ALASKA LEGISLATURE COMMITTEE FILES 1987-1988 8672
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1053

Projected Increase in U.S. Demand at current prices — 47,000 mt

Conclusion - "This result suggests that the forecasted supply of salmon to the U.S. market until 1990 could be absorbed by the market at current prices, provided no supply and distribution constraints exist . . . . In reality, average real prices for farmed salmon likely will continue to decline until 1990 but not greater than 25-30% below current prices . . . . Production efficiencies in regions like Norway and Chile are improving, and increasing competition is forcing producers to reduce the fairly healthy profit margins they have enjoyed to date."

Source: Market Access and Penetration Strategy - DPA Group, Inc.

FARMED SALMON PRICES IN U.S. (AVERAGE)

	1986	1987	Jan	Feb
Atlantics 4-6 lb.	$3.85	4.60	5.50	
Pacific Salmon 4-6 lb.				
Coho, Chile		$3.83	4.20	3.65*
Canada		$3.59		
King		$4.04		

Source: Seafare Group, Preliminary findings

* Seattle price during large scale promotion at $4.99/lb. retail. Fish did not sell well and price dropped from $4.20 to $3.65 as distributors dumped their inventories.

OBSERVATIONS CONCERNING 1987 PRICE MOVEMENTS

A disease (hitra) outbreak in Norway in late 1986 led to a surplus of farmed salmon early in 1987 as vulnerable fish were harvested early, and to a shortage later. This shortage was compounded by a poor harvest of wild cohos, resulting in unusually high prices for farmed and wild salmon in 1987 (and high prices for Alaskan fishermen). The prices of both Norwegian and Alaskan salmon can be expected to come down again as production picks up.

Source: Barry Lester, SPC Sales Manager

NOTES ON THE EUROPEAN MARKETS

It should be noted that the European market for Alaskan salmon seems to be holding up in terms of volume due to the decades old relationship between Alaskan suppliers and their markets, primarily smokers, and the price and product attributes of wild Pacific salmon - lower price, firmer flesh, redder color, larger sizes. Market share is declining, however, as the market expands, and the overall supply of both wild and farmed fish determines the price. The long-term trend is probably for continued sales volume, but lower price and eroding market share.

The European market is very important for troll and high quality net kings and cohos. The Norwegians and Scots are also starting to smoke fish for export to these markets in direct competition with the buyers of Alaskan salmon. Major efforts are underway by ASMI to promote Alaskan salmon there using Federal monies.

Source: Combination of Market Access and Penetration Strategy by DPA Group, Inc., and data in ASMI TEA application concerning sales volumes, corroborated in discussions with several major brokers.

FRESH MARKETS FOR WILD PACIFIC SALMON

Currently, much of the Washington, Oregon, and California king and coho production is marketed fresh in the restaurant, fish shop, and retail trades. The large majority of fresh kings and cohos marketed in the U.S. come from these sources. Only 10% or less of Alaskan king and coho production is sold fresh due to higher margins available in the frozen markets and the difficulties of getting fresh product out of Alaska in volume.

Source: Seafare Group, personal communication, corroborated by various Alaska producers.

COSTS OF PRODUCTION FOR FARMED SALMON

Estimated total costs of production		FOB Farm	FOB U.S. LA	Port NY
B.C. 1987	$5 Cdn/kg =	$1.70 U.S./lb.	$1.95	$2.75
Norway 1984	$31 Kr/kg =	$1.56 U.S./lb.		
at current exch rate		$2.22 U.S./lb.	3.37	3.02
Washington 1987		$2.05 U.S./lb.	2.10	2.75
Scotland 1985	3.20UKL/kg =	$1.94 U.S./lb.		
at 1987 exch rate		$2.66 U.S./lb.	?	?

Sources: B.C. - DPA Group, Inc. Overview of the B.C. Salmon Farming Industry
Norway - Norwegian Directorate of Fisheries, Study of Profitability of Fish Farms
Washington - Seafood Leader, Winter 1987 "Farming Washington's Inland Sea"
Scotland - Highlands and Islands Development Board From "Atlantic Salmon Farming Industry: Past Performance and Future Potential" by Irish Sea Fisheries Board Oct. 1986

NOTES ON LIKELY EFFECT OF INCREASED PRODUCTION AND PRICE DECLINES ON MARKETING STRATEGY OF FARMING INDUSTRY

"There appear to be few feasible market opportunities for B.C. farmed salmon other than in fresh form. At current costs of production, expected prices for farmed product as a frozen, canned, smoked, or further processed product would not yield sufficient net returns to be a viable option over the long run . . . .

Much of the value inherent in farmed fish is lost if it is sold in any product form other than fresh. As a frozen or canned product, it is unlikely to receive prices better than those prevailing for wild product . . . .

Less than top quality farmed product can be sold as fresh, frozen, or higher value-added processed form (e.g., smoked, pate product) . . . . A scarred fish exterior or extensive scale loss may be acceptable if the fish is going to be steaked or filleted."

Source: Market Access and Penetration Strategy, DPA Group, Inc., pg. 6-7.

PRODUCERS CAN BE EXPECTED TO DEVELOP VALUE ADDED LINES

Some Norwegian and Scottish salmon farming companies are building smokers in European countries and marketing their fish as finished product -- Barry Lester, Troll Producers Association

"Norwegian producers are finally offering their farmed salmon in forms other than the traditional whole, dressed, head-on. U.S. buyers have been clamoring for more frozen salmon and more convenient forms for years. This summer Frionor complied, bringing out a new line of frozen sides and loins . . . . The move to portions will allow Norwegian producers to increase exports without straining an already overburdened airline system that hauls thousands of tons of fresh salmon to the U.S. each year . . . .

Meanwhile, Alaskan salmon producers (who introduced frozen steaks and loins several years ago) are readjusting market strategies in the face of an unexpectedly low harvest." Seafood Business, November/December 1987, pg. 66.

Norwegian and Chilean salmon farmers can be expected to produce fillets and steaks from lower quality or small fish in particular as competition heats up and freight costs become more important in determining profitability. Both producers are far from the North American market and shipping heads and backbones that far is expensive. Overall, the price of head-on fresh Norwegian fish may drop about a dollar by the early 1990's. The price difference between Norwegian and B.C. fish will not hold up. Arnie Einmo, Dory Seafoods personal communication.

ALASKA'S COMPETITIVE POSITION

Water temperatures affect fish growth rates quite markedly. The optimum temperature range for salmon growout is 10-15° C. Water temperatures in areas of Alaska with large amounts of glacial runoff have colder summer water temperatures compared to areas with a more oceanic character, such as the outer coast of Southeast Alaska, outer Prince William Sound, Kodiak, and the Alaska Peninsula. Areas such as inner Prince William Sound, northern and eastern Southeast Alaska, and to some extent central Southeast Alaska, are at the lower end of the range.

Winter temperatures of colder than 4° C are considered poor for growing conditions, while 5-7° is medium, and greater than 7° is best. Areas close to the mainland such as inner Prince William Sound, upper Cook Inlet, and eastern and northern Southeast Alaska have winter water temperatures in the 2-4° range. More oceanic areas have temperatures in the 4-5° range. While techniques such as upwelling can be used to raise the temperature, this would also increase the costs.

Areas that have significant ice accumulation in the winter are not likely to be either warm enough or suitable from an engineering standpoint.

There are many other factors that affect the suitability of a site. While temperature is the most important factor in determining growth rates, other factors affecting mortality, such as algal blooms, are less common in colder waters. Evaluating the suitability of a site requires looking at quite a few factors. These have been surveyed in B.C. and that information is available. However, how the various factors affect economic viability has not been fully analyzed.

Source: Biophysical Criteria for Siting Salmon Farms in British Columbia, B.C. Ministry of Agriculture and Fisheries.

EXCHANGE RATES

Perhaps the most important factor affecting prices for both farmed and wild salmon is the strength of the dollar. With the dollar weak, export prices for salmon from the U.S. are more favorable, but the profit margin for imported salmon is less favorable. Salmon produced and consumed in the U.S. is not directly affected except to the extent that U.S. consumers must compete with foreign consumers.

The recent decline in the dollar has cut into the profit margins of foreign farmers, and they have raised their prices as much as possible. In addition, there is currently a shortage of salmon available which has also pushed the price up. Prices to fishermen and farmer alike are quite good. A turnaround in the dollar would put U.S. farmers and fishermen at a disadvantage, and make domestic markets relatively more desirable than in the weak dollar situation.

Another complicating factor is the movement of various foreign currencies relative to the dollar. For instance, the yen has appreciated considerably more than the kroner. A table follows that lays out the recent changes in exchange rates.

BACKGROUND ON CONTRACTORS

Three contractors were selected, DPA Group, Inc. to do the cost of production model, and Seafare Group working with Dr. James Anderson of the University of Rhode Island to do the market study.

DPA Group, Inc. is a medium sized Canadian consulting firm with extensive experience in farmed salmon economics in B.C. They have done market studies, industry financing studies, feed studies, and world supply estimates for the B.C. government and industry. They have much more extensive data on the actual costs in B.C. than anyone else we could find, and B.C. is obviously more similar to Alaska in terms of environment and species than other farming regions.

Seafare Group is a Seattle consulting company that edits Seafood Leader magazine and organizes seafood expositions. They will be working with Dr. James Anderson, a recognized authority on salmon markets who has also worked with DPA Group, Inc. Dr. Anderson's work is the most definitive available on market sizes and competitive interactions between competing products. He will be building on work already done and trying to answer some of the competition and market size and price questions.

There is also a considerable body of work that has been done by the B.C. and federal governments in Canada. This includes long-term modeling work that projects the impacts of increases in wild, ranched, and farmed salmon production on prices. Through cooperating with the Canadians on studies of this type the state will gain access to some of this information, which will be of use in planning for hatcheries and salmon marketing.

PP/1t0095r
Attachment
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DISTRIBUTION:

Senate Resources Committee
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Dr. James Anderson, University of Rhode Island

MEMORANDUM

State of Alaska

TO: Distribution

DATE: March 16, 1988

FILE NO:

TELEPHONE NO:

THRU:

SUBJECT: Cost of Production Model for Pen Rearing and World Markets for Salmon: Pen Reared Salmon Impacts

FROM: Paul Peyton, Program Manager Paul
Division of Business Development
Department of Commerce & Economic Development

Attached is the final report on Costs of Production. The World Market report is still being worked on due to difficulties in identifying existing domestic markets for Alaska's salmon. This information is not compiled anywhere and must be derived indirectly. The task has proved more difficult than anticipated and the completion date has been moved to March 23.

Please call if you have any questions or suggestions concerning these findings. I have asked the contractors to be available for hearings next week and they will be available the 22nd and later.

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Attachment
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02-001A (Rev. 6/85)

COST OF PRODUCTION MODEL FOR PEN-REARING OF SALMON IN ALASKA AND CURRENTLY PRODUCING REGIONS

FINAL REPORT

Prepared for:
State of Alaska Department
Department of Commerce
and Economic Development
Juneau, Alaska

Prepared by:
The DPA Group Inc.
In association with
Hatfield Consultants Ltd.
and Dr. Trond Bjorndal
Vancouver, B.C.

March, 1988

EXECUTIVE SUMMARY

A. PURPOSE OF STUDY

The purpose of this study is to determine costs of production for net-pen rearing of salmon in Alaska. The State Department of Commerce and Economic Development commissioned the study in December, 1987 in conjunction with a second study to assess the impacts of projected farmed salmon supplies on markets for Alaska's wild salmon. Together, these studies can be used to determine the potential economic viability of production in Alaska.

The study first analyzes costs of production in the regions projected to be the largest suppliers. It then develops costs of production for Alaska from an analysis of biological, environmental and logistic conditions in the state.

B. SCOPE OF STUDY

Costs of production (COP) for Norway and Scotland were developed largely from recent studies. Costs of production for Chile were developed from recent studies and from COP models developed by Hatfield Consultants Ltd. for the Chilean industry. Costs of production for British Columbia were developed from a unit cost model recently developed by the DPA Group Inc. for the industry.

Costs of production for Japan were not developed because no cost of production data is available in the public domain or from the firsthand experience of study team members. However, sufficient data was obtained from previous studies and a recent visit by a study team member to draw some important conclusions about its cost structures and its development potential. These are presented in a narrative form.

In order to assess conditions for pen rearing salmon in Alaska we conducted reviews of previous environmental studies in Alaska. We also held telephone interviews with several fisheries officials in the state of Alaska Department of Fish and Game and the National Marine Fisheries Service.

In order to develop growth data and feed conversion ratios we compared published results of the National Marine Fisheries Service salmon farming research projects at Little Port Walter and Auke Bay to those of a recent broodstock management program in British Columbia.

C. COSTS OF PRODUCTION IN CURRENTLY PRODUCING REGIONS

A summary of unit costs for farmed salmon in each major supply region is shown in Exhibit 3.13. In all cases, product is assumed to be sold in a head-on, dressed form. In the exhibit, a yield factor is applied to the unit costs previously calculated on a round weight basis. Yield factors range between 85% and 90%. Yields are highest with larger fish.

EXHIBIT A: COMPARATIVE DRESSED-WEIGHT UNIT COSTS IN US DOLLARS

	Norway	Scotland	B.C.	Chile	Japan
Unit Costs Per kg Round Wt. Basis	$5.05	$5.46	$3.32	$3.20	$5.67
Average Size	4 kg	2.5 kg	3.4 kg	2.5 kg	2.0 kg
Processing Yield	.90	.87	.89	.87	.85
Unit Costs Per kg Dressed Wt. Basis	$5.61	$6,28	$3.73	$3.68	$6.67
Unit Costs Per lb	$2.55	$2.85	$1.70	$1.67	$3.03

Exchange rates to US dollars are 1987 year-end rates:
NOK: 6.2325; UK pound: 1.8715; CDN$: 0.7693; Yen: 0.0081.

Source: As in Exhibit 3.12.

Chile and British Columbia have the lowest unit costs. Japan has the highest. However, the lower unit costs of the Chilean and British Columbian industries do not necessarily mean that higher returns are being earned in these regions. Freight costs to major markets are a significant factor. Pricing is based on numerous factors including size, species, and grade. Generally larger sizes and high quality are preferred attributes. Preferences for particular species will generally vary by area. Time of harvests and level of marketing effort will also influence net returns.

Large areas of southcentral and southeast Alaska are not suitable for salmon culture due to the presence of ice, icebergs and large river systems. Salinities are generally more consistent throughout the year in areas away from mainland waters, where blooms are also less likely to occur.

Smolt production capacity in both southcentral and southeast Alaska is likely adequate to meet potential demand from a salmon farming industry. Some fish feed production capability exists in southcentral, however fish feed would most likely be imported from Washington State or British Columbia because of more specialized production in these regions.

The following areas would be favoured for development in terms of their proximity to population centers, airports and processing plants:

- along the eastern half of southeast Alaska near Juneau, Ketchikan and Petersburg/Wrangell;

- along the western side of Baranof Island near Sitka;

- in southcentral Alaska near Kodiak, Homer, Seward, Cordova, Valdez and Whittier.

Netpen operations in these areas would also be less likely to be affected by phytoplankton blooms. However, all areas are likely to be affected by predators.

D. COSTS OF PRODUCTION IN ALASKA

The area around Ketchikan is probably the best area for development of pen rearing of salmon in Alaska because of warmer summer and winter temperatures. This area also has more constant salinities throughout the year. Chinook could be expected to reach a harvestable size of two kilograms during the second winter in saltwater. However, the Ketchikan area would have lower growth rates and higher conversion rates than in most areas of British Columbia where salmon farming occurs because of seasonally lower water temperatures.

The cost profile of a farm assumed to be located in the Ketchikan area is summarized below.

Capital Investment

Capital investment is assumed to be similar to that of British Columbia. However, cage systems and equipment are assumed to be imported and slightly more expensive. The estimated total capital investment for the farm is shown below.

	U.S. $
Sea cage system and equipment	$380,000
Facility on floating barge with equipment	250,000
	$630,000

The total capital investment is $2,520 per tonne. Like British Columbia accommodation and other facilities are assumed to be on a floating barge due to the lack of extensive road systems in the south central portion of southeast Alaska.

Unit Costs

Unit costs are shown in Exhibit B. Unit costs are $4.49 per kilogram.

EXHIBIT B: ESTIMATED UNIT COSTS PER KG FOR CHINOOK SALMON IN ALASKA

	Unit Costs (US Dollars)	%
Variable Costs		
Smolts	0.40	9
Feed	2.00	45
Stock Insurance	0.07	2
Processing	0.52	11
Interest on Working Capital	0.27	6
Total Variable Costs	**3.26**	**73**
Fixed Production Costs		
Wages	0.32	7
Overhead	0.24	5
Depreciation	0.49	11
Interest	0.18	4
Total Fixed Costs	**1.23**	**27**
Unit Costs per Kilogram	**4.49**	**100%**

Source: The DPA Group Inc.

Assuming a yield factor of about 85%, unit costs on a dressed weight basis would be $5.28/kg or $2.40/lb.

E. SUMMARY

The landed costs of farmed salmon from each major supply region and from Alaska in three major markets are shown in Exhibit C.

EXHIBIT C: COMPARISON OF LANDED COSTS PER LB IN MAJOR MARKETS (U.S. DOLLARS)

	Supply Region					
Market	Norway	Scotland	B.C.	Chile	Japan	Alaska
Los Angeles	3.80	4.17	2.06	2.63	N/A	2.77
New York	3.46	3.83	2.44	2.63	N/A	3.18
Tokyo	4.25	4.62	2.89	3.85	3.21	3.36

As indicated in the exhibit, Alaska is competitive from a cost standpoint in all markets.

However, costs at an industry level are only well known for Norway. As a result, the cost comparisons should be viewed with caution. Alaska would be selling farmed salmon in smaller sizes than Norway, Scotland and British Columbia and would compete more directly with Chile. British Columbia and Chile have cost advantages over Alaska in both Los Angeles and New York.

Alaska would also likely have a short window period in which to sell. This would also likely result in more direct competition with the Chileans.

Landed costs in major markets are sensitive to exchange rates. Fluctuating exchange rates could make Alaskan farmed salmon more or less competitive in all markets. However, the U.S. and Canadian currencies are closely linked and generally shift from each other only slowly. As a result, British Columbia would likely have cost advantages over Alaska in all major markets.

TABLE OF CONTENTS

1.0 PURPOSE AND SCOPE OF STUDY

Purpose of Study

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In order to assess conditions for pen rearing salmon in Alaska we conducted reviews of previous environmental studies in Alaska. We also held telephone interviews with several fisheries officials in the state of Alaska Department of Fish and Game and the National Marine Fisheries Service.

In order to develop growth data and feed conversion ratios we compared published results of the National Marine Fisheries Service salmon farming research projects at Little Port Walter and Auke Bay to those of a recent broodstock management program in British Columbia.

In the following section of the report we present an overview of worldwide farmed salmon production. In Section 3.0 we analyze and compare costs of production in each major supply region. In Section 4.0 we estimate costs of production in areas suitable for pen-rearing salmon in Alaska. In Section

5.0 we summarize Alaska's potential cost advantages and disadvantages.

2.0 OVERVIEW OF WORLDWIDE FARMED SALMON PRODUCTION

2.1 Introduction

Aquaculture is defined as the culturing of finfish, shellfish and aquatic plants. Species currently being cultured commercially include shrimp, oysters, carp, tilapia, catfish and salmon. Worldwide production from aquaculture has grown rapidly from about 2.6 million tonnes in 1970 to about 10 million tonnes in 1986, accounting for 10-12% of total fisheries output worldwide. China and Japan account for 35 percent of world aquaculture production. The United States produces two percent of the world total. Production is mostly catfish.

Aquaculture production can be classified as either extensive, semi-intensive or intensive. The extensive method is the simplest. Aquatic environments such as oceans and lakes are stocked at low densities with little management of the species and little or no supplemental feeding. The semi-intensive method involves higher stocking densities in smaller culture units, more intensive management and some supplemental feeding. The intensive method employs still higher stocking densities in a controlled environment.

Salmon ranching, roe on kelp and scallop spat collection in Alaska can be classified as extensive forms of aquaculture. Pond rearing of catfish and trout in several other states and seapen rearing of salmon in Washington and Maine are classified as semi-intensive production.

Intensive forms of aquaculture for the most part have only been successful with some tropical species although rearing of trout in Idaho could possibly be classified as such. Intensive rearing of Atlantic salmon in land-based tank farms has been attempted but has generally not been successful. Much greater success with rearing salmon has been achieved with netpen rearing of Atlantic salmon in Norway. Production has increased from 1,500 tonnes in 1975 to over 45,000 tonnes in 1986. Along with growing demand for fresh seafood in major markets, this industry has spurred the development of netpen rearing of salmon around the world.

The first phase of the production cycle is in a freshwater hatchery. Fertilized salmon eggs reach the smoltification stage anywhere between six and 18 months. Juveniles are then placed in netpens supported by floating cages situated in marine locations. The growout period in saltwater can take up to three years.

Supplemental feeding exists through most of the freshwater phase and virtually all of the saltwater phase. Pen-reared fish are typically fed commercially-produced pelleted feed.

World production of farmed salmon in 1986 is shown in Exhibit 2.1.

EXHIBIT 2.1: WORLDWIDE PRODUCTION OF FARMED SALMON IN 1986 (Metric Tonnes)

	Atlantic	Chinook	Coho	Total
Norway	45,675	-	-	45,675
Scotland	10,300	-	-	10,300
Ireland	650	-	-	650
Faroes	600	-	-	600
Iceland	100	-	-	100
Sweden	150	-	-	150
Finland	40	-	-	40
Spain	150	-	-	150
France	-	-	180	180
Italy	50	-	-	150
Eastern Canada	297	-	-	297
B.C.	-	89	400	489
Washington State	-	-	1,400	1,400
Chile	-	-	1,000	1,000
New Zealand	-	500	-	500
Japan	-	21	7,200	7,221
	58,012	610	10,180	68,802

Source: The DPA Group Inc. Worldwide Farmed Salmon Production Forecasts to Year 2000, Department of Fisheries and Oceans, 1988.

As indicated in the exhibit, Norway was the world's largest producer of farmed salmon in 1986, producing about two thirds of the world supply (or about 8% of the 1986 total supply of farmed and wild salmon). The other supply region with considerable Atlantic salmon production in 1986 was Scotland.

The culturing of Pacific species has been more recent and Japan was the only significant producer in 1986. In Washington State, pan-sized Coho production is well established but relatively static.

The production figures in 1986 significantly understate the production potential of British Columbia and Chile, where rapid expansions in the number and size of farms has occurred during the last three years. In British Columbia, emphasis has been with production of Chinook and Coho, with more limited production of trout and Atlantic salmon.

In a recent study conducted by the DPA Group Inc., we estimated that due to economic and biological factors, Norway, Scotland, B.C., Chile and Japan would emerge as the leading producers of farmed salmon, producing nearly 82% of the world's supply of farmed salmon by the year 2000.

A summary of actual farmed salmon production in 1986 and projections for 1990 and 2000 by major producing regions is shown in Exhibit 2.2.

EXHIBIT 2.2: PRODUCTION OF FARMED SALMON TO 2000 (tonnes)

	1990	(%)	1995	(%)	2000	(%)
Norway	100,000	63	150,000	56	200,000	51
Scotland	25,000	16	37,500	14	50,000	13
British Columbia	15,600	10	25,500	9	33,000	8
Chile	5,500	4	14,370	5	23,000	6
Japan	10,000	6	15,100	6	15,100	4
Other	2,260	1	27,590	10	72,860	18
Total	**158,460**	**100**	**270,060**	**100**	**393,960**	**100**

Source: The DPA Group Inc. Worldwide Farmed Salmon Production Forecasts to the Year 2000, Department of Fisheries and Oceans, 1988.

Norway and Scotland are projected to continue as world leaders in farmed salmon production to the end of the century because there is still significant opportunities for both industries to become more efficient and new cage technologies should allow them to continue with new site development in more exposed marine environments.

British Columbia and Chile have considerable areas with undeveloped coastlines and are generally believed to have better growing conditions than their European counterparts. To a large extent the salmon farming industries in these regions are less mature and opportunities to reduce costs are greater.

Japan on the other hand is affected by lethal water temperatures in summer which prevents long growout periods and requires harvesting within a short time period. Production is expected to continue to increase substantially however because farmed salmon can reach market size in less than one year.

The four largest supply regions are all expected to export most of their production. Japan is expected to consume all of its production to the end of the century. The major markets for farmed salmon are in the U.S., Japan and Europe. As indicated in Exhibit 2.2, the total production of farmed salmon in the year 2000 is projected to be about 0.4 million tonnes. The five major producing countries are expected to produce 0.32 million tonnes. Competition in these markets is therefore expected to increase, particularly in the U.S. where all of the major exporters currently compete.

In order to determine the viability of production in Alaska, the costs of producing pen-reared salmon in these supply regions should be compared to estimated costs of production in the state.

In the following section of the report we describe the costs of production in each major supply region.

3.0 COMPARATIVE COSTS OF PRODUCTION

3.1 Introduction

Costs of production of farmed salmon are largely determined from biological, environmental and technological factors. Industrial structure and political factors also influence costs. Industrial structure refers to the number and size of farms and their degree of vertical integration. Political factors include government support and restrictions.

However, there are several important factors to consider in the analysis. Firstly, the economics of salmon farming in most supply regions is not well understood. Industry-wide cost of production surveys in Norway, for example, have often overstated costs because many farms surveyed were in their development phases (Bjorndal, 1987). Surveys similar to those periodically undertaken in Norway have also yet to occur in British Columbia and Chile. Even if they had, the surveys would also likely not be very representative of the future cost structure of these industries since most farms established since 1984 first began production at small (pilot) scales and have yet to complete their second production cycle at larger scales.

Secondly, particularly with Pacific species, there is a considerable amount of experimentation being undertaken with genetic selection, sex manipulation, size and time of entry of smolts into saltwater, and stocking densities. The impacts of rapid improvements in broodstock and husbandry on costs of production are difficult to measure.

Empirical data from Norway suggests that there are modest economies of scale in production at the farm site level (Salvanes, 1986). However, the size of farms in Norway is restricted for the most part to small and medium-sized farms, yet in Scotland, B.C. and Chile hoirzontal integration, i.e. multi-site farms, is common. The level of vertical integration in these industries is also higher. Assessing how these structural differences and political constraints impact on costs of production are beyond the scope of this study. Structural aspects of each major supply region can however be described.

The approach adopted in the study is to develop unit costs for an efficient, industrial-scale growout site in each major supply region. This makes sense from several perspectives:

- there is a general trend worldwide towards larger, industrial scale production units;
- even though some industries have salmon farms with production capacities in excess of 1,000 tonnes annually, these tend to be spread over several

sites, in order to reduce risk; a typical site has a production capacity ranging between 100 and 400 tonnes;

- it requires an assumption as to the location of the site which simplifies estimations of freight costs for inputs and shipments of production to market;
- with increased competition for markets worldwide only the more efficient producers will likely survive.

Another factor to consider is how farms in each supply region are financed. The debt to equity ratio of farms in all regions is highly variable. To some extent they are dependent on the amount of government financial support available to farms in each region. However, as will be explained, government financial support in all regions is becoming less important. The rate of return therefore can be expected to equate to a firm's long run cost of capital. In the analysis a real rate of interest of 7% is assumed for all regions. Also land costs are disregarded.

A related factor is the tax structure to pay for the level of government support. However, only in Scotland is there a direct tax on production, although Norway may soon introduce an application fee for licences.

Also disregarded are general taxes. General tax rates vary considerably from region to region. In addition to income taxes, there are sales taxes, tax allowances and depreciation rates to consider. Comparative analyses of these by region would be very complex and are beyond the scope of the study.

Two final considerations are worthy of mention. While costs of production in various industries have been described in previous studies, they are not all in the same year and are not expressed in the same currencies. The approach taken is to first discuss costs of production in their local currencies. This should allow an easier comparison of costs in future years should exchange rates fluctuate. Costs of production from each major supply region are however translated to US dollars in the summary of this section.

The metric system is the recognized system of measurement in most countries. As a result, unit costs of production are first presented in this fashion and are also later converted to the U.S. system.

3.2 Norway

Structural Aspects

Norway is projected to continue as the world's largest producer of farmed salmon to the end of the century.

Production of Atlantic salmon in the year 2000 is forecasted to be 200,000 tonnes.

In 1985, there were about 559 growout farms with total growout capacity of about 3.4 million m^3. Also there were about 150 new licences issued in 1985 (Bjorndal, 1987). By 1987, there were also 611 smolt producers with a total capacity of about 183 million smolts (Hempel, 1988).

The most important structural aspect is the presence of the large number of small farms because both pen volume and ownership of multiple site farms are restricted. These restrictions reflect the regional development policies of the Norwegian government. With the exception of some of the earliest farms, the size of farms is limited to a maximum of 8000 m^3 of netpen capacity.

The Norwegian government is considering a proposal from the Fish Farmers Association to allow a 50% increase in the maximum size of each farm, to 12,000 m^3. Smolt production capacity is limited to one million smolts annually per unit although multiple unit ownership is permitted. Sea Farm A/S was the largest producer in 1985 and produced 9% of total output (Bjorndal, 1987).

The distribution of farms surveyed in the profitability survey in 1984 by size category is shown in Exhibit 3.2. Except for new entrants, the distribution is considered representative of the total population of farms. Most farms in the >7000 m^3 category are between 7000 m^3 and 8000 m^3. A summary of the profitability study itself is shown in Appendix B.

EXHIBIT 3.2: DISTRIBUTION OF FARMS BY SIZE CATEGORY IN NORWAY IN 1984

	<3000 m^3	3000-4999 m^3	5000-6999 m^3	>7000 m^3	Total
No. of farms	19	31	20	27	97
Percent of Total	19%	32%	21%	28%	100%

Source: Profitability Study of Fish Farms, Directorate of Fisheries, 1984.

A regional breakdown of farms in 1985 is shown in Exhibit 3.3

EXHIBIT 3.3: DISTRIBUTION OF FARMS BY REGION IN NORWAY IN 1985

	Finnmark, Troms and Nordland	Nord- and Sor-Trondelag, More and Romsdal	Sogn og Fjordane, Hordaland	Rogaland, Skagerakkyst
No. of Farms	161	183	156	59
Percent of Total Production	22%	34%	38%	6%

Source: T.Bjorndal, Fiskeoppdretts - økonomi (Economics of Aquaculture) Oslo: Cappelen, 1987.

The area with the largest amount of production includes the counties of Sogn og Fjordane and Hordaland which are located in the south. The city of Bergen is located in Hordaland. Profitability of farms in this area is also highest (see Appendix B).

The industry is supported by a strong marketing organization which negotiates with exporters minimum prices for producers and manages promotion campaigns for the industry. A levy of 1.25% of sales is assessed to both producers and purchasers/ exporters to support these activities.

Government Support

Considerable government support has been provided to the industry since its inception. Financial assistance is provided mostly through the Regional Development Fund, in the form of loans, loan guarantees and grants to new business establishments in the regions. Financial support provided by the Regional Development during the period 1961-1986 totalled 1,279.3 million kroner as shown in Exhibit 3.4. However, in 1986, the Norwegian government made a decision to reduce financial support to farms. Further, it eliminated financial support programs for smolt producers.

EXHIBIT 3.4: NORWEGIAN GOVERNMENT FINANCIAL SUPPORT TO SALMON FARMING 1961-1986 (MILLION NOK)

Year	Loans	Guarantees	Grant	Total
Total	388.0	678.9	212.4	1,279.3

Source: The Royal Norwegian Ministry of Fisheries

Significant public funds for scientific research and development are also allocated to the industry. Funding provided to government research institutions, universities, and research councils increased from 52.2 in 1984 to 152.1 million NOK in 1987 (Hempel, 1988).

The government does not provide any direct marketing support. However, two special marketing programs were recently introduced to increase exports of Norwegian seafood products to Japan and the U.S. No subsidies for export credit or transportation exists. However, between 1978 and 1980, Scandinavian Airline Systems (SAS), cooperated with major exporters in developing a transport and distribution system for fresh fish. During this period, SAS did offer preferential rates, but no longer does so. The government does not levy special taxes against the industry. However, it is considering charging an application fee for new licences.

Production Plan

Scale and Location

The analysis is undertaken for a fish farm raising Atlantic salmon in 8000 m^3 of pen volume. The farm is assumed to be relatively efficient and can support stocking densities as high as 25 kg/m^3 and therefore produce about 200 tonnes annually.

The farm is assumed to be located in an area between Bergen and Trondheim with nearby access to road connections.

Capital Investment

The total capital investment for the farmer is shown below.

	NOK (000's)
Sea cage system with equipment	1,835
Facility on land with equipment	1,765
	3,600

Source: Bjorndal, 1987.

The total capital investment is 3.6 million NOK or 1,800 NOK per tonne.

Operating Expenses

The estimated operating costs are based on the following assumptions:

- 60,000 salmon smolts are set out every year in May;
- The smolt price is 14 kr;
- The feed price is 6 kr per kilogram;
- The feed conversion ratio is 1.7:1;
- Mortalities are:
  - 7% in the first month after release
  - 4% during the next four months
  - 2% per half year for the balance of the production cycle;
- Processing costs are 5 kr per kilogram;
- Stock insurance is 3% of the average carrying value of inventory;
- Labour: 4 person years;
- Wages including benefits are:
  - 250,000 kr for a farm manager
  - 200,000 kr for three farm labourers;

- Overhead costs include insurance on fixed assets, electricity, fuel, repair and maintenance, medicine, and administration;

- Harvesting begins about 20 months after the release of smolts and continues at the same rate over the year;

- Average weight of fish is 4 kg at harvest.

With these assumptions this farm will be capable of producing about 50,000 fish for a total production of 200 tonnes per year after the third year from startup.

Fixed assets are depreciated on a straight line basis over the following periods:

	Years
Buildings	20
Seapen system and equipment	6
Site investments	50

The investment in buildings includes a processing facility. The seapen system is depreciated over a 6-year life. However the economic life of newer steel cage systems used in Norway is not yet well known. Technological obsolescence may also become a factor beyond a certain period.

Unit Costs

Unit costs are shown in Exhibit 3.5. They are derived from 1986 cost data. Unit costs per kilogram are 31.45 kroner (14.30 kr/lb).

EXHIBIT 3.5: UNIT COSTS PER KG FOR ATLANTIC SALMON PRODUCTION IN NORWAY

	Unit Costs (kr)	%
Variable Costs		
Smolts	4.20	13
Feed	10.70	35
Stock Insurance	0.85	3
Processing	4.40	14
Interest on working capital	2.00	6
Total Variable Costs	**22.20**	**71**
Fixed[1] Costs		
Wages	4.25	14
Overhead	2.00	6
Depreciation	1.70	5
Interest on capital	1.30	4
Total Fixed Costs	**9.25**	**29**
Unit costs per kilogram	**31.45**	**100**

Source: Bjorndal, 1987.

1 includes some semi-variable costs such as wages.

3.3 Scotland

Structural Aspects

Scotland is projected to produce 50,000 tonnes of farmed salmon in the year 2000 and remain the world's second largest producer of farmed salmon to the end of the century. Like Norway, Scotland will continue to produce Atlantic salmon.

No restrictions on size or ownership exist in Scotland. In 1987, 126 companies operated 196 cage sites and 11 tank sites. There were also 72 smolt production companies who operated 80 tank and 51 cage sites.

Groupings of sea farm sites by their scale of production in 1987 is shown in Exhibit 3.6. As indicated in the exhibit, the largest concentration of farms are in the 101-200 to 201-300 tonne range.

In contrast to Norway, there is more concentration of production and more vertical integration. In 1987, 45% of production was from the largest 20 farms.

EXHIBIT 3.6: DISTRIBUTION OF SEA FARM SITES IN SCOTLAND BY SCALE OF PRODUCTION IN 1987

Production (tonnes)	Number of Sites	% Share of Production
0	49	0
<10	21	0.9
10-25	41	5.5
26-50	15	4.4
51-100	24	13.9
101-200	26	30.5
201-300	13	24.2
300-400	5	12.9
400-500	1	3.4
>500	1	4.3
Total Sites	**196**	**100**

Source: Department of Agriculture and Fisheries for Scotlana.

Salmon and smolt production in various regions of Scotland are shown in Exhibit 3.7.

EXHIBIT 3.7: SALMON AND SMOLT PRODUCTION IN VARIOUS REGIONS OF SCOTLAND

	Western Isles	Northern Isles	Rest of Scotland	Totals
1987 salmon (tonnes)	1,830	2,211	8,680	12,721
1987 smolts (numbers '000)	2,059	112.8	11,122.6	13,294.4

Source: Department of Agriculture and Fisheries for Scotland.

Most production is off the mainland of Scotland, particularly on its western shores.

The Scottish Salmon Growers Association provides marketing support to the industry through advertising campaigns. The Association charges a levy on smolts in inventory to pay for the costs of promotion.

Government Support

The Highlands and Islands Development Board has been central in channelling UK government financial support to the industry. Most farms are sited within the area covered by its jurisdiction. Between 1965 and the end of 1987 the Board itself had provided a total of 50.7 million pounds in financing to the industry. Most of this was in the form of grants which after a qualifying period, are non-repayable, but part constituted loans and equity participation. During the same period, about 4.1 million pounds have gone to scientific research and development. Two EEC programs, FEOGA and IDP, have also provided funding to the industry. However, like HIDB, funds have not increased with the growth in the industry.

A royalty is now being collected by the government on output. A royalty of 50 pounds per metric tonne applies to farms with production in excess of 50 tonnes. For those with less than 50 metric tonnes of production, a royalty of 45 pounds per metric tonne applies. Royalties in 1987 could have represented as much as 15% of the research and development funds provided to the industry through HIDB.

Production Plan

Scale and Location

The analysis is undertaken for a fish farm raising Atlantic salmon at annual production levels of 200 tonnes.

The farm is assumed to be located on the Scotland's west coast.

Capital Investment

The total capital investment for the farms is shown below.

	Pounds Sterling (000's)
Sea cage system and equipment	220.0
Facility on land with equipment	146.3
	366.3

Source: Shaw and Muir, 1987.

The capital investment is 0.366 million pounds or 1,831.5 pounds per tonne.

Operating Expenses

The estimated operating costs are based on similar assumptions to those of Norway except for the following:

- smolt prices are slightly lower at 1.25 pounds
- smolt to harvest survival rate is 80%
- wages are also lower:

Farm Manager	25,000 pounds
Labour	7,500 pounds

The average size of fish at harvest is also lower at 2.5 kg. As a result, about 100,000 smolts are initially required to reach production of 200 tonnes.

Unit Costs

Unit costs are shown in Exhibit 3.8. They are derived from 1986 cost data. Unit costs per kilogram are 2.92 pounds (1.33 pounds/lb).

EXHIBIT 3.8: UNIT COSTS PER KG FOR ATLANTIC SALMON PRODUCTION IN SCOTLAND

	Unit Costs (Pounds)	%
Variable Costs		
Smolts	0.65	22
Feed	1.00	34
Stock Insurance	0.10	3
Processing and Packaging	0.20	7
Interest on working capital	0.12	4
Total Variable Costs	**2.07**	**72**
Fixed Costs		
Wages	0.28	9
Overhead	0.27	9
Depreciation	0.17	6
Interest on capital	0.13	4
Total Fixed Costs	**0.85**	**28**
Unit Costs per Kilogram	**2.92**	**100%**

Source: S.A. Shaw and J.F. Muir, Salmon: Economics and Marketing, Croom Helm, 1987.

3.4 British Columbia

Structural Aspects

British Columbia is projected to be the world's third largest producer of farmed salmon by the end of the century. Production is forecast to be 33,000 tonnes in 2000, 75% of which is projected to be comprised of chinook salmon.

No restrictions on size or ownership exist in British Columbia. In 1987, 85 farms operated 115 sites. Smolt production is concentrated to a few producers. Eight smolt producers produced about 90% of production in 1987. Total production capacity was about 30 million smolts. (B.C. Salmon Farmers Association).

No breakdown by production size or geographic area was available for 1987. However, DPA conducted a study in 1986 which projected the number and size of farms for 1987 through to 1990 (the projected number of farms for 1987 was 82 farms operating 113 sites). The study projected a trend towards increased concentration of production: 60% of the production in 1990 would be from 12% of the farms. The area projected to have the largest amount of production through to 1990 was the Sunshine Coast.

The study also projected a trend towards more vertical integration, including backward integration by fish processing companies through the provision of working capital financing to farms.

Technologies employed are similar to those of Norway and Scotland. However, stocking densities, particularly with chinook, are much lower than in the Norwegian or Scottish industries. Stocking densities are generally less than 8 kg/m^3, significantly lower than in Norway.

The B.C. Salmon Farmers Association (BCSFA) provides marketing support to the industry. The BCSFA began a generic promotion campaign in 1987. A levy was previously charged on wild salmon eggs distributed to producers. In 1988, the levy is being shifted to smolt sales, since increasingly the industry is becoming self sufficient in egg supplies.

Government Support

Direct financial assistance to the industry has been mostly loans provided by a joint federal/provincial program for industrial development and an agricultural credit program of the provincial Ministry of Agriculture and Fisheries. The total outstanding loans at the end of 1987 from these programs were $3.8 million (57 loans) and $0.3 million (11 loans) respectively. The joint federal/provincial program expires in 1988.

Aquaculture is also a qualifying industry for a provincial venture capital corporation (VCC) program in which investors can qualify for a credit of up to 30% of their investment. A total of five aquaculture VCC's have been formed.

Support for scientific research and development is also being provided by the provincial Ministry of Agriculture and Fisheries and the federal Department of Fisheries and Oceans. Total support in 1987 was about $3 million.

There are no special taxes or royalties levied against the industry. Annual lease costs for aquatic land are ususally less than $2,000.

Production Plan

Scale and Location

The analysis is undertaken for a fish farm raising chinook salmon at an annual production level of 250 tonnes.

The farm is assumed to be located in the Sunshine Coast area.

Capital Investment

The total capital investment for the farm is shown below.

	$Cdn (000s)
Sea cage system and equipment	442
Facility on floating barge with equipment	308
	750

Accommodation and storage facilities are assumed to be on a floating barge. The total capital investment is $3,000 per tonne.

Operating Expenses

The estimated operating costs are based on the following assumptions:

- 104,000 salmon smolts are set out every year in June;
- the smolt price is $.75 which includes a BCSFA levy of $.08;
- the feed price is $1.00 per kg;
- the feed conversion ratio ranges between 1.3 and 1.9;

- Mortalities range between 1% and 3% per month;

- Processing costs are $0.77 per kg;

- Stock insurance is calculated as 4% of the average carrying value of inventory;

- Labour - 4 person years;

- Wages including benefits are:

General Manager	$35,000
Farm Manager	25,000
Labourer 1	17,500
Labourer 2	17,500
	$95,000

- Fixed costs include insurance on buildings and equipment, electricity, fuel, repair and maintenance, medicine and administration;

- Harvesting occurs between 16 and 24 months in saltwater;

- Average weight of fish is 3.4 kg at harvest.

With these assumptions the farm will be capable of producing about 73,500 fish for a total production of 250 tonnes per year. The harvest weight of 3.4 kg reflects the current production strategies of most farms. However, the average size of chinook harvested to date has been less than 3 kg (B.C. Salmon Farmers Association).

Fixed assets are depreciated on a straight line basis over the following periods:

	Years
Buildings	20
Seapen system and miscellaneous equipment	6
Site investments	50

The economic life of fixed assets in British Columbia is assumed to be the same as Norway's and Scotland's because similar technologies are employed in each industry.

Unit Costs

Unit costs are shown in Exhibit 3.9. They are derived from 1987 cost data. Unit costs are $4.32 per kilogram ($1.96/lb).

EXHIBIT 3.9: UNIT COSTS PER KG FOR CHINOOK SALMON IN BRITISH COLUMBIA

	Unit Costs $Cdn	%
Variable Costs		
Smolts	0.26	6
Feed	1.47	34
Stock insurance	0.09	2
Processing and packaging	0.77	18
Interest on working capital	0.29	7
Total Variable Costs	**2.88**	**67%**
Fixed Costs		
Wages	0.38	9
Overhead	0.30	7
Depreciation	0.56	13
Interest on capital	0.20	5
Total Fixed Costs	**1.44**	**33%**
Unit Costs per Kilogram	**4.32**	**100%**

Source: The DPA Group Inc., 1988

3.5 Chile

Structural Aspects

Chile is projected to be the world's fourth largest producer of farmed salmon by the end of the century. Production by the year 2000 is forecast to be 23,000 tonnes, about 60% of which is expected to be coho salmon. The balance is expected to be mostly Atlantic salmon, with only limited production of chinook salmon. Chinook production is mostly limited by shortages of eggs available for import.

In 1986, 22 farms producing salmon and/or trout were in operation.

No restrictions on size or ownership exists. Groupings of farms by their installed capacity in 1986 is shown in Exhibit 3.10. The data includes an unspecified amount of trout production capacity.

EXHIBIT 3.10: DISTRIBUTION OF FARMS IN CHILE BY SCALE OF OPERATION IN 1986

Production Range	No. of Farms	Total
1-10	3	14
11-100	3	14
101-300	6	27
301-500	6	27
501-1000	2	9
>1000	2	9
	22	100%

Source: Ricardo Mendez Zamorano Desorrollo Y Estado De Situacian Actual De La Salmoniculture En Chile, Fundacion Chile, 1987.

Salmon production in Chile is concentrated in an area south of Puerto Montt.

The industry is characterised by sizeable companies rather than small family operations. A number of the companies also own seafood processing plants in southern Chile.

Growing conditions in Chile are generally considered to be slightly better than British Columbia. To date the industry has been mostly reliant on imports of coho salmon from the states of Washington and Oregon. Typically, juveniles are placed in saltwater after 10 months in freshwater which is usually in December when they have reached 35 grams. The reliance on wild coho eggs has meant that production has been mostly harvested after 12 to 16 months in saltwater in sizes ranging from 1.5 to 2.5 kilos. If fish are not harvested in this time period, early maturation usually occurs and they cannot be held over until the following fall and winter.

Government Support

No direct financial assistance is provided to the industry. There are also no export credits or transportation subsidies. Some support for research and development is provided through Fundacion Chile, CORFO and some state universities. Some marketing support is also provided through PROCHILE (Mendez (1988).

Production Plan

Scale and Location

The analysis is undertaken for a fish farm raising coho salmon at annual production levels of 200 tonnes.

The farm is assumed to be located in an area south of Puerto Montt.

Capital Investment

The total capital investment for the farm is shown below (prices in Chile are usually quoted in U.S dollars):

Sea cage system and equipment	$124,000
Facility on land with equipment	83,000
Total	**$207,000**

Source: Mendez, 1987.

The total capital investment is about $1,000 per tonne.

Operating Expenses

The estimated operating costs are based on the following assumptions:

- 93,000 salmon smolts are set out every year in December;
- the smolt price is $0.40;
- the smolt size is 35 grams;

- the feed price is $0.65 per kg;
- the average feed conversion ratio is 2:1;
- Mortalities are:
  - 7.5% in the first quarter;
  - 4.5% in the second quarter;
  - 1.5% in subsequent quarters;
- Labour:

Farm General Manager	14,400
Operations Manager	12,000
Technical Support (2 Advisors)	24,000
Labourers (17)	20,400
	70,800

- Fixed costs include annual lease costs, insurance, electricity, fuel, repair and maintenance, medicine, and administration;
- Harvesting begins in mid December, 12 months after the release of smolts and continues until the end of March;
- Average weight of fish is 2.5 kg at harvest.

With these assumptions the farm will be capable of producing about 80,000 fish for a total production of 200 tonnes per year.

Fixed assets are depreciated on a straight-line basis over the following periods:

	Years
Building	10
Seapen system and miscellaneous equipment	3
Site investments	25

Fixed assets are depreciated over fewer years than in Europe or British Columbia because lower quality designs, i.e. wooden cages, are typically used.

Unit Costs

Unit costs are shown in Exhibit 3.11. They are derived from 1987 cost data. Total unit costs are $3.20 per kilogram ($1.45/lb).

EXHIBIT 3.11: UNIT COSTS PER KG FOR COHO SALMON PRODUCTION IN CHILE

	Unit Costs USD	%
Variable Costs		
Smolts	0.19	6
Feed	1.21	38
Stock insurance	0.10	3
Processing	0.50	16
Interest on working capital	0.18	6
Total Variable Costs	**2.18**	**69**
Fixed Production Costs		
Wages	0.60	18
Overhead	0.26	8
Depreciation	0.09	3
Interest on capital	0.07	2
Total Fixed Costs	**1.02**	**31**
Unit Costs per Kilogram	**3.20**	**100%**

Sources: Hatfield Consultants Ltd. (1987), Mendez (1987), Wurmann (1987).

3.6 Japan

Japan is projected to be the world's fifth largest producer of farmed salmon by the end of the century. Production by the year 2000 is projected to be 15,000 tonnes and almost entirely comprised of coho salmon. Virtually all production in 1986 was coho salmon. About 20-25 tonnes of chinook was reportedly produced. Experimentation with Atlantic salmon rearing is also being undertaken.

Production is largely at small scales and organized through cooperatives. In 1986, a total of 19 organizations operated 264 sites. Average production per site in 1986 was 28 tonnes, indicating small scale production. Bjorndal confirmed this in a visit in 1987. Further he indicate low level technologies for cage design and feeding systems are employed.

Eighty seven percent of the sites were located around Miyagi, near the northeast end of Honshu. In 1986 these sites produced 81% of the total production.

Although the scale of growout sites is very small compared to other industries, processing and marketing is concentrated to three large processing companies, most notably Nichero Fisheries.

Since the industry began in 1973, it has relied on imports of coho salmon eggs from Washington and Oregon.

Feed production is also not undertaken at a large scale. Supplies of mackerel, sardine and mysid shrimps are available year around for feed production from local parts.

Government Support

No direct financial assistance has been provided to the industry.

Production Plan

Coho smolts are usually one year olds (SI's) when they are placed in saltwater at average sizes of 150 grams from mid-October to early November. The fish are then raised in net pens for about 7-9 months at stocking densities of 10 to 15 kg/m^3.

The coho can grow to 2.5 kilograms by July and are harvested between 1.5 kg and 2.5 kg. Coho must be harvested before August because lethal temperatures are reached.

Unit Costs

Unit cost data for Japan is not available in the public domain. However, the production cost of farmed salmon in 1986 was reportedly about 700 yen/kilo (318 yen/lb) (Sato, 1987). Prices for eggs were six yen per egg. Prices for smolts weighing between 100 grams and 250 grams were 1,000-1,500 yen per tonne. Feed consists of moist pellets manufactured from mostly raw fish (sardine, mackerel and filefish) with some formulated feed added.

3.7 Summary

A summary of capital investment per tonne is shown in Exhibit 3.12.

EXHIBIT 3.12: COMPARATIVE CAPITAL INVESTMENT PER TONNE IN U.S. DOLLARS

	Norway	Scotland	B.C.	Chile	Japan
Capital Investment per tonne (local currency)	18,000	1,832	3,000	238,140	N/A
Capital Investment per tonne					
1987	2,888	3,428	2,308	860	-
1986	2,432	2,701	2,173	1,000	-

Conversion to U.S. dollars are at 1987 (1986) year-end rates:[1]
NOK: 6.2325 (7.400); U.K. pound: 0.5343 (0.6782);
Cdn $ 1.2998 (1.3805); Peso: 238.14 (204.73).

1 International Financial Statistics, Vol. XLI No. 1, January, 1988. International Monetary Fund, Washington, D.C.

Scotland has the highest capital investment per tonne. The significant difference in capital costs between Scotland and Norway in 1987 is largely due to exchange rate fluctuations. However, sites are generally more costly to develop in Scotland because they are located in areas more remote from population centres. Also, sites with greater exposure are more common in Scotland. In addition, cage systems tend to be imported from Norway. British Columbia has lower investment costs than Norway because facilities are assumed to be on floating barges and they do not conclude processing facilities.

The economic life of fixed assets in the regions is assumed to be the same since similar technologies in cage design are employed in each area. Chile has the lowest capital investment cost per tonne because of the use of lower quality cage systems and lower building costs. However the economic life of fixed assets is assumed to be half that of other regions. The capital investment per tonne in Japan is not known but is assumed to be similar to Chile's.

A summary of unit costs for farmed salmon in each major supply region is shown in Exhibit 3.13. In all cases, product is assumed to be sold in a head-on, dressed form. In the exhibit, a yield factor is applied to the unit costs previously calculated on a round weight basis. Yield factors range between 85% and 90%. Yields are highest with larger fish.

EXHIBIT 3.13: COMPARATIVE DRESSED-WEIGHT UNIT COSTS IN US DOLLARS

	Norway	Scotland	B.C.	Chile	Japan
Unit Costs Per kg Round Wt. Basis	$5.05	$5.46	$3.32	$3.20	$5.67
Average Size	4 kg	2.5 kg	3.4 kg	2.5 kg	2.0 kg
Processing Yield	.90	.87	.89	.87	.85
Unit Costs Per kg Dressed Wt. Basis	$5.61	$6,28	$3.73	$3.68	$6.67
Unit Costs Per lb	$2.55	$2.85	$1.70	$1.67	$3.03

Exchange rates to US dollars are 1987 year-end rates:
NOK: 6.2325; UK pound: 1.8715; CDN$: 0.7693; Yen: 0.0081.

Source: As in Exhibit 3.12.

Unit costs in local currencies are not all expressed for the same years. As previously indicated they are not converted to US dollars in the year collected because the impact of fluctuations in exchanges rates would then be difficult to gauge. In addition a domestic inflation factor for each country since the year the data is collected is also not applied because for the most part input costs do not correlate directly with general price indices. For example, the cost of feed is largely dependent on the world price of fish meal and fish oil which can fluctuate significantly due to biological factors such as El Nino's in South America.

As indicated in the exhibit, Chile and British Columbia have the lowest unit costs. Japan has the highest. However, the lower unit costs of the Chilean and British Columbian industries do not necessarily mean that higher returns are being earned in these regions. Freight costs to major markets are a significant factor (these are discussed in Section 5.0). Pricing is based on numerous factors including size, species, and grade. Generally larger sizes and high quality are preferred attributes. Preferences for particular species will generally vary by area. Time of harvests and level of marketing effort will also influence net returns.

Exchange rates can affect costs significantly, particularly since the largest producers (except Japan) export most of their production. Exhibit 3.14 compares the same unit costs translated at average rates in 1986.

EXHIBIT 3.14: IMPACT OF EXCHANGE RATES ON UNIT COSTS PER LB

	Norway	Scotland	B.C.	Chile	Japan
Unit Costs/lb 1987	2.55	2.85	1.70	1.67	3.03
Unit Costs/lb 1986	2.18	2.25	1.60	1.44	2.35
% Change	7%	27%	6%	6%	29%

Exchange rates to U.S. dollars are at 1987 (1986) year-end rates:
NOK: 6.2325 (7.400); U.K. pound: 0.5343 (0.6782);
Cdn $ 1.2998 (1.3805); Peso: 238.14 (204.73); Yen: 0.0081 (0.0063)

Source: As in Exhibit 3.12

The exhibit indicates that all unit costs expressed in US dollars were lower in 1986. The impact was most dramatic with the change in value of the pound sterling. The analysis partially explains some trends in the industry, including less than anticipated sales by Norway in the US in 1987. Norway did however place more emphasis on penetrating the Japanese market. In 1987 Chile also began selling to Japan.

4.0 COST OF PRODUCTION MODEL FOR ALASKA

4.1 Introduction

Development of likely costs of production in Alaska requires an analysis of conditions for rearing. British Columbia is considered the best model for analysis of Alaska's potential for three important reasons:

- British Columbia more closely parallels Alaska socio-economically and environmentally than other regions;
- the predominant species reared in British Columbia are Pacific species and these would also be the predominant species reared in Alaska because of restrictions on imports of exotic species into the state;
- British Columbia and Alaska would likely serve similar markets.

In this section we summarize the following analysis described in a technical appendix prepared by Hatfield Consultants Ltd.:

- general environmental and logistic conditions for pen-rearing salmon in Alaska;
- differences in growth and feed conversion rates between British Columbia and Alaska.

We then develop likely unit costs of production for Alaska from these for the area with the best development potential.

4.2 Environmental and Logistic Conditions

Conditions which are important in considering the location of a netpen site can be classified under environmental or logistic categories.

Environmental factors include water quality characteristics and potential problems with plankton blooms and predators. Logistic factors include access to critical inputs such as smolts, feed, labour and transportation routes.

These conditions are discussed for southcentral and southeast Alaska, the two areas which according to state fisheries officials contacted, development of net-pen rearing of salmon would most likely occur.

4.2.1 Physical Marine Conditions

An overview of ice formation and iceberg conditions, temperatures and salinities in southcentral and southeast Alaska is presented. The information is then used to develop assumptions about growing conditions, growth rates and feed conversions.

Southcentral Alaska

Ice Formations and Icebergs

Ice formation and the presence of icebergs in embayments and low winter air temperatures impose constraints on development of netpen sites in southcentral Alaska; in particular, these are:

- the presence of pack ice and fast ice in Cook Inlet;
- the presence of ice and icebergs in embayments connected to Prince William Sound and near Seward; and
- the potential for ice formation on floating structures.

Apart from the presence of sea ice and glacier ice in embayments in southcentral Alaska, the air temperature and wind conditions in that area make it generally susceptible for ice formation on floating structures (La Belle et. al. 1983).

Water Temperatures

Studies have shown that growth of salmon fed normal rations is highest at approximately 15°C (Brett, 1982). Below 5°C, conversion drops off appreciably. Mean winter surface temperatures in South Central can be expected to be between 2.5 and 5.0°C and mean summer surface temperatures can be expected to range between 7°C and 13°C.

Salinity

Lower and fluctuating salinities can affect the physiological condition of the salmon (i.e. in relation to the osmoregulatory adaptation to ambient salinity levels) and can influence outbreaks of harmful phytoplankton. In other words sudden variation in salinity levels can cause stress in fish. Generally growth is best under conditions of moderate salinity.

Xiong and Royer (1984) state that average surface salinities in summer are 27.3‰ and in winter are 31.2‰, based on intensive studies near Seward. At greater depths (i.e. 250 m), salinities are approximately 33‰ year round. Colonell (1980) and Muench and Nebert (1973) describe the presence of relatively fresh water lying in a thin surface layer in Valdez Arm and Port Valdez during summer and autumn. Muench and Nebert (1973) indicate that minimum mean surface

October period, though salinities in the upper 20 m were, at times, less than 1% near the head of Port Valdez (in late July/early August). Lower surface salinities over the summer period are attributed to freshwater runoff from land areas and high precipitation.

Southeast Alaska

Icebergs

Icebergs are present in several bays and straits in northern and eastern Southeastern Alaska (LaBelle et al, 1983):

. Cross Sound, Icy Strait and Glacier Bay;
. Taku Inlet;
. Tracy Arm and Endicott Arms; and
. the end of Frederick Sound.

The presence of icebergs suggests a potential for damage to floating structures and, in general, these areas would be avoided. Also, the icebergs apparently can greatly reduce summer temperatures in surface waters (Pickard, 1967).

Water Temperatures

Mean monthly surface temperatures for the coastal waters along southeast Alaska (Brower et al, 1977) and five lighthouse installations (Jones, 1978) in southeast Alaska and in Auke Bay near Juneau (Bruce et al, 1977) were analyzed.

These data show mean high temperatures in summer to range between 9.0^{c} and 14.6^{o}C. Mean low temperatures in winter range between 2.3^{o}C and 5.2^{o}C. The mean low temperature for the general coastal area (Brown et al, 1977) is slightly higher than these values at 6.0^{o}C.

Salinities

Larger rivers along the mainland shoreline can produce lower and fluctuating salinities (Pickard, 1967) and consequently make nearby areas unsuitable for locating netpens for adult growout. These areas include the mouths of the Stikine River, Taku River, Unuk River, Chilkat River and Speel River.

4.2.2 Phytoplankton and Marine Mammals

Phytoplankton

Two phytoplankton species, Chaetoceros convolutus and Heterosigma akashiwo, have caused serious mortalities amongst salmon cultured in marine netpens in British Columbia. Chaetoceros convolutus causes asphyxiation through physical damage of the gills by silicate processes projecting from the diatom. Heterosigma akashiwo can also lead to asphyxiation because they are toxic to salmon and cause irritation and mucus buildup in gills. Conditions appear suitable for both species in southcentral and southeast Alaska (Gaines and Taylor, 1986). Chaetoceros diatoms have been responsible for chinook salmon mortalities in seapens at Little Port Walter (National Marine Fisheries Service, unpublished). Chaetoceros convolutus has also been collected during surveys near Valdez in Prince William Sound (Horner et al 1973.) The occurrence and intensity of phytoplankton blooms vary greatly both geographically and temporally and prediction is difficult (Gaines and Taylor, 1987). In general, Heterosigma blooms tend to occur in early summer, often in association with lower salinities resulting from increasing river flow, while Chaetoceros blooms tend to occur in the late summer or fall.

Harmful phytoplankton could affect sites in both southcentral and southeast Alaska. As in British Columbia, the effects on production could be direct mortalities or reduced growth when oxygen depletion occurs and rations are restricted.

Marine Mammals

Marine mammals such as otters and sea lions have affected production at sites in British Columbia by killing fish in pens, by damaging netpens allowing fish to escape, and by causing high stress levels in the fish thereby reducing growth rates. A National Marine Fisheries Service report (unpublished) indicates that otters, seals and possibly sea lions have killed fish at the experimental facilities near Little Port Walter. Steller's sea lions and harbour seals occur essentially along the entire Gulf of Alaska coastline (U.S. Department of the Interior, 1984).

Predation from marine mammals will likely be a similar problem in southcentral and southeast Alaska waters to that which occurs in British Columbia. This will require investment in predator control measures such as predator nets. Again, density levels would likely be kept low so that if stress develops when predators are nearby (but do not necessarily attack fish in the pens), it would not compound stress already resulting from high densities.

4.2.3 Smolt Production Capabilities

Southeast Alaska

Four state hatcheries in southeast Alaska produce chinook salmon and three hatcheries produce coho salmon (Hansen, 1987). In addition, 10 private non-profit hatcheries operated by regional aquaculture associations and other non-profit groups raise chinook or coho or are permitted to raise these species.

In 1986, nearly 5 million chinook eggs were collected from these facilities and more than 2.7 million juvenile chinook were released. Similarly, slightly more than 4 million coho eggs were collected and 1.5 juvenile coho were released.

In 1986, private non-profit hatcheries in southeast Alaska had total permitted chinook egg capacities of 6.73 million and total permitted coho egg capacities of 15.47 million eggs. Most fry production of both species is in the Whitman Lake and Neets Bay hatcheries operated by the Southern Southeast Regional Aquaculture Association.

Southcentral Alaska

Five state hatcheries in southcentral Alaska produce chinook salmon and five hatcheries produce coho salmon. In 1986, 1.5 million chinook eggs were collected and 1.5 million juvenile chinook were released. Slightly more than 6.5 million coho eggs were collected and 7 million coho juveniles were released.

Three private non-profit hatcheries operated by regional aquaculture associations and other non-profit groups raise chinook or coho salmon or are permitted to raise these species. In 1986, the private non-profit hatcheries had total permitted chinook egg capacities of 1.15 million and total permitted coho egg capacities of 3.1 million.

Clearly, a large smolt production capability exists in both southcentral and southeast Alaska and this production is spread throughout each region. Hansen (1987) indicates that a number of hatcheries are constructed below lakes and water intakes in the lakes are placed at different depths so temperatures can be adjusted. This means juvenile growth rates and smolt timing can be manipulated to achieve release objectives.

4.2.4. Fish Feed

Currently there is fish feed production capacity in southcentral. However, capacity is limited and technologies employed in production are not as advanced as those in Europe, British Columbia or Washington State.

The main ingredients in commercial fish feeds are fish meal and fish oil. These are manufactured in the reduction process from whole fish or fish waste from the processing sector. Alaska's reduction industry is not well developed, despite the availability of significant quantities of fish waste. In addition the reduction plants in Alaska produce fish meal and fish oil which is unsuitable for fish feed. According to representatives of a fish feed manufacturer in Washington State, if a new feed plant were to be constructed, it would likely be constructed in tandem with a new reduction plant, both of which would require significant capital investment. Alaska would more likely be supplied by fish feed manufacturers in Washington State or British Columbia since transport by barge to Alaska is not a significant cost.

4.2.5 Potential Development Areas

Initial development could be expected to occur in suitable bays or shoreline areas (protected from high winds or waves) away from areas affected by water ice cover, icebergs and large river systems and as close to transportation centers and processing/packing facilities as possible.

Small to medium-sized communities having airport and port facilities are distributed throughout both southcentral and southeast Alaska. Apart from the major airport in Anchorage, smaller airfields and port facilities are located throughout the area (e.g., Homer and Seward).

Larger airports and port facilities are situated along eastern southeast Alaska (Juneau, Petersburg, Wrangell and Ketchikan) and Sitka. These are also the major population centers. Ideally, fish farms would locate within three to four hours by boat from logistic centers to minimize the amount of time that harvested fish are in transit prior to boarding flights to market areas.

The following areas would be favoured for development in terms of their proximity to population centers, airports and processing plants:

- along the eastern half of southeast Alaska near Juneau, Ketchikan and Petersburg/Wrangell;
- along the western side of Baranof Island near Sitka;
- in southcentral Alaska near Kodiak, Homer, Seward, Cordova, Valdez and Whittier.

4.3 Growth and Conversion Rates

4.3.1 Generalized Temperature Regimes

The temperature data reviewed for South Central and southeast were used to develop four generalized temperature regimes in which salmon culture might take place:

- relatively cool winter temperatures and warm summer temperatures (that might occur in bays in southcentral Alaska and near Juneau);
- relatively warm winter temperatures and warm summer temperatures (that might occur in bays near Ketchikan);
- relatively warm winter temperatures and cooler summer temperatures (that might occur in the Frederick Sound/Petersburg area); and
- relatively cool winter temperatures and cool summer temperatures (that might occur in the northern inlets of southeast Alaska close to iceberg areas).

Clearly, general good-case and poor-case growing conditions would be, respectively, warm winter/warm summer conditions and cool winter/cool summer conditions. Since specific conditions can vary from site to site and from year to year, extreme best case and worst case conditions would likely lie outside these general scenarios.

Probable monthly growth rates for chinook were developed for a scenario of relatively warm winter temperatures and warm summer temperatures that might occur in the south central portion of southeast Alaska. Chinook would likely be preferable to coho for net pen rearing in Alaska since they have shown greater survival rates than coho during longer growout periods in British Columbia (B.C. Salmon Farmers Association). The fish sizes and growth rates obtained for chinook salmon at Little Port Walter and at five locations in British Columbia, together with unpublished growth rate data from the Pacific Biological Station in Nanaimo, B.C., have been used to develop the growth profile. These are shown in Exhibit 4.1.

Juvenile chinook are assumed to be placed into saltwater in June at 7 grams. In the warm winter, warm summer temperature regime, they are projected to reach a harvestable size of at least 2 kilograms after 21 months and are projected to grow to 2.5 kilograms after 24 months in saltwater.

In the cool winter/cool summer temperature regime, chinook are projected to reach only about 1 kilogram after 24 months in saltwater. If chinook were held over a third summer and harvested in October they would still be less than 2 kilograms.

4.3.2 Feed Conversion

Feed conversion rates are influenced by environmental variables (such as temperature, salinity, photoperiod, oxygen concentration) and operational variables (such as fish size, ration, food quality). Food conversion efficiency is normally greater for smaller fish sizes, decreasing as the fish grow (Brett and Groves, 1979). Over a given temperature range, on the other hand, food conversion efficiency usually reaches a maximum at a particular temperature and is lower at both lower and higher temperatures. Similarly, the optimum ration amount for maximum food conversion is normally lower than the maximum ration that the fish will consume. In turn, maximum conversion efficiency occurs at a lower ration quantity, as temperature is reduced below the optimum. Generally, optimum feed conversion efficiency for salmon appears to occur at temperatures between 10^{o}C and 15^{o}C at ration levels at 60-90% of maximum.

EXHIBIT 4.1: ESTIMATED GROWTH RATES FOR CHINOOK SALMON GROWN UNDER TWO GENERALIZED MEAN MONTHLY TEMPERATURES REGIMES IN SOUTHEAST ALASKA

	WARM WINTER/WARM SUMMER				COOL WINTER/COOL SUMMER			
	Temp.	Approx. Size (grams)	Daily Growth Rate (%)	Food Conver-sion	Temp.	Approx. Size (grams)	Daily Growth Rate (%)	Food Conver-sion
June	10.0	13	2.2	1.5	8.0	12	2.0	1.7
July	11.0	25	2.1	1.5	9.5	24	2.1	1.7
August	12.0	49	2.2	1.5	9.5	45	2.1	1.7
September	10.5	92	2.1	1.5	8.5	79	1.9	1.7
October	7.5	125	1.0	1.7	7.5	108	1.0	1.9
November	5.0	149	0.6	1.7	5.0	125	0.5	1.9
December	3.5	174	0.5	1.7	3.5	133	0.2	1.9
January	5.0	197	0.4	1.7	3.5	142	0.2	1.9
February	5.0	222	0.4	1.6	3.0	146	0.1	1.8
March	4.5	243	0.3	1.6	5.0	165	0.3	1.8
April	5.0	266	0.3	1.6	5.0	165	0.3	1.8
May	6.0	301	0.4	1.6	6.0	187	0.4	1.8
June	10.0	406	1.0	1.7	8.0	237	0.8	1.9
July	11.0	570	1.1	1.7	9.5	323	1.0	1.9
August	12.0	851	1.3	1.7	9.5	439	1.0	1.9
September	10.5	1181	1.1	1.7	8.5	575	0.9	1.9
October	7.5	1512	0.8	1.9	7.5	736	0.8	2.0
November	6.0	1704	0.4	1.9	5.0	805	0.3	2.0
December	5.5	1870	0.3	1.9	3.5	830	0.1	2.0
January	5.0	1990	0.2	1.9	3.5	856	0.1	2.0
February	5.0	2104	0.2	3.0	3.0	881	0.0	2.1
March	4.5	2170	0.1	2.0	3.0	908	0.0	2.1
April	5.0	2236	0.1	2.0	5.0	936	0.1	2.1
May	6.0	2454	0.3	2.0	6.0	1027	0.3	2.1

For potential sites in Alaska having similar temperatures and salinities to those in British Columbia (e.g., the north B.C. coast site), similar conversion rates could be expected. However, potential locations in southeast Alaska will likely have winter temperatures lower than those experienced in British Columbia (i.e., less than 5°C). Food conversion rates under these conditions will be slightly poorer than for comparably sized fish grown at higher temperatures.

Also the feed conversions obtained from dry feeds at British Columbia sites were mainly under conditions of moderate salinity. Similar conditions can be expected in areas of southeastern Alaska, particularly along the mainland side. However, along the western side, salinities could, on average, be higher. The feed conversion efficiency of dry feeds could be reduced at high salinities (greater than 25%) given higher energy requirements for osmoregulatory functions (Shaw et al, 1975; Brett, 1979).

Probable feed conversions for dry feeds utilized in southeastern Alaska for the two temperature regimes are also shown in Exhibit 4.1. These feed conversions have been adjusted to reflect a decrease in feed conversion efficiency as the fish increase in size, and decreases that might occur at seasonally lower temperatures.

4.3.3. Summary

Large areas of southcentral and southeast Alaska are not suitable for salmon culture due to the presence of ice, icebergs and large river systems. Salinities are generally more consistent throughout the year in areas away from mainland waters, where blooms are also less likely to occur.

Smolt production capacity in both southcentral and southeast Alaska is likely adequate to meet potential demand from a salmon farming industry.. Some fish feed production capability exists in southcentral, however fish feed would most likely be imported from Washington State or British Columbia because of more specialized production in these regions.

The following areas would be favoured for development in terms of their proximity to population centers, airports and processing plants:

- along the eastern half of southeast Alaska near Juneau, Ketchikan and Petersburg/Wrangell;
- along the western side of Baranof Island near Sitka;
- in southcentral Alaska near Kodiak, Homer, Seward, Cordova, Valdez and Whittier.

Netpen operations in these areas would also be less likely to be affected by phytoplankton blooms. However, all areas are likely to be affected by predators.

The area around Ketchikan is probably the best area for development of pen rearing of salmon in Alaska because of warmer summer and winter temperatures. This area also has more constant salinities throughout the year. Chinook could be expected to reach a harvestable size of two kilograms during the second winter in saltwater. However, the Ketchikan area would have lower growth rates and higher conversion rates than in most areas of British Columbia where salmon farming occurs because of seasonally lower water temperatures.

A profile of a salmon farm can now be developed to allow comparison to costs in other supply regions by assuming that the growth of chinook in this area would approximate that of the warm winter/warm summer condition shown in Exhibit 4.1. Costs for major inputs such as smolts, feed and labour will be estimated for this area.

4.4 Estimated Costs of Production

4.4.1 Production Plan

Scale and Location

The analysis is undertaken for a fish farm raising chinook salmon at an annual production level of 250 tonnes, or the same at British Columbia.

The farm is assumed to be located in the Ketchikan area.

Capital Investment

Capital investment is assumed to be similar to that of British Columbia. However, cage systems and equipment are assumed to be imported and slightly more expensive. The estimated total capital investment for the farm is shown below.

	U.S. $
Sea cage system and equipment	$380,000
Facility on floating barge with equipment	250,000
	$630,000

The total capital investment is $2,520 per tonne. Like British Columbia accommodation and other facilities are assumed to be on a floating barge due to the lack of extensive road systems in the south central portion of southeast Alaska.

Operating Expenses

The estimated operating costs are based on the following assumptions:

- 140,000 salmon smolts at 7 grams are set out every year in June
- smolts are assumed to be supplied from Alaskan hatcheries
- the smolt price of $0.54 is the same at that of British Columbia except without the BCSFA levy
- feed is imported from Washington State by barge and the feed standard price is $1.01 per kg
- the feed conversion ratio is slightly higher than British Columbia and ranges between 1.5:1 and 2.0:1
- processing costs of $0.52 per kg are slightly lower than British Columbia because of lower labour rates in the processing sector
- stock insurance, farm wages and fixed costs are comparable to British Columbia
- harvesting occurs after 20 to 24 months in saltwater
- average weight of fish is 2.5 kg at harvest (this assumes slightly better growth than that shown in Exhibit 4.1).

With these assumptions, the farm will be capable of producing about 73,500 fish for a total production of 250 tonnes per year.

Depreciation is based on the following assumptions:

Buildings	20
Seapen system and equipment	6
Site investments	50

The economic life of fixed assets is assumed to be similar to that of British Columbia, Norway and Scotland.

Unit Costs

Unit costs are shown in Exhibit 4.2. Unit costs are $4.49 per kilogram.

EXHIBIT 4.2: ESTIMATED UNIT COSTS PER KG FOR CHINOOK SALMON IN ALASKA

	Unit Costs (US Dollars)	%
Variable Costs		
Smolts	0.40	9
Feed	2.00	45
Stock Insurance	0.07	2
Processing	0.52	11
Interest on Working Capital	0.27	6
Total Variable Costs	**3.26**	**73**
Fixed Production Costs		
Wages	0.32	7
Overhead	0.24	5
Depreciation	0.49	11
Interest	0.18	4
Total Fixed Costs	**1.23**	**27**
Unit Costs per Kilogram	**4.49**	**100%**

Source: The DPA Group Inc.

Assuming a yield factor of about 85%, unit costs on a dressed weight basis would be $5.28/kg or $2.40/lb.

5.0 SUMMARY

In order to assess Alaska's potential competitiveness with other supply regions, the landed costs of production in major markets must be compared. In order to do so, we first determine selling and freight costs per unit. These are shown in Exhibit 5.1.

EXHIBIT 5.1: SHIPPING AND SELLING COSTS PER LB TO MAJOR MARKETS[a] (U.S. DOLLARS)

	Supply Region					
	Norway	Scotland	B.C.	Chile	Japan	Alaska
Selling Costs	0.06	0.11	0.14	0.14	0.14	0.14
Freight to shipping point	0.05	0.07	0.10	0.09	0.04	0.09
	0.11	0.18	0.24	0.23	0.18	0.23
Additional Freight[b] to:						
Los Angeles	1.14	1.14	0.12	0.73	N/A	0.14
New York	0.80	0.80	0.50	0.73	N/A	0.55
Tokyo	1.59	1.59	0.95	1.45	as above	0.73

[a] Shipping and selling costs are current to March, 1988.
[b] All shipments were assumed to be air freighted to their destinations, except for shipments from B.C. to L.A. which were assumed to be trucked. The bulk rate for fresh fish or an LD3 container rate from current tariff sheets were used for shipments by air. No allowances were made for ice in containers since the increased costs associated with ice can often be offset by volume discounts.

Selling costs in Norway are less than other regions because of the participation of the Fish Farmers Sales Organization. Scotland's selling costs are also less because of a higher level of vertical integration.

With regard to the major exporters, freight costs from Norway and Scotland to major markets are comparable. British Columbia has the best freight cost advantage to Los Angeles and New York. However, Alaska has the lowest freight cost to Japan.

The landed costs of farmed salmon from each major supply region and from Alaska in three major markets is shown in Exhibit 5.2.

EXHIBIT 5.2: COMPARISON OF LANDED COSTS PER LB IN MAJOR MARKETS (U.S. DOLLARS)

	Supply Region					
Market	Norway	Scotland	B.C.	Chile	Japan	Alaska
Los Angeles	3.80	4.17	2.06	2.63	N/A	2.77
New York	3.46	3.83	2.44	2.63	N/A	3.18
Tokyo	4.25	4.62	2.89	3.85	3.21	3.36

As indicated in the exhibit, Alaska is competitive from a cost standpoint in all markets.

However, as previously indicated, costs at an industry level are only known for Norway. As a result, the cost comparisons should be viewed with caution. Alaska would be selling farmed salmon in smaller sizes than Norway, Scotland and British Columbia and would compete more directly with Chile. British Columbia and Chile have cost advantages over Alaska in both Los Angeles and New York.

Alaska would also likely have a short window period in which to sell. This would also likely result in more direct competition with the Chileans.

As discussed in Section 3.7, landed costs in major markets are sensitive to exchange rates. Fluctuating exchange rates could make Alaskan farmed salmon more or less competitive in all markets. However, the U.S. and Canadian currencies are closely linked and generally shift from each other only slowly. As a result, British Columbia would likely have cost advantages over Alaska in all major markets.

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APPENDIX A

METRIC CONVERSION RATES

APPENDIX A
Metric Conversion Rates

1 kilogram = 2.2046 pounds
1 Kilogram = 1,000 grams
454 grams = 1 pound

1 metric tonne = 2204.6 pounds
1 metric tonne = 1,000 kilograms
1 metric tonne = 1.1 ton

1 metre = 1.1 yards
1 kilometre = 1,000 metres
1 kilometre = 0.62 miles

APPENDIX B

PROFITABILITY STUDY OF
FISH FARMS IN NORWAY, 1984

Production cost per kilo farmed salmon, 1984. Figures in 1984 kroner.

	Size of facility			
	Under 3.000 m^3	3.000-4.999 m^3	5.000-6.999 m^3	7.000 m^3 & over
Smolt	7.93	5.45	6.82	5.97
Feed	10.99	9.97	10.98	10.57
Other variable cost	0.60	0.69	0.62	0.58
Wages	6.51	5.06	4.82	4.80
Total variable costs	26.03	21.17	23.24	21.87
Fixed operating costs	3.77	3.38	4.37	4.16
Depreciation	1.42	1.40	1.43	1.61
Interest[a)]	2.65	3.03	3.18	3.10
Total	33.87	28.98	32.22	30.74
Production (tonnes)	28.30	69.80	101.20	141.10
Man-years per farm	1.59	2.50	3.98	5.07
Sample size	19	31	20	27

a) Interest includes interest on debt and calculated interest on equity.

Source: Directorate of Fisheries: Profitability Study of Fish Farms, 1984.

APPENDIX C

POTENTIAL DEVELOPMENT AREAS FOR SALMON FARMING IN ALASKA:

TECHNICAL SUMMARY

Prepared for:
State of Alaska
Department of Commerce
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Juneau, Alaska

Prepared by:
The DPA Group Inc.
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Vancouver, B.C.

March, 1988

TABLE OF CONTENTS

1.0 INTRODUCTION

The purpose of this study is to determine the feasibility of pen-rearing salmon in Alaska. The approach is to develop likely costs of production for pen-rearing of salmon in Alaska and compare these costs to those of existing supply regions.

Development of likely costs of production in Alaska requires an analysis of conditions for rearing. British Columbia is emerging as a major supply region and is considered the best model for analysis of Alaska's potential.

This technical report summarizes the following:

- general environmental and logistic conditions for pen-rearing salmon in Alaska;
- differences in growth and feed conversion rates between British Columbia and Alaska.

In order to assess conditions for pen rearing salmon in Alaska we conducted reviews of previous environmental studies in Alaska. We also held telephone interviews with several fisheries officials in the state of Alaska Department of Fish and Game and the National Marine Fisheries Service.

In order to develop growth data and feed conversion ratios we compared published results of the National Marine Fisheries Service salmon farming research projects at Little Port Walter and Auke Bay to those of a recent broodstock management program in British Columbia.

In the following section of the report we determine areas suitable for pen-rearing salmon in Alaska. In section 3.0 we estimate growth and conversion rates. Also, in this section we describe how the analysis of the potential for pen-rearing salmon in Alaska from a biophysical standpoint will be used to determine its economic viability.

2.0 ENVIRONMENTAL AND LOGISTIC CONDITIONS

2.1 Introduction

Conditions which are important in considering the location of a netpen site can be classified under environmental or logistic categories.

Environmental factors include water quality characteristics and potential problems with plankton blooms and predators. Logistic factors include access to critical inputs such as smolts, feed, labour and transportation routes.

These conditions are discussed below.

2.2 Physical Marine Conditions

This section contains an overview of ice formation and iceberg conditions, temperatures and salinities in southcentral and southeast Alaska. According to fisheries officials contacted, these are the two areas where development of net pen-rearing would most likely occur. The information is then used to develop assumptions about growing conditions, growth rates and feed conversions.

Southcentral Alaska

Ice Formations and Icebergs

Ice formation and the presence of icebergs in embayments and low winter air temperatures impose constraints on development of netpen sites in southcentral Alaska; in particular, these are:

- the presence of pack ice and fast ice in Cook Inlet;
- the presence of ice and icebergs in embayments connected to Prince William Sound and near Seward; and
- the potential for ice formation on floating structures.

LaBelle et al (1983) indicate that during late December open pack ice can normally be expected along Cook Inlet between the head of the inlet and a line approximately between Cape Douglas and a point just south of Ninilchik. At times, close pack ice can extend further to a line approximately between Cape Douglas and Homer. Within Prince William Sound, LaBelle et al (1983) indicate that icebergs from glaciers can normally be encountered in the vicinity of Glacier Island (at the mouth of Valdez Arm), in Unakwik Inlet and Port Wells (between Valdez Arm and Whittier), in Blackstone Bay (to the south of Whittier), in the head of Port Nellie Juan and in Knight Island Pass (to the south of Port Nellie Juan). Near Seward they indicate icebergs are present in Aialik Bay and Harris Bay (southwest of Seward) and in the East Arm of Nuka Bay.

Apart from the presence of sea ice and glacier ice in embayments in southcentral Alaska, the air temperature and wind conditions in that area make it generally susceptible for ice formation on floating structures (La Belle et. al. 1983).

Water Temperatures

Mean monthly sea surface water temperatures are summarized in Exhibit 2.1. These data suggest that, in general, mean winter surface temperatures can be expected to be approximately 2.5 - 5.0°C and mean summer surface temperatures can be expected to be approximately 0 - 13°C.

Surface temperatures are often recorded as routine measurements because they are easier to measure than temperatures at greater depths. However, salmon are suspended in structures that place them below the surface, but in the upper 6-10 m of the water column (depending on the net depth selected by individual operators). Therefore, subsurface temperatures (between 0 and 10 m) are usually more appropriate for determining the growing conditions for salmon. Temperatures recorded at 10 m near Seward are also shown in Exhibit 2.1. These data indicate that at that depth mean spring and early summer temperatures are slightly lower than the surface temperatures, while mean fall and winter temperatures are approximately the same.

EXHIBIT 2.1: SUMMARY OF MONTHLY SEA SURFACE TEMPERATURE IN SOUTHCENTRAL ALASKA

	Coastal[1]		Seward[2]	
Month	Kodiak-Cook Inlet	Prince William Sound	0 Meters	10 Meters
January	4.0	4.5	4.0	4.0
February	3.0	5.0	4.0	4.0
March	4.0	4.0	2.8	2.8
April	4.0	5.0	3.3	3.3
May	5.0	6.0	6.0	5.4
June	7.0	9.0	9.2	7.0
July	9.0	11.5	12.9	10.8
August	11.5	12.5	12.8	12.8
September	10.5	12.0	11.4	11.7
October	9.0	9.0	7.6	8.2
November	7.0	8.0	7.0	7.1
December	5.5	6.0	5.0	6.0

1 Estimates based on isopleths and cumulative percent frequency graphs

2 Based on graphed monthly means, 1979-1983.

Source: Brower et. al. 1977; Xiong and Royer 1984.

Salinity

Xiong and Royer (1984) state that average surface salinities in summer are 27.3‰ and in winter are 3.12‰ based on intensive studies near Seward. At greater depths (i.e. 250 m), salinities are approximately 33% year round. Colonell (1980) and Muench and Nebert (1973) describe the presence of relatively fresh water lying in a thin surface layer in Valdez Arm and Port Valdez during summer and autumn. Muench and Nebert (1973) indicate that minimum mean surface salinities (0-125 m) were approximately 3% over the July - October period, though salinities in the upper 20 m were, at times, less than 1% near the head of Port Valdez (in late July/early August). Lower surface salinities over the summer period are attributed to freshwater runoff from land areas and high precipitation.

Southeast Alaska

Icebergs

Icebergs are present in several bays and straits in northern and eastern Southeastern Alaska (LaBelle et al, 1983).

- Cross Sound, Icy Strait and Glacier Bay;
- Taku Inlet;
- Tracy Arm and Endicott Arms; and
- the end of Frederick Sound.

The presence of icebergs suggests a potential for damage to floating structures and, in general, these areas should be avoided. Also, the icebergs apparently can greatly reduce summer temperatures in surface waters (Pickard, 1967).

Water Temperatures

Mean monthly surface temperatures for the coastal waters along southeast Alaska (Brower et al, 1977) are presented in Exhibit 2.2. Mean surface temperatures recorded at five lighthouse installations (Jones, 1978) in southeast Alaska and in Auke Bay near Juneau (Bruce et al, 1977) are also summarized.

These data show mean high temperatures in summer (August) to range between 9.0°C (Decision Rock) and 14.6°C (Guard Island). Mean low temperatures in winter (February/March) range between 2.3°C (February at Point Retreat) and 5.2°C (February at Lincoln Rock). The mean low temperature for the general coastal area (Brown et al, 1977) is slightly higher than these values at 6.0°C. The Five Fingers location is at the junction of Stephens Passage and Frederick Sound. The cooler summer temperatures at the Five Fingers location (and possibly further westward at Decision Rock) could reflect the cooling influence of glaciers in Stephens Passage and Frederick Sound. Pickard (1967) notes that Stephens Passage appears to receive considerable freshwater from the Taku River and Juneau Icefield and that flow from Stephens Passage could influence water property features at its junction with Frederick Sound. He also notes that water in the eastern portion of Frederick Sound is cool in summer as a result of nearby glaciers. Pickard (1967) reported average temperatures of 6.7°C for Stephens Passage and 8.0°C for Frederick Sound in the upper 10 m of water during August, 1965. Average temperatures in other locations range from approximately 4.0°C (in inlets containing icebergs, for example, Tracy and Endicott Arms along Stephens Passage and Glacier Bay) to approximately 12-14°C in other locations (such as Lynn Canal, near Juneau and Boca de Quadra, near Ketchikan).

EXHIBIT 2.2: SUMMARY OF MEAN MONTHLY SEA SURFACE TEMPERATURE IN SOUTHEAST ALASKA

Month	Coastal[1]	Guard Island	Lincoln Rock	Decision Light	Five Finger Light	Point Retreat	Auke Bay
January	6.5	5.2	4.4	3.9	3.6	2.6	3.2
February	6.5	4.9	5.2	4.2	3.0	2.3	2.5
March	6.0	5.2	5.3	4.5	3.4	2.9	3.0
April	6.5	6.2	6.2	5.1	4.3	3.6	4.8
May	8.0	8.3	8.1	6.0	5.4	4.9	8.0
June	10.0	12.4	11.4	7.1	7.8	8.5	12.0
July	12.5	14.5	12.8	9.2	9.6	11.4	13.2
August	13.0	14.6	13.6	9.0	9.6	12.3	13.5
September	12.5	12.9	11.5	8.7	8.1	10.2	11.0
October	10.5	10.4	9.3	7.5	6.5	7.3	7.2
November	9.0	7.8	6.7	5.6	5.5	5.3	5.0
December	7.5	5.9	5.1	4.0	4.2	3.7	4.5

1 Estimates based on isopleths and cumulative percent frequency graphs

Source: Brower et. al. 1977; Bruce et al. 1977; Jones 1978.

In general, winter temperatures are lower, as expected, and show less variation amongst locations (compared to summer values); with a trend from south to north of approximately 4.5 - 5.0°C in southern locations (i.e., near Ketchikan) to 2.5 - 3.0°C in more northern locations (i.e., near Juneau).

As described previously, surface temperatures are commonly recorded as routine measurements because they are easier than temperatures taken at greater depths. Temperatures can differ between surface and greater depths in southeast Alaska, particularly over the summer (Bruce et al. 1977; Pickard, 1967). Bruce et al (1977) show little difference over the fall, winter and spring period between the surface and 5 m but show water at a 5 m depth to be 2.0 - 3.0°C cooler in summer (July). Pickard (1967) shows a similar trend amongst vertical depth profiles developed for inlet site samples in August, 1965. Data recorded by the National Marine Fisheries Service for several years at facilities in Auke Bay near Juneau and Little Port Walter on Baranof Island are summarized in Exhibit 2.3. These data suggest winter temperatures at 4 - 5 m are similar to surface measurements near those locations (see Exhibit 2.2). However, the summer temperatures at the greater depth appear to be several degrees cooler than surface temperatures in Auke Bay (as noted above). The temperatures at Little Port Walter appear to be similar to surface measurements recorded nearby (e.g. Decision Light shown in Exhibit 2.2). The August data in Pickard (1967) indicate lower surface temperatures (9°C) in portions of Chatham Sound (where little Port Walter is located) south of its junction with Frederick Sound, compared to locations further north (e.g., near Angoon) where surface temperatures were approximately 12°C.

EXHIBIT 2.3: SUMMARY OF AVERAGE MEAN MONTHLY TEMPERATURES RECORDED AT 4-5 M DEPTHS AT AUKE BAY AND LITTLE PORT WALTER

Month	Auke Bay[1]	Little Port Walter[2]
January	4.5	5.2
February	3.0	5.0
March	3.0	5.4
April	4.0	4.8
May	6.5	5.6
June	10.0	8.1
July	12.0	9.6
August	12.0	9.4
September	11.0	8.4
October	9.5	7.3
November	6.0	5.8
December	3.5	5.4

[1] Approximations based on averaged graphical data, 1960-68.
[2] Average mean monthly temperatures, 1984-1987.

Sources: Bruce <u>et al.</u> 1977, Thrower pers. comm.

Salinities

Larger rivers along the mainland shoreline can produce lower and fluctuating salinities (Pickard, 1967) and consequently make nearby areas unsuitable for locating netpens for adult growout. These areas include the mouths of the Stikine River, Taku River, Unuk River, Chilkat River and Speel River.

Lower and fluctuating salinities can affect the physiological condition of the salmon (i.e. in relation to the osmoregulatory adaptation to ambient salinity levels) and could influence outbreaks of harmful phytoplankton.

Pickard (1976) shows that most larger rivers in southeast Alaska (e.g. Stikine, Taku, and Chilkat) have peak flows over the summer period from melting glaciers and snow packs. Smaller rivers either have high flows in both summer and fall/early winter (from precipitation) or high flows primarily in fall/early winter. Low flows for all systems generally occur over late winter and early spring.

As a result, one would expect:

- generally higher surface salinities during late winter and early spring; and
- generally lower surface salinities and greater fluctuation in salinities, in waters closer to the mainland (where most large and moderate-sized river systems are located) relative to seaward coastal areas.

In general, Pickard (1967) found surface salinities over the summer in inlets without icebergs were lower at the head ends (range 1-11% compared to the inlet mouths (range of 17-32%). Salinities in deeper waters during summer ranged from 31.2 to 34%, which are similar to surface values recorded at ocean recording stations off the western shore of southeast Alaska.

Bruce et al (1977) indicate that in Auke Bay, surface salinities are typically much lower (16-17%) in summer (July) than in winter and early spring (30% January and April), and in winter/early spring are similar to deep water values (30-31%). They also show that at depths of 5 m, the summer values (20-21%) are typically more saline than surface values. Lower summer surface salinities are attributed to peak runoff from nearby large, glacial-fed streams. At Little Port Walter (which is located further from the mainland streams), mean monthly salinities at 4 m depth are generally higher ranging from 26-30% in summer/early fall to 31-33% in winter. Pickard (1967) shows high surface salinities (greater than 30%) in southern Chatham Sound (near Little Port Walter), Sumner Sound and Clarence Strait, recorded during June and August.

2.3 Phytoplankton and Marine Mammals

Phytoplankton

Two phytoplankton species, Chaetoceros convolutus and Heterosigma akashiwo, have caused serious mortalities amongst salmon cultured in marine netpens in British Columbia. Conditions appear suitable for both species in southcentral and southeast Alaska (Gaines and Taylor, 1986). Chaetoceros diatoms have been responsible for chinook salmon mortalities in seapens at Little Port Walter (National Marine Fisheries Service, unpublished). Chaetoceros convolutus has also been collected during surveys near Valdez in Prince William Sound (Horner et al 1973.) The occurrence and intensity of phytoplankton blooms vary greatly both geographically and temporally and prediction is difficult (Gaines and Taylor, 1987). In general, Heterosigma blooms tend to occur in early summer, often in association with lower salinities resulting from increasing river flow, while Chaetoceros blooms tend to occur in the late summer or fall.

Harmful phytoplankton could affect sites in both southcentral and southeast Alaska. As in British Columbia, the effects on production could be direct mortalities or reduced growth when oxygen depletion occurs and rations are restricted. In British Columbia, the strategy in stocking is to maintain densities at low levels (e.g., less than 8 kg/m3) to minimize losses should bloom conditions occur.

Marine Mammals

Marine mammals such as otters and sea lions have affected production at sites in British Columbia by killing fish in pens, by damaging netpens allowing fish to escape, and by causing high stress levels in the fish thereby reducing growth rates. National Marine Fisheries Service (unpublished) indicate otters, seals and possibly sea lions have killed fish at the experimental facilities near Little Port Walter. Steller's sea lions and harbour seals occur essentially along the entire Gulf of Alaska coastline (U.S. Department of the Interior, 1984).

Predation from marine mammals will likely be a similar problem in southcentral and southeast Alaska waters to that which occurs in British Columbia. This would likely require investment in predator control measures such as predator nets. Again, density levels would be kept low so that if stress develops when predators are nearby (but do not necessarily attack fish in the pens) it will not compound stress already resulting from high densities.

2.4 Smolt Production Capabilities

Southeast Alaska

Four state hatcheries in southeast Alaska produce chinook salmon and three hatcheries produce coho salmon (Hansen, 1987):

Hatchery	Location	Species Reared
Snettisham	near Juneau	chinook, coho
Hidden Falls	northeastern Baranof Island	chinook
Crystal Lake	near Petersberg	chinook, coho
Deer Mountain	near Ketchikan	chinook
Klawock	near Craig	coho

In 1986, nearly 5 million chinook eggs were collected from these facilities and more than 2.7 million juvenile chinook were released. Similarly, slightly more than 4 million coho eggs were collected and 1.5 juvenile coho were released.

In addition, 10 private non-profit hatcheries operated by regional aquaculture associations and other non-profit groups raise chinook or coho or are permitted to raise these species:

Hatchery	Location
Whitman Lake, Neets Bay, Meyers Chuck and Burrard Inlet	near Ketchikan
Gunuk Creek	near Petersburg
Medvejie Creek, Sheldon Jackson College and Port Armstrong	near Sitka
Salmon Creek and Sheep Creek	near Juneau

In 1986, private non-profit hatcheries in southeast Alaska had total permitted chinook egg capacities of 6.73 million and total permitted coho egg capacities of 15.47 million eggs. Most fry production of both species is in the Whitman Lake and Neets Bay hatcheries operated by the Southern Southeast Regional Aquaculture Association.

Southcentral Alaska

Five state hatcheries in southcentral Alaska produce chinook salmon and five hatcheries produce coho salmon:

Hatchery	Location	Species Reared
Big Lake	near Anchorage	coho
Fort Richardson	near Anchorage	coho, chinook
Elmendorf	near Anchorage	coho, chinook
Trail Lake	near Seward	coho, chinook
Kitoi Hatchery	near Kodiak	chinook, coho.

In 1986, 1.5 million chinook eggs were collected and 1.5 million juvenile chinook were released. Slightly more than 6.5 million coho eggs were collected and 7 million coho juveniles were released.

Three private non-profit hatcheries operated by regional aquaculture associations and other non-profit groups raise chinook or coho salmon or are permitted to raise these species:

Hatchery	Location
Eklutna	near Anchorage
Esther Lake	near Whittier
Solomon Gulch	near Valdez

In 1986, the private non-profit hatcheries had total permitted chinook egg capacities of 1.15 million and total permitted coho egg capacities of 3.1 million.
Clearly, a large smolt production capability exists in both southcentral and southeast Alaska and this production is spread throughout each region. Hansen (1987) indicates that a number of hatcheries are constructed below lakes and water intakes in the lakes are placed at different depths so temperatures can be adjusted. This means juvenile growth rates and smolt timing can be manipulated to achieve release objectives.

2.5 Fish Feed

Currently there is fish feed production capacity in southcentral. However, capacity is limited and technologies employed in production are not as advanced as those in Europe, British Columbia or Washington State.

The main ingredients in commercial fish feeds are fish meal and fish oil. These are manufactured in the reduction process from whole fish or fish waste from the processing sector. Alaska's reduction industry is not well developed, despite the availability of significant quantities of fish waste. In addition the reduction plants in Alaska produce fish meal and fish oil which is unsuitable for fish feed. According to representatives of a fish feed manufacturer in Washington State, if a new feed plant were to be constructed, it would likely be constructed in tandem with a new reduction plant, both of which require significant capital investment. Alaska would more likely be supplied by fish feed manufacturers in Washington State or British Columbia since transport by barge to Alaska is not a significant cost.

2.6 Potential Development Areas

As discussed previously, certain areas of southcentral and southeast Alaska are not suitable for salmon culture given the presence of ice, icebergs and large river systems. Therefore, initial development would be expected to occur in suitable bays or shoreline areas (protected from high winds or waves) away from these areas and as close to transportation centers and processing/packing facilities as possible.

Small to medium-sized communities having airport and port facilities are distributed throughout both southcentral and southeast Alaska. The population sizes of coastal communities in the lower Cook Inlet, Kodiak Island and Prince William Sound areas are shown in Exhibit 2.4. Apart from the major airport in Anchorage, smaller airfields and port facilities are located throughout the area (e.g., Homer and Seward).

Larger airports and port facilities are situated along eastern southeast Alaska (Juneau, Petersburg, Wrangell and Ketchikan) and Sitka. As shown in Exhibit 2.4, these are also the major population centers. Ideally, new fish farms would want to locate within three to four hours by boat from logistic centers to minimize the amount of time that harvested fish are in transit prior to boarding flights to market areas. This would tend to create development in physically suitable areas along the eastern half of southeast Alaska (near Juneau, Ketchikan and Petersburg/Wrangell) and along the western side of Baranof Island (near Sitka), and in southcentral Alaska (near Kodiak, Homer, Seward, Cordova, Valdez and Whittier).

2.7 Summary

Large areas of southcentral and southeast Alaska are not suitable for salmon culture due to the presence of ice, icebergs and large river systems. Salinities are generally more consistent throughout the year in areas away from mainland waters, where blooms are also less likely to occur.

Smolt production capacity in both southcentral and southeast Alaska is likely adequate to meet potential demand from a salmon farming industry. Some fish feed production capability exists in southcentral, however fish feed would most likely be imported from Washington State or British Columbia because of more specialized production in these regions.

The following areas would be favoured for development in terms of their proximity to population centers, airports and processing plants:

- along the eastern half of southeast Alaska near Juneau, Ketchikan and Petersburg/Wrangell;
- along the western side of Baranof Island near Sitka;
- in southcentral Alaska near Kodiak, Homer, Seward, Cordova, Valdez and Whittier.

Netpen operations in these areas would also be less likely to be affected by phytoplankton blooms. However, all areas are likely to be affected by predators.

EXHIBIT 2.4: POPULATIONS OF COMMUNITIES IN SOUTHCENTRAL AND SOUTHEAST ALASKA (1980)

Southcentral		Southeast	
Keani/Cook Inlet		Juneau	19,528
		Sitka	7,803
Kenai	4,324	Ketchikan	7,198
Soldotna	2,320	Petersburg	2,821
Homer	2,209	Wrangell	2,184
Seldovia	479	Metlakatla	1,056
Ninilchik	341	Haines	993
Port Graham	161	Skagway	768
English Bay	124	Hoonah	680
		Kake	555
Kodiak Island/Shelikof Strait		Craig	527
		Angoon	465
Kodiak	4,756	Klawock	318
Old Harbor	340	Hydaburg	298
Port Lions	215	Saxman	273
Ouizinkie	173	Pelican	180
Larsen Bay	141	Tenakee Springs	138
Akiak	105	Klukwan	135
Karluk	96	Meyers Chuck	50
		Kupreanof	47
Prince William Sound		Kasaan	25
Valdez	3,079		
Cordova	1,879		
Seward	1,834		
Whittier	198		
Tatitlek	68		

Source: U.S. Census Population 1981 and 1982, cited in U.S. Department of the Interior 1984.

3.0 GROWTH AND CONVERSION RATES

3.1 Generalized Temperature Regimes

The temperature data reviewed in Section 2.1 (Physical Marine Conditions) have been used to develop four generalized temperature regimes (Exhibit 3.1) in which salmon culture might take place:

- relatively cool winter temperatures and warm summer temperatures (that might occur in bays in southcentral Alaska and near Juneau);
- relatively warm winter temperatures and warm summer temperatures (that might occur in bays near Ketchikan);
- relatively warm winter temperatures and cooler summer temperatures (that might occur in the Frederick Sound/Petersburg area); and
- relatively cool winter temperatures and cool summer temperatures (that might occur in the northern inlets of southeast Alaska close to iceberg areas).

Clearly, general good-case and poor-case growing conditions would be, respectively, warm winter/warm summer conditions and cool winter/cool summer conditions. Since specific conditions can vary from site to site and from year to year, extreme best case and worst case conditions would likely lie outside these general scenarios.

EXHIBIT 3.1: GENERALIZED MEAN MONTHLY TEMPERATURES AT 4 M DEPTHS

Month	Cool Winter/ Warm Summer	Warm Winter/ Warm Summer	Warm Winter/ Cool Summer	Cool Winter/ Cool Summer
January	.5	5.0	5.0	3.5
February	3.0	5.0	5.0	3.0
March	3.0	4.5	4.5	3.0
April	5.0	4.5	4.5	3.0
May	6.0	6.0	6.0	6.0
June	10.0	10.0	8.0	8.0
July	11.0	11.0	9.5	9.5
August	12.0	12.0	9.5	9.5
September	10.5	10.5	8.5	8.5
October	7.5	7.5	7.5	7.5
November	5.0	6.0	6.0	5.0
December	3.5	5.5	5.5	3.5

3.2 Growth Rates

Chinook would likely be preferable for net pen rearing in Alaska since they have shown greater survival rates than coho during the longer growout periods in British Columbia needed to attain market size (B.C. Salmon Farmers Association).

The fish sizes and growth rates obtained for chinook salmon at Little Port Walter and at five locations in British Columbia are summarized in Exhibit 3.2. These data have been used together with unpublished growth rate data from the Pacific Biological Station, Nanaimo, B.C. (R. Brett, H. Kreiberg, pers. comm.) and the mean monthly temperatures shown in Exhibit 3.1 to develop probable monthly growth rates for the south central portion of southeast Alaska. Estimated maximum growth rates for different fish sizes and the temperature range expected for marine growout sites in Alaska are shown in Exhibit 3.3. Seasonal growth scenarios for the generalized good growing temperatures and poor growing temperatures (Exhibit 3.1) are shown in Exhibit 3.4. As indicated in Exhibit 3.4, the approximate size of chinook after 26 months in saltwater is 3.5 kg under good growing temperatures and 2.5 kg under poor growing temperatures. With good growing temperatures, chinook could be expected to reach a harvestable size of two kilograms during the second winter in saltwater. Most farmed salmon is sold between October and April, during the off-season of the wild fishery. With poor growing temperatures, chinook would likely have to be held over until the following fall.

EXHIBIT 3.3: ESTIMATED MAXIMUM GROWTH RATES[1] FOR CHINOOK AT DIFFERENT WEIGHTS AND TEMPERATURES

	TEMPERATURE (°C)						
WEIGHT (g)	2	4	6	8	10	12	14
5	0.4	0.9	1.3	1.8	2.2	2.7	3.1
10	0.3	0.7	1.0	1.4	1.8	2.2	2.5
50	0.2	0.3	0.5	0.6	0.8	1.0	1.2
100	0.2	0.3	0.5	0.6	0.8	1.0	1.2
500	0.2	0.2	0.3	0.4	0.5	0.6	0.7
1000	0.1	0.2	0.2	0.3	0.3	0.4	0.5
2000	0.1	0.1	0.2	0.2	0.3	0.3	0.4
3000	0.1	0.1	0.1	0.2	0.2	0.2	0.3

[1] Percent body weight per day.

Sources: Brett, pers. comm.; Kreiberg, 1981a; 1987b; National Marine Fisheries Service, unpublished.

EXHIBIT 3.2: MEAN MONTHLY TEMPERATURES AND GROWTH RATES FOR CHINOOK SALMON AT LITTLE PORT WATER, ALASKA AND FIVE LOCATIONS IN BRITISH COLUMBIA

MONTH	LITTLE PORT WALTER 1982 BROOD STOCK			LITTLE PORT WALTER 1984 BROOD STOCK			NORTH B.C. COAST			SOUTH B.C. COAST (Gulf Islands)			SOUTH B.C. COAST (Sunshine Coast)			SOUTH B.C. COAST (Pacific Biological Station)			SOUTH B.C. COAST (West Coast of Vancouver Island)		
	Temp.	Size	Rate	Temp.	Size	Rate	Temp.	Size	Rate	Temp.	Size	Rate	Temp.	Size	Rate	Temp.	Size	Rate	Temp.	Size	Rate
JUNE	-	-	-	7.3	5.0	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JULY	-	-	-	9.2	-	1.7	12.1	4.5	2.7	-	4.5	2.5	18.8	4.5	3.3	18.0	4.5	2.4	-	4.5	3.2
AUGUST	-	-	-	8.8	-	1.7	12.0	-	2.7	13.8	-	2.5	16.8	-	3.3	16.8	-	2.4	16.1	-	3.2
SEPTEMBER	-	-	-	7.7	-	1.7	8.8	-	2.7	12.6	-	2.5	15.1	-	3.3	14.4	-	2.4	13.2	-	3.2
OCTOBER	-	82	0.5	6.0	-	1.7	8.8	59	2.7	11.3	50	2.5	11.9	84.0	3.3	11.3	40	2.4	11.4	129	3.2
NOVEMBER	-	-	0.5	4.4	-	0.3	6.5	-	0.6	9.6	-	0.6	9.7	-	0.6	8.0	-	0.8	9.7	-	0.6
DECEMBER	-	-	0.5	5.2	-	0.3	5.0	-	0.6	-	-	0.6	6.7	-	0.6	6.7	-	0.8	6.9	-	0.6
JANUARY	-	-	0.5	4.8	-	0.3	5.5	-	0.6	-	-	0.6	6.7	-	0.6	7.8	-	0.8	7.2	-	0.6
FEBRUARY	-	-	0.5	-	-	0.3	5.1	-	0.6	7.3	-	0.6	7.6	-	0.6	7.1	-	0.8	7.5	-	0.6
MARCH	-	-	0.5	-	-	0.3	6.0	166	0.6	-	180	0.6	7.9	208	0.8	9.0	180	0.6	8.7	286	0.7
APRIL	-	-	0.5	4.7	150	0.3	8.0	-	0.6	8.5	-	0.5	9.0	-	0.8	10.2	-	0.6	8.6	-	0.7
MAY	-	276	0.5	5.8	-	1.0	8.3	232	0.6	-	246	0.6	11.8	391	0.8	12.0	250	0.6	10.0	442	0.7
JUNE	9.0	-	0.9	7.7	-	1.0	10.9	-	0.7	12.3	-	0.9	14.9	-	1.0	15.5	-	0.7	13.2	-	0.8
JULY	10.1	636	0.9	8.7	273	1.0	12.5	-	0.7	13.4	-	0.9	16.6	-	1.0	16.8	-	0.7	16.2	-	0.8
AUGUST	10.1	-	0.9	8.3	-	1.0	13.1	-	0.7	14.7	-	0.9	16.7	-	1.0	19.0	-	0.7	16.2	-	0.6
SEPTEMBER	9.3	-	0.9	8.1	591	1.0	11.5	-	0.7	13.8	-	0.9	15.8	-	1.0	15.9	-	0.7	14.5	-	0.8
OCTOBER	8.8	946	0.9	6.8	-	-	10.2	537	0.7	11.2	931	0.9	12.1	1302	1.0	13.2	630	0.7	11.9	1317	0.3
NOVEMBER	6.5	-	0.3	6.4	-	-	8.6	-	-	10.4	-	-	9.4	-	-	10.5	-	-	11.7	-	-
DECEMBER	5.2	-	0.3	5.8	-	-	7.0	-	-	9.0	-	-	7.7	-	-	9.3	-	-	8.7	-	-

EXHIBIT 3.2: (Cont'd)

MONTH				LITTLE PORT WALTER			NORTH B.C. COAST			SOUTH B.C. COAST (Gulf Islands)			SOUTH B.C. COAST (Sunshine Coast)			SOUTH B.C. COAST (Pacific Biological Station)			SOUTH B.C. COAST (West Coast of Vancouver Island)		
	1982 BROOD STOCK			1984 BROOD STOCK																	
	Temp.	Size	Rate	Temp.	Size	Rate	Temp.	Size	Rate	Temp.	Size	Rate	Temp.	Size	Rate	Temp.	Size	Rate	Temp.	Size	Rate
JANUARY	4.9	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EBRUARY	5.0	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ARCH	4.6	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PRIL	4.8	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AY	5.4	1814	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UNE	7.3	2198	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ULY	9.2	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UGUST	8.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPTEMBER	7.7	3776	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

EXHIBIT 3.4: ESTIMATED GROWTH RATES FOR CHINOOK SALMON GROWN UNDER TWO GENERALIZED MEAN MONTHLY TEMPERATURES REGIMES IN SOUTHEAST ALASKA

	WARM WINTER/WARM SUMMER				COOL WINTER/COOL SUMMER			
	Temp.	Approx. Size (grams)	Daily Growth Rate (%)	Food Conver- sion	Temp.	Approx. Size (grams)	Daily Growth Rate (%)	Food Conver- sion
June	10.0	13	2.2	1.5	8.0	12	2.0	1.7
July	11.0	25	2.1	1.5	9.5	24	2.1	1.7
August	12.0	49	2.2	1.5	9.5	45	2.1	1.7
September	10.5	92	2.1	1.5	8.5	79	1.9	1.7
October	7.5	125	1.0	1.7	7.5	108	1.0	1.9
November	5.0	149	0.6	1.7	5.0	125	0.5	1.9
December	3.5	174	0.5	1.7	3.5	133	0.2	1.9
January	5.0	197	0.4	1.7	3.5	142	0.2	1.9
February	5.0	222	0.4	1.6	3.0	146	0.1	1.8
March	4.5	243	0.3	1.6	5.0	165	0.3	1.8
April	5.0	266	0.3	1.6	5.0	165	0.3	1.8
May	6.0	301	0.4	1.6	6.0	187	0.4	1.8
June	10.0	406	1.0	1.7	8.0	237	0.8	1.9
July	11.0	570	1.1	1.7	9.5	323	1.0	1.9
August	12.0	851	1.3	1.7	9.5	439	1.0	1.9
September	10.5	1181	1.1	1.7	8.5	575	0.9	1.9
October	7.5	1512	0.8	1.9	7.5	736	0.8	2.0
November	6.0	1704	0.4	1.9	5.0	805	0.3	2.0
December	5.5	1870	0.3	1.9	3.5	830	0.1	2.0
January	5.0	1990	0.2	1.9	3.5	856	0.1	2.0
February	5.0	2104	0.2	3.0	3.0	881	0.0	2.1
March	4.5	2170	0.1	2.0	3.0	908	0.0	2.1
April	5.0	2236	0.1	2.0	5.0	936	0.1	2.1
May	6.0	2454	0.3	2.0	6.0	1027	0.3	2.1

Growth rates normally decrease as fish increase in size and maximum growth rates occur at a temperature optimum and are therefore lower at lower temperatures and at higher temperatures (Brett, 1979). Brett et al (1982) estimated the optimum temperature for juvenile chinook salmon fed a maximum ration to be 19°C and fish fed a 60% ration to be 15°C.

In addition to temperature, growth rates can be affected by other factors including the presence of stressing factors (e.g., densities, handling, and the presence of predators), feed quality and ration level. Consequently, under commercial production conditions, maximum growth rates are often not achieved. In fact ration levels are usually reduced deliberately to obtain more cost-effective feed utilization (e.g., at 70 - 90% of maximum rations). In general, if other factors were the same in British Columbia and Alaska, the mean winter growing temperatures expected for Alaskan waters indicate winter growth rates could be substantially lower than those occurring in British Columbia cf. temperatures in Exhibit 3.2). Rates of digestion and feed consumption are highly reduced at low temperatures (1-5°C) resulting in growth rates that could be 20-40% of the maximum achievable at optimum temperatures (Brett, 1979).

3.3 Feed Conversion

Feed conversion rates are influenced by environmental variables (such as temperature, salinity, photoperiod, oxygen concentration) and operational variables (such as fish size, ration, food quality). Food conversion efficiency is normally greater for smaller fish sizes, decreasing as the fish grow (Brett and Groves, 1979). Over a given temperature range, on the other hand, food conversion efficiency usually reaches a maximum at a particular temperature and is lower at both lower and higher temperatures. Similarly, the optimum ration amount for maximum food conversion is normally lower than the maximum ration that the fish will consume. In turn, maximum conversion efficiency occurs at a lower ration quantity, as temperature is reduced below the optimum. Generally, optimum feed conversion efficiency for salmon appears to occur at temperatures between 10°C and 15°C at ration levels at 60-90% of maximum. Brett et al. (1982) found the temperature for maximum food conversion for juvenile chinook salmon fed a maximum ration to occur approximately 20-21°C but for salmon consuming 60% of the maximum ration appeared to occur at approximately 15°C.

Feed conversion rates for dry diets obtained at five farm locations in British Columbia are shown in Exhibit 3.5. For sites having similar temperatures and salinities to those in Alaska (e.g., the north B.C. coast site) similar conversion rates would be expected.

EXHIBIT 3.5: FEED CONVERSION RATES AT FIVE MARINE SITES GROWING CHINOOK SALMON IN BRITISH COLUMBIA

TIME PERIOD	NORTH B.C. COAST			SOUTH B.C. COAST (Gulf Islands)			SOUTH B.C. COAST (Sunshine Coast)			SOUTH B.C. COAST (Pacific Biological Station)			SOUTH B.C. COAST (West Coast of Vancouver Island)		
	5			2			3			1			4		
	Size		F.C.R.	Size		F.C.R.	Size		F.C.R.	Size		F.C.R.	Size		F.C.R.
	St.	End		St.	End		St.	End		St.	End		St.	End	
JULY - OCT. 1985	4.5	59	1.3	4.5	50	-	4.5	84	-	4.5	40	2.1	4.5	129	1.3
OCT. 1985 - MAR. 1986	59	166	1.4	50	180	1.8	84.0	208	2.1	40	180	1.6	129	286	2.3
MAR. - OCT. - 1986	166	537	1.0	180	931	-	208	1302	1.6	180	630	1.9	286	1317	1.7

Sources: Kreiberg 1987a; Kreiberg 1987b.

However, as previously described, potential locations in southeast Alaska will likely have winter temperatures lower than those experienced in British Columbia (i.e., less than 5°C). Food conversion rates under these conditions will be slightly poorer than for comparably sized fish grown at higher temperatures. Brett (1979) suggests that conversion efficiencies at relatively low temperatures (1-5°C) are 50% of the maximum efficiencies which, as discussed above, occur at higher temperatures (e.g., between 10°C and 20°C). Therefore, for lower mean winter temperatures (3-5°C) that might occur in Alaska growout waters, slightly poorer conversions can be assumed compared to fish grown in British Columbia.

The feed conversions obtained for dry feeds at British Columbia sites were mainly under conditions of moderate salinity (Exhibit 3.6). As previously discussed, similar conditions can be expected in areas of southeastern Alaska, particularly along the mainland side. However, along the western side, salinities could, on average, be higher. The feed conversion efficiency of dry feeds could be reduced at high salinities (greater than 25%) given higher energy requirements for osmoregulatory functions (Shaw et al, 1975; Brett, 1979).

EXHIBIT 3.6: RANGE OF MEAN MONTHLY SALINITIES RECORDED AT FIVE CHINOOK SALMON CULTURE SITES IN BRITISH COLUMBIA; JULY 1985 - DECEMBER 1986.

LOCATION	MEAN MONTHLY SALINITY RANGE
1	24.8 - 29.9
2	21.6 - 27.7
3	19.5 - 26.4
4	19.1 - 32.0
5	19.9 - 25.1

Sources: Kreiberg 1987a; Kreiberg 1987b.

Probable feed conversions for dry feeds utilized in southeastern Alaska for the two temperature regimes described in Section 3.1 are shown in Exhibit 3.4. These feed conversions have been adjusted to reflect a decrease in feed conversion efficiency as the fish increase in size, and decreases that might occur at seasonally lower temperatures.

Near surface salinities (4 m depth) at the Little Port Walter Research facility ranged from 26.8 to 32.6‰; these are similar to but, in general, slightly higher than the salinities occurring at sites in B.C. (Exhibit 3.6). Experiments at Little Port Walter suggest that fish grow at similar rates using a dry pellet (Icicle Seafoods, Seward) and a semi-moist diet (Biodiet). Semi-moist and moist diets are preferred by some growers when salinities are high because they produce less physiological demand on the fish for osmoregulatory functions (Brett and Groves, 1979), compared to dry diets. However, dry diets are often preferred over moister diets, particularly in remote locations, because they are less expensive to transport and have longer storage times.

Summary

The area around Ketchikan is probably the best area for development of pen rearing of salmon in Alaska because of warmer summer and winter temperatures. Chinook could be expected to reach a harvestable size of two kilograms during the second winter in saltwater. However, the Ketchikan area would have lower growth rates and higher conversion rates than in most areas of British Columbia where salmon farming occurs because of seasonally lower water temperatures.

We will assume that the growth of chinook in this area would approximate that of the warm winter/warm summer condition shown in Exhibit 3.4. In other words, a profile of a salmon farm can now be developed to allow comparison to costs in other supply regions. Costs for major inputs such as smolts, feed and labour will be estimated for this area.

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