aquaculture notes

SALMON FARMING: A PROFILE

Adapted from
the British Columbia Subsidiary Agreement
on Small Business Incentives and
the Aquaculture Incentive Program publication
of the same title by

Curt Kerns
Aquaculture Specialist
Marine Advisory Program
University of Alaska Fairbanks

University of Alaska Fairbanks
March 1988

Alaska Sea Grant College Program
Aquaculture Note #12

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

This publication was sponsored by the Alaska Sea Grant College Program, which is cooperatively sponsored by the U. S. Department of Commerce, NOAA Office of Sea Grant and Extra-Mural Programs, under grant number NA86-AA-SG041, project numbers A/71-01 and A/75-01; and by the University of Alaska Fairbanks with funds appropriated by the state. We would like to thank the Ministry of Economic Development-British Columbia Expertise Centre and the Department of Regional Industrial Expansion for permission to reprint and revise their publication.

Alaska Sea Grant College Program
138 Irving II
University of Alaska Fairbannks
Fairbanks, Alaska 99775-5040

FOREWARD

Salmon farming is an important issue in Alaska. The state has the world's largest stock of naturally spawning salmon. At the same time, its hatchery program is reaching fruition. More than 75 percent of the record 1987 Prince William Sound harvest of salmon came from hatcheries. Alaska produces more than 90 percent of the total U.S. harvests and nearly 50 percent of the world harvests of Pacific salmon, generating revenues of $500 million annually.

On the other hand, Alaska's seafood industry continues to be highly seasonal, and markets, driven by supply-limited high prices and increased farmed salmon production by 14 other countries, are demanding fresh fish on a year-round basis. Consumer demand, caused by increasing awareness of seafood's health value, is resulting in increasing seafood imports. Alaska's seafood industry could face a diminishing market share and relegation to less valuable market strata over the next 20 years if it is unable to respond to market demands.

Public debate has been extensive, with opinions divided. A year's moratorium on salmon farming permitting was legislated during the 1987 session of the Alaska Legislature. Unfortunately, with the rapid growth of salmon farming elsewhere, prices of farmed fish could--and probably will--soften within 10 years. As five or more years are required to start a farming sector, the debate can't continue long enough to answer all of the questions by using the experience of other nations. The current high profitability, which is of great assistance in starting a new industry, eventually will diminish.

Because of the high cost of doing business in Alaska, questions of profitability are being discussed by legislators, seafood industry participants and would-be aquaculturists and investors. Profitability is of central importance to all involved.

Because of these problems and because many of the original source documents are not available, this publication has been prepared using the experiences garnered by British Columbian provincial agencies from their salmon farming industry. British Columbia probably is the best location from which to draw information for Alaska because of its geographic proximity, similar salmon species and the number of farms in operation.

The text is taken from **Salmon Farming: A Profile**, a booklet published by the Ministry of Enterprise , British Columbia Enterprise Centre, 770 Pacific Boulevard South, Vancouver, B.C., V6B 5E7, (604)660-4188; and the Department of Regional Industrial Expansion, 1011-1055 Dunsmuir St., Vancouver, B.C., V7X 1K8, (604)666-2255. For the purpose of making this publication more valuable to Alaskans, I have added annotated text following each section, indicated in bold face type, updating some information and emphasizing aspects of interest to Alaska aquaculturists.

Curt Kerns
University of Alaska Fairbanks
Marine Advisory Program
March, 1988

INTRODUCTION

Fish farming has grown rapidly in British Columbia during the past two years, with expectations of even greater growth in the immediate future. The following profile of a typical fish farm is specifically intended to outline a series of norms or rules of thumb that tend to exist in the British Columbia fish farm industry. For purposes of this model we have chosen a farm size of 110 tons, having a sea water floating cage culture. Because this sector is new to British Columbia, knowledge of the development and operation of a fish farm is fragmentary and the reader should be guided accordingly.

Farm size varies from that of "Mom and Pop" ventures with a few thousand fish in a single pen to that of medium-sized companies with a million or more fish cultured at several sites. The average production objective is typically 200 to 250 mt per year at each site.

BASIC REQUIREMENTS

Biophysical and Locational Suitability

Biophysical characteristics include water temperature, which is important to fish growth, prevention of fish diseases and plankton growth. An ideal site will indicate a summertime high of 63 to 68 degrees Fahrenheit and a winter low of 41 or 42 degrees Fahrenheit. Salinity for marine farms will measure 15 to 30 parts per thousand. Sea pen circulation, important for oxygen supply and disposal of fish waste, will register 1 in. per sec. A sloping ocean floor and depth greater than 33 ft below the sea pen will also benefit waste disposal. Wave height, a function of wind and exposed water, will be less than 3 ft. The site will be reasonably free from predators (seals, otters, sea lions, minks), pollution (industrial or septic), and show a low occurrence of fish disease (viral, bacterial, fungal) and parasites.

Site selection is quite difficult, although almost any location will work, given enough investment. The objectives, life skills and personalities of the would-be farm operator need to be carefully considered. Potential negative responses of neighbors are often overlooked. For further discussion of site selection, see the Alaska Marine Quarterly Vol. 2:3, available from the Alaska Marine Advisory Program, 2221 E. Northern Lights, Rm. 220, Anchorage, AK 99508-4143.

Permits and Licenses

A lease of license of occupation must be issued by the Ministry of Forests and Lands. Issuance of a lease from Lands is predicated on receipt of concerns and recommendations from a number of federal, provincial and municipal agencies and interested private sector groups. Several additional permits/licenses may be needed such as a federal Aquaculture Enterprise License and federal navigation compliance; a Provincial Waste Management Permit, a Water License, and a municipal Business License.

The permitting requirements in British Columbia are quite extensive, often requiring a year or more to satisfy. Virtually all of the British Columbia requirements are in place in Alaska, although the form may be different. A would-be salmon farmer in Alaska must comply with Coast Guard regulations, tideland site lease stipulations, the Clean Water Act and state business licensing requirements.

Accommodation

Normally, a house is built or a trailer is parked on the uplands where access is available by road. However, in many cases where steep topography precludes on-land accommodation, a house and storage facility are constructed on a concrete, decked barge, approximately 40 ft x 20 ft, which is anchored a short distance from the house. Costs range from $15,000 for a used trailer to $50,000 for a house or house/barge combination.

Skills and Experience Required

Ideally, the fish farmer will have managerial skills, specific knowledge of accounting procedures and fish culture, or be in a position to employ professionals in the appropriate discipline. At lease some practical experience in all phases of fish farming is essential.

Knowledge of small boat net, ropes, lines, cables, and fish handling is essential. So are construction experience and general familiarity with living and working around marine environments during all seasons and conditions. If a fish farmer is going to take an active role in the day-to-day management of a farm, the operator should be in excellent physical condition. Knowing how to use scuba equipment is important because it enables the farmer to observe the fish directly as well as accomplish required underwater tasks.

EXPENDITURE/FINANCING

Capital Costs

Typical capital costs for a fish farm with 110 ton per year of output at full production:

Buildings	$ 30,000
Cages and nets	100,000
Equipment	51,000
Infrastructure	29,000
	$ 210,000

Capital cost expenditures will be phased in as the fish grow over the two and a half to three year grow-out cycle for chinook and the one and a half to two year cycle for coho.

Capital costs can be less initially if European-built equipment is used. But the author recommends domestically produced equipment--which is rapidly becoming available--because repair and maintenance services and parts can be provided domestically and this equipment can be adapted to local conditions.

Normalized Annual Expenses

Annual operating expenses once the farm is operating at full capacity will approximate $450,000. As the following breakdown indicates, expenses are dominated by the cost of feed.

Expenses	Cost	Cost per lb of salmon
Smolts	$35,000	0.16
Feed	200,835	0.91
Disease Control	3,520	0.02
Harvesting (minimal)	26,698	0.12
Fuel and Supplies	24,000	0.12
Labor	30,000	0.14
Maintenance	6,500	0.03
Management salaries	35,000	0.16
Communications	8,000	0.04
Insurance	8,000	0.04
Lease fees	1,000	
Professional fees	8,000	0.04
Mortality insurance	30,000	0.14
Miscellaneous	4,000	0.02
Depreciation	19,750	0.09
Term loan interest	12,381	0.06
Operating loan interest	2.317	0.01

Smolts: The current standard price in British Columbia is C $.65 per smolt. Alaskans should figure initial prices to be US$1 to US$2 per smolt.

Feed:To promote high survival, the best feed available should be used. Feed prices for FOB to an Alaskan firm will be highly variable , depending upon location. For an accurate price, estimate both initial purchase price and delivery to the particular site.

Disease control: While not disease per se, harmful algae blooms can result in substantially greater costs than those mentioned here.

Harvesting: This appears to be the tendering cost.

Labor: In order for the farm to be staffed every day, two or three workers are require,. Some farms don't have staff present one or two days a week, although someone must always be on call.

Mortality insurance : Two companies in British Columbia offer stock insurance. Their rates, depending on the deductible (usually 20 to 30 percent) are from 4 to 5 percent of market value.

Financing Constraints

Because fish harvesting does not begin for approximately one and a half years, and, during that time feed and other costs will amount to $350,000, provisions must be made at the outset to finance this negative cash flow. Traditionally, financing for working capital would be provided by the banking industry. In this instance, some banks are reluctant to become involved, citing the newness of fish farming. Therefore, working capital is covered by injections of equity capital as required.

Operating financing is just now becoming available from a few domestic banks in British Columbia. The typical arrangement is 50 percent of the market value of the fish available 12 months from harvesting. Mortality insurance is mandatory. Another source of operation financing is from large fish processing companies. This type of loan is conceptually no different than operating monies advanced by processors to commercial salmon harvesters. Feed companies occasionally are a source of operating financing for commercial salmon growers.

Financing

As indicated above, total financial requirements, spread over six quarters, are $560,000; $210,000 for capital costs and $350,000 for working capital. Some farms are financed privately, or through offshore banking interests (eg. Norwegians) who have exposure and experience in fish farm financing. Larger farms raise funds through private placements of stock market underwritings. Others tie financing to equipment purchases. In this profile, equity of $200,000 is injected into the company, and $250,000 is borrowed from the bank--$100,000 of which is in the form of a Business Improvement Loan and the remainder in the principal's name against his personal assets. The remaining $100,000 is assessed through the Aquaculture Incentive Program (AIP) . The five year AIP loan is interest-free and, in recognition of the unusually long time frame before a positive cash flow can be established, the loan payments do not commence until the beginning of fourth year.

Growth of Norwegian-financed ventures appears to be slowing in British Columbia as financial institutions await the results of the first round of farms built. Equity investors from other countries , particularly the United States, express increasing interest. Seven ventures have gone public on the Vancouver Stock Exchange. As aquaculture is now considered agriculture, various programs offered by the U.S. Department of Agriculture and the State of Alaska should be explored.

GROW-OUT

Smolts

Any time from May to October when fry reach a minimum size and when biophysical conditions are most favorable , coho and chinook smolts are placed in the water to be grown-out. Approximately 55,000 smolts are required, usually 50 percent of each species, although some farmers may opt for a different mix, often dictated by smolt availability. Price of smolts range from .55¢ to .90¢ each, depending on size, quality and demand. Grow-out for coho can take anywhere from 12 months (pan-size) to 24 months and for chinook from 2 months to 36 months. Ideally the smolts' parents would be domesticated fish and, therefore, conditioned to a captive environment. By raising one-half coho and one-half chinook, the fish farmer is reducing his risk. Although not substantiated by current research, there are those who contend that coho are more susceptible to diseases such as bacterial kidney disease (BKD), and they have a more severe problem where the males mature at an early age, causing problems of stress with the other fish and expending energy rather than accumulating weight. In terms of market, chinook can be grown to a larger size and, thereby, command a premium price. On the other hand, coho grow more quickly , providing cash flow at an early stage. After 15 months, a coho can weigh up to 12 lb; however, after two years the coho would weight 5.5 lb and the chinook 7 lb.

The general consensus in regard to smolts is that quality stock (large, healthy, rapidly growing, with the smallest 15 to 20 percent graded out) is of paramount importance. Coho salmon tolerate higher density (< 10 kg/m^3 or6 lb/ft^2) than do chinook salmon (< 5kg/m^3 or .3lb/ft^3), grow somewhat faster and are somewhat more tolerant to handling. Sexual precocity (jacking) is a problem with both species, but more so with coho. Any male coho salmon that weighs more than 170 to 180 g by early July can be expected to jack. The results with testosterone neutered coho have not been satisfactory under production grow-out

conditions. Many growers in British Columbia routinely separate the largest 20 to 30 percent of any given lot of either species from the others, expecting that the fastest-growing fish will mature early. With low densities and good quality feed, coho salmon are ready for market in about 18 months, chinook salmon in 24 months; higher densities and lower quality feed or lower feeding rates result in grow-out periods of 24 months for coho and 30 months for chinook salmon.

Survival Rates

Fifty percent is considered an appropriate survival rate, which is simply the percentage of smolts that survive the grow-out stage to the point where they can be marketed. Survival is a function of disease, non-smolting (not all smolts make the transition when placed in salt water), natural disasters (plankton bloom) and predators. Most operators hope to achieve a minimum survival rate of 50 percent . In Norway, with established operations, they have achieved a survival rate approximating 70 percent with Atlantic salmon. It is apparent that a higher survival rate has a significant impact on the operating profit of a salmon farm. British Columbia operators are optimistic that they can achieve a 60 to 65 percent survival rate.

Fifty percent survival is the rule in British Columbia. Significant shortages have been noted, with harvests being less than one-half the estimated number. Small fish decompose rapidly, so early mortalities may not be noticed. Bird predation and unnoticed loss during net changing and other handling are thought to contribute to the lower-than-expected harvests.

Fish Feed Requirements

Industry rule of thumb is that for every 1.8 lb of feed, salmon will gain 1 lb (conversion rate). Salmon feed costs range from $.36 to $.55 a lb. Since feed costs account for almost 50 percent of the total costs, the conversion rate, feed cost and quality are critical factors.

Very little hard data exists on feed conversion efficiencies. A ratio of 2 lb of feed for every 1 lb of round weight of fish that survive to market size is more commonly used than the ratio of 1.8 to 1.

Production Model

For planning purposes, a computerized production model is constructed by inputting the various facts and assumptions referred to above. The model will forecast, for instance, how much food will be consumed, at what cost, how large the fish will be at any given time, how many fish will be ready for market and what the sales revenue will be.

Net pen requirements can be determined by factoring the standard stocking density of .5 lb of fish per cubic foot of water. In our example, one pen is sufficient for each species until, for coho, the second year, when two new net pens are required in part to handle the second-year smolts. For chinook, a second pen is required in the sixth quarter. From this point on, the five pens can be juggled between species as smolts are introduced and mature fish are harvested. For instance, in the eighth quarter a large harvest of the first year coho frees a pen for the larger chinook. The following quarter, the situation is reversed as chinook are harvested and the three-year coho smolt arrive.

Developing a computerized production model can be quite time-consuming. Dr. William Smoker of the University of Alaska Southeast, Center for Fisheries and Ocean Sciences, has developed a model that uses *Lotus 1-2-3* on an IBM compatible microcomputer.

SEA CAGE SYSTEM

The sea cage is composed of net pens, nets and an anchoring system.

Net Pens

Deciding on the type and size is a major task, since there is a variety of configurations, materials, engineering techniques and manufacturers. Some farmers maintain that small pens, 20 ft x 20 ft, should be used for the smolts' first four months, moving to a 50 ft x 50 ft pen thereafter. Different technologies are employed for different wave regimes, with extremely strong steel built systems employed where sites are exposed, to wood-constructed systems for sheltered locations. One strong argument for Norwegian-built steel cage systems is that suppliers are able to offer up to 80 percent financing. With regard to shape, round pens are stronger and in terms of space utilized by the fish, more efficient. On the other hand, square and rectangular pens are easier and less costly to build and are more adaptable when attaching walkways. Wooden platforms are favored by many because nets are less likely to be snagged and wood is easier to walk on, however, they require constant cleaning.

A typical pen would measure 50 ft x 50 ft and cost $10,000. The frame for the main element consists of two rectangular, galvanized tubes which are strengthened with two parallel running square tubes placed in the center underneath. Each main element is equipped with a stabilizer and eight pontoons made and filled with polyethylene. Each of the main elements are connected by welded hinges, mounted so that the load is distributed to a number of elements. Non-hinged connections have the advantage of being very stable and can be lifted high above the water, but because they are inflexible, use in rough water is not prudent. The walkway is 3.5 ft wide and made of galvanized steel. Attached to the walkway are handrails measuring 3.5 ft x 7 ft, made of galvanized pipe.

Several British Columbia farms have started using larger pen frames, 70 ft x 70 ft x 100 ft. At least one farm uses 170 ft diameter pen frames. Preliminary results indicate increased survival and faster growth rates, providing stock density is held down. Fish continually jump out of the water to renew the air in their swim bladders. Salmon larger than about 100 g (.25 lb) held in pens 20 ft x 20 ft or smaller will often hit the frames. The resulting physical trauma is often slow to heal and can be the source of secondary infection.

Nets

Nets are made of nylon and vary in mesh size depending on the size of the fish. Square- or hexagon-shaped mesh are favored because they allow an easy flow of water and are less likely to kink when the nets are stored or dried. Chinook smolts are introduced to nets when they weigh approximately .1 oz, which makes .25 in. mesh appropriate. Coho smolts weigh .4 oz when entering salt water and utilize .5 in. mesh. When they attain 9 oz, both species are normally moved to nets with 1 in. mesh where they stay until disposition. The mesh size for predator nets is 3 in. The larger the mesh, the better the water flow (oxygen and waste disposal), and the less surface area available for attachment of fouling organisms. Another method to discourage growth on nets is to apply an anti-fouling substance, usually by utilizing a copper base. Fouled nets result in water pressure on the mesh several times above normal.

Net depth is important because the fish require cooler water found at depth during the warm summer months, if surface water temperatures rise above preferred levels,. In addition, deep water provides a degree of darkness necessary to chinook salmon and affords some protection against a shallow outbreak of plankton bloom. Nets which can be lowered are another way to guard against plankton bloom, although the effectiveness of this method is not proven.

The nets have a four-year life expectancy as the ultraviolet rays weaken the nets. A net for a 50 ft x 30 ft enclosure would cost $3,000.

In choosing mesh size, the farmer must consider security, high water flows and protection from predators. Some British Columbia farmers are moving away from using .5 in. stretch mesh (.25 in. square or bar) nets, even for chinook smolts, finding that .75 in. stretch is large enough to keep fish from getting stuck in the net (gilling), plus allowing for higher water flows and less resistance to currents. After the fish reach about 100 g (.25 lb), they may be moved to 1.5 in. stretch (.75 in. bar) mesh nets. Some farmers may not use larger mesh sizes; others, particularly those with large pens (>50 ft x 50 ft) use 2 to 2.5 in. stretch mesh nets. Knotless nylon webbing is often used, particularly with smaller mesh sizes. Some farmers use knotted web for the largest sizes as it is somewhat stronger than knotless.

Net depth selected depends upon several factors. Shallow nets (<50 ft) are much easier to handle than deep nets and require less weight to hold open against currents. In areas with warm surface waters (68 degrees F, 20 degrees C), such as much of lower British Columbia and Puget Sound, deeper nets provide a less stressful environment than shallow nets. A 50 ft x 50 ft net is about the maximum size that can be employed using hand labor. Species selection is an important determinant of net depth. Rainbow trout or steelhead trout remain on the surface almost all of the time. Nets with a depth greater than 25 ft are consequently not necessary. Coho salmon held in net pens can be found anywhere from the surface down to 50 ft or deeper. Chinook salmon require the deepest nets; except during feeding they seldom venture near the surface.

National Marine Fisheries Service personnel in Alaska have found that using a white polyester net with mesh no more larger than 1.25 in. stretch offers some protection from marine mammal predation.

Anchor Systems

For greatest safety, net pens are individually anchored. Two concrete blocks weighing about 1,100 lb are placed on either side of the pen; the distance from the pen is determined by multiplying the water depth by 2.4. A chain is attached to the anchor and at the surface to a bouy from which a plastic rope leads to the net pen. The system is moored by anchors and pick-up bouys.

The number of anchors used and their mass depend upon current speeds and net pen depths. Deep net pen complexes located in areas with high current velocities (> 2.5 mph) often have to use at least one 5 to 10 ton anchor per 50 ft x 50 ft pen frame, with a scope (anchor line length to water depth) of 5:1. A very advantageous site will offer shore anchoring, such as between two islands.

HARVESTING AND PROCESSING

For coho, harvesting takes place between the 18th and 24th months when the fish average between 3 and 5 lb. Chinook are harvested between the 27th and 36th months, weighing an average of 14 lb.

No clean pattern has emerged with regard to processing. Many farms will simply sell the fish straight from the pens to an established fishing company which will transport the fish live to the company's facilities for processing and marketing. Other farms will remove the fish from the pens, stun, and bleed them in special tanks, and ice the fish before transporting them to processors. Fish treated in this manner maintain their integrity for at least 12 hr. A limited number of farms will process the fish on site and ship direct to the market. A 12 percent to 14 percent weight loss is experienced when the fish are cleaned. The head and tail remain intact. Prices vary depending on the time of year (lower when fresh, wild fish are available) and size (the larger the fish the higher the price per pound). The following prices are a reasonable estimate of what a producer will receive and a retailer will pay.

As the previous table illlustrates, the larger the fish, the higher the price per lb. The typical fish farmer stuns, bleeds, and prices his fish at a cost of approximately $.27 per lb. At this point, the fish is sold to the distributor. Outside farm gate costs include cleaning and packaging. Prices assume that fish is fresh and of excellent appearance.

Because of work involved in growing fish, most farmers prefer processing to be handled by other firms. Fish should not be bled on site because blood released in proximity to remaining fish results in them going off-feed.

Demand for most food items is relatively inelastic. That is, small differential between supply and demand can cause a moderate to large price change. During the fall of 1987, the price differential between coho and chinook salmon was negligible, reflecting perhaps 1987's small commercial harvest of coho salmon. (Typically, chinook salmon bring US$.50 to US$1 more per pound than coho.) During October and November 1987, prices received by the grower FOB Vancouver, B.C. for gutted and gilled coho salmon, wet ice packed in totes, was, in U.S. currency, about $1.70 lb for < 1 lb fish, $1.30 for 1 to 2 lb fish, $2.40 for 2 to 4 lb fish, $3.25 for 4 to 6 lb fish, and $4.20 for 6 to 9 lb fish. Chinook salmon often did not bring much more. Demand has been very weak for fish less than 2 lb dressed weight.

OVERALL SEA FARM VIABILITY

Variables

Product price, feed cost/conversion rate and the survival rate all impact significantly on fish farm profitability, Our model indicates that costs per pound are approximately $2.12. With selling prices of $3.49 to $4.43 there is sufficient leeway to allow for price fluctuations. Since feed costs account for 50 percent of total fish farm costs, dramatic increases in profit would result with an improvement in the conversion rate or a reduction in feed costs. An increase in the survival rate from 50 to 60 percent would increase sales by 20 percent and have an even greater effect on net profit. A critical variable is the Canadian/U.S. dollar relationship. B.C. farmed salmon will be marketed principally in the U.S., and all prices are quoted in U.S. dollars. If the Canadian dollar traded at par with the U.S. currency, fish prices would drop from C$4 to C$3, all things being equal.

Internal Rate of Return

In a normalized year the fish farm will show a pre-tax profit of $265,468 on sales of $721,369 or 36.8 percent on sales. IRR is a healthy 25.68 percent (after taxes), commensurate with the inherent risks.

In order to be profitable, a farm must have its fish survive, avoid overcapitalization, minimize startup and operational costs and have reasonable transportation costs.

Salmon farming has been demonstrated to be very profitable in Norway and certain other countries. High revenue:cost ratios cannot, however, be expected to last indefinitely. Virtually every manufactured item and commodity that the author is aware of is eventually produced in quantities greater than supply. If salmon farming does come to Alaska, due to our late start, would-be farmers should consider company structure and associations that will maximize operating efficiencies.

It is the author's opinion that two farm structures will emerge as the most cost-efficient:

1. A medium-sized company with five or more sites clustered together with accompanying central purchasing, handling, warehousing, net construction, handling and repair facilities, smolt production and marketing arrangements.

2. A grower's cooperative with the same capabilities as the medium-sized firm and separate ownership and operation of each grow-out site with joint ownership of purchasing, warehousing, net operations, smolt productions and marketing.

Experience in other endeavors such as commercial fishing indicates that people work harder for themselves than for a company. It may well be that Alaskans can form growers' cooperatives that will be competitive with other nations' salmon farming ventures.