

**THE PRICING OF AQUATIC LANDS FOR SALMON AQUACULTURE
IN BRITISH COLUMBIA**

by

Donald G. Reddick

B.A., Simon Fraser University, 1984

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS
in the Department
of
Economics

© Donald G. Reddick 1988

SIMON FRASER UNIVERSITY

June, 1988

All rights reserved. This work may not be reproduced in whole or in part, by photocopy or other means, without permission of the author.

APPROVAL

Name: Donald G. Reddick

Degree: Master of Arts

Title of project: The Pricing of Aquatic Lands for Salmon Aquaculture in British
Columbia

Examining Committee:

Chairman: Dr. John Chant

Dr. Don DeVoretz
Senior Supervisor

Dr. Parzival Copes

Dr. Richard Schwindt

Dr. Robert Brown
Dean
Faculty of Arts

Date Approved: June 8, 1988

PARTIAL COPYRIGHT LICENSE

I hereby grant to Simon Fraser University the right to lend my thesis, project or extended essay (the title of which is shown below) to users of the Simon Fraser University Library, and to make partial or single copies only for such users or in response to a request from the library of any other university, or other educational institution, on its own behalf or for one of its users. I further agree that permission for multiple copying of this work for scholarly purposes may be granted by me or the Dean of Graduate Studies. It is understood that copying or publication of this work for financial gain shall not be allowed without my written permission.

Title of Thesis/Project/Extended Essay

The Pricing of Aquatic Lands for Salmon Aquaculture in

British Columbia.

Author: _____

(signature)

Donald G. Reddick

(name)

28 June 1988

(date)

ABSTRACT

This thesis examines provincial pricing policy for Crown aquatic lands used in salmon aquaculture. A history of the industry and pricing policy is presented along with a review of the new zone-based pricing system introduced in July, 1987. The existing policy is analyzed to determine the extent to which it (a) promotes an economically efficient use of aquatic lands allocated to salmon aquaculture, and (b) captures the potential economic rent associated with salmon farm sites. It is argued that existing fee levels underestimate potential tenure value, resulting in a number of inefficiencies caused by the rent-seeking behavior of industry participants. Distortions arising from the current method of pricing sites (per unit hectare fees) are also discussed.

Difficulties for policy improvement caused by the heterogeneous nature of salmon farm sites and uncertainties surrounding industry development are noted and a number of policy alternatives explored. Market-based pricing involving cash-bonus bidding and a modest ad valorem royalty is judged to be a superior policy for the long term. Because the use of market-based pricing in the intermediate and short term is limited by practical considerations, possible means of improving assessment-based pricing are discussed, one option being an appraisal pricing system using estimated industry cost functions. Periodic site auctions can be used as a bench mark for appraised tenure values in the short and intermediate term.

ACKNOWLEDGEMENTS

I would like to express my appreciation to a number of individuals who have provided assistance. This thesis would not have been possible without the patience and encouragement of my Senior Supervisor, Dr. Don DeVoretz. Dr. Richard Schwindt is to be thanked for his helpful comments and research assistance. I also thank Dr. Parzival Copes for his input both in the thesis and throughout my graduate studies. Dr. Terry Heaps provided useful suggestions on the mathematical aspects of the thesis and identified several potentially embarrassing errors.

The help of numerous government employees is gratefully acknowledged. Lynn Kennedy of the B.C. Ministry of Forests and Lands deserves special recognition for her willingness to take time out of a busy work schedule to discuss Ministry pricing policy. Gary Cain and Joe Truscott of the B.C. Ministry of Agriculture and Fisheries provided much of the statistical data presented in the thesis. Of course, the content of the thesis does not necessarily represent the views of these individuals - I take responsibility for any errors or omissions.

Finally, I would like to thank my family for their patience and prayers and the Lord I serve for His strength when I really needed it.

TABLE OF CONTENTS

Approval	ii
Abstract	iii
Acknowledgements	iv
List of Tables	vii
List of Figures	viii
1. Introduction	1
2. Salmon Farming and the Farm Site	4
2.1 Salmon and Salmon Aquaculture	4
2.2 The Importance of the Farm Site	5
3. Salmon Farming in British Columbia	8
3.1 History	8
3.2 Farm Structure	9
4. Provincial Aquatic Lands Administration	27
4.1 Provincial Jurisdiction Over Salmon Farm Tenure	27
4.2 The Provincial Lands Agency	28
4.3 Pricing Constraints and Objectives	28
4.4 Revised Pricing Criteria	36
5. Emergence of Existing Pricing Policy	44
5.1 Original Aquaculture Tenure Pricing Policy	44
5.2 Problems Concerning Land Value Assessment	49
5.3 B.C. Finfish Aquaculture Inquiry	51
5.4 New Pricing System for Salmon Farm Tenure	55
6. Analysis of Existing Pricing Policy	58
6.1 Site Valuation Methods	58
6.2 Site Fee Levels	61

6.3	Pricing Criteria: Site Rent Collection	69
6.4	Economic Efficiency	71
6.5	Accounting for Uncertainty	97
6.6	Administrative Efficiency	100
7.	Pricing Policy Alternatives	104
7.1	Market-Based Pricing	105
7.2	Assessment-Based Pricing	113
7.3	Summary	124
	Conclusion	126
	Appendix 1	127
	Appendix 2	135
	References	139

LIST OF TABLES

Table		Page
1	British Columbia Farmed Salmon Production, 1979-1986	11
2	World Production of Farmed Salmon in 1986 and 1990(forecast)	12
3	Comparison of Tenured Salmon Farms and Farm Applications, by Region, as of November 30, 1987	15
4	Total Tenure Area, Improvement Area, Pen Volume, and Holding Capacity, by Region, as of November 30, 1987	19
5	Regional Averages - Site Tenure Area, Improvement Area, Pen Volume, and Holding Capacity, as of November 30, 1987	20
6	Number of Companies Having Single or Multiple Sites, by Region, as of November 30, 1987	23
7	Estimated Annual Tenure Fee Payments, by Region, as of November 30, 1987	65

LIST OF FIGURES

Figure		Page
1	Regional Classification of the British Columbia Coast	16
2	Salmon Farm Pricing Zones	56
3	Hypothetical Production Function Isoquant Map	89
4	Isoquants Differentiated by Site Biophysical Characteristics	90
5	Hypothetical Long Run Cost Curves for Farms Having Different Site Characteristics	93

CHAPTER 1

INTRODUCTION

The emergence of the salmon aquaculture industry in British Columbia has resulted in a significant growth in demand for aquatic lands for aquaculture purposes. Salmon aquaculture, or more particularly salmon "farming", involves the rearing of young salmon in sea-pens until marketable size is reached. The coastal waters of British Columbia provide many suitable sites for salmon farming as well as other forms of aquaculture. To establish a salmon farm, an application must be made to the provincial government for aquatic land tenure. Growth in the number of farm tenures has been dramatic. As late as 1984, only 10 salmon farms were in operation on the British Columbia coast (DPA Group Inc. 1986, p.2-5). By November, 1987, 153 farms had been granted tenure by the provincial government, with an additional 144 applications for tenure being reviewed (B.C. Ministry of Agriculture and Fisheries 1988).

While the salmon aquaculture industry holds promise for the strengthening of the British Columbia coastal economy, its projected growth has raised a variety of questions and concerns. The list includes conflicts between alternative coastal resource users, potentially adverse environmental impacts arising from salmon farm operations, and the possibility of market competition between pen-reared salmon and the commercial wild catch. These and other issues have caused salmon farming to come under increasing public scrutiny in British Columbia.

In November, 1986, a public inquiry was commissioned by the provincial government to review the impacts of marine finfish aquaculture operations.¹ An

¹ See Gillespie (1986).

important finding of the inquiry was that the pricing system for salmon farm sites was inadequate. The Chairman noted that the annual charge for finfish farms (at the time \$200) was considerably less than that for other commercial or industrial uses of public (Crown) land, and that existing charges were "insufficient compensation to government for private use of Crown land" (Gillespie 1986, p.48). It was suggested that a new rental structure be established "consistent with other approaches used by the provincial government" (p.48). These views were consistent with those of the DPA Group Inc., who in a report prepared for the federal Department of Fisheries and Oceans in September, 1986, noted that the annual rental fee for aquatic land "understates the real value of the lease", and that "(t)he system for calculating the annual assessments for the use of an aquatic land lease should be reevaluated" (DPA 1986, p.24). The minimum annual fee for farm sites has recently been increased to \$500, and a new interim pricing system based on industrial log-storage rates has been introduced.

This paper focuses on provincial pricing policy for aquatic lands used in salmon aquaculture. The current policy is analysed to determine the extent to which it (a) promotes an economically efficient use of aquatic lands allocated for salmon farming, and (b) captures the potential economic rents generated by the use of salmon farm sites. Problems associated with existing pricing policy are discussed, and alternatives explored. Based on the paper's findings, adjustments to the current pricing system are proposed.

Chapters 2 through 5 provide the necessary background information. Chapter 2 outlines the nature of salmon farming and the importance of the farm site in the production process. Chapter 3 offers a brief history of the British Columbia aquaculture industry as well as a statistical look at industry structure at the sea

farm level. In Chapter 4, provincial jurisdiction over salmon farm tenure and the pricing responsibilities of the provincial lands agency are presented, along with the statutes and pricing objectives that shape government policy. A more concise set of objectives is proposed to facilitate policy analysis. Chapter 5 describes emergence of the existing pricing policy for salmon farm tenure.

In Chapter 6, the existing pricing system is analyzed. Shortcomings of the current system are examined using the pricing criteria established in Chapter 4. Among other things, it is argued that current tenure fees underestimate potential tenure value. A model predicting the effect differential site characteristics will have on farm output, production costs and water usage is developed, and used to show the potential distortions caused if the current pricing policy is used to collect farm site rents.

Policy alternatives are reviewed in Chapter 7. Market-based pricing involving cash-bonus bidding and a modest ad valorem royalty is judged to be a superior policy for the long term. Because practical considerations limit its feasibility for the intermediate and short term, possible improvements in assessment-based pricing are explored. If potential economic rents from site use prove to be small, the use of an ad valorem royalty to collect site rents is recommended. If potential site rents are large, a profit share arrangement using estimated industry cost functions will hold a number of advantages over other assessment techniques. Periodic site auctions can be used in the short term and intermediate term as a means of evaluating the accuracy of existing assessment methods.

CHAPTER 2

SALMON FARMING AND THE FARM SITE

2.1 Salmon and Salmon Aquaculture

Salmon are anadromous species in the wild, meaning they spawn in fresh water streams yet spend most of their lives at sea. Hatching from fertilized eggs, young salmon (called fry) remain in fresh water until a physiological process known as smolting occurs. This process enables adaptation to salt-water conditions. The time required to reach the smolt stage varies between salmon species. Atlantic salmon, for example, take at least one year, while Pacific chinook and coho require approximately 6 months. After becoming smolts, salmon migrate to the sea, spending most of their lives feeding there and undergoing the bulk of their growth. Salmon return to their home streams to spawn when they reach sexual maturity. Atlantic and coho salmon are 3 to 4 years old at maturity and weigh 4.5 to 6.5 kilograms, while chinook are generally 4 to 5 years old at maturity and commonly average between 14 and 18 kilograms.

Highly prized as a food fish world-wide, salmon have traditionally been supplied to markets by commercial fishermen who intercept migrating wild stocks as they approach their spawning streams. However, new sources of supply have become available through aquacultural methods. Salmon aquaculture involves the human cultivation of salmon in a water environment. Aquacultural methods vary in the degree of human control in the cultivation process. In the case of salmon ocean ranching, for example, control is limited to the culturing of young salmon to the smolt stage. Released to the sea from a designated site, the salmon are harvested at or near the site upon return. Salmon farming introduces a greater

degree of control. Cultured smolts are placed in salt water enclosures and reared there until maturity. This enables, among other things, greater control of market availability, enhanced productivity by supplemental feeding, protection against predators and the monitoring and prevention of fish disease. While the greatest degree of control can be achieved in land-based fish farms where most characteristics of the water environment can also be controlled, high construction costs have meant the vast majority of farms involve enclosures in marine waters.

Farmed salmon are predominantly grown in sea-cage systems. A typical system consists of net-pens, floats and anchoring arrangements. Though net-pens can take on a number of designs, all essentially involve nylon net suspended from a floating frame. A number of pens are usually employed on each farm, anchored individually or in a series. Depending on the biological and physical factors outlined below, sea-cage systems may be shore based or located offshore.

2.2 The Importance of the Farm Site

The farm site plays a multi-dimensional role in the production of pen-reared salmon. First, it provides a medium for raising salmon. This role can be clarified by viewing the farm as a production system involving three interrelated components (Allen et al. 1984, p.18). The physical component of the production system consists of the sea-cage system and its associated operating equipment. The biological component incorporates the living fish and their associated biological characteristics (i.e. age to maturity, survival and growth rates, food and oxygen requirements, etc.). The culture component is the water

environment in which the physical and biological components interact.

As the culture environment affects both the physical and biological components of the farm production system, its characteristics have an important influence on farm productivity and production costs. For example, site exposure to wind and waves will determine the engineering specifications of the physical component (i.e. anchoring and securing requirements for floats and pens, the need for breakwaters, etc.), as will tidal range. Water circulation or flushing rate through sea-pens will affect the biological component by determining the degree of waste removal and the supply of oxygenated water available to the fish. Water temperature and salinity influence fish growth. As accumulated waste feed and fish feces on the ocean floor can release toxic gases, water depth below sea-pens is also an important consideration. Other interactions between the culture environment and the other components arise due to the existence of predators (i.e. seals, otters, eagles, etc.), environmental conditions conducive to plankton blooms which are harmful to salmon, and water pollution from local industry, communities or marinas.

The farm site also plays a spatial role in the aquaculture production process. Interactions within the culture environment can be adjusted by altering the spatial location of the sea-cage system components. For example, pens can be spaced such that concentrations of waste feed and fish feces harmful to fish health do not arise. Similarly, site size can be extended to provide an additional "buffer zone" between the farm and potentially harmful adjacent activities (e.g. the discharge of marine fuel associated with recreational boating).

Once a location is chosen, many of these factors will be beyond the farmer's control. As a result, site selection is critical. Indeed, in cases where

site conditions are particularly detrimental to production, the only solution may be to move the farm to another location, as has happened on occasion in other countries (Bjorndal 1988, p.123). Locational factors are equally important to site selection. Proximity to roads, processors, market shipping points, as well as to a labour pool, electric power, communication links, and fresh water will all have a bearing on farming costs.

CHAPTER 3

SALMON FARMING IN BRITISH COLUMBIA

3.1 History

Salmon farming first began in British Columbia in 1972 with the establishment of a farm on the Sechelt Peninsula. Located in the southern coastal region near Vancouver, the region is a popular recreational and retirement area with developed infrastructure and favourable farm site conditions. By 1975, there were four operating farms. This slow rate of industry growth continued until 1984. A number of reasons can be offered to explain this trend (DPA 1986, p.2-5). Lack of expertise and limited technology resulted in low salmon survival rates and poor production techniques. Advertising and promotional activity were limited in scope and industry quality standards undeveloped. Because producers emphasized small (pan size) salmon, British Columbia farms faced strong competition from similarly sized farmed trout and salmon imported from the United States. By 1984, only 10 farms were in operation.

Since 1984 the industry has experienced rapid expansion. In 1985 there were 38 farms with saltwater operations; by the end of 1986 the number had risen to 70. As outlined in the next section, the industry is presently still growing, with well over 200 tenured farms expected by the end of 1988.

The dramatic growth of the British Columbia farmed salmon industry can be attributed to a number of factors (DPA 1986, p.2-7; Bjorndal and Schwindt 1987, p.16-17). One is the demonstrated success of the Norwegian salmon farming industry and its ability to enter lucrative United States fresh seafood markets. Another has been Norwegian government restrictions on domestic farm size and

ownership. Given its proximity to the United States market, favourable site conditions and few government restrictions of the type found in Norway, British Columbia has received a considerable amount of Norwegian investment. Finally, development has also been encouraged by the provincial and federal governments which see the industry as a means of revitalizing coastal economies.

3.2 Farm Structure

The salmon aquaculture industry can be divided into a number of interrelated levels. The federal government as well as private broodstock farms supply eggs to the industry.¹ Private hatcheries and smolt producing operations in turn provide young salmon to grow-out farms which raise the fish till market size is reached. The harvested salmon are then processed either by the existing wild-caught processing sector, specialized farmed salmon processors, or the farm operators on site. The end product - fresh salmon - is largely exported by processors, brokers or the farm companies themselves.

Attention here will be given to industry structure at the grow-out farm level.² The British Columbia salmon farming industry is in the midst of rapid growth, making description of farm characteristics difficult. Current conditions are influenced by the fact that many farms are still in the start-up phase, and can be expected to change as the industry matures.

¹ In regard to the first source, the Department of Fisheries and Oceans supplies surplus wild eggs from its Salmon Enhancement Program.

² See DPA (1986) for an overall review of industry structure.

3.2.1 Production

British Columbia salmon farms have historically produced Pacific chinook and coho salmon.³ Table 1 presents growth in production between 1979 and 1986. The erratic behavior of industry output in the early 1980s can be attributed to the unsettled financial conditions faced by producers during these years. The high volume in 1982, for example, was largely explained by the failure of Apex Bio Resources, the largest producer in the province at the time, which slaughtered much of its stock during the year in an unsuccessful attempt to remain solvent (Bjorndal and Schwindt 1987, p.18).

Output is expected to grow substantially in the future. Marketable fish (i.e. 2-4 year old salmon) from the many farms established since 1985 are only now coming to maturity. Given the increasing numbers of new farms and anticipated reductions in salmon mortality rates, production is projected to reach as much as 20,000 tonnes by 1990, with a possible market value of \$163 million (B.C. Ministry of Agriculture and Fisheries 1987, p.8).

As revealed in Table 2, British Columbia farms accounted for less than one percent of total world production of pen-reared salmon in 1986 (the most recent year for which world production statistics are available). Norway was the largest supplier, producing 68 percent of world output, followed by Scotland (15 percent) and Japan (11 percent). Assuming future estimates for British Columbia and other countries are correct, British Columbia farms will produce approximately 8 percent of total world output by 1990.

³ Since 1984, however, significant quantities of rainbow trout, Atlantic salmon and steelhead have been also been introduced.

Table 1: British Columbia Farmed Salmon Production, 1979-1986

Year	Coho		Chinook		Total Production	
	Quantity (Tonnes)	Value (\$'000)	Quantity (Tonnes)	Value (\$'000)	Quantity (Tonnes)	Value (\$'000)
1979	41	157	-	-	41	157
1980	157	898	-	-	157	898
1981	176	985	-	-	176	985
1982	230	980	43	228	273	1,136
1983	73	350	55	358	128	708
1984	64 ¹	306	43	396	107	702
1985	71 ¹	421	50	398	120	819
1986	299	1,972	89	657	388	2,629

1 = Includes an unspecified amount of marine pen-reared rainbow trout.

Source: *Fisheries Production Statistics of British Columbia*, Annual. B.C. Ministry of Environment, 1986, and personal communication with Fisheries Branch, B.C. Ministry of Environment.

Table 2: World Production of Farmed Salmon in 1986 and 1990(forecast)¹

Country	1986 (Tonnes)	1990 (Tonnes)
Norway	45,500	100-120,000
Scotland	10,000	20,000
Japan	7,000	25-30,000
Chile	2,000 ²	8-10,000
Ireland	1,000	10,000
Faroe Islands	600 ³	10,000
British Columbia	400	10-20,000
Iceland	200	2-5,000
USA ^{4,5}	-	3,000
New Zealand	-	2,000
Total Production	66,500	190-230,000
B.C. share of production	-	8%

1 = Inclusive of Atlantic Salmon

2 = 1986/87 season

3 = 1985 figures

4 = Including ocean ranching

5 = Production figures for 1986 not available

Sources: Bjorndal (1988, p.140). Figures for British Columbia were revised after personal communication with Fisheries Branch, B.C. Ministry of Environment.

The anticipated tripling of world pen-reared salmon production by 1990 raises the question of the impact such a major supply increase will have on market prices and hence the profitability of salmon farm operations. Bjorndal (1988, pp.138-41) identifies a number of factors that will influence the ultimate market outcome. At present, pen-reared salmon has already been introduced to the most important geographical markets - Western Europe, the United States, and Japan. For considerable supply increases to not cause price declines, deeper market penetration and the opening up of new market segments will be necessary. If prices fall despite these events, as some have predicted,⁴ competition between producing countries may become intense. Producer location in relation to the important consumer markets, the favorability of natural growing conditions for pen-reared salmon, and the extent of government-imposed regulations on salmon farm operations⁵ will all influence the competitive balance between producing countries.

3.2.2 Farm Characteristics

The most recent information on the structure of the British Columbia salmon farming industry at the sea farm level is found in the Salmon Farm Survey conducted by the B.C. Ministry of Agriculture and Fisheries (MAF) between September and November of 1987 (B.C. Ministry of Agriculture and Fisheries 1988). The following draws heavily on this source.

As of November 30, 1987, there were 118 operating salmon farms on the British Columbia coast, a 69 percent increase in the number of farms operating

⁴ See, for example, DeVoretz (1987).

⁵ As has occurred in Norway, regulations may take the form of size restrictions on farm production capacity (possibly affecting the ability to achieve scale economies) and ownership limitations (reducing the possible benefits of horizontal and vertical integration).

at the end of 1986 (70). An additional 35 farms had been issued site tenure but had not yet begun operations, raising the total number of tenured sites to 153.

Table 3 provides a regional breakdown of existing farm sites and site applications. Figure 1 accompanies Table 3, illustrating the various regions. As shown in Table 3, the vast majority of farms by the end of 1987 were located in the South Coast - 97 percent are found in the waters surrounding Vancouver Island and the adjacent mainland coastline. This result is explained by the significant infrastructure advantages offered by the South Coast region compared to locations in the Central and North Coast. Focusing on the South Coast, activity is the greatest in the Sunshine Coast/Lower Mainland region (40 percent of total provincial sites) followed by Campbell River/Desolation Sound (27 percent) and Alberni/Clayoquot (14 percent).

Table 3 also records the number of regional operating sites as of October, 1986. Comparing the 1986 and 1987 figures, the Campbell River/Desolation Sound and Sunshine Coast/Lower Mainland regions experienced the greatest absolute increases in the number of operating farms (20 and 13 new farms respectively). In percentage terms, the Campbell River/Desolation Sound and Northwest Vancouver Island regions have seen the most growth, both experiencing a tripling in the number of active farms. Of the 35 non-operating farms that received tenure in 1987, 37 percent were on Vancouver Island, 34 percent were in the Sunshine Coast/Lower Mainland area, and 26 percent were in the Campbell River/Desolation Sound region.

Table 3 also presents the number of applications for new farm tenure in each region. Of the 144 applications under review at the time, 39 percent were for the Campbell River/Desolation Sound area. Vancouver Island accounted for 37

Table 3: Comparison of Tenured Salmon Farms and Farm Applications, by Region, as of November 30, 1987¹

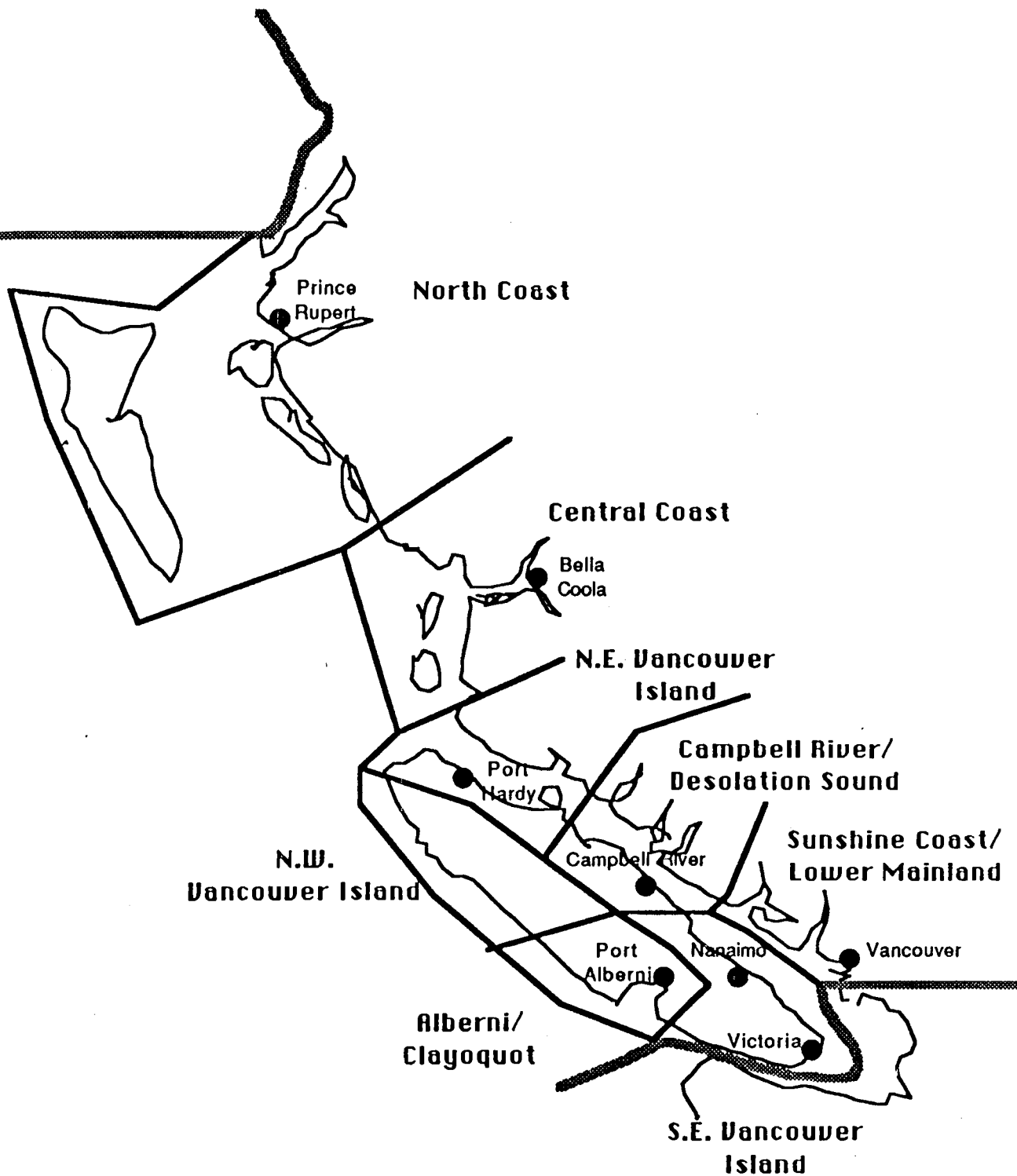
	North Coast	Central Coast Island	Northeast Vancouver Island	Northwest Vancouver Island	Southeast Vancouver	Campbell River/ Desolation Sound	Alberni/ Clayoquot	Sunshine Coast/ Lower Mainland	British Columbia (Total)
Operating Tenures	3 (2)	0 (0)	4 (3)	8 (3)	8 (7)	32 (12)	16 (12)	47 (34)	118 (70)
Non-operating Tenures	1	0	4	1	3	9	5	12	35
Total Tenures	4	0	8	9	11	41	21	59	153
Farm Tenure Applications	7 (N/A)	7 (N/A)	8 (N/A)	5 (N/A)	4 (12)	56 (84)	36 (N/A)	21 (48)	144 (251)
Investigative Permit Applications ²	48 (N/A)	40 (N/A)	42 (N/A)	82 (N/A)	17 (10)	39 (13)	34 (N/A)	21 (1)	323 (94)

1 = Numbers in parentheses correspond to 1986 figures.

2 = B.C. Ministry of Agriculture and Fisheries records.

Source: B.C. Ministry of Agriculture and Fisheries (1988)

Figure 1: Regional Classification of the British Columbia Coast



Source: B.C. Ministry of Agriculture and Fisheries (1988)

percent, while 14 percent were for the Sunshine Coast/Lower Mainland region. The Central and North coast regions received 10 percent of all applications.

The potential for future development is also revealed by investigative permit data. Before applying for site tenure, an investigative permit must be obtained to determine site suitability for salmon aquaculture. As shown in Table 3, 323 investigative permits were recorded by MAF in 1987, three times the number recorded in 1986. The Northwest Vancouver Island region accounted for the greatest number of investigative permit applications (84), followed by the North Coast (48). The Sunshine Coast/Lower Mainland area received the second fewest applications (21).

These results suggest that new farms will increasingly be established in the more northern reaches of the South Coast - i.e. Northwest Vancouver Island - and possibly in the North Coast. MAF has attributed this trend to the growing shortage of available and biophysically suitable sites on the Sunshine Coast (B.C. Ministry of Agriculture and Fisheries 1988, p.2).

Table 4 provides a regional breakdown, in percentage terms, of aggregate provincial tenure area, improvement area, pen volume, and capacity held by the 118 operating farms.⁶ As would be expected, the results are closely linked to the number of operating farms found in each region. The dominance of the Sunshine Coast/Lower Mainland region is striking, containing almost 40 percent of total provincial tenure area and over 50 percent of improvement area, pen volume and capacity. The Campbell River/Desolation Sound area contains the second highest

⁶ Tenure area is a measure of total site size, while improvement area encompasses only the space occupied by site improvements such as net-pens, docks, floating work and accommodation facilities, etc. Site capacity is derived by multiplying pen volume by an assumed average fish stocking density of 8 kg/m³.

level of aggregate activity, with over 25 percent of the provincial total in all categories.

In Table 5, provincial and regional averages for site tenure area, improvement area, pen volume, and holding capacity are presented. The average British Columbia farm site is 5.15 ha, approximately 2100 m² of this area used for site improvements. Pen volume on the average farm is a little over 21000 m³, with an associated holding capacity of 170 tonnes.

Significant differences exist between the regions in all categories. Mean farm tenure area is the largest in the Northwest Vancouver Island region (11.19 ha), much greater than average site size in the Campbell River/Desolation Sound and Sunshine Coast/Lower Mainland regions (5.39 ha and 4.85 ha respectively). Turning to mean site improvement area, the results are somewhat reversed. Sunshine Coast/Lower Mainland farms have the highest site improvement area on average (2709.15 m³), whereas farms in the Northwest Vancouver Island region have the lowest average improvement area in the province (897.23 m³).

The contrasting results for regional farm size and site improvement area can be explained by several factors. Because salmon farming involves the rearing of salmon in stages (i.e. different year-classes), it takes anywhere from 3 to 5 years to fully develop a new farm. The Sunshine Coast was one of the first regions to experience salmon farm development. As such, farms in this region are older and more fully developed in terms of site improvements. More remote areas such as Northwest Vancouver Island have only seen farm development recently. Combining the fact that new farms are still in the development stages with the observation by MAF that the size of farm tenure requested by applicants for new farm sites appears to be growing (B.C. Ministry of Agriculture

Table 4: Total Tenure Area, Improvement Area, Pen Volume, and Holding Capacity, by Region, as of November 30, 1987

Region		Tenured Area (ha)	Improvement Area(m ²)	Pen Volume (m ³)	Capacity (Tonnes)
North Coast		5.60	4069.68	40665.31	325.32
	n	2	2	2	2
Central Coast		-	-	-	-
	n	0	0	0	0
N.E. Vancouver Island		38.56	6516.00	39285.00	314.28
	n	4	4	4	4
N.W. Vancouver Island		89.54	7177.84	57981.18	463.85
	n	8	8	8	8
S.E. Vancouver Island		16.37	12078.70	126888.90	1015.11
	n	8	8	8	8
Campbell River/ Desolation Sound		161.76	58225.51	625128.68	5001.03
	n	32	29	29	29
Alberni/ Clayoquot		69.13	15611.20	171682.00	1373.46
	n	16	11	11	11
Sunshine Coast/ Lower Mainland		227.85	119202.69	1171278.00	9370.22
	n	47	44	43	43
Provincial Total		608.81	222881.62	2232909.07	17863.27
	n	118	106	105	105

(n) = Number of recorded farms.

Source: B.C. Ministry of Agriculture and Fisheries (1988)

Table 5: Regional Averages - Site Tenure Area, Improvement Area, Pen Volume, and Holding Capacity, as of November 30, 1987

	North Coast	Central Coast	Northwest Vancouver Island	Southwest Vancouver Island	Campbell River/ Desolation Sound	Alberni/ Clayoquot	Sunshine Coast/ Lower Mainland	British Columbia (Total)
Tenured Area (ha)	2.80	-	11.19	2.34	5.05	4.32	4.85	5.16
Mean			9.64					
Largest	•	-	20.25	3.25	17.00	10.00	12.90	57.00
Smallest	•	-	0.11	2.00	1.96	2.00	0.50	0.11
n	2	0	4	8	32	16	47	118
Improvement Area (m ²)	2034.84	-	897.23	1509.84	2007.78	1419.20	2709.15	2102.66
Mean			1629.00					
Largest	•	-	3024.00	3895.50	6184.00	2700.00	4752.00	6184.00
Smallest	•	-	801.00	256.00	105.00	72.00	360.00	72.00
n	2	0	4	8	29	11	44	106
Pen Volume (m ³)	20332.66	-	7247.65	15861.11	21556.16	15607.45	27239.02	21265.80
Mean			9821.25					
Largest	•	-	15120.00	51736.50	106608.00	35100.00	111636.00	111636.00
Smallest	•	-	6007.50	1536.00	1080.00	432.00	2160.00	432.00
n	2	-	4	8	29	11	45	105
Capacity (Tonnes)	162.66	-	57.98	126.89	172.45	124.86	217.91	170.13
Mean			78.57					
Largest	•	-	120.96	413.86	852.86	280.80	893.09	893.09
Smallest	•	-	48.06	12.29	8.64	3.46	17.28	3.46
n	2	0	4	8	29	11	43	105

• = Where sample size (n) was less than 3, statistical values were not published to ensure confidentiality.

Source: B.C. Ministry of Agriculture and Fisheries (1988)

and Fisheries 1988, p.2) may explain the observed results of small farms on large sites.⁷ As time passes, the extent of operations on these sites will increase.⁸

In terms of average pen volume and holding capacity, farms in the Sunshine Coast/Lower Mainland and Campbell River/Desolation Sound regions again stand out. Sunshine Coast farms have pen volumes of over 27000 m³ on average, and mean holding capacities of approximately 218 tonnes, both figures three times greater than those for the Northwest Vancouver Island region. Again, these results may be more a sign of current industry disequilibrium than a long-term trend. Campbell River/Desolation Sound farms have pen volumes of 21500 m³ on average, with an associated holding capacity of 172 tonnes. MAF notes that the overall tendency appears to be toward development of larger farms than in the past (B.C. Ministry of Agriculture and Fisheries 1988, p.2).

Table 5 also reveals that large variations exist between individual farms along the coast, both between and within regions. The largest farm site on the coast is 57 ha (Northwest Vancouver Island) while the smallest is only 0.11 ha (Northeast Vancouver Island). In terms of improvement area, the largest farm is found in the Campbell River/Desolation Sound region (6148 m²) while the smallest is in Alberni/Clayoquot (105 m²).

⁷ It should be noted that sites in the Sunshine Coast/Lower Mainland region can be expected to be smaller on average than those in the more northern areas. The greater amount of alternative coastal resource use in this region (i.e. recreational boating, fishing, etc.) reduces the likelihood of government granting a request for a large farm site.

⁸ There may be other reasons for the recent establishment of small farms on large sites. Section 6.4.2 offers an explanation based on the theory of rent-seeking.

Variations are particularly large for pen volume and holding capacity. The largest farm in these categories has a pen volume exceeding 111000 m³ and holding capacity of 893 tonnes (Sunshine Coast/Lower Mainland). In contrast, the smallest farms in the province have pen volumes of less than 1000 m³ and holding capacities under 10 tonnes.

The Salmon Farm Survey results do not distinguish between grow-out farms and broodstock farms. The latter are generally much smaller operations, and most likely account for the smallest farm figures recorded in the Survey. However, significant variation appears to exist even if these operations are excluded. While this remaining variation could again be the result of unsettled development in the industry, other forces may also be at work. As discussed in Section 6.4.4, differences in farm characteristics may persist in the long run due to the effect of heterogeneous site characteristics on the profit-maximizing size of farm operations.

3.2.3 Farm Ownership: Site Concentration and Foreign Investment

As late as 1986, salmon farming in British Columbia was primarily characterized by single farm operations.⁹ More recently, multi-site operations have become common.

Table 6 shows the extent of multi-site holdings by region as of November, 1987.¹⁰ Of the 118 active sites, 71 were single site operations. Seventeen firms

⁹ DPA (1986, p.3-7) report that of the 49 sites producing fish for commercial sale as of June, 1986, 40 were single site operations. Three companies operated 2 site operations, while one firm operated 3 sites.

¹⁰ The data represent an underestimate of multi-site operations because account is not taken of firms registered under different names but held in common ownership. MAF staff did not attempt to determine multi-company ownership when conducting the Farm Survey because company ownership in the industry is in a state of flux. Inter-regional holdings are also not recorded, although at the

Table 6: Number of Companies Having Single or Multiple Sites,
by Region, as of November 30, 1987¹

Region	Number of Sites					
	1	2	3	4	5	6
North Coast	1	1				
Central Coast						
N.E. Vancouver Island	1		1			
N.W. Vancouver Island	4	2				
S.E. Vancouver Island	6	1				
Campbell River/ Desolation Sound	24	2		1		
Alberni/ Clayoquot	8	2		1		
Sunshine Coast/ Lower Mainland	27	3		2		1
Total	71	11	1	5	0	1

• For example, in the Campbell River/Desolation Sound area there are 24 companies that hold one site, 2 companies that hold two sites each, and 1 company that holds 4 sites, for a total of 32 sites in this region.

1 = The data do not account for companies having different names but under common ownership.

Source: Computed from the B.C. Ministry of Agriculture and Fisheries' 1987 Salmon Farm Survey data, personal communication with Ministry staff, April, 1988.

conducted multi-site operations, with eleven companies controlling 2 sites, one firm utilizing 3 sites, four firms operating 4 sites, and one firm holding 6 sites. When considering the various regions, the Sunshine Coast/Lower Mainland area contains the highest degree of multi-site activity.

A possible explanation for the trend toward multi-site holdings is cost savings gained from horizontal integration of farming activities. Horizontal integration could result in economies due to common financing, joint purchasing of feed and equipment, and joint slaughtering and processing.¹¹ Multi-site holdings might also enable diversification of risks associated with fish disease, especially if pursued on an inter-regional basis.

Foreign participation in the British Columbia salmon farming industry is subject to few restrictions. Though its exact current magnitude is difficult to assess because of a lack of formal reporting requirements, several studies provide evidence that foreign involvement in British Columbia farms, particularly by Norwegian interests, is large and growing.

Foreign investment as of June, 1986, is documented by DPA (1986, pp.3-12,13). At that time, 11 of the 54 operating salmon farms had either foreign equity participation or foreign loans.¹² Foreign investment in these farms was

¹⁰(cont'd) present time multi-site operations appear to be largely intra-regional in nature.

¹¹ Economies may be *real* or *pecuniary* in nature. In this context, pecuniary economies will arise if volume purchasing provides the buyer with market power in negotiations with input suppliers. Real economies would in this case involve resource savings from such things as volume purchases (e.g. lower transportation costs per unit with large input shipments). While multi-site holdings may confer pecuniary economies from volume buying, there is no current evidence to suggest that volume buying will entail real economies.

¹² Foreigners held a controlling interest in 6 of the 11 farms. Of the remaining 5, 2 farms were joint ventures between residents and foreigners and 3 involved foreign minority interests.

estimated to be \$9 million, 40 percent of the total capital investment in the industry at the time. Ten of the 11 farms received backing from Norwegian interests.

Bjorndal and Schwindt (1987, pp.23-26) provide a detailed description of the various Norwegian firms having ownership ties with British Columbia farms. This involvement is expected to grow. As noted in a trade publication¹³ cited by the two authors, the majority of farms operating or under construction in 1986 were either owned or operated with Norwegian expertise and financial backing.

A number of factors explain the prevalence of Norwegian aquaculture investment in British Columbia. Farm size and ownership regulations limit the investment opportunities available to established Norwegian firms. This fact, in conjunction with the transportation advantage held by British Columbia over European locations in supplying the North American market, make British Columbia farms attractive to Norwegian investors. Additionally, in line with international trade theory, Bjorndal and Schwindt (1987, pp.29-31) point out that Norwegian investors enjoy a cost advantage over British Columbia producers in terms of farming knowledge which can only be exploited by direct foreign investment.¹⁴

A final explanation is that residents have experienced difficulties in obtaining capital from domestic banks due to bank unfamiliarity with salmon farm operations. Though financing requirements for salmon farming are not large in comparison with other industries,¹⁵ the strain created by heavy reliance on

¹³ Gilje, S. (1986) "Farmed Fish Jumping in Canada," *NorAm Report*, May, pp.1-4.

¹⁴ It is argued that domestic personnel skilled in salmon farming technology are still few in number, and that transactions costs make it difficult for Norwegians to capture a return from their knowledge without direct participation in the British Columbia industry. Assuming domestic farm operators can indirectly acquire foreign knowledge through imitation, this cost advantage held by foreigners will not last.

¹⁵ DPA (1986, pp.3-16,17) report that the average capital investment per site in

personal equity financing has caused some residents to seek foreign financing.

3.2.4 Future Outlook and Implications for Aquatic Land Usage

Because the British Columbia salmon farming industry is rapidly expanding, it is difficult to make precise predictions about the ultimate shape the farming industry and its demand for aquatic lands will take. However a few important trends can be noted.

1. Declining availability of biophysically attractive sites in the Sunshine Coast/Lower Mainland and lower Vancouver Island areas will result in farm development in the more undeveloped areas such as the western and northern regions of Vancouver Island.
2. Future farms will tend to be larger, both in terms of tenure area and production capacity.
3. Multi-site farm operations will become more common, due to the entry of multi-site operations as well as consolidation of existing enterprises. Production will thus be concentrated in a fewer number of firms.
4. The proportion of annual foreign investment (direct and portfolio) to total investment will be maintained (if not increased) over the next several years.¹⁶

¹⁵(cont'd) 1986 was \$405,000. Annual operating expenditures were approximately \$330,000 per site. These numbers can be expected to increase with the trend toward larger farm operations.

¹⁶ DPA (1986, p.19). This result is attributed to a continued unwillingness on the part of domestic banks to provide financing until proven production and sales records are established.

CHAPTER 4
PROVINCIAL AQUATIC LANDS ADMINISTRATION

4.1 Provincial Jurisdiction Over Salmon Farm Tenure

Jurisdiction over salmon farm tenure on Canada's west coast lies primarily with the British Columbia provincial government. This is true because of the province's ownership of most aquatic lands where salmon farming occurs. Aquatic lands are defined as the foreshore (the area between the high and low water mark) and submerged offshore lands. The common law position, generally, is that ownership of submerged lands confers exclusive use rights to the waters above.¹ As a result, the right to allocate and price farm sites goes hand-in-hand with proprietorship over submerged lands.

The dividing line between provincial and federally owned lands on Canada's west coast has been a question before Canadian courts on numerous occasions.² At present, all foreshore lands and submerged lands found in bays, inlets and other waters *inter fauces terrae* (within the jaws of the land) are provincially owned. In addition, the Supreme Court of Canada has ruled that all submerged lands between Vancouver Island and the British Columbia mainland also belong to the province.³ The protected nature of the waters associated with provincially owned submerged lands has made them the most desirable for salmon farming,

¹ These rights may be overlaid by statutory modifications and administrative regulation; for example, navigation and fisheries acts. Jurisdictional complications arising from such modifications are outlined in Section 4.3.3.

² The landmark cases are *Atty.-Gen. of Canada v. Atty.-Gen. of B.C.* (1984) 1 S.C.R. 365 and *Reference re Offshore Mineral Rights in B.C.* (1967) S.C.R. 795.

³ See *Atty.-Gen. of Canada v. Atty.-Gen. of B.C.* (1984).

thus explaining the province's leading role in site allocation and pricing.⁴

4.2 The Provincial Lands Agency

The B.C. Ministry of Forests and Lands (MFL) is the agency currently responsible for the administration of provincially owned lands, including aquatic lands for salmon farming.⁵ Its role includes the provision of Crown lands for particular uses and the formulation of lands pricing policy.

As defined by MFL, pricing policy involves six policy components; (1) method of land valuation, (2) method of pricing, (3) method of payment, (4) form of tenure, (5) term of tenure, and (6) method of disposition (B.C. Ministry of Lands, Parks and Housing 1986(a), p.8). Pricing policy thus dictates the terms under which Crown land will be made available for particular uses. Discussion of the various pricing options available for salmon farm tenure will focus on alternative specifications of these pricing components.

4.3 Pricing Constraints and Objectives

MFL makes Crown land available to the public for a wide variety of uses, each within the context of a particular land use program.⁶ Pricing policy for

⁴ The province does not allocate farm sites in public harbours and ports. Sites in these areas are administered by federal regulatory agencies and harbour commissions.

⁵ Provincial lands administration was previously the responsibility of the B.C. Ministry of Lands, Parks and Housing (MLPH) until a ministry reorganization in 1986. Because MFL inherited the past policies of MLPH, references to lands policy in the following text are often from MLPH.

⁶ Programs include land for agricultural, aquacultural, commercial, industrial, transportation, communication and utilities uses.

Crown land programs is shaped by several important considerations. First, policy must conform with the pricing-provisions of the B.C. *Land Act* (R.S.B.C. 1984) and its associated amendments. Second, pricing policy should be consistent with government-established pricing objectives. To facilitate policy development, the provincial Cabinet has endorsed a number of general pricing guidelines.⁷ In addition, objectives are set out in the policy statement for each particular Crown land program. Because both the *Land Act* statutes and the government-established pricing objectives play an important role in the determination of pricing policy for aquacultural lands, each is considered in turn below.

4.3.1 *Land Act* Statutes

Crown aquatic land cannot be sold by the province under normal circumstances (s.14). However, three forms of tenure are available under the *Act*; general license (or investigative permit) (s.10), license of occupation (s.36) and lease (s.35). An investigative permit can be issued for up to one year, and in the case of salmon farming allows a site to be studied to determine biophysical and locational suitability. A license of occupation grants the right to occupy and use Crown land for a specified purpose. The province retains the right to grant to other parties licenses for other non-interfering uses of the licensed area.⁸ A lease offers exclusive use rights to a site. Under normal circumstances leases to any one person cannot exceed 520 hectares in area (s.17(1)) nor be of a term greater than 60 years (amendment to s.18). Similar conditions apply for a license of occupation.⁹ The method of pricing both leases and licenses of occupation is

⁷ Though the pricing guidelines do not have the force of legislation, they are used by the lands agency as a basis for policy determination.

⁸ Personal communication with MFL staff revealed that in the case of salmon farming this is not done in practice.

⁹ However, it is MFL policy that licenses of occupation have a term of no

subject to the terms considered desirable by the Minister (ss.35,36).

Crown land tenures may be disposed by various methods under the *Act*. Possibilities are disposition by direct application (s.7) or by public auction, tender, or lot draws (s.8(1)). In each case, disposition is subject to terms and restrictions on land use deemed desirable by the Minister (ss.7,8(1)). Finally, transfer (assignment) of Crown land tenures requires ministerial approval in all cases where Crown land was not initially granted by outright sale (s.94(2)). The Minister may require the applicant to carry out certain stipulations prior to transfer approval (s.94(4)).

It can be seen that while the *Land Act* restricts tenure for salmon farming operations to two basic forms - lease and license of occupation¹⁰ - it allows for a great deal of policy flexibility within these tenure forms. Leases or licenses of occupation can be offered for terms of varying lengths and priced using any method considered appropriate by the Minister. The method of tenure disposition can range from direct application to competitive bidding. Granted tenure may be authorized as transferable or nontransferable.

4.3.2 Normative Pricing Principles

In addition to meeting the requirements of the *Land Act*, pricing policy must conform with a number of general pricing guidelines established by government. In the case of Crown land programs, the provincial Cabinet has endorsed a set of normative pricing principles that serve as a basis for pricing policy. These principles are documented in B.C. Ministry of Lands, Parks and Housing (1986(a)) and will be summarized here.

%(cont'd) longer than 10 years.

¹⁰ An investigative permit does not grant the right to begin actual operations.

1. *Fair Return to the Crown:* Adopted pricing policy should confer a "fair" or market value price to the province for the allocation of Crown land to private interests. As noted by the Ministry:

To provide the land for private use at less than market value would imply that the provincial government is sanctioning the economic benefit of a few individuals at the expense of the public (B.C. Ministry of Lands, Parks and Housing 1986(a), p.3).

2. *Neutrality:* Pricing of Crown land should involve no hidden incentives or dis-incentives for particular land uses, unless warranted by policy objectives. Where warranted, incentives should be explicitly identified.
3. *Comparability:* Similar types of tenure (i.e. having similar form and term) for comparable types of land should result in a consistent level of pricing in all policy areas. Indiscriminant pricing between policy areas should be avoided.
4. *Equity:* Pricing should not involve discrimination on an individual or group basis. Replacement tenures should not be priced so as to impose undue hardship on existing tenure holders. Individuals should have equal opportunities to acquire Crown land.
5. *Flexibility:* Pricing should be adaptable in light of changing market conditions and specific Crown land program needs. To ensure a fair return to the Crown, provisions should exist for rental and fee review. Crown land dispositions should be subject to special provisions in instances where subject lands involve special management requirements. When warranted, it

should be possible to withdraw Crown land from disposition or from disposition for specific uses.

6. *Administrative Efficiency*: Pricing policy should be structured to minimize administrative cost and effort.

Conflicts can be expected to arise when trying to adhere to all of these pricing principles. To reconcile conflict cases, certain principles must take precedence over others. It is MFL policy to choose pricing systems that ensure administrative efficiency over those which promote fair return when conflicts arise between the two principles. Equity takes precedence in all cases of conflict.

4.3.3 Crown Aquacultural Land Program Objectives

In the case of aquacultural lands, pricing policy should also meet the objectives of the Crown aquacultural land program. These objectives are presented in B.C. Ministry of Lands, Parks and Housing (1986(b)), and can usefully be classified as those relating to (a) the allocation of aquatic land to aquaculture and (b) the appropriate pricing of allocated lands.

Allocation Objectives

Government policy dictates that the allocation of all Crown lands be based on the concept of "highest and best use" (B.C. Ministry of Lands, Parks and Housing 1986(a), p.2). Highest and best use is determined in economic and social terms by the lands agency after considering the alternative potential uses of particular Crown land parcels. A primary goal of the Crown aquacultural program has thus been to achieve an appropriate allocation of aquatic Crown land to

aquaculture.

The allocation decision has required reconciliation of opposing considerations. On the one hand, the provincial government has recognized the potential of aquaculture operations to help diversify and strengthen the economies of coastal communities. As such, its policy has been to provide Crown aquatic land for aquacultural purposes to promote industry development. On the other hand, the government has also recognized that Crown aquatic lands are subject to special environmental circumstances and multiple usage by a number of often competing coastal interests.¹¹ In light of these considerations, the provincial government has attempted to develop policy for the provision of aquatic land to aquaculture that "will provide Crown land deemed necessary for encouraging the growth and development of a viable aquaculture industry, in a manner which minimizes conflict with other legitimate uses and which protects the environmental integrity of Crown aquatic lands" (B.C. Ministry of Lands, Parks and Housing 1986(b), p.3).

The designation of aquatic lands acceptable for aquacultural use has been complicated by the regulatory involvement of a number of agencies in both the provincial and federal governments. For example, at the federal level, the Department of Fisheries and Oceans has the authority under the federal *Fisheries Act* to impose conditions on any development that affects fish habitat and fishery resources (i.e. finfish and shellfish stocks) by structural intrusions or alterations and pollution. Under the *Navigable Waters Protection Act*, the federal

¹¹ Aquatic lands have many potential uses. MFL offers aquatic land for aquacultural use (finfish, shellfish, marine plants), commercial use (marinas), industrial use (log handling and storage) and residential use (private moorage development). Other users of the waters associated with provincial aquatic lands include recreational boaters, recreational and commercial fishermen, tow-boat operators, as well as up-land property owners seeking access to deep water or simply enjoying the view.

Department of Transport is responsible for reviewing site improvements (i.e. sea-cage systems, docks, breakwaters, etc.) to make sure they do not constitute a hindrance to public navigation. At the provincial level, the B.C. Ministry of the Environment under the *Provincial Fisheries Act* is responsible for making sure that aquaculture operations are compatible with a site's biophysical environment. Because many of the concerns of these agencies overlap, a great deal of regulatory duplication exists.

Before granting tenure for the aquacultural use of a particular site, the lands agency must be sure that the tenure it authorizes does not violate the requirements of these various agencies. The establishment of an inter-agency application referral process and the working out of agreements between agencies to avoid regulatory duplication have thus been important sub-objectives of the Crown aquacultural land program.

Reconciliation of competing demands for the use of coastal waters has involved one of the six components of pricing policy - the method of Crown land disposition. Two disposition methods have traditionally been employed when allocating Crown lands: the *planned disposition method* and the *direct application method* (B.C. Ministry of Lands, Parks and Housing 1986(a)). Under the planned disposition method, an inter-agency Crown land planning program is used to ascertain areas with potential for particular land uses. Competing demands are reconciled during the planning process, and a final allocation decision reached prior to offering the land for private use. Where land is not made available by planned disposition, the direct application method applies, in which case individual applications for uncommitted Crown lands are accepted by the lands agency. In contrast to the planned disposition approach, the allocation decision under the direct application method is made *ex post*; that is, after an application for a

particular land use has been received. Approval or disallowance of the application is based on the suitability of the site for the particular use (as determined by the inter-agency referral process) and by the requirements of other government agencies and concerned interest groups.

In the case of the Crown aquacultural land program, aquatic lands have historically been allocated using the direct application disposition method. Upon receipt of an application for aquacultural use of a particular site, the lands agency has utilized the inter-agency referral process to determine the number and extent of alternative uses of the proposed area. In cases where alternative site usage is deemed more desirable in economic and/or social terms - e.g. when an area is heavily used by recreational boaters or contains shellfish stocks possibly harmed by farm effluents - applications are disallowed.

Pricing Objectives

The pricing objectives of the Crown aquacultural land program are found in B.C. Ministry of Lands, Parks and Housing (1986(b)) and B.C. Ministry of Forests and Lands (1987(c,d)). They are designed to conform to the provincial cabinet-approved normative pricing principles as well as the special features associated with aquaculture operations. As outlined by the government, pricing policy for aquaculture tenures should:

- (1) encourage the highest and best use of submerged Crown land,
- (2) ensure a fair rate of return to the province for use of aquatic lands, while at the same time encouraging the growth of a profitable aquaculture industry,

- (3) provide the security of tenure necessary for production and investment viability, while at the same time retaining the province's long-term options over the use of Crown aquatic lands,
- (4) recognize the distinctive development and production stages of aquaculture operations by allowing for the phasing in of tenure payments during the non-producing start-up years of aquaculture operations,
- (5) be based on area productivity,
- (6) account for external (spillover) effects arising from aquaculture operations,¹² and
- (7) enable the recovery of administration costs.

4.4 Revised Pricing Criteria

In summary, it is clear that pricing policy for aquacultural lands should ideally be designed to meet a wide range of objectives. Allocation of submerged lands to salmon aquaculture is to be based on the concept of "highest and best use". Pricing of allocated lands should provide a market value return to the Crown, but also encourage the growth of a profitable salmon farming industry and recognize the distinctive stages of farm operations. Fee comparability should be pursued, with sites of differing productivity priced to reflect their differential benefits. Due to the possibility of changing market conditions and land program

¹² As noted in B.C. Ministry of Forests and Lands (1987(c), p.2), potential spillover effects of concern are pollution, restricted access to Crown lands for ingress, egress and anchorage, and reduced values of adjacent lands due to aesthetic value deterioration.

needs, pricing provisions should be flexible. Where possible, the external effects arising from aquaculture operations should be incorporated into pricing policy. Finally, pricing policy should be designed to minimize administration costs.

These various objectives may be integrated into two overall objectives. Specifically, the government may employ a pricing policy that (a) maximizes the present value of the total economic rent attributable to aquaculture operations on Crown aquatic lands, and (b) captures the component of total economic rent attributable to the salmon farm site. To clarify these objectives, the concept of total economic rent and site rent must be explained.

In general terms, economic rent is defined as returns from production that remain after payments have been made to all inputs used to produce a particular commodity. Within this definition, inputs, in addition to their standard interpretation (i.e. labour, raw materials, physical capital), include such factors as invested financial capital and managerial skill. Payments are viewed as providing an opportunity cost return; that is, they are sufficient to ensure inputs remain in their current use.

Applying the concept of rent to salmon aquaculture, total economic rent from aquaculture operations, from a provincial perspective, will be aquaculture returns in excess of the opportunity cost of all inputs involved in farm operation, where in addition to payments to standard inputs, costs include a normal return on invested capital and risk-taking and the foregone benefits of alternative site usage.

The existence of economic rent raises the question of its source. Two sources - limited supply of productive resources and short-run market disequilibrium - are of particular importance for the case of salmon farming in

Economic rent arising from limited supply of productive resources has long been recognized by economists.¹⁴ As an illustration, consider the example of agricultural land. Demand for land, like any input, is a derived demand based on, among other things, the value of the commodity it yields. If an abundance of fertile land exists, each parcel having the same productivity (i.e. requiring the same application of inputs to yield a unit of output) and proximity to input and output markets, land used in agriculture will yield no economic rent.¹⁵ However, in reality the amount of available land is restricted by our natural endowment, and differs in terms of its location and productivity for agriculture. One can expect wealth-maximizing land owners to provide land for agricultural use until the point where marginal land just yields an opportunity cost return to both its owner and applied inputs. Intramarginal lands - i.e. lands of greater productivity and/or superior location when compared to marginal land - will yield economic rent due to their superior characteristics.¹⁶ Such rent is commonly classified as "differential rent" (Gunton and Richards 1987, p.32).

This analysis can be directly applied to the case of salmon farming on provincial aquatic lands. Aquatic lands differ in terms of their productivity for salmon aquaculture due to important differences in biophysical characteristics and

¹³ For a general discussion of the sources of economic rent, see Gunton and Richards (1987, Chapter1).

¹⁴ David Ricardo, the famous classical economist, is acknowledged as the first.

¹⁵ Land will continue to be made available to produce agricultural goods until falling product prices imply agricultural land just yields opportunity cost returns.

¹⁶ For the sake of simplicity it is assumed that all lands have equal opportunity costs. While in reality different land will have differing opportunity cost uses, this assumption does not alter the point of the example - i.e. that because of differences in land productivity, some lands will capture economic rent.

location. At the going market price of pen-reared salmon and given the existing salmon farming technology, certain sites will be marginal for salmon aquaculture, while others will yield higher returns due to superior characteristics. As such, the latter will generate differential rent.¹⁷ Throughout the paper, economic rent attributable to differences in site characteristics will be referred to as *differential site rent*.

The existence of differential rent in salmon farming may not be limited to differences in site quality. Other factors of production may also generate differential rents. Importantly, farm managers and technicians may generate returns in excess of their opportunity costs due to superior skills. Such differences may be significant at the present time due to the newness of the salmon farming technology and the resulting lack of trained managers and technicians. However, as training becomes more readily available and "learning-by-doing" knowledge increases, differential rents from this source can be expected to subside.¹⁸

The spirit of the government pricing objectives implies that pricing policy should result in the capture of differential site rents. It does not appear to be the government's intent to also capture differential rents arising due to superior managerial or technical skills.¹⁹ As a result, pricing policy should ideally

¹⁷ It should be remembered that, from a provincial perspective, the magnitude of differential rents associated with particular sites will be influenced by the opportunity cost of alternative site usage. It is thus possible for sites having inferior characteristics to generate greater differential rents than superior sites, if the latter have sufficiently high opportunity cost uses.

¹⁸ That is, the greater supply of skilled managers and technicians can be expected to drive their expected return in salmon aquaculture employment down toward opportunity cost levels.

¹⁹ Recall that the Crown aquacultural land program objectives state that pricing is to be based on site productivity. In addition, the normative pricing principle criterion of fee comparability will be violated if sites of similar productivity

distinguish between these two sources of rent, capturing the former while leaving the latter as a reward for efficiency.²⁰

Economic rent can also exist due to short-run market disequilibrium. Rent in this case is analogous to windfall profits arising from unanticipated increases in demand. It exists due to a lag in an industry's supply response to short-run profits. Disequilibrium rent is dissipated over time by the competitive behavior of existing suppliers and new industry entrants.

With regard to salmon aquaculture, part of the high rates of return captured by Norwegian farmers in recent years may fall under this rent category. However, other countries are developing aquaculture industries in response to the demonstrated success of Norwegian farms. Supply increases can be expected to ultimately eliminate disequilibrium rents currently being captured by established farmers.

Economic rents generated in salmon aquaculture in the long-term will therefore revert to differential rents. The ability of British Columbia salmon farms to generate differential rents in comparison with farms in other countries will in part be determined by their comparative site productivity and locational advantages. While specific studies have yet to be undertaken, it appears that British Columbia may have several advantages over other producing countries. For example, British Columbia farms are closer to major pen-reared salmon markets in the western United States than are competing Norwegian farms and enjoy the additional benefit of warmer waters. However, coastal infrastructure is far more

¹⁹(cont'd) were to be priced differently due to differential rents generated by superior management.

²⁰ Distinguishing between these two sources of differential rent will be difficult in practice. Problems arising under fee assessment are discussed in Chapter 7.

developed in Norway, meaning that certain farms in British Columbia (i.e. those that would be located in the Central or North Coast regions) may not prove economic. The recent emergence of other producing countries like Chile will require further comparisons.

Assuming salmon farming proves profitable in British Columbia, differences in site characteristics will undoubtedly give rise to differential rents. It is suggested here that government pricing policy be geared to maximize and capture such rents.

The general objective of rent maximization has been proposed in a number of studies concerning public resource pricing²¹ and will be used in this study for several reasons. First, in the case where a public resource is used by private interests, economic rent may be viewed as an appropriate measure of the contribution of the resource to society's welfare (Gunton and Richards 1987, Chp.1).²² As such, its value should be maximized, and due to public ownership, captured by the government on the public's behalf. Second, economic rent gives explicit meaning to the concept of fair market value, while recognizing the need to account for the opportunity cost of resource use. Third, because economic rent is a surplus, its capture by government does not distort the decision-making of firms in ways that impair economic efficiency. As a result, pursuit of this objective will maximize the value of resources to society, and not hurt the

²¹ See, for example, Gunton and Richards (1987), Mead et al. (1984), and McDonald (1978).

²² Public policy makers do not always hold this view. Employment generation may be considered as more important. For example, while significant resource rents might be generated if fishing effort was reduced in certain commercial fisheries, policy makers often choose to allow rent dissipation through excessive fishing effort in order to maximize employment opportunities. For a discussion of this tendency in the context of Canadian commercial fisheries, see Copes (1979).

competitive ability of firms.²³

To make the objective of rent maximization and capture operational, the following revised criteria will be used to evaluate pricing policy.²⁴ While consistent with the objectives established by the provincial government for aquacultural lands pricing, they provide a more precise framework for policy analysis.

1. *Pricing policy should promote an economically efficient use of aquatic lands.* Economic efficiency has four aspects. First, aquatic lands should only be allocated to salmon aquaculture if the net benefits to society exceed the costs; that is, only when positive economic rent will be generated.²⁵ Second, because an accelerated offering of aquatic lands will tend to depress realizable rents,²⁶ allocation should be timed such that the present value of economic rent is maximized. Third, aquatic lands should be allocated to efficient salmon farmers. If this objective is not met, the potential benefits from the use of aquatic lands in salmon aquaculture will not be maximized.²⁷ Fourth, pricing policy should encourage the achievement of productive efficiency (least-cost production) by farmers using allocated aquatic lands. Unintended distortions in relative input

²³ It should be noted that resource rent capture is a complicated task in practice. "Second-best" policy solutions that introduce distortions must often be considered. The existence of problems for aquacultural lands pricing is discussed in Chapter 7.

²⁴ The suggested criteria are commonly accepted by resource economists. See, for example, Mead et al. (1984) who employ similar criteria in their study of alternative pricing schemes for offshore oil and gas in the United States.

²⁵ Recall that the calculation of economic rent involves consideration of the opportunity cost of alternative site usage.

²⁶ The reasons for this are discussed in Section 6.4.2.

²⁷ Possible objections to this criterion on non-efficiency grounds are discussed in Section 6.4.3.

prices or output levels chosen by farm operators should be avoided.

2. *Pricing policy should enable the government to collect the differential site rents associated with provincial aquatic lands.* As the owner of aquatic lands, the Crown has the right to collect the differential rents associated with salmon farm sites. Tenure holders should receive a competitive rate of return on invested capital, with allowance for factors such as risk. Differential rents attributable to managerial or technical skill should not be captured by the Crown, but left as a reward for efficiency.

3. *Pricing policy should incorporate provisions to account for uncertainty.* Salmon farming involves a number of uncertainties, including changing market prices for pen-reared salmon and the possibility of fish disease. To ensure a fair return to the Crown while also protecting tenure holders, pricing policy should allow for fee adjustment. Additionally, it can be shown that expected economic rents will be increased if pricing policy facilitates risk-sharing between the government and tenure holders.²⁸ As such, pricing policy should incorporate risk-sharing.

4. *Preference should be given to pricing alternatives that minimize administration and compliance costs.* Other things being equal, pricing alternatives that involve lower administration and compliance costs will increase the size of available economic rents. Given the high priority placed on administration costs by government, this objective should play an important role in the selection of a particular pricing policy.

²⁸ This result is discussed in Section 6.5.

CHAPTER 5

EMERGENCE OF EXISTING PRICING POLICY

Existing tenure pricing policy for salmon farm sites is in a state of flux. Dissatisfaction with the results of past policy and pressures on MFL to develop new measures in a relatively short period of time have resulted in an interim policy which will be reviewed in 1990. The following section traces the emergence of the existing policy.

5.1 Original Aquaculture Tenure Pricing Policy

As noted in Section 4.3, the B.C. *Land Act* stipulates that Crown aquatic lands cannot be granted in fee simple, leaving three tenure forms - lease, license of occupation, and investigative permit - as alternative available forms. The original pricing policy for all aquacultural Crown land use, including salmon farming, was but a specific application of a general policy used for other Crown lands made available under these alternative tenure forms.

Under the general policy for Crown lands, leases and licenses of occupation are normally made available for terms of up to 20 and 10 years respectively with annual fees based on a given percentage of assessed land value, the assessment carried out by the B.C. Assessment Authority (BCAA). Depending on the type of land use (i.e. commercial, industrial, etc.) and the classification scheme within a particular use¹, the percentage is generally either 8 percent or 5

¹ Classifications within particular land use programs are rough measures used to differentiate between extensive versus intensive uses of Crown lands as well as land location when determining appropriate user fees. For example, in the case of Crown land for general commercial development, "Type A" land use is classified as commercial use of land in urban areas involving substantial improvements, while "Type B" land use refers to commercial usage of rural or remote lands

percent for leases, and 7.5 percent or 4.5 percent for a license of occupation. The minimum annual rental fee varies between land programs but is generally no greater than \$500. Applicants for leases or licenses of occupation are required under the general policy to submit management plans specifying proposed operations, and must meet all government zoning, building, and health requirements. Investigative permits (general licenses), on the other hand, are for short-term land requirements, available for six months for temporary uses and up to one year for investigative purposes. The flat fee charged for an investigative permit also varies between programs but is again no greater than \$500. One-time documentation and application fees (\$150 and \$50 respectively) round out the tenure charges.

The original pricing policy for aquacultural use of submerged Crown lands is outlined in B.C. Ministry of Lands, Parks and Housing (1986(b)). Original policies for each of the six pricing policy components, as well as additional pricing policy considerations, are presented below.

5.1.1 Method of Disposition

As previously noted, submerged Crown lands have historically been made available for aquaculture by direct application. Under the original policy, in the event that more than one application was received for aquacultural use of the same site, the land was to be disposed on a "first come/first served" basis. If significant simultaneous interest was expressed for a particular parcel, a public auction would decide the site recipient. In cases where the lands agency decided to make certain lands available for aquaculture using a planned disposition approach, it had the option to dispose of sites either by public competition

¹(cont'd) requiring only minor or temporary improvements.

(auction, tender, or lot draw) or by continuing with the direct application method.

Applicant eligibility requirements for disposition were consistent with those of other Crown land programs: applicants were to be either (a) Canadian citizens or permanent residents 19 years of age or older, or (b) corporations registered in British Columbia or incorporated under Canadian law. In addition, non-Canadians who owned the upland adjacent to a proposed site could also apply.

5.1.2 Tenure Form and Term

Under the original policy, a lease was issued in cases where longer-term tenure was desired by the applicant, where substantial site improvements were proposed (i.e. a shore-based dock, floating residence, a large breakwater, etc.) and/or where definite boundaries were necessary to avoid conflicts with adjacent resource users. If improvements were of a substantial nature and adjacent uplands were occupied, upland owner approval was necessary for a lease to be issued. An initial lease was available for a maximum of 10 years, with the option of a 20 year replacement lease that could be exercised following the mid-term of the initial tenure.

In contrast, a license of occupation was issued where shorter-term tenure was desired and where minimum improvements were proposed (i.e. simply an offshore sea-cage system with few ancillary facilities). In light of the lesser probability of upland owner conflict (owing to fewer site improvements that might impede ingress or egress), upland owner's consent was not normally required. Site survey to establish boundaries was also not normally required. The initial term for a license of occupation was set at 10 years. A 10 year replacement license could be applied for after the mid-term of the initial tenure.

An investigative permit was made available for site study. Reserving the site for the permit holder for a maximum of one year, an investigative permit did not grant the right to undertake site development or aquacultural production.

5.1.3 Method of Pricing and Payment

Aquaculture tenure pricing, though similar to the general pricing policy, was modified to take into account the special nature of aquaculture production. In the case of salmon farming, farms are not able to produce a steady flow of marketable-sized fish until a number of years after start-up, thus experiencing cash-flow problems in their early years. With this in mind, pricing policy for lease and license of occupation tenures was established such that land payments would only be a portion of regular payments during start-up years.

Lease fees for an initial 10 year tenure were set at 1 percent of initially assessed land value for years 1 to 5 and 5 percent of the annually-adjusted land value in years 6 to 10. Land values were to be determined by the BCAA, who based their assessment on a productivity rating model for aquaculture.² For a replacement lease, rental fees remained at 5 percent of annually-adjusted land value. Fees were payable annually in advance,³ and in no case were to be less than \$200 per tenure.

The means of determining license of occupation fees were similar to those used for lease arrangements, but total payments were to be less. Fees were

² The workings of this model are discussed in Section 5.2. Because BCAA land values were not available during the early years of salmon farm development in British Columbia, the minimum \$200 annual fee was normally charged.

³ An additional option existed where the sum of fees for the whole tenure term could be prepaid; the sum discounted, depending on tenure term, using an associated standard discount factor determined by the lands agency. This option no longer exists.

payable annually in advance at 1 percent of initial assessed land value for years 1 to 5 and at 4 percent of annually adjusted land value for years 6 to 10. Replacement lease fees were set at 4 percent of annually adjusted land value. As in the case of a lease, the minimum annual rental fee for a license of occupation under all circumstances was \$200 per tenure.

The charge for an investigative permit was \$100.

5.1.4 Tenure Assignment

The assignment (sale) of a lease or license of occupation by an original tenure holder to a second party required prior consent from the Ministry. The tenure had to be brought to a sufficient level of development prior to assignment approval and new tenure holders were required to meet eligibility requirements and management provisions associated with the original tenure. Investigative permits were non-assignable.

5.1.5 Tenure Approval: Special Requirements

Under the original policy, a number of special requirements were to be met before the lands agency would grant tenure for aquaculture operations. These started with the requirement that applicants for aquaculture tenure submit an aquaculture management plan.⁴ Proposed aquaculture operations, as outlined in the management plan, would then have to meet specific requirements involving

⁴ In the case of lease or license of occupation applications, the management plan was to include (a) the location and size of the proposed site (b) a description and location of proposed improvements (c) a description of proposed aquaculture operations including technology used, duration of the development (start-up) stage, and yearly anticipated production, and (d) information concerning access, servicing and adjacent uses. In the case of an investigative permit, applicants were to provide a written outline of proposed operations, including a designation of the location and size of the area to be licensed and a description of any activities or improvements to be carried out during the permit term.

environmental and navigational considerations, public access and upland owner consent, and local government by-laws.⁵ Adjustments to the management plan necessary to meet these various requirements were determined through the inter-agency referral process. Under the referral procedure, all applications and their associated management plans were forwarded by the lands agency to other agencies having jurisdiction over aquaculture operations, and comments solicited. Necessary changes to the plan would then be made, with the amended plan becoming part of the tenure document granting site use.

Final requirements for the issuance of site tenure included the purchase of public liability insurance (\$1,000,000 minimum), and where required by the Regional Lands Director, the posting of a clean-up and performance guarantee (the amount to be specified by the Regional Director). The tenure holder was also required to submit annual production statistics to the lands agency over the entire tenure term.

5.2 Problems Concerning Land Value Assessment

During the early years of the Crown aquaculture program, the slow development of the salmon farming industry resulted in a limited demand for farm sites. In light of this, little attention was given to pricing policy. However, as interest in salmon farming increased after 1983 and demand for farm sites grew, an important problem relating to the means of assessing the value of salmon farm sites emerged.

⁵ For a more detailed outline, see B.C. Ministry of Lands, Parks and Housing 1986(b).

Because of a lack of experience with salmon aquaculture, the BCAA had little data on the value of land for salmon farming upon which to base its assessments. Instead, it used a pricing model developed for the assessment of oyster culture sites.⁶ Under this model, a productivity rating for oyster culture was assigned to each oyster culture site based on an assessment of the physical and biological factors pertaining to marine culture.⁷ Each factor was rated on a scale of 0 to 5, the accumulated total representing the productivity rating. A fee schedule tied to the productivity ratings was used to determine the annual site rental.⁸

In practice, the productivity rating model was only occasionally used to determine the value of salmon farm tenure. Because of questions concerning the validity of the model⁹ and the appropriateness of using a oyster culture assessment technique for salmon farming, regional Lands officers rarely used BCAA assessments, instead simply assessing the \$200 minimum annual fee for most tenures.

⁶ Productivity Rating for Aquaculture, British Columbia Assessment Authority Schedule No. 8500.

⁷ These factors were water temperature, salinity, substrate, wave action, predation, tidal flow, navigation, competition, and area access.

⁸ The relationship between the productivity rating and rental fees was based on information acquired from a small number of Crown land auctions held for oyster culture leases. The number of sites involved in the auctions was apparently limited (possibly only two). Questions have been raised about the reliability of the relationship between fees and actual site value when the productivity rating model is used (personal communication with MFL staff).

⁹ See *supra* note 8.

5.3 B.C. Finfish Aquaculture Inquiry

On October 31, 1986, MFL imposed a moratorium on the issuance of Crown land leases and licenses of occupation for salmon farm operations. The moratorium was precipitated by concerns of the United Fishermen and Allied Workers Union and other groups about the impacts of the salmon farming industry given the escalation in applications for farm tenure. A one man Commission of Inquiry was established by the B.C. government on November 6, 1986, in response to the moratorium. The Commissioner, David Gillespie, was charged with preparing a report and recommendations for the government within 30 days on (a) the impact of salmon farming on commercial salmon markets and production facilities, the marine environment and wild fish stocks, the activities of other interest groups using aquatic lands, and (b) government approval and monitoring procedures.

The final report of the Inquiry, issued on December 12, 1986, noted a number of concerns associated with salmon aquaculture pricing policy.¹⁰ The predominant \$200 annual fee for salmon farm tenure was viewed as "insufficient compensation to the government for the private use of Crown land" (Gillespie 1986, p.48). Government officials readily admitted that the annual rental charged for salmon farms was in many cases considerably less than for other commercial or industrial uses of public land, including aquatic Crown land uses such as log storage, marinas, and in some cases, shellfish aquaculture. As a result, the Commissioner recommended a review of the existing rental structure with the intent of increasing the rental rate. The new rental structure was to be "consistent with other approaches used by the provincial government" (p.48).

¹⁰ See Gillespie (1986) for a presentation of the other concerns regarding the impact of salmon farming.

During the course of the Commission-sponsored public hearings on the impacts of salmon farming, a number of persons expressed concerns that investigative permits were being used to tie up sites to prevent competition and for financial gain through speculation. Others cited incidences where permit holders had illegally begun farming operations without remedial action being taken by the government. While recommending that government step-up its surveillance of the activities conducted on investigative sites in order to prevent abuses, the Commissioner defended the role of the investigative permit, noting that it "provides the opportunity to conduct site research and investigation without committing government to subsequent approval of a fish farm" (p.47). To minimize the ability of applicants to tie up potential sites for speculative purposes or to reduce competition, the Commissioner recommended a commitment bond be required for each tenure, establishing the commitment of an applicant to "seriously pursue his aquaculture interests" (p.48).

Recommendations were also made to help deal with growing user-group conflicts. During the early years of the Crown aquacultural land program conflicts between aquacultural and other uses of aquatic lands were few and could be handled on a case-by-case basis using the inter-agency referral process. However, the rapid growth in applications for salmon farm tenures in more recent years produced a number of problems for the traditional direct application method of allocating Crown aquatic lands. The large number of applications received under the direct application policy had burdened the referral process and created adjudication delays. The high projected growth of salmon farming in coastal areas traditionally used by many other groups intensified perceived user conflict. During the Commission-sponsored public hearings, competing site users complained about the identification and protection of their interests in the

inter-agency referral process, and the discretion available to the lands agency when selecting interest groups to participate in referral discussions (pp.40,44).

To deal with these problems, the Commissioner recommended that the inter-agency referral process be supplemented by the initiation of a program of coastal resource identification studies. These studies would be undertaken in areas involving intense user-group conflict and would identify sites of high value for important non-aquaculture interests. Designated areas would then be reserved from aquaculture operations, with aquaculture activities directed to non-conflict locations. Three areas were identified for coastal studies: Campbell River-Johnstone Strait, Sechelt Inlet, and the Islands Trust region (an area encompassing most of the islands in the Georgia Strait). It was also suggested that the provincial government expand its list of referral groups and increase the time available for response. Finally, as a further means of reducing impacts on other resource users as well as to reduce the possibility of disease transference between farms, a minimum distance separation of 3 kilometers between salmon farms was recommended.

The provincial government planned to move quickly in introducing a plan to implement the intent of the Inquiry's recommendations. Quick action was necessitated by several factors. As a result of the moratorium, MFL was not adjudicating or issuing leases or licenses of occupation for salmon farming.¹¹ Because approximately 200 applications for leases and licenses and 300 investigative permits were being processed when the moratorium was established,¹² the government was under pressure to develop new policy that

¹¹ However, the Ministry did continue to accept applications during the moratorium, including those for investigative permits.

¹² News Release, B.C. Ministry of Forests and Lands, December 19, 1986.

would allow the moratorium to be lifted. In addition, many industry participants expressed concern that a lengthy moratorium would damage investor confidence in the British Columbia salmon farming industry.

In regard to pricing policy for salmon farm tenures, MFL initiated a pricing review in late January, 1987. Attention was focused on concerns that tenure pricing did not adequately reflect land value, and that inequity existed between the treatment of salmon farmers and other tenure holders (B.C. Ministry of Forest and Lands 1987(c)). The Ministry's plan of action was to undertake an evaluation of alternative pricing strategies and develop a proposal that could be reviewed and revised after consultation with relevant government agencies and negotiations with the British Columbia Salmon Farmers Association (BCSFA).

During the course of the pricing review, a gradual lifting of the moratorium and the introduction of several new policies for salmon farming were announced by the provincial government. As of March 10, 1987, the moratorium was partially lifted in areas scheduled for or already under coastal resource identification studies, and lifted completely outside the study areas.¹³ The minimum annual rental for a lease or license of occupation and the fee for an investigative permit were all increased to \$500. Applications for licenses of occupation or leases received before or after the establishment of the moratorium would be processed according to new 3 kilometer spacing guidelines. Investigative permits, however, would not be subject to a spacing requirement.¹⁴ A number of new policies concerning applicant notification of adjacent property

¹³ On the recommendation of the Gillespie Commission, coastal resource identification studies had already been initiated in the Campbell River-Johnstone Strait and Sechelt areas. The Islands Trust study was to begin shortly.

¹⁴ Because investigative permits do not allow either development or production, MFL felt that problems requiring the implementation of spacing requirements would not arise.

users and other tenure holders as well as the requirement that established fish farms undertake environmental monitoring programs were also introduced.

MFL's review of salmon farm tenure pricing was completed in June and a new pricing policy implemented on July 1, 1987. Consideration of available options resulted in the selection of a zone based pricing system.

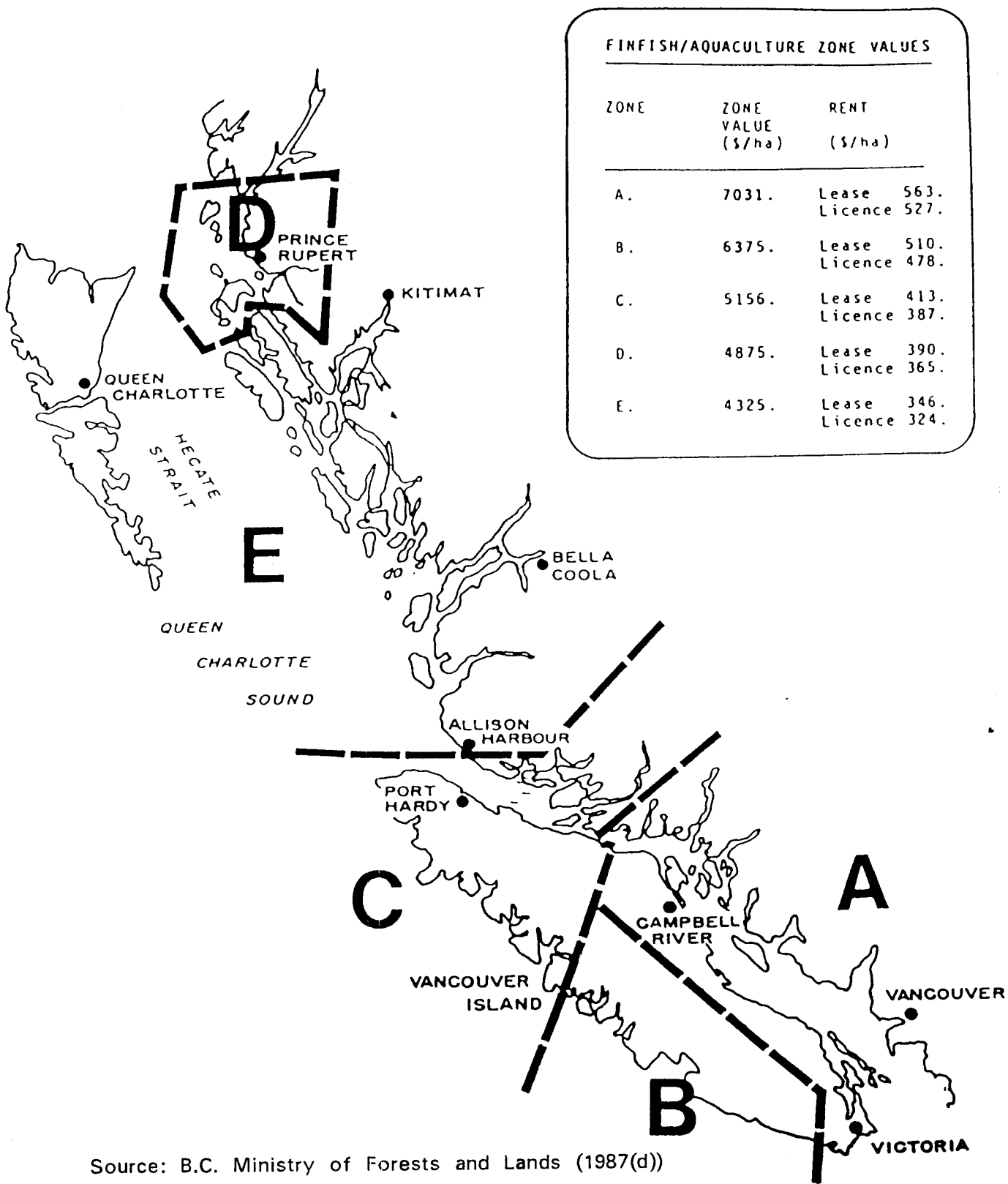
5.4 New Pricing System for Salmon Farm Tenure

Under the new pricing system for salmon farm tenure, the British Columbia coast is divided into five aquacultural pricing zones (see Figure 2). Established after MFL discussions with regional Lands officers and the BCSFA, the boundaries are based on three criteria: access (to markets, services, and amenities), intensity of competing use, and amount of tenure application activity (B.C. Ministry of Forests and Lands 1987(c), p.4). Zone A, encompassing the Georgia Strait area, ranks the highest based on these criteria, whereas Zone E, encompassing the northern coast with the exception of the Prince Rupert area, is the lowest.

Each aquaculture zone has been assigned a corresponding per unit hectare land value that will be used in the calculation of salmon farm tenure fees. Zone values were determined after an MFL analysis of the tenure fees currently being charged for competing uses of submerged lands, and subsequent negotiations with the BCSFA. The initial analysis considered fees being charged for shellfish, finfish (salmon), log-handling and marina uses in each zone. Its intent was to determine zone values that would result in salmon farm fees being comparable with those charged for similarly intensive uses.¹⁵ As a result of the analysis, an

¹⁵ The selection of this approach to determine acceptable zone values was affected by two constraints; time pressures to introduce a new pricing scheme in a short period of time and a lack of data on the actual value of land used for

Figure 2: Salmon Farm Pricing Zones



Source: B.C. Ministry of Forests and Lands (1987(d))

acceptable range of aquaculture zone values, based on current intensive log-storage zone rates, was used in negotiations with the BCSFA. The final aquaculture zone values that emerged from these negotiations are shown in the table accompanying Figure 2.

Annual salmon farm fees per unit hectare under the new pricing system are defined as 8 percent of the zone value for a lease and 7.5 percent of zone value for a license of occupation.¹⁶ The minimum annual fee for both tenure forms is \$500, as decided in March, 1987. In recognition of the time lag experienced by new farms before full production is reached, a rental discount of 60 percent will be applied for each of the first 3 years of new farm tenures. The price of investigative permits is also now set at \$500.

MFL will review the new pricing system in 3 years to determine its acceptability and impacts on the salmon farming industry. During the interim period, the Ministry has retained the right to adjust lease and license fees pursuant to adjustment in zone values.

¹⁵(cont'd) salmon farming (B.C. Ministry of Forests and Lands 1987(c), p.4). In addition, it was felt that this strategy would address concerns about the lack of fee comparability between salmon aquaculture and other aquatic land programs.

¹⁶ The increase in the percentage rates used in assessing fees was justified on the grounds that other programs involving similar intensities of land use (e.g. log handling) involve the use of these rates.

CHAPTER 6

ANALYSIS OF EXISTING PRICING POLICY

Upon examination, the existing pricing policy for salmon farm tenure in British Columbia suffers from a number of problems. First, the government currently lacks an adequate means of determining the value of tenure use-rights. Second, existing tenure fees may underestimate actual tenure value. Finally, because of the above problems as well as others, the existing policy does not best achieve the government's pricing policy objectives.

6.1 Site Valuation Methods

As noted in Section 5.2, the provincial lands agency has experienced difficulties in determining the value of aquatic lands used for salmon farming. Its problems can be attributed to the relatively recent application of the salmon aquaculture technology in British Columbia, a resulting lack of information on the historical value of salmon farm sites and the relationship between site characteristics and farm profitability, and an absence of comparable commercial uses of aquatic lands upon which to base a proxy fee for salmon aquaculture.

An obvious solution would appear to be an appeal to prices determined in markets where site tenure rights are currently traded. Because the Province is a monopoly owner of submerged lands used in salmon aquaculture, market prices for the use of privately-owned sites do not exist. However, because government-issued tenure rights are transferable, private market transfer prices might be a useful source of information. Unfortunately, though Ministerial approval of tenure transfer is necessary, it is not MFL policy to collect transfer

price information. While this policy could be changed, several difficulties exist if such information is to be used. First, salmon farmers have an incentive to under-report transfer prices in order to avoid the possibility of higher fee assessments.¹ Second, many individuals applying for site tenure are now registering as incorporated companies. As this means ownership transfer can occur without a change in the title of the tenure holding entity, MFL will have no official record of a transfer, and hence a transfer price, when ownership rights are exchanged within the corporation.²

One means of overcoming valuation problems would be to generate market-value prices through a system of competitive bids for salmon farm sites. The possibility of using site auctions in the various regions as a means of generating site value information in the short and long term is discussed in Chapter 7.

If market information on farm value does not exist or is not available, alternative methods of site valuation might be used. One approach is to arrive at a proxy value by considering the market or assessed values of alternative commercial uses of aquatic land. The existing provincial pricing policy relies on this method - salmon farm zone values are based on assessments for intensive log-storage use of aquatic lands.

¹ The revealing of true site value will adversely affect current tenure holders who do not plan to transfer their site use rights (through higher fees) as well as those who plan to do so in the future (through lower possible transfer prices). As such, one would expect the industry to pressure existing sellers not to report.

² While this trend toward incorporation may be an attempt to avoid the detection of tenure transfer, it conveys other advantages, including a greater ability to raise needed financial capital.

The reliability of this approach hinges on the comparability between salmon farming and other commercial practices. The existence of comparability is questionable in most cases. Salmon aquaculture represents a new and unique use of submerged lands.³ There is no reason to believe that its costs or benefits will be similar to other commercial uses such as log-storage or marinas. The validity of comparing different uses can also be questioned on the grounds that particular aquatic lands are not equally suited for different uses. Finally, determination of alternative commercial values involves many of the same problems experienced when independently assessing salmon farm sites (i.e. lack of market prices and arbitrary assessment techniques).

Due in part to the severity of these comparability problems, some jurisdictions in other countries have based salmon farm tenure fees on a percentage of assessed upland value.⁴ While use of upland value as a basis for site value has some merit - it may provide an indication of the infrastructure advantages conferred by site location - it does not account for site biophysical characteristics and is difficult to use in remote areas where upland values are unknown.

A final means of determining farm site value is to directly assess the contribution made by water in the salmon rearing process. A recent attempt to do this (i.e. the B.C.A.A. productivity rating model - see Section 5.3) has

³ While other forms of aquaculture are present along the British Columbia coast (e.g. shellfish and marine plant aquaculture), their technologies are fundamentally different. For example, in the case of off-bottom shellfish culture, shellfish (e.g. oysters) are attached to ropes or wire suspended in the water column and grow without supplemental feeding.

⁴ An example is Washington State, which uses upland values in its water-dependent rental formula. Appendix 2 provides a review of the pricing policies for salmon farm tenure in Washington State and a select number of other jurisdictions.

suffered from information unavailability and a flawed methodology. Assuming sufficient information on farm production costs and site characteristics will become available, a possible assessment technique based on neoclassical production theory and the work of Salvanes (1987) is presented in Chapter 7.

6.2 Site Fee Levels

Despite these methodological problems, it is important to determine whether current fee levels reflect the value of tenure use-rights. This question can be answered by first considering the factors that will affect the value of aquacultural lands.

From a market perspective, aquacultural land value will be determined by demand and supply conditions. Demand for farm sites is a derived demand, based on a number of factors, including (a) the expected market price of farmed salmon (b) production costs, and (c) the biophysical and locational characteristics of available farm sites and their impact on farming costs. Supply of aquatic lands is under monopoly control of the Province. The amount of aquatic lands⁵ made available for salmon farming, and their supply price, is thus a provincial resource allocation decision.

Under the assumptions that the supply of other inputs used in salmon farming will eventually be price elastic - i.e. available to the industry in quantities that do not involve a significantly rising supply price⁵ - and that

⁵ DPA (1986, pp.iv-v,9-1) report that the significant number of anticipated salmon farms may mean some shortages in farm inputs such as smolts, feed and diagnostic services in the short term. However, with the possible exception of raw materials for broodstock feed, additional demands for key inputs are expected to be satisfied by increases in input supply capacity.

aquatic lands suitable for salmon aquaculture will eventually become scarce,⁶ the farm site will become the input to which economic rents will accrue. The component of total rent attributable to differential site characteristics will represent the pecuniary (monetary) benefit generated by the associated aquatic lands. Site market value will be the difference between site rent and the fees levied by the government for site use.

The question of the appropriateness of current tenure fee levels thus reduces to the determination of current and future site rents. Such an exercise cannot be undertaken with a great deal of precision at the present time. Current site rents are difficult to ascertain because of an absence of empirical data on farm revenues and costs.⁷ Future rents will be influenced by as yet undetermined industry outcomes such as the extent of bio-technical and production technique improvements and the price effects of anticipated supply increases in world farmed salmon markets. However, despite these uncertainties, several pieces of evidence do suggest the potential for significant site rents.

Consider first the example of Norway, the world's largest producer of pen-raised salmon. First established in the 1960s, the Norwegian salmon farming industry has since the latter 1970s proven to be extremely profitable. This is revealed in a number of studies. Ridler and Kabir (1987), using 1982 cost and return data on 104 salmon farms published by the Norwegian Department of Fisheries, show that the average annual profit per farm (after deducting an opportunity cost return for owners' capital (and owner's labour, where employed))

⁶ Scarcity may eventually be caused by occupancy of all suitable sites or by possible government restrictions on the ultimate number of allowable sites.

⁷ In the case of many sites, current rents do not exist because farms are in the start-up stage with little or no sales to report.

exceeded \$100,000, with the amount varying from \$29,000 for the smallest farms⁸ to over a quarter of a million dollars for larger farms.⁹ In another study, Bjorndal (1988) provides estimates of average production costs for a Norwegian farm producing 200 tonnes of output in 1986. Assuming an ex-farm salmon price of \$8 (CDN) per kilogram and given estimated average total production cost - including a 7 percent real return on capital - of \$5.63 per kilogram,¹⁰ total annual profits at full production are approximately \$475,000. Corroborating evidence of profitability in Norway can be seen by the heavy demand for new farm licenses. Approximately 2500 people applied for the 150 licenses awarded by the government in 1985/86 (Bjorndal 1988).

Comparisons between British Columbia and Norway must be qualified by a number of considerations. The Norwegian industry is characterized by more experience with the salmon farming technology and international product marketing. Because Atlantic salmon have been successfully domesticated in Norway while Pacific salmon have yet to be domesticated in British Columbia, yields will be higher in Norway.¹¹ Finally, infrastructure is far more developed

⁸ The smallest farms had pen volumes of less than 3000 m³. Total annual production cost for these farms was reported to be approximately \$73,000 (Ridler and Kabir 1987, p.144).

⁹ Larger farms had pen volumes of 7000-15000 m³ (total annual production cost = \$575,547 (p.144)). The reported profit figures were averages for farms within certain size (pen volume) categories, and as such did not reveal variations in individual farm profits due to differences in site characteristics or management skills.

¹⁰ NOK5 = CDN\$1

¹¹ Domestication involves the selective breeding of broodstock salmon that are more docile, less disease prone, and exhibit better growth rates, the objective being to obtain a supply of high quality salmon eggs. Procedures necessary to develop a domesticated strain of eggs are technically difficult and expensive. Successful domestication of Atlantic salmon was achieved in Norway through the combined efforts of government and the salmon farming industry. DPA (1986, pp.7-2,3) have concluded that if government assistance is not forthcoming in British Columbia, private industry will require considerable time to successfully

along the Norwegian coast than in many areas of British Columbia, giving Norwegians a cost advantage in the construction and operation of sea farms. However, Norwegian superiority in farm management and marketing skills will subside as British Columbia farmers improve through "learning-by-doing". The second advantage may be overcome if Pacific salmon can be domesticated. Benefits from more developed infrastructure in Norway should be balanced with British Columbia's proximity to the major North American seafood markets where both countries are expected to compete. Finally, Norwegian farms must comply with a number of regulatory restrictions which may increase their production costs.¹²

In light of the Norwegian experience, it is interesting to consider the level of fees charged for salmon farm tenure in British Columbia under the new zone pricing system. Table 7 presents an estimate of the distribution of fees currently being charged for farm tenure in the various coastal regions.¹³ Under the new policy, total annual tenure revenue from all farms in the province is currently about \$325,000.¹⁴ The mean annual tenure fee on a province-wide basis is just over \$2700.¹⁵ In all regions, mean annual site fees are less than \$5000.

¹¹(cont'd) domesticate Pacific salmon.

¹² For example, restrictions on farm pen volume may hamper the achievement of scale economies - see Salvanes (1987).

¹³ Reported figures were calculated using the 1987 Salmon Farm Survey data on farm sizes and existing salmon farm zone rates. Due to the unavailability of tenure status information for specific farms, lease rates were simply used. Because many issued tenures are licenses of occupation, actual fees will be less than fees reported here.

¹⁴ Estimate based on total tenure fees calculated using lease rates. The reported figure does not include revenues from investigative permits.

¹⁵ Calculated as a weighted average of the regional mean tenure fees (number of regional sites used as weights).

Table 7: Estimated Annual Tenure Fee Payments, by Region,
as of November 30, 1987

Region	Mean	Estimated Tenure Fee (\$) Maximum	Minimum
North Coast ¹	1092 (2.80)	*	*
Central Coast	- -	- -	- -
N.E. Vancouver ² Island	3981 (9.64)	8363 (20.25)	45 (0.11)
N.W. Vancouver ² Island	4621 (11.19)	23541 (57.00)	388 (0.94)
S.E. Vancouver ³ Island	1317 (2.34)	1830 (3.25)	1126 (2.00)
Campbell River/ ³ Desolation Sound	2843 (5.05)	9571 (17.00)	1103 (1.96)
Alberni/Clayoquot ⁴	2203 (4.32)	5100 (10.00)	1020 (2.00)
Sunshine Coast/ ³ Lower Mainland	2731 (4.85)	7263 (12.90)	282 (0.50)
Province	2731 (5.16)	23541 (57.00)	45 (0.11)

Figures in parentheses represent associated tenure sizes in hectares.

* = In regions where less than 3 sites were recorded, information was withheld to maintain confidentiality.

1 = Fees calculated using Zone E lease rate.

2 = Zone C lease rate.

3 = Zone A lease rate.

4 = Zone B lease rate.

Source: Calculated by author using 1987 Salmon Farm Survey data and salmon farm zone lease values. Because many farms have license of occupation tenure, actual fees may be less.

In the Sunshine Coast/Lower Mainland and Campbell River/Desolation Sound areas, regarded to be the most desirable areas for salmon farming in the province, mean annual tenure fees are less than \$3000. Average annual tenure fees are currently the highest in North West Vancouver Island region (\$4600). These results can be attributed to the relatively minor differences in hectare fee rates between regions and the larger size of the more recent sites established in the northern Vancouver Island area.

Existing rental fees can be put into perspective by comparing them with estimates of the production costs of salmon farm operations in British Columbia. Based on data from a limited number of anonymous salmon farm management plans acquired by MFL, annual total costs (i.e. fixed plus variable costs) can be calculated for several farms having various levels of production.¹⁶ Assuming these farms operated in Zone A on average sized (5 hectare) sites, it can be shown that annual rental fees will amount to less than one percent of total annual production costs for all farms.

This evidence indicates that current tenure fees will only be reflective of tenure value in circumstances where salmon farm operations yield little more than opportunity cost returns. However, the demonstrated success of Norwegian farms and the extent of the current interest in salmon aquaculture in British Columbia suggest that salmon farming may prove to be highly profitable.

The appropriateness of existing fee levels can ultimately be judged by determining the current market value of site use-rights. With this in mind, a variety of groups associated with salmon farm siting were contacted.¹⁷ A number

¹⁶ B.C. Ministry of Forests and Lands (1987(d)). Figures were obtained from plans for 100, 200 and 500 tonne farms.

¹⁷ Contact was made with industry participants, a realtor, and a consulting group

of factors had to be taken into consideration. First, in order to get a measure of the value of site use-rights alone, data had to be obtained from sites having no farm improvements (i.e. net pens, docks, etc.). Second, trading in undeveloped farm sites is not officially allowed by the government, making acquisition of market information difficult.¹⁸ Trade does, however, occur. By registering approved tenure in the name of a holding company, individuals can "sell" use-rights by offering shares to other parties who subsequently wish to pursue site development. Government restrictions are avoided because the tenure-holding entity does not change.¹⁹

While market-value information is not generally made public, several data points were obtained. In a telephone interview with an anonymous industry source, it was learned that farm tenures having fully approved management plans, clean-up bond (\$1000) and site insurance are currently being traded at prices ranging from \$30,000 to \$75,000, depending on site characteristics and tenure size.²⁰ Two tenures north of Powell River (Desolation Sound region) and one on the Sechelt Peninsula (Sunshine Coast Region) were reportedly being offered for \$33,000 each at the time of the interview. In addition, an oyster culture license converted to salmon farm tenure was for sale for \$56,000. Confirming evidence was obtained in a telephone interview with a Vancouver realtor, who reported that tenure for a previously occupied site off Nelson Island (Desolation Sound

¹⁷(cont'd) offering expertise on site selection and development.

¹⁸ The intent of this restriction is to stop the possibility of site "flipping" for profit. As discussed below, the restriction is easily avoided.

¹⁹ This practice was confirmed by regional Lands officers and anonymous industry participants. Site transfer can also occur when only an investigative permit is held. Payment for farm tenure is simply made contingent upon tenure approval by the lands agency.

²⁰ Interview conducted by Richard Schwindt on May 11, 1988. Farm tenure currently has a 10 year term.

region) had recently been offered for \$80,000.²¹ The realtor at the time had a tenure for sale for \$50,000 in an undisclosed area.

More sophisticated site transfer arrangements appear to be emerging. In one reported case, an undeveloped site in the Campbell River area was traded by an original tenure holder for a \$10,000 plus future payments equal to one percent of annual gross sales revenue.²² In other cases, payments of up to 15 percent of annual farm profits have been granted to original tenure holders in exchange for tenure use-rights.²³

Due to limited sample size and the unofficial nature of the reported market values, the above information should be treated with caution. A number of factors will influence the current market value of site tenure. The costs of identifying a viable farm site and obtaining management plan and tenure approval can be significant,²⁴ meaning that market value in certain cases may reflect little more than a payment for past site expenses incurred by original tenure holders. Uncertainty about the magnitude of future output prices and costs will cause expected future rents to be discounted by tenure market participants. Since unclaimed potential sites undoubtedly remain in many areas (in particular, the northern and western areas of Vancouver Island), an overall situation of site scarcity has yet to be reached.²⁵ Farm managers and technicians may be in

²¹ Interview conducted on May 10, 1988 by the author. The realtor requested anonymity.

²² Information obtained in a telephone interview with Fred Sverre of Entech Environmental Consultants Ltd. on June 7, 1988.

²³ Ibid.

²⁴ Interviews with industry consulting groups revealed that site identification and approval costs range from \$10,000 to \$100,000, depending on farm location (e.g. travel expenses), survey requirements, legal fees, etc.

²⁵ However, as noted in Section 3.2.2, a growing shortage of suitable farm sites

greater shortage at the present, enabling them to capture a large share of current scarcity rents.

However, it is undoubtedly true that tenure rights associated with farm sites having superior biophysical and locational characteristics have acquired a market value in excess of site identification and development expenses. Their market value can be expected to grow in the future as suitable sites become increasingly scarce and improved production techniques become available throughout the industry.²⁶

6.3 Pricing Criteria: Site Rent Collection

The discussion in Section 6.2 indicates that if significant site rents emerge in British Columbia, the existing fee system will not capture them. As a result, the objective of site rent collection by the Crown will not be met. This outcome has a number of income-distribution implications. The most obvious is that private interests will receive the monetary benefits attributable to a public resource. A more subtle point involves the benefits captured by existing versus "second-hand" tenure-holders under the current pricing arrangement. When existing tenure holders sell their site use-rights to another party, they can be expected to include in the transfer price the present value of anticipated future rents from site use. This will reduce the possible net benefits obtained by the second-generation tenure holder.²⁷ Because site rents will in effect be "bid away",

²⁵(cont'd) is occurring in the more desirable regions such as the Sunshine Coast.

²⁶ The extent of this increase will of course be governed by market prices for pen-reared salmon and the fees levied by government for site use.

²⁷ First discussed by Tullock (1975), the "transitional gains trap" is a classic problem that arises when government allocates valuable property rights at a price below their true value. Such policy often represents a misguided attempt to

future attempts by the lands agency to price aquacultural lands to reflect their true value will only place financial hardship on many farm operators.²⁷

The expected extent of rent capitalization into tenure market value is increased by provisions for tenure renewal that currently exist in tenure contracts. As noted in Section 5.1.2, the original pricing policy for salmon farm tenure granted tenure holders the right to file for a replacement tenure at the mid-term of their initial tenure. In the case of an initial 10 year lease, the leasee had the right to apply for a 20 year replacement lease after 5 years. After the first 5 years of an initial 10 year license of occupation, the license holder could apply for a 10 year replacement tenure. These provisions were not changed when the current pricing policy was brought into effect in July, 1987.

Another income-distribution issue concerns the fee comparability problems that exist under the current zone pricing arrangement. When establishing the new pricing system, the lands agency attempted to introduce a degree of fee comparability by partially basing fee levels on the general locational advantages (i.e. infrastructure availability) associated with each aquaculture zone. However, when compared with the total cost of farm operation, differences in zone rates are relatively small. In addition, as acknowledged by the lands agency,²⁹ significant variations in site capability remain within each zone. As a result,

²⁷(cont'd) increase the inter-generational incomes of a particular group. It is ironic that the license limitation program introduced in the British Columbia commercial salmon fishery in 1969 has resulted in the transitional gains trap problem. Transferable vessel licenses have since acquired significant market values, creating high entrance costs for new fishermen. For a more detailed discussion, see Fraser (1979).

²⁸ Market uncertainty may mean that subsequent tenure-holders will also capture site rents. Of course, overly optimistic expectations could cause the opposite result - second generation losses.

²⁹ B.C. Ministry of Forests and Lands (1987(d), p.4)

some tenure holders will receive more net benefits than others due to site superiority.

In deciding to use the current zone system, MFL concluded that a tradeoff had to be recognized between fee comparability and administration costs. The question for policy improvement is thus whether alternative pricing methods can improve fee comparability without incurring prohibitive administration costs.

Failure to capture the economic rents associated with salmon farm sites will also have adverse resource allocation implications. These, along with other distortions caused by the current pricing policy, are discussed below.

6.4 Economic Efficiency

Section 4.4 listed four criteria necessary for an economically efficient use of aquatic lands in salmon farming. Each provides a standard by which to evaluate the current pricing policy.

6.4.1 Efficient Aquatic Land Allocation

The first criterion requires an efficient allocation of aquatic lands amongst competing uses – submerged lands should only be allocated to salmon farming if the net benefits (measured in economic and social terms) are positive. Pricing policy should thus be designed to encourage the "highest and best use" of aquatic lands. Before considering the existing policy, it is important to clarify the role pricing policy can play in the achievement of an efficient allocation of aquatic lands.

Pricing policy would play an active role if the price system were relied upon to allocate Crown lands. Consider the operation of unrestricted realty markets. In such markets, demand and supply forces will determine the prices for particular land parcels. Assuming away transactions costs for the moment,³⁰ competition amongst alternative users of particular parcels will result in those parcels' market prices being reflective of the parcels' highest value in use. In a zero transactions cost world then, an overall pricing policy for aquatic lands involving allocation of use-rights to the highest bidder would meet the highest use objective.

An alternative approach to land allocation - one in which pricing policy plays a more limited role - is to determine administratively the socially optimal allocation. This is the method currently adopted by the provincial lands agency when allocating Crown lands. As noted by the agency:

Given the special circumstances affecting Crown land ... highest and best use in economic and social terms is determined by the Ministry and guided by the land application referral process or Crown land planning processes (B.C. Ministry of Lands, Parks and Housing 1986(a), p.2)³¹

The "special circumstances affecting Crown land" and the desirability of administrative resource allocation in the case of aquatic lands can be given an economic interpretation.

Coase (1960) has noted that administrative direction of resources may result in socially more efficient outcomes than reliance on the market in cases where transactions costs make consideration of the value of certain actions (whether

³⁰ Transactions costs are those costs that are incurred in the process of market transactions. They may be more specifically defined as the costs of (a) identifying the parties with whom to undertake exchange (b) providing information in regard to the exchange opportunity (c) bargaining in order to reach agreeable terms, and (d) enforcing the agreement reached (see Dahlman 1975, pp.147-48).

³¹ These processes were outlined on pages 34-35.

socially beneficial or harmful) uneconomic in a market setting.³² In the case of aquatic land use, the transactions costs associated with a market approach to land allocation appear to be particularly high. For some users (e.g. recreational boaters and sportsfishermen) total benefits, though large, may be so diffuse as to make the transactions costs associated with leasing use-rights prohibitive, putting such users at a competitive disadvantage in a bidding arrangement.³³ In addition, due to incomplete information, the market may prove a poor evaluator of the potential future losses arising from the possibly adverse environmental impact of salmon farm operations.

It can be concluded that, in principle, the use of administrative mechanisms is an efficient means of allocating aquatic lands. The particular form the administrative mechanism should take requires further study. At present, the provincial lands agency allocates submerged lands using the land application referral system.³⁴ Questions have been raised as to whether alternative administrative arrangements would better account for the diverse interests and

³² The classic example is of a polluting firm that damages the environment of a large residential community. While the social damage may exceed the private benefit to the firm, transactions costs may preclude an organized effort on the part of residents to compensate the firm for reduced pollution. Government may step in and dictate the level of socially optimal pollution. Several important points should be noted. First, as Coase so elegantly demonstrates, the amount of pollution and "clean environment" that results in the case of no government intervention will only be affected by the liability assignment if transactions costs are sufficient to limit exchange possibilities between residents and the firm. Second, government intervention is only justified if the gains from regulation exceed the costs.

³³ The market approach to aquatic lands allocation may be possible where alternative users are organized and have a well-defined interest in a particular location. For example, sportsfishermen's groups and/or fishing lodge operators in the Campbell River area could conceivably bid as a group for water use rights over favorite local fishing spots without incurring prohibitive transactions costs.

³⁴ Similar arrangements are used in other jurisdictions - see Appendix 2.

needs associated with coastal land and water use.³⁵ As explained in Section 6.5, the administrative costs incurred under the existing application disposition method may be unnecessarily high.

Although the role of pricing policy in the achievement of an efficient allocation of aquatic lands may by necessity be limited, there are a number of reasons why its importance should not be overly discounted.

First, appropriate decision-making in regard to aquatic land allocation requires information on the benefits generated from alternative aquatic land uses. An accurate means of assessing the economic rent generated from aquatic lands used for salmon farming would provide a useful source of information for the decision-making process.³⁶ Because the current pricing policy lacks an adequate method of assessing aquacultural land value, the benefits from aquatic land use in salmon farming cannot be assessed properly. The importance of improved assessment techniques and/or the use of market-competition disposition methods should therefore not be overlooked when attempting to gain information useful for the determination of appropriate aquatic land allocation.³⁷

Second, pricing policy will influence the amount of aquatic lands used for salmon farming in areas where salmon aquaculture has been judged to be the "highest valued use". When making a decision on site size, prospective tenure

³⁵ For a brief discussion of the possibilities, see Province of British Columbia, Ombudsman (1987).

³⁶ Of course, other sources of information - e.g. the amount of employment generated - will also be needed.

³⁷ Information on the economic benefits generated by salmon farming should be interpreted with care. As Arrow and Fisher (1974) have shown, the possibility of irreversible environmental damage caused by industry development means that the expected value of industry development is necessarily reduced.

holders will take a number of factors into account, including the constraints imposed by pricing policy. Consider, for example, the current arrangement where tenure fees are determined on a per unit hectare basis. Economic theory suggests that, other things being equal, tenure applicants will include aquatic lands within their site proposal until the expected marginal revenue product of the last unit of aquatic land employed just equals the per unit hectare land price.³⁸ Because the per unit hectare fee is set by the lands agency, pricing policy currently determines the margin of aquacultural land profitability. Hence, policy will influence the size of farm sites, and therefore the overall amount of submerged lands employed in salmon farming.³⁹

In light of the influence pricing policy can have on aquatic land use in salmon farming, care must be taken to not unwittingly cause policy-induced distortions in aquatic land allocation. With this in mind, a number of problems can be identified with the current pricing system.

At the present time, per unit hectare fees are the only means employed by the lands agency for capturing a return for farm site use. If the fee is set below the opportunity cost value of aquatic lands in a particular area, prospective tenure holders will apply for "too much" submerged lands from an

³⁸ More generally, given the expected profit-maximizing level of farm output and assuming all inputs are initially variable, the expected product per dollar spent on aquatic lands will be equalized with equivalent measures for all other inputs, i.e.:

$$\frac{MP_1}{P_1} = \frac{MP_2}{P_2} = \dots = \frac{MP_n}{P_n}$$

where 1,2,...,n = the various farm inputs employed, including aquatic land

MP_i = the marginal product of the ith input

P_i = price of the ith input.

³⁹ A more indepth discussion of the relationship between pricing policy and farm input decisions is provided in Section 6.4.4.

allocative perspective. Though salmon farming may be judged the highest valued use in the area, aquatic lands could be put to other uses, and if the hectare fee is set low enough, aquaculture use (at the margin) will be socially undesirable.

As noted in Section 6.2, hectare fees are currently an insignificant fraction of total farm production costs. In line with economic theory, one would predict that, in the case of many farm sites, aquatic lands currently have a low revenue product at the margin.⁴⁰ While this result may be justified in remote areas where aquatic lands have few alternative uses (e.g. Northern Vancouver Island, the North Coast), the low fees being charged in high conflict areas such as the Sunshine Coast/Lower Mainland and Campbell River/Desolation Sound regions will only intensify conflict between salmon farmers and other users, necessitating administrative arbitration that is expensive for all parties involved.

If per unit hectare fees are set at above opportunity cost levels for submerged lands in order to capture differential site rents, prospective tenure-holders will apply for "too little" lands from an allocative perspective. Though this does not appear to be a problem at the moment, it will be if zone hectare fees are significantly increased upon discovery by the lands agency that aquatic lands are being under-priced in relation to the benefits they generate.

To conclude, from the perspective of efficient aquatic land allocation, per unit hectare fees should not be used to collect differential site rents because of the allocative distortions they will introduce. Other, non-distortive methods must be employed. Per unit hectare fees should instead be set at opportunity cost levels to encourage efficient aquatic land allocation. If the determination of

⁴⁰ However, in high conflict areas where tenure size is restricted by the lands agency, the marginal benefit from extending tenure size by one hectare may exceed the current per unit hectare fee charged.

opportunity cost values is difficult owing to complexities associated with measuring the private and social benefits from alternative uses (e.g. recreation), predesignated restrictions on site size should be considered. If such restrictions are introduced, per unit hectare fees will no longer play an allocative role in pricing policy. As discussed in Section 6.6, the desirability of their continued use as a rent capture tool will hinge on the size of differential site rents.

6.4.2 Timing of Site Allocation

The second condition for efficient use of submerged lands in salmon aquaculture concerns the timing of site allocation. Ideally, potential sites should be made available for salmon farming at the point in time when the present value of the economic rent from aquacultural use is maximized. In reality, the information necessary for optimal timing is largely unavailable,⁴¹ and determination of the appropriate social discount rate may be somewhat arbitrary. However, in general terms it is clear that if submerged lands having their highest use value in salmon farming are withheld from aquacultural use, potential economic rents for industry participants and the Crown will be lost. Conversely, as discussed below, an accelerated offering of aquatic lands will depress realizable rents.

Up until now, the provincial lands agency, while attempting to achieve an equitable balancing of coastal interests, has encouraged the development of the salmon farming industry by generally making land available upon application. With

⁴¹ In order to properly weigh the costs and benefits of allowing salmon farm development, accurate information is needed on the future market prices of pen-reared salmon, the anticipated rate of improvement in industry bio-technical and management skills, as well as the opportunity cost of aquatic land use in aquaculture and the potentially adverse environmental effects of salmon farm operation. Needless to say, a great deal of uncertainty would be involved in the cost-benefit analysis.

the exception of the moratorium imposed on the issuing of tenure between November, 1986, and March, 1987, no restrictions have been placed on the overall number of salmon farm tenures to be made available.⁴² A perceived lack of restraint has raised concerns that salmon farm development is occurring too quickly, without sufficient consideration of alternative coastal resource user interests, municipal government objectives, etc.⁴³ Thus, the question of timing has become paramount. However, the focus here will be on the more narrow issue of whether potential resource rents are being dissipated.⁴⁴

Realizable resource rents will generally be reduced in an industry if input suppliers reach capacity constraints during the course of rapid industry development. This problem will arise in particular when industry development was unforeseen or could not have been anticipated by input suppliers. The result is rapidly rising short-run input supply prices. While higher input prices may simply mean a rent transfer from output producers to input suppliers, they will also reflect higher input production costs (i.e. due to the level of input demand, input suppliers are forced to use less efficient stand-by equipment and workers). This latter result will cause potential resource rents to be reduced.

In the case of salmon farming, concern over "unbalanced development" caused by rapid industry expansion has been one rationale for the Norwegian government's policy of restricting the number of new aquaculture licenses

⁴² Restrictions have been placed on the location of tenures in high conflict areas. See B.C. Ministry of Forests and Lands, Coastal Resource Identification Studies (1987(e,f,g)) for details.

⁴³ In addition to Gillespie (1986), an excellent review of these concerns is found in Province of British Columbia, Ombudsman (1987).

⁴⁴ But see *supra* note 43.

annually issued.⁴⁵ The British Columbia government has adopted a different approach, allowing development to occur at a pace largely dictated by the salmon farming industry itself. In light of this approach, it is of interest to consider whether supply constraints will dissipate realizable rents from salmon farming.

DPA (1986) addressed the question of potential bottlenecks in supply industries in its report to the federal Department of Fisheries and Oceans. Taking into consideration estimates that indicated significant increases in the number of future farms, DPA nonetheless concluded that additional demands for critical inputs would not result in major supply constraints.⁴⁶ Based on these findings, the possibility of significant rent dissipation through inefficiencies in input supply industries does not appear to be great.

However, realizable rents may be reduced by accelerated industry development because of an important deficiency in the existing pricing policy. As noted in Section 6.2, the level of current fees may underestimate the true value of site tenure, leaving site rents to be captured by tenure holders. An interpretation of the "gold rush" mentality attributed by some to industry development is thus that individuals are attempting to be the first to acquire valuable tenure rights under the direct application ("first-come/first-served") disposition method. Economic theory suggests that this may lead to a partial dissipation of potential economic rent from site use.

⁴⁵ Bjorndal (1988, p.126) reports that a particular concern has been the capacity of veterinary and extension services (i.e. education and research).

⁴⁶ See *supra* note 5. The consulting group was careful to note that the quality of some inputs would not necessarily satisfy the industry's demands (e.g. a surplus of coho eggs was expected while the predominant industry demand would be for chinook) (DPA 1986, p.7).

Cheung (1974) has shown that when income from the use of a resource remains unassigned (i.e. not captured by the owner), it will be dissipated through the competitive actions of individuals attempting to capture it.⁴⁷ If current fees for site use under-value site tenure, unassigned potential resource rents will exist under direct disposition. One form that competitive behavior may take to capture these potential rents is "premature" application for salmon farm sites. In order to outpace rivals, potential site users will apply for tenure prior to the point in time when farm operations would be profitable (i.e. prior to the emergence of output markets or farm production costs that would normally justify site development). The extra expense resulting from these "early" tenure payments is justified from the perspective of the individual tenure holders, who view them as a cost that must be incurred in order to be the first to claim a site. Such payments might be viewed as an early payment for the private right to future site rents, and as such do not involve rent dissipation. However, in cases where tenure fees underestimate the the value of alternative site uses, uncompensated forgone benefits will be a source of rent dissipation.

Cheung argues that individuals will attempt to minimize the dissipation of unassigned income. Their ability to do so will be influenced by the constraints they face. In the case of salmon farm development, rent dissipation would be reduced if successful site applicants were not required to immediately develop their sites and begin production. Under current arrangements, however, diligent use provisions in tenure contracts require that sites be developed and production started shortly after tenure has been granted. As a result, a potential source of rent dissipation will be losses attributable to the mis-incentives embodied in the current pricing policy. To be the first to claim a good site, an individual will

⁴⁷ Though Cheung's analysis considers the case of price controls, his analysis is applicable here.

not only be willing to make a premature site application – given the constraint imposed by diligent use requirements, he will also be willing to sustain operation losses during the early years of industry development in order to have first access to farm rents in later years. From a social perspective, these losses will represent rent dissipation.⁴⁸

This is not to suggest that the best answer to the problem is to remove diligent use requirements from tenure contracts. Instead, an appropriate means of site valuation must be developed so that unassigned rents no longer exist (i.e. are assigned to the resource owner – the Crown).

6.4.3 Selection of Site User

The third criterion for economic efficiency is site allocation to efficient (least-cost) salmon farmers. Other things being equal, achievement of this objective will maximize the economic rent generated from farm operations on aquatic lands.

The land disposition method used by the government will determine who initially receives site tenure. Under the direct application method currently employed in British Columbia, selection of efficient site users is not guaranteed given the possibility that inefficient users may stake the first claim to particular farm sites. However, because site tenure is transferable, efficient site users may eventually hold tenure rights as a result of market exchange. While this will mean the efficiency objective will indirectly be achieved, such action is not

⁴⁸ Farm managers will have an incentive to prolong the development stage. This provides an alternative explanation of the current situation where many new tenures exhibit few site improvements on relatively large sites (see Section 3.2.2).

costless.⁴⁹ Of greater concern may be the problems discussed in Section 6.3. The amount of differential site rent collected by the Crown will be reduced along with the ability to raise fees in the future when aquatic land value becomes known to the authorities (i.e. economic rent will have been bid away by second generation tenure holders).⁵⁰

If site allocation is to continue under the direct application method, the likelihood of selecting an efficient user will be increased if site use fees are adjusted to more accurately reflect the true value of tenure. Higher fee levels will discourage site acquisition by inefficient operators and also reduce the gains from rent-seeking tenure transfer.

An alternative to the direct disposition procedure is to use market-competition disposition methods. As discussed in Chapter 7, market techniques, although not without problems, may prove effective for the identification of efficient site users.

Objectives other than economic rent maximization may mean that the selection of efficient site users will not be important in certain cases. For example, to enhance economic opportunities for coastal native Indians, preference in tenure allocation in certain areas may be given to local Indian bands. The objective of site allocation to efficient site users may also be criticized on the normative grounds that "family farm" (i.e. small scale) operations will be

⁴⁹ Some resource rent will be dissipated due to the increased number of transactions involved.

⁵⁰ If the government was able to detect ownership transfer to a more efficient site user, fees might be increased to capture the higher net returns from more efficient site use. However, this possibility would simply reduce the incentive for tenure transfer to more efficient users, violating the efficiency objective of this section.

eliminated. Similarly, it might be argued that, due to the current knowledge and financing advantages enjoyed by foreigners (i.e. Norwegians), pursuit of this objective will imply foreign control of British Columbia farm sites.

If these concerns are important from a public policy perspective, the extent of tenure transferability will have to be limited. Otherwise, as argued above, market transactions may ultimately revert tenure ownership to more efficient site users.

6.4.4 Productive Efficiency

To meet the fourth requirement for economically efficient use of aquatic lands, pricing policy should encourage least-cost production (productive efficiency) by farm operators. As demonstrated below, different pricing methods, by altering the constraints faced by farm managers when making input-output decisions, will have different effects on the magnitude of farm costs and revenues. Ideally, pricing policy will not distort profit-maximizing or cost minimizing decisions, except where such distortions are warranted in light of tradeoffs with other policy objectives.⁵¹ To the extent that a chosen pricing policy unintentionally discourages the achievement of optimal input combinations and production on farm sites, inefficient resource allocation will result, reducing the size of potential benefits from resource use available to both tenure holders and government.

Before examining the potentially distortive effects of the current pricing system, it is important to discuss first the anticipated effect site biophysical and locational characteristics will have on the decision-making of salmon farm

⁵¹ An example of a warranted distortion in farm decision-making would be a tax or restriction on output designed to curtail adverse external effects arising from farm production (e.g. negative environmental impacts).

operators. Site characteristics are clearly heterogeneous in British Columbia.⁵² While the particular relationship between site characteristics and farm costs has yet to be empirically quantified, it is evident that cost effects exist.⁵³ Economic theory allows a number of general predictions of the effect of heterogeneous site characteristics on farm output levels, production costs and the demand for water. Though verification of these predictions is difficult due to a lack of available empirical data, they have important implications for appropriate site pricing policy. For this reason, they are developed here.

The Effect of Heterogeneous Site Characteristics

To start, consider the simple case where annual production of marketed farmed salmon (y , measured in tonnes) is a function of two inputs; water (X_1 , measured in cubic meters employed in net-pens) and a composite input (X_2) representing a combination of the other inputs employed.⁵⁴ The productivity of X_1 and X_2 is assumed to be influenced by site quality (α). The parameter α can be viewed as an index of site biophysical characteristics, with a larger α causing greater input productivity per unit for a salmon farm. The general form of the production function is:

⁵² This is revealed in an extensive study by Cain et al. (1987), who examine biophysical characteristics important in site evaluation for British Columbia farms. Significant differences in siting opportunities in British Columbia coastal waters are noted for many site characteristics (i.e. water temperature, oxygen content, water flow, etc).

⁵³ Cain et al. note possible procedures for mitigating undesirable farm site conditions. All are cost increasing.

⁵⁴ Modelling production in this way eliminates the possibility of investigating the relationship between water and specific inputs (i.e. feed, smolts, capital, labour, etc.) in the production process. This simplification is justified because (a) the primary concern here is the effect of site heterogeneity on total production and the demand for water, and (b) empirical data does not currently exist with which to specify the relationship between water and particular inputs.

$$(1) \quad y = f(\alpha, X_1, X_2)$$

$$f_1 > 0, f_2 > 0, f_\alpha > 0, f_{11} < 0, f_{22} < 0, f_{\alpha\alpha} < 0, f_{1\alpha} > 0, f_{2\alpha} > 0$$

where the function is assumed to be well-behaved⁵⁵ and f_1, f_{11} etc. represent the associated first and second-order partial derivatives.

Next, assume that farm sites vary in terms of their proximity to input and/or output markets by a given distance (D). Transportation costs for outputs and inputs are assumed to be a constant rate (a) and (b) per unit distance respectively.

In light of these assumptions, total production cost is:

$$(2) \quad C = r_1 X_1 + (bD + r_2) X_2 + aDy$$

where r_1 = unit price of water (exogenously determined by government)

r_2 = composite unit price of other inputs (exogenously determined in competitive input markets)

Annual farm profits are thus:

$$(3) \quad TP = (p - aD)f(\alpha, X_1, X_2) - r_1 X_1 - (bD + r_2) X_2$$

where p = unit price of farmed salmon (exogenously determined in export markets)

⁵⁵ That is, the function is single-valued with continuous first and second-order partial derivatives.

Modelling the problem in this way, comparative static analysis can be undertaken. From the perspective of profit-maximization, the effect of site quality (α) and site location (D) on the level of farm production and the absolute amount of water employed can be determined. When considering the dual approach of cost minimization, the comparative static effect of site quality and location on total, average, and marginal production cost, as well as the relative amount of water employed (i.e. in comparison with the composite input) can be investigated.

The comparative static procedure is presented in Appendix 1. The findings are summarized here.

Profit Maximization

1. Other things being equal, the greater is site quality:
 - (a) the greater will be the total profit (economic rent) generated in salmon farming,
 - (b) the greater will be the profit-maximizing level of production, and
 - (c) the greater will be the profit-maximizing amount of water employed.

2. Other things being equal, the closer the location of the farm site to input/output markets:
 - (a) the greater will be the total profit (economic rent) generated in salmon farming,
 - (b) the greater will be the profit-maximizing level of production, and
 - (c) the greater will be the profit-maximizing amount of water employed.

Cost Minimization

1. Other things being equal, for any given level of output produced, farms having greater site quality will:
 - (a) have lower total and average production costs than farms having poorer site quality,⁵⁶ and
 - (b) employ more water relative to other inputs than will farms having poorer site quality,⁵⁷

2. Other things being equal, for any given level of output produced, farms having greater locational advantages will:
 - (a) have lower total, average, and marginal production costs than farms having poorer locations, and
 - (b) employ less water relative to other inputs than will farms having poorer locations.

The profit-maximization results indicate that total annual production is expected to be positively related to site quality and location - the more advantageous are these characteristics, the greater will be production, *ceteris paribus*. Higher production levels are anticipated to have an *output effect* on the demand for water - holding factor prices constant, greater production requires greater amounts of all inputs used, including water. While the magnitude of these effects will require empirical verification, the incentive for greater production and water usage is clear.

⁵⁶ The effect on marginal production costs cannot be determined using the specified model. See Appendix 1, p.133.

⁵⁷ This result requires the assumption that site quality has a greater relative effect on the marginal product of water than on other inputs - see Appendix 1, pp.131-32.

The cost minimization results show that superior site quality and location are expected to lower production costs for any given level of output and have a *substitution effect* on water usage. To clarify the substitution results, it is helpful to consider the effect differences in site biophysical characteristics will have on technical production possibilities facing farm operators.

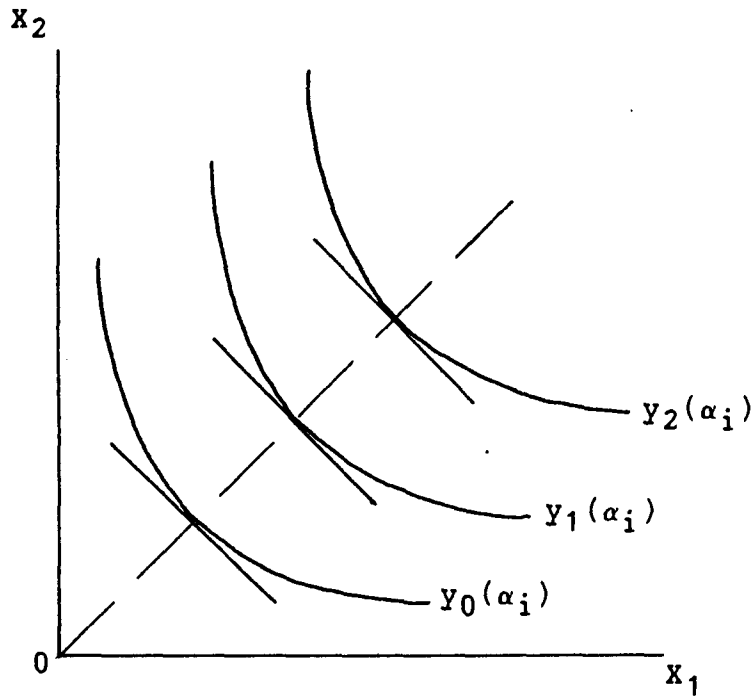
Figure 3 illustrates the isoquant mapping associated with (1) assuming the production function is homothetic⁵⁸ and that site conditions are of a particular quality (α_i). In production theory it is normally assumed that inputs are homogeneous in terms of their productivity characteristics. How will the isoquant mapping faced by farms differ if site biophysical characteristics differ, *ceteris paribus*?

For simplicity, assume that two types of farm sites exist; superior (α_s) and inferior (α_i). As illustrated in Figure 4 and mathematically shown in Appendix 1 (pp.131-32), differences in site quality will have two main effects on farm isoquants. First, farms having superior sites will achieve greater output for every X_1X_2 combination, meaning their isoquants will appear to have been shifted inwards when compared to those belonging to inferior site farms. Second, under the assumption that site biophysical conditions increase the marginal product of water relative to other inputs, superior site isoquants will also have a steeper slope for any given X_2/X_1 ratio.⁵⁹

⁵⁸ If the production function is homothetic, the firm's output expansion path is neutral - i.e. for a given set of factor prices, an increase in output does not change the ratio of factor inputs. The plausibility of this assumption will be discussed shortly.

⁵⁹ It should be stressed that this assumes site conditions have a greater effect on the marginal product of water than on other inputs - verification will require empirical study of the exact nature of the production function for pen-reared salmon in British Columbia. It is not inconceivable that site conditions might instead increase the relative marginal product of other inputs, in which case superior isoquants will have a flatter slope for any given factor ratio. What is

Figure 3: Hypothetical Production Function Isoquant Map

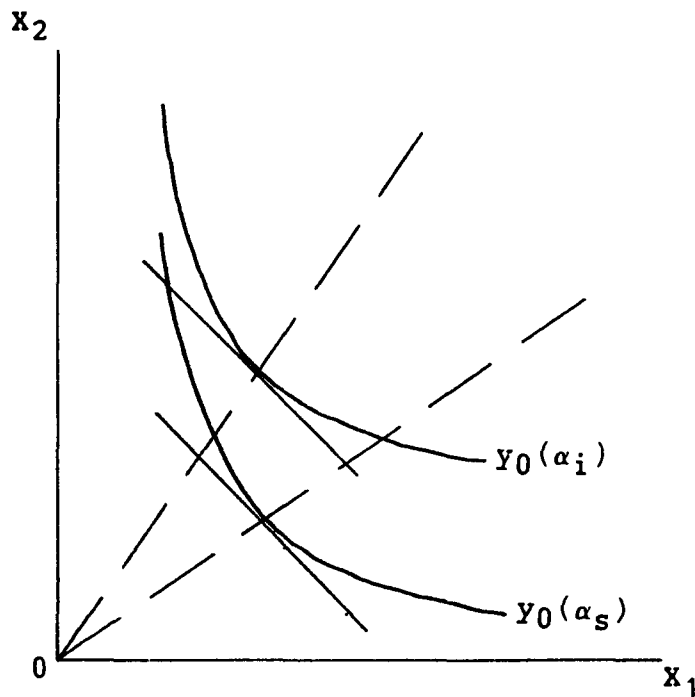


Given the influence site biophysical characteristics have on the technical production possibilities available to the farm operator, the potential for a substitution effect caused by biophysical differences is apparent. As shown in Figure 4, for the same level of output and holding relative input prices constant, farms having better site quality will be more water intensive, *ceteris paribus*.⁶⁰

The possibility of a substitution effect induced by differences in site location can also be seen. Superior site location alters relative input prices (e.g. transportation costs associated with variable inputs such as feed will be less), causing a substitution away from water *at a particular output level* when -----
⁵⁹(cont'd) clear is that differing site conditions will alter isoquant slope, and therefore factor intensity.

⁶⁰ But see *supra* note 59.

Figure 4: Isoquants Differentiated by Site Biophysical Characteristics



compared with sites having poorer location characteristics.

The importance of these substitution effects will be determined in part by the substitution possibilities allowed by the salmon farming technology. Due to a current lack of empirical data, the extent of input substitutability cannot be specified at the present time. However, observation of salmon farm operations suggests that substitution possibilities should exist. Net-pen dimension can be altered to accommodate more or less water volume, fish stocking density can be altered for a given pen volume, etc. Such adjustments may prove to be a profit-maximizing response to particular site conditions.

The existence of substitution effects caused by heterogeneous site conditions offers an alternative explanation for the finding by Salvanes (1987) that the production function for Norwegian farmed salmon is non-homothetic.⁶¹ Salvanes (pp.17-18) offers two hypotheses. First, the technology may have the nature of non-homotheticity due to indivisibilities in capital and the high fixed costs of using specialized equipment for harvesting and feeding. Only large farms can take advantage of these processes, giving rise to capital intensity with scale. Second, due to differences in relative factor prices facing big versus small farms, substitution occurs with scale, resulting in an observed non-neutral expansion path.⁶²

An alternative explanation for non-homotheticity is that differences in site biophysical conditions have caused factor intensity to be altered with scale. The model developed here suggests that larger farms will be superior site farms, *ceteris paribus*, and that the observed output expansion path in an unregulated industry characterized by heterogeneous farm sites will be non-neutral because of the influence of site biophysical conditions on farm isoquants. While restrictions on the size of all newly established farms in Norway mean that superior site farms will not necessarily be larger farms, it is interesting to note that large farms established prior to the introduction of size restrictions are located in the country's southern coastal region where water conditions are known to be more favourable (Salvanes 1987, p.24) and that such farms have factor intensities that differ from farms in other regions.

⁶¹ Non-homotheticity implies that the industry output expansion path is non-neutral - i.e. for given set of factor prices, an increase in output changes the ratio of factor inputs.

⁶² Differences in relative prices are explained by segmented labour markets, with larger farms tending to be located in regions with higher relative labour costs.

The predicted effects of site biophysical characteristics and location are summarized in Figure 5, where long run average total cost (LRATC) curves and long run marginal cost (LRMC) curves are constructed for two hypothetical farms facing different site conditions.⁶³ LRATC₂ and LRMC₂ are associated with a farm having superior biophysical and locational characteristics.⁶⁴ Profit maximization requires both farms to operate where LRMC = MR = P.⁶⁵

The superior site farm (Farm 2) is expected to produce a higher level of output (y_2 versus y_1) and to use a greater absolute amount of water (due to the output effect on water usage). The intensity of water usage relative to other farm inputs will be determined by the relative strength of the biophysical and locational substitution effects and the influence of biophysical conditions on the productivity of water *vis-a-vis* other inputs.

The areas ABCD and AEFG represent total economic rent associated with the operation of Farm 1 and Farm 2 respectively. The sources of these rents should be clarified. Assume that the technology employed on each farm is identical. In the analysis here, the level of the costs curves will determine the magnitude of the total rents generated.⁶⁶ A number of factors can be expected

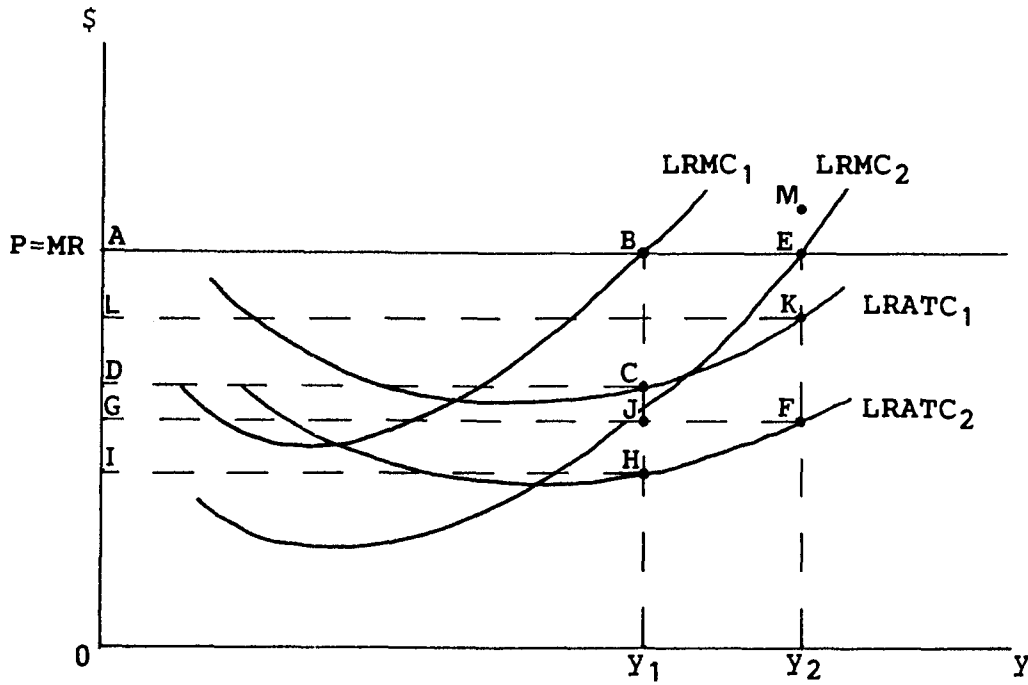
⁶³ With production technology, input prices, and input productivity characteristics acting as the main constraints, movements along the LRATC and LRMC curves can be given the standard interpretation - i.e. adjustments in all variable inputs (including water) to achieve minimum production cost. As usual, measured costs are assumed to include an opportunity cost return for invested financial capital, compensation for risk, and the opportunity costs of site usage.

⁶⁴ For the sake of illustration, it is assumed that marginal production costs are lower for the superior site farm (see *supra* note 56).

⁶⁵ It is assumed that farms are price-takers in export markets.

⁶⁶ The size of potential rents will also be dependent upon the slope of the cost curves. Comparative static analysis can only be used to compare the slopes of cost curves associated with farms having differing site characteristics when empirical information is available to evaluate the sign of the third-order partial derivatives that necessarily arise in the comparative static procedure. This

Figure 5: Hypothetical Long Run Cost Curves for Farms Having Different Site Characteristics



to influence the level of the cost curves in addition to site characteristics. Important factors include the opportunity cost of site usage and the level of managerial and technical skill employed on the farm. The level of the cost curves will in turn affect an additional source of cost savings and therefore economic rent - economies of scale from production. Larger levels of output (due to a lower overall cost structure caused by the factors listed above) will make possible the use of specialized equipment for such operations as feeding, enabling lower production costs. Determination of differential site rent should take into consideration all these factors, ultimately counting only those rents attributable to the site itself.

 "(cont'd) information is currently not available.

Referring again to Figure 5, assume that site opportunity costs and managerial and technical skill do not differ between Farm 1 and Farm 2 - i.e. differences in the levels of the cost curves are solely attributable to site biophysical and locational differences. A direct comparison of the differences in site rents attributable to site heterogeneity can be made by considering output level y_1 . At y_1 , Farm 2 generates DCHI more rent than Farm 1 due to superior site characteristics. The difference in total rents generated when Farm 2 operates at its profit-maximizing level (i.e. DCJG + BEFJ), however, represents rents captured by Farm 2 due to greater amounts of water used and the effects of scale economies. Of this amount, only the rent attributable to water itself should be counted when determining the differential fee assessment.

Referring again to Figure 5, the distinction between greater economic rent captured by Farm 2 resulting from scale economies and rent caused by superior site characteristics can be made by comparing the long run average total production costs of Farm 1 and Farm 2 at output level y_2 . The difference between $LRATC_1$ and $LRATC_2$ at y_2 (i.e. K-F) represents the per unit cost difference made possible by superior site characteristics alone. Differential site rent generated by Site 2 is therefore LKFG. If long run average production cost for Farm 1 at y_2 were M instead of K, the entire amount AEFM would be the differential rent generated by Site 2.

This detailed demonstration of the anticipated effect of site characteristics on total rents yields several insights for pricing policy. First, other things being equal, farms having sites with superior biophysical and locational characteristics can be expected to produce larger amounts of output and to use larger amounts of water. Therefore, in addition to the rationale provided by greater site rents, higher tenure fees for superior sites will be justified by the the higher

opportunity costs associated with greater water usage (i.e. larger farm size, greater environmental pollution, etc.). Second, superior site farms will generate greater economic rents than farms with lesser quality sites due to site and possible scale advantages. Differences in tenure fee levels should only account for rents attributable to the site itself.

Policy-Induced Distortions: Per Unit Hectare Fees

In Section 6.4.1, the potential distortions caused by the current pricing policy were discussed from the perspective of efficient aquatic land allocation. It was argued that per unit hectare fees should not be used as a means for collecting significant differential site rents. The resulting high fees would reduce submerged land demand by tenure holders to the point where "too little" aquatic land would be used for salmon farming. The discussion of possible distortions caused by per unit hectare fees can now be extended to consider their impact on production costs and the size of total rents generated by salmon farm operations.

As noted in Section 6.4.1, the low level of current hectare fees encourages tenure holders to employ aquatic lands in farm production until the marginal benefit generated (relative to the use of other inputs) approaches zero. This may cause spatial use of the site to be extended on a number of margins. For example, spacing between net-pens may be increased until the marginal benefits (e.g. reduced concentration of waste feed and fecal contaminants) equal the higher marginal costs of joint feeding, pen monitoring, etc.⁶⁷ Similarly, the buffer zone between farm operations and adjacent coastal resource uses can be

⁶⁷ Spatial dispersal of net-pens generally only occurs for large farm operations. For farms producing low output levels, the problem of waste concentration appears to be minor.

increased until the additional benefits of a reduction in interference, pollution, etc. are only minor.⁶⁸

If per unit hectare fees were raised above their opportunity cost levels in order to capture differential site rents, farm decision-making could be altered in several ways. Low value uses of aquatic lands would be eliminated,⁶⁹ and if fees were raised high enough, site operations would be packed more closely together. The end result of water fee increases would be higher farm production costs, shifting the cost curves in Figure 5 upwards. In the process, production levels would be reduced. Overall, potential economic rent associated with the site and other inputs (e.g. managerial skill) would be reduced.

Farm managers might attempt to make a number of cost-reducing adjustments.⁷⁰ One option will be to make net-pens deeper. The feasibility of this action will be determined by site characteristics (i.e. the depth of the ocean floor, currents, etc.) and the technology (feeding and harvesting may be made more difficult). Alternatively, water could be used more intensively - for example, stocking density could be increased (but at the eventual cost of greater fish mortality due to stress caused by increased crowding).

Finally, substitution between water and other inputs might occur (i.e. greater stocking densities combined with reduced net-pen volume). One prediction of the

⁶⁸ However, as first mentioned in *supra* note 40, in cases where farm tenure is restricted by the lands agency, the marginal benefit to the farmer from extending this buffer zone by one hectare may exceed the current per unit hectare fee charged.

⁶⁹ That is, the size of site buffer zones would be reduced, but see *supra* note 68.

⁷⁰ Due to an absence of empirical data on the role played by water in the production technology associated with pen-reared salmon, the following predictions are only speculative.

model developed in this section is that, for the same increase in the per unit price of water, farm sites having inferior biophysical characteristics may substitute away from water to a greater extent than superior water farms.⁷¹ Referring to Figure 4, for the same level of output, an equal rise in the relative price of water will result in less water usage on the inferior farm because of the lower productivity of water and the associated effect on the available substitution possibilities (i.e. the slope of its production isoquants).

In summary, the current means of assessing site fees is inappropriate for the collection of differential site rents. If potential rents prove to be significant, per unit hectare fee increases to enable rent capture will result in higher farm production costs and thus rent dissipation. Alternative, less distortionary pricing methods must be sought.

6.5 Accounting for Uncertainty

The economic rent generated in the salmon farming industry will vary with output market prices and industry production costs. At the individual farm level, rents can also be expected to vary as a result of changes in local environmental conditions (i.e. plankton blooms) and the emergence of diseases that affect salmon stocks. Therefore, to ensure a fair return to the Crown while also recognizing the risk to tenure holders, pricing policy should allow for fee adjustment.

If fee adjustment provisions take the form of risk-sharing between the government and tenure holders, pricing policy will increase the expected economic rent from salmon farming. This result can be seen by considering economic

⁷¹ But see *supra* note 59.

theory and the conditions that currently govern the ability of tenure holders to insure themselves against salmon farming risks.

Assuming tenure holders are risk averse, they will seek to minimize the undesirable burden of farm operation risk. This can normally be accomplished in a number of ways, including the acquisition of insurance or through the pooling of risk via incorporation and the issuing of equity shares. However, due to the short history of the salmon farming industry in British Columbia as well as the limited experience of many farm operators, insurance markets are incomplete⁷² and capital markets less than perfect.⁷³ Both facts imply that tenure holders will have to bear a great deal of the risk themselves.

The risks associated with salmon farming will affect the decisions of potential investors and existing tenure holders in a variety of ways. For example, marginal farm sites otherwise developed under conditions of greater certainty will be viewed as unprofitable by investors who require an additional return for risk-bearing. On viable sites, risk due to such factors as output or market price variability can be expected to cause a reduction in the farm's profit-maximizing level of output and therefore water usage.⁷⁴

⁷² DPA (1986, p.3-19, note 7) report that insurance companies require technical and management experience before making insurance available. Fish mortality premiums are approximately 3-4 percent of the estimated market value of fish inventory, with insurance policies carrying large deductibles for disease. As a result, as of May, 1986, more than half of total farmers were self insured for inventory losses.

⁷³ DPA (p.3-18,19) note that working capital loans from domestic banks are only available if strict criteria are met. Inventory financing is generally not available. Financing from Norwegian banks is available mostly to companies with Norwegian involvement. At the present time, eight salmon farming companies are listed on the Vancouver Stock Exchange. For many salmon farm companies, personal equity is therefore the main source of financing.

⁷⁴ See Henderson and Quandt (1980, pp.119-20) for a general proof of this result.

These effects represent a loss in potential economic rents from the aquacultural use of submerged lands. If government is better able to bear risk, as argued by Arrow and Lind (1970),⁷⁵ it can minimize these losses by taking over or sharing the risk burden experienced by tenure holders.

One way in which risk-sharing can be facilitated is through the pricing provisions of the government's contract with tenure holders (Leland 1979). Contracts can contain unconditional or conditional payment clauses. Unconditional payments are payments for resource use that do not depend on subsequent events - e.g. a fixed annual lump-sum fee. If all payments are unconditional, the tenure holder bears the entire risk involved in resource use. Conditional payments are payments that depend on future conditions - e.g. the amount of profits in a profit-sharing contract. As the level of conditional payments relative to unconditional payments in a contract is increased, the risk burden is transferred from the tenure holder to the government. Given the above mentioned gains from risk-sharing, desirable pricing policy from a risk distribution perspective will thus involve conditional payments to a greater extent than unconditional payments.

Under the existing pricing policy, adequate provision for fee adjustment and risk-sharing does not exist. As discussed in Section 5.4, the lands agency does have the right to adjust tenure fees pursuant to adjustment in zone values. However, the lack of an appropriate means of assessing aquatic land value has left the agency with no means of justifying changes in zone rates. The use of per unit hectare fees as a basis for fee adjustment and risk-sharing in light of

⁷⁵ Their argument is that, assuming returns from a particular resource are a small portion of a government's total revenue, government should be risk neutral in regard to income variations from the resource. As such, government expected revenues are not reduced when it takes on more risk, but actually increased because of greater expected revenues from firms who, bearing less risk, are willing to undertake more investment and greater production.

changing revenue and/or cost conditions can be questioned on allocative and productive efficiency grounds.⁷⁶ Finally, adjustments in tenure fees to account for changing site conditions in particular areas are not possible given the sweeping nature of zone rate pricing.

These problems suggest that a number of changes be considered to improve pricing policy in this area. The method of aquatic land valuation must be improved so that changes in aquatic land value can be identified and documented. A more appropriate basis for fee adjustment and risk-sharing (i.e. one that does not distort farm input decision-making) should be devised. Finally, fee adjustment and risk-sharing should ideally be made possible at a more disaggregated level to account for site risks (i.e. plankton blooms, fish disease) in particular areas.

6.6 Administrative Efficiency

Administrative efficiency concerns the administrative cost of implementing and operating a particular pricing scheme, where cost includes compliance costs borne by tenure holders. Other things being equal, pricing alternatives that involve lower administration costs will increase the size of available economic rents.

Because "other things" are not equal under different pricing policies in practice, achievement of administrative efficiency is not as simple as selecting the pricing method that has the lowest total administration costs. Some policies will involve greater administrative expenditure than others, but also provide a greater ability to generate and collect differential site rents. The guiding principle

⁷⁶ See Sections 6.4.1 and 6.4.4. The resulting uncertainty surrounding the level of per unit hectare fees will complicate input decision-making if fee alterations are significant.

for policy selection under the administrative efficiency objective should be to choose pricing arrangements that maximize the size of differential site rent net of administration costs.

The appropriate policy from an administrative efficiency perspective will in part be determined by the level of expected economic rent generated in salmon farming. Consider, for example, the current pricing policy.

Existing policy would be administratively efficient if there were little potential for economic rent in salmon farming. While it has been argued that the method of aquacultural land valuation is arbitrary (i.e. log storage values are used) and the method of pricing distortionary (see Section 6.4), these problems could be viewed as unimportant if potential economic rents were minimal. The low cost of fee assessment under the current policy would be given greater weight, especially given the limited economic rents generated by a more detailed and administratively expensive approach to pricing. Direct disposition of aquacultural land tenure and the use of the inter-agency referral process could also be justified on cost/benefit grounds. In the absence of sufficient potential for economic rent in farming, an expensive Crown land planning program involving government identification of areas acceptable for salmon farming would be unwarranted given the low demand for salmon farm sites. Site identification would be best left up to interested private parties, with occasional land use conflicts handled on a case-by-case basis using the inter-agency referral process.

The administrative efficiency of the current pricing policy can be questioned, however, given the high demand for aquatic land for salmon farming and the significant potential economic rents. Though the nature of administration costs

associated with the current approach to fee assessment would not increase with the emergence of economic rents,⁷⁷ the loss in potential economic rent due to policy induced distortions will undermine the net benefits of the current pricing method. For aquatic land disposition, reliance on the direct application method and the inter-agency referral process may become an administratively costly means of determining appropriate sites for salmon farming. Because of the low level of current tenure fees in all coastal regions, many sites (especially those in the South Coast) may prove profitable for salmon farming. The handling of a large number of site applications on a case-by-case basis, each requiring the participation of a number of government agencies and concerned interest groups, will involve high arbitration costs and possible duplication of effort when applications are received within the same area. While the Coastal Resource Identification Studies are an attempt to reduce these costs - i.e. salmon farm applicants now have greater information about the level of alternative user interest in an area and hence the probability of tenure approval in the inter-agency referral process - the extent to which they should be viewed as a definitive reference for site location is unclear.⁷⁸ A more specific identification of areas acceptable for salmon farming may be required to reduce arbitration costs. The possibility of aquatic land use planning involving a coastal resource committee composed of government agencies, local communities and interest groups may prove viable over the long term.⁷⁹

⁷⁷ That is, fee assessment would still simply involve multiplication of established zone hectare rates by farm area. Total administration costs arising from fee assessment would, of course, increase because of the larger number of established farms.

⁷⁸ Farm applicants can still choose to pursue their tenure applications in many cases if they feel that tenure will be granted upon administrative review.

⁷⁹ For a brief discussion of the issues surrounding this and other planning options, see Province of British Columbia, Ombudsman (1987).

Administrative efficiency questions thus reduce to whether more comprehensive planning and pricing policy are justified given the level of expected rents in salmon farming and the resulting demand for farm sites. Evidence provided here on the potential profitability of salmon farm operations and the existing large numbers of tenure applications in British Columbia appear to indicate that such steps are warranted.

CHAPTER 7

PRICING POLICY ALTERNATIVES

The analysis of Chapter 6 indicates the current pricing policy for salmon farm tenure in British Columbia is no longer appropriate given the expanding and potentially lucrative nature of the salmon aquaculture industry. New policy must be devised to generate and capture anticipated site rents.

Viable options for policy reform are circumscribed by several key considerations. Of first importance is the heterogeneous nature of the resource. Pricing policy should account for biophysical and locational differences at a non-prohibitive administrative cost. Second, the salmon farming industry in British Columbia is still in the development stages – international prices for pen-reared salmon and British Columbia production costs are bound to change as the industry matures. Therefore, pricing policy must be adaptable to changing conditions. Finally, policy reform must consider the constraints imposed by the legacy of the existing pricing policy. Tenure contracts for many of the best farm sites have already been issued, granting long term use-rights to tenure holders.

Broadly speaking, three alternative policy courses can be identified. The first is a shift toward market-based pricing techniques where site tenure is allocated using competitive bidding. The second approach is to continue with direct disposition of tenure but to improve fee assessment methods. Finally, a mixture of market techniques and fee assessment can be used.

While market-based pricing is preferable, its widespread application in the short-term is limited by practical considerations. Therefore, reliance on direct disposition and fee assessment will continue over time. The reasons for these

conclusions, and suggestions for a new policy approach incorporating both market and assessment techniques, are presented in the remainder of the chapter.

7.1 Market-Based Pricing

Under market-based pricing site tenure would initially be allocated and periodically reallocated using competitive bidding. This approach was recommended by Pearse (1982) in his report on Pacific fisheries policy and possesses many attractive features.

In theory, bidding for site tenure will meet the rent capture objective and many of the economic efficiency objectives established for pricing policy.¹ When cash-bonus (lump-sum payment) bidding is used, prospective tenure holders will consider their expected revenues and costs over the life of the tenure. Assuming competitive demand conditions prevail, bids will reflect the discounted stream of future site rents expected by each auction participant.² More efficient farm operators, anticipating greater site rent, will outbid less efficient operators while still capturing differential rents attributable to superior management or technical expertise. Therefore, in addition to meeting the rent capture objective, market techniques also select the most efficient site user.³

¹ Some economic efficiency objectives (e.g. optimal aquatic land allocation to salmon farming) will require government decisions independent of the actual bidding procedure.

² As noted below, the presence of significant uncertainty makes estimation of costs and revenues difficult, reducing the ultimate advantages gained from using market-based pricing.

³ If uncertainty exists, winning bidders will not necessarily be the most efficient site users – they may simply be less risk averse than more efficient operators, or better able to diversify risk. However, assuming transactions costs are not prohibitive, the two parties may find it beneficial to form a partnership.

In terms of productive efficiency, cash-bonus bidding receives high marks because it does not distort relative prices faced by the farm operator. The lump-sum payment will be viewed as a sunk cost, thereby not affecting production decisions.

Though the efficiency attributes of cash-bonus bidding are desirable, the unconditional nature of fee payment violates the objective of risk-sharing between government and tenure holders. As a result, a conditional element to tenure payment should be introduced. While various options exist, the most feasible is a modest output royalty.⁴ Output royalties can be levied on either physical production (specific royalty) or on the value of output (ad valorem royalty). The latter will facilitate greater risk-sharing, and is suggested here.⁵ While the use of output royalties normally causes economic inefficiency by distorting farm production decisions,⁶ the effect may be counter-balanced by the incentive for increased production due to greater risk-sharing.⁷

⁴ Mead et al. (1984) and McDonald (1978) review alternative bidding arrangements using the criteria of rent capture, risk-sharing, and other objectives. Both conclude that cash-bonus bidding in conjunction with an output royalty is preferable. Though greater risk-sharing might be achieved through more elaborate bidding schemes - i.e. net profit-share bidding where bids are based on a promised percentage of future profits - they involve increasing administrative expense, becoming very similar to elaborate assessment schemes. Pearse (1982, p.149) recommended cash-bonus bidding be supplemented with an output royalty in the case of mariculture leases.

⁵ In the case of an ad valorem royalty, swings in salmon market prices or farm production will result in fee adjustment. Specific royalties will only provide insurance against variations in production.

⁶ Specific (per-unit output) royalties increase average and marginal production costs, reducing the profit-maximizing level of production. The output-reducing effect of an ad valorem (percentage of total revenue) royalty is caused by a reduction in average and marginal firm revenue.

⁷ See *supra* note 74, Chapter 6.

Under conditions of relative certainty, market-based pricing can significantly reduce the administrative cost of determining tenure value. As discussed below, the information requirements for accurate assessment techniques are great. These requirements are avoided when the market approach is used - cost and revenue calculations are reflected in the value of individual bids. Given the unique characteristics of individual farm sites and the large number of tenures anticipated for the future, this is an important advantage when considering administration costs.

Though market-based pricing is appealing, its widespread use in the short-term in British Columbia is limited by several practical considerations. First, bidding techniques can only be used for uncommitted sites or in cases where existing tenure has expired.⁸ Because of the rapid establishment of salmon farms in British Columbia, farm tenure has already been granted for many farm sites. If tenure holders exercise their right of tenure renewal, pricing for a large number of farm tenures will be based on fee assessment for at least 20 years. Within the foreseeable future, the use of market-based pricing will therefore be restricted to as yet undeveloped sites.

The immediate use of competitive bidding for all uncommitted farm sites would be inappropriate. Given the unsettled nature of production costs and uncertainties surrounding future output prices, bidders will attach a high discount

⁸ A third possibility is the auctioning of farm tenures that revert back to the Crown. Tenure reversion occurs when either (a) the tenure holder ceases farm operations and does not assign site tenure to another party, or (b) site use-rights are revoked because of violation of tenure contract conditions (i.e. failure to pay tenure fees, non-compliance with environmental regulations, etc.). It is unlikely that tenure reversion will be a large source of marketable farm sites. Telephone interviews with regional Lands officers in May, 1988, revealed that only one tenure had reverted back to the Crown in recent years. Located in the Campbell River/Desolation Sound region, the tenure had proven unsuitable for salmon farming owing to strong ocean currents. The absence of tenure reversion is yet another indicator that site tenure currently has market value.

rate to anticipated future site rents. Cash-bonus bidding would also increase start-up capital requirements for new farms at a time when many farm operators rely heavily on personal equity financing. This could eliminate the participation of small operators in the bidding procedure, reducing potential competition.

If market techniques were to be used for all uncommitted sites, a sudden shift from direct disposition to planned disposition would have to occur. This does not appear possible. The resulting requirement that the lands agency take the lead role in identifying site location, size and timing of availability would put a heavy workload on agency staff, especially since little data on potential farm sites currently exists (B.C. Ministry of Forests and Lands 1987(c)). The agency might also be hesitant to initiate site location on a widespread scale in light of the current political controversy surrounding the location of salmon farm sites.

A more realistic policy approach is for the lands agency to begin to identify a specified number of uncommitted farm sites in the various coastal regions. With an inventory of potential sites, periodic regional auctions could be undertaken, generating market-value information that could be used as a bench-mark for appraised values on committed sites. To maintain competitive bidding conditions, regional auctions should be well advertised and staggered in terms of their timing. As is commonly done in other resource industries where use-rights are offered by market-competition, an appraised floor price should be set to protect Crown interests in the event of limited demand.⁹

The term of auctioned farm tenure should be consistent with normal planning periods for depreciation of site improvements. This will provide an

⁹ Schwindt (1987) reports that this is done in the British Columbia forest sector when timber harvesting rights are offered by competitive bidding techniques.

opportunity for investment recovery by tenure holders while at the same time enabling the lands agency to reallocate site tenure in the future by competitive bidding (where feasible). The renewal provisions in existing tenure contracts are not necessary for all farm operations and perpetuate the need for costly fee assessment arrangements. Due to the more limited nature of the physical capital requirements of off-shore sites, farm tenure may be limited to 10 years. In the case of shore-based sites allocated to successful bidders who also acquire an upland lease from the government, longer-term tenure may be necessary to enable investment recovery on long-lived assets (i.e. piers, buildings, etc.). Given the difficulties posed for site reallocation when uplands necessary for a shore-based operation are owned by an existing tenure holder, use of competitive bidding will be precluded, requiring the continued use of assessment techniques over time.

As existing tenures expire over the long-term, site tenure can be reallocated using market techniques. Widespread use of competitive bidding will be feasible because of greater industry knowledge of the relationship between farm production costs and site conditions and the existence of more complete financial capital markets. The term of reallocated tenure should again be tailored to the investment requirements for deep-water versus shore-based operations.

While tenure reallocation by market competition will enable periodic re-evaluation of tenure value and maintain over time the advantages associated with the use of competitive bidding, reallocation raises several questions which need to be addressed.

A primary concern is that investment decisions made by existing tenure holders near the end of tenure term (i.e. repairs to site improvements,

appropriate fish inventory levels, etc.) will be adversely affected by the uncertain outcome of the upcoming auction. The affects will be particularly adverse if investment recovery upon loss of tenure is difficult because of problems associated with the resale of farm assets. Resale problems might arise because (a) markets for used equipment and immature fish are undeveloped,¹⁰ or (b) site improvements are relatively immobile.¹¹

The nature of the salmon farming industry in British Columbia may reduce the difficulties associated with asset resale. The problem of capital immobility does not appear large since the majority of salmon farms are off-shore operations with no significant land-based investments.¹² While further study is required, it appears that net-pens, floating docks and barges, and even fish stocks can be exchanged between farms at non-prohibitive cost.¹³ Given the large number of anticipated salmon farms in British Columbia in the future, the emergence of well-developed markets for second-hand net-pens, docks, fish stocks, etc. is not implausible.

From a policy perspective, uncertainty for investment decision-making caused by tenure reallocation can be reduced by adjusting the timing of the tenure

¹⁰ For example, limited demand for used farm inputs may mean that farm assets have to be sold at heavily discounted prices upon loss of site tenure.

¹¹ Immobility will be a problem if a tenure holder fails in his bid to reacquire site tenure yet finds that the usefulness of certain fixed site improvements (e.g. piers, roads, land-based buildings) will extend beyond his existing tenure term. Costly arbitration may be necessary to determine the appropriate transfer price for assets reverting to the new tenure holder.

¹² In a telephone interview with an official involved in the 1987 B.C. Salmon Farm Survey (Gary Caine, B.C. Ministry of Agriculture and Fisheries) it was learned that approximately 70 percent of all salmon farms in British Columbia are currently off-shore based.

¹³ The potential for such exchange was learned by the author during a tour of salmon farms on the Sunshine Coast in September, 1987, and confirmed in a telephone interview with an industry analyst (Dave Egan, DPA Group Inc.).

reallocation auction. One option would be to conduct the auction several years prior to tenure expiry, enabling the existing tenure holder to adjust his investment plans based on the auction outcome. This would, however, increase the uncertainty experienced by potential future tenure holders when formulating bids.¹⁴ Determination of the appropriate timing of the tenure auction under this option will thus require the balancing of opposing considerations. Alternatively, the timing of the tenure reallocation could be left up to existing tenure holders who would be free to choose any date within their existing tenure term. This approach would grant the greatest degree of flexibility in investment decision-making – by initiating a tenure reallocation auction, existing tenure holders could determine whether the recovery of additional investment expenditure would be made possible by an extension in their tenure term. Disadvantages associated with this approach include a reduction in the competitiveness of the bidding procedure if a large number of existing tenure holders chose to have tenure reallocation auctions at approximately the same time.¹⁵

A second concern associated with tenure reallocation is that the possibility of losing site use-rights to another party will reduce the incentive for existing

¹⁴ For example, future costs and revenues will be less certain due to the extended time frame.

¹⁵ Additional disadvantages will depend on the timing of actual tenure reallocation. Consider, for example, the case where the winner of the tenure reallocation auction receives site use-rights upon the expiry of the existing tenure. If the existing tenure holders chose to have tenure reallocation auctions during the early years of their tenure term, the value of future site use-rights will be subject to a greater level of uncertainty, reducing the effectiveness of the bidding procedure in capturing future site rents. While this problem could be avoided if the winner of the tenure reallocation auction received site use-rights immediately (e.g. one year after the auction), existing tenure holders would then face the possible loss of the remaining years of their existing tenure term when they initiate a tenure reallocation auction. This might reduce their willingness to take advantage of the investment flexibility offered by a tenure-holder-initiated auction scheme.

tenure holders to maintain the environmental integrity of the site.¹⁶ This concern appears to be less serious. The most important pollution problems caused by salmon farms arise from the discharge of various farm effluents (e.g. excess fish feed) and are generally encountered on sites having conditions unfavorable for salmon farming (i.e. poor tidal flushing, shallow depth, etc.) (Gillespie 1986, p.17). Tenure holders are currently required to undertake environmental monitoring programs and to meet government established environmental standards. In addition, they have an incentive to minimize environmental abuses in order to maintain a healthy environment for their fish. As a result, while greater enforcement of environmental standards may be required, significant deterioration in site quality caused by the possibility of tenure reallocation is not likely.

A final important problem for tenure reallocation in the long term will be the virtually simultaneous expiry of the many tenures granted at the outset of industry development. To maintain competitive demand conditions, a means of staggering tenure expiry will have to be devised. One possibility is to use a regional lottery system where tenure extensions from one to five years are granted. Lotteries should be conducted well in advance of the anticipated tenure expiry dates. Tenure holders would continue to pay fees based on assessment methods during the extension period.

¹⁶ The argument is that existing tenure holders will use the site more intensively and give less regard to the long-term effects of their actions. For example, movement of net pens to avoid waste accumulation on the ocean floor might occur less frequently.

7.2 Assessment-Based Pricing

Tenure fee assessment will be the primary basis for pricing policy in the immediate future. Given the inadequacy of existing valuation and pricing methods, new assessment techniques and pricing methods will have to be devised that better meet policy objectives. Improvements will unfortunately necessitate significant administrative expenditure because of the extensive information required for assessing differential site rents.

7.2.1 Assessment of Site Value

Accurate determination of site value by direct assessment will be difficult. The heterogeneous nature of farm sites will require the collection of detailed information on farm costs, revenues and site characteristics. The large number of anticipated farm tenures will add to administrative expenses. Cooperation of farm operators in the data collection process will be essential, but may be hard to achieve. Distinctions between site rents, rents to other superior inputs, normal returns to capital, and fair allowance for risk will be difficult to make in practice.

With many farms in the early development stages in British Columbia and the application of the salmon farming technology to the Pacific salmon species still in its infancy, widespread collection of detailed cost and revenue data would be inappropriate at the present time. Until full-scale production levels have been reached by most farms and farm operators are judged to have sufficient experience with the technology, site assessment techniques will have to rely on information generated from periodic site auctions or a random sampling of the costs and returns of regional farm operations of various scale sizes. Once the

salmon farming industry moves beyond the development stage, more extensive use of financial data will be possible.

A corollary exists between the assessment problems presented by salmon farm sites and those faced in the British Columbia forest industry. In forestry, the granting of long-term timber harvesting rights by government has required the use of appraisal techniques to determine timber tract value. Tracts can differ significantly in terms of their terrain and location to timber processing centers and market shipping points, having important effects on logging operation costs.¹⁷ Variations in timber quality also exist.¹⁸ As a result, a detailed appraisal method has been developed to calculate the value of "stumpage" rights.

The stumpage system is discussed in length elsewhere¹⁹ and will only be summarized here. Under the current system, harvesting costs for particular timber tracts are appraised using costing manuals generated from industry surveys.²⁰ Account is then made for timber transportation costs to the nearest designated processing center. An appraised allowance for risk and profit rounds out the total cost calculation. Timber value is appraised using prevailing prices in regional log markets. The difference between assessed costs and revenues in effect represents the assigned value of timber harvesting rights.

¹⁷ See Cooney (1981).

¹⁸ Salmon farming and forestry differ here. Assuming international market sales of pen-reared salmon require certain quality standards, significant variations in farmed salmon quality should not exist and therefore will not pose a problem for site valuation.

¹⁹ See Schwindt (1987).

²⁰ Based on the sample data, the cost structure for an "average efficient operator" is determined for the various regions of the province.

While the stumpage system suffers from a number of problems,²¹ it could serve as a basic model for assessing tenure value in salmon farming. Regional cost surveys for deep-water and shore-based farms of varying scale sizes could be used to determine average production cost categories. Output transportation costs could be accounted for by appraisal methods based on the identification of regional processing centers or market shipping points. An appraised allowance for profit and risk could be tied to site capital investment assessments. Projected tenure value - i.e. anticipated site rent - would represent the difference between the sum of the above costs and estimated annual production revenue. The latter figure could be determined using management plan output forecasts and average output prices in major export markets.

The ability of this method to assess differential site rents accurately will clearly hinge on the appropriateness of revenue and cost appraisals. Accurate cost measurement will be particularly difficult. Annual collection of detailed cost information from a large number of farm operators will not be administratively feasible, requiring the use of costing manuals similar to those employed in forestry. The averaging techniques necessary for the construction of such manuals will blur the relationship between site conditions and farm production costs, reducing the accuracy of differential site rent measurement.

The accuracy of farm site assessment techniques may be increased by using cost information generated from econometric studies. In particular, the relationship between site characteristics and farm production costs could be modelled using econometric techniques and a site quality index. Because a more detailed profile of the cost structure associated with particular site conditions will be useful, a

²¹ For example, Schwindt (p.197) notes that, because of the particular formula used in calculating stumpage payments, the allowance for profit and risk is not tied to capital, but sales.

brief sketch of a proposed methodology will be provided here along with a discussion of its strengths and weaknesses.

7.2.2 Evaluating Site Production Costs: A Proposed Method

The first requirement to determine the influence of site conditions on farm production costs will be to devise a site quality index that can be used to classify farm sites. While its particular composition will require further study, the site index can be viewed as a weighted average of the critical factors that influence site productivity (i.e. water temperature, dissolved oxygen, salinity, etc.), with larger weights given to factors that are acknowledged to be more important.²² Once the index has been constructed, site biophysical information recorded in farm management plans can be used to rank sites according to their biophysical suitability. Sites with similar rankings will then be grouped and used for the cost estimation procedure.

To assess the effect of site conditions on farm production costs, the underlying role played by the site in the production process must be determined. Unfortunately, direct estimation of production functions involves econometric difficulties.²³ However, these difficulties can be avoided by employing the mathematical concept of duality.²⁴ Duality states that, under certain regularity

²² The concept of a site index is not new. For example, site indexes have been used to determine the influence of timber tract conditions on logging costs (see Cooney 1981 and Heaps 1985). Work has already begun to determine the important factors that influence the biophysical productivity of British Columbia farm sites. Cain et al. (1987), in an indepth study on British Columbia siting criteria, identify critical biophysical factors and rank them according to their importance.

²³ Generally speaking, good parameter estimates cannot be obtained because the independent variables (i.e. capital, labour, etc.) are invariably correlated with the error term.

²⁴ For a discussion of duality and its application in econometric work, see Varian (1984).

conditions, the underlying structure of production can be represented by a cost function relating total production cost (C) to the level of output (y) and input prices (r_i), i.e.:

$$C = C(y, \sum_{i=1}^N r_i)^{25}$$

the translog cost function is a particular functional form that meets the criteria for duality, and was used by Salvanes (1987) to estimate the total cost function for Norwegian farmed salmon production.

While Salvanes could not include site conditions in his analysis because of information unavailability, his approach can be duplicated in the British Columbia context. After grouping farms according to site conditions, cross-sectional data on farm production costs (used to determine input prices) and annual production levels will have to be collected. Total cost functions can then be estimated by group.

The resulting cost function estimates will be useful for several reasons. First, they will provide an empirical test for the importance site conditions play in farm production costs. Second, the estimated cost functions could be used for site valuation. For example, annual site value (V) at full production could be assess using the formula:

$$V = y_0[(p-aD) - AC^*(\alpha_i, y_1, \sum_{i=1}^N r_i)]$$

where y_0 = annual marketed production of farmed salmon in tonnes

p = value per kilogram of farmed salmon in a designated export market

²⁵ Estimation problems are avoided because exogenously determined input prices will be independent of the error term.

a = assessed unit transportation cost per kilometer for farmed salmon

D = appraised distance in kilometers to a designated processing center or market shipping point

AC^* = assessed per kilogram production cost of farmed salmon, based on the cost function associated with site conditions (α_i) and given total annual production in tonnes (y_i) and actual or assessed input prices (r_i).

An advantage to using estimated cost functions over more traditional costing formulas is that the latter become quickly dated and do not account for the fact that firms change input mixes in response to input price changes (Schwindt 1987, p.206). As long as technology has not changed and input price variations are not large, the "dual" nature of the estimated cost functions will capture the cost effects associated with input substitution.

A number of drawbacks should be noted for the use of estimated cost functions. First, group estimation will require a large sample of farms with similar site conditions (e.g. 35 farms per group) in order to generate statistically significant results. If large sample groups cannot be identified, site condition criteria will have to be relaxed to increase sample size, reducing the accuracy of the cost estimation procedure. Second, a detailed survey of individual farm's production costs will be expensive.²⁶ Third, determination of farm input prices will be difficult for factors such as capital. In particular, an appraised allowance for profit and risk will be necessary. As a result, the distinction between differential site rent and rents to other factors will be somewhat arbitrary.²⁷

²⁶ However, an advantage is that the usefulness of the estimated functions will endure for a longer period than costing manuals.

²⁷ Additional problems exist for the determination of capital costs. In econometric work, reported depreciation rates are often used to determine the unit price of capital. Because depreciation rates are primarily set for tax purposes, they may not reflect actual capital utilization. For an approach to calculating the price of capital in salmon farming, see Salvanes (1987, p.26).

Many of these drawbacks are shared with other costing methods. The additional advantages offered by using estimated cost functions warrants consideration of their use as part of an overall assessment strategy.

The above approaches to site value assessment will require significant administrative expenditure. Their use will only be justified if site rents in British Columbia prove to be large. If this is not the case, cruder estimates based on auction prices or occasional cost and revenue surveys will be more appropriate.

7.2.3 Pricing Methods

Choice of a particular pricing method under tenure fee assessment will again hinge on the magnitude of emerging site rents. As argued in Chapter 6, fees based on site area are an inappropriate device for rent capture, justified only when expected site rents are minimal.²⁸ An alternative would be to base tenure pricing on an output royalty. A precedent for their use has already been established in salmon farming.²⁹

Output royalties are attractive given their relative ease of administration, when compared to more elaborate pricing methods – e.g. profit taxes (Gunton and Richards 1987). Fee evasion should not be a major problem since most production is exported and market channels are well-defined. Both royalty types enable risk-sharing between the government and tenure holders,³⁰ and will result in automatic tenure fee adjustment as farm operations move from the start-up

²⁸ A similar argument can be made for fees based on pen volume. A discussion of the form of water volume pricing that exists in Chile is presented in Appendix 2.

²⁹ As discussed in Appendix 2, a specific royalty is currently being used in Scotland.

³⁰ See *supra* note 5.

stage to full production capacity.

While royalties may be justified if site rents are modest, their use as a rent capture tool under conditions where large differential site rents exist involves important drawbacks. To capture site rents successfully, royalty rates would have to be differentiated by site or by region. The resulting need for calculation of a complex rate structure would add significantly to policy administration costs. By distorting production decisions, output royalties will reduce the size of potential economic rents from salmon farming.³¹

A more advanced means of pricing salmon farm tenure is represented by a profit-tax (rate-of-return royalty) system. When profit is properly defined - i.e. as income above all costs including a normal, risk-adjusted return to capital - profit-tax arrangements have substantial theoretical support as rent capture tools.³² Sophisticated profit-tax schemes are commonly used in other resource industries.³³ However, due to the large number of tenures involved in the British Columbia salmon farming industry and the smaller aggregate revenues anticipated, a more simplified approach to profit-taxation will be necessary.

In line with the assessment techniques presented in Section 6.2.1, annual tenure payments could be based on a profit tax levied against the difference between appraised costs and reported sales revenue. Cost appraisal would eliminate the need for annual collection of detailed farm cost data as well as

³¹ See *supra* note 6.

³² When profit is properly measured, a fixed rate (flat) profit tax will not distort production decisions. A flat tax of less than 100 percent will not, however, capture all economic rent - intra-marginal and marginal rents will be taxed at the same rate, leaving some rent to producers. For a discussion of profit taxation and a brief survey of the literature, see Gunton and Richards (1987, p.36-38).

³³ An example is the Saskatchewan mining industry - see Anderson (1987).

the inefficiency incentive that arises when reported costs are used.³⁴ As in the case of output royalties, the monitoring of farm revenues would be simplified by the well-defined nature of export market channels.

The success of profit taxation as a rent capture device will depend on the accuracy of cost estimates and assumptions made about the appropriate allowance for risk and a fair return on capital. A reduction in the tax rate would to some extent correct for the unintentional taxation of non-site rents (at the cost of lower rent income to the Crown).

Productive efficiency will be achieved under this policy.³⁵ Of all the assessment-based pricing methods, profit taxation will best meet the objective of fee comparability. Risk-sharing will also be possible given the nature of tenure payment. In addition, tenure payments will only increase after farms have passed the start-up stage.

The main drawback for a profit-tax system will be administration costs. However, based on the criterion of administrative efficiency, such costs will be justified in the presence of significant differential site rents. If appraised profit taxation is viable, additional funding for administration will be generated within the program.

³⁴ If farms are taxed on income above reported costs, the incentive to keep costs down is reduced.

³⁵ Some inefficiency will arise if the definition of profit incorrectly includes opportunity cost returns to some inputs (e.g. opportunity cost returns to invested financial capital) – for a diagrammatic explanation, see Gunton and Richards (1987, p.47). However, the efficiency effects of this may be small (ibid., p.36).

7.2.4 Tenure Disposition, Transferability, and Term

Since direct disposition will be the dominant form of tenure allocation in the near future, the objective of efficient site user selection will not generally be met. The efficiency effects of this will ultimately be unimportant, given the possibility of tenure transfer. However, the current combination of low fees, long-term tenure, tenure transferability and expected future site rents may have undesirable income-distribution consequences and create difficulties for future pricing policy due to the "transitional gains trap" problem.³⁶ Answers to the transitional gains problem must be sought.

Copes (1988) has argued that, in the case of commercial marine fisheries where limited entry licenses have been issued, fishing rights should be made non-transferable to avoid the transitional gains problem. Non-transferability means license holders can only capture the gain from resource access by using their acquired right directly to fish - only "serious" operators benefit from the use of a public resource. When non-transferability is combined with a limited license term, the government is able to reallocate fishing rights to future generations, who can also capture resource benefits.

Though the objectives of fisheries rationalization differ from pricing policy objectives in salmon aquaculture - fisheries rationalization is often undertaken to improve fishermen's incomes while an important objective of aquaculture pricing policy is market value pricing³⁷ - the apparent benefits from prohibiting the transfer of salmon farm tenure at the present time are similar. If

³⁶ To review the problems associated with the transitional gains trap, see Section 6.3.

³⁷ As noted in Section 6.4, tenure allocation may at times be used to achieve public policy objectives other than a fair return to the Crown (i.e. providing economic opportunities for coastal Indian bands).

non-transferability could be successfully enforced, the problem of rent-seeking by "non-serious" industry participants would be curtailed. Additionally, the lands agency would have the ability to increase fees in the future when differential site rents become known without placing a financial burden on salmon farmers who "bought into" the industry. Not surprisingly, some jurisdictions have tenure non-transferability in place as part of their pricing policy.³⁸

The apparent advantages of prohibiting tenure transfer are, however, mitigated by practical considerations. Transferability has already been guaranteed in existing tenure contracts. From a political perspective, tenure-holder opposition would make it difficult to revoke transferability. In addition, non-transferability would be difficult to enforce. As noted earlier, tenure transfer is currently occurring without government detection through changes in company shareholdings. Attempts to block this means of transfer might lead to other, more costly forms, ultimately dissipating site rent. Finally, non-transferability could create hardship in some cases.³⁹

As a result, other means of dealing with the transitional gains problem need to be pursued. The most direct is for the lands agency to actively seek information on current tenure value. If fees are adjusted to reflect true tenure value, site rents will accrue to the Crown and not transitional tenure holders. Information can be gained by requiring that tenure transfer prices be reported when an official transfer is made through the lands agency. A more promising possibility is the generation of market-value information through the initiation of

³⁸ Examples include Nova Scotia and Scotland - See Appendix 2.

³⁹ In cases where uplands on a shore-based farm are owned by a farm operator and contain farm-related improvements (i.e. piers, processing facilities, etc.), recovery of upland investment would be difficult if site rights were non-transferable and the operator wished to leave the industry.

regional site auctions. The magnitude of the transitional gains problem can be reduced by making tenure term more consistent with normal site investment planning periods. Finally, the policy objective of market value pricing should be made clear to the salmon farming industry in order to dampen tenure-holder expectations of site rent capture.

7.3 Summary

Market-based pricing has been argued to be a superior method of allocating and pricing salmon farm tenure. Cash-bonus bidding accompanied by a modest ad valorem royalty best meets the twin objectives of rent capture and risk-sharing. Where possible, site reallocation can be facilitated by making site tenure consistent with single-term investment planning. To maintain competitive bidding conditions, auctions should be well publicized and staggered in terms of their timing. Available assessment techniques can be used to establish a minimum offer price to protect Crown interests in the event of limited site demand.

Since practical considerations limit the widespread use of market-based pricing in the short term, and because many farm tenures have already been allocated by direct disposition, assessment-based pricing will be extensively used in the years ahead. The appropriateness of particular farm site valuation and tenure pricing methods will be determined by the magnitude of differential site rents. If rents prove to be small, hectare-based pricing and/or a modest output royalty will best meet the objective of administrative efficiency. In order to avoid unintended distortions in farm decision-making, hectare fees should not be raised above defined opportunity cost levels for aquatic lands.

Assuming differential site rents prove to be significant, as measured by site auction values and random cost/revenue surveys over the short to intermediate term, a modified profit-tax system similar to the one proposed here should be considered. Since a number of farm tenures will not be amenable to market techniques, the usefulness of a profit-tax system will remain once many tenures revert to market-based pricing.

CONCLUSION

Public policy in regard to natural resource use must be forward looking and not reactionary. Lack of coherent planning in regard to resource allocation and pricing has created long-term problems with no easy solutions in important British Columbia industries like the commercial salmon harvesting sector.

In his report on Pacific fisheries policy in 1982, Commissioner Peter Pearse noted that many current policy problems in commercial fisheries have arisen because of "rapid change which has overtaken the government's rate of response" (Pearse 1982, p.3). The extremely rapid emergence of the salmon aquaculture industry in British Columbia has certainly tested the government's response rate.

While coastal land allocation and environmental issues currently dominate policy discussions about the salmon farming industry, important questions must be addressed in regard to pricing policy. Aquatic lands may prove to be an extremely valuable input in the production of pen-reared salmon. Given the commercial nature of resource use, pricing should be geared to capture resource rents when they emerge.

However, salmon farmers should not be burdened with distortionary pricing policy. Methods to capture differential rents must be carefully designed to meet both rent capture and efficiency objectives. It is hoped that the analysis and alternatives presented here will contribute to the formulation of appropriate public policy.

APPENDIX 1

This appendix outlines the comparative static procedures used to derive the results found in Chapter 6, Section 6.4.4.

Profit Maximization

Annual farm profits were defined as:

$$(1) \quad TP = (p-aD)f(\alpha, X_1, X_2) - r_1X_1 - (bD + r_2)X_2$$

where $f(\alpha, X_1, X_2)$ = annual production of marketed pen-reared salmon (y),
in tonnes

X_1 = water, measured in cubic meters employed in net pens

X_2 = composite input

α = composite site index

p = unit price of farmed salmon (exogenously determined in export markets)

a = transportation rate per unit distance for y

b = transportation rate per unit distance for X_2

D = distance to input/output markets

r_1 = unit price of water (exogenously determined by government)

r_2 = composite unit price of other inputs (exogenously determined in competitive input markets)

The first-order conditions for profit maximization are:

$$(2) \quad \frac{\partial TP}{\partial X_1} = (p-aD)f_1 - r_1 = 0$$

$$\frac{\partial TP}{\partial X_2} = (p-aD)f_2 - (bD + r_2) = 0$$

The second-order conditions for a maximum are:

$$f_{11} < 0, f_{22} < 0, f_{11}f_{22} > f_{12}^2$$

Under the conditions where the second-order conditions for a maximum are met, the implicit function theorem says that the first-order conditions (2) can be solved to obtain:

$$(3) \quad X_1 = X_1^*(r_1, r_2, \alpha, a, b, D, p)$$

$$X_2 = X_2^*(r_1, r_2, \alpha, a, b, D, p)$$

where (3) gives the profit-maximizing factor demands. Substituting (3) into (1) yields the indirect profit function:

$$(4) \quad TP^*(r_1, r_2, \alpha, a, b, D, p) = (p-aD)f(\alpha, X_1^*, X_2^*) - r_1 X_1^* - (bD + r_2)X_2^*$$

From the envelope theorem:

$$\frac{\partial TP^*}{\partial \alpha} = (p-aD)f_\alpha(\alpha, X_1^*, X_2^*) > 0$$

$$\frac{\partial TP^*}{\partial D} = -af(\alpha, X_1^*, X_2^*) - bX_2^* < 0$$

$$\frac{\partial TP^*}{\partial r_1} = -X_1^* < 0$$

i.e. maximum total profits increase as site quality increases, and decrease when either site proximity to input/output markets grows or the price of water is increased.

Moving on to the comparative static properties of the model, substituting (3) into (2) yields the identities:

$$(5) \quad (p-aD)f_1(\alpha, X_1^*, X_2^*) - r_1 = 0$$

$$(p-aD)f_2(\alpha, X_1^*, X_2^*) - (bD + r_2) = 0$$

Focusing on the profit-maximizing reaction of farm operators to differences in site quality, α , we differentiate (5) with respect to α , yielding:

$$(6) \quad (p-aD)f_{1\alpha} + (p-aD)f_{11}\frac{\partial X_1^*}{\partial \alpha} + (p-aD)f_{12}\frac{\partial X_2^*}{\partial \alpha} = 0$$

$$(p-aD)f_{2\alpha} + (p-aD)f_{21}\frac{\partial X_1^*}{\partial \alpha} + (p-aD)f_{22}\frac{\partial X_2^*}{\partial \alpha} = 0$$

Putting (6) into a matrix format, Cramer's Rule can be used to determine the comparative static effect of site quality on the profit-maximizing amount of water (X_1^*) and other inputs (X_2^*) employed. The results are as follows:

$$(7) \quad \frac{\partial X_1^*}{\partial \alpha} = \frac{-(p-aD)^2 f_{1\alpha} f_{22} + (p-aD)^2 f_{2\alpha} f_{12}}{|H|} > 0 \quad (\text{provided } f_{1\alpha}, f_{2\alpha}, f_{12} > 0)$$

$$\frac{\partial X_2^*}{\partial \alpha} = \frac{-(p-aD)^2 f_{11} f_{2\alpha} + (p-aD)^2 f_{21} f_{1\alpha}}{|H|} > 0 \quad (f_{1\alpha}, f_{2\alpha}, f_{21} > 0)$$

where $|H|$ is Hessian determinant (positive, under the circumstances where the second-order conditions for profit-maximization are met).

Thus, the greater is site quality, the greater will be the profit-maximizing amount of water and other inputs employed.

The profit-maximizing reaction of the farm operator to differences in site location can also be presented using the comparative static procedure. We differentiate (5) with respect to D and put the resulting equations into the appropriate matrix format. It can be shown that the comparative static results (again using Cramer's Rule) are:

$$(8) \quad \frac{\partial X_1^*}{\partial D} = \frac{a(p-aD)f_{11}f_{22} - (af_2 + b)(p-aD)f_{12}}{|H|} < 0$$

$$\frac{\partial X_2^*}{\partial D} = \frac{(p-aD)(af_2 + b)f_{11} - a(p-aD)f_{11}f_{21}}{|H|} < 0$$

The greater the distance salmon farm operations from input/output markets, the less will be the profit-maximizing amount of water and other inputs employed.

These results allow us to make predictions about the the comparative static effect site quality and location will have on the profit-maximizing level of farm production. The profit-maximizing supply function for the firm is:

$$(9) \quad y^* = f(\alpha, X_1^*(r_1, r_2, \alpha, a, b, D, p), X_2^*(r_1, r_2, \alpha, a, b, D, p))$$

$$= y^*(r_1, r_2, \alpha, a, b, D, p)$$

To show the comparative static effect of site quality on output, we differentiate (9) with respect to α , yielding:

$$\frac{\partial y^*}{\partial \alpha} = f_\alpha + f_1 \frac{\partial X_1^*}{\partial \alpha} + f_2 \frac{\partial X_2^*}{\partial \alpha}$$

Since f_α , $\frac{\partial X_1^*}{\partial \alpha}$ and $\frac{\partial X_2^*}{\partial \alpha}$ are all positive,

$$(10) \quad \frac{\partial y^*}{\partial \alpha} > 0$$

Using an analogous procedure, it can be shown that $\frac{\partial y^*}{\partial D} < 0$.

Cost Minimization

The cost minimization problem is to minimize:

$$C = r_1 X_1 + (bD + r_2) X_2$$

subject to: $f(\alpha, X_1, X_2) = y_0$

where C = total production cost

y_0 = output constraint

To start, we form the Lagrangian:

$$(1) \quad L = r_1 X_1 + (bD + r_2) X_2 + \lambda (y_0 - f(\alpha, X_1, X_2))$$

The first-order conditions for cost minimization are:

$$(2) \quad (a) \quad \frac{\partial L}{\partial X_1} = r_1 - \lambda f_1 = 0$$

$$(b) \quad \frac{\partial L}{\partial X_2} = (bD + r_2) - \lambda f_2 = 0$$

$$(c) \quad \frac{\partial L}{\partial \lambda} = y_0 - f(\alpha, X_1, X_2) = 0$$

The sufficient second-order conditions for cost minimization are:

$$f_1 > 0 \quad f_2 > 0 \quad \lambda > 0; \quad f_{11} < 0 \quad f_{22} < 0 \quad f_{12} = f_{21} > 0; \quad f_{12}^2 > f_{11}f_{22}$$

Equating (2a) and (2b) yields the cost minimizing rule:

$$(3) \quad \frac{r_1}{(bD + r_2)} = \frac{f_1}{f_2}$$

i.e. as b , D , r_1 , or r_2 change, *ceteris paribus*, we expect input substitution so as to minimize the production cost of y_0 .

Note the effect site quality (α) will have on the position and shape of a given isoquant for output y_0 . If α increases, the isoquant shifts to the left - i.e. to maintain y_0 , less X_1 is necessary for any given X_2 . This can be seen by first taking the total derivative of y :

$$dy = f_\alpha d\alpha + f_1 dX_1 + f_2 dX_2$$

Setting dy and dX_2 equal to zero yields:

$$0 = f_\alpha d\alpha + f_1 dX_1$$

If $d\alpha$ is positive (i.e. site quality improves) a compensating reduction in X_1 must occur to keep output constant at y_0 .

Site conditions will also affect isoquant slope. This can be seen by differentiating the slope of the isoquant with respect to α , i.e.:

$$\frac{\partial}{\partial \alpha} \frac{f_1(\alpha, X_1, X_2)}{f_2(\alpha, X_1, X_2)} = \frac{f_{1\alpha}f_2 - f_1f_{2\alpha}}{(f_2)^2}$$

To the extent that better site conditions raise the marginal product of water

relative to the marginal product of other inputs (i.e. $f_{1\alpha} > f_{2\alpha}$) the isoquant will become steeper at every X_1/X_2 ratio - *ceteris paribus*, production will become more water intensive (the optimal X_1/X_2 ratio increases for given factor prices). To the extent that better conditions raise the relative marginal product of other inputs (i.e. $f_{2\alpha} > f_{1\alpha}$) the isoquant will become flatter at every X_1/X_2 ratio - *ceteris paribus*, production will become less water intensive.

The influence of site conditions on the marginal productivity of water *vis-a-vis* other inputs cannot be determined *a priori*. Empirical estimation of the production function for farmed salmon in British Columbia is required. It is clear, however, that site conditions may influence relative factor intensity.

Under the conditions where the second-order conditions are met, the implicit function theorem says that the first-order conditions (2) can be solved to yield:

$$(3) \quad (a) \quad X_1 = X_1^*(r_1, r_2, \alpha, b, D, y_0)$$

$$(b) \quad X_2 = X_2^*(r_1, r_2, \alpha, b, D, y_0)$$

$$(c) \quad \lambda = \lambda^*(r_1, r_2, \alpha, b, D, y_0)$$

Equations 3(a) and 3(b) are conditional factor demand functions (i.e. factor demand when output and other parameters are held constant) while 3(c) is marginal cost at y_0 .

To derive the comparative static properties of the model, we substitute (3) into the (2), yielding the following identities:

$$(4) \quad r_1 - \lambda^*(r_1, r_2, \alpha, b, D, y_0) f_1(\alpha, X_1^*(r_1, r_2, \alpha, b, D, y_0), X_2^*(r_1, r_2, \alpha, b, D, y_0)) = 0$$

$$(bD + r_2) - \lambda^*(r_1, r_2, \alpha, b, D, y_0) f_2(\alpha, X_1^*(r_1, r_2, \alpha, b, D, y_0), X_2^*(r_1, r_2, \alpha, b, D, y_0)) = 0$$

$$y_0 - f(\alpha, X_1^*(r_1, r_2, \alpha, b, D, y_0), X_2^*(r_1, r_2, \alpha, b, D, y_0)) = 0$$

To determine the comparative static effect of site quality (α), we differentiate (4) with respect to α , yielding:

$$(5) \quad -\lambda^* f_{1\alpha} - f_1 \frac{\partial \lambda^*}{\partial \alpha} - \lambda^* f_{11} \frac{\partial X_1^*}{\partial \alpha} - \lambda^* f_{12} \frac{\partial X_2^*}{\partial \alpha} = 0$$

$$-\lambda^* f_{2\alpha} - f_2 \frac{\partial \lambda^*}{\partial \alpha} - \lambda^* f_{21} \frac{\partial X_1^*}{\partial \alpha} - \lambda^* f_{22} \frac{\partial X_2^*}{\partial \alpha} = 0$$

$$-f_{\alpha} - f_1 \frac{\partial X_1^*}{\partial \alpha} - f_2 \frac{\partial X_2^*}{\partial \alpha} = 0$$

Putting (5) into a matrix format, Cramer's Rule can be used in an attempt to determine the comparative static effect of site quality on (a) the amount of water and other inputs employed to produce the unit level of output (Y_0), and (b) marginal production cost. The results are as follows:

$$(6) \quad \frac{\partial X_1^*}{\partial \alpha} = \frac{-\lambda^* f_1 (f_{2\alpha} f_2 + f_{\alpha} f_{22}) + \lambda^* f_2 (-f_{1\alpha} f_2 + f_{\alpha} f_{12})}{|H|} \geq 0$$

$$\frac{\partial X_2^*}{\partial \alpha} = \frac{-\lambda^* f_1 (-f_{21} f_{\alpha} + f_{11} f_{2\alpha}) + \lambda^* f_2 (-f_{11} f_{\alpha} + f_{11} f_{1\alpha})}{|H|} \geq 0$$

$$\frac{\partial \lambda^*}{\partial \alpha} = \frac{\lambda^{*2} f_{1\alpha} (f_{21} f_2 - f_1 f_{22}) - \lambda^{*2} f_{2\alpha} (f_{11} f_2 - f_1 f_{12}) + \lambda^{*2} f_{\alpha} (f_{11} f_{22} - f_{12}^2)}{|H|} \geq 0$$

where $|H|$ is the Hessian determinant (negative under the circumstances where the second-order conditions for constrained cost minimization are met).

The results are indeterminate because the quantitative influence site conditions have on input productivity cannot be determined *a priori*. In regard to X_1 and X_2 usage, the effect of site conditions will depend on the magnitude of the shift in the production isoquants and the change in isoquant slope. A similar rationale applies for the indeterminate effect of site conditions on marginal production cost. Again, verification of the actual effects will require an empirical study of the production function for pen-reared salmon in British Columbia.

The cost minimizing reaction of farm operators to differences in site proximity to input/output markets, along with the effect on marginal production cost, can also be presented using the comparative static procedure. We differentiate (5) with respect to D and put the resulting equations into the appropriate matrix format. It can be shown that the comparative static results (again using Cramer's Rule) are:

$$(7) \quad \frac{\partial X_1^*}{\partial D} = \frac{-b f_1 f_2}{|H|} < 0$$

$$\frac{\partial X_2^*}{\partial D} = \frac{b f_1^2}{|H|} < 0$$

$$\frac{\partial \lambda^*}{\partial D} = \frac{\lambda^* (f_2 f_{11} - f_1 f_{12})}{|H|} > 0$$

The greater the distance salmon farm operations from input/output markets, the greater will be the relative amount of other inputs employed in comparison with water, and the greater will be the marginal costs of production.

The envelope theorem can be used to show the effect site quality and location have on total and average production costs for the given level of output y_0 . Substituting (3) into the original cost equation yields the indirect cost function:

$$\begin{aligned} C^* &= r_1 X_1^* + (bD + r_2) X_2^* \\ &= C^*(r_1, r_2, \alpha, b, D) \end{aligned}$$

By the envelope theorem we know that:

$$(8) \quad \frac{\partial C^*}{\partial \alpha} = \frac{\partial L}{\partial \alpha} = -\lambda_{f\alpha}^* < 0$$

$$\frac{\partial C^*}{\partial D} = \frac{\partial L}{\partial D} = bX_2^* > 0$$

These results show that an increase in water quality will reduce the total cost of producing any particular level of output. Greater distance from input/output markets will increase total farm production costs. Since minimum average total cost is simply minimum total cost divided by the given level of output, its behavior in the face of changing water quality and site location is identical to that of minimum total cost.

APPENDIX 2

The following is a brief summary of the current pricing policies for salmon farm tenure used in jurisdictions outside of British Columbia.

Atlantic Canada

The Atlantic provinces of Newfoundland, New Brunswick and Nova Scotia were surveyed in January, 1988.¹ In each province, salmon farm sites are allocated by direct application, with tenure approval determined using an inter-agency referral process. The standard form of tenure is a ten year lease or license of occupation. Granted tenure is transferable upon government approval in Newfoundland and New Brunswick, but is non-transferable in Nova Scotia. Tenure fees in all provinces are determined on a per unit hectare basis. The highest per unit fee is found in New Brunswick (\$100) followed by Newfoundland (\$12) and Nova Scotia (\$2).² Hectare fees are not differentiated by region.

Washington State³

Salmon farm sites in Washington State are allocated on a direct application basis. Tenure approval is determined by an inter-agency referral process. Granted

¹ The following officials were contacted: Newfoundland - Robert Warren, Department of Forest Resource and Lands; New Brunswick - John Paul Robecheaux, Ministry of Natural Resources; Nova Scotia - Brian Mews, Department of Lands and Forests.

² Nova Scotia also levies a \$100 annual salmon farm license fee.

³ Information on pricing policy in Washington was obtained in a telephone interview with Bob Hoyser, Washington State Department of Natural Resources, in March, 1988.

tenure is transferable. Site fees are levied on a per acre basis, with \$250 (U.S.) per acre (\$618 (U.S.) per hectare) charged for the first three years of farm operation. In subsequent years, a rental formula based on upland value is used to assess site fees.⁴ Because the salmon aquaculture industry has developed only recently in Washington, most farm operators are paying the \$250 per acre start-up fee. However, a small number of farms are now being assessed using the rental formula, with site fees averaging \$680 (U.S.) per acre (\$1680 (U.S.) per hectare).

Chile⁵

Site tenure fees in Chile are levied on both aquatic lands and the water column associated with site. In regard to submerged lands, tenure holders are curiously required to only rent the area occupied by anchors and other attachments that secure the the floating structures of the farm. While annual rental fees for aquatic land use are assessed at 16 percent of estimated foreshore value, the relatively small area employed by submerged attachments makes resulting fees insignificant. The rental for water column use is based on a historical charge levied for all private uses. Regardless of the volume of water used for site net-pens, tenure holders pay a flat annual fee of 100 gold pesos (\$450 (U.S.)).

⁴ The formula is as follows. Upland value is first assessed on a per square foot basis. Next, 30 percent of this value is used as a base, with 5 percent of the base equalling the charge per foot for leased aquatic lands. For example, if assessed upland value is \$1 per square foot, the associated fee per foot of leased aquatic land is $\$1 \times .30 \times .05 = \$.015$.

⁵ Information on pricing policy in Chile was obtained from Dr. Richard Schwindt, Department of Economics, Simon Fraser University in April, 1988.

Scotland⁶

Aquatic lands for salmon farming in Scotland are granted by government using a direct application-referral method. Granted tenure is non-transferable. Prior to 1987, an annual rental fee of £20 (\$45 (CDN)) per fish farm was charged to encourage development. However, based on a view that the Scottish industry had become sufficiently profitable to warrant higher fees, the government entered into negotiations with representatives of fish farmers to establish a new fee system effective January, 1987. The outcome was a specific royalty of £50 (\$110) per ton of salmon produced, the fee subject to annual adjustment based on the price of salmon in Scottish wholesale markets.⁷ Payments are expected to represent 1 1/4 per cent of total farm revenues, with a 100 ton farm paying approximately \$11,000 (CDN) per year.

Norway⁸

A government license is required to establish and operate a salmon farm in Norway. Licenses are periodically allocated by the national government, the last allocation occurring in 1985 when 150 licenses were awarded. The total number of outstanding licenses has been controlled by the government in an attempt to adapt industry production to market demand and industry input demand to available supply capacity (in particular, for veterinary and extension services -

⁶ Information obtained from *Fish Farmer*, November/December 1986, p.10-11 (Scottish salmon aquaculture industry trade publication).

⁷ A three year phase-in to full rates was granted for newly established farms, and farms producing less than 50 tons were to be charged a reduced rate of £45 per tonne produced.

⁸ Information on salmon farm policy in Norway was obtained from Bjorndal (1988), Bjorndal and Salvanes (1987) and from a discussion with Dr. Trond Bjorndal in June, 1988.

i.e. education and research). The national allocation is split amongst the various coastal regions of Norway, the intent being to maintain a pattern of scattered development along the Norwegian coast.

Once the regional allocation is announced, interested parties can apply for an available license. As part of the application procedure, a potential farm site must be identified by the applicant and ultimately be approved by local government authorities. License applications are ranked by the local authorities, and passed on to the national fisheries agency which makes the final decision on who will receive a license.⁹

A prerequisite for site tenure is thus the acquisition of a salmon farm license. Licenses (and hence farm sites) are transferable upon government approval. However, transferability is limited by the fact that licensing regulations restrict farm ownership. One firm (person) can only hold a majority interest (51 percent or more) in one fish farm.¹⁰ Licenses have an indefinite term. No fees are currently charged for salmon farm licenses or for site tenure.¹¹ Tenure size is indirectly restricted by the licensing regulation that salmon farm pen volume, not exceed 8000 m³.¹²

⁹ The criteria used for ranking applications is largely left up to the local authorities. One apparent criterion has been that applicants have previous involvement in a local fishing industry. The national authorities appear to rely heavily on the local ranking when deciding who will receive a license.

¹⁰ The rationale for this policy is to maintain an owner-operator structure in the industry.

¹¹ Plans are underway to introduce a license application fee for future license allocations.

¹² The purpose of this regulation is again to maintain control over total industry production and input demand. As shown by Salvanes (1987), the 8000 m³ capacity restriction may prevent the exploitation of scale economies.

REFERENCES

- Allen, P.G., Botsford, L.W., Schuur, A.M. and Johnston, W.E. (1984) *Bioeconomics of Aquaculture*, Amsterdam: Elsevier.
- Anderson, D. (1987) "Innovation in Public Rent Capture," in Gunton, T. and Richards, J. (1987) *Resource Rents and Public Policy*, Halifax: The Institute for Research on Public Policy, pp.147-80.
- Arrow, K. and Fisher, A. (1974) "Environmental Preservation, Uncertainty, and Irreversibility," *Quarterly Journal of Economics*, May, pp.312-19.
- _____, and Lind, R. (1970) "Uncertainty and the Evaluation of Public Investment Decisions," *American Economic Review*, June, pp.364-78.
- B.C. Ministry of Agriculture and Fisheries (1988) "1987 Salmon Farm Survey," Draft Report, Victoria.
- _____ (1987) "British Columbia Aquaculture Industry Update," Aquaculture Information Bulletin No. 3-1.
- B.C. Ministry of Forests and Lands (1987(a)) "Crown Land for Public Acquisition," 1/5 (87.05.29), Victoria.
- _____ (1987(b)) "Crown Land for Finfish Aquaculture," 1/5 (87.06.12), Victoria.
- _____ (1987(c)) "Proposed Pricing Policy for Aquaculture Tenures," memorandum, Victoria.
- _____ (1987(d)) "Methodology - Pricing for Finfish Aquaculture Tenures," memorandum, Victoria.
- _____ (1987(e)) "Coastal Resource Identification Study - Aquaculture Opportunities: Desolation Sound - Johnstone Strait," Victoria.
- _____ (1987(f)) "Coastal Resource Identification Study - Aquaculture Opportunities: Sechelt - Sunshine Coast," Victoria.
- _____ (1987(g)) "Coastal Resource Identification Study - Aquaculture Opportunities: Western Georgia Strait," Victoria.
- B.C. Ministry of Lands, Parks and Housing (1986(a)) "Normative Pricing Principles," *Land Administration Manual*, Victoria.
- _____ (1986(b)) "Aquaculture Land Use Policy," *Land Administration Manual*, Victoria.
- Bjorndal, T. (1988) "The Norwegian Aquaculture Industry: Industrial Structure and Cost of Production," *Marine Policy*, April, pp.122-42.

- _____, and Schwindt, R. (1987) "Norwegian Direct Investment in the British Columbia Salmon Aquaculture Industry: A Case Study," mimeograph, Department of Economics, Simon Fraser University.
- _____, and Salvanes, K. (1987) "Ramevilkar for naeringa," in *Fishkeoppdretts-økonomi*, T. Bjørndal editor, Oslo: J.W. Cappelens Forlag (in Norwegian).
- Cain, G., Truscott, J., Reid, S., and Ricker, K. (1987) *Biophysical Criteria for Siting Salmon Farms in British Columbia*, Aquaculture Association of B.C. and B.C. Ministry of Agriculture and Fisheries.
- Cheung, S. (1974) "A Theory of Price Control," *Journal of Law and Economics*, April, pp.53-71.
- Coase, R. (1960) "The Problem of Social Cost," *Journal of Law and Economics*, October, pp.1-44.
- Cooney, T. (1981) "Investigation of Methods to Determine Economic Recoverability of Timber Inventories on a Regional Basis," M.S.F. Thesis, University of British Columbia.
- Copes, P. (1988) "Transferable, Non-Transferable and Limited Term Fishing Rights: Fisheries Rationalization in a Socioeconomic Context," mimeograph, Department of Economics, Simon Fraser University.
- _____. (1979) "The Evolution of Marine Fisheries Policy in Canada," *Journal of Business Administration*, Fall 1979/Spring 1980, pp.125-48.
- Crommelin, M. and Thompson, A. (Editors) (1977) *Mineral Leasing as an Instrument of Public Policy*, British Columbia Institute for Economic Policy Analysis, Vancouver: University of British Columbia Press.
- Dahlman, C. (1979) "The Problem of Externality," *Journal of Law and Economics*, April, pp.141-62.
- DeVoretz, D. (1987) "Salmon Demand Functions in Future British Columbian Pen Reared Salmon Markets," mimeograph, Department of Economics, Simon Fraser University.
- DPA Group Inc. (1986) "Industrial Organization of the B.C. Salmon Aquaculture Industry - Final Report," Department of Fisheries and Oceans, Vancouver.
- Fraser, A. (1979) "Limited Entry: Experience of the British Columbia Salmon Fishery," *Journal of the Fisheries Research Board of Canada*, Vol. 36, pp.754-63.
- Gillespie, D. (Chairman) (1986) "An Inquiry into Finfish Aquaculture in British Columbia - Report and Recommendations," Ministry of Forests and Lands, British Columbia.

- Gunton, T. and Richards, J. (1987) *Resource Rents and Public Policy in Western Canada*, Halifax: The Institute for Research on Public Policy.
- Heaps, T. (1985) "An Analysis of the Present Value of Stumpage under a Variety of Economic and Management Conditions," Economic Council of Canada, Discussion Paper No. 284.
- Henderson, J., and Quandt, R. (1980) *Microeconomic Theory: A Mathematical Approach*, New York: McGraw-Hill.
- Layard, P., and Walters, A. (1978) *Microeconomic Theory*, New York: McGraw-Hill.
- Leland, H. (1979) "Optimal Risk Sharing and the Leasing of Natural Resources, With Application to Oil and Gas Leasing on the OCS," *Quarterly Journal of Economics*, August, pp.413-37.
- McDonald, S. (1978) "Federal Energy Resource Leasing Policy," *Natural Resources Journal*, October, pp.747-60.
- Mead, W., Moseidjord, A. and Muraoka, D. (1984) "Alternative Bid Variables as Instruments of OCS Leasing Policy," *Contemporary Policy Issues*, pp.30-43.
- Pearse, P. (Commissioner) (1982) *Turning the Tide: A New Policy for Canada's Pacific Fisheries*, Vancouver: Commission on Pacific Fisheries Policy.
- Province of British Columbia, Ombudsman (1987) "Aquaculture: A Discussion Paper," Office of the Ombudsman, Victoria.
- Ridler, N. and Kabir, M. (1987) "A Cross-Sectional Analysis of Costs of Farming Atlantic Salmon (*Salmo Salar*)," *Canadian Journal of Agricultural Economics*, March, pp.141-54.
- Salvanes, K. (1987) "The Structure of the Norwegian Fish Farming Industry - An Empirical Investigation of Economies of Scale," Institute of Fisheries Economics, Norwegian School of Economics and Business Administration.
- Schwindt, R. (1987) "The British Columbia Forest Sector: Pros and Cons of the Stumpage System," in Gunton and Richards, *Resource Rents and Public Policy*, op. cit.
- Silberberg, E. (1978) *The Structure of Economics: A Mathematical Analysis*, New York: McGraw-Hill.
- Tullock, G. (1975) "The Transitional Gains Trap," *Bell Journal of Economics*, Autumn, pp.671-78.
- Varian, H. (1984) *Microeconomic Analysis*, New York: W.W. Norton and Company.