COASTAL AQUACULTURE:

Protein, Profits, and Problems for a Hungry World

Steven J. Shupe

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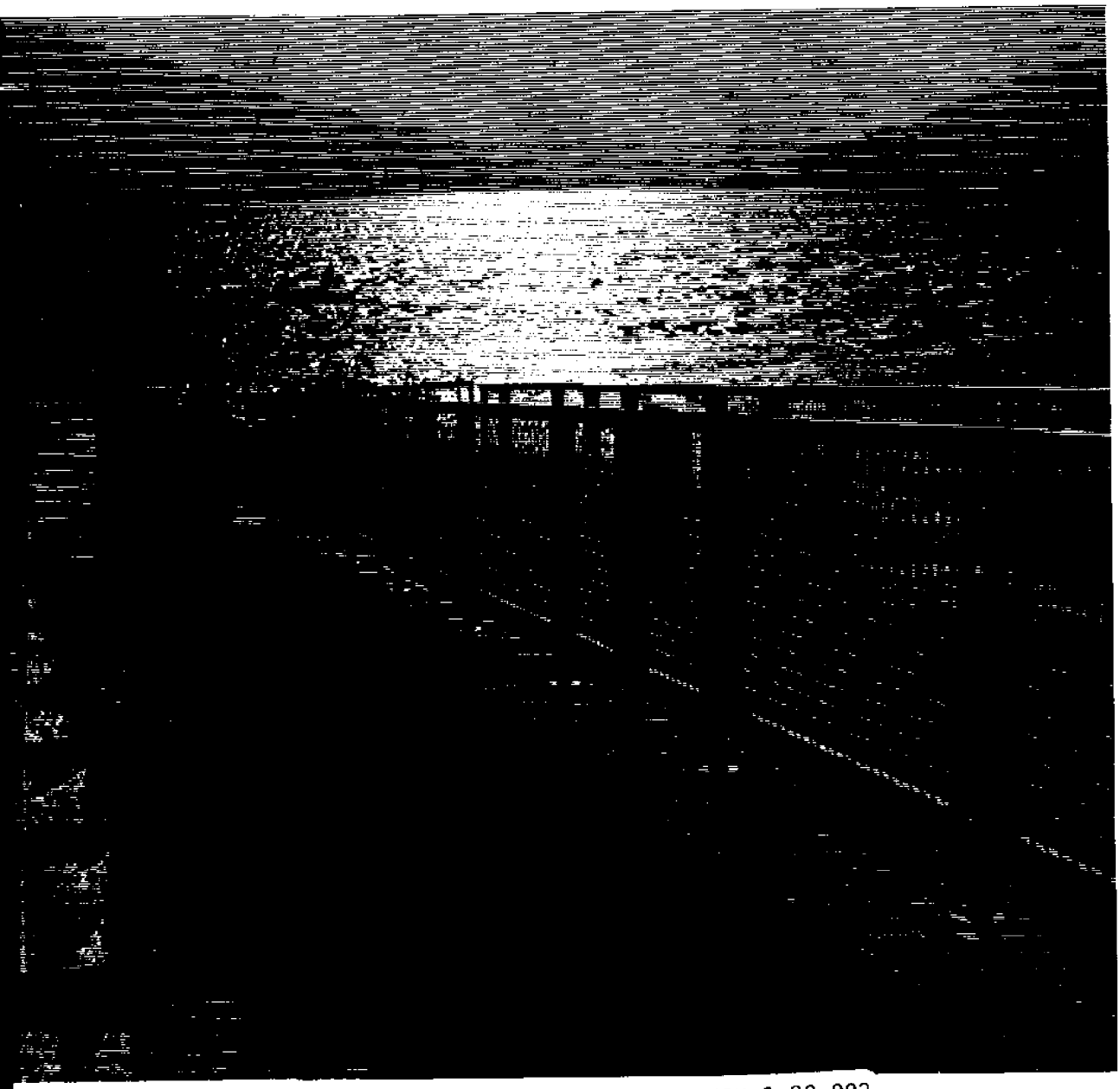

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Technical editing by Sandra Ridlington

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PREFACE

The evolution of human society is marked by a progression of developments that have allowed for our survival and expansion over the globe. Among the most significant of these developments is the rise of agriculture. When people were freed from the restraints of hunting and gathering, opportunities arose for socialization, thought, and prosperity. Agriculture's advantages over hunting and gathering (i.e., efficiency and reliability) were of such magnitude that it today provides over 95% of the world's total food supply.[1]

A similar shift to cultivation has not, however, occurred in water-based food production. In exploiting aquatic resources, civilizations have generally clung to hunting and gathering techniques. Only in recent times have aquatic cultivation methods been utilized to the extent of producing a measurable portion of total fishery products. Currently, aquaculture accounts for approximately one-tenth of the worldwide harvest of 60 to 70 million metric tons of edible finfish and shellfish.[2]

As civilization continues to evolve, the question remains as to whether aquaculture will grow from its 10% share to an eventual position of dominance over the traditional modes of harvesting the ocean. Many feel that such development will be required in order to avert malnutrition and starvation in coming generations. Others believe that the world's future demands for food can be satisfied without it. Whatever the case, the future promises to hold many difficulties for the aquaculture industry.

This report discusses the impediments that have already acted to inhibit seafarming in the coastal zones of the United States. Section I provides an overview of the worldwide aquaculture industry, including a summary of the advantages of aquatic husbandry over both land-based agriculture and traditional fishing techniques. The impediments to aquacultural development in the U.S. follow in Section II, broken into three categories of constraints: socioeconomic, biological, and legal. In Section III, West Coast salmon ranching is used to illustrate how these factors have combined to inhibit a particular aquaculture enterprise. The study then concludes with a discussion of the type of planning that will be required to ameliorate the problems both faced and created by aquaculture along our nation's coastlines.

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Young salmon spending their transitional period in the brackish water of a bay. Photo: Jim Larison, Oregon State University Sea Grant College Program.

I. INTRODUCTION

A. Overview of Worldwide Aquaculture

Aquatic husbandry began thousands of years ago with the raising of fish in inland waters. The Greeks and Romans are known to have fattened fish in ponds, while Egyptian tomb carvings indicate that cultivated fisheries may have existed there as well.[3] It was in Asia, however, where early aquaculture gained a foothold that has continued into modern times. There, the need for protein to feed growing populations led the ancient civilizations of China, India, and southeast Asia to develop methods of intensive fish production.

From its beginnings in finfish cultivation, the aquaculture industry has diversified in modern times to include a variety of commercially valuable aquatic animals and plants. Diversification has also arisen with respect to the growing number of countries in which aquatic husbandry is practiced. Consequently, a look at modern aquaculture takes one across the face of the globe with glimpses of oysters maturing in the tidal flats of southern Brittany, mussel-encrusted piles rising from Manila Bay, carp thriving in manure-enriched ponds of southeast Asia, and drummed abalone dangling beneath oil platforms of the Santa Barbara Channel. These and numerous other operations currently produce more than 19 billion pounds annually of high-protein food from the aquatic environment.[4]

Production in more than seventy countries contributes to total aquaculture harvests. Asia, however, remains the source of a vast majority of worldwide output.

Regional Percentage of World Production

Region	%
Africa	0.05
Asia	84.43
Europe	13.05
Latin America	0.86
North America	1.61

Source: T. V. R. Pillay, "State of Aquaculture, 1981." Quoted from a transcript of the lecture delivered at a World Conference on Aquaculture, Venice, Italy, 21 Sept. 1981.

China alone produces nearly 9 billion pounds of aquacultural harvests yearly, leading all other nations in both mollusk and seaweed cultivation.[5] The leading producer of cultivated crustaceans is Indonesia, while India ranks first in finfish farming (see Table 1).

Finfish historically have accounted for the bulk of the worldwide aquaculture output. Today, however, finfish share their leading role with mollusks, with each sector contributing roughly 7 billion pounds annually to the aquaculture market.[6] Cultivated seaweed accounts for most of the remaining 25% of the market (4.8 billion pounds per year), while crustaceans currently comprise less than 1% of the total. Although their market shares vary, each sector has exhibited a common trait in recent years—rapid expansion. The first half of the 1970s saw the annual total aquaculture harvest more than double, with this upward trend continuing into the current decade.[7]

Table 1

Leading Cultivated Finfish Producers in 1980

Country	Thousands of Metric Tons	Millions of Pounds
India	830.2	1826.4
China	813.3	1789.3
USSR	340.0	748.0
Japan	249.4	548.7
Indonesia	177.5	390.5
Philippines	151.6	333.5
Taiwan	128.0	281.6
Bangladesh	65.0	143.0
USA	55.6	122.3
Romania	41.3	90.9
Thailand	39.4	86.7
Yugoslavia	29.1	64.0
Italy	28.2	62.0
Hungary	26.5	58.3
France	25.3	55.7

Source: Adapted from T. V. R. Pillay, "State of Aquaculture, 1981," a transcript of a lecture delivered at a World Conference on Aquaculture, Venice, Italy, 21 Sept. 1981.

The recent growth and diversification of aquaculture has resulted not only from the need for protein but also from the desire for profit. Whereas aquatic husbandry in rural Asia developed primarily for subsistence, many modern aquacultural ventures are motivated by economic considerations. Aquatic entrepreneurs in the United States and in other industrialized nations are increasingly turning to modern technology and high-value species (e.g., abalone, lobster, salmon) to reap lucrative harvests. This desire to maximize profits, as well as the need for protein, provides significant incentive for additional growth and diversification of the fledgling aquaculture industry.

This incentive alone, however, is not

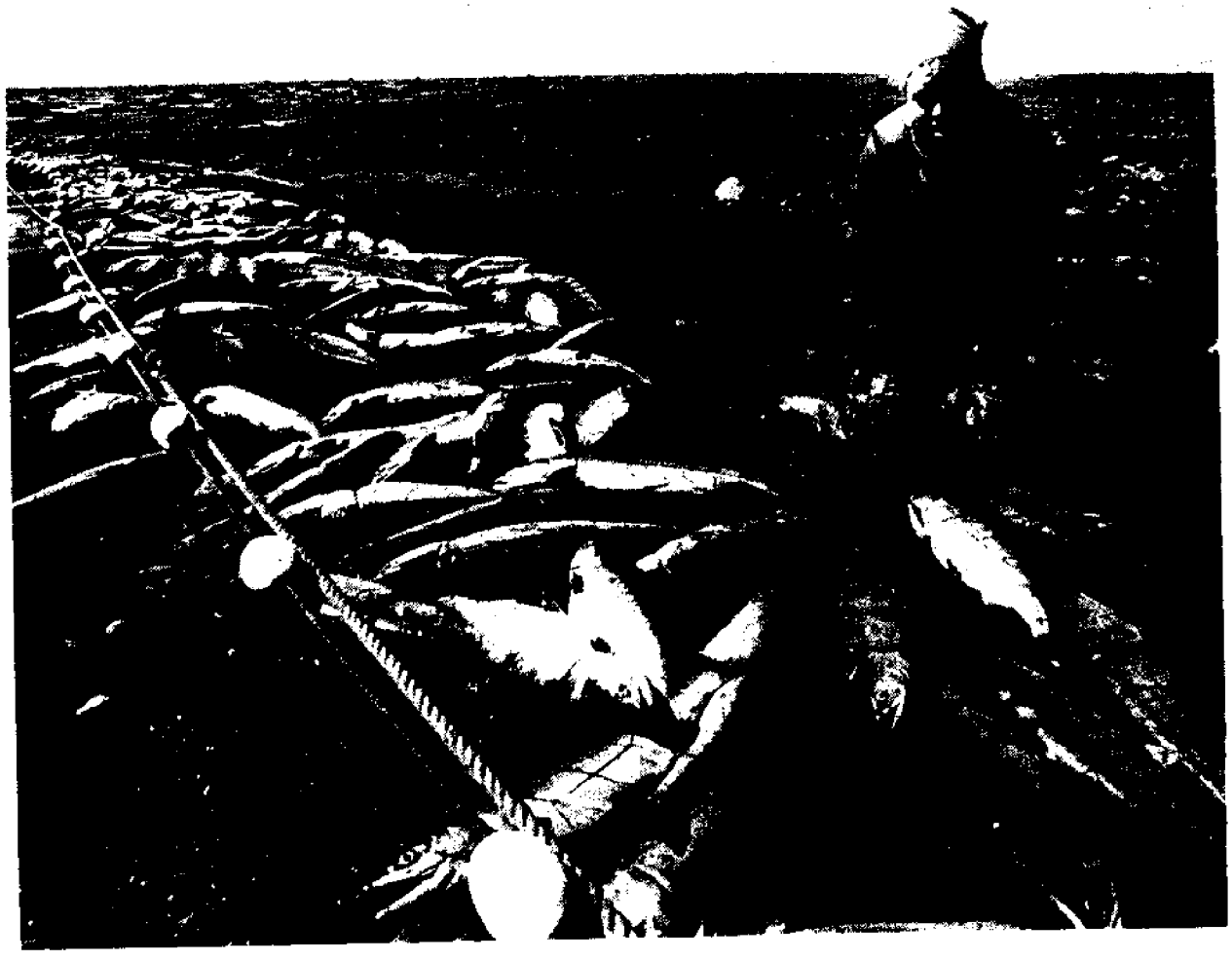
sufficient to ensure the continued expansion of the industry. If aquaculture practices are to grow, their advantages over traditional modes of food producton must prove more compelling than the socioeconomic, biological, and legal constraints to their development.

B. Advantages over Traditional Fishing Methods

The advantages that aquatic husbandry has to offer over traditional methods of harvesting fishery resources are numerous. They are difficult to characterize briefly, however, because of the great diversity within the aquaculture industry. It is hard to picture aquaculture as a single entity when one eye is on a computerized laboratory controlling the temperature of shrimp larvae, while the other peers into a stilted Thai hut where garbage scraps are fed to the caged fish below. Nonetheless, the many components of the aquaculture industry share certain advantages over traditional methods of harvesting fishery products.

The most obvious of these advantages is the efficiency involved in cultivation. For much the same reason that our ancestors found farming and domestication of animals preferable to hunting and gathering, so too is aquaculture an attractive means for saving time and effort. Not only can the aquaculturist make physical conditions conducive to production, but expenses are greatly reduced when the need to search for and capture the product is eliminated. In this age of high energy costs, it is particularly advantageous to maintain control over aquatic harvests, through physical barriers, natural homing mechanisms, or acoustical signals to which several species have been successfully trained to respond.[8]

The second major advantage of aquaculture lies in the absolute quantity of food that it can potentially produce. Worldwide harvests of natural stocks from the ocean and inland waters have reached and, in some cases, exceeded the limit of production for many species. Even when considering the total sustainable harvest of all commercial aquatic species (esti-



Picking salmon from a gillnet along the Bering Sea. Photo: Jim Larison, Oregon State University Sea Grant College Program.

mated at 100 to 120 million metric tons per year),[9] we are already harvesting more than half this amount annually. Inadequacies in existing fisheries are expected to become even more apparent as the worldwide demand for food steadily climbs. With the application of cultivation techniques, however, fishery harvests can be increased many times over. Although it is difficult to quantify the potential global output of aquaculture, one expert speculates that through farming the sea and inland waters we will have the capacity in fifty years to produce ten times the sustainable harvest of natural fishery stocks.[10] This vast potential expands yearly as technology develops to allow for more intensive production of fish and shellfish. Survival is enhanced by new vaccines, growth is promoted by controlling the thermal and chemical properties of the water, efficiency is gained through breeding, and productivity is increased through innovative feeding and rearing techniques.

Examples of recent improvements in aquaculture abound. For instance, researchers in Hawaii have developed a pilot system of plastic-enclosed tanks in which the equivalent of 65,000 pounds of shrimp tails is produced per acre.[11] This compares with a typical output of 2,000 lb/acre from shrimp raised in ponds. Also a number of species including lobster, catfish, and salmon currently thrive in warmed water diverted into their rearing facilities from industrial plants. A further example of increased efficiency is found in Idaho where a ten-acre trout farm utilizing enriched feed and recycling systems raised 12% of the total trout commercially produced in the U.S. in the mid-1970s.[12] Output from this single site equals over a million pounds of fish annually.

The final major advantage of aquaculture relative to traditional harvesting methods is its potential for enhancing the natural ecosystem. Rather than exploiting existing fishery stocks, aquatic husbandry can be used to supplement depleted resources. This is already being done on a large scale with Pacific salmon, as well as in Japan with shrimp. Furthermore, if seafarming could supply consumer demands for certain fishery products, it would allow natural stocks to be used more fully in the aquatic food chain. This would not only promote a healthier natural environment, but reduce existing conflicts between humans and coastal mammals (e.g., competition for California abalone with the sea otter). All this discussion is certainly not meant to disregard the important role that commercial fishing has played—and should continue to play—in our society. Nor does it imply that aquaculture development will be problem-free (see Section II, "Constraints on Coastal Aquaculture in the U.S."). But the potential advantages of cultivating aquatic products as compared to the fishing and gathering of natural stocks may indeed prove significant in terms of increased quantity, efficiency, and conservation.

C. Advantages over Agriculture

The benefits of aquaculture relative to land-based agriculture are also numerous. The most obvious advantage stems from the acreage requirement associated with agricultural development. Most suitable farming and grazing lands are already utilized worldwide; thus, agricultural growth is limited. Tracts of additional agricultural land could be carved from areas like the Amazon, but both the environmental impacts and the questionable success of such projects constitute serious drawbacks. Environmental and economic tradeoffs likewise arise with increased production through irrigation in arid regions already experiencing competition for limited water supplies.

Unlike agricultural expansion, cultivating fishery products will not create severe additional strains on terrestrial resources. Even in those instances where land is required by artificial ponds or by coastal aquaculture facilities, the food output per acre from these operations is generally much greater than from agriculture. The efficiency of aquaculture—both inland and marine—is enhanced by its three-dimensional character. Whereas agriculture is confined to the surface of the land, coastal aquaculture can utilize nutrients in surface water, in bottom sediment, and in the fertile zone between. The day may soon arrive when cultivated lobsters look up to see racks of oysters floating on the surface, while salmon feed nearby as they home back to the facility from which they were hatched and released.

The applicability of this three-dimensional concept has already been ingeniously demonstrated for inland aquaculture. In China, as many as seven edible species of fish and crustaceans may be found filling the biotic niches of a single pond.[13] On a carp farm, for exam-

ple, a grass carp may consume the pond's surface vegetation while below, silver carp feed on mid-water phytoplankton, and bighead graze the zooplankton. At the bottom, the detritus-feeding mud and common carp may be found swimming with the black carp as it searches for snails.[14] Although less advanced, this "polyculture" concept has also been applied in North America where commercial crayfish thrive on the waste-laden effluent from catfish ponds.

The three-dimensional character of aquaculture is not the sole reason for its relative efficiency over agriculture. Finfish are more thrifty producers of protein than are farm animals. Because fish exist in an essentially weightless state in water, they waste less food energy in moving than do land dwellers.[15] Also, no energy is expended to maintain body heat since they are cold-blooded. With these factors working to their advantage, fish generally consume fewer than 100 kilocalories to produce a gram of protein, as compared to 800 kilocalories required by feedlot beef.[16] Furthermore, studies have shown that cultivated trout and salmon can convert 1.1 pounds of food (dry weight) into 1.0 pound of edible product, while the food-to-product ratio in chickens is 2 to 1 and for swine, 5 to 1.[17] We may soon find that the disparity between these ratios becomes of acute importance as world population expands upon our finite land base.

Economic ratios also dramatically indicate the potential advantages of aquaculture. In a Japanese program for shrimp enhancement, each yen spent on supplementing natural stocks yielded ten yen worth of additional catch.[18] On the other side of the Pacific, a 1:7 dollar ratio resulted between hatchery costs and the added value of commercial harvests of coho salmon.[19] Additionally, private salmon ranching operations are reported to have the potential for up to a 4000% return on investment.[20] One need only look at the plight of many of today's farmers to see that such high profits are rarely realized in land-based agriculture.

* * *

II. CONSTRAINTS ON COASTAL AQUACULTURE IN THE U.S.

Despite its many advantages, aquaculture in the United States developed quite slowly. The birth of the domestic aquaculture industry occurred in the 1850s, when seed oysters from Chesapeake Bay and Puget Sound were transplanted to Long Island waters and San Francisco Bay, respectively, in order to meet growing consumer demands.[21] Next came the landmark year of 1885 when the nation's first commercial marine hatchery was built at Woods Hole, Massachusetts. It was not until the mid-twentieth century, however, that alternatives for artificially raising fish were implemented and that shellfish cultivation began on a large scale. Even with this increased interest in aquatic husbandry, by 1965 the output from aquaculture still comprised less than one-

Table 2

U.S. Aquaculture Production

Species[a]	1979 Pounds Cultivated (millions)	1979 Value in Dollars (millions)	1980 Pounds Cultivated (millions)	1980 Value in Dollars (millions)
Catfish	40.6	28.8	76.7	55.6
Trout	25.0	21.0	48.0	37.5
Clams	8.9	5.4	9.1	5.6
Oysters	6.8	11.6	7.2	12.3
Salmon	2.4	0.9	7.6	3.4
Shrimp	0.0	0.0	0.3	1.2
Total[b]	83.7	67.7	148.9	115.6

(a) Data shown are live weight harvest for consumption except for oysters and clams which are meat weight. Excluded are eggs, fingerlings, etc. which are an intermediate product level.

(b) These estimates do not include aquaculture production for all species such as abalone, mussels, striped bass, crawfish et al., which is estimated to be about 12.0 million pounds.

Source: U.S. Department of Commerce, "Statistics from Fisheries of the United States, 1980," in Appendix to *The American Fisheries and Reference Book*, 2nd ed. (Cambden, Maine: National Fishermen, 1981), p. 12.

half of 1% of total domestic fishery production.[22] Then came a period of rapid expansion. By 1980 the quantity of fish and shellfish cultivated throughout the nation equalled 4% of the total domestic catch.[23]

The recent impressive growth rate of the American aquaculture industry is reflected further in Table 2. The total harvest of major cultivated species jumped from 83.7 million pounds in 1979 to 148.9 million pounds in 1980.[24] A majority of this expansion, however, resulted from the inland species catfish and trout. In fact, the table indicates that *coastal* aquaculture comprises a relatively small portion of the overall industry.

Without further consideration, it might be conjectured at this point that there is little additional demand in the U.S. for cultivated marine species. Perhaps our fertile coastal zone provides adequate natural supplies of seafood to satisfy domestic markets. Or maybe potential is limited by the fact that the average American eats only 13 pounds of fish products each year. This value is a mere fraction of Japan's annual per capita consumption of 79 pounds, and well below the worldwide average of 24 pounds per year.[25] These conjectures, although helpful in understanding our nation's slow start in the seafarming business, are not valid regarding the potential of coastal aquaculture. Large and profitable domestic markets for fishery products cultivated in coastal waters do exist. Table 3 indicates that in 1980 the U.S. imported 324 million pounds of the types of seafood products that could potentially be raised at coastal facilities. The value of these imports exceeded 1 billion dollars.

Table 3

U.S. Imports of Cultivable Seafood—1980

Species	Pounds Imported (millions)	Value in Dollars (millions)
Shrimp	219.3	719.3
Lobster	52.7	283.5
Scallops	20.9	82.0
Oysters	17.0	20.3
Salmon	5.7	14.3
Clams	5.5	6.9
Abalone	3.0	15.4
Total	324.1	1141.7

Source: U.S. Department of Commerce, "Statistics from Fisheries of the United States, 1980," in Appendix to *The American Fisheries and Reference Book*, 2nd ed. (Cambden, Maine: National Fishermen, 1981), p. 52.

If indeed the market exists, the question remains as to why aquatic entrepreneurs have not filled this billion-dollar niche. As in any fledgling industry, part of the reason is the need for development of new technologies. Yet even regarding those species for which technology is adequate, coastal aquaculture operations face many difficult hurdles. Seafarming's potential impact on the marine environment and upon established commercial fishing has made it an extremely controversial subject in coastal areas. The development of coastal aquaculture in the United States is impeded by socioeconomic concerns, by biological considerations, and by constraints of the law.

A. Social and Economic Concerns

Major barriers faced by coastal aquaculture development stem from its potential socioeconomic impacts. Many coastal inhabitants fear that thriving aquaculture activities could economically undermine the existing fisheries industry as well as significantly alter the character of their communities. The recalcitrance growing from such concerns has tended to inhibit acceptance of aquaculture proposals along the nation's coastlines. A further socioeconomic barrier to aquaculture has arisen from the difficulty faced in financing the new enterprises. These social and economic constraints to development are examined in the following sections.

Undermining Existing Markets

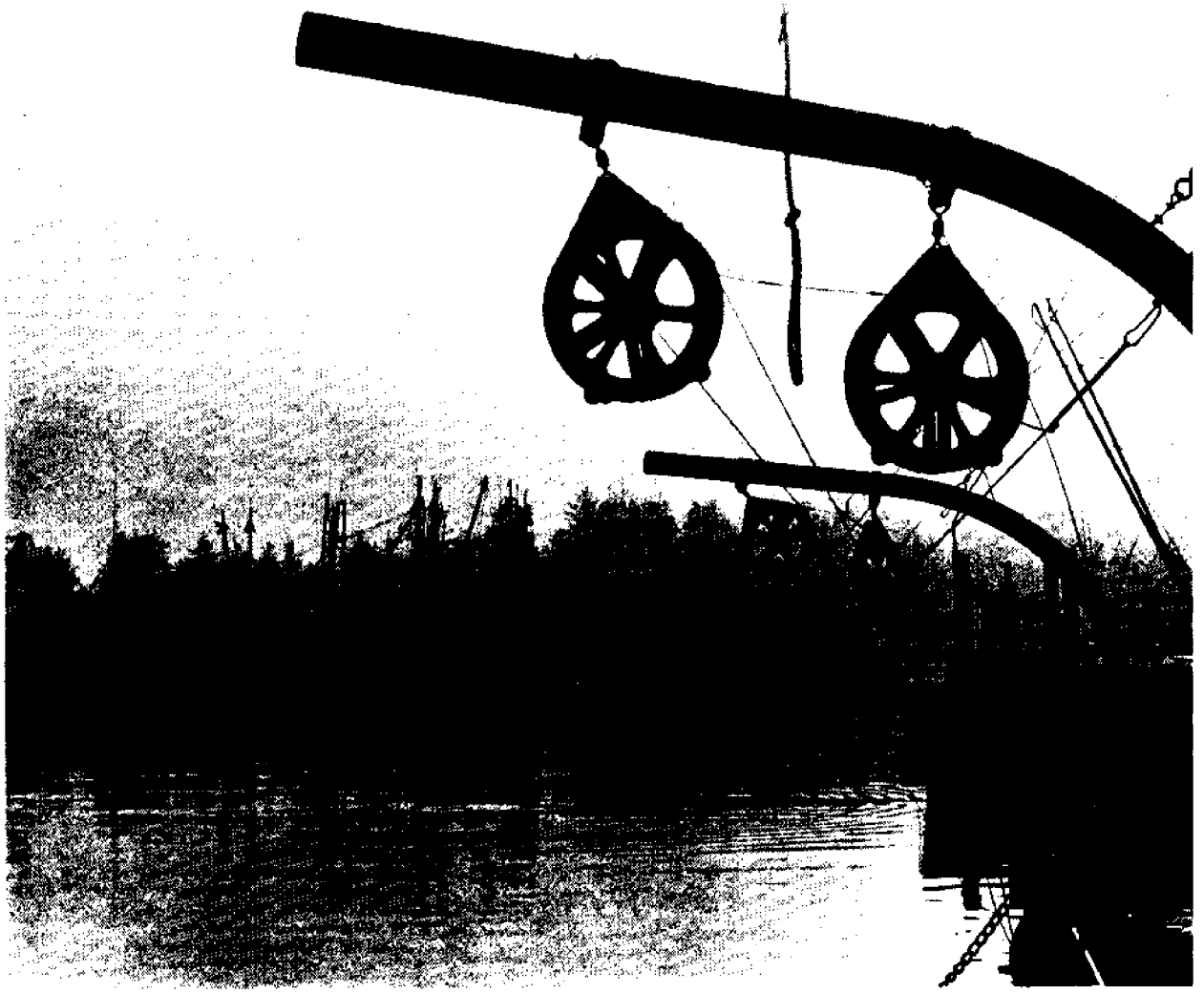
Despite the numerous success stories of those who have built up a fishing fleet from a single-boat operation, the fishery business remains a risky venture for many. Even in a year when the harvest is relatively plentiful, success depends on an adequate price for the catch. Consequently, any factor that threatens to undermine this market price is fought by those whose livelihood depends upon selling their fishery harvests. Coastal aquaculture development is perceived as posing such a threat to the commercial fisheries market for two reasons. First, with aquaculture output adding to the supply, the natural tendency is for prices to fall unless there is a concurrent upward shift in demand. This phenomenon reportedly occurred in the European aquaculture market during the 1970s when the real price of three major cultivated species—

French oysters, Spanish mussels, and trout—fell dramatically as supplies increased.[26] Second, fishery interests argue that cultivated harvests are typically of lower quality than natural catches. This diminished quality could undermine the reputation of seafood products, with consumers then turning more frequently to meat and poultry for their protein intake. Those who advance this argument point to artificial diets, chemical taints, and the manipulation of the natural life cycle of many cultured species as factors that diminish quality.

Proponents of aquaculture reject the argument that the quality of cultured products would undermine the viability of the seafood market. To the contrary, with increased control and uniformity, the overall quality of the product could potentially be enhanced. In support of this contention, proponents raise such examples as cultivated mussels in Maine that bring $18 to $25 per bushel, compared to as little as $3.75 per bushel for natural harvests.[27] The price differential results from the lack of grit and pearl in the cultured product, and its high meat-to-shell ratio. In addition, captive lobsters raised in warmed effluent from a California power plant were judged to have flavor comparable to that of wild stocks and were considered more tender.[28]

Aquaculturists also take issue with the contention that the increased supply will undermine market prices. They argue that aquaculture output entering the stream of commerce will tend to stabilize the market and create a more reliable price both for themselves and for the existing fishing industry. Rather than simply lowering the price, a steady flow of products will encourage expansion of the seafood processing and distribution network, with consumers then coming to depend more heavily on this now-reliable staple.

Despite the optimism of aquaculture enthusiasts, the commercial fishing industry generally views this new venture as a



Troll fishery, Charleston, Oregon. Photo: Jim Larison, Oregon State University Sea Grant College Program.

threat to market prices rather than as a welcome partner. The concern that aquatic husbandry will displace existing fishing operations in the seafood market presents coastal aquaculture with a significant and politically potent obstacle to future development.

Altering Coastal Communities

The second socioeconomic barrier to aquaculture development stems from its potential impact on coastal communities. Although seafarming operations typically generate little pollution, they nonetheless have the potential for significantly altering the character of coastal regions. Most modern operations are capital-intensive enterprises that require artificial structures in the tidal zone or along coastal property. Those who value the amenities of natural vistas and of fishing-oriented communities see the effects of widespread aquaculture development as a threat to their quality of life. The loss of limited coastal sites to semi-industrial facilities, the intrusion of such activities on the aesthetics of the region, and the potential harm to the existing character of the fishing-oriented society lie at the heart of local opposition to aquaculture proposals.

Perhaps some of the resistance in coastal communities would be overcome if aquaculture brought with it the certainty of numerous new jobs. But modern aquaculture in the U.S. carries no such promise due to its high capital input relative to labor needs. Once construction is complete, the demand for labor is generally quite small. This fact, teamed with the fear that jobs in fishing operations may be undermined by seafarming, reinforces opposition to its development. Aquaculture's potential for altering the character of coastal zones is of further concern in that the economy of a coastal region often depends upon the synergistic relationship between tourism and commercial fishing. There can be little doubt that a vast majority of tourists would prefer strolling through colorful wharf areas while fish are being landed, to looking at aquaculture structures rising from the tidal flats. And certainly for most people, the value of a weekend drive along the coastline is diminished when they are confronted by additional construction.

Aquaculture proponents argue that such concerns are exaggerated. The assertion is made that with proper planning and care, production facilities can be assimilated into the coastal zone without degrading its valuable environmental and social characteristics. Regardless of the validity of this assertion, the fact remains that aquaculture development is *perceived* by many coastal inhabitants as a threat to the character of their community. It is this perception, right or wrong, that has created an additional barrier to aquaculture expansion.

Difficulties in Financing

The first two socioeconomic barriers to aquaculture development are partially responsible for creating the third. The controversy over aquaculture's potential impacts has added to the reluctance of lending institutions to provide financial support for seafarming ventures. The difficulty in attracting investors and lenders will continue to impede aquaculture so long as the uncertainty exists regarding its acceptance by political bodies in the coastal zone. It is not only the controversial nature of the development, however, that creates the uncertainty. Financial institutions and investors are leary of an enterprise in which the associated technology is relatively unproved, as is the case in many aspects of cultivating marine species. Unfortunately, there are several examples of lessons being learned the hard way. One Florida investor who attempted to promote a shrimp venture sold out in 1981 after losing $6 million over the previous twelve years.[29] On the other side of the continent, an attempt at raising seed oysters likewise met with financial disaster. In this instance, a million-dollar loan came due prior to the maturation of floating racks of oysters. When harvest time finally arrived, there were insufficient funds available to gather the millions of oysters. The mature oysters reportedly grew so heavy that they sank the rafts, leaving only ripples and the outstanding debt.[30]

Because of the high initial capital investment typically required by aquaculture, the need for financing is critical. Consequently, the difficulty in identifying outside funding has inhibited participation by small operators in the U.S. coastal aquaculture industry. As an example, a small Oregon firm sold the beginnings of a salmon ranching operation to Weyerhauser Company in 1975, who has since invested the $14.5 million in capital necessary to get the program off the ground.[31] This instance and other examples of corporate involvement,

combined with the need for large capital investments, have led to the characterization of coastal aquaculture in the United States as "aquabusiness." This characterization in turn adds to the controversy over the intrusion of aquaculture facilities into the coastal zone environment. The current harvesters of coastal fish and shellfish see their livelihood and the lifestyle of their community being subverted by the threat of big business. Time will tell whether such a fear proves valid.

B. Biological Impediments

In addition to socioeconomic barriers, the aquaculture industry faces biological constraints that may limit its potential. Such constraints are difficult to summarize since each aquaculture operation will encounter different biological impediments, depending upon the particular methods used and the species being raised. For instance, a seeded oyster bed may operate for decades without encountering any biological problems, while salmon ranching currently faces a number of such concerns ranging from an insufficient egg supply to an overload of the coastal carrying capacity. Despite the diversity, the biological impediments commonly confronting the aquaculture industry can be categorized into two general types. The first is the problem of inhibited reproduction by species in captivity, and the second stems from strains encountered in the natural ecosystem.

Inadequate Reproduction

If all seafarming operations were as easily restocked as the shrimp ponds along the Thai coast, the development of the aquaculture industry in the United States and elsewhere could accelerate significantly. In Thailand, the incoming tides carry small shrimp through gated ponds where they reach market size after four to six months.[32] Rarely is nature so benevolent a provider, however, in coastal aquaculture ventures. In fact, natural biological mechanisms commonly inhibit the restocking of aquaculture operations. Many species held captive in an artificial environment fail to reproduce in sufficient numbers to propagate the next generation required in aquatic husbandry. In such cases, an alternative source must be found to replenish the seed stock, typically through artificial propagation or through importation of eggs or juveniles. Yet each of these alternatives has its limits.

The biological constraint of inhibited reproduction is demonstrated in several cultivated species. An example is the milkfish, which constitutes an important source of protein in the Philippines, Taiwan, and the Indonesian archipelago (approximately 150 million metric tons is cultivated annually).[33] When a milkfish is raised in captivity, a fatty substance forms over its reproductive organs and causes them to atrophy. Consequently, the raising of this species is limited by the number of wild fry that can be caught each year and placed in the rearing ponds. Eel production is also restricted because of the species' inability to reproduce naturally in captivity. In the case of the Japanese eel industry, the cultured harvest is currently constrained by the available quantity of elvers imported from as far away as Europe and North America.[34] Shrimp is another commercial species whose reproduction problems in captivity inhibit successful aquaculture production. Recent research, however, may help to overcome this problem. It has been discovered that removing a single eye stalk of a captive shrimp eliminates the chemical inhibitor responsible for disrupting its sexual maturation.[35] Also, studies indicate that spawning can be facilitated by altering the temperature, flow rate, and salinity of the water in which the shrimp reside.

Despite encouraging scientific results, innovative techniques for increasing seed stocks may prove too costly or require too much control to free the aquaculture industry from the biological constraint of reproductive limitations. Furthermore, there is no guarantee that research will provide the key to the artificial propagation of each cultivated species requiring assistance. As the coastal aquaculture industry in the United States continues to expand and diversify, it will doubtless run into problems of insufficient seed stock. Already this problem has been a limiting factor in the salmon ranching industry. Even with extensive importation, there are simply not enough salmon eggs to supply the demands of existing private operations.[36] The California oyster cultivation is another segment of the industry that is unable to replenish its own needs. As a result, seed oysters must be brought in from other states, Canada, and Japan.[37]

Ecological Strains

The importation of eggs, fry, and other

seed stock leads into a second category of biological impediments faced by coastal aquaculture. Seeding the coastal environment with stock brought in from other regions has the potential for adversely affecting the existing ecosystem. Imported eggs and fry may carry diseases to which the indigenous population is susceptible. The resulting outbreak could devastate the natural environment and commercial fisheries. It is further feared that imported fish, by breeding with the natural stock, may induce subtle genetic changes detrimental to the overall health and quality of the species.

Widespread coastal aquaculture can also strain the ecosystem simply from the numbers involved. The marine environment is limited in its capacity to assimilate and support aquatic populations. When too many individuals of a species are introduced, an imbalance in the natural ecosystem can occur. The introduced population may simply push out the natural species, or each may suffer from too little food and space. Aquaculture in some coastal zones may be limited by this restriction. If the carrying capacity of the environment is exceeded by expanded aquaculture inputs, the seafarming operation is doomed to failure, with concurrent harm to commercial fisheries as well.

A third strain on the natural ecosystem results from the physical intrusion of aquaculture facilities into fragile coastal zones. Coastal marshes, tidelands, and estuaries are of critical importance to many marine species, providing a protected, fertile habitat for spawning and rearing of the young. They also are prime sites for aquaculture facilities. If an expanding aquaculture industry should monopolize these important sites, there would be a tradeoff between increased fishery output from the facilities and decreased production of natural populations.

Because of this environmental tradeoff, seafarming entrepreneurs have been faced with a barrier in identifying appropriate locations for their facilities. One developer who searched 5,000 miles of coastline in eight states for a shrimp cultivation site abandoned the effort after concluding that conservation laws made it "virtually impossible" to lease suitable tidelands.[38] Although the developer may have been too easily deterred, there is no doubt that the regulatory scheme is extremely complex. This complexity as well as other legal impediments comprise the final set of constraints faced by coastal aquaculture.

C. Legal Constraints

Regulatory Complexities

The extent of government control over aquaculture varies significantly between different countries. In some, such as the Philippines and New Zealand, the industry is extensively regulated, while aquaculture development in others receives a freer rein. Canada, for example, has chosen to implement few controls in order to facilitate innovation within the growing aquaculture industry.[39] In the United States, aquaculture is only moderately regulated compared to other activities within the nation. There are, however, a significant number of laws that face the entrepreneur who wishes to farm U.S. waters. More than twenty federal agencies are involved to some extent in aquaculture regulation, with approximately 120 federal laws affecting the industry.[40] Despite this large number, it is actually the state governments which are responsible for the vast majority of aquaculture control. This fact arises from state jurisdiction over the coastal waters and resources out to the three-mile limit.

In all coastal states, an aquaculture proposal is met by numerous permit requirements involving various administrative bodies at each level of government. With today's concern over safety and the environment, the list of agencies encountered can become quite lengthy. The state agencies responsible for coastal protection, pollution control, food quality, and wildlife maintenance are only the beginning. A California abalone farm established in 1972 ended up dealing with thirty-seven federal, state, and local bodies before receiving full approval for its project. The process took two years and cost the company over $20,000 in fees and staff time.[41] In a typical aquaculture development, additional costs can result from compliance with permit requirements. A capital investment may be needed to conform to control stipulations, and monitoring activities frequently must be a part of ongoing operations.

The state of Hawaii leads the nation in facilitating the aquatic entrepreneur's journey through the regulatory maze.[42] Nonetheless, the process remains quite complex even in paradise. The first step faced by an aquaculture development proposed along the Hawaiian coast is dictated by the state's Shoreline Protection Law. The applicant must receive a Special Management Area permit from the county au-

thority responsible for shoreline protection. If the project includes facilities close to the highwater mark, a shoreline setback variance must also be granted. In addition, the county issues building permits for any structural proposals, and a grading permit is required when a potential for erosion exists. The County Board of Water Supply becomes involved in the permitting process if a well is planned, while the County Planning Commission must review the proposal for its consistency with floodplain management. Stricter structural regulations will be imposed if the project is deemed to lie in a flood-prone or tsunami-prone area.

In addition to county regulations, the number of required state permits is likewise great. For instance, a National Pollutant Discharge Elimination System (NPDES) permit must be received from the state Department of Health prior to the discharge of any liquid effluent from an aquaculture facility. This department is also responsible for issuing a Shellfish Sanitation Certificate if an operation involves the raising of clams, oysters, or other shellfish. The Department of Land and Natural Resources joins the process of review when there is potential impact on state historical sites. It also issues the Conservation District Use permits for projects sited on submerged lands or within other designated shoreline areas. A further shoreline permit is required from the Harbors Division of the Department of Transportation, while the Department of Agriculture becomes involved if importation of non-indigenous species is proposed. In addition, the Department of Planning and Economic Development reviews the application for consistency with the state's coastal zone management plan.

In Hawaii and elsewhere, the list of required permits continues. A permit from the Army Corps of Engineers is necessary whenever a proposal involves construction, dredging, or filling in navigable waters. If the project is sufficiently disruptive, a federal environmental impact statement may also be required. Regulatory complexity in a state can be further compounded by the competing interests of the various agencies involved. For example, the California Health Services Department requires that floors on fish processing plants be smooth to facilitate cleaning, while OSHA stipulates that they be rough to prevent employees from slipping.[43] Conflicts of more widespread significance arise where an administrator responsible for encouraging aquaculture development runs into the policy of another state agency designed to preserve natural coastlines.

Jurisdictional Impediments

In most coastal states, fish and wildlife departments have become the dominant agencies regulating aquaculture. The legislative decision to send aquaculture entrepreneurs to wildlife administrators generally was made with little thought to long-range planning. When the novel enterprise of aquaculture first came before legislators, they simply passed it on to the agency that already dealt with fish. The numerous other health, safety, and environmental agencies naturally became involved in the review process as well, but the state fish and game department typically would be responsible for setting aquaculture policies. To many, this legislative decision made as little sense as having a wildlife department regulate cattle ranching and farming. It was felt that the mentality of those accustomed to regulating the hunting and fishing of wild resources was unsuited to establishing policy for aquatic husbandry. Such was aquaculture's first jurisdictional impediment.

As time passed, seafarming suffered further from its inability to be neatly pigeonholed into a state's institutional framework. For the purposes of regulation, it simply could not fit precisely into any existing sector. Instead, aquatic husbandry bounced within an administrative triangle at whose vertices lay commercial fishing, agriculture, and industrial activities. For some purposes, a seafarming operation might be considered an industrial venture, while at other times fishing or agricultural rules might apply. As a result, aquaculture is currently faced with regulatory constraints from three directions, but without benefiting from a direct association with any of the sectors. Fish ranching aptly demonstrates this difficult position. In Oregon, salmon ranchers must be issued fishing licenses; furthermore, their effluents are treated the same as those from manufacturing plants, while they receive neither the zoning benefits nor the economic supports for which a cattle or sheep rancher would be eligible.

The aquaculture industry can be expected to continue to suffer from this impediment of jurisdictional rootlessness until it becomes identifiable as a sepa-

rate, politically influential entity. With the recent rapid expansion of the industry, aquaculture's time may have already arrived. After failing to pass in preceding years, the National Aquaculture Act made its way through Congress and was signed into law in 1980.[44] The Act recognized aquaculture as a distinct activity, stipulating that it is in the national interest to encourage its development. The statute's main thrust was to direct the Secretaries of Commerce, Interior, and Agriculture to design a national plan by early 1982 to promote aquaculture research and development. It also established a federal council to facilitate the effectiveness of federal research and assistance programs.

Congress has yet to appropriate the funds needed to carry out the National Aquaculture Act's provisions. An interagency committee, however, is presenting a proposal in the current legislative session to implement the Act. In connection with this legislation, the aquaculture industry is reportedly lobbying for the establishment of a national aquaculture center to manage all future programs.[45] The lobby is also working hard for an amendment of the Act to define aquaculture as a form of agriculture. It remains to be seen whether aquaculture's cause and constituency have become of sufficient import to compel congressional action.

Private versus Public Rights

A third legal barrier currently facing aquaculture arises from the conflict associated with private enterprise's intrusion into a public resource. Being predominantly under public ownership, coastal waters and tidelands have long been considered a resource that the government must manage for the benefit of all. Developments that contravene the public right to traditional use of these coastal areas cannot receive state approval. This right, and the state's duty to enforce it, are embodied in the Public Trust Doctrine.

The roots of the Public Trust Doctrine extend into English common law, where the sovereign held title to all lands underlying tidal waters. Although the sovereign could transfer title of these lands to individuals, common law established that their use was to remain open for the public good. This Public Trust concept was developed in recognition of the importance of unrestricted navigation and the value of commercial fisheries to all society. In the U.S., state governments inherited this trust responsibility as a consequence of their ownership of most submerged land below navigable waters out to a distance of three miles from their shores.

The protection provided by the Public Trust Doctrine was first articulated in American jurisprudence in the case of *Illinois Central Railroad* v. *Illinois*.[46] In 1869, the Illinois legislature had granted the railroad company title to more than one square mile of Lake Michigan's bed offshore of Chicago. The Supreme Court upheld the subsequent repeal of this grant on the ground that the state could not abdicate its trust over the submerged lands if such action proved detrimental to public navigation or fishing. This Trust Doctrine has since been asserted to protect the public interest in *marine* coastal zones as well.

Deal Island, Maryland. In this small hatchery, scientists and technicians from the University of Maryland and the state's Tidewater Fisheries Administration grow seed oysters for planting along the public fishing grounds of the northern Chesapeake Bay. Photo: Skip Brown, University of Maryland Sea Grant College Program.

Aquaculture that encroaches upon tidelands squarely faces the restrictions of the Public Trust Doctrine. In some aquatic husbandry, however, such as in oyster culturing in mud flats, the impact on the public interest is of insufficient magnitude to invoke the doctrine. For such activities the state may properly lease its submerged lands to private enterprise. On the other hand, where aquaculture operations require significant construction in the tidal zone or fencing to protect the "crop," a conflict may arise with the public's right to navigation and fishing. In such cases of extensive disruption, a court could invoke the state's trust responsibility and prevent approval of the proposed development.

As our awareness has grown over the importance of estuaries and tidelands to the marine ecosystem, so too has the potential application of the Public Trust Doctrine expanded. Even though a particular tidal development may not directly interfere with navigation and fishing, its impact on natural spawning and rearing sites for commercially important species could in the long run harm ocean fisheries. Consequently, the Public Trust Doctrine might be invoked to prohibit state approval of such development in important estuarine and tidal areas. Aquaculture proposals are particularly vulnerable to such attack, not only because of the physical intrusion of their facilities on tidelands, but also from their potential for biologically impacting indigenous species.

The Public Trust Doctrine has never been applied further seaward than the state waters and submerged lands adjacent to the coastline. Aquaculture in the open ocean, however, is not without controversy regarding private rights in a public resource. Many feel that carving out private rights in the bounty of the oceans is anomalous to the historic concept that the sea's living resources are the common heritage of all citizens. There is concern that if seafarming businesses are allowed to graze the public's aquatic pastures, we will be repeating the nineteenth-century mistakes made on the public lands of the West. A new wave of corporate robber-barons might be created to reap huge profits from public resources to the exclusion of the rest of the citizenry.

Analogies and dramatics aside, there is indeed a pressing issue involved with the concept of the government granting permits for private exploitation of the ocean's

U.S. Fish and Wildlife hatchery, Spring Creek, Washington. Aquaculture facilities require extensive waterfront footage. Photo: Jim Larison, Oregon State University Sea Grant College Program.

nutrients. Political pressures in states with powerful commercial fishing and environmental lobbies may make legislatures hesitant to support corporate proposals. Such reluctance to allocate to private enterprise a portion of the sea's finite capacity to nourish aquatic species may prove to be a significant legal constraint to aquaculture development. Already there is one segment of the seafarming industry in which this controversy has come to a head—salmon ranching along the West Coast.

* * *

III. WEST COAST SALMON RANCHING

Salmon ranching operations provide a graphic example of the potential of coastal aquaculture. Comparison of the required capital investment to the amount of fish potentially produced reflects the promise of vast amounts of protein and great profits. In the past decade of actual ranching experience, however, it has been the inherent *problems* of raising salmon that have instead come to the fore. Biological constraints teamed with legal and socioeconomic concerns have greatly impeded the industry's progress along the West Coast. These impediments are examined in subsequent sections in order to illustrate specific barriers faced by a particular type of coastal aquaculture. To assess the problems of salmon ranching, however, one must first understand the species' life cycle and the principles involved in raising the fish.

A. Species of Pacific Salmon

The complex journey taken by Pacific salmon from birth to death has made it the subject of both intense scientific study and religious worship. From ancient tribal ceremonies to modern corporate laboratories, societies have long sought to fully comprehend the coming of "the Salmon People," genus *Oncorhynchus*. Salmon are anadromous fish, meaning that they are found in both fresh and salt water during different periods of their life cycle. After hatching from eggs in the shallows of rivers and streams, the salmon fry migrate towards the ocean. For most species of salmon, the journey seaward takes from several months to years, during which time they feed and grow in the freshwater environment. As the juveniles approach the ocean, hormonal changes help them adapt to the saline waters of estuaries. They emerge into the sea as "smolts," typically a few inches in length, and graze in the open ocean for up to several years. The adults then return to their area of birth to deposit their eggs or sperm. After spawning, the Pacific salmon die.

Although theories differ regarding the origin of this impressive fish, many believe that the complex life cycle of the salmon resulted from the advance and retreat of the Ice Age.[48] Salmon are thought to have evolved from freshwater fish that were forced by the effects of inland glaciation to adapt to the sea. Ice jams and heavy siltation are factors that could have compelled adult salmon to seek the marine environment for survival. Dilution of coastal waters with excessive glacial runoff during warming periods may also have played a part in the salmon's evolution. It is thought that the species first arose along the North Atlantic coast, with subsequent migration to the Pacific via the Arctic Ocean.

Five species of the Pacific salmon are found along the western coasts of the United States and Canada. (A sixth species of Pacific salmon, the cherry or masu, spawns only in Asia.) Although their migratory and spawning areas overlap, each species has distinct characteristics. The largest of the five is the chinook, which generally favors the upper stretches of large rivers for spawning. This fish, also known as the king salmon, averages about 22 pounds at maturity, although some adults weigh over 100 pounds. After spending one to two years as juveniles in fresh water, chinook live in the ocean from four to five years before returning to spawn. Chinook and coho are the two most important species in the salmon fishery off northern California, Oregon, and Washington. Coho (silver salmon) are smaller than chinook, averaging about 12 pounds as returning two-year-old adults. Coho tend to spawn in the lower stretches of coastal rivers during the late summer and fall. Because of their size and commercial value, chinook and coho are prime candidates for ranching operations.

The sockeye, or red salmon, is the major commercial salmon species off southern Alaska and Canada. Its life cycle is unique in that the fry must migrate to and reside in a lake before traveling to the ocean. This particular need of the sockeye may limit the practicality of rais-

ing the fish in existing aquaculture facilities. On the other hand, the life cycle of the chum (dog salmon) actually facilitates ranching. Wild chum often spawn in estuaries, with the fry emerging directly into saline water. This feature eliminates the need for a long acclimation to the marine environment, and the returning adults will not have to use up their edible reserves fighting their way upstream to spawn. Each of these factors adds to the potential success of salmon ranching. The chum's dependence on estuaries, however, has also contributed to its recent demise. Its southern runs in Oregon and California were nearly eliminated as human activity and pollution intruded upon the estuaries of this region.

The fifth species of Pacific salmon, the pink or humpback, is the smallest and least commercially desirable in U.S. markets. It prefers northern climes, sharing large runs with the chum in Alaskan waters. The pink fry head immediately to the sea after hatching and spend two years grazing before coming back to fresh water to spawn. Because of their quick adaptability to saline water, both the pink and chum salmon have been extensively ranched in Japan and the Soviet Union. In fact, of the 3 billion smolt released into the Pacific from all ranching facilities in 1980, 85% were chum and pink originating mostly from Asia.[49]

B. Existing Ranching Operations

The green light to West Coast salmon ranching was initially given by the state of Oregon. Legislation was passed in 1971 allowing private enterprise to begin ranching chum salmon.[50] Two years later the ranching of chinook and coho was also approved, with pink salmon added to the list in 1979. Over the past decade, the Oregon Fish and Wildlife Commission has issued twenty permits to private ranchers for the annual release of 180 million smolt.[51] This figure is more than twice the number of juvenile salmon released by the state from its public hatcheries.

Salmon ranches that have been licensed under Oregon law take away from nature the responsibility of hatching and rearing the juvenile fish. A typical operation consists of two facilities, a hatchery and a release/capture site. At the first facility, millions of fry are hatched from salmon eggs then fed for several months until

Rearing tanks for young salmon at the Ore-Aqua salmon aquaculture facility at Springfield, Oregon. The salmon eventually are transferred to larger ponds at the Springfield facility and raised to smolt stage. Photo: Tom Gentle, Oregon State University Extension Marine Advisory Program.

they become ready for transfer to the coastal release/capture facility. Provided with an enriched food supply and warm water, fry can grow at an accelerated rate. For instance, it has been reported that coho fry at Weyerhauser's facilities reach releasable size in six months rather than the year and a half required in the wild.[52]

Following their transfer to the coastal release/capture facility, the juveniles are held from a few days to up to five weeks in order to acclimate to saline water and to become imprinted with the odors and location factors that will guide them back to the facility as adults. They are then released into an estuary or nearshore waters as smolts (typically five inches in length), and those that survive return in from one to five years depending upon the species raised. Only a small fraction of the released smolts return as adults to jump the fish ladder into the capture facility. At existing ranching operations, less than 1% of the released fish have generally returned in subsequent years.[53] This small number of marketable adults currently creates much red ink in the industry. Those involved in ranching, however, expect the return rate to improve as operating experience is gained, with consistent returns of 2% to 5% anticipated for the near future.[54]

Red ink has not been the only problem facing the budding salmon ranching industry over the past years. In 1980, the Oregon Fish and Wildlife Commission suspended issuing further coho, chinook, and chum permits for five years in order to assess the environmental impacts of ongoing operations.[55] In other West Coast states, ranching has been even more severely restricted. Salmon in Washington may be raised only in pens, while Alaska limits private hatcheries to non-profit cooperatives that are used primarily to supplement ocean catches. California requires a private salmon rancher to apply to the state legislature in order to gain an operations permit. To date, only one applicant has been successful in getting special legislation passed for a permit, and its facilities are sanctioned solely on an experimental basis.[56]

Governmental reluctance to embrace salmon ranching has sprung from pressures developed by two unanswered questions: First, what effect would salmon ranching have on the natural environment, and second, to what extent might it adversely impact the existing commercial salmon industry?

C. Impacts on the Natural Environment

Despite the importance of salmon to West Coast fisheries, many mysteries remain regarding this fish. Little is known of the salmon's specific feeding and migratory patterns during its years in the open ocean, and science has yet to gain a full understanding of the homing mechanism that brings it back to the stream of its birth to spawn. There is also a knowledge gap regarding the juveniles' habits in estuaries and the precise chemical processes undergone during their transition into the marine environment. Without answers to these many questions to help guide development, it is feared that the introduction of vast numbers of ranched salmon may significantly impact the natural environment. Of particular concern is the potentially adverse effect on the natural stocks of salmon, both through genetic interference and through overloading the aquatic ecosystem.

Genetic Interference

Genetic interference with wild salmon has been an issue ever since public hatcheries began to release fry to supplement natural runs. It was feared that some hatchery-released fish, instead of homing back to the facilities, might spawn with natural populations and introduce detrimental genetic characteristics. This concern over straying was well-founded, in that even in wild salmon the homing mechanism is known to malfunction. In coho stocks, it is estimated that between 5% and 15% of the returning adults spawn in streams other than the one of birth.[57] But this phenomenon, under natural conditions, actually is of benefit to salmon populations. The small degree of straying creates a mixing of the natural gene pool and also allows for replenishing runs which have been decimated by disease or disaster. For instance, salmon straying from other streams would eventually restock the Toutle River runs eliminated in 1980 by the explosive eruption of Mount St. Helens.

By selecting eggs from local sources, public hatcheries have attempted to minimize the potential for straying and upsetting the natural genetic processes. Private salmon ranching operations, however, have generally not been able to implement this safeguard. Local egg supplies have failed to meet the ranchers' demands; thus, salmon eggs have been

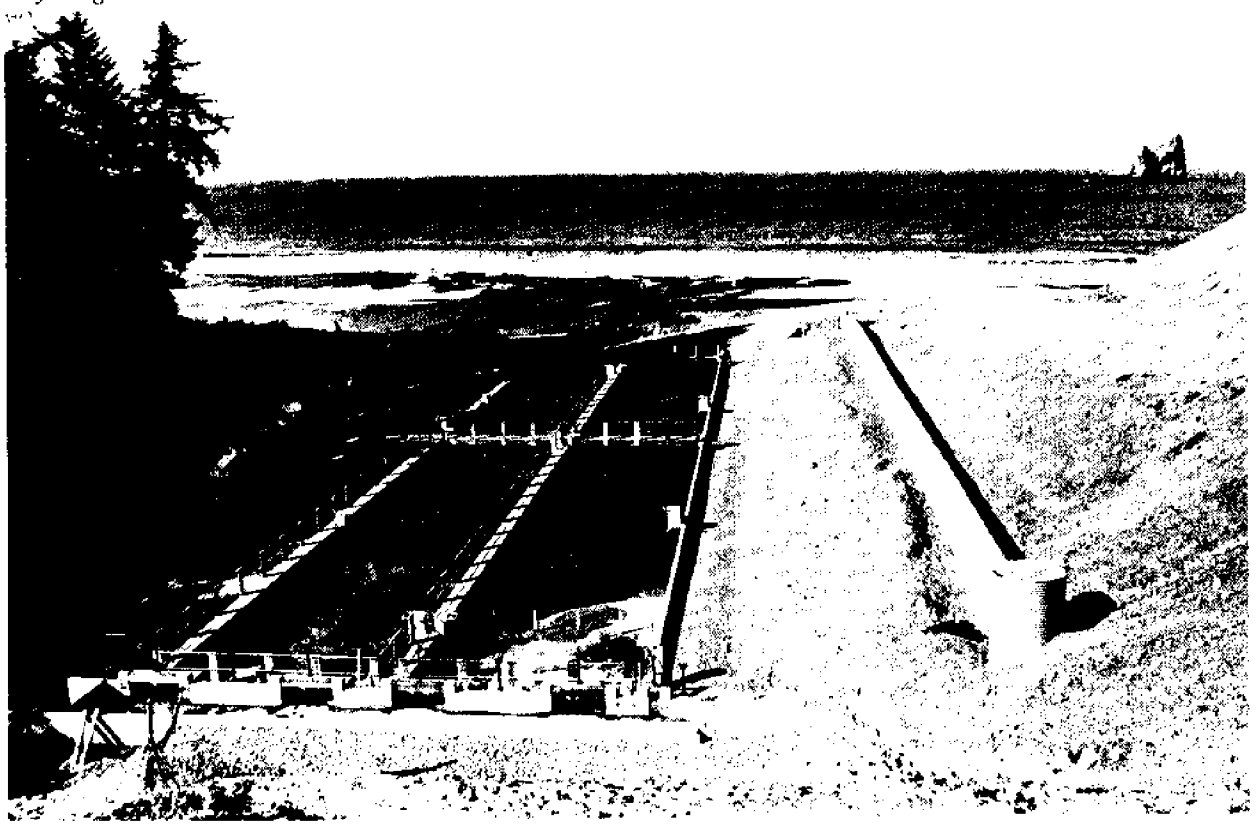
imported from as far away as Japan. To what extent this artificial introduction might adversely impact the genetic character of wild stocks is unknown. The concern over this unanswered question is greatly compounded by indications that the homing mechanism of imported salmon breaks down with greater frequency, resulting in significant straying and spawning away from the release/capture facility.[58] Consequently, salmon ranching not only introduces an artificially imported gene pool, but the increased incidence of straying multiplies the potential for cross-breeding with indigenous stocks. It is feared that such interference may reduce the vitality of the natural populations and cause further depletion of salmon runs along the West Coast.

Carrying Capacity Overload

The second major concern over the impact of salmon ranching on the natural environment stems from the introduction of millions of smolts into the coastal zone. A private release/capture facility typically discharges into an estuary where the smolt adjust to the marine environment before heading to sea. There is some concern that the delicate balance in an estuarine ecosystem could be upset by such an influx of smolt. Not only could the natural stocks of young salmon be adversely impacted by increased competition, but the entire food chain might be strained, with unknown consequences on other aquatic species.

Even after the smolts journey into the ocean, there have been indications that the carrying capacity may not suffice to support the introduction of cultured salmon. This worrisome conclusion has resulted from analysis of coho runs relative to the number of juveniles released from public hatcheries. Figure 1 shows that when Oregon hatchery output increased during the 1960s, coho populations off northern California and Oregon (called the OPI Area) grew correspondingly. In early 1970, however, a point was reached where additional hatchery releases did not result in increased production. Coho abundance in fact has fallen over the past decade even as hatchery releases rose.

Although a variety of factors may be involved in this decline, Figure 2 indicates that the amount of nutrients made available by ocean upwelling may be the limiting factor in coho production. When upwelling (caused by steady northeasterly winds) brings up nutrient-rich bottom waters, the ocean ecosystem is able to support more salmon smolt. It appears



Burnt Hill Salmon Ranch on the southern Oregon coast. This ranch is unique in that its salmon are released directly into the ocean. Returning salmon reenter the shoreside facility, bypassing the upstream trip in fresh water. Photo: Tom Gentle, Oregon State University Extension Marine Advisory Program.

from the data that in years of little upwelling, fewer fish survive to maturity despite increased releases from hatcheries. The smolt may either starve or remain vulnerable to predation longer due to a decreased growth rate from lack of food.

Because of this possibility that hatchery releases have strained the ocean's carrying capacity, the state of Oregon has rolled back the number of coho smolt permitted to be discharged from both public and private facilities. It is not yet established whether private ranching of other cultured salmon species will likewise require curtailing as a result of overloading the marine environment.

very companies whose past careless logging practices choked off many prime salmon runs are now stepping in to cash in on the unfulfilled consumer demand for the fish.

The undermining of the commercial salmon industry by aquaculture would have potentially far-reaching socioeconomic repercussions in the coastal zone. Salmon catches have historically played a unique role in the development of the West Coast fishing industry. As explained by one veteran from the Oregon coastal community of Newport: "You go down to the waterfront and ask any owner of a boat more than sixty feet long how he got started. Ninety-nine percent of them

Figure 1

Trends of Coho Abundance Compared with Smolts Released from Hatcheries (3-Year Moving Average) in OPI Area.

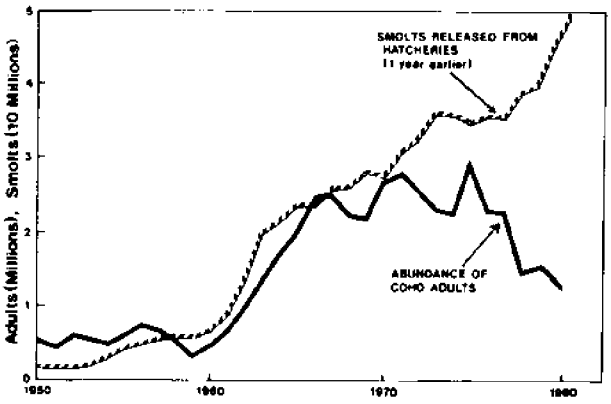
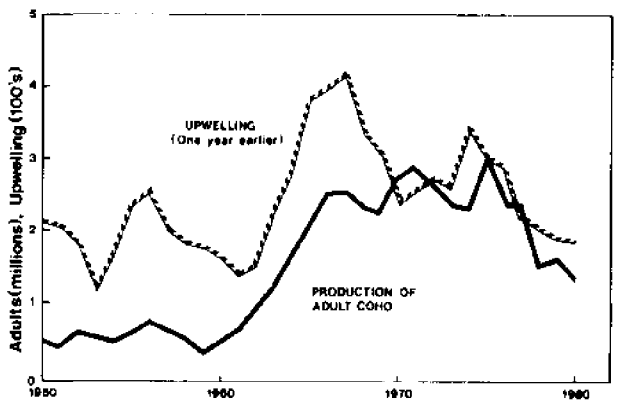


Figure 2

Trends of Adult Coho Production and Ocean Upwelling in the OPI Area (3-Year Moving Average).



Source: Oregon, Department of Fish and Wildlife, *A Plan for Oregon Coho Salmon* (Portland, Ore.: n.p., 1981), pp. 3 and 4.

D. Impact on Commercial Fishing

Despite the gravity of the associated environmental concerns, even more vociferous opposition to salmon ranching centers around its potential impacts on the existing commercial salmon industry. The social and economic problems inherent in aquaculture (discussed in Section II.A.) are particularly acute regarding the raising of salmon. Commercial salmon trollers perceive ranching as a threat to their market price, to their right to catch fish, and to their very livelihood. The genuine fear exists that successful salmon ranching businesses could completely displace ocean harvesting in a competitive market where fuel and maintenance costs continue to climb. Displacement of salmon fisheries by aquabusiness would be particularly resented because of the involvement of large timber companies in salmon ranching development. It is seen as ironic that the will have started as a salmon troller. That's a good apprentice system—I wouldn't want to lose that. That's the only way you can get started. If that fishery goes, a lot of the other fisheries are going to be hurting for fishermen."[59]

The commercial fishing industry has proved that it is capable of more than simply words when it comes to protecting the salmon trollers. When Crown Zellerbach Company was issued a salmon ranching permit by the Oregon Fish and Wildlife Commission in 1979, the Federation of Independent Seafood Harvesters (FISH) filed suit to rescind the state action. The fight had begun.

E. The Legal Conflict

The events leading up to the case of *Federation of Independent Seafood Harvesters* v. *Oregon Fish and Wildlife Commission*[60] commenced when Crown Zellerbach applied for a salmon ranching

permit in December, 1977. The request was made to the Department of Fish and Wildlife for the annual release of several million coho and chinook smolt into the Tillamook Bay estuary. Under Oregon administrative law, a public hearing was required in considering the application. Prior to the hearing, held in November 1978, FISH petitioned to intervene in opposition to the requested permit. Additional interveners included the All-Coast Fisherman's Marketing Association and the Oregon Environmental Council, a private organization concerned with salmon ranching's impact on the natural ecosystem.

The Administrative Hearing

At the hearing, FISH and the other interveners attacked the permit on two legal grounds. First, they argued that the Crown Zellerbach permit would contravene the directive in section 508.710(1) of the Oregon Revised Statutes that: "No permit shall be issued which may tend to deplete the natural runs of anadromous fish or any population of resident game fish." FISH alleged that since scientists are currently unable to determine the actual impacts of releasing millions of smolt into the estuary, any permit to do so "may tend to deplete" existing fish populations. Under this statutory interpretation, an applicant could receive a ranching permit only after meeting the burden of proving that its salmon operation would not harm indigenous fish. Because Crown Zellerbach and the state lacked the data to make such a showing, FISH contended that the permit request should be denied.

The inability to prove that the proposed smolt release would not harm the estuarine environment also provided the grounds for the second legal challenge at the hearing. Goal 16 of the Oregon land use planning standards requires that state agencies must "recognize and protect the unique environmental, economic, and social values of each estuary."[61] FISH argued that this clause commanded the Fish and Wildlife Commission to identify and ameliorate any potentially adverse impacts prior to permitting salmon ranching to proceed in the Tillamook estuary. Since the impacts were unknown, the agency would be unable to achieve the prerequisite to permit issuance.

The Oregon Fish and Wildlife Commission chose not to interpret the statute and Goal 16 in the restrictive manner set forth by the interveners. After reviewing the hearing proceedings, it granted the permit to Crown Zellerbach under the following reasoning:

> Conclusion of Law
>
> Because of the lack of conclusive evidence as set forth [in the findings] it is impossible to determine at the present time whether or not the issuance of the proposed salmon hatchery permits would violate ORS 508.710(1)(4), or Statewide Planning Goal 16.
>
> Order
>
> Since it appears that the only way of determining whether or not Applicant's proposed program will have a detrimental effect on the estuarine resources is to conduct an experimental hatchery release program, coupled with adequate testing and monitoring, it is ordered that the proposed Chinook and Coho salmon hatchery permits for five million fish each be issued subject to [detailed conditions to be met by Crown Zellerbach.][62]

Judicial Resolution

FISH appealed the order of the Commission, with the case eventually being carried to the Oregon Supreme Court. On December 2, 1980 the Oregon assistant attorney general and counsel for Crown Zellerbach appeared before the court in favor of upholding the permit. FISH, All-Coast Fisherman's Marketing Association, and the Oregon Environmental Council argued against the permit on the grounds previously set forth at the hearing. In August of the following year, the court ruled in favor of FISH's position, stating that the permit was invalid because it "may tend" to harm existing fish runs and it contravened the estuarine protection standard of Goal 16. No permit, not even on an experimental basis, could be granted until the Commission "affirmatively finds that permit issuance will not be injurious to existing fish populations."[63]

This high standard of proof dictated by the supreme court essentially forecloses the further development of salmon ranching in Oregon estuaries under existing statutes. It is difficult to conceive that science can provide absolute proof that the release of millions of smolt into an estuary will not tend to deplete existing

populations to some extent. Yet this is now the prerequisite to salmon ranching required by law. Furthermore, other coastal aquaculture ventures may be inhibited as well by the second element of the court's restrictive holding. The court affirmed that Oregon agencies have a duty to make findings that their actions are consistent with state land use Goal 16. A finding merely that "evidence is inconclusive" regarding the impacts of a proposal was held to not meet this duty.[64] Instead, an agency is required to conclusively identify and assess a proposed coastal development's impact on the estuary prior to permit approval. Such a restriction under Goal 16 may prove particularly constraining to the infant aquaculture industry where many subtle questions remain regarding its potential effect on estuarine ecosystems. Likewise, if the court maintains its stance that definitive findings be made consistent with all state land use goals, seafarming may also be restrained by Goals 17, 18, and 19, which protect shorelines, dunes, and ocean resources.[65] Consequently, all coastal aquaculture in Oregon—not just salmon ranching—may have been dealt a severe blow by the 1981 holding in *Federation of Independent Seafood Harvesters* v. *Oregon Fish and Wildlife Commission.*

* * *

IV. A NEED FOR PLANNING

The salmon ranching experience in Oregon foreshadows many of the pitfalls that await future coastal aquaculture development in the United States. The biological and socioeconomic impacts of seafarming result in a legal web that may increasingly inhibit the expansion of the industry. If aquaculture is to play a significant role in supplying our nation's food supply, farsighted planning will be necessary to facilitate its progress.

The Oregon Supreme Court, in rescinding Crown Zellerbach's ranching permit, indicated where the key lay to opening the door to aquatic husbandry. As stated in that case, if a current law proves too restrictive to allow for development, "it is the legislature's prerogative to rewrite the statute."[66] With such power vested in state legislatures and Congress, these bodies will undoubtedly be the focus of much aquaculture lobbying. Already many suggestions have been made for statutes to promote aquatic husbandry. Proposals have included laws to facilitate acquisition of suitable coastal sites, to provide for reduced power and water rates, and to make agricultural types of incentives available to aquaculture development.[67] It has also been recommended that treaties be drafted to regulate the international trade of seed stock to prevent importing diseases and parasites.[68]

The list of statutory particulars designed to aid seafarming can become quite lengthy. Before lawmakers can effectively deal with the specific legislative needs of the industry, however, it will be necessary to address the underlying policy question on which the future of coastal aquaculture hinges: To what extent should private rights for aquaculture be created in the ocean and coastal zones?

A. Delineating Rights

Section II.C. presented the issues involved in the controversy over private enterprise's intrusion into a historically public resource. The public-versus-private rights conflict was seen to arise from two major factors. The first involved the states' trust responsibility to manage coastal waters and submerged lands in a manner consistent with the public good. The second stemmed from the issue of allocating a portion of the finite carrying capacity of the open ocean to specified private developments. Lawmakers must squarely face these issues to determine if coastal aquaculture will be allowed to expand and bring a significant amount of protein to the nation's tables.

Proponents of aquaculture argue that the benefit that coastal aquaculture potentially provides to society justifies the allocation of public resources to private development. Certainly, it seems consistent with the Public Trust concept to use the coastal zones for supplementing the food supply available to the citizens of our country and the world. Should the incidental profits flowing to corporate coffers make a difference in weighing the desirability of such use of public resources? Concurrent private profit has not been a bar in the past. Numerous private tideland developments have been permitted so long as, in addition to the developer's gain, some public benefit was created (e.g., increased housing; a place to dump municipal waste). For example, a recent plan to extend a community's airport runway into an estuary to accommodate a private airline's new jets survived a court challenge based on the Public Trust Doc-

trine.[69] The court reasoned that although the airline stood to profit from the proposal, the runway extension held sufficient community benefit to justify such use of the state's tideland.

From past judicial interpretations, it appears doubtful that the Public Trust Doctrine will bar widespread use of the coastal zone for aquaculture facilities if a state legislature makes a commitment to promoting such development. But legislators must still grapple with the threshold question of whether to allow private aquaculture to use limited coastal sites and resources. If so, to what type of enterprise should the permits be issued? Do publicly held corporations deserve a preference over partnerships and other operations in which only a few individuals profit? Perhaps some sort of state fund could be established to which the permittees would be required to contribute a portion of their net gains. Or is it sufficient merely to charge annual payments for the use of publicly owned tidelands, as is currently done with leased oyster beds?

Such questions will face lawmakers as they address the issue of coastal aquaculture in nearshore waters and submerged lands. As aquaculture turns farther seaward, additional issues of public-versus-private rights will arise. As previously discussed, objections to the use of the open ocean for grazing by salmon ranchers have already arisen. Does such private use constitute an unfair exploitation of a public resource? Aquaculturists contend that grazing their stocks in the ocean is no more exploitive than is the current practice of harvesting natural populations. Partnerships, corporations, and individual members of the commercial fishing industry are already reaping private profits from the seas's resources. Furthermore, salmon cultivators argue that their ranching operations are in fact paying a "tax" for the use of public waters. This payment comes in the form of the large number of returning fish that are caught in the commercial and recreational fisheries. Statistics show that salmon homing back to Oregon ranching operations do contribute a significant portion of the total ocean harvest. More than 20% of the coho salmon caught in 1982 off Oregon and northern California is expected to have originated as smolt from private ranches.[70] Legally, these fish (estimated to be nearly 200,000 adults) will belong to those who catch them, not to the ranchers who previously hatched, reared, and released them as young salmon.

This public privilege to reap the profit from the efforts of private interests adds an additional twist to the controversy over coastal aquaculture. As legislators struggle with defining the extent of aquaculturists' rights to utilize public resources, they must also determine to what extent the public may dip into the fruits of seafarming efforts. The political pressures are expected to prove significant as corporate operators attempt to protect their investments from public interception. Anticipation of such pressure was in part responsible for the recent defeat of salmon ranching legislation in the State of Washington. This concern was reflected in one elected official's warning that "[no] one should be naive enough to think that corporations are going to raise fish for someone else to harvest . . . . Should fish ranching ever be enacted, you can be certain that laws to protect 'their' fish would soon follow."[71]

There is surely room for argument in this legislator's contention, but one thing is decidedly clear. If coastal aquaculture is to assimilate smoothly into our nation's economy and society, it will be necessary to resolve the conflict between private and public rights. State governments as well as federal bodies must weigh the tradeoffs involved and develop a clear policy towards aquatic husbandry. If a state decides that it is not advisable to commit the use of its public resources to aquaculture enterprise, then this policy determination should be espoused quickly. Otherwise, wasted effort will go into planning private seafarming ventures which are doomed to eventual prohibition. If, on the other hand, aquaculture is deemed a desirable addition to a state's economy, the legislature should establish guidelines so that the budding industry can know what to expect regarding its right to use the ocean and coastal zones.

B. Regulatory Simplification

In addition to delineating the extent of private aquaculturists' rights in public resources, a state legislature must take a second major step if it decides to promote seafarming. This involves simplifying the regulatory process through which a developer must journey. "Regulatory Complexities" in Section II.C. demonstrated the intricacy of the procedure for receiving permission to cultivate aquatic species. Experience has shown that many potential aquaculturists are deterred from

pursuing their plan by the plethora of agencies, permits, and paperwork encountered. If the legislatures of coastal states wish to attract additional participation in the aquaculture industry, most must consolidate their permitting process into a more manageable framework.

Regulatory streamlining would do far more than simply reduce a bit of inconvenience for the aquaculture applicant. The costs and time involved in the permitting process provide significant obstacles to businesses contemplating entry into the field. Also, the complexity of the process creates uncertainty over the success of the permit requests, thus making financial backing more difficult to attract. Each of these barriers proves particularly debilitating to small businesses interested in aquatic husbandry. Without internal financial capabilities or legal and managerial staffs, an operation rarely can surmount the regulatory hurdles that are faced. As concluded by one commentator, the choice available to state governments is to either simplify the process or consign aquaculture solely to the large corporate operators who can afford high-priced attorneys.[72]

There are several measures available for simplifying the aquaculturist's quest for project approval. One of the most obvious and superficially attractive is simply to reduce the number of permits required. Such a move, however, is more easily said than done. Each of the permits administered by the various agencies is normally designed to protect either public health, safety, or environmental quality. Consequently, it is difficult to eliminate particular permits without risking an increased degree of harm. What can be safely achieved, however, is consolidation. Both efficiency and timeliness can be promoted through combining similar aspects of the procedure into a single requirement.

A prime example of regulatory consolidation is the joint hearing procedure. If more than one agency requires a hearing prior to issuing an aquaculture-related permit, the proceedings can be joined to alleviate hardship on the applicant. At the single joint hearing, representatives from each agency would be present to scrutinize the seafarming proposal and to question the applicant. Not only would such consolidation ease the burden on the hopeful aquaculturist but it could also help reduce interagency conflicts that can arise when permits are issued independently.

Another means of consolidation would be to designate a lead agency as the sole contact for aquaculture applicants. After receiving the permit request, the lead agency would determine which other administrative agencies are required to be involved, and forward the seafarming request for their review. This model can have two variations. Either each of the contacted bodies independently decides whether to issue its respective permit and informs the lead agency of the decision; or each body merely makes recommendations to the lead agency, which then formulates the final determination. In both alternatives, the seafarming applicant's job is simplified by interacting with only one body. A greater burden, however, is placed upon the state administrative system in this model. The lead agency is saddled with the responsibility of ensuring that the proper agencies are contacted and that the permit review procedure is carried through to completion.

If the legislature feels that these consolidation measures of joint hearings and lead-agency designation are too burdensome to administer, other means of regulatory simplification are possible. For example, an individual within each agency could be designated the aquacultural specialist who handles all seafarming-related matters reaching the particular agency. Establishing such a network of specialists in the state's administrative system could result in greatly expediting the overall aquaculture permitting process. Also, deadline regulations could be promulgated to require timely action to be given to aquaculture permit applications. Such deference to seafarming would be easily justified in light of the policy in many coastal states to give water-related activities a preference when allocating limited coastal sites and resources.[73] In the allocation process, housing projects and other developments that do not require marine resources become subordinate to proposals that are intimately tied to the coastal environment.

As a final method of simplification, each coastal state that elects to promote aquatic husbandry should develop a concise, readable summary of the steps required to be taken in order to acquire all the necessary permits. Hawaii is one state which has already compiled such a guide.[74] In attempting to reduce the aquaculturist's regulatory burden, the state first acknowledged the need for extensive permits and procedures to safeguard the coastal environment. But it

also recognized the hindrance to aquaculture posed by an uncoordinated set of requirements. As concluded by the state director of Economic Planning and Development, "when controls strangle enthusiasm for an honest profit in an honorable enterprise, there is something seriously wrong."[75]

C. Conclusion

In reviewing the literature on coastal aquaculture, one encounters an unbounded enthusiasm for analogies. Proponents of seafarming are fond of comparing the current state of the commercial fishing industry to the frontier days in the western U. S. when the land's wild food resources were merely hunted and gathered. They then point to the displacement of these inefficient methods by modern farming and ranching practices, questioning just how far our nation could have developed on beaver, bison, and berries. The analogy is drawn that "primitive" methods of harvesting the ocean must likewise give way to efficient cultivation and husbandry techniques.

Not surprisingly, critics of aquaculture see the analogy unfold in a somewhat different manner. True, the current ocean fishers are similar to frontier hunters and trappers who reaped nature's harvests. But they see these rugged individuals as having been pushed out by corporate robbers who plundered the public lands of the West in search of profit. From railroad barons to lumber magnates, the searchers proved quite efficient in their quest. Opponents of aquaculture compare this nineteenth-century quest to the current desire of aquabusiness to utilize public resources in the ocean and coastal zones. The analogy concludes with a picture of additional plunder and profit at the expense of the public interest.

It is questionable whether either of these analogies alone serves much purpose in illuminating the issues facing coastal aquaculture. Together, however, they aptly presage what lies ahead in the political arena. As the fledgling aquaculture industry matures, the vociferous conflict between competing interest groups can be expected to grow even more intense. This observation punctuates the need for legislative planning that anticipates problem areas and ameliorates potential controversies before they ripen. Perhaps with such foresight, aquaculture can become a beneficial addition to coastal regions without disrupting either existing commercial fisheries or the environmental amenities valued by society.

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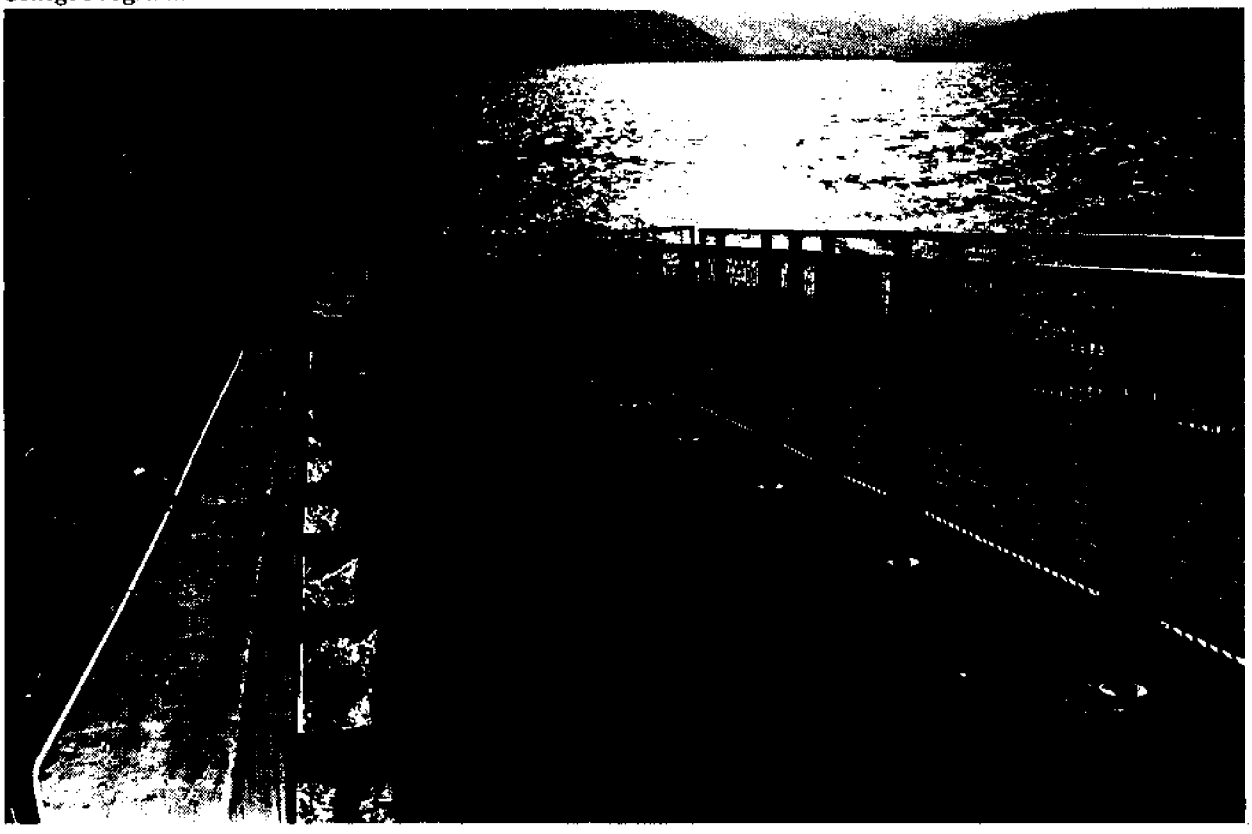

U.S. Fish and Wildlife hatchery, Spring Creek, Washington. Photo: John Hyde, Oregon State University Sea Grant College Program.

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