

ALASKA LEGISLATURE SPECIAL COMMITTEE / SUBJECT FI
1904 SCOMM 75: MARICULTURE (FISH FARMING),

pens, even if the disease itself already exists in natural stocks. When an exotic disease breaks out in a river inhabited by natural stocks, the entire river must be poisoned to eradicate it; this has happened in the U.S. and in Norway.

Recently the deadly VHS disease erupted again at a hatchery in Washington, and was also detected in wild salmon. The source of VHS is a mystery. But the fact that it never appeared in the U.S. until shortly after the establishment of fish farming, and that two of the three hatchery outbreaks of the disease in Washington have occurred within ten miles of major salmon farms, seems to lead to an apparent connection.

Those advocating fish farming in Alaska claim that all these risks can be minimized with the proper controls, siting guidelines and, of course, adequate funding. Indeed, to allow ANY fish farming, funding would be required for a whole new layer of bureaucracy spanning four departments (DEC, DNR, Fish and Game, and Public Safety), including lab space, state fish pathologists, biologists, and protection officers as well as office personnel.

But no amount of regulation can be effective if enforcement can't be guaranteed -- a costly and virtually impossible task when fish farms would be located in remote places and monitored sporadically. For example how can we prevent a farmer in some isolated bay from releasing diseased fish into the wild to save the huge expense of proper disposal? (Such actions are alleged to be taking place in Norway).

More than 70,000 people are employed seasonally in Alaska's seafood industry. They depend on the state to manage fisheries resources for a sustained yield. An average of only 3 people are needed to run the average fish farm. Fish farming has been touted as a fine "Mom & Pop" operation, a family business -- well, maybe if you're a member of the Rockefeller family, because it takes about \$1,000,000 to get started and it's a minimum of two years before you can expect any return on your investment! Financing for ventures in Alaska would likely come from out of state and foreign investors, so even if the industry were able to reap a profit, much of it would not benefit Alaskans. A much better "Mom & Pop" operation is shellfish farming, which has the legislature's full support (and mine), and which is now developing in various parts of Alaska.

Economic diversification and development deserve our support, but it should not be blind support of "anything at any cost." Potential benefits must always be weighed against potential harm. I concur that within human limitations, damage can be minimized in fish farming, but I doubt that adequate adherence to protective measures can be achieved, and I can't see a reason to take any risks when potential benefits are so minuscule.

We can best serve Alaska by responsibly managing our fisheries resources according to sustained yield principles, maximizing returns by controlled harvest and through enhancement efforts, continuing to support the "Americanizing"

and "Alaskanizing" of our fisheries, increasing incentives for shore-based processing, strengthening our marketing and quality assurance/education efforts, and by overall efforts to maintain a healthy marine environment.

The legislature recently received the final recommendations of the Finfish Farming Task Force appointed by Governor Cowper. The report confirms that the potential negative impacts of fish farming on natural stocks cannot to be eliminated, and does not present any evidence that Alaska stands to gain enough to justify taking the risks involved. The report recommends that the legislature act this session to resolve this issue.

To this end I have introduced Senate Bill 397, which would ban commercial finfish farming in Alaska. The current moratorium on fish farming will expire this July, unless action is taken. I hope that the members of the public will make their views known to their elected representatives in Juneau so that the legislature can resolve this issue once and for all.

Mary made call
on 2-14-90

Spoke with Dr. Ross Antipa, Chief of Staff of the Washington State Senate Committee on Environment and Natural Resources.

(Has PhD in fisheries biology and has done considerable research on fish disease. Now Committee staff in Senate. Olympia, phone number 206-786-7413)

So far no one has proven that the recent outbreaks of the deadly VHS fish disease in Washington are caused by the fish farming industry, but timing and other evidence certainly indicate the connection.

Last year over 500 Atlantic salmon were sold on commercial fish tickets. This is proof that large numbers of fish are escaping from fish farms and are entering the fisheries.

Many of the stocks used by Washington hatcheries and fish farms are imported from Europe. The eggs must be certified which should guarantee that they are disease-free. But certification is done by statistical sampling which leaves room for a large margin of error.

VHS virus first appeared last year at two hatcheries. This year it appeared at one more. Two of these three occurrences were within 10 miles of major Atlantic salmon farms. VHS has now shown up in wild salmon, so there are at least four areas with the virus. It has shown up in both coho and chinook. In Europe it has killed off huge numbers of wild trout.

Dr. Antipa notes that as soon as any fish farming is allowed, the farmers become a real political force, contributing to campaigns, lobbying, forming coalitions with other groups, working for changes in the regulations which restrict them, and so on. He said that has certainly been the experience in Washington and British Columbia.

PACIFIC FISHERIES
LEGISLATIVE TASK FORCE

Salmon Net Pen Aquaculture - Remarks of L. Joe Miller
FEB 7, 1987

My name is L. Joe Miller, I live on Whidbey Island. Our waterfront property is far removed from the areas zoned for salmon net pen culture.

I chair a large organization on South Whidbey known as Save Our Shores and I also chair The Marine Environment Consortium, a coalition of concerned groups throughout Puget Sound. My professional background is in local government as a city manager in Bellevue Washington and Rochester New York.

I will confine my remarks to the issues of land use, impact upon the human environment, and my recommendations for the sharing of responsibilities between state and local authorities.

The concern of our members centers principally on water quality, property values, noise, lighting, odor, view obstruction, adequacy of regulation, financial impacts on local governments, the physical mass and appearance of structures, access and shore facilities and the preemption of traditional marine uses, such as sports fishing, commercial fishing, water sports, recreational boating, commercial boating (safe harbors and limitation on operating speeds).

We urge a careful analysis of the economic issues including: (1) how many jobs will result from this industry and how many existing jobs might be lost; (2) is there any validity to the balance of payments claims; (3) are there any successful financial net pen operations in this state; (4) what is the risk of price manipulation and destabilization of the fishing industry; (5) how much revenue is this industry liable to produce and how will it be distributed within our society.

If a salmon pen were located in tanks on dry land it would be regarded as industrial in nature and would never be allowed in a residential district. At best it might be described as a feed lot. In fact, it is not farming at all but is simply a feed lot for fish, with all attendant problems.

Under our law such an operation would be exempt from local zoning restrictions only if the facility were operated by the state itself. That exemption would not extend to the states lessees. The same rules apply to the submerged lands along our shores.

The films we have seen of fish pens in Norway and Scotland appear to be well removed from established residential areas. We think this a good idea and should be an essential element of siting criteria in this country.

I suggest that a basic issue is: If we are to have net pens, how should the program be administered? More specifically, what are the respective roles of state and local governments?

Clearly, the missions and expertise of the various state agencies suggest their responsibility in the areas of marine biology, public health, water quality and marketing. You will note that the Washington State interim guidelines are limited to these areas and, I believe, appropriately so.

On the other hand, local governments are better able to know and understand the impacts on the owners and users of adjacent properties, and the traditional users of the aquatic areas in question. This is commonly known as land use planning and administration, the traditional and proper province of cities and counties. Land use uniquely requires the intimate involvement and participation of affected neighbors.

The state can't perform this role effectively because their departments are not easily accessible, their personnel can't know the local issues and conditions, local concerns are not within their missions or imperatives, and indeed, there is strong potential for conflict between state and local goals and objectives. Finally, land use issues are not within the technical capacity of the state agencies involved. Fisheries and agriculture experts are not experienced land use planners.

These local issues are profoundly important to the people in the local communities and you can be sure that those people will be involved in this process somewhere, somehow. The economical and expeditious place for this to happen is in the local land use process, not in the state legislatures or the courts.

I believe that we are beginning to sort out the appropriate state and local roles in the State of Washington. Heretofore, counties have been too passive because they perceived that they were powerless. They are beginning to realize that they do indeed have substantial jurisdiction in these local issues that I have described. Also, the state authorities appear to be recognizing that this is a shared program. It would be useful, and indeed, essential, to develop some formal clarification and definition of the respective roles if we are to move toward a workable environment.

If net pens are to operate here at all, the industry, the neighborhoods, and the state and local governments are going to have to establish a better atmosphere of trust and role sharing. I doubt that much will happen in net pen aquaculture in this state until the present relationships are substantially improved.

**Some relationships between pathogenic bacteria and
salmon net pen culture**

Pacific Fisheries Legislative Task Force, State Capitol, Olympia,
Feb. 7, 1987

Dr. Arthur H. Whiteley, Professor, Department of Zoology,
University of Washington

I intend in these few minutes to comment on one aspect only of pen rearing of salmon - the relationship to pathogenic bacteria and other agents of disease.

The growth of bacterial populations in a natural environment is limited by the availability of nutrients. In a typical, natural marine environment the bacterial populations are relatively sparse. Given appropriate nutrients, either in the form of dissolved materials or sediments, the opportunity for growth in these populations will be much enhanced. It is generally agreed that salmon pen culture contributes substantially to the eutrophication of the environment of the pen - both in terms of soluble and finely suspended material, and in terms of larger particles that form heavy sediments on the bottom. In this way, the pens enrich the local environment for bacterial growth. Those bacteria already present in the water and substratum can increase. Any brought in with the introduced fish can increase as well. A variety of diseases can thereby be fostered by the pens. Some of these are of bacterial origin, some are viral, and some are due to organisms such as fish lice, parasitic worms, etc. The enhancement of the bacteria by nutritional enrichment works to the disadvantage of the penned fish. They are already stressed by the conditions in which they grow. They are therefore susceptible to bacterial invasion. Notably *Vibrio anguillarum* and *Renibacterium salmonarum* infect the penned fish and often kill them, and other vibrios and aeromonads are of major importance as salmon pathogens. *Vibrio anguillarum* produces disease in penned salmon in this State and in British Columbia. It also is ubiquitous in Norwegian waters, and is responsible for many of their fish farm diseases. With the advent of intensive fish farming in Norway, a new disease, the "hitra" disease, has appeared and now is responsible for 80% of the disease problems in the Norwegian fish farms. Its cause is uncertain, but vibrio species occur in connection with the disease

outbreaks (Håstein, 1986).

A significant question is whether these infections affect wild fish. Weston (1986) concludes that the evidence argues against such transmission. Others point out the difficulty of making such a determination because of the mobility of the wild fish and other complexities associated with working in a submerged, marine environment (Trust, 1986; Johnson, 1989; Staley, pers. com.). It takes only a few minutes exposure for a fish - penned or wild - to become infected. Often the route of transmission is through the gills. The infected fish often die, but if they survive, they frequently become carriers of the pathogenic organism. Both viruses and bacteria can be shed through the feces of the fish, thus spreading the focus of contamination in the natural environment. Moreover, in certain cases (*Renibacterium*) the bacteria can be passed from a female to her eggs, where it associates with the yolk, and transmits the disease to her offspring (Trust, 1986). It is too early to conclude that there is no transmission from a pen to the general environment and to the wild fish there. On the contrary, it is the opinion of microbial ecologists that an infected fish pen would in all likelihood serve as a focus for the infection of fish in the environment, and from them for the transmission of disease to their offspring (Staley, pers. com.).

In addition to pathogenic bacteria, the stressed salmon can serve as a focus for a number of serious viruses. These, too, may enter their host through the gills, and can be transmitted to other fish and to next generations (Trust, 1986). It is expected that they will be locally enhanced by the concentrations of wastes associated with fish pens (Staley, pers. com.), and this enhancement poses problems for the penned fish, and for wild fish as well. The danger that such viruses can be transmitted to wild fish is recognized by laws that prevent introduction of salmonids from the Columbia River system, which is infected by viruses, into any other river system in this State.

These pathogens and related ones that will multiply in the accumulated fish wastes, can serve as a reservoir of infection of marine invertebrate organisms as well. This, too, is a difficult field of inquiry because of the nature of the environment and the mobility of some of the organisms, and most information is derived from study of captive invertebrates. It is believed,

however, that animals living in degraded environments (which I assume would include under-pen locales) can be seriously disabled by such bacteria. Bacteria that degrade chitin, including *Vibrio*, *Beneckea* and *Pseudomonas*, cause shell disease in a host of crustacea, including spiny lobsters, tanner crabs, king crabs, various shrimp, and others of economic importance (Johnson, 1983). The species of *Vibrio* bacteria that infect crabs and shrimp include those associated with salmon pens or are present in local waters: *V. anguillarum*, *V. parahaemolyticus*, *V. alginolyticus*. (Johnson, 1983). Laboratory experience indicates that animals kept in clean sea water are difficult to infect, but those in the presence of sewage sludge developed shell disease. In addition to causing shell diseases, bacteria invade shrimp, crabs and other crustacea and cause internal infections. Again, the total relation of these infections to stress, to polluted environments, to salmon pen sewage is not resolved (Johnson, 1983), but we believe this relationship needs analysis in relation to establishing fish pens in the vicinity of shrimp and crab populations.

There is a well documented literature demonstrating that molluscan embryos and larvae - some of commercial significance - are subject to serious infection by these same species of vibrio bacteria. Abalone embryos and Pacific oyster (*Crassostrea gigas*) embryos and veliger larvae in hatcheries suffer serious mortalities from vibriosis (Sparks, 1985; Jeffries, 1984; Tubiash and Elston, 1984). It would be prudent to determine carefully the potential damage that may be caused by juxtaposing salmon pens to oyster and abalone culture facilities, and to native bivalve beds.

It would be of interest, also, to determine if vibriosis similarly affects these same kinds of molluscan larvae and embryos in the natural plankton, thereby affecting natural populations. Beyond that, it is important to know if populations of these *Vibrio* species or other pathogens, enhanced by sewage or fish pen wastes, infect other forms of invertebrate larvae or adults. I am thinking of the sponges, sea urchins, starfish and the host of other invertebrates which, though not of direct commercial value, are absolutely fundamental to the ecosystems of these water and to their productivity. Their impairment would sound the death knell for these waters.

Some of these bacteria are pathogenic to man as well. Knowledge of the genus *Vibrio* is expanding rapidly. This genus, which includes *V. cholerae*, includes species that typically live in marine locales (Kelly et al., 1982). *V. anguillarum* appears not to infect humans. However, *V. vulnificus* and *V. parahaemolyticus* do infect humans. *V. vulnificus*, a recently recognized species, is a deadly pathogen that is carried in sea water. It is readily filtered and concentrated from sea water by oysters and clams and it is easily transmitted to humans when these bivalves are eaten. The results are often fatal. Other than through ingestion, humans can contract the disease through simple contact of sea water with open wounds or mucosal tissues. It is predominately a warm water organism, which suggests that our waters may be safe from it, but virulent strains of this species have been found in Oregon associated with fish, crabs and clams and in Japan associated with eels (Tison and Kelly, 1986; Kelly and McCormick, 1981; Tison and Kelly, 1984; Blake, Weaver and Hollis, 1980). A preliminary search for this species in the San Juan Islands has not revealed it, but its presence in warmer bays there, and in the Canadian Gulf Islands, or elsewhere in the Sound cannot yet be discounted (Kelly, pers. com.). *V. parahaemolyticus* is, by contrast, commonly found around the San Juan Islands and doubtless is ubiquitous here (Kelly, pers. com.). It causes acute gastroenteritis in humans (Tison and Kelly, 1984; Blake, Weaver and Hollis 1980). This form of gastroenteritis appears to be transmitted exclusively through food, usually seafood (Blake, Weaver and Hollis, 1980). It can be a very significant infectious agent: in Japan, over a 10 year span, 24% of reported cases of food poisoning were attributed to this bacterium.

V. parahaemolyticus, thus, is present here, is a known pathogen of humans, and is transmitted through filter feeders such as clams and oysters. *V. vulnificus* is found nearby, and with further searching may be found in the Sound and Gulf. Simple contact with infected sea water will lead to serious infection. The former species, and probably the latter as well, thrives in heavy, enriched sediments such as sewage sludge. It can also be expected to grow in salmon pen sludge (Staley, pers. com.; Kelly, pers. com.).

It has been argued by associates of the salmon pen aquaculture industry that human diseases associated with these vibrios have been rarely found in the Puget Sound region, and therefore no danger is posed by them. Thus fish pen aquaculture is justified. It is good that the base line now, before salmon pens are well established, is essentially zero. The water is relatively clean, now, and the populations of these pathogens are within tolerable limits, using customary screening methods for detecting these pathogens. But a further complication is introduced by a recent paper (Grimes, et al, 1986). They find that when such pathogens as I have been discussing are introduced into marine waters, they rather quickly lose their identity as measured by conventional culture methods. They enter into dormancy, but remain viable though not culturable by traditional methods. Failure to find them using these methods could lead to overlooking a substantial, but cryptic source of serious pathogens in the environment.

The important question, then, is not whether these organisms pose a present health threat, or ecological threat. The proper question is: can these organisms, and this ecosystem, and these humans tolerate the eutrophic burden that will be imposed by a full blown fish pen industry? It is our belief that there are many too many questions that need resolution, of a public health nature, and of an ecological nature, before we proceed further.

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- The main obstacles to increased consumption in the United States derive from limitations of supply. Fish are primarily caught and supplied from the open seas. Not only does the catch itself fluctuate from year-to year (season to season), but the U.S. is heavily dependent on foreign suppliers. In recent years, imports have accounted for at least 60% of domestic consumption. In 1985, the figure was 64.4%. Our 60% import level reflects the superior organization and equipment of foreign fishing industries, their high commitment to quality, and the fact that some foreign countries developed new, high value products that the U.S. has not yet managed (or attempted) to emulate.

- Numerous opportunities present themselves for expansion in the seafood industry. Moreover, for many important species, that demand appears to be strong enough to offset the higher prices that will follow limited supply.

- Since it is unlikely that domestic supply can meet the increased demand, imports will continue to make up the difference.

- It is clear that aquaculture holds great potential for establishing a steady supply of high quality seafood. Aquatic animals thus reared can be harvested at the optimum time and processed immediately (Seafood Processing & Distribution by Resource Dev. Inc., report 715, Nov. 1986).

Ocean Harvest Static for 20 Years

- The annual harvest world-wide of fishery products from our oceans has remained static for the past 20 years, yet world population has passed 5 billion and is expected to double in 35 years. (August 5, 1986 presentation to National Conference of State Legislators, Dr. James Avault, fishery biologist La. St. Univ.).

\$4.5 billion in Seafood Deficit in 1985

The United States imported \$4.5 billion in seafood in 1985. Fish is our largest food import (Sci. of Food and Agriculture, Nov. 1985).

EXAMPLES

-\$48.2 million in fish analog (surimi) from Japan alone in 1985

-\$1.2 billion in wild caught and cultured shrimp in 1985

-\$80 million in farmed salmon in 1985, primarily for Norway, Canada, Scotland, Ireland, Denmark, Chile and New Zealand (see worldwide Pen Reared Salmon attached)

Percapita Fish Consumption Rising Rapidly

U.S. annual percapita consumption of commercial fish and shellfish has risen from 12.3 pounds in 1982 to 14.5 pounds in 1985. (Washington Seafood Marketing Study, Dec. 1986).

If we are to reach consumption of 20 pounds percapita by 1990, an additional 1.5 billion pounds of seafood are needed to satisfy demand. (Seafood Bus., Jan/Feb 1987).

Prepared by John Pitts, DVM, Washington State Department of Agriculture, January 1987

Norway

- 1973 production = 170 tons, 1985 = 27,000 tons, est. 1986 - 40,000 tons.
- "Imports of fresh salmon from Norway totaled 15.8 million pounds Jan-Oct '86, compared with 11.2 million pounds during the same period in 1985" (Seafood Bus., January '87), refers to U.S. imports only.
- Wholesale value of fresh Atlantic Salmon exceeded \$4.00 per pound during the '86 period.
- In 1985, Norway produced 78% of all farmed Atlantic Salmon. In 1985 71.8% of all fresh salmon entering the U.S. originated in Norway, valued in excess of \$60 million.

Scotland

- Farmed production increased from 600 tons in 1980 to 7,000 tons in 1985, and 8,000 tons in 1986. Planned production for 1987 - 14,000 tons.
- Scotland is the second leading exporter of Atlantic Salmon to U.S., \$4 million value in 1985.

Major Producers of Pacific Salmon (25% of the farmed salmon)

Japan

- Currently the largest producer, primarily farmed Coho.
- 1985, 6,900 tons were produced for domestic consumption.

United States

- Washington State production of pan-sized Coho was 1,685 tons (3,369,000 pounds) in 1985, with a wholesale value exceeding \$10 million.
- Production was primarily by one company, on approx. 8 surface acres of marine water.

Canada

- Industry established in British Columbia, New Brunswick and Nova Scotia.
- The 70 currently operating farms in B.C. represent investment of \$75 million, employs 375 directly, and spend \$50 million/yr. on services and supplies.
- B.C. plans to produce 30,000 metric tons of salmon by 1990, primarily for U.S. export market.

Chile

- Exported 0.3 million pounds Coho to U.S., Jan-Oct 85, and 1.4 million pounds during same period 1986.
- Total production in 1986 was 800% over 1985.
- "We imported more Chilean cultured Coho in 1986 than were caught by Oregon fishermen", (Dr. J. Lannan, O.S.U. fishery biologist.)

The United States imported \$80 million in farmed salmon in 1985. The 1986 figures are not yet available, but will be much higher. The U.S. Market for farmed salmon is estimated to be worth \$130 million by 1990.

Finland:
1983 - 372 jobs at 103 farms
1984 - 515 jobs at 129 farms
1985 - 721 jobs at 194 farms

Support industries such as fish processing, net making, feed production, cage construction, etc., create a multiplier of 1.5 to 2.0 for upland employment. (source: Highlands and Islands Development Assoc., 1986).

Norway: 1984 - 2,000 jobs at 500 farms
1986 - 2,700 jobs at 700 farms
1987 - 150 new farms permitted (Ministry of Fishery, Norway, pers. comm., Oct. 1986).

Total jobs related to Norwegian salmon industry expected to go from 4,000 in '84 to 12,000 in '90. (Water Farming Jour., Nov. '86).

Canada: December, 1986 - 75 farms in British Columbia
23 farms in Bay of Fundy

Average employment is 5.5 jobs/farm - 539 jobs total. Upland support not included.

Puget Sound: January, 1987

Domsea, Manchester, employs an average of 140 people at 3 farms and 2 hatcheries, and their processing plants. 1985 Coho production was 3,369,000 pounds with an estimated wholesale value of \$10,107,000.

Sea Farms, Pt. Angeles, 13 jobs at 2 acre farm (will add 6 more in 87-88 as they expand), 2 jobs at Hadlock site, and 5.5 jobs at Rochester hatchery. Additional seasonal employment during harvest and summer. 1987 production est. = 500,000 lbs.

ScanAm Farms, Cypress Island, 11 full time plus seasonal employ. 50,000 pound production '86, est. 700,00 lbs. in 1987.

Prepared by John Pitts, DVM, Washington State Dept. of Agriculture, Jan. 1987

SPECIES	POUNDS GROWN	PRICE/LB. EX-VESSEL	VALUE EX-VESSEL	PRICE/LB. WHOLESALE	VALUE WHOLESALE
HARDSHELL CLAMS					
BUTTER	18,231	\$0.27	\$4,911	\$0.50	\$9,116
NATIVE LITTLENECK	534,417	\$0.52	\$277,523	\$1.10	\$587,859
MANILA	2,847,558	\$0.53	\$1,500,094	\$1.25	\$3,559,448
SOFTSHELL	405,256	\$0.38	\$155,497	\$1.00	\$405,256
OYSTERS					
OLYMPIA	2,447	\$21.47	\$52,526	\$21.47	\$52,537
PACIFIC	6,020,000	\$1.07	\$6,437,788	\$2.51	\$15,110,200
KUMAMOTO	36,661	\$9.19	\$336,757	\$9.19	\$336,915
EUROPEAN (O. EDULIS)	1,219	\$16.92	\$20,623	\$16.72	\$20,382
MUSSELS	264,000	0.53	140,844	\$1.10	\$290,400
TROUT (RAINBOW, CUTTHROAT)					
EGGS	75,000			\$28.00	\$2,100,000
JUVENILES (LIVE)	12,600			\$25.00	\$315,000
PAN-SIZED	552,000	\$1.60	\$883,200	\$2.00	\$1,104,000
SALMON (COHO)					
EGGS	420			\$120.00	\$50,400
JUVENILES (LIVE)	1,000			\$64.00	\$64,000
PAN-SIZED	3,369,000	\$1.36	\$4,581,840	\$3.00	\$10,107,000
TOTAL	14,139,809		\$14,391,602		\$34,112,511

NOTES:

1) Whole weight is reported for all species except oysters. Oysters are reported as pounds of shucked meat. A gallon of oyster meat weighs about 8.75 pounds and a pound of meat is equivalent to around 5 pounds whole weight (in the shell). If oysters were reported in whole weight like everything else, their total production would be around 30 million pounds and total aquaculture production would be around 38 million.

2) "Ex-vessel" values are those reported to the department. These are consistently below market value. Consequently, I have included a best guess wholesale value (value of finished product including processing, packaging and shipping in most cases). I consider wholesale value to be the best estimate of actual value for the industry and the most consistent.

3) Washington is a major producer of eggs and juveniles for stocking trout farms. These are sold live and are consequently reported as final product (harvested fish) elsewhere.

RECEIVED

JUL 4 1985

PLANNING

DEPT.

NATIONAL AQUACULTURE IMPROVEMENT ACT OF 1985

Food Security Act of 1985
Title 17 -- Related and Miscellaneous Matters
Subtitle D. National Aquaculture Improvement Act of 1985

An Act

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 Improvement Act of 1985".

FINDINGS, PURPOSE, AND POLICY

SEC. 2. (a) FINDINGS--Congress finds the following:

(1) The harvest of certain species of fish and shellfish exceeds levels of optimum sustainable yield, thereby making it more difficult to meet the increasing demand for aquatic food

(2) To satisfy the domestic market for aquatic food, the United States imports more than 50 per centum of its fish and shellfish, but this dependence on imports adversely affects the national balance of payments and contributes to the uncertainty of supplies.

(3) Although aquaculture currently contributes approximately 13 per centum of world seafood production, less than 6 per centum of current United States seafood production results from aquaculture. Domestic aquacultural production, therefore, has the potential for significant growth.

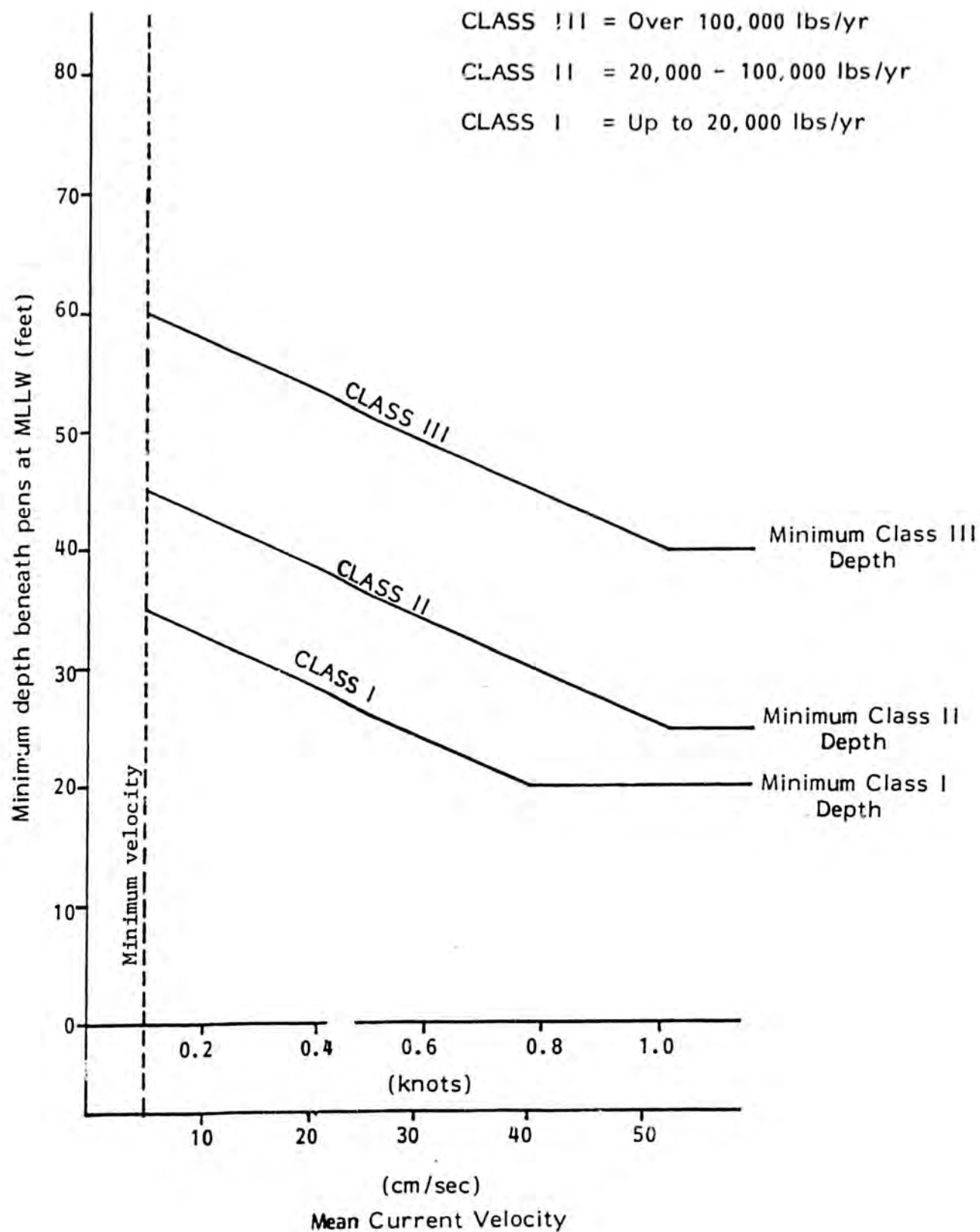
(4) Aquacultural production of aquatic plants can provide sources of food, industrial materials, pharmaceuticals, and energy, and can assist in the control and abatement of pollution.

(5) The rehabilitation and enhancement of fish and shellfish resources are desirable applications of aquacultural technology.

(6) The principal responsibility for the development of aquaculture in the United States must rest with the private sector.

(7) Despite its potential, the development of aquaculture in the United States has been inhibited by many scientific, economic, legal, and production factors, such as inadequate credit, diffused legal jurisdiction, the lack of management information, lack of supportive Government policies, and the lack of reliable supplies of seed stock.

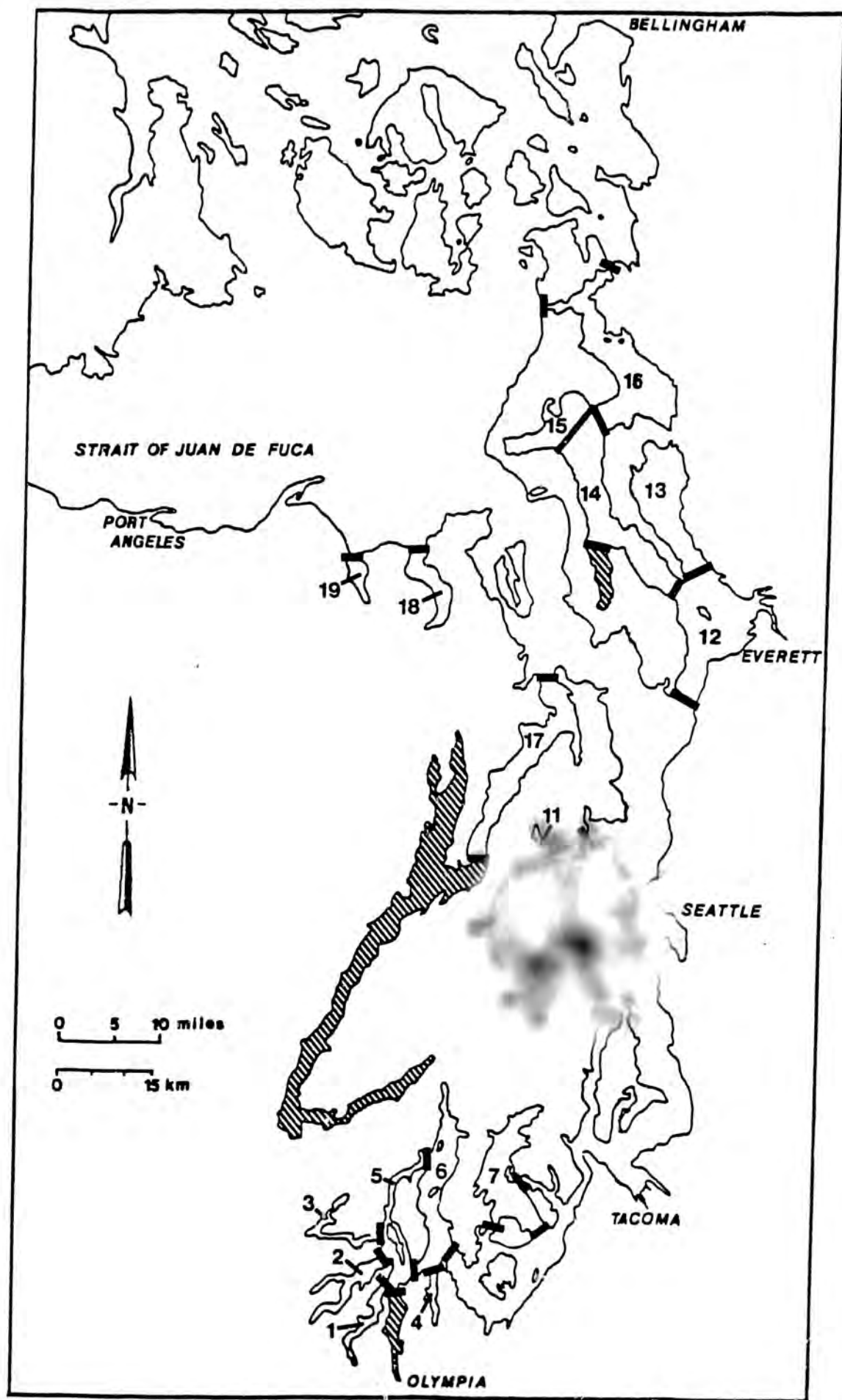
(8) Many areas of the United States are suitable for aquaculture, but are subject to land-use or water-use management policies that do not adequately consider the potential for aquaculture and may inhibit the development of aquaculture.



MINIMUM DEPTH AND CURRENT VELOCITY FOR NET-PEN SITING

WATER QUALITY CONSIDERATIONS IN NET-PEN CULTURE

- **Dissolved oxygen**
 - Reduced through respiration and decomposition of organic matter
- **Nutrients**
 - Toxicity
 - Stimulation of phytoplankton growth
- **Mitigation strategies**
 - Avoid areas with existing chronic water quality problems
 - Avoid areas with poor flushing
 - Avoid a high density of pens in a small area



OTHER INTERIM GUIDELINES

- 150 to 300 ft from habitats of special significance
- 1500 ft from critical bird and mammal habitats
- Unpelletized wet feed should not be used
- Predator control measures must comply with federal and state regulations
- Tributyltin should not be used as an antifouling agent
- Only FDA licensed antibiotics should be used. They should be used on a short term basis and not administered prophylactically over extended periods.
- Transfer and importation of fish in accordance with state and federal regulations
- An operations plan must be prepared including project description, and anticipated operational practices.
- A site characterization survey should be done before permit approval
- Annual monitoring should be performed at all Class II and III facilities



ALASKA MARINE RESOURCE QUARTERLY

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COOPERATIVE EXTENSION SERVICE, UNIVERSITY OF ALASKA FAIRBANKS, USDA AND SEA GRANT COOPERATING



Shellfish Mariculture

by
Michael Kaill
Mariculture Coordinator
FRED Division
Alaska Department of Fish and Game

Introduction

Alaska has the potential to enter a new resource industry - shellfish mariculture. Although oyster farming has been with us for some time, its growth has been hampered by lack of infrastructure. Culture of other species of shellfish, though unproved in Alaska, has been demonstrated in Japan, Canada, and the Pacific Northwest as well as other places. Recent action by the Alaska legislature has begun to clear away some of the obstacles keeping Alaska from realizing its potential.

Environmentally, Alaska is well suited to shellfish mariculture. However, there are some challenges that must be addressed.

Bourne and Brett (1984) suggest that:

"Several criteria must be considered when deciding if an animal is suitable for culture; three of the most important are an inexpensive and plentiful source of juvenile (seed), a rapid growth rate (or reasonably so), and a high price for the product."

Added to this are the technical as well as social factors involved in site selection for a sea farm in Alaska's tidewaters.

Permitting and Permit Activity

Legislation has been passed to authorize the collection of spat for bivalve shellfish farming. In order to meet the intent of this legislation, the Alaska Department of Fish and Game (ADF&G) has undertaken the following tasks:

1. Created a permit system for commercial collection of spat (juvenile shellfish) to be used as seed for bivalve shellfish farming. At this time there are three commercial scallop spat fishermen.
2. Revised the Fish Transport Permit (FTP) so that it will be appropriate for the shellfish program. The purpose of the FTP is to protect natural and enhanced stocks against disease problems and unwanted mixing of gene pools.
3. Proposed new regulations for the shellfish mariculture program. At the time of this

writing, these regulations are under public review.

4. Prepared a unified application system for a shellfish farm. One of the problems expressed by the public is the heavy load placed on applicants as they deal with the many agencies involved in permitting. ADF&G, working cooperatively with other agencies, has produced a single application form for ADF&G, Department of Environmental Conservation (DEC), Department of Natural Resources (DNR), and the Governor's Division of Governmental Coordination (DGC). DGC will receive the application form from the applicant and coordinate review. The unified application form is now in the final stages of review.
5. Began to develop information on key issues in anticipation of the 1987-88 legislative session. This effort is being coordinated by ADF&G and involves DEC, DNR, Department of Labor, and the Commercial Fisheries Entry Commission (CFEC). CFEC is involved not from the point of view of limited entry, but of commercial fishery licensing. This information packet will include discussion papers on important issues, an analysis of management systems in other states and countries, and an analysis of selected policy options.

Permit Activity: The Department of Environmental Conservation has issued or is in the process of issuing certification for about 50 shellfish farming operations. Of that number, about ten oyster and mussel operations are producing product for the market. Main centers of production at this time are Halibut Cove Lagoon (in Kachemak Bay) and the Wrangell/Petersburg area. There are several operators in Kodiak, Ketchikan, and parts of Prince William Sound that are seriously working toward producing products in marketable quantities.

Promising Aspects of Mariculture in Alaska

Market: In order for a cultured product to be successful, it should command a high and stable price and be in high demand. For the species holding best promise for mariculture in Alaska (oyster, scallop, and mussel) the situation is encouraging - particularly since the American public is turning to seafood as one way to increase quality of life and health.

Sites for Sea Farms: One of Alaska's great advantages over the "lower 48" for mariculture is its extensive and highly complex shore line. Pollution (including the recent problems with "visual" pollution) seems to be a major obstacle to the continued development of mariculture elsewhere in the Pacific Northwest. Alaska's low pollution levels, together with the many protected coves and bays found in much of the state, show a real advantage in this area. Low population densities suggest that this will not be a problem for some time.

It is important to note that sea farm siting requires careful coordination, not only with areas of environment and alternative uses (subsistence, scenic esthetic, commercial anchorage, and others).

Stability: A successful mariculture would use one of Alaska's strong resources to augment sometimes problematical oil revenues. The "boom-or-bust" nature of Alaska's industries is frequently mentioned. Sea farming has the potential to create a steady economic benefit to the state.

Benefits to Rural Alaska: Since mariculture operations require remote siting and a fair amount of year-round labor, it is expected that coastal rural Alaska will receive a large share of any economic benefits coming to the state through mariculture.

Growth Potential: Mariculture is a growing industry. Even in countries where it is a major force, sea farms are a relatively recent development. There is good potential for increases in profit margin, ease of operating the farms, safety to the plants and animals being farmed, and for reduction of negative visual and environmental effects. Areas of promise are: advances in equipment technology (feeding, cleaning of cages, flotation systems, handling of product) and technical advances in biological areas (genetic engineering, inexpensive seed production from hatcheries, new species/polyculture development).

Working in coordination with the commercial fishing industry, innovative combinations of mariculture and commercial fishing can be developed. For example, one of the most profitable aspects of mariculture involves seeding some selected sections of the ocean floor with small scallop. Subsections of

Shellfish Mariculture *continued*

that area are then harvested by commercial fishermen, a plan similar to crop rotation.

Problems and Challenges

PSP: Bivalve shellfish are filter feeders and, as such, are capable of concentrating the toxin from several species of free-swimming microscopic organisms. The result can be Paralytic Shellfish Poisoning (PSP). The problems with this are primarily associated with human health, expense, loss of shelf life, and logistical problems involved with testing to make sure that a particular shipment of product does not have PSP toxin above tolerance levels.

One of the advantages of scallop culture is that the traditional product form (shucked adductor muscle) does not have appreciable amounts of toxin and can be marketed with a minimum of testing for PSP.

One need of the industry is for more efficient PSP testing, particularly for southeast Alaska.

Siting: Remote site locations maybe necessary to get good water quality and to get away from conflict-prone high-use areas. However, the remote sites have problems from the point of view of getting and supporting workers on site, getting the products to market, and general logistics (maintenance service, supplies, etc.). Site selection must consider trade-offs between these factors.

Seed Supply: A basic need for any farm is an inexpensive and reliable seed supply. Shortage of seed is one of the reasons that shellfish mariculture in Alaska has not grown more quickly. Options are to purchase from a hatchery or capture from wild sources.

A joint ADF&G/OFCF project now under way in Kodiak is testing feasibility of capturing weathervane scallop spat using spat collectors developed by the Japanese scallop farmers. OFCF (Overseas Fisheries Cooperation Foundation) is a quasi-government Japanese foundation funding projects whose objective is to promote international goodwill. Other similar but smaller-scale projects are under way in various parts of the state.

Economics: The profit margin for a shellfish farmer may be narrow. To operate a successful business, the farmer must have a good financial plan, including an understanding of the critical economic parts of the farming operation. Examples are minimizing equipment cost, controlling logistic problems, getting best use of labor, and effective marketing.

Disease and Genetics Issues: These issues are not cause for serious concern as long as proper safeguards and programs are in place (inspections, lab support, etc.). In general (providing that there is no introduction of exotic stocks), any disease threats from indigenous stocks can be dealt with using existing policy and procedure. Review and policy adjustments are ongoing, as the resource agencies accommodate these new programs.



Mike Kaill examining kelp near Kodiak Island.

A Quick Look at Alaska Mariculture by Species

Scallop: here are several species of scallop in Alaska. Scallop of interest to mariculturists are: the weathervane (*Patinopecten caurinus*), the purple-hinge rock scallop *Crassodoma (Hinnites) gigantea*, and two or more species collectively called "bay scallop" (genus *Chlamys*). Of these, the large, commercial weathervane is of great interest. A close relative is the basis of the rich scallop culture in Japan. The weathervane has a high demand in the U.S., commanding a consistently high price based on product from the trawl fishery. The purple hinge is not commercially taken, since it is sparsely (though widely) distributed. If a hatchery program for seed could be initiated, this species, with growth and product quality close to the weathervane, could show much promise.

However, the bay scallop complex, composed of smaller, slower growing scallops, might be marginal for culture.

Oyster: There is currently a "half-shell" oyster industry in Alaska. Many of the farms are in the Wrangell-Petersburg area, though new interest is appearing in the Ketchikan area, Prince William Sound, and Kodiak. The Alaska-produced product (Japanese oyster, *Crassostrea gigas*) is of high quality. One of the reasons for this is that the oyster is on the edge of its range, and seldom comes into reproductive condition in Alaskan waters. Energy that would go into gonadal tissue is devoted to flesh, creating a plump, yet relatively fast growing oyster. Seed is provided by producers in Washington and Canada, which is a problem because of expense and logistics. The Japanese oyster is presently the only authorized mariculture Alaska import.

Mussel: Although not a common seafood item in Alaska, the blue mussel (*Mytilus edulis*) is a highly prized delicacy in Europe. There is an increasing appreciation for this species in Alaska, particularly when diners realize that the cultured mussel is far superior to the one taken from the beach. Culturing blue mussel has the advantage of readily available seed (dense concentration of spat settlement in some areas) and an 11-month growing season, compared to 2 to 3 years in other species.

Other Species: Other species of shellfish are candidates for culture in Alaska, but are not nearly as strong as the species mentioned above. These include surf clam, razor clam, as well as species not yet authorized by the legislature such as sea urchin, shrimp, and crab.

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Salmon Ocean Ranching in Alaska

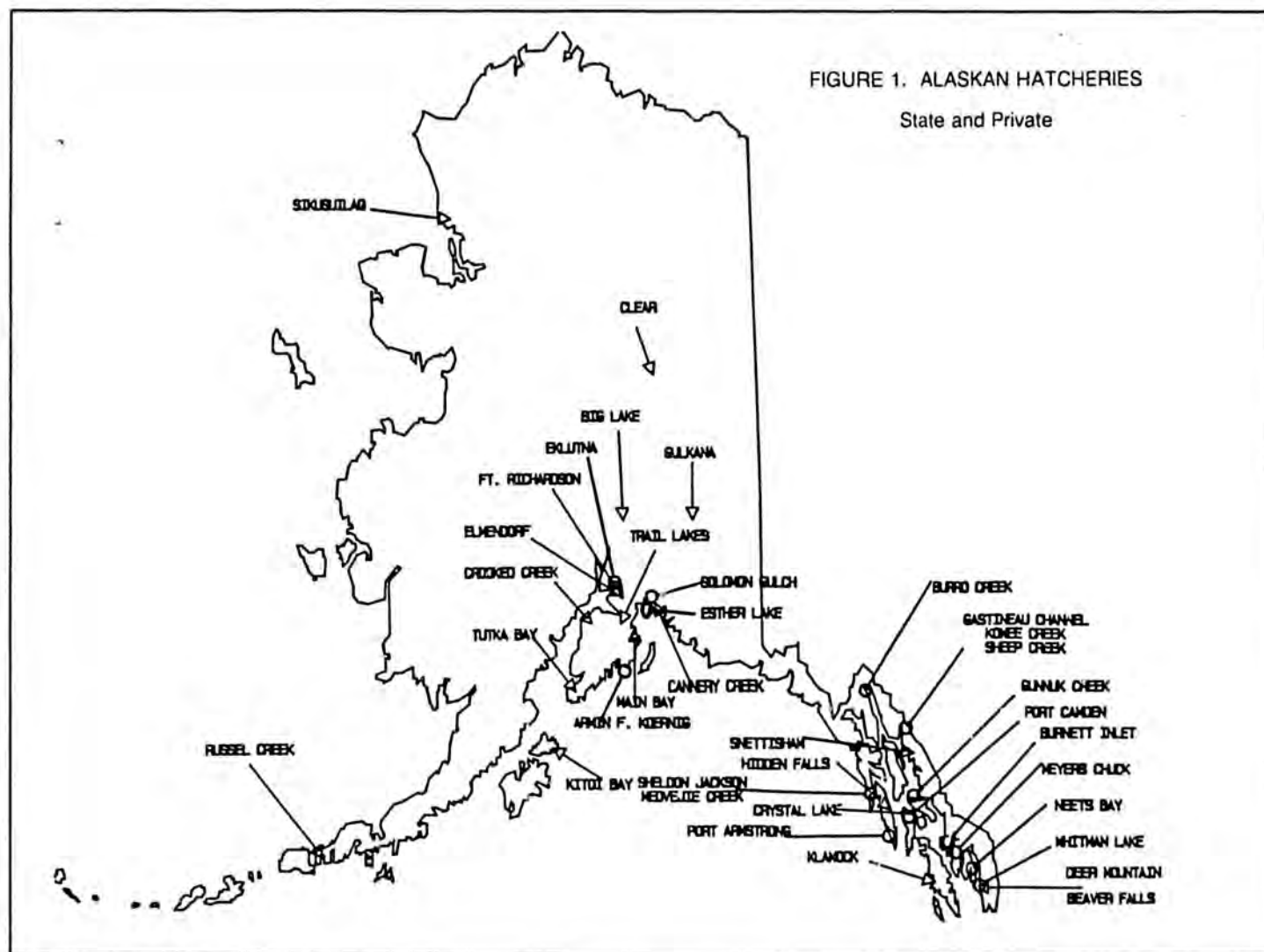
by
Brian J. Allee, Ph.D.
 Director
 FRED Division
 Alaska Department of Fish and Game

Introduction

The largest and most successful form of aquaculture in Alaska is salmon ocean ranching. It was created out of need by the state legislature in the early 1970s when natural salmon runs were depleted statewide. Enabling legislation in 1971 began with a public program and expanded in 1974 to statutes allowing for a private nonprofit sector. Ocean ranching of salmon is an established technology over 100 years old which takes advantage of the fact that salmon "home" or return unerringly to their location of release.

The source of initial production comes from freshwater hatcheries which control the environment such that roughly eight times the survival is achieved over their natural counterparts. This is true because a constant, reliable source of water is applied during the egg to juvenile salmon release phase, as contrasted to natural production which can be severely limited based upon lack of water flow, natural streambed dynamics, and freezing temperature regimes. Depending upon the species' life history strategy, the salmon are released into the marine environment as fry for chum or pink salmon, or as smolts for chinook or coho salmon, or into a freshwater lake as sockeye salmon fry. It is this unique, instinctual migratory behavior of leaving freshwater as juveniles, growing and initiating maturation in the marine environment with the return back to freshwater to spawn that

distinguishes Pacific salmon and sea run trout like steelhead and makes them so economically valuable. This life style is called anadromy and its survival value is obvious in that the richness of ocean pastures can be exploited by what was originally a freshwater fish. Moreover, the fact that salmon specifically return or "home" to their location of release causes aquaculturists to have some control over their migration as if they were on a chemical leash. That the leash is chemical has been determined by many laboratory and field experiments which all prove that anadromous salmon and trout have an uncanny sense of olfaction, or they smell their way home. In the course of going home, these fishes are caught in the commercial, sport, subsistence, and personal-use fisheries and contribute substantially to the social and economic lives of urban and rural Alaskans.



Ocean Ranching *continued*

Present Status

There are currently 19 public hatcheries run by the Alaska Department of Fish and Game (ADF&G), Fisheries Rehabilitation, Enhancement and Development (FRED) Division, and 25 private nonprofit permits with 18 operational hatcheries practicing the technology of salmon ocean ranching throughout Alaska. The scope of the program is bold and worldwide in perspective (Fig. 1). These hatcheries took 1.338 billion salmon eggs last year, plus over 10 million trout eggs (Fig. 2). The Alaskan salmon ocean ranching program is the largest in North America, approximately one-half the size of Japan's and roughly equal to Russian programs. Sockeye salmon production alone is the largest in the world with over 100 million eggs taken. These phenomenal records were achieved from inception in the early 1970s to the present, a relatively short 17 years. As yet, preliminary data suggests that the returns in 1987 from both the public and private nonprofit program account for roughly 18 percent of the total salmon harvest statewide. When the data for Alaskan hatchery returns in 1987 is graphed, it shows that most of the returns to date are from pink salmon, followed by chum and sockeye salmon (Fig. 3). The reason pink salmon ocean ranching has been so successful relates to their 2-year life cycle and the fact that they are economical to raise.

Aside from the biological successes, salmon ocean ranching has had a profound impact on the economic and social structure of Alaskan communities. One study conducted in 1984 predicts that the statewide program will generate net benefits over costs of \$90 million to the Alaskan economy for just the commercial fishery portion of the program. A more recent study to quantify the economic impacts of the ocean ranching program utilizes an impact model developed by the Institute of Social and Economic Research (ISER) at the University of Alaska Anchorage. This model determined that the economic contribution of ocean ranching to resident personal income was \$75 million and over 2,000 resident jobs from fish dollars directly earned in the fishing industry, or by indirect or induced spending in other sectors of the community.

Since these programs produce significant numbers of fish for the sport fishery as well, both economic studies have underestimated the total economic impact. Because values

FIGURE 2. ALASKAN HATCHERY EGG TAKES 1987

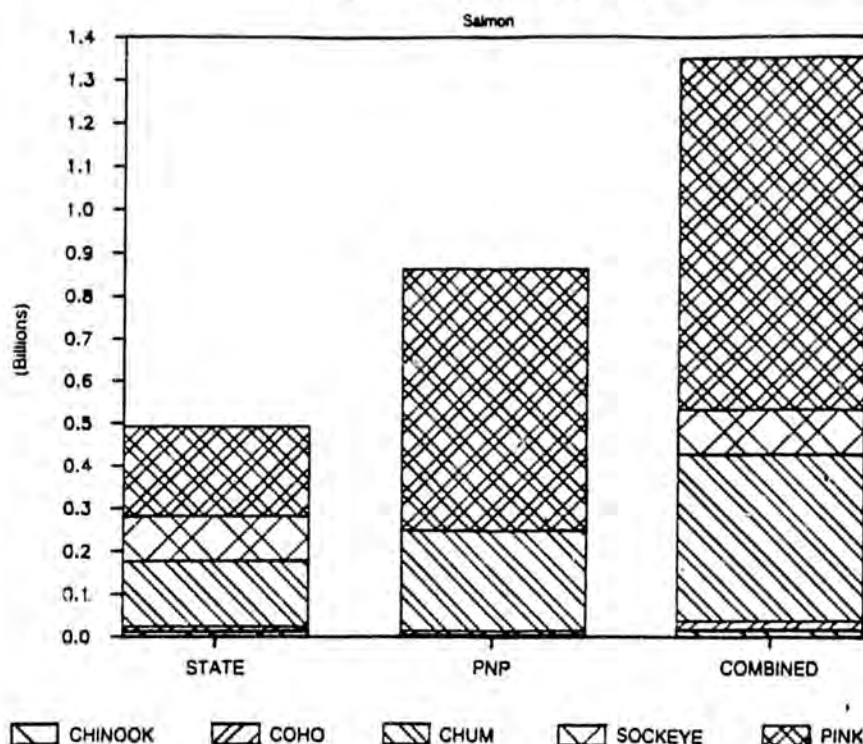
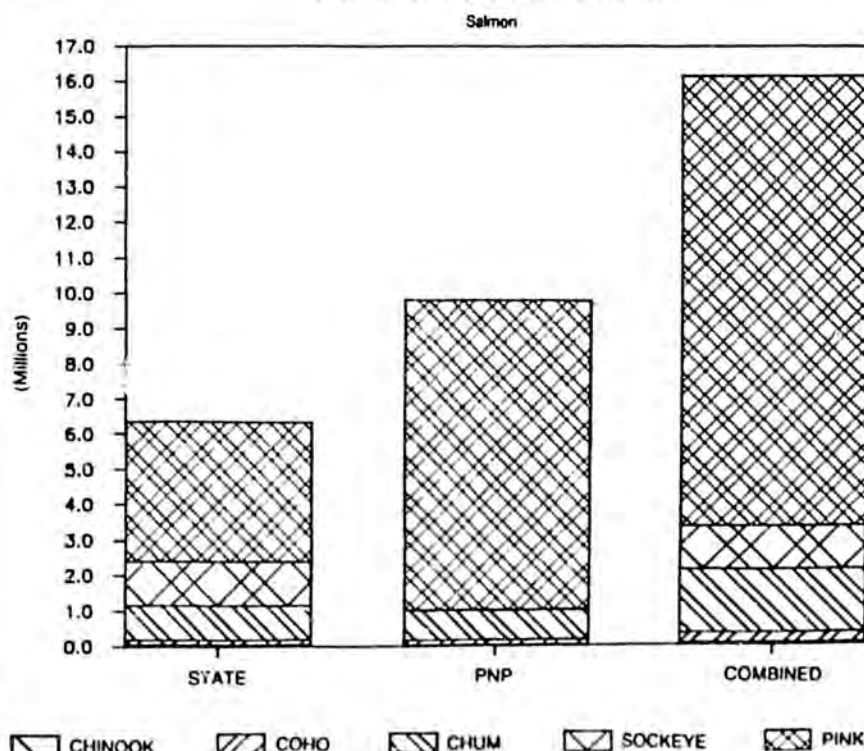


FIGURE 3. ALASKAN HATCHERY RETURNS 1987



Ocean Ranching *continued*

have not been generated for the recreational value, it has been difficult to compute the economic benefit in total to date; when this is done, an even greater economic impact than presently projected will result.

An insight into the scope of the salmon ocean ranching program in the immediate future can be seen in the projected adult return and revenue from the 1988 egg take. Given the generation times of the salmon species involved, this can be two years or 1990 for pink salmon and six years or 1994 for chinook salmon. The projected adult common property fishery harvest of salmon from both state and private nonprofit programs represent roughly 34 million fish and \$76 million in gross revenue (Figs. 4 and 5).

In addition to anadromous salmon and steelhead trout, the public enhancement program (the ADF&G/FRED program) produces substantial numbers of landlocked or resident species, such as rainbow trout, Arctic grayling, Arctic char, sheefish and, most recently, lake trout. The culturing and future production potential of these species is encouraging based upon sport fishermen demand from both resident and tourist sectors.

Salmon ocean ranching in Alaska is an unparalleled biological and economic success and has achieved a world-class status after only ten years of adult returns. On this basis, the full potential of the present program has not been reached yet based upon the capacity of the production systems. It is this production potential in terms of continuing salmon supply that will provide the foundation for Alaska's world market salmon share and help to strengthen the salmon industry against future salmon harvest fluctuations.

FIGURE 4 ALASKA STATE AND PNP HATCHERY PROGRAMS

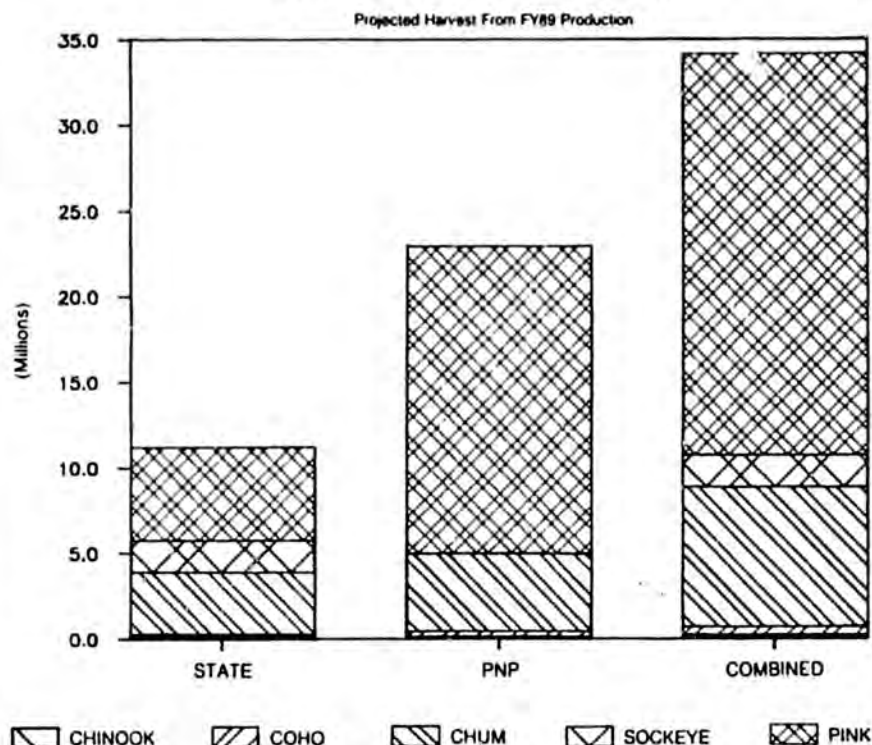
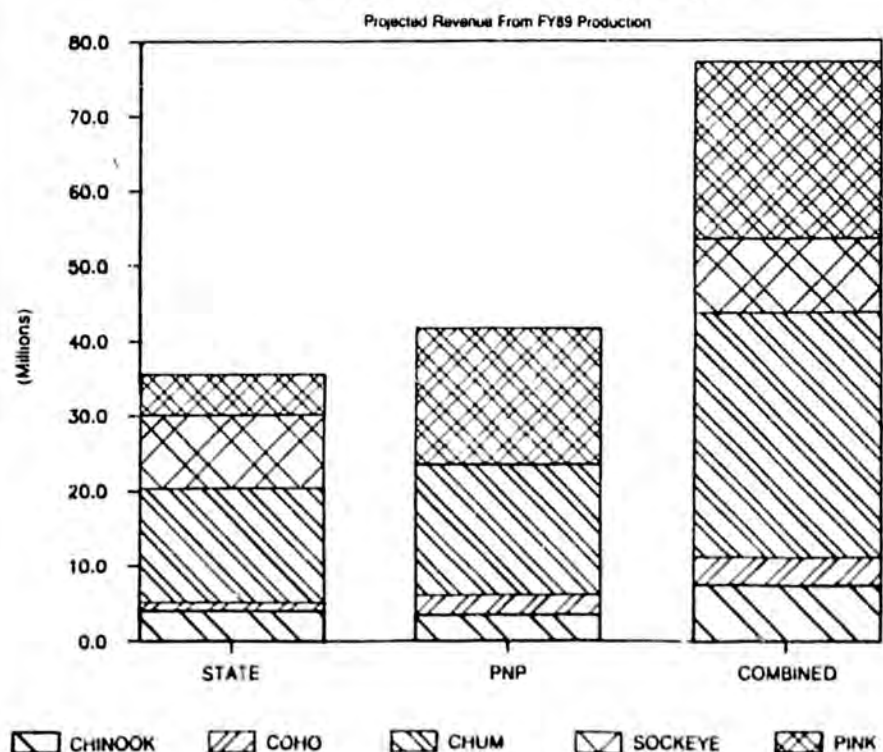


FIGURE 5 ALASKA STATE AND PNP HATCHERY PROGRAMS



Economics of Salmon Farming

by
Brad Pierce
Legislative Analyst
House of Representatives
Research Agency

The recent debate in the Alaska State Legislature over aquatic farming legislation (HB 108 and SB 106) has been highly emotional and often lacking in basic factual information. The most controversial subject has been whether to allow finfish and, more specifically, salmon farming in Alaska. Conflicting testimony has been offered before legislative committees concerning the feasibility of salmon farming in the state and its potential economic effects on the existing commercial fishing industry. Offered below is some basic economic information on salmon farming and estimates of impacts I have gleaned from a variety of sources in the course of studying this subject for the legislature during the past year.

The worldwide development of salmon farming to date, beginning in Norway in the early 1970s, has largely been a phenomenon of small to medium-sized companies. This has been primarily the result of an 8,000 m³ (cubic meter) pen size limitation in Norway, which was designed to encourage family businesses. As a social policy, the volume limitation has been successful in maximizing employment and improving the economies of coastal communities. However, it has also been a major contributor to disease problems in the Norwegian salmon farming industry as it encourages farmers to overstock pens to maximize returns on their investment. Farmers in Norway routinely produce 200 mt of Atlantic salmon annually within these volume constraints. Farms in New Brunswick or Nova Scotia with a comparable production capacity would typically have 2-3 times this net pen volume and far fewer disease problems caused by stress from overcrowding.

There are substantial economies of scale in salmon farming, though these tend to be tempered by the risk of disease outbreaks in very large single-site operations. To avoid domestic volume constraints, the effects of exchange rate fluctuations, and to reduce shipping costs to primary markets in the U.S., many successful Norwegian aquaculture firms have invested heavily in the burgeoning British Columbia salmon farming industry. About 40 percent of the investment capital in the B.C. salmon farming industry has come from

Norwegian sources, although many other sources of capital (including the Vancouver Stock Exchange) have been used. Aquaculture is now the fastest growing industry in B.C. The result has been an evolving corporate farm type structure (as opposed to small family farms in Norway) to the Canadian industry as smaller operators have acquired investment capital and have purchased others or expanded their operations to multiple sites.

A recent survey of B.C. salmon farms (November 25, 1987) by the Ministry of Agriculture and Fisheries listed 113 operational farms and 38 sites which were licensed but not operational. Average farm volume has increased from 6,767 m³ in 1986 to 20,821 m³ in 1987, while total B.C. farm volume has increased from 466,895 m³ to 2,123,739 m³. Likewise, the average farm holding capacity increased from 53.5 mt in 1986 to 166.6 mt in 1987, and total holding capacity grew from

3,717 mt to 16,990 mt. According to the Ministry of Environment, there are 38 commercial fish hatcheries with a combined capacity of 65 million eggs, although due to limited egg supplies, actual production is less than half of capacity.

Estimates of stock on hand in B.C. farms by species are as follows (in mt):

Chinook	2,768
Coho	1,214
Atlantics	81
Rainbow trout	194
Total	4,257

The cost structure of a typical B.C. salmon farm (Table 1) is presented in terms of the break even cost per pound of operations. Generally, it takes at least 6 quarters between the time smolts are put in a pen until the first harvests begin and the farmer can realize some cash flow. By the time full production is

TABLE 1. COST STRUCTURE OF A 110 mt B.C. SALMON FARM*
 (in U.S. Dollars)

Capital Costs		Total Initial Financial Requirement	
Buildings	\$ 22,500	Capital Costs	\$ 157,500
Cages & Nets	75,000	Operating Capital	262,500
Equipment	38,250		
Infrastructure	21,750		
Total	\$ 157,500	Total	\$ 420,000
Operating Expenses		Annual Costs	Cost per lb. Salmon
Smolts		\$ 26,925	\$ 0.12
Feed		150,626	0.67
Disease Control		2,640	0.01
Harvesting		20,024	0.09
Fuel & Supplies		18,000	0.08
Labor		22,500	0.10
Maintenance		4,875	0.02
Management Salaries		26,250	0.12
Communications		6,000	0.03
Insurance		6,000	0.03
Lease Fees		750	0.00
Professional Fees		6,000	0.03
Mortality Insurance		22,500	0.10
Miscellaneous		3,000	0.01
Depreciation		14,813	0.07
Term Loan Interest		9,286	0.04
Operating Loan Interest		1,738	0.01
Total Annual Expenses		\$ 341,926	\$ 1.52

*Source: Canada-British Columbia Subsidiary Agreement on Small Business Incentives.

Economics *continued*

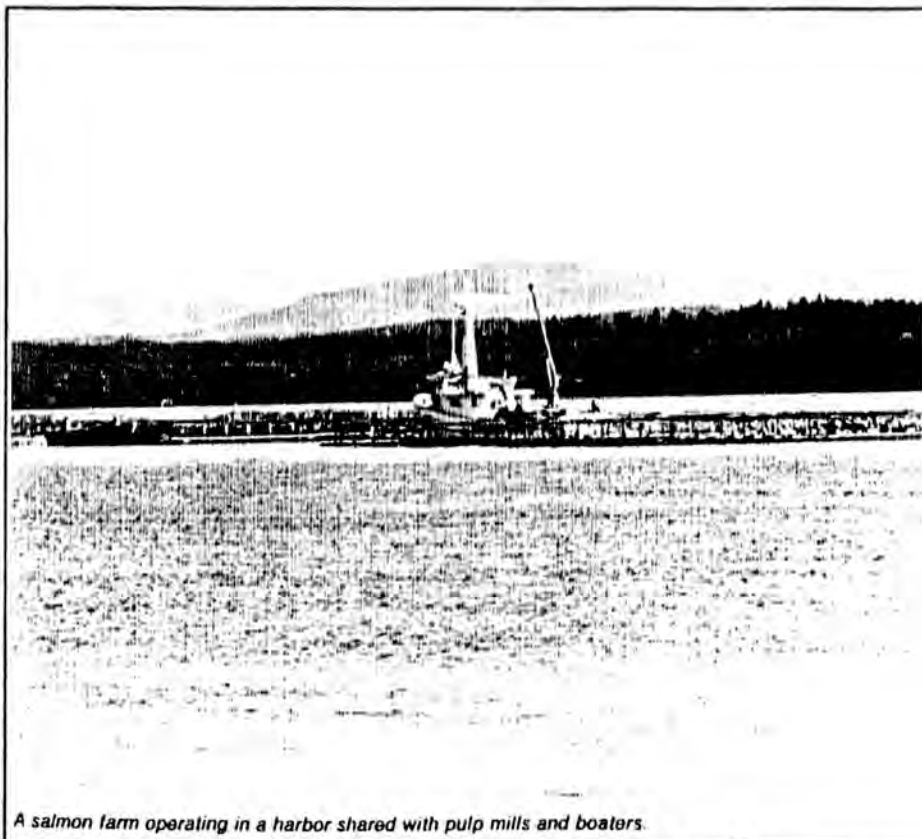
achieved (usually by the third year of operation) the average grower probably has a total investment of \$1 million (U.S.) in the operation. For 4-6 lb. fish, B.C. growers have been receiving farmside prices of \$2.30-\$2.65/lb. producing margins of 50-75 percent (larger fish command higher prices and produce greater margins). Production costs and mortality rates are expected to come down considerably in the near future through greater use of domesticated broodstock and improved husbandry techniques. These factors are likely to increase profitability even as increasing supplies of farmed fish in the marketplace tend to lower product prices.

The focus of the B.C. industry is turning from southern inside waters northward, to outside regions with more oceanic conditions. Colder water temperatures in northern B.C. produce slower growth rates, but these are more than compensated for in decreased mortalities (due to disease episodes and plankton blooms) compared to those experienced by southern B.C. farmers.

Currently the B.C. industry directly employs 544 persons - 318 full-time farm employees, 137 part-time workers, and 89 office employees. Salmon farming employees are not highly paid. The average annual wage assumed in another recent B.C. survey was \$18,000 - similar to wages paid in the seafood processing industry. The major difference is that salmon farming provides year-round employment to local residents, while the seafood processing industry tends to employ large numbers of seasonal nonresident workers. One has only to peruse a copy of the "Canadian Aquaculture Buyer's Guide" to realize that the industry is developing a substantial support sector with local businesses supplying smolts, net pens, feed, consulting and diagnostic services, processing, shipping, and marketing.

The Economic Impact of Salmon Farming in Alaska

During the past year, several attempts have been made to forecast the economic impact of a salmon farming industry (or varying scales of production) in Alaska with widely differing results. Given the fact that growing conditions in Alaska are very similar to those in northern B.C. and the cost structure of the Canadian industry cited previously, there is little doubt



A salmon farm operating in a harbor shared with pulp mills and boaters.

that salmon farming is economically feasible in the state. Even with marginally higher production and shipping costs, farmers in Alaska should be able to become competitive and realize reasonable profit margins.

A salmon farming industry in Alaska is likely to have purchasing and sales patterns that are similar to the existing fishing industry. For example, purchases of equipment are likely to be made outside the state, while basic supplies such as smolts and feed are more likely to be purchased locally. Alaska will have a smaller support sector than B.C. because the economy is much less mature. The most prudent approach to calculating economic impacts appears to be to assume an effect that is comparable (in proportional terms) to the existing commercial fishing industry. An additional consideration is that much of the capital investment for salmon farming is likely to come from outside the state as it has in B.C. (and as it has in the Alaska commercial fishing industry as well). This means that a certain amount of gross revenues will go to pay debt service and returns to outside investors, which will tend to offset the higher resident wage impact cited previously.

With these caveats in mind, my best guess is that a 10,000 mt Alaska salmon farming industry would produce 600 direct full-time jobs, a payroll of \$9.9 million and gross sales of about \$66 million. Note that a 10,000 mt industry is likely to be several years in the future, although a 4,000 mt industry could be realized within 4 years of the passage of enabling legislation. Purchases of feed from local processors (estimated at \$23 million) and eggs/smolt from public and private hatchery operators (about \$9.6 million) would also ripple through the state economy.

Presently, we do not have a feed plant in Alaska capable of supplying dry feed at economical prices. However, there are surimi plants in the Aleutians that produce fish meal byproducts (currently sold to Taiwan eel farmers) that could easily convert to supply fish feed at prices that are competitive with feed costs in other salmon farming countries. Surplus salmon eggs from Alaska's ocean ranching program are readily available. In 1986, Alaska's public and private nonprofit hatcheries had 4.6 million chinook and 23.2 million coho eggs that could not be used for enhancement projects under current genetic

Economics *continued*

regulations. These surplus egg supplies vary from year to year, but are expected to remain at substantial levels into the foreseeable future.

Even though there is little evidence of direct price competition between wild and farmed salmon in the existing economic data, there is little doubt that farmed production is rapidly gaining a dominant share of growing premium markets worldwide, while wild production is declining in market influence. About 97 percent of the harvest of premium species in Alaska is marketed in frozen form and only three percent fresh, while almost all farmed salmon is marketed in fresh product form. There is a fundamental consumer preference for fresh fish that is likely to increase in the future as greater volumes of farmed salmon become available. Thus, the market impact of worldwide salmon farming production will occur regardless of whether or not a salmon farming industry exists in Alaska.

Various attempts have been made to model the future market impacts of farmed salmon production on the existing commercial fishing industry, with little success. Salmon markets are extremely volatile and do not lend themselves readily to mathematical modeling techniques. Recently both the supply of, and demand for, fresh farmed salmon have exploded. Seafood markets in general have been very strong worldwide. Farmed salmon is a relatively new phenomenon in the marketplace. In a sense, salmon farmers have created their own markets by offering a high quality product year-round. With such a short market history to trend from and only a vague idea of the potential market size, economists have a difficult time forecasting the market impacts of farmed salmon production with confidence. However, these recent attempts at estimating market impacts are useful in illustrating the relative impact of worldwide farmed salmon production on the existing fishing industry in Alaska compared to a proposed local salmon farming industry.

We know that demand for salmon products in general is price elastic, i.e., a one percent increase in supply results in a less than one percent decrease in price. Estimates vary widely on the degree of price elasticity. A recent University of Alaska study applied the existing range of elasticity estimates for salmon products to the value of the Alaska commercial salmon harvest, assuming a 100,000 mt

increase in worldwide annual farmed salmon production by 1990. Several simulations were run varying the structure of a salmon farming industry (small vs. large farms) and the substitution effects of farmed for wild species. The worst case scenario forecast a \$36.4 million annual loss in gross revenues to Alaska commercial salmon fishermen, while the best case estimated a \$5.1 million loss.

Using this methodology, the potential market loss attributable to a 10,000 mt Alaska salmon farming industry would range between \$2.4 million (worst case) and \$0.4 million (best case). If we think of these market impacts in proportional terms and relate them to the 1987 Alaska salmon harvest value (estimated at \$458 million), worldwide farmed salmon production could potentially cause an 8 percent decrease in revenues by 1990. By comparison, production from an Alaska salmon farming industry could decrease commercial

fishermen's gross revenues by an additional one-half of one percent.

In conclusion, salmon farming is feasible in Alaska and development would offer substantial economic benefits to the state with minimal incremental impact on the existing commercial fishing industry. Aside from the immediate economic benefits, salmon farming would offer significant spinoff effects as the technology of broodstock development could be applied to the present ocean ranching system. Recently developed diploid techniques, which produce all female fry, seem particularly promising. Husbandry practices developed by farmers could also be applied to other species. Indications are that B.C. growers are 2-4 years away from the commercial farming of black cod, which offers another very large market potential. I hope this information contributes some perspective and clarity to the ongoing debate.



Transferring smolt (from hatchery location) to a salmon farm

Salmon Farming: Gambling with Alaska's Wild Stocks?

by
Alaska Trollers Association

The fishing industry feels the value of shellfish and vegetable culture to the state and local communities outweighs the associated costs. It is these forms of mariculture which will fit into the Alaskan style of life, and economy, with few negative impacts on our existing socioeconomic structure. On the other hand, we strongly oppose the implementation of salmon farming in Alaska. Our opposition rests not on the concern over a single issue, but rather the cumulative effect this proposed industry will have on the state's economy, the fishermen of this state, and our entire industry.

To begin, let's take the issue of what agency in the state government will be charged with the responsibility of regulating this proposed industry and the implications on the protection of our wild stocks. We should first consider that Alaska produces 90 percent of all salmon landings in the United States or 43 percent of the world's landings from wild, natural runs of salmon. While the spread of disease from penned to wild salmon may be of a low order of probability, the potential for major damage to the wild stocks does exist. Therefore, any discussion of this new industry must focus on the regulatory climate which will protect our massive investment, an investment, by the way, which has produced one of the world's most successful ocean ranching programs.

Currently the stringent regulatory safeguards on wild stocks is adequate. Still we are worried that regulations like strictly forbidding the importation of non-indigenous or exotic species of fish, a primary safeguard in our present system, may fall by the wayside because the development of the proposed industry is perceived as more important than the possible effects to the gene pool and disease on our wild stocks. For instance, in Norway this safeguard was circumvented in 1986 with the importation of Scottish smolts. In sidestepping the normal caution of nonimportation, the Norwegians introduced a new disease form into their waters which quickly spread and caused massive mortality to their inventory of fish. Just how much havoc this outbreak caused is hard to determine since there seems to be reluctance on the part of the Norwegians to let the rest of the world know what happened. Closer to home we have

seen British Columbia transfer Atlantic salmon to the Pacific coast. The threat this transfer represents to wild stocks, particularly steelhead, remains to be seen.

We are also worried about the possible effects to wild stocks from escaped pen-reared fish. It has become apparent that these fish do escape no matter how stringent the protections are. For 25 years Norway has been in the farming business and just this spring they discovered that 10 percent of the fish in their streams weren't from wild stocks after all, but instead were escaped farmed fish.

It is interesting to note that the promoters of pen-reared salmon are even now seeking to circumvent prudent regulatory controls. The proposed bills allowing mariculture in the state place the authority for management of the proposed industry under the Department of Commerce and Economic Development instead of the Department of Fish and Game which has the mandated safeguards needed to protect our wild stocks. Our concern with the placement of management is certainly not a reflection of the promoters purported position of wanting strict regulation and safeguards, but a reflection that the management of this prospective industry would be given to an agency with little experience in the biological and technical basis needed to protect our wild stocks and current industry.

Actions and incidences such as the introduction of exotics raise the question of how a private, for-profit industry will impact our wild runs of salmon and whether the profit motive will cause the industry to try to evade prudent regulatory safeguards in the interest of short-term profits.

The cumulative negative effect of salmon farming is again typified when one asks the question of where the resources will come from to manage this prospective industry. Herein lies one of our major concerns with the mariculture industry. Proponents suggest that their industry will take little from the existing system but as most of us know there are no free lunches out there; you just can't get something for nothing as the fish farm promoters suggest. There will have to be government programs created or expanded to regulate fish farming practices and these regulatory programs will cost money and state resources. It is a safe bet that the money and

resources won't come from an increasing state budget and we know the new operations won't be paying taxes until they start showing a profit, which will be many years down the road.

As you may know, state agency funding is determined by using one of two criteria, either through what is called formula funding or discretionary funding. Formulas are used to determine funding levels for such agencies and programs as the Department of Education and municipal revenue-sharing. The monies left over after formula funding are termed discretionary funds. Discretionary funds are what currently run agencies like the Department of Fish and Game and the Department of Natural Resources; these funds are determined by our policy makers every year at budget time. To many, a fish is a fish; therefore, it is a safe bet that the funds to run this proposed industry will come out of the current fish management programs. These are the same programs that are producing such a high rate of return to our state's economy, the same programs that are already being cut to the bone because of revenue shortfalls.

The question then is what happens when an agency such as the Department of Fish and Game sees budget reductions; it affects their ability to make accurate resource management decisions. Because of the lack of information on which to base sound management decisions, there is the tendency to manage the resource conservatively. This may appear good for the state, and is how any prudent manager would respond, but when one considers that a portion of the resource has been wasted when it could have been harvested, it becomes a loss to the fishermen and our economy. For example, a recent analysis done for the Bristol Bay fishery indicated that for each additional \$86,000 put into the management program, management error decreased by one percent. In this fishery one percent represents a direct loss to fishermen of \$2.76 million. In this instance if the funds had been available to reduce management error by the required one percent the economy would have seen at least a 3,000 percent return on investment. We might also point out that this doesn't include losses to other segments of our economy in which these dollars would have circulated if the resource had been optimally managed.

Salmon farming has become one of the most controversial subjects within the fishing industry this year. The following articles explain two opposing viewpoints on the issue.

II, by chance, mariculture management funds don't come out of fishery management funds, they'll come out of things like hatchery funding. This would be the ultimate irony - because if salmon farms get hatchery money, then fishermen will have to make up any deficits with more assessment taxes to themselves in order to keep these hatcheries open. In this case, fishermen would be financing the fish farm industry, an industry they don't want in the first place and in fact would be in direct competition with them.



A fisherman picks wild salmon out of his gillnet on the Copper River flats.

Along with the guise of strict regulation and limited use of the states decreasing management resources, proponents of pen rearing like to say that their industry will provide a boost to our state and local economies. It should be pointed out that our current fishing industry already employs approximately 50,000 people directly, this does not include employment in associated support industries in all segments of our economy. We don't feel that salmon farming can even come close to the positive impacts the current industry has on our state, and in fact the economic impact this proposed industry will have is the transfer of jobs and wealth from an established segment of the economy to a new, smaller group who may not even be Alaskan residents. Although proponents are selling the concept that the farms will be owned and run by local residents and be typical of small business like your local fisherman, or grocer, the real world depicts a different reality. Small, locally-owned operations won't have a

chance. Because of the startup and operating costs involved, mom and pop type Alaskan operations may be able to get their food in the door, but it is doubtful that they could stay afloat if hit with a disease outbreak or a downturn in the industry which all experts project in the next 3-5 years. In fact we would submit that if fish farming were to come to Alaska we would see the industry dominated by a few wealthy individuals and multinational corporations predominantly from Norway. As with any other industry, as it progresses through its life cycle more technology is required in order for businesses in that industry to remain profitable. Technology usually means a more capital intensive industry with fewer employees. This type of industry is certainly not what most of our local community members can afford or are being promised.

At a seminar in Seattle, John Spence from Hardy Seafoods, a thriving mariculture company in British Columbia, told the audience that "mom and pop operations were just a dream." He said these small operations are being bought up by larger organizations and that by 1990 the industry in B.C. would be controlled by 20 or so large companies.

In the October issue of B.C. Business, an article titled "The Norwegian Connection" states that since Canadian banks aren't willing to advance funds for mariculture development, Norwegian financial offers are eagerly accepted, and the Norwegians are now estimated to control 60 percent of the industry in British Columbia. These financing packages also contain clauses which require the farmer to buy building facilities and supplies from Norwegian suppliers. The article goes on to state that should reality fail to live up to projected goals, the Norwegians could call in their mortgages and end up owning the industry in B.C. outright.

As mentioned above the isolated issues are bad enough but cumulatively they increase the damaging effects to our existing industry. In no other way is this point exemplified more than the issue of competition between product forms.

Proponents profess first, that their product will not compete with our wild-caught product for a share of the world market. Second, that even if Alaskan pen-reared salmon did compete with our wild product this competition would be such a small increment that it wouldn't make that much difference, and finally, that world seafood consumption is

increasing. Our response to their first claim is we must realize that there is only one market for fish products in the world; fish of all kinds compete on this market. Since the volume of pen-reared salmon projected by 1990 will triple, salmon farm producers will look to new markets and product forms to keep pace with production. In order to remain profitable, they will have to try to take traditional markets away from our wild-caught product. For instance, farmers in Alaska will attempt to target markets like Japan which currently consumes 84 percent of our frozen salmon each year.

Secondly, as the supply of all fish products increases, the price paid by the consumer will decline. As with all products, price is directly related to available supply. Since Alaskan pen-reared salmon will compete in the world market, as any product, the increases in production will have a direct effect on the current price of the product and certainly an effect on ex-vessel prices.

Finally, with regard to the fact that worldwide seafood consumption is on the increase, it must be borne in mind that we are primarily concerned with the consumption of salmon and not of seafood in general. The market for salmon is a much more limited demographic market and even though it will share in the general increase in consumption the increase won't be to the extent that mariculture proponents would lead us to believe.

Pen-reared salmon production will cost the fishing industry through lost management, fisheries enhancement, and possible harmful effects on our wild stocks. It is ironic that not only would we pay for production through losses to our existing industry, but that product which we inadvertently help produce will further cut into the existing economy by competing with our wild product in the world markets.

Mariculture proponents are fond of saying that we have a right to fail. We, the fishermen say yes, but not at our expense. We have in Alaska the last great wild salmon runs in the world, these runs are the second largest revenue generators in this state and are proving to be Alaska's true Permanent Fund. Pen-reared salmon compete with this resource and dilute the value of our already massive investment. No one can say for certain that no harm will come to our wild stock from pen-reared fish. It just doesn't make good economic sense to gamble with our industry's future knowing what the stakes are.

Salmon Farming: Bright Star for Alaska's Future?

by
Rodger Painter
Executive Director
Alaska Mariculture Association

Few issues in recent memory have stirred a stronger debate in the seafood industry than proposals to remove the legal roadblocks to development of salmon farming in Alaska.

The Alaska Mariculture Association believes fishermen should not feel threatened by Alaska salmon farms.

A host of arguments have been raised against salmon farming, but the strongest objections involve concerns about the impacts on markets and threat of disease spreading from farmed stocks to wild populations.

Market Impacts

Nothing in the debate over mariculture has been more elusive than a common vision of the marketplace.

Opponents of salmon farming in Alaska contend the new production will add to an impending glut of world salmon markets and help drive down dockside prices. Advocates dispute this monolithic vision of the marketplace, saying that markets for cultured and wild products are discrete and there is little overlap. This means Alaska farmed salmon will compete directly against foreign imports, not traditional markets for wild salmon.

One group of researchers from the University of Alaska (UA) surveyed U.S. seafood buyers and concluded worldwide production of farmed salmon appears to have had a relatively minor impact on domestic demand for Alaska salmon. UA economists also completed a study showing Alaska salmon farms should have a negligible effect on salmon markets, but worldwide production could result in a significant lowering of price.

These conclusions have been bolstered by the record value of this year's salmon catch. According to preliminary figures, Alaska salmon fishermen were paid in 1986 a record \$461 million for 90 million fish, the smallest harvest of the decade. This is in sharp contrast to the 1985 record of 147 million salmon worth \$389 million.

These price increases come at a time when the overall imports of farmed salmon into the U.S. continue to increase, despite a drop in Norwegian production.

U.S. Consumption and Market Trends

Virtually all marketing experts agree the hottest seafood market is the United States. National Marine Fisheries Service (NMFS) statistics show the per capita consumption of seafood rose from 12.9 pounds (finished weight) in 1981 to 14.7 pounds last year. While a 1.8 pound gain doesn't sound like much, the increase means Americans ate 582 million pounds more seafood in 1986 than they did only five years earlier. That represents a 20 percent growth in market volume.

In the past, U.S. consumption of salmon increased slowly from .1 pound per capita in 1970 to .4 pound per capita in 1980. Increased supplies from Alaska and Norway then boosted that figure up sharply to .8 pound in 1985, but a drop in landings in 1986 pushed that figure back down to .5 pound, according to Pacific Fishing magazine.

Some analysts say consumption of salmon probably would not have fallen and overall seafood consumption would have been much higher if more seafood was available.

Domestic fisheries landings appear to have leveled off, and foreign producers seem to be the primary beneficiaries of improved seafood markets. Fishermen are earning more for smaller catches, but the primary effect of the laws of supply and demand has been to push up seafood import's alarming rates: imports of edible fish and shellfish increased by \$1.8 billion or 58.6 percent over the five-year period. These forces have resulted in a U.S. seafood trade deficit of \$3.5 billion in 1986, a 79.6 percent increase in five years.

The people who sell most of Alaska's salmon production appear to agree that Alaska's involvement in salmon farming does not pose problems for sales of wild salmon. Processing company officials testifying before the Alaska legislature or quoted in the industry and general news media generally voice concern about the growth of salmon farming worldwide, but discount the impact of Alaska's participation.

Ward Cove's President Alec Brindle says: "The Norwegians with their fish have nearly taken the U.S. market over. It's affecting our markets, but at the same time our market is growing. It's a question of whether or not the market can grow to accept the increased capacity. Frankly, I don't see how Alaska can stand still while the market passes it by."

Important to consider when debating the market impact of Alaska salmon farms is the fact that some major Alaska seafood companies already are purchasing farmed salmon to satisfy consumer demand. Super-market ads and restaurant menus in Anchorage show Norwegian salmon has even achieved substantial penetration of in-state markets. These are the fish that would be displaced by salmon farms in Alaska.

A Fairbanks resident interested in farming cohos recently observed that the only salmon available most of the year in the Interior city is imported from Norway. "How would commercial fishermen be hurt if I try to displace it from seafood counters?"



Nets are stretched over fish pens to keep birds out.

Disease Threat Differs Little from Hatchery Operations

An irony of the current debate over salmon farming is that the salmon industry is beginning to tout the virtues of Alaska's "wild" product. While this may have an appealing ring with consumers, the new tag doesn't jibe with the increasing percentage of the catch accounted for by fish released from private and state hatcheries.

The aquaculture component of Alaska's salmon production is becoming significant. In fact, state biologists estimate about 70 percent of Prince William Sound's record 25.6 million pink catch this year came from area hatcheries. Just what percentage of the

statewide harvest will come from enhanced stocks is unclear, but it should be significant and is likely to get larger in coming years.

More than 1 billion eggs were taken by Alaska's public and private hatcheries during 1986 and that number is increasing.

These massive numbers of eggs are taken to hatcheries and handled in ways identical to salmon farming facilities, except the juvenile fish are released to intermingle with wild stocks, often after short-term stays in salt water net pens. Farmers simply hold the fish in net pens to adult size.

These similarities are critical because private and state hatcheries have a very good track record in dealing with disease, and there have been no indications of infections spreading to wild stocks. One of the strongest objections many fishermen have to salmon farming is the potential risk of spreading disease from pen-reared fish to the wild and enhanced salmon runs.

While no person would argue salmon farming poses no risk to wild stocks, most scientists agree the disease threat of pen rearing differs little from ocean ranching.

Brian Allee, former president of Alaska's most successful private hatchery system and Director of Alaska Department of Fish and Game (ADF&G) Division of Fisheries Rehabilitation, Enhancement and Development (FRED), told a House Resources Committee:

"The Alaska Department of Fish and Game feels that a fish farm and a PNP (private non-profit) hatchery are functionally similar in terms of the biological concerns. And since all PNP hatcheries require permits, by way of consistency, so should all fish farms. Based on this assumption, the statewide disease and genetics policy should be applied to the fish farm permit, in order to reduce the risk of damage to the wild stocks of salmon, which are a common property resource. Both policies have been well developed and implementation of these policies will serve as more than sufficient control."

The most comprehensive U.S. scientific study of the effects of mariculture conducted to date (The Environmental Effects of Floating Mariculture in Puget Sound, by Dr. Donald Weston, for the University of Washington) downplayed the potential disease threat of salmon farming:

"While fish held in culture are likely to show more frequent appearance of disease than wild fish, disease does not appear to be transmitted to the wild populations. The bacterial diseases of salmonids in mariculture are not transmissible to humans... Increased bacterial abundance in sediments beneath a mariculture facility is quite probable, but it has not been demonstrated that this increased abundance is of any significance in terms of human health."

Control of disease is one of the challenges inherent in aquaculture and other forms of animal husbandry. The concerns voiced now by opponents of salmon farming are very similar to statements by some fishermen when Alaska's salmon ranching program was being debated in the legislature during the 1970s.

The success of Alaska in dealing with disease problems and the resulting strong support of fishermen testify to the ability of salmon culturists to effectively deal with disease.

Alaska has one of the world's best salmon aquaculture disease management programs, but even the best procedures do not completely erase the threat of disease. Many fishermen will recall serious outbreaks of disease in Alaska hatcheries which led state managers to destroy diseased brood stock and, in some cases, start all over again. But, these problems have been overcome and these same hatcheries are unqualified success stories with no apparent effect on wild stocks.

Salmon farmers also are likely to have reoccurring disease problems, but are showing the industry can respond quickly to those challenges. The large losses of Norwegian farmed stocks to the Hitra disease this year provides a prime example. The National Marine Fisheries Service reports that a new vaccine for Hitra already is being used by Norwegian farmers and the smolt surviving the outbreaks have built a resistance to the disease and are in high demand.

Some critics have questioned whether disease management practices such as the use of antibiotics would affect other marine organisms or lead to the development of disease-resistant strains of bacteria. Most scientists discount these theories, saying the levels of antibiotic usage will be so low that it won't be measurable in the marine environment and, even if it was, the selective

build-up of disease-resistant organisms is highly improbable.

The effect of salmon farming upon water quality is another issue raised frequently. The experience of two of the largest and longest operating salmon farming facilities in the U.S., as described by Bill Waknitz of the National Marine Fisheries Service, is:

"Domsea Farms has a very large facility in Clam Bay, Washington, near the town of Manchester. This facility is not only 5.4 times larger than the Norwegian size limit, but is thought to be the largest single salmon farm in the world, and it has been in continuous operation for almost 15 years. This facility is located 300 yards from the end of a pier owned by the United States Environmental Protection Agency (EPA). Attached to the end of this pier is the National Marine Fisheries Service net pen research complex. This is the largest net pen research system in the U.S. seawater intake for the EPA Region 10 Water Quality Laboratory is located at the end of this pier, 20 feet from the NMFS facility and 300 yards from Domsea Farms. The water drawn through this intake is used by EPA as the clean reference water against which samples of suspected polluted marine water are compared, through a variety of laboratory tests... If the water quality in Clam Bay were adversely affected by the presence of the giant Domsea facility and the NMFS complex, EPA would take remedial action."

Tests on the Domsea farm by the EPA reveal that sediments under the net pen complex are only two inches deep and extend no further than 100 feet from the pens. The EPA compared the effect of the farm on the sea floor with that of a dock.

This information does not suggest that the concerns of mariculture critics should be dismissed. To the contrary, these scientific findings point out that the biological and environmental problems posed by mariculture are manageable if proper siting and culturing practices are followed.

Alaska's ocean ranching program has encountered only minimal problems because of a conservative approach. These policies should be imposed upon mariculture operations in Alaska to ensure we continue to enjoy the benefits of the state's most important natural resources - its abundant fisheries resources.

Environmental Effects of Mariculture

by
Richard D. Reed
Regional Supervisor
Alaska Department of Fish and Game

The evaluation of floating mariculture facilities in Alaska is needed to determine if there are any environmental effects resulting from these operations. There have, however, been studies of mariculture facilities in Washington's Puget Sound. From that, insights into potential environmental effects from floating mariculture can be gained.

Based upon Puget Sound studies, Weston (1986) suggests floating mariculture operations may result in one or more of the following potential environmental effects: (1) accumulation of organic-rich sediments beneath the facility, (2) changes in water circulation, and (3) changes in water quality. In addition, predation problems can arise if not properly addressed in the operation of the facility.

Probably the most common environmental effect associated with floating mariculture is accumulation of organic-rich sediments in the form of wastes, uneaten food, and shell debris on the benthic substrate below the facility. Møller (1976) found that the magnitude of pollution (feed loss and excrement) from a Norwegian fish farm using fresh or wet feed can reach 60 percent of the total amount of food used. Such deposition can result in physical and chemical changes in the natural bottom sediment (Milne, 1979). Included in these changes are increased oxygen consumption within the sediment and increased concentrations of total volatile solids, total organic carbon, sulfides, nitrogenous compounds and phosphates (Weston, 1986). Although Weston (1986) reported that organic-rich sediments occurred around most culture facilities reviewed, the depth of the accumulations depended upon the water depth and current velocities. In general, he found that accumulation of sediments can be expected beneath any culture facility located in less than 15 meters of water. Accumulation of such sediments and the resultant oxygen depletion in the interstitial water can have effects upon the infaunal invertebrate community. Loss of species that are intolerant of organic enrichment (such as echinoderms, crustaceans, and molluscs) often occurs (Weston, 1986). In addition, impacts to bottom vegetation such as eelgrass beds can be expected if facilities are sited over such areas.

Conversely, such mobile species as fish and crabs can be attracted to culture facilities. Romero et al. (1982) reported that the highest densities of crabs in Ria de Arousa, on the northwest coast of Spain, were associated with mussel culture rafts. Pease (1977) found crab and fish species more abundant under culture facilities in Puget Sound than in control sites, and Beveridge (1984) mentions high densities of wild rainbow trout observed around Scottish fish rearing facilities. Increased numbers of crabs and fish under and around culture facilities are probably a result of abundant food supply and possibly cover opportunity.



A farm worker hand feeds penned salmon.

Any anchored floating facility can be expected to somewhat alter water circulation in its immediate vicinity, and floating mariculture operations are no exception. Milne (1979) reported that studies done on Japanese floating fish farms showed reduced currents within the pens as compared to the surrounding water. The effects of these circulation changes are generally minimal but can result in increased sedimentation below the facility when water velocities are reduced and any suspended material is dropped (Beveridge, 1984).

Changes in water chemistry can also result from mariculture operations. These changes are usually an increase in ammonia concentrations and decrease in dissolved oxygen (Beveridge, 1984; Weston, 1986).

Normally these changes do not cause a problem unless the facilities are sited in areas of extremely restricted flushing or in areas of intense mariculture operations which is beyond what would be expected in Alaskan locations.

Proper siting of facilities can usually address the effects discussed above. Floating mariculture facilities should be located in well flushed locations with water depths adequate to prevent grounding at all tidal stages. Sensitive marine habitats such as eelgrass beds or the mouths of anadromous fish streams should also be avoided.

Predation is a common problem with mariculture operations throughout the world. The list of predators includes all types of fish or shellfish-eating mammals, fish and birds (Lindberg, 1976; Milne, 1979; Beveridge, 1984). Usually precautions such as installation of screening or netting will significantly reduce losses. However, if large numbers of predators are present, predator control can become a problem. Given the undeveloped state of most potential mariculture sites in Alaska, predation might be expected from such important mammalian species as mink, marten, otters, seals or sea lions. To reduce potential predation problems, especially from seals and sea lions, care should be taken to avoid known concentration areas such as haulout locations.

Currently, there are no formal guidelines or siting criteria intended to minimize environmental effects for mariculture facilities in Alaska. Instead, each application is evaluated on a site-specific basis through the state's interagency review process for projects in the coastal zone. During reviews, the Departments of Fish and Game, Environmental Conservation and Natural Resources, among others, evaluate all aspects of the proposal, including potential environmental effects.

To improve this process, an interagency team is developing criteria for identifying sites where mariculture facilities would be most suitably located. Included in the criteria will be consideration of competing uses, the physical and ecological requirements of mariculture sites, and human-use patterns. It is hoped that guidelines can be established which will provide potential mariculture operations with sites that have the necessary physical and biological attributes, but which

Criteria for Establishing Salmon Farms



Environmental Effects

continued

cause minimal social and environmental conflicts.

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by

David Benton

Special Assistant to the Commissioner
Department of Fish and Game

The prospect of pen-rearing salmon in Alaska has become one of the hottest topics in the state. From fish camps, to city hall, to the legislature, the topic of whether or not to allow salmon pen-rearing is causing a heated debate.

The market success of the Norwegian salmon farming industry and the growth worldwide in fish farming generally have spurred interest in pen-rearing salmon in Alaska. During the 1987 session of the Alaska State Legislature, bills were introduced to legalize salmon pen-rearing. Senate Bill 106 and House Bill 108 would "encourage the establishment and growth of an aquatic farming industry" in Alaska. The bills would establish a permit system which would be administered by the Department of Commerce and Economic Development for aquatic farms and private-for-profit hatcheries.

In response to this action in the legislature, Governor Cowper directed the Fisheries Cabinet to review the mariculture issue and prepare a recommendation to him. The cabinet prepared for the governor a set of criteria for judging any authorizing legislation. The governor approved these criteria, and they were presented to the legislature.

The governor's position stated that mariculture may provide substantial economic benefits to our coastal communities and help diversify and stabilize our economy if it is developed in an orderly fashion which provides the maximum benefit to Alaskans. The governor emphasized that we must ensure protection for our fisheries resources, other resource users and the environment.

The governor then set out eight points which he felt legislation must satisfy to meet these goals. These are:

1. **The mariculture industry must benefit Alaskans.**

The mariculture industry must be developed in a manner which does not result in unfair competition with existing fisheries or cause undue economic

displacement in our coastal communities. Legislation should, to the extent possible under the law, provide for local hire at mariculture facilities and give preferential access to mariculture permits and mariculture related tidelands leases to Alaskans.

2. **The mariculture industry must pay for itself and the state should get a fair return for the use of state resources.**

Legislation should contain provisions for recovering administrative and other state costs associated with managing the industry. The legislation should also ensure that the state gets a fair return for the use of tidelands and other resources.

3. **The development of the mariculture industry in Alaska should be done in an orderly fashion which encourages a stable, dependable industry.**

Legislation should provide general criteria which will lead to the development of a regulatory program which discourages speculation on permits and tidelands leases, encourages sound financial planning, and provides for a diverse industry ranging from "Mom and Pop" ventures to larger corporate operations.

4. **The mariculture industry must meet all state and federal requirements for human health, product quality and sanitation.**

Legislation should ensure that mariculture facilities meet all state and federal requirements for human health, safety, and sanitation. Legislation should also require that mariculture products meet or exceed all state and federal product quality and human health standards, and provide the means to ensure that state regulators can protect human health and product quality.

5. **Mariculture activities must be managed to ensure protection of the biological integrity of natural plant and animal stocks.**

Legislation must address the issues of pathological and genetic protections for natural sea vegetable and fish stocks.

Criteria *continued*

6. **Mariculture activities must be managed in a manner which ensures adequate environmental safeguards and habitat protection.**

Legislation must ensure that mariculture facilities are sited, designed and operated to protect air and water quality, to provide for proper disposal of wastes, and to minimize adverse effects to important fish and wildlife habitat.

7. **Mariculture facilities must be sited to minimize land-use conflicts, maintain navigation and ensure access to upland areas.**

Legislation should provide guidance for siting facilities to minimize conflicts with other tidelands users, reducing visual and aesthetic impacts, maintaining navigation and ensuring access across state tidelands.

8. **Broodstock acquisition for mariculture purposes should be carefully regulated, especially for species subject to limited entry fisheries.**

Legislation should contain provisions limiting the acquisition of broodstock for species subject to limited entry fisheries. Legislation should grant the Department of Fish and Game the authority to regulate the acquisition, transport, and propagation of mariculture broodstock, and provide the Board of Fisheries the ability to resolve allocation decisions regarding broodstock acquisition if necessary.

Last March, the House Resources Committee held extensive hearings on House Bill 108. As expected, the bill generated considerable controversy statewide with proponents arguing that mariculture represented a significant new economic opportunity for Alaskans; and opponents expressing concerns over the potential effects on wild fish stocks, restrictions on traditional uses of our coastal areas, and a loss of income from existing commercial fisheries.

Late in the session it became apparent that authorizing legislation was not going to pass. All parties became concerned that the questionable legal status of pen-rearing salmon could lead to speculation on tidelands sites and a "gold rush" mentality similar to the

situation which developed in British Columbia. The resulting confusion and inevitable litigation would not be to anyone's advantage, so a carefully crafted moratorium bill was introduced and passed in the waning hours of the session. This bill (Senate Bill 297) placed a moratorium which expires July 1, 1988, on issuing permits for most finfish farming. It also authorized shellfish farming and limited finfish farming in fresh water.

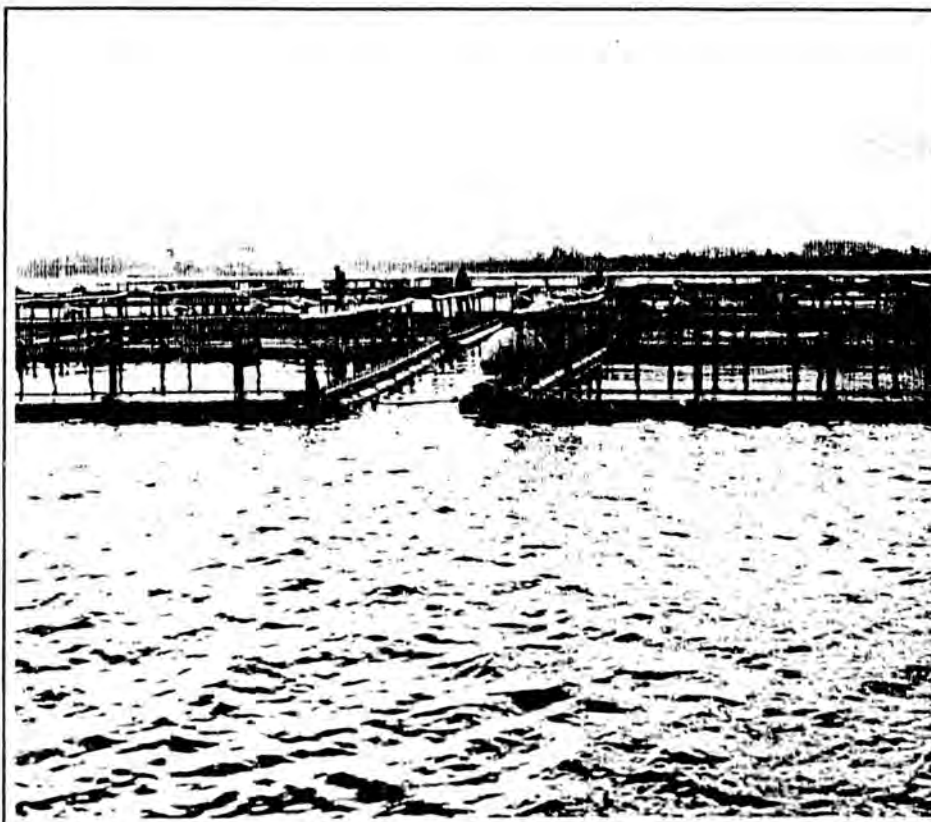
At the close of last session, the legislature established an informal workgroup to continue working on the mariculture issue. This group included Senators Eliason, Duncan, and Zharoff and Representatives Herrmann, Ellis, and Pearce. The administration has continued to work on this issue under the auspices of the Fisheries Cabinet.

In May, following the end of the legislative session, the Fisheries Cabinet identified two major tasks to be performed over the interim. First, the cabinet agreed that a consistent and uniform permitting program for shellfish mariculture needed to be developed and implemented. Second, the issues identified

during last session needed to be addressed in a systematic fashion.

Given these two tasks, the agencies set about to develop a shellfish permitting program. This has involved developing a new shellfish farm permit from the Department of Fish and Game and streamlining existing permitting procedures under the Alaska Coastal Management Program. This will result in a package where the prospective farmer will be able to secure most state permits through one application instead of going to numerous agencies.

At this time, the administration is working on a number of fronts on the broader issue of finfish mariculture. The resource agencies have gone through an extensive process to identify the key outstanding issues which remain to be resolved. Research is being conducted to see how these issues are addressed in other parts of the world, most notably British Columbia, Washington, California, and Maine. These areas were chosen because they offer a range of management systems and have social, economic and biological characteristics similar to Alaska.



Washington state salmon pens anchor in a nonresidential area.

Selecting a Site for a Salmon Farm

by
Curt Kems
Aquaculture Specialist
University of Alaska
Marine Advisory Program

Salmon farming, an endeavor that began in the Pacific Northwest, has become one of the fastest growing industries in neighboring British Columbia, as well as in a number of other countries located in higher latitudes on both sides of the equator. To be successful, however, experience suggests much more is required than just tossing a dart at a map. A site meeting a number of different criteria is required. Requirements of husbandry for the species and species life stage must be met. The physical characteristics of a good site fall within a somewhat narrow range. For the firm to be successful factors involving social, political, regulatory and transportation criteria must be met as well. This article will discuss the physical and biological requirements of siting salmon farms.

Physical Requirements

The physical/environmental characteristics of waters surrounding ice-free coastal Alaska are determined largely by the source, the massive Japanese or Kuroshio Current that moves easterly across the Pacific Ocean, dividing at approximately the border of the State of Washington and the Province of British Columbia. Those waters being the natural habitat of Pacific salmon, they quite satisfactorily meet the requirements of temperature, salinity, and oxygen for salmonids during their juvenile to nearly mature life stages. Waters which emanate from the open ocean appear to be associated with some of the most successful farms. Some important exceptions, however, have been noted in Puget Sound - particularly during the chaetoserous bloom of October/November, 1987. Local conditions that alter the basic physical and chemical parameter of open ocean waters typically do so in an inimical manner, particularly in Alaska. Fortunately most of the waters of Alaska that are adjacent to the Gulf of Alaska may well be suitable for salmon farming. The gulf is, after all, the main rearing area of Pacific salmon of both North American and Asian origin.

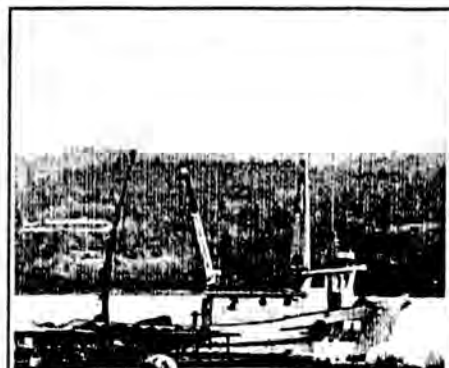
Physical/Environmental Influences: The optimum temperature for salmonids (salmon and trout) is 38-60°F; salinity 22-30 ppt; oxygen levels should be above 7 mg/l. Certain

local land forms and characteristics can create localized conditions that fall beyond these ranges, so are to be avoided by the would-be salmon farmer. Areas with extensive freshwater inputs, particularly that of glacial origin; bays, sounds or other relatively enclosed areas with shallow sills barring access routes to deep water; extensive tidal flats; very high current velocities; insufficient water depth; and areas subject to industrial or organic pollution are the main problem spots.

Freshwater influences: Salmonids are referred to as being anadromous. That is, they typically mature, reproduce, incubate their eggs and spend their first days, months or even years in fresh water, and then migrate to salt water for their main growth. Once capable of osmoregulating (physiologically adjusting their blood sodium and chloride ion content) in saltwater (during this life stage salmonids are called "smolts"), they migrate downstream into saltwater. King, coho, and chum salmon and steelhead trout oftentimes spend days or months in areas of intermediate salinity such as estuaries or moving back and forth between oceanic waters and river mouths. Consequently, the upper reaches of narrow arms, with extensive freshwater inputs may be highly satisfactory to the rearing of fry (the free swimming life stage after absorption of the yoke sac and before smoltification), and to smolts and shortly thereafter. Low salinities are thought to assist with the transitional phase incurred during and just after smoltification by assisting with keeping blood salinities normal, between 10 and 12 ppt. Experience indicates, however, that areas of low salinities, <5-10 ppt particularly if salinities change with depth, tides, or weather, can cause problems during the later grow-out phase. Once salmon have adapted to sea water they appear to prefer salt concentrations to remain consistently high. Areas that have wide salinity changes (greater than 5 ppt within a period of less than a day) should be avoided, as should sites with extensive freshwater lenses (>2-4 ft), especially during the summer months.

Glacial waters are often quite cold (<36°F), and highly turbid, which can irritate a fish's delicate gill membranes. Generally, glacial water should be avoided for those reasons. There may be, however, an occasional exception. If a site offers many other advantages and is some distance from the source, or the source is of low volume even during periods of high runoff, and the glacial

water is very shallow (<1-2 ft) and inexpensive power is available, deep water might be upwelled satisfactorily. Some sort of solid material skirt or shroud that encircles the pens and runs from above the water line to below the glacial runoff (which offer other advantages such as keeping floating debris or oil away from the fish) would be helpful. Careful temperature and salinity measurements over the course of a year or more during a variety of weather conditions, however, should be made before a site with glacial influence should be chosen.



Seafoods of Norway salmon farm operating in Port Angeles, Washington, harbor.

Enclosed areas: A satisfactory site should have water that is exchanged often. Bays, sounds, or arms that have a sill or shallow area (depth of less than that found at the pen site) between the site and open water should be avoided. Nutrients from metabolic waste products and uneaten feed can stimulate algae growth in an enclosed area. After the algae dies and sinks, bacteria and fungi consume cell walls and contents. The respiration of the decomposing organisms can deplete oxygen. High winds can then bring the oxygen deficient water to the surface. At best, fish grow poorly and are much more susceptible to disease in low (<5 mg/l) oxygen water. At worst (<2 mg/l) they all die.

The most desirable location for a cabin, float plane or boat moorage may not be the best place for a salmon farm.

Tide Flats: Large tidal flats can cause wide temperature changes. Waters can become too warm (>65°F) in summer and too cold (<38°F) in winter for good growth. Extensive tide flats typically are found near the mouths of

Selecting a Site *continued*



large rivers which carry heavy sediments. The strong fresh water influence can be harmful, as was mentioned previously.

High current velocities: With the high tidal range found in coastal Alaska there are probably no open areas with insufficient current velocities. Norway, for example has a tidal range of about 10 ft. Too high of current speeds are much more likely. At water flows above 5 mph (7 ft per second) it becomes difficult to keep nets from billowing up and forming pockets. Fish do not appear to grow as well or remain healthy in net pens that routinely deform sufficiently to trap them in pockets. While very heavy (1,000 lb) anchors can be used to secure the corners of net pens, much heavier webbing and support ropes must be used to avoid tearing of the net fabric and consequent loss of fish. Anchoring the pen complex becomes much more difficult and consequently expensive in high currents.

Water depth: Adequate water depth assists in spreading wastes and uneaten feed over a large enough area to prevent buildup. Minimum water depth should be 60 ft at the lowest tide on the shallow side of the pen complex - unless special accommodations (such as rearing species that typically use just the upper portion of the water column such as steelhead/rainbow trout) are made. In essence, the deeper the better. An ideal site would have 90 ft or greater depth right next to shore. Stiff legs (rigid attachments between shore and the pens) could then be used to anchor the complex.

Weather Protection: While cages are built that will sustain near-open ocean conditions caring for fish during extended periods of heavy waves is difficult and can be hazardous to operators and workers. Shelter from storm winds and waves is highly desirable. Moderate waves (2-4 ft) can be smoothed by the use of a log boom. Log booms must be properly constructed, however. More damage can be done by a loose log than by the waves that have turned it into a battering ram. Due to the complex manner that storms often move in, picking a site with less than one-half mile of open water in all directions is advisable. Adequate shelter from the prevailing storm winds and waves may require open water distances of less than that.

Biological Requirements

There are several important biological requirements in siting a prospective salmon

farm: The presence or freedom from harmful algae blooms, certain marine plants, predators, and large numbers of other salmonids can spell the difference between success and failure of a farm.

Algae: There are at least two species of phytoplankton that are harmful to salmonids. *Chaetoceros convolutus* is a diatom that has long setae (spikes) with hooks on the ends that can form long chains. They can block and damage gills. The initial response of fish is to feed poorly or not at all. After gill damage occurs troubled fish will be at the surface with their heads pointed up current, next to the netpen edge. Gills become coated with mucus, can have a mottled appearance, and bleed easily. If examined under a microscope the gills appear inflamed as the diatom causes a reaction not unlike that of an insect bite on a human. Dead fish, particularly small ones, often are found with their mouths stretched wide open.

Blooms occur most often in the fall under conditions of little wind and sunny weather, although spring blooms do occur. Water clarity is not a useful guide as even very low concentrations of *Chaetoceros* can cause problems (>5 cells per milliliter). Rainbow trout and Atlantic salmon appear to suffer the worst with neutered coho salmon following. Smaller individuals of the same species may have higher mortalities than do larger ones. This algae is known to occur and to have adversely affected fish in Southeast Alaska and in Prince William Sound.

Heterosigma akashiwo caused extensive mortalities of farmed salmon in certain areas of southern British Columbia during late June of 1986. Thought to occur in heaviest concentrations near the interface of nutrient-laden rivers and salt water, it may produce a mucous-like substance that is toxic to fish. Rainbow trout are the most susceptible species; larger individuals of a given species appear to be troubled more than smaller ones. Its occurrence in Alaska is unknown to the author.

Kelp Beds: Locating a farm near large kelp beds should be avoided. Kelp beds can experience large seasonal die-offs and create huge volumes of drifting materials that can foul nets or in extreme cases cause damage to pens. Herring spawn on kelp also. Eggs can foul nets to the point of blocking water flows.

Predators: Seals and sea lions can wreak havoc with salmon, their natural prey. Farms should have heavy guard nets surrounding pens and placed far enough away so that tidal currents do not cause the nets to touch. Locating a farm near haulouts is to be avoided.

Other salmonids: Large populations of salmon nearby can bring diseases and predators. Consequently, farms should be located some distance away from streams with large spawning populations of salmon.

Other Criteria

This article has been a brief discussion of some of the factors to be considered in siting a salmon farm. There are additional criteria, some rather abstract, to be used before a final choice is made. Social and political considerations of neighbors should not be overlooked. It is quite difficult to argue with the contention that salmon farms change the vista of waterfront property. Proximity to people, goods, services, and transportation figure in importance to costs and chances of success. Lastly, and perhaps the most important, is the site and its location must be suited to the personalities, capabilities, and desires of the operator(s) and his or her staff.

A Cautionary Note: It must be emphasized that selecting an optimum location for salmon farming is, as yet, very much more an art than a science. The vagaries of weather can cause severe problems to salmon farmers. While our pool of knowledge of the cultural requirements of salmon and trout is quite extensive, there is a lack of knowledge about specific weather conditions and the resultant physical and biological oceanographic effects. Cells of low oxygen waters are the principal physical concerns, and the ecology, and distribution of blooms of at least two species of single-celled algae that can cause harm to salmonids are of very high biological importance. It must be emphasized that due to our lack of knowledge about the above mentioned physical and biological oceanographic concerns, even by closely following the guidelines contained in this article and others of a similar nature, success in farming salmon may be elusive. One thing is well known - failure is very expensive.

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Dolly Garza

Dear Reader:

The Marine Advisory Program is pleased to send you the fourth edition of the Alaska Marine Resource Quarterly. We hope you find it full of useful research and technology information as it applies to the fishing industry and other marine resource use groups.

We would like to continue sending this publication at no charge, but this year the Marine Advisory Program has taken some federal and state budget cuts. As a result, we are requesting a subscription of \$8 per year. The fee will cover the cost of printing and mailing.

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Donald Kramer, Chairman

Donald E. Kramer

Technical Editor: Curt Kerns
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"Rider"
Reidar Solberg
President
AIFMA Coop
4248 Squalicum Lake Road
Bellingham, WA 98226
(206) 592-5977

January 12, 1990

Senator/Representative
State of Alaska
Juneau, Alaska 99801

Dear Madam or Sir:

During this past summer, evidence began coming out of Norway that all was not well on the salmon farms. Visitors returning from Norway reported reading in local newspapers reports of widespread disease in farm fish and pollution in the fjords. Some of these diseases are known but there are some new ones that no one has seen before. The nature of these new diseases is unknown even to scientists.

My board of directors directed me to go and see first hand. My trip included interviews with journalists, scientists at the Institute of Marine Research at Bergen, a visit to a local salmon farm, and discussion with local townsfolk.

The Institute of Marine Research is the only scientific institute in the world that is looking into the disease and genetic effects of farmed salmon on wild stocks of salmon. There is a concern among scientists, whom I spoke to, that the Norwegian government may not continue to fund these programs in the future.

The local populace is in an uproar over what is happening on the local salmon farms.

I learned that many farmers, when faced with the need to destroy diseased fish, simply release them into the fjord where they can spread disease to wild stocks. Likewise, I have heard reports of Canadian farmers releasing contaminated farm fish in Vancouver, B.C..

Faced with the tragedy of economic disaster, it is understandable that a farmer would take this low-cost

way out. The cost of enforcing such clandestine activity, especially in remote areas of Alaska, would be very high.

I have taken the liberty of providing you with translations of several articles from local Norwegian newspapers which show the extent and the seriousness of a problem that "does not exist." Proponents of salmon farming have neglected to report on this critical issue.

We have to keep in mind that, while Norway has some 100,000 of wild stock salmon, Alaska is blessed with stocks in excess of 100 million salmon.

After personally seeing what is happening in Norway and listening to the public outcry, I can only hope that you conclude with me that the risks are too great for Alaska to entertain salmon farming.

Sincerely yours,

Reidar Solberg
President
AIFMA Coop

INTRODUCTION

The Board of Directors of the Alaska Independent Fisherman's Marketing Association, "AIFMA", in December of 1989 directed me to go to Norway and look into the effects of farm raised salmon on wild stocks of salmon. The areas of concern were disease and genetic intermingling. Where I received my information was at the Institute of Marine Research in Bergen, the Bergen Tidende newspaper, a fish farm on the island of Austrovul, and a number of local people through out western Norway.

My hope, after looking at the situation in Norway, is that we will hold off introducing fish farming in Alaska because of the threat of spreading disease to the hundreds of millions of wild stock salmon and the threat of spawning interruption by escaped or released farm raised salmon. The possibility also exists that diseased farm fish, or fish with heavy doses of antibiotics could effect the market conditions of natural salmon which have been handled and presented with so much care over the years.

A very unnerving bit of information, I learned, is that when faced with the need to destroy diseased salmon, many farmers simply release them into the fjord where they can mingle with the wild stocks of salmon. I have heard of this happening on farms on Vancouver Island, B.C. Diseased farm salmon were released at the direction of the British Columbia Fisheries Department.

SUMMARY

At this point in time the Institute of Marine Research in Bergen is the only one that is doing studies to determine what affect the farm raised salmon will have on wild stock of salmon.

we must remeber that Norway has only 100,000 wild stock spawners, where as we have returns as high as 60 million to Bristol Bay alone. If you tally up the return of salmon to all other Alaska fishing areas, and the river systems in Canada the potential loss would be devastating both ecologically and financially.

In Norway, the intent of the fish farms was to generate income for families in the island communities. There are a number of bankruptcies occurring at this time, even though the farms have be heavily subsidized by the Norwegian government. The interesting thing is that the control of smolt is in the hands of big busniness. The three major players in the smolt production is British Petroleum, Sea Farms (a multi-national corporation), and Mowi (this is Norsk Hydro, one of Norway's largest corporations).

In talking with the Norwegian scientist, their feeling is that fish farming has gone much faster then the scientific community has progressed in this area. There are 700 farms in Norway that can produce 250 tons of fish per year per farm. The question then arises, where is the food for the fish farms going to come from? Do we take the pollock, herring, and other fish with their high protein content and grind it up into a fish meal to feed salmon when we have starvation throughout the world.

Looking at possible risk of our wild stocks of salmon, whether it be through disease or through genetic destruction, allowing the onslaught of fish farms on the Pacific Coast is much to great of a risk. The statement made by a prominent Norwegian scientist, that in ten years there has been a destruction of ten thousand years of salmon genetics.

I come from the commercial fishing community and I think about the amount of damage one case of botulism in Belgium did to the market of salmon world wide, I have a real concern about the medications going into farm raised salmon. The amount of dollars generated by the commercial salmon fishery is much to great to risk loosing because of the efferts of certian special interest groups. Whether these groups be Weyerhauser Corporation in the state of Washington, B.C. Hydro with their push for dams on the Frazier River in Canada, or any group that would want to begin fish farming in Alaska, we cannot risk the value of wild stocks of salmon.

FISKERIDIREKTORATETS - HAVFORSKNINGSINSTITUTT
Nordnesparken 2, Postboks 1870- Nordnes
N - 5024 Bergen, Norway

Professors;

Snorre Tilseth
Brit Hjeltne
Arne Ervik
Geir Dahle
Dr. Oystein Skaala

Institute of Marine Research
P.O. Box 2906
5011 Bergen Nordnes
Norway
phone- 32 77 60

My meeting at the took place on the morning of November 30, with Magne Kalhovde also attending. Snorre Tilseth, the director of the fishery, was unable to attend. Brit Hjeltne was very helpful by giving us a tour of the facilities. She then gave us a run-down of the diseases affecting fish farms.

Farm fish diseases;

- (1)- Vibriosis (Vibrio bacteria)
Bacteria disease affecting salmon as well as trout
In farm fish as well as wild stocks
Detected as early as 1918
Virus is in the water, is much harder on farm fish due to the close environment which causes "stress."
- (2)- Hitra (Cold water vibriosis)
Seen in fish farms since 1977
Mostly in winter months
- (3)- Furunkulosis
Problem began on trout farms
The disease begins with blistering, then moves into the blood stream
Norway's problem began with fish brought in from Scotland in 1985
In 1988 the disease showed up in two other river systems in. No answer to where it came from.
- (4)- Salmon lice
A real problem for farm fish
Treatment is Nuvan (Neguvon insecticide that has an impact on crab, clams, etc.)
- (5)- Gyroactylus Salaris
Fresh water parasite
Appeared in farms in late 70's to early 80's
Created a huge problem
The thinking is that it came from Sweden due to movement of smolt from one river to another.
- (6)- BKD
First seen in Norway in 1980
- (7)- Infectious Anemia of Salmon (IAS)- was called (SAS)
New disease that appeared in 1984
They think it's a virus but aren't sure
To this point it has not appeared in wild stocks of salmon

Bergen Tidende (news articles)

(1) Furunkulose in two fish farms.

Even if the fish has got the infection it is still all right as food. That is as long as the fish is not ill and the illness has left no visible tracks, such as outward bleeding, sores, etc.

(2) Illness to live with. Furunkulose

It doesn't have to be a catastrophe for Norwegian fish farming. We already know how to live with Viberiose. We try not to "stress" the fish when the temperature in the water is high. Although the bacteria is in the water, it does not affect the fish as good food. To rid the water of Furukulose is impossible..

(3) Yersinia Ruckeri

The bacteria yersinia ruckeri is found in Norwegian fish farming. The bacteria was unknown in Norway untill a few years ago.. The illness is very infectious and can affect the fish if it is being "stressed" for example, under transportation. It can live both in sea water and in fresh water.

(4) Salmon Anemi Syndrom (SAS)

The veterinary institution thinks that SAS comes from a virus. The illness was first detected in 1984.. Six fish farms had to slaughter all their fish and begin all over again when they had SAS in their fish farms. SAS is a blood illness, the blood gets thin and it then affects the liver. At this time we don't know if the illness is contagious through roe, but it's contagious from fish to fish.

(5) Infeccious Salmon Anemi

The feared illness salmon anemi has attacked fish farms in west Norway county of Hordaland. (Bergen is in Hordaland.) Infeccious salmon anemi is so far only affecting Norway. The illness has a high rate of death. The salmon anemi has not entailed as big loses as the "Hitra disease" but the problem with salmon anemi is that we don't know what causes the infection. We don't have any drugs to attack the infection and it will take a long time to find a vaccine. The fish farms that get hit by the infection, all the fish must be slaughtered as soon as possible. We can not see that it spreads through roe, but we know that it spreads through the sea.

(6) Unknown fish illness

An unknown fish illness is ravaging at Stord. Over the whole bottom of a lake on Stord there have been found dead fish. The dead fish is being attacked by a fungus. It is not known if the fungus is the real reason for the dying of the fish.

(7) Hitra disease vaccine

Hitra disease vaccine is too expensive. Experiments this year with the "hitra disease" vaccine look very good so far. It may be necessary to us the vaccine on the same fish later. The problem is that the vaccine is very expensive, over \$100 for a liter.

(8) Bakteriell Nyresykdom

A fish farm had to slaughter all their fish fry because it was infected by the illness "bakteriell nyresykdom". This caused big loses for the owners with no money for compensation. This will probably mean that other fish farms with the illness will try to hide it in stead of slaughtering the infected fish.

(9) Gyrodactylus Salaris (salmon parasite)

Gyrodactylus Salaris (GS) is caught by wild fish in many of the rivers from fish farms which are dealing with rainbow trout. It will be a lot more difficult to get permission to have a rainbow trout farm.

(10) Furunkulose

It's been found that Furunkulose can begin in rivers as well as in the sea. It can act in four different ways.

1. High rate of death.. Interior bleeding and swelling of the spleen.
2. Not as high rate of death, outside sores visible.
3. Wrong color of the intestine of the fish.
4. No rate of death. The disease can begin in high water temperature.

(11) New illnesses

More new fish illnesses crop up. We know hardly nothing about these new illnesses. We think it has to do with viruses. As an unknown, we don't have any drugs against the viruses. The question is, how can new illnesses break out all of a sudden. Some of the illnesses can come from the fact that there are too many fish in the fish farms, and that the farms are giving too much medication. The other problem with medicine is that it can effect the export of the fish. The USA may say that they don't want to import any fish which has been given antibiotics.

(12) Bacterium Kidney Disease

This disease develops slowly and breaks out on fish as late as half a year later. It can be wounds in the fish meat and smoked fish can get a bit of a wrong color..

(13) Selling unslaughtered fish

Make it illegal to sell fish unslaughtered. The reason is that there may be a parasite in the fish. The parasite lives in the intestine of the fish. The parasite is not dangerous for human consumption.

(14) Gyrodactylus Salaris

Drammen watercourse has been hit by the freshwater parasite Gyrodactylus. It will cost millions to save the salmon stocks in the Drammen river.

(15) Furunkulose

Tons of fish die. The only thing we can do is to work for better environments and hope that the researchers will find an effective vaccine.

(16) Gyrodactylus

32 rivers have parasites on the fish now (Feb. 24, 1989). To get rid of the infection we have to put poison in the rivers to kill all the fish so that the infection will dissipate and a new salmon stock can be brought in to the rivers.

(17) Gyrodactylus Salaris

The parasite hangs on small salmon in the rivers. As the parasite eats on the salmon it creates a sore on the skin which brings fungus, virus, bacteria into the salmon and kills it. The parasite doesn't have eggs, but gives birth to another parasite which is half formed with another, so the multiplication is fast.

(18) Virus from USA

A fish farm in North Trondelag has got a new virus that has not been found in Norway before. The virus is known on the Pacific Coast of the USA. The virus gives anemi to the fish.

(19) Furunkulose

Salmon that escape from fish farms bring infections to other areas. Escaped salmon which has been infected by furunkulose is on it's way up the river system. It is proven that fish which have escaped have brought furunkulose to another fish farm.

(20) Furunkulose

To try and restict the Furunkulose, management has said that it is illegal to transport fish for one area to another.

(21) Vaccination

The vaccination of all the fish in the fish farms is out of the question at this time.

(22) Furunkulose

All fish with Furunkulose is to be slaughtered. Fish farmers are doing all they can to stop the infection of and spreading of Furunkulose. Now they are slaughtering all their fish that have Furunkulose.

(23) Hitra disease

The return of Hitra disease after the winter of 1988 is taking place. Fish farmers along the west coast are cheering because of good growth of the fish, good temperatures in the sea, and not to much disease.

(24) Hitra disease

We have now developed an effective vaccine against "Hitra disease". It gives 95% protection to the fish. That means that the "Hitra disease" is on it's way to being wiped out. (April 1988)

PROTECTION ZONES FOR SALMONS - A CONCEPT FOR THE
PRESERVATION OF GENETIC DIVERSITY OF WILD SALMONS
AND REDUCTION OF THE SPREADING OF DISEASES BETWEEN
DOMESTIC AND WILD SALMONS

by

Senior Engineer Bjørn Lindgren, LENKA,
The Ministry of Environment, Norway.

BACKGROUND

Norway has some 500 local populations of wild salmon, each having its particular spawning river. During thousands of years these populations have developed local, genetic, distinct characteristics as regards size, growing speed, behaviour and ecological adaption.

These local populations constitutes a vast genetic recourse, which we, in the line of the recommendations of the Brundtland commission, believe we are responsible to protect and manage as intact as possible as a resource for the coming generations.

From the Nature Conservation part of view, the protection of genetic diversity is an aim in itself. From the aquacultural industry's point of view, the genetic variations found in wild salmon populations constitutes the biological basis for the future sustainable development of salmon R-94

farming, with particular importance for breeding programmes.

There is therefore a general agreement among the authorities in Norway that the wild salmon populations should be kept healthy and strong, an agreement also of course shared by those who have a commercial or recreational interest in wild salmon fishing.

Let me also for the background mention that the different salmon populations over the years have been severely affected, by acid rain, water course regulations, parasites and overfishing both in the rivers and in the seas.

IMPACT ON WILD SALMON POPULATIONS FROM AQUACULTURE.

During the last years there has been a growing concern in Norway on what effects the growing fish farming industry will cause for the wild salmon populations.

Two main points have come into focus:

1. The breeding programmes have resulted in a domestic salmon, which are genetically significantly different from wild salmons. Surveys in 1987 in 54 rivers in the southern part of Norway shows that out of 615 caught salmons, 83, that is 13%, were escaped salmons from fish farms. The actual figure is probably however much higher. The catches were organized through the Norwegian gene bank project. Catching was done by local co-workers, who were instructed to drop all salmons which could be identified as domestic salmons in the first hand. The 83 salmons in this figure are thus the remaining domestic salmons identified by the experts of the project after the sorting out done in the first hand by local co-

workers.

Because of figures like there is a growing fear that continuous interbreeding between escapees and wild fish will cause a considerable reduction of the natural genetic diversity in salmon populations.

The most alarming and pessimistic prognoses by one the leading experts in Norway on genetics, professor Harald Skjærvold at the Norwegian Agricultural University, anticipates that we may have 50% reduction of the natural genetic variety in the course of a periode of 7 to 10 years. I must add, however, that there are different points of view among norwegian genetic experts, mostly because of uncertainty as regards the spawning success of escapees in competition with the wild salmons.

2. The two-way spreading of diseases between wild fish and fish farms is another problem. The general picture in Norway is that the different fish diseases mainly cause problems for the farms, not the wild populations. The diseases exist in nature and is part of the ecological balance broadly speaking.

As an example of this, the second best salmon river in Norway, the Numedals-lågen was infected by furunculosis in the seventies. But during all the years furunculosis where found in Numedals-lågen it did not have any significant effects on the magnitude of the catches.

But there is one important exeption in this picture, the Gyrodactyllus Salaris, a parasite which now has spread to 30 Norwegian rivers causing death to young salmons in their first three living years in the fresh water periode. The parasite has virtually wiped out the salmon populations in many of those 30 rivers. We believe

that the reasons for these dramatic effects is that the parasite is introduced to norwegian watercourses (it is native to Sweeden and the Baltic sea). Norwegian salmon populations has no "ecological defence" against it. The Gyrodactylus Salaris is spread mainly through the distribution of salmon fry and waters from infected hatcheries.

Let me also add that there is a considerable concern in Norway on the long-term effects of the growing pressure of fish-diseases on the environment. The alarming growth in use of antibiotics is one question of particular importance. To day the use of antibiotics in agriculture extends the use in agriculture and human medicine, put together.

A research programmed was therefore startet in 1987 to strengthen the knowledge on long term effects of the use of antibiotics.

THE PROTECTION ZONE CONCEPT.

The concept which was put on the agenda of Lenka by the Ministeries of the Environment and the Fisheries was to see if one could hope to reduce genetic mixing and the two-way spreading of diseases by establishing zones in the fiord areas outside the outlets of the most important salmon rivers where fish farming should be restricted or not allowed at all.

To have a thorough discussion and evaluation of the zone concept, Lenka arranged a meeting in February 1988. Most of the norwegian experts in the field of genetics, fish diseases, and the ecology and behaviour of salmons were participating.

The recommendations from the meeting were in short:

1. The zone concept should be elaborated in detail for a sample of the genetically most important salmon populations by an expert group.
2. Because of the uncertainty on whether the zones will prove to be an efficient measure, zones should be established for a temporary periode of 5 years. After 5 years there should be a evaluation of the effects of the zones.
3. A research programme covering both genetic effects, veterinary research, and the development of more escape proof farming plants should be established for the same periode to support the following evaluation of the zone concept.

As a follow up of the meeting, Lenka established two fast working groups, one expert group which should work out a detailed proposal for zones, and a group which should work out the frames of a research programme.

The expert group proposed 51 zones covering 125 rivers, which were considered of special genetic importance.

The sampling of the 125 rivers were done according to the following criteria:

- one should have sample of rivers along all the coastline of Norway, so that conditions following gradients like north-south, inner fiords/ outer coastal areas, temperature and salinity which are believed to be important for the ecological adaption and genetic diversity were included.
- one should include all rivers where the local populations has special features which represent extreme deviation from the "normal".

as regards morphology, behavior, growing speed and ecological adaption.

- one should include rivers with populations with big numbers of individuals, which generally are more resistant against genetic pollution than populations with a fewer individuals.

The detailed designing of the zones followed three main criteria:

- The zones stretches roughly out 20 km from the outlet of the river. Studies indicates that there are a considerable larger procentage of escaped domestic salmons in rivers if salmon farms are located within a range of 20 km from the outlet, than in rivers where farms are located further out. The critera however was to a great part adjusted by topography and local conditions. In fact zones varies from very great ones in the long fjords to rather small ones round the outlet of rivers.
- Between the zone border and the outlet of the river there are other rivers on both sides of the fjord, which in this connection are believed to function as "buffer" rivers. The idea is that escaped domestic salmon in the spawning periode will tend to go up in these rivers before they reach the river one is trying to protect.
- The borders of zones for rivers infected by Gyrodactylus Salaris are drawn roughly where the salinity during the spring flood is 15- 18 pro mille. Experiments show that Gyrodactylus Salaris survives only 15 minutes in waters where the salinity is higher than 15 pro mille. If salmon farms are located in waters with a salinity higher than this, one should be fairly safe that the farms will not turn out to be

breeding places for this particular parasite.

The research group recommended a programme covering the following aspects:

- A monitoring programme covering a sample of rivers where zones are established, compared by rivers with no zones.
- The impact on genetic diversity from escaped domestic salmon.
- The development of genetic dominant markers to be used in pilot experiments to study the genetic effects on populations of wild fish through generations.
- The studies of the behaviour of escaped domestic salmon, particularly on the question of their spawning success.
- The development of escape proof technology in fish farming plants.
- The development of improved technology for disinfection of waste water from production and slaughtering units.
- Veterinary research, with particular emphasis on the pattern of two-way spreading of diseases between fish farming plants and wild populations.

The research activities are recommended to be implemented within an annual financial framework of 5 million N kr, and within a period of 6 years. A follow-up programme was recommended at the end of the 6 years-period, particularly with a view to the genetic consequences.

PUBLIC HEARING OF THE PROPOSAL

The proposals of the expert group were sent on a public hearing by The Ministry of Environment, and The Ministry of the Fisheries, late June. The time schedule is that the final decision on whether to establish protection zones or not will be made by the two ministries in course of 1988.

As for Norway, the concept of protection zones is a new strategy in the field of the protection of marine genetic resources. The protection zones is an effort to protect genetic resources in situ, and is regarded as a supplement to the salmon gene bank project, which has been going on for a few years. The monitoring part of the research-programme is carried out by the gene-bank-project.

Whether the zones will prove to be an effective measure against genetic pollution and the spreading of fish diseases remains to be seen. However faced with the challenge of preserving genetic diversity in a time where more and more marine species are being commercially cultivated and farmed and more and more of the coastal zone areas are being occupied for mariculture we think the zone concept is well worth to be tried out and evaluated. The doubts on the real effects of the zones is in our opinion an argument for their establishment on a temporary basis, not against it.

If the zones should turn out to have no significant effects, we will simply terminate the project at the end of the 5 year period. But if they should prove to contribute to the preservation of genetic diversity, it would be a big failure not to establish them now, given the possible speed of the reduction of genetic diversity that I mentioned earlier.

Juneau Empire 11-14-90

Virus infects pond-raised shrimp

THE ASSOCIATED PRESS

CHARLESTON, S.C. A deformity-causing virus in imported pond-raised shrimp has been found to infect three species of South Carolina shrimp under laboratory conditions.

The experimental transmission of the virus from Pacific white shrimp to native Atlantic shrimp species raises the question of whether the same thing could happen in the wild, state biologist Susan Harris said.

Stunted growth, reduced survival, aimless sinking and swimming and wrinkled or crinkled antennae are among the symptoms of Runt Deformity Syndrome, which is caused by the virus. Up to 60 percent of the Pacific white shrimp sampled at the Waddell Mariculture Center showed signs of the syndrome, Harris said.

The virus can be passed in fecal

matter and effluent from shrimp ponds and has a relatively long residence time in the environment, perhaps years, Harris found.

Harris has recommended disinfection of pond bottoms, tanks and effluent, and that all affected animals should be destroyed or cooked. The virus won't hurt humans, she said.

"I recognize the enormity of this. It will definitely adversely impact the fledgling industry. Unfortunately for the (shrimp) farmers, they represent (or should) a relatively small proportion of the population and economy of the state. Our first responsibility should be to protect the public resources of the state," Harris wrote in a memo to the state Marine

Resources Division.

The Waddell Mariculture Center is now sterilizing its shrimp mariculture facilities.

Others are not concerned about the findings. Paul Sandifer, director of the state marine division said experts told him not to worry because problems can be controlled by preventing shrimp from escaping from ponds. The wildlife department has proposed rules requiring shrimp farmers to take extra precautions to prevent shrimp from escaping.

Pacific white shrimp are imported from hatcheries to raise in South Carolina ponds. The shrimp grow faster and larger and are more profitable than their Atlantic cousins.

Juneau Empire 11-14-90

Pollution threatens commercial shellfish beaches in Washington

THE ASSOCIATED PRESS

TACOMA, Wash. — More than a third of Washington's 80,000 acres of shellfish habitat are so polluted that some kind of harvest restrictions are required to protect public health, ecology officials said.

Closure of commercial shellfish beds is especially frustrating because the demand for oysters, clams and scallops from Puget Sound is high, largely due to pollution in East Coast shellfish beds.

"It's ironic that the same contamination processes are now at work in Puget Sound," said Tim Determan, a state Department of Ecology shellfish specialist. He was among the participants in a state shellfish conference last week.

According to a new survey by the state Departments of Ecology and Health, 36 percent of the state's shellfish beds are so tainted by water pollution that harvest is restricted or prohibited.

The survey also says 40 percent of Washington's recreational beaches, where residents dig for clams and other shellfish, are seriously threatened by pollution and may have to be closed for harvest.

Programs to eliminate pollutants at the source are falling behind the rapid population growth near Puget Sound, and contaminated bays and estuaries are not getting any cleaner, conference participants said.

"I think there will definitely be more shellfish beds closed in the next 10 years unless we can be more successful in protection," said Bob Saunders, head of the Ecology Department's Shellfish Protection Unit.

"We're losing areas rapidly," added Bill Taylor, a fourth-generation clam and oyster grower from the South Sound area.

Shellfish populations around urban and industrial areas such as Commencement Bay and Budd Inlet

were choked out decades ago. The new pollution problems are cropping up in more rural parts of the sound, including Burley Lagoon near Purdy, Minter Bay on the Key Peninsula, and several bays in the South Sound.

The pollution is coming from leaking septic tanks, small sewer systems and farm manure, officials said.

"The frustrating part is that it's really not all that complex and it is possible to fix it," Saunders said.

The Puget Sound Water Quality Authority and several other agencies have been working for more than five years to stop the flow of sewage in several watersheds. They have persuaded farmers to fence streams to keep livestock out and have stepped up inspection of septic tanks.

John Dohrmann of the water quality authority said it takes a long time to repair the damage caused by decades of human activity.



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CONTACT: Steve Hunter, Assistant Director
(206) 459-6012
Ron Holcomb, Information Officer
(206) 459-6149

FISH KILL REPORT RELEASED

OLYMPIA--The August fish kill in the Black and Chehalis rivers was caused by pollution not natural environmental conditions, according to a report released today by the Department of Ecology.

"Although water quality in the Black and Chehalis rivers was not ideal for salmon, trout and whitefish in early August, this fish kill was not caused by the ambient river conditions," said Ecology Director Chris Gregoire. "However, on and after the afternoon of August 8, the day the fish kill was reported to Ecology, our investigators were not able to find physical evidence of pollutants actively entering the Black River."

Gregoire said the investigation is continuing and Ecology is taking action to tighten pollution requirements for fish farms and other wastewater dischargers located on the Black River.

"We are not closing the book on this case, nor are we saying that enforcement actions won't be taken at a later date. The report we are issuing today summarizes the results of the investigation to date and actions we feel are necessary to prevent future problems."

Gregoire said Ecology, the departments of Fisheries and Wildlife, and the Chehalis Tribe conducted one of the most exhaustive investigations ever of a fish kill in Washington.

Gregoire said it appears that something toxic entered the Black River about August 6 nine miles upstream from the confluence of the Black and Chehalis rivers. Ecology was notified and responded to the incident on August 8.

"Although our spill responders were on the scene shortly after being notified on August 8, they failed to take water samples that day," Gregoire said. "However, water samples collected by Fisheries and private citizens were analyzed by Ecology."

Gregoire said the agency should have also notified the Chehalis Tribe of the fish kill. "This was a unique event because a second fish kill occurred downstream several days after the initial kill. From now on, we will put out a widespread warning during all fish kill incidents."

Gregoire said Ecology learned a lot from the incident and the experience will be used to improve response should there be future fish kills of this kind.

During the investigation, Ecology inspected four fish-farms, several dairies, a blueberry farm, a turf farm and several businesses that handle chemicals. Several tips about possible illegal dumping of chemicals into the river were also investigated.

"Numerous samples of water, sediments and fish were collected by Ecology and analyzed for literally hundreds of pollutants," Gregoire said.

Eleven people who reported stinging eyes while swimming in the river on August 7 and 8 were also interviewed.

According to the report, all fish in a nine-mile stretch of the Black River were assumed to be killed.

Fisheries estimates show that 320 adult chinook salmon, 100,000 coho salmon fingerlings, 16,500 cutthroat trout, 118,000 forage fish (sculpins, dace, shiners, suckers and lampreys), 320 mountain whitefish, and 3 adult steelhead trout were killed.

The report concluded that facilities along the river need to have their wastewater discharge permits upgraded.

The Global Aqua facility is receiving special attention because it is the largest fish-rearing facility on the Black River and is located where the fish kill began.

The report also identified several corrective actions that are needed. Among the actions underway or being considered are:

- o a short-term cooperative water quality monitoring study by Ecology and the Chehalis Tribe;
- o an immediate increase in inspections of water pollution sources in the greater Chehalis River watershed to get a better idea of what pollutants are getting into the water and to ensure that facilities have the required permits;
- o an assessment of whether an intensive Ecology water quality study is needed in the Black River; and
- o an assessment of whether an ambient water quality monitoring station on the Black River should be established by Ecology.

Ecology has also been working for the past year on a new general permit for fish-rearing facilities. Ecology is drafting the permit with the help of governmental agencies, environmental organizations, the aquaculture industry and the public.

--over--

Gregoire said the incident highlighted the need for investigators to receive notification of fish kills and spills as soon as possible.

"It is essential that people call Ecology immediately when they see a spill occur or if they observe an unusual number of dead fish."

Suit Likely Over Salmon Pens

The emerging industry of salmon farming poses many potential dangers to the marine environment, including pollution from unconsumed antibiotic and hormone-laced feed, fish feces, and fish carcasses; the spread of disease from crowded pens; and genetic imbalances due to the escape of exotic salmon species into surrounding waters. Despite our repeated requests that it require Clean Water Act discharge permits for salmon pens, the State of Washington has issued draft regulations that purport to exempt such facilities from these permits. Therefore, staff attorney Stephan Volker has served the state and the Environmental Protection Agency with a 60-day notice of our intent to sue to enforce this requirement of the Clean Water Act.

Algae Bloom!

(The Blob that Killed the North Sea)

by Buck Jenkins

April in the Northern Hemisphere heralds the spring thaw, and thoughts turn longingly towards May, when new life springs forth with vigor. For Norwegians, there will be a certain nervousness as their "Day of Days," Syttende Mai, draws near—especially for those who live on the southern coasts or who make their living from fish farming. They wait to see if the disaster of 1988 will recur—a drama with the flavor of an early Japanese flick that would have a title something like "The Blob that Ate New York," only this blob sucked life from the North Sea, destroying everything in its path.

The spring of 1988 was an unusually warm and sunny one in Scandinavia—a phenomenon that brings with it a sense of well-being. On May 9 at a fish farm in the Gullmarfjord on the west coast of Sweden, abnormal behavior among the caged rainbow trout was observed. By May 11, most of these fish were dead.

On May 14, the same abnormal behavior was noticed by fish farmers at Hamborgsund and Arendal. Mortality among wild fish was also reported along the west coast of Sweden. By May 17, fish farms along the south coast of Norway as far west as Lindesnes had lost most of their fish. On May 23-24, a "massive fish kill" occurred at four Atlantic salmon farms in the Flekkefjord area.

The Norwegian scientific community began a major campaign to determine the cause of these deaths

Last May, Scandinavian fish farmers noticed abnormal behavior by their fish. Several days later they were dead. This was the first clue anyone had of the deadly blob that was threatening all marine life in the North Sea.

among caged and wild fish. A tide of algae measuring six miles wide and 30 meters deep was monitored. It was identified as *Chrysochromulina Polylepis*, a single-celled organism releasing a hitherto unknown toxin. Where the algae concentration reached its peak, most marine life perished. The tide was being pushed by wind and currents westward along Norway's coast.

Fish farms near Gothenburg, Sweden, were towed into the nearby river and the affected fish recovered within two hours. The Norwegian Fish Farmers Association took its cue from the Swedes and mounted a massive towing operation. Every conceivable sort of sea-going vessel was used, including tugs, ferries and supply ships.

Coast Guard and research vessels, with aircraft and satellite aid, monitored the algae front. As the tide advanced, they advised fish farmers when to tow the huge fish pens, measuring 100 meter across, into the inner fjords. In two weeks, 120 fish pens were moved to safety.

Odd Ustad, spokesman for the Norwegian Fish Farmers Association, called the rescue operation "the largest of its kind in the world" and pronounced it "a great success."

Although the farmed fish escaped, other marine life did not. The seabirds' hatching season was at its height, and there were heavy losses of birds along the south coast. The Purple Snail has virtually disappeared from some affected areas, and no one knows yet whether this disappearance is temporary or permanent.

As far as is known, most wild fish escaped because they were able to swim away from the algae tide—or bloom. However, fish that were biologically programmed to remain in certain areas (such as cod fingerlings which instinctively hide in shallow, rock-sheltered areas) were nearly decimated. Similarly, animals living on soft or sandy sea bottoms could escape the toxin by burrowing, whereas animals living on hard sea bottoms and unable to move quickly, such as the Purple Snail, would be killed in great numbers.

By June 15, the invasion of the killer algae was over, but the work of analyzing and diagnosing the significance of this potential disaster had just begun. Clearly many people would do much complicated scientific work and many experts would make pronouncements. What was the cause of the bloom? Was Norwe-

future emergencies? In November 1988 I traveled to Norway to learn what was being done to throw light on these and other significant questions. As might have been predicted, there were wildly divergent views.

En route to Oslo, I thumbed through *Scanorama*, the in-flight magazine for SAS. One article jumped out at me: "Dawn of Doomsday." The article covered more than the disastrous bloom of *Chrysochromulina polylepis*. It also discussed other major eruptions in the biological life of the Baltic and North Seas: the recent death of seals from a virus resembling the distemper-virus; the invasion of other seals into the vacated territory; massive increases of starfish along the Norwegian coast, etc. The author of "Doomsday" (Tony Samstag, a free lance journalist living in Oslo) spoke of definite links between these biological oddities and the contemporary increase of pollutants into the North and Baltic Seas from human, agricultural and industrial waste.

At the opposite end of the spectrum was a short interview I conducted by telephone with Odd Ustad, public relations manager of the Norwegian Fish Farmers Sales Organization located in Trondheim. Ustad stated categorically that the recent algae bloom was "no problem" for the Norwegian fishing industry. He pointed out that the loss of 500 tons was only .06 percent of the total production of farmed fish in Norway. While this loss was catastrophic to the individual farmers involved (fewer than 10), insurance helped to cover the loss to some extent.

Ustad went on to describe the entire algae bloom situation as a tempest in a teapot. "After all," he continued, "algae blooms are common all over the world. British Columbia, Chile and Scotland experienced similar algae invasions in 1988." He also said that algae blooms are so common in Japan that Japanese fish farmers routinely relocate their fish farms in summer—he felt that some such relocation system would have to become part of Norwegian fish farming in the future.

was now ready to interview scientists. My first interview was with Dr. Bjarne Underdal, professor of the Department of Food Hygiene at the Norwegian College of Veterinary Medicine. Dr. Underdal agreed with Odd Ustad that algae blooms are quite common in nature—he even said that there is a Biblical reference to "red tide," which could very well have been an algae bloom.

Underdal explained how algae blooms occur. Algae are forms of single-celled plants which live by

Algae blooms are common all over the world. British Columbia, Chile, Japan and Scotland experienced similar algae invasions in 1988. Even the Biblical reference to a "red tide" in Exodus may well have been an algae bloom.

consuming the fragments of waste produced by sea creatures. Algae usually exist in off-shore environments where upwelling currents stir up sea bottoms, bringing massive amounts of fragments of dead bodies and waste products of sea animals to the surface.

Very often in nature the presence of a plentiful food supply triggers a rapid reproduction (which in the case of the algae is cell division); thus a "bloom" or efflorescence of algae can result. Conditions for such a bloom were especially favorable in the spring of 1988 because the sun shone a great deal more than normal.

One of the mysteries surrounding the "*Chrysochromulina* disaster" concerned the exact process by which the algae destroyed marine organisms. One report I had read before coming to Norway asserted that the algae clogged the gills of fish, suffocating them. Another report said that the algae bloom harbored a virus or bacteria which attacked the fish and other organisms, producing a fatal disease. Dr. Underdal, who was personally in-

of death of the marine organisms, was eminently qualified to isolate the real cause—a toxin produced by the heavily concentrated algae.

The experiments established that for some unknown reason the *Chrysochromulina polylepis* algae were producing a deadly toxin which attacked three groups of cells in fish and other marine organisms, destroying their ability to perform necessary body functions and killing toxified victims rather quickly. Dr. Underdal said that the toxin simultaneously damaged cells responsible for digestion, the production of hemoglobin, and the regulation of salt in the body. (These salt-regulating glands are located in the gills, a fact which might have led to the appearance of organisms being choked to death.)

Dr. Underdal (as well as Odd Ustad) wanted one point specifically stressed. In no way does the toxin produced by *Chrysochromulina* become stored in the flesh of the organism; thus the meat of farmed salmon and trout which were towed away from the algae bloom was in no way affected.

Even though the process by which this algae bloom killed fish and other organisms had been isolated (although as of this writing the exact chemical structure of the toxin was still a matter of conjecture), I still needed a lot more information. For this, I turned to Bjørn R. Braaten, research manager for Aquaculture at NIVA (the Norwegian Institute for Water Research). Braaten had some opinions about the significance of last summer's "algae disaster."

Like other scientists I interviewed, he stressed that algae blooms (and occasionally toxic ones) have been around a long time and are a routine part of nature's overall process, which is often marked by large seasonal variations—what some people might refer to as "disasters," such as the periodic collapse of entire species for brief periods of time.

Without the existence of fish farming along the Norwegian coast, the existence of an ecological disaster could have gone undetected. The death of 500 tons of farmed fish was a sure indication of the presence of an environmental problem in the region. In the past, even the massive



death of many marine organisms in the region might have been chalked up to unknown sources. Although Ustad had pronounced the algae bloom "not a major problem" for the fish farming industry, Braaten observed that the toxin produced by *Chrysochromulina polylepis* had disastrous effects on many other organisms.

Still, Braaten expressed concern over a couple of salient points concerning this spring's outburst of *Chrysochromulina polylepis*. Although this particular species of algae has been known to scientists since 1960, this spring's bloom was the first known example of this particular algae producing toxin. Braaten said that algae are toxic and non-toxic at different times, and the reason for this difference is not understood. He offered the theory that possibly the algae were being disturbed by some environmental irritant and produced the toxin in self-defense.

A second point which he discussed was that the very size and duration of the bloom argued for the presence of an immense concentra-

tion of nutrients. These nutrients had to contain large amounts of nitrogen and phosphorus, which are supplied by run-off from the land. In recent years, these elements have greatly increased because of pollution of the North Sea, the Skagerrak, the Kattegat and the Baltic Sea by human waste and fertilizer contained in the run-offs. However, Braaten said, it was difficult for a scientist to draw an unqualifiedly positive correlation between increased pollution of the sea and this spring's large algae bloom.

Unqualified correlation or not, the algae bloom has made many people increasingly aware of the complexities of the ecological process and the dangers of upsetting it with more and more pollution. Fish farms themselves, because of their tremendous concentration of fish in small areas, may be contributing to the pollution problem. One Oslo source who wishes to remain unidentified said some government officials were considering refusing permits to new fish farms, and oth-

The one-celled algae *C. polylepis* extended its toxic tentacles into the North Sea areas known as Kattegat and Skagerrak last summer. The dates on the map shows the movement of the algae tide.

continued on page 33.



Fish farms like the one pictured above were towed to the safety of fjords to escape the algae tide. Photo by Robert Paulson.

ers were suggesting it might be wise to reduce the number of fish farms (presently 700).

Europe, too, is beginning to act. Recently there was a conference in Brussels with the title, "EEC Workshop of Eutrophication and Algal Blooms in the North Sea Coastal Zones, the Baltic and Adjacent Areas." At the 1987 North Sea conference in London, the countries surrounding the North Sea pledged to halve their 1985 levels of environmental toxins and nutrient discharges by 1995. Norway pledged to do this by 1992. Fortunately or unfortunately, Norwegian discharges make up only 3 percent of the total. This demonstrates the necessity of international cooperation in solving the pollution problem.

Another positive result of the algae bloom was the announcement by Norsk Hydro, the world's largest producer of complex fertiliz-

ers, that it would begin trials of a phosphate-free fertilizer. It is also developing a low-phosphate fertilizer.

Norway, with the most to lose if pollution isn't stopped, is again leading the way and setting the standard. In a recent Norwegian opinion poll, more than 97 percent of those questioned said that they would like to see their government focus more on environmental measures, and 85 percent were willing to pay what this would cost.

The Norwegian Council for Scientific and Industrial Research (NTNF) is already intensifying research into sea and fjord pollution with the aim of developing technology which can be used for environmental surveillance of the sea and fjords.

With this resolve, perhaps the spectre of "the blob that ate the coast of Norway" can be kept at bay. □



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MUTUAL IMPACT OF WILD AND CULTURED ATLANTIC SALMON IN NORWAY

By

*Emmy Egidius, **Lars Petter Hansen, **Bror Jonsson
and ***Gunnar Nævdal

* Institute of Marine Research
P.O.Box 1872, Nordnes, N-5024 BERGEN

** Norwegian Institute
for Nature Research
Tungasletta 2 , N-7000 TRONDHEIM

*** Department of Fisheries Biology,
University of Bergen
P.O.Box 1839, Nordnes, N-5024 BERGEN

ABSTRACT

The development and current status of the fish farming industry, enhancement and sea ranching of salmon in Norway are briefly described, and an account is given of the natural salmon river populations in different parts of the country.

Record of cultured salmon in the open sea, coastal waters and rivers are briefly reviewed, and so are also migration studies on liberated farmed salmon. Diseases common to wild and cultured populations are described and discussed in relation to mutual impact.

The current situation is discussed in relation to actual and potential effects on natural gene pools and spreading of disease agents. Initiatives to protect natural gene pools are discussed, and experiments to gain additional knowledge of the genetic resources are outlined.

INTRODUCTION

Farming of Atlantic salmon in Norway commenced around 1970, and since then the production has increased steadily. In 1987 the annual production amounted to 47.417 metric tons, and the predictions for 1988 are around 75.000 tons. The production takes place along larger parts of the coast, but is low in southeastern parts and in the northernmost county Finnmark.

Wild Atlantic salmon is found in rivers all along Norway, and despite damage of stocks in southern Norway due to acid precipitation and in mid- and northern Norway due to the parasitic monogenean fluke Gyrodactylus salaris, the total reported catch of salmon has varied between 1050 and 2147 metric tons over the last 27 years. The annual variation in the production of the different rivers is considerable. All rivers seem to have their own stock with specific life histories and productive traits. Investigations of the population structure of Norwegian salmon using gene markers have been conducted by Ståhl and Hindar (1987).

Atlantic salmon has been released in Norwegian rivers for many years to enhance local stocks. They have mostly been released as unfed fry (10-15 millions a year), but also as underyearlings or smolt. Smolts (4-500 000 a year) are released primarily to compensate for damages to recruitment caused by river regulations (Hansen *et al.* 1987). Most fish released are from local stocks (Ståhl & Hindar 1988). Ocean ranching has so far been carried out on an experimental basis only, although the results have been most encouraging (Hansen and Jonsson 1988).

It is a reasonable assumption that the fish farming industry in Norway will continue to increase, and we therefore need to take good care of our several hundred local populations of wild salmon. Moreover the possibilities to augment the stock enhancement work and to develop ocean ranching of salmon should be assessed.

Many questions have been raised about the impact of the growing fish farming industry on the natural salmon populations. This concern has mainly been focused on two aspects; the transfer of disease from farmed to wild fish and the danger of eradicating salmon gene pools by

breaking down isolation mechanisms between stocks, and decreased fitness of the wild salmon due to introduction of nonindigenous gene or gene combinations. Transfer of diseases from wild to farmed fish is also a matter of concern, and for the fish farming industry strong and healthy wild populations with a high degree of genetic variation is a good insurance if the cultured populations should be subject to massive disease infections or unexpected genetic alterations.

The aim of the present case study is to give an overview of the relationship between wild and cultured salmon in Norway, including initiatives to protect the natural gene pools. The greater part of the study is based on published papers and reports, and in addition some discussion on validity of concern is included.

DESCRIPTION OF THE SITUATION

Recent development in farming and ocean ranching of Atlantic salmon has led to an increased proportion of reared fish in nature. Based on fin morphology and scale analysis the proportion of reared fish (ranching and farm escapees) has increased from about 10% in 1986 to about 20% in 1988 in commercial fisheries in Norwegian home waters (Hansen *et al.* 1987a, Lund and Hansen 1988, Lund *et al.* in prep.). If not caught in the fisheries, the adult salmon enter rivers to spawn (Hansen *et al.* 1987b). Using direct observations of body morphology, brood stock surveys in rivers in southern Norway in 1987 revealed that 23 (43%) out of 54 rivers examined contained reared salmon (Gausen 1988). In total of 615 salmon examined 83 (13%) were determined to be of reared origin.

These escaped fish spawn in the streams. For instance, in the small river Imsa there is an annual run of between 100 and 200 mature rainbow trout which have escaped from fish farms. They spawn and they leave the river system as kelts (Jonsson and Hansen, in prep.). The number of viable offspring is extremely low. Because Atlantic salmon is a species native to Norway it is likely that reared salmon can yield viable offspring in nature. However, the reproduction success of reared salmon in nature is still unknown (Ståhl and Hindar 1988).

Experimental releases of farmed Atlantic salmon show that there is a

seasonal variation in survival. Survival of escaped salmon during their first sea year is much higher for those escaping in spring than for those escaping during the rest of the year (Hansen & Jonsson 1986, 1989). Adults escaping during summer seem to enter rivers at random and behave like homeless fish (Hansen et al. 1987b). When escaping from sea cages at the smolt stage the fish return to the same area from which they escaped and enter rivers in this area to spawn (Hansen et al. 1989).

Reared salmon might affect natural populations in several ways. For example the fluke Gyrodactylus salaris is at present spread to 32 rivers by stocking fish from infected hatcheries. This parasite attacks salmon parr and causes heavy mortality. In 1984 the estimated loss of salmon to Norway was around 250-500 tonnes (Johansen & Jensen 1986), and now the damage is still higher as the fish in more rivers have been infested by the fluke. Salmon smolts are still imported to Norwegian fish farms from other countries, which imposes a continuous risk of importing disease and parasites to which Norwegian salmon stocks are not adapted.

Extinction of local, indigenous fish stocks and erosion of genetic resources are subjects of growing concern to salmon management in Norway. The primary causes of excess salmon mortality in the present century are acid precipitation (Hesthagen & Mejdell-Larsen 1987), and the parasite Gyrodactylus salaris (Johnson & Jensen 1986, 1988). Effects of escapees from salmon farms on natural stocks also is a matter of concern among biologists. For these reasons the Directorate of Nature Management has established a gene bank for salmon based on deep frozen sperm. In 1986 and 1987 sperm collected from a number of salmon rivers throughout the whole country were stored (Gausen 1986 and pers comm.). In total sperm from 69 stocks are by now stored in the sperm bank.

DISEASES

Of the interaction problems between wild and farmed salmonids, diseases is possibly the largest and most serious one. Disease in fresh water farmed fish has been known for considerable time. Sea water farming started more recently, and it was believed that

conditions in seawater would be much better, with cleaner water and less disease problems.

Very little was known about diseases and parasites in free-living marine fishes when the fish farming industry started, and still there are immense gaps of knowledge. It has also appeared that diseases expected to occur only in fresh water, thrive very well in seawater.

The case of the salmon lice, Lepeophtheirus salmonis, is maybe the one giving the best illustration of an interaction between wild and farmed fish. This parasite was well known, it was described by Krøyer as early as in 1838. It is a copepod with a life cycle of 10 stages, 3 pelagic stages and 7 attached to or living on the host. It is found circumpolarly in the northern hemisphere and is host specific for salmonids; the lice disappears from the fish in fresh water within a short time. When and where the free-living fish is infected is not known. The chance for a pelagic-living larvae to encounter its specific host in the open sea, does not seem very large. When wild salmon still were abundant in the rivers, the saying of experienced fishermen was that a high density of lice on the upward migrating fish, was indicative of a good salmon run. Only once, in Canada in 1940, lessions and death probably due to salmon lice were reported (White 1940). Actually, it should have been foreseen that salmon lice could become a potential problem in salmon farming. Under the intensive conditions found in farms, it is no longer a problem for the pelagic larvae to find their spesific host and complete their life cycle producing new larvae easily finding new hosts and so on. It soon became evident that the lice, if present in large numbers, were harmful to salmon. They live on mucus, skin and blood and in the most advanced cases fish are seen with large open lessions especially in the head region. Even if wild-living salmonids arround fish farms have been observed carrying large numbers of lice (Djupvik, pers. com.) lessions or mortality in such fish are not reported.

We still know little about diseases in free-living marine fish, clearly it is among the farmed fish we really encounter the problems. The largest problems are seen in connection with bacterial infections. Vibriosis due to the bacterium Vibrio anguillarum is probably the most well known of such diseases. Vibriosis was one of the economically

most important diseases in marine fish farming, but can now be controlled efficiently through vaccination. Vibriosis is known from a large amount of freeliving marine fish, but epidemics are rarely seen. Along the Norwegian west coast local outbreaks of vibriosis in young saithe are found annually, reaching epidemics proportions in certain years (Egidius et al. 1983). Experiments have shown (Egidius and Andersen 1978) that there is some host specificity amongst V. anguillarum strains isolated from for example rainbow trout and saithe, and more recent investigations have shown that there at least at the DNA level is a slight difference between strains from different hosts (Wiik et al., in press). Mass mortality due to vibriosis is reported in homeward migrating salmonids when entering the rivers, but it does not seem to occur very frequently. Coldwater vibriosis due to V. salmonicida has not yet been reported in wild salmon.

Furunculosis due to the bacterium Aeromonas salmonicida var. salmonicida is another of the important bacterial diseases that must be considered. Furunculosis is endemic in the wild salmonid populations in Scotland, Ireland and Canada, but free-living affected fish are not frequently seen. In fish farms on the other hand the disease can be disastrous and in general of great economic importance. With furunculosis it seems clear that the free-living fish is the reservoir for the disease in farmed fish. In farmed fish the disease outbreaks seem linked with fish density in tanks and cages and other stress inducing factors.

The bacterium Yersinia ruckeri is a newcomer in European fish farms. Even if the disease was believed to be a fresh water one, it has spread to salmon farms all along the Norwegian coast. Possible effects on free-living salmonids are not known. Although the bacterium has been isolated from marine scavenger fish like saithe around affected sea cages, it is not known if the saithe just harbours the bacterium for a short time or if it can be pathogenic also for this and other marine species.

Bacterial kidney disease (BKD) due to Renibacterium salmoninarum is probably the most dreaded of the salmonid diseases mainly because its development is slow and because the diagnostics is difficult and time consuming. BKD was first thought to be purely a disease of farmed

fish, but with improved diagnostic methods the bacterium was also found in wild stocks though its impact there is unknown. We most probably have the same situation as with furunculosis: that the infection reservoir is in the wild stocks, but the disease problems break out under farming conditions. The disease in farms can lead to higher infection rates of wild stocks in the vicinity.

Of fungal disease agents Ichthyophonus hoferi is common and often harmful in several species of marine fish. It has been found in farmed salmon, but until now without showing much effect.

Of parasites the monogenean fluke Gyrodactylus salaris has done great harm in Norwegian salmonid rivers. The fluke is believed to have been imported with smolts for farming from Sweden to Norway in the early seventies. This fluke is now spread to about 30 salmon rivers, many of which are nearly emptied of Atlantic salmon. In the fish farming industry Gyrodactylus is no problem. Infected fish are easily treated and the parasite disappears when the smolts are put into sea water. This is the only disease mentioned here where apparently wild stocks are the losers.

Examples have been given of disease interactions between free living and farmed salmonids, mostly to our knowledge in the disfavour of the farmed fish. Our general knowledge on disease in free living marine populations including salmonids, is still far too restricted, but there clearly is reason for great consideration and carefullness in movements of fish from different regions.

GENETIC VARIATION AND GENETIC STRUCTURE OF SALMON IN NORWAY

Population structure of salmon in Norway

Ståhl and Hindar (1988) have made a comprehensive monograph of the Norwegian salmon stocks with reference to the population structure, number of spawners (population size) and differences within and between wild and farmed salmon stocks. From studies on biochemical genetics they concluded that the natural salmon is divided into genetically distinct populations; sometimes more than one within the

same river system. Farmed salmon (commercial stocks for intensive farming and culture aimed stocks) is not a homogeneous group and it is not possible to distinguish between wild and cultured salmon on the individual level by use of biochemical gene markers.

Potential genetic impact

Skjervold (1988) gave an overview of the types of genetic impact the fish farming could have on natural salmon stocks. In spite of the difficulties in estimating the numbers of escapees from fish farms, and of the magnitude of their contribution to the recruitment of salmon, evidently a great potentiality exists of significant gene transfer risk from farmed salmon to occasional rivers.

The farmed salmon has been subjected to intensive selection for improvement of productive traits, especially improved growth rate and late maturation. Genetic selection is performed systematically through a large scale program on improvement for fish farming conducted by the Fish Farmers Association and the Fish Farmers Sales Organization in Norway. In addition most egg producers make phenotypic selection of broodstock, and probably also seminatural selection as an adaptation to life under farming condition (domestication) has taken place for 4-5 generations. The genotypes of the farmed fish may differ in several respects from the genotype of the population from which they originated several generations ago. It is difficult to predict how this change will affect their adaptation with respect to survival in the natural environment, but escapees which reproduce in rivers chosen by random will always decrease the differentiations between the wild salmon populations.

The origin of the salmon used for fish farming is important. Ståhl (1987) has shown that especially the Baltic salmon differs in genetic composition from the salmon in the north-east Atlantic, and east-Atlantic salmon differs in several aspects from the west-Atlantic stocks. As far as we know there has been no import of west-Atlantic live salmon to Norway (except for scientific purpose), but for several years we have had importations of smolts from Iceland, Scotland and especially from Sweden and Finland (Baltic salmon).

Gjedrem and Aulstad (1974) observed that a strain of Baltic salmon showed much lower resistance to vibrio disease than the Norwegian strains, indicating that genetically differences in resistance to certain diseases exist between geographically distant groups. Escapement of fish with other adaptations to diseases and parasites in the environment will represent a risk for transferring such disease agents to natural population. Thus newly established or potential hybride populations may be eradicated due to spontaneous or accidental disease outbreaks.

Hybridization, hybride vigor and short term adaptation

Crossbreedings of natural and escaped salmon in the rivers are expected to cause increased heterozygosity, which may lead to hybrid vigor for some traits. Hybride vigor most often is found for traits with low heritability (Skjervold 1988), and survival traits have low heritabilities as far as they have been studied (Gjerde 1986). Thus, hybridizing with natural salmon in a river may give the impression of very well adapted fish; an adaptation which may oust nonhybride natural salmon, but last only for the first generation. Altukhov (1981) described a similar case with chum salmon where liberation of non-indigenous fish resulted in very low production both of the introduced fish and of the indigenous fish in the same river.

Genetic drift, reduced genetic variability and low numbers of spawners

Low numbers of spawners (effective population size) will always increase genetic drift, decrease heterozygosity and consequently increase the risk of loss of genes. A number of 100 specimens of each sex is recommended by Allendorf and Ryman (1987) but in several cases of artificial reproduction for enhancement work and intensive fish farming, the spawning populations are considerably less than recommended based on theoretical considerations. However, judged from the results of Ståhl and Hindar (1988) the heterozygosity is higher in artificial than in most natural populations, and the genetic variability within populations is not reduced due to culture activities. This may be due to the fact that cultured populations usually represent different natural populations and contain more genetic variation than any single population. Therefore the risk of

reducing the fitness of salmon through reduced genetic variability does not seem to be serious for the moment, although it should be kept in mind by monitoring both cultured and natural populations through several generations.

In conclusion the escapement of farmed salmon, and liberation of non-indigenous salmon for enhancement work represents a risk of decreasing the genetic variability between populations, possibly also reducing the long time fitness by first generation hybrid vigor in adaptive traits through hybridization between indigenous and non-indigenous fish. For the moment, however, loss of genetic variability through low numbers of broodstock for culture purpose does not seem to represent a risk.

INITIATIVES

To avoid impact of cultured salmon on wild stocks a series of initiatives have been taken or are being planned in Norway. These initiatives are listed below with a statement of the status of each of them.

Technical improvement

In addition to representing a risk for wild salmon, salmon escaping from fish farms always represent a loss for the fish farmer. Improvement of technical facilities to prevent escapement therefore is an immediate initiative to prevent contact between wild and cultured salmon. Usually, the security of a fish farming facility is a compromise between the chance of loss and the cost of investment. Landbased facilities are more safe than ordinary net pens, and closed or semiclosed pens are also an alternative. For the moment, landbased facilities for marine culture are not much used in Norway, but closed or semiclosed systems are under development. No specific demand is required for fish farming devices, but it has been proposed to establish protective areas for salmon where no farming activities will be allowed unless they are secured with respect to escapement. Within the zones technical improvements may prevent contact between natural and farmed salmon.

Gene banks (sperm banks)

Salmon from Gyrodactylus-treated streams are taken care of by artificial breeding and liberation, partly also in intensive culture (Ståhl and Hindar 1988). A sampling program for deep-freezing of sperm is undertaken (Gausen 1986). In 1986 sperm from 48 strains were preserved, while in 1987 the sperm bank increased to contain sperms from 69 populations. By using such sperms, populations which have been eradicated may at least partly be reconstructed. By use of androgenetic techniques more complete natural populations may be reconstructed from sperm banks (Scheerer et al. 1986).

Restriction on transfer of live material

For many years there has been a lack of smolts for the fish farming industry in Norway, as the smolt production did not increase as fast as the development of food fish production. For this reason, some imports have been legislated, in some cases with disastrous results concerning cultured salmon (i.e. import of furunculosis from Scotland) and natural populations (possible import of Gyrodactylus salaris from Baltic countries). In 1988 there was a surplus of smolts in Norway. This situation is expected to persist, and there is no longer any reason for import of live salmon, although even this year (1988) there has been an import of salmon eggs from Iceland. Transport of live material within the country probably also has contributed to the spread of Gyrodactylus. This seems to be a problem especially in cases where salmon farms are situated in fresh water systems also supporting anadromous salmonids, or in brackish water with a salinity lower than 14 to 18 o/oo. For this reason restrictions of transfer within Norway are also proposed, but not yet decided upon.

Use of indigenous fish for enhancement work

Enhancement has been conducted for several years by releasing offspring from occasional salmon of unknown origin, also farmed fish. To protect the between strain variation, in principle now only endemic fish are allowed to be used for enhancement of natural stocks. Only when such fish is unavailable, non-indigenous fish are allowed used.

Areas protected from fish farming

Hatcheries for commercial production of smolts for intensive fish farming are usually not located in or close to rivers with anadromous salmonid populations. However, some existing hatcheries are located close to rivers with sea-run fish, and inland in Norway plants for rainbow trout productions (mostly small) are sometimes located in lakes draining to salmon rivers. Such fish farms have probably spread Gyrodactylus salaris. Hereafter no new installation for intensive production or for enhancement work for other than indigenous populations, will be allowed in rivers supporting anadromous populations.

To protect larger areas, a plan has been formulated for time restricted protective areas for wild salmonids. This plan is now subjected to consideration by involved official agencies and private organizations, and the fate of the proposal is yet uncertain. The aim of the proposal is to protect larger areas and secure references for observation of gene introgression and spread of disease agencies. To prevent further spread of Gyrodactylus salaris no new culture activities will be allowed where this parasite has been found. This include the river drainage and a defined area usually within about 20 km of the river mouths. Usually, rivers having a mean annual catch of more than 500 kgs anadromous salmonids will be protected. A few larger fjord areas (Sognefjorden, Trondheimsfjorden) are also proposed to be held free from new aquaculture installations. Such protective areas are proposed for five years as it is desirable to gain experience about the effect of such restrains before long-lasting decisions are made. If escapement free facilities are constructed, limited farming activities may be allowed, and existing farms within the areas will be allowed to continue.

MONITORING AND RESEARCH

The establishment and increase of the intensive fish farming industry represent a new and possibly serious threat to the natural populations of Atlantic salmon in Norway as well as in several other countries. From a management point of view actions are taken or will be taken to

conserve the natural population in coexistence with the developing fish farming industry, and possible commercial sea ranching activities. A first approximation to such management is to monitor the changes that really take place, and then to develop new methods for interaction studies. Further studies on quantities of escaped reared salmon in coastal areas and in the rivers, studies on infection sources for disease agents, occurrence of disease agents in natural populations and development of methods for defence against parasites (i.e. Gyrodactylus) in natural environment are required. Reconstruction of eradicated (or strongly decreased) natural populations from live gene banks or sperm banks by androgenesis is another area of research and development. Concerning genetic impact, the discussion is often loose and concentrates more on potential impact than on actual facts. To base this discussion on observed or experimental data will be a great challenge for scientific activities in the near future. Further studies on genetic differentiation of natural populations is important. To study hybridization and gene introgression, use of gene markers is a promising method. For other species (cod, brown trout) broodstocks homozygous for specific gene markers (biochemical or morphological) are developed (Skaala *et al.* 1988). No suitable markers are yet found for salmon, but this will be further investigated for application in field studies on interaction between populations. If such studies are difficult or impossible to perform with salmon, they will be performed with brown trout as a model species.

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