198 tingles in the dredge hauls and in 1979, thirty-two stations yielded 99 tingles. In 1979, although there were more stations with tingles, concentrations were not so high and they were more evenly distributed over the ground. This change could have been caused by dredging activities. More important, however, was that there had been a significant reduction in numbers of tingles in the catches from this area, the mean number per haul having fallen from 5.35 to 2.67. In 1979 oyster stocks on Sowley ground had improved; further examinations will be necessary to determine whether the high level of predation by tingles there is a recurring feature.

3.8 Settlement of oysters on different types of cultch

Oysters settle on a wide range of materials on the sea bed. Spatting fisheries can often be improved by relaying shells of oysters and other shellfish to provide settlement surfaces for the mature larvae. Young oysters can frequently be found attached to stones and rocks and the very large settlement of spat which occurred on Sowley ground in 1975 was in fact mainly on stones and gravel in that area.

During the 1978 survey of the oyster grounds in the Solent some time was spent examining oysters to determine the material on which they had settled. Two grounds were examined and the results are given in Table 22. Six dredge hauls were made on Ground A and two hauls were made on Ground B and the quantity of different shells in the catch was estimated and the attachment surfaces of the oysters were recorded.

The average oyster shell offers a much larger surface area for spat attachment than does a limpet shell or a limpet chain of which the effective collecting surface is mainly the dead terminal shell. The survey data for Ground B indicate that there was approximately one spat for every oyster shell and one for every three limpets in the catch, so three limpet shells or chains on the sea bed provide a spat settlement surface equivalent to an oyster shell of average size. It is therefore likely that on a shell size or shell weight basis they could be equally effective in catching spat. This suggestion would also be in line with the result from Ground A

where, although no counts of shells were made, slipper limpets predominate in the catch and the majority of oysters are attached to limpet shells.

Table 22 Percentage of oysters from dredge hauls attached to different types of shell material on two grounds in the Solent

Attachment surface	Free	Oyster shell	Limpet shell or chain	Other shells and stones	Total catch of oysters
Ground A	43.5	12.5	42.5	1.5	1 424
Ground B	40.5	37.5	22.0		170

Although further work is needed to determine the effectiveness of various cultch types in gathering spat the indications are that there may be little difference between slipper limpet and oyster shells.

Although there is concern over damage to cultch on the ground in some areas by dredging, in other areas this is not a problem. On Ryde Middle Bank and Bramble Bank for example, old oyster shells exist in sufficient quantity to ensure that their depletion by dredging is not likely in the near future. The large quantities present in fact make dredging relatively inefficient in these areas and to some extent the cultch acts as a protection against overfishing. Addition of cultch might improve the suitability of grounds to receive spat in places such as Warner Shoal, Osborne Bay, Chilling and Newtown Bank where suitable cultch is often patchy in distribution.

On Sowley and Lepe Middle grounds where the settlement of oysters mainly occurs on the abundant stones and gravel, there are two aspects which are of concern. First, following a good recruitment of young oysters, dredging over the loose, gravelly substrate probably damages some of the juvenile stocks. It may be preferable to leave these grounds undredged for a season following a good recruitment year. Second, there is evidence that in some areas probably 25% of oysters between 30-45 mm are killed by oyster drills (tingles) in the course of one summer. The areas where highest concentrations of drills occur on the Sowley and Lepe grounds do not always coincide with the areas of high densities of oysters so the overall losses from this pest would be less than 25% per season, but there is no doubt that, from the evidence of drilled shells found on these grounds, considerable numbers of oysters are killed by predators. Thus any beneficial effect of protection of young stocks from damage by dredging may be offset by damage by drills.

Where extensive dredging takes place on grounds where slipper limpets are the main cultch material, the chains and many of the shells become broken or buried and are unavailable for future spat settlements. However even on the most heavily worked areas, there is to date, no evidence to suggest that any reduction in recruitment of oysters can be attributed to this cause. Nonetheless, the maintenance of good quantities of clean cultch on the surface of the sea bed has previously been demonstrated to be one of the most important considerations for the success of this type of oyster fishery (Waugh, 1972). Should cultch be destroyed by dredging, its replacement by natural means, e.g. allowing the natural limpet population to regenerate on the ground, or artificial means, by laying shells brought in from elsewhere, must feature in the rational management of these grounds.

Between 1973 and 1977 the Stanswood Bay Fishermen's Cooperative have laid on the ground approximately 375 tonnes of shells of various kinds. These have been introduced into the northern part of the fishery in an attempt to improve the available cultch surfaces on which oyster spat might settle. The programme of relaying shells has been: 1973, 120 tonnes cockle shells; 1974, 77 tonnes mussel shells; 1975, 45 tonnes oyster shells; 1976, 80 tonnes oyster shells; 1977, 52 tonnes cockle shells.

During the survey carried out in 1974 spat on shells from 9 sampling stations where cockle shells have been laid in 1973 was recorded as follows: 1 on cockle shells; 33 on slipper limpets; 4 on live oysters; 4 on dead oyster shells.

Mussel shell laid early in the summer of 1974 was examined for spat in the following autumn. Four hundred and twenty mussel shells were recovered by dredging (2.2 kg in weight) and these were found to have 5 spat attached. It can be calculated that the 77 tonnes of mussel shell could have collected about 175 000 spat in 1974. If 50% survived to the legal size for removal it could be expected that about 4.4 tonnes of additional oysters might have been available for harvesting in 1976 as a result of relaying this shell in 1974 assuming that these spat would not have settled in the absence of the mussel shell. If these shells were not broken up or buried they would, of course, be available in subsequent years to receive further settlements of spat.

In 1978 a more extensive analysis was made of the material obtained from grab hauls in the area where shells had been relaid. From 28 grab stations, representing 56 square metres of bottom samples, 322 oysters and spat were found. A summary of the results from these examinations is given in Table 23. Where oyster shells have been relaid little direct information can be obtained since dead shell naturally occurring on the ground cannot be distinguished from that brought in from elsewhere.

Table 23 Numbers of oyster spat attached to various types of shells from 28 grab stations in the 1978 survey of the Stanswood Bay oyster fishery

	Spat attachment surface						
	Live and dead limpet shells	Live and dead oyster shells	Mussel shells	Cockle shells	Other surfaces	Attachment unidentifiable	Total
Number of spat	125	31	3	2	8	153	322
Total number of shells with or without spat attached	192		30	200			

Other work in the Solent in 1978 has suggested that the relationship between spatfall and shell type is not simple, because different shells offer varying surface areas for spat settlement. It is therefore concluded that calculations based on weights of shells will give the more realistic estimates.

From the 28 grab stations (56 square metres) over the area where the shells had been relaid (635 000 square metres) it has been estimated that only 7.37 tonnes of cockle shells and 1.78 tonnes of mussel shell were on the ground in 1978. It is possible that many shells have been broken up by dredging, buried or scattered to other parts of the fishery in the course of dredging activities. From these amounts of shell remaining on the ground it can be calculated that 22 678 oysters and spat occurred on cockle shell and 34 017 on mussel shell. With 20 000 oysters per tonne and bearing in mind that nearly 50% of the stock caught was unatttached it would be safe to assume that no less than 5 tonnes of oysters were obtained from settlements on relaid cockle and mussel shell in 1978. It would also be reasonable to postulate that the 125 tonnes of oyster shell laid in 1975 and 1976 collected at least as many spat as an equivalent tonnage of mussel shell, i.e.:

$$\frac{\frac{125}{77} \times 34\ 017 \times 2}{20\ 000} = 5.5 \text{ tonnes.}$$

Thus the minimum benefit to the Stanswood Bay several order fishery from the cultch relaying programme would be not less than 10.5 tonnes of oysters of saleable size. It can be assumed that the majority of the 4.4 tonnes of oysters caught on the mussel shell in 1974 had been removed by dredging before 1978. This figure will not include oysters which settled on any of the relaid shells in the good recruitment year in 1975 and have already been removed from the fishery, nor does it take account of the fact that many shells are probably scattered outside the area of this examination. However, these calculations are sufficient to demonstrate that the programme of improving the fishery by laying shell on the ground can produce very worthwhile results.

There are indications that oyster and mussel shells are more efficient as spat collectors and remain longer on the ground than do cockle shells, but it would require more carefully controlled experiments to demonstrate this conclusively.

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