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Artificial and Competitive Natural Production of Oysters and Marine Finfish in the U.S. as Determinants of the Need for or Impracticality of Breed Improvements

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Because applied breeding programs can be fully considered only in the context of the industry or fishery to which they relate, background was presented on the U.S. oyster and salmon aquaculture industry - natural and artificial production. This information came from the results of two very recent surveys (1981) of the private marine finfish aquaculture industry in the Northeast U.S. and the other on private marine commercial aquaculture in the Northeast done privately under contract to the National Marine Fisheries Service; also from a 1979 publication in Marine Fisheries Review, from published articles by Matthiessen, 1970 and 1979, by Ryther, 1981, and by Loosanoff and Davis, 1963. Copies of the contract reports and one article were made available to the Genetics Working Group members, and can be obtained through the U.S. Mariculture Committee members. Information on the salmon culture came largely from published articles by Mahnken, Novotny, and Lindbergh.

Survey of Private Marine Finfish Aquaculture in the Northeast U.S.

Less than five small businesses are pursuing marine finfish aquaculture as producers in the Northeast U.S. Indications are that two or three times that number were in operation three years ago. Most finfish aquaculture activity in the Northeast is in the research and development area, predominately in the universities. In 1979 finfish production was less than 90,000 pounds with revenues less than $231,000. There is a wide diversification of methods for marketing and production, with production of bioassay and research specimens most attractive at this time. It was concluded that the state of Maine will most likely have the highest number of private finfish aquaculture endeavors in the next five years due to its general receptivity to aquaculture activity.

Marine Shellfish Culture in the Northeast

At present some 257 businesses pursue marine shellfish culture in the Northeast states. These range from a one-man effort to virtually integrated aquaculture companies reporting multi-million dollar gross annual sales. Shellfish

production had a total value of more than 16 million dollars from aquaculture efforts in '79. However, very little of this involves artificial culture in hatcheries. Yet, depletion of natural seed stock has severely hampered extension or maintenance of aquaculture production levels. The number of aquaculture endeavors in the Northeast has dropped, the reasons being attributed to pollution and disease.

Artificial Production of Oysters in Hatcheries in the U.S.

Oyster production in the U.S. has been diminishing for nearly 80 years and present U.S. production is not even equal to what once came from the Chesapeake Bay alone. Yet, the U.S. in 1972 still produced more oysters (41.7%) than other major producing countries (Japan, 29.1%; Korea, 9.3%; France, 8.9%; and Mexico, 5.6%). Interest in identifying and solving problems of the oyster industry has been substantial. A partial 22-year (1948-72) bibliography devoted almost entirely to oysters cites 4117 references (Joyce, 1972). A limited but important part of the total research efforts concerns hatchery propagation of oyster seed or juveniles. Seed production is an undependable link in the natural reproductive cycle of oysters. Reliance on natural spawning has declined over the years due to factors as physical destruction and pollution of nursery areas, and the practice of growing transplanted oysters in water too cold to induce spawning. Commercial oyster hatcheries developed primarily in response to failures in natural reproduction, notably in New England. Since the early 60s, several private shellfish hatcheries have been constructed to compensate for these failures.

Operating costs and levels of success vary widely for individual hatcheries from year to year. In the case of hatcheries that sell seed oysters, current prices ought to be adequate to show profit during successful years and cover most expenses during average years. Without exception, however, hatcheries experience at some time heavy mortalities during the larval and early juvenile periods. Several hatcheries have closed as a result.

A second factor determining the success or failure of a hatchery is the probability that post-larval stages will survive to marketable size outside the hatchery. The failure of the hatchery-reared seed to survive under natural conditions in any number has frequently been the more serious of the two problems. Juvenile oysters of the cultchless variety stand little chance of survival in nature if planted on the bottom when small. A loss of up to about 70% could be expected and tolerated between the early juvenile stage and completion of the final fourth growing season.

Present Status of the U.S. Oyster Industry by Region with Regard to Prospects for Economic Artificial Culture in Hatcheries for either Private, Commercial Culture or Public Restocking

New England States

The New England States have experienced the sharpest decline in oyster production of any region in North America. In 1910 the four states of Maine, Massachusetts, Rhode Island, and Connecticut produced the same amount of oysters as does the entire U.S. today. These states now have a production less than 2% of their 1910 production. At one time the New England industry was based upon production of seed oysters along the Connecticut shore which were transplanted to private beds elsewhere. The source of supply has diminished as a result of set failure. The steady deterioration of the shoreline environment is believed certainly to be a factor in failure of natural reproduction. The oyster fishery in New England has traditionally been a private fishery and remains so today. As noted above, commercial oyster hatcheries developed primarily in response to failures in reproduction in New England. It is believed that currently very little of the oyster production in New England comes from hatchery operations.

New Jersey and Delaware

Oyster production in these two states is confined for the most part to the Delaware River where in its lower reaches pollution has not been as intensive as in the shallow coastal bays. After 1930 production declined to half the

earlier volume. In 1957 the Delaware River population was almost eliminated by disease. Only recently has production volume increased. The fishery is largely a private one. However, seed beds are state-controlled.

The major problem of the industry is inadequate seed supply. Since 1960, research has concentrated upon methods of producing seed resistant to the MSX disease using hatchery techniques developed in the Northeast. The economic justification for hatchery production is questionable because of the high cost of hatchery operations and the low market value of oysters in this region. Resistance to MSX appears to be hereditary so stocking of spawning beds with resistant oysters has some justification. However, the wild oysters appear to be developing genetic resistance through the action of natural selection.

Chesapeake Bay

Chesapeake Bay traditionally has been the leading producer of oysters in North America. In 1966 the value of the harvest was approximately half the national total. Yet, current production is only a quarter of what it was at the turn of the century. There is little indication of an upsurge in the industry in the near future. Gradual deterioration of seed-producing areas through pollution and siltation must be a factor. However, adverse environmental factors and disease are believed by many to be more incidental to social, economic, and legal troubles in the industry.

The Chesapeake oyster industry is largely a public, though state-subsidized industry. The fishery is conducted in very primitive fashion.

A considerable amount of effort has been directed towards oyster research in this area by federal, state, and private groups. Investigations on the technical and economic feasibility of producing oysters by hatchery methods were initiated at the Chesapeake Bay Laboratory at Solomons, Maryland, and at the Virginia Institute of Marine Science, Gloucester Point, Virginia. Because Chesapeake Bay still has a relatively large supply of wild oysters for harvesting and transplanting, hatcheries probably cannot be competitive here with wild set.

South Atlantic States

The oyster industry of the South Atlantic States - North Carolina, South Carolina, Georgia, and the east coast of Florida - has remained stable during the last several decades, but with only half the reproduction of about the turn of the century. Because of the low market value for local oysters, there is relatively little incentive to farm oysters on a systematic basis. Efforts to do so on a private basis would be resisted by local fishermen or thwarted in many counties by local regulations. Once-productive beds have been polluted - silted over - and relatively little effort has been made to restore beds as by planting cultch. The great majority of the oysters grow intertidally, those below the low tide mark rarely surviving because of heavy infestation by parasites and predation.

Unlike the situation in the states further to the north, reproduction in these states may be so intensive as to create a problem of quality, producing oysters suitable only for canning. Spatfall is almost continuous from May to October and is roughly three to four times as intensive as in Connecticut or Maryland.

Methods of culture that would involve a distinct increase in cost production as hatcheries would have little justification in these states where there is a large amount of potentially suitable growing area and high reproductive potential.

In the past, oysters from the southern states have been planted in Long Island Sound and in the waters of Cape Cod in the hope that they might survive and assume the favorable appearance and flavor of the New England oyster. Unfortunately, survival through the New England winters has been negligible.

Gulf Coast States

Oyster production in the Gulf states - the west coast of Florida, Alabama, Mississippi, Louisiana, and Texas - is unusual in comparison with other regions

in that production volume has remained quite stable since the turn of the century. Today, nearly half of the U.S. oysters are produced in the Gulf of Mexico. However, the value of the Gulf States oysters is the lowest of all the east coast oysters.

The industry, a mix of public and private fisheries, is primitive. It faces various environmental problems - periodic hurricanes, and intrusion of saline water over previously brackish water oyster beds permitting an influx of a serious oyster predator. Pollution with oil and domestic sewage has endangered or eliminated once-productive beds. In most oyster-producing areas of the Gulf, high mortalities occur each year as a result of epidemic diseases, the most common being attributed to the fungus Dermocystidium. In Florida mortalities attributed to disease may be as high as 100% under certain conditions in certain areas. Aransas Bay, Texas, once the leading oyster-producing area in Texas, did not produce any oysters at all for five years as a result of an epidemic disease.

Despite these factors, the Gulf environment is generally favorable for oyster culture. In parts of Florida oysters have grown to a size of five inches in a period of ten months although such growth is exceptional. More typically, an oyster becomes three inches in length one year after setting. Favorable growth and the fact that reproduction is seldom a problem are two advantages not enjoyed by most other oyster-producing areas in the U.S.

In Texas where disease is perhaps the major concern in the industry, a private group has initiated an oyster hatchery program, its purpose being to develop a strain of Texas oyster resistant to local disease and to culture these oysters in coastal ponds.

U.S. West Coast Oyster Industry

The inhibiting effect of cold water is especially prevalent on the U.S. west coast where the Japanese oyster, Crassostrea gigas, is reared. The west coast industry is dependent upon growers being able to purchase oyster seed to restock growing beds.

Prior to '71 the west coast industry was heavily dependent on shipments of oyster seed from Japan. Since '71 substantial and more or less consistent additions to this supply of seed have been available from three natural spawning areas in west coast waters where C. gigas populations have established themselves.

Current emphasis on hatchery techniques to produce oyster seed is motivated by lack of a constant west coast source of seed, and a threefold increase in the cost of Japanese seed between 1960 and 1975. The future of west coast oyster seed hatcheries depends on the interactions of several variables which, together, determine the market for oyster seed. At present the west coast grower can choose among three potential seed sources: 1) imported Japanese seed, 2) domestic and Canadian wild seed, and 3) hatchery seed. Wide variation in the supply of wild seed has provided a difficult marketing environment for planning and developing west coast hatcheries.

The first oyster seed hatchery was built on the west coast in '67 with hopes of competing with Japanese seed. Some seed was sold, but the hatchery eventually failed due to biological problems. It has since then reopened.

During the 1970s other hatcheries were opened, but the total seed sold or produced by all hatcheries and used by growers on the west coast has never been very large. Early in the 1970s the consistent natural sets meant that hatchery seed had to compete with the relatively inexpensive wild seed, as well as the more expensive Japanese seed. The hatcheries were basically unable to compete.

Finally, in 1975 and 1976 when, for practical purposes, no wild seed was collected on the west coast, the growers, especially in Washington, turned to

the hatcheries and requested they produce the tens of thousands of cases of seed the growers needed. After 4 years of being unable to sell seed due to the large natural sets, the remaining hatcheries simply were not in a position to produce so much in such a short time. Thus, orders were sent to Japan in 1976 for seed to be delivered in 1977.

Hatcheries have continued to exist on the west coast despite these problems. Five are in commercial operation, but only one small hatchery of the five is strictly independent of other income sources, and sells seed to west coast oyster growers. Two hatcheries primarily produce cultchless seed, and depend in large part on sales of seed in Europe. The other two commercial hatcheries are associated with organizations which also grow oysters.

Brief Summary of U.S. Salmon Culture

Ocean Ranching

In 1976 there were 154 salmon hatcheries on the Pacific Coast which, together, released 376 million salmon smolt to the ocean. More than half of that production came from Columbia River Basin hatcheries. The current returning migration of these species is very significantly influenced by these hatchery releases, 46% of the coho and 40% of the chinook. Returns now average 1-2% of releases. This average is increasing, and returns as high as 20% have been reported for some hatcheries.

Ocean ranching was until recently restricted to public fisheries. It has now become also a private enterprise in some places. Through complex licensing procedures individuals may build and operate their own hatcheries in return for at least a portion of the adult migration that returns in the states, Oregon, California, and Alaska. Release and return salmon farming is not legal in the state of Washington where there is most interest in salmon farming.

In addition to the large number of Pacific salmon being released, smaller U.S. programs are underway involving the Atlantic salmon. However, it is believed major expansions in this area will probably result from new introductions of Pacific salmon (Ryther, 1981).

Pen Culture

With the ocean salmon fishery dwindling, interest in the farming of pan-sized salmon started developing in the U.S. in the 60s at the Seattle, Washington, laboratory of the National Marine Fisheries Service. Universities in the Pacific Northwest, which had done considerable research on salmon in the past, have begun expanding efforts.

Although some of these cultured fish are reared in ponds, most are reared in floating cages of net-pens. Commercial farms producing coho and chinook salmon have been established at several sites within central and southern Puget Sound in the state of Washington. (Net-pen culture is also practiced by the Washington Department of Fisheries for the purpose of releasing fish to the common property fishery.) Coho salmon is the species of greatest interest because of its resistance to disease and willingness to accept pelleted dry food.

Initial experiments at the Northwest Fisheries Center in '69 showed that it was possible to rear coho salmon from 15 to 340 g in 6 to 8 months and to maturity in an additional 10 to 12 months. When the water is heated to 11.2 to 12.8°C, subyearling coho will grow to 20 g smolt size in 8 months after hatching, compared to the 12-14 months at hatcheries where unheated water is used. By completing growth in saltwater pens, it is possible to grow marketable, pan-sized coho in as little as 14 months from the time eggs are taken.

Saltwater production of pan-sized salmon in the U.S. during the '73-'74 growing season was about 350 metric tons. The bulk of this production came from Puget Sound net-pens, primarily from one grower whose production exceeded the '73 harvest of Atlantic salmon from Norwegian farms, estimated to be 270 metric tons.

Although production is increasing, there are serious limiting factors and profitable operation has not yet been demonstrated. Most growers believe salt-water diseases are the most serious threat to successful commercial salmon farming. The need for research on disease and disease resistance has been emphasized.

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