BULLETIN No. 131

Oyster Farming in the Maritimes

By J. C. MEDCOF

Fisheries Research Board of Canada
Biological Station, St. Andrews, N.B.

PUBLISHED BY THE FISHERIES RESEARCH BOARD OF CANADA UNDER THE CONTROL OF THE HONOURABLE THE MINISTER OF FISHERIES

1961

Oyster Fishing, Malpeque Bay—Prince Edward Island

(From a painting by Lorne H. Bouchard, A.R.C.A.)

"... & y a quantite d'isles remplies de grand nombre de gibier, & coquillages de plusieurs sortes: entre autres des huistres . . ."

—— from the description of Acadia in: "Les Voyages du Sieur de Champlain", Paris, 1613, page 159.*

*[. . . *and there are numerous islands stocked with great quantities of game, and shellfish of several kinds: among others, oysters* . . .]

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For a listing of recent issues of the above publications see inside of back cover.

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ABSTRACT

For centuries oyster farmers have followed "rule-of-thumb" methods to improve the quality and increase the quantity of their harvests. But modern oyster farming, based on knowledge of oyster biology, began in France in 1870 and in eastern Canada in the 1930's. It has been encouraged here by leasing oyster ground and by co-operative efforts of the Canada Department of Fisheries and Fisheries Research Board which maintain an experimental oyster farm in each of the maritime provinces (Nova Scotia, New Brunswick and Prince Edward Island) and a Biological Sub-Station for oyster studies on Malpeque Bay, P.E.I. But fishing wild (naturally produced) oysters on public beds has generally produced about half the annual harvest of 7 million lb (landed weight) over the last 10 years.

The industry is based on the Atlantic oyster (*Crassostrea virginica*) which is found in the relatively warm southern Gulf of St. Lawrence and in the Bras d'Or Lake. Our stocks are isolated northern outposts of this species which characterizes the Atlantic coast of North America southward of Cape Cod.

Oyster farming in the Maritimes is expensive because of natural conditions. The producing areas are ice-bound 5 months of the year, the growing season is short, the annual growth is slight and oysters are old (5 to 7 years) by the time they reach minimum legal marketable size (length 3 inches). The larval period averages 21 days, after which the young oyster settles down for life. Our oysters have an international reputation for shell and meat quality but our oyster farmers sell their products almost exclusively in Canada, catering to the luxury half-shell trade. Shucked and canned oysters are also produced here, but only in trifling quantities.

Farming has three phases: providing collectors for larvae to settle on, rearing the settled larvae (spat) to bedding size (diameter 1½ to 2 inches), and maturing the bedding oysters to market size on oyster beds. Conditions for spat collection are best at the heads of inlets where the bottom is soft. Rearing spat quickly to bedding size, which takes up to 3 years, is best in the middle reaches of inlets where the bottom is firm and the water warm. And maturing to well-shaped, marketable oysters (another 2 or 3 years) is best near the mouths of estuaries where the bottom is hard, the salinities high (26 to 30 parts per thousand) and the water relatively cool. Grounds for these three phases must be carefully selected to insure good catches of spat, to avoid losses of older oysters from ice damage, wind action, silting and natural enemies, and to avoid contamination with domestic sewage or industrial wastes. Rearing grounds and maturing grounds must be approved by and leased from the Department of Fisheries. The average lease comprises 5 acres. A well-managed acre of maturing ground can produce 250 imperial bushels of good oysters a year.

Cardboard collectors covered with a film of concrete, rings of waste plywood coated with concrete and shells are recommended for spat collection. The Fisheries Research Board provides a spatfall prediction service based on studies of spawning and planktonic larvae and advises industry when to expose collectors for successful spat collection. The Board and the Department are trying to develop oyster hatcheries to insure earlier and more dependable spatfall and fast growth to bedding size.

Spat on concrete-coated cardboard or on plywood films are separated from their collectors (sometimes using spat threshing machines) at the end of their first summer when they are 3 months old, or early the following spring. They are reared on the bottom to bedding size. They must be cultivated to remove enemies and competitors and to insure good shape. The worst enemies, starfish, are mopped and killed by putting them ashore above high water or by dipping them in brine. The worst competitors, mussels, are culled out during cultivating and fishing and killed by putting them ashore above high water or by putting them through a crusher. Bedding oysters can be fished from rearing grounds with hydraulic harvesters and separated, if clustered, before careful planting on maturing beds to avoid crowding. By these methods oyster farmers can usually obtain the quantity of good bedding oysters they need and so regulate their

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production of market oysters. However, most oyster farmers still make extensive use of wild bedding oysters picked by hand from the beaches in public areas or fished under permit from beds in polluted areas. There are too few of these to meet the demand and expansion of the industry now requires controlled spat collection and rearing of bedding oysters.

Some oyster farmers plant the whole of their maturing ground with bedding oysters every year (multiple planting), others sub-divide their ground and stock a different part each year (single planting). Each method has its own advantages. The maturing grounds also require cultivation and may require starfish mopping.

Shipworms abound in oyster areas and wooden equipment used by oyster farmers must be protected. An inexpensive paint has been developed for this purpose and other devices are being tested.

In the late 1950's, a disease, deadly to oysters but harmless to consumers, almost eliminated oyster production in New Brunswick and Nova Scotia, both on public beds and leased grounds. This disease is still spreading. Although the germ has not been identified, it is almost certainly the same as the one that destroyed Malpeque Bay and other Prince Edward Island oyster stocks beginning in 1915. It took 20 years for Malpeque stocks to recover from this epidemic, but when they did recover they were resistant to the disease and now all Prince Edward Island oysters are resistant. Since 1957 the Department has moved 25,000 imperial bushels of Island oysters to disease-affected mainland areas, hoping that they will breed, produce disease-resistant young and thus re-establish the stocks in less than 20 years—perhaps by 1965 or 1970. These are surviving well and there are prospects for recovery of the mainland's wild stocks and for expansion of the oyster farming industry on the mainland and Prince Edward Island by using new culture methods that are being developed.

Most oysters are fished in autumn but in some places they are fished in winter through the ice. Some oysters are picked from the bottom by hand by walking or wading but most are taken with some sort of gear from boats. Only rakes and tongs are permitted for fishing public beds but oysters farmer may use any gear they choose on leased grounds. They commonly use tongs, or rakes from oared boats and dredges from powered boats. Besides these, a highly efficient hydraulic escalator harvester is beginning to be used. Oyster farmers should combine cultivation with fishing for market. In this process, some land their whole catch as it comes from the dredges but most cull their catch in their boats, returning old shell to the bed and retaining living oysters. They land these, separating the young oysters to be returned to the beds later and retaining those of marketable size. Or all this may be done in the boat. The separated under-size stock are then returned immediately to the beds and only market oysters are landed.

It is best to hold market stock in a cool building until they are shipped unless the holding period is long. Current methods of holding oysters in water involve many risks and improvements are needed. Contamination is the most serious risk because most holding grounds are close to shore. Holding is permitted only in approved clean areas and some are inconveniently far from other working areas.

Cleaning, grading and packing must be done on shore to make sure they are thorough enough to meet Department inspection which is prerequisite to marketing. Market oysters are graded according to shell shape. Producers give marketing too little attention and some do an inferior job as compared with dealer--producers who are better equipped. Advertising and decorative packaging may become necessary when production increases and oysters are forced to compete vigorously with other luxury foods.

Because oyster areas are regularly covered by ice up to 3 feet thick from November or December until late April or early May, most oysters for winter consumption must be fished in autumn and stored. Many of them are shipped to Montreal cold storage warehouses and held for up to 5 months.

The Department of Fisheries controls oyster fishing and, on advice from the Department of National Health and Welfare, prohibits the fishing of oysters from areas that are contaminated by domestic sewage or by industrial wastes. However, the Department of Fisheries recognizes that oysters cleanse themselves when exposed to pure water and issues special permits for fishing contaminated oysters well before the autumn marketing season opens. These are relaid and held in approved clean-water areas for at least 2 weeks. By that time they are thoroughly cleansed and fit for marketing. Pollution of our inshore waters tends to increase with industrial and municipal development and almost every year the Department of Fisheries closes one or two more oyster areas to fishing for direct marketing. Oyster farmers should co-operate with their local authorities to limit this encroachment on their livelihood. Oyster beds sometimes die out from silting from land wash following timber clearance and may be affected by construction of causeways and mining operations. These effects are not as well understood as pollution but may be more important in the long run.

In spite of difficulties, prospects for oyster farming in the Maritimes are bright. The oyster lends itself to management and culture better than any other of our marine species.

CHAPTER 1. INTRODUCTION

1.1 What Oyster Farming Is

Oyster farming is the practice of one or more of the many methods of improving the quality or increasing the quantity of oysters produced. It can be a full-time or part-time job.

1.2 Why Farm Oysters?

By practising oyster farming you may improve production and earn more money than you would get from merely fishing wild oysters growing on natural beds.

1.3 How to Succeed

To be successful you must know your job. Because your job is not simple and because in many cases it is new to you, you must learn. You can and must learn from experience but you can avoid many difficulties and get ahead faster if you are willing to learn from advice and from reading.

You should learn the methods which have been tested and found to work in Canada's maritime provinces. You must also learn the principles on which these methods are based so that you can apply them wisely to your own special needs. The Fisheries Research Board is constantly trying to develop new methods and the Department of Fisheries is testing them and demonstrating those that are worth while at its Experimental Oyster Farms. There is an Experimental Oyster Farm in each of the three maritime provinces and you can learn much if you visit and discuss your problems with your nearest Oyster Farm Supervisor. However, you cannot make progress unless you understand what you learn and work hard in applying it.

The Maritimes oyster industry is now at a very low ebb and the Department is trying hard to encourage oyster farming because it believes that oyster farming is the best way to restore and expand the industry. But we need more than oyster farming to achieve this end. We need co-operation. You should farm oysters, of course, but you should also co-operate with other oyster farmers and with government in its administration of the oyster industry. This Bulletin has been written to help you do all these things.

1.4 How to Use this Bulletin

This Bulletin is a revised form of Fisheries Research Board Bulletin No. 60, "Oyster Farming in Eastern Canada", written by Dr. A. W. H. Needler and published in 1941. There have been many changes since 1941 and this new Bulletin tries to bring you up to date so you can do your job properly. It cannot give all the answers because many problems are still unsolved but it does summarize present knowledge on most of the problems of oyster farming in this region. To begin with, you should read its whole 18 chapters through completely. This will give you an understanding of oyster culture as a whole but you should also refer to the various parts of the Bulletin frequently for information on particular problems as they arise.

The Bulletin starts with an index to save you time when you are looking up information. Use this index. It has a simple system of numbering chapters and sections of chapters which helps you get the information you need quickly. After the "Introduction", which you are reading now, comes Chapter 2, a history of oyster farming on our coast and then an account of the biology of the oyster. If you don't have some knowledge of these two subjects you will make many mistakes. Next comes a description of the various steps in oyster farming from selecting grounds (Chap. 4) to marketing the final product (Chap. 14). It is easy to appreciate the importance of these chapters to your farming operations but the next four chapters are important too. They include discussions of subjects such as the relationship of oysters to pollution and public health. At the back of the Bulletin there is a list of titles of books I think you will find interesting and useful. There is also a list of meanings of some of the special terms used in talking about oyster farming. You should familiarize yourself with these terms to get a clear understanding of your work.

If you cannot find what you are looking for in this Bulletin you may consult other Canadian publications on oysters. A list of these is provided in Circular No. 32, General Series, of the Fisheries Research Board Biological Station, St. Andrews[1]. If you still cannot find what you want from these or from your local fisheries officer, submit your problem to the Deputy Minister of Fisheries, Ottawa.

1.5 How to Keep Up to Date

Although present methods of oyster farming can be profitable, improvements are needed. Better methods are being discovered in other countries and in our own. Many of those that seem most promising are being tested now at the Board's Biological Sub-Station and on the Department of Fisheries Experimental Oyster Farms and on leaseholds of progressive oyster farmers. From time to time the Fish Inspection Laboratory of the Department of Fisheries and the Department of National Health and Welfare assist in this work. By pooling findings from all these sources, much new and useful information is being built up. Consequently this Bulletin will not remain up to date for long. To overcome this, new information is published as need arises in Circulars of the Fisheries Research Board's Biological Station, St. Andrews, N.B. The Department mails copies of these to oyster farmers free of charge.

[1]This circular can be obtained gratis by sending a request to:
Fisheries Research Board of Canada
Biological Station
St. Andrews, N.B.

1.6 Keeping Records

To be successful you must be open-minded and alert to this new information. When you get Circulars or other communication, read them and file them away for later use. Like any pioneer, you will be keen to try out these new ideas, and ideas of your own, in your oyster farming operations and you will want useful information stored away where you can get it at a moment's notice. Besides this, you should be anxious to benefit your fellow oyster farmers by communicating the results of your efforts to the Board and the Department. If your are going to learn from your own experience or help others with what you learn, you will have to keep good records of your operations—what you do, where and when you do it, quantities of stock, labour, materials used, or money spent or received and the results you get, good or bad. You will find that your memory is not nearly good enough to retain the detailed information you need to make the best use of your experience.

1.7 Acknowledgments

Dr. Needler's "Oyster Farming in Eastern Canada", Bulletin 60, has served the needs of eastern Canadian oyster farmers very well for nearly 20 years. In this revision I have therefore kept to his general pattern of presentation. Much that is new has been added in the belief that the oyster farmer needs more information today than ever before. And much that is obsolete has been removed but I intend it as a compliment when I acknowledge that I have retained many sections of his writing in almost their original form.

I have had generous assistance from Fisheries Research Board and Department of Fisheries staff—especially from Dr. R. R. Logie who helped in planning the revision and supplied information on oyster disease; from Mr. H. R. Found who supplied information about practical problems and costs of oyster farming operations, and from my colleague Mr. R. E. Drinnan, who patiently helped in many different ways. I must also acknowledge help from Mr. J. R. Menzies and Drs. E. T. Bynoe and A. D. Tennent of the Department of National Health and Welfare who have helped me with Chapter 17; from Drs. A. W. H. Needler and D. B. Quayle of the Fisheries Research Board of Canada, from the late Dr. T. C. Nelson of the New Jersey Department of Conservation and Economic Development, and from Mr. James B. Engle, for their contributions to and criticisms of the manuscript. Acknowledgements for illustrations appear in pertinent legends, except for those prepared by Mr. Wm. McMullon to whom I am most grateful. I must also thank Mrs. W. J. Stickney and Mrs. R. M. Lord for their patient assistance in preparing this Bulletin.

CHAPTER 2. HISTORY OF OYSTER FARMING

2.1 Origins

Nobody knows exactly where or when oyster farming began. The Japanese are perhaps the oldest oyster farmers but the Romans were growing oysters in Lake Lucrinus near Naples in 95 B.C. Their methods were the rule-of-thumb kind. Scientific oyster culture, by which we mean oyster farming based on an understanding of biology of oysters, started in France after her natural oyster beds had been ruined by overfishing. It was in 1857 that Professor Costé was instructed by Napoleon III to conduct experiments on collecting spat and building oyster beds. Costé's efforts were so successful that the French industry soon recovered. News of this soon reached the United States of America where oyster farming of a sort had been going on since about 1855. And in 1867, Captain Townsend of New Haven, Connecticut, began applying Costé's findings to improve the already established practices.

2.2 Canadian Beginnings

Even in pre-Confederation days there was some oyster farming in Prince Edward Island but it, too, was of the rule-of-thumb kind. It was not until the turn of the century when overfishing had done its worst that Dr. Joseph Stafford, an early associate of the Fisheries Research Board, laid the basis for scientific oyster farming in Canada. He was asked to study oysters on both the Alantic and Pacific coasts. In the period 1904 to 1913 he conducted investigations that have made his name familiar to oyster biologists the world over. He also gave advice on management of our oyster resources. His advice was sound and it was supported by the Department and by outside consultants like Dr. Julius Nelson of New Jersey who was engaged to deliver public lectures at various places in Prince Edward Island in 1914. However, the advice was not immediately applied by industry in spite of the great need. On the Atlantic coast application had to wait until one man who had real faith in the possibilities of oyster farming made it his business to see that it was applied in an area where the oyster industry was considered a lost cause. That man was Dr. William A. Found, a native of Prince Edward Island, and the area was Malpeque Bay, P.E.I.

By the late 1800's oysters from Malpeque Bay, P.E.I., had become famous for their abundance and fine quality. For 20 years the annual catch from this one inlet averaged more than 4 million lb but production declined seriously in the early 1900's. At various times the Department engaged experienced oyster men to try to correct this situation. Among these was Captain Ernest Kemp from England. But their efforts did not offset the decline. Finally in 1915, the Malpeque fishery disappeared completely for many years. Over 90% of the oysters died from a contagious disease that affected them. By 1922 there were signs of recovery which were followed hopefully for several years. Improvements were very slow indeed and finally the Deputy Minister of Fisheries, Dr. Found, asked the Fisheries Research Board to appoint a biologist to study oysters and to attempt scientific oyster farming as a means of restoring the fishery. The Board appointed Dr. A. W. H. Needler in 1929 and interest centered at Bideford

River, a tributary of Malpeque Bay. The next year the Board erected its Biological Sub-Station on Bideford River near Ellerslie and the Department set up a government reserve of oyster ground which was the beginning of the Prince Edward Island Experimental Oyster Farm. Dr. Needler was given direction of both. An experienced scientific co-worker, Mr. H. P. Sherwood, was brought here from Britain for a season and work began in earnest. The task was to devise culture methods suited to the special conditions in our areas.

2.3 Recent History

Dr. Needler visited with United States oyster biologists and oyster farmers, read reports from other countries, and he and Mr. Sherwood tested methods that seemed promising. Some Malpeque oysters had survived the 1915 epidemic disease and reproduced in scattered areas at the heads of creeks. They fished many of these and planted them on beds prepared for them in Bideford River to serve as spawning stock. Dr. Needler tested a new spat collector just invented by Dr. Prytherch who was then working in Connecticut, U.S.A. This was the cardboard egg-crate filler coated with a film of concrete. It met our needs better than other collectors such as bags of shells because it was so easy to remove and separate the spat that settled on it. These could then be reared as individuals (unclustered) to the well-shaped oysters demanded by the half-shell trade. The big handicap was that when these spat were separated and planted on the bottom, starfish ate many of them and many others were washed ashore or buried in silt. To overcome this, Dr. Needler invented the screen-bottomed, board-covered, floating tray in which he reared seed oysters through their first summer after they were removed from the collectors. On the trays they were safe from starfish and from being washed about or smothered. By autum most grew to bedding size (large enough to resist starfish attack) and could be planted on maturing grounds. Commercial-scale trials at the Experimental Oyster Farm showed that oyster culture in Malpeque Bay could be profitable when these two devices were employed. This was made known to the public and in the early 1930's provisions were set up under which would-be oyster farmers were able to lease suitable ground from the Federal Department of Fisheries for oyster culture in Prince Edward Island. Several leases were completed and a few pioneer oyster farmers began vigorous operations. By 1937 or 1938 approximately 40,000 egg-crate filler collectors (10,000 bundles) were exposed in the Malpeque Bay region to collect spat and there were over 1,000 spat rearing trays in the Bentinck Cove area alone (near Summerside, P.E.I.). By 1939 a total of 33 leases had been completed on the Island and provisions for similar leases had been set up in Nova Scotia and in parts of New Brunswick. The Malpeque fishery had been re-established and there were great hopes for oyster farming throughout the Maritimes. That year $3\frac{1}{2}$ million lb (36,000 boxes) of oysters were marketed.

In the interval 1929 to 1939, the staffs of the Biological Sub-station and the Experimental Oyster Farm at Ellerslie increased. Biological studies of oysters were begun in Nova Scotia and New Brunswick and an Experimental Farm had been opened up in Bras d'Or Lake in Nova Scotia. Much new information was assembled and some improved methods of oyster farming were devised. Basically, however, the system was the same. It required egg-crate fillers to collect spat and floating trays to prevent starfish from killing spat during their second summer. Unfortunately, this system was less successful in other parts of Prince Edward Island and in mainland areas than in Malpeque Bay. Oyster farming outside the Malpeque region never did get under way before the economic upset of World War II dealt it a staggering blow from which it has not yet recovered. Soaring costs of labour and materials made the use of rearing trays unprofitable so people stopped putting out collectors. There was no economical means of raising spat to bedding size. Oyster farming languished—first, on the mainland, next in those parts of the Island where it was not well established, and finally in Malpeque Bay itself.

In spite of much investigational work in the next 15 years supervised successively by Drs. C. J. Kerswill and R. R. Logie, the Board failed to find an economical substitute for floating trays with which to circumvent starfish attacks on young oysters. Thus it is fair to say that the old starfish problem brought oyster culture nearly to a standstill. But that is not the whole of the sad story!

In 1955 the mainland oyster fisheries, which depended on naturally-produced stocks, suffered the first impact of the worst disaster they have ever known. A devastating epidemic oyster disease, which is harmless to man, appeared at Cocagne, N.B., and spread in both directions along the mainland shore of Northumberland Strait. As it spread it wiped out the native stock. It has now affected almost all areas from Shippegan, N.B., in the north to the Strait of Canso in the southeast, so that the Bras d'Or Lake region and a few small harbours are the only areas outside the Island that are producing normally. The effects of the disease on Maritimes oyster harvests may be judged from Fig. 1.

The Fisheries Research Board studied this disease and found that Island oysters are resistant to it. As a result, the Department has been transplanting mass quantities of Island oysters to devastated mainland areas hoping thereby

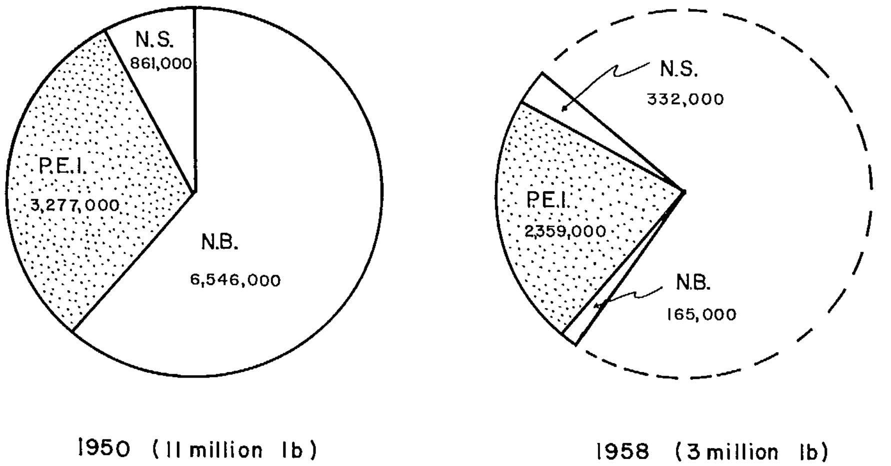


FIG. 1. Oyster production of the Maritimes before and after onset of the oyster disease.

to provide the breeding stock needed to re-establish their oyster populations. Transplanted oysters are faring well and oystermen now begin to feel hopeful. United States east-coast oysters are now also suffering devastating losses from an unidentified disease. We trust that the trouble will soon be cleared up in both countries. However, even if we overcome disease, we shall again be faced with the same two old problems Dr. Needler and many others have faced—how to increase the number of seed oysters that settle and how to save them from being eaten by starfish. In his day Dr. Needler found economical ways of dealing with these problems in the Malpeque Bay area. But now they require different solutions, because concrete-coated, egg-crate collectors work only in a few places, and because floating trays are everywhere too costly.

In the last 5 years, experiments started by Mr. George Wilson of the Department of Fisheries have clearly proved that spat can be reared directly on the bottom in Conway Narrows, a tributary of Malpeque Bay, with very small losses. It was the late Honourable G. S. Sharp of Tyne Valley, P.E.I., who discovered this and made practical use of it in his oyster farming operations. By all accepted standards this is a most unpromising area but discovery of its usefulness promises to be the most important development since the 1930's, when Needler began using floating trays. There are areas in other parts of the Maritimes that resemble Conway Narrows although they have yet to be tested. It may now be possible to produce an abundance of bedding oysters to stock leased areas if we can catch seed oysters economically, and we are hopeful of this.

Thus, although we find ourselves in the midst of disaster far worse than Dr. Found ever knew, there are bright hopes of emerging from it. We believe that devastated mainland oyster populations will be restored within 10 years, and that we now have the key to a new and potentially vast development of scientific oyster farming throughout the Maritimes. To realize this, industry will have to become more specialized. Some areas are best for spat production, some for rearing bedding oysters, still others are best for maturing. Until now every district has tried to be self-sufficient and we have taken little advantage of the special qualities of different areas. It will take time to work out the new system but we are confident that it will come.

The Department's work on oysters is carried out by its Conservation and Development Service of which Dr. A. L. Pritchard is Director. Mr. H. R. Found, with headquarters at Ellerslie, P.E.I., is immediately in charge of Maritimes oyster work, including the operation of its Experimental Oyster Farms, under Dr. R. R. Logie of Halifax who supervises fish culture work. The Fisheries Research Board's Biological Station at St. Andrews continues to maintain the Biological Sub-Station at Ellerslie with Mr. R. E. Drinnan in immediate charge under the direction of Dr. J. C. Medcof of St. Andrews. The Sub-Station's efforts are concerned almost entirely with solution of oyster problems. Mr. Drinnan and Mr. Found and their assistants co-operate closely in biological investigation and application of investigational results for the betterment of the industry. You need their help and they need yours.

CHAPTER 3. BIOLOGY OF OUR OYSTER

3.1 Family Relations

The oyster of the maritime provinces is the same species as that which grows on the Atlantic and Gulf of Mexico coasts of the United States and is often called the Atlantic or eastern oyster. Its scientific name is *Crassostrea virginica* (formerly *Ostrea virginica*). It is distinctly different from the common European oyster. It is also different from the two species that live on our west coast—the Pacific oyster, which was introduced from Japan, and the Olympia oyster which is native to British Columbia. In other parts of the world there are other kinds, each with its own peculiar biological characteristics. Our oyster–farming methods are based on our knowledge of the biology of the Atlantic oyster and its enemies and competitors. It is important that you should know the main facts of their biology because methods of handling and farming will fail unless they are taken into account. This chapter deals with oyster biology. Chapter 9 deals with the biology of its enemies and competitors.

3.2 Geographic Distribution

Most of the oyster beds in the Maritimes are still found where the Indians and early explorers found them; that is, close to shore in the southern Gulf of St. Lawrence. If you explore southward and westward you will find a few struggling stocks on the outer coast of Nova Scotia. But there are no oysters in the Bay of Fundy region.

Southward along the United States Atlantic coast you will traverse a long reach of State of Maine waters which, like the Bay of Fundy, produce no oysters. Oysters are not found in quantity again until you reach the southern New England States, south of Boston and Cape Cod. Although oysters are common here, New England as a whole produces less than 5% of the total United States crop. The greatest production is in the Chesapeake Bay region but it is also heavy southward into the Gulf of Mexico. In these regions the oyster is a rival for first place among valuable sea products.

Thus, our Gulf of St. Lawrence oyster population is isolated. It is the last northern outpost of the species, and it is an almost discouragingly tiny stock. Indeed it produces only a fraction of 1% of the North American Atlantic coast's oyster harvest as shown in Fig. 2. Nevertheless oysters are important to us, and they could be much more important.

Our oyster does not spawn until water temperatures reach 68°F (Fahrenheit) and, as Fig. 3 shows, there are very few places in the Maritimes where the water regularly gets that warm in summer. Bay of Fundy waters are much too cold. Over the years many plantings have been made there but the oysters have always died after a year or two. A few populations on the outer coast, like the one in Mahone Bay, N. S., were fished by the Indians in pre-historic times

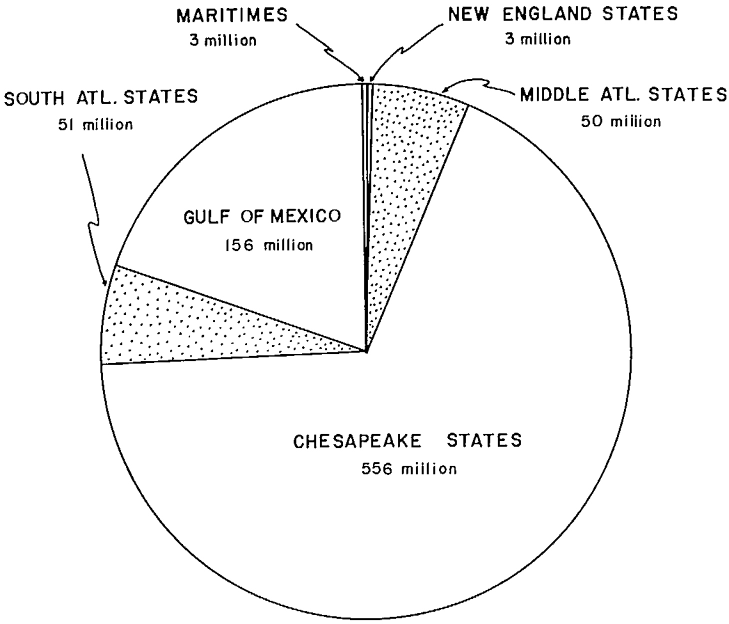


FIG. 2. Oyster production from various parts of the Atlantic coast of North America in 1958 (815 million lb whole oysters).

but have since become extinct. At present, Musquodoboit Harbour, about 25 miles east of Halifax, is the only inlet on the mainland outer coast that has a stable population and it is too small to encourage commercial fishing. There are many more oysters in the warmest parts of the Bras d'Or Lake and in Aspy Bay, Cape Breton Island, N.S. Both these waters are nearly cut off from the Atlantic. The real home of the oyster in eastern Canada is the shallow southern part of the Gulf of St. Lawrence. In this protected region the tidal currents are too slight to stir up the deeper, colder water and the bays warm nicely. Miscou Island, N.B., can boast of having the most northern of all breeding populations of Atlantic oysters. Northward from Miscou the water is again too cold.

Even most parts of the southern Gulf are too cold. Oysters abound only in sheltered bays and river mouths. For 5 or 6 months of the year these waters are covered with ice 2 feet thick but in spring they warm quickly because they are shallow, and they stay warm for several months.

For many years Miramichi Bay, N.B., supported the largest population. The stocks of Malpeque Bay, P.E.I., and Shippegan–Caraquet, N.B., were next in importance, and there were many other well known populations. Figure 4 gives some idea of the size and importance of our annual oyster harvests. Recently they have fluctuated about 7 million lb valued at roughly $400,000.

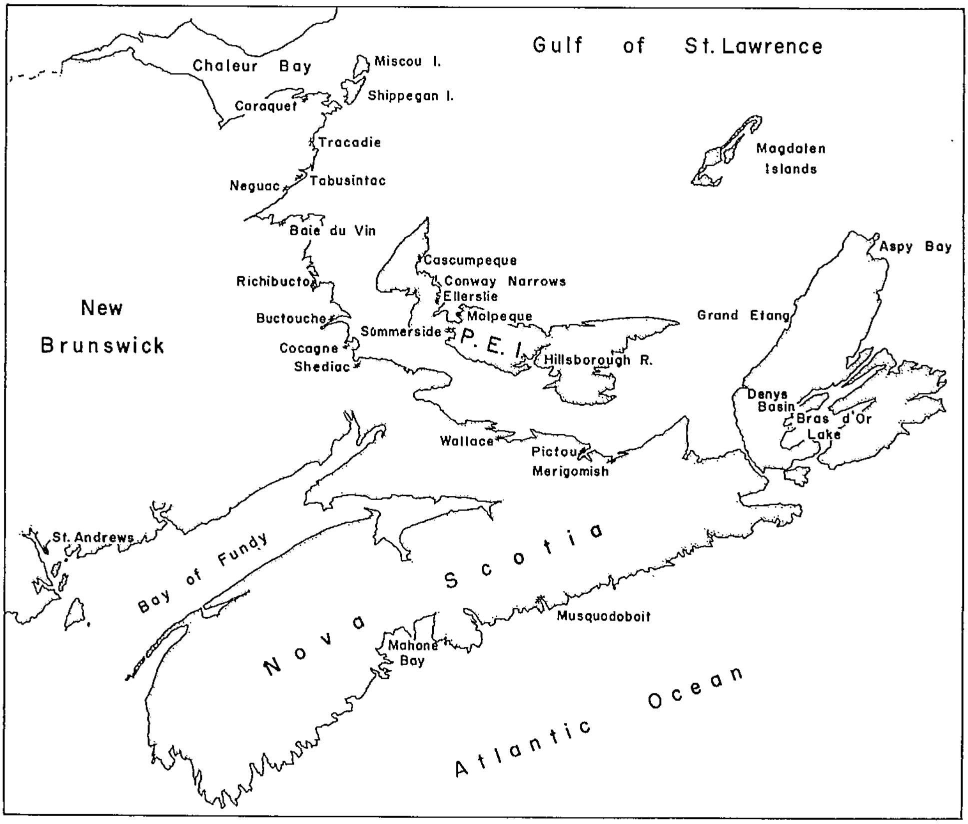


FIG. 3. Map showing location of principal oyster producing areas of the Maritimes and other places mentioned in this Bulletin.

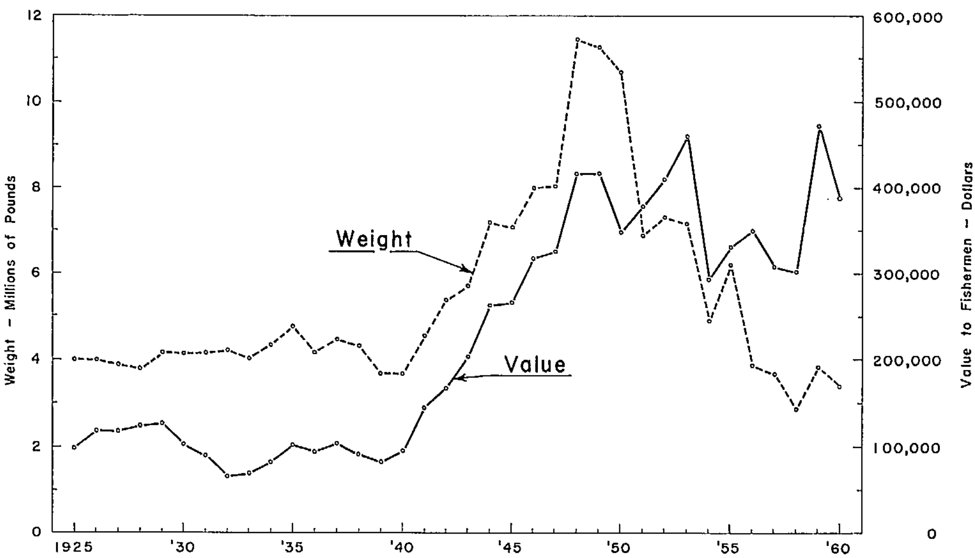


FIG. 4. Weight (shell included) and value (wharf price to fishermen) of the Maritimes oyster harvest for the years 1925–1960.

3.3 Anatomy

It will help you in thinking about some of your problems if you know the main points concerning the anatomy of adult oysters.

Shell. The oyster's shell is dead just as the fingernails on a man's hand are dead. It grows by being added to by the living part (meat). The shell is in two halves or valves which cover the sides of the animal. Normally the oyster lies on its cupped left side, so the flat right valve is uppermost. The dorsal (back) edge of the shell is usually straighter than the ventral (belly) edge which is sweepingly curved (Fig. 6–7). The narrow hinged end of the oyster's shell is the front end which means that the open or lip end is the hind end. The hinge contains a tough elastic pad which makes the lip ends of the valves spring apart unless the oyster pulls them together by shortening its shell muscle which is fastened to each valve at a purple spot. The two valves fit together neatly and make an air-tight and water-tight seal when the oyster closes.

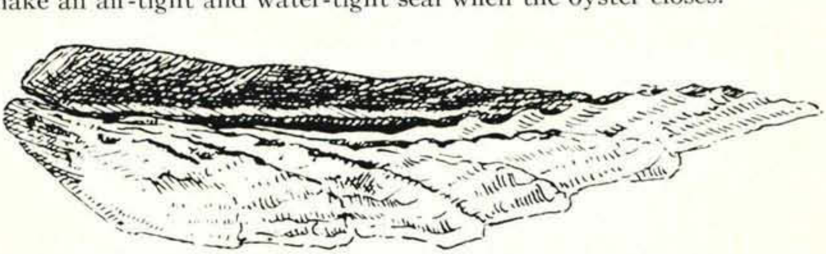


Fig. 5. Side view of oyster to show how new shell layers are formed inside the old and project at the edge to give the shingled-roof appearance. This shows best in the lower valve. (After Gaarder and Bjerkan.)

The shell is approximately 95% calcium carbonate (the same material as limestone) and more than twice as heavy as water, so it sinks quickly. It is built up from the inside of the valves (Fig. 5) layer after layer. Each new layer is a little longer and a little wider than the last and, therefore, sticks out to form a new edge like the lowest tier of shingles on a roof. The oldest parts of shells are the outside layers at the hinge ends of the valves. The newest parts are the layers which cover the inner faces of the valves and project around their margins to form the sharp lip. The inner face of the shell is smooth, generally very hard and white except for a purple scar on each valve where the shell muscle attaches. In the summer growing season, the hard white surface may show glossy yellow blotches and dull chalky patches of varying sizes and shapes. The chalky deposits help preserve internal shell contours which seem to be important to the proper functioning of the animal.

Closing the shell is the oyster's main defence against enemies and adverse conditions. It serves well, but some animals are able to drill through it, chip it away or pry it apart.

Meat. For a good look at live parts of an oyster you should remove the flat upper valve which covers the right side. If you do this carefully you will see (Fig. 6) a thin, white sheet of tissue, with a brown or black whiskered margin,

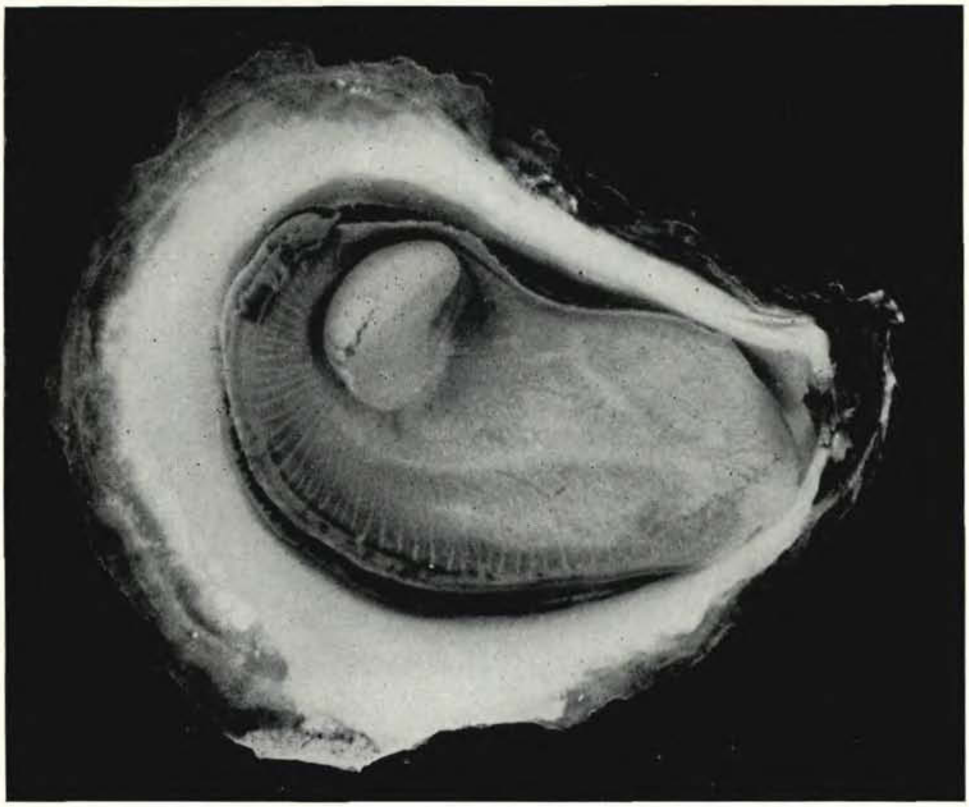
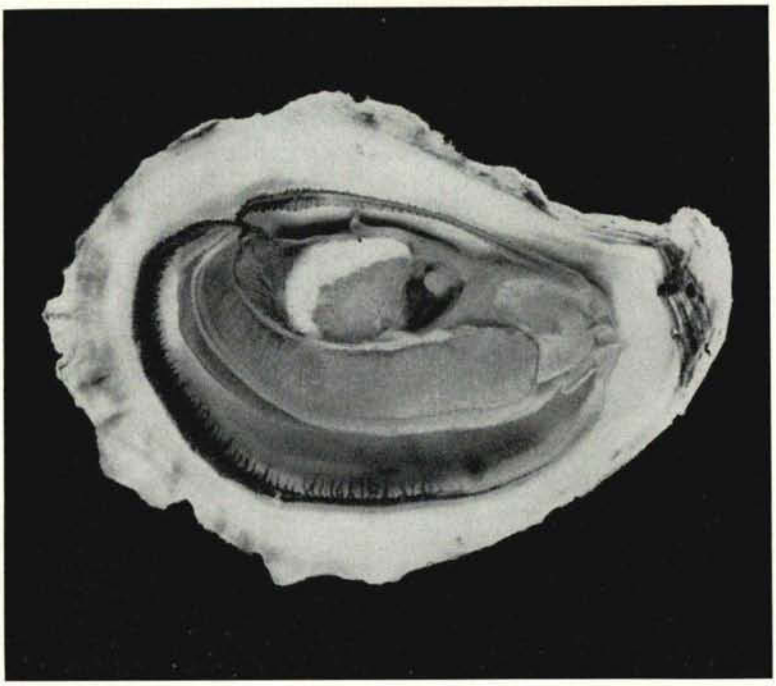


FIG. 6. Oyster meat lying in left (cupped) valve after removal of right valve. The right half of the mantle, marked with its radiating lines and dark margin, hangs like a curtain and masks everything but the powerful shell muscle.

covering the meat. This is the right half of the mantle. It forms new shell by producing sheets of lime over the entire inner face of the right valve and beyond it to produce the lip. The left half of the mantle lines the left valve. You will find it below. The edges of the mantle can curl up or lie flat so as to regulate the flow of water through the gap between the valves when they open. The whiskers or feelers along the dark mantle edges serve as strainers to keep coarse particles from fouling the delicate filtering system. Besides this, they warn the oyster of danger for they are very sensitive to light and to chemical changes in the water. Oysters are also sensitive to mechanical disturbance. You can see this best if you keep them in an aquarium. Even walking across the room or sneezing near the aquarium frightens them and they slow down their water pumping.

Near the middle of the right half of the mantle you can see the kidney-shaped end of the powerful shell muscle which you had to cut through to remove the right valve. This muscle has two components, a dark and light part which show better in the photo reproduction in Fig. 7. It takes a pull of over 20 pounds (suddenly applied) against this muscle to open the shell of a 3- to -4 inch oyster.



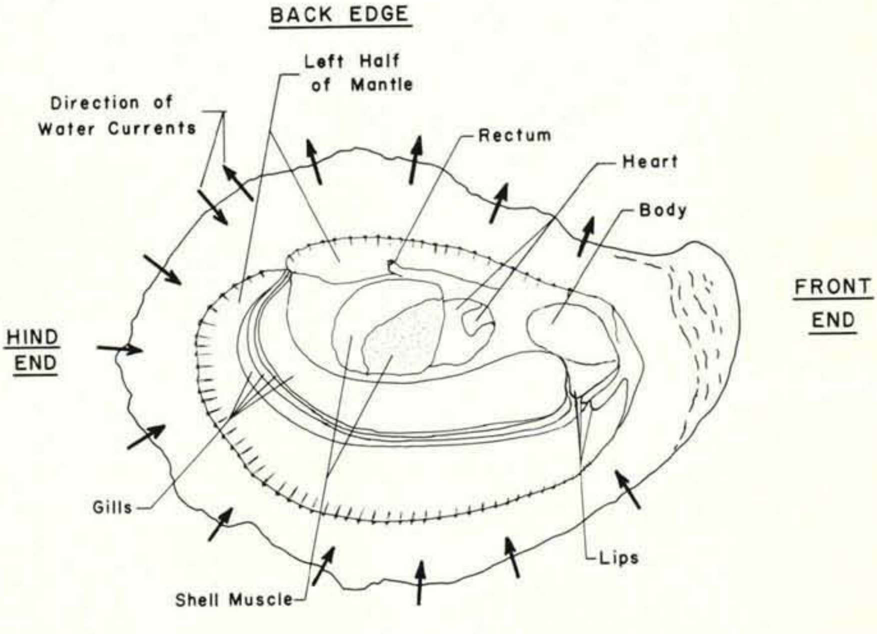


FIG. 7. *Above:* Meat of a thin oyster lying in its left shell. The right half of the mantle has been removed to show the superficial anatomy. *Below:* Features shown in the photograph above. The short arrows show where water enters and leaves when the animal is feeding.

Smaller pulls will open it if applied long enough to fatigue the muscle. For instance, a pull of 2 pounds (continuously applied) will open the shell after about 3 weeks.

To see more you must lift and look under the right half of the mantle or cut it away (Fig. 7). You will find that it is attached to the central and front ends of the body and, at the upper hind end, to the left half of the mantle. Now you can see the front end of the body which is thickest. It is in this area during summer that you will notice the clear veins which we shall mention later as the first signs of spawning activity (Chap. 6.1). Further back and against the shell muscle, you can see the heart which will beat slowly after the animal recovers from the surgical shock of shell-removal and mantle-removal which you have just performed. The blood is like water, clear and nearly colourless, so you will not be able to see many of the blood vessels.

Hanging down in an arc from the belly side and hind end of the body you can see four large gills arranged one below the other, like pages in a book. As a group they are sometimes called the beard of the oyster. The gills are lined with rows of pores. Microscopic whips called cilia drive water through these pores into an inner chamber which empties to the outside along the back side of the oyster as shown by the arrows. The main job of the gills is filtering food from the water. They pass the food forward to four triangular lips on the belly side of the front end of the body. These look like small gills and surround the mouth which leads directly into a stomach. The stomach is surrounded by a brown digestive gland which may show vaguely through the front end of the body if the animal is not too fat. The intestine leads from the stomach, coils about inside the body and empties through the rectum which is just above the shell muscle and behind the heart (Fig. 7).

If you damage the meat when you are opening a freshly-fished oyster you will sometimes discover a clear flexible rod about $1\frac{1}{2}$ inches long and about the thickness of a match. Some people are disturbed when they find it and call it an eel or a worm. But actually it is part of the oyster, the crystalline style, an important part of the digestive system. Most of it lies in a sac of the intestine but its front end projects into the stomach. It is turned by cilia lining the wall of the sac. The end which projects into the stomach churns up the food and furnishes a powerful digestive juice. The style dissolves in less than an hour after an oyster closes its shell but may be formed within 15 minutes after the oyster opens its shell and starts feeding again. Finding a style is proof that you are eating an oyster that is as fresh as it can be.

PEARLS. Pearls are small deposits of shell material formed around some nucleus such as the cyst of a parasite. They are usually imbedded in the mantle or just under the surface of the meat but they are sometimes formed as blister pearls attached to the inside of the shell. Our oysters seldom produce pearls and those we have seen have all been valueless—opaque, lusterless and often misshapen—the same sort you find so commonly in mussels. In our region the best pearls are formed by freshwater mussels in lakes and rivers, but the pearls of commerce nearly all come from marine species of shellfish that are not close relatives of oysters, although they are often spoken of as pearl oysters.

3.4 Spawning and Fertilization

Some of our oysters spawn when they are about 1 inch long and they normally spawn every year thereafter as long as they live. In early summer a milky layer develops just under the surface of the body. In average-size females this layer contains tremendous numbers of very small eggs (up to 70 million) and in males even greater numbers of sperms. When they are spawned, eggs measure only 1/500th of an inch in diameter. They are nearly spherical and have no means of moving (Fig. 8, A). Sperms are tadpole-shaped with heads about 1/10,000th of an inch in diameter and thread-like tails about 1/500th of an inch long with which they swim (Fig. 8, B).

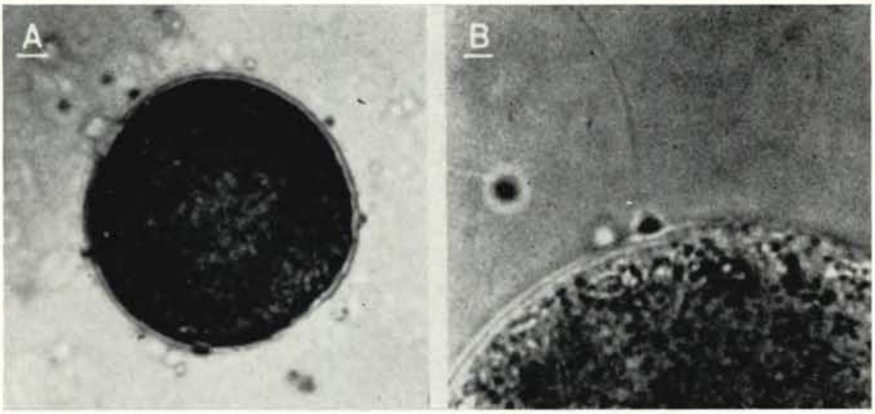


Fig. 8. A. Oyster egg immediately after spawning, photographed through a microscope (actual diameter of egg 1/500th inch). B. Still higher magnification of an oyster egg that is about to be fertilized by a sperm (head and tail show) that has attached to it. (Photo: Courtesy Rayonier, Incorporated.).

When females spawn they clap their shells gently, about twice a minute, and at each clap they puff out a small cloud of eggs into the water. In contrast, males merely open their shells slightly and shed their sperms in a steady, barely visible flow like curls of smoke rising from a cigarette. There is no mating act because adult oysters cannot move. However, the sperm carries a hormone and this will stimulate other oysters (male and female) to spawn if they are near enough for it to reach them. From this you will understand why oysters should be reasonably close together to insure a good heavy spawning.

Our oysters do not spawn until the water warms to about 68°F and then usually when temperature is rising. But they will not spawn when temperatures reach 68° if they are not ready. Sometimes they are not ready until temperatures have risen much higher than 68°. Sometimes the whole summer goes by and the water fails to warm to spawning temperatures. In such years no spawning occurs. Usually, however, our oysters start to spawn in one of the early spells of warm weather which raises the water temperature above 68°. Generally this is in late June or early July and sometimes corresponds in timing with the phase and declination of the moon which combine to produce extreme low tides in the heat of the day.

Oysters do not release all their spawn during their first spawning. After some spawning, which may continue for about half an hour, they stop but may start again several days later when further temperature rises or other conditions encourage it. The spawning of one individual may be spread over a number of weeks, and it is common for the spawning season in one locality to last a month or 6 weeks.

When oysters have spawned, the sperms from the males swim about in the water and come into contact with and fertilize (unite with) the eggs from the females. This fertilization usually takes place within a few hours after spawning. If oysters are scarce and far apart on the bottom, sperms may fail to meet with and fertilize the eggs. Unfertilized eggs die after a few hours. Because one oyster stimulates others if they are nearby, many oysters usually spawn at almost the same time. These bursts of spawning assure that eggs and sperms are present together and result in the production of large broods of young oysters of the same age and size.

The European oyster (*Ostrea edulis*) differs quite remarkably from our own in its breeding habits. It retains its eggs in the shell cavity where they are fertilized and develop into an advanced larval stage before release. The presence of developing young in the parent oysters during the breeding season (months without an "R" in their spelling) makes them unpleasant to eat although not injurious.

3.5 Free-swimming Larva

After a few hours the fertilized egg develops into a small *larva* (the plural is larvae) and begins to swim by means of vibrating hairs. It becomes part of a vast community of minute plants and animals that spend part or all their lives swimming or drifting about in the water. This community of living organisms is the plankton.

After about 36 hours a tiny shell forms and grows until it covers the larva, which then looks like a small clam but it is only 1/300th of an inch long. At this stage it develops a special organ for swimming—a disc, covered with vibrating hairs, which it can thrust out and withdraw between the shells at will.

The larvae swim and drift. They do not float at the surface. They are usually most abundant a few feet down. Even by vigorous swimming they do not move far horizontally. Their swimming efforts carry them mostly upward in the water. When they stop swimming they sink, and they may spend much time resting on the bottom. By swimming up they are often caught in tidal currents and carried about. They may be moved back and forth only short distances in their native area or they may be transported many miles from where they were spawned.

The larva feeds on microscopic plants and animals of the plankton community, grows rapidly, and changes its appearance and shape (Fig. 9). It is colourless at first, pale rose when 4 days old (Fig. 9, 1) and chocolate or purple after 10 days. By this time (Fig. 9, 3) the left shell has become noticeably larger and more cupped than the right. After 3 weeks it has grown to almost seven times its

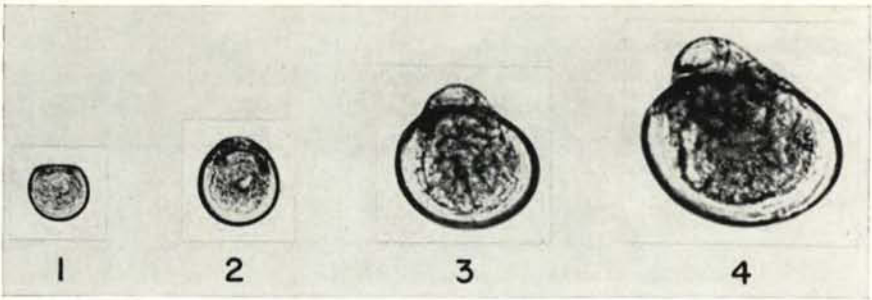


FIG. 9. Stages in development of oyster larvae. (Photo: Charlotte Sullivan.)

original size and is like a grain of pepper, about 1/75th of an inch high and barely visible to the naked eye. It still has its swimming disc (Fig. 10, 1) and other well developed organs. It has two eyes and a tongue-shaped foot (Fig. 10, 2) which it can thrust out between the shells for crawling and it is equipped now to attach itself to some support.

Large numbers of oyster larvae die during the free-swimming period—some fail to find sufficient food, others are eaten by a variety of small animals in the water. Only a fraction of 1% of fertilized eggs develop to full-grown larvae.

3.6 Setting of Larva

Few people have ever seen or ever will see an oyster larva attach itself, or "set", as most people term it. Nevertheless, so far as the oyster farmer is concerned, setting is probably the most important single act that any oyster ever performs. A few people have studied and described it. Dr. H. F. Prytherch of the United States Fish and Wildlife Service made history by filming it through his microscope 30 years ago. The frames shown in Fig. 10 are taken from his famous movie.

Before settlement, the larva goes on an extensive tour—swimming until it encounters a solid object, crawling over it (Fig. 10, 2) and swimming away again if not satisfied. It tries to select a firm surface free of slimy growths and it prefers one on which some other oyster larvae have already settled. It likes company. When it finds just the right spot it goes through a performance something like a dog making a bed (Fig. 10, 3—10, 5). Finally it lies down on its left side, extrudes a blob of cement (Fig. 10, 6) which flows into the space between the shell and surface of attachment and sets firmly within a few minutes.

From the above you will agree that "settlement" is a poor term for describing the vigorous process of larval attachment. However, the word came into use before biologists discovered the larval phase of the oyster's life-history. At that time oystermen believed that parent oysters spat their young onto rocks or shells and that the young were covered with a mucilage in which they set (became fastened down). Because of this misunderstanding, newly attached oysters were called *spat*, and the name has stuck. Because whole beds of oysters

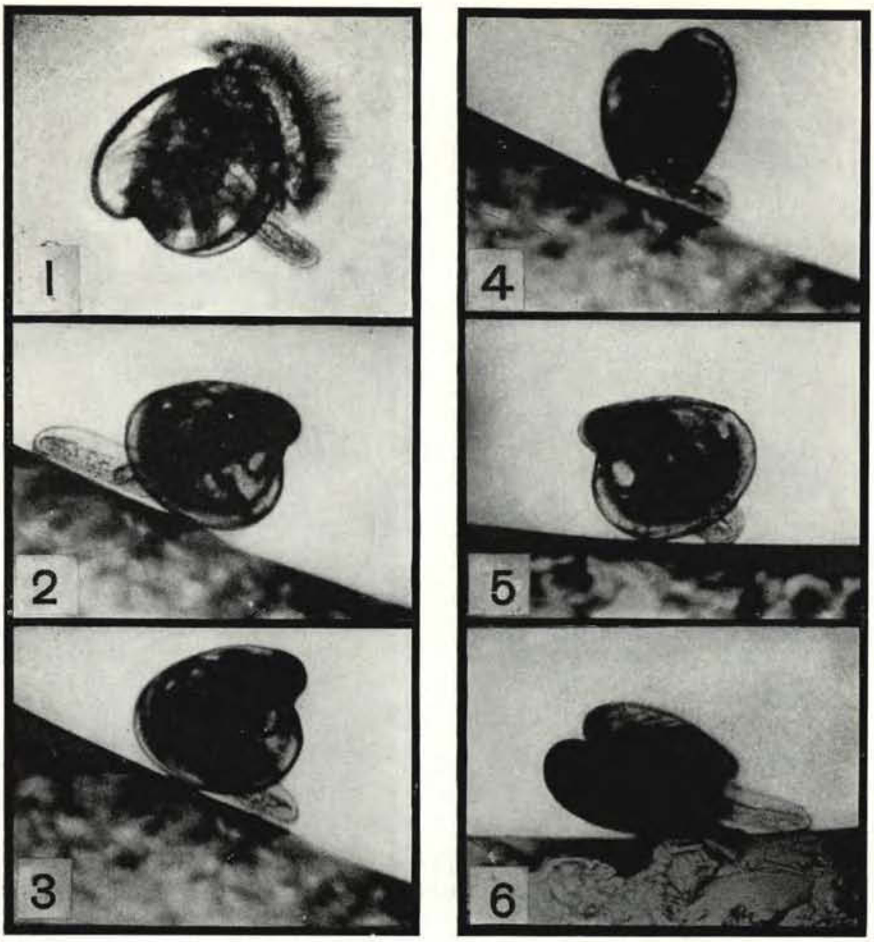


FIG. 10. Stages in the settlement of a full-grown oyster larva: 1. Swimming tour with swimming organ and foot extended. 2. Crawling tour with foot only extended. 3, 4 and 5. "Making the bed" on the chosen spot. 6. Cementing. (Photo: H. F. Prytherch.)

spawn at the same time, many larvae mature and settle at about the same time. And because newly settled larvae are called spat, the simultaneous settlement of many larvae is called a spatfall or a set of spat.

Depths at which spatfall is heaviest vary from place to place. In most inlets spatfall ranges from surface to bottom in depths up to 25 feet or more. In some estuaries fresh water at the surface keeps larvae down and limits the vertical range of spatfalls. Light also affects spatfall. The catch is usually heaviest on shaded lower surfaces if they are clean. On the bottom of the sea, clean surfaces are often most abundant near shore where wave action prevents silting. Consequently, heaviest spatfalls often occur in shallow shore zones where spat are exposed to many dangers.

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Oyster larvae will attach to many different materials—shells, stones, brush, leather, iron, glass, eel-grass, etc. But, as said before, the surface must be firm, smooth and reasonably clean. In most places silt and slime (tiny plants) create shortages of clean surfaces for spatfall. Consequently, under natural conditions most ready-to-settle larvae die because they fail to find setting places. Reducing this heavy loss of mature larvae is one of the oyster farmer's chief ways of increasing production. He does this by providing clean materials at exactly the right time for larvae to attach to and survive. This is called spat collection and the materials supplied are called spat collectors or *cultch*.

Growth rate of larvae in our waters is known and their size at settlement is known. Thus, by catching samples of swimming larvae in a fine net and measuring them it is possible to predict dates of spatfall many days in advance. This allows oyster farmers to put out spat collectors immediately before spatfall so the larvae will have clean surfaces to settle on. Our first spatfalls usually occur in late July.

3.7 Spat

After cementing itself to some firm, clean surface the oyster can no longer move about. It remains in its place unless moved by man, by wave action or by some other agent. It can feed only on what the water brings to it. It is unable to escape overcrowding if too many have attached in a small space and it cannot run away from its enemies.

As it grows, its appearance changes. Viewed through a magnifying glass, a spat is golden for the first few days because that is the colour of the new shell which it grows around the edge of its chocolate-coloured larval shell (Fig. 11).

It may be difficult even with a glass to distinguish oyster spat from spat of other shellfish such as slipper limpets and jingle shells. By lifting the shell edge with a needle or a knife point you can usually decide. If there is no lower half-shell, it is likely a slipper limpet. If there is a lower shell not cemented to its support but with a clear, round hole through it, then it is a jingle shell. If there is a lower half-shell without a hole and cemented to its support, it is an oyster.

Under favourable conditions spat grow quickly but they are so small at the start that by the tenth day after settlement they are still only about 1/16th of an inch long. As the season advances they turn much darker and begin to look more like oysters and by autumn, those that settled earliest may be as much as an inch long. Those that settled last may still be less than a quarter of an inch long.

Often 25 or more spat will settle on a square inch of suitable surface (Fig. 11) but of these only 2 or 3 have room to survive to any size. When sets are heavy, large numbers are killed by overcrowding or starvation.

Change from a free-swimming to a fixed life exposes young oysters to new enemies. The principal enemy in our waters is the starfish. If spat settle on rocks or shells on the bottom, starfish may kill well over 90% of them before they

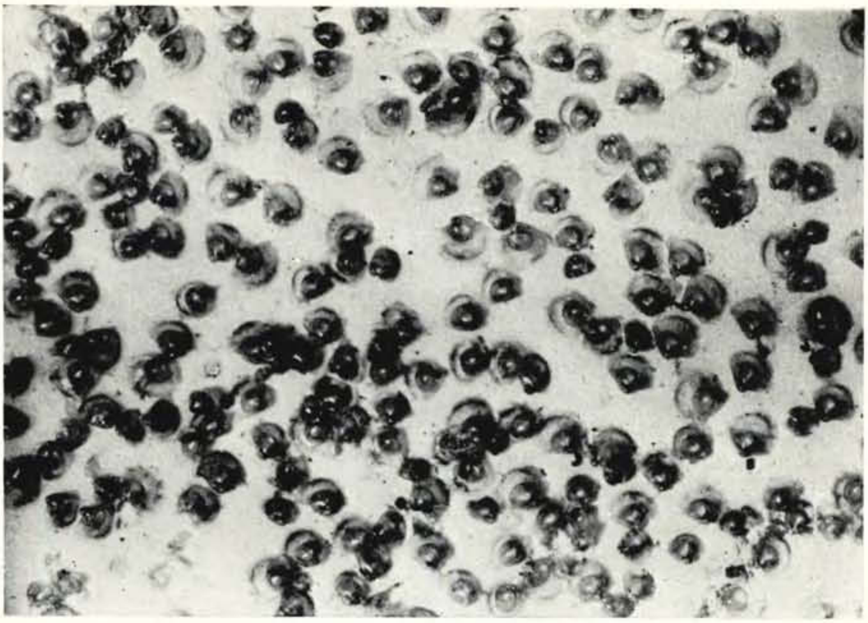

FIG. 11. Ten-day-old spat showing shell growth and early stages of crowding. (Photo: H. F. Prytherch.)

are a year old. Certain small snails called drills also kill spat and there are other less important enemies. Oyster farmers increase spat survival by removing enemies or by keeping growing spat in protected situations until they are large enough to be relatively safe. As oysters grow they become less easy prey for their enemies and less likely to be smothered by small amounts of silt. The year of settlement and the next year are the most dangerous times.

3.8 FEEDING

After settlement, the oyster obtains its food by opening its shells and filtering water. The water is drawn through the fine pores in the gills into the gill cavity by rhythmic beating of thousands of small hairs. This sets up the water currents into and out of the shell (Fig. 7). The filtering apparatus is too delicate to handle anything much above microscopic size. However, oysters eat almost all types of those minute plants and animals that live suspended in the water, as well as suitable-sized fragments of larger plants and animals. These are collected on the outsides of the gills, imbedded in sheets of mucus which the gills concentrate into strings, then passed along to the lips and mouth.

The quantity of suitable food in the water varies greatly from time to time. Sometimes there is not enough and sometimes even when there is enough, silt interferes with feeding. Feeding is also hampered when the water gets too fresh from heavy rains or spring run-off.

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Because the oyster is a filter-feeder, it cannot feed when it is out of water. But when it is in water it feeds almost continuously, day and night, if conditions are favourable. An oyster 4 inches long sometimes filters at the rate of 8 gallons an hour but lower rates are more usual. The warmer the water, the faster it feeds but there is an upper limit, between 80° and 90°F, and a lower limit, about 40°F, beyond which little or no feeding takes place. Thus, in our cool Canadian Atlantic waters, feeding is possible during only half the year.

When there is enough food present and when feeding conditions are right, the oyster is usually in good condition. The meat is then plump and creamy-white and fills the space between the shells or, as some say, it is fat. In our areas when the water temperature is over 40°F but below 60°F the oyster seems to be unable to feed fast enough to keep in good condition even when food is normally abundant. Feeding seems to be best at temperatures between 60° and 68°F. It is then that the meats are plumpest. In spring, spawn develops under these temperature conditions and in autumn reserve food in the form of animal starch (glycogen) is stored in the tissues.

When oysters are overcrowded they compete with one another for what food is available and they do not fatten or grow well.

On rare occasions one variety of microscopic plant is abundant and oysters feeding on it extract a green dye which they store in their gills and lips (Fig. 7). The autumn of 1947 was the last time this condition was widespread in the Maritimes. Green-gilled oysters are usually plump-meated and well-flavoured. In France they are highly prized and at Marenne good-quality oysters are nearly all held in special ponds where this greening regularly occurs, to prepare them for market.

3.9 Growth

The rate of growth varies a great deal. It is influenced by water temperature and currents, food supply, exposure to light, intertidal exposure and other factors. Growth is slow in the Maritimes. It doesn't begin until May when the water temperature approaches 50°F and it stops again in October when water temperatures fall below this level. Our oysters usually take from 4 to 7 years to reach marketable size (length 3 inches) as shown in Fig. 12. The fastest growing oysters are often poorly shaped with long, thin shells, especially if they are crowded. The best oysters are usually those that grow slowly or at intermediate rates without crowding.

Oysters may live to be over 20 years old but the older they get the slower they grow. Some get to be 15 inches long and weigh well over 3 pounds.

Practically all growth occurs in the four warmest months—mid May to mid September. Spat and yearlings may grow continually throughout this period. Older oysters grow a little in spring but they slow down in early summer during spawning and most of their growth occurs in late summer.

FIG. 12. Sizes of cultured oysters at different ages. *Upper row (left to right)*: (1) Oyster spat ($\frac{3}{4}$ inch) removed from collector $4\frac{1}{2}$ months after spatfall. (2) Bedding oysters ($1\frac{3}{4}$ inches) after 2 years on rearing grounds (planted on bottom as spat). They are now ready for transplanting on maturing grounds. (3) Young oyster ($2\frac{1}{4}$ inches) after 1 year on maturing ground. *Lower row:* Oysters (1) after 2 years ($2\frac{3}{4}$ inches), (2) after 3 years ($3\frac{1}{4}$ inches) and (3) after 4 years ($3\frac{1}{2}$ inches) on maturing ground. (Photo: G. F. M. Smith.)

3.10 SHELL SHAPE AND QUALITY

The best oysters have nearly-round, strong, hard, heavy, deeply-cupped, symmetrical shells. They look well when served and generally ship well and keep well in cold storage.

An oyster cannot move so if it is growing on very soft bottom it sinks slowly into the mud. Or, if it is growing in places where silt is settling, it tends to become buried. In either case it often grows long and narrow and thin (Fig. 13) perhaps to keep the lips of its shell above the mudline. Clustering, which is a form of crowding, also spoils shell shape. On hard, clean bottom it tends to be round. Under conditions favouring rapid growth, oyster shells are often thin and flat even when they are on hard, clean bottom. Shells are thickest, hardest, heaviest and most cupped when oysters grow slowly in cool-water, seaward areas. Where water is too fresh, as in upper parts of creeks and estuaries, shells are often light,

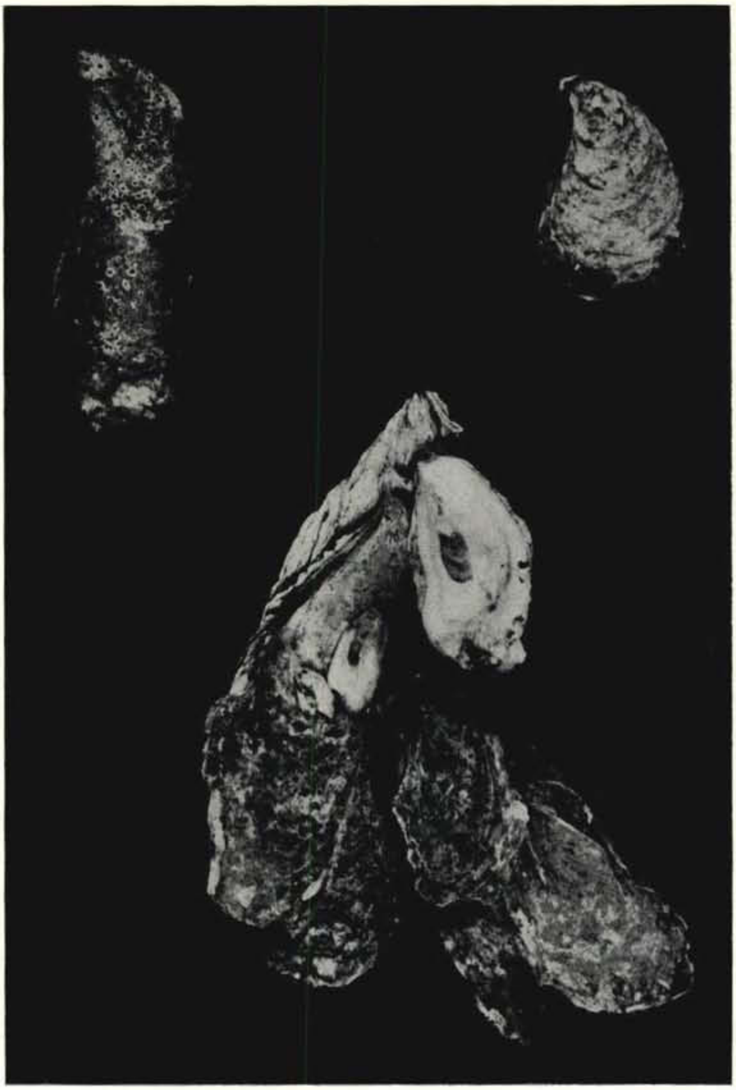

FIG. 13. How shape is affected by growing conditions: Centre, misshapen clustered oysters; right, well shaped cup oyster from hard bottom; left, long, narrow, twisted oyster from soft bottom.

chalky and weak and easily damaged during fishing and packing, even when they are of good shape. Oysters from such areas are often leaky and do not keep well in cold storage.

Crowding spoils shell quality even on good grounds. Shells of adjacent oysters become cemented together and shape is distorted.

Obviously, then, shape and quality of oysters' shells are determined by the conditions under which they grow. Spat from poorly-shaped parent oysters will grow to good shape under good conditions. And the reverse is true. We must pay attention to these things because we sell our oysters in the shell and often store them. In countries where oysters are shucked and the meats sold fresh or canned, oyster farmers need not be concerned about shape.

3.11 Meat Quality and Condition

Appearance, saltiness and fatness are the main factors determining meat quality. By fatness we mean plumpness because oysters never get fat in the greasy sense. They do not store their reserve food in the form of oils as herring do (Table I). They store it in the form of animal starch (glycogen).

Table I. Composition of oyster meats (after Pease, 1932).

Constituent	Based on weight of fresh meats	Based on weight of completely dry meats
	%	%
Water	76.10	0.00
Solids	23.90	100.00
Protein	10.12	42.43
Glycogen	6.14	25.75
Fat	1.91	7.98
Mineral matter	1.82	7.60

A fat oyster is a glycogen-rich oyster. Its meat is creamy-white (on rare occasions the gills are green) and is so plump that it nearly fills the space between the shells. Such oysters usually grow in down-river areas near the sea on hard bottom in cool, salty waters. Meats of up-river oysters are usually stringy, transparent and watery, dark (especially along the mantle edge) and fresh tasting as compared with those from down-river, or bay areas.

It is well known that oysters need not spend all their lives in seaward areas in order to develop fat meats. Poorly-shaped oysters which may have grown rapidly to marketable size in muddy parts of rivers usually fatten well by autumn if they are moved, early in the year in which they are to be marketed, to areas where the native oysters are fat. This was practised for many years by one Cape Breton dealer who bought River Denys Basin oysters and relayed them in Big Harbour in the Bras d'Or Lake just outside the Basin. After a year, these naturally thin oysters were in excellent condition.

A convenient gauge of fatness and general meat quality of an oyster is its *Index of Condition* which is the weight of its meat (dried) in relation to the volume of the space between its shells. The actual formula is:

$$\text{Index of condition} = \frac{\text{Dry weight of meat in grams}}{\text{Volume of shell space in millilitres}} \times 1000$$

The Index for high-quality meats usually ranges from 100 to 150; for medium-quality meats, 80 to 100, and for poor meats, below 80. Fatness of meats varies a great deal with season as shown in Fig. 14. There is little change in cold months (November to April) when oysters are hibernating and water temperatures are below 40°F. In spring when water temperatures first rise, oysters usually get thinner (Index drops) but with further warming a period of spring fattening and spawn development sets in. Fattening continues until the first major spawning when there is a sudden and drastic drop in Index. Most oysters remain thin for about 2 months when water temperatures are highest and further spawnings and shell growth are taking place (Fig. 14). By late August, temperatures begin to drop and autumn fattening begins. This usually continues for about a month as the water cools. In October or November the Index often shows a slight drop while the cool water turns really cold. Onset of hibernation brings an end to fatness changes. Oysters normally enter hibernation in excellent condition. No doubt this favours their survival through the long winter.

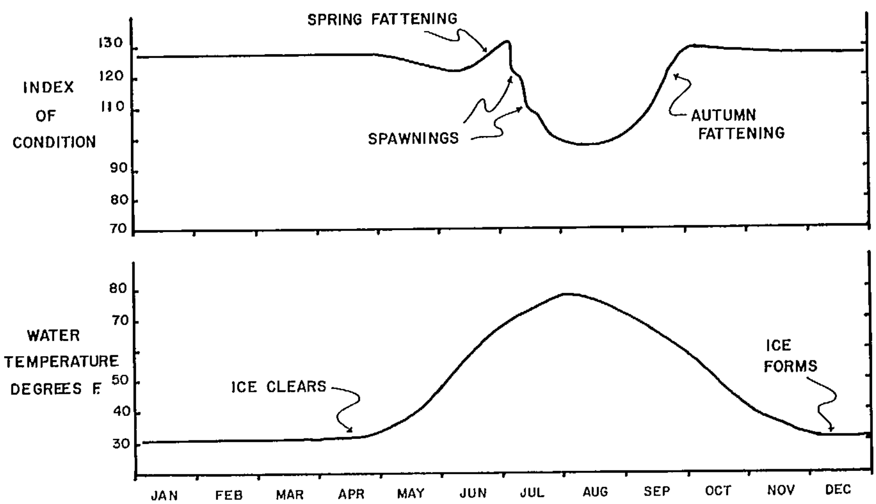

FIG. 14. Seasonal variations in fatness of oysters and how it is related to water temperatures.

You may be unable to detect all these changes in the stocks of oysters you work with. In parts of the Bras d'Or Lake, for instance, you will find no spring fattening. And sometimes changes are far more prominent than you might expect from Fig. 14. In some years, for example, the late fall decrease in condition is quite remarkable.

In spite of all these changes our oysters are always edible because, after spawning, they do not incubate their young as European oysters do in the months without an "R" (Chap. 3.4).

Crowding, overgrowth by mussels and silt deposition interfere with oysters fattening. Flavour improves with fatness but the colour of the mantle edge, which may make oysters more or less attractive, seems to depend on district and to vary very little with season. Even transferring oysters from one district to another may have little effect on mantle colour.

3.12 Hibernation

Oceans have their climates and seasons just as we have them on land. As compared with the open ocean the climate of the inshore waters where our oysters live is extreme—very warm in summer and very cold in winter. The longest season is winter which is usually thought of as beginning in December when the ice forms, and as ending with the spring break-up in April or May. Winter is also the season when there are fewest changes in the aquatic climate. For 5 months water temperatures in our oyster-producing inlets remain almost constant at 28° to 32°F. During this season there is often nothing in the water that an oyster could eat.

Our oysters are nicely adjusted to these conditions. They stop filtering (trying to feed) at low temperatures. They would only wear themselves out if they tried because there is little food. They also stop growing. Most of the time they do not even open their shells, so they are protected from many of their enemies. If the heart continues to beat it must beat very slowly indeed.

Unlike the bear that lives on his fat during his winter sleep, the oyster shows almost no loss in meat weight. It seems dormant in every way. It really and truly hibernates. Perhaps it is because our oysters are used to long hibernation that they keep so well during long periods of air cold storage. As far as can be learned, oysters from farther south do not store so well.

3.13 Sexual Maturity

There is no way of telling whether an oyster is male or female merely by looking at its shell. Nor is there any simple way of telling sex by examining its meat because there are no obvious, distinctive, permanent sex organs as there are in higher animals. Indeed, even the cells whose business it is to produce sperms and eggs are not differently coloured and concentrated into recognizable ovaries and testes as they are in molluscs like scallops. Instead, they are widely scattered in small clusters close to the surface over most parts of the body. Among the clusters there are small branching tubes that lead ripe spawn to the outside. But most of the time these tubes are collapsed and cannot be seen.

If an oyster is watched carefully while it is spawning its sex can be identified because then the behaviour of males and females is different as described in

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Chapter 3.4. And there is another way, providing the oyster is nearly ready to spawn. A small piece of tissue from the spawn layer below the skin can be removed and examined under a microscope. If there are eggs present it is a female and if there are sperms it is a male (Fig. 8). Occasionally oysters are hermaphroditic—that is, they produce both eggs and sperms at the same time.

Another peculiar feature that oysters share with some of the lower animals is that they may change their sex. They may produce eggs one year, sperms the next and, in the year following, eggs again. However, almost all really large, old oysters are females.

Ages at which oysters reach sexual maturity and spawn for the first time vary, and depend to some extent on growth rate. In Bideford River, a tributary of Malpeque Bay, P.E.I., 30% of yearling oysters (oysters in their second summer and therefore 1 year old) produce sperm and spawn. Hardly any produce eggs at this age. By their third summer all oysters are sexually mature and about 3 out of 4 are males. As age increases, the proportion of females increases. Thus the proportion of females among oysters that are fished and marketed is high. In contrast, most of the oysters that are returned to their bed because they are too small to market are males. Some people argue that this selective fishing of old female oysters is partly the cause of the decline of our oyster fisheries. They argue that a reserve of really large oysters should be preserved as spawning stock in every oyster-producing inlet.

CHAPTER 4. SELECTING GROUNDS FOR OYSTER FARMING

4.1 Importance of Selection

Why be careful? An oyster farmer's success is decided to a great extent by the conditions under which he works. In order to grow oysters he must obtain control, by leasing, of grounds where conditions are favourable. Once a selection is made and operations have started, it is expensive to change. It is therefore important for you to make a good selection in the first place.

As explained in Chapter 3.2, oysters can grow only in limited parts of the Maritimes. And within these limited areas their quality and vigour vary greatly. Some places are altogether too poor to be attractive to oyster farmers. Some are good for catching spat, others for rearing spat to bedding-size oysters and still others for maturing oysters. Each of these operations is favoured by special conditions and not all these special conditions are likely to be found in a single small area. The choice of oyster ground that will satisfy your particular needs is, therefore, an important and complex problem.

Advice from Department of Fisheries. The Department of Fisheries offers free advice on this problem. Although final selection is the responsibility of the oyster farmer himself, you will be wise to have the ground you choose examined and to get outside opinions on its suitability. The ground you first select may be good but you should finally lease and use only the best available. Examination by an agent of the Department is a normal requirement before grounds are leased and it offers an opportunity for close contact between oyster farmers and the Department. This close contact should insure that all concerned understand the needs and that these needs are satisfied as far as possible.

4.2 Where Conditions Are Suitable

Our oyster-producing regions. It was pointed out in Chapter 3.2 that Maritimes oysters are a northern outpost of the main stock of this species, which centres far to the south. Most Canadian Atlantic waters are too cold for production of oysters. Only in southwestern parts of the Gulf of St. Lawrence and in parts of Bras d'Or Lake and Aspy Bay, Cape Breton Island, are there any large areas where waters are warm enough. Commercial production is limited to these waters and it is there where we should do our oyster farming.

Oyster farming is often proposed in areas outside these regions where no oysters grow naturally. It is true that there are inlets in other regions where oysters can survive and grow and even some where they can reproduce. But even our best waters are none too warm and prospects are better in waters that are now producing oysters than elsewhere. So far, the best areas are not fully exploited. So it seems unwise to spend much effort in less promising places.

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Because we are growing oysters at the cold northern margin of their range, we have special problems, for example, growth here is slow and we must contend with heavy ice in winter. Consequently we have had to develop our own methods. These are different from those practised further south on the Atlantic coast and quite different from those employed in British Columbia where the oyster is of an entirely different species. We have some advantages. For instance we have relatively few oyster enemies and when our oysters have grown they are far more valuable than in southern areas where oysters are so abundant. We can compete in the high quality, half-shell trade but we cannot compete in supplying large quantities of shucked oysters at low prices. There is, therefore, little to encourage oyster farming anywhere in the Maritimes except where really high quality oysters can be grown for the half-shell trade. For the present at least, it seems wise for Canada to continue to depend on growers outside the Maritimes for supplies of shucked oysters.

Conditions suitable only in inlets. Even in our best oyster-producing regions the right conditions for oyster farming are to be found only in the moderate depths of sheltered inlets. It is only here that you find the warm waters and firm, non-shifting bottoms that are needed. This is in sharp contrast with conditions elsewhere: on the United States east coast oysters are often farmed in open areas like Long Island Sound, and on the Pacific coast of both the United States and Canada oysters are regularly grown on intertidal flats.

Different conditions within inlets. Generally waters near the heads of inlets are warmer and less salty than those near the mouths. Furthermore, these bottoms tend to be softer and less likely to shift because they are more sheltered.

Unless they are too fresh (less than 2% salt as compared with open sea water which is 3% salt) the waters in the middle reaches of inlets are better for oyster farming than those right at the mouths. Most years they will warm enough to permit spawning and will stay warm long enough to permit a reasonable amount of growth. At the very heads conditions may not be good. Most of the twisty, narrow, thin-lipped, poorly-cupped, soft-shelled, fast-growing oysters with thin meats come from soft bottoms at the heads of inlets (Fig. 13).

Shell and meat quality are generally high in waters near the mouths but here growth is slow and spawning may be irregular.

Thus, in each inlet there is a tendency for quality to be higher but production slower toward the mouth.

4.3 Purposes for Selecting Grounds

Where possible you should try to use both up-river and down-river areas to best advantage. You can catch spat and grow them to bedding-size oysters at heads of inlets but you should plant bedding-size stock near the mouths for maturing to good-quality, market oysters. If both types of bottom are not available, you may find it impossible to divide your efforts in this way. But this need not bar you from oyster farming. Here in the Maritimes, and more monly still in the United States, some oystermen concentrate only on producing bedding oysters for sale to lessees, others mature bedding-size oysters that they purchase from other oystermen. The tendency to specialize in this way is likely to increase as our industry expands. There would be a ready market for bedding oysters if anyone chose to rear them. The supplies from polluted public fishing areas are inadequate.

Choosing grounds for spat collection. Requirements for successful spat collection in any area include a stock of parent oysters and water temperatures high enough for spawning. These conditions are found most commonly toward heads of inlets.

For collecting spat on materials spread on the bottom, you will need firm grounds free of starfish. And if you plan to leave spat over winter on bottoms where they are caught, those bottoms must be deep enough to escape ice damage. If you plan bottom spat collection you should lease bottom for this purpose through the Department of Fisheries. This gives you legal control of oysters you produce. Leasing for this purpose is just as important as leasing for rearing or maturing.

To collect spat near heads of inlets on materials suspended from floats or from fencing, depths and shelter must be adequate but bottoms need not be firm, nor need you lease ground for this purpose. It has been the policy of the Department to maintain open (unleased) ground in some areas for use by persons wishing to catch spat on suspended collectors.

Choosing grounds for rearing bedding oysters from spat. If you plan to grow spat on the bottom you should pick out firm ground that is well sheltered and not subject to heavy ice action. To get best growth and to make it easy to fish oysters when they reach bedding size, rearing grounds should be shallow and free of heavy growths of eel-grass. Sparse growths may be an advantage. If you have caught spat on bottom collectors you may be able to use the collecting ground for rearing the spat to bedding-size oysters. But this does not always work to advantage because you might find better rearing ground if you were to search for it. For example, we have failed to catch spat in Conway Narrows, P.E.I., but it is the best rearing area we know.

Conway Narrows is a shallow tributary of Malpeque Bay. It is the only large shallow area we know of that is good for rearing spat on bottom and we have learned about it only recently. The Narrows is narrow—only half a mile wide—and several miles long. It lies between a chain of low sandy islands and the shore and joins two sizable bays. The water is quite salty and there are no sizable brooks feeding into it but there is an almost continuous current through it. It is warm in summer and ice-bound in winter. Depths at low water even in the centre seldom exceed 2½ feet. At winter low tides, ice does not seem to touch bottom in most of the area. The bottom is sandy with a thin growth of eel-grass about 6 inches long. This seems to prevent the sandy bottom and the oysters on it from shifting. Starfish of all sizes are rare. There are few native oysters, and few oyster larvae are found in the water at any time. There is practically no silting, little fouling growth and almost no shells of any kind in the whole area.

We can probably find other grounds in the Maritimes that are as good as or better than Conway Narrows for bottom rearing of spat. We hope you will join the search for such places. Any new area should be tested with small plantings because the oysters may not survive. Any risky adventure in oyster farming should be carried out on a small scale. Large-scale profits usually depend on well proved methods.

You should not confine your search to straits behind barrier beaches like Conway Narrows because suitable conditions for bottom rearing of spat are sometimes found in a narrow shore zone in sheltered creeks. In such places a light growth of eel-grass may prevent spat from being washed about on the bottom. Some of our oyster farmers have succeeded in improving rather exposed rearing grounds by building fixed or floating protective barriers to reduce wave action in places where spat were washed about too much.

Occasionally it is necessary to improve small parts of the bottom itself if it is too soft or overgrown with dense, tall stands of eel-grass (Chap. 4.6). This kind of improvement is so expensive that it is hardly worth while treating large areas of rearing ground. It may, nevertheless, be to your advantage to improve some ground for shoal-water rearing of spat to bedding size.

The abundance of enemies and competitors of small oysters varies from year to year. Although they may be rare on ground when you select it, they may be bothersome later on. Nevertheless, it is unwise to choose any ground for rearing young oysters if it is overrun with starfish or mussels and overgrown with dense eel-grass.

Before World War II, spat were regularly raised to bedding-size oysters in floating trays and this is still practised to a limited extent. Tray rearing favours rapid growth and high survival but has become prohibitively costly for most growers. Trays are moored in upper parts of inlets near where spat are collected and it is unnecessary to lease the ground where they are moored.

Choosing grounds for maturing. Good conditions for rearing spat and for maturing bedding-size oysters to marketable oysters are seldom found on the same ground. Firmness of bottom, freedom from eel-grass, depths sufficient to prevent ice damage, high salinities and only moderately high temperatures are best. Right conditions for maturing high-quality oysters are commonly found in middle reaches of oyster-producing inlets. Near the mouth, or right at the mouth, the water is likely to be so cold that oyster growth is too slow to make oyster farming profitable. And in the uppermost parts the water is likely to be too warm or too fresh to produce good-quality oysters. Canadian consumers prefer oysters with hard shells and salty flavour. These characteristics are found only in oysters grown in water that is quite salty. The best range of saltiness is 2.5 to 3.0%. In areas where conditions are not well known, it is wise to test them by small-scale plantings before choosing your ground for leasing. Advice on salinity may be had from the Department or the Board.

As a rule maturing grounds should be down-river from rearing grounds which you may want to select at the same time. Oysters usually do much better when transferred to down-river areas than if transferred up-river. You should keep this in mind in choosing your maturing ground because you want to be sure of good survival and good shell and meat quality in your marketable oysters.

Conditions suitable for maturing oysters are usually found in areas where good oysters were formerly abundant or where they are produced naturally in small numbers. Learn something about the history of your ground before you decide to lease it.

Maturing grounds should not be so exposed that oyster farming operations are possible only in unusually good weather. By using large boats and mechanical fishing gear (drags, starfish mops, etc.) you can work exposed oyster beds on days that would be too windy for small boats and manually-operated gear. But this sort of operation is seldom profitable unless it is carried out on a large scale. For small-scale operations which justify only inexpensive equipment, shelter is an important factor in selecting maturing grounds.

Heavy winter losses are to be expected on shallow maturing grounds. This may result from mechanical damage by ice or by freezing. Oysters can freeze and thaw without damage if they are not disturbed. But frequent freezing and thawing in nature seem to be damaging. In severe winters, oysters on shallow grounds are sometimes frozen into the ice if it rests on the bottom for long periods. And in late winter these frozen-in oysters may appear on the surface of the ice. This phenomenon is commonest in the latter parts of winters with little snow. The ice tends to wear away by evaporation from its surface but its thickness is maintained by freezing from below. Oysters that work up through the ice surface by this peculiar process seldom survive.

In winters when snow is deep and ice is thin and when the cold snaps do not coincide with low tides, there may be very little damage in shallow water. A succession of such winters may give you a false impression of the risk of winter damage in shallow areas.

In areas with small and irregular tidal ranges the ice may rest for long periods on oysters just below low-tide level. This happens in areas like Malpeque Bay where the tide is irregular and sometimes remains low for 12 hours at a stretch. Experience has shown that in these areas winter damage often extends to depths of 18 inches or 2 feet below the lowest low-tide levels, and even deeper on areas exposed to drift ice during the spring break-up.

In a few oyster areas tidal range is great and there are always two good tides a day. In these places oysters just below low-tide mark never come into contact with ice for more than 2 or 3 hours and winter damage at this level is not great. Indeed, there may even be considerable natural production of marketable oysters on grounds that are exposed at the lowest low tides. But in most oyster inlets winter losses at these levels are often heavy.

In general, the shallower the ground the easier it is to fish oysters. Tonging, for instance, is possible to depths of 15 or even 20 feet but is much slower and harder than at 4 or 5 feet. Recently-developed, escalator-type, mechanical harvesters work best at depths of 3 to 9 feet. Ordinary oyster dredges with power hoisting can be used with about equal ease at all depths. For maturing beds you should choose the shallowest grounds that are safe from ice and outside the zone of shifting sand. But you can modify your choice according to the type of fishing gear you intend to use.

There are two main types of bottom that are good for maturing oysters. These are beds of old shells and sandy bottoms containing just enough mud to make them sticky. Both types are firm and do not shift. Shell bottoms or old shell beds are accumulations of dead shells (mostly oyster shells) with various proportions of sand or mud. Generally the more shells the better, but if shells are too abundant it is not hard to fish off the loose ones and then the bottom makes good maturing ground.

You usually find suitable, firm, sand-mud bottom in intermediate positions between the loose shifting sand of shallow or exposed areas and the soft mud of highly sheltered or deep areas. The right combination of sand and mud produces a soil that is hard enough to prevent oysters from sinking and sticky enough not to shift in storms.

Prodding the bottom with a square-ended pole will help you find the ground you need. If resistance is very slight when you touch bottom, that ground is too soft even if it is hard a few inches down. On good ground you will notice a definite resistance as soon as you touch bottom but you can push the pole into the bottom by hand. If the bottom is not sticky enough to grip the pole a little when you pull it out, that bottom is likely to shift in storms.

Luckily, neither silt nor mussels are usually abundant towards mouths of inlets where high-quality oysters can be grown. Avoid both. Both are hard to remove and likely to return.

4.4 Other Points in Selecting Grounds

Ensure sufficient food. If there is not enough food (plankton) in the water, oysters do not grow well regardless of size or age. In good feeding areas the water often has a greenish tint because of the millions of microscopic plants it contains. In such places it is often impossible to see bottom in water over 6 feet deep. This is because the plankton blocks underwater vision just as dust in a dust storm blocks our vision through air. In other areas food supplies seem insufficient and waters stay clear. Oysters from such areas seldom fatten enough to be useful in the half-shell trade. For this reason food supply on maturing grounds is especially important. Moderate currents help growth and fattening because they bring food to oysters. Dead-water areas may be poor for growth when food is scarce.

Convenience. The cost of producing oysters depends to a considerable degree on positions of grounds. Neither rearing nor maturing grounds should be too far from your headquarters or from a landing place where you can safely keep boats and other gear. The shorter the distance, the better chance you have of protecting your beds from being molested and the less time you waste in getting to work or in carrying materials back and forth.

POLLUTION. It is unwise to select maturing ground in waters that are dangerously polluted by domestic sewage or likely to be polluted in the near future (Chap. 17.7). There should be a wide margin between the grounds you select and areas where pollution is known to be dangerous. Unless you take this precaution, you may some day find yourself in a position where you are forbidden by law to market your oysters without purification. Purification (Chap. 17.6) increases production costs and may make your oyster farming venture unprofitable. You will be wise to seek advice on pollution problems from your local Fisheries Officer before selecting maturing grounds.

Rearing grounds where spat are grown to bedding-size oysters may be selected with less concern about pollution. Moderate sewage contamination may not be harmful to oyster growth and, since bedding oysters are too small to be marketed, no public health problem arises.

Water contaminated by industrial wastes may pose problems that are quite different from those involving domestic sewage. Many chemical wastes discharged into our harbours may be distasteful and possibly harmful not only to humans who eat oysters from these harbours but also harmful to the oysters themselves. Their growth rates and fattening may be interfered with or they may even be killed. Where there is danger, the Department has imposed legal restrictions on fishing for direct marketing.

OYSTER DISEASE. Transplantings of oysters of all sizes and ages are also subject to legal restrictions because there are risks of spreading oyster disease (Chap. 2.3 and 10). It would be dangerous to move disease-affected stock to regions where the local oyster stocks are susceptible to disease. And it would be foolish to plant disease-susceptible stock in areas that are affected.

You must consider how these restrictions will affect oyster farming operations in your district before you decide on leasing. Will you have difficulty in getting the right kind of stock? Will there be a market for the bedding oysters or the mature you produce? Consult the Department before you make transplantings into or out of your area.

ADMINISTRATIVE POLICIES. The Department tries to encourage oyster farming without interfering with major existing public fisheries for oysters. Regulations and policies adopted for this purpose vary from district to district in accordance with conditions. There are areas where no leases are issued and in many places there are limits on the size of lease issued. Details about policies as they apply to your district can be obtained from the Department of Fisheries, Ottawa, or from your local Fisheries Officer.

4.5 How Much Ground to Lease

To answer this question you must first decide on the scale of your operations. Are you going to make oyster farming a part-time or full-time job? Whichever you decide on, you should obtain enough ground but no more. If you do not get enough at first, it may be impossible later on to get what you need in a convenient place. And if you get too much, you will lower your efficiency by scattering your efforts over too wide an area. This problem of concentrating your efforts is discussed in Chapter 8.3.

PRODUCTIVE CAPACITY OF REARING GROUNDS. One acre of ground suitable for rearing separated spat on bottom can produce more bedding-size oysters per year than growers used to get from the number of floating trays they were able to moor safely over one acre of bottom. The actual number of spat that can be successfully bottom-reared probably varies a good deal from place to place but may average 1,500,000 per acre (Chap. 7.3). This allows 4 square inches for each oyster. Harvesting such an acre should yield enough bedding-size oysters to stock roughly 15 acres of maturing grounds and grow into 1,500 barrels (300,000 lb) of mature marketable oysters. Bottom suitable for rearing usually occurs in small areas, often in a narrow band in the shore zone. Except in a few places like Conway Narrows, P.E.I., it is usually impossible to avoid including some unsuitable bottom in any lease of rearing ground. In considering production figures like the above you must remember to apply them only to the suitable ground within your lease.

PRODUCTIVE CAPACITY OF MATURING GROUND. Maximum yearly production of marketable oysters from one acre of bottom varies greatly and is hard to predict (Chap. 8.3). Quality suffers when oysters are crowded so it is unwise to increase production by overstocking. Experience shows that in our waters 200 boxes (20,000 lb) a year is the highest per-acre yield you should expect from most maturing grounds without lowering quality. In practice this figure refers to the good ground in your lease—not to the total acreage—because almost every lease contains some poor ground.

LITTLE GROUND NEEDED. From what has been said, 5 acres of good maturing ground and 1 acre of good rearing ground should be enough to produce 1,000 boxes (100,000 lb) of marketable oysters a year. Even allowing for the unsuitable ground included in leases, acreages need not be great. It is cheaper to develop a small area fully than to squander efforts over a large area.

For the small producer a very small acreage is sufficient. Unless you are in a position to hire help, you will not be able to develop a total of more than 2 or 3 acres to capacity.

4.6 PROBLEMS IN IMPROVING POOR GROUNDS

IMPROVEMENT EXPENSIVE. In this Chapter stress is laid on selection of ground. This is very important because it is hardly worth while trying to farm oysters unless good ground is available. You may have some poor ground in your lease and you may wish to improve the poor parts for rearing or maturing. Or, for convenience or other reasons, you may lease sandy bottom that tends to shift, muddy bottom that is too soft, or grassy bottom that is overgrown with dense, tall stands of eel-grass. But you should do this only if you are prepared to incur great expense because it usually involves covering the bottom with a substantial layer of sand or shells or both.

You can form some idea of the cost of bottom improvement from the facts that it takes about 800 cubic yards of sand to make a layer 6 inches deep over an acre and that approximately 1,800 bushels of oyster shells are needed to cover an acre with a single layer without any overlapping.

You must realize, too, that artificially improved bottom may not remain as permanently suitable for oyster farming as naturally good ground. Silting, which is responsible for most soft bottoms, will almost certainly be a problem on improved grounds that are near heads of inlets. Floating masses of eel-grass may be just as bad in shoal areas. Exposed, sandy bottom that has been stabilized by spreading shells may be ruined in a single night by a freak storm. And areas that have been cleared of eel-grass may be overgrown again unless you take the greatest precautions against this.

Improve only small areas. Because of the great expense and the risk of wasted effort, we advise improving only small areas and then only when these are going to be especially useful. For example, you may need a place to hold oysters for market (Chap. 12.4) or you may wish to harden a few soft spots in a lease which is for the most part naturally suitable for growing oysters. If you need any considerable area of firm bottom it is best to select naturally firm bottom to begin with. You may have to give up the idea of oyster farming if such ground is not available.

Improving sandy bottom. Sandy bottom usually tends to shift. If this tendency is not too great it can be overcome by a coating of shells, whole or crushed. This is a common way of treating maturing grounds in parts of the United States and Britain (Fig. 44).

Improving soft bottom. Soft mud on spat collecting grounds, rearing grounds or maturing grounds can be hardened by adding sand or gravel. It may be further improved by spreading shells (if you can get them), either whole or crushed, on top of the sand. Sand mixes with mud to form a tough crust to receive the shells. Whole shells placed directly on soft bottom will sink and bury and become completely useless.

Very soft mud may require a 6-inch layer of sand and a similar thickness of shells. Moderately soft bottom needs somewhat less material. In this work it is important to use markers and spread your sand and shells evenly just as if you were planting oysters (Chap. 8.4). This treatment is usually effective in controlling eel-grass (Chap. 9.8) if sufficient depth is added.

In shallow water, sheathing the bottom before spreading sand and shell may save you money because you will then need less material to make a good surface. It is more than 10 years since slabs from lumber mills were used at Malagash, N.S., to sheath a soft-bottom area before gravel was spread. The improved ground has been satisfactory ever since. Sheathing can be effective in controlling eel-grass (Chap. 9.8) as well as for hardening soft bottom that is free of eel-grass. Tar paper under sand and gravel has been recommended for eel-grass control on small areas.

An even better sheathing material for soft bottom or grassy bottom is polyethylene sheeting (thickness 6 mils) such as contractors use to protect building materials that are left outdoors. This has been used successfully in Washington State to line dykes before the gravel layer is spread. It has also been used, without any addition of gravel, by Dr. Victor Loosanoff in the United States (Fig. 15), and we have tested it here to improve soft bottom in intertidal beaches for spat collection (Chap. 6.3). Dr. Loosanoff reports that in spite of exposure to tramping and sharp shells, his sheeting has already served through 3 years—winter and summer—and is still good. Presumably it would have to be brought ashore every autumn to avoid ice damage or loss in our areas.

FIG. 15. Polyethylene plastic sheeting spread on soft, muddy beaches provides a clean base for collecting spat where this is otherwise impossible. (Photo: Victor Loosanoff.)

Dykes are used in the State of Washington, U.S.A., to rear Olympia oysters in places where there are no suitable natural shallow grounds. The wooden or concrete walls must be built exactly right or the dykes will not work and they are expensive. We think dykes would work here for rearing bedding oysters but should not be considered seriously until we are satisfied that areas of suitable natural bottoms are inadequate.

CHAPTER 5. NATURAL SOURCES OF BEDDING OYSTERS

Bedding oysters are young oysters that are large enough ($1\frac{1}{2}$ to 2 inches) to resist attack by most starfish and are therefore safe to plant out on maturing beds. You can get your supply of bedding oysters by artificially rearing them from spat or, as explained in this Chapter, by gathering wild (naturally produced) oysters in areas where this is permitted.

5.1 Picking Bedding Oysters

There is a substantial natural production of oysters along the shores. This is because vigorous wave action washes away silt and keeps surfaces of shells and other cultch clean for spatfall. Fouling usually prevents spatfall in deep, still water. Although they settle abundantly in this shore zone, most wild oysters die long before they grow to marketable size. They may be killed by mechanical damage by ice, by freezing and thawing or be lost by being frozen into the ice and carried away during the spring break-up. Large oysters seem more susceptible to winter killing than small.

There is, then, a high natural production but a low survival in the shallow shore zone. If you are farming oysters you can take advantage of this high production and avoid the poor survival. You do this by picking the wild stock from the shore zone when it is young. This is slow work but it can be rewarding.

In some districts, for example, Malagash, N.S. (Fig. 16), there are shallow bars or reefs running out from shore and covered with oyster shells that are

Fig. 16. A view from the outer end of a bar at low tide, at Malagash, N.S. This bar is 30 feet wide and $\frac{1}{4}$ mile long. Its edges are heavily stocked with small oysters and the central part is covered with mussels.

exposed a few days each month at the lowest low tides. These bars seem to have been built up through the centuries by accumulation of shells of oysters that have grown up and died right there. Sometimes these shell-bars take heavy sets of spat and 2 or 3 years later they are excellent for picking. The larger oysters are scarce and poorly shaped because they have been growing among clusters of shells. If they are collected and transplanted they will not grow to a really good shape but they will improve. Small oysters from the bars react differently. Even if poorly shaped, they will usually grow to fair shape if singled out and planted on hard bottom. Thus, in picking bar oysters you have a choice. You may pick large oysters that will grow to low-priced, poor-shaped stock in a few years, or you may pick bedding sizes that will grow to high-priced, good-shaped oysters in a longer period.

When you are picking oysters it is usually best to take every good one you see, regardless of size. Don't think of leaving small ones until next year. The chances are they will be dead before that.

Needless to say you should choose your times for picking. Most oysters are likely to be low on the beach, about or just beyond the low-water mark at the lowest low tides. You must watch your tide books and be prepared to wade in shallow water. Otherwise picking may not be worth while.

It is the policy of the Department of Fisheries to encourage oyster farmers to make use of wild oysters that are likely to die before they reach marketable size. Accordingly, provision is made in fishery regulations for picking them. Your local fisheries officer will tell you what regulations apply to your district.

5.2 Fishing Bedding Oysters

There are inlets, for example, Summerside Harbour, P.E.I., where natural production of oysters is heavy but where the water is seriously polluted by sewage. Oysters from such places are not fit to eat and fishery regulations forbid their direct marketing. If they are transferred in summer to clean-water areas for a period of 2 weeks or more, they cleanse themselves and become quite wholesome. Bacteriological tests have proved this and the practice of relaying them for cleansing (Chap. 17.6) is long established both here and in other countries.

If oysters are left in their native polluted areas, they create a constant hazard to public health. Unprincipled fishermen may gather them and bootleg them to unwary consumers who may contract intestinal disease. It is best to remove this risk by using polluted oysters in a safe way as soon as they are big enough to handle. The Department of Fisheries, with the approval of the Department of National Health and Welfare, has therefore authorized controlled use of these wild stocks. Fishing is permitted in spring and summer, when it is illegal to market any oysters. They are transplanted to clean-water areas and left there at least until the following autumn. By that time they have freed themselves of all traces of pollution and are perfectly wholesome for marketing.

The Department of Fisheries has gone even further to protect public health. It has waived the size limit for summer fishing in one of our largest polluted areas (Summerside Harbour, P.E.I.) and permits fishermen to take oysters as small as $2\frac{1}{2}$ inches for bedding and maturing. Fishing polluted areas year after year under these regulations tends to keep the average size of good-shaped oysters very small. Because of this it becomes more and more difficult for bootleggers to find any quantity that have grown big enough to peddle. The fact that oysters have grown in sewage-contaminated water does not detract from their usefulness as bedding oysters. Some claim that oysters grow faster in polluted than in clean water.

5.3 Advantages of Naturally Produced, Bedding Oysters

For many years now most oyster growers have found it impossible to produce bedding oysters from artificially collected spat at reasonable costs. As a result, they have depended entirely on supplies of wild oysters picked from shallow waters or fished from sewage-polluted areas. Oyster culture would have died out completely by now if there had been no natural sources of bedding oysters.

It is to be expected that natural sources will always be important because wild oysters are relatively cheap. We should make the fullest possible use of them —fuller than we do now. Even if we did this, however, we could never build a great oyster culture industry. There just aren't enough wild oysters of bedding size. If oyster culture is to be important we must also produce vast quantities of bedding oysters by artificial means such as those described in Chapter 7.

5.4 Handling

In handling wild bedding oysters you should remember that you are working with living animals and that you want them to go on living. You should give them the same care you would give oysters you plan to market. If the weather is warm, as it often is when bedding oysters are being handled, you will have to be even more careful than when you are holding oysters for market (Chap. 12.4).

Shore-zone oysters are usually well shaped and single and make excellent bedding oysters. Oysters fished from polluted areas are usually poorer shaped and frequently clustered. You should separate all clusters and when you plant, plant carefully (Chap. 8.2 to 8.4).

CHAPTER 6. COLLECTING SPAT

Areas that the Department is willing to lease sometimes have a few wild oysters growing on them but not enough to make harvesting worth while. To get a crop you must stock your leased ground with bedding oysters. These are at least 2 inches long—big enough to resist attack by ordinary starfish. For the last 10 years our growers have depended on wild oysters for all their bedding stock and in most districts supplies have been hopelessly small. You may have to rear your own bedding oysters if you are going to farm oysters on a reasonable scale. The first step in this direction is to collect spat. If you are in a good area for spat collection you should be able to sell any extra spat you can produce to people who cannot or do not collect spat.

6.1 General Instructions

Chapter 3 explained that oysters spawn in warm spells in early summer; that after spawning there is a free-swimming larval stage of 3 to $3\frac{1}{2}$ weeks; that the larvae finally fix themselves as spat to some firm clean surface and are thereafter unable to change their position. Most materials in the sea are silty or slimy and this means that most larvae fail to find a clean surface for attachment and die. You can put out clean materials at the right times and places for larvae to attach and thus increase survival. This is spat collection.

You should try not only to collect spat but you should also make sure that as many as possible grow into high-priced oysters. Methods with inferior results may pay if very cheap. But in most cases it pays to use the best methods of keeping spat survival high and keeping shell-shape and quality high. You can do this by protecting the spat from their enemies and by separating them at an early age and rearing them as single oysters.

It is very difficult to collect spat in some places. If you are faced with this problem it would probably be cheaper if you were to buy spat produced elsewhere by other oystermen than to try catching them yourself at a great distance from home. Spat can be shipped long distances safely and cheaply. It is hoped that in the future more and more oyster farmers in good spatting areas will produce spat for sale to lessees who cannot collect it themselves (Chap. 18.5).

If you are going to collect your own spat you must answer three questions: What kind of collectors should I use? Where am I going to put my collectors? When should I put them out? We shall answer the last question first.

When to put out collectors. The surfaces of good collectors may be fouled with slime or silt very soon after they are put in the water. It is safest, therefore, to put out collectors only a few days before a spatfall so they will be clean and attractive to settling larvae.

Each burst of spawning during a warm spell produces a whole brood of larvae all about the same size and age. About 3 weeks later each brood should produce a spatfall. There may therefore be several good sets distributed over a number of weeks. But because there may be only one really good set and because spat which settle earliest in the season grow largest before autumn, it is best to place spat collectors in the water just before the first heavy set is expected. In some areas the Department and the Board provide spatfall prediction services for oyster farmers. You may be able to take advantage of these predictions in setting out your collectors. If not, you can do your own predicting by making use of information supplied in Chapter 3.4 to 3.6, in the following manner.

Oysters do not spawn unless the water is about 68°F or warmer and then usually during a warm spell. After ice breaks up in spring the water sometimes warms to 68°F very quickly but oysters have to ripen before they can spawn. Usually they are not ripe until late June or early July. If you can determine when they spawn you can predict spatfall. It usually comes 20 to 25 days after spawning.

You can decide when spawning is likely to occur by taking water temperatures during warm spells. It is usually best to do this in the afternoon or at low tide in areas where there is a great rise and fall of tides. You should take temperatures somewhere near where spat are to be collected and out from shore where the water is 2 to 3 feet deep. The thermometer should be read while the bulb is still immersed in the water. Cheap thermometers will do if their accuracy is checked by comparison with one that is reliable. Spawning is likely to occur on the day when water temperature shows a sudden rise to above 68°F. You can tell when spawning does occur by examining the oysters. You should examine them about every second day at times when your temperature readings lead you to expect spawning.

A ripe oyster has a creamy appearance over most of its body because there is a layer of ripening spawn just under its skin. For a good view you must remove the mantle (Fig. 7). The thickness of the spawn layer varies a great deal as you may see from cutting across the body with a sharp knife. It is usually not thicker than one-eighth of an inch. After spawning you will notice narrow, grayish, clear veins running through this layer. If the spawning has been heavy the whole end of the body next to the hinge will have lost its creamy layer and will have a thin, watery appearance. Here and there just under the surface you may be able to see the network of fine canals through which the eggs travel.

Oysters in shallowest water spawn first because it warms first, but they do not all spawn at the same time. Therefore, during your every-other-day examinations during critical warming spells, you should open about a dozen oysters from shallow water in the area you are interested in. If half the oysters suddenly appear to have shed some spawn it means there has been a general and important spawning during the warm spell just passed. It also means that you should put out your collectors in about 18 days. This will be early enough to catch the first spat from this spawning. It is unwise to put them out any earlier. If you do they will only foul and lose their efficiency before the spatfall.

This old method of prediction is reasonably good but it is based on the risky assumption that if there has been a spawning there will be a spatfall. Occasionally a whole brood of larvae will die or be swept out of their inlet a few days after spawning and there is no set. This can result in enormous losses if many collectors have been put out. They quickly foul and become useless.

The method of prediction now used by the Department and Board in their service to industry was worked out at the Biological Sub-Station at Ellerslie over 20 years ago. It is much more reliable because it depends on counting and measuring larvae caught in a fine-mesh silk or nylon net in various stages of their development. We know the growth rate of the larvae and can tell how long it will take for any partly-grown brood to reach full size and settle. After an early announcement of an expected date we usually issue a final confirmatory prediction of the spatfall date about a week before the event. Few of them are wrong. Unfortunately this method of prediction is too involved for most oyster farmers to work out for themselves. Plankton nets and microscopes are expensive and you need to be trained to use them.

Where to collect spat. A good area for spat collection must have enough parent oysters nearby to produce an abundance of larvae. The water should warm up quickly for oysters to spawn early every year and there should be enough shelter to prevent storm damage to collectors. In general, these conditions are found only towards the heads of oyster-producing inlets. Any inlet with these requirements may be satisfactory but trial collection is the only sure test. In any strange area you should try spat collection on a small scale at first. The risk of failure is less, of course, if you know that natural production of spat is regular and heavy.

Depths at which collectors catch most spat vary from place to place. In most inlets that we have studied, you can catch spat anywhere from half-tide level on the beach out to the middle of the inlet and at any depth from top to bottom. If large quantities of fresh water flow into your inlet surface waters may be too fresh for larvae. For this reason, too, you may be unable to collect spat anywhere near shore or near the surface in offshore parts of the inlet. Your collectors will have to be deep enough to avoid the fresh surface layer. Larvae are often most abundant close to the bottom even though there may be few clean surfaces there for them to settle on. Thus the levels at which natural spatfall is heaviest are not necessarily the best levels for setting out collectors. The best places can be discovered only by experience. To help yourself learn by experience you should keep written records of where you put collectors and what you catch (Chap. 1.6).

Kinds of collectors. Oystermen refer to anything that collects spat as cultch and oysters will set on a great variety of cultch—indeed on almost any clean, firm surface. But the number of kinds of cultch from which you may choose will probably not be great because what you use must be available in large quantities; it must be cheap and it must be easy to handle. Cultch is of two general classes:

(1) Kinds from which spat can be removed at an early age for rearing as separate oysters. These include roofing tiles or old-fashioned cardboard egg-crate fillers or fish netting or brush. To be effective most of these must be coated with a film of concrete or lime and sand.

(2) Kinds to which spat are left attached for at least 2 years and perhaps until they are harvested. Shells come in this class of cultch. You may use oyster, mussel, scallop or other kinds of shell.

For one reason or another, no one collector of either class now in use is entirely satisfactory We need a new type that is efficient, cheap, compact and rugged. The Fisheries Research Board is studying the problem and you, too, should be constantly looking for better kinds and better ways of using what we have. We hope someone will make an important discovery soon. If a good type of cultch were found, it could easily revolutionize the whole industry.

The kind of cultch you should use will depend on conditions in the area where you collect spat, on how much money you have to spend and on the kind of oysters you hope to grow. In Malpeque Bay areas, concrete-coated, egg-crate filler collectors have worked well for those who have tried them and these are described first.

6.2 Preparation and Use of Egg-crate Filler Collectors

If you plan to catch spat on a reasonably large scale it may be profitable for you to use these collectors (Fig. 17). Their big advantage is that the spat they catch can be separated on a mass scale in a threshing machine with low labour costs. In some places these collectors can't be used because they foul so badly or because wave action beats them to pieces. In areas where tidal currents are weak, few spat settle in the middle of these collectors or if they do set there, they do not grow well. Besides all this, cardboard fillers of the type required are not as readily obtained as formerly and fox-wire netting which many prefer for wrapping them into bundles is limited in supply and increasingly expensive. It must be admitted that these collectors are troublesome to make but there is no denying that where they work they are hard to beat. With them you can still produce first-class single spat at reasonable costs. If two or three growers near you are interested, you may find it an advantage to work with them in preparing what collectors you need.

Use strong egg-crate fillers. To stand exposure and handling, the fillers must be strong and the extra cost of a specially strong grade is well repaid. These are commonly known to the trade as export fillers to distinguish them from the lighter domestic grade. In recent years they have commonly been purchased in large quantities without the "flats", which are sheets of cardboard placed between them when packing eggs, at less than $35.00 per thousand. In looking for suitable fillers you should be sure that the cardboard strips they are made of are cut so they lock together well to form open, square compartments

(Fig. 17). Pulp board is recommended. Straw board collapses in water. You should be sure, too, that they have not been coated with wax or similar dressing because this prevents the cement coating from sticking to the cardboard.

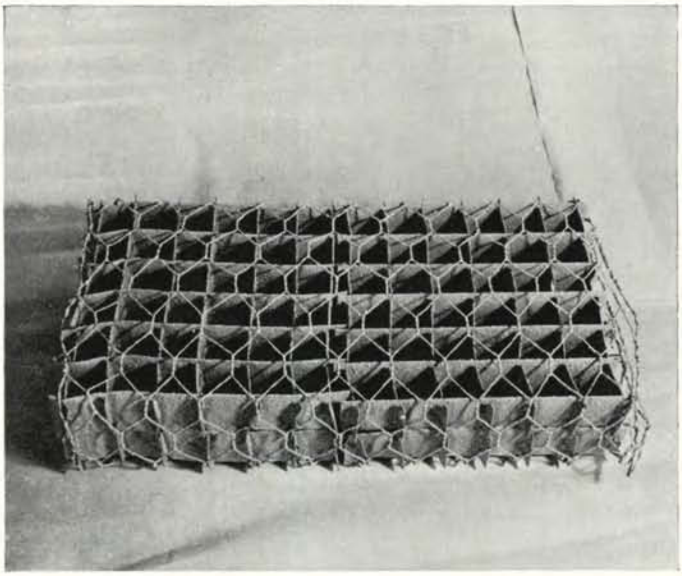

FIG. 17. Bundle of four cardboard egg-crate fillers wrapped in fox wire, dipped in concrete and now ready for use. (Photo: G. F. M. Smith.)

BUNDLING COLLECTORS. Only rarely can egg-crate collectors be used without bundling. Bundling reduces breakage and simplifies handling. They may be wrapped in wire netting or crated in wooden frames. If you bundle them first and then coat them with concrete you save labour and get firmer bundles. Besides, you avoid damaging the concrete coating. Damage is inevitable when you handle coated collectors that have not been bundled.

Any convenient or cheap material which will withstand the action of sea water may be used for bundling fillers. Sizes of bundles may be varied to suit convenience but it is best to make them no more than two fillers thick. Otherwise spatfall and growth may suffer.

The Department's Experimental Oyster Farms prefer to bundle fillers in groups of four by wrapping them in wire fox-pen netting (Fig. 17). These bundles are about 24 inches high, 12 inches wide and 5 inches thick. The netting is cut 2 feet by 3 feet and shaped around a wooden dummy before the fillers are put inside. After that the bundle is laced snugly with No. 16-gauge galvanized wire at each end and across its face where the cut ends of netting meet. Fillers bundled in netting should be dipped after they are wrapped. Heavy netting gives fillers more protection and lasts longer than light. Fox netting of 2-inch mesh and No.

16-gauge wire, galvanized before and after weaving, lasts about two seasons. Heaviest grades of chicken wire seldom last more than one season.

Some prefer to bundle fillers in wooden frames or open crates of various sizes. The frames are usually 4 to 4½ inches wide and hold two layers of fillers which are kept in place by laths or other narrow strips. The most popular size of frame holds 6 fillers. Fillers can be dipped before or after crating. The wood must be pretected from shipworms (Chap. 11.5 to 11.10). Wooden crates are cheaper than wire wrappers and at the end of the season fillers can be taken from them more easily. Their chief drawback is that they tend to float and may have to be weighted when they are set out.

Preparing concrete dip. Many different mixtures of cement and other materials in fresh water may be used as a dip. The one preferred at Experimental Oyster Farms is made with equal volumes of cement, slaked lime and moderately fine sand that has passed through a screen of ⅛-inch mesh. All materials should be fresh and sifted through a fine screen just before mixing. Enough water is added to give the required soupy consistency which is best judged by dipping a filler. An even coat about 1/32nd to 1/16th inch thick should be produced.

Quantities of materials required. One 85-pound bag of cement, 45 pounds of quicklime, and sand enough to fill a cement bag are sufficient for 200 egg-crate fillers or 50 bundles of 4 fillers.

Dipping fillers. You should keep the mixture well stirred while dipping. And you should pause when the filler or bundle of fillers you are dipping is submerged. This allows the cardboard to get damp. If you dip them too quickly the concrete film dries too quickly and will not stick. You must not pause too long, however, because if the cardboard gets too damp it will collapse. You may have to add a little water to the mixture now and then to keep it soupy. For best results two or three men should work together. Rubber-coated or plastic-coated gloves are satisfactory for protecting your hands from the lime and cement in the mixture.

Fillers must dry slowly. To make strong coatings you should keep the fillers damp after dipping (by sprinkling if necessary) and in the shade until the concrete is set. Good results are obtained by piling them in a building with little circulation of air.

Putting out filler collectors. Concrete-coated egg-crate fillers seldom work well if they are laid out flat on natural bottoms. This is true whether you use unbundled collectors or those that are bundled in wire or crates. They are liable to fill in with mud and this prevents spatfall or soon smothers spat that do settle. If placed on bottom near shore, bundles may be stood on end and kept upright by fastening them to stakes. But if there are many starfish you may lose most of your catch to these hungry enemies. The Experimental Oyster Farms usually wrap their fillers in wire and suspend the bundles from floats or fences with wire bales stapled in position on their supports.

You can make a satisfactory float with two molasses puncheons or two or four gasoline drums (Fig. 18 and 19). Or you can build a fence by driving spruce

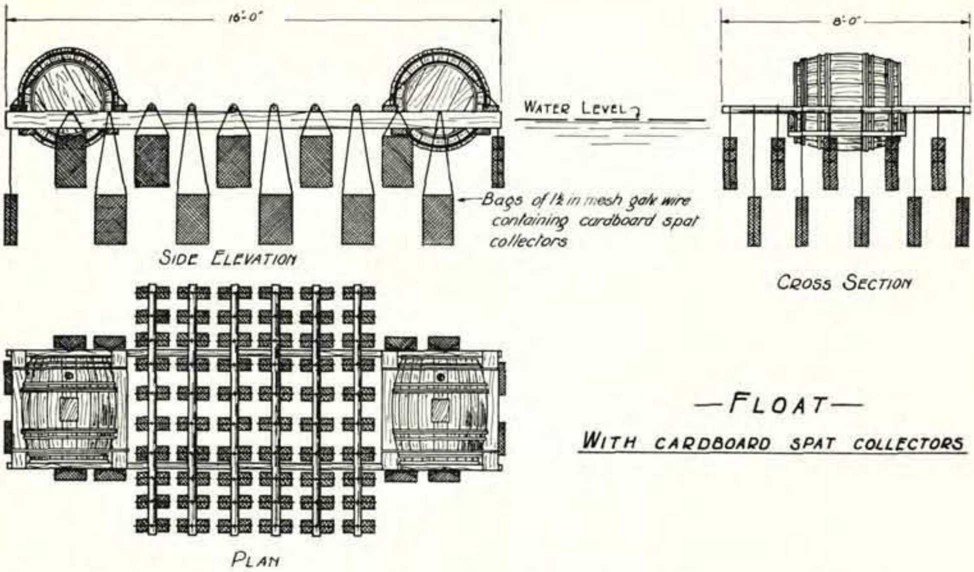

FIG. 18. Puncheon float for suspending egg-crate filler collectors. Staggering depths of collectors reduces crowding and improves spatfall and growth. (Drawing: H. R. Found, after H. A. Lynch.)

FIG. 19. Gasoline drum float for suspending collectors.

or other softwood poles into the bottom to form "X" supports for other poles that are fixed horizontally between the "X's" (Fig. 20). Bundles are then strung from the horizontal poles by their bales or by wires fastened to the bales.

You should always use galvanized wire to suspend crates or bundles. Ungalvanized wire soon corrodes and breaks in sea water and you lose your collectors. Experience shows that it is not safe to suspend 4-filler bundles with wire weaker than No. 13 gauge. You need heavier wire for larger bundles.

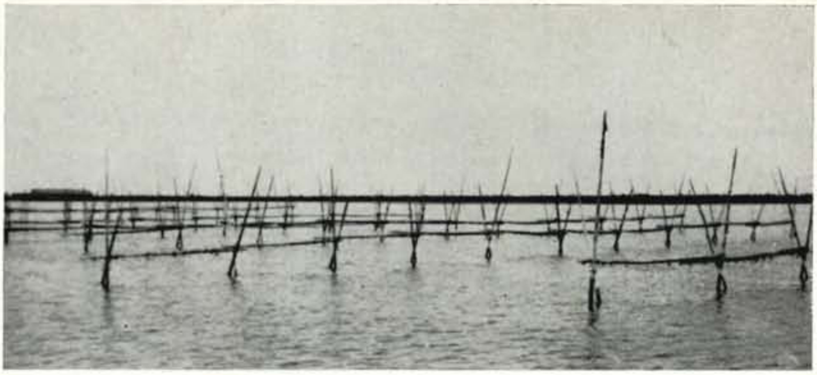

FIG. 20. Fencing with suspended collectors at the Shippegan Experimental Oyster Farm, New Brunswick.

DO NOT OVERCROWD COLLECTORS. The expense of putting out filler collectors is reduced by placing them close together. But practical experience and study both show that where floats are used the number of spat obtained is seriously reduced by overcrowding. Collectors are expensive and they are only useful if they catch a good set that will grow well. There is no sense in spoiling your chances by crowding them. This can be easily done. For example, a float of the sort shown in Fig. 18 can carry 80 four-filler bundles in the 10×10 feet area it covers. If the bundles are all suspended at the same depth, spatfall on the central bundles may be only half that on bundles close to the edge and the spat that do settle in the middle grow very slowly. These bad effects of crowding can be greatly reduced with only a little extra cost. All you need do is suspend your collectors in two or more tiers (Fig. 18) instead of all at one depth. There is much less likelihood of overcrowding where collectors are suspended in a single line from fences but here, too, it is an advantage to stagger the depths. It not only improves spatfall and spat growth but also reduces damage that may occur in storms when bundles bump together.

TENDING COLLECTORS. After you have put out collectors and caught a set you must still keep close watch. It is worth while to shake collectors occasionally if this dislodges any great amount of silt. This should help growth and survival of spat. Occasionally you may get a dense growth of green or brown sea moss (algae) or a set of sea squirts (tunicates) on collectors after the spatfall. If you have a good catch of spat and if the fouling growths are heavy, it will pay you to control them (Chap. 9.9).

HOLDING COLLECTORS OVER WINTER. Spat on egg-crate fillers (Fig. 21) may be threshed in autumn and kept over winter in crates or wire-bottomed trays held off the bottom. Autumn-separated spat grow very well during their second summer but over-winter losses may be high. Sometimes whole trayfuls smother. If the shells of spat are badly damaged in threshing, many die during winter. Unless you have a well tested area for bottom rearing of spat and can thresh early in the autumn, we recommend that you leave spat on their collectors

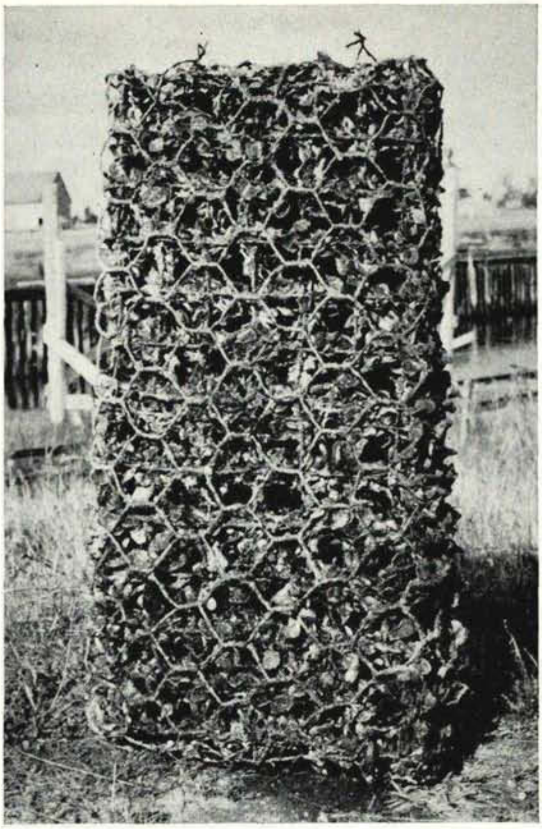

FIG. 21. Bundle of four concrete-coated, egg-crate fillers covered with spat from Bras d'Or Lake, N.S., at end of their first summer's growth. Each filler bears over 1,250 spat $\frac{1}{4}$ to $1\frac{1}{4}$ inches long. (Photo: R. E. Drinnan.)

over winter and thresh early the following spring. This treatment is more expensive but spat damaged in threshing have a better chance of repairing their shells and surviving. In some cases this is unnecessary. But if you want to try fall threshing in your area, do it on a small scale at first. The possibilities of autumn threshing and autumn planting are being tested (Chap. 7.3) but we have too little information to make recommendations. Whatever you do, remember you are handling living animals. This is not a simple operation.

Bundles or crates of collectors are regularly held over winter at Experimental Oyster Farms by sinking them, after the water temperature drops below 40°F, on hard bottom or on wooden platforms. These are usually 12 feet square, built on skids to keep them off the bottom and provided with 2-foot railings around the edge. They are loaded by piling on collectors several tier deep until they sink. Platforms should be submerged well below the ice level and raised early the next spring before the water gets too warm. Starfish do little damage

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to the oysters over winter and it is unnecessary to treat the wood used in platforms because shipworm larvae do not settle at that time of year.

SEPARATING SPAT FROM COLLECTORS. Egg-crate filler collectors can be broken up and the spat separated by hand. This was regular procedure in the early 1930's but it soon became and still is a prohibitively expensive operation. Spat-threshing machines have been in use now for 20 years. These reduce costs of separating spat to about 3¢ per filler. The first machine was developed in 1939 by Messrs. Brenton Clark and Victor Travers, oyster farmers, of Summerside, P.E.I. It worked so well that it was copied by other growers and by the Experimental Oyster Farms. The original design has been altered and improved (Fig. 22) but the principle is the same. The frame of the thresher is a wooden tank. Inside it, wooden baffles rotate under sea water inside a cylindrical jacket of wire netting. They crush collectors that are fed in through a hole in the jacket.

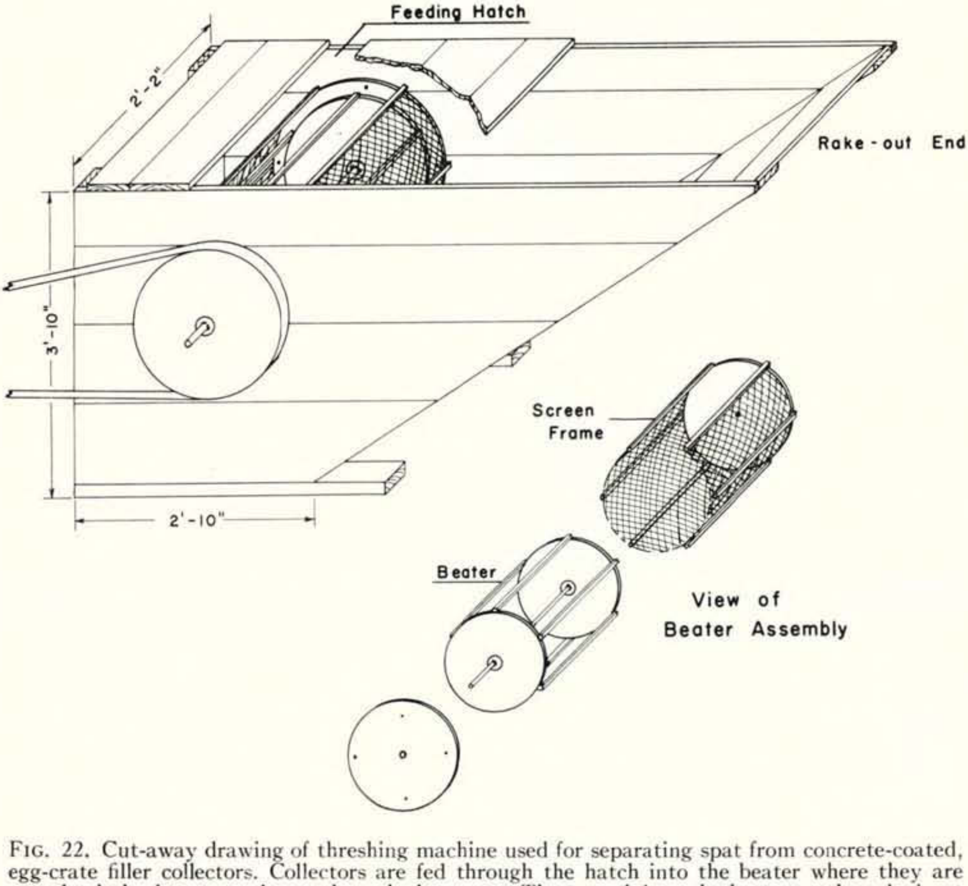

FIG. 22. Cut-away drawing of threshing machine used for separating spat from concrete-coated, egg-crate filler collectors. Collectors are fed through the hatch into the beater where they are completely broken up and pass through the screen. The spat sink to the bottom to be raked out and the pulp from the cardboard floats off at the rake-out end in a stream of water that is fed constantly by a hose which is kept in the feeding hatch when the machine is operating. (Drawing: W. McMullon, after H. R. Found.)

Cardboard parts of the collector are chewed up, pass through the mesh of the jacket and float away because a hose keeps the tank overflowing with sea water throughout the threshing operation. The concrete coating of the collectors and the spat, separated from the cardboard, pass through the mesh of the jacket and sink to the bottom and may be raked or shovelled out periodically. In one of the new-type threshing machines there is an endless belt that brings the spat from the bottom to collecting baskets placed at the sloped end of the tank.

Up to 20% of the spat may be killed in threshing but costs of threshing are so much below costs of manual separation that the 20% loss can be accepted.

For construction details you should write the Department of Fisheries, Experimental Oyster Farm, Ellerslie, P.E.I.

NUMBER OF SPAT PER COLLECTOR. The original set of spat on a single filler may be 50,000 or more, but not more than 1,000 have room for satisfactory growth. When sets are heavy a high proportion of spat die, or are stunted from crowding. It is believed that best results are obtained with sets of 1,000 to 1,500 per filler (4,000 to 6,000 per bundle of 4 fillers). With such sets there are always more spat on lower surfaces than on upper or vertical surfaces but for the filler as a whole this averages 2 spat for every square inch of collector surface. When you get a good set (Fig. 21) you can usually thresh out 1,000 spat suitable for rearing, from each filler.

COST OF SEPARATED SPAT. The cost of spat collection with concrete-coated, egg-crate fillers varies greatly from place to place, depending on labour costs. The Experimental Oyster Farm at Ellerslie estimates that the total cost of preparing collectors, suspending them in the water, holding them over winter, and separating the spat is not more than 55¢ per filler. Of this, about two-thirds is for labour. With good sets this means a cost of about 55¢ per 1,000 separated spat. If sets are less than 1,000 per filler, the cost per thousand will be higher. A 1¼-bushel box contains 250 to 300 marketable oysters worth $8 to $25, depending on quality. Keeping this in mind, the cost of spat collection is low.

6.3 SHELL COLLECTORS

For many years the Department of Fisheries has used egg-crate filler collectors almost exclusively on its Experimental Oyster Farms. This is unfortunate in a way because there are many other kinds of collectors which will work, even if they are inferior in some ways and inconvenient in others. Everyone should have a chance to see and learn more about these other types; first, because right now there is such a desperate shortage of young oysters; and second, because there are many places where egg-crate collectors just won't work or where people cannot or will not take time to prepare them. Accordingly, the next few sections tell about kinds of collectors that are being or have been used here or in other countries, even though we may have little experience with them ourselves.

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If you decide to use any of these instead of egg-crate collectors, you should remember that you are experimenting almost on your own. You must be ready to accept failures without being discouraged. Please keep records and let us know about your experiments whether they are successful or not because the information may be useful to others.

Shells of molluscs are certainly the commonest of all natural collectors of oyster spat. They may be shells of living or dead animals—oysters, mussels, quahaugs, scallops or snails of various kinds. However, under natural conditions most shells are so badly fouled with slime that they catch few spat. There are different ways of treating shells to increase spatfall but no matter what you do to them you almost invariably end up with an awkward problem on your hands.

If a shell is fit to catch spat it usually catches so many that they grow into clumps of mis-shapen oysters of low market value. To avoid this the young oysters may have to be separated during their second or third season. This requires a lot of labour and labour is usually expensive. In places where egg-crate fillers work, most people finally come to the conclusion that they would have been better off with egg-crate fillers from which spat can be separated (threshed) at low cost.

Recently we have been testing mussel shells as collectors. Dutch oyster growers consider them very good because they tend to go to pieces after a year or two in the water. As a result, many of the spat that settle on them become separate oysters without effort from the growers.

The mere presence of shells in an area where oyster larvae are about to settle does not insure a spatfall because under normal conditions the shells are not fit to take a set. They are usually overgrown with slime or covered with silt. It is usually necessary to give them special treatment to make them useful.

STIRRING UP SHELLY BOTTOM. This is probably the simplest of all ways of increasing spatfall on shells. Stirring has to be done at the right time, which is just before spatfall is expected. Stirring exposes buried shells that are free of slime and therefore suitable as cultch. There are different ways of stirring.

Whatever is on an oyster bed should be fished up occasionally and worked over to separate clusters of oysters, to remove mussels and to help clear away the silt that accumulates. This can be done by tonging or dragging. Live mussels should be removed (Chap. 9.3) but dead shells of all kinds can usually be safely returned to a bed unless they are very crowded or infested with boring sponge. When they are thrown overboard some of these shells are sure to light with clean parts exposed. These clean parts may catch spat. Working over a bed just before spatfall sometimes results in heavy catches.

If you are hard pressed and can't find time to fish up and work over what is on your beds immediately before spatfall, you may help matters by some form of harrowing the beds. A spring-tooth farm harrow may be useful or you may remove the bag from an oyster dredge and tow the frame only. Either treatment tends to stir up silt which may be carried off by tidal currents and expose clean shell surfaces that may take a set.

What we have just said about an oyster bed applies also to barren shelly ground on which you hope to get a spatfall.

The main advantage of these methods of increasing spatfall, if they work, is their cheapness. They have disadvantages. One is that the clean surfaces usually foul quickly so you can't be sure of getting a set. Another weakness is that most spat which settle on shells on deep grounds, where these treatments are easiest to apply, are soon destroyed by starfish. You should not look for good survival of your catch of spat unless you are prepared to combat starfish. Besides all this, harrowing not only increases sets on dead shell, it also increases sets on living oysters and this adds to your job of cleaning them before packing and marketing. Generally speaking, this kind of treatment improves the quality of living oysters on your beds. So all is not lost, even if you don't get a set.

Spreading clean shells on bottom. This is another way of increasing spatfall on shells. For this purpose shells should be brought ashore and weathered to kill slime and remove silt. Large quantities of shell can be obtained when you are fishing and working over your beds (Chap. 12.2). Instead of throwing shells back, you bring them ashore and pile them above high-water mark. It usually takes several weeks for shells to weather properly and you may prefer to use shells you fished last year.

You should spread shells on your beds, or wherever you plan to collect spat, just before a heavy spatfall is expected. Almost any kind of shell will catch spat. Oyster shell is most commonly used. You may want to try mussel shells which are popular with Netherlands growers. Trials at Ellerslie have been only partially successful because of silting. Experience may lead to improvements.

The quantity of shell that should be spread may be determined by experience. About 1,500 or 1,800 bushels of oysters shells are needed to cover an acre with a single layer but this is usually too thick if a heavy set is obtained, especially if the spat are to be reared without removal to other grounds. If you plan to transplant or to sell your catch of spat while it is still on the shells, that is a different matter. You may then decide to cover the ground.

To avoid waste you should be careful to spread your shells evenly but don't spread them too thin if you plan to fish them for sale or for transplanting.

Shells may be spread on deep-water maturing grounds where they need not be fished up after spatfall. But in deep water they usually suffer starfish attack unless you protect them by starfish control. You may decide to spread them in shallow water—perhaps on spat rearing ground or in places where they are exposed at low tide. In such cases you may or may not have to transfer them in autumn to deeper water to avoid winter losses. This adds substantially to costs but it does reduce starfish damage.

No matter how you treat them, shells spread on the bottom have a low spat-collecting efficiency. One side rests on the bottom so settling larvae cannot get at that half of the potential collecting surface. It is lost from the beginning. The other half, the side that faces up, may also foul soon after scattering. If shells are scattered from a boat and sink to the bottom through water, cupped shells tend to land concave side up. Each cup then presents a nice pocket to collect silt and smother any spat that do settle in it. This is a vexing problem especially with mussel shells which all have deep cups.

Just recently United States investigators have succeeded in catching spat on shells scattered on sheets of polyethylene plastic that have been spread over the bottom or placed in bags that are laid on the plastic (Fig. 15). This prevents the shells from sinking into the mud. We tested this method at Ellerslie in 1960 and found that shells scattered on plastic sheets cautgh 5 times as many spat as those spread on natural bottom.

In spite of everything that can be said against catching spat by spreading shells on the bottom, it must be remembered that this is the method which the world's largest oyster industry depends on. Thousands of bushels are spread every year in the United States to produce their enormous supplies of cultivated oysters. Because their oysters are sold shucked, United States growers do not have to worry much about shell shape, which is often poor. We have to be more careful because we cater almost entirely to the half-shell trade.

WIRE BAGS OR CRATES OF SHELLS. These are commonly used in some places for spat collection. They are rather heavy for hanging from floats or fences so they are generally set out on firm bottom in shallow water, often in the intertidal zone. Bags should be stacked upright in groups to provide good circulation of water through them and permit swimming oyster larvae to get at the shells. Sometimes they are stacked about and wired to a stake for support. They should never be laid flat on the bare bottom. Bagged or crated shells don't silt up like bottom-spread shells and they are more efficient because spat can settle on upper, lower and vertical surfaces. In most cases spat caught on bagged or crated shells suffer less starfish damage than those spread directly on bottom. Either of these ways of packaging shells is more expensive than spreading them on bottom. Besides this, they have to be moved out of the shallow-water zone before freeze-up or they will be lost in the ice. However, if you are planning to sell your shells after they take a set or to plant them elsewhere on your own beds, you will find it cheaper to handle packaged shells than to fish up shells scattered loose on the bottom. This advantage partly compensates for packaging costs.

It is best to make shell bags from fox-pen wire because it is strong, but chicken wire can be used. Bags are usually made oblong and large enough to hold a peck or a peck and a half of shells. Crates should have solid tops, bottoms and ends but the sides should be made of laths spaced sufficiently to allow good water circulation but close enough to prevent shells from sifting out. The lengths and widths of crates can be varied but they should be no more than 4 or 5 inches thick or there will be a poor catch on the central shells. The wood used in crates must be protected from shipworms (Chap. 11.5 to 11.10). Crates loaded with shells do not float and need not be weighted.

A promising variation of packaging shells to keep them off bottom was tested last year in Bideford River, P.E.I. Mussel and oyster shells were put out in hammocks of fine-mesh fish netting such as is used on sardine weirs. Hammocks of chicken wire were also used. Both were strung from stakes set in shallow water in and just beyond the intertidal zone. These stayed clean and took a good set. Mussel shells spread on bottom nearby caught few spat.

SHELL STRINGS. These are used in vast quantities in Japan and to some extent in British Columbia for spat collection. They have been tested with reasonable success at the Experimental Oyster Farm in Bideford River, P.E.I. (Fig. 23). Oyster shells or scallop shells are easily pierced either with a hammer with a pointed head or with a pedal-operated punching machine which any mechanic can contrive. These are strung on galvanized iron wire, 9-gauge or heavier, depending on the length and weight of the strings. It is best to use shells that are punched off-centre. These spread out better than centre-punched shells and you can thread more on a foot of wire. The Japanese use pieces of bamboo stem 1 to 2 inches long as spacers between shells to increase spatfall and spat growth. You should always use clean shells and the strings may be up to 15 feet long. They may be hung vertically as a single string from floats or fences or draped at the middle to form double strings, or they may be draped in horizontal loops from stakes in the intertidal zone or laid on plastic sheeting. In Bideford River the heaviest spatfall is usually close to bottom regardless of whether the shells are put out in the intertidal zone close to shore or in the river channel. Like shells in bags, crates or hammocks, shell strings stay clean and sometimes take heavy catches. Spat taken on shell strings present the same rearing problems as those taken on any shells.

6.4 Other Collectors

BRUSH COLLECTORS. Brush has been and still is used in many parts of the world to collect spat. It presents problems to those interested in growing single oysters and many of our growers have dismissed the idea of using brush without much thought. The simple fact is that brush will catch spat very well in some places. If you have decided not to use egg-crate filler collectors you might at least try brush. If you have any chance at all you should be collecting spat by one means or another.

In the Bras d'Or Lake we have caught spat on bare twigs and even on leaves of many kinds of trees and bushes including spruce. Some believe better catches are made with brush that is cut and dried for a few months before it is put out. Naked brush doesn't work very well in places where there is much silting.

It is generally believed that brush catches better if it is dipped in a cement +lime+sand mixture like that described for dipping egg-crate fillers. We have never made careful comparisons.

Brush may be tied into bundles and fastened to fences or stakes. Or the butts of individual branches may be stuck into the bottom in fence-like rows.

OTHER METHODS. The methods mentioned below will show what a great variety of materials can be used. There is no doubt that we are negligent in not trying to use cheap materials that are at our doorsteps. Unless it can be used

FIG. 23. Part of a string of scallop shells suspended from a float in Bideford River in July for spat collection and taken up in October. One shell is turned to give a better view of the 3-month-old spat. Spacers between the shells would have increased the catch and the growth rate.

more than once, any collector should be cheap. Besides being attractive to spat, collectors for most of our areas should be easy to transport.

The Australians have used slabs of fine-grained rock from quarries. French and Netherlands oyster growers use lime-coated roofing tiles which they pile criss-cross on the flats. The spat and lime are cleaned off and the same tiles are used year after year. These take work but they get results.

Fish netting that is too old and weak to be fished any more can be dipped in lime or cement+lime+sand mixtures and hung from stakes or fences or floats to catch spat. Plastic screening has been tried a few times.

Half-thickness wooden laths dipped in lime or cement–lime–sand mixtures and poked into the bottom individually like branches of brush catch well.

Dr. D. B. Quayle has experimented with waste wood film from plywood factories and this has been used industrially in British Columbia. It was tested for the first time in Bideford River in 1960. The best thickness of veneer is about the same as that used in strawberry boxes. It is cut into sections about 4 inches wide and 30 inches long and stapled into circular collars about 10 inches in diameter (Fig. 24). After dipping in cement+lime+sand mixtures and drying, these are suspended from floats or fencing or placed directly on firm flats in protected coves. They shift very little on the bottom. They can be simply threshed by rolling in the hands or if left in the water, they crumble after about a year to produce single or nearly single oysters.

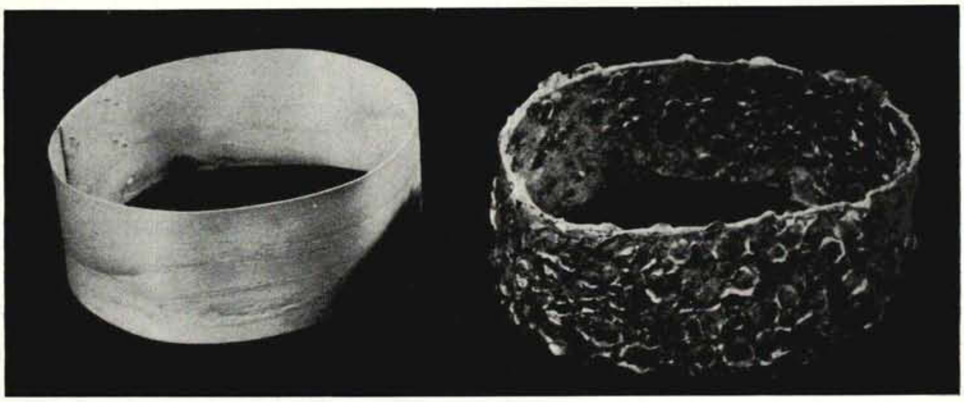

FIG. 24. Rings of waste wood veneer (*left*) were dipped in a cement–lime–sand mixture and exposed in Bideford River, P.E.I., in July 1960. The November photograph (*right*) shows that these are good collectors and that spat grow well on them.

If you are a good oyster farmer you will use your imagination and test some of the materials you have at hand. You may find cheap ways of producing spat that can be sold to other oyster farmers. Can you find effective ways of using beach pebbles, eel-grass, straw or other things you may think of? Collectors that won't work in other areas may work in yours. Let us know the results of whatever tests you make.

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CHAPTER 7. REARING BEDDING OYSTERS FROM SPAT

7.1 Rearing on Trays

In the late 1930's, when labour and materials were inexpensive, Dr. A. W. H. Needler developed the covered, floating tray method of growing threshed spat into bedding-size oysters—that is, to nearly 2 inches long. The frames of the trays were made of 2- by 4-inch soft wood and the lids of $\frac{1}{2}$-inch boards. The bottoms were made of $\frac{1}{4}$-inch mesh galvanized wire screen that allowed free circulation of water. In the trays the oysters were protected from being washed ashore and from starfish so mortalities were low and growth was rapid. Most spat reached bedding size by the end of one season on trays.

Today rearing trays are prohibitively expensive and are little used except by Experimental Oyster Farms. When rearing trays disappeared our oyster farming industry went into eclipse for want of sufficient supplies of bedding oysters. It is bound to stay that way until we find some new way of preventing starfish from getting at oysters until after they have reached bedding size and can resist starfish attack. Thus, the real bottle-necks in oyster farming today are the same as Dr. Needler had to deal with. Probably the worst is the starfish problem (Chap. 9.1).

If you are able to produce bedding oysters at low cost in your area you should consider the possibilities of selling them at a profit to other oyster farmers who are not able to produce enough to meet their needs. Selling oysters at bedding size gives quicker returns than selling at mature size.

7.2 Rearing on Deep Grounds

Maturing beds that grow high quality oysters are usually deep, cool-water grounds in open bays or in lower parts of estuaries. Experience has shown that it is unprofitable to plant threshed collector spat directly on these grounds. Growth is slow and there are heavy losses from starfish, from other enemies, and from smothering in silt.

You face much the same problems in handling last year's spat that have settled on shells in shoal water. Losses will be heavy if you plant them on deep maturing grounds although smothering by silt is usually less than among newly threshed spat or among spat that are caught on maturing grounds and left there to grow up.

7.3 Rearing on Shallow Grounds

In rearing spat the best plan is to force their growth by planting them in shallow waters towards the heads of inlets where the water is warm and where you can protect them from starfish. The importance of careful choice of rearing grounds is stressed in Chapter 4.3. Here we discuss how to use these grounds. Our experience is limited but we can speak confidently on some points.

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PLANTING. The time spat are planted is important to success. It should be done when the water is warm enough to allow them to make repairs to damaged shells and other adjustments to their new homes. Mid autumn or early spring would seem to be good times but you can't always choose. For instance, other parts of your autumn work program may force you to make summer transfers of spat on shells from spat-collecting grounds to your rearing areas in order to avoid winter losses. If you are obliged to do this you should be most careful to avoid long air exposure in the heat of the day.

You have more latitude in planting threshed spat on the bottom than growers had in the old days when they reared them on trays. They had to delay threshing until the spat were so large that they would not be lost by sifting through the wire-cloth bottoms of their trays. So far as we can determine, spat below this size (diameter less than $\frac{1}{4}$ inch) survive in reasonable numbers when planted on good rearing ground. However, if there is much silt you can expect a good deal of smothering among the smallest spat.

Density is another matter of importance in planting spat on the bottom but one on which it is difficult to advise. In planting spat threshed from egg-crate filler collectors, you can allow an area 2 inches square for each spat which seems a good deal of space for a tiny oyster. This is equivalent to 1,500,000 spat per acre. Evenness of planting is important because if oysters are bunched they will not grow to good shape and may even form clusters. You can spread them by hand but you should wear gloves because their shells are sharp. You may use a shovel or even a whirling-disc spreader like those used for scattering salt on roads. You should always plant spat from a boat when the tide is high enough to give you a depth of at least 2 feet. In falling gently to the bottom through water, most spat scatter and land right side up on the bottom. If you plant onto a bare flat at low tide, you are almost certain to get bunching and many spat will land wrong side up or be driven into the mud and smother (Chap. 8.4).

When spat are on shells they must be planted on rearing grounds with more space between. Your losses from smothering will be heavy because many spat on under sides of shells will be killed. But there is less likelihood of losses from washing ashore than when you plant separate threshed spat which are very light. Another disadvantage of planting spat attached to shells is that they have to be separated after they have grown to $1\frac{1}{2}$ or 2 inches, or before.

SURVIVAL AND GROWTH. Separate spat from egg-crate filler collectors threshed in the spring have been planted directly on the bottom in Conway Narrows for four successive years. Survival seems to be less than on trays but it is still remarkably high. Recently we have also tried planting autumn-threshed spat. Results are encouraging but with so little experience we are less sure of the results. Ordinarily growth on the bottom is about half as fast as on trays. It usually takes threshed spat 2 years in the Narrows to grow to bedding size. They reach this size in 1 year on trays.

Last year some mussel shells with a light set of spat were planted there. They survived and grew very well and we assume that spat growing on oyster shells would do as well.

Winter survival is not a problem in Conway Narrows but it may be a problem on good rearing grounds you wish to use. Occasionally spat on the bottom in shoal-water areas will grow to bedding size in a single summer. In such cases you can transfer them to maturing grounds that autumn. But if they don't, you are up against a problem. Sometimes you can sell them at this stage to other lessees. If you wish to keep them yourself you may risk planting them on the shallowest parts of your maturing beds where starfish control is easiest. Or, you may shift them for wintering to some place where you know winter survival is good, then return them the next spring to your shallow rearing ground to complete growth to bedding size. This is probably the best treatment for spat attached to shells even though the extra fishing and handling increases production costs. Efficient mechanical harvesters may simplify this problem.

A highly successful method of wintering threshed collector spat and small bedding oysters has been tested for several years at the Experimental Oyster Farm at Malagash, N.S. There, the oysters are put in wire-bottomed ($\frac{1}{4}$-inch mesh) trays that are set in racks which have been built in a dammed inlet to a salt marsh. They are placed there in late November and removed in April or May and planted as soon as the ice breaks up. This might work equally well in other areas.

Oysters handled in this way can be packed in trays 4 inches deep without serious risk of loss so long as they are in the state of hibernation. When water temperatures exceed 40°F there is risk of smothering.

CULTIVATING. Cultivating is very important in insuring good quality of older oysters growing on maturing grounds (Chap. 8.5). It is also important on rearing grounds although some of the advantages it provides, such as regular shape, are not so important because at this stage the oysters are small and their shape can be improved later before they reach market size. Cultivating removes enemies. It may also involve separation of clusters of spat that have settled on shells. This improves shape and may increase survival. Separation is often delayed until the young oysters have reached full bedding size.

Cultivation probably improves growth by clearing away silt but we have too little experience to speak with confidence on this and other effects of cultivating oysters on rearing grounds. However, we are carrying on a great deal of work in Conway Narrows now and we hope that we shall soon have more to say about shoal-water, bottom rearing of bedding oysters.

TRANSPLANTING. Transplanting is necessary because if you leave oysters in warm areas until they are market size, they usually grow to poor shape. For good shape, growth during the last 2 or 3 years should be slow. Therefore, as soon as they are big enough to resist starfish attack ($1\frac{1}{2}$ to 2 inches long) you should transplant them to deep beds where their shape will improve. The shell they form will be harder and a little more cupped, their meats fatter and more salty than in the warm, up-river areas. By transplanting you can take advantage of good features and avoid bad features of both up-river rearing grounds and of down-the-bay maturing beds.

Fishing bedding-size oysters. Fishing small oysters, either wild or cultivated, is not always easy even in shallow water. Picking is the simplest way to gather separate oysters but some prefer a combination of raking with a garden rake and picking. Fishing young oysters that you have grown to bedding size while still attached to shells is easier. The shells can be raked into heaps and forked with gravel forks into dories. Mechanical methods of fishing are preferable in large-scale operations because the above methods require much expensive labour. The hydraulic escalator harvester just developed may be the answer (Chap. 12.1).

Importance of shoal-water, bottom rearing. We still have much to learn about this phase of oyster culture but we think it is the best way to produce bedding oysters from spat. There is little expense and bottom-reared, bedding oysters are superior to tray-reared. Their shells are harder, deeper-cupped and more symmetrical. Thus, bottom rearing seems to be the answer to one of industry's two toughest problems. The other, of course, is how to get spat. The Department is undertaking experiments in mass production of bedding oysters in Conway Narrows to discover the best methods and to make bedding oysters available to lessees in disease-affected areas (Chap. 10.7). We are also searching for other areas like the Narrows.

7.4 Rearing on Suspended Shells (Raft culture)

The Japanese have for many years reared large quantities of oysters to marketable size by raft culture. Pierced oyster shells or scallop shells with their catch of spat are removed from their collector strings (Fig. 23) and restrung on wire or rope but spaced at wider intervals (6 to 8 inches). These chains of shells are suspended from log rafts. This method has been tested on a small scale at Ladysmith Harbour, B.C. Growth rate and quality were surprisingly high.

There may be places on our coast where this method would be worth while for growing spat to bedding size. The fast growth of suspended oysters would probably reduce the age at marketing by a year and the high survival would at least partly offset the extra expenses. The young oysters would have to be separated before transplanting to maturing grounds. The floating tray which Dr. Needler used accomplished these same objects but became uneconomic. Suspended shells should be tested as part of our search for an economical way of producing good, cheap, bedding oysters. Fencing or pontoons instead of floating logs could be used for supporting shell strings.

CHAPTER 8. MATURING OYSTERS

Under natural conditions oysters have to spend their whole lives on the spot where they settle as spat because they are stuck there. Actually only a small proportion of those that settle live long enough to grow to market size. Otherwise, the sea would soon be full of oysters. Enemies and other destructive agencies keep the numbers low and the few that do survive often grow to poor shape. The oyster farmer's aim is to obtain large quantities of cheap young oysters to plant them while they are small on good ground and to protect them from enemies until they are marketable. This insures good quality and high survival at low cost. Reasonably fast growth on maturing grounds is desirable but it should not be so rapid that it interferes with good shape and meat quality (as it often does under natural conditions). It usually takes 3 or 4 years to bring 2-inch bedding oysters to market size without sacrificing quality.

Maturing is the final stage in the farming of oysters and it determines their quality and value. You will want to do everything you can to produce the best and this means applying all your knowledge. It is worth reviewing the important points even though some of them are dealt with earlier or later in this Bulletin.

8.1 Points to Remember

Lease your maturing ground. There is only one way to secure legal control of oysters you are maturing. You must lease the ground they are on.

Use firm clear bottom. On soft bottoms oysters grow to poor shape or may sink so deeply in mud that they smother. On sandy bottoms they may smother because sand shifts in storms and buries them. Maturing grounds should be firm enough to prevent oysters from sinking but should not shift. You should also avoid grounds that have heavy growths of eel-grass (Chap. 9.8).

Choose moderately warm water. Where water is too warm, oysters will grow poorly-cupped, thin shells. On the other hand, where it is too cool they may grow so slowly that there is no profit in farming them.

Choose salty water. Canadian consumers prefer oysters with salty flavour and hard shells. These are characteristics only of oysters grown in salty water.

Choose fertile water. For good growth and fattening the water must produce an abundance of oyster food.

Use safe and convenient depths. Maturing beds should be deep enough to be safe from winter damage but not so deep as to make oyster farming operations difficult. The depth of your beds should be adjusted to your fishing methods (Chap. 12.1).

Convenience. If possible choose maturing grounds that are not too far from your headquarters. It will save you time and make it easier to protect your stock.

Large-scale improvement of bottom is unprofitable. You can improve poor bottom (Chap. 4.6) but this is expensive and often does not make permanently good maturing ground. On the other hand, it may be worth while for you to improve small areas of poor bottom in your lease.

Avoid pollution. If possible avoid leasing ground that is polluted or near sources of pollution.

Avoid oyster disease. Before you make any transfer of oysters, large or small, from one district to another, be sure you know what risks are involved and whether it is within the law. Oyster disease is devastating. You must avoid it at all costs.

Enemies, competitors and excess shells. Oyster enemies may cause serious losses. If they are numerous on your maturing grounds and large enough to kill bedding oysters, you should remove and destroy them before planting the area. You may have to continue this protection throughout the period of maturation. Competitors like mussels produce the same effects as crowding and must be combated like enemies (Chap. 9.3). Too many shells on a bed also produce the bad effects of crowding. Excess shells should be removed before you plant bedding oysters.

Obtain advice. The Department is prepared to advise regarding suitability of conditions and examines areas before approving applications for leases. This may help you to a wise choice but it cannot assure you that oysters will grow on the ground you lease.

8.2 Kind of Oysters to Plant

Plant single oysters. Clustering spoils shape and when clusters of oysters are planted they smother more easily than singled (separated) oysters. Besides this, clustering prevents the survivors from growing to good shape. The earlier oysters are singled the better but it is not possible to single oysters that have settled on shells until they are about 2 years old. All bedding oysters should be singled when planted on maturing grounds, if not earlier. This should be done even if many are killed in the process. Losses will be more than repaid by the improved quality and survival after planting.

Plant good-shaped oysters. To fetch a good price, oysters must be regular in shape, wide in proportion to their length and have thick, well-cupped, firm shells. On good maturing ground the shape and shell strength of poor oysters will improve but there are limits to the extent of their improvement. Once shell has been formed it cannot be moulded. It is only the shape and quality of the shell that is formed after bedding oysters are planted on maturing grounds that are affected by transplanting. Shell hardness, and therefore shipping quality, nearly always improves, but you should not expect noticeable changes in the shape of oysters which have almost reached market size before you plant them on maturing grounds. Large, narrow, flat oysters will not become round and deep-cupped, nor will crooked oysters be made straight. The smaller they are when you plant them, the more their shape can improve. Unless they are quite small it usually does not pay to put poor-shaped oysters on a maturing bed.

If you rear your own bedding oysters you can at least partly control the quality of the stock you plant, but if you are obliged to buy cultivated bedding oysters from other lessees or gather or buy wild stock, you must take what you can get.

8.3 How Many Oysters and How Often to Plant

Plant enough for maximum yield of good oysters but don't overcrowd. Bedding oysters should be planted on maturing grounds as thickly as possible without lowering quality. If they are too thinly spread, the work of cultivating them and fishing them for market is needlessly increased. You will find it better to develop a part of your ground to full capacity than to half-use the whole area. At the same time it is foolish to try to increase production by overcrowding. If oysters are too close together they may cluster or they may not even get enough food to survive.

Number of oysters to plant. Because about 10% of any oyster population normally dies from natural causes every year and because it is practically impossible to fish up all the oysters you plant, you cannot hope to harvest more than 65 to 75% of the bedding oysters you plant. You must allow for this in your planting program. For example, let us suppose that you wish to harvest a crop of 200 boxes of mature oysters from your ground 4 years from now. This is equal to 100 barrels or 250 imperial bushels or 20,000 pounds or between 50,000 and 60,000 individual oysters. To allow for the annual 10% natural mortality for each of the 3 or 4 years that it is going to take your bedding-size oysters to grow to market size, you must plant between 70,000 and 90,000 bedding oysters on your ground this year. (There are between 3,000 and 4,000 bedding oysters $1\frac{1}{2}$ to 2 inches long in a $1\frac{1}{4}$-bushel box.) Some people plant bedding oysters on the same ground every year (multiple planting), while others make each year's planting of bedding oysters on a separate plot (single planting).

Compared with multiple planting, this system of single planting involves relatively little culling at harvesting because there is less variety in the size of the oysters brought up. However, the single-planting system has some disadvantages. For example, all oysters do not grow at the same rate. So, even if oysters are the same size when planted, there is always some culling to be done when they are fished. And more than one fishing is usually necessary to completely harvest a plot that has been stocked by a single planting. There are other disadvantages which result from the grower's tendency to leave the bottom, and the oysters on it, undisturbed for long periods. During these periods there may be unexpected silting, heavy sets of spat or clustering of oysters that happen to be touching one another and any of these may lower quality. These risks may be overcome or partly overcome by annual or semi-annual cultivating.

On beds stocked by multiple plantings, much of this cultivating is taken care of during the annual harvestings. For this reason, many growers prefer multiple plantings to single planting. Multiple planting does involve more culling but on the average it gives better shell shape and it also gives heavier yields per acre per year. This higher yield is important in regions where the area of good maturing ground is limited.

MAXIMUM YIELDS WITH MULTIPLE PLANTINGS. Under this scheme of stocking you have several different sizes and ages of oysters all growing together on the same ground and every acre of most good ground can mature about 200 boxes of marketable oysters every year. On grounds planted in this way the oysters, of all sizes, cover less than one-third of the bottom. Figure 25 gives you some

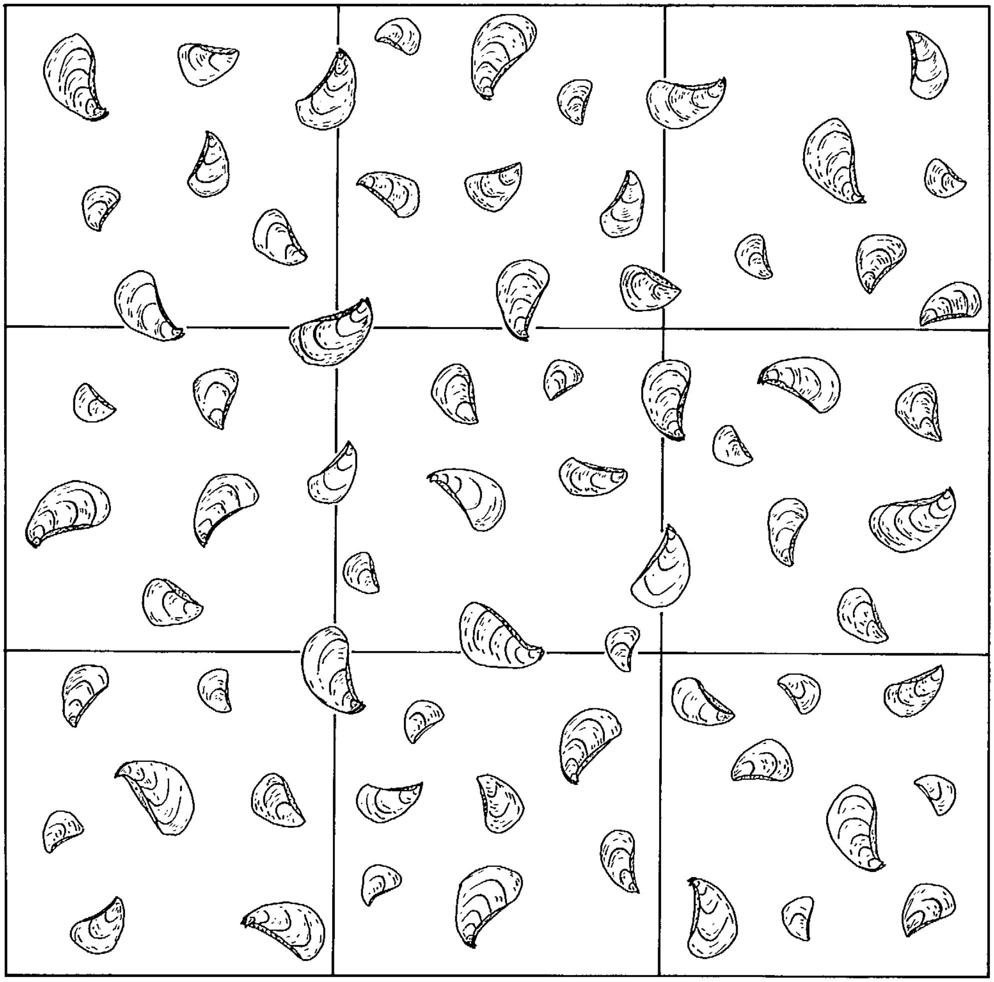

FIG. 25. Diagram showing distribution and sizes of oysters (drawn to scale, 1/7 natural size) on 1 square yard of a bed that is being managed under the multiple-planting system to produce 100 barrels (200 boxes or 250 bushels) of oysters per acre per year. (Drawing: P. J. Downer.)

idea of what the bottom looks like when it is being managed in this way. If the oysters were evenly spread, more could be planted and annual yields of good oysters might be greater. But it is hard to plant evenly and experience shows that a maximum annual yield of 200 boxes per acre is the most you should try for. This means that every year you will have to plant every acre with 80,000 to 90,000 bedding oysters. This is equivalent to about 25 boxes if the oysters are $1\frac{1}{2}$ to 2 inches long.

Maximum yields with single plantings. If there is little silt and little spatfall on your maturing ground, it may be more convenient to plant whatever bedding oysters you have each year, on a new empty plot. Under this system of single plantings there is room without crowding for about 120,000 to 140,000 bedding-size oysters (35 to 40 boxes) on every acre of the new plot and these should produce a single crop of about 300 boxes after 3 or 4 years. Experience shows that it is unwise to plant more heavily.

8.4 When and How to Plant

Planting bedding oysters on maturing ground is one of the most important steps in oyster farming and it is worth while to take simple precautions, even though you may be rushed with your work at the time and may think precautions unnecessary.

The best time to plant is early spring or mid autumn when the oysters are active and can repair any shell damage they may suffer in handling. If you are obliged to plant in mid summer, you should protect the stock from long exposure on hot days. The principles are the same as in planting spat (Chap. 7.3).

Mark the suitable bottom carefully before planting. It is hard to be sure of your exact position on water. You can make costly mistakes even when you feel most certain. Lessees have been known to plant their bedding oysters on other people's leases. It will pay you well to make the extra effort of marking off suitable parts of your maturing ground with stakes or buoys and shore ranges. In this way you avoid planting on poor ground where bedding oysters smother or grow to poor-shaped adults that fetch low prices.

Spread oysters evenly. To make full use of good ground without overcrowding any part of it, you must spread bedding oysters as evenly as possible. When you shovel them overboard you must broadcast them and not dump shovelfuls in one spot. You cannot spread them evenly without using plenty of stakes or buoys to mark the ground already covered.

Oysters falling through water right themselves. The normal position of any oyster on firm bottom is with the thicker, more curved shell down. In this position it grows to a regular shape with the lip directed upward. If planted upside-down the lip is liable to be buried and the oyster will smother unless the bottom is really firm. And if the oyster lives, the lip will reverse, grow upward and spoil the shape.

About 95% of well-shaped bedding oysters right themselves in falling through water 2 to 3 feet deep. They therefore land in the normal position on smooth bottom. More than half of crooked or clustered oysters land right way up. You should plant oysters when the water is at least 3 feet deep to be sure that most will land right side up. It is worth waiting for the tide to rise to provide this depth for planting. It reduces smothering and improves shape.

Oysters reaching bottom right way up may turn over if they happen to land on other oysters or on coarse shells. This is another reason for avoiding too dense planting, for planting evenly and for removing coarse shell and mussels before stocking your maturing grounds with bedding oysters.

8.5 Cultivating

An oyster bed is like a garden. It needs to be cultivated. By cultivating we mean fishing up oysters, separating them if they are clustered, removing spat and shell that may be attached to their shells and returning them to bottom, thinning them out and scattering them well to prevent crowding. Cultivating may also include removal of old shell because too much shell on a bed spoils the shell shape of growing oysters. Cultivating is usually combined with control of enemies and competitors which are like weeds in a garden (Chap. 9) or with fishing (Chap. 12.2). But cultivating is of more than incidental importance, and every maturing bed should receive some cultivation every year, even when there is no need for predator control or fishing. For this reason it deserves separate mention. The total effects of cultivating are highly beneficial.

Cultivating improves shape. The Netherlanders, who are among the world's best oyster culturists, spend much time cultivating their maturing grounds. Separation of clusters, removal of old shell and the incidental clearing away of silt free the shell edge for symmetrical growth that improves shell shape. Even if it breaks off small bits of shell, this damage is quickly repaired. It does not cause crooked shells. It is unwise, however, to do your intensive cultivation when there is a wide margin of new shell still in the fragile feathery stage. A great part of this may be broken away and seriously set back the oyster's growth.

Cultivating improves growth and fatness. Cultivating involves picking up oysters and putting them down again. This simple operation seems to be stimulating. It leaves oysters sitting well above neighbouring shells and above the silt which oysters collect and deposit on the bottom around themselves as part of their daily living. In their new positions the cultivated oysters seem to feed better and consequently grow and fatten better.

How often and when to cultivate. Most growers agree that maturing grounds should be cultivated at least twice a year. Beds that are worked according to the multiple-planting scheme (planted with bedding oysters every year and fished every year) can be cultivated every autumn. But weather is often unfavourable at that season and cultivating is often hurried and none too thorough. It is well therefore to plan a less hurried cultivation in spring before growth gets under way. This can often be combined with the work of combating enemies and competitors (Chap. 9). At that time weather is better for boat work and if you have boat space, the culling may all be done without coming ashore. The benefits of spring cultivating are great because they extend over the whole growing season from its very beginning.

CHAPTER 9. ENEMIES AND COMPETITORS AND THEIR CONTROL

Under natural conditions many oysters are killed by other marine animals which prey on them and many others are crowded out of existence by competitors. Damage by enemies is conspicuous because they kill oysters. Competitors more often reduce quality and growth rate. Their damage may be just as serious in the long run but it is less conspicuous. By comparison with other countries, we are fortunate in eastern Canada in having so few oyster enemies and competitors. You can increase production by growing oysters in places where there are no enemies and competitors or by destroying those that are present in the same way you destroy weeds in a garden. To protect oysters in either of these ways you must know the life-histories of the competitors and enemies, their distribution and the ways in which they attack oysters or compete with them. This same knowledge helps you avoid introducing these pests when transferring oysters to new grounds.

To some extent you can combine enemy and competitor control with fishing (Chap. 12.2) or with gathering shells for spat collection (Chap. 6.3).

9.1 Starfish

On our coast the oyster's worst enemy and the biggest obstacle to oyster farming is the common starfish or sea star (*Asterias vulgaris*). Other species of starfish occur here but they do not bother oysters. In the northern United States there is a larger kind of starfish (*Asterias forbesi*) that thrives in warm waters where oysters grow. It is large enough to kill even the largest oysters. Recently it destroyed most of the oysters in Long Island Sound and brought its oyster industry almost to a standstill.

Our common starfish is a northern form that does not thrive too well in waters that are warm enough for oysters, so it seldom grows to a large size in our oyster areas. Adults are usually killed by water warmer than 77°F but the young can stand 81°F. Summer warming of the water therefore keeps some of our shallow or sheltered grounds practically free of starfish. In most places, however, there are enough starfish to cause serious damage among small oysters.

Life-history. Our starfish usually spawn in May or early June, about a month before oysters. They shed their eggs and sperms into the water where the eggs are fertilized and develop into swimming larvae. Swimming lasts about 3 weeks and larvae may be carried great distances before they settle. When they do settle they are still too small (about 1/20th of an inch) to be obvious to the naked eye and by the time they are first visible they have changed to look like their parents.

Because they settle about a month earlier and grow rapidly, a starfish of the current year's hatch is big enough to kill a new oyster spat as soon as it settles but not large enough to attack spat that settled the year previous. Starfish growth is influenced by abundance of food and other factors. On some grounds in Malpeque Bay, P.E.I., 1-year-old starfish are about $1\frac{1}{2}$ inches in diameter and 2-year-olds about $2\frac{1}{2}$ inches. There is little growth in winter although starfish remain active and kill some oysters all year round.

Starfish become sexually mature and breed when they are 1 year old.

SIZE AND ABUNDANCE ON OUR OYSTER GROUNDS. Most starfish on Malpeque oyster grounds are less than 2 inches in diameter and only a few are more than 3 inches across. Most appear to be less than 2 years old. On some grounds there are a few older starfish 8 inches or more in diameter. Where the water is colder than in our oyster inlets, they grow larger still.

As many as 60,000 starfish per acre (12 per sq yd) have been found on some of our oyster maturing grounds but more commonly there are about 6,000 per acre. They are usually less numerous on soft mud or pure sand than on oyster beds.

MIGRATIONS. After their early swimming stage starfish do not normally move great distances. Experiments with marked starfish on Prince Edward Island oyster beds showed that in 4 months they wandered on the average only 20 yards from their point of release. But a few individuals wandered as far as 200 yards during this period. On a straight course they move about 20 feet per day. It is not believed that they are able to detect food at a distance. They seem to find their prey by chance wandering back and forth and they seem to stay where they find food abundant.

Recently, underwater observers have described how starfish can contract themselves into ball forms by folding their arms. They also describe seeing starfish in this state bowling along the bottom carried by tidal currents. We are not aware that this takes place in oyster inlets where tides are usually weak.

DAMAGE TO OYSTERS. Starfish get at oysters by pulling their shells apart. To do this they usually wrap their arms around their prey (Fig. 26) and exert a steady pull with the suction cups on the ends of their numerous small tube-like feet. These line the lower sides of the arms. A starfish 17 inches across (measured from arm-tip to arm-tip) can exert a pull of 10 pounds for 6 hours. Sometimes the oyster is actually torn apart. More often it fatigues and gapes under the strain of trying to keep its shell closed. After that the starfish feeds in its peculiar way. To do this it extrudes its stomach, which looks like a cellophane sac, and wraps this round the meat of the oyster. You may sometimes see the stomach if you suddenly pull a starfish away from its prey. Experiments show that one starfish may kill as many as three oysters about half its own diameter in 1 week. It can kill much larger numbers of small spat. Enough starfish occur naturally on some grounds to kill almost all of a heavy planting or natural set of spat in a month.

An oyster is hard to open and it is safe unless the diameter of the attacking starfish is more than $1\frac{1}{2}$ times the diameter of the oyster (Fig. 27). The bigger the starfish, the easier it is for it to open an oyster and large starfish require

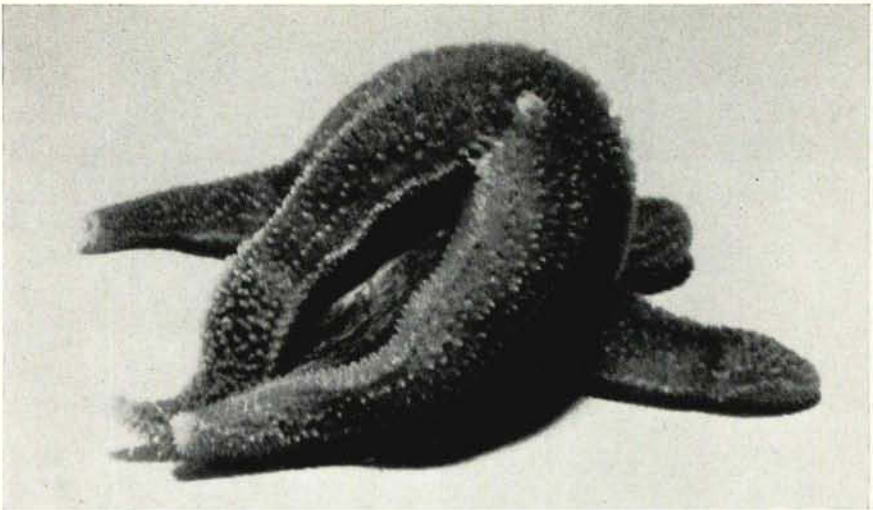

FIG. 26. This starfish will pull on the oyster's shells until they gape ever so slightly. After that it can digest out the meat.

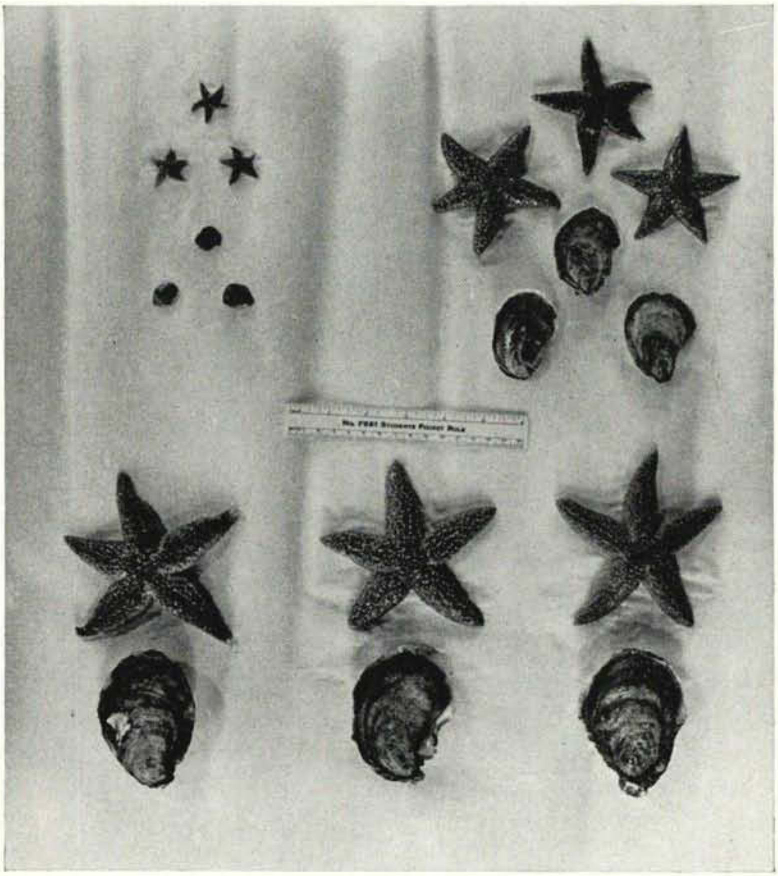

FIG. 27. Starfish of three sizes, with the largest oysters each can destroy. (Photo: G. F. M. Smith.)

more food than small ones. Because most of our starfish are less than 2 inches in diameter, the oysters in worst danger are spat or small bedding oysters. There are exceptions. On some maturing grounds starfish are large enough and numerous enough to be a real threat, even to market-size oysters.

STARFISH DO SOME GOOD. Starfish usually prefer mussels to oysters and they destroy large numbers of these oyster competitors. Where mussels are abundant, starfish may do more good than harm.

Starfish do almost all their feeding from spring to autumn—very little in winter.

PROTECTING SPAT FROM STARFISH. Because starfish are not very active at low temperatures, spat that have just been threshed from collectors or spat on shells can be held on bottom over their first winter without serious losses, even in places where damage is heavy at other seasons. But starfish begin to feed heavily in spring so it is important to plant or replant spat in safe places early in spring.

Newly settled starfish are widely distributed. They settle on bottom and on floating or suspended objects like oyster collectors. They grow so fast that they are large enough to kill oyster spat produced later the same year. Losses of spat on natural materials are therefore often high and sometimes approach 100%. Oyster farmers usually use suspended collectors and put them in the water just in time to catch spat—not before. Almost invariably this is too late to catch young starfish. This is fortunate because it is the answer to the riddle of how to protect spat during their first year. However, you must suspend your collectors from racks or floats or young starfish will crawl onto them from the surrounding bottom. Neither newly settled nor older starfish can swim. They cannot reach suspended collectors so the spat are safe.

PROTECTING YOUNG OYSTERS FROM STARFISH. In their second summer and, in fact, right up to the time they reach bedding size, young oysters must be protected from starfish. In the 1930's and early 1940's, floating rearing trays provided an economical solution to this problem and oyster culture began to flourish. Spat separated from collectors in spring and placed in trays usually grew to bedding size by autumn and could then be planted on maturing grounds when they were about 15 months old. Swimming-stage starfish settled in the trays in early summer but they were too small to attack tray oysters. Older starfish which were large enough to kill yearling oysters were on the bottom and could not reach the trays. When floating trays became uneconomical, oyster culture went into eclipse. Only now are we beginning to find ways of providing the kind of protection that trays used to afford young oysters.

There are some firm, shallow, sheltered grounds where starfish are rare and where spat and young oysters show remarkably high survivals for several seasons. Conway Narrows in the Malpeque Bay area, P.E.I., is an example. Spat threshed from egg-crate collectors either in the autumn of the year they settle, or in the spring following, will grow to bedding-size oysters of highest quality in 2 or 3 years in Conway Narrows (Chap. 7.3). Spat caught on shells do the same. There are few large starfish there and little winter kill. We are only beginning to understand how to use Conway Narrows to best advantage and where to look for other areas like it. Possibly we could create areas like it that would remain free of starfish.

HOW TO CONTROL STARFISH—POISON OR REMOVE? It is practically impossible to find places for rearing spat to bedding size that are *completely* free of starfish. And on some maturing grounds there may be many starfish large enough to destroy the smaller bedding oysters you plant. In such cases you must try to control the starfish. There are two ways of doing this. You may remove them or poison them.

When you are fishing or cultivating it is well worth while to keep all starfish you catch instead of throwing them back. On shallow rearing grounds like Conway Narrows, picking starfish by hand at low tide may be the cheapest and most effective way to remove them. Some growers or their children use a stick with a barb, such as a large, straightened cod hook, to pick up starfish. On deeper rearing grounds and on maturing grounds, most growers prefer to remove them by mopping.

Starfish can be killed by a variety of chemicals spread on the bottom just as insects can be killed by spraying. If even a small piece of quicklime touches a starfish it will die in a day or two. Or if starfish are immersed in brine it kills them almost instantly. There are other chemicals that are even more deadly but these are not recommended.

STARFISH SURVIVE MUTILATION. When starfish are torn apart, one of the pieces, but only one, will commonly survive. If a starfish looses an arm it will grow a new one. If you want to kill starfish you have gathered, it is therefore useless to tear up or beat them the way you would a crab and then return them to the water. You should be sure they are dead. You should kill them by exposing them to air for a long time, by dipping them in hot water or in brine.

STARFISH KILLED BY EXPOSURE TO AIR. Starfish are killed by long exposure to air. Perhaps this is why they are not found in large numbers above ordinary low-tide level and why you can rear spat on the bottom in some places close to shore. Starfish can stand short exposure, however, and if you hope to kill them by air exposure, you must put them where they will dry out thoroughly. Many growers land them and pile them well above high-water mark.

MOPPING FOR STARFISH. Starfish mops are made by knotting clumps of cotton waste, 2 to 3 feet long, onto wires about 2 feet long. As many clumps are tied at their centres onto each wire as it will hold and are kept on by rings or crossbars at each end of the wire. Usually about 4 pounds of cotton are tied onto one wire. The material usually used is known to the trade as "white unsized cotton slasher thrums". Sized cotton, which has been treated with chemicals to make it firm or shiny, may be used if the sizing comes off in water. The cotton is useless unless it is soft and snarly because starfish are caught by the threads entangling their spiny surfaces.

Mops are used in gangs fastened to a drag frame as shown in Fig. 28. The width of the main bar varies from 5 to 10 feet and it is supplied with short mop chains at intervals of 8 to 12 inches. Circular twists of the frame at the ends of the bar serve as runners to keep the bar off bottom and thus prevents it from damaging oysters. The best size of frame will depend on the size of your boat and your equipment for hoisting.

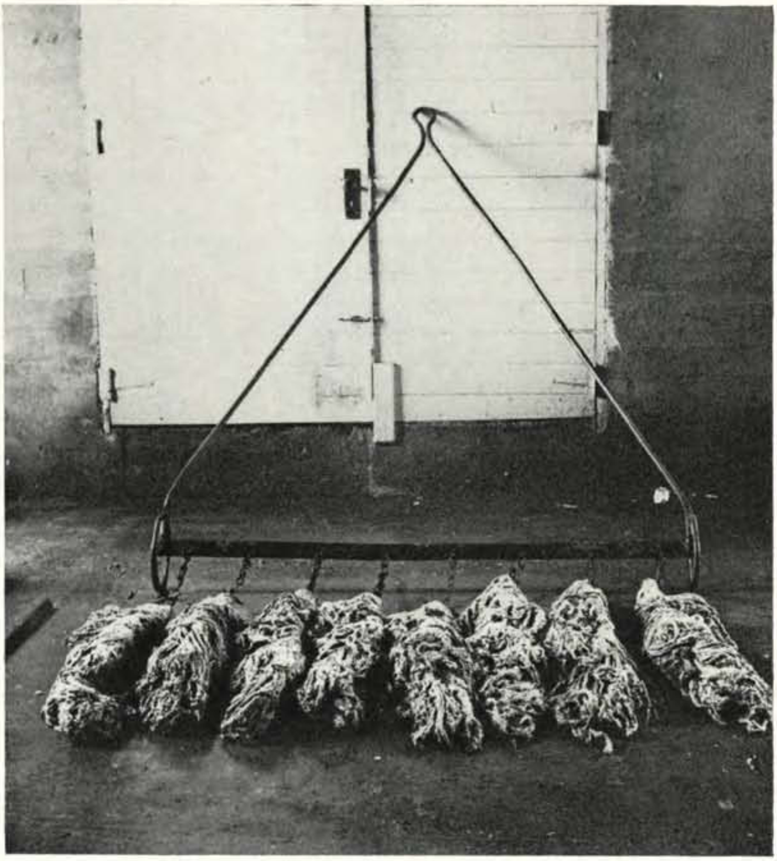

FIG. 28. Starfish mops attached to their towing frame. (Photo: G. F. M. Smith.)

Starfish mops must be towed very slowly over the bottom and hoisted frequently to remove or kill the starfish they catch. You will save time and expense by using two sets of mops. You tow one while you remove starfish from the other. The length of time mops should be towed before hoisting depends on the abundance of starfish. The more numerous the starfish, the sooner the mops will reach the stage where as many starfish fall off as are being caught. Ten minutes is often a suitable towing time.

Starfish may be removed from mops by hand. This can be the most time-consuming and therefore the most expensive part of mopping operations. If you rig your boat with a trough of hot water kept warm by the engine exhaust, you can dip the mops in it when they are brought aboard. This kills the starfish almost instantly and many drop from the mops without having to be picked out. This saves time and money.

Only recently United States investigators have found that strong brine kills starfish almost as quickly as hot water and brine is less awkward to work with. It is important to keep the brine saturated. To be sure of this there should always be some undissolved salt in the bottom of the trough. This system has not been used in eastern Canada but has much to recommend it. After 1 to 2 minutes in brine, starfish become very soft and many drop from the mops without picking. But if left in too long, the starfish get pickled and stiff and more have to be picked from the mops. It is claimed that 2 minutes is plenty of time to kill starfish and that it is then safe to throw them overboard.

The cost of mopping varies so much that it is impossible to give figures that are generally applicable. Boats have to be operated almost constantly during mopping operations and two men are needed to make best use of the gear. Wear on mops is one of the smaller expenses. They should be renewed frequently.

Tests show that if mopping is continued long enough, a high proportion of starfish may be removed from a bed. In one experiment 3,200 medium-to-large, marked starfish were placed on 1 acre of sand and shell bottom. One set of mops was used from a small boat and the starfish were removed by hand. Mopping the acre for half a day ($4\frac{1}{2}$ hr) caught 45% of the starfish. A full day's mopping (9 hr) took 65%; 2 days (18 hr) took 80% and 28 hours, 85%. Further mopping caught no significant numbers. Mops do not catch very small starfish effectively.

Effectiveness is probably greater if mopping effort is interrupted rather than continuous. By leaving a day between repeated moppings of the same bottom, starfish have a chance to move from sheltered positions among shells to places where they can be more easily caught. Effectiveness also varies with type of bottom and amount of shelter which starfish find on it.

It pays to mop a bed if there are worthwhile quantities of small oysters on it that may be killed and if starfish are numerous. It pays, for example, when there are natural sets of spat on deep rearing grounds that are infested with starfish, or when unusually large starfish are present among older oysters.

Mopping, even if thorough, must not be expected to reduce the numbers of starfish for a long period. Early every summer swimming-stage starfish are carried considerable distances and settle on grounds that have been mopped. They will kill spat that settle on the ground that year but they will not be large enough until the next season to damage oysters that you plant there. By that time they will be a problem and, where starfish are numerous and large, you will have to mop at least once every year.

Quicklime for destroying starfish on oyster grounds. Some growers in Malpeque Bay areas have used quicklime for starfish control. Experiments at Ellerslie showed that a concentration of 500 pounds per acre killed starfish and was not seriously harmful to any commercially valuable fish or shellfish on oyster beds at the time of the tests. Lime seems to be harmless to oyster larvae too and has no permanent ill effect on the amount of oyster food.

It is not always easy to obtain the right quality of granular lime from suppliers. If it is ground too fine, much of it blows or floats away. Care should be taken to avoid air-slacking which occurs so readily with pulverized or granular lime. If starfish are very abundant, killing them with quicklime may be cheaper than mopping. Four men in a motor boat equipped with a disc spreader for spreading the lime evenly can treat several acres in an hour, so labour costs are low. In our liming tests we killed 65 to 70% of the starfish. Probably slightly more than 500 pounds per acre would have given better results.

Killing starfish with other chemicals. The recent scourge of starfish in Long Island Sound has prompted United States investigators to search for poisons that will kill starfish without harming oysters and other useful marine animals. They argue that agriculturists use 2-4-D to control weeds so why shouldn't oyster growers use something similar to control starfish. Promising discoveries have been made at the Milford, Connecticut, laboratory but so far it has not been established that oysters, and consumers of oysters, are not adversely affected by the several chemicals which these investigators have found to be deadly to starfish. Studies are continuing.

9.2 Boring Sponge

Most people do not realize that boring sponges are sponges at all because they are so very different from bath sponges. The common small yellow boring sponge (*Cliona*) is seldom seen because it lives in tunnels (diameter 1/16th inch) which it bores for itself in the hard shells of oysters. It also attacks shells of other molluscs, living or dead (Fig. 29), and even limestone rock. Shells of old oysters are sometimes completely riddled by the sponge and as brittle as soda crackers. The sponge uses the holes in the shell surface as water intakes and outlets connecting with the extensive tunnels below. Sponge borings are seldom confused with the single straight borings made by drills.

Biology. The sponge uses the shell only as a home. Like the oyster, it feeds on minute, water-borne plants and animals. They strain these from water drawn into their tunnels through the intake holes and they expel the strained water through the outlet holes in the shell surface.

The sponge has two methods of reproduction. It lays eggs that develop into microscopic, free-swimming larvae that are carried about in the water for a considerable time. When the larvae settle they may be far away from their parents. After settling they seem to develop very slowly and inconspicuously for the first 2 years.

They attach to outer surfaces of shells and bore in. In attacking living oysters they usually begin at the oldest part of the lower shell, that is, near the hinge. They excavate their tunnels slowly until after a few years they may have

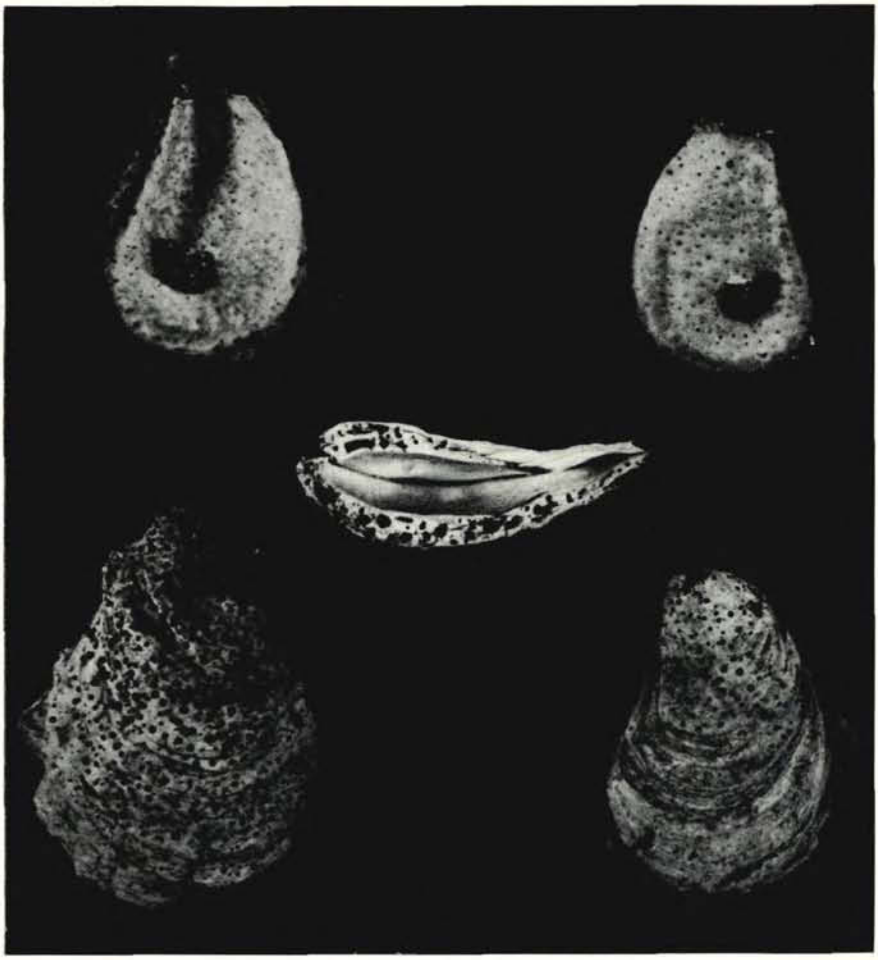

FIG. 29. Oysters affected by boring sponge. *Upper, left and right:* Inner face of cupped and flat valve of an oyster that was about to die. The perforations in the purple areas where the muscle attaches are very weakening. *Lower, left and right:* Outer face of cupped and flat valve of an oyster that is still vigorous. The whole of the cupped valve has been attacked, but only the oldest part of the flat valve. *Centre:* Lengthwise cut through the shells of an oyster damaged to about the same extent as the lower. There are no sponge tunnels in the newest part of the flat valve.

destroyed as much as 45% of the shell substance. For a long time the outer and inner surfaces of the shell may show little damage but the body of the shell becomes a maze of intercommunicating tunnels filled with sponge tissue, interrupted here and there by a pillar of lime joining the two shell surfaces (Fig. 29). In advanced stages the sponge even attacks the hinge ligament.

The other method of reproduction is to spread from infected shells to other shells with which they are in contact. Tunnels are extended to bridge the gap. So far as the oyster grower is concerned, this is the more important method of spread because this kind of infection progresses more rapidly.

Effect on oysters. Regardless of method of infection, results are the same in the long run unless you control these sponges. For a long time the oyster does not seem to be affected by the sponge although the holes in the outer surface are usually conspicuous after the first year or two. Later on the sponge pierces the inner surface of the shell as well. In summer the oyster quickly patches these inner holes with layers of lime and other shell material which show up as raised black dots (Fig. 29) like pepper. In autumn when the water temperature drops to below 45°F, the oyster finds it impossible to make good shell repairs but the sponge is still active. For this reason, infested oysters fished in the cold season may have holes reaching right through their shells and be leaky. This may or may not be damaging if the oyster is left on the bed, although by the next spring peculiar yellow spots will be found in the meats opposite the holes. In spite of this, the oysters apparently grow and fatten normally the following summer.

But eventually, when the sponge attacks the hinge ligament or that part of the shell where the muscle is attached, the oyster finds it impossible to open and close the shell properly. At this advanced stage of infestation, fattening, growth, and general vigour are all affected and the oyster dies if it is not killed by predators which it can no longer resist.

Effect on industry. Our worst plague of boring sponge arose in Malpeque Bay, P.E.I., between 1945 and 1955. High-quality oysters on down-the-bay beds were worst affected. When they were fished and shipped to market the sponge bodies in the tunnels in the shells rotted and dripped from one oyster onto others. They all stank and the shells of many were so weak that they broke up like crackers under the oyster opener's knife. It was impossible to open them without having fragments of dirty shell scattered through the meat. Such oysters were not popular and sales were affected. The boring sponge can be a first-rate menace to any oyster industry that caters to half-shell trade.

Since about 1955 the sponge problem seems to have cured itself, but it may arise again and it is well to know what can be done to control it.

Control measures. Several methods of combating sponge were worked out at the Ellerslie Biological Sub-Station in the early 1950's. And since then the United States Fish and Wildlife Service has discovered the usefulness of brine. None of the methods is perfect because none prevents attack by sponge larvae and because it is impossible to remove all the sources of sponge larvae. Practical control is approximate and involves—

(1) Treatment of infested oysters to kill sponge already present and thus halt sponge damage.

(2) Removal of infested dead shells from oyster beds to prevent sponge spreading from them, by contact, to newly planted bedding oysters or to treated oysters that have been replanted there.

(3) Repetition of these treatments at appropriate intervals to control the the effects of infestation by larvae.

United States investigators report that the best treatment to kill sponge in oysters or in old shells is to dip them in strong brine. This can be kept on a fishing boat in a trough like that used for killing starfish. The brine should be kept up to full strength by having undissolved salt in the trough and by stirring it occasionally. Freshly fished oysters should be immersed for 5 minutes. Oysters that have been out of water for an hour need only a 1-minute treatment. The brine treatment has not been used industrially in Canada because our sponge problem disappeared before the usefulness of brine was discovered. However, we have tested it experimentally and have found that it works well.

We have also shown that soaking for 12 to 16 hours in fresh water, or for shorter periods in various poisonous chemicals, is effective in killing sponges. We have also found that placing oysters in floating trays in creeks in springtime, when there are occasional freshets, will kill sponge. Planting oysters in the intertidal zone has the same effect at any season of the year. However, none of these treatments is as simple and effective as brining.

Infested, spongy, shell should be fished up and treated like spongy oysters if it is going to be returned to the beds but need not be treated if it is going to be taken ashore. There is no point in planting sponge-free oysters on a ground that has much infested shell on it.

The treatment to kill sponge in infested oysters and the treatment or removal of infested shells must be carried out every second or third year. It is costly work but can be combined with cultivating and fishing.

9.3 Mussels

Mussels are the oyster's chief competitor for food and space. They are a common cause of poor quality and may even kill oysters.

Biology. The life-history of mussels is similar to that of oysters but different in detail. For example, mussels spawn over a longer period, beginning earlier and continuing later. After the free-swimming stage, mussels fix themselves to some support by elastic threads (the beard) instead of cementing their shells to it. Mussels can cast off their beard and re-attach themselves somewhere else and sometimes they change their position slightly. They feed in the same way and on the same sort of food as oysters. They often live in the same places and have common enemies like starfish.

The blue mussel (*Mytilus edulis*) is the commonest type in our oyster areas. It can live in all parts of oyster inlets but it also thrives in water that is much too cold for oysters. The ribbed mussel (*Volsella demissa*) is common toward the heads of oyster inlets but is not such a serious competitor.

Interference with spat collection. If large numbers of mussel larvae settle on collectors, they will smother oyster spat that have settled already and discourage further oyster spatfall. This makes collectors more or less useless, depending on the density of the mussel catch.

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Fortunately the main catch of mussel larvae in our oyster areas generally precedes the oyster spatfall just as the catch of starfish larvae precedes it. So, by putting out collectors at just the right time for oyster sets you are likely to avoid mussel problems on collectors.

Before you plant out spat be sure to remove mussels. They are a plague on rearing grounds as well as on collectors.

DAMAGE ON OYSTER GROUND. Mussels are often abundant on oyster rearing and maturing grounds especially in shallow water. They often deposit quantities of soft, sticky "mussel mud" that ruins hard bottom and smothers oysters (Fig. 30). They crowd oysters and result in shell distortion, thinness of meats and even death.

FIG. 30. Mussels compete for food and space with oysters, distort their growth, and may smother them by depositing sticky, black, "mussel mud".

You cannot grow good oysters where mussels are abundant. You must remove them from grounds where you rear spat to bedding-size oysters and from your maturing grounds too. This can be done during cultivation using either regular fishing methods or the recently developed method of hydraulic fishing with escalator harvesters. You should leave these mussels ashore to die. You may use their shells for spat collection in the way Netherlands oyster growers do. Where mussels settle heavily year after year, they may make oyster farming unprofitable.

9.4 Oyster Drills

Several kinds of snails are able to bore small holes through the shells of other molluscs and kill them. They bore by rasping with their toothed tongues but they produce shell-softening fluids that make this work easier. Some drills can kill oysters and are known as oyster drills. In parts of the United States, oyster drills cause millions of dollars worth of damage every year.

Biology. Only one species, the common oyster drill (*Urosalpinx cinerea*), is of importance in Canadian Atlantic areas and it is common only in the region about Malagash, N.S. However, it is also found in Minas Basin, N.S., and in Summerside and Charlottetown Harbours, P.E.I.

It is a brown snail with a rough and sharply pointed shell about 1 inch long (Fig. 31). Its eggs are laid in summer in yellow, flattened, vase-shaped capsules attached to shells or stones. The young develop in the capsules and when they emerge they crawl about actively. Because there is no free-swimming stage, the drill tends to spread rather slowly. There is danger of carrying it from place to place in shipments of oysters but this danger is less than was formerly supposed. Nevertheless, we should keep alert.

Damage to oysters. Before the oyster disease struck Malagash, the drills used to kill many small and medium-size oysters on the bars there. The victims could be recognized by careful examination because they had a straight-sided hole about 1/16th of an inch wide through one shell—usually the upper. Drills also feed on mussels and those in Minas Basin feed chiefly on barnacles. They hibernate from late autumn until about mid May. They usually hide in some cranny and may be buried by silt. They are most destructive in the warmest part of the summer.

Control. The drill is patchy in its distribution even in inlets where it is most abundant. Thus, the simplest way to avoid trouble in areas where it does occur is to select culture grounds that are free of drills. At least until now this has not been a great inconvenience.

Because they are so inconspicuous, it is almost impossible to avoid including drills and their egg cases in summer shipments of oysters from infested areas. The best time to make transfers is in early spring before egg-laying gets under way. And before moving them out of their native area, the oysters should be spread on a slatted or screened floor and washed with a hose at a good pressure. You would be well advised to take these precautions whenever you move oysters taken from an infested area—even if you plan to plant them in another part of the same inlet.

9.5 Blister Worms

There are many kinds of marine worms and some live as parasites or semiparasites in other animals. One of these is the mud blister worm (*Polydora*) which lives on the inside of shells of oysters and causes some damage.

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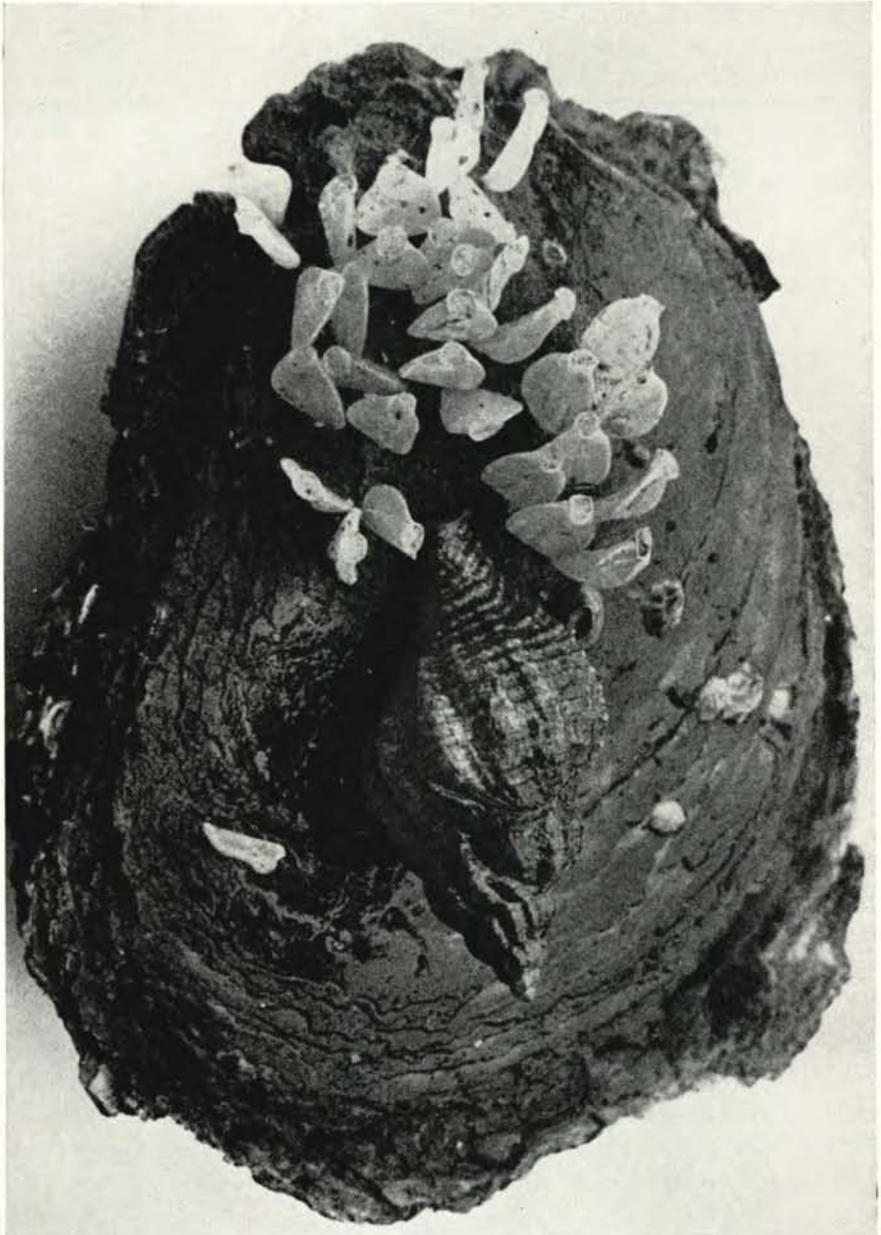

FIG. 31. The oyster drill is a kind of snail that bores holes the size of a darning needle through oysters' shells then rasps out the meats. It often attaches its white, bottle-shaped egg cases to oyster shells. (Photo: P. J. Warren, after D. A. Hancock, U. K. Ministry of Agriculture, Fisheries and Food.)

The blister worm enters oysters when it is in its early free-swimming stage. It attaches to the inner face of the lip of the shell and begins to gather mud about itself. Apparently to protect itself, the oyster lays down a film of shell over the worm and the mud it has gathered and this produces a dark, flat pocket or blister usually less than 1 square inch in area (Fig. 32). The worm lives in a "U"-shaped tunnel in the mud inside the blister. The ends of the "U" are open to the sea water at the free edge of the shell. From one end the worm can thrust forth its head, from the other, its tail.

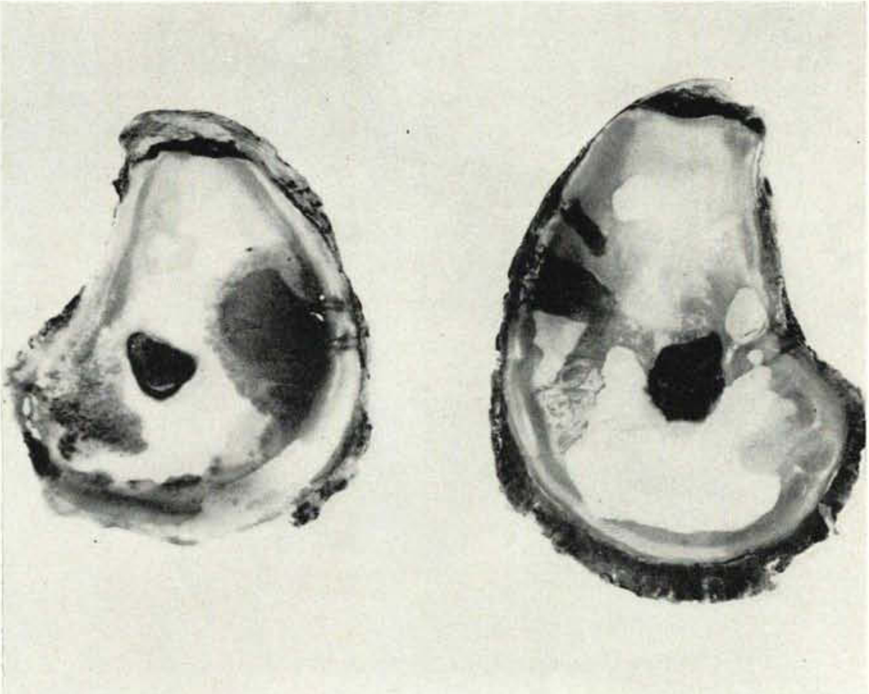

FIG. 32. Cupped (*left*) and flat (*right*) valves of an oyster from Gillis Cove, Bras d'Or Lake, N.S., with severe mudworm blisters. The oyster makes a thin covering of shell over the mud that has been collected and the worm maintains a runway to the outer edge of the shell.

The size of the blister seems to depend partly on how soon the oyster covers the worm with a film of shell. If it does this before it has collected much mud, the completed blister with the worm inside can scarcely be seen. This is generally true in the Malpeque Bay area. If the oyster is late in forming the shell film, the worm may have gathered a great deal of mud and the completed blister is rather large. This sometimes occurs in parts of the Bras d'Or Lake.

In our areas the worm is never abundant enough to be seriously harmful to the oyster, as it has sometimes been in Australia and parts of the United States. If a large blister is broken when an oyster is opened, the mud spreads over the meat to give it a disagreeable taste and smell. Besides this, of course, large blisters have an unappetizing appearance. Such a condition is rare in oysters from this coast but it has been serious enough at times to affect market values of oysters from one or two small areas in the Bras d'Or Lake.

Control measures have never been resorted to in our areas. United States investigators report that brining oysters as described for control of boring sponge, kills the worms.

9.6 Flatworms

A minute flatworm (a rhabdocoel) about 1/16th of an inch long sometimes lives on the gills of our oysters but sometimes swims about in the shell liquor. There are usually not more than three or four in one oyster but sometimes the count rises to 2,000 or more. The worms disappear a day or two after oysters are fished and there is no evidence that they are harmful in any way to consumers.

This inconspicuous parasite has come to our attention only recently and is still being studied. We are not sure how important it is but we are suspicious that it may sometimes be harmful to oysters on certain Malpeque Bay beds.

9.7 Crabs

Mud crabs (*Neopanope*) are common in our oyster areas. These are plump little dark gray or black animals seldom more than 2 inches wide. They are too small to damage adult oysters but they have been observed to destroy spat. So far as we know, the damage they do has not been serious here. They cannot swim so collectors suspended from fences or floats are safe.

No control measures have been developed but they may be needed if spat collection directly on the bottom becomes popular.

9.8 Eel-grass

Biology. Eel-grass is a perennial flowering plant belonging to the pond-weed family. It thrives best in water which reaches a temperature of 60 to 80°F in summer. It is therefore rare in most parts of the Bay of Fundy but abundant in the southern Gulf of St. Lawrence. In the Gulf it grows in shallow water where the plants are never exposed or where they are exposed for only brief periods at low tide. It seldom grows in water deeper than 10 feet at high tide.

Eel-grass has inconspicuous, green flowers and reproduces by seeds, but it spreads mostly by extending its long, strong, underground root-stocks which form a network in the soil. It will grow in a variety of soils from soft mud to hard sand and gravel. It does not establish itself easily in shifting sand and after it has established itself it may not grow as luxuriantly as in other types of soil.

Eel-grass acts as a breakwater. It prevents erosion and helps stabilize shifting bottom but may encourage silting in areas where it grows vigorously. In autumn many leaves break free in storms and wash ashore in great windrows. In heavy storms the root-stalks may also be washed out. About 1930 a disease killed off eel-grass on both the North American and European sides of the Atlantic. It recovered very slowly, but in most places it now grows as well as ever, although the disease is still present. The killing off made some formerly-useless grounds suitable for oyster culture, but many of these have been abandoned since the grass has recovered its vigour.

EFFECT ON OYSTERS. In some places oystermen complain about eel-grass because it interferes with fishing. It fouls tongs, rakes and dredges and greatly reduces their fishing efficiency. Dense stands reduce water circulation. This may not conspicuously retard oyster growth but does tend to distort shape and lower the quality of oysters. Fatness of the meats may also be affected. Sometimes in autumn broken-off eel-grass leaves are blown into shallow water and cover beds of oysters and smother them.

In other places eel-grass aids oyster growers. Conway Narrows, P.E.I., is an example. Here, the Department is producing mass quantities of bedding oysters by growing spat in shoal water on sandy bottom where there is a sparse growth of short eel-grass. The roots prevent the soil from shifting and burying small oysters and the short stems and leaves prevent oysters from being washed away in storms. The Bras d'Or Lake is another example. There, spat often settle on eel-grass. The patterns of the eel-grass blades are discernable on the cupped shells even of old oysters and prove that in some areas oyster stocks are maintained almost entirely by eel-grass spat (Fig. 33).

CONTROL. Where eel-grass is too thick on oyster beds, dragging with toothed oyster drags and tonging will reduce the density especially if the bottom is soft. But this will not eliminate the grass. Mowing is another temporary control

FIG. 33. Lower shells of young wild oysters from Gillis Cove, Bras d'Or Lake, N.S., that settled and grew as spat on blades of eel-grass. They will always carry these leaf impressions.

measure. If the grass is quite long on your bed it may be worth while mowing it at low tide with a scythe if the water is shallow. If it is too deep, there are various types of power-driven mowers for water weeds which can be used. But this is like mowing a lawn. The grass grows again.

Some have tried smothering out eel-grass in small areas by covering it with 3 to 6 inches of gravel, sand or shell (Chap. 4.6). This hardens the bottom as well as clearing out the plants. It is best to mow the grass before beginning this work and to stake the plot carefully when the spreading is done to insure even distribution. In some cases it pays to be sure the grass is well smothered by sheathing the bottom with slab wood or with strips of tar paper or polyethylene sheeting (Chap. 4.6) before spreading the soil or shell. This kind of control is effective for a long time and improves the bottom. In the United States polyethylene sheeting has been used without any covering for improving the bottom. If it were used in this way for eel-grass control, it might be best to use black sheeting to prevent light reaching the plants.

Experiments with weed killers have shown that "Benoclor 3", spread in the right way and at the right concentration will kill eel-grass completely. Eventually, of course, an area cleared with this weed-killer will be reseeded but this generally takes several years. You should not attempt chemical control until you know what you are doing. The Research Board's St. Andrews Biological Station's Circular No. 23, "Control of eel-grass in oyster culture areas", describes workable methods and is available on request from the Station or from the Department of Fisheries, Ottawa.

From what has been said it is obvious that controlling eel-grass can be expensive. It is often desirable to control it in small areas for special purposes, such as for providing a temporary bedding ground for market oysters. But it is usually uneconomical to control it over wide areas.

9.9 Fouling Growths on Spat Collectors

Fouling growths may smother spat on various sorts of collectors. Green or brown moss (algae) are the commonest plant pests but colonies of sea squirts, also called sea grapes, which are animals, have occasionally given trouble. There are many different species of sea squirts but the one bothering oyster growers is a semi-transparent, greenish or brownish, gristly blob, a quarter of an inch to an inch across. When touched it squirts jets of water from two small openings.

Any of these fouling growths can be killed by exposing the collectors to air for 24 hours in good summer drying weather. A little longer may be required in dull weather but don't keep your collectors out of water for more than 48 hours.

Brining is advocated by United States workers as another and often cheaper treatment where sea squirts are involved because collectors need not be brought ashore. You will need a tank in your boat or on a scow and you should follow the the same procedure as for killing starfish (Chap. 9.1). Immersion for 3 minutes followed by exposure to air for an hour will kill them. If you soak the collectors in brine for 10 minutes, this alone is said to kill the squirts and no air exposure is necessary. Some species of squirts are tougher than others. So, if you are planning to kill them by brining, you should test the method on a few collectors to make sure it works on the species that is troubling you.

There is seldom more than one settlement of squirts in a season so a single treatment is likely to be all that is required. But moss will sometimes grow again. If you have chronic troubles in the place you collect spat and hold your collectors, you may have to abandon it or move your collectors to some cleaner area soon after you get a good catch of spat.

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CHAPTER 10. DISEASES OF OYSTERS

10.1 Importance of Disease

It was stated in Chapter 1 that the starfish is the principal obstacle to oyster production in the Maritimes. This is true. Starfish are always with us and do their deadly work so quietly that we sometimes forget how great a menace they are. The second most important obstacle has been oyster disease. It is much more spectacular in its effects.

Several kinds of oyster disease have been reported from the United States and other countries. So far as we know, we have to contend with only one kind but it is deadly. It has caused epidemic mortalities in almost all our important producing areas. Right now our industry is still reeling from the last and most disastrous series of disease losses it has ever experienced (Fig. 1). Most of the New Brunswick and Nova Scotia stocks have been affected already and the few remaining ones are threatened.

Fortunately the disease is not injurious to consumers. Thousands upon thousands of infected oysters must have been eaten over the past 45 years but nobody has suffered.

In contrast, it is difficult to appreciate the deadliness of this disease to oysters. Where it strikes it kills more than 95% of the oyster population.

10.2 Prince Edward Island Mortalities (1915-1939)

Spread. Our oyster disease which has been called the Malpeque disease was first noticed in Malpeque Bay, P.E.I., near Curtain Island. This was in 1915 following the importation of large quantities of small oysters from the United States east coast. The next year it appeared in other parts of Malpeque Bay and in Cascumpeç Bay. Between 1916 and 1939 it spread gradually from harbour to harbour until it had affected all parts of Prince Edward Island.

Recovery. By 1922 the Malpeque Bay oyster stocks had begun to recover and after 1929, recovery was hastened by oyster culture practices encouraged by the Board and the Department. Several times in the 1930's, test lots of oysters were gathered from the mainland and from the then unaffected parts of Prince Edward Island, and these were planted in Malpeque Bay. All died. In contrast, Malpeque stock always thrived wherever it was planted on Prince Edward Island—even in places like Hillsborough River where the natives were sick and dying in 1939. (No Island oysters were taken to the mainland for fear of spreading the disease.) From these tests it seemed quite clear that disease was still present in Malpeque Bay. It also appeared that those Malpeque oysters which had survived the 1915–1916 epidemic must have had a resistance to the disease and that their offspring had inherited this resistance.

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As a result of these findings, the Department forbade all interprovincial plantings of oysters. It was hoped that this law would prevent the disease from spreading from Prince Edward Island to the mainland. Malpeque oysters (adults and spat) were planted in a number of Island areas, however, like Hillsborough River in the hope of hastening the recovery of the fishery.

10.3 Mainland Mortalities (1950 to present)

For nearly 10 years the regulations forbidding interprovincial plantings of oysters seem to have prevented the disease from spreading. But disease started killing oysters in large numbers in Kent County, N.B., in 1954 and 1955. We have since discovered evidence that Island oysters had been illegally planted there a year or two earlier, in spite of the regulations.

On the mainland, the disease spread rapidly. In 1955 there were mortalities on the south shore of Miramichi Bay and at Shippegan, N.B., and at Malagash and Pictou. The disease had spread to the north shore of Miramichi Bay in 1956, was at Caraquet, N.B., in 1957, and by 1960 was found on Miscou Island, N.B. The Bras d'Or Lake and Aspy Bay, both in Cape Breton Island, N.S., are now the only oyster areas of importance that have not certainly been attacked.

10.4 Characteristics of Disease

Means of spread. In the period 1915 to 1939, the disease spread slowly from area to area in Prince Edward Island. It is not known just how it spread. It may have been carried by water currents or by fishermen moving infected fishing gear, boats and oysters from one harbour to another. By comparison, the spread along the mainland coast since 1950 has been rapid.

Season of mortalities. Oysters die from the disease in greatest numbers in two seasons: (1) in late winter or early spring and (2) in late summer. These are the times when they seem to be in their weakest state. In spring they are emerging from their long hibernation during which they have taken no food. In late summer they are exhausted from spawning.

Losses from disease in any area are usually small the first year they are observed. But by the end of the second year half the stock is usually dead and by the end of the third year about 90% is dead. It takes nearly 6 years for the disease to run its full course but few people realize this because after the third year oysters in affected areas are so scarce that further deaths among the few scattered survivors go unnoticed. After 6 years the death toll has usually claimed more than 95% of the stock. On the average fewer than 2% survive to rebuild the stocks.

Symptoms. In many cases infected oysters become weak. They do not fatten normally in autumn and if they survive the winter, they fail to grow or spawn the next summer. They soon gape if stored in air. This gaping shows up both in storage experiments and in marketing of oysters from affected areas. Sometimes the dying oysters have small yellowish-green pustules on their bodies but not always. These seem to be only a secondary symptom. Furthermore, affected oysters are sometimes fat and grow and seem normal until near death. Indeed, there are no obvious and unmistakable symptoms of the disease.

AGES AFFECTED. Oysters of all ages are affected. Spat produced after the first year's heavy losses may survive well for a year or two. But this seems to be because it takes time for them to contract the disease not because they are more resistant than older oysters.

10.5 CAUSATIVE ORGANISM

Disease research is slow and difficult and in spite of careful and continuing investigations, we still have not identified the germ which causes the trouble. We are in close touch with United States biologists who are studying an oyster disease like our own. The co-operation is most helpful, but it is not yet certain whether the two diseases are the same or different.

Even though we have not identified the germ, we have studied the symptoms of the mainland disease with great care and have come to three important conclusions which seem to be reliable: (1) The few oysters which survive an epidemic are resistant to the disease. They can grow and spawn normally. (2) Resistance to disease is hereditary. That is, offspring of the survivors inherit their parents' resistance to disease. (3) The mainland disease is almost certainly the same as that which affected Prince Edward Island in the period 1915–1939.

10.6 LENGTH OF RECOVERY PERIOD

Oyster stocks in Malpeque Bay, P.E.I., were the first to be affected by our oyster disease. That was about 1915. They had begun to recover by the time oyster culture work by the Board and the Department got under way in 1929. But it was 1935 before they were properly re-established. The natural recovery period was therefore about 20 years.

Disease affected the oysters in Hillsborough River, P.E.I., in 1936 and by 1939 had killed 90% of the stock. The Department planted 100 barrels of Malpeque oysters there in June 1939. And for the next several years, large but unknown quantities of disease-resistant spat from the Ellerslie Experimental Oyster Farm were sold to oyster growers in the Hillsborough River region to stock depleted beds. By 1948 or 1949 the stock seemed to have recovered fully. Perhaps this was merely because the introduced stock matured and was fished then. But most people believe that it was because these resistant, introduced animals bred, produced many resistant spat and thus restored the population. They believe it was the introduction of breeding stock which shortened the recovery period from 20 years (which was the natural recovery period of Malpeque Bay) to 10 years. Some other Prince Edward Island areas, such as Savage Harbour, have histories like Hillsborough River's but their records are not as well known.

10.7 REHABILITATION OF MAINLAND AREAS

Evidence that the mainland disease was the same as the Prince Edward Island disease built up quickly right from the first. It was not long before some people were advocating immediate mainland plantings of Island oysters to rebuild the stocks. But it was not and still is not absolutely certain that the mainland disease and Island disease are the same—there was convincing evidence but not proof. As long as there were enough oysters to encourage any fishing, many mainland interests did not want to bring in Island oysters because these would almost certainly carry the Island disease. Their argument was that the mainland disease might be some minor ailment (different from the Island disease) from which the oyster population would recover quickly without assistance. And, if Island oysters were brought in, there would be a lapse of at least 10 years before production could be restored, just as there had been in Hillsborough River. It seemed wise to move slowly.

But by 1956 it seemed clear that all the important mainland areas were doomed. The disease was still spreading and there were no signs of recovery in any area. So, in 1956 the Board and Department co-operated in planting an experimental lot of Island oysters at Richibucto and Shippegan, N.B., and at Malagash, N.S. The purpose was to find out if they would survive, if they would reproduce and if their offspring would be resistant to the mainland disease.

The experiment progressed well during the months following and at the same time Dr. R. R. Logie, who was then in charge of the Ellerslie Sub-Station, was producing more and more evidence that the Island and the mainland diseases were identical. This suggested that importing Island oysters would hasten recovery. Accordingly, in 1957 the Department undertook a regular program of massive springtime transfers of Island oysters to affected mainland areas. Four years' efforts have just been completed and 4 to 5 million oysters, mostly from Summerside Harbour, have been moved. It was mportant to act quickly because a year's delay in planting meant a year's delay in recovery.

In each area approximately 3 barrels of Island oysters were given free to each oyster grower to plant on his lease and massive plantings were made on public fishing grounds and permanent government reserve areas. This was no small task. But, in tribute to the many co-operating agents of that Department and the lessees, it must be said that the work was done well. Staff of the Department's Conservation and Development Service, local fisheries inspectors and crews of patrol boats transported the oysters. Mr. H. R. Found, Officer in Charge of Oyster Experimental Farms, deserves special mention for his organization of the work.

Mature oysters were chosen for transfer because supplies of small oysters like many of those planted in Hillsborough River were not available. Most of the transplanted stock were of inferior shape and it was fully realized that they would never be salable. But there were good arguments for belief that the heavy spawnings, of which these adult animals were capable, would hasten recovery—perhaps reduce it from 20 to 10 or 15 years.

The poor shape of the transplanted oysters was disregarded. For breeding stock this is no disadvantage. (We know that poor shape is not inherited. It is caused by bottom conditions (Chap. 3.10).) And there were several advantages in using this quality when such large quantities were needed. It did not interfere with consumer supplies because this class of oyster is not ordinarily salable. They were cheap for the Department to buy. There was little inducement for poachers to fish them after they were planted in their new homes so they would probably be left there to spawn year after year for many years.

Plantings made so far are summarized in Table II.

TABLE II. Quantities of disease-resistant, Prince Edward Island oysters transferred in various years to mainland areas for rehabilitation of devastated populations. (1 box = $1\frac{1}{4}$ Imperial bushels = 45 litres.)

Area planted	Quantity planted, in boxes				
	1957	1958	1959	1960	Total
New Brunswick					
Shippegan Area	2,000	200			2,200
Caraquet Bay			2,150	1,050	3,200
Lameque Bay			600		600
Miramichi Bay		5,600	400		6,000
Kent County Areas		3,000	600		3,600
Shediac Bay				18	18
Tracadie Bay				400	400
New Brunswick total					16,018
Nova Scotia					
Wallace-Malagash	1,000				1,000
Caribou Harbour		110	760		870
Pictou Harbour		90			90
Amet Sound			2,000		2,000
Merigomish Harbour				280	280
Nova Scotia total					4,240

10.8 Prospects of Recovery

Since these plantings were made there have been good spatfalls in several of the areas. It is too early to judge whether recovery is under way. Although the treatment has been different we hope that recovery of mainland areas will follow the Hillsborough River pattern even though only large oysters were used this time. And we hope areas will be back in production by 1967 or soon after.

We feel sure now that the germ of the Island oyster disease has spread to most parts of the mainland because Island oysters have been transplanted to so many places. There can be little risk now in transferring oysters back and forth between Island and mainland areas that have been affected, or between different mainland areas that have been affected. Under these conditions it may be expected that the Department will soon relax some of its restrictions on interprovincial transfers. We believe that this freedom could have immense importance in hastening recovery of natural populations and in encouraging expansion of oyster farming (Chap. 18.4).

There are still two areas of importance that have not certainly been affected by the disease. These are the Bras d'Or Lake and Aspy Bay, both in Cape Breton Island, N.S. It seems inevitable that the disease will someday reach these areas and that their oyster industries will collapse for at least 10 years. This is not a pleasant prospect but it is one that must be faced. Right now the market depends on these two areas and on Prince Edward Island for supplies of east coast half-shell oysters. Demands are heavy and supplies inadequate. We are not worried about continuity of supply from the Island. All its oysters are disease-resistant. But we can never be sure how long the susceptible Cape Breton stocks will remain disease-free. It would seem wise to keep their production as high as possible for as long as possible by avoiding every risk of infecting them. Moving oysters to Aspy Bay or the Bras d'Or Lake from any part of the Gulf of St. Lawrence would invite destruction of their fisheries. After some mainland areas have recovered, such precautions may be less important but now they demand special vigilance.

So far as oyster disease is concerned, the long-range prospects of our oyster industry are not discouraging. This contrasts sharply with the situation in the United States where a similar disease is ravaging their vast oyster industry. There the growers find themselves without stocks that are resistant to the disease. They are justly alarmed. We, on the other hand, have a confident feeling that a new era is just opening for Maritimes oyster culture.

In 1900 Malpeque oysters earned a great distinction. They were awarded the "grand prix" in Paris at the International Exposition. In the 1930's and 1940's they earned an even greater distinction. They were credited with restoring Hillsborough River and other Island fisheries. Now, we hope, they are restoring the mainland fisheries. If they succeed, the name "Malpeque" will indeed be famous.

What we must avoid at all costs is the importation of new oyster diseases. We must be especially careful right now to prevent importation of United States east coast oysters. We think that is how our troubles began in Malpeque Bay in 1915. The disease they have in the United States now may be different from ours and conceivably could wipe out all our stocks—mainland and Island alike—if it once got started here.

CHAPTER 11. SHIPWORM PROBLEMS

Shipworms are abundant in warmer waters of the Canadian Atlantic coast. They are not enemies of oysters but they are enemies of oyster farmers who use much wooden equipment which must be left in water for long periods. This equipment must be protected from shipworms.

11.1 Biology of Shipworms

The shipworm (*Teredo navalis*) is not really a worm at all but a kind of small clam with a very long body. Its shells are toothed and suited for burrowing into wood. They contrast in this way with the shells of the ordinary clam which are suited for burrowing into sand or mud. Shipworm burrows are lined with white limey shell and the entrance can be closed by a pair of plugs.

In our oyster areas shipworms begin to spawn in early summer when the water warms to about 60°F. Spawning goes on during most of the summer and finishes up with a heavy burst in late August or September. The young pass through a swimming stage like that of the oyster and other bivalves. When still less than 1/50th of an inch long, these settle and start to burrow into wood if they can find bare wood. They are unable to dig through most paints and some chemicals repel them.

After they once enter wood they never leave their burrows to attack other wood. But they can attack new wood that may be fastened to the wood in which they are living, by extending their burrows into it. They can't leave their burrows because of their shape which makes them prisoners. After any part of the burrow is excavated, its width remains about the same. It is not widened very much in later life. But as the rapidly growing shipworm digs deeper and deeper into the wood, the diameter of the new digging is wider and wider to accommodate the gently tapering, cone-shaped body (Fig. 34) which is much too big to emerge from the tiny hole in the surface of the wood.

The shipworms that settle earliest in summer will be large before winter sets in. Many of their burrows will be 9 inches long and ¼ inch wide at their widest parts. And many of them will have spawned in September when only 3 to 4 months old.

Shipworms obtain some of their food by straining water, as oysters and clams do. They pump this through their bodies in much the same way as the oyster (Chap. 3.8). However, they also digest the tiny wood chips that are cut away from the bottom of their burrows by the chewing action of the shells.

Shipworms die if the wood they are living in is dried thoroughly.

11.2 Danger Season

Because shipworms can't leave their burrows, most worm infection takes place during the season when the larvae are settling. And it is only at this season

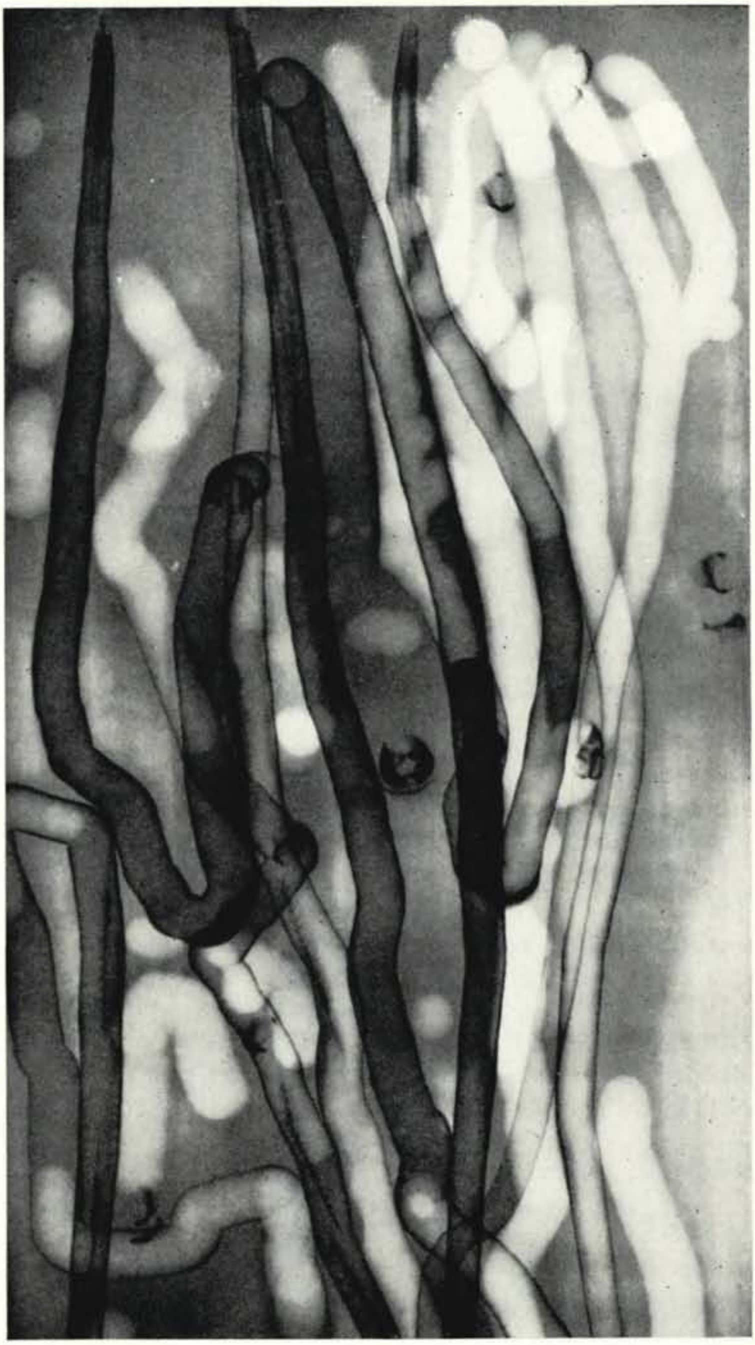

FIG. 34. X-ray photograph of wood infested with young shipworms. The gently tapering tunnels (gray and white in photo) are lined with lime. Small, paired, jaw-like shells (black) do the boring. (After D. B. Quayle, radiograph by H. Duncan.)

that wood needs protection. However, this season is long—from mid June to the end of September. Unless you protect it against shipworms, you should not leave wooden equipment in the water for more than a few days at a time from June 15 to September 30.

11.3 Shipworm Damage Serious

Shipworms have cost man more than all the ships that have ever been sunk in naval battles. They create very serious industrial problems wherever wooden equipment is exposed in our warmer waters. Untreated wood may be completely honeycombed in a month if exposed when larval shipworms are settling (Fig. 35). As many as 100 larvae sometimes settle on every square inch of unprotected wood surface.

Shipworms will attack any small patch of wood that has been missed in applying protective paints or that has had the paint scratched off it. From these

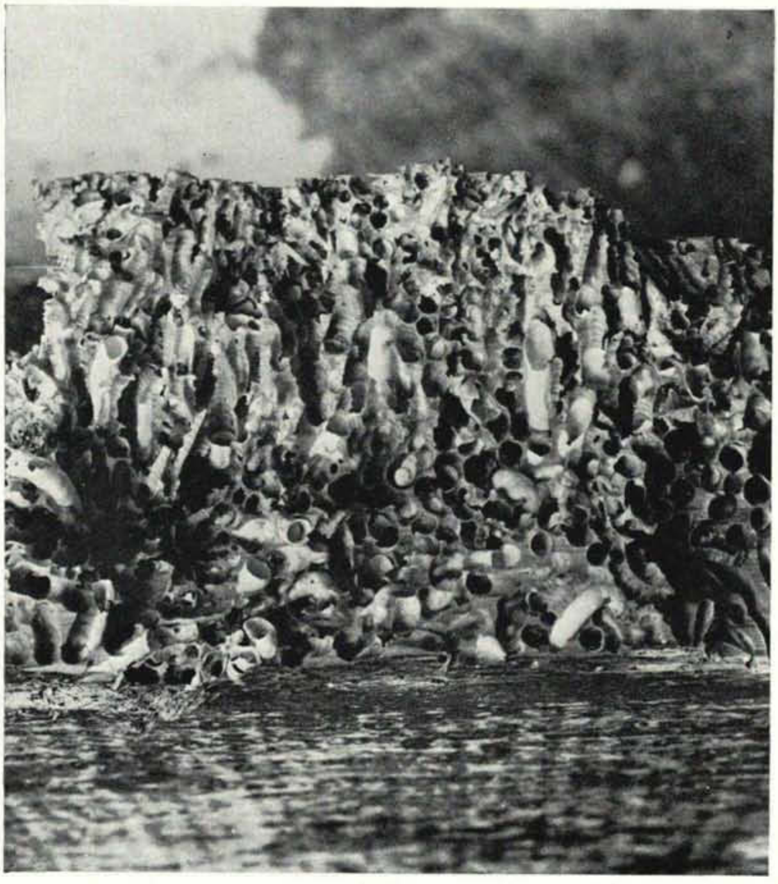

Fig. 35. Broken edge of unpainted 2-inch plank after exposure for 2 months (July and August) to shipworm attack in Bideford River, P.E.I. Limy linings show clearly in some burrows. (Photo: G. F. M. Smith.)

patches the worms will burrow in all directions under the surface but mostly they follow the grain of the wood. By the end of summer they may have weakened the wood over wide areas.

11.4 Special Problems of Light Movable Equipment

Oyster farmers are especially interested in protecting light movable equipment such as floats and crates for spat collectors, holding trays, boats and dories. Such equipment presents problems different from those of permanent structures such as wharves and bridges which cannot be removed from water for renewal of surface coatings. Wood in permanent structures is usually pressure treated with creosote that penetrates several inches, giving effective protection which is not destroyed by surface wear. It is cheaper to protect equipment which can be removed from the water by paints of various sorts. And if you remove it often enough, you can even prevent damage without painting.

11.5 Protection by Frequent Drying

To protect wooden equipment you must remove it from the water long enough to dry thoroughly. This kills young shipworms. And you must remove it often enough to prevent serious damage from worms that settle in the intervals when it is submerged. You can usually kill young worms in dories by leaving them out of water from (say) Saturday evening until Monday morning. A few hours of hot sun is enough. You should turn your dory upside down to hasten the drying and killing. Young shipworms do not grow large enough in a week to do serious damage but a longer, continuous time in water means rapidly increasing damage. In a month there may be 100 burrows up to $\frac{1}{2}$ inch long and $\frac{1}{16}$ inch in diameter per square inch.

If you do it regularly, removing dories from the water every week-end provides good enough protection. But for most other equipment this is either impossible or involves too much extra labour and spare equipment. You will have to paint it.

11.6 Protecting Wood With Tar–copper Oleate Mixture

A cheap substitute for copper paint was developed in 1937 experiments at Ellerslie. This has been in general use for protection against shipworms for many years by the Department and by our oyster farmers. It gives satisfactory protection when properly applied.

Preparation. The mixture is made by dissolving a pound of copper oleate in half a gallon of stove oil or kerosene and mixing the resulting solution with a gallon of ordinary net tar. Benzol or gasoline may be used instead of stove oil but they are more expensive and more dangerous to handle. More stove oil than half a gallon will not mix smoothly with each gallon of tar.

Application. The mixture may be applied with a brush or by dipping. It forms a firmer coating if applied hot, and this is recommended if it is possible to heat it without danger of fire. On planed lumber, two coats are recommended for greater thickness and better assurance of covering all the surface. On rough lumber, a single coat carefully applied has been found satisfactory. Equipment should be treated each year.

COVER ALL THE SURFACE. The effectiveness of any surface protection depends on maintaining an unbroken covering. Enough shipworms can enter through a small untreated patch like a crack in a board to weaken a large area. You must, therefore, apply the mixture at least once every year over the whole surface and prevent it from wearing off.

DRYING. As with ordinary paint, you must dry the tar-copper oleate paint before placing in the water. You must not let it blister in hot sun while it dries because blisters break easily and leave bare spots.

COST. The cost is about a tenth of that of copper paint or white paint. Using stove oil, the cost at time of writing is about 90c per gallon; using benzol, it would be slightly higher. The mixture covers about as much surface as ordinary paints.

WEARING QUALITIES. The mixture described above does not stand wear as well as white or copper paint. But if you apply it and dry it properly it will last from the beginning of open water until danger of shipworms is past.

COMPARISON WITH OTHER PRESERVATIVES. This is the cheapest effective protection we know. Copper or white paints are much more expensive. Creosote applied under pressure gives the most complete protection because it is not spoiled by chafing, but the initial expense is very high and the wood is made very heavy. The tar–copper oleate mixture is recommended for the rough wooden equipment used in oyster farming. Its poorer wearing qualities give it less advantage over copper paint for boats, but it has been used satisfactorily on them too.

11.7 COPPER PAINT AND WHITE PAINT

Copper paint has long been a standard preservative for boats and other light wooden equipment. Even in a single coat it gives complete protection against shipworms if all the surface is covered. It is best to let copper paint dry before the equipment is put back into the water but even if you don't, you get fair protection.

In our experiments white paint gave the same protection as copper paint. Many consider copper paint to be superior but this may be because boats usually are coppered just before heavy summer shipworm attacks and have already had a coat of paint of some kind in spring. This provides more protection than if the early spring painting is relied on.

Both copper paint and white paint give as good protection and have better wearing qualities but they are so expensive that it pays to use the tar-copper oleate mixture on most oyster culture equipment.

11.8 Creosote

Experience may show that over a long period of years it is cheapest to use pressure-creosoted lumber for some oyster culture equipment, but the initial expense is very high and creosoted lumber is too heavy for use in floats and trays without providing additional buoyancy.

Creosote applied with a brush or by dipping affords little protection against shipworms.

11.9 Other Treatments

Other treatments to kill shipworms or to protect wood against shipworm attack have been used with some success. The Romans used to char the bottoms of their boats and a modern version of this method is still practised in some places. The bottoms are flamed with a torch made by dipping a large rag in kerosene. However, most people prefer to apply some surface coating that can be brushed on. Tar alone, applied hot, may be effective but it is not always good enough. The method of dipping whole floats or trays in a vat of hot tar is effective in preserving the wood and protects wire cloth tray bottoms from rusting as well. However, this involves the high initial cost of a vat for heating the tar, and there is a fire hazard.

There are many patent products and treatments, many of which are good. Spraying with solutions of sodium arsenite is effective for killing shipworms but this may be harmful to nearby oysters and to those who eat them. Investigations have not exhausted all possibilities. We are working on one now that involves treatment with bluestone and caustic soda. But so far the combination of tar and copper oleate is the cheapest effective preservative that has been tested thoroughly.

11.10 Prevent Chafing

The tar and copper oleate mixture and paints of various kinds protect wood because they form a complete surface coating that shipworms cannot penetrate. They are useful only as long as this continuous coating is maintained. You must therefore be careful to prevent chafing. You may find some of the following suggestions helpful. Protect keels of boats from scraping bottom by tacking on wood or metal strapping after you have finished painting. Always moor floats and trays far enough apart to allow them to swing in the tide without bumping one another. If you haven't enough moorings you can fasten trays together in pairs with bumpers made of old automobile tires. The bumpers should be nailed to the trays or they will chafe. Do not drag equipment to water or out of water. Carry it, or if necessary, use smooth rollers or some sort of runners. Inspect your equipment regularly to make sure the coating is continuous. When you find repainting is needed, do it immediately.

CHAPTER 12. FISHING

12.1 Fishing Methods and Fishing Gear

As the oyster industry developed on this continent, methods of fishing changed. At first, hand picking in shallow water supplied demands. Then rakes were used to get oysters from deeper water. Tongs were developed as an improvement on single rakes. Later still, dredges of various kinds were developed to fish deep beds and to reduce fishing costs. Some dredges were manually hoisted but the larger types were power hoisted. Recently, several methods of hydraulic fishing have been developed. They are called hydraulic because they depend on water currents to lift oysters off the bottom. The one that seems most likely to interest east-coast Canadian oysterman is the hydraulic escalator harvester which is useful in shoal water. All these methods, old and new, are still in use here. Each has its advantages and disadvantages. Table III shows the efficiency of several types of oyster fishing gear.

Hand picking. Oysters are still picked at low tide where there are shallows or bare flats. When oysters can be seen (sight fished) they can be picked profitably, even when they are too scarce on the ground to make other fishing methods profitable. When the water is roiled, some pick oysters by feeling for them with their feet. This is usually slow business and is worth while only in places where oysters are common and where empty shells are scarce. Pickers do not confine themselves to the intertidal flats in warm weather. They wade out to waist depth or even beyond if the water is clear enough for picking and they often tow a small dinghy to pick into.

Picking for market (autumn and early spring) is not a common method of fishing now because the number of large oysters in shallows and on intertidal beaches in clean-water areas is generally small. Besides this, the water is too cold in the marketing season to encourage wading. However, picking in summer is important to oyster farmers—especially to those with small leases. For many years now they have depended mostly on picking to obtain supplies of bedding oysters for stocking their maturing grounds. It seems likely that picking will always have a place in oyster farming but it will become less and less important as we improve our methods of mass culture of bedding oysters.

In muddy areas the worst part of picking is fatigue from wading about in mud and carrying catches of oysters. Some pickers have developed mud sleds with wide runners to carry their catch. You can haul a mud sled with a rope like a snow sled or you can push it with a handle like a baby carriage. The handle helps support your weight.

Mud shoes are not used here but they have been in use for many years in British Columbia and in Washington State. Modern mud shoes (Fig. 36) are made of aluminum tubing but the old-timers used wood. We are convinced that

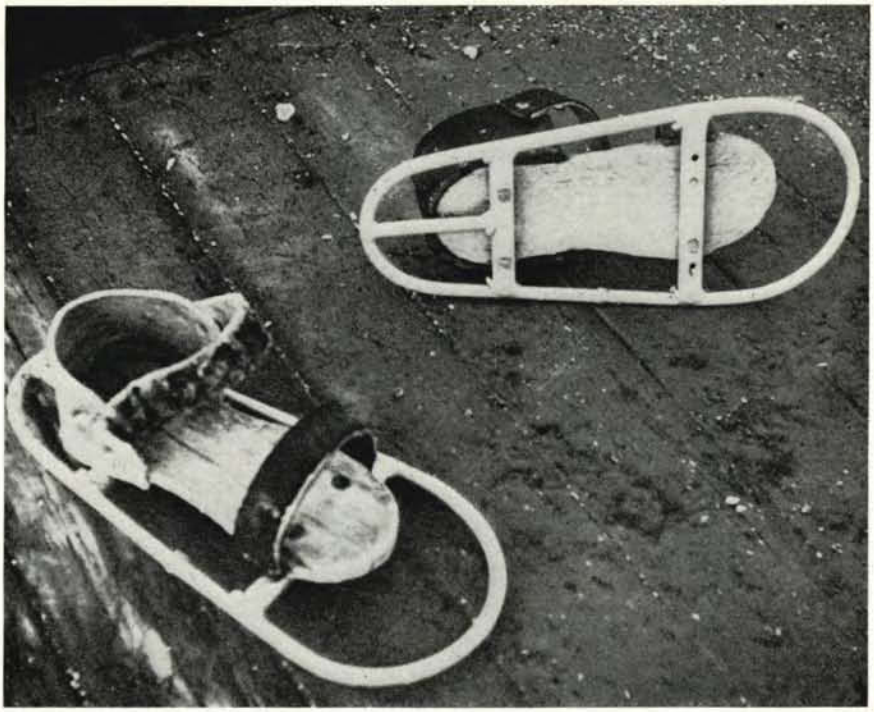

FIG. 36. Mud shoes made of aluminium tubing and wood with canvas harness, commonly used on soft grounds in Pacific coast oyster areas. These would be useful in some parts of the Maritime Provinces.

some of out oyster farmers and pickers would find them useful in soft grounds. Washington State oystermen claim that on their flats mud shoes double the amount of work a man can do in a day.

RAKING. Oyster rakes are of two general types—small rakes usually with short handles and large rakes with long handles.

Small rakes of many kinds are used for sight fishing in water that is too deep or too cold for picking. All have short heads and long curved teeth. There are short-handled "pickers" for use in one hand and others, like those used in the clear waters of the Bras d'Or Lake, which have handles up to 12 feet long. The fishermen there often spread crude cod liver oil on the water to cut down surface rippling and improve their view of the bottom for sight fishing.

Large rakes are used for blind fishing, i.e., raking the bottom to catch oysters which are unseen or not readily seen. The style of these rakes varies a good deal from place to place. The head is usually straight and 2 to 3 feet wide. The teeth are about 6 inches long, slightly curved and set at right angles to the handle which is usually not more than 15 feet long. There is a shallow bag of wire netting on the back of the head and running up the handle for about 12 inches. Such rakes are used from boats. Up until about 1952, when the oyster disease struck, a similar rake was used at Buctouche, N.B., for fishing through the ice. The handles on these were very long. Some were over 30 feet and permitted raking of the steep banks of the river channel to depths of 25 feet. The fisherman throws his rake into the water allowing the handle to slide through his hands. When the head strikes bottom he puts the handle over his shoulder and tugs on it in a series of short hauls with a constant downward pressure. He continues this until the handle is nearly perpendicular. The rake is then hoisted. This type of rake is good for sloping bottoms or soft bottoms in which oysters are partly buried. No tests have been made to determine what proportion of the oysters is caught when a rake is hauled over a piece of soft bottom. But rakes do seem to be less efficient than tongs for fishing firm, level bottoms which produce the best quality oysters. Even if there is a bag of wire netting on the rake, many oysters are lost off the ends during the haul and many that are raked together during the haul drop off the teeth during hoisting. Rakes are not very efficient.

Rakes of all kinds are used in the public fishery for wild oysters but almost never used by oyster farmers for fishing cultivated oysters from their well-stocked, mostly level, firm, leased grounds.

TONGING. A set of tongs (Fig. 37) is like a pair of rakes with the handles fastened together, scissor-fashion, about one third of the way up from their heads. The teeth of the two rakes point inward. Handles may be any length from about 8 to 24 feet but they are seldom more than 18 feet. Heads may be of iron or wood and 2 to 3 feet wide. Teeth are usually curved and about 3 inches long and $1\frac{1}{2}$ to 2 inches apart. They are usually set in the head so as to be almost parallel to bottom when the tongs are closed. But they may be pointed a little downward if you wish to dig into the bottom. Tongs may or may not have a basket of wire netting on the back of one or both of the heads.

In fishing, the tongs are lowered and the heads opened. They are closed by a series of short lifting jerks which scrape up oysters from an area of 2 to 3 square feet depending on the depth of the water and the length of the tong handles. They are then lifted and the oysters taken into the boat (frontispiece). If there is no wire basket on the heads, the tongs must be rested on a narrow culling board that is fastened horizontally to the inner side of the gunwale and the handles must be kept vertical to prevent spilling the catch during culling. If there is a basket on one of the heads, no culling board is needed and the tongs are laid crosswise on the gunwales for culling.

Oyster tongs are satisfactory on small areas of level bottom in moderate depths. They have been used in depths as great as 18 feet but the work increases with depth and the long handles needed for deep-water fishing are cumbersome. Currents make deep-water fishing difficult even with iron heads which weight tongs better than wooden heads. If there is any breeze, tongs are hard to handle when they are hoisted. Tonging is essentially a fine-weather job and the greatest depths for efficient working are 12 to 15 feet.

Tongs are still the principal gear used in the public fishery for wild oysters because our conservation laws forbid the use of dredges on public beds. Tongs are also the usual gear for fishing cultivated oysters on small leased areas. They

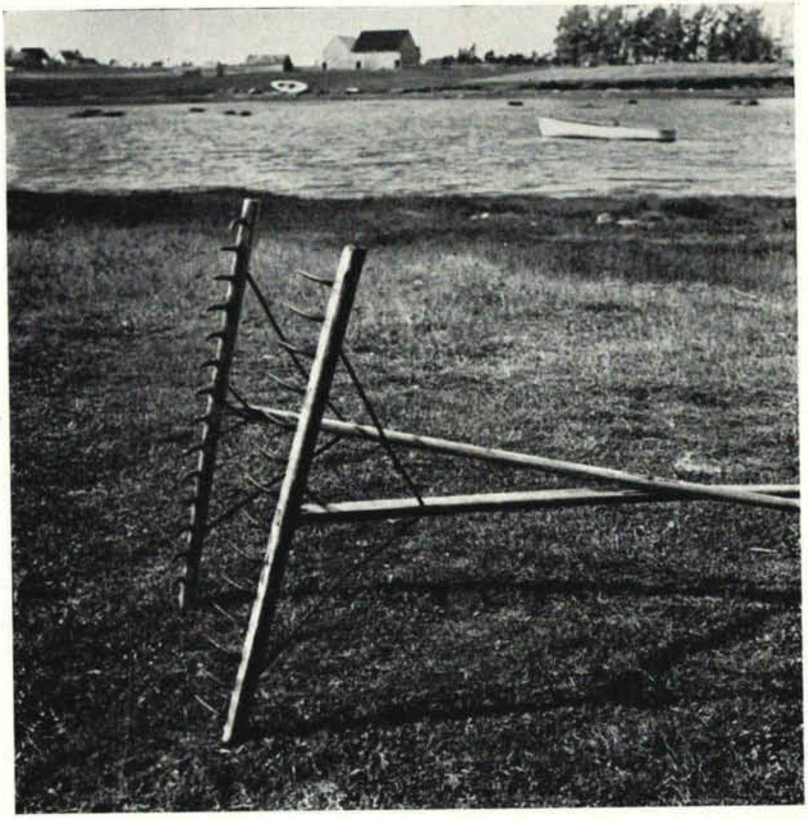

FIG. 37. Oyster tongs, Malpeque Bay type, with teeth set in wooden heads. There is no basket of netting. (Photo: G. F. M. Smith.)

are being replaced slowly by mechanized harvesting equipment. On larger areas, power-hoisted drags are used and more and more small drags that can be hauled by outboard motors appear every year. Nevertheless, tongs are likely to remain the gear of the small oyster farmer for some years. Tongs damage oysters less than many kinds of drags and they cost only a few dollars. They can be used from small, inexpensive, oared boats.

An oysterman fishing in moderate depths hoists his tongs about one hundred times every hour and therefore covers a total of about 2,000 square feet in an 8-hour day. This includes some overlapping, of course, and some parts of the bottom are missed. In the hands of an experienced fisherman, tongs are quite efficient in removing oysters from the area covered by any one grab. They bring up close to 90% of the oysters over $3\frac{1}{2}$ inches long (Table III) but they are not very good for fishing bedding-size oysters. In fishing marketable oysters, most oystermen consider that tonging is not worth while unless they can average about one oyster in each lift. And a day's catch of 1 to 2 barrels (500 to 1,500 oysters) is considered good fishing on public beds.

DREDGING. The oyster dredge (also called drag) was developed as an improvement on long-handled rakes and tongs for fishing oysters from greater depths and for reducing costs in large-scale operations. It may be likened to a special kind of large rake backed with a bag and towed along the bottom by a Manila or wire rope in place of a handle. Dredges are fished from powered boats and are only slowly coming into use by our east coast oyster farmers. Consequently there has been little effort to develop efficient types. British Columbia, United States and European oyster growers are far ahead of us. We should learn to use dredges and test various designs to find which work best under our conditions.

The essential parts of a dredge are the blade and bag and the frame which supports them and finally the bridle which in most dredges is rigid and welded to the frame (Fig. 38 and 40). The bridle carries a swivel eye for attachment to the tow warp. Some dredges have a pressure plate or diving plate on the upper side of the frame or bridle near the mouth of the bag (Fig. 38). This helps keep the dredge right-side-up when it is being set and reduces skipping when it is being towed.

FIG. 38. Small oyster dredge (blade 18 inches) commonly used from outboard motor boats in Bideford River, P.E.I. The pressure plate permits light construction for easier manual hoisting. The angle of the plate can be changed by adjusting the length of the wires joining its forward corners to the frame.

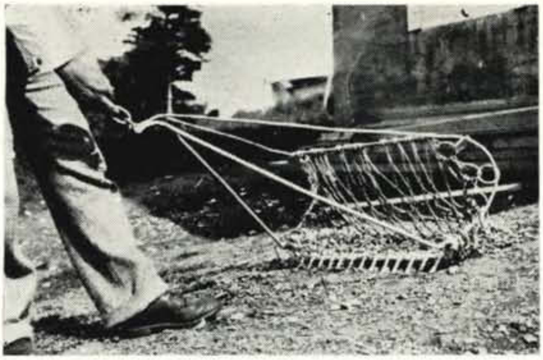

FIG. 39. Old-type toothed oyster dredge used from small motorboats and hoisted manually or mechanically. (Photo: A. B. Needler.)

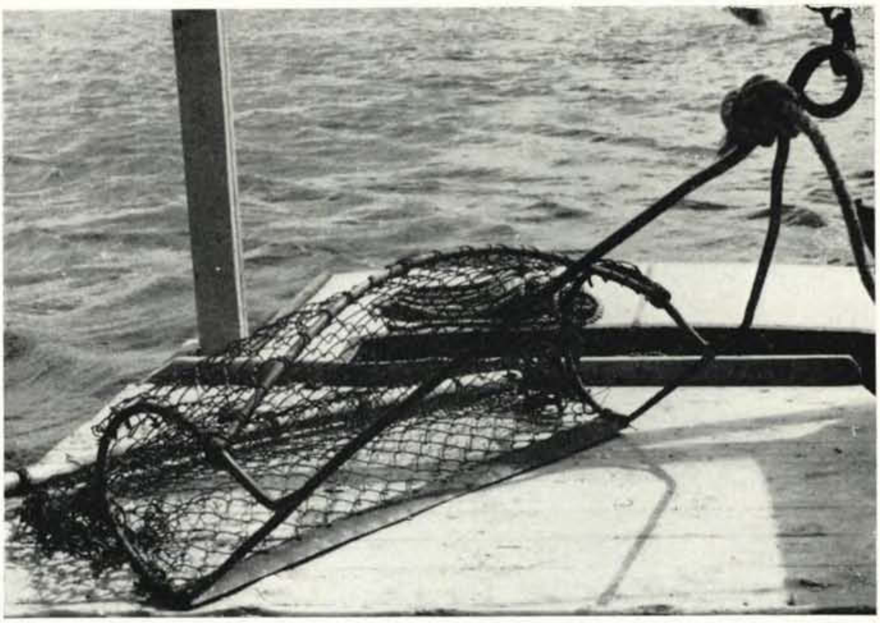

FIG. 40. Oyster dredge (blade 30 inches) aboard the *Royal II* (Victor Travers, owner) which is typical of larger oyster boats of southern Malpeque Bay, P.E.I. The dumping ring at the centre of the club stick does not show clearly through the flexible-mesh wire bag.

The blade is often toothed (Fig. 39) and the type of teeth varies a good deal. Short, thick, dull teeth directed steeply downward are used on firm bottoms. Longer, more slender teeth are used on soft bottoms where oysters are partly buried. But many dredges, especially those with pressure plates, have no teeth. The blades of these are made of flat iron and in some the angle can be adjusted for hard or soft bottom.

Bags are variously made. The belly may be like that of a scallop drag, made of rings and clinch links but of smaller gauge wire (Fig. 38). The back may be of the same construction or of nylon rope, either knitted or held by crimps, to produce mesh of suitable size. But in the larger Malpeque Bay dredges the whole bag is often made of flexible-link wire netting (Fig. 40).

Frames are variable because patterns and sizes of dredges differ so much. The oldest designs (Fig. 39) are more or less open and resemble rake heads. Some of the newest and largest (none shown here) are like rectangular boxes with open forward ends. In these, the bag is sometimes fixed throughout its length to the frame which slides along the bottom on runners or shoes. Many of the new dredges have locking tail gates and need not be up-ended for dumping. None of ours have tail gates. We continue the old system which requires a club stick and ring at the end of the bag, a dumping line with its fairleads to the mechanical hoist and, of course, the complex operation of these.

Dredge width varies a good deal depending on the size and hoisting power of the boats used.

Until recently, heavy dredges were preferred in boats with power hoisting devices because they were steadier and less likely to skip and damage oysters. But many newer designs are light and have pressure plates which compensate for the lightness. These plates are nothing more than flat, rectangular sheets of metal 6 to 10 inches wide and as long as the dredge is wide. The plate is fixed crosswise above the mouth of the dredge with its forward edge lower than its after edge. In towing, water pressure on this slanted plate presses the dredge blade against the bottom. The faster the tow, the harder it presses. Dredges with pressure plates must be strong but they need not be heavy. Almost all the manually hoisted dredges are very light and have pressure plates. A popular size used from outboard motor boats in Malpeque Bay has a blade 18 inches wide. It is important to have the pressure plate set at the proper angle and this depends on many things such as dredge design, bottom character and how fast you tow. It can be adjusted to suit these.

The bridles on the newer, box-like designs of dredges are sometimes made of wire rope instead of iron rods which in older-type dredges are welded at a fixed angle to the frame (Fig. 38–40). Bridle cables are often attached a little back from the forward end of the new-style dredges. This arrangement allows the dredge to fish at varying depths and with varying boat speeds without frequent adjustment of the length of the towing cable. In operating older-type dredges, it is necessary to adjust length of towing warp when depth or boat speed changes because the blade and its teeth, if it has teeth, must be kept at just the right angle to the bottom for efficient fishing.

A dredge is usually towed with a hemp or Manila rope over the boat's stern. The British and Netherlanders use wire rope on a winch which is more convenient and almost as good as hemp in easing the strain when the dredge strikes solid objects. The tow rope is usually fastened to a mast or cleat somewhere amidships rather than at the stern because this improves steering. Small dredges used from outboard motor boats usually have a single Manila rope attached which serves for towing and manual hoisting. Sometimes the only hoisting device for larger dredges is a niggerhead (Fig. 41). In such cases a hoisting line led through blocks on the gallows is attached to the dredge as well as the towing line. In other cases wire rope from a single-drum winch is also attached to the dredge alongside the tow line. The wire is left slack while towing and used only for hoisting. With either type of mechanical hoist, the towing rope is left overboard when the dredge is boarded. Some boats tow from the starboard quarter and have a rectangular gallows built up across the stern about 6 feet above deck level (Fig. 41). The catch is dumped on a culling table directly below the gallows.

FIG. 41. Stern gallows, culling table and rigging for towing dredge from the starboard quarter of *Royal II*. The tow line lies slack across the culling table but the hoisting line is taut and leads through three blocks to the niggerhead on the right. The dumping line with its hook is looped over a nail in the forward upright on the port side to keep it out of the way when not in use. It leads through two blocks, one on the gallows and one on the gunwale.

In a large boat with a strong mast, the rigging can be different. The strain of towing can be taken up by Manila rope as described above but the dredge is brought alongside amidships by one cable led from a double-drum winch through a block on the end of a horizontal boom. The dredge is boarded by peaking the boom with a cable on the second drum of the winch and the catch is dumped amidships, then swinging the boom inboard and lowering the dredge by slacking the towing cable. With this rig the boom must be long enough for the dredge to clear the hull when it is brought alongside and hoisted.

The British employ this rig without the Manila tow rope. They use wire rope which during the tow is led from the boom end through a block on the starboard quarter.

Netherlands and United States west-coast growers often fish two dredges—one over each side of the boat.

Dredging oysters is an operation requiring skill and experience. Improper dredging may be not only inefficient but it may also be damaging to oysters and to the bottom. Slow, steady towing is best to avoid jumping and bumping which misses and damages oysters. The dredge should be emptied as soon as it is filled because a full dredge also misses and damages oysters. In a general way the length of the towing cable regulates the extent to which the dredge digs in. The shorter the cable and the greater the boat speed, the less it digs in. For dredging on shallow or soft grounds less cable is needed than on deep, hard grounds. A rough rule is to use a towing line that is 3 to 5 times as long as the water is deep.

In dredging you should try to cover the bottom as systematically as possible. This means using markers to show what part of the ground you have covered. Even with careful dredging and going back over the ground, you can seldom recover more than three-quarters of the marketable oysters on a piece of bottom. With careless dredging you may get no more than half, even by spending a great deal of time. If dredging is carried out carefully, however, it pays because it is so fast. Even with a small, two-man motor boat and a small drag, it is usually possible to make 20 to 40 tows in a day and to cover 25 to 30 times the area covered by a tonger. The drags we have tested do not take as high a proportion of the oysters from the ground they cover as tongs do. But in spite of this lower efficiency, a drag operated for a day from a two-man boat usually takes 10 to 15 times as many market oysters as one man with a pair of tongs.

Our best dredge took 30% of the large oysters (over 3 inches long) in its path (Table III). It was not very good at fishing bedding-size oysters. There is obviously a great need for improvements in dredge efficiency and some thought has been given to developing a hydraulic dredge something like that used in fishing ocean quahaugs and bar clams.

If you are dredging, it is well to sheath the side or stern of your boat to protect it from chafing when the drag is hauled in. Gunwale rollers are used with some rigs to protect the boat and to make the work easier.

ESCALATOR HARVESTER. The escalator hydraulic harvester (Fig. 42) is the most recently developed oyster fishing gear. It is effective in shoal water just deep enough to float a fishing boat down to about 10 feet. The model now in use at the Experimental Oyster Farm at Ellerslie, P.E.I., has a fishing depth range of $2\frac{1}{2}$ to 6 feet. It takes a higher proportion of the oysters from the bottom and causes less bottom disturbance than any other gear we have tested. It depends on powerful jets of water (Fig. 43) to lift oysters off the bottom and onto an endless belt which brings them to the surface. Besides this, it fishes very quickly—peak rates of up to 40 or more bushels per hour. In fishing trials conducted so far, it

Fig. 42. Escalator harvester modified by Fisheries Research Board for fishing oysters. Water is fed from an inboard pump through 4-inch hose to the scoop which is submerged. (Photo: R. E. Drinnan.)

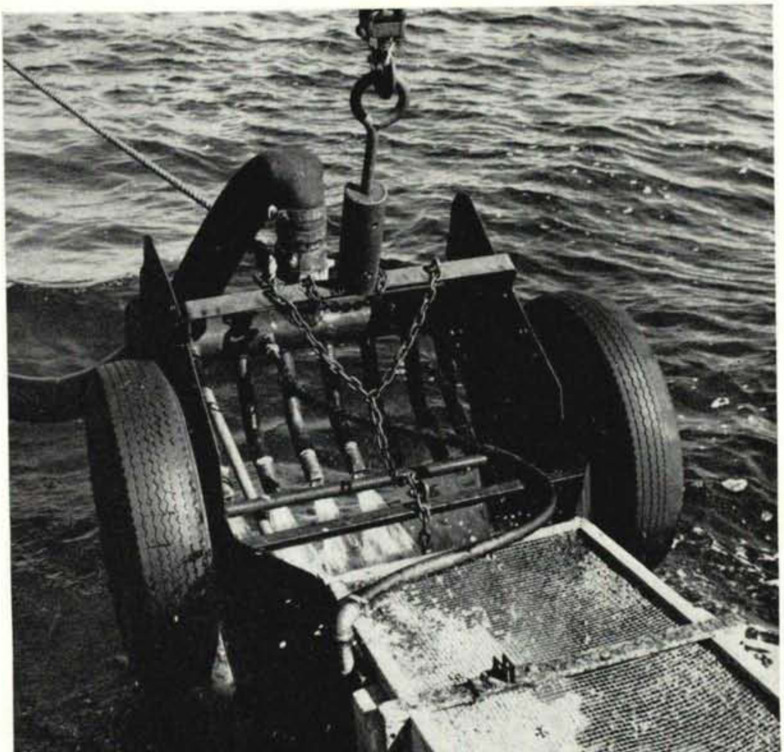

Fig. 43. The wheeled scoop ready to submerge onto an oyster bed. Horizontally directed, flat-spray jets of water wash oysters from the bottom onto an endless belt (hidden from view by screening) which brings them to the surface. (Photo: R. E. Drinnan.)

has been necessary to run the machine at no more than two-thirds capacity. If it is run any faster, fishermen are unable to handle the catch. It fishes almost 100% of the oysters in its path regardless of their size (Table III). This is a point of interest to those who grow bedding oysters which are hard to fish with tongs or rakes and tedious to pick by hand. Besides being fast and efficient, the escalator harvester brings up clean oysters. They are thoroughly washed by the water jets in the harvester head.

A harvester like that shown in Fig. 42 and its auxiliary equipment, including the boat, costs $7,000 to $10,000 to build. Roughly half this is for labour. So, if an oysterman is a good mechanic, he can reduce this cash outlay considerably. Perhaps less expensive units (motors, pumps, etc.) could be used in the construction. It seems likely that some oyster farmers will build harvesters because they are useful in so many culture operations. Besides fishing large and small oysters, the harvester is good for clearing off mussels, old shell and silt from maturing grounds at low cost.

Information on escalator harvesters may be had by writing the Director, Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B.

COMPARISONS OF FISHING EQUIPMENT. Table III summarizes some of the information referred to in the last few sections. When we speak of the "fishing efficiency" of a particular kind of gear, we mean the number of oysters it catches out of every 100 oysters on the piece of ground it actually passes over when it is used. Fishing efficiency varies greatly from one kind of gear to another and even for the same gear under different conditions. For example, in most kinds of gear the efficiency is lower for small oysters than for large. The escalator harvester has the highest efficiency of all four kinds of gear listed and is the only kind that fishes all sizes of oysters with equal efficiency. This is of special importance to unspecialized oyster farmers who carry out all phases of oyster farming on their leaseholds. They must handle oysters of all sizes—spat, bedding-size and adults. The escalator harvester cuts down on back work which is so expensive in this age of mechanization.

TABLE III. Proportion of oysters captured from ground actually covered by different kinds of oyster harvesting gear.

	Size of oyster			Rate of yield (boxes of marketable oysters per 8-hr day)
	Market (3–4″)	Medium (2–3″)	Small (1–2″)	
Rakes (1 man—rough estimate)	50–70%	30–50%	25%	2
Tongs (1 man)	90%	60%	40%	2–4
Standard dredge (2 men)	30%	23%	13%	30–60
Escalator harvester (3 men)	95%+	95%+	95%+	180–200

Fishing rates listed in the last column of Table III apply to moderately well stocked areas where a tonger can fish 2 to 4 boxes a day. Catches would all be higher for areas that are better stocked. In considering these figures you must remember that although it takes only one man to work a pair of tongs, it takes at least two men to operate a drag and at least three to work an escalator harvester to advantage. If you want to work out the catch per man per day for the different kinds of gear, you must reduce the figures listed, by the number of men required to operate the gear in question.

12.2 Making Fishing a Part of Oyster Farming

Oyster fishermen tonging wild oysters from public beds are interested in only one thing—picking market-size oysters from their catch. After that, they dump everything else back onto the beds. To you and to every oyster farmer fishing can and should mean much more. Fishing should be made a real part of oyster farming. It should of course produce good, mature oysters ready to be marketed but it should also aid future production of the largest possible crops of high-quality oysters.

Fishing is expensive and brings up great quantities of bottom material besides marketable oysters. This gives you a good chance for cultivating (Chap. 8.5). Cultivating is an important part of oyster farming and too often the chance to cultivate is neglected in the rush of fall fishing. It doesn't pay to be in that much of a hurry.

Removal of enemies. When enemies and competitors of oysters come up in tongs or dredges, you should never return them to the beds alive. British oystermen, searching for simple ways of destroying them, have set up small shell crushers alongside the culling tables in their boats (Fig. 44). During fishing operations they feed the crusher everything that comes up in dredges except, of course, live oysters. This kills mussels and slipper limpets but not all the starfish. Unless you operate a power boat that is big enough to carry a crusher or a brine trough (Chap. 9.1), it is best to bring ashore all the enemies and competitors you catch. Ordinarily it is not too hard to sort them out.

Care of small oysters. You must take care of young oysters brought up when you are fishing. Their size will determine what you should do with them. Some will be single and large enough to be returned immediately to the bed to mature. Those that are clustered should be singled either aboard or ashore before being replanted. Some that are very small will do better if planted on rearing ground for a year before being returned to maturing ground. If this is not convenient, you should find no difficulty in selling them to other lessees who wish to stock their rearing grounds.

Obtaining shells for spat collection. It was mentioned in Chapter 8.1 that too much loose shell on a bed can spoil the shape of growing oysters. If this is one of your problems, fishing gives you a good chance to thin out excess shell. If you collect your own spat or catch spat for sale to other lessees, it will be best for you to bring the extra shell ashore to weather until the following

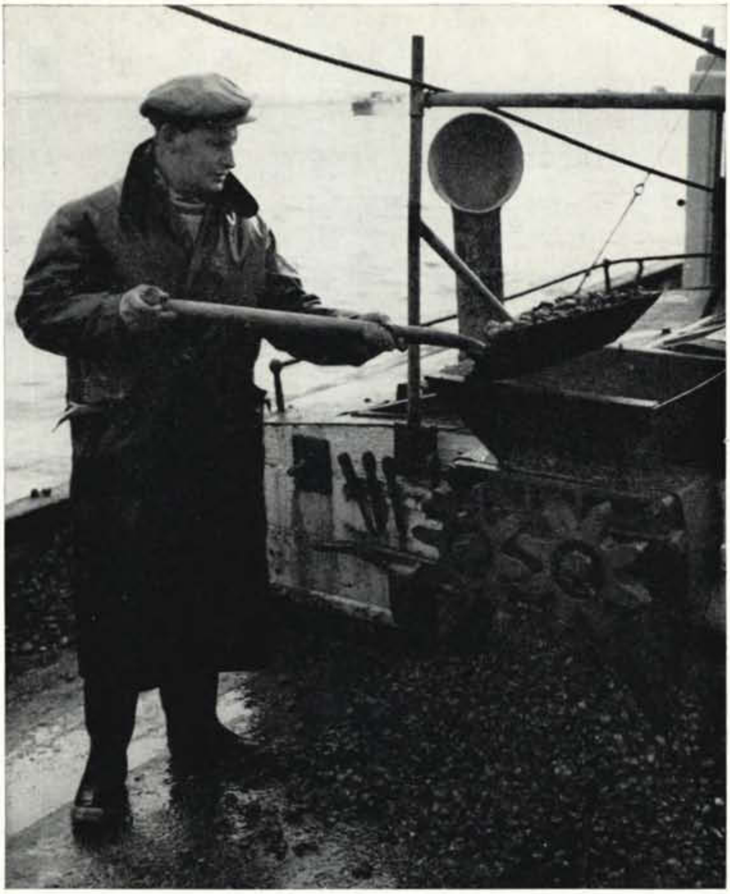

FIG. 44. An oyster fishing boat with a grinder installed for crushing old oyster shells and killing pests like mussels and slipper limpets. (Photo: P. J. Warren, after H. A. Cole, U. K. Ministry of Agriculture, Fisheries and Food.)

summer and use them for spat collection (Chap. 6.3). Otherwise, you may install a crusher in your boat, if you have room, and dispose of the shell that way.

Some oyster companies in Washington State, U.S.A., grind all the shells from their shucking plants and use the resulting shell meal as a dressing for their beds. These companies and the British, who have experimented with shell crushers aboard fishing boats, believe that this bottom dressing greatly improves beds. So far, nobody on our coast has tried to use excess shell in this way.

CULLING. Culling may be done aboard during fishing if you have room for a culling table and enough help. You will need cleaning irons (Fig. 45). But even with extra help on a large boat culling aboard is sure to slow down fishing and if fishing must be done quickly, you may be obliged to cull ashore. This may be awkward in an oared boat but it need not be difficult in a large power boat.

When culling is done ashore it may be best to fetch in the whole catch—shells, oysters, mussels and starfish. This practice speeds up fishing and requires only a small crew. But it is not popular with our oyster farmers because it also requires extra handling and extra boat space. Extra boat space is sometimes provided by tender scows that can be brought to the fishing grounds. The bulkiness of the catch creates a handling problem which Pacific coast growers have overcome by using small conveyor belt systems powered by electric or gasoline engines. These take the costly back work out of getting the unsorted catch from fishing boats to the cullers and the discarded shell to the crushers or back to the boats.

The main advantage of culling ashore is that it can be done there in stormy weather when work on beds is impossible. You need a building for culling ashore, however, and this and the extra handling of the bulky catches and occasional extra trips to beds to return small oysters or shells must all be considered when you are deciding whether to cull ashore or in your boat. When you are making up your mind don't think only of your convenience. Consider what is best for your beds. Whatever you do is going to involve hard work. This is unavoidable if you are going to grow worthwhile quantities of good-quality oysters.

In this chapter little is said about fishing bedding oysters from rearing grounds because that is usually thought of as being an integral part of the rearing operation (Chap. 7).

12.3 When to Fish Oysters

Oysters should be sold whenever profit is greatest. Your profits depend on market demand, the condition of your oysters and the ease of handling them.

When oysters are in demand. There may be small, local demands for oysters throughout the year but the heaviest demands of wholesale markets are in the cool months from September to May. The greatest consumption is in autumn and early winter.

In eastern Canada it is customary to fish oysters in autumn and store them for use in winter when inlets are ice-bound and fishing is difficult or impossible. Experience has shown that oysters can be stored alive for several months under proper conditions and still compare reasonably well in quality with newly fished oysters. It has also been shown that fat oysters fished in late autumn are best for this purpose. As a result, there is usually an intense demand for good oysters in late autumn.

Demand for cultivated oysters is also influenced by the public fishery. Oysters are most abundant on public beds when the fishing season first opens. This and the good weather at that season attract many fishermen. Normally it is too early at that time of the year to place oysters in storage for winter. So, in the years before the oyster disease cut back production, the supply for immediate consumption sometimes exceeded demand. This glutting depressed prices. Markets for cultivated oysters were therefore poor at the beginning of the public fishing season. This is the reason why lessees were allowed a longer fishing season.

Those interested only in the public fishery sometimes complain about this but marketing conditions would be worse if oysters from leased grounds were marketed only during the public fishing season. The autumn market glut would be worse and all oysters would fetch lower prices. Besides this, it would be impossible to hold many markets that demand fresh oysters at other times than during the public fishing season. These demands are now being met by lessees who have a longer marketing season.

WHEN OYSTERS ARE IN BEST CONDITION. Our species of oyster is different from the European oyster. Ours does not incubate its young (Chap. 3.4) and therefore can be eaten all the year round, but fatness and flavour vary with season. Figure 14 shows that oysters are very thin just after spawning and generally remain thin during the warmest months. Most people prefer fat oysters to lean oysters and the Figure shows that oysters are reasonably fat any time from mid autumn until just before their early summer spawning. They are fattest just before spawning and again in late autumn. But immediately before spawning, oysters have a flavour of spawn that many people do not like. The late fall or early spring oyster is therefore the most favoured, both for fatness and flavour. It just happens that there is an "R" in all the months of this time of the year. So, in a limited sense, the "R" rule applies to our oysters as well as to the European type. An American joker has suggested that we might keep oysters in good condition the year round by changing the spelling of the four summer months to Mayr, Juner, Jurly and Augurst.

At times there is a faint quality of staleness in the flavour of winter-fished oysters because, when they are hibernating, they do not actively pass water through their shells. Even so, the flavour of winter-fished oysters is nearly always superior to that of oysters held in cold storages; these develop a storage taste that sometimes becomes objectionable after several months' storage. Connoisseurs seem to agree that their order of preference in oysters, so far as flavour is concerned, is somewhat as follows: (1) fresh oysters fished in late autumn, (2) fresh oysters fished in mid autumn, (3) fresh oysters fished in early spring, (4) fresh oysters fished in winter, (5) stored oysters, (6) lean summer oysters, (7) oysters heavy with spawn.

BEST TIME FOR HANDLING MARKET OYSTERS. In hot weather, oysters must go quickly from producer to consumer to avoid refrigeration expenses. Oysters can be held for many days in cool weather when temperatures in coastal warehouses can be held just above freezing. This does not impair their shipping qualities but they must be kept cool to protect flavour. In cold weather they must be protected from freezing and this is expensive. Thus it is easiest and cheapest to handle market oysters in cool weather.

12.4 HOLDING OYSTERS FOR MARKET

Bad weather sometimes interrupts fishing so you may sometimes be obliged to hold oysters to accumulate enough for large shipments or to provide reliable

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supplies for regular shipments. To maintain quality and to prevent losses you should ship as soon as possible after fishing. Holding oysters for shipment requires great care whether you hold them in air or in water.

HOLDING OYSTERS IN AIR. Holding oysters in air has many advantages over present methods of holding them in water. It requires no extra labour and does not expose oysters to inshore water. Inshore water is often bad for holding oysters for two reasons. It may be so fresh that it spoils flavour, and it may be polluted and contaminate oysters dangerously. Oysters keep better in air than when badly crowded in water. Therefore, unless you are prepared to set up special holding facilities for water storage, or unless you are obliged to hold them for a very long time before shipment, it is best to hold oysters in air. If kept just above freezing temperature, as in winter storage (Chap. 15.3), they can be kept for many days. This can be done at any time of year by using rooms that are artificially heated or cooled. In doing so you should take the same precautions as in winter storage.

HOLDING OYSTERS IN WATER. If your oysters are on exposed grounds it may be most convenient for you to fish them when the weather is favourable some weeks before marketing. Some do this and relay their catches temporarily on firm bottom in sheltered water close to where they will be landed finally for shipment. Others place them in trays. In either case, expenses are increased, the oysters are usually overcrowded, some are smothered, and fatness and other qualities may suffer.

For the present we must expect that temporary relaying and tray holding will continue. If you are going to do either, get advice about where to relay and take precautions. It pays to delay fishing as late as possible. This gives oysters a chance to fatten fully. If they are to be relayed for any considerable period, don't crowd them. Use plenty of trays or scatter them evenly on bottom. Experiments have shown that they get thin if they are more than two deep in a tray or scattered more than one layer deep on bottom.

Deep-water, bottom relaying can be expensive because it involves another fishing and because it is seldom possible to recover much more than about three-quarters of the oysters that are put down. Besides this, there is the regular loss from smothering of oysters that land with the lip buried in mud.

There are a few places where oysters can be relayed on bottom in shallow water at reasonable costs without polluting them or making them thin or spoiling their flavour. But these places are rare and have to be sought out. You may be obliged to artificially create a small piece of good bottom for relaying (Chap. 4.6).

Holding on submerged trays or platforms with legs to keep them off bottom is better than relaying directly on bottom for many reasons. Mortalities from smothering are not nearly so high, all the oysters put on the trays can be recovered and they usually come up very clean for packing. You can crowd them more than on bottom without affecting fatness. However, they should not be more than two deep. Trays or platforms should be built to allow some water circulation through the bottom. This can be done by slatting. Wire bottoms are expensive. The sides of holding trays should not be more than about 6 inches high because they cut down water circulation. Trays should be set out in places that are protected from strong seas or oysters will be lost. You should avoid dead-water areas too and you should set out trays as deep as you can without making them hard to recover.

BETTER METHODS NEEDED. Present methods of holding are expensive and dangerous and we are studying the problem hoping to discover ways of overcoming the need for bedding and traying. One way would be to use gear that will fish in bad weather or gear that will fish very rapidly in good weather. Other ways would be to provide cheap refrigeration or water storage in controlled ponds (Chap. 15.7).

CHAPTER 13. CLEANING, GRADING AND PACKING

Consumers are willing to pay, and to pay well, for good oysters. But when they do, they expect them to be well cleaned, well graded and attractively packed. To help matters, the Department has set up a number of regulations governing cleaning, grading and packing. Knowing these regulations is part of your job. You should write the Department for printed copies of them so you will know how to prepare your pack. You need all the information you can get.

13.1 How to Clean

When your oysters have come from the boats or holding trays, your next job is cleaning as required by fish inspection regulations. You can do this work best by standing at a bench about 36 inches high. There should be space enough in front of you to hold at least a bushel of oysters as they come from the fishing boats. And there should be containers beside you for (1) each grade that is being packed, (2) small oysters that are to be replanted and (3) materials that are to be discarded. Sometimes the number of containers is confusing to beginners.

One of the oldest oyster companies on Prince Edward Island sub-divides this job. There are several cleaners who clean all marketable oysters as they come in and then pass them to one or two graders who are skilled at the job.

Clean thoroughly. It is impossible to judge an oyster's quality until it can be separately handled and examined. This requires several treatments. You must cull out sticks, stones and other foreign objects that come in with oysters. And you must remove all pieces of shell, small oysters, mussels, limpets and other marine growths that are attached to oysters. This is done with a small, hatchet-like, cleaning iron, which should be lighter than a hammer and have an axe-like edge. Such irons can be made cheaply by a local blacksmith (Fig. 45).

Separate clusters. Consumers don't want clusters even if the oysters in them are all of good quality. They have to be separated before they are used and they pack much better in boxes when they are singled. Cleaning irons are good for separating clusters.

Reject dead and weak oysters. It takes only a few dead oysters in a box to make a smell that is bad enough to disgust a customer. Dead or weak (dying) oysters can usually be recognized by cleaners because of their hollow or loose sound when tapped with a cleaning iron. Broken oysters must be rejected from packs because they soon die in air storage and ruin the appeal of the oysters that are still good. Many of these broken oysters would live if returned to water promptly and could be marketed as sound oysters the following year when they have repaired their shells.

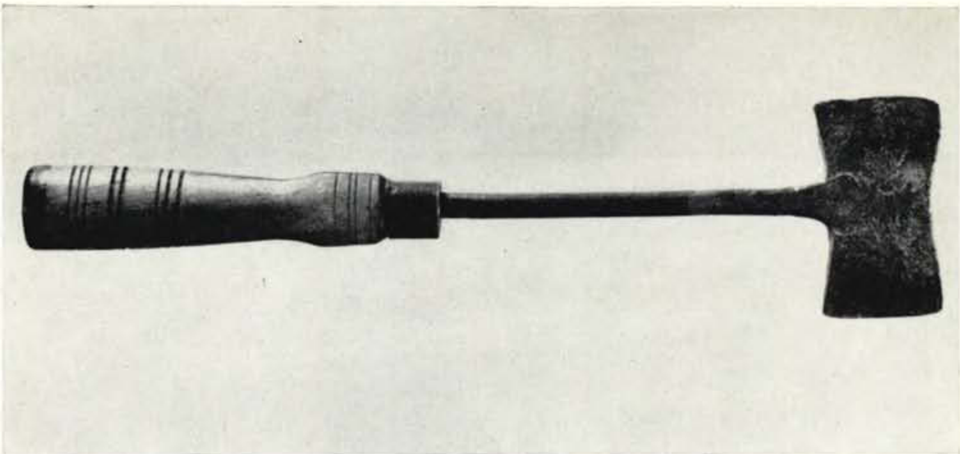

FIG. 45. Cleaning iron used for removing old shell, spat, limpets, etc., from oysters before shipment and for other purposes such as separating clustered bedding oysters.

MUDDINESS. Some Canadian wholesale dealers ask producers to supply oysters with some mud left on them. They believe this delays drying and therefore improves keeping quality. When they are being sold for immediate consumption, clean oysters might be expected to have some consumer preference over muddy oysters. Some New England firms that cater to the half-shell trade have devised elaborate high-pressure spray systems for washing their oysters. Where clean salt water is not available, fresh water is used.

However, you should find out what your buyer wants and satisfy his requirements. Never ship oysters with a great excess of mud.

13.2 CLEANING AND GRADING ON SHORE

Most people combine the work of cleaning and grading. The need for grading and its importance in marketing are dealt with in Chapter 14.4 and some suggestions on how to go about the combined job of cleaning and grading have just been made (Chap. 13.1). From what has been said, you will understand why you should do this work on shore. There you can work at a table with containers arranged about you. In the rush and tumble that must go on aboard a fishing boat, even skillful graders find they cannot give the work the attention it needs. Poor graders do an even poorer job. Ordinarily the best you can do on a boat is a rough preliminary cleaning and grading. However, if you are selling your catch to a packer and shipper, preliminary grading may be all that is expected of you.

Shore grading requires a building. In a building you can work comfortably during poor fishing weather. This leaves you free to make better use of good fishing weather when it comes. If you do the final grading and packing of your catch, you will need a building unless your catch is small.

13.3 Grading for Shell Shape

Consumers like oysters with round, deeply cupped, strong shells. Good shell shape and good meat quality usually go together and this is the basis for the system of grading now enforced by the Department of Fisheries and the one we all must go by. It is by no means an ideal grading system. It describes the shell which hides the part you eat but provides a vehicle for it when it is served. There is no official system of grading for overall quality and it is questionable if a practical one could be devised. All we can say is that what we have now is a vast improvement over the chaos that preceded the adoption of grades for shape—Commercial, Standard, Choice, and Fancy Shape. These are illustrated in Fig. 46. Detailed descriptions of the grades can be obtained from the Department of Fisheries. If you pack oysters for market you will be expected to know them.

The Department did not invent these grades. It adopted them from one section of the trade which had been using them successfully for many years. They can be sight-learned quickly, although they seem complicated when you read them. The Department has instructed its inspectors with great care so they

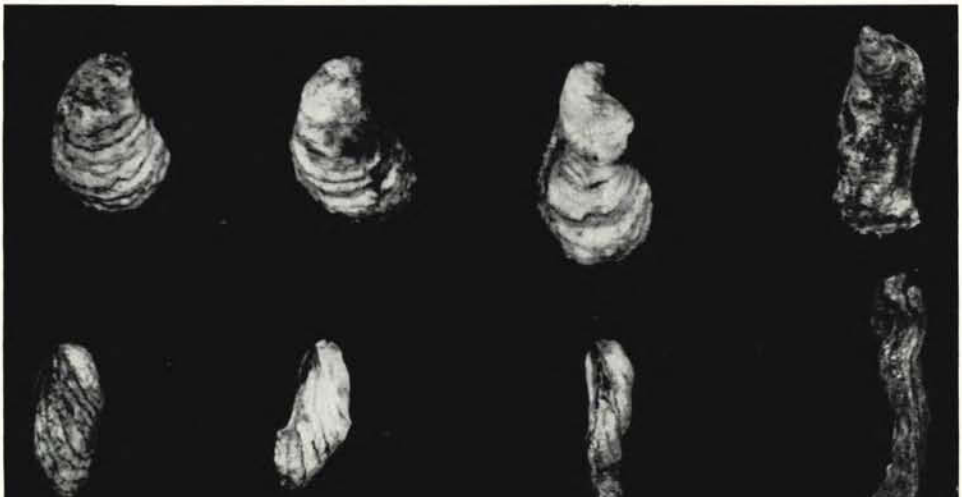

FIG. 46. Bottom, edge and top views of four groups of three oysters graded according to shape. Left to right, Fancy, Choice, Standard and Commercial.

will be able to recognize well-graded and poorly graded packs and the inspectors will be glad to help you learn to grade.

When you have graded your oysters, the grade you claim for each lot must be shown on its container. Remember that this describes the contents as a whole—not each oyster in it. There is bound to be some variation. The inspector's job is to make sure that your pack measures up to the standard you claim for it. If it does not, he must refuse to approve it (stamp it with the official inspector's stamp) for marketing. Turning down poorly graded shipments before they reach market is a service to you and to all oystermen (Chap. 14.4). It costs the Department money. If you pack oysters for market, you will be wise to learn and practise good grading. It will save you trouble when your shipments are inspected, your customers will notice the difference and in the end you will be the richer for it.

13.4 Grading for Size

Size of oysters is important because it determines the number of oysters you need to fill a shipping container and also determines the number of servings (profits) a restaurateur can expect to get from a standard containerful. Oysters must be at least 3 inches long because that is the minimum legal size limit. Most dealers and consumers prefer oysters that are not much above the size limit, although some prefer and request larger oysters and will pay more for them. It is usually best to pack lots of different sizes in different containers. Some dealers would like to have the approximate numbers of oysters in containers stamped on when they are inspected or have them labelled small, medium or large. This description of the pack might be useful but it is not a legal requirement. To fill a $1\frac{1}{4}$-bushel box, it takes approximately 250 oysters 3 inches long; 200, $3\frac{1}{2}$ inches long; or 175, 4 inches long. The count for any particular size varies somewhat because shape varies.

13.5 Grading for Meat Quality

We have had many enquiries about the feasibility of grading for meat quality and there are ready means of measuring some of the more important characteristics that determine it. One standard of meat quality is already insisted on, of course. All oysters must meet a sanitary standard (low bacteria count) which is rigidly controlled by the Department of Fisheries acting on advice from the Department of National Health and Welfare. There are only two sanitary grades—marketable and unmarketable. Sanitary standards are in your interests as well as the consumer's (Chap. 17).

Besides this, there are other meat qualities that are important but for which no commercial standards have been set up. One of these is fatness. In research programs, we regularly use an Index of Condition to measure fatness (Chap. 3.11). This is not difficult to determine but it takes time to work out. Perhaps it could be applied industrially. The colour of the mantle is another meat characteristic that varies a great deal from district to district. To some extent this affects marketability of oysters and there are colour standards that could be used to describe the colour of the mantle edge. Saltiness is another variable characteristic and there are ways of describing it too.

There are great variations not only in the characteristics themselves but also in consumer preference for, say, salty oysters. Obviously grading oysters in the shell for meat quality would not be simple. So far, producers and consumers seem to be reasonably satisfied with their ability to describe most combinations of meat characteristics merely by naming the region from which the oysters are fished. To help them in this, the Department insists that the area of origin be stamped on every shipping container of oysters. Everyone has his preferences. Some prefer Shippegan oysters which are known for their extreme saltiness and very fat meats with pale mantle edges. Bras d'Or oysters are generally only faintly salty, thinner and dark-mantled. Thus, although it seems quite possible to develop and apply grading standards for meat quality, the likely benefits at this stage in the development of the industry are not great enough to justify the effort.

13.6 Packing and Filling

When shipments of oysters are received, the containers are not full and this sometimes leads to complaints. Some of these are unjustified because oysters unavoidably shake down during shipment. Even with reasonable care, oysters are often 1 to 2 inches down in a $1\frac{1}{4}$-bushel box when they reach central Canadian markets from the Maritimes. However, greater shrinkages do occur and should and can be avoided if real effort is made to fill containers properly. This can be done by shaking them several times during packing and by hand-packing open spaces that are not filled by shaking. Some New England firms use vibrating platforms to achieve this or use lidless containers that can be heaped up before they are covered with burlap. This makes allowance for settling.

In trying to please customers you should not fill a box so full that you have to force down the lid. This usually breaks some oysters.

13.7 Containers

Containers that may be legally used for shipping oysters in Canada are defined by regulations, copies of which may be obtained from the Department of Fisheries or its officers. The commonest container is the half-barrel box which holds $1\frac{1}{4}$ imperial bushels but it is also legal to ship in half-bushel and peck boxes. Barrels ($2\frac{1}{2}$ imperial bushels) are seldom used now because they are cumbersome to handle and wasteful of cold storage space because of their shape.

The Department of Fisheries has found it necessary to set up basic standards for sturdiness, cleanliness and general appearance of shipping containers. You can meet these minimum legal requirements by using relatively cheap containers, but it is usually good business policy to package valuable products like oysters in durable and attractive containers somewhat above the minimum requirements (Chap. 14.7).

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The Department drew up its regulations for shipping containers after discussions with industry. And it has changed regulations to satisfy industrial needs when this seemed justified. It has recognized, for instance, that methods of packaging and types of package may need changing when new markets are being developed.

CHAPTER 14. MARKETING

14.1 Thoughts About Marketing

The marketing problem goes far beyond the problems discussed in Chapter 13 but includes them. If the oyster industry is to expand in a sound way, we must first of all understand what successful marketing depends on. Only then can we hope to make progress.

Successful marketing of any product depends first of all on a desire or demand for it by users or consumers. Salesmen don't expect that demand for a product will spring up full-blown. They know that it has to be developed and cultivated and then fought for if it is to be maintained. When you market your oysters you are competing for public favour. You are competing not only with other oyster producers but you are also competing with producers of a great many other luxury foods.

Handling of most food products has improved greatly in recent years and buyers demand better and better cleaning, grading, packing and inspection. Besides this they have come to expect steady supplies at standardized prices. We have made some improvements in our handling of oysters but we have not kept pace with the increasingly high merchandising standards being adopted by other food industries. Too much reliance has been placed on the inherently high quality of most Maritimes oysters when they are fished and too little attention has been given to handling. Another condition which has encouraged laxness is low supply and high demand. Today you can sell almost any oyster at a high price. We get just as much money for our oysters now as we did in 1950 but we produce less than half as many (Fig. 4).

However, if markets are to be expanded, or even maintained in competition with other products, a completely new approach must be made to handling and marketing problems. You must not only build your customers' confidence by supplying what they ask for and pay for. You should also organize your business to make sure that they get as much as they want when they want it. Nor is it enough to maintain a steady supply to established customers. If you want to stay in business, you must create new customers. If you can remember eating your first oyster, you will understand that it is not easy to create new customers. They have to be tempted and then educated in oyster eating.

All these principles come into play when you market your oysters. Marketing is not a simple matter and many small-scale oyster farmers prefer selling their catch to local dealers as soon as they have cleaned and graded it roughly. From there on, the dealer assumes the task of marketing.

14.2 What Consumers Ask For

Almost all oysters produced in the Maritimes are sold to Canadians for eating raw on the half shell. These consumers have reasonably clear ideas of

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what they like. The oysters they like best are of medium size, 3 to 4 inches long; they are singles (not clustered); their shells are round, well cupped, free of internal blemishes like mud-worm blisters, and well filled with creamy-white meat that has a strong salty flavour. They must be clean, inside and outside, and, of course, sanitarily wholesome. When they are assured that a pack has these qualities, consumers are willing to pay, and pay well, for what they get.

14.3 Quality

Quality is of special importance in marketing a luxury product like oysters. Everyone feels he must eat meat and potatoes but a man will not eat oysters unless they are temptingly attractive.

Today the quality of many food products is very high and they are attractively packaged. Beside them, Canadian Atlantic oysters often look unattractive. One reason for this is that many producers are perfectly satisfied as long as their pack meets the minimum government standards for marketability. Others are even happy when they can circumvent regulations. Our oyster industry cannot be healthy and grow as long as this kind of loose thinking keeps such practices alive. We need imaginative handling of our problems. The desire should be to raise standards so that oysters will command premium prices. To do this we need grading and we need better grading which in the end means better quality.

Good oysters are easy to sell at profitable prices. Poor oysters are hard to sell in the shell because the trade looks for the best packs. And even when they are sold, poor oysters bring small profits. The cost of packing and shipping them is the same as for high-grade oysters but they must sell for less. Besides this, they don't store well and almost every winter some spoil and have to be dumped after they have run up high cold storage bills in Montreal.

Selling poor oysters is not only difficult and unrewarding in itself, but the presence of poor oysters on the market tends to damage sales of better grades by lowering public liking for all oysters. This makes it difficult to obtain good prices even for good oysters. It isn't worth your while farming oysters unless they are of high quality and well graded. Even marketing low-quality oysters (Commercial grade) fished from public fishing areas seems unwise. It might be better if fishermen were to sell these locally to lessees for fattening (Chap. 3.11) and shucking (Chap. 16.4).

14.4 Importance of Grading

What grading is. Grading recognizes and describes differences in quality inasfar as this can be done on the basis of shell shape. The best grades of oysters sell for more than four times the price of the poorest. Grading is only a system of helping the purchaser get the quality of oyster he wants at a reasonable price and of helping the producer get a reasonable price for the quality of oyster he has to sell.

Need for grading. If you mix oysters of various grades together, the price you get for the lot is likely to be close to that usually paid for the poorest grade in it. It pays to grade because if a purchaser can't be sure of what he is getting, he won't pay much for it or, as often happens, he will buy somewhere else. If you are able to grow good oysters, it is foolish to take low prices for them by selling them ungraded. Grading helps the buyer and helps the producer.

Grading must be uniform and reliable. Markets can be held and expanded only if purchasers obtain the grades they order, pay for, and expect to receive. For example, if the quality of oysters that are represented as Choice grade varies from time to time and place to place, dealers are unable to estimate what prices they can get on resale. They will therefore play safe either by offering a low price or by buying somewhere else where the grade is reliable.

The Department trains its inspectors in grading and in recognizing well- and poorly-graded packs. It also insists that all packs must have passed inspection before they are marketed. Among other things, this insures that the same standards of grading are applied throughout the Maritimes. This is an important service to industry. It gives stability to the price structure.

14.5 Inspection

Producers and shippers should assist officers of the Department of Fisheries in their work of inspection. One of the best ways to do this is to read the regulations so you will know what is expected of a shipper. Proper inspection gives the customer assurance that he will get what he bargains for and pays for. It assures him that he will get well-filled, sturdy containers of clean oysters of the quality (grade) he orders. It encourages him to buy without expecting bargains. It also protects the shipper. Once oysters have passed inspection, it is difficult for dishonest purchasers to avoid paying full prices. Sometimes they claim that shipments are not up to promised standards. By this kind of misrepresentation, unscrupulous dealers have sometimes obtained oysters at low prices and been able to undersell their competitors. Such practices tend to lower general price levels so that honest dealers, shippers and producers all suffer. Inspection encourages honest dealings and high standards.

14.6 Continuity and Adequacy of Supply

A dealer in oysters must establish contacts and supply his customers. If he fails to supply them he loses them. To stay in business he must have a reliable supply. He will take this into account when he accepts orders from consumers and he will make purchase agreements only with producers who can be relied on to supply his needs. He will not sell to new customers unless he is sure he can supply those he has already bargained with.

If you are a producer and do not do your own marketing, you should do business only with dealers who have interests in the continuing welfare of the oyster industry—not with the man who is interested only in a quick dollar. You stand to profit by helping dealers maintain steady supplies because stability in marketing is necessary for sustained expansion.

14.7 Packaging and Advertising

If you walk through a warehouse of a wholesale food dealer, you will be struck by the bald appearance of oyster boxes as compared with containers used for shipping oranges and grapefruit. These fruits sell for approximately the same price apiece as oysters, and fruit dealers have learned that it helps their business to use attractive containers. These are stamped with trade slogans and coloured pictures declaring the tastiness and wholesomeness of the fruits. Even a fleeting glance at cheerful looking cartons of oranges in transit tells you without words that the public likes them and eats them. Packaging and advertising are natural companions but most oystermen have not discovered this. Oysters are tasty and wholesome too but we have never put much store in advertising these facts. This reluctance to speak up for our products may not always have worked out to our advantage.

Production is low now. Last year only 12 million oysters were shipped from the Maritimes. If you started westward with these, giving each Canadian one oyster as a sample, our whole production would have been distributed before you reached Winnipeg. It may be argued that it would be foolish to advertise when we have so few oysters to sell. On the same basis it may be argued that sober advertising would be useful now to keep the public oyster-conscious. We hope to have more oysters to sell some day, and we want them to be in demand when we offer them. We must not let the public forget how good oysters are.

If Canadian Atlantic oysters of higher grades are produced in sufficient quantity, new markets can be developed at home and abroad. But this will require well planned efforts to bring them to the attention of new purchasers who may be regular oyster eaters, or people who have never eaten oysters and may be hesitant or even afraid to begin. This may be done by individual contacts or by various other methods of publicity and advertising.

However, advertising should not overrate production. Over-enthusiastic advertising sometimes stimulates orders for shipments the producer cannot possibly satisfy. It is always difficult to interest disappointed people a second time.

14.8 Organization

In speaking of organization it is well to recall that there are 1,300 oyster lessees in eastern Canada and that altogether they produce fewer oysters each year than some of the individual firms in the United States (Chap. 3.2). Yet every one of our lessees is a potential marketing agent of small shipments and everyone has his own ideas of what the oyster industry should be. This is one of the main reasons why it is difficult to establish and maintain marketing standards in our region.

If they were supported by producers, a few reputable organizations who knew the importance of grading and inspection could market our production more profitably than 1,300 competitors, no matter how enterprising they might be. Organizations can pool producers' resources to promote continuity of supply; reduce packing, grading, shipping and advertising costs; play an important part in maintaining quality by precept and practice, and they can curb vicious price-cutting wars and dishonest dealings that destroy the whole structure of industry.

We have some organization now but we need more.

CHAPTER 15. STORAGE

Our oyster-producing inlets freeze over with 2 feet of ice every winter and a large part of our oyster catch is consumed after the ice forms. Thus it happens that we store oysters in air longer in eastern Canada than anywhere else in the world. Very few oyster growers try to handle the storage problem themselves. In the autumn many of them, or the local dealers to whom they have sold their catch, ship the oysters to merchants who place them in refrigerated cold storages. The storage houses that handle most of our oysters are in Montreal and there are many storage problems. In thinking about these and about all oyster handling operations, it is important to remember that oysters are living animals with many of the same problems of keeping alive that you and I have. They must not be treated like rocks even though their shells seem to be made of stone.

Storage life is a term frequently used in discussing storage problems. By this we mean the length of time oysters may be stored in air with no serious deterioration in flavour and with few deaths. Under good conditions storage life may be 4 months or even longer. Under poor storage conditions it may be less than a month. It is therefore important to know the principles and problems involved in storage.

In recent years costs of cold storage have been rising and this raises prices of oysters to consumers or reduces returns to dealers or both. Besides this, many cold-storage operators are reluctant to handle oysters now. They prefer to deal in merchandise that has a quicker turnover and higher profits. For this reason we are busy studying what happens to oysters during storage under many different conditions. We hope this will lead to better and less expensive methods of storage.

15.1 Good Oysters Store Best

Oysters with strong, round, deep-cupped shells resist breakage (especially along the edge) while they are being fished, packed and shipped. For this reason few of them will leak and die when stored under good conditions. Fat oysters are not only the most palatable but store better than lean oysters.

Shell quality and meat quality tend to be best in late autumn and oysters fished then store best. They bring the best prices and because they require shorter periods of storage than those fished in early autumn, they are altogether more profitable to handle.

In some years oysters store better than others, and oysters from some areas consistently store better than those from others. These matters are not fully understood.

15.2 Cool Weather Handling

Freezing, especially repeated freezing and thawing, is likely to kill oysters. They will survive freezing under certain conditions but are damaged if jarred

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when frozen. If frozen accidentally, they should be thawed gradually with a minimum of handling. This reduces the number of "weaks" that are susceptible to early spoilage.

On the other hand, exposing oysters to high temperatures for lengthy periods weakens them, increases losses and spoils flavour.

For long storage life it is important to keep oysters at a steady, cool temperature up to the time they are placed in cold storage. This may require shipping them in trucks or railway cars that are refrigerated.

15.3 Best Storage Temperatures

The most important storage condition is low temperature. Commercial storages maintain various temperatures below 40°F but the best results are obtained at temperatures that are just above freezing, usually about 34°F. If oysters are in good condition when they are received, they will keep for 4 months at this temperature. Storage life at temperatures much above 40°F is generally a matter of weeks, not months. We hear reports occasionally of successful storage for very long periods under special conditions, e.g., in piles of eel-grass on the beach or in cool cellars. We know too little about these to comment but we should explore all possibilities of improving conventional practices.

15.4 Drying Shortens Storage Life

Drying may be a frequent cause of death of stored oysters. Packing in damp seaweed and leaving mud on the shells may reduce drying enough to reduce deaths. Drying can be kept at a minimum by storage in a damp atmosphere and by sprinkling with fresh water if necessary. But water should not be allowed to collect in storage containers. Dirty water may contaminate oysters lying in it.

Some oystermen believe that stored oysters occasionally open their shells very slightly. They claim that at these times small amounts of shell liquor drain out unless the oysters are stored cupped-shell-down. These are points that should be studied further.

15.5 Stored Oysters Cannot Be Fed

It is a common misconception that oysters can be fed corn meal or other materials during storage. This is not true. Oysters can feed only when they are under water. And their delicate feeding mechanism (Chap. 3.8) will handle only microscopic food particles collected from water which is made to flow through their shells.

15.6 End of Storage Life

Toward the end of storage life a few of the weakest oysters in the containers die. They spoil quickly and the storage operator soon discovers this because nothing stinks quite like rotting oysters. They usually gape (not always) and the death of these few is usually a signal that the whole lot should be disposed of soon. Most of them will still be quite wholesome but they must be culled carefully when opened because some will have developed an unpalatable storage flavour. These are usually the "weaks". They tend to open easier than sound oysters and may have a hollow sound when tapped. Some call them cluckers. If these are numerous, the whole pack should be destroyed. Serving stale oysters is one of the quickest ways of discouraging (or losing) consumers.

15.7 Water Storage

European oyster growers store their oysters at the coast in tanks or ponds of sea water and ship them in small lots as the markets require them. It has often been suggested that we should adopt the same practice. Our species of oyster is different and our winter conditions are different from the European but the suggestion has merit and we are exploring the possibilities.

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CHAPTER 16. SHUCKING

16.1 What Shucking Is

Shucking oysters means removing the shells. Generally the process is thought of as including cleaning and washing the meats and placing them in marketing containers. We often have enquiries about shucking and where to get shucked oysters.

Traditionally eastern Canada's supply of shucked oysters has come from eastern United States. But disease has reduced the supply and dealers are turning to Pacific coast sources. In 1956, Canada imported close to 80,000 U.S. gallons of shucked oysters valued at $530,000 from the United States. This would be equivalent to about 70,000 boxes or 7 million lb of whole oysters, about the same quantity as we used to grow in the Maritimes every year. Besides this, we import many canned oysters from the United States. From this you can see that Canadians are much more active consumers of oysters than the size of our half-shell trade would indicate. This is important in thinking about the future or marketing our own products.

Most Europeans are like us. They consider the oysters they grow as extreme luxuries, much too valuable to be eaten except on the half shell. The main difference between us and Europeans is that they do not have access to outside supplies of shucked oysters.

16.2 Shucking in British Columbia and the United States

Conditions in the Maritimes contrast sharply with those on our own Pacific coast and on both the Atlantic and Pacific coasts of the United States. In all these regions the oyster business operates on a vast scale and almost their whole production is sold in the shucked state.

There are many reasons for this. The main reason is that oysters are more plentiful and grow much faster in those regions than they do here. At the point of production a bushel of whole oysters gives a much larger dollar return if it can be sold in the shell for the half-shell trade than if it is sold shucked. But oyster shells are heavy and shipping costs are high. This means that whole oysters must sell for very high prices if they are to be shipped far inland. It also means that few people can afford to buy oysters in the shell.

Shuckers are willing to accept a small per-pound profit from their products and make reasonable total profit by handling very large volumes. This business policy has many advantages. It expands markets enormously. Housewives on the prairies, for instance, may not know how to open oysters and probably wouldn't eat them raw anyway. But they can and do buy shucked oysters for cooking. They can buy them fresh or frozen in attractive plastic containers or cold-sealed tin cans. They can buy them inexpensively.

16.3 Shucking in the Maritimes

Shucking on a commercial scale has never succeeded in the Maritimes except at times when economic conditions were especially favourable. It has always collapsed suddenly when normal trade relations returned. There was some properly conducted shucking in Cape Breton Island during World War II and in New Brunswick in 1949 and 1950. Our economy in those times required cancelling imports of shucked oysters and many other items from the United States.

To insure that consumers would get a clean, wholesome product the Department of Fisheries, with advice from the Department of National Health and Welfare, has established regulations under which commercial shucking may be carried out and compulsory inspection of the products before marketing. Similar regulations apply in the United States. Thus, the Canadian consumer may safely buy inspected, shucked oysters produced in either country.

The health department has insisted that shucking be carried on in sanitary surroundings and with proper equipment. This means that very few producers are in a position to carry on shucking but most of them agree with the health department's ruling that if shucking is to be done at all, it must be properly done.

16.4 Future of Shucking in the Maritimes

Until now, those who have shucked oysters have usually treated this branch of the business as a temporary venture or as a side-line. Most of them were producers or dealers who derived most of their income from selling good-quality oysters to the half-shell trade. In many cases they shucked only the mis-shapen and very large oysters which they did not wish to include in well-graded packs. Consequently the meat yield per bushel and the dollar returns for shucked oysters have been low compared with those in the United States where all types of oysters, not just culls, are shucked. The appearance of our product has been inferior correspondingly.

This statement is not intended to imply that our approach to shucking is wrong. It has already been suggested (Chap. 14.3) that it would be better not to offer the half-shell market any oysters of Commercial grade. Shucking is an obvious way of avoiding this. Nor does this imply that shucked Commercial grade oysters need always be poor. We have already pointed out (Chap. 3.11) that by suitable transfer, thin oysters can be fattened. Where mechanical fishing methods can be used to reduce handling costs, it may some day be worth while relaying Commercial grade oysters for fattening and shucking.

It is well to keep an open mind on shucking when it is remembered that today we import more than twice as many shucked oysters from the United States every year as we grow and sell to our half-shell trade. If our costs of growing could be brought down sufficiently we might someday find it profitable to do more shucking than we do now. However, it seems unlikely that small-scale producers can hope to find shucking profitable. The relatively high overhead costs of providing suitable surroundings and equipment for sanitary shucking require large-volume processing to make it worth while. Shucking may be more inviting if you are a dealer or processor.

CHAPTER 17. OYSTER INDUSTRY AND PUBLIC HEALTH

Oysters are like any food that is eaten raw—they may be carriers of harmful bacteria. In rare cases they have been found to carry undesirable chemicals concentrated from the water they live in. Because of these hazards, it is necessary for government officers to keep careful watch and to rigidly control every operation that affects the sanitary quality of oysters. It is also necessary for you as a grower and for dealers and Department of Fisheries law enforcement officers to have a clear and sympathetic understanding of the regulations. Lack of understanding seriously weakens any law.

17.1 Oysters Possible Carriers of Disease

Lettuce, radishes, celery, apples, strawberries and oysters on the half shell are all living products. They are all eaten raw and all may carry millions of germs. Most of the germs are altogether harmless. Others, like the germs of apple scab, strawberry blight and oyster disease, are harmful only to vegetables, fruits or oysters. Still others may be harmful to the people who eat them. These latter are the germs with which we are most concerned.

Oysters can carry typhoid fever bacteria and germs of other intestinal diseases which are less conspicuous but nevertheless distressing and possibly dangerous. The same sort of risks are associated with milk. When you consider these facts, it does seem strange that the same people who are most careful about the milk they drink are sometimes careless about the oysters they eat or offer to others.

There is no need to go into a panic about the risks of drinking milk or eating oysters but there is a real need for constant watchfulness and stern action when this is required.

17.2 Sources of Pollution

Actually we should be more careful about our oysters than we are about milk because our civilization has fantastically primitive sanitary habits. Moses issued special instructions to the Children of Israel regarding their bathroom habits. And in some ways our practices are no better and are sometimes worse than those Moses prescribed in the desert 5,000 years ago. We dump our sewage into our rivers, lakes and bays, then swim in them, wash in them and drink from them. We must blame ourselves for whatever happens. We are equally to blame for dangerous germs sometimes carried by oysters because, when the facts are laid bare, you will find that they are almost invariably derived from our own sewage.

No matter what you think about this situation, it exists. You must try to understand it and take precautions to protect yourself and others from its hazards.

17.3 Fate of Sewage in the Sea

When sewage enters a marine inlet it mixes with the sea water and spreads, becoming more and more diluted as tidal currents churn it and carry it about in the inlet and to the sea beyond. Most bacteria that are dangerous to man do not survive very long and do not reproduce actively in sea water. Thus, pollution decreases by actual death of bacteria as well as by dilution. These two processes tend to limit serious pollution to the immediate vicinity of its source. But if the volume of sewage discharged is great and if it is discharged in its raw, untreated state into sea water, it may then pollute a wide area. This happens in the neighbourhood of most towns and cities in the Maritimes. Small municipalities are frequent offenders, and indeed there are hundreds of individual home-owners up and down our coast who boast of their own private sewage lines. These offenders know little and say less about their contributions to the nation's pollution problems. But regular sanitary surveys of the Maritimes show that roughly a quarter of our actual and potential oyster ground is contaminated by domestic sewage and direct marketing of oysters from them has been prohibited.

17.4 Control of Oyster Pollution

Obligations. The facts of oyster pollution problems are fairly clear from studies carried on here and in other countries. Our Minister of National Health and Welfare is responsible for protecting the health of oyster consumers. If oysters are to be sold, they must be free of detectable pollution, which means that they must come from areas that have been approved as safe. The Minister of National Health and Welfare has defined the clean-water areas and the Minister of Fisheries is responsible for seeing that industry markets oysters that have been fished only from these areas.

Whether we like them or not, these are the rules under which the oyster industry must carry on. Most people consider them fair and just and by no means crippling to industry. Every reputable oysterman wants to sell his products with a good conscience. He wants them to be safe and he wants them to be known to be safe. There is no other basis for a sound industry. He will not only abide by regulations but he will also help officers of the Department of Fisheries to bring offenders to justice. This is usually distasteful but every oysterman should understand that it is one of his responsibilities. In actual fact his own livelihood is threatened every time polluted oysters are sold because their consumption could touch off an epidemic. Such an event would shake public confidence in our oyster industry so badly that it would take years to recover. Every oysterman would suffer. This happened on a vast scale in the United States following the Chicago typhoid epidemic in the 1920's. People just stopped buying oysters.

Occasionally a few oysters are fished illegally from polluted waters and peddled locally in the Maritimes by irresponsible people interested in a quick dollar. They are afraid to offer their catches to reputable dealers or to grade and pack them themselves for inspection and shipment. Fisheries officers are constantly watching for offenders.

Examination of shellfish growing areas. The Department of National Health and Welfare regularly examines all our shellfish-producing areas. This includes sanitary surveys of shorelines for possible sources of pollution and bacteriological examinations of the water and of the shellfish themselves. These examinations must take into account the effects of season, weather, tide and general characteristics of the land drainage area. This is important because, depending on these factors, there can be great variations in pollution levels of an inlet.

In carrying out their examinations, bacteriologists do not look for dangerous bacteria because, even in heavily contaminated areas, these are much too rare to be readily counted. The form they study is a sewage bacterium, *Escherichia coli*, which used to be referred to as *Bacillus coli*. It is harmless, very abundant in human excrement, and its numbers can be counted without great difficulty. Its level of abundance in water or in oysters tells you how great the chances are of dangerous types of bacteria being there too. This is reasonable because both ordinary sewage bacteria and dangerous bacteria come from the same source—human excrement.

Standards of safety. The rules used in Canada to decide whether an area is dangerous are similar to those used in the United States. They are somewhat arbitrary but long experience has shown that they are safe. An area is considered polluted if sewage bacteria are found in significant numbers in a series of samples of water taken from representative parts of that area. But, as already indicated, other considerations (e.g., nearness of sewage lines) are taken into account along with counts of bacteria in deciding on closures.

Closed areas. When sanitary surveys or bacteriological examinations of an area show that it is dangerously polluted, the Minister of Fisheries drafts fishery regulations describing and defining the area and prohibiting marketing of oysters from it. Such grounds are referred to as closed areas.

Sometimes sources of pollution are small and can be eliminated. If this is done and re-examination shows that pollution has disappeared, closed areas may be opened and fished once more. It is regrettable that such happenings are so rare. There should be more effort to clean up pollution.

17.5 Magnitude of Pollution Problem

Present conditions. Few people realize that we have spoiled such vast areas of the water around us. We can still sail over it but much of it is no longer fit for bathing or growing shellfish. It is estimated that a quarter or more of our potential oyster-growing ground is already closed.

Trends. It is bad that so much oyster ground should be closed. But it is still worse that more and more areas are closed every year (Fig. 47). Pollution is the creeping paralysis of the oyster industry. It may not be many years before we have no clean water. So far, efforts to halt this trend have been unsuccessful although they may have slowed it down. You and all oystermen should be alert to, and should make special efforts to oppose pollution in your areas before it becomes firmly established. Too often nothing is done until pollution is an accomplished fact. This is a matter of great concern to the whole oyster industry and to the provincial and federal governments.

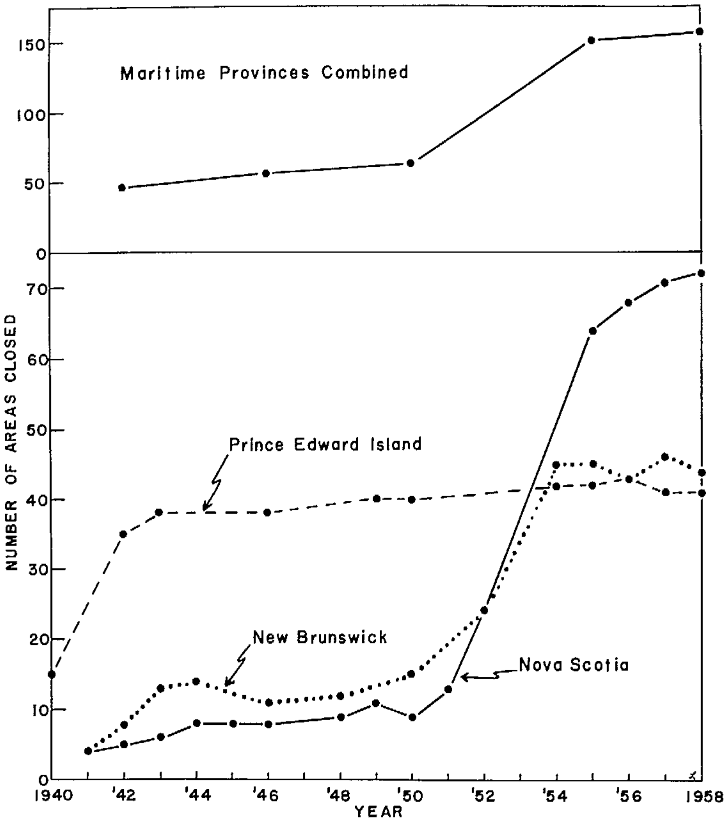

FIG. 47. Graph showing the steady increase in the number of shellfish growing areas that have been closed to fishing for direct marketing because of pollution by sewage.

They are concerned for two main reasons:

(1) Closing an area robs oyster fishermen and oyster farmers of income and robs consumers of what could be a pleasant and wholesome food.

(2) Closed areas represent a serious threat to public health. They accumulate heavy unfished stocks of wild oysters that are a great temptation to poachers. Poachers are willing to risk the penalties for illegal fishing and they have little regard for the health of consumers who are willing to risk dealing with them. Policing closed areas is one of the most difficult and harrying tasks assigned to fisheries protection officers.

17.6 Safe Use of Polluted Oysters

The simplest way to remove the risk of dangerously polluted oysters reaching the public is to fish them and use them in some safe way. The Fisheries Research Board has co-operated with the Department of National Health and Welfare and with the Department of Fisheries in discovering safe ways to use wild oysters that grow in polluted areas.

Biological basis. As long as the water is warm enough for feeding, oysters constantly filter large volumes of water and strain out bacteria and other microscopic particles which constitute their food. Every oyster kills (digests) thousands upon thousands of bacteria which it strains from the water every hour. Besides this, it traps many others in mucus which it deposits on the bottom and thus removes them from circulation. The vast majority of these bacteria are harmless types that make their home in the sea just as we have many types of bacteria that make their home in the soil. Where sewage bacteria are present the oysters feed on them too. In this way oysters and many other filter-feeding marine animals help keep the waters as pure as they are. The speed of feeding and digestion processes depends on water temperature. Under ordinary summer conditions it takes only a few hours for an oyster to digest and free itself of a meal of bacteria. Ordinarily this takes longer at lower temperatures but at temperatures below about 40°F oysters cease feeding and hibernate. It may surprise you to know that hibernating oysters usually have very clean meats even though they may be fished from polluted areas.

If polluted oysters are allowed to feed in water that contains no bacteria, they soon become clean because they digest the bacteria they have previously eaten. This has been proved for ordinary sewage bacteria and for the dangerous types as well.

Use of hibernating oysters. Because hibernating oysters contain so few sewage bacteria, the Department of Fisheries, on advice from the Department of National Health and Welfare, allows fishing for direct marketing in a few mildly polluted areas in late autumn and winter. These areas are closed at other times of the year. Their positions and fishing seasons are described in fishery regulations.

Worthwhile fishing in winter is not possible in most areas but it can be done with rakes through holes in the ice if the water is deep enough to let the rake reach a reasonably large area of bottom through one hole. This kind of fishing was traditional along the steep bank of the river channel at Buctouche, N.B., before the oyster disease destroyed the stocks there.

Use as bedding oysters. Oysters in the shore zone of polluted areas may be picked by hand for bedding (Chap. 5.1). These oysters are usually small but with approval of the Department of National Health and Welfare, the Department of Fisheries has devised special regulations which permit spring and summer fishing (tonging) of both small and market-size oysters from deep-water beds in certain polluted areas. This fishing takes place when the consumer market is closed. The fisherman sells his oysters to oyster farmers who bed them (Chap.

5.4 and 8.3–8.5) and cultivate them on clean-water maturing grounds and refish and sell them when they are large enough for the consumer market. Because their stay on the maturing grounds is long, these oysters have more than ample time to cleanse themselves.

SHORT-TERM PURIFICATION OF MARKET-SIZE OYSTERS IN NATURAL WATERS. Experiments have shown that polluted market-size oysters soon free themselves of ordinary sewage bacteria when they are relayed in pure-water areas in summer. Accordingly, authority may be obtained from the Department of Fisheries to relay market-size oysters from polluted areas to clean-water areas for purification in summer. The fishing and relaying must be complete well before the regular fishing season opens, as specified in fishery regulations. This insures that all the transferred oysters have spent 2 weeks or more in clean water before the regular fishing for the consumer market begins. This gives them ample time to cleanse themselves thoroughly.

Short-term purification of this sort may be carried out only in approved clean-water areas and under direct supervision of agents of the Department of Fisheries.

Experience has shown that oysters may be purified in this way on grounds that are too shallow to escape winter damage and even on intertidal flats. Planting on intertidal flats has the advantage that it permits almost complete recovery of all the stock planted. This can be done by picking at low tide which is faster and cheaper than tonging. If tidal flats are used, the oysters should be scattered at high tide through at least 2 or 3 feet of water. This insures that they will land right-way-up on the bottom. If you don't do this you may have heavy losses from smothering.

If there is any risk that you will be unable to sell your purified oysters before winter, it will be unwise to relay them in shallow water. They may be winter-killed.

TANK TREATMENT. The principles by which polluted oysters cleanse themselves in pure natural waters work equally well in tanks. The British and Japanese take advantage of this fact in treating sewage-polluted oysters of their species. Under the British system, oysters are first of all hosed to remove mud, then the outsides of their shells are sterilized by a bath in a mild chlorine solution. This prevents contamination of the tanks to which the oysters are next moved and immediately flooded with purified (chlorinated then de-chlorinated) sea water. They soon digest the last meal they took while in polluted water and are clean in 24 hours. As a final precaution, all this water is drained off, the oysters are hosed down again and treated in another tankful of purified water for 24 hours. Thereafter they are marketed.

The British have used this method with satisfactory results for 30 years. Their recent studies show that mildly polluted water can be used in cleansing tanks. It needn't be chlorinated because the oysters will purify it themselves. They do this by straining out the bacteria present. After that, of course, the water is pure and the oysters soon cleanse themselves as if they had been given clean water to start with. The British and Japanese methods involve considerable capital outlay and so far neither has been adapted to our conditions.

FUTURE OF CLEANSING OPERATIONS. Considerable attention has been given to cleansing because our pollution problem is steadily increasing (Fig. 47). It may not be many years before many of our oysters will require cleansing treatment before consumption. It is important, therefore, that we should learn more about cleansing methods.

17.7 POLLUTION ABATEMENT

You can judge from this Chapter that pollution caused by human body wastes is one of the most serious threats to our oyster industry. You may rear bedding oysters wherever they grow well but it may be unwise to mature oysters on a large scale on grounds close to polluted areas. Substantial increase of sewage inflow could easily render the neighbouring grounds useless for maturing oysters for direct marketing.

Communities should make the best possible use of their natural resources and water is one of their important natural resources because it has so many uses. It is generally agreed that its use for any one purpose should not unduly hamper its usefulness for other purposes. And in most instances, communities can safeguard the cleanliness of water for shellfish culture and other purposes and still find ways of looking after its waste disposal problems. Sometimes it is possible to reclaim polluted waters at reasonable cost by removing the sources of contamination. But it is usually cheaper to design and install good new sewage treatment facilities than to try to remodel poorly designed systems already installed. By foresight many pollution problems can be avoided at reasonable costs. But, for prevention or for cure, money spent in limiting water pollution is usually a sound investment.

Sewers are not the only sources of bacterial pollution. Inlets can be contaminated by land wash. The opening up of new agricultural or recreation areas may result in land wash that renders good oyster grounds too polluted for safety. Increased boat traffic in formerly little-used harbours may have the same results.

Little has been said in this Chapter about pollution except that caused by sewage. This does not mean that other types, such as chemical pollution, are not important. The two types often go together. But chemical wastes such as are discharged from paper mills sometimes kill or stunt the animals in the areas they affect and thus remove the public health problem so far as shellfish are concerned.

Silting and changes in patterns of silting caused by land erosion may restrict river channels, build up huge mud flats and smother oyster beds. This sometimes follows lumbering operations, the opening of new agricultural areas, road and causeway construction, mining of various kinds and gravel washing operations. In a special sense of the term, all these are forms of pollution. They do not attract attention from public health officers but in the long run they may be more devastating to shellfish production than the common types of pollution discussed earlier in this Chapter.

These are all problems that you must cope with. To deal with them effectively, you should pool your efforts with other oyster farmers and with your government services. The time for action is before pollution gets such a foothold that areas have to be closed. You can do a great deal to protect your interests if you are willing to try.

CHAPTER 18. PROSPECTS OF MARITIMES OYSTER INDUSTRY

18.1 Oyster Industry Will Depend on Farming

Right now the oyster industry of the Maritimes is severly depressed (Fig. 1 and 4) and the average quality of oysters being marketed now seems to be below the standards reached in the late 1930's and 1940's. Less conspicuous but similar trends are detectable in most of the world's oyster areas that depend on natural production. It has been suggested that these changes are part of some grand, world-wide, cyclic change in climate and that some day production will rise again. This may be true, but there are better grounds for believing that the falling off has been caused by man-made changes in oyster-growing waters and is therefore permanent. In other words, public fisheries of naturally produced (wild) oysters can no longer be relied on to supply the quantity and the quality of oysters we have had in the past and would like to have in the future. Oyster farming must be resorted to if we are to have a vigorous oyster industry.

18.2 Rivalry Between Public Fishery and Oyster Farming

Traditionally, the oyster fishery was an economic stabilizer in many shore communities. In bad years when there was no sale for pulp wood or poor runs of lobsters or poor crops on the farms, fishermen-farmers resorted to oyster fishing. Proceeds from an autumn's oyster fishing have saved many a family from privation. It is understandable that when oyster farming began in the Maritimes, public fishermen were disturbed to see fishing rights on certain bottoms being leased to private persons. A rivalry was born then between public fishermen and oysters farmers that still persists in some districts.

Today, however, unemployment insurance and other social services provide economic stability and the bitterness of the old rivalry has died down. All parties now regard fishing oysters from public beds and farming oysters on leased grounds as legitimate businesses with certain interests and problems in common. There has even been some co-operation. Co-existence of both branches of the oyster industry is necessary and they can be mutually beneficial.

18.3 Public Fishery Prospects

On the mainland, disease has destroyed almost all the oyster stocks and seems likely to destroy the few that are left. Natural recovery aided by rehabilitation efforts is expected to restore stocks. But it will probably be a good many years before public beds are back in production. A few beds may silt over and fail to recover. This happened to some beds in Malpeque Bay, P.E.I., following the 1916 oyster epidemic.

Prince Edward Island's small public fishery will probably not change greatly except as it may be affected by pollution.

Prospects of the public fishery in the Maritimes as a whole are not cheerful nor are they completely dismal. But they are not as hopeful as the prospects for oyster farming.

18.4 Oyster Farming Prospects

The future of oyster farming in the Maritimes is the subject of much speculation. Some sides of the picture are bright, others dark.

Dark side. Mainland oyster farmers have little reason for present cheerfulness. Many have lost substantially from the epidemic oyster disease. Some saw the handwriting on the wall and fished and sold whatever market-size oysters they had on their beds just before mortalities struck their districts. This lessened the blow, but they lost all the small stock they were rearing or maturing. Other growers lost everything—large oysters and small—either because the disease struck them without warning or because they failed to heed warnings.

Through its rehabilitation scheme, the Department has provided each lessee of oyster ground with a few barrels of adult, disease-resistant, Prince Edward Island oysters. Heavy plantings of the same stock have also been made on old public fishing beds in each major district. These transferred oysters are serving as breeding stock. But it may be many years before local breeding will have produced adequate spatfalls, on natural cultch or artificial collectors, to restore oyster production to former levels.

Perhaps naturally-produced or cultivated, disease-resistant, bedding-size oysters will be available soon in Prince Edward Island or elsewhere in sufficient numbers to supply mainland oyster farmers. If they were available now, the leased grounds could be brought into full production several years earlier. But there is no assurance that they will be available.

Prince Edward Island oyster farmers themselves have not been free of losses. In recent years an oyster blight, different from Malpeque disease, has caused heavy losses in central Malpeque Bay. A cure of this condition will have to be found before these growers can rebuild their stocks but the outlook for the Island as a whole is better than that of the mainland where recent losses from disease have been so very, very heavy.

There are other dark sides to the picture which involve both the mainland and the Island. Oyster farming in both areas is in a primitive state. About 1950, the Department estimated that leased areas were producing at approximately 10% of their capacity. There were two main reasons: (1) It was hard to catch spat and costly to rear them to bedding size; (2) oyster farming, as now practised, requires much manual work and most lessees are unable to spare enough time from their other work to do a thorough job of growing oysters.

Since 1950 conditions have not improved. In most places the Department and Board have been unable to provide seed stock or to suggest simple and reliable methods of catching spat. Many oyster farmers are not well enough informed to work out methods that would be effective in their areas. In truth, there has been little real oyster farming. Beds are poorly stocked. There is almost no labour-saving machinery. Oyster farmers have not formed active organizations to help one another by self-education or by pooling capital investments in buildings, wharves, boats or gear. This is an age of specialization when people are trying to do fewer things, and to do them better and more profitably. Oyster farming needs better methods and better organization. Without them it seems inevitable that the number of lessees will decrease.

There is much we can learn from the French, the Japanese and the Netherlands oyster industries. We have a long way to go and problems like pollution are threatening.

BRIGHT SIDE. There are two most cheerful features in the prospects for the Maritimes oyster farmer. The first is that the Department of Fisheries is working hard with oystermen to restore the fishery. The second is that there is an excellent market for oysters. The Canadian public is willing to buy all the good oysters that are available and pay two to four times as much for them as they did in 1950. This seems likely to continue and there is still reason to believe that our product would be acceptable on foreign markets if we ever saturate our domestic market.

A technique for cheap bottom rearing of mass quantities of bedding oysters from spat was discovered recently. And in 1959 the escalator oyster harvester became a reality. This labour-saver can be useful in rearing and harvesting bedding oysters, in harvesting adult oysters and in cleaning and cultivating beds. Besides this, promising new methods of cheap spat collection that can be applied by oyster farmers are being developed. It is 20 years since so many technical advances have been made in quick succession. If oyster farmers would use these new methods and keep a bright eye open for others, we could soberly predict an unprecedented expansion of the oyster farming industry. A tenfold increase in the next 20 years could be accomplished.

When the disease has run its course on the mainland there will be no need to maintain the laws which now forbid interprovincial plantings. Freedom to ship spat or bedding oysters wherever they are needed should prove a great boon. United States oyster farmers have proved this. Some of their districts are well suited for one particular purpose—such as catching spat, rearing bedding oysters, or maturing oysters—but at the same time are practically useless for all other purposes. Industry recognizes this and each area is used for the specialized purpose for which it is best suited. In this way the producing area and total production has been increased many-fold. These United States areas would be of little consequence if they were managed as individual units comprehending all phases of oyster culture, as ours in the Maritimes are now and have been heretofore. Many important maturing grounds would have never produced an oyster.

When restrictions on interprovincial shipments of oysters are removed, similar developments should be possible here. Spat could be caught in Malpeque Bay, P.E.I., or the Bras d'Or Lake, N.S., where this can be done almost every year. These could be reared to bedding size in places like Conway Narrows where this can be done cheaply, and the bedding oysters could be planted in places like Shippegan and Shediac, N.B. These last-named areas are excellent for maturing oysters of the highest quality but their production is kept low by their poor conditions for spatfall and rearing.

There may be a chance to begin this specialization very soon, because spatfall in Prince Edward Island has been heavy in 1958, 1959 and 1960. Island oystermen who work in polluted areas might sell some of these oysters, when they reach bedding size, to mainland growers who may wish to follow the stocking practice set by Hillsborough River growers in the 1940's (Chap. 10.6).

Another possible source of bedding oysters that seems more and more likely is artificial spat production in controlled, fertilized tanks or ponds and rearing of spat to bedding-size oysters by similar methods.

18.5 Form of the New Industry

Public fishery. There is little reason to expect great changes in the form of the public fishery which depends on the natural production of wild oysters. However, it does seem likely that there will be more active exploitation of polluted areas to supply bedding oysters for lessees and to supply market-size oysters to those interested in cleansing operations. In other words, public fishermen will work more closely with oysters farmers. This should mean better organization, which is most desirable.

Oyster farming. In contrast with the public fishery, oyster culture seems likely to change radically and there are already indications of the directions the changes are likely to take. The most obvious is the tendency to specialization as indicated in the preceding section.

Some oystermen will probably specialize in catching spat and selling it to those who have good facilities for rearing it to bedding-size oysters. An important obstacle so far in the development of this phase of oyster culture is the lack of suitable cheap cultch for spat collection, but we believe this can be overcome. Spat catching as a separate operation has several things to recommend it. Perhaps the most important is that it should give quick returns. Cash crops have many advantages and spat should usually be salable the year they are caught. There are good years and bad years, of course, but the best spat-collecting areas seldom fail completely and there is the possibility, which now seems more and more likely, that spat production in tanks or controlled ponds may eventually make spat as sure a crop as radishes.

Other oystermen may specialize by concentrating on bottom rearing of bedding-size oysters from spat which they may catch themselves or buy from others. This is a long-established practice in the United States, but it has not yet been attempted here on a large scale except by the Department of Fisheries. It will likely be possible industrially in only a few places like Conway Narrows. Rearing bedding oysters will involve longer-term investment than spat production

—two or three years—and more risk. It will also require a high degree of mechanization along lines that are only gradually becoming clear. The extent of the undertaking will depend on the number of oyster farmers who wish to buy and on the quantities of spat available. Spat production may not always be under direct control of those who do the rearing and in such cases there must be close intergration and organization of the inter-dependent parts of the industry.

Maturing oysters during their last 2 or 3 years before marketing is a specialized phase of the industry already well established in Malpeque Bay, P.E.I. Most of the bedding oysters used in this operation come from Summerside Harbour and most of the oyster farmers who mature oysters there concern themselves only with this branch of the industry and with marketing problems. If you are interested in this kind of specialized operation, you can buy wild, bedding-size oysters fished under special regulations from polluted areas like Summerside Harbour or from pickers. It is expected that more and more growers will take part in this specialized phase of the industry, but there is a limit to available supplies of bedding oysters. Many growers will probably come to depend more and more on those oyster farmers who specialize in rearing bedding oysters for sale, and less on fishermen and pickers who handle wild stock.

Going along with this sub-division and specialization of the oyster industry there will be greater dependence on new and refined methods of farming. To succeed, oyster farmers will have to inform themselves much more fully than they have in the past. They will want to learn more about improved methods that are being tested on the Department's Experimental Oyster Farms and operators of the Experimental Farms will want to alter their experimental programs and general schemes of operations to accommodate the needs of oyster farmers. There will probably be much more emphasis on demonstrations and educational projects.

It seems more than likely that some of our less active oyster farmers will lose interest as this specialization increases and will relinquish their leaseholds. There will be no need for such grounds to lie idle, because with mechanization such as we now foresee the amount of ground a single lessee can operate will increase. There should be a great accompanying increase in intensity of farming and this should make it more profitable. If farmed areas are producing at only 10% of their capacity, even a small improvement would have a great effect on total production. This we can confidently expect.

From the outsider's point of view, the most conspicuous of all changes will likely be in marketing. Today you may see live Canadian lobsters swimming about in tanks of artificial sea water in Montreal, Detroit, Chicago, Winnipeg and many other cities far from the sea. The whole system of lobster marketing has been changed in the last 10 years by improvements in methods of handling. As our understanding of oyster storage and handling problems improves, conspicuous changes may be expected in methods of oyster marketing and in the radius of marketing activity. Export markets may develop.

These changes will be accompanied by improvements in the quality of our half-shell oysters. This, in turn, may involve the development of a small auxiliary shucking industry as a means of marketing Commercial grade oysters.

There will be much greater emphasis on the sanitary quality of the product, as there is now in France, because our growing pollution problem will force attention more and more in this direction. Indeed, within a few years, a high proportion of our catch may undergo cleansing treatments before marketing. This accent on cleanliness will involve closer co-operation among producers and public health officials and heavier demands on both. Invariably, refinements of this sort are accompanied by more obvious refinements in merchandising. The dealer will make more effort to appreciate the consumer's likes and needs. He will put up oysters in convenient, attractive packages, advertise their delectable and health-giving qualities and make them more generally available in hotels and sea-food restaurants not only in Montreal but also in cities further west and here in the Maritimes and possibly even in foreign markets.

We have faith in the future of the Maritimes oyster industry. Support from government fisheries departments, federal and provincial, will still be needed but if the new industry is to be strong and free, this support must not be too fatherly.

READING LIST

Canadian Atlantic Sea Shells, by E. L. Bousfield. National Museum of Canada, Ottawa, Canada, ($1.00).

Seashores, by H. S. Zim and L. Ingle. (A Golden Nature Guide), Simon and Schuster Publishers, New York.

Oysters, by C. M. Yonge. Collins Co., Publishers, St. James Place, London.

Useful publications for oyster farmers of the Maritimes. Fisheries Research Board of Canada, Biological Station, St. Andrews, General Series Circular No. 32.

The glorious oyster, by Hector Bolitho. Sidgwick and Jackson, Publishers, London.

A hydraulic escalator shellfish harvester, by J. S. MacPhail. Bulletin of the Fisheries Research Board of Canada. No. 128, Ottawa, Canada.

How to know the American marine shells, by R. Tucker Abbott. The New American Library of World Literature, Publishers, 501 Madison Ave., New York 22, (75 cents).

Rearing	Phase of oyster culture concerned with growing spat to bedding-size oysters.
Rehabilitation	Restoring disease-affected oyster stocks.
Relay	Fishing oysters in one area, transporting them and planting them in a new area.
Resistant	Able to ward off or withstand disease without adverse effects.
Salinity	A measure of saltiness of water. By 3% salinity we mean that every 100 pounds (10 gallons) of water has 3 pounds of salt dissolved in it.
Shuck	Remove shells of oysters, etc., and prepare meats for consumption or marketing.
Slipper limpet	Mollusc with humped, oval, shell about 1 inch long; often attached to oysters.
Spat	Small oyster that has completed the larval stage and is fixed on the bottom, but has not yet grown to bedding size.
Spring tides	Short series (about 3 days) of tides that rise very high and drop very low; these occur at all seasons of year, usually every second or every fourth week depending on the moon.
Thickness	The thickness of an oyster is the distance between the outer surface of upper shell and outer surface of lower shell measured where the oyster is thickest.
Width	The width of an oyster is the edge-to-edge, straight-line distance across the shells at right angles to the length axis, measured where the width is greatest. (Anatomically, this is actually the height of the oyster. See Fig. 7.).
Wild oysters	Naturally produced (uncultivated) oysters.
Winter kill	Over-winter mortality of oysters, etc. from causes not well understood.

MEANINGS OF SOME TERMS USED IN BULLETIN

Barrel	An oyster barrel contains $2\frac{1}{2}$ imperial bushels (approximately 3 U.S. bushels). It will hold 500 to 600 marketable oysters weighing about 200 pounds.
Barrier beach	Long neck of land, usually sand or gravel, separating a lagoon from open sea.
Bedding oyster	Oyster 2 or 3 years old and $1\frac{1}{2}$ to 2 inches long; suitable for planting on maturing ground.
Biology	Science of living things; includes anatomy, life-history, behaviour, etc.
Board	Fisheries Research Board of Canada, under the Minister of Fisheries.
Conservation	Wise use to insure continued ample supply.
Cultch	Materials used to collect oyster spat.
Cultivating	Stirring up oysters by various means and removing enemies, competitors, old shell, silt, etc.
Department	Canada Department of Fisheries.
Drag	Device for towing over the bottom by a cable or rope from a boat to catch oysters, etc.
Dredge	Same as drag.
Drills	Snails (several species) which feed on molluscs by boring holes in their shells then licking out the meats.
Hibernate	Go into a dormant state during winter.
Intertidal	Beach, etc., that is covered by water at high tide and exposed to the air at low tide.
Jingle shell	Small, flattened shellfish sometimes mistaken for oyster spat.
Larva	Immature stage of an animal, differing in appearance and behaviour from the adult. The oyster larva is planktonic. (Plural, larvae.)
Lease or Leasehold	Part of the sea bottom over which an oyster farmer has legal control under contract with the federal Department of Fisheries.
Length	Length of an oyster is the straight-line distance from the hinge end to the middle of the lip end.
Maritimes	The Canadian Atlantic provinces of New Brunswick, Prince Edward Island and Nova Scotia.
Maturing	Phase of oyster culture concerned with growing oysters from bedding size to market size.
Molluscs	Group of soft-bodied animals, usually with limy shells, including the oyster, scallop, periwinkle, etc., and also squid and octopus.
Picking	Gathering oysters by hand from shallow water.
Plankton	Community of small (usually microscopic) plants and animals that live suspended in sea water independent of the bottom.
Raft culture	Japanese system of growing oysters from spatfall to maturity on chains of shells suspended from floats.

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