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THE LEGAL AND INSTITUTIONAL STATUS AND POTENTIAL OF AQUACULTURE IN RHODE ISLAND

THE LEGAL AND INSTITUTIONAL STATUS AND POTENTIAL OF AQUACULTURE IN RHODE ISLAND

THESIS SUBMITTED IN PARTIAL COMPLETION OF THE REQUIREMENTS FOR THE MASTERS OF MARINE AFFAIRS DEGREE, UNIVERSITY OF RHODE ISLAND

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9 APRIL, 1976

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ABSTRACT

THE LEGAL AND INSTITUTIONAL STATUS AND POTENTIAL OF AQUACULTURE IN RHODE ISLAND

As the title suggests this study delves into the legal and institutional aspects of Rhode Island aquaculture with only a minimal reference to the biological parameters. Set against the background of resurging Congressional interest, the current status of aquaculture in the state is reviewed.

The authority of both the federal government and the state over aquaculture is explored, and the legal ramifications of the various potential conflicting uses that aquaculture might induce are illustrated in some detail, the point is made that aquaculture must have adequate legal protection from certain competing uses: however, in Rhode Island there are other entrenched interests which make the favored status of aquaculture unlikely.

The types of aquaculture practiced in Rhode Island are divided into extensive and intensive forms. Current efforts are discussed with accompaning photographs, and depuration is presented as a means for expanding the waters available for aquaculture.

To gain insight into the institutional nature for Rhode Island aquaculture, the relevant state agencies and possible required permits are outlined, along with the impact of existing state laws affecting aquaculture. It is made evident that aquaculture needs to be clearly defined in state law and distinguished from fishing and other marine

related activities. In addition, the question of whether aquaculture should receive special treatment analogous to the development of American agriculture is raised. The legislation of other states is reviewed and it is recommended Rhode Island take positive steps either in the form of legislation similar to the Florida aquaculture or in the state sponsored pilot projects.

SECTION I - BACKGROUND

Chapter I

A. DEFINITION:

Aquaculture is a generic term which encompasses all types of artificial means used to direct aquatic organisms in their growth and development processes. Aquaculture has been defined in various pieces of Federal legislation[1] as "the culture and husbandry of aquatic organisms; the control and management of aquatic plants and animals reared in large numbers in controlled or selected environments for economic or social benefit." Mariculture is that aquaculture carried on in salt or brackish waters. When the term aquaculture is used in this paper, it refers to the conduct carried on in any fresh, brackish, or salt water area depending on which is being discussed. However, primary emphasis will be on activities in the marine environment.

B. THE IMPORTANCE OF AQUACULTURE TO THE UNITED STATES:

Why Aquaculture? There are several reasons:

1. The most obvious is the predicted shortage of animal and plant protein that is already beginning in some areas of the world, with potential to precipitate a food crisis. Massachusetts Institute of Technology through the National Science Foundation has recently completed a study to "identify major gaps in U.S. research efforts for development of protein resources to the end of the century." They recommend effort in 14 areas including aquatic

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[1]H.R. 370, HR 1800, HR 2230, HR 2795, HR 2814, and HR 5565 of the 94th Congress and the NOAA Aquaculture Plan Final Draft, November 1975.

protein, specifically to "study and resolve basic problems affecting economic efficiency and productivity of selected species for production by monoculture and polyculture."[2]

2. It is becoming evident that many of the traditional species of food fish and shellfish are rapidly approaching their maximum sustainable yield.[3] Commercial fish catches presently exceed 70 million metric tons (mmt) per year and are fast approaching the estimated maximum of about 100 mmt per year.

3. Many of the wild stocks of marine fish off of our coasts have been depleted. Haddock, which once flourished in the cold water off Cape Cod, is nearly extinct. The total U.S. fishing catch in I.C.N.A.F. subarea 5 (Georges Bank, Gulf of Maine, Southern New England) has dropped nearly 50% over the last decade. This fact has had an undesirable impact on both commercial and recreational fisheries.[4]

4. Aquaculture has more favorable feed conversion rates and higher productivity rates per unit area than agriculture. The simplest fish ponds of Southeast Asia produce yields in the range of 1 mmt per acre, a production that is impressive by any standard for high-quality animal protein.[5] This yield could be doubled without much increase in

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[2] Ocean Science News, Vol. 18, No. 2, January 9, 1976.

[3] M.A. Robinson and Adele Crisvaldi, "Trends in World Fisheries," Oceanus, Vol. 18, No. 2, (Winter 1975) and Arthur W. Brownell, The North Atlantic Fisheries Crisis, Report to the New England Governor's Conference, Newport, R.I., July 23, 1971. (Boston, Mass., Office of the Commissioner of the Department of Natural Resources).

[4] Ibid.

[5] John H. Ryther, "Mariculture: How much Protein and for Whom?", Oceanus, Vol. 18, No. 2, (Winter 1975), p. 19.

the costs of production. While wild stocks are limited to natural constraints such as predators and limiting factors in the environment, aquaculture is unlimited. In the ideal culture, production is limited only by the fecundity of the species and the food supply.

5. The U.S. is heavily dependent upon imports for its supply of food. This adversely affects the balance of payments and makes impossible any guarantee of a continuous supply. The U.S. fishery production is less than 3 million metric tons (mmt) while U.S. consumption is about 8 mmt. This yields an $800 million dollar balance of payments deficit.[6] Our consumption is several billion pounds live weight and is expected to increase 3 billion more by 1990. The U.S. portion is further accelerated by greater competition from foreign markets which will reduce imports or increase prices, deterioration of fisheries habitat and the use of rivers, lakes, bays, and estuaries for other purposes. Finally, world wide aquaculture has doubled in the last five years, but U.S. production has not kept pace.[7] Aquaculture has yielded about 10% of the world's fish production; however, 3% of U.S. fish supplies come from private aquaculture.

Internationally China ranks the largest in aquaculture with an annual production of 1.2 mmt. She is followed by Japan with 487,000

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[6] Statement by Congressman Murphy, December 10, 1975, at the congressional hearings in the Merchant Marine and Fisheries Committee on HR 370, HR 1900, HR 2230, HR 2795, HR 2814 and HR 5565.

[7] Ibid.

mmt, India with 480,000 mmt, and the U.S.S.R. with 190,000 mmt. The United States is far down the list with 40,000 mmt.

It is clear from these six items that the U.S. could benefit from commercial aquaculture that would augment harvests from wild stocks of fish and shellfish and increase the United States supply of protein food, while concurrently reducing dependences upon imports.

C. THE DIFFUSE NATURE OF THE GOVERNMENT INTEREST AND THE INDUSTRY:

Aquaculture is presently diffused throughout the Federal Government. The Department of Interior has an impact through the U.S. Fish and Wildlife Service. The U.S. Fish and Wildlife Service largest aquaculture related activity is the national fish hatchery system with over 90 installations yielding over 46 species of fish. This activity started in New England in 1871 with the desire to restore anadromous fish runs. The U.S. F. & W. S. also runs two schools for aquaculturists which are open to all interested persons.

The Soil Conservation Service of the Department of Agriculture provides technical assistance on one-half of the total acreage involved in commercial fish ponds. Last year (1974) they spent $1.4 million dollars on aquaculture activities. They supervise over 8,000 ponds and 450,000 feet of raceways.[8]

The Department of Commerce has broad aquaculture interests

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[8] William B. Davey, Deputy Administratof for Water Resources of the Soil Conservation Service, U.S. Department of Agriculture, Ibid.

through the National Ocean and Atmospheric Administration. The University Sea Grant is servicing over 90 aquaculture related projects. The National Marine Fisheries Service is equally involved. The NOAA Aquaculture Plan Final Draft found in the Appendix gives a comprehensive overview of their efforts, both present and future intentions, and forms a basis for development of the proposed National Aquaculture Plan.

The biggest Federal investor in aquaculture has been the Economic Development Agency who has contributed $10 million to the Enominee Indians in Washington for various aquaculture projects, particularly an oyster farm.[9] In the regulatory realm, aquaculture is affected most directly by the E.P.A. concerning discharges, and the F.D.A. with regard to food preparation and interstate shipments of aquaculture products.

Aquaculture may be diffuse in the Federal Government, but the industry itself is diffuse. There are lobsters in Maine; eels, clams, and oysters in the Mid-Atlantic; pompano, shrimp and plants in Florida and the Gulf; oysters, salmon, lobsters on the Pacific Coast; freshwater trout in the Rocky Mountains, Great Lakes and Appalachian Mountains, bait minnows in the Mid-West; and channel cat fish in the Southeast. In addition, the institutions and centers of expertise are varied and diverse. The University of California has the largest and most comprehensive aquaculture program. However, Texas A & M, the University of Rhode

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[9] Mr. Heath, Director, Enominee Aquaculture Project, Billingham, Washington, Ibid.

Island, Virginia Institute of Marine Science and the Woods Hole Oceanographic Institution are actively involved. In addition to being diffuse, aquaculture is not a large industry in the U.S. The total value is estimated between $100-200 million.

Presently, aquaculture provides one-half of all U.S. catfish, more than 40% of the oysters, all of the trout, and 10% of the salmon.[10] The potential of aquaculture both in luxury foods and low value species is tremendous. The National Marine Fisheries Service states that 500,000 acres would yield 2 billion pounds of fish after 25 years of operation. This would be enough for the projected U.S. population of 300 million by the year 2000.

D. THE DEVELOPMENT OF A COORDINATED NATIONAL POLICY AND RHODE ISLAND'S RESPONSE:

As evidenced by the above statistics, the U.S. has a lot to be gained by an active aquaculture program. From the diffuse nature of the U.S. industry, it is clear that the primary needs are for:

1. determination of a national policy
2. coordination of programs and effort
3. information dissemination to the users

Six bills were introduced in the 94th Congress to provide for a national aquaculture program.[11] These bills underwent joint hearings before the Oceanography & Fish & Wildlife Conservation Subcommittees of the House

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[10] NOAA Aquaculture Plan Final Draft, p. 2.

[11] Note 1 supra.

Merchant Marine & Fisheries Committee on the 1st and 2nd of May, 1975, and on the 10th, 11th and 12th of December, 1975, with the likelihood of further hearings in 1976. There is a strong movement afoot in Congress to get a major aquaculture program underway in compliment with the revitalization of the fish industry.

The present series of bills emphasize pilot projects. (see bill in Appendix B) This, however, is subject to change and/or deletion. In any case, those states with interests in aquaculture can anticipate the possibility of increased Federal activity in the areas of the above mentioned three broad needs.

In addition to the new Federal emphasis on coordination, it has become evident that many states put undue restraints on potential aquaculture interests. Permit systems are often bulky and inappropriate. Mr. James J. Sullivan of the University of California Sea Grant noted that it required 12 permits in 4 years before one of their proteges could get into commercial culture.[12] Along with the problem of permits is the situation of discriminatory local laws not designed to contend with modern aquaculture. States are confused on how to classify aquaculture. Some Gulf states treat it as a form of agriculture while Washington incorporated aquaculture into its Shoreline Management Act of 1971. Florida has the nation's only Mariculture Act as such, while Arkansas has the most liberal fish farming (ponds) legislation.

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[12] James J. Sullivan, University of California Sea Grant, hearings, op. cit.

NOAA's Aquaculture Plan outlines the major role of the states as one of establishing laws, policies and administrative procedures which will encourage aquaculture and to maintain high quality environments in bays, estuaries and coastal waters.

In appreciating aquaculture, one must be sensitive to the fact that it is a small industry, highly dependent on time and the continuity of environment both physical, legal and economic. There are substantial environmental variables that affect aquaculture (weather, temperature, disease, water purity, etc.) without the uncertainties of long waits for possible rejected permits or a hostile legal structure.

In view of the foregoing state of affairs and being aware of the importance of aquaculture, the Governor of Rhode Island has delegated to the Rhode Island Fisheries Taskforce specifically the duty to access the present and possible future of the aquaculture industry in Rhode Island. It is toward this mandate that much of the remainder of this paper is directed. A more complete and balanced study is being conducted by the author and Mr. George Seavey of the Rhode Island Coastal Resources Center.

SECTION II - THE LEGAL CONTEXT OF AQUACULTURE IN RHODE ISLAND

The question of the legal context of aquaculture is somewhat of a chicken and the egg question. Some feel that if the economic potential and technical feasibility can be shown, the legal system will more readily respond. Those who feel aquaculture must first prove itself feel that "in the long run the legal system must see aquaculture as one of the many competing offshore water use opportunities."[13]

There are others who feel if aquaculture is to succeed it must first have adequate legal protection. Aquaculture requires exclusive use of water space and a financial investment. The security of any financial investment in the use of the waters for aquaculture depends upon the legal status of such activity. The need for legislation to protect New England aquaculturist has been pointed out by Gates et al and Olsen et al.[14]

What legal authority affects aquaculture? And what legal conflicts develop surrounding aquaculture? It is within the legal context of the State of Rhode Island these questions will be examined.

Chapter II - Authority

This chapter discusses the basis of the legal authority over the practice of aquaculture. The area of concern is divided geographically between the Contiguous Zone on the one hand and the Territorial Sea and Internal Waters on the other.

A. IN THE CONTIGUOUS ZONE:

1. By the Coastal Nation:

The Law of the Sea Convention on the Territorial Sea and the

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[13] H.P. Henry, "A General Legal Perspective," Aquaculture: A New England Perspective, ed., T.A. Gaucher, (Portland, Maine: Research Institute of the Gulf of Maine, 1971) pp. 51-57.

[14] J.M. Gates et al, Aquaculture in New England, (Kingston: University of Rhode Island Technical Report #8., 1974), p. 69 and S.B. Olsen et al, Commercial Marine Fish and Fisheries of Rhode Island, (Kingston: University of Rhode Island Technical Report #34, 1975) p. 45.

Contiguous Zone specifically recognizes the authority of the coastal nation to prevent infringement of customs, fiscal, sanitary or immigration regulations in the Contiguous Zone (art. 24). While the Convention did not specify the width of the Territorial Sea, the breadth of the Contiguous Zone is the area out to 9 miles from the 3 mile Territorial Sea for the United States.

The Convention did not authorize exclusive fishing zones in this area, but most nations do have such zones. The United States established its zone by the Fisheries Zone Act of 1966.[15] As many are aware, the United States will soon go to a 200 mile exclusive fisheries zone. It is not the purpose of this paper to discuss the ramifications of such legislation, but rather to observe that the United States has reserved sole international authority over fisheries matters in the zone.

The question of whether aquaculture should be considered fishing is not clear. Kane feels that "mariculture, for the purpose of regulation, undoubtedly will be considered a fishery."[16] However, fishing operations are transient, while a mariculture operation would require exclusive use of a limited portion of the water body for extended periods of time. The comparison has been to more permanent obstructions like an oil derrick.[17] The oil derrick, however, is directly connected to a particular space in an oil field. Mariculture activities lack this recognized

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[15] 16 U.S.C. 1091-94, P.L. 89-658.

[16] Thomas Kane, Aquaculture and the Law (Miami: University of Miami Sea Grant Technical Bulletin No. 2, 1970) p. 30.

[17] J.O. Smith & D.C. Marshall, Mariculture a New Ocean Use (Athins: University of Georgia, 1974), p. 324.

nexus to the continental shelf.

Whatever the classification of aquaculture, the more mobile activity generally gives way to the fixed activity. Vessels underway are obligated to navigate around less maneuverable vessels, such as fishing boats. Aquaculture unlike oil derricks must not require absolute priority. Rather, a process of reasonable accomodation facilitated by appropriate aquaculture licensing practices will reduce the potential for conflict and enhance acceptance.

2. By Federal or State Government:

The question of the extent of federal or state authority in the Contiguous Zone remains unclear. Generally it can be said that the Federal Government controls activities in the Contiguous Zone. Almost all foreign activity is excluded with the exception of innocent passage; therefore, any foreign protest is unlikely. Since the United States controls the fishery as mentioned above, it seems reasonable that it could create additional fisheries. In addition, the Federal Water Pollution Control Act authorizes the United States to license mariculture in the Contiguous Zone.[18]

It has been argued that while the Fisheries Zone Act and the Outer Continental Shelf Lands Act[19] clearly did not allow the extention of state authority beyond the three mile territorial sea, they did not diminish any states rights that did exist. In Skiriotes v. State of Florida,[20]

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[18] Federal Water Pollution Control Act Amendment of 1972, 33 U.S.C. 1328 (supp. 1973), amending 33 U.S.C. 1151 (1948).

[19] 43 U.S.C. 1331 (1970).

[20] 313 U.S. 69, 61 S. Ct. 924, 85 L. Ed. 1193 (1941). see also Kane op. cit., pp. 31-33.

the U.S. Supreme Court upheld the state's right to exercise its jurisdiction beyond its territorial waters, where the fishery was of particular interest to the state---in this case, the sponge fishing in Florida.

> . . . If the United State may control the conduct of its citizens upon the high seas, we see no reason why the State of Florida may not likewise govern the conduct of its citizens upon the high seas with respect to matters in which the state has a legitimate interest and where there is no conflict with acts of Congress.

Should the question arise over state conflicts with acts of Congress in the Contiguous Zone, the matter would probably have to be resolved in the courts.

B. IN THE TERRITORIAL SEA:

1. Federal Control:

In the Territorial Sea and Internal Waters, the authority of the United States is complete and undisputed. This fact is recognized in International Law by the Convention on the Territorial Sea and Contiguous Zone. The Federal Government has paramount authority. Article 18 of the United States Constitution gives the Congress power over interstate commerce and foreign commerce. The Rivers and Harbors Act of 1899 created the authority of the Army Corp of Engineers to control any obstructions to navigation. In United States v. Appalachian Electric Power Co., the Supreme Court held that congressional authority over navigable waters is as broad as the needs of commerce.[21] In addition to commerce, the

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[21] 311 U.S. 377, and 426-27, From Smith & Marshall, Op. cit., p. 315.

federal government has authority over the territorial seas for purposes of pollution abatement. (Federal Water Pollution Control Act Amend. of 1972)

2. State Control:

While the federal government has paramount authority in areas where it has legislated (commerce and pollution), the states are free to act in the absence of conflicting federal legislation. The Submerged Lands Act of 1953[22] released and relinquished to the states all right, title and interest of the United States to the lands, improvements, and natural resources beneath the navigable waters within state boundaries out to 3 miles. The states, through this Act, have exclusive authority within state boundaries over fish, shrimp, oysters, clams and other marine animals. This last phase appears broad enough to cover any aquaculture project envisioned.

The context of conflicting congressional legislation is illustrated in Corsa v. Tawes.[23]

> Since the decision in Manchester v. Commonwealth of Mass., 1890, 139 U.S. 240, 11 S. Ct. 559, 35 L. Ed. 159, it has been beyond dispute that in the absence of conflicting congressional legislation under the Commerce Clause, regulation of the coastal fishing is within the police power of the individual states. . . Congress has not sought to impose uniformity, but has been content to leave the matter to local authority and has recently made this intention explicit in the Submerged Lands Act of 1953 . . .
>
> (emphasis added)

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[22] U.S.C. 1311 (1964).

[23] 149 F. Supp. 771 (D. Md. 1957) aff'd 355 U.S. 37, 78, S. Ct. 116, 2 L. Ed. 2d 70. From Kane Op. Cit., p. 35.

States have the right to control their fisheries for the public good subject to the framework of their constitution. In Rhode Island the constitution provides in Article 1, Section 17, until a recent amendment, that:

> The people shall continue to enjoy and freely exercise all the rights of fishery, and the privileges of the shore, to which they have been heretofore entitled under the Chapter and usages of this state.

Under the recent constitutional amendment of 1970, the following clauses were added:

> ...and they shall be secure in their rights to the use and management of the natural resources of the state with due regard for the preservation of their value; and it shall be the duty of the general assembly to provide for the conservation of the air, land, water, plant, animal, mineral and other natural resources of the state, and to adopt all means necessary and proper by law to protect the natural environment of the people of the state by providing adequate resources, planning for the control and regulation of the state and for the preservation and restoration of the natural environment of the state.

The major value of the amendment was to make extremely clear the fact that the General Asembly has a duty to enact legislation in this area and the necessity to be guided by ecological concerns when doing so.

Although under Section 17 the people should continue to enjoy the privileges "to which they have been heretofore entitled" regulation of shellfisheries and fishing from boats was a well established practice before the constitutional provision.[24] The broad power of the General Assembly to regulate fishing is evident from Payne and Butler v.

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[24] State v. Collens, 2 R.I. 561 (1850); State v. Medbury, 3 R.I. 138 (1855); New England Oyster Company v. McGarney, 12 R.I. 385 at 392 (1879).

Providence Gas Company, p. 327.[25]

> "Therefore the whole subject of fisheries, floating and shellfish, and all kinds of shellfish whether oysters, clams, quahogs, mussels, scallops, lobster, crabs, or fiddlers, or however they may be known and designated and wherever situated within the public domain of the State of Rhode Island are under the fostering care of the General Assembly. It is for the legislature to make such laws regulating and governing the activities of lobster culture, oyster culture, clam culture or any other kind of pisciculture, as they may deem expedient. They may regulate the public or private fishery; they may even prohibit fee fishing for a time and for such times as in their judgement it is for the best interest of the state so to do. They may withhold from public use such natural oyster beds and clam beds as they may deem desirable. They may make a close time within which no person may take shellfish or other fish and generally they have complete dominion over fisheries and fish as well as all kinds of same. We find no limitation in the constitution of the power of the General Assembly to legislate in this regard and they may delegate the administration of their regulations to such officers as they may see fit."

It is obvious then, the General Assembly was within its powers when it created the Coastal Resources Management Council. The Council has broad authority over any person, firm, or governmental agency proposing any development or operation within, above or beneath the tidal water below the mean high water mark, extending out to the extent of the state's jurisdiction in the territorial sea (G.L.R.I. 46-23-6 (B) as amended).

Specifically related to aquaculture, the Council may "issue, modify or deny permits for any work in, above, or beneath the water areas under its jurisdiction, including conduct of any form of aquaculture."

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[25] 33 R.I. 211

(G.L.R.I. 46-23-6 (D)(a) as amended) The Council is granted authority to investigate complaints alleging violations of state laws or riparian rights in the state's tidal waters (G.L.R.I. Section 46-23-6 (D)(f) as amended). The Council is also charged to examine programs and proposals comprehensively, considering their long-term benefit to the people of this state, as well as short-term exigencies. The potential of aquaculture as an employer and major food source in the future will obviously weigh in the Council's considerations. This concept of the greater public good in regard to state control of fisheries has been clearly expressed in State v. Cozzens,[26] and State v. Kofines.[27] In Cozzens the right of the legislature was upheld to create regulations which provided incentives to private entrepreneurs in securing the benefit of all the people.

> "...the commissioners feel the public is benefited more from use of the land as a private oyster bed under lease than as a public bed." ...The object of these sections is not the benefit of the lesees of the private bed, but by holding out motives to them to plant and cultivate oysters to secure to the public a more abundant supply.

This same logic should apply to other forms of aquaculture today.

The primary right of the public was affirmed in Kofines.

> As all the inhabitants of the state --- are interested in the franchise and as all cannot fish for lobster, and but comparatively few do, it is manifested that if the interest of all are to be conserved the fishing must be carried on for the ultimate benefit of the people of the state and not merely for the profit and involvement of the fishermen engaged in the business whose conduct in the premises must be unselfish enough to include the interest of those who cannot personally attend to the matter. (p.224)

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[26] 2 R.I. 561 (1850).

[27] 33 R.I. 211

While the control of the Coastal Resources Management Council is paramount in the area of aquaculture, the General Assembly has delegated authority to other state bodies that would also have an impact on aquaculture. These agencies will be discussed further in the section "Permits for Aquaculture" below.

Chapter III - Use Conflicts

Aquaculture by its nature involves potential conflict with established prior uses. In this section the intent is to discuss some of the more common conflicts and the legal position of aquaculture.

A. RIPARIAN RIGHTS:

"Riparian" refers to nontidal waters or that of a river. "Littoral" means the waters of a lake, sea, or other tidal body. For the purposes of this discussion, riparian will be used for both. In general, the riparian landowner by virtue of his location adjacent to a body of water has certain rights on that water. These rights are based in common law unless the state modifies them by statute. Some of the generally accepted riparian rights are those of ingress, egress, boating, bathing, fishing, and the right to an unobstructed view. These rights are passed on by title or lease. They are however, subject to reasonable regulation for the greater common good. There are also riparian rights which are defined by law.

The riparian right of ingress and egress entitles the landowner to access upon the water from his property to the navigable point of the

stream, lake, river, canal, etc., in front of his land.[28] The riparian owner has no title or ownership in this water, but only has the right of access for navigation or other lawful reason.[29]

This right means in general that an aquaculturist must avoid blocking the riparian's access by dams, dykes, or other obstructions in small bays, lagoons or creeks (a practice in Oregon's salmon and trout culture). He must not completely screen off an area in front of another's land or for example use rafts (oyster culture) that would block access.

However, the riparian rights are not absolute or without limitations, nor do they extend to the use of the entire body of water. An aquaculturist must cause substantial impairment to the landowners riparian rights before the riparian can hope to gain legal relief.[30] If the area of culture is not too large and/or is easily circumvented without hardship then such slight impairment probably would not warrant compensation. If, on the other hand, access to the main body of the water or at least to the navigable waters adjacent to his lands is denied, the riparian landowner could argue for compensation for the loss of his legal rights of ingress and egress.[31] Even if the aquaculturist has a lease from the state (G.L.R.I. 20-10-1, as

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[28] U.S. v. Rands, 389 U.S. 121, 88 S. Ct. 265, 19 L. Ed. 2d 329 (1967).

[29] Shively vs. Bowlby, 152 U.S.1, 14 S. Ct. 548, 38 L. Ed. 331 (1894).

[30] Kane, op. cit., p. 40.

[31] Ibid. pp. 38-44

amended), he must still take care not to affect the riparian owner's rights.

This situation is changed if the aquaculturist is himself the riparian owner. If he causes no interference with adjacent owners, then no legal complications arise. However, he may find violations of his own riparian rights vital, if such violations affect his culture activities.

The courts have been divided in the interpretation of riparian rights. In Colberg, Inc. v. State of California[32], the riparian owner lost 81% of his business due to 2 low highway bridges being built. Through some tortured reasoning the bridges were held to be an improvement to navigation which was considered to be in the public interest of commerce. By means of navigational servitude, the court decided for the state saying the general welfare is best served through the utilization of navigable waters for bridges, in this case. In Webb v. Giddens,[33] the situation was similar with land fill rather than a bridge being the object which denied access to the main body of a lake. However, the court decided in favor of the riparian saying "that this right would be virtually meaningless unless he were allowed access to the main body of the lake".

Generally, leases are subject to an implied reservation by the state of its paramount right to enter during the term of the lease and make improvements for the benefit of navigation even though such entry and improvement might injure the lessee. The state would not be liable for damages due to the

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[32] 67 C. 2d 408, 62 Cal. RPTR, 401, 432 P. 2d 3(1967); cert. den. 390 U.S. 949, 88 S. Ct. 1037, 19 L. Ed. 2d 1139 (1968).

[33] 82 So. 2d 743 (Fla., 1955).

improvements but would be liable for damages through negligence. A classic case of this navigational servitude is found in Rocky Point Oyster Co. v. Standard Oil Co.[34].

Another riparian right is that of an unobstructed view. This is a common law right subject to Rhode Island statute; however, this writer has found no legal opinion on the subject. As Rhode Island has many areas of exceptional visual aquatic delight, it is undoubtedly of concern to property owners who enjoy their view. This right, like the right of egress and ingress cannot be taken without compensation, and likewise if the unobstructed view is only slightly impaired, no compensation will be granted.

Most of an aquaculturist's equipment is underwater and what rafts or stakes that might be involved only stick up a few feet. It seems unlikely then that aquaculture would run the risk of obstructing the view and incure the required payment of compensation.

It is also generally considered a riparian right to be able to dredge a channel to the navigable part of the stream. However, this "right" is subject to the consent of the State and Federal government. The Army Corps of Engineers approval is required at the Federal level. At the State level, the Coastal Resources Management Council must be approached. It is unlikely that a private dredge operation would be permitted so close as to allow silting or damage to an established aquaculture project.

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[34] 265 F 379 (1920).

B. NAVIGATION:

Navigational conflicts with aquaculture in Rhode Island start at the territorial sea (3 mi) and work landward. While it is unlikely that offshore aquaculture will flourish in Rhode Island, the potential for conflict warrants a brief discussion. Under international law, foreign vessels have the right of "innocent passage" through the territorial sea. Article 15 of the 1958 Geneva Convention on the Territorial Sea and Contiguous Zone states:

1. The coastal state must not hamper innocent passage through the territorial sea.
2. The coastal state is required to give appropriate publicity to any danagers to navigation of which it has knowledge, within its territorial sea.

These statements do not prohibit aquaculture, but the location and dangers must be announced. In addition, foreign vessels must comply with local laws during their innocent passage. If aquaculture is a legally constituted activity and not so large that it unreasonably obstructs navigation, little conflict with international navigation should result.

The public has the right to use the navigable waters of Rhode Island for navigation. This right is paramount to all other rights but is subject to reasonable interpretation.35 This right is also protected by the federal

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35 Rogers v. Tallman & Mack Fish Trap Co., D.C.R.I. 1964, 234 F. Supp. 358.

government.[36] The right of navigation is, however, subject to regulation and the state can lawfully use its police power to impose reasonable restrictions. This regulation falls under the guise of the state's public purpose doctrine. Rhode Island should have no difficulty reasonably restricting the public right of navigation if a more desirable public good were in conflict with it. Should aquaculture be determined a desirable activity, it would not be allowed to totally obstruct navigation. Its location should be out of the main channel as much as possible so as to force only a "reasonable" detour in navigation. Some of the major navigational activities are shown on Map No. 1.

The aquaculturist who wishes to obstruct navigation for aquacultural purposes by building dams, dykes, screens, rafts or otherwise exclusively using navigable waters must first get state permission. In Rhode Island this means he must receive the approval of the Coastal Resources Management Council. The other state agencies involved are outlined below in the section "Permits for Aquaculture." The Council can base its approval on the aforementioned statute giving them authority over aquaculture permits and the "public purpose," "public interest" or "public welfare" doctrine. The legal basis of the Council would be further solidified by specific mention of aquaculture in the development of Rhode Island's Coastal Zone Management Plan.

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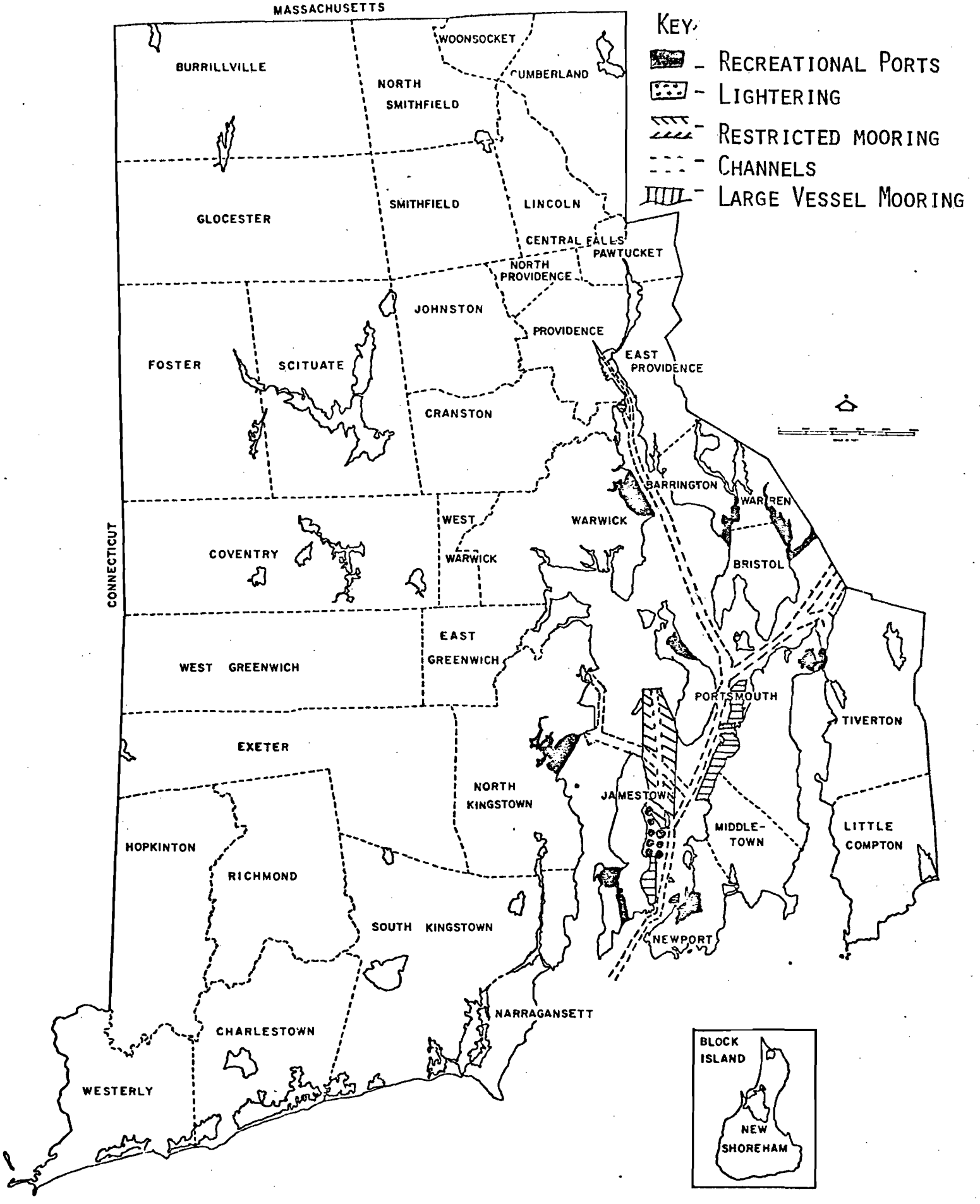
[36] Cummings v. City of Chicago, 188 U.S. 410, 23 S. Ct. 472, 47 L. Ed. 525, (1903).

MAP NO. 1 : POSSIBLE NAVIGATIONAL CONFLICTS WITH AQUACULTURE IN NARRAGANSETT BAY

State of Rhode Island



Once obtaining state approval, the aquaculturist must get federal approval. The Army Corps of Engineers must give permission to construct dams, dykes, bridges (33 U.S.C. 401), wharves, piers, jetties or other structures (33 U.S.C. 403) before commencing construction. Presently, the Army's authority stems from the Congress's power over the navigable waters of the U.S. to further commerce.[37] The passage of the National Aquaculture Act mentioned earlier would further clarify the Nation's interest and the Army's control over Aquaculture.

C. FISHING:

The right to fish in public waters is a common law right. The court in Rhode Island has stated in Nugent v. Vallone,[38]

> While the state holds title to soil under public waters of the state, it holds such title not as proprietor but only in trust for the public to preserve rights to fishing, navigation, and commerce in such waters.
>
> (emphasis added)

The right to fishery is also protected in the Rhode Island Constitution as was mentioned earlier. If someone wants to conduct aquaculture in public waters, is he allowed to? This became a question of what is in the best interest of the people of Rhode Island. As has been said, the Management Council and other concerned state agencies work under the "public purpose," "public interest" or "public welfare" doctrine. To avoid lengthy litigation,

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[37] U.S. Constitution Art. 1, Sec. 8 cl. 3, and the Rivers and Harbors Act of 1899.

[38] 91 RI 145, (1960)

Rhode Island should enact legislation specific to aquaculture defining its importance to the public interest.

Rhode Island is unique in its large recreational fishery. Aquaculturist should take care to cause the least possible conflict with sport fishing and recreational shellfishing. These interest groups form a powerful lobby. If aquaculture was unfortunate enough to locate in prime natural shellfishing areas, it is certain that aquaculture's contribution to the public interest would be in question. See Map No. 2 for areas of high recreational shellfishing activity.

If the aquaculturist owns his own pond or is in private waters which are non-navigable, then there are no conflicts as the right of fishing belongs to the owner of the soil under these waters. However, in the case of a stream, the owner must have "due regard" for the riparian rights of those upstream or downstream.

> He cannot lawfully kill, materially injure, or obstruct the free passage of those he does not take.[39]
> (emphasis added)

From this it would appear the aquaculturist cannot dam or dyke a stream even on his own property to carry on aquaculture. Once again though the state can legislate for the public good to allow such activities, but the riparian owners would have to be compensated for their loss. Presently, the Department of Natural Resources has general control over cultivation and protection of inland fish (G.L.R.I. 20-4-5) and there is specific legislation against "all obstructions erected to hinder the passage of fish". (G.L.R.I. 20-4-10)

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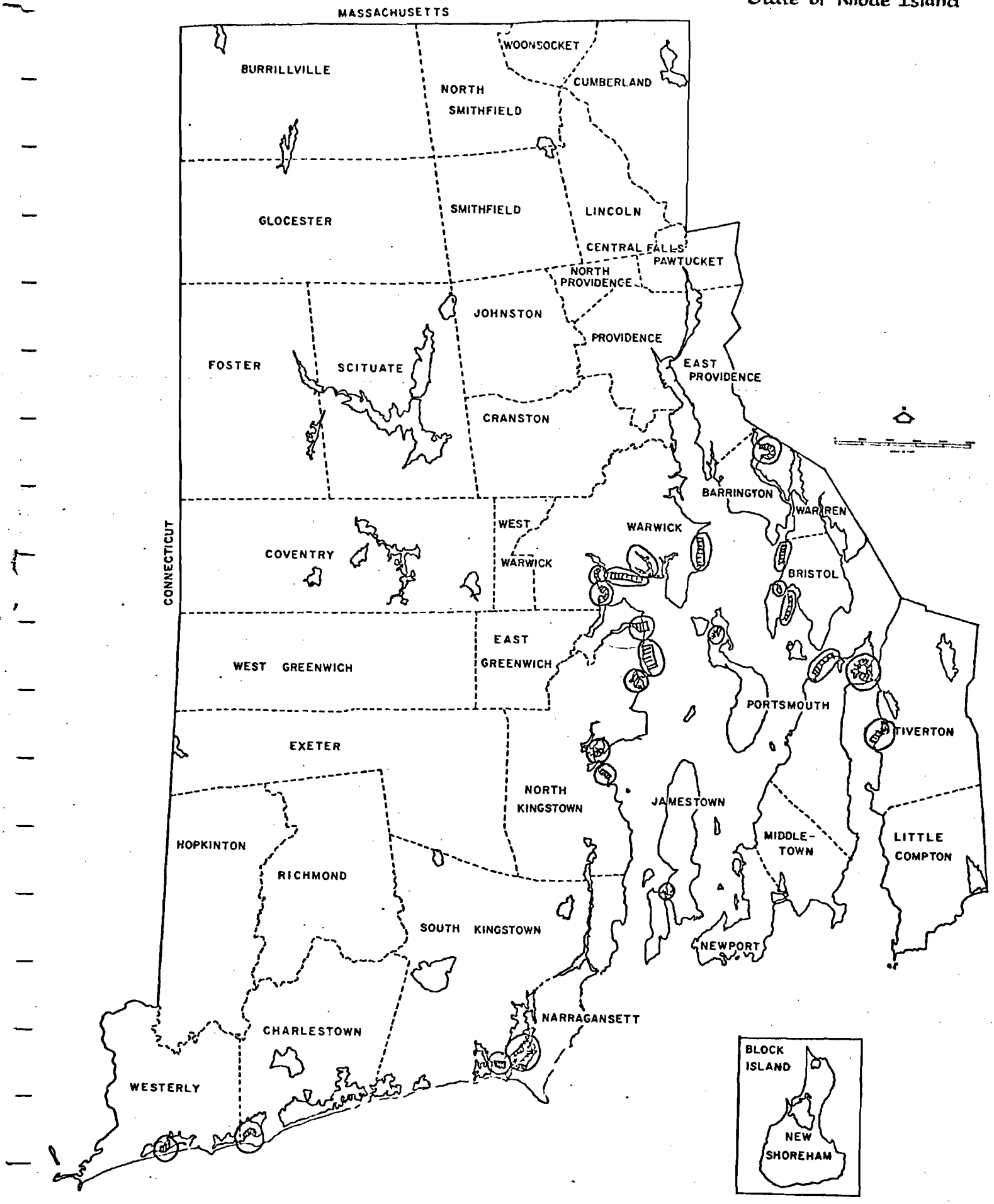
[39] State v. Haskell, 84 Vt. 429, 79 Atl. 852, 854 (1911).

MAP NO. 2 : AREAS OF HIGH RECREATIONAL SHELLFISHING ACTIVITY

State of Rhode Island



DATA FROM GEORGE SEAVY, COASTAL RESOURCES CENTER

D. RECREATION:

The rights of recreation have traditionally been the use of the navigable waters of the state for such things as bathing, boating and fishing. These recreational rights are not absolute or private rights, but are rights subject to regulation by the police power of the state. This fact was demonstrated in City of Miami Beach v. Elsalto Real Estate.[40]

> ...the police power should be exercised by municipal officials to afford all of the people light, air and an opportunity for recreation.
>
> (emphasis added)

This police power can be used both to authorize or deny recreation. Once again, the public purpose doctrine of the state comes into play. If aquaculture was deemed to have the greater importance, the state could grant the use of an area of public water to aquaculture at the expense of recreation.

In Rhode Island, recreational uses of the water are a firmly intrenched interest. Very careful consideration would be necessary to determine the value of recreation verses that of aquaculture. Presently, it is likely that the need and benefit of recreation both for present and future generations would dominate the decision making. However, aquaculture may become an important source of food. "Whether or not water areas should be leased for aquaculture or developed as recreational facilities may depend to a large extent upon the availability of food in the future to feed the people of the United States and the basic policy choices which will have

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[40] 63 So. 2nd 495 (Fla. 1953), Found in Kane op. cit. p. 70.

to be made in the future. Obviously, it is more important to feed the populace than to assure them of a place to recreate. It is a complex problem of priorities which should receive considerable study."[41]

E. WATER QUALITY:

Pollution is a serious problem for aquaculture both in its effect on projects and the fact that aquaculture can be a source of pollution.

In dealing with pollution, the federal government has left to the states the primary authority to deal with the problem as is noted in 33 U.S.C. Section 466.

> In connection with the exercise of jurisdiction over the waterways of the Nation and in consequence of the benefits resulting to the public health and welfare by the prevention and control of water pollution, it is declared to be the policy of Congress to recognize, preserve, and protect the primary responsibilities and rights of the states in preventing and controlling water pollution.
>
> (emphasis added)

However, the federal government has enacted pollution legislation. The first was the Rivers and Harbors Act of 1899 (33 U.S.C. Section 407), which prohibits the throwing, discarding or discharging of any refuse matter of any kind or description in the navigable waters of the U.S. The most sweeping has been the Federal Water Pollution Control Act Amendments of 1972 (33 U.S.C. Section 1151) which gives the Environmental Protection Agency broad powers to limit all forms of water pollution. This act specifically requires the EPA "to establish procedures and

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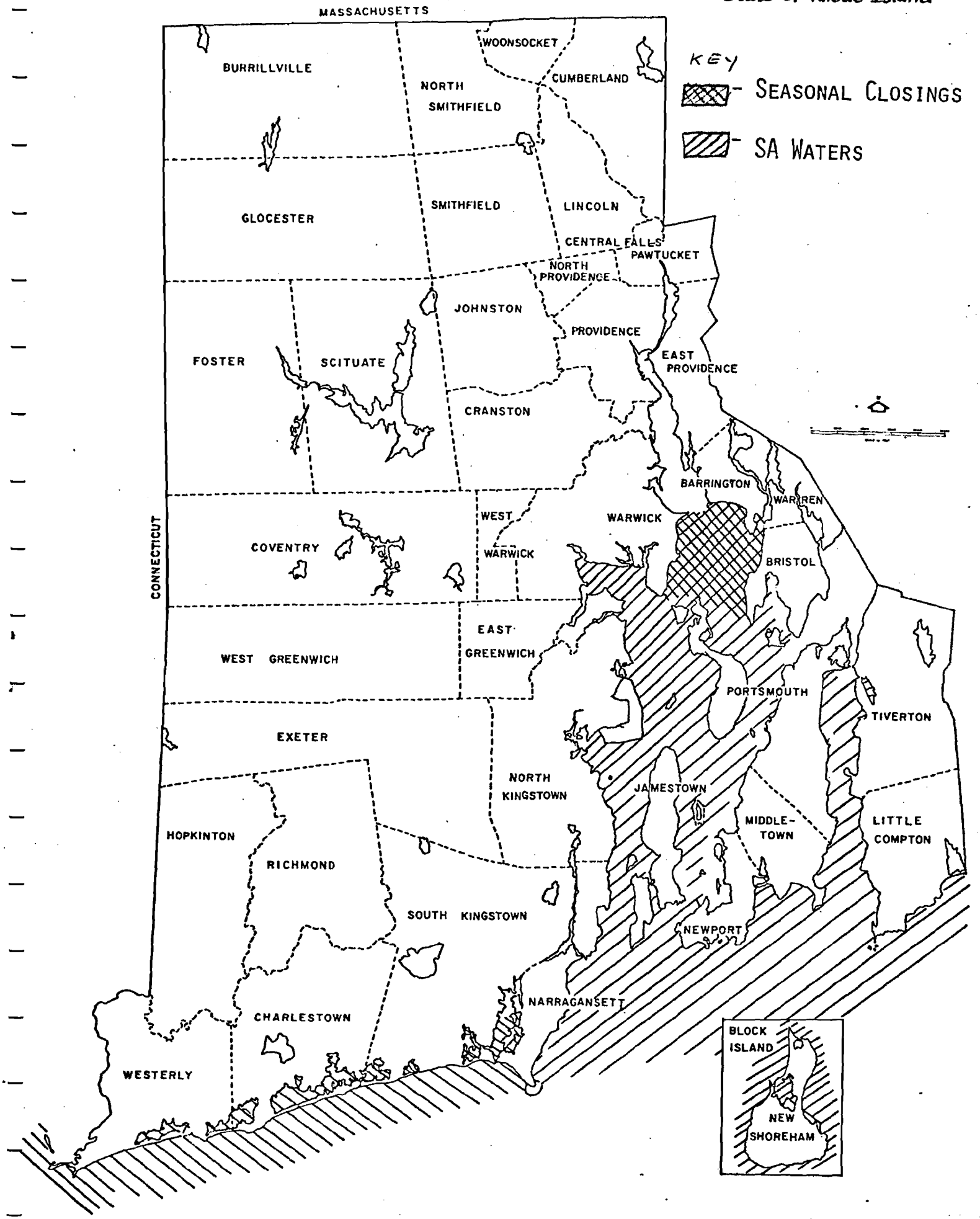
[41] Kane op. cit. p. 71.

guidelines --- to permit the discharge of a specific pollutant or pollutants under controlled conditions associated with an approved aquaculture project..." (Section 318). These procedures and guidelines have been a subject of much concern to American aquaculturist as they may severely affect the way they do business. After repeated delays the guidelines are expected to be released in mid 1976. Certain interim guidelines are explained under the section below - "Permits for Aquaculture."

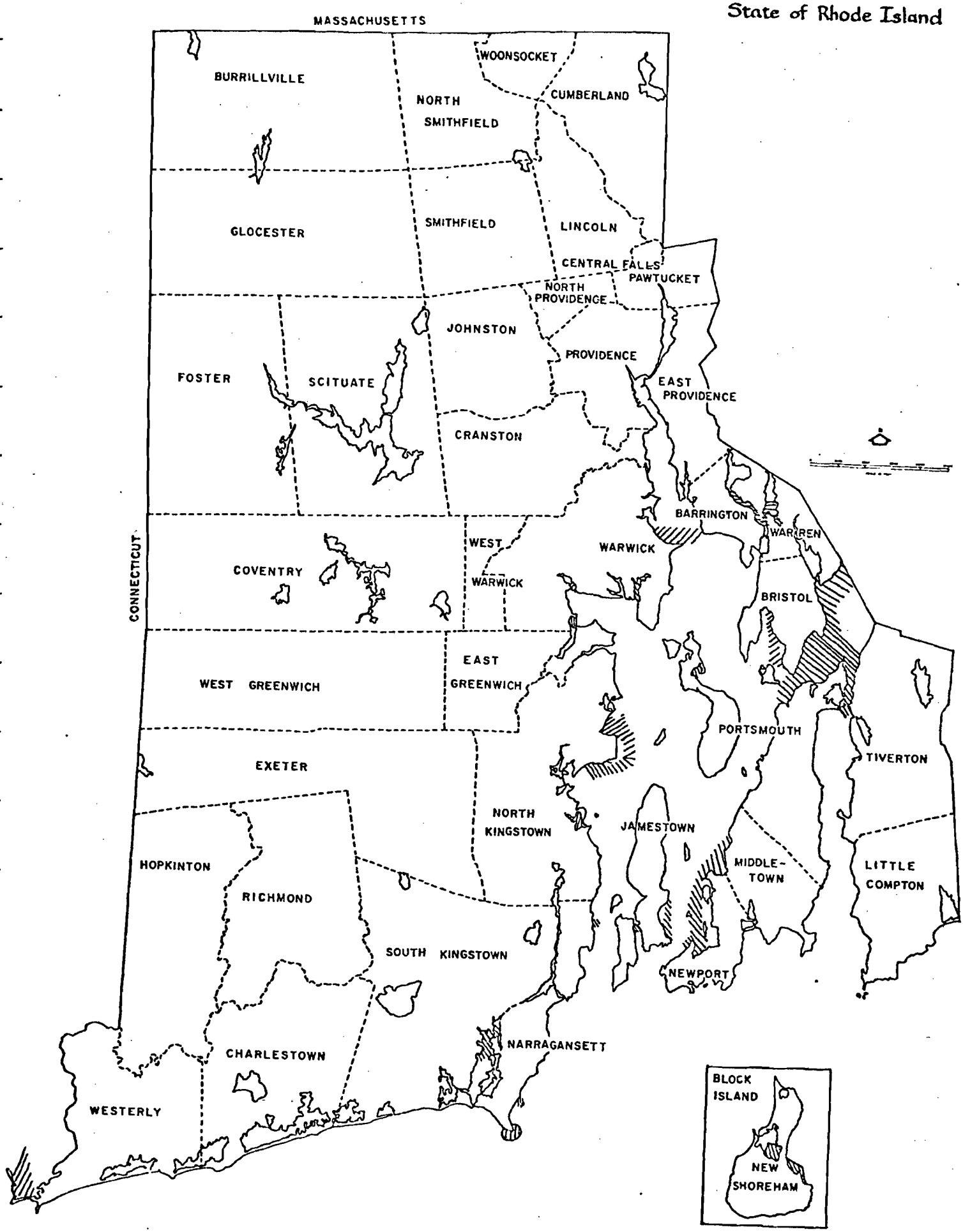
In the State of Rhode Island, the Director of the Department of Health is charged with the prevention, control and abatement of new or existing pollution of the waters of the state (G.L.R.I. 46-12-3). To do this, the DOH may order the adoption of pollution prevention equipment that is practicable or reasonably available (Section 46-12-8) and may prosecute violators. The Coastal Resources Management Council has control over land use for sewage treatment facilities. One would hope the Management Council would not permit sewage treatment adjacent to an established aquaculture project.

The Department of Health has classified the waters of the state. Map No. 3 shows the areas of Class SA water which are suitable for aquaculture. Map No. 4 shows the areas of Class SB waters which would be suitable for aquaculture if depuration is carried out. More will be said on this in the section below on "Types of Aquaculture Practiced in Rhode Island." Map No. 5 shows the areas of Class SC and SD waters which would be closed to aquaculture.

MAP NO. 3: SHOWING CLASS SA QUALITY WATERS

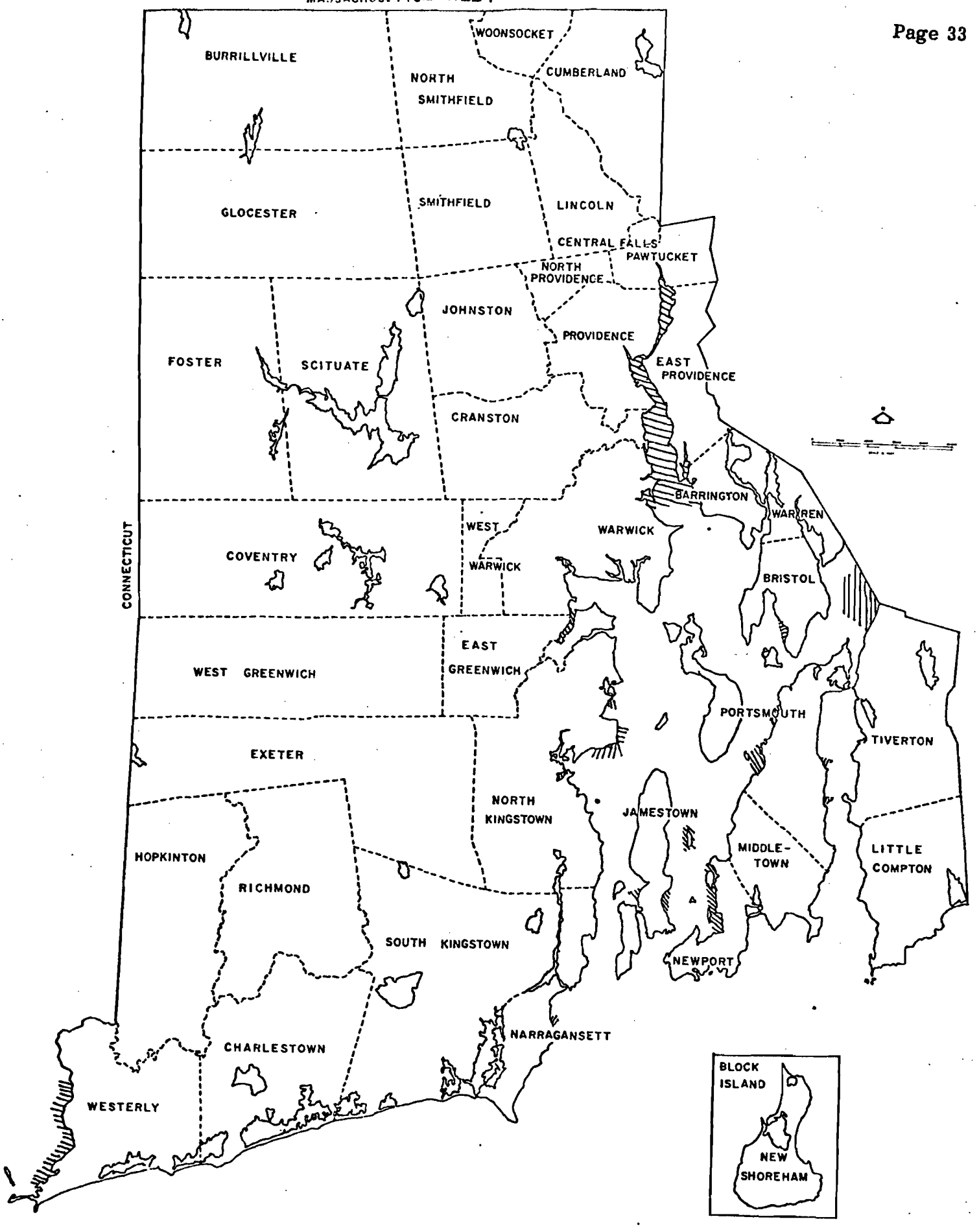


State of Rhode Island



MAP NO. 5: SHOWING CLASS SC & SD QUALITY WATERS WHERE NO AQUACULTURE WOULD BE ALLOWED.

State of Rhode Island



Should an aquaculturist be compensated for damages caused by pollution? Because he must obtain a lease and expend money to establish his activity, it seems logical that he should. However, with regard to municipal waste, there is no uniform legal treatment. Virginia,[42] for example, has held that the aquaculturist by his lease obtained only the right to plant and propagate the cultivated species and did not receive any other rights by the lease. This means "the use of tidal waters for discharge into them of sewage is a public use."

On the other hand, many states have determined that the aquaculturist can collect damages for sewage damage. The case is treated like any other leased property in which a substantial investment has been made. This writer is unsure how Rhode Island would view the matter as no relevant court cases have been unearthed. It is true that numerous oyster beds in the upper regions of Narragansett Bay have been damaged or destroyed by sewage and other pollutants.

As far as industrial pollution goes, the aquaculturist has a good case for damages. In Payne and Butler v. Providence Gas Co., the court found that

> Anyone who deposits shellfish in public waters, not a natural oyster or quahog bed, for the purpose of culture and growth, and defines the land so as to give public notice of the fact that he has exclusive possession of the same, and in an action for injury caused to said shellfish, sufficient title is shown by proof that he was in possession under a claim of right not disputed by anyone having a better title. (31 RI 295 (1910)).

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[42] Darling v. City of Newport News, 123 Va. 14, 96 S.E. 307, 3ALR 748 (1918).

Commonwealth v. City of Newport News, 158 Va. 521, 164 S.E. 689 (1932)

From Kane Op. Cit. pp. 74-75

In this case damages were paid for oil pollution of oyster beds. It would appear that any type of authorized aquaculture whether by permit or lease would be protected against industrial pollution. This fact has been repeatedly observed by Iverson[43] and is further substantiated by G.L.R.I. 20-10-22 which states that oysters in private beds are the personal property of the lessee.

Documented cases of damage to aquaculture from industrial pollution are rare. Often the results are manifested in an indirect manner - lowered oxygen concentrations, lowered PH and/or increased turbidity. Three examples serve to underscore the enormity of the problem.

One of the best documented and most quoted cases of alteration of a culture operation is that associated with the expansion of duck farms adjoining the oyster fishing of Moriches Bay and Great South Bay,[44] Long Island, New York. Organize matter and nutrients originating from untreated waste from these duck farms completely altered the ecological characteristics of the two embayments into which the effluents emptied. The most striking effect was a change in the types of dominant phytoplankton present. Unfortunately, the forms of phytoplankton encouraged by the eutrophicated conditions were not suitable for oyster growth and oyster production declined.

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[43] E.S. Iverson, Farming the Edge of the Sea (London: Fishing News (Books) Ltd., 1968) p. 251.

[44] William E. Odum, "The Potential of Pollutants to Adversely Affect Aquaculture," Gulf and Carribbean Fisheries Institute Vol. 25:1973, p. 170.

The disaster associated with Japan's Minamata Bay (mercury poisoning) and the James River, Virginia (kepone poisoning) demonstrates the potential of industrial effluents to severely disrupt inshore fisheries and aquaculture.

The use of power plant effluent has in some cases resulted in contamination of aquaculture. The Chalk Point Power Plant, Maryland, produced oysters with green meat and high copper concentrations due to erosion of copper from condenser tubes. The continual use of low levels of chlorine, used by many generating stations as a treatment for prevention of condenser slimes and fouling organisms, has been shown to reduce the growth of mussels and clams.[45]

On the other side of the coin, Aquaculture, like many other industries, has the potential to generate pollutants for which the aquaculturist may be held legally responsible. Some of the pollutants created by operations include both organic materials originating from excess primary production or inefficient supplemental feeding and toxic compounds such as herbicides, pesticides and fish poisons used to control unwanted animals and plants. It is possible to utilize excess organic effluents for beneficial purposes such as culturing additional algal and animal species.

Construction of aquaculture facilities can result in physical

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[45] Ibid, p. 170.

alteration of the environment - including changes in circulation patterns, increased sedimentation, interference with freshwater input to the estuary, and direct destruction of productive areas. Intensive raft-culture may interfere with natural estuarine production.[46]

F. DREDGING AND FILLING:

The Coastal Resources Management Council has authority over any development or operation within, above, or below the tidal water.... (G.L.R.I. 46-23-6 (b)) and this would include dredging and filling. The silt caused by this type of activity could destroy an aquaculture activity.

The United States is liable for damages caused by dredging and filling in navigable waters. The recovery of damages has been authorized in the court of claims by 28 U.S.C. Section 1497, and there is a long series of cases which allow the oyster culturist to recover damages.[47]

The same burden appears to apply to dredging and filling by individuals. In Taylor v. Barton, C.C. & N.Y. Canal Co.,[48] the

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[46] For a complete discussion of aquaculture as a source of pollution, see W.E. Odum, "Potential Effects of Aquaculture on Inshore Coastal Waters," Environmental Conservation, Vol. 1, No. 3, Autumn, 1974.

[47] H.J. Lewis Oyster Co. v. United States, 107 Supp. 570 (Ct. of CL., 1952); Slipp v. United States, 68 F. Supp. 205 (Ct. of CL., 1946); Beacon Oyster Co. v. United States, 63 F. Supp. 761 (Ct. of CL., 1946); from Kane Op. Cit., p. 79

[48] 224 Mass. 307, 112 N.E. 650 (1918) from Kane Op. Cit., p. 80.

Massachusetts court awarded damages for the destruction of oyster beds due to the excavating and dredging of the Cape Cod Canal, while the right to such damages is fairly clear, legislation enabling claims to be made for all types of aquaculture at the state and local level would help eliminate unnecessary litigation and expense to the aquaculturist.

G. LAYING OF PIPELINES AND CABLES:

The CRMC has authority similar to that over dredge and fill under G.L.R.I. 46-23-06 (B). An aquaculture lease is a property right[49] and the culturist would have to be compensated for a "taking" if a cable or pipeline were authorized through the area of his activity. The question of the predominant public good must be considered when the two activities come into conflict. The balancing of public uses should be considered in before granting an aquaculture lease.

When the cable or pipeline is adjacent but not through the aquaculture area, damage can occur to the aquaculture but no "taking" has occurred. In this situation, the aquaculture activity must prove negligence on the part of the pipeline operation. The situation is clearly illustrated by Vodopia v. Tennessee Gas Transmission Company,[50] where an oyster lessee sought damages to his leased beds caused by the construction of a pipeline across a bay. The silt from the construction carried by the ebb and flow of the tide caused damage to the oyster beds.

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[49] See Payne and Butler v. Providence Gas Co., cited above.

[50] 152 F. Supp. 14 (E.D. La., 1957) from Kane, Op. Cit., p. 82.

> Unless it is shown that Tennessee was negligent in the construction of its pipeline and that negligence caused the damage in suit, there can be no recovery --- This case prevents the inevitable collision which occurs when oil and gas operations are performed in the vicinity of leases being operated for the production of oysters, muskrats, etc. Each industry has a right to operate side by side under its permits or leases, and as long as it operates reasonably and with due regard for the right of others, any damage to those rights is dam num ubsque injuria.

It would seem reasonable to prevent unnecessary damage between two industries to require a "buffer zone" around sensitive aquaculture areas. Map No. 6 shows the present location of pipelines and cables in Narragansett Bay.

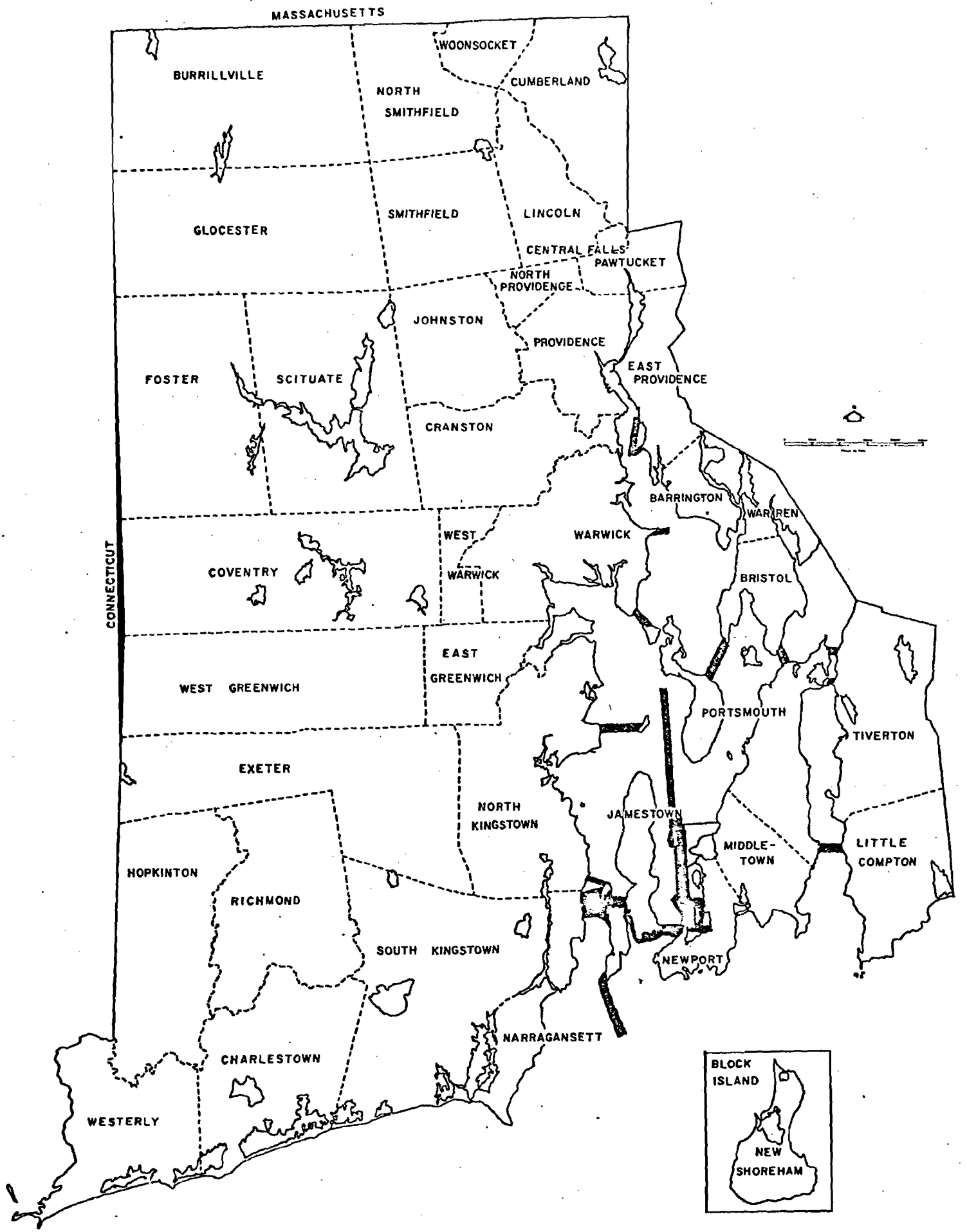
In concluding this commentary on the use conflicts with aquaculture, the following quote from an 1893 Yale Law School Journal seems appropriate. The verse follows a scholarly expose' on the conflicting claims over oyster beds, and suggested that to solve some problems "one precedent of acknowledged weight and ancient lineage" which had not as of that time been cited in court, might provide the best solution to the difficulty -

> Once (says an author; where I need not say)
> Two travellers found an oyster in their way.
> Both fierce, both hungry, the dispute grew strong,
> While, scale in hand, Dame Justice passsed along.
> Before her each with clamor pleads the laws,
> Explains the matter and would win the cause.
> Dame Justice, weighing long the doubtful sight,
> Takes, opens, swallows it before their sight.
> The cause of strife removed so rarely well,
> "There! take (says Justice) take ye each a shell.
> We thrive at Westminster on fools like you.
> "It was a fat oyster -- live in peace -- Adieu."

Legal precedent for aquaculture has developed considerably since that time; however, the area of potential litigation and enrichment of attornies is tremendous. Without specific aquaculture laws, Dame Justice will continue to eat many oysters.

MAP NO. 6: SHOWING THE LOCATION OF PIPELINES AND CABLES IN NARRAGANSETT BAY.

State of Rhode Island



Chapter IV - Types of Aquaculture Practiced in Rhode Island

There are basically two types of aquaculture, extensive and intensive. These types can be placed on an energy-dollar-cost continuum. At the lower end of the production cost continuum is the traditional fishing wild stocks, followed by transplantation, stocking of the waters, controlling the lifecycle in hatcheries, pond aquaculture, raceways, and closed cycle culture at the upper end. One goes from no costs of production, relying on natural forces to rather costly production with high levels of technology.

A. EXTENSIVE AQUACULTURE:

Extensive culture is the oldest and simplest form, dating from 2000 years B.C. in China. It has been practiced successfully in many parts of the world, particularly Southeast Asia and the Far East. For the purposes of this discussion it can be distinguished from intensive culture by two characteristics, the relatively large amount of space required and the fact that the animals forage for a naturally produced food supply.

The typical species cultivated extensively in Rhode Island are the filter-feeding mollusks, such as oysters, scallops, and quahaugs. These animals remain stationary and use the large food producing area of the embayment as a food source by simply pumping the water through their systems. In other parts of the country seaweeds are also grown extensively as are fin fishes.

The advantages of extensive culture are:

(1) The animals do not need to be fed extraneously with natural or prepared feeds. Due to their low trophic level, they simply forage on the natural algal populations and the associated living and dead flora and fauna.

(2) Operating costs are very low. Very little labor is required. The major activities are stocking and harvesting.

(3) The technological requirements are low. No special education is necessary to operate such a venture as most of the "technical part" (food and reproduction) is left to nature.

(4) There is less ecological impact on the area. Due to the large area and natural flushing, extensive cultures do not pose the same pollution problems that intensive cultures do.

The disadvantages of extensive culture are:

(1) The method generally requires a large amount of space. Coastal wetlands are becoming scarce and costly. Often they are unavailable in large tracts or their use is severely restricted.

(2) Because of the space requirements, extensive culture is likely to run into use conflicts with recreation and/or various industries.

(3) Similar to the above is the fact that aquaculture cannot be done everywhere which puts an additional demand on the suitable coastal areas and wetlands available.

(4) The life cycle, especially reproduction, cannot always be controlled except in a hatchery.

(5) The production is lower than that achieved in intensive culture.

(6) Due to the large area, poachers and natural catastrophies such as storms and floods are a problem.

1. Past Efforts:

There is an early history of extensive aquaculture activity in Rhode Island waters, mostly during the late 19th and early 20th centuries. The primary emphasis was on bottom oyster culture, in which large beds, mostly within Narragansett Bay, were leased by the state to private operators for a nominal fee, usually between $5 to $10 per acre. During peak activity approximately 20,000 acres of bed bottom were under lease arrangements resulting in revenues to the state of some $130,000 annually.[51] The oyster harvest peaked in 1910 when 15.3 million pounds were landed.[52] Over 75 different individuals and organizations were involved in these programs, including several corporations whose primary interest involved the culturing and marketing of native oysters. The Narragansett Bay Oyster Company, Rhode Island Oyster Farms Company, and the American Oyster Corporation are major examples of companies that leased considerable acreage. Most activity occurred in the upper Bay area, near Wickford,

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[51] Personal communication - Tom Wright, retired Chief of Division of Fish and Wildlife of the Former Department of Fish and Game, February, 1976.

[52] Olsen et al Op. Cit., p. 109.

and along the northern shores of Prudence and Aquidneck Islands. Some activity also occurred in the Warren and Barrington Rivers and in South Kingstown's Point Judith Pond, which was apparently successful until pollution of the waters and poaching problems became prohibitive.

Almost all of these aquaculture programs involved attempts at extensive type culturing in that sites were selected and leased, and oyster seeds were scattered over the area to develop under natural conditions. Harvesting of the crop followed after a suitable intervening growth period. Very little support activity or maintenance of the beds themselves were involved. While mortality due to predation, poaching or other factors certainly must have been a significant factor during these years, there apparently was enough of an economic incentive present to maintain a vital and growing industry along our immediate coast for a considerable time.

The years that followed the 1910 peak saw a rapid decline in the oyster culturing industry. Both the number of individuals and commercial companies involved and the total amount of leased acreage steadily decreased. A small resurgence of interest in the late 1920's may have been due to the effects of the economic depression of the time, but it never regained full original intensity. (see Fig. 1) Nineteen thirty-seven saw the commencement of another rapid decline from which this form of aquaculture has never as yet adequately recovered. There are many theories as to the cause of this massive decline which include water pollution, a series of poor sets, hurricane damage to the beds, disease and predation, and poor fishery

Fig. 1

OYSTER LEASES IN NARRAGANSETT BAY

Year	No. of Individual Companies	No. of Plots	No. of Acres
1934	28	92	6,768.0
1933	27	92	6,524.3
1932	30	97	6,580.3
1931	28	95	5,946.7
1930	24	85	4,766.9
1929	27	86	4,440.6
1928	30	88	4,277.4
1927	36	99	4,060.4
1926	38	94	3,335.5
1925	40	96	3,818.7
1924	41	90	4,172.0
1923	42	102	4,622.5
1922	53	122	5,936.0
1921	43	122	6,171.9
1920	45	119	7,137.0
1919	48	162	12,627.8
1918	54	196	10,384.7
1917	67	271	13,987.8
1916	71	304	16,351.1
1915	78	301	17,936.6

DATA FROM DEPARTMENT OF NATURAL RESOURCES ARCHIVES

management. It is probable that some combination of all these and other factors were involved. It is known that present water quality characteristics in areas of the extreme upper Bay once leased for culture could never support such activity today. Even if oysters could be successfully cultured in this area, which is doubtful, modern public health regulations would prevent any human consumption of them.

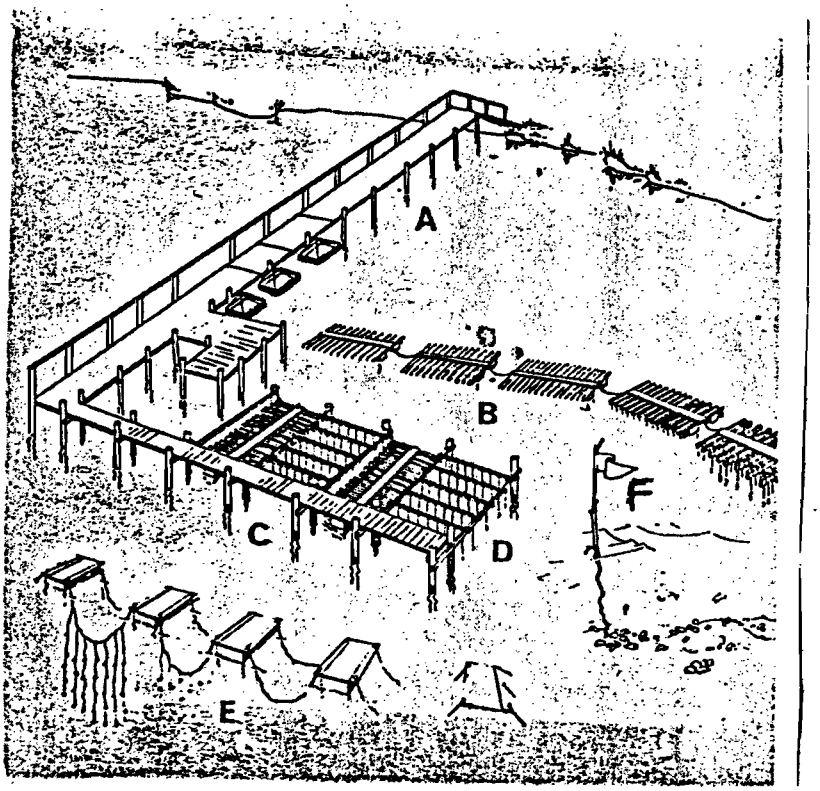
This evidence of a once flourishing aquaculture industry in Rhode Island certainly is indicative of the latent potential for such activity today. However, at the present time such extensive is limited to small scale plots.

2. Present Efforts:

Extensive culture can be "intensified" especially regarding oysters. Rather than simply growing oysters on the bottom where they are subject to predation and silting over, most modern culturists use a three dimensional approach, of suspending the oysters on strings (see Fig. 2). These can be from rafts, long lines from floats, from docks, and from rocks either on the surface or just off of the bottom.

In Rhode Island Jim Riley and Wes Maxwell of Mystic Aquaculture Reserach are using rafts for cultures of oysters in Fosters Cove and Charlestown Pond. They plan to develop a rack type of system which will keep the oysters suspended just below the surface. (see Fig. 3) Matthiessen has developed a rack system which suspends the oysters just off the bottom. This method would allow boat traffic above the racks which is precluded by other systems. Raft oyster culture can reduce the growing

Fig. 2



Three methods of off-bottom oyster culture have been tested by the NMFS biological laboratory in its work at the oyster culture center on the Tred Avon River. In the schematic drawing, A is the dock; B, the experimental rafts; C, rigid structure; D, strings of oysters suspended from the structure; E, long lines suspended from floats; and F, bottom culture.

time of marketable oysters from four to five years to 27 months and the losses from predation and other sources by 40-70 per cent.[53] Therefore, it is fast becoming the modus operandi of the oyster culture industry.

The Mystic Aquaculture outfit is the only extensive aquaculture effort presently in the state that has commercial possibilities. Oyster spat are collected on cultch consisting of old oyster or scallop shells which hang on strings from floating rafts in Fosters Cove. After an approximate six month period, the oysters are then transferred to a selected area in Charlestown Pond for maturation. Growth rates will normally increase in the larger pond due partially to higher salinities and nutrient levels and more stable temperatures. At all times, the crop is kept suspended from the bottom to avoid drill and starfish predation. The rearing site in the main pond at the present time is approximately 100 by 200 ft. in size and is designated by marker buoys. The selected site is situated in the western pond basin and north of the barrier in 7 feet of water, and is thought to present few conflicts with other more dominant uses of the pond.

Their operation is small but the operators are proceeding carefully with an eye toward a larger and more profitable business. Even at the largest possible size they envision for themselves (40 racks, 100 oysters per string, 500 strings for each 10' x 10' rack yielding 60 bushels a rack

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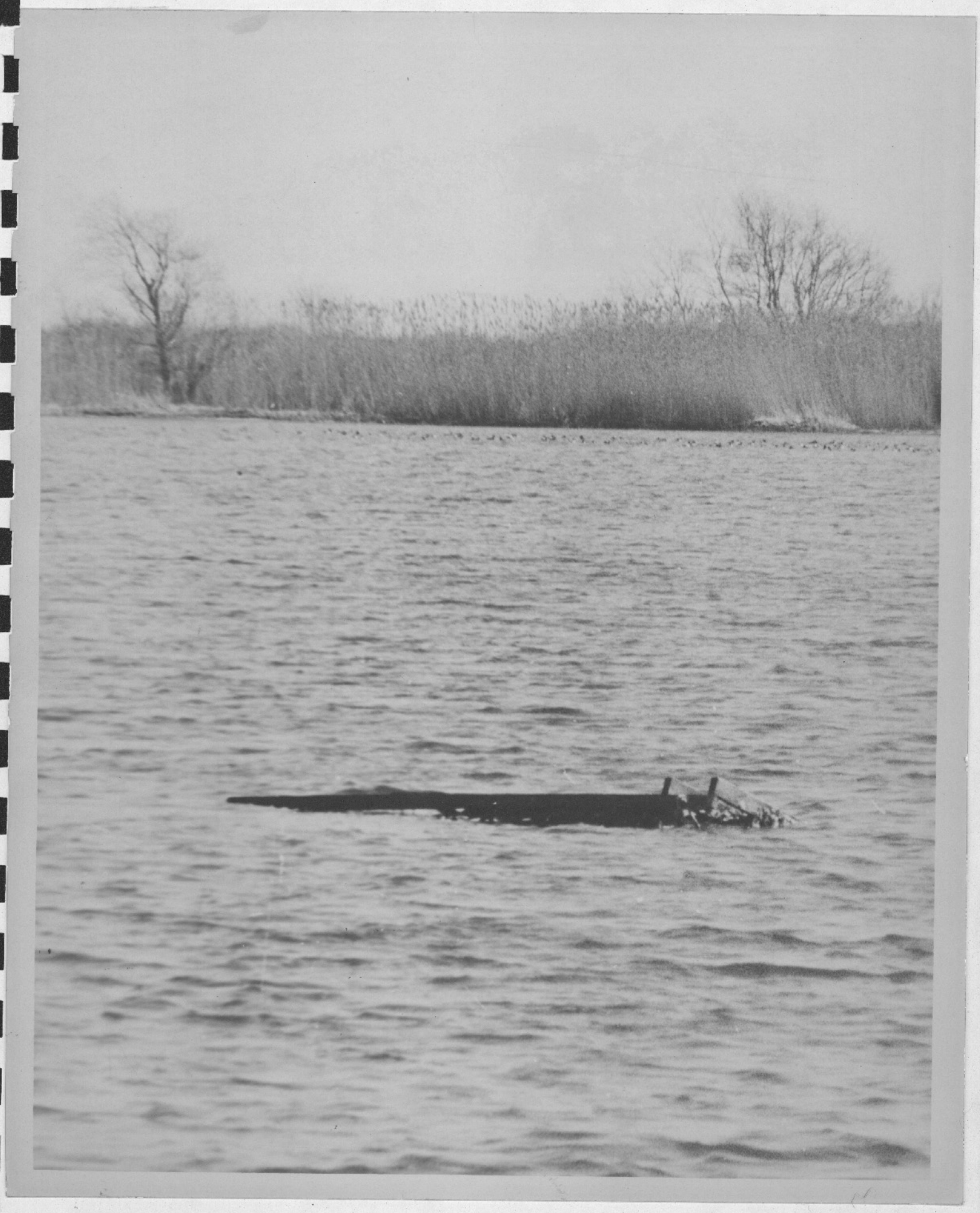
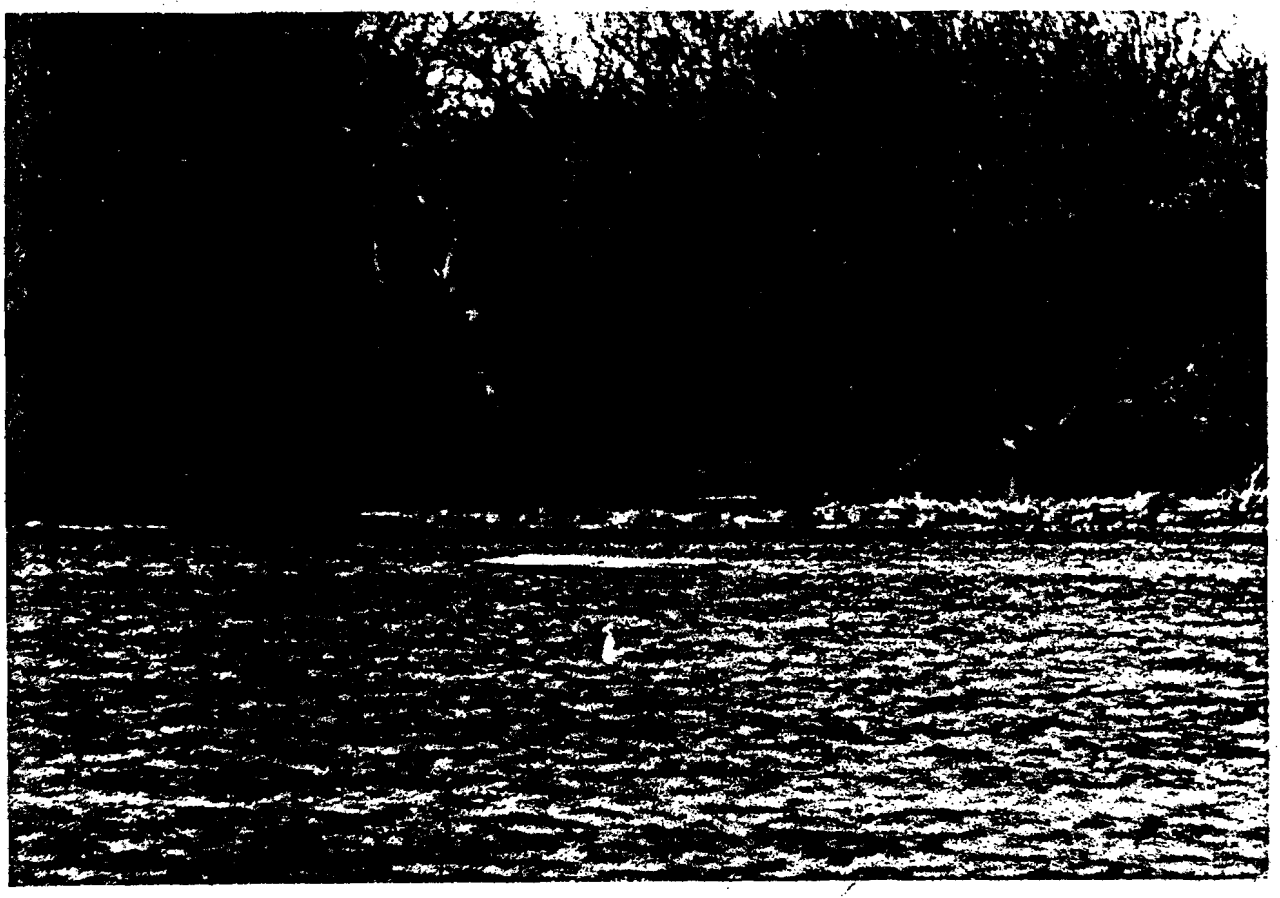
[53] Olsen et al., Op. Cit., p. 44.



Mystic Aquaculture Research's oyster spat collection rafts in various areas of Fosters Cove, Charlestown, Rhode Island (distortion due to telephoto lens).



after 2 years),[54] their expected income after expenses will only serve to supplement their income from other sources.

There are numerous other people in the state who culture shellfish as a parttime venture or as a hobby. These are people who enjoy the activity and are happy if they can supplement their income. They have no desire to become a large scale operation. It is this writer's opinion that the future of extensive aquaculture, at least in the short run, will be of the scale as to be an income supplement and not a major economic factor. This has been the history of such activities over the last 10 years or so. The small scale has led to a generally innocuous activity with a minimum of use conflicts.

In contrast to states in Japan where entire estuarine systems are utilized for raft aquaculture (only small channels are left open to boat traffic) other water activities in Rhode Island currently have priority. It is unlikely that large scale extensive aquaculture could acquire the necessary space to achieve optimal size in the face of powerful groups of boaters and recreational fishermen. Rhode Island is not hungry nor in need of protein. Feasible aquaculture activities are for the higher priced luxury foods with good markets. (oyster vs. mullet or blood worms) At present the priorities in the state favor the established water use interests and extensive aquaculture will remain small and isolated.

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[54] Personal communication, Wes Maxwell and Jim Riley, Mystic Aquaculture, February, 1976.

B. INTENSIVE AQUACULTURE:

Intensive aquaculture, though pioneered by the Japanese, is primarily a product of Western Technology. While a relative newcomer to aquaculture techniques, it is widely practiced in the United States. By intensive culture it is meant that the cultured species are removed from their natural environment and raised using varying degrees of technology to replace the natural foods and/or water flows, etc. As might be assumed, this form of aquaculture is near the upper limits of the energy cost continuum.

The advantages of intensive aquaculture are:

(1) Increased production. By forced feeding in raceways or augmentation of natural foods, the animals grow faster. Faster growth is also aided by other factors such as temperature control, etc.

(2) Faster economic return. This is especially important in the U.S. where aquaculture produces a high priced product and the profit motive is stronger than in other parts of the world where aquaculture provides a primary source of low cost protein. Since the costs of production are higher and the value of the product is high, the tendency is to emulate the cattle feed lot approach. More animals can be grown in less space and in less time with a faster return to capital.

(3) Controlled environment. The risks of natural disaster, such as storms and predators, are removed. Much of the uncertainty and risk can be reduced by controlling increasing numbers of environmental

parameters.

(4) Reduced conflict with competing uses. This is perhaps the greatest advantage to this form of aquaculture in Rhode Island. By controlling the environment, the aquaculture operation does not necessarily have to occupy scarce wetlands or limited shoreline. The operation can be made relatively compact and hence be easier to locate.

The disadvantages of intensive aquaculture are:

(1) Expense. The more technology provides for the care and feeding, the greater the expense. The equipment and machinery for handling or even for occupying large volumes of seawater with adequate protection and minimum risks from corrosion, fouling, weather, etc., are extremely costly. Capital outlay for a major mariculture facility, whatever the configuration or method of culture, can easily run to millions of dollars. Operating costs, particularly where pumping large volumes of water is involved, but also including the inevitable labor requirements, are also high.

But the single greatest cost of intensive mariculture is usually that of food. Typically, the prepared pelletized feeds now in use consist of mixtures of animal and vegetable meals and oils, fortified with mineral and vitamin supplements. Requiring a high and complete protein content for rapid growth, such feeds usually contain a significant proportion, as much as 25 to 50 per cent, of fish meal. Food normally accounts for

25-50 per cent of total operating costs.[55]

(2) The need for special training and increasing technology. The more natural processes are substituted or augmented, the greater the level of sophistication and training required to operate successfully. Intensive aquaculture requires more education and technical expertise.

(3) Ecological. Disease, always the nemesis of animal breeders, is a far greater problem in the aquatic medium where, in contrast to terrestrial situations, the spread of pathogens from infected to uninfected individuals is virtually impossible to prevent. The incidence and spread of disease is directly proportional to the density of the animals, not so much because their proximity facilitates transmission but, probably more important, because crowded animals are frequently, if not always, in a condition of physiological stress, which makes them particularly vulnerable to the onset and effects of diseases.

There are external environmental factors created by the pollution caused by the flushing of the waters from an intensive aquaculture system. It has been estimated that the wastes of about 10 pounds of hatchery-reared trout are equivalent to those of one human. A million-pound culture facility produces the same kinds and quantities of wastewater as a city of roughly 100,000 people.[56] Discharge of such wastes into estuaries or

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[55] Ryther, J.H. "Mariculture How Much Food and For Whom" Oceanus Volume 18, No. 2, Winter 1975, p. 20.

[56] Ibid.

coastal waters is not only undesirable but, under present regulations, possibly illegal depending on the rules set by EPA for Aquaculture discharges (see section on permits).

1. Present Efforts:

Blount Seafood of Warren, Rhode Island is the state's first commercial effort at intensive mariculture. They are raising coho salmon in two 1,500 gallon silos. Operating expenses have been kept down by using clam slurry from the seafood plant's other operations as a supplement to the pelletized food and by the discovery of two pure saltwater wells with constant 58° temperature year around. The Company has invested approximately $10,000 in establishing the program, a large portion of which involved facility construction, pumping and piping costs, etc. They have long range plans to expand the operation to handle as many as 200,000 fish if these initial trials succeed.

Thus far, the operation appears to be succeeding well. In operation for approximately nine months, the fish have more than tripled in size, and have been completely disease free. Total mortality has been low, most of it due to human error which must be expected in any new and innovative program of this kind. Ted Blount, president of the Company, is hopeful for the future but is particularly concerned about the regulatory uncertainty regarding the EPA discharge limits[57] (see permits section).

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[57] Personal communication, Ted Blount, president, Blount Seafood, February, 1976.

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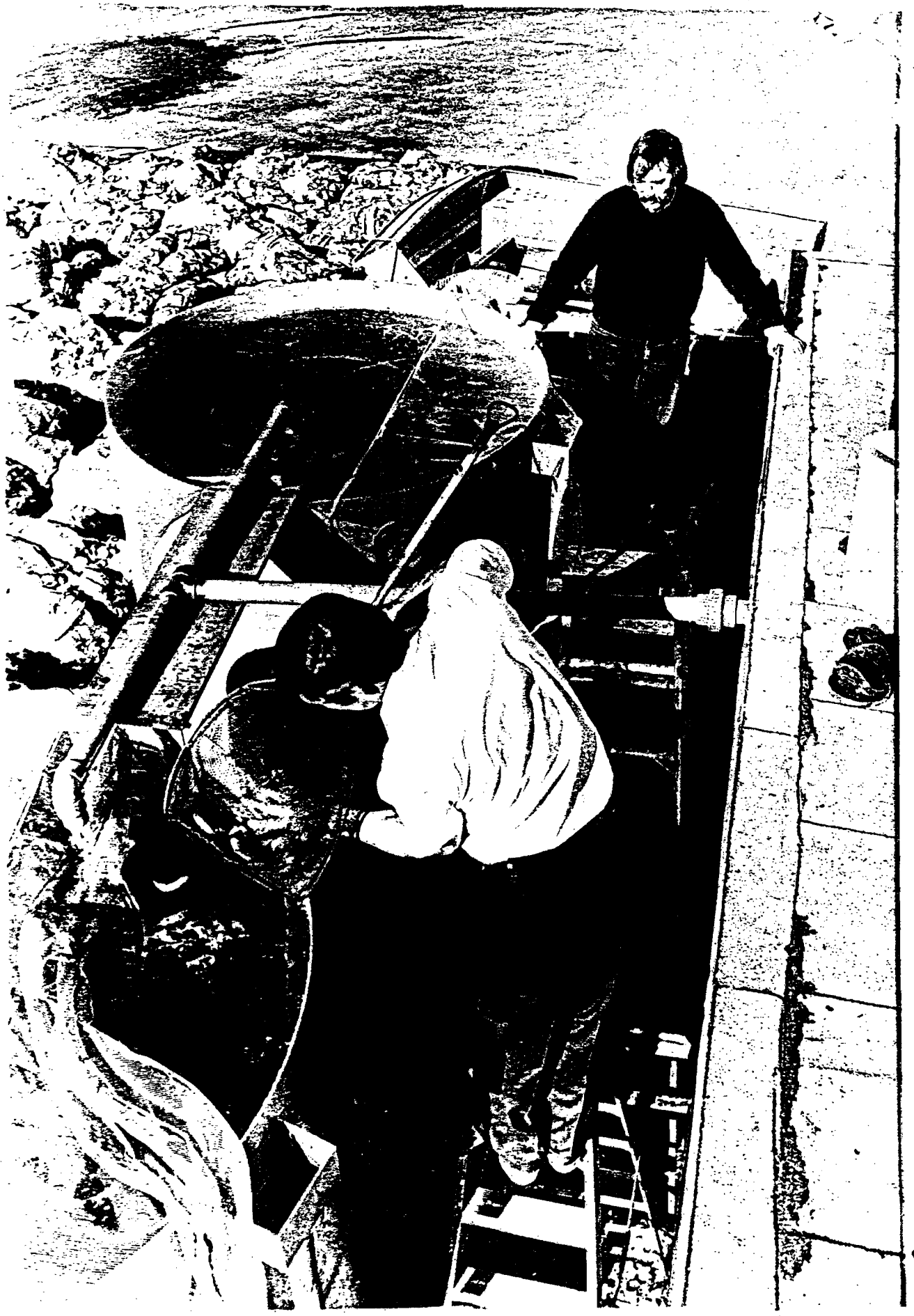
BLOUNT SEAFOOD, TRANSFER OF SMOLTS FROM U.R.I. BY TRUCK



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BLOUNT SEAFOOD, SHOWING 1,500 GAL. SILO'S. THE SILOS ARE NOW ENCLOSED IN A HOUSE FOR YEAR ROUND PROTECTION.

The state has sponsored several forms of intensive culture. The DNR has operated fish hatcheries and John Karlsson of the DNR is successfully operating a scallop hatchery at Jamestown with the ultimate goal of reestablishing the species in Rhode Island waters.

American Fish Culture of Carolina, Rhode Island, has been in intensive fresh water aquaculture since 1877. They presently raise only Brook and Rainbow Trout which are sold as stock for sport fisheries. Their business has been sharply cut back due to the competitors from imports, particularly Japan and Denmark. At one time they exported food fish throughout New England and New York and employed 16 men. Today production is at 40,000 lb. a year and they only employ three. They have no regulatory problems. An extensive natural filtering and settling system satisfies EPA regulations. They are a well-established firm which enjoys its anonymity.[58]

At the highest point on the energy-dollar-cost continuum is closed cycle aquaculture. Significant and pioneering work has been done by Dr. Mead of the University of Rhode Island and Dr. Price at the University of Delaware. Raising shellfish in such a system has many advantages. The crop is totally isolated from the natural and manmade disturbances that can destroy an industry virtually overnight. It grows faster because it grows year-round. Toxic metals and other pollutants present in

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[58] Personal communication, Walter Eddy, manager, American Fish Culture, March 1976.

natural waters and stored by shellfish can be eliminated from the water in the closed-cycle system. Shellfish produced in a controlled environment are uniform in size and shape, a great marketing plus. Furthermore, closed systems can be operated almost anywhere, eliminating competition with recreational and other iinterests for the use of bays and estuaries.

The concept has been proven in the laboratory but the only commercial venture attempted, Rhode Island Aquaculture, was not successful. Its failure was due primarily to a lack of money and the difficulties of extrapolating successful laboratory cultures to a large scale commercial operation. What started out as a business venture developed into a risky biological undertaking.[59] To ease the transition from the laboratory to commercial operation in such cases, a state or federally sponsored pilot project would be advisable. However, in the long run, aquaculture enterprises once firmly established desire as little state or federal intervention as possible.

The demise of Rhode Island Aquaculture and many other ill-fated aquaculture ventures in other parts of the country illustrates the argument that present day aquaculturists are pioneers and must be met halfway. The position is analoguous to agriculture 50 years ago. Intensive aquaculture is a new high risk venture with great potential; however, to augment its successful development both state and federal support are required.

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[59] Personal communication, Don Costa, January, 1976, and Paul Schauer, March, 1976.

It is the state's role which this paper is intended to illuminate. At the present time intensive aquaculture with its cattle feed lot approach, appears to have the brightest future in Rhode Island. As mentioned, the conflicts of use with the other interests of the bay are minimized. This fact, along with its high output and flexibitility of location, encourages future development of intensive aquaculture.

It should be noted however, that the arguments favoring intensive aquaculture are not unique to Rhode Island and such activities could locate almost anywhere. The features of Rhode Island which lend itself to aquaculture are its extensive south shore ponds, the bay, and certain of its rivers. This would be extensive aquaculture. If those areas are to remain pre-empted by other competing uses, the future of aquaculture in Rhode Island does not appear to be particularly favored.

C. THE ROLE OF DEPURATION

Related to both the present shellfish industry and to aquaculture in the state is the question of depuration. Depuration is the process by which shellfish cleanse themselves from bacteriological contaminants in a controlled seawater environment. Natural depuration is obtained by transfer of the animal to an "Approved" shellfish rearing area and allowing the natural filtering process to cleanse the animal. That process is now augmented, or in some cases replaced, by ultraviolet light depuration. Holmsen and Stanislao (1966) determined that depuration by ultraviolet

light was economically superior to the transfer process.[60] Should a successful depuration scheme be developed for Rhode Island, closed areas could be resurrected for both industries. This is particularly important should the Food and Drug Administration succeed in passing stronger regulations in connection with the National Shellfish Sanitation Program (NSSP) that might force the state to close further areas to shellfishing.

Depuration facilities are currently operating in Massachusetts, New Jersey and Maine. Processes vary, usually subjecting the shellfish to bacterial destroying ultraviolet light while in an environment in which the natural filtering ability of the animal cleanses it. Depuration time varies with species and original NPM environment of the animal, but 24 to 48 hours is generally sufficient to reduce bacterial levels to those safe for human consumption. Construction costs vary with capacity and local building conditions. Holmsen and Stanislao (1966) found that the cost of processing quahaugs in a depuration plant with the capacity of 105,000 bushels annually was 44.3 cents per bushel.[61] The Massachusetts Division of Marine Fisheries at its Newberryport facility charges $1.00 per bushel for depurating soft shell clams taken from conditionally approved areas in

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[60] Andreas Holmsen and Joseph Stanislao, The Economics of Quohog Depuration (Kingston: URI Agricultural Experiment Station, 1966), p. 11.

[61] Ibid, p. 35.

that State. Any operating costs of the plant over the course of a year, that are not covered by digger fees are prorated back to the cities and towns from which the clams originated, on the basis of volume processed. In New Jersey, a commercially operated ultraviolet depuration facility near Sandy Hook, Raritan Bay, charges between $1.00 and $1.50 for depuration of 40 or 72 hours. Mr. Warren Finn, an East Greenwich shellfish dealer, has under consideration the construction of a 1,000 bushel capacity, 48 hour depuration facility. The plant would release 500 bushels a day. Processing cost of depuration is estimated at between 4 and 3 cents per pound ($3.20 - $2.40 per bushel). Initial management uncertainties account for the higher figure. It is felt by Mr. Finn that after the operation becomes standardized, good management could result in reductions in processing costs so as to favor the lower range of the cost spectrum. The plant would consist of a 60 x 120 foot building utilizing 20, 500 gallon capacity tanks. Cost of the facility would approximate $385,000. Mr. Finn emphasizes that to insure the economic viability of a depuration facility in Rhode Island, it would be necessary that the State shellfish regulations recognize not only depuration as an accepted shellfish sanitizing method, but also thermal processing as well.[62] This would insure that "chowders" could be developed and marketed more readily. Currently, a task force commissioned by the Governor is considering this

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[62] Data from Marine Affairs class paper by Jerome McGourthy, December, 1975.

and other implications of proposed Federal regulations. There are currently 5,500 acres of shellfish harvesting grounds within the upper Narragansettt Bay area designated permanently closed to shellfish harvesting due to "moderate" pollution levels. In addition, there is approximately 700 acres designated "Polluted" (see Maps Nos. 4 and 5). Surveys by Richard Sisson of the DNR Wickford Laboratory indicate that the moderately polluted acreage contains a large quahaug population of high commercial value--i.e. large populations of little necks and cherrystones. For the past several years the most productive quahaug grounds in Narragansett Bay has been an area within a square bounded by Conimicut Point and Nayatt Point to the north, and Warwick Point, Prudence Point, and Popasquash Point to the south. This area is a conditionally "approved" area, closed only when heavy rains force the storm sewers to open into the bay (see Map No. 3). According to Sission,[63] the standing crop in the area may be conservatively valued at $11.4 million and can yield a yearly harvest worth $3 million. Currently Sisson is conducting an intensive assessment of stocks in the upper Narragansett Bay area. Preliminary results in five designated areas of the upper bay and lower Providence River indicate the following estimates of harvestable quahaugs:

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[63] Richard D. Sisson, personal communication with Jerome F. McGourthy, November, 1975.

Area	Bottom Composition	Stock in lbs. per acre
1		16,985
2	silt-sand	6,124
3	gravel-sand-silt	6,954
4	sand-silt clay-shell	16,445 (area permanently closed)
5	sand	7,249

The figures show the varying yield potential within the bay both for wild stocks and the possibility for aquaculture and indicate the potential economic loss which accompanies the closing of an area to harvesting. Approximately 15,000 acres of good harvesting and aquaculture grounds in the upper Narragansett Bay now conditionally or permanently closed due to moderate or temporarily moderate levels of fecal coliform, would be opened, and remain open under the Federal regulations, if Rhode Island shellfish regulations recognized depuration as an acceptable sanitizing method applicable to shellfish harvested in moderately polluted areas.

Chapter V - Permits for Aquaculture in Rhode Island

Due to the broad authority of the Coastal Resources Management Council over any development in state waters and its special charge over the issuance of permits for aquaculture, the process has been simplified. The potential aquaculturist need only to approach the Council for a permit.

However, depending on the extent of the aquaculture activities, other state agencies may be involved directly, independently or consulted by the Management Council.

	Activity	Responsible Agency
1.	Wells:	G.L.R.I. 46-15-6 (n) - Any person who wishes to drill a well must first register with the Water Resources Board.
2.	Effluent Discharge:	G.L.R.I. 46-12-24 & 25 - Any person who plans to discharge sewage into the waters of the state must first consult with the Department of Health. "Sewage" is defined in 46-12-1. The CRMC (46-23-6 (B)(f)) has control over land use for sewage treatment facilities. At the Federal level an EPA permit must be obtained. There are no published guidelines to date. However, the Federal Register Vol. 38, No. 128, July 5, 1973, p. 18001, notes that if discharges of ponds or raceways are less than 30 days a year, no permit is required. If annual production is less than 20,000 pounds, no EPA discharge permit is required.

	Activity	Responsible Agency
3.	Importing Animal Life:	G.L.R.I. 4-18-1 regulates the "Importation of Wild Animals." It is unclear if this statute could be applied to fish and shellfish.
4.	Structures in coastal zone waters:	G.L.R.I. 46-23-6 (D) gives the CRMC power to regulate this activity.
5.	Conservation Lands	G.L.R.I. 46-35-1 - Local conservation commissions have advisory powers over open areas under their jurisdiction.
6.	State Waters or Ponds:	G.L.R.I. 20-36-1 gives D.N.R. jurisdiction over state water out to 200 miles for the regulation of marine fisheries resources. The 200 mile control would probably be proved unconstitutional in a court test. 46-23-6 (B)(D) gives the CRMC jurisdiction over any "development" in state waters. The division of authority between DNR and CRMC has a wide range of overlap. For aquaculture it is the CRMC's authority to grant permits and DNR's to enforce the regulation. This ambiguity should be cleared up by specific aquaculture legislation.
7.	Leasing State Lands:	G.L.R.I. 20-10-1 gives the D.N.R. the right to lease public bottom to inhabitants or to any corporation chartered under the laws of the state. This function has been taken over by the CRMC. There is no provision for leasing the bottom land for other than oyster culture neither is there any provision for lease of the water column.

	Activity	Responsible Agency
7.	Leasing State Lands: (continued from preceding page)	42-64-6 gives the Economic Development Corporation even broader authority to manage state property for all types of commercial development.
8.	Depuration:	Under 21-14-8, the Director of the Department of Health "may cause to be transferred shellfish from any waters so declared to be polluted to cleaner waters in the state approved by said director." Department of Health's authority to transfer shellfish is for sanitary purposes. The Department of Natural Resources has the same authority for management purposes under 20-11-14: The Director of DNR is authorized to transfer shellfish from uncertified waters of the state to approved areas. The law could be made clearer if the wording state "...For reharvest or for depuration..." At present, the transfer of shellfish is for reharvest only. In addition, the CRMC has some authority in this area also: "The Council shall take necessary measures to prevent the loss of fishing grounds because of pollution and will encourage the reclamation of presently polluted grounds where certain types of fishing are not at present permitted by regulations promulgated by the Department of Health. (p. 46, CRMC Policies and Regulations)

Chapter VI - Impact of Existing Laws and Institutions on Aquaculture

Rhode Island has exercised extensive control over its shellfish and fisheries. Currently, shellfish production is directly related to state conservation efforts such as limitations on harvesting, redistribution of animals and shells, and maintenance of natural beds. Aquacultural enterprises will require similar investments of state or private concern and money. Any unlicensed exploitation would endanger the success of an aquaculture enterprise. These and other reasons cause aquaculture to parallel shellfish cultivation in terms of its required legal environment.

However, Rhode Island's shellfish legislation is not entirely conducive to aquaculture. The following is a brief review of Rhode Island laws affecting aquacultural pursuits and how they might possibly be changed.

Some generally favorable laws are:

G.L.R.I. Section 20-1-14 allows the DNR to appoint special "oyster guards" to protect lessees against poachers. An oyster guard may arrest without a warrant any person he finds taking oysters wrongfully from leased oyster ground and he may seize any boat or vessel or equipment used in the wrongful taking of oysters. The costs of these special constables is borne by the lessees.[64] Poaching is a real problem for anyone practicing extensive aquaculture in a natural environment. It would be desirable to extend the option of such protection to any licensed aquacultural activity.

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[64] From personal communication with Mr. Tom Wright, retired chief of the Division of Fish and Wildlife of DNR, February, 1976.

G.L.R.I. Section 20-4-8 provides stiff penalties against those causing damage to fish cultivation equipment or fish or fish spawn owned by DNR or private parties. This law is intended for hatcheries and inland fisheries. It would enchance its effectiveness if aquaculture were specifically mentioned.

G.L.R.I. Section 20-4-20 grants exclusive ownership and right to cultivation of fish and shellfish to proprietors of lands upon which a pond is created or maintained by excavating and enclosing and by artificial flowing of coastal waters. However, before excavation is started, the plans must be approved by the DNR.

G.L.R.I. Section 20-10-22 provides that oysters planted or growing in any private oyster ground shall be the personal property of the lessee for the term of his lease. This statute should be expanded to include any shellfish or fish held in captivity by a licensed aqualculturist.

G.L.R.I. Section 20-10-27/28 provide penalties for wrongfully taking oysters and/or damaging oyster beds. All of chapter 10 applies to oyster ground leases. To encourage the security of other aquacultural efforts, the same statutes should apply to lease right in other forms of culture.

G.L.R.I. Section 20-10-1 allows DNR to lease oyster beds to inhabitants of the state or to any corporation chartered under the laws of the state. While protecting the interests of the Rhode Island residents, this law also allows the stimulation of the oyster industry (and by interpretation, aquaculture) by out-of-state interests acting through state citizens or through state corporations. The legality of this type of arrangement was upheld by New England Oyster Co. v. McGarvey, 12 R.I. 385 (1879) where a resident lessee could enter into a valid contract allowing a non-resident to plant oyster beds, grow oysters, gather them and export them for sale outside of the state.

G.L.R.I. Section 20-29-18 allows the granting of scientific and educational permits for the capture of birds, eggs, and nests. Applicants must present to the department a testimonial from a recognized scientific or educational authority certifying the good character and fitness of the applicant. Such a permit process should be extended to marine species and for aquacultural study. The statute has already been stretched to allow fishermen to bring in undersized and gravid female lobsters for research projects at the University of Rhode Island.[65]

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[65] Personal communication, Tom Wright, Feburary, 1976.

G.L.R.I. Section 20-4-1 allows the DNR to take sole possession of any shores or public tidewaters not under lease to anyone else to make experiments in planting, cultivating, propagating, managing, and developing any and all kinds of shellfish.

The DNR should be encouraged in this role and perhaps be given authority to delegate authorized private interest the permission to conduct aquacultural research.

G.L.R.I. Section 20-16-1 allows the DNR the useful authority to open and maintain the breechways connecting the salt ponds to the ocean for the purpose of conservation of the marine life in such ponds.

G.L.R.I. Section 20-11-14 allows the DNR to transfer shellfish from uncertified waters of the state to approved areas for re-harvest. The statute should be worded so that transfer "for depuration" is permitted. This fact must be made clear so as to avoid the $100.00 fine for improper transfer in Section 20-11-19.

G.L.R.I. Section 21-14-6 is a similar regulation that prohibits taking of shellfish from polluted waters except for transplanting in unpolluted areas. A modification to allow transplanting for depuration would enhance the viability of the shellfish industry in the state.

There are other Rhode Island laws which, while designed to aid the shellfish industry, prove to be a hindrance to aquaculture. In several cases where the intent is clearly to preserve wild stocks, a lot of unnecessary litigation could be prevented by a clarification of the law with regard to aquaculture.

The laws defining seasons (oysters - G.L.R.I. Section 20-9-1; scallops - G.L.R.I. Section 20-13-7; quahaugs - G.L.R.I. Section 20-11-8) should be amended to exempt aquacultural stocks. The fresh-water fish, trout and bass, regulations do permit the year around capture of stocks artificially cultivated in private ponds (G.L.R.I. Section 20-21-4).

Laws affecting the transplanting of juvenile forms or adults should be worded so as to permit a licensed aquaculturist to accomplish transfers necessary to his operation. G.L.R.I. Section 20-9-13 holds the DNR responsible for transfer of oysters from Charlestown Pond and Green Hill Pond. G.L.R.I. Section 20-13-7 gives the DNR similar authority over scallops. Both laws limit the amount of the animals to be transplanted to other waters at 25% of the total available for transplanting. An aquaculturist who breeds his own stock should be excused from this percentage.

Laws regulating possession of undersize animals and the capture of gravid females should provide an exemption for licensed aquaculturists. (Sec. 20-12-7 for lobsters; Sec. 20-9-20 for blue crabs; Sec. 20-13-6 for seed scallops; Sec. 20-11-142 for quahaugs; Sec. 20-11-18 for soft shell clams; Sec. 20-14-1 and 2 for striped bass.) Laws imposing a maximum

daily take (Sec. 20-11-7 for quahaugs and Sec. 20-13-3 and 4 for scallops) should be modified in the case of the aquaculturist.

The towns of Rhode Island have control over the development of a potential aquaculture project through the CRMC hearing process which is required to be advertised in the local papers. However, the towns of New Shoreham on Block Island and Tiverton have reserved the right to control the fisheries of Great Salt Pond and Nomquit Ponds respectively (G.L.R.I. Sec. 20-17-1, 2). In the case of individual town control, the would-be aquaculturist must check with each town.

The CRMC is granted authority to impose fees for private use of the coastal resources (G.L.R.I. Sec. 46-23-6(D)(C)). This is a reasonable action on the part of the CRMC; however, the schedule and method of imposing such fees should be clarified. Any fairly large scale aquaculture project has many uncertainties to contend with simply from the nature of the business, and any uncertainties about fees to be levied at some future time could be a significant deterrent.

Chapter VII - Laws Affecting Aquaculture in Other States

This section gives a preliminary analysis of the laws and institutional structures in four other states: Washington, Oregon, California, and Florida. The attempt is to determine their policy on aquaculture and what Rhode Island could possibly adopt. Florida comes the closest to having an explicit aquaculture policy, while the others carry out aquaculture activities under ad hoc policies or legislation which has developed over time, reflecting the needs of the prevailing commercial aquaculture activities of each state.

Washington

The State of Washington was the second after Rhode Island to enact legislation establishing a comprehensive coastal zone management program. In Washington, aquaculture falls under the review of both the Department of Ecology and the Department of Natural Resources. In their Coastal Zone Management Plan submitted January 16, 1976, the D.O.E. through the Final Guidelines for the Shoreline Management Act of 1971 (p. 11) makes the following statement specifically directed toward aquaculture:

> "Aquaculture (popularly known as fish farming) is the culture or farming of food fish, shellfish or other aquatic plants and animals. Potentially locations for aquacultural enterprises are relatively restricted due to specific requirement for water quality, temperature, flow, oxygen content and in marine waters, salinity. The technology associated with present day aquaculture is still in its formulative stages and experimental. Guidelines for aquaculture should therefore recognize the necessity of some latitude in the development of this emerging economic water use as well as its potential impact on existing uses and natural systems. Guidelines:

(1) Aquaculture enterprises should be located in areas where the navigational access of upland owners and commercial traffic is not significantly restricted.

(2) Recognition should be given to the possible detrimental impact aquacultural development might have on the visual access of upland owners and on the general aesthetic quality of the shoreline area.

(3) As aquaculture technology expands with increasing knowledge and experience emphasis should be placed on under water structures which do not interfere with the navigation or impair the aesthetic quality of Washington shorelines.

The DNR, in keeping with the "key marine land use objective" of increasing the production of food, supports various aquaculture activities. They lease beds of navigable waters below low tide and along second class tide lands. These leases may not exceed 10 years and when used for oyster cultivation are restricted to forty acres. The Department of Fisheries reviews the leases to insure protection and adequate seeding of existing oyster beds. DNR sponsors research and study in aquaculture, has done economic analysis and field research, and is studying "methods for increasing the amount of space available for growing shellfish." (p. 74, Washington State Coastal Zone Management Program, January, 1976.)

Oregon

"A letter from the Legislative Council Committee of the State of Oregon, says in part:

....those aspects of aquaculture relating to food fish are within the jurisdiction of the Fish Commission of Oregon and to some extent the State Game Commission. Operating under the authority of the ORS Chapters 506, 507, 508, 509, 511, and 513 the Fish Commission

has the responsibility of preserving, propagating, protecting, cultivating, developing and promoting all food fish, shellfish and inner-tidal animals in Oregon waters. It conducts a continuous program of research, operates fish hatcheries, issues commercial fishing and fish dealer licenses. The Fish Commission promulgates rules and regulations designed to control harvest to achieve the maximum yield of the State without injury to the ultimate supply of fish and shellfish. The State Game Commission formulates policies and carries out programs for the management of wild life including game fish in Oregon. The Game Commission has rule making powers necessary to the administration of its duties. It operates fish hatcheries at various locations and has research facilities at the Oregon State University. It relates to certain aquacultural activities of the public in that it provides for a public easement under the provisions and restrictions of law to enter upon submergable land and remove oysters and other shellfish from such land."

The State of Oregon has specific legislation dealing with:

1. Commission to classify State submerged land suitable for oyster cultivation.
2. Oyster cultivation, cultivation fees and use taxes.
3. Chum salmon hatcheries.

Oregon has also established a leasing procedure for submerged and tidal land for the extraction of oil, gas and sulphur and the lease of navigable bays and river beds for the extraction of minerals. There does not, however, appear to be any legislation dealing with the lease of State land for aquacultural purposes except for the aforementioned laws dealing with oyster and salmon.

Chapter 508.700 provides for permits for chum salmon hatcheries. It provides for the establishment of such rules and regulations "as the Commission deems desirable to any person to construct and operate a chum salmon hatchery." The Commission is authorized to permit the artificial rearing of chum salmon and to set whatever rules and regulations it deems necessary.

In the State of Oregon the land lying between the high-tide mark and the vegetation line falls under the jurisdiction of the State Highway Division. Use of this area is authorized on a permit basis. Act 608 - 1971 established the Oregon Coast Conservation and Development Commission, which was to "develop and prepare a comprehensive

> plan for the aid of conservation and development of the natural resources of the coastal zone that would provide the necessary balance between conflicting public and private interest in the coastal zone.[66]

This writer has been unable as yet to determine what this Commission's practice was on aquaculture or what legislation resulted from the report.

California

The 1971 session of the California State Legislature enacted three laws concerned with aquaculture: Mariculture, oyster cultivation, and Domesticated Anadromous Fishery.

> The mariculture law appears in Section 6480-6505 of the California Revised Statutes. It provides for the recognition of mariculture, the leasing of submerged lands and water areas, protection against poaching, and the right of the public to access public beaches.
>
> The mariculture act provides for the cultivation of marine life which is not native to the area under cultivation. Those varieties of marine life which occurred naturally in a particular area as of January 1, 1971 are thus excluded from cultivation in that area.
>
> Leases of State "water bottoms" (undefined) are only to be made in the public interest, and only to citizens or domestic corporations of California. Cultivation areas are established by the State Lands Commission. Parties may submit applications for leasing State marine waters as well as water bottoms. The term of the lease is not to exceed 25 years, and it may be renewed for not more than 20 years. Ninety (90) days prior to the leasing of any water bottom, legal notices inviting bids will be posted. Lease is made to the highest bidder as long as the cost exceeds $10 per acre. Leasing of water bottom "shall in no way affect public access for recreational purposes to State lands contained in the leased area," except when permitting of access detrimentally affects cultivation. The laws further state that it is a misdemeanor for any unauthorized person to take or destroy any marine life or boundary markers.

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[66] The information concerning Oregon and California laws is from Gordon M. Trimble, Legal and Administrative Aspects of an Aquaculture Policy for Hawaii: An Assessment, (Honolulu: Hawaii State Department of Planning and Economic Development, 1972) pp. 51-53.

> The third act is entitled "Domesticated Anadromous Fishery." Anadromous fish are ones like salmon which head upstream to spawn. The law specifies that operators of such a fishery must be able to identify the fish that they have cultivated. Further it states that when this fish is in the wild it becomes the property of the State and may be taken by anyone having a sport or commercial fishing license. Finally the law provides for the examination of cultivated fish prior to their release to determine if they are free of any disease that might affect the native stock.[67]

Florida

Florida has the nation's second largest coastline (after Alaska) and has become a leader in the development of her marine resources. Florida's Mariculture Act was the first state law in the country authorizing the lease of submerged land and its vertical water column. A copy of the law and its guidelines is included in Appendix d & E and the law is discussed here at some length. It is this writer's opinion that if Rhode Island wishes to encourage aquaculture, particularly the "extensive" variety, legislation similar to the Florida act should be considered.

The act provides that the submerged lands and the water column may be used for either commercial or experimental purposes. Aquaculture is defined as the cultivation of animal and plant life in a water environment. The water column is defined as the "vertical extent of the water including the surface thereof, above a designated area of submerged bottom land."

The applicant applies to the Board of Trustees of the Internal Improvement Trust Fund giving pertinent information and a description of the project. All riparian owners within one thousand feet of the project are

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[67] Ibid.

notified as well as the general public, and if any objectives are raised a hearing is held. The lease is for a maximum of 10 years. A basic rent is collected depending on the location and value of the activity and what it replaces. In addition, a much criticized provision[68] is included for the payment of royalties once the aquaculture is in operation. The maximum area will be dependent upon the capacity of the firm to utilize the area efficiently, and a performance bond is required. Public use can be utilized in lease areas and the Board is to designate in advance those areas of submerged land and water columns for which it would not be in the public interest to lease to aquaculturist. These include such things as recreational, commercial, sport fishing and other traditional uses, exploration for petroleum and other mineral and scientific instrumentation.

The Florida Act has been challenged for its weaknesses and its constitutionality. Where aquacultural activity interferes with vested riparian rights, there may be an unconstitutional taking without compensation. So far this has not been proven. Some of the more fundamental weaknesses are concerned with navigation, public access and inadequate provisions for onshore facilities.

The statute fails to deal adequately with federal control over navigation. An amendment should require a permit from the U.S. Army Corps of

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[68] Paul F. Brute, Jr., "Application of First Mariculture Law, Operation under the Law," Proceedings of the First Annual Workshop, World Mariculture Society, ed. James W. Avault, Jr. (Baton Rouge: Louisiana State University Press, 1970) p. 53.

Engineers and the U.S. Coast Guard for all aquaculture sites in navigable waters. Concurrent jurisdiction of the Corps of Engineers exists for channel construction and other coastal projects in state waters, and parallel procedures for aquaculture can scarcely be regarded as innovative.

Public access is provided in Guideline 13 (Appendix E) for at least one opening, appropriately marked, to be designated as a means of ingress and egress in the leased area for boating, fishing and other public uses. However, no lights are required and the access might become a navigational hazard.

Nothing is said about any shore based facilities that might be necessitated by a large scale operation. The Act concerns itself with only the water column. A court could interpret it as intended for offshore areas only without commitment of any kind for shore-based installationas. In such an event, the opportunity is provided for local zoning officials to frustrate the operability of the venture.

Chapter VIII - Conclusion

A. STATE AQUACULTURE LEGISLATION?:

It should be clear from the above discussion that an aquafarming operation may by its very nature break a myriad of regulations as they are presently constituted. Steps to ameliorate this situation can take the form of amending the various laws mentioned in Chapter VI or enacting a state aquaculture bill as Florida has done. Besides the present legal entanglements of size/age, sex, quantity, and season, the aquaculturist must secure for himself exclusive use of an area and the water column. It is evident that aquaculture needs to be clearly defined in Rhode Island law and distinguished from other activities such as fishing.

In addition, Rhode Island must determine whether aquaculture deserves any special treatment analogous to the history of American agriculture. Present Rhode Island aquaculture is small and insignificant. It is probably fair to say that modern aquaculture is not presently encouraged. It is this writer's opinion that in Rhode Island, where there is better than average potential, the industry must be allowed an equal opportunity. The ultimate success or failure should not be due to an antiquated set of laws.

To give aquaculture an equal opportunity two courses of action are recommended. The first would be to pass an Aquaculture Bill similar to that passed by Florida, which can be found in Appendix C and was discussed above. Such a bill should:

(a) define aquaculture and give examples of species and operations that might be contemplated (i.e. oyster rafts, salmon silos, etc.);

(b) provide for the lease of the bottom and the water column;

(c) acknowledge the existence of aquaculture as an industry different from commercial fishing and clarify the relation of aquaculture to existing fishing laws;

(d) provide, through Rhode Island's Coastal Zone Management Plan, provisions for allocation or zoning of areas particularly suitable to aquaculture with a minimum of potential use conflicts;

(e) contain provisions that would protect the aquaculturists from degradation of the water quality and acknowledging the responsibility of the aquaculturist towards maintaining appropriate water quality;

(f) define the lessor's power to grant and revoke leases and licenses with provisions included for explicit definition of lease duration;

(g) describe methods for applying, advertising for, assigning, renewing, transferring, etc., leases;

(h) outline the rights to be conferred or withheld, such as navigation, access, recreation, etc.;

(i) provide rental and fee structures;

(j) outline hearing procedures;

(k) prescribe safety provisions and requirements for Federal permits (Army Corps, EPA, FDA, etc.);

(l) establish offenses and subsequent penalties;

(m) establish minimum product quality standards. Aquaculture can benefit from agriculture's experience that the quality standards need to be developed after commercial production of a particular species. A uniform product of high quality should enhance consumer acceptance. Standards would also protect responsible aquaculturists from less reputable enterprises.

Provisions c, d, e, and m are not in the Florida act. Some of these recommendations and others can be found in Gates, pp. 65-67.

B. A STATE SPONSORED AQUACULTURE PROGRAM?:

An alternative course of action would be to set up a state aquaculture program. Since aquaculture is in its infancy, the need for a general law might be questioned. The DNR, under Title 20-4-1, could acquire several of the coastal areas most suitable for aquaculture and sponsor pilot projects and research by private and public interests. If future aquaculture development parallels past agriculture development, two conclusions may be drawn: (a) the development is a slow process (b) most of the research is sponsored by Federal and State governments. The justification for government research in the field of aquaculture is similar to the justification of government research in agriculture. R&D in a new field is expensive, long term and risky so that the private sector is not likely to make major R&D investments. Government R&D, however, has the advantages that

results are available to all, duplication of effort is avoided and long range programs may be undertaken.[69]

Private interests that partake of the DNR hospitality would be provided with an opportunity to demonstrate the feasibility and value of commercial aquaculture under favorable, rather than marginal, environmental and legal conditions. In return the aquaculturist would have to permit public scrutiny and study as a means of stimulating or assisting aquaculture in other areas. Because the profit incentive is involved, maximum emphasis would probably be placed upon sustained production which is the only true measure of the project's viability.[70]

Aquaculture in Rhode Island can be presently categorized as a "backyard" industry, generally done parttime as a supplement to the income of the practitioner. A state sponsored program might be the impetus to determine whether larger scale commercial operations could again be a viable economic force in the state. Olsen has recommended both courses of action -- new legislation and state sponsored pilot projects, in his study of Rhode Island fisheries.[71]

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[69] Trimble, Op. Cit., p. 45.

[70] Gates et al, Op. Cit., pp. 71-72.

[71] Olsen et al., Op. Cit., p. 45.

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265 F. 379 (1920

Rogers v. Tallman & Mack Fish Trap Co.
D.C. R.I. 1964, 234 F. Supp. 358.

2. High production costs

Culture, harvesting and processing of marine plants tends t be labor intensive which may make culture in U.S. less economical than in foreign countries.

3. Market development

The worldwide demand for phyco-colloids such as agar, algin and carrageenan for use in a wide variety of foods, pharmaceutical and cosmetic products is increasing but no significant market has develope in U.S. for direct use of marine plants for human food. Recently interest has developed in the use of seaweeds as a source of fertilize since they contain useful quantities of many trace elements needed to stimulate growth of agricultural crops.

4. Improved culture systems

Research with Eucheuma in Florida indicates culture in tank can produce 60 times the yield per unit of area of open water culture. (Dawes, 1974) The development of intensive culture systems could improve the profitability of marine plant culture in U.S.[1/]

5. Genetic improvement

Marine plants used in aquaculture have not been improved t selective breeding as have land plants used in agriculture. Similar improvements in yield, growth rate and disease resistance can be anticipated.

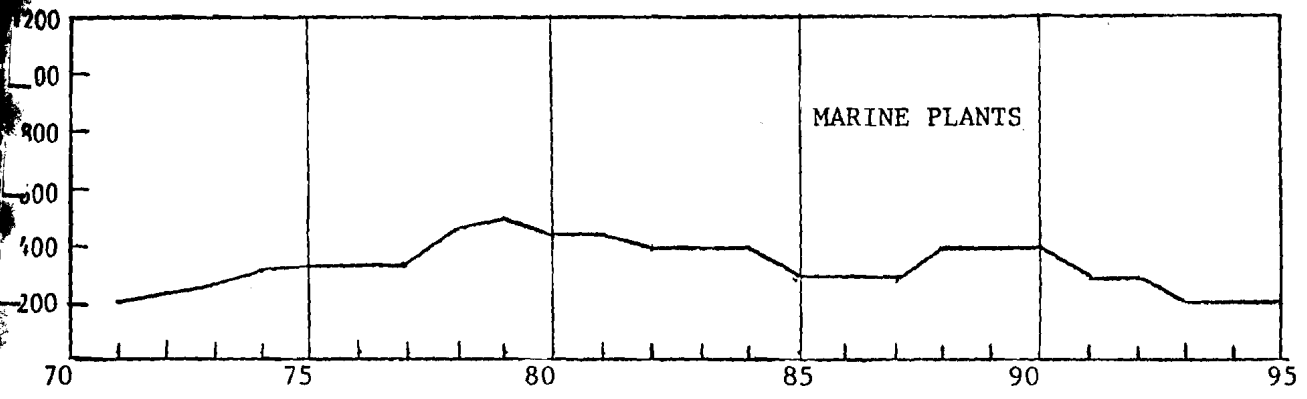
1/ Dawes, C.J., A.C. Mathieson and D.P. Cheney, Ecological Studies of Florida Eucheuma (Rhodophyta, Gigartinales) I, Seasonal Growth and Reproduction. Maritime Science Bulletin. (in press)

6. Nutrient requirements

Marine plants utilize nutrients directly from the water but their requirements as related to growth, disease resistance and reproduction are unknown. Some Sea Grant supported research in Florida, New Hampshire, Washington and California concerns nutrition of various species.

Actions required

The problems of developing private aquaculture of marine plants, possible solutions and actions required are summarized in the following listing.



Problem	Possible Solutions	Action Required By
Space in suitable environments	o Revise state laws, policies and coastal zoning plans to encourage private aquaculture.	o State government, industry, public
	o Modify substrate for seaweed culture	o Industry
	o Develop intensive culture in tanks	o University, industry
High production costs	o Mechanization	o Industry
	o Improved processing techniques	o Government, university, industry
	o Develop intensive culture systems	o University, industry
	o Relocate in low labor cost areas	o Industry
Market development	o Promotion	o Industry
	o New products or product form	o University, government, industry
Improved culture systems	o Biological research to establish parameters	o University, government
	o Systems engineering to increase efficiency	o Industry, government
	o Quality control	o Industry
Genetic improvement	o Long term genetics research	o Government, university
	o Selective breeding	o Industry
Nutrient requirements	o Biological research	o University, government
	o Select sites in proper environment	o Industry
	o Provide proper nutrient levels in intensive culture systems	o Industry

In summary, aquaculture of marine plants in the U.S. holds considerable potential but its development will require the following actions:

1. Federal action, principally through support of university research and NMFS research in the Pacific Northwest, is needed to establish biological parameters for development of improved culture systems and for genetic improvement.

2. State action is needed to assure availability of space for culture of marine plants in suitable environments.

3. Industry action is needed to reduce production costs, develop new products and markets and to control quality.

NOAA programs related to aquaculture of marine plants consist of Sea Grant projects at universities in California, Hawaii, Florida, Delaware, New Hampshire and Washington funded at $337,000 in 1975.

Funding for Sea Grant marine plant projects should increase by about 50% during the next three years and then decrease gradually to about the current level. In the Pacific Northwest marine plant aquaculture, mainly by NMFS, should increase gradually during the next five years at which time culture of one species should be ready for prototype testing which will require additional funds for three years. Culture of a second species should be ready for field tests shortly thereafter.

Appendix 2.

Medium Priority Programs

Several species or species groups have distinct potential for aquaculture but have not reached commercial production for a variety of reasons. In some cases natural supplies have been sufficient to supply the market and there has been little economic incentive for private aquaculture. As maximum sustained yield levels of natural stocks are reached, it may become attractive to produce some of these species by farming. In other cases, the level of biological and technological information has been insufficient to indicate to potent investors an opportunity for private aquaculture with acceptable risk.

Finally certain species appear in the medium priority list because of their relevance to NOAA responsibilities and policies. For example freshwater species such as trout, catfish, crawfish and several species of baitfish are reared commercially but primary responsibility at the federal level for these species is lodged within other agencies. The authorization for the Sea Grant program specifies the seas and the Great Lakes which generally excludes programs related specifically to inland fish farming. The authori of NMFS primarily relates to marine and anadromous species except for statistics, marketing and similar programs related to commercia fisheries in freshwater and administration of the Commercial Fisher Research and Development Act of 1964 (PL 88-309). As a result NOA activities related to private aquaculture in freshwater consist ma of cooperation with other agencies to achieve national goals of increasing the supply of aquatic products to meet projected U.S. for the future.

Low Cost Fishes

Over half of the 13 billion pounds produced by aquaculture in the world consists of fin fish produced in 10 nations in Southeast Asia. Most of this production is based on various species of carp reared in low-technology aquaculture in freshwater ponds or species such as mullet and milkfish reared in brackish water ponds along the coast.

In the U.S., the concept of culturing such species is a departure from previously held views that only high-valued species are suitable subjects for aquaculture. There is no industry in the U.S. at the present time based on the concept of producing low cost fishes, but extensive experimental culture of freshwater species has been done by Auburn University and experimental mullet culture has been developed by the Oceanic Institute in Hawaii.

The development of warm water fish culture utilizing species that will produce maximum protein returns at the least cost has much appeal. Fishes selected for maximum productivity and desirable growth characteristics under warm water conditions might include carps, buffalo fish, tilapia, mullet, milkfish and catfish. Selective breeding of adaptable species for maximum growth would be an essential part of the development just as it has been for poultry and livestock. Scientists at Auburn University have corroborated the Chinese experience that species combinations are highly useful and productive in pond fish culture. In this polyculture system fish which utilize plants, plankton and detritus would be reared with appropriate omnivorous or carnivorous fishes.

Pond culture of carp and buffalo fish will yield more than 1 ton per acre per year and up to 10 tons per acre per year has been reported in Israel. The herbivorous white amur or grass carp may be started in a pond as fry and will produce more than 4 thousand pounds per acre per year. If culture facilities permit introduction of 3-inch fingerlings, 2 pound white amur may be harvested in 3 months. Three crops a year could yield a total of 8-12 thousand pounds per acre assuming fertility of the water could be maintained.

The U.S. consumer has shown a preference for marine species or for fish which live in cold fresh water. With the exception of cultured catfish, their preferences have inhibited the development of pond fish culture. The question then is, "How could large volumes of cultured pond fish be used for food in view of the fact that these species are not well accepted?" Briefly, the answer is to use them for processed products in which convenience, food value, standardized quality, and price are more important than the name of the species. Recent developments in the field of fish processing technology have made it practicable to use a wide variety of species not accepted as prime food fish. Methods are now available for production of high quality fish blocks from mechanically separated minced flesh of one or more species. Yields can be increased and labor cost reduced by mechanically separating edible flesh from the skin and bones. This method lends itself to flavor and texture control and improved stabilization of the product during frozen storage. It is also possible to combine filleted fish of various species with the minced flesh to achieve more desirable texture in the final product.

Fish blocks made from comminuted flesh of buffalo fish and carp by NMFS technologists at Seattle, were found to be highly acceptable and considerable enthusiasm has been shown on the part of processors in inland areas where wild buffalo fish, carp and other warm-water species are relatively abundant. It is obvious, however, to even the most optomistic processor of these species that a commercial operation of major proportions would quickly reduce wild stocks to uneconomic levels. The processor of fish sticks and portions must have a large and reliable supply of low-cost raw materials which can be provided only by large industrial aquaculture operations.

Space for pond culture of freshwater fishes can be found in the low-valued delta land along the Gulf of Mexico. A recent government study indicated that over 2 million acres of delta land in the Gulf states is apparently available and suitable for aquaculture development. Development of pond fish culture on only one-fourth of this delta land, with a production of 4,000 pounds of fish per acre would yield 2 billion pounds of landed fish per year. Similar areas along the Gulf and Southeast coasts could be used for construction of ponds for brackish water species. In addition, use of geothermal water in Western United States could increase production of warm water fishes. Production from farming of low-cost fishes would supply much of the additional fish which will be needed by our expanding population.

Obviously, extensive research, development, and economic analysis will be needed to determine the feasibility of this concept and to

demonstrate commercial applicability. A start was made in FY 1975 by the NMFS Utilization Research Center in Seattle, Washington in cooperation with the Northwest Fisheries Center. Processing technology experiments indicated that commercially acceptable products can be made from carp and similar species, using labor saving mechanical flesh separators. A NOAA program in cooperation with other federal and state agencies which share responsibility in this subject area should follow this sequence:

1. Utilize natural stocks of carp, buffalo fish, tilapia, mullet and other species which can be obtained at a low cost for development of processing industry and a market for minced flesh products recognizing the fact that natural supplies of some of these species are quite limited.

2. From a survey of available knowledge determine which species of fish suitable for aquaculture could be expected to produce protein at the lowest cost.

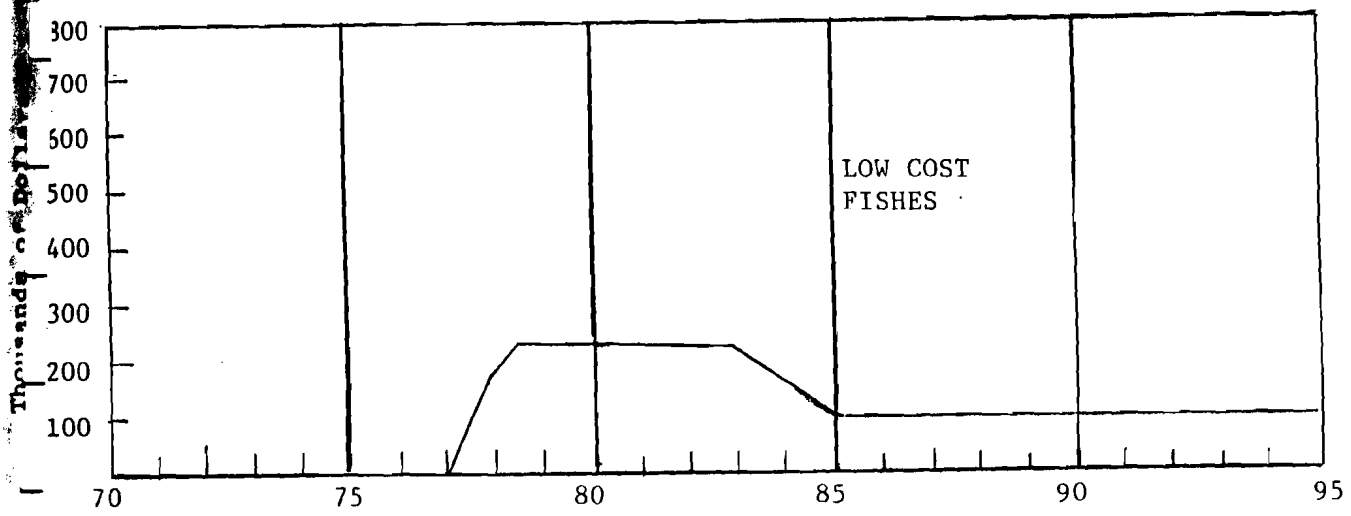
3. Develop techniques for pond culture of selected fresh and brackish water species in the Southern states, where there is a long growing season and available land and water. These studies would be directed toward improving efficiency of traditional pond culture methods to minimize production costs.

4. Develop techniques for high density culture and determine economic feasibility. Although polyculture in ponds will be applicable in areas where low cost land, water and labor are available, intensive culture systems hold more promise for future development of

aculture in the U.S. The constraints of available land, ter, waste control and zoning may be overcome by high technology ulture systems with water treatment, reuse and carefully controlled nvironmental conditions.

5. Develop methods for utilizing waste heat and geothermal waters for aquaculture of low cost fishes and determine economic feasibility.

NOAA programs related to low cost fishes have been primarily exploratory studies to determine if acceptable products could be made from carp, mullet and similar species. Biological research to determine the status of knowledge concerning culture of various species should begin as a Sea Grant project and continue with development of culture techniques for use in the U.S. during the following 5 years. NMFS research to develop intensive culture systems should begin in FY 1978 and continue for about a decade. NOAA funding should increase to about $200,000 for a 5 year period and then decrease to $100,000. Participation and funding by state and other federal agencies will be needed to provide an adequate level of effort to assure development of aquaculture of low cost fishes.



2.2 Catfish

Private catfish farming has been a viable industry for more than 5 years and about 2,000 farmers and 12 processing firms are concentrated in 13 Southern states; about 80% in Mississippi, Arkansas and Louisiana.

Total production from farming is estimated at over 50 million pounds round weight of which 20 million pounds are processed for the market by large firms and the other 30 million pounds are processed locally on a small scale or are sold through fee-fishing lakes. Private production, which is considerably larger than harvest from wild stocks, has stabilized at the present level. Industry is concerned about the effects of increased production costs and market resistance to high prices which have reduced profit margins and increasing imports of low priced catfish produced in Latin America.

Many individual catfish farms have failed because of poor construction or design of ponds, inadequate prevention or control of disease, or lack of markets, but the number of failures is trending downward.

Three major problems which limit the expansion of the farm-raised catfish industry are: the high cost of prepared feeds, consumer resistance to high retail prices and competition from low priced imported catfish. In addition, water supplies are dwindling and more stringent effluent control procedures are being required which will probably make it necessary to install water reuse and treatment facilities. This will also cause some farmers to go from the open-pond culture system to raceway culture which lends itself to water reuse.

disease control and prevention methods are used on a regular throughout the industry, losses from disease are still significant.

atfish farming is another good example of successful private ulture which is likely to expand without major government programs. nge research on nutrition, genetics, water quality and intensive systems is important to the continued growth of the industry. ion service activities to encourage application of disease tion, control methods, improved culture and effluent control s would be helpful to individual farmers.

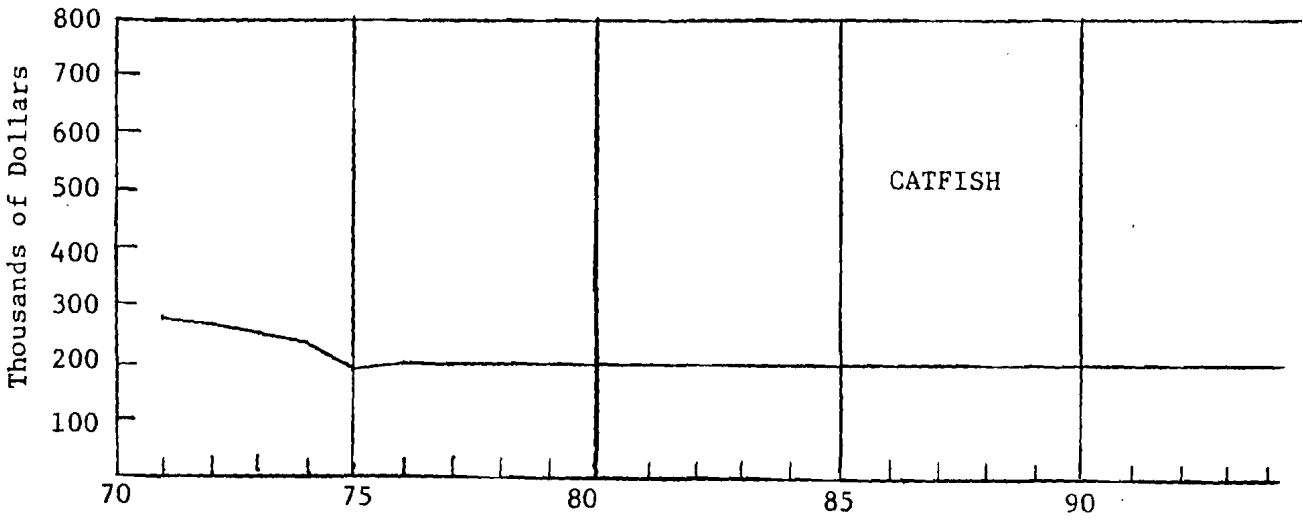
The potential for expanding catfish culture depends on production and market prices. With satisfactory profit potential the try output could double during the next decade. The major ing factors will be continuing high feed costs, water supply and ent control problems, market development and foreign competition.

NOAA catfish programs in 1975 included the transfer of $150,000 Fish and Wildlife Service of the Department of Interior for gical research, nutrition studies and gear development. State ams under PL 88-309 in Puerto Rico concerned polyculture of el catfish and tilapia and those in Nebraska concerned high ity catfish rearing in irrigation canals. In addition, NMFS ting and statistics programs include catfish.

Federal responsibility for development of aquaculture of catfish and freshwater species involves several agencies including the rtment of Agriculture and the Department of Interior.

NOAA activities related to catfish probably will be limited to service programs such as marketing and statistics in cooperation with other federal agencies and in funding state programs under the Commercial Fisheries Research and Development Act of 1964 (P.L. 88-309). NOAA is also concerned with the possibility of polyculture of catfish and several low cost species to produce acceptable products for the mass feed market in anticipation of the projected increase in demand for aquatic products in U.S.

NOAA catfish programs will require continued funding at the FY 1975 level.



2.3 Clams

Many species of clams live in the intertidal or subtidal areas along our coasts and in bays and estuaries. Six of these hold some potential for aquaculture:

1) The Eastern Hard Shell Clam, Mercenaria mercenaria, known as littlenecks or cherrystones when small and quahogs when large, occurs from Maine to the Gulf of Mexico. Wild stocks are harvested on public lands. Private aquaculture ventures are located on Long Island, New York; Wilmington, North Carolina and in several other locations.

In the New York venture, hard shell clams are raised along with oysters in a private hatchery and held in trays in the warm effluent from a power plant to accelerate growth. When the clams reach the proper size they are planted on privately controlled beds. This venture was begun recently and it is too soon to determine its financial success. This company also selectively harvests natural sets of clams on the beds under its control and occasionally transplants seed clams to areas where growth and survival are better. Procedures for this more primitive form of aquaculture are well established and operations are profitable.

The North Carolina venture includes a hatchery capable of producing more than four million seed clams per year for sale or for planting on leased beds. Again, it is too early to evaluate the financial success of this venture.

The Virginia Institute of Marine Science hatchery at Wachapreague, Virginia successfully produces seed clams and has achieved good survival by placing coarse material such as gravel on the beds prior to planting. If this technique is proven to be successful in pilot scale tests, it will be ready for commercial application.

Intensive culture using artificially produced algal foods is being tested by the University of Delaware. In this Sea Grant supported project, hardshell clams have been grown to marketable size in one third the time required for wild stocks in Delaware Bay.

2) The soft shell or steamer clam, Mya arenaria, is harvested by hand in the intertidal zone in New England and by hydraulic escalator harvester in the subtidal beds of Chesapeake Bay. Fairly extensive beds of soft shell clams occur at the mouth of several rivers in the Pacific Northwest. Several firms have begun harvesting these clams with hydraulic escalator harvesters on privately owned or leased beds in the intertidal zone.

Larvae of the soft shell clam have been reared experimentally in hatcheries and it appears that commercial aquaculture could succeed if seed supplies were available, intertidal beds could be leased and predators could be controlled. One limiting factor in New England at the present time is the availability of tidelands for private clam culture. Also during cycles of high abundance the green crab, Carcinus maenas would destroy plantings unless beds were fenced to exclude these predators.

In the Pacific Northwest a primitive aquaculture system could be based on transplanting seed clams from contaminated areas at the mouths of rivers to clean areas for cleansing and growth. Later, when hatchery produced seed becomes available, these operations could be expanded into full scale aquaculture.

3) The butter clam Saxidomus nuttalli occurs on the Pacific Coast from Alaska to California. This species is extensively utilized except in areas where harvesting is prevented because of paralytic shellfish poisoning which occurs when the clams feed upon the dinoflagellate Gonyaulax. This condition is prevalent in Alaska where extensive beds of butter clams remain unutilized.

Commercial farming of butter clams, principally in the state of Washington, is largely based on selective harvesting of natural stocks on privately owned or leased beds in the intertidal zone or on subtidal beds leased from the state. In some cases, intertidal beaches, which have become unproductive because of a change from gravel to sand, have been restored to full productivity by depositing a layer of gravel over the beach. The coarse gravel provides the small clams

with protection against wave action and predatory crabs.

4) The native littleneck clam of the Pacific Coast Prothothaca staminea, like the butter clam, has been harvested for many years. At the present time the entire U.S. commercial production of littleneck clams comes from private clam farms and prices have increased in response to the limited supply. As with butter clams, the productivity of sandy beaches has been restored by depositing a layer of gravel. The primitive form of aquaculture of both butter and littleneck clams may develop into full scale aquaculture when hatchery-produced seed becomes available.

5) The Manila clam Tapes semidecussata (Venerupis japonica) was accidently introduced from Japan with seed oysters many years ago and now has become the most valuable commercial clam in the Pacific Northwest. Occurring high in the intertidal zone, the Manila clam fits a separate niche from the native littleneck clam and the butter clam.

Production of the Manila clam in U.S. is principally from licensed clam farms in the state of Washington and supplies are fully utilized.

Larvae of the Manila clam can be cultured readily in hatcheries and quantities of seed for prospective clam farmers can be purchased from several private hatcheries.

Techniques for rearing hatchery-produced seed clams to a size of about 15 millimeters at which size they can be planted on growing beds have not been fully developed and this has discouraged commercial clam farming. When this problem is solved aquaculture of the Manila clam should expand rapidly.

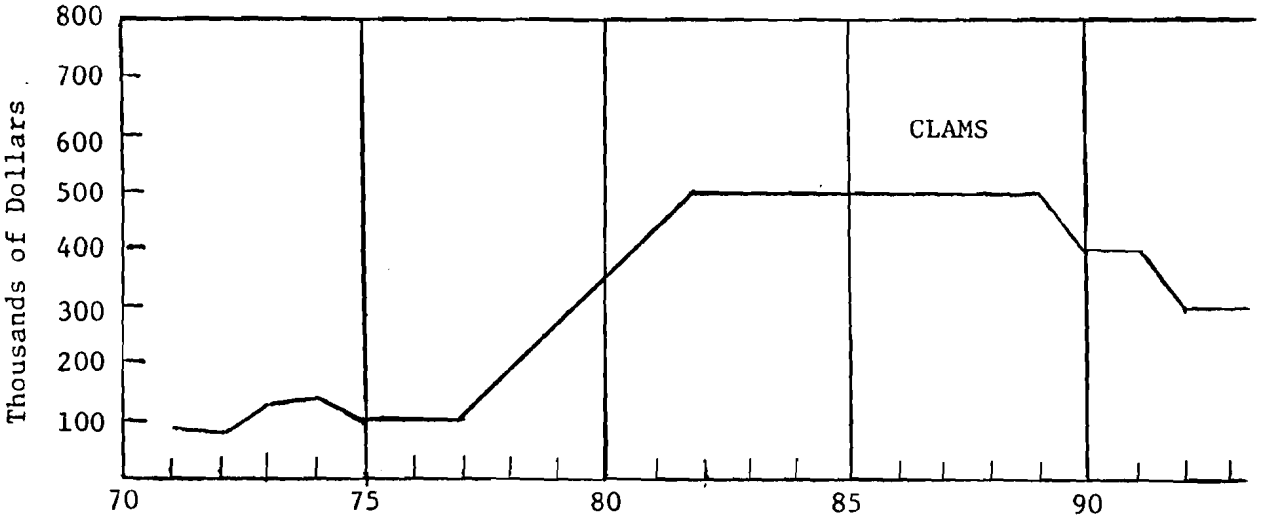
6) The geoduck Panope generosa, the largest temperate water clam, is extremely abundant in Puget Sound Washington below the low tide level where commercial harvest occurs on beds leased from the state. Methods for rearing the larvae of the geoduck clam have not been developed and an extended period of research and development will be required before aquaculture of this clam can become a reality.

In summary, the increasing demand for clams, the limited supply, their sedentary nature, and the fact that they obtain their own food without additional cost makes it attractive to consider aquaculture as a means of increasing production. Although the life history of most clams is well known and larval culture in hatcheries is possible, there remains a problem of increasing survival of juveniles until they reach the size at which they can be planted on intertidal or subtidal beds. In some places, tidelands may not be available for private clam culture because of legal restrictions or local customs. Aquaculture in such places would require the development of intensive culture methods for use on shore or culture in deeper waters beyond the intertidal zone.

Although NMFS conducted research on hardshell and softshell clams of the Atlantic Coast during the 1950's and 1960's, these investigations have been completed. As of 1975, NOAA programs related to clams included occasional pathological studies at the NMFS Laboratory at Oxford, Maryland, and studies of processing techniques at the Resource Utilization Laboratory at Gloucester, Mass. Sea Grant supported research included projects at the University of Delaware on

intensive culture methods and a small study in Florida on selective breeding of hardshell clams.

Future NOAA programs should include an expansion of pathology studies at the NMFS Laboratory at Oxford, Maryland and new genetics research projects at Milford, Connecticut. Sea Grant projects at universities are needed to obtain adequate biological and technological information for development of private aquaculture of various species of clams. Funding for NOAA programs should increase from the 1975 level of about $100,000 to about 1/2 million dollars annually during the next 5 years and continue at that level for perhaps a decade.



4 Abalone

Several species of abalone occur from Mexico to Alaska but the largest and most important from a commercial and recreation standpoint is the red abalone Haliotis rufescens which is found principally in California. Commercial landings of abalone are less than a million pounds per year but the demand is great and prices are high and increasing.

Many years ago, Japanese workers developed procedures for rearing larvae of abalone through their pelagic stage and for feeding and culture of juveniles until they were large enough to plant in the sea. A number of Japanese government hatcheries rear abalones to about 1 centimeter in diameter at which time they are sold to fishermen's cooperatives at a moderate price for planting in areas where macro-algae are available for food. Growth rate of abalones is rather slow and about three years after planting is required for them to reach harvestable size.

Private abalone culture began in California in 1965 and although the firm developed satisfactory mass cultivation techniques for red abalone, they could not obtain an open coastal lease exclusive from the public in which to grow them to market size.

Another group located along the central California coast near Cayucos, became operational in 1968. This venture is directed toward mass cultivation of red abalone from the egg to harvestable size in shoreside ponds. They recently completed a new hatchery based upon information developed during their pilot hatchery operations and expect to grow 1 million abalones up to a size of 3 to 4 inches in approximately 3 years in shoreside ponds.

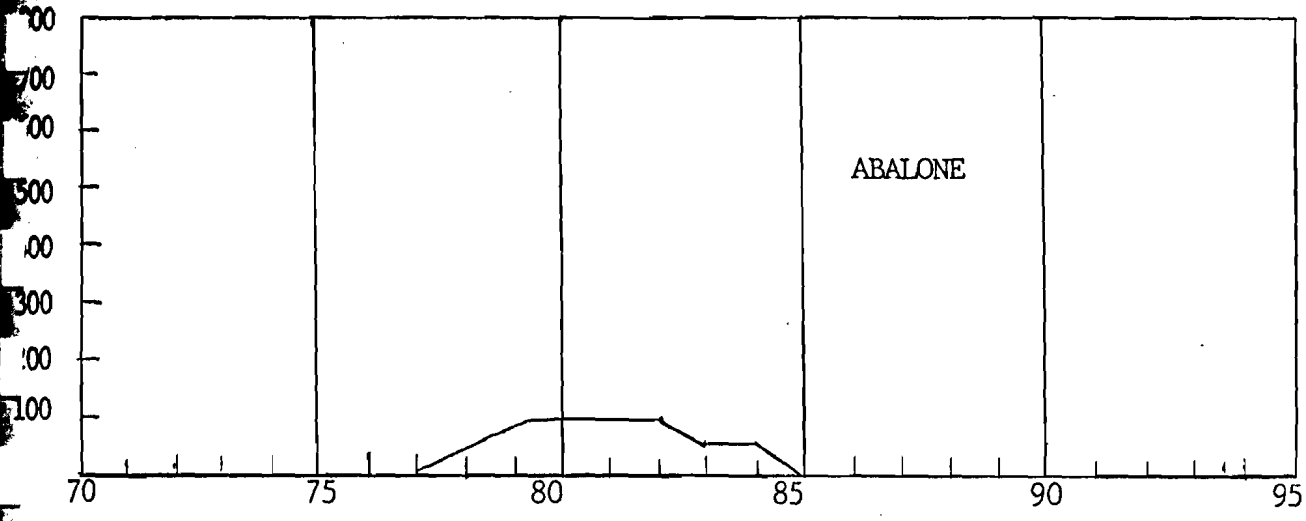
A third firm established in 1972 expected to purchase seed abalone and to grow them in specially designed habitats placed in a 50 acre, open coastal trace near Point Sur which they have leased from the state.

Most private abalone culturists feel that they are "breaking trail" and that their profit potential is reduced because so much time and money are required for research and development. Prototype tests of culture systems would make it possible for abalone culturists to move directly into production. This would also make it easier to attract investment capital.

The principal problems of abalone culture include the slow growth rate, high post-larval mortality, design of tank culture systems, design of open coastal habitats, cost-effective feeds and feeding systems, and adequate space for production facilities.

The State of California Department of Fish and Game has done some research on abalone culture and several completed studies by the University of California were funded by the Office of Sea Grant.

NOAA activities related to abalone culture should be limited for the present to funding of Sea Grant projects at university and state P.L. 88-309 projects to provide adequate biological and technological bases for development of private aquaculture and pathological research at NMFS laboratories when needed. At some time in the future, genetics research and selective breeding to improve growth rate will be needed.


ABALONE
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2.5 Bay Scallop

The bay scallop has traditionally enjoyed high consumer acceptance in the U.S. and the scallop industry would be much larger than it is if the natural supply of this bivalve were greater and its annual abundance more predictable. The newly developed calico scallop fishery of the Southeast Atlantic states provides a product of similar size which may reduce the price of bay scallops during periods when calico scallops are abundant. Supplies of bay scallops are variable, probably because of their short life cycle and environmental changes in shallow bays where they live.

There appears to be a distinct possibility of aquaculture of bay scallops because they live in the near shore environment where private control of production areas is possible. As compared to the American oyster, and the hard clam, relatively little scientific work has been done on the culture of bay scallops. However, the species has been induced to spawn and larvae have been reared successfully through metamorphosis by various investigators. The species has also been reared from post-larval stage to marketable size under controlled conditions in the laboratory as well as in the natural environment.

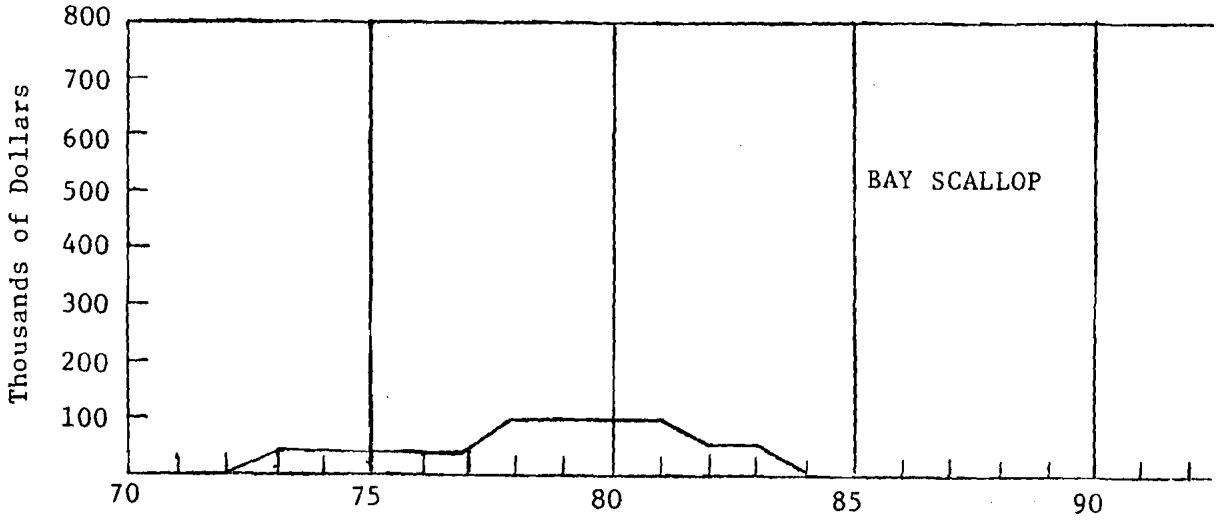
Little has been published on the rearing of juvenile bay scallops but scientists of the Virginia Institute of Marine Science were able to transfer post-larval scallops from the hatchery to semi-natural conditions approximately one week after metamorphosis. After a growth period in trays, the scallops were placed on-bottom in a fenced portion of a shallow bay where they reached commercial size in less than a year.

There is adequate biological and technological information for aquaculture of bay scallops at the present time but pilot scale testing would be desirable to make sure that the methods developed at Wachapreague, Virginia can be applied successfully at commercial levels. Limiting factors are the availability of juveniles, water quality, the cost of water front land and a legal framework which will allow individuals to lease areas for scallop culture.

A number of individuals and firms are interested in beginning aquaculture of bay scallops and it appears likely that a viable industry will develop within the next five years.

The following areas of research are relevant to scallop culture as they are to culture of other mollusks: genetics, disease, nutrition, culture systems, engineering and economic analysis. Hatchery design may be a minor problem if the techniques and systems developed for oyster hatcheries are applicable to scallop culture. The expertise of NMFS scientists in larval oyster culture should be applied to the solution of problems inherent in scallop culture.

The NOAA program related to bay scallop culture consists only of the Sea Grant supported research by Virginia Institute of Marine Science. Expansion of efforts to permit testing of laboratory findings in field trials will require about $100,000 per year for five years. Genetics research will also be needed if a commercial bay scallop aquaculture industry develops.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BAY SCALLOP
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2.6 Pandalid Shrimp

The family Pandalidae is represented by 9 species. Pandalus borealis, the Northern pink shrimp, is subject to an intensive commercial fishery in the Northern Pacific and the Northwestern Atlantic. A similar species P. jordani, the ocean pink shrimp, replaces P. borealis as the dominant ocean speices south of Alaska. Since these species are abundant and low priced, there is little reason to consider them for aquaculture at this time.

The largest of the Pandalidae, the spot prawn Pandalus platyceros, occurs along the West coast of North America from Unalaska to San Diego, and in Asian waters including Siberia, Korea and Japan. The spot prawn lives in bays and inlets as well as on the continental shelf and slope at a depth of 4 to 487 meters (13 to 1600 feet). It reaches the weight of 110 grams (1/4 pound) and a length of 25 centimeters (10 inches). This species exhibits the fastest natural growth rate of the Pandalids, although slower than that of many Penaeid shrimp.

The spot prawn is fished commercially with trawl and pot gear. The 1973-74 season catch was 65,963 in California and 70,000 pounds in Washington. No information is available on catches in Oregon and Alaska.

The spot prawn has characteristics which indicate that it may be a suitable species for aquaculture. It lives at salinities of 25-30 parts per thousand and temperatures from 2^{o} to 20^{o}C. (35.6^{o} to 68.0^{o}F.) and adapts well to shallow water environments. It is gregarious and no significant cannibalism occurs even if held under crowded conditions. Adult breeding stock can be captured at depths of 30-120 meters (100-400 feet) and transported great distances with low mortalities. No serious disease problems have occurred to date in captivity.

A research team at the National Marine Fisheries Service, Aquaculture Experiment Station, Manchester, Washington, recently succeeded in attempts to get adults to mature in captivity. About 70 females which had been held at Manchester after spawning the previous year, produced eggs which hatched successfully. At this point a major obstacle to aquaculture, maturation and reproduction in captivity, has been removed for the spot prawn but not for Penaeid shrimp of the Gulf of Mexico. This suggests that additional efforts be applied to develop procedures for aquaculture of the spot prawn in temperate waters.

Other advantages of the spot prawn are that the larvae are large at the time of hatching (6-7 millimeters) and feed directly on zooplankto during the first stages of development. During later development the larvae and postlarvae adapt to artificial diets. Survival to metamorphosis has routinely been between 68 and 78% at 14°C. (57.2°F.) thus making the spot prawn a candidate for aquaculture along the West coast where surface temperatures are near this level.

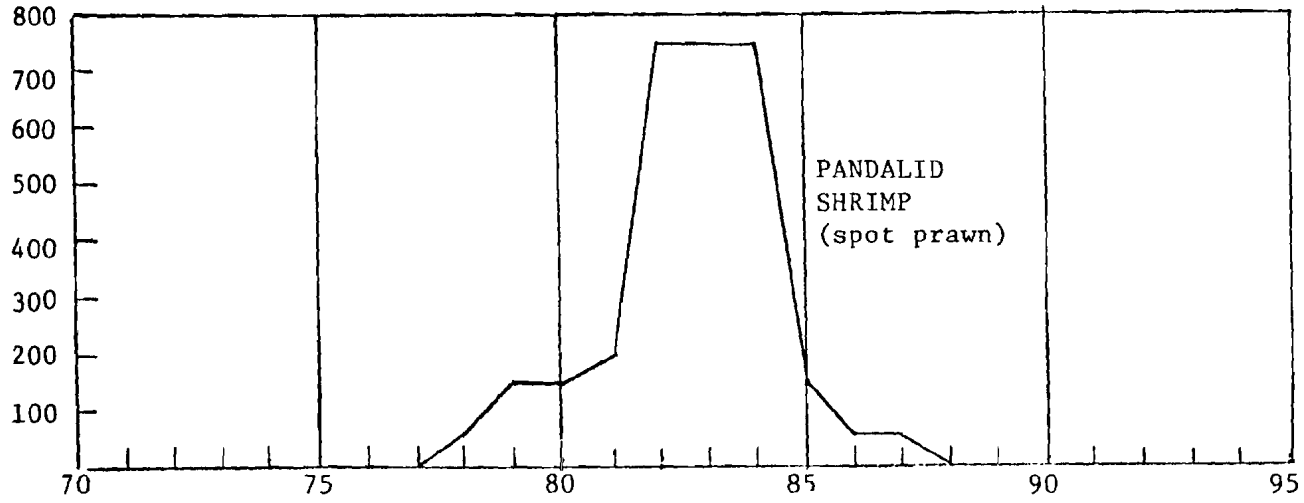
At the present time there is inadequate technological and economic information regarding P. platyceros culture to encourage the development of commercial aquaculture. Research to determine the feasibility of culture is being conducted by California Fish and Game, University of California, Davis and the National Marine Fisheries Service. At the present level of research effort and funding viable aquaculture cannot be expected in less than 5 or 6 years.

Potential problems in the culture of Pandalid shrimp are about the same as those for Penaeid shrimp. However, the environmental requirements will differ as the spot prawn is basically a temperate

water species. First experiments indicate accelerated growth and satisfactory survival when juvenile spot prawn are held at 14° to 18°C. (57.2° - 64.4°F.) instead of their natural environmental temperature of 10°C. (50°F.) or less.

Finally, there appears to be some potential for rearing the spot prawn as a companion crop with salmon grown in floating and submerged cages. Both species require about the same environmental conditions but, of course, would have to be kept in separate containers because of the predation problem.

The present status of knowledge concerning the potential for aquaculture of the spot prawn is largely the result of exploratory studies conducted at Manchester, Washington by NMFS scientists incidental to the salmon project and studies in the State of California laboratory at Granite Canyon and a Sea Grant project at the University of California and at the University of Washington. NOAA funding should increase to about $200,000 annually for three years. Higher funding will then be needed for three years for prototype testing after which the level of effort could be decreased.



Appendix 3.

Low Priority Programs

A number of species appear to have potential for aquaculture but adequate biological and technological information is needed to evaluate this potential and to provide a sound basis for development of an aquaculture industry.

Other species may appear on the low priority list because they are peripheral to NOAA's area of responsibility even though commercial aquaculture of these species may already exist.

3.1 Marine Fishes

On a world-wide basis, several species of fish are farmed in the marine environment and contribute significantly to the supply of protein and the development of commerce especially in Asia.

Annual production of milkfish, Chanos chanos is estimated at 167,000 metric tons. In Japan more than 30,000 metric tons of the yellowtail, Seriola quinqueradiata, were produced by private aquacultu in 1968 exceeding the catch from wild stocks. Mullets are also produc by aquaculture especially in Southeast Asia.

In Japan, more than a dozen other marine or anadromous fishes are being cultivated in sea water on an experimental or commercial basis. In Great Britain methods have been developed for rearing the plaice, Pleuronectes platessa, and a pilot scale project has been conducted to develop commercial aquaculture methods.

In the United States there are relatively few species of marine fish which are readily adaptable to aquaculture at the prese

time. Adequate supplies of many species are available by harvesting wild stocks, and prices are too low to attract investment in aquaculture. Some flat fish are in good demand and in short supply but methods for aquaculture have not been developed although it appears likely that the British experiments with plaice will provide a good starting point for development of procedures applicable to U.S. species. Preliminary work in Sea Grant projects in North Carolina and Hawaii have indicated fast growth of the dolphin fish Coryphaena in captivity. Known in Hawaii as mahi mahi this fish is in high demand and may have some potential for aquaculture.

Japanese research and development on the culture of the yellowtail Seriola has led to an extensive aquaculture industry but it is not known whether these methods would be adaptable to Seriola dorsalis, the American species prized by California anglers.

The maturation, spawning and larval culture of a number of marine fish can now be accomplished routinely at the NMFS Southwest Fisheries Center. Marine fishes which have been successfully matured and spawned include the Northern anchovy, Engraulis mordax; the Pacific sardine, Sardinops caeruleus; the croaker, Bairdiella icistia, and the Pacific mackerel Scomber japonicus.

3.1.1 Pompano

The pompano is a highly-prized fish caught in small quantities in the southern part of the United States. Initial research by the National Marine Fisheries Service and the Florida Department of Natural Resources indicated potential for private aquaculture of pompano and a number of small-scale commercial efforts began along

the Florida coast. Most of these commercial ventures have failed because they were begun before an adequate technological base for culture of pompano.

The first attempts at pompano culture were based on the collection of wild fingerlings from the surf zone. Since methods for achieving spawning in captivity and larval culture had not been developed, commercial aquaculture depended on the availability of seed from wild stocks. In addition, nutritional requirements were not well understood and the available foods were apparently deficient. Environmental requirements and factors which caused extensive mortalities were poorly understood. Recently methods have been developed for spawning pompano and rearing the larvae and reportedly are being used by a commercial aquaculture firm in the Dominican Republic.

Although there is a high probability that the problems listed above could be solved by a well-funded research program, conducted by a competent staff, there is little or no effort going into this project at the present time. NOAA funding for efforts to develop comercially applicable procedures for maturation and spawning of pompano in captivity would require about $100,000 annually for five years.

3.1.2. Sablefish or black cod

The most likely species for marine farming in the Pacific Northwest is the sablefish or black cod, Anoplopoma fimbria. Scientists of the Fisheries Research Board of Canada held black cod in tanks of running sea water at the Nanaimo, British Columbia laboratory and found that they grew rapidly with good conversion rate when fed chopped marine fish including the dogfish shark Squalus. Black cod are gregarious and well suited to intensive culture. Limiting factors at this time are the relatively low market value of the product, because large quantities

available from the harvest of wild stocks, and the difficulty of obtaining juveniles for aquaculture. Commercial aquaculture would require development of methods for collecting large numbers of wild juveniles or for inducing maturation and spawning in captivity.

1.3 Striped Bass

Several anadromous fish in addition to salmon can be cultured in the marine environment. Striped bass, trout and char, among others may have some potential for aquaculture in marine or estuarine waters.

Despite its anadromous nature, the striped bass Morone saxatilis has been induced to mature and spawn in full sea water; fresh water was needed only for fertilization. Striped bass eggs and larvae require slow acclimation to increase salinity over an 18 day period to survive in full sea water. Once this is achieved, metomorphosis is completely successful and growth is rapid if the fish are well fed. This development suggests that a sea water hatchery for this species may be possible where fresh water is at a premium as in Southern California and that marine farming might be developed.

3.1.4 Tropical Aquarium Fish

Small colorful marine fish and invertebrates are in great demand for use in aquaria. The value of marine and freshwater fish imported annually for the aquarium trade is estimated at 300 million dollars. With a questionable supply from wild stocks and the possibility of import restrictions to prevent accidental introductions of undesirable species into U.S. waters, aquaculture of salt water aquarium fish may develop in the future.

3.1.5 Tropical Food Fish

There is some research and development in progress in Hawaii and in other Pacific Islands to develop culture methods for selected marine food fishes. In Hawaii the thread fin "moi" Polydactylus sexfilis stands out because of its biological characteristics and consumer appeal. Since this fish is widely distributed and highly esteemed as food throughout the Indo-Pacific, techniques developed in Hawaii will benefit aquaculture over a broad geographic area.

Mullet, genus Mugil, is highly prized in the Pacific Islands. Culture methods are being investigated in Hawaii under a Sea Grant project and significant progress has been made in developing methods for stimulating spawning and rearing the larvae in captivity. Tropical food fish aquaculture in Sea Grant projects was funded at about $200,000 in 1975. Funding should continue at this level for about a decade.

Aquaculture of the rabbit fish Siganus is being developed in Sea Grant-sponsored projects in the Palau Islands and Guam. Siganids have high aquaculture potential because of the ready availability of fry in shallow water, their rapid growth rate, their subsistence on plant food, and the excellent market. Induced spawning and rearing of larvae have been accomplished on a small scale. The development of aquaculture for food production and commerce in Guam, American Samoa and the Trust Territories of the Pacific Islands is important to U.S. Research and development projects in the Palau Islands are jointly sponsored by NOAA, Interior and the Universities of Hawaii and Guam.

3.1.6 Tuna Baitfish

The pole-and-line fishery for skipjack tuna is primarily dependent upon the baitfish resource. The principal baitfish used by the Hawaiian skipjack fishery is the nehu, Stolephorus purpureus, a small delicate

anchovy which possesses most of the qualities of good baitfish, but suffers mortality of as much as 30% despite careful handling.

Attempt at aquaculture of introduced baitfish species have been made by the National Marine Fisheries Service and the Hawaii Division of Fish and Game, the most successful being with the tilapia, (Tilapia mossambica). However, the lack of interest by the fishermen in the use of this bait compelled the state to abandon the operation.

Two freshwater species, the freshwater thread fin shad Dorosoma petenense and the euryhaline top minnow Poecilia vittata have some potential for use as baitfish. The thread fin shad established breeding populations in freshwater reservoirs in Hawaii. Top minnows are easy to raise in captivity as indicated by experiments in Hawaii and in American Samoa. A number of native marine species including the cardinal fishes (Apagonidae), the goat fishes (Mullidae) and the mullets (Mugilidae) hold potential for aquaculture but the lack of knowledge concerning the biology and culture methods will require research and development.

The concept of baitfish production by aquaculture conducted by Pacific islanders for sale to tuna boats holds promise for local employment in profitable ventures and increased harvest of underutilized skipjack resources.

Summary

NOAA programs related to culture of marine fishes have been mainly exploratory attempts to rear a few species which appear from their life cycles and demand to be candidates for aquaculture. Continuation of these efforts, largely through the Sea Grant program, is needed to provide biological and technological information as a basis for decisions regarding the commercial potential for aquaculture.

Funding should increase from the 1975 level of about $250,000 to about $500,000 during the next 5 years and continue at that level for as much as a decade to permit development of culture methods to commercial applicability.

3.2 Other Freshwater Species

Several freshwater species in addition to catfish, carp, buffalo fish and tilapia which are discussed elsewhere in this report are grown in private farming ventures.

3.2.1 Trout

Private trout farming based on techniques developed in governmen hatchery programs have become well established throughout most of the United States where suitable water supplies are available. All of the rainbow trout which enter commercial channels, about 30 million pounds, are produced in private trout farms.

In the Pacific Northwest, commercial trout culture is centered in Idaho, Montana, and other Rocky Mountain states although there are commercial ventures in Washington, Oregon and California. In addition over 100 farms which produce trout as a primary source of income, there are more than 700 which raise trout for sale to individuals for stocking private waters or to operators of "pay ponds" where the public can catch trout for a fee.

In the Midwest, trout are produced in commercial hatcheries in Minnesota, Wisconsin, Michigan and Ohio. In the Southeast region, a small trout industry exists in the lower Appalachian area consisting of about 8 production firms which have been in operation for an average of 4 years. Total production estimated at 2.5 million pounds annually, has shown fairly steady growth.

In the Northeast region there are several small and a few large

trout breeders and most of their production is sold for stocking private waters of fee-fishing lakes.

In the past, U.S. trout producers faced severe competition from foreign producers but now imports from many areas are limited because of danger of introducing dangerous diseases. Government regulations (50 CRF 13.7) require that imports be certified as free from Myxosoma cerebralis and viral hemorrhagic septicemia.

Recent shortages and increased prices of fish meal, a major component of trout food, and generally rising production costs have narrowed the profit margin. Proposed effluent control regulations will also add to production costs. Major technical problems of trout production have been solved but improved procedures are needed to lower production costs and thereby increase profitability.

Expansion of the trout farming industry is limited to areas with satisfactory freshwater supplies and available land. Operating costs including food supplies are increasing and the industry is so fragmented that concerted market development programs to expand high priced markets have not been undertaken.

New production techniques such as the silo system which has been used experimentally in Rhode Island for salmon might be used for trout culture where availability of land is a constraining factor. However, conventional raceway production facilities are more efficient presently because water, not land, is the limiting constraint.

In the U.S. Pacific Northwest, trout have been grown in saltwater or in floating net pens on an experimental basis for about a decade and this process is just approaching commercial application by one firm in Oregon.

With adequate markets, at prices commensurate with production costs, trout production in the U.S. could double by 1985. The trout farming industry is a good example of viable aquaculture at the present time, and few additional government efforts are needed. Private trout farmers are likely to apply new techniques developed for use at public trout hatcheries and will benefit from continued government research and development in genetics, nutrition and disease control for trout and salmon.

NOAA programs related to trout culture have been mainly in the marketing and statistics area plus some state projects funded under the Commercial Fisheries Research and Development Act of 1964 (P.L. 88-309). In addition, some aspects of NOAA research and development related to net pen and ocean ranching of salmon will apply to private aquaculture of the anadromous steelhead trout Salmo gairdneri irrideus. No expansion of NOAA efforts is anticipated because of extensive programs of other federal and state agencies related to trout culture.

3.2.2 Crawfish

Crawfish production by aquaculture is estimated at 6-10 million pounds. The industry which is largely based in Louisiana began about 1960 and includes many small farmers and a few large processors. The industry is growing and cultured crawfish account for up to 50% of the total production. Farmers using accepted management techniques have a good chance for success.

One of the major problems of the crawfish industry is the cost of harvesting. Since crawfish require aquatic vegetation for food and cover, they must be harvested by using traps or lift nets and these methods require a great deal of labor.

Another serious problem is the year-to-year fluctuation in the wild crop. This causes severe price fluctuations and in a year of plentiful wild stocks, prices may drop enough to curtail the harvest of the cultured crop.

Virtually all of the research concerning crawfish culture has been done at Louisiana State University, because Louisiana is the principal producing state. Although there is an adequate biological and technological base for aquaculture, additional research is needed in nutrition, disease problems, food formulation and behavior. In addition, market research is needed to determine the potential for developing additional markets in U.S. and Europe. Technological research on product form, quality control and peeling methods is needed.

Crawfish farming is another example of viable commercial aquaculture which does not need major government efforts. With a successful program to develop markets outside of Louisiana, production could be doubled during the next decade.

NOAA programs related to crawfish include one small Sea Grant supported study in Louisiana and minor NMFS efforts in statistics and marketing. Other federal and state agencies also fund some crawfish studies.

Funding for NOAA programs should continue at the 1975 level of about $25,000. If interest develops in farming of northern species of crawfish, some expansion will be needed to develop culture methods.

3.3 Mussels

The blue mussel Mytilus edulis occurs from the Arctic Ocean to South Carolina on the East Coast and from Alaska to California on the West Coast. Abundant populations of this small bivalve cover rocks, pilings and mud flats in many intertidal and shallow areas, firmly attached to almost any solid object by hairy tufts of byssal threads. The blue mussel is the most abundant edible mollusk in New England.

In Europe, mussels are highly prized food and extensive mussel aquaculture industries are located in Holland, France and Spain. Despite numerous attempt to establish a fishery, mussels have never found substantial favor in the United States but small quantities are harvested to supply a specialized market in cities with large foreign-born populations.

In 1973, a State agency in Maine began a consumer education program and the resulting market demand for mussels exceeded the capacity of the small local fishery. If the market for mussels continues to expand, natural stocks could not meet future demands and aquaculture ventures would be needed. In 1975 one new firm in Maine began mussel culture on two miles of ropes suspended from rafts. This very modest beginning looks promising since rafted mussels reach market size in

18 months. The labor-intensive raft culture techniques used in Spain are not directly applicable to northern New England nor are the techniques of the capital intensive, hard-bottom industry of the Netherlands. Joint efforts of industry, universities, and government will be needed to predict market development, determine quantities available from natural stocks and to develop the technology for an economically competitive aquaculture system for mussels.

Looking to the future when increased quantities of seafoods will be needed coincident with a decrease in available energy, there may well be a place for mussel culture since this species is known to be one of the most efficient converters of phytoplankton to high protein food.

Sea Grant programs related to mussels include a joint effort of University of New Hampshire and University of Maine and to investigate the potential for raft culture in New England and a study at University of Washington. Funding for mussel projects should continue at the present level of less than $100,000 for 3 to 5 years. If demand continues to grow, research and development activities should then be expanded to about $200,000 for 5 years.

3.4 Crabs

Several species of crabs are harvested commercially on the U.S. continental shelf and within bays and estuaries. The Alaska king crab, *Paralithodes camtschatica*, and the snow crab, *Chionoecetes bairdi*, are found in deeper water usually well off shore and it is difficult to visualize commercial aquaculture of these species at this time. Of the remaining species the Dungeness crab *Cancer magister* of the West coast, the rock crab *Cancer irroratus* of the East coast, and the blue

crab Callinectes sapidus of the Atlantic and Gulf coast might be considered for aquaculture. The larvae of all three species have been reared in the laboratory. Juvenile crabs feed readily on low cost foods such as scrap fish, however, conversion rates are poor and growth is relatively slow.

Natural stocks of crabs vary greatly from year to year with corresponding price changes, although there is a generally upward trend in price and demand for crabs along with other crustaceans. However, the difficulty of rearing carnivorous, cannibalistic crabs for 2 to 3 years for a market with sharp price fluctuations, militates against aquaculture. In the future, as a better technological base is developed, aquaculture of crabs might become an economic possibility if demand increases and natural stocks become fully utilized.

Recent research by NMFS scientists at College Park, Maryland provide some basis for optimism regarding culture of the blue crab. Under experimental conditions juveniles grew to marketable size of 5 inches in 15 to 18 months and scientists believe that this growing period can be reduced by development of suitable artificial foods.

Several tropical species such as the stone crab Menippe, the Sa or mangrove crab Scylla serrata, and the coconut crab Birgus latro hold some potential for aquaculture in the future but adequate biological and technological information concerning these species is not available this time.

NOAA programs related to the blue crab in 1975 included a study of nutrition by NMFS in Maryland and a Sea Grant study of pathol

in North Carolina. One Sea Grant project in Florida concerned culture of the stone crab and one in California concerned the mangrove crab. A small project at the University of Guam investigated mass culture techniques for tropical crabs. NOAA funding related to crab aquaculture should continue at the 1975 level of about $150,000 for 5 to 7 years to provide adequate biological and technological information to permit evaluation of aquaculture potential of various species.

3.5 Marine Baitworms

The baitworm fishery is the fourth largest fishery in Maine with an annual landed value of about 2.0 million dollars. The two principal species are the blood worm Glycera dibranchiata and the sand worm or clam worm Neanthes (Nereis) virens. At retail, marine baitworms are among the most valuable marine products. The principal market for both species, Long Island Sound to Chesapeake Bay, is increasing in response to expanding recreational fisheries. The baitworm fishery has expanded into Eastern Maine and Canada to supply this demand.

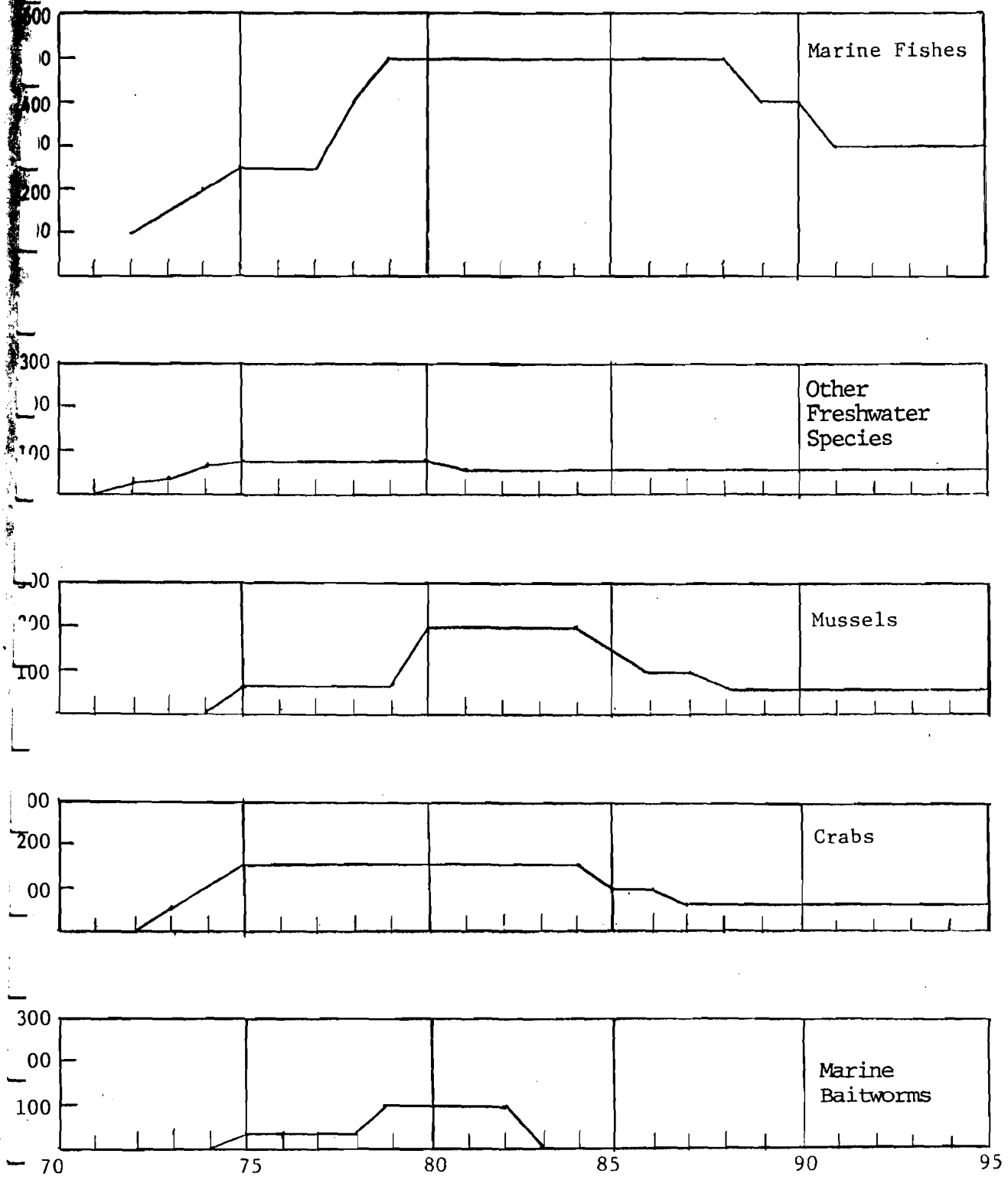
As the demand for marine baitworms increases, harvests from natural stocks will reach the maximum sustainable yield level. At that time, it will be attractive to consider the possibility of supplementing supplies by aquaculture. Researchers at the University of West Florida funded by Sea Grant believe there is a commercially profitable way to breed and raise the local lug worms, Arenicola, which are also valuable for bait. Although their findings may not be directly transferrable to the blood worm and sand worm, their work suggests the desirability of

limited research to develop a biological and technological base for aquaculture of marine baitworms in the Northern part of our Atlantic and Pacific coasts.

NOAA funding related to aquaculture of marine worms should continue at the 1975 level of less than $50,000 for 2 years then increase to $100,000 for 4 years.

Several species have future potential for aquaculture but rate lower on the priority scale at this time for various reasons. Projected funding trends are shown in the following graphs, Figure 3.

FIGURE 3: Projected NOAA Funding Trends for Low Priority Programs



Appendix 4 - Multi-species Programs

Despite differences among species and variations among regions of the United States, there are many common elements and problems in the aquaculture of various species. To establish a broad basis for future aquaculture development several multi-species programs are needed.

4.1 Intensive Culture Systems

As shorelines and estuaries become fully utilized, it will be increasingly difficult to obtain private control over tidelands and near shore areas for aquaculture. One alternative is to develop intensive culture systems which take less space or which ultimately might be located inland away from the crowded shoreline by using artificial seawater. Even in the freshwater environment, fish culturists face increasing land costs, water shortages and more stringent waste control requirements. This trend could lead to intensive cultivation in raceways, silos and similar facilities using recirculated and reconditioned water.

NOAA would be wise to look ahead a decade and begin now to develop the technology for intensive culture systems which will permit continuation and expansion of aquaculture in the U.S. Most of the funding needed for development of intensive culture systems is included in the programs proposed for individual species. In addition, about $200,000 annually would be needed for a decade beginning in 1979 to develop concepts and designs and to evaluate economics of high technology culture.

4.2 Low-Energy Systems - Polyculture

Opposite to the approach suggested in the above section is the concept of aquaculture systems which will produce food with the least input of energy. These systems will probably be extensive in area but will utilize wind power, waste nutrients, thermal effluents and geothermal or solar heating and biological reconditioning of water. Several species will be grown together (polyculture) to utilize all available space and food sources. Species chosen for these systems will largely be fast growing herbivores or filter feeders, low on the food chain which are the most efficient in converting plants to animal protein.

It is also possible that freshwater aquaculture and agriculture can be brought together to make full use of irrigation systems. Systems could be designed in which the waters modified by the presence of growing animals could supply nutrients for agricultural crops, and the residues of agriculture (stalks, plant tops, etc.) could be used for

for aquaculture feeds and even for production of energy (e.g., through methane digestens) to operate the system. Such systems already are operating on a small, experimental scale and much of the technology already exists.

With the growing awareness of energy shortages, NOAA should stimulate research and development to determine the feasibility of low energy aquaculture systems.

NOAA efforts in culture of low cost fishes will include some aspects of this problem but additional efforts are needed to develop concepts and designs of low energy input systems and to evaluate their economics. This will require about $400,000 annually beginning in FY 1980 and continuing for about a decade.

4.3 Genetic Improvements

Present aquaculture is largely based on rearing stocks of fish or shellfish which are essentially the same as wild populations. Animals and plants grown in agriculture have been genetically modified to achieve desirable characteristics and to resist diseases. The application of scientific genetics research and selective breeding could vastly improve aquatic species to make them more adaptable to aquaculture. Certain species such as trout, salmon, oysters, freshwater prawns and lobsters can be grown through their entire life cycle in captivity so genetic improvement can be achieved. For others such as Penaeid shrimp and most oceanic fishes procedures have not been perfected for achieving maturation in captivity and genetic improvement cannot begin until this has been accomplished.

Some genetic improvements have already been made with trout to crease growth rate and reproductive capacity; salmon to shorten their ife cycle from 4 to 3 years; and in oysters to achieve disease resistance. is is only the beginning. NOAA should develop and maintain continuing netics programs for major aquacultural species.

Facilities are needed for long term research on genetic improvement various species of aquatic animals and plants. Because of the riations in environmental requirements, several stations will be equired. Funding needs include new or expanded facilities for genetic provement of salmonids in 1978 (500,000), mollusks in 1979 (500,000), reshwater prawns in 1981 (700,000), lobsters and marine shrimp in 1983 700,000) and low cost fishes in 1985 (1.0 million). Funding for perations is generally included in programs proposed for individual pecies.

.4 Disease Control

Most commercial aquaculturists consider disease control to be their ost serious problem. Losses are often unpredictable and causes are nknown. Even though disease organisms have been identified, treatments re generally unavailable expect for salmonid culture in freshwater. arine pathology is a new science deserving much more attention if aqua-culture is to succeed. The difficulty and long term nature of this esearch and its broad application to various species indicates the ecessity for federal funding of university research and major government athology centers.

It may also be desirable to establish certification and control programs, referably at the state level, to prevent the spread of certain diseases.

Marine pathology investigations will require several major centers with fully adequate equipment at stratigic locations. Funding needs include new or expanded pathology centers for Atlantic (500,000 in 1980), Pacific (1.5 million in 1984), Gulf (2.0 million in 1985) and tropical environments (2.0 million in 1986).

4.5 Nutrition and Feeds

Cost-effective food is a primary requirement for most aquaculture since food is often the largest cost item. Scientific research to determine the nutritional requirements for each cultured species is needed first. Then food rations can be formulated, often by private industry. Testing of foods at pilot scale is also needed to determine conversion rates, long term diet deficiencies and effect on disease resistance.

Because of the broad application and long term nature of nutrition studies, university and government research is indicated. Funding needs are included in expenditures proposed for individual species.

4.6 Legal and Institutional Problems

Major deterrents to expansion of aquaculture are the difficulty of obtaining private ownership or control of adequate areas of tidelands or near shore water areas and obtaining the numerous permits or clearances required by local, state and Federal agencies. It is not unusual for a new company to invest $50,000 to $100,000 just to get the required permits to begin an aquaculture venture, and there is always the risk of failing to obtain the final permit.

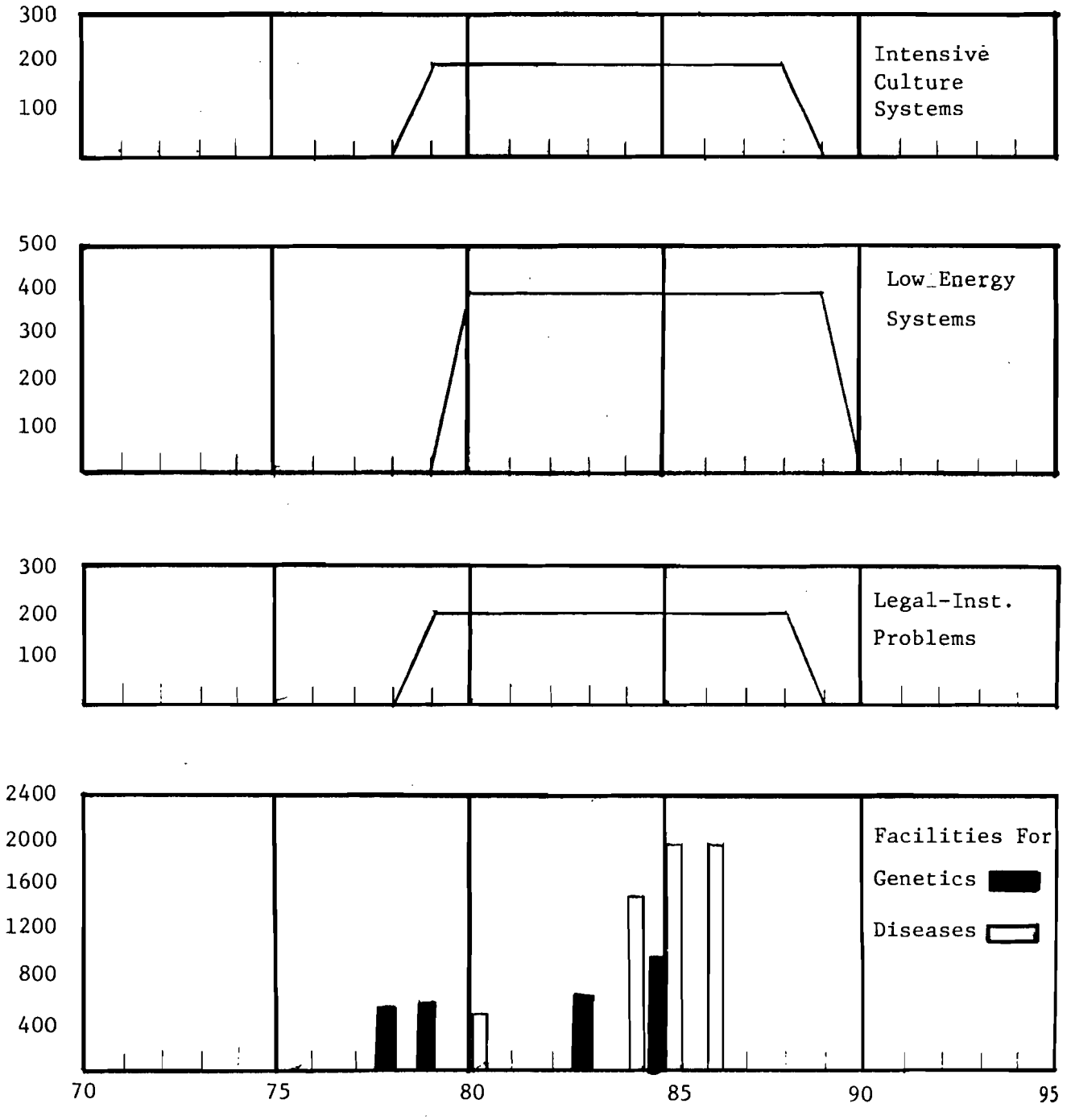
Government could help this situation by declaring a national policy of encouraging food production by aquaculture and by drafting model legislation to simplify the permit system.

Another problem is the increasing regulation of importation of exotic species which may be useful for aquaculture. Government regulations should provide procedures for testing various species and approving for entry those which are suitable for aquaculture under specified conditions. Funding needed to provide staff attention to legal and institutional problems at national and regional levels will require $200,000 annually beginning in FY 1979.

Projected funding trends for multi-species programs and major facilities are shown in Figure 4.

Operating funds for these facilities are included in programs proposed for individual species.

FIGURE 4: Projected NOAA Funding Trends for Multi-Species Programs



Appendix 5 - NOAA's Authority for Aquaculture Programs

Following is a partial listing of legislative authorizations which generally or specifically authorize aquaculture activities of the National Marine Fisheries Service and Office of Sea Grant.

5.1 (NMFS) Joint Resolution No. 22, 41st Congress - Original Act of Feb. 9, 1871 Office of Commissioner of Fish and Fisheries Established - Propagation of Food Fishes and Investigations to Ameliorate Predator Damage. 16 U.S.C. 744-745.

5.2 (NMFS) Public Law 203 - Act of Apr. 28, 1922 Propagation of Mussels. 16 U.S.C. 750-751.

5.3 (NMFS) Public Law 502 - Original Act of May 11, 1938 Columbia River Basin Fishery Development Program. (Mitchell Act). 16 U.S.C. 755-757.

5.4 (NMFS) Public Law 1024 - Original Act of Aug. 8, 1956 Fish and Wildlife Act of 1956. 16 U.S.C. 742a-742k.

5.5 (NMFS) Public Law 85-342 - Act of March 15, 1958 Fishery Research and Experimentation (Reservoirs and Flooded Rice Lands). 16 U.S.C. 778-778c.

5.6 (NMFS) Public Law 87-173 - Act of Aug. 30, 1961.

5.7 (NMFS) Construction of a Shellfisheries Research Center at Milford, Connecticut. 16 U.S.C. 760h-760i.

5.8 (OSG) Public Law 89-688 - Act of October 15, 1966 National Sea Grant College and Program Act of 1966. 33 U.S.C. 1121-1124.

6. NOAA Aquaculture Program, FY 1975-1976

NOAA has ongoing projects in aquaculture which predate development of the NOAA aquaculture plan as listed in Table 3. Some of these will require expansion to provide timely solutions to problems; others will be completed or phased out when funds are needed for higher priority projects. An improved planning system being developed under contract, will provide PERT network type displays for each species to indicate factors inhibiting development of viable aquaculture and to help us select areas needing immediate attention. This system will be operational in time for preparation of the budget request for FY 1978.

It is already obvious that the pace of some ongoing projects should be quickened. Since commercial application of research results takes as long as a decade, research should begin now if it is to provide the scientific basis for expansion of aquaculture to meet the increased needs projected for the future.

In some cases, development of aquaculture is impeded by the lack of scientific biological information. For example, private shrimp farming in U.S. will be handicapped until we discover how to get adults to mature and spawn in captivity. For species such as salmon, disease control and genetic improvement of stocks are needed. For oysters the immediate problems, distribution and marketing, must be solved by industry, although long-range studies are needed to identify and control diseases

and to develop genetically improved strains for aquaculture. For many species we lack the biological and technological information needed for development of private aquaculture or public hatcheries.

In some cases, national action is needed to reduce institutional barriers which limit development of aquaculture. NOAA funding for aquaculture in FY 1976 is shown in Appendix Table 4.

APPENDIX
Table 3

NOAA AQUACULTURE PROGRAM FY 1975
ACTIVITIES BY SPECIES, ORGANIZATION, LOCATION, FUNDING LEVEL, & SUBJECT AREA
(Explanation of abbreviations are presented at the end of the table)

Species	Organization	Location		Funding Level	Major Subject Area
Salmon					
Pacific Coast	NMFS	Seattle		341.0	Pen culture systems, disease control, delayed releases, coho and kings.
	NMFS	Auke Bay		524.0	Ocean ranching systems, pink, chum, red, coho and king.
	NMFS	Seattle		84.0	Nutrition, disease control, alternate protein sources.
	OSG (UW)	Seattle		156.0	Nutrition and diets, pathology, selective breeding, pen-rearing.
	OSG (OSU)	Corvallis, Newport		102.0	Food conversion, nutritional requirements, vaccine development direct release systems, heated sea water.
	OSG (MeSF)	Wiscasset		11.0	Feeding efficiency, power plant effluent culture.
	OSG (HSU)	Arcata		43.0	Waste water pond system, sewage effluent use.
			Total	1261.0	
Atlantic Coast	OSG (URI)	Kingston		79.0	Closed cycle system, economic analysis, feeds.
	OSG (UNH)	Durham		50.0	Diets, disease, seed supply, pen-rearing.
	OSG (UMe)	Orono		20.0	Breeding.
			Total	149.0	
Marine Shrimp	NMFS	Galveston		353.0	Intensive culture systems, maturation, disease control, nutritional requirements.

ACTIVITIES BY SPECIES, ORGANIZATION, LOCATION, FUNDING LEVEL, & SUBJECT AREA
(Explanation of abbreviations are presented at the end of the table)

Species	Organization	Location		Funding Level	Major Subject Area
Marine Shrimp (continued)	OSG (TAMU)	Houston, Galveston		144.0	Pond culture systems, disease, feed conversion, economic analysis, maturation.
	OSG (UM)	Coral Gables		23.0	Nutrition-feeds, culture system engineering.
	OSG (LSU)	Baton Rouge		22.0	Artificial ration development.
	OSG (UGa)	Savannah		8.0	Pathology
			Total	550.0	
Freshwater Prawn	NMFS (88-309)	Florida		18.0	Mass culture, nutritional needs.
	NMFS (88-309)	Hawaii		29.0	Culture technology
	NMFS (88-309)	Puerto Rico		18.0	Prawn culture
	OSG (UGa)	Savannah		83.0	Ration development, selective breeding, tank systems-juveniles.
	OSG (Hawaii-DLNR)	Honolulu		72.0	Nutrition feeds, selective breeding, disease, pond systems, pilot scale plant.
	OSG (SC)	Charleston		97.0	Larval feeds, nutrition, breeding, pilot scale hatchery, engineering, water quality.
	OSG (FAU)	Boca Raton		10.0	Selective breeding, culture systems.
			Total	327.0	
Northern Lobster	OSG (UCD)	Davis		143.0	Artificial and natural feeds, diseases, genetics and selective breeding, system development, growth and survival, system engineering, cost analysis.
	OSG (SDSU)	San Diego		100.0	Heated effluents-feeding requirements, growth and survival, raceway systems, disease.

APPENDIX
Table 4

NOAA AQUACULTURE PROGRAM FY 1975
ACTIVITIES BY SPECIES, ORGANIZATION, LOCATION, FUNDING LEVEL, & SUBJECT AREA
(Explanation of abbreviations are presented at the end of the table)

Species	Organization	Location	Funding Level	Major Subject Area
Northern Lobster (continued)	OSG (SUNY/CORNELL)	New York	19.0	Feeds, culture systems (early stages).
	OSG (URI)	Kingston	76.0	Culture systems.
		Total	338.0	
Bivalve Molluscs (Primarily Oysters)	NMFS	Milford	125.0	Genetic improvement, nutrition, hatchery diseases control, rearing and spawning.
	NMFS (88-309)	Puerto Rico	28.0	Culture of mangrove oysters.
	OSG (VIMS)	Gloucester Point	108.0	Nutrition, feeds, disease monitoring, selective breeding, open systems production of spat, pilot testing.
	OSG (OSU)	Newport	120.0	Larval feeds, diseases, selective breeding, hatchery improvement, heated effluents.
	OSG (UDel)	Lewes	230.0	Natural foods, pathology, closed cycle systems, water quality, engineering, pilot testing.
	OSG (UW)	Seattle	80.0	Disease monitoring, genetics, culture of clams and mussels.
	OSG (SC)	Charleston	25.0	Disease monitoring.
	OSG (UMe)	Orono	151.0	Pathology, genetics, selected breeding including mussels, cultchless rearing, evaluation of environment, thermal discharge rearing.

NOAA AQUACULTURE PROG... FY 19

ACTIVITIES BY SPECIES, ORGANIZATION, LOCATION, FUNDING LEVEL, & SUBJECT AREA
(Explanation of abbreviations are presented at the end of the table)

Species	Organization	Location		Funding Level	Major Subject Area
Bivalve Molluscs (Primarily Oysters) (continued)	OSG (SUNY/CORNELL)	New York		60.0	Diseases in hatcheries.
	OSG (UGa)	Savannah		31.0	Selective breeding.
	OSG (FSU)	Tallahassee		26.0	Selective breeding.
	OSG (UGuam)	Guam		10.0	Induced spawning.
	OSG (UMass)	Amherst		23.0	Heated effluents.
			Total	1017.0	
Mussels	OSG (UMe)	Orono		37.0	Raft culture, power plant effluents.
	OSG (Aband.Farms)	Walpole		22.0	Raft culture
			Total	59.0	
Crabs	NMFS	College Park		86.0	Blue crab nutrition.
	OSG (UM)	Miami		34.0	Larval food (stone crab), tank culture, seed production.
	OSG (ECU)	Greenville		9.0	Pathology (blue crab)
	OSG (UCSD)	San Diego		13.0	Breeding (Scylla) culture systems, seed production.
	OSG (UGuam)	Guam		9.0	Mass culture techniques.
			Total	151.0	
Plants	OSG (UCSC)	Santa Cruz		15.0	Nutrition (Iridaea)
	OSG (USF)	Tampa		17.0	Nutrient effects (Eucheuma), tank culture, spore culture.
	OSG (UNH)	Durham		20.0	Nutrient requirements (Chrondrus), culture technique, spore culture, seed stock selection.
	OSG (UW)	Seattle		46.0	Nutrient requirements (Iridaea and Gigartina).
	OSG (UDel)	Lewes		29.0	Selective breeding, culture techniques, seed supply.
	OSG (UCD)	Davis		19.0	Selective breeding (salt tolerance), culture techniques, establish seed supply.

APPENDIX
Table 4

NOAA AQUACULTURE PROGRAM FY 1975
ACTIVITIES BY SPECIES, ORGANIZATION, LOCATION, FUNDING LEVEL, & SUBJECT AREA
(Explanation of abbreviations are presented at the end of the table)

Species	Organization	Location	Funding Level	Major Subject Area
Plants (continued)	OSG (UH)	Honolulu	105.0	Selective breeding (Euchema), seaweed farms, economic analysis of farms, seed supply, pilot testing.
	OSG (CIT)	Pasadena	53.0	Kelp bed establishment, seed supply.
	OSG (UCSB)	Santa Barbara	33.0	Economic models (Gelidium, Macrocystis and Porphyra)
		Total	337.0	
Finfish	NMFS	St. Petersburg	150.0	Catfish contract with FWS biological, nutrition, gear.
	NMFS (88-309)	Puerto Rico	25.0	Polyculture of channel catfish with tilapia.
	NMFS (88-309)	Nebraska	7.0	High density catfish rearing in irrigation canals and cages.
	NMFS (88-309)	New Mexico	15.0	Vertical raceway production of trout.
	OSG (UWisc)	Madison	51.0	Artificial feeds (perch and walleye), artificial spawning, (pike and perch), economic analysis, controlled systems.
	OSG (OI)	Waimanalo	140.0	Natural food (mullet larvae), artificial spawning (mullet).
	OSG (UGuam)	Guam	10.0	Artificial food (rabbit fish).
	OSG (NCSU)	Raleigh	23.0	Spawning of dolphin, larval rearing systems, seed supply.
	OSG (UNC)	Chapel Hill	29.0	Eel culture.
		Total	450.0	
Mixed Species	NMFS (88-309)	Texas	77.0	These tasks include work on abalone, fish, shrimp, turtles, finfish, octopus, Artemia, clams, oysters, scallops, lobsters, bait worms, rabbit fish and seaweed. Areas of research include nutrition, feeds, pathology, selective breeding, culture systems, institutional barriers, pilot testing, thermal effluents and seed supply.
	NMFS (88-309)	Oregon	24.0	
	NMFS (88-309)	Guam	40.0	
	NMFS (88-309)	California	70.0	
	NMFS (88-309)	Pennsylvania	9.5	
	NMFS (88-309)	Alabama	16.5	
	OSG (WHOI)	Woods Hole	130.00	
	OSG (Palau)	Palau	42.0	
	OSG (UGuam)	Guam	26.0	
	OSG (UAlaska)	Fairbanks	15.0	

APPENDIX
Table 4

NOAA AQUACULTURE PROGRAM FY 1975
ACTIVITIES BY SPECIES, ORGANIZATION, LOCATION, FUNDING LEVEL, & SUBJECT AREA
(Explanation of abbreviations are presented at the end of the table)

Species	Organization	Location	Funding Level	Major Subject Area
Mixed Species (continued)	OSG (URI)	Kingston	44.0	These tasks include work on abalone, crawfish, shrimp, turtles, finfish, octopus, Artemia, clams, oysters, scallops, lobsters, bait worms, rabbit fish and seaweed. Areas of research include nutrition, feeds, pathology, selective breeding, culture systems, institutional barriers, pilot testing, thermal effluents and seed supply.
	OSG (OSU)	Newport	12.0	
	OSG (TAMU)	College Station	55.0	
	OSG (VIMS)	Gloucester Point	30.0	
	OSG (UW)	Seattle	23.0	
	OSG (UWF)	Pensacola	24.0	
	OSG (LSU)	Baton Rouge	18.0	
	OSG (UG)	Honolulu	237.0	
	OSG (L-D)	St. Croix	300.00	
		Total	1184.0	

Totals - NMFS = 1663
NMFS (88-309) = 368
OSG = 3792
5823

EXPLANATION OF ABBREVIATIONS

NMFS - National Marine Fisheries Service-a component of the National Oceanic and Atmospheric Administration, (NOAA) Department of Commerce-inhouse programs.

NMFS (88-309) - Funds made available to the States under the Commercial Fisheries Research and Development Act of 1964 (P.L. 88-309) to carry out research and development of the Nation's commercial fisheries. These are cost-sharing projects with the States.

OSG - Office of Sea Grant-a component of NOAA established by the National Sea Grant College and Program Act (P.L. 89-688) to administer and direct the National Sea Grant Program for the purpose of accelerating national development of marine resources.

Aband Farms - Abandoned Farm, Inc.

CIT - California Institute of Technology

ECU - East Carolina University

FAU - Florida Atlantic University

FSU - Florida State University

Hawaii DLNR - Hawaii Department of Land and Natural Resources

HSU - Humboldt State University

L-D - Lamont-Doherty Geological Observatory

LSU - Louisiana State University

MeSF- Maine Salmon Farms, Inc.

NCSU - North Carolina State University

OI - Oceanic Institute

OSU - Oregon State University

Palau - Trust Territories, Micronesian Mariculture Demonstration Center

SC - South Carolina Wildlife and Marine Resources Department/Clemson University/College of Charleston

SDSU - San Diego State University

SUNY/CORNELL - State University of New York/Cornell University

TAMU - Texas A&M University

U Alaska - University of Alaska

UCD - University of California-Davis

UCSB - University of California-Santa Barbara

UCSC - University of California-Santa Cruz

U Del - University of Delaware

U Ga - University of Georgia

U Guam - University of Guam

UH - University of Hawaii

UM - University of Miami

U Mass - University of Massachusetts

U Me - University of Maine

UNC - University of North Carolina

UNH - University of New Hampshire

URI - University of Rhode Island

USF - University of South Florida

UW - University of Washington

UWF - University of West Florida

UWISC - University of Wisconsin

VIMS - Virginia Institute of Marine Sciences

WHOI - Woods Hole Oceanographic Institution

APPENDIX Table 4 — Funding for NOAA Aquaculture Program Activities FY 1976
(in thousands of dollars)1/

Species	Total 1976	Funding By NMFS	Funding By OSG	Percentage NMFS	Percentage OSG
Salmon	1403	943	460	67.2	32.8
Marine Shrimp	550	351	199	63.8	36.2
Freshwater Prawn	262	0	262	0	100
Oysters	1114	250	864	22.4	77.6
Lobsters	334	0	334	0	100
Mussels	59	0	59	0	100
Crabs	150	87	63	58.1	41.9
Marine Plants	337	0	337	0	100
Fin Fish	403	150	253	37.2	62.8
Mixed Species	956	0	956	0	100
TOTAL	5568				

1/ Excludes State PL88-309 programs for marine shrimp (80.0), mollusks (124.0), crabs (57.0) and catfish (29). Also excludes operation of Columbia River salmon hatcheries under the Mitchell Act.

Appendix 7 - Executive Summary

Aquaculture: The culture or husbandry of aquatic animals or plants by private industry for commercial purposes or by public agencies to augment natural stocks.

1. The Seafood Supply Problem

Traditional stocks of marine resources, once thought to be unlimited are now estimated at a maximum level of harvest of 100-150 million metric tons per year. Fish catches currently exceed 64 million tons annually, and are increasing. On a worldwide basis, a shortage of fisheries products can be expected within ten years if population continues to increase.

In the United States, most of our traditional fisheries resources are already being harvested at or near maximum sustainable yield levels. Imports have increased but world demand is also expanding. This situation is expected to limit the amount of seafood available for export to the U.S. or to make it excessively expensive. Thus the demand for traditional seafoods in U.S. will become critical within the next decade, resulting in physical shortages and increased prices of many products.

2. The Status of Aquaculture

Worldwide output from aquaculture has approximately doubled during the last five years and now amounts to some six million metric tons (13.2 billion pounds), roughly ten percent of world fish production. Some countries already rely upon aquaculture for over 40% of their total fisheries supply and expect production from aquaculture to increase.

In the United States, public aquaculture of salmon began a century ago and more than one quarter of our salmon (27,000 metric tons or 60 million pounds) originates in hatcheries. Private aquaculture produces 40% of our oysters, half of our catfish and crawfish, and nearly all of our trout and small quantities of several other species for a total of 65,000 metric tons (143 million pounds). This is about 3% of U.S. landings or 2% of U.S. total consumption of fishery products.

3. The potential for increasing food production in U.S. through aquaculture

There is good potential for increasing fisheries production in the United States by expanding hatcheries and other forms of public aquaculture and by encouraging private farming of fish and shellfish.

For some species such as oysters, trout, catfish and salmon, aquaculture methods are well known and production could be readily increased to meet projected demand. For other species such as shrimp, scallops, crabs, lobsters and most marine fishes, research and development are required to provide adequate biological and technological knowledge for development of aquaculture.

Although aquaculture in U.S. has largely concentrated on species in high demand and limited supply, it is not restricted to high-valued products. Fish, such as buffalo fish and mullet and various species of carp, can be reared in ponds and processed into acceptable low-priced food products.

4. What is needed to expand aquaculture?

While high hopes have been held for rapid development of aquaculture in the United States, the promise for most species has not been fulfilled. During the past five years when world aquaculture harvests have doubled, U.S. production has remained static. Although 10% of the world's fisheries supply is produced by aquaculture, only 3% of U.S. supplies are attributable to private farming of fish and shellfish.

In the Federal Government, there is a diffusion of efforts regarding aquaculture. Several agencies, and components within agencies, have conducted aquaculture research and development within the framework of specific missions. Coordination, if any, has been primarily to avoid undesirable overlap but, far more serious than overlap, are the number of gaps in the research and development effort.

Many state and local agencies, regional commissions and universities are also involved to some degree in aquaculture, but there has been no adequate mechanism for bringing unity to the various projects, and no national policy or program to guide and coordinate these diffuse efforts.

4.1 A National Policy

A national policy is needed to recognize that development of aquaculture is in the national interest and to call for the protection of coastal and estuarine environments so that aquatic foods can be produced in these areas.

4.2 An Aquaculture Plan

A plan is needed to identify goals and to describe actions which must be taken by Federal and State Governments, universities and industry to achieve these goals.

4.3 Coordinated Efforts of Government, University and Industry

Coordination and joint planning are needed to achieve maximum effect from the diverse but useful aquaculture activities now underway.

Within the Federal Government, NOAA is the logical agency to spearhead efforts to develop private aquaculture. NOAA has a record of accomplishment in this field, authorizing legislation and a cadre of professional scientists in government laboratories and Sea Grant programs at the nation's leading universities. Through a coordinated aquaculture program, efforts of Federal, State, and university

specialists can be directed toward high priority problems to achieve prompt solutions. Industry participation will be encouraged. Short-term efforts will be balanced with long-range research on problems or situations expected one to two decades in the future.

5. Roles and Responsibilities

5.1 Federal Government

Federal leadership and guidance should be expressed by a National policy to encourage aquaculture as a means of expanding food production. Federal actions are needed to channel the diverse efforts within and without government into a coordinated program which will provide the scientific and technical information, environmental protection and institutional arrangements required for expansion of aquaculture.

Many of the concepts and techniques which have made private aquaculture possible in the United States have resulted from research and development conducted in government laboratories or sponsored in universities by the Federal Government. Continuation of federal efforts will be needed to provide an adequate information base for development of aquaculture of additional species and solutions to long-range problems of currently farmed fish and shellfish.

5.2 State Governments

States have a significant role in the development of aquaculture since they have primary responsibility for resource management. A major role of the states is to establish laws, policies and administrative procedures which will encourage aquaculture and to maintain high quality environments in bays, estuaries and coastal waters.

5.3 Universities

Research and development projects at academic institutions largely supported by federal or state funds, have provided much of the basic knowledge needed for industrial development, including aquaculture. These efforts must continue with direction to the solution of problems which are limiting the deveopment of aquaculture.

For aquaculture to grow and flourish, information and communications are essential. Government must help in the technology transfer process in the same way and for the same reasons that it has helped in agriculture. A strong effort in advisory services through universities is needed to be certain that results of research are transferred to industry expeditiously and in the most useful form.

5.4 Private Industry

The role of industry in aquaculture is to apply results of scientific research and technological development to produce quality products for U.S. consumers at an acceptable price with an adequate margin of profit.

For some species such as oysters, trout and catfish, aquaculture methods are well known and production can be readily increased by private industry to meet projected demand levels. For other species, research beyond the capability of industry is required to provide adequate biological and technological information for development of private aquaculture.

Private companies are often unwilling or unable to conduct research or development because of the uncertainty of results, the need for specialized facilities and capabilities, and the lack of potential for patentable discoveries. Even so, estimated industry expenditures during the past five years for research and development include over 22 million dollars for marine shrimp and freshwater prawns, over 4 million for salmon and over 6 million for oysters and clams. Some of these expenditures represent contributions to joint programs with government or universities, but most are for direct industry efforts. Further efforts by industry are needed to develop cost-effective production methods, assure high quality and consistent supply of products, and to expand markets.

6. The NOAA Aquaculture Plan

6.1 Goals and Objectives

The primary NOAA goal for fisheries is to maintain or increase the national availability of a broad spectrum of aquatic resources and products for the U.S. consumer. As related to aquaculture, the goal is to increase, by public hatcheries or by private industry, productio of selected species which are in short supply.

The objective of NOAA programs will be to provide the scientific, technical, legal and institutional base needed for the development of aquaculture and to facilitate early application of research results by information dissemination and extension activities.

6.1.1 Leadership and Coordination

NOAA will provide leadership among federal agencies in joint planning and coordination of programs to achieve common objectives and will encourage other federal agencies, the states, local governments, the academic community, and the private sector to cooperate and participate in the development of aquaculture.

6.1.2 Research and Development

NOAA will conduct or sponsor research to provide biological and technical information necessary for development of public and private aquaculture of selected species.

NOAA will carry biological and technological research and development for private aquaculture through the pilot or prototype stage. This is defined as the stage of development sufficiently large in production of organisms to permit assessment of commercial application. NOAA will encourage industry participation in research and development efforts and prototype testing recognizing that, for additional species proposed for aquaculture, there may be no existing industry.

NOAA will seek a balance between long and short range research development so that long range requirements for continuous improvement of aquaculture which are beyond the capability of industry to solve for itself, will be ensured.

6.1.3 Environmental and Institutional Problems

NOAA will take action to determine economic, social, institutional and legal barriers to the advancement of aquaculture and to cooperate with regional, state and industrial groups to minimize or remove such barriers.

NOAA will foster the development of comprehensive coastal zone management programs to ensure adequate and equitable consideration of aquacultural efforts and to protect coastal and estuarine areas from degradation which would prevent their use for aquaculture. NOAA will encourage the states to provide legal and institutional frameworks which will facilitate development of aquaculture.

6.1.4 Information Dissemination

NOAA will encourage early application of research results by providing scientific and technical information to the aquaculture community as a whole, through publications, workshops and advisory services.

NOAA will establish a national advisory program for aquaculture as a specialized function of the National Marine Advisory Service, to keep industry, public and government officials informed of new developments in aquaculture, to provide personalized transfer of information to aquaculturists, and feedback from users to research and development units.

6.2 The Planning System

The first step in developing an aquaculture program is to determine the status of aquaculture of various species and to identify the factors

which are inhibiting or limiting its full development. A detailed examination of each limiting factor or barrier is needed to determine the probability that it can be removed, the actions required, the time and costs involved and the benefits which would accrue from its removal. With this information, it will be possible to select for emphasis those programs related to the removal of barriers which have the greatest importance or urgency in the development of viable aquaculture. After an action is taken to remove the identified barriers, it will be necessary to disseminate information through publications and advisory services to encourage prompt application of findings by industry.

The development of an improved planning system with computerized storage and retrieval of information was begun in 1975 by the Center for Quantitative Sciences of the University of Washington as a Sea Grant project. This system will provide PERT network displays for each species to indicate factors inhibiting viable aquaculture and to facilitate the selection of areas needing immediate attention.

7. Benefits

Aquaculture will benefit the U.S. consumer by increasing the supply of fish and shellfish which have reached the upper limit that can be obtained from wild stocks. Higher outputs should result in lower real prices for consumers. Public aquaculture to augment natural stocks will benefit recreational and commercial fishermen.

Aquaculture can also provide for year around availability of species normally harvested seasonally.

Although fish and shellfish farmers have traditionally concentrated on expensive products, several species of warm water fish can be reared in low energy input systems and processed into acceptable products for the low priced market.

8. Funding needs

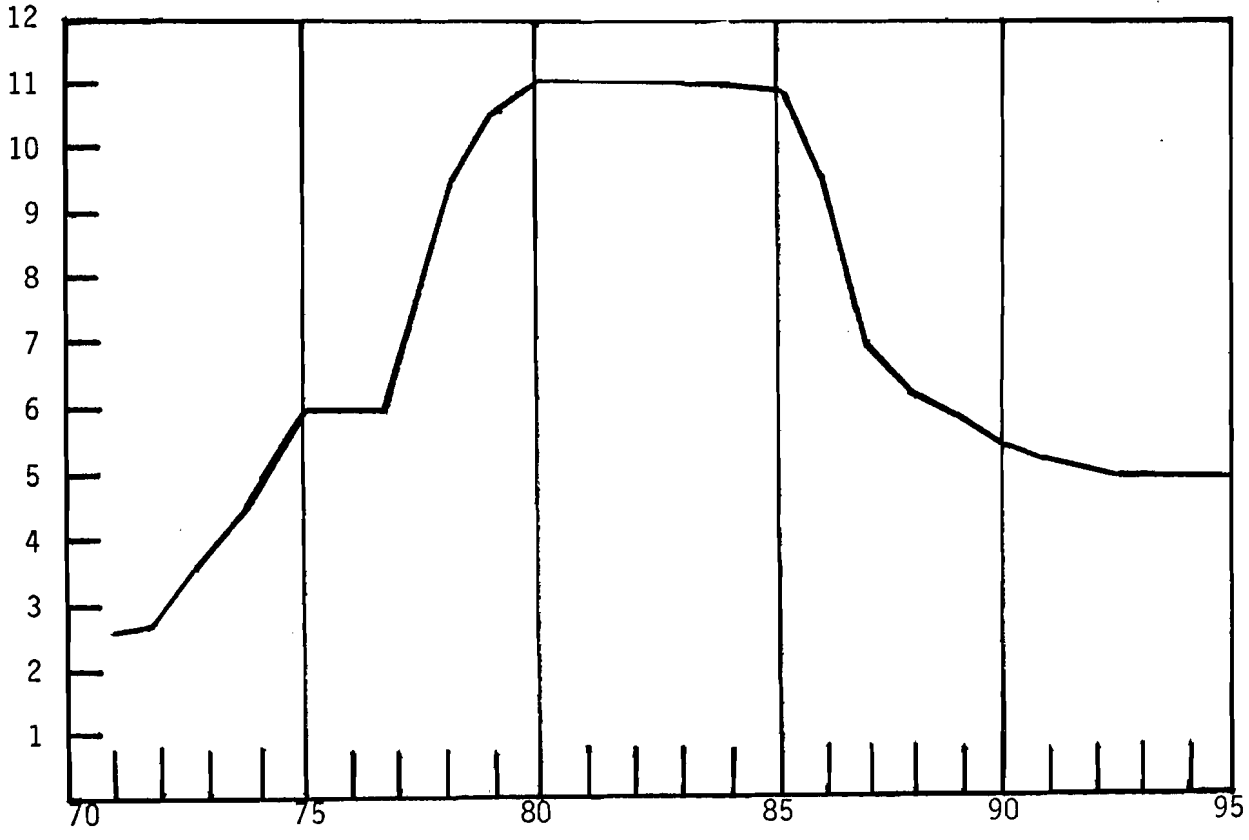
In total, the NOAA aquaculture program should approximately double and continue at that level for about 8 years. Thereafter, the program should decrease to about 5 million dollars and continue at that level for perhaps another decade. (Fig. 1) Funding trends for high, medium and low priority species and multi-species are included in the Appendix. Detailed funding requirements for individual programs will be provided in annual budget requests.

9. Conclusion

The present status of aquaculture demonstrates the commercial success of rearing several major species. With the solution to some biological, technological, institutional or marketing problems, production of these species could be increased to help the U.S. meet the anticipated demand

for seafood. Additional species also have potential for aquaculture but research and development are needed to provide an adequate scientific and technical base. The development of aquaculture will require the coordinated efforts of federal and state agencies, university researchers and private industry. NOAA proposes to take the lead in these efforts.

FIGURE 1: NOAA Aquaculture program Long Range Funding Trend



APPENDIX B

94TH CONGRESS
1ST SESSION

H. R. 2231

IN THE HOUSE OF REPRESENTATIVES

JANUARY 28, 1975

Mr. MCCLOSKEY introduced the following bill; which was referred to the Committee on Merchant Marine and Fisheries

A BILL

To provide for the development of aquaculture in the United States, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "National Aquaculture Development Act of 1975".

FINDINGS AND STATEMENT OF PURPOSE

SEC. 2. (a) The Congress finds—

(1) that a world food crisis in the form of shortages of animal and plant protein is being predicted for the future, and is already being realized in some areas;

(2) that the level of harvesting of existing ocean

food fish and shellfish, which represent a major source of protein, will soon reach the maximum natural production level;

(3) that many wild stocks of marine fish and shellfish adjacent to the United States are depleted, which has an undesirable impact on both commercial and recreational fisheries;

(4) that the United States is heavily dependent upon imports for its supply of seafood, which adversely affects the balance of payments, and makes impossible any guarantee of a continuous supply;

(5) that production from commercial aquaculture in the United States could augment harvests from wild stocks of fish and shellfish and increase the United States supply of protein food, while concurrently reducing dependence upon imports;

(6) that current public and private efforts to develop aquaculture are highly diffuse and in need of coordination, and that it is necessary to establish clear national objectives for aquaculture;

(7) that some Federal and State laws and regulations regarding uses of fresh, brackish, and salt waters may require amending to permit or stimulate aquaculture;

(8) that increased scientific and technical knowl-

edge is necessary in order to make aquaculture commercially feasible for new species;

(9) that there is an insufficient data base upon which can be developed public aquaculture to enhance marine stocks of fish and shellfish heavily exploited commercially or recreationally;

(10) that a strong commitment by the Federal Government to aquaculture would stimulate private investment and accelerate the development of private commercial aquaculture; and

(11) that it is therefore necessary and proper for the United States to carry out a national aquaculture development program.

(b) It is the purpose of this Act to provide for a national program for aquaculture development in order to increase sources of marine protein for the consumer, to increase the availability and quality level of consumer fishery products, to develop new resources, to improve or maintain recreational fisheries, to initiate new business, industry, and employment, and to provide other national benefits.

DEFINITIONS

SEC. 3. As used in this Act—

(1) The term "aquaculture" means the culture and husbandry of aquatic organisms; the control and management of aquatic plants and animals reared in large numbers

in controlled or selected environments for economic or social benefit.

(2) The term "fish and shellfish" include finfish, mollusks, crustaceans, and all other forms of aquatic animal or plant life, exclusive of birds and marine mammals.

(3) The term "pilot aquaculture facilities" includes hatcheries, rearing ponds, raceways, salt water pens, gravel incubators, and other facilities or equipment used for artificial propagation of fish and shellfish, together with such lands, buildings, equipment, or other appurtenances necessary for their operation and maintenance.

(4) The term "Secretary" means the Secretary of Commerce, unless otherwise specified.

NATIONAL AQUACULTURE COORDINATION AND DEVELOPMENT

SEC. 4. (a) The Secretary of Commerce is hereby authorized and directed to carry out a national aquaculture development program consistent with the policies and provisions of this Act. In consultation with interested Federal agencies and other public and private organizations and with the concurrence of the Secretary of the Interior, the Secretary shall establish national objectives for aquaculture development. The Secretary shall also act as the interagency coordinator for all Federal programs and activities in aquaculture. In the performance of coordination functions, the

Secretary shall encourage participation by other Federal agencies in aquaculture, enhance interagency communication on aquaculture matters, and shall consult with and work with other Federal agencies in a manner designed to insure that all Federal aquaculture programs and activities are consistent with the national objectives established pursuant to this subsection.

(b) Activities regarding aquaculture development which the Secretary may, as he deems appropriate, carry out pursuant to the authority vested by subsection (a) of this section include, but are not limited to—

(1) construction, operation, and maintenance of hatcheries or similar facilities and undertaking of natural habitat improvement activities;

(2) assistance to public and private organizations and individuals interested or engaged in aquaculture through advisory and other services;

(3) coordination of aquaculture activities with efforts to enhance wild commercial and recreational fish and shellfish stocks;

(4) development of therapeutic substances for control of fish and shellfish diseases;

(5) consultation and cooperation with Federal, State, and local governments, regional commissions, institutions of higher learning, private industry, and other

public and private organizations for the development of new aquaculture technology;

(6) research and experimentation with utilization of waste products (including thermal effluents) for aquaculture;

(7) development of improved, new, and economical sources of nutrition for fish and shellfish growing;

(8) development of centralized information retrieval and dissemination systems;

(9) investigation of legal and regulatory constraints inhibiting the development of aquaculture;

(10) identification of economic feasibility factors for aquaculture, assessment of economic feasibility for particular species, and development of scientific and technical handbooks and operating manuals for aquaculture;

(11) inventory of public and private aquaculture in the United States to include statistics of acreages, gallons of waterflow, production in pounds and numbers, techniques used, and unresolved problems which private enterprise cannot solve by itself; and

(12) performance of basic and applied research to establish a sound information base for the development of aquaculture.

PILOT AQUACULTURE FACILITIES

SEC. 5. (a) The Secretary, in consultation with affected States, shall locate, construct, operate, and maintain such

pilot aquaculture facilities as he deems appropriate in order to develop aquaculture technology relative to particular species of fish and shellfish. The principal purpose of such facilities shall be to develop the expertise necessary to make economically feasible the commercial culture of species of fish and shellfish which could not previously sustain a profitable commercial operation. In locating such facilities, the Secretary is authorized to purchase, lease, or otherwise acquire the necessary interests in land if such purchase, lease, or other acquisition is not contrary to applicable Federal, State, or local law.

(b) Section 31 of title III of the Act of July 22, 1937, as amended (50 Stat. 525; 7 U.S.C. 1010), is further amended by adding at the end thereof the following new sentence: "Notwithstanding the preceding sentence the Secretary, upon request by the Secretary of Commerce, may make available national forest lands for siting of pilot aquaculture facilities which the Secretary of Commerce is authorized to locate, construct, operate, and maintain pursuant to the National Aquaculture Development Act of 1973; except that (1) before making such an authorization, the Secretary shall first determine that the siting would not be contrary to the principles expressed in the Act of June 12, 1960 (74 Stat. 215; 16 U.S.C. 528–531); and (2) the Secretary shall not authorize the siting of more than three facilities

(c) Paragraph (8) of section 2668(a) of title 10, United States Code, is amended by striking out the semicolon at the end thereof and inserting in lieu thereof the following: "(including easements to the Secretary of Commerce for the establishment of pilot aquaculture facilities authorized by the National Aquaculture Development Act of 1973));".

(d) The Secretary shall issue each year an aquaculture economic feasibility report with respect to each species being grown pursuant to the authority vested by subsection (a) of this section. Such report shall be made available to the interested public and the Congress.

(e) Information derived from the operation of pilot aquaculture facilities established pursuant to subsection (a) of this section shall be made available to the interested public under the provisions of the Freedom of Information Act (5 U.S.C. 552). Wherever practical, the Secretary shall develop technical and scientific handbooks and operating manuals to assist the public in establishing their own aquaculture facilities. In addition, the Secretary shall provide opportunities for Federal, State, and private aquaculture experts to work in pilot aquaculture facilities.

(f) Federal agencies having jurisdiction over developments of activities adjacent to pilot aquaculture facilities shall, to the fullest extent possible consistent with essential

national needs, take measures to avoid any adverse impact on such facilities.

GRANTS AND CONTRACTS

SEC. 6. The Secretary may carry out such functions and duties authorized by this Act as he deems appropriate through grants to or contracts with the States, regional commissions, local governments, institutions of higher learning, private industry, and other public and private organizations; except that the duties and functions of the Secretary pertaining to establishment of national objectives and coordination of Federal activities set forth in section 4 (a) of this Act shall not be carried out by grant or by contract.

FUNDING

SEC. 7. Notwithstanding any other provision of law, there is authorized to be appropriated for each fiscal year beginning with the fiscal year ending June 30, 1975, an amount equal to 30 per centum of the gross receipts from duties collected under the customs laws on fishery products (including fish, shellfish, mollusks, crustaceans, aquatic plants and animals, and any products thereof) during the period January 1 to December 31, both inclusive, preceding the beginning of each such fiscal year. Such sums shall be maintained in a separate fund and shall be used by the Secretary to carry out the provisions of this Act and to cover administrative costs incurred by the Department of

Commerce. The sums appropriated under the authority of this section shall be expended for such one or more of the purposes specified in this Act, and at such times, in such manner, and in such amounts as the Secretary finds will effectuate substantial accomplishment of any one or more of the purposes of this Act. The sums appropriated under the authority of this section shall, notwithstanding the provisions of any other law, continue to remain available for the purposes of this Act until expended.

RESEARCH

SEC. 8. The Secretary, in consultation with the Administrator of the Environmental Protection Agency, is authorized to undertake research to identify the nature and extent of pollution created by various types of aquaculture and to develop appropriate control technology. The results of such research shall be made available by the Secretary to the Administrator. In addition, the Secretary is authorized to carry out such other research as he deems appropriate in order to perform his functions and duties under this Act.

REGULATIONS

SEC. 9. The Secretary is authorized to promulgate such rules and regulations as he considers necessary to carry out his functions and duties under this Act.

SEVERABILITY

SEC. 10. The provisions of this Act shall be severable and if any part of the Act is declared unconstitutional or the applicability thereof is held invalid, the constitutionality of the remainder and the applicability thereof shall not be affected thereby.

EFFECTIVE DATE

SEC. 11. The provisions of this Act shall take effect on the date of enactment.

TERMINATION OF AUTHORITY

SEC. 12. The authority contained in this Act shall expire at the end of the fiscal year during which occurs the fifth anniversary of the date of enactment.

94TH CONGRESS
1ST SESSION

H. R. 2231

A BILL

To provide for the development of aquaculture in the United States, and for other purposes.

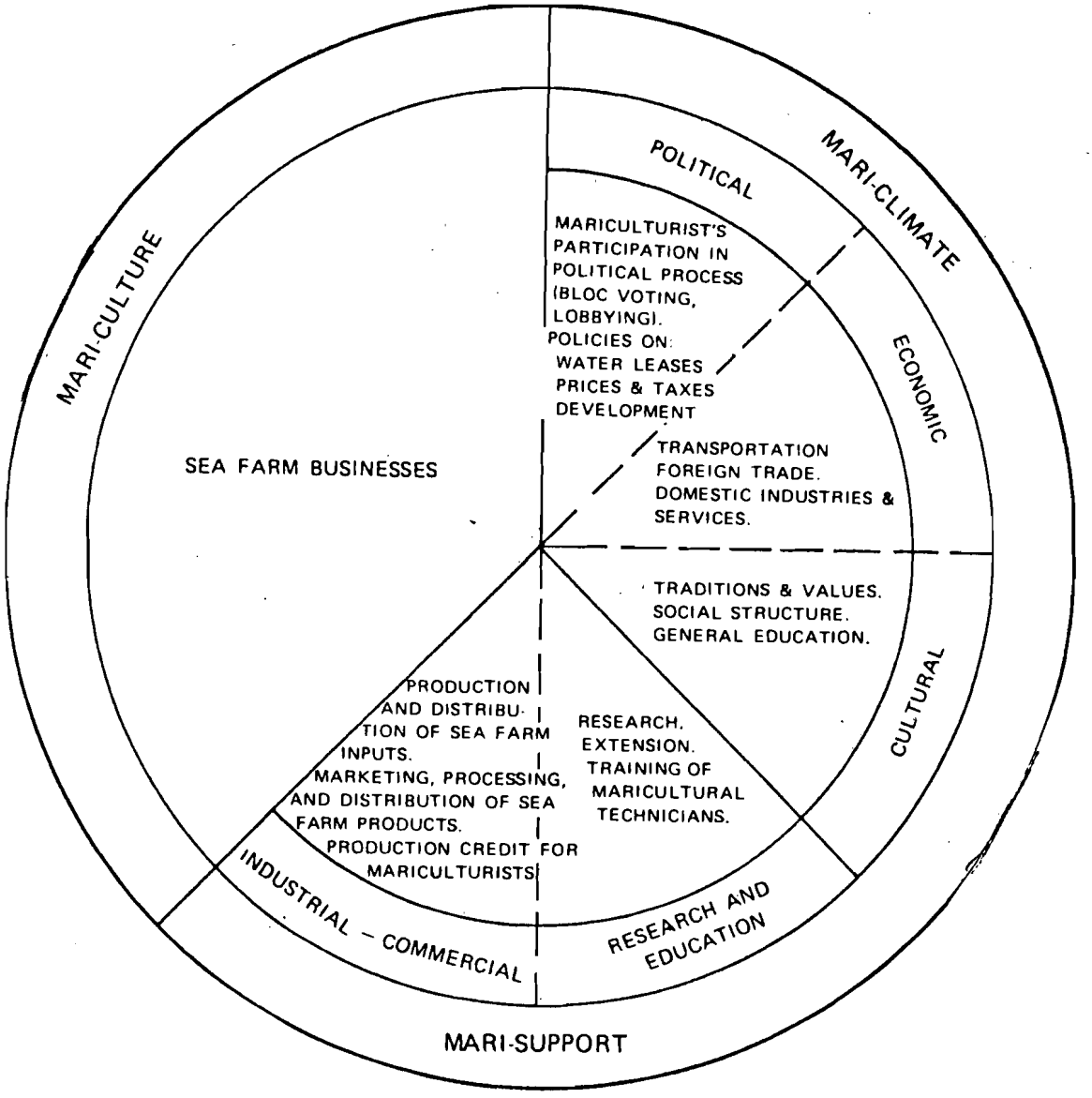
By Mr. McCLOSKEY

JANUARY 28, 1975

Referred to the Committee on Merchant Marine and Fisheries

APPENDIX C1

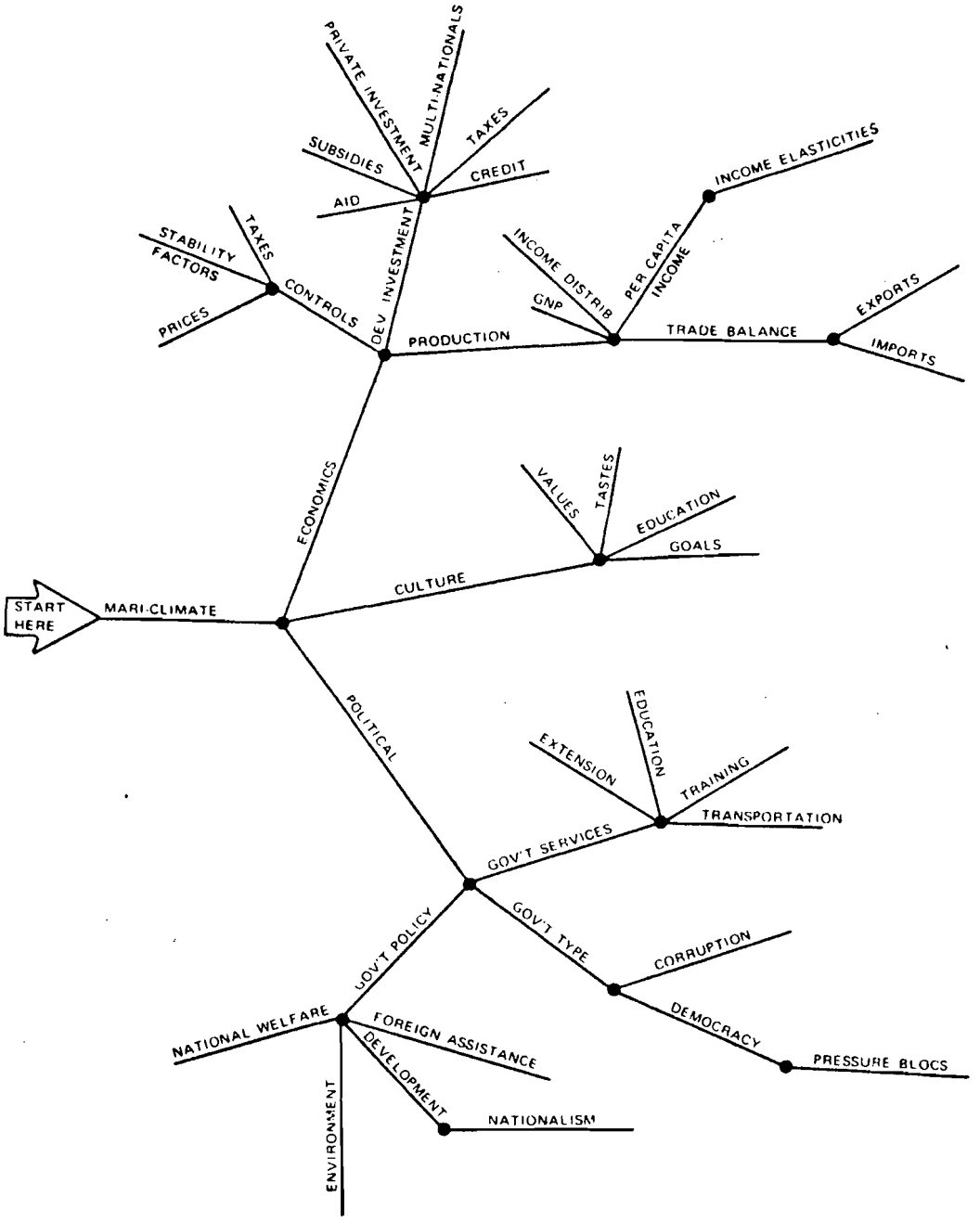
MAJOR FACTORS IN MARICULTURE PRODUCTION



From: Robert C. Landis "A Technology Assessment Methodology--Mariculture"

APPENDIX C_2

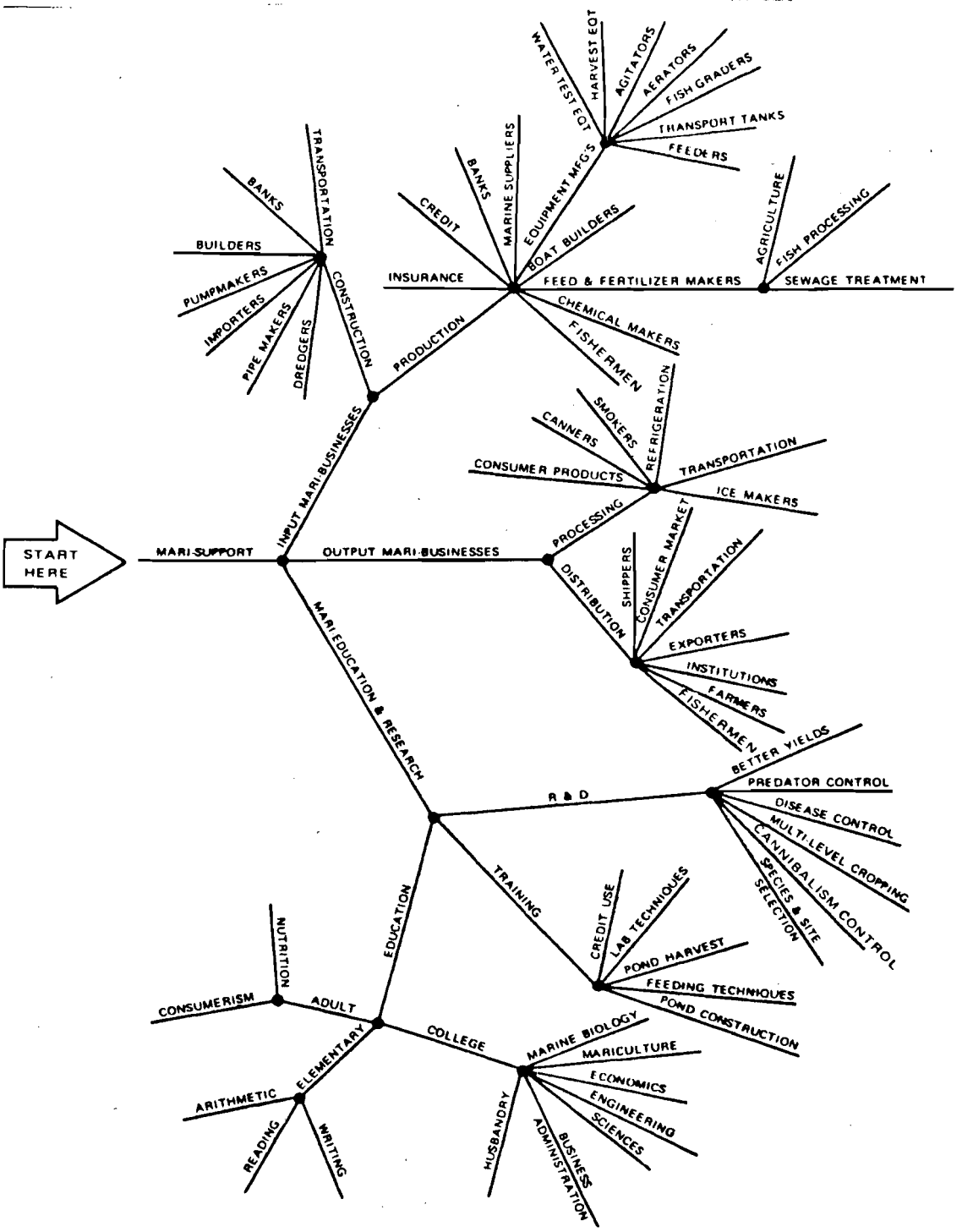
SOME ELEMENTS OF MARI-CLIMATE



From: Robert C. Landis "A Technology Assessment Methodology--Mariculture"

APPENDIX C_3

SOME ELEMENTS OF MARI-SUPPORT



From: Robert C. Landis "A Technology Assessment Methodology--Mariculture"

APPENDIX D

AQUACULTURE LAW: State of Florida

CHAPTER 69-46

Committee Substitute for House Bill No. 526

AN ACT relating to submerged lands; amending chapter 253, Florida Statutes, by adding sections 253.67, 253.68, 253.69, 253.70, 253.71, 253.72, 253.73, 253.74, and 253.75; authorizing the Trustees of the Internal Improvement Fund to lease submerged lands and the water above to persons desiring to engage in aquaculture activities; prescribing procedures; prescribing the essential features of lease contracts; providing penalties; authorizing the trustees to adopt rules and regulations; requiring the trustees to request recommendations from the Board of Conservation or Game and Fresh Water Fish Commission prior to granting a lease; authorizing the Board of Conservation and Game and Fresh Water Fish Commission to designate areas of state-owned submerged land for which they recommend reservation for uses that are possibly inconsistent with aquaculture activities; directing the Board of Conservation and Game and Fresh Water Fish Commission to supervise and report on the operations of lessees; providing an effective date.

Be it Enacted by the Legislature of the State of Florida:

Section 1. Chapter 253, Florida Statutes, is amended by adding sections 253.67, 253.68, 253.69, 253.70, 253.71, 253.72, 253.73, 253.74, and 253.75 to read:

253.67 Definitions.--As used in this act:

(1) "Aquaculture" means the cultivation of animal and plant life in a water environment.

(2) "Water column" means the vertical extent of water, including the surface thereof, above a designated area of submerged bottom land.

(3) "Board" means the State Board of Conservation.

(4) "Trustees" means the Trustees of the Internal Improvement Fund.

253.68 Authority to lease submerged land and water column.--To the extent that it is not contrary to the public interest, and subject to limitations contained in this act, the trustees may lease submerged lands to which they have title for the conduct of aquaculture activities and grant exclusive use of the bottom and the water column to the extent required by such activities. Such leases may authorize use of the submerged land and water column for either commercial or experimental purposes. Provided

however that no lease shall be granted by the trustees when there is filed with them a resolution of objection adopted by a majority of the county commission of a county within whose boundaries if the same were extended to the extent of the interest of the state the proposed leased area would lie. Said resolution shall be filed with the trustees within 30 days of the date of the first publication of notice as required by section 253.70, Florida Statutes.

Prior to the granting of any such leases the Trustees shall establish and publish a list of guidelines to be followed when considering applications for lease. Such guidelines shall be designed to protect the public's interest in submerged lands and the publicly owned water column.

253.69 Application to lease submerged land and water column.--Any applicant desiring to lease a portion of the submerged lands of this state for the purpose of conducting aquaculture activities shall file with the trustees a written application in such form as they may prescribe, setting forth the following information:

(1) The name and address of the applicant.

(2) A reasonably concise description of the location and amount of submerged land desired and either:

(a) Attaching a map or plat of a survey of such lands; or

(b) Enclosing a sum sufficient to defray the cost of such a survey as estimated by the board.

(3) A description of the aquaculture activities to be conducted, including a specification whether such activities are to be experimental or commercial and an assessment of the current capability of the applicant to carry on such activities.

(4) Such other information as the trustees may by regulation require.

253.70 Public notice and hearings.--

(1) Upon receiving an application under this act that satisfactorily sets forth the information required by section 253.69, Florida Statutes, the trustees shall give notice of the application by publication in a newspaper published in the county in which the submerged lands are located not less than once a week for three (3) consecutive weeks and mail copies of such notice by certified or registered mail to each riparian owner of upland lying within one thousand (1,000) feet of the submerged land proposed to be leased, addressed to such owner as his name and address appears on the latest county tax assessment roll.

(2) If no written objections are filed within thirty (30) days after the date of first publication of the notice and if the trustees find that the proposed lease is not incompatible with the public interest, the trustees have authority to consummate the lease contract as hereinafter provided. However, failure to mail the notice to the riparian upland owners shall not invalidate such lease.

(3) If written objections are filed, the trustees or their designee shall hear and consider the same at a public hearing which shall be held in the county from which the application was received. Timely notice of such hearing shall be given by at (leaset) least one (1) publication in a newspaper published in the county in which the submerged lands are located and by certified or registered mail to each riparian owner of upland lying within one thousand (1,000) feet of the submerged land proposed to be leased, addressed to such owner as his name and address appears on the latest county tax assessment roll.

253.71 The lease contract.--When the trustees have determined that the proposed lease is not incompatible with the public interest and that the applicant has demonstrated his capacity to perform the operations upon which the application is based, they may proceed to consummate a lease contract having the following features in addition to others deemed desirable by the trustees:

(1) TERM.--The maximum initial terms shall be [twelve (12) years for commercial leases and five (5) years for experimental leases.] ten years. Leases shall be renewable for successive terms up to the same maximums upon agreement of the parties. However, before renewing the term of any lease, the trustee shall invite objections by following the publication procedures of section 253.70, Florida Statutes.

(2) RENTAL FEES.--

(a) The lease contract shall specify such amount of rental per acre of leased bottom as may be agreed to by the parties and shall take the form of:

1. Fixed rental to be paid throughout the term of the lease; or

2. A basic rental charge which will be supplemented by royalties after the productivity of the aquaculture enterprise has been established.

[illegible]

(b) In setting the amount of the rental charge or royalties the trustees shall consider such factors as the probable rates of productivity and the marketability and value of the product of the enterprise.

(c) All leases shall stipulate for the payment of the annual rental in advance on or before January 1. Failure of the lessee to pay such rent

within thirty (30) days of such date shall constitute ground for cancellation of the lease and forfeiture to the state of all works, improvements, and animal and plant life in and upon the leased land and water column.

[(d) No taxes, assessments, or licenses other than those imposed or authorized by this act shall be levied or imposed on said leases or leased lands, but the annual rent or royalties exacted and paid shall be held and considered all that can be exacted by the state or any of its instrumentalities, including municipalities.]

[(d) At periodic intervals, not less frequent than annually the lessee shall file with the trustees a certified balance sheet and profit and loss statement showing in detail all expenses paid and all receipts from its activities under the lease.]

(3) MAXIMUM AREA TO BE LEASED.--The trustees shall not lease a larger area of submerged land to any single lessee than has been demonstrated to be within his capacity to utilize efficiently and [consistently] consistent with the public interest. However, the trustees may hold a reasonable area of adjacent bottom land in reserve for the time when a holder of an experimental lease will begin operation under a commercial lease. Successful conduct of aquaculture activities on an experimental basis may be accepted as a demonstration of capacity to conduct such operations on a commercial basis.

(4) PERFORMANCE REQUIREMENTS; BOND. Failure of the lessee to perform substantially the aquaculture activities for which the lease was granted shall constitute ground for cancellation of the lease and forfeiture to the state of all the works, improvements, and animal and plant life in and upon the leased land and water column. In addition, the trustees shall require execution of a bond in an amount and with a surety satisfactory to them and conditioned upon the active pursuit of the aquaculture activities specified in the lease.

(5) DISPOSITION OF IMPROVEMENTS AT TERMINATION OF CONTRACT.--Each contract entered into under this act shall stipulate the disposition of improvements and assets upon the leased lands and waters, including animal and plant life resulting from aquaculture activities.

(6) ASSIGNABILITY OF LEASES.--Leases granted under this act shall be assignable in whole or in part with the approval of the trustees.

253.72 Marking of leased areas; restrictions on public use.--

(1) The trustees shall require all lessees to stake off and mark the areas under lease by appropriate ranges, monuments, stakes, buoys, and fences, so placed as not to interfere unnecessarily with navigation and other traditional uses of the surface. All lessees shall cause the area

under lease and the names of the lessees to be shown by signs appropriately placed pursuant to regulations of the trustees.

(2) Except to the extent necessary to permit the effective development of the species of animal or plant life being cultivated by the lessee, the public shall be provided with means of reasonable ingress and egress to and from the leased area for traditional water activities such as boating, swimming, and fishing. All limitations upon the use by the public of the areas under lease that are authorized by the terms of the lease shall be clearly posted by the lessee pursuant to regulations by the trustees. Any person wilfully violating posted restrictions shall be guilty of trespass and shall be punished by imprisonment for not more than sixty (60) days or by fine not exceeding fifty dollars ($50), or both.

253.73 Rules and regulations.--Subject to the requirements of chapter 120, Florida Statutes, the trustees may adopt rules and regulations necessary and appropriate to carry out the provisions of this act.

253.74 (Penalty) Penalties.--

(1) Any person who conducts aquaculture activities in excess of those authorized by lease agreement with the trustees or who conducts such activities on state-owned submerged lands without having previously leased the same shall be guilty of a misdemeanor and subject to imprisonment for not more than six (6) months or fine of not more than one thousand dollars ($1,000), or both. In addition to such fine and/or imprisonment, all works, improvements, animal and plant life involved in the project, may be forfeited to the state.

(2) Any person who is found by the Board or the Air and Water Pollution Control Commission to have violated the provisions of chapter 403, Florida Statutes, shall be subject to having his lease of state owned submerged lands cancelled.

253.75 Studies and recommendations by the board and the Game and Fresh Water Fish Commission; designation of recommended traditional and other use zones; supervision of aquaculture operations.--

(1) Prior to the granting of any lease under this act, the trustees shall request a recommendation by the board, when the application relates to tidal bottoms, and by the Game and Fresh Water Fish Commission, when the application relates to bottom land covered by fresh water. Such recommendations shall be based on such factors as an assessment of the probable effect of the proposed leasing arrangement on the lawful rights of riparian owners, navigation, commercial and sport fishing, and the conservation of fish or other wildlife or other natural resources, including beaches and shores.

(2) The board and the Game and Fresh Water Fish Commission shall both have the following responsibilities with respect to submerged land and water column falling within their respective jurisdictions:

(a) To undertake, or cause to be undertaken, the studies and surveys necessary to support their respective recommendations to the trustees;

(b) To institute procedures for supervising the aquaculture activities of lessees holding under this act and reporting thereon from time to time to the trustees; and

(c) To designate in advance areas of submerged land and water column owned by the state for which they recommend reservation for uses that may possibly be inconsistent with the conduct of aquaculture activities. Such uses shall include, but not be limited to, recreational, commercial and sport fishing and other traditional uses, exploration for petroleum and other minerals, and scientific instrumentation. The existence of such designated areas shall be considered by the trustees in granting leases under this act.

Section 2. This act shall take effect immediately upon becoming a law.

Approved by the Governor June 4, 1969.

Filed in Office Secretary of State June 4, 1969.

APPENDIX E

AQUACULTURE LEASE GUIDELINES: State of Florida

1. The proposed use of the leased lands shall have no appreciable detrimental effect on any existing industry.

2. The proposed use of the leased lands shall have no permanent effect on the wildlife or ecology of the leased lands, and surrounding areas.

3. The wildlife and ecology of the leased lands must be able to be naturally restored within one year of the termination of the lease.

4. No lease shall be made without an opportunity provided for competitive bidding among prospective lessees, similar to the bidding outlined in Ch. 253.54, F. S., (concerning oil and gas leases).

5. The Department of Natural Resources shall make a survey of each site as required by Sec. 253.75, F.S., that is the subject of an application to lease. Based upon the survey data, an estimate will be made of the quantity of marine resources that will be forfeited by the general public to the private lessee. In those cases where the surveys indicate that the resources that would be denied to the public by exclusive lease are substantial enough to require restitution, the Board may require the lessee to perform rehabilitation, stocking or other remedial projects as would tend to improve the marine productivity diminished for the general public by the lease concerned.

6. The findings and conclusions of such survey shall be permanently filed as public information with the State of Florida Board of Trustees of the Internal Improvement Trust Fund.

7. Only that amount of the bay bottoms in any County will be leased which shall be considered reasonable and fair as determined by the Board.

8. The maximum initial terms shall be ten (10) years with leases renewable for successive ten (10) year periods upon agreement of the parties.

9. A basic rental charge which will be supplemented by royalties after the productivity of the aquaculture enterprise has been established.

The lessee shall maintain adequate accounting records of their operations. Annual statements of financial position and net income shall be prepared by the lessee and audited by a certified public accountant.

After the initial year of operations, a review of the lessee's financial statements shall be made by the lessor.

Following each year of operation under the lease, the lessee shall forward to the lessor a statement of gross receipts audited by a certified public accountant.

10. All leases shall be subject to cancellation by the Board in the event the cultivation of animal and plant life within the leased area or areas ceases to be actively pursued.

11. All leases to contain a clause holding the Board and the State harmless.

12. Written approval from the upland riparian owner or owners must be filed with the Board prior to issuance of proposed lease.

13. Leased area or areas will be marked and identified as follows:

> Along the shoreline boundaries of each leased area, the lessee shall place at least one (1) sign every 1,000 feet, and additionally at every location on the shoreline where the public is afforded access to the sovereignty waters under lease.

Where the leased area is enclosed by a net, fence or other type of enclosure, the lessee shall place along said enclosure at least one sign every 1,000 feet. When the enclosure is less than 1,000 feet in length, a sign shall be located at each end of said enclosure and at the midway point between the ends.

At least one opening shall be provided for by the lessee to allow ingress and egress by the public to and from each leased area for water activities, such as boating, swimming and fishing. Said opening or openings shall be appropriately marked and identified.

All signs required above are to be a minimum of 4 feet high and 6 feet long, of a durable material, and erected in such a manner above the average high water level to be clearly visible to the general public.

Each sign shall be conspicuously lettered as follows:

R E S T R I C T E D

Aquaculture Area

Leased to (lessee)

By
State of Florida Board of Trustees of
the Internal Improvement Trust Fund

and each sign shall also be lettered to reflect any restriction on public use authorized by the Board of Trustees of the Internal Improvement Trust Fund.

Each lease area shall also be marked in accordance with U. S. Coast Guard and U. S. Army Corps of Engineers regulation concerning structures in navigable waters.

August 26, 1969