Impacts of Individual Transferable Quotas in Canadian Sablefish Fisheries: An Economic Analysis

by

Adam Soliman

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Abstract

In 1990, the Department of Fisheries and Oceans implemented the Individual Transferable Quotas (ITQ) system to achieve its management goals. The purpose of this study is to investigate the effectiveness of this system. It aims to determine whether and how the ITQ system creates an economically viable industry; what problems the ITQ system has generated and what factors should be considered in addressing them; and what the risk of holding these quotas is to the fisher. To this end, I will focus on efficiency as a critical dimension of economic viability and the fisher's competitiveness. I will begin by comparing the ITQ to the Limited Entry system which preceded it and explore claims regarding the impact of ITQs on the sustainability and viability of fishing firms and the sablefish fishery. Next, I will conduct a detailed and comprehensive analysis of the industry's cost structure that highlights the value/purchase price of the quota, which is widely considered to be a crude measure of industry profitability. This analysis will examine Barichello's (1996) model in order to calculate the risk associated with holding sablefish quotes and Monk and Pearson's (1989) Policy Analysis Matrix (PAM) in order to determine whether the sablefish industry is efficient. I will then source industry information to compute the costs of fishing by conducting a financial analysis of firms that are representative of the sablefish fishery. The cost structure presented in the financial analysis will be utilized to apply the PAM to the sablefish fishery, which will determine whether it is efficient and if the ITQ system has created a highly subsidized industry. My analyses will demonstrate that the industry is economically viable under the ITQ system and that if the ITQ system was meant to correct market failures in the sablefish industry, it has partially succeeded in doing so. Key findings will be related to criticisms of ITQs and the implications of these findings will be considered. Lastly, I will detail the questions that the research has raised and make recommendations for future research.

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Acknowledgments

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Dedication

For my parents, wife and children, a constant source of encouragement and support through my many adventures.

Chapter 1: Introduction

Estimates vary as to the percentage of global fisheries that are now managed by Individual Transferable Quotas (ITQs) According to Costello, Gaines, and Lynham (2008), only about 1% of global fisheries are managed under ITQs. To the contrary, Chu (2008) claims that ITQs regulate 10% of the world's marine harvest. Canada was among the first countries to implement ITQs in the late 1970s, and today ITQ fisheries represent 74% of the catch, by weight, of all BC fisheries (Ecotrust, 2009).

BC's sablefish industry offers an excellent opportunity to gauge the effectiveness of the policy instruments utilized by Canada's Department of Fisheries and Oceans (DFO) to achieve its management goals in Pacific capture fisheries. These goals have been described by Munro, Turris, Clark, Sumaila, and Bailey (2009) as: "i) enhancing the economic viability of the fisheries; and ii) ensuring the sustainability of the fishery resources that provide the basis of these fisheries" (p. 2). This paper will look at the two management approaches employed by the DFO over the past 30 years to achieve those goals in BC's sablefish fishery: the Limited Entry system, used between 1981 and 1989, and the Individual Transferable Quota (ITQ) system, which was implemented in 1990 and is currently in use.

Research (Munro, Turris, Clark, Sumaila, & Bailey, 2009) suggests that the ITQ system eliminated Total Allowable Catch (TAC) overages, which had soared under the Limited Entry system. The ITQ system has therefore enabled the DFO to realize its sustainability goal for sablefish. However, it remains to be seen whether the ITQ system has achieved the DFO's goal of enhancing fisheries' economic viability. This paper will address that gap through: a) analyzing the cost structure of representative firms; b) analyzing the main components of efficiency; and c) analyzing the factors affecting the quota values and lease rates.

Focus of Inquiry

This thesis will focus on the ITQ system in the Canadian Pacific sablefish fishery. Specifically, it will ask:

- Does the ITQ system create an economically viable industry? If so, how?
- Has the ITQ system generated problems of its own? If so, what factors should be considered when designing solutions to these problems?
- What is the risk associated to the fisher with holding these quotas?

In Chapter 2 this paper will approach these questions through a literature review which will define the term "ITQ" and explain how it came to be adopted in the Canadian Pacific sablefish fishery. Therein, it will explore the debate about claims made regarding the impacts of ITQs as they relate to the sustainability of the fishery, the economic viability of fishing firms in general, and the economic viability of the sablefish fishery in particular. To do so, the study requires a comprehensive examination of the industry's cost structure, specifically the value/purchase price of the quota – widely considered to be a crude measure of industry profitability (Barichello, 1996; Munro, 2009).

In Chapter 3, I will examine Barichello's (1996) model (which was applied to the dairy industry) in order to calculate the risk associated with holding sablefish quotas. That is, the impact that quota-holders' expectations regarding the continuation of, elimination of, or change in government policies have on the market values of sold or leased quotas. Next, I will examine Monke and Pearson's (1989) Policy Analysis Matrix (PAM) to address the question of whether the sablefish industry is efficient.

In Chapter 4 I will source industry information to compute the costs of fishing. Therein, I will first apply Barichello's (1996) model to the sablefish fishery and discuss the results in order to answer the following questions: what is the risk of holding quotas when the rules that govern them are subject to substantial change or expected to change significantly, and how can that risk be quantified? Second, I will conduct a financial analysis of firms that are representative of the sablefish industry; this analysis will include asset valuation and will determine whether the industry is profitable as well as whether the quota values pose a significant barrier to new sablefish fishery entrants. Lastly, I will apply the PAM to the sablefish fishery by utilizing the cost structure that was presented in the financial analysis.

In Chapter 5, I will relate and discuss the findings of my analysis in light of six topics raised by the critics of ITQs. In Chapter 6 I will summarize my key findings, make recommendations for future research, and acknowledge limitations of the methodology.

Chapter 2: Literature Review

ITQs or Individual Fishing Quotas are a fisheries management tool that has been increasingly employed by governments around the world since the 1970s. As of 2008, approximately 10% of the marine harvest was managed through ITQs. An ITQ is defined as follows:

At minimum, ITQs share the following features:

- the fish come from publicly owned property;
- fishery regulators establish a total allowable catch (TAC), usually expressed in weight;
- fishery regulators establish a limit on the total number of fishers (vessel, or fishing firm) who have access to that fishery;
- fishery regulators grant each of these fishers a specific share of the TAC, which is sometimes called a catch share and is usually expressed as a percentage. This share is usually given at no cost and its size is based on fishing capacity as demonstrated over a politically determined period of time;
- fishers are subject to monitoring and enforcement in order to ensure that catch shares are not exceeded;
- catch shares are transferable; that is, they can be leased or sold to other fishers

By no means do all ITQs look alike. Elements that vary or that are debated include:

- whether they are initially sold, or given for free;
- whether the quotas are granted in perpetuity, or on a renewable basis;
- whether quotas are described as private property, rights, or privileges that may be renewed, revoked or terminated by the government;
- whether they involve some capture of resource rent by governments for the owners of the resource (the public);

- whether transferability is allowed on a permanent or temporary basis, or both;
- the assignment of responsibility for underwriting the cost of monitoring and enforcement (industry or taxpayers)

ITQs were introduced to the Pacific sablefish fishery in 1990. To understand why, it is necessary to provide a brief history of the fishery.

Although sablefish is a relatively unknown product to Canadian consumers of fish (some 95% of the catch is exported) (Marine Stewardship Council, 2010), it has been harvested off the coast of B.C. and Alaska for more than 40 years. For almost 30 years, it was considered bycatch in domestic markets because of the low-landed prices paid by processors. This changed in the 1970s, when Canadian and American fishers discovered receptive markets in Japan. As burgeoning markets attracted more entrants into the industry, technological innovations in fishing dramatically increased vessel productivity (Sporer, 2008). These twin developments, frequently characterized as an "overcapacity" issue, raised concerns among fishing firms about economic viability and concerns among regulators as well as the industry about a potential conservation crisis.

The Limited Entry System

In 1981, the DFO responded to concerns about over-fishing by initiating a fishery management system that became known as Limited Entry**.** The system enforced government-imposed limitations on the amount of fish that could be harvested (TACs), the times during which the fish could be harvested (seasons), and the number of fishers (to 48 vessels with Category K or sablefish licences). It also restricted gear to trap or longline (Sporer, 2001).

Unfortunately, the cure proved to be worse than the disease. Now faced with a limited allowable number of fish, the fishers who remained in the industry competed fiercely to maintain or increase their market share. They upgraded technology and invested heavily in boats that could catch and hold more fish in a short period of time. As the speed of harvesting increased, TAC limits were reached more quickly. Regulators responded by shortening fishing seasons and by 1989, the season had shrunk to a mere 14 days, down from 245 days in 1981 despite a 42% increase in the TAC (Canadian Sablefish Association, n.d.). In 1990, the season was projected to be open for only eight days.

The drastic reduction in season length significantly raised the stakes for fishers; as the potential for profit in short periods of time increased, so did the cost of lost fishing days. As a result, powerful economic incentives to fish even in adverse conditions exacted a human cost in the form of workplace accidents. In addition, the economic and fishing climate worsened and firms suffered economic losses because of both “gear wars” (crews sabotaging competitors’ gear) and crews making economically motivated decisions to abandon their own gear at sea.

Shortened seasons also affected the viability of markets. As fishers allocated more time to hauling and setting and less time to the proper treatment and storage of catch, product quality declined (Turris, 2000). And because all of the TAC was harvested in an increasingly short period of time (see “season length” column in Table 1 below), there was a sharp decrease in the year-round availability of fresh fish products in the marketplace.

Compounding the problems occasioned by ever-shortening seasons and increased fishing power was the fact that throughout the Limited Entry period, the DFO lacked the capacity, the resources, and/or accurate enough information to adequately monitor fishing practices (Sporer, 2008) or catches in real-time. There were no DFO officers addressing issues in the sablefish fishery and the DFO was not monitoring sablefish landings (Sporer, 2008). Furthermore, the Limited Entry system included no mechanisms to assign or enforce individual accountability for TAC overages. Not surprisingly, TAC overages became chronic and serious as season length shrank (see Table 1 below).

Table 1 *Quantities of Actual Catch; Total Allowable Catch (TAC), Overage or Underage (Difference Between TAC and Catch), Fishing Season Length and No. of Active Vessels by Year*

Year	Catch (tonnes)	TAC (tonnes)	Overage / Underage (tonnes)	Season length (days)	Active vessels
1981	2636	3190	-554	245	N/a
1982	3628	3190	438	202	N/a
1983	4123	3190	933	148	23
1984	3824	3190	634	181	20
1985	3951	3650	301	95	27
1986	3900	3650	250	63	41
1987	4178	3740	438	45	43
1988	5075	4015	1060	20	45
1989	4722	4015	707	14	47

Note. Adapted from *Impacts of harvesting rights in Canadian Pacific fisheries* (Statistics and Economic Analysis Series No. 1-3, p. 9), by G.R. Munro, B. Turris, C. Clark, U. Sumaila, and M. Bailey, 2009, Ottawa, Canada: Fisheries and Oceans Canada, Economic Analysis and Statistics Branch.

At the same time, cutthroat competition between fishers was thought to have raised the hidden ancillary environmental costs of bycatch, discards, and fish mortality caused by the "ghost-fishing" that occurs when abandoned gear continues to catch fish that are never actually landed (Munro et al., 2009). Licence violations such as misreporting, exceeding trip limits and out-of-season fishing also occurred (Munro et al., 2009).

To government and industry alike it became clear that the Limited Entry system was inefficient on multiple levels. Munro et al. (2009) describe it as having been "totally ineffective in preventing the emergence of excess fleet capacity over time" and having resulted in "severe economic and resource conservation consequences" (p.2).

Implementation of ITQs

In 1990, after holding consultations with licence holders and gaining the support of a majority among them (Sporer, 2008), the DFO adopted a new approach: Individual Vessel Quota (IVQ) management.

Like the Limited Entry system, the IVQ system requires sablefish fishers to have licences and limits the number of licences issued to 48. However, it differs in that it allocates each licence holder a set share of the TAC—an "individual vessel quota". The amount of this share is determined by a formula that considers previously demonstrated fishing capacity and vessel length. The percentages used in the formula are 70% of the quota based on historical catch and 30% of the quota based on the licenced vessel's overall length. Historical catch is determined by taking each licencee's best catch in either 1988 or 1989. This number is then divided by the total of all sablefish vessels' highest landings in either 1988 or 1989, and then multiplied by 70% of the 1990 TAC. Each individual vessel's overall length is determined by a certified marine surveyor and then divided by the total length for the fleet. This number is then multiplied by 30% of the 1990 TAC (Sporer, 2001). In contrast to the Limited Entry system, fishers can now fish year-round, but they must notify the DFO when they set out and when they return. In addition, vessels are equipped with electronic monitoring equipment (cameras) and industry-funded third-party monitors provide at-sea and dockside monitoring. Licence holders who exceed their quota allotment in a given year can therefore expect to see their shares proportionately reduced in the following year; conversely, a portion of unused quotas can be carried forward from one year to the next.

In 1995, quotas were made transferable on a per-pound basis (Sporer, 2008); that is, they could be traded, leased, or sold. For this reason, IVQs became known as Individual Transferable Quotas (ITQs). Permanent transfers (i.e., sales) of quotas must be approved by the DFO.

An important development coincided with the implementation of ITQs in the sablefish fishery: the industry's move towards co-management. Although "co-management" can and does take many forms and is by no means restricted to the use of ITQs in the fishing industry, for the purposes of discussing the effects of ITQs in the Pacific sablefish fishery it should be considered an integral part of the ITQ system. This is primarily because it is inextricably linked to an overhauled system of monitoring the fishery. Co-management involves extensive, negotiated cooperation between the

DFO, the Canadian Sablefish Association, the CSA (a non-profit association formed to represent the interests of sablefish licence holders), and more recently, a CSA corporate subsidiary known as Wild Canadian Sablefish Ltd. Through a series of contractual agreements with the DFO, the CSA now directly undertakes many fishery management activities that were formerly carried out by the DFO directly or subcontracts them out to third parties. Table 2 below summarizes the respective contributions of the DFO (Minister) and the CSA (K-Fleet) to the management of the sablefish fishery through joint project agreements.

Table 2 *Joint Project Agreement Financial Contributions of the Department of Fisheries and Oceans (DFO), Financial Contribution of Canadian Sablefish Association of Canada (CSA) and In-kind Contributions of CSA*

Year	DFO (dollars)	CSA (K-fleet) (dollars)	CSA (K-fleet in-kind (dollars)	Total (dollars)
2002	97,849	359,521	1,879,061	2,336,431
2003	98,249	352,461	2070,617	2,521,327
2004	81,000	263,008	1763,945	2,107,953
2005	153,120	362,188	2181,300	2,696,608
2006	199,537	2027,387	0	2,226,924
2007	308,900	54,500	767,500	1,130,900
2008	172,646	26,124	428,959	627,729
2009	482,500	54,500	580,500	1,117,500
TOTAL	1,593,801	3,499,689	9,671,882	14,765,372

Note. The 2002-2006 data are reproduced from *Impacts of harvesting rights in Canadian Pacific fisheries* (Statistics and Economic Analysis Series No. 1-3, p. 37), by G.R. Munro, B. Turris, C. Clark, U. Sumaila, and M. Bailey, 2009, Ottawa, Canada: Fisheries and Oceans Canada, Economic Analysis and Statistics Branch. The 2007-2009 data are from each year's Joint Project Agreement, received from Leslie Budden, Executive Assistant for Wild Canadian Sablefish, personal communication, April 26, 2010.

Another development that has impacted the way ITQs are handled in the sablefish fishery is the move to multi-species management, commonly referred to as "groundfish integration". This began as a pilot project in 2006 and has since been made permanent. Sporer (2008) provides a concise summary of the project's operation:

> Seven distinct commercial groundfish fleets—Sablefish, Halibut, Inside Rockfish, Outside Rockfish, Lingcod, Dogfish and Groundfish Trawl—are managed as distinct fisheries. But they are integrated by the new requirement to reallocate IVQ between vessels and fisheries to cover catches of non-directed groundfish species (both retained and released). A vessel's catch is calculated by adding both landed weight and the estimated mortality of all catch either utilized at-sea or released at-sea . . . Commercial groundfish vessels are individually accountable for all their catch (both retained and released). Each commercial groundfish vessel is now required to acquire individual vessel quota (IVQ) to account for mortality of all legal/marketable-sized groundfish that are managed under species and area TACs. A vessel catching fish in excess of the IVQ holdings identified in its licence condition (plus any allowable overages) is restricted from further fishing until additional IVQ has been acquired. For groundfish species that are not managed under a TAC, all catches (retained and discarded) are recorded, monitored, and audited. For most of these non-TAC groundfish species, trip limits are in place. (p. 410-411)

The concurrent introduction of ITQs and co-management into the sablefish fishery has resulted in dramatic and positive change in that the industry now fishes within a very close range of the annually determined TACs. As shown by Table 3 below, the total fishing effort has dropped, seasons are now year-round versus 14 days in 1989, and TAC overages have been reduced dramatically.

Table 3 *Quantities of Actual Catch, Total Allowable Catch (TAC), Overage or Underage (Difference Between TAC and Catch), Fishing Season Length and No. of Active Vessels by Year*

Year	TAC[a] (tonnes)	Catch[b] (tonnes)	Overage/ Underage (tonnes)	Season length (days)	Active vessels[b]
1981	3190	2636	-554	245	n/a
1982	3190	3628	438	202	n/a
1983	3190	4123	933	148	23
1984	3190	3824	634	181	20
1985	3650	3951	301	95	27
1986	3650	3900	250	63	41
1987	3740	4178	438	45	43
1988	4015	5075	1060	20	45
1989	4015	4722	707	14	47
1990	4260	4275	15	255	30
1991	4560	4532	-28	365	26
1992	4560	4557	-3	365	25
1993	4560	4546	-14	365	21

Year	TAC[a] (tonnes)	Catch[b] (tonnes)	Overage/ Underage (tonnes)	Season length (days)	Active vessels[b]
1994	4521	4533	12	365	22
1995	3709	3709	0	365	24
1996	3169	3168	-1	365	21
1997	4023	3893	-130	365	24
1998	4023	4164	141	365	24
1999	6394	6323	-71	365	29
2000	3646	3532	-114	365	32
2001	2812	2753	-58	365	29
2002	1928	1894	-34	365	27
2003	2675	2591	-84	365	30
2004	4088	3859	-229	365	32
2005	4213	3822	-391	365	35
2006	3417	4091	674	365	34
2007	2938	3277	339	365	34
2008	1454	2745	1291	365	34
2009	2160	2391	231	365	31

Note. The 1981-2005 data are reproduced from *Impacts of harvesting rights in Canadian Pacific fisheries* (Statistics and Economic Analysis Series No. 1-3, p. 38), by G.R. Munro, B. Turris, C. Clark, U. Sumaila, and M. Bailey, 2009, Ottawa, Canada: Fisheries and Oceans Canada, Economic Analysis and Statistics Branch. [a]The 2006-2009 data are from A. Keizer, DFO Sablefish and Halibut Coordinator, personal communication, March 23, 2010. [b]The 2006-2009 data are from *Preliminary summary commercial statistics 1996-2009* [data sets by year], by Fisheries and Oceans Canada, 2009. Retrieved from http://www.pac.dfo-mpo.gc.ca/stats/comm/summ-somm/index-eng.htm. [c]The 2006-2009 data are calculated by subtracting TAC from Catch.

I will now turn to a discussion of total landed sablefish values and the prices of sablefish per KG. The landed values are calculated by multiplying the price of sablefish by the total quantity landed during a given year. The TAC for a given year plays a major factor in the actual landed quantities, while overages or underages account for any differences. As shown in Table 4, the price of sablefish has risen twice: once between 1995 and 1997 and again between 2000 and 2003. The price seems to have stabilized since 2006 and the average mean is now $7.10 per kg. Although the financial crisis and its devastating effect on Japan (a major buyer of Canadian sablefish) may have contributed to this stabilization, the primary reason appears to be that new markets are willing to bear pay higher prices for sablefish.

Table 4 *Landed Values of Sablefish and Per KG Prices from 1981 to 2009*

Year	Landed Values[a] ('000s 2007 $)	Price per KG (2007 $)	Year	Landed Values[a] ('000s 2007 $)	Price per KG (2007 $)
1981	13,853	5.26	1996	33,588	10.60
1982	12,965	3.58	1997	40,960	10.52
1983	11,189	2.71	1998	32,421	7.78
1984	11,899	3.11	1999	39,712	6.28
1985	20,424	5.17	2000	37,449	10.61
1986	19,535	5.01	2001	32,948	11.96
1987	23,265	5.57	2002	27,451	14.50
1988	27,349	5.39	2003	23,856	9.21
1989	21,311	4.52	2004	19,825	5.13
1990	24,685	5.78	2005	32,830	8.59
1991	34,986	7.72	2006	33,973	6.80
1992	30,724	6.74	2007	23,669	6.64
1993	28,238	6.22	2008	20,268	6.55
1994	37,472	8.27	2009	17,117	6.54
1995	33,920	9.15			

Note. The 1981-2005 data are reproduced from *Impacts of harvesting rights in Canadian Pacific fisheries* (Statistics and Economic Analysis Series No. 1-3, p. 35), by G.R. Munro, B. Turris, C. Clark, U. Sumaila, and M. Bailey, 2009, Ottawa, Canada: Fisheries and Oceans Canada, Economic Analysis and Statistics Branch. [a]The 2006-2009 data are from *Preliminary summary commercial statistics 1996-2009* [data sets by year], by Fisheries and Oceans Canada, 2009. Retrieved from http://www.pac.dfo-mpo.gc.ca/stats/comm/summ-somm/index-eng.htm.

The following section explores the implications of this data for sustainability and economic viability in greater detail.

Claims about ITQs

To apply the discussion of ITQs to the sablefish fishery, it is necessary to first examine the ongoing debate about ITQs in general. The controversy centers on claims pertaining to economic viability and sustainability. This paper focuses primarily on the question of economic viability in one B.C. fishery, but it is important to point out that the two concepts are prominent and interrelated in any discussion about the harvesting of a destructible natural resource. For this reason I will also briefly touch upon claims made about the relationship between ITQs and sustainability.

ITQs and Sustainability

As a management tool, the ITQ system has many proponents. They claim that fishers have newfound respect for TACs in arguing that ITQs promote sustainability through ownership (Costello, Gaines, & Lynham, 2008). This argument rests on three key points: (a) whether or not ITQs are legally considered to be private property, in which case they are valuable assets which for all intents and purposes are a form of property; (b) as rational economic actors, fishers can only be conduced to invest in conservation-friendly behaviour if they cooperate and their cooperation is more likely if they can enjoy exclusive access to the benefits of that behavior, and; (c) it is the ownership of property that can ultimately be leased or sold which gives fishers the means to monetize the benefits of their investment. In other words, secure property rights are essential pre-conditions for the cooperative behavior necessary to achieve sustainability goals. Other ITQ proponents have further clarified this argument in stating that property rights are necessary for the promotion of environmental stewardship, but only sufficient for that purpose if complemented by science-based TACs and effective enforcement (Grafton, 2006).

Bromley (2009) has argued against ITQ proponents' assumption (stated or implicit) that property rights are sufficient and/or necessary for environmental stewardship. He asserts that were this so, there would be no examples of responsible environmental stewardship under public management (such as well-managed national parks) – and nor would there be so many numerous examples of private landowners who have liquidated their own natural capital for short term profits (for personal gain or subsequent reinvestment in other sectors).

As we have seen, ITQs have many variations. Bromley (2009) has urged us to identify exactly *what aspect* of ITQs explains or conduces fishers to engage in more environmentally respectful behaviour. Is it the promise of capturing the long-term benefits of *not* overfishing they hold for "owners"? Or would the TAC-respecting effects of ITQs be more accurately attributed to sound TACs supported by effective systems of monitoring enforcement? Bromley has argued that it is in fact the latter because if this were not so, there would be no need for robust monitoring to keep fishers compliant. To conclusively identify ownership as the factor most predictive of environmentally responsible behaviour in a given management system, that system would need to be compared to others wherein certain key factors – including enforcement and monitoring – were held constant.

Others (Pinkerton & Danielle, 2009) have argued that ITQs – to the extent that the system squeezes out fishers who must pay high leasing costs for a substantial or greater portion of their catches – are recreating the same cost pressures which lead to environmentally irresponsible behaviour in other contexts.

Munro et al. (2009) offer an explanation that helps to clarify the environmental respectful behaviour of fishers under ITQ. They present the following game theory model, which aligns the incentives of fishers with those of regulators, to explain the end of the "race-to-fish" dynamic:

> There are two broad categories of games: non-cooperative, or competitive, games; and cooperative games. In cooperative games, the "players" are assumed to be coldly rational, with each "player" being prepared to cooperate, only if it believes that it will be better off by cooperating, than it would be by playing competitively. The stability of such cooperative games is always at risk of being undermined by "player" noncompliance (cheating), and by free riding, which, for the purposes of this report, can be defined as the enjoyment of the fruits of cooperation by non-participants in the game (i.e., poaching). (p. 4)

The Principal-Agent framework (Munro et al., 2009) further helps explain the change from competitive behavior to cooperative behavior. In the context of the sablefish fishery, the principal would be the resource manager (DFO) and the agent would be the fishers represented by the Canadian Sablefish Association (CSA). The Principal-Agent relationship is concisely summarized by Munro et al. (2009) and Clarke and Munro (1987), respectively:

> A strict hierarchical relationship exists in which the principal (leader) chooses an incentive scheme (e.g. set of regulations) to be applied to the agents (followers). The principal's incentive scheme, along with the actions taken by the agents, determines both the returns to the agents and to the principal. As seen from the perspective of the principal, a first-best situation exists when the principal can, at minimal cost, contractually and enforceably specify the actions of the agents. Wishes, urges and desires of the agents, contrary to the best interests of the principal, are entirely suppressed. The agents are essentially robots. (Munro et al., 2009, p. 10)

> In the normal second-best situation, the principal lacks the power, or more to the point finds it too costly, to force a set of actions upon the agents. The agents thus have some freedom of choice. The principal can hope to influence the agents' choices, only indirectly through the incentive scheme. This gives rise to the concept of an incentive gap, which is the difference between the actual return to the principal, and what it would receive under a first-best situation. It reflects the insufficiency of the principal's incentive scheme in compensating for its inability to monitor perfectly the agents' actions. At the heart of the Principal-Agent problem is monitoring imperfection. (Clarke & Munro, 1987, p. 4)

Munro (2009) has also quoted the Canadian Sablefish Association website to provide evidence of a narrowing "incentive gap" and an increasing alignment of objectives between the Association and its regulators. According to the CSA, "… the Canadian Sablefish Association and the Department of Fisheries and Oceans both share the same primary objective – the proper care and management of the sablefish resource" (Munro, 2009, p. 26).

ITQs and Sustainability of Pacific Sablefish

Returning to the Pacific sablefish fishery, we must consider whether it is in fact sustainable and, if so, whether that is because of ITQs. Munro et al. (2009) have highlighted the fact that under ITQs, sablefish TAC overages have been virtually eliminated. While a reduction in fishing effort is also thought to have coincided with a decrease in the fish mortality associated with ghost-fishing, bycatch, and discards, (Munro et al., 2009) have argued that the ITQ system produced a "dramatic improvement . . . in terms of ensuring the sustainability of the fishery resources" (p. iv).

Munro et al. (2009) find reason for optimism in the active cooperation of industry actors. This is because the Canadian Sablefish Association has made it possible to enhance the long-term value of the resource through substantial "voluntary" contributions to stock assessment and research. In another paper, Munro (2009) quotes the CSA in stating that the sablefish cooperative game has a "self-enforcing" nature and that there is an emerging alignment between the goals of the CSA and the DFO: ". . . the Canadian Sablefish Association and the Department of Fisheries and Oceans both share the same primary objective – the proper care and management of the sablefish resource." (p. 26)

It is also encouraging that the fishery is in the final stages of gaining sustainability certification from the Marine Stewardship Council. As of March 2010, the fishery was expected to achieve certification (with conditions) within months (Furness, Knapman, Nichols, & Scott, 2010). Further, Canadian Pacific sablefish caught by trap or longline (gear used by K licence holders) was ranked as a "best choice" in 2006 by SeaChoice, a sustainable seafood program formed by five major Canadian conservation organizations.

Another element to consider is sablefish quota values, which Munro et al. (2009) have linked to sustainability: "If the resource is not managed to be sustainable, future TACs will decline as will the value of the ITQ" (p. 24). Further, recent data suggest that (a) sablefish quota values appear to have trended upwards from 1990 (when the ITQ system was implemented) and spiked in 2003 at $103.89 (adjusted into 2007 dollars), and (b) sablefish quota values declined from 2004, bottomed out in 2008 at $54.56 (adjusted into 2007 dollars) and increased again in 2009. The lower quota value in 2008 may be a function of the financial crisis as well as the lower TAC quantities set in 2008.

Finally, it is interesting to note that quota lease rates (adjusted into 2007 dollars) reached higher levels in 2009 than in any of the previous 6 years. In five years of those six, quota lease rates plunged below $6. Table 5 below illustrates these shifts.

Table 5 *Quota Values and Quota Lease Rates Adjusted to 2007 Dollars*

Year	Quota value ($ per kg)	Quota lease rate ($ per kg)
1990	18.82	n/a
1991	20.79	n/a
1992	21.91	n/a
1993	28.70	n/a
1994	34.41	n/a
1995	47.68	n/a
1996	n/a	n/a
1997	n/a	10.88
1998	56.50	5.38
1999	66.15	7.28
2000	92.68	10.94
2001	91.10[a]	n/a
2002	93.35	9.83
2003	103.89[b]	8.79[c]
2004	93.88	7.98
2005	80.31	5.74
2006	66.08	5.46[d]
2007	71.00	4.85[d]
2008	54.56	5.25[d]
2009	76.05	9.25[d]

Note. All monetary data converted to 2007 dollar values. Adapted from *Impacts of harvesting rights in Canadian Pacific fisheries* (Statistics and Economic Analysis Series No. 1-3, p. 38), by G.R. Munro, B. Turris, C. Clark, U. Sumaila, and M. Bailey, 2009, Ottawa, Canada: Fisheries and Oceans Canada, Economic Analysis and Statistics Branch except for 2001 and 2003 quota values and 2003 quota lease rate, from Garth Leighton, Pacific Boat Brokers, personal communication, May 12, 2010
[a]quota value is $35 / lb (j-cut) x 2.2 = $77 / kg. [b]Quota value is $43.5 / lb (j-cut) x 2.2 = $95.7 / kg. [c]Quota lease rate is $3.75 / lb (j-cut) x 2.2 = $8.25 / kg. [d]2006-2009 data are converted into kg and adjusted into 2007 dollars and are adapted from *Commercial fishing licence, quota, and vessel values: As at March 31, 2007* (p. 39), by S. Nelson, 2007, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Although all of the above indicators suggest that the fishery is well managed, questions remain as to sustainability in the sablefish fishery and its relationship to ITQs. Is compliance with TACs attributable to the use of quotas, or to the implementation of an adequately funded system of monitoring, enforcement and individual accountability? Comparing environmentally respectful behaviour in the sablefish fishery under the ITQ system to its monitoring- and enforcement-challenged predecessors (Limited Entry and the state of open access that preceded it) may be analogous to comparing apples and oranges.

The dynamics of the sablefish species itself remain mysterious. Sumaila, Volpe, and Liu (2005) point out that "Ecological data regarding wild sablefish are rudimentary at best" (p. 3). However, survey indices for the past three years suggest the stock is in decline (Cox & Kronlund, 2009). In 2009, the DFO developed and implemented a management plan designed to increase the B.C. spawning stock above the 2007 level within 10 years and with 90% certainty (Furness et al., 2010). Marine Stewardship Council certification will be conditional in part on evidence of the plan's success.

The problem of discards, identified by Furness et al. (2010) as an uncertainty associated with the B.C. sablefish fishery, remains to be resolved. According to the Canadian Sablefish Association, the discarding of sub-legal sablefish is a significant problem – and one largely attributable to the fishing practices of groundfish trawl vessels. As the DFO (2009) point out:

> … high discard rates in all fisheries are of concern because (i) the operating model estimates of stock status would be optimistic and (ii) failing to account for discard mortality in future projections means that actual recovery rates will be slower. (p. 4)

Assonitis (2008) found that up to 49% of the yield-per-recruit is potentially lost because of at-sea discarding of sablefish. At the time of this writing, the Canadian Sablefish Association was proposing a plan that would raise economic incentives for more selective fishing (R. MacDonald, Executive Director, Canadian Sablefish Association, personal communication April 13, 2010).

Concerns have also been expressed about the impact of the sablefish fishery (among other fisheries) on Rougheye Rockfish, which appears in bycatch and is a "species of special concern" according to the Canadian Species At Risk Act (Wallace, 2007). Wallace has also identified issues connected with the use of onboard electronic monitoring systems and databases (as cited in Furness et al., 2010).

Not all questions regarding sustainability are unique to sablefish. Proponents of other resource management schemes claim that compliance with TACs is significant but not sufficient as a gauge of sustainability. For example, Curtin and Prellezo (2010) implicitly recognize this in their discussion of the ecosystem-based management of marine resources:

> …disjoined sectoral management has resulted in these impacts being viewed individually, in context only with the sector that has caused it. Given the increased awareness of the interconnectedness of ecosystems, it is considered that this compartmentalised [sic] view of resource management is now outdated. [Ecosystem-based management] seeks to broaden the scope of traditional resource management so that it considers a wider range of ecological, environmental and human factors in the exploitation of resources. EBM aims to resolve the former's inadequacies by providing a system of management that views the ecosystem as whole, where all the drivers and all their impacts are considered in relation to their effects on ecosystem functioning. It also involves broadening stakeholder involvement, evaluation of multiple simultaneous ''drivers'' or ''pressures'' on ecosystems and emphasizing the *geographically based nature of it in contrast to being single species or single issue driven* [emphasis added]. (p.1)

These remarks about sustainability in the sablefish industry suggest that the economic viability of any industry is inextricably linked to the health of the resource on which it is based. I have highlighted considerations that analysts of the BC sablefish industry would do well to bear in mind. However, the question of whether a given fishery is ecologically sustainable is one on which I would respectfully defer to the practitioners of ecology.

Economic Viability

Much of the debate around ITQs centers on whether this management tool conduces greater economic viability among the fishing industry in question. Proponents of ITQs argue that it does, primarily by eliminating the "race-to-fish" dynamic that pervades unregulated open-access or

Limited Entry systems (Costello et al., 2008; Munro et al., 2009). That is, being freed from cutthroat competition to maintain or increase the market share of a capped number of fish reduces the economic pressure on fishing firms to overcapitalize by investing in gear that can catch and hold more fish.

Munro et al. (2009) offer some evidence that economic viability has been achieved in the sablefish industry. They argue that the trend of increasing market values for sablefish quotas from 1990 to 2005 can be viewed as a crude measure of fishers' perception that the economic health of the fishery is steadily increasing. Table 6 below illustrates quota values, quota lease rates, licence fees and landed values from 1981 (all adjusted to 2007 dollars), when the Limited Entry scheme was implemented in the sablefish fishery, to 2009. In referencing this table it is useful to remember that the ITQ system was implemented in 1990.

Table 6 *Quota Values, Quota Lease Rates, Licence Fees and Landed Values by Year, Adjusted to 2007 Dollars*

Year	Quota value ($ per kg)	Quota lease rate ($ per kg)	Licence fees ('000s of $)	Landed value ('000s of $)
1981	n/a	n/a	N/a	13,853
1982	n/a	n/a	n/a	12,965
1983	n/a	n/a	n/a	11,189
1984	n/a	n/a	n/a	11,899
1985	n/a	n/a	n/a	20,424
1986	n/a	n/a	n/a	19,535
1987	n/a	n/a	n/a	23,265
1988	n/a	n/a	0.73	27,349
1989	n/a	n/a	0.73	21,311
1990	18.82	n/a	0.73	24,685
1991	20.79	n/a	0.63	34,986
1992	21.91	n/a	0.63	30,724
1993	28.70	n/a	0.63	28,238
1994	34.41	n/a	0.63	37,472

Year	Quota value ($ per kg)	Quota lease rate ($ per kg)	Licence fees ('000s of $)	Landed value ('000s of $)
1995	47.68	n/a	0.63	33,920
1996	n/a	n/a	505.35	33,588
1997	n/a	10.88	631.45	40,960
1998	56.50	5.38	624.88	32,421
1999	66.15	7.28	1,577.48	39,712
2000	92.68	10.94	959.59	37,449
2001	91.1[a]	n/a	874.37	32,948
2002	93.35	9.83	187.43	27,451
2003	103.89[b]	8.79[c]	640.32	23,856
2004	93.88	7.98	1,030.52	19,825
2005	80.31	5.74	950.20	32,830
2006	66.08	5.46[d]	817.22	33,973[g]
2007	71.00	4.85[d]	676.1	23,669[g]
2008	54.56	5.25[d]	315.85	20,268[g]
2009	76.05	9.25[d]	930.55[e]	17,117[g]

Note. All monetary data converted to 2007 dollar values. The 1981-2005 data are adapted from *Impacts of harvesting rights in Canadian Pacific fisheries* (Statistics and Economic Analysis Series No. 1-3, p. 38), by G.R. Munro, B. Turris, C. Clark, U. Sumaila, and M. Bailey, 2009, Ottawa, Canada: Fisheries and Oceans Canada, Economic Analysis and Statistics Branch except for 2001 and 2003 quota values and 2003 quota lease rate, from Garth Leighton, Pacific Boat Brokers, personal communication, May 12, 2010.
[a]quota value is $35 / lb (j-cut) x 2.2 = $77 / kg. [b]Quota value is $43.5 / lb (j-cut) x 2.2 = $95.7 / kg. [c]Quota lease rate is $3.75 / lb (j-cut) x 2.2 = $8.25 / kg. [d]2006-2009 data converted into kg and adjusted into 2007 dollars; from *Commercial fishing licence, quota, and vessel values: As at March 31, 2007* (p. 39), by S. Nelson, 2007, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd. [d]2006-2009 data converted into kg and adjusted into 2007 dollars; from *Commercial fishing licence, quota, and vessel values: As at March 31, 2007* (p. 39), by S. Nelson, 2007, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd. [e]from Adam Keizer, DFO Pacific sablefish coordinator, personal interview, March 23, 2010. [f]The 2006-2008 licence fees are calculated according to the DFO's licence fee formula: $241.00 multiplied by the number of tonnes of sablefish authorized to be taken under the licence, minus 40% of that product where the product is less than $2,500.00, or minus $1,000.00 where the product is $2,500.00 or more. Note that 2 FK licences are not operating as well as two FK currently operating. FK pays no license fees. [g]The 2006-2009 landed value data are from *Preliminary summary commercial statistics 1996-2009* [data sets by year], by Fisheries and Oceans Canada, 2009. Retrieved from http://www.pac.dfo-mpo.gc.ca/stats/comm/summ-somm/index-eng.htm

In their discussion of ITQs in the halibut fishery, for which "the same conclusions hold" as for sablefish, Munro et al. (2009) posit that quota values:

> . . .reflect the market's perception of the net present value of the future stream of net economic returns from the fishery. As such, the market value of quota is affected by the market prices for halibut, fishing costs and *the long-term health of the resource* [*emphasis added*]. (p. 24)

However, ITQs have also been criticized for having compromised the economic viability of the industry. For example, it has been claimed that in B.C.'s halibut fishery, the ITQ system has created "armchair fishermen" – or quota owners who treat their quotas as a pension by leasing them out indefinitely – thereby dissipating wealth from the industry (Butler, 2004; Ecotrust, 2009; Pinkerton & Danielle, 2009).

It has also been argued that the quotas protect those who have them from market forces that would otherwise increase efficiency (Pinkerton & Danielle, 2009). Although those who lease quotas face much tighter margins and tend to become more efficient, those fishing their own quotas profit so highly "that they are under little pressure to be technically efficient" (Pinkerton & Danielle, 2009, p. 710).

Pinkerton and Danielle (2009) have highlighted the dearth of "detailed empirical studies assessing changes in efficiency in the same fishery following the creation of individual quota programs" (p. 707). They have suggested that efficiency gains should be analyzed not only from the perspective of quota owners, but also from the perspective of quota lessees, crew, potential entrants into the market, and the public interest.

Bromley (2009) has argued that ITQs in no way increase efficiency in fisheries and are actually doing the exact opposite. In his view, ITQs: (a) heavily subsidize producers (fishers) by offering perpetual, free access to a resource that has obvious economic value to its owners (the public), and; (b) protect quota holders' market shares and guarantee their "extra-competitive" economic returns by erecting considerable barriers to the entry of new players in the market.

Pinkerton and Danielle (2009) and Pinkerton and Edwards (2010) point out other economic problems associated with ITQs, particularly those that place no restrictions on transferability. These include the possible re-emergence of the cost pressures that led to unsafe practices among marginal quota lessees; distortions of market power created by the initial quota granting process; unequal access to capital among industry players, and; transaction costs associated with asymmetrical access to information among quota leasers, holders, and fish processors.

ITQs and Economic Viability in Sablefish

The sablefish fishery has undergone many changes since the implementation of ITQs. Fishing firms face new costs associated with: changing personnel requirements; increased consultation with governments; calculations and transfers of IVQs; dockside monitoring; computerization; the now year-round operations of the sablefish fishery (Canadian Sablefish Association, n.d.). The sablefish fishery has also felt the impact of international developments such as rising fuel prices, the concomitant conversion of agricultural land to the production of biofuels and a subsequent rise in food prices, and the global financial crisis that began in 2008. Nevertheless, the sablefish fishery under ITQs has been characterized by industry analysts as "one of B.C.'s most lucrative" (Nelson, 2009, p. 67). And, as the foregoing discussion shows, the Canadian Sablefish Association, which represents all but one sablefish licence holder, is very satisfied with the current state of affairs.

In their analysis of the effects of ITQs on the sablefish and two other B.C. capture fisheries, Munro et al. (2009) concluded that ITQs represent a dramatic improvement over the previous Limited Entry system in terms of the industry's economic viability. Single-species ITQs are said to allow fishers to "better plan their season, to minimize wastage, service the market, and fish in a cost-effective and efficient manner. If the weather conditions are poor, fishers remain in port, or travel to different fishing grounds with more favourable conditions" (Munro et. al, 2009, p. 15).

The ITQ system has certainly had a profound effect on the industry's ability to service markets**.** In contrast to the bad old days when seasons were reduced to as little as 14 days in an effort to control TAC overages, sablefish fishers can now work year-round – which ensures a more stable, higher-quality supply to international markets. Figure 1 below reveals the value in Canadian dollars, by month, of sablefish catch for the years 2005 to 2009 inclusive.

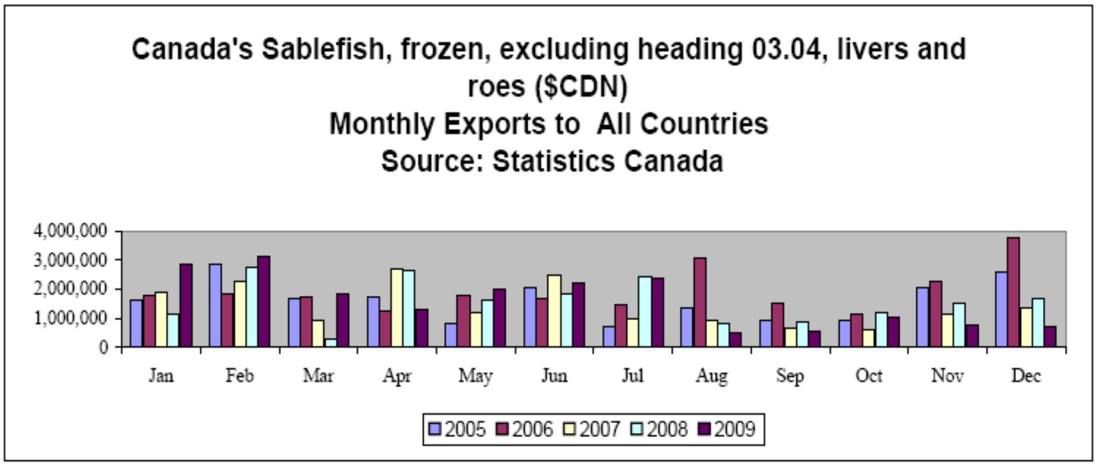

Figure 1. Canada's sablefish, frozen, excluding heading 03.04, livers and roes ($CND). Reproduced from "Canada's sablefish, frozen, excluding heading 03.04, livers and roes ($CND)," by Agriculture and Agri-Food Canada Fish and Seafood Online, 2010, *Export reports—2010 by species,* Ottawa, Ontario, Canada: Statistics Canada. Retrieved from http://www.ats-sea.agr.gc.ca/sea-mer/03037916-eng.pdf

Yet economic viability has other dimensions besides profitability – such as efficiency, for example. The question to answer therefore is: Has the ITQ system produced a sablefish industry that can be considered efficient?

Critics suggest that there are good reasons to examine this question. I am not aware of any study that has systematically examined the Pacific sablefish fishery from the point of view of efficiency or considered efficiency-related criticisms (such as the issue of "armchair fishing") of other ITQ fisheries in BC.

According to the Canadian Sablefish Association, "armchair fishing" does exist within the sablefish fishery; however, the CSA does not characterize armchair fishing as an ongoing practice by people who don't fish at all, but as one that rotates among different fishers every year. For example, one fisherman, having looked at enterprise as a whole, stated:

> "I've got these licenses. I'm best to invest in refitting my boat this year, and going after tuna. And taking my quota, you know, the quota's going for $4, $4.25 a pound. And you have no expenses, zero expenses on this right?" (R. MacDonald, personal communication, April 13, 2010).

In other words, quota leasing offers sablefish fishers more options for managing an investment portfolio, which typically includes other licences. According to Nelson (2007), the average sablefish licence holder has 2.6 additional licences. This practice has attracted criticism from fishers outside of the sablefish fishery. In 2006, Earle McCurdy, Chair of the Canadian Council of Professional Fish Harvesters (CCPFH) and President of the Fish Food and Allied Workers in Newfoundland, told media:

> We need fairness and consistency across regions. Why are black-cod and other quota-holders able to make money off the fishery without ever getting their hands dirty? The fishery shouldn't be run like that, shouldn't be controlled by carpetbaggers. (Canadian Council of Professional Fish Harvesters, 2006, p. 2)

Ron McDonald, Executive Director of the CSA, strongly dismisses such views: "I just think it's a lot of people belly-aching, because they see the sablefish licence holders with a well-managed, better-managed fishery, and secondly, a more profitable fishery" (personal communication, April 13, 2010).

However, the dynamics of leasing do appear to be changing, which has implications for how the CSA approaches its duties as co-manager. Ron McDonald goes on to comment on this topic:

> And a lot of us are getting older, getting more money, and more and more are moving over to leasing. And you know, it's interesting; when I've got to deal on some of the policy issues with them, I've got to take into consideration from the comments they're giving: 'Are you fishing?'. . . Because they will have a different view on some issues based on whether or not they're fishing. . . . There's more armchair fishing, certainly. Every year I see more. It's not a problem right now. It could become a problem—of access. (personal communication, April 13, 2010)

In closing this section it is salient to note that at its heart, efficiency in any industry is directly related to the extent to which it can exist without subsidy. Sumaila et al. (2009) define fishery subsidies as "financial transfers, direct or indirect, from public entities to the fishing sector, which help the sector make more profit than it would otherwise" (p. 2). Khan, Sumaila, Watson, Munro, and Pauly (2006) and Sumaila, Teh, Watson, Tyedmers, and Pauly (2008) have identified 12 types of subsidies to fisheries: (a) boat construction, renewal and modernization; (b) fishing port construction and renovation; (c) marketing support, processing and storage infrastructure; (d) tax exemption; (e) vessel buyback; (f) fuel subsidies; (g) rural fisheries community development; (h) fisheries management and services; (i) fishery research and development; (j) fishery development projects and support services; (k) foreign access agreements; and (l) fisher assistance programs.

Not all subsidies are seen in a negative light. Monke and Pearson (1989) have argued that subsidies to industry are justified when they are designed to address the externalities of a market failure, such as environmental degradation or the overutilization of common property resources. Sumaila et al. (2009) distinguish between the "good, the bad, and the ugly" subsidies to fisheries. "Good" subsidies are those which help to monitor and rebuild fish stocks and "bad" subsidies are those that serve to increase fishing efforts by increasing commercial fisheries' profits or reducing their costs—in effect, funding the overexploitation of marine resources. "Ugly" subsidies are less easily distinguished; depending on how they are designed and implemented, they may lead to a decline or increase in fishing effort. Examples include income supports such as employment insurance or vessel buyback programs that are meant to reduce overall fishing capacity, but ultimately enable owners to reinvest the funds received in bigger boats.

I will return to the question of whether ITQs constitute subsidies in Chapter 4; after determining that they do to a certain extent, I will examine whether they should be considered good, bad, or ugly and whether have they enhanced the economic viability of the sablefish fishery.

Before doing so, it is necessary to introduce the two economic models that will be applied in Chapter 4. In Chapter 3, I will examine Barichello's (1996) model (which was applied to the dairy industry) in order to calculate the risk associated with holding sablefish quotes. I will be including an element which, to the best of my knowledge, has yet to be calculated in fisheries: costs associated with policy risk. That is, the impact that quota-holders' expectations regarding the continuation of, elimination of, or change in government policies has on the market values of sold or leased quotas.

Next, I will examine Monke and Pearson’s (1989) Policy Analysis Matrix (PAM) to address the question of whether the sablefish industry is efficient.

Chapter 3: Method

The Policy Risk Parameter

Quota purchase prices are not merely a reflection of the conditions of supply and demand for sablefish. They contain an important dimension that is not readily identified: quota buyers' and sellers' expectations regarding the future stability of the policy regime that effectively imparts value to quotas. In other words, were quota holders to expect the government to significantly change the rules or to scrap the quota system entirely, the value of quotas could plummet. Conversely, were quota holders to anticipate long-term stability for a regime that supports its profitability, quota values could be expected to rise or at least be maintained. Quantifying the effect of "policy risk" on quota values is important because identifying the extent to which industry profitability depends on the support of a given policy regime concurrently exhibits the extent to which that industry can be considered internationally competitive: As Barichello (1996) observed:

> Understanding how government program benefits are capitalized holds more than academic interest. . . . it allows one to move from knowing the value of some protective asset (for example, a quota) to its otherwise unobserved annual income flows. Policy makers distinguish between protected industries which are high cost or inefficient and those with low costs that receive large economic rents due to the protection. This knowledge may allow us to estimate the annual benefits of protection from capital value of a quota, when the capital value alone normally conceals such information. (p. 283)

Analyzing the effect of policy risk on quota purchase values would support the use of Monke and Pearson's (1989) Policy Analysis Matrix (PAM) approach because it will help quantify how alternative policy scenarios could be expected to affect those values – and the consequent implications for industry viability**.** Barichello's (1996) model enables quantification of the effect of policy risk on quota values. By applying this model to the dairy industry, he revealed that the policy risk effect can be significant and vary widely over time. For example, the policy risk parameter was between 20 and 30 per cent of milk quota values in four provinces over a decade.

My research has applied Barichello's (1996) model to the sablefish fishery in the years 1997 to 2009, the most recent for which data is available. In this model, quota prices depend on the following:

> . . . the annual profits from that quota (its rental value), discounted at some rate of interest, and incorporating an expectation of growth in those annual profits (or capital gains) and the risk that the policy creating the quota rents may change to reduce or eliminate those rents (Barichello, 2009, p. 4)

Adapting the model to the sablefish fishery, we can determine policy risk by entering values into the following equation:

$P_q = R(1\text{-}d)/r + d - g)$

where

P_q = the sale price of sablefish quotas,

R = the profits (price less marginal costs) expected to be generated by sablefish quotas,

d = the “default” risk; i.e., the probability that quota rents will fall to zero because of a change in policy regime (for example, one that significantly decreases TACs to the point where quotas are no longer valuable, or one that ends the quota system altogether),

r = the nominal rate of interest, to account for non-diversifiable systematic risks that are associated with changes in macroeconomic variables such as interest rates, and

g = the expected rate of growth in P_q as a result of any possible new benefits to quota ownership, such as tax advantages, TAC increases, or expected allocations of new quotas.

Computing the values of all of the variables reveals the value of d, the extent to which policy risk affects the market value of quotas.

The Policy Analysis Matrix

The Policy Analysis Matrix (PAM) is a conceptual tool developed by Monke and Pearson in 1989 for the purpose of analyzing three principal issues in agricultural sectors: (a) the actual competitiveness and profitability of, and impact of policy on, agricultural systems; (b) the economic efficiency (or comparative advantage) of agricultural systems, and potential effects of public investment policies on this economic efficiency; and (c) the optimal allocation of funds for primary and applied agricultural research. As such, the PAM presents complex information about industry revenues, costs and profits in the form of a matrix that allows the relationships between values to be easily grasped. This is illustrated below in Table 7.

Table 7 *Policy Analysis Matrix Layout*

		Cost		
	Revenue	**Tradable inputs**	**Domestic factors**	**Profit**
Private prices	A	B	C	D
Social prices	E	F	G	H
Divergences and efficient policy	I	J	K	L
Effects of market failures	M	N	O	P
Effects of policy distortion	Q	R	S	T
Effects of efficient policy	U	V	W	X

Note. Private profits D = A – B – C; Social profits H = E – F – G; 0utput transfers I = A – E; also equals M + Q + U. Input transfers J = B – F; J also equals N + R + V. Factor transfers K = C – G; K also equals O + S + W. Net transfers L = D – H; L also equals I – J – K; and equal P + T + X.

The PAM row that includes variables A, B, C, and D represents a calculation of the private (that is, actual observed) revenues, costs, and profits of a composite firm that is representative of the agricultural system under study. The calculation requires an accounting of all factors of production (the level of the level of accounting detail is determined by the policy question under study) and the categorization of each cost as “tradable” or “domestic”. Information from this row alone can yield a useful economic profile of an agricultural system under current conditions.

The next row (containing variables E, F, G, and H) calculates the “social” revenues, costs, and profits of all of the factors described in the first row. These values are extrapolated from research into world averages of costs to produce a comparable product. Taken together, they constitute an international benchmark of efficiency. In Monke and Pearson’s (1989) model, efficiency is highest under conditions that produce the highest possible levels of national income.

The following row of the matrix is comprised of values I, J, K, and L. These values result from subtracting the “social” values of the second row from the “private” values of the first row. Divergences between private and social values reveal whether policies that govern the scenario described by the first row of calculations are actually supporting or degrading industry competitiveness, profitability and efficiency. In so doing, they quantify (in positive or negative terms) the amount of social profit, or the extent to which a given policy creates a situation that diverges from the most efficient state of production. Data from this row therefore allow policymakers to grasp the costs, in economic terms at least, of policies that create divergences from efficiency in order to serve non-efficiency goals such as affordable food, food security, or income re-distribution.

According to Monke and Pearson's (1989) model, policies that create such divergences are market-distorting: these are policies which typically arise from government interventions in economies which reduce national income and/or redistribute wealth. Monke and Pearson characterize most policies that are designed to serve such non-efficiency goals as counterproductive and undemocratic:

> The establishment of an efficient economy and the maximization of aggregate income are not the only, or necessarily the most important, goals of economic policy. When policy-makers are dissatisfied with the implications of income maximization, policies will be used to alter the economy. In some cases, these interventions will reflect neutral policymakers acting on a mandate from society. But more often, policies respond to the desires of special interest groups within or outside agriculture. (p. 2)

At the same time, Monke and Pearson (1989) see the kind of quantitative analysis permitted by the PAM as essential to the policymaking process and ultimately complementary to policy “negotiation”:

> Even if the appropriate tradeoffs between efficiency and nonefficiency objectives are not known, quantitative analysis of the economic impacts of policies retains immense importance. But rather than inform the government as to the appropriate actions it should be taking (or not taking), policy analysts provide fuel for the on-going debate between those who wish to change policies and those who wish to maintain them. Few, if any, policies are immutable, and disaggregated information about efficiency and nonefficiency effects of policy allows policymakers to form opinions about 'good' and 'bad' policies on an individual basis. Appropriate policy then emerges as a result of negotiation among those with potential to influence policy. (p. 7)

In other words, economists can aid resource policy negotiations by supplying timely, accurate, and relevant information with respect to changes in priorities, sectors, technologies, and economies. Quantitative policy analysis such as that provided by the PAM can therefore be a "dynamic simulation tool to guide patterns of growth and technical change" (Monke & Pearson, 1989, p. 6).

Correct use of the PAM yields many more layers of useful information to policymakers than can be detailed here. One element of particular relevance to this research is that the PAM also includes a process to further analyze the departures from efficiency (divergences) identified by the variables I, J, K and L. The process allows these divergences to be analyzed in terms of whether, and to what degree, they result from distorting policies or from appropriate government responses to market failures. The latter arise when "prices of goods or services will not reflect their true scarcity values because the private sector is unable to develop the institutions necessary for efficient market functioning" (Monke & Pearson, 1989, p. 2). Market failures occur when there is a lack of information about market options, when small numbers of buyers or sellers have the power to influence market prices, and as the result of externalities when benefits or costs from production activities are not reflected in market incentives.

In Monke and Pearson's (1989) analysis, all policies that serve non-efficiency goals in the absence of market failures should be considered distortionary, while all those which offset the effects of market failures in order to raise national income should be considered efficient. Further examination is thus required to ascertain the precise effects of policy.

The PAM and Pacific Sablefish

Applying the PAM to the Canadian Pacific sablefish fishery will offer insights into the industry's profitability, efficiency, and competitiveness. The model's usefulness for distinguishing between the effects of distorting policy and appropriate responses to market failure is particularly relevant to this research.

As we have seen, the ITQ system (as well as the Limited Entry system which preceded it) was a policy response to market failures in which rational profit-maximizing behaviour on the part of individual producers led not to the efficient distribution of resources or higher national income, but to over-capitalization, poorly served markets, economic losses resulting from destructive competition (for example, gear wars), unsafe working conditions, and resource degradation. However, given that critics have argued that ITQs actually degrade the economic viability of fishing (i.e., Bromley, 2009; Pinkerton & Danielle, 2009), it is reasonable to ask whether the ITQ system in the Pacific sablefish industry is in fact conferring benefits more than it is offsetting market failure. Economic viability can be equated with competitiveness, and as Monke and Pearson (1989) have pointed out, competitiveness requires more than profitability: in truly competitive systems, businesses break even after earning *normal* profits (profits which are at a level sufficient to maintain their investment).

Applying the PAM to the sablefish fishery requires the construction of a composite of the costs and profits of a firm that is representative of that industry. The Pacific sablefish industry lends itself well to this type of analysis because it is relatively small (there are only 48 licenced vessels). To be truly exhaustive, the construction of a firm-level budget for actual, observed production costs (fixed and variable, tradable and domestic) would require detailed and comprehensive information on fixed inputs, direct labour, intermediate inputs (those which are used up within a year), and outputs. The construction would also consider any products or services generated in the course of sablefishing that have economic value. The PAM analysis undertaken in this paper will be simplified due to the challenges associated with collecting proprietary information from fishers; however, it will still yield useful information with regard to the following questions: Has the ITQ system in the Pacific sablefish fishery adequately addressed market failure or created new market distortions? And to what extent can the industry be considered efficient?

For the purposes of analyzing the sablefish industry's revenues, costs and profits, I have chosen to focus on the year 2007. This will provide a picture that is still current enough to be relevant, while avoiding the need to address the atypical market conditions that resulted from the global financial crisis in 2008 and 2009. It also allows for the extrapolation and analysis of data that has already been collected by Nelson Bros Fisheries Ltd. (Nelson, 2007, 2009).

Nelson Bros Fisheries Ltd. annually collects DFO catch statistics, landed value data, and revenue and expense information from industry participants in order to develop and publish annual profiles of commercial west coast fisheries, including Pacific sablefish. Nelson (2009) describes the challenges associated with offering a definitive profile of an "average" fishing firm:

> The actual number of profiles within each fleet is almost as great as the number of vessels itself, as individual operators execute unique strategies (for fishing, marketing, leasing vs. owning, etc), possess a variety of vessel and equipment types (big boats, small boats, fast, slow, new, old, steel, wood, etc), and feature unique capitalization circumstances (asset costs, book values, debt levels, payment structures, equity arrangements, etc.). Given the diversity of fleet arrangements and a limited sample-size of industry participants consulted, revenue and cost information presented is deemed representative, but is not presented as precise or definitive. (p. 1)

It is also important to note that Nelson Bros Fisheries' financial profiles define profitability as "earnings before interest, taxes, depreciation and amortization" (Nelson, 2009, p. 2); that is, cash flow from operations. This calculation includes revenues and expenses that are directly related to fishing, but excludes non-cash items such as depreciation and capital charges such as interest and principal payments. Ideally, a PAM analysis would include estimations of replacement costs for assets, debt load and annual financing obligations. However, such costs have not been considered in Nelson Bros Fisheries' financial schedules because of the difficulty acquiring what is seen as commercially sensitive information and because the diversity of capitalization arrangements would greatly complicate such analyses.

It is equally necessary to consider Nelson's (2007) own disclaimer about the valuations it assigns to licence, vessel, and quota values. The sample size of licence and vessel values for the Pacific sablefish industry was less than three, which explains why Nelson (2007) states that this data has a "low" (p. 37) confidence level. The sample size of quota valuations was between three and five and the sample size of quota lease values was more than five; accordingly, Nelson (2007) rates the confidence level for these data as "medium" (p. 37).

In Chapter 4 I will source industry information to compute the costs of fishing. I will first apply Barichello's (1996) model to the sablefish fishery and discuss the results in order to answer the following questions: What is the risk of holding quotas when the rules that govern them are subject to substantial change or expected to change significantly, and how can that risk be quantified? Second, I will conduct a financial analysis of firms that are representative of the sablefish industry. This analysis will include asset valuation and will determine whether the industry is profitable as well as whether quota values pose a significant barrier to new sablefish industry entrants. Lastly, I will apply the PAM to the sablefish fishery utilizing the cost structure that was presented in the financial analysis. This will answer the following questions: Is the sablefish fishery efficient and has the ITQ system created a highly subsidized industry?

Chapter 4: Data Analysis

The Policy Risk Parameter

Barichello (1996) explained that parameter *g* (the rate of growth in quota values) is important to include because, over time, the value of quotas has increased and owning them has become more profitable. However, Barichello went on to note that while possibilities still exist for policy changes to facilitate growth, they are "considerably outweighed by possible changes that would reduce rents" (p. 295). The reasons for this include the fact that rents fostered by quota schemes are already large by most standards, political opposition, and pricing systems that are designed to avoid the emergence of monopolies.

Given that the sablefish industry has a relatively small number of licences which are mainly owned by family operations, the quota values and lease rates would be suspect to the inclusion of data noise. Quota holders could hold quotas in one business entity and lease it to their other business which engages in the fishing practice. In setting their prices, the quota holder choose to charge a lease rate that fits his or her tax planning while optimizing their net returns. The income received by a fisher as crew share is taxed according to the individual's tax brackets while returns received from leasing out quotas would be taxed under a different tax bracket. Another situation is during succession planning. When succession is within a family, a fisher would choose a quota value that fit his or her family arrangements and not necessarily market prices. In the dairy sector, these family transactions would not be recorded or included.

This data noise suggests that I choose a longer period for the growth rate and smooth both the quota values and lease rates. In addition, I will average the real interest rates over a period of 5 years. The averaging of real interest rate over such a period is considered appropriate given that the fisher would take into consideration the real interest rate over a longer period and not necessarily the current period's rate alone. It is expected that the fisher would consider historical rates for several years. Therefore, I will use a five year average. In choosing a suitable growth rate in quota values, I used several formulas. First, I used the annual growth rate over a period of 7 years.

Table 8 displays the calculation of the policy risk parameter values for the years 1997 to 2009 inclusive.

Table 8 *Calculated Risk Parameter Using 7 years Annual Growth Rate, 1997 to 2009*

Year	Pq ($)	R ($)	r	R/Pq	g	d
1997	53.56[a]	10.88	4.88	0.20	0.16	0.26
1998	56.50	5.38	5.41	0.10	0.15	0.18
1999	66.15	7.28	5.20	0.11	0.17	0.21
2000	92.68	10.94	4.55	0.12	0.18	0.23
2001	91.10	10.39[a]	4.61	0.11	0.15	0.20
2002	93.35	9.83	4.48	0.11	0.10	0.15
2003	103.89	8.79	3.34	0.08	0.11	0.15
2004	93.88	7.98	2.58	0.08	0.08	0.13
2005	80.31	5.74	2.18	0.07	0.05	0.09
2006	66.08	5.46	1.90	0.08	0.00	0.06
2007	71.00	4.85	1.87	0.07	-0.04	0.01
2008	54.56	5.25	1.76	0.10	-0.07	0.01
2009	76.05	9.25	1.69	0.12	-0.03	0.07

Notes: Annual growth rate = quota price / quota price 7 years earlier raised to the power of 1/7, then subtract 1. Pq = quota value / KG (expressed in 2007 dollars); R = quota lease rate / KG (expressed in 2007 dollars); r = 5 year average real interest rate (converted to decimals by dividing by 100); R/Pq = the ratio of lease rate to the quota value; g = expected growth rate in quota values; d = policy risk parameter.
[a]Calculated values have been linearly interpolated, i.e., calculated by averaging the previous and following two years.

The mean value over the period is 13 %. It falls noticeably during 2007 and 2008 and rises again during 2009. The recent rise may reflect the industry's collective concerns about negative effects such as the continuous downward trend in TAC or the sharp decline in TAC in 2008 combined with the financial crisis – or may perhaps stem from the ITQ policy itself.

Second, I used the annual growth rate over a seven-year period for 1997, an eight-year period for 1998 and a nine-year period for 1999 through to 2009. Although it would have been preferable to use an annual growth rate over a nine-year period, I used seven years for 1997 and eight years for

1998 due to the missing data on quota values for 1995 and 1996. Table A1 displays the calculation of the policy risk parameter values for the years 1997 to 2009, inclusive. The mean value over the period is 15%.

Third, I carried out a sensitivity analysis while smoothening out the quota values and lease rates over a three-year period. Both the quota values and the lease rates were averaged with the data for the previous and following years. Tables A3 and A4 display the calculation of the policy risk parameter values for the years 1998 to 2008 inclusive. The calculations for 1997 and 2009 were not included due to missing data for lease rates in 1996 and 2010. The mean value over this period is 13 % when using an annual growth rate over a period of seven years. When I use an annual growth rate over a period of eight years for 1998 and nine years for year 1999 to 2008, the mean value is 15 %.

Barichello (2009) explains that the policy risk parameter basically shows how the rental income is discounted into the quota capital value when the interest rate and expected appreciation of quotas are taken into account. In other words, is there an increased or decreased discount rate applied to the pricing of the quota from “other factors” than the prevailing interest rate and the history of the quota prices (Barichello, 2009, p. 7). Barichello (2009) interprets the primary “other factor” to be the perception of risk to the existing rent structure or perhaps the policy regime.

As Barichello (2009) explains, the expected growth rate in quota values is a key element in policy risk parameter analyses. According to Stuart Nelson (personal communication, May 21, 2010), factors affecting fishers’ growth expectations in a given year include: yearly TAC amounts; the selling prices of sablefish, which are influenced by the Japanese economy and emerging new markets; aquaculture; other sources of supply; First Nations’ land claims; DFO policies; additions to the list of endangered species compiled by the Species At Risk Act (SARA); and the quality of scientific research that would help mitigate environmental assessment concerns.

To better understand the above results, it would be useful to compare them with the results for the policy risk parameter that were calculated and presented by Barichello (2009). The average growth rate in (nominal) dairy quota prices going back to 1998/99 is nine percent (Barichello, 2009) (p.6), while the growth rate in sablefish quotas values for the same period is 2.74 %. Barichello (2009) states that the mean value of the policy risk parameter for dairy quotas from 1998 to 2009 is 15 %. (p. 7). The mean value of the policy risk parameter in sablefish quotas over the same period is between 13 % and 15%. Although the growth rate of the dairy quota is higher than the growth rate of the sablefish quota over the same period of time, the average mean of the risk parameter (the risk associated with holding the dairy quota) is almost the same for the sablefish quota. One interpretation of this difference is that although holding quotas in a supply management scheme is risky, holding quotas in a natural resource sector where the quota management scheme has sustainability objectives also has its own risks. There is international pressure to dismantle the management scheme for the dairy quota because it supports free international markets. On the other hand, the sablefish quota is managed by a scheme that has sustainability objectives; that is, the government, represented by the Department of Fisheries and Oceans, has the mandate of taking precautionary actions in order to maintain healthy fisheries. These actions include setting TACs, adding to the list of endangered species, and enacting new regulations to minimize discard rates.

In addition to facing the risk of policy changes, sablefish quota holders face an additional risk related to the biological factors that the DFO has to take in consideration when establishing TAC quantities every year. All policy risk parameter results display a downward trend. This trend is to be expected because when a new management scheme is implemented, fishers are initially uncertain about whether it stays the same or undergoes major changes that reduce a lucrative stream of revenue. The policy risk parameter captures both the risk of changes to policy and the risk posed by sustainability mandates. As time passes, several indicators could cause the fishers to view the management scheme as more stable. These indicators include government contribution to research, lobbying and strong representation by the CSA on behalf of the fishers, and the development of new markets. The policy risk parameter also captures factors which arise from one season to another and factors which help to mitigate some of the fishers' concerns. For example, obtaining sustainability certification from the Marne Stewardship Council would decrease the risk perceived by fishers.

Now that the sablefish industry and policy governing it seem quite stable, the risk has declined and d has declined along with it. In this case, the policy risk parameter captures more of the biological risks and less of the risk associated with policy being terminated. The declining value of d suggests that the policy risk parameter measures traditional policy risk adequately and comprehensively in the early years of a policy regime, when the policy risk dominates d.

Financial Analysis

I will begin this analysis by using data collected by Nelson Bros Fisheries Ltd. (Nelson, 2009) to present the 2007 cost structures of three firms that are representative of the industry. This will be followed by a second analysis of the data, which will examine the viability of the fleet in hypothetical scenarios that investigate how profitability would be affected if the producers who own the quotas accounted for the quotas' opportunity cost at the rates they would have received if they had leased them out during 2007. I will then summarize the aggregate cost structure of the entire industry. Finally, I will examine the replacement costs of assets for all three tiers of production.

My analyses will consider that most sablefish fishers also participate in other fisheries. This is in part due to the integration of the sablefish fishery with other groundfish fisheries, which began as a pilot project in 2006 and has since become permanent. In 2007, the average sablefish business held 2.6 other licences, with halibut and tuna fishing being the most common diversification activities (Nelson, 2009).

Combining Nelson Bros Fisheries Ltd. data with anecdotal reports from the CSA confirms that there is a high degree of stratification within the sablefish fishery. According to the CSA, about 17 of the 48 licences are trap licences, with the balance being longline; those with trap licences land the majority of the catch (R. MacDonald, personal communication, April 13, 2010). The top third of producers earned more than a combined $23.5 million in gross revenues.

In 2007, for example, the 11 producers who constitute the top third of producers landed more than 77% of the catch (see Table 9 below).

Table 9 *Breakdown of 2007 Catch Quantities of Sablefish by Production Tier*

Production tier	Catch (lbs)	Catch (%)	Catch per vessel (lbs)	No. of vessels
Top third	5,063,778	77	460,343	11
Middle third	1,174,046	18	106,731	11
Bottom third	338,085	5	30,735	11
Total	6,575,909	100	199,270	33

Notes: Reproduced from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 68), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

As mentioned, sablefish-directed vessels have, on average, 2.6 other licences per vessel. Accordingly, the above tables include revenues not only from sablefish, but also from other groundfish.

I will now proceed to analyze the industry as it would operate if all active licencees were required to pay (or account for) market rates for all or a portion of the most important factor of production in all the production tiers: sablefish quotas. As will be demonstrated, the results of this analysis are revealing.

First, I will examine the lowest tier of production and show how vessel profitability changes in scenarios where vessel owners pay for 30%, 60%, 100%, and none of their quotas, assuming that all other costs remain at observed 2007 levels. In all cases, I will be accounting for the opportunity cost of the quotas owned.

Tables 10, A4, A5 and A6 respectively, illustrate these scenarios for the bottom tier.

Table 10 *Cost Structure of Bottom Tier Representative Firm When Leasing 30% of Quotas*

Bottom tier (1/3) Individual vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	30,735	3,706	34,441
Vessel price ($ per lb)	4.50	1.24	4.15
Gross revenue (gross stock) ($)	**138,308**	**4,582**	**142,890**
Fishery specific expenses ($)			
Fuel	10,245	--	10,245
At sea monitoring	2,869	--	2,869
Offload monitor	615	74	689
Licence / co-management fees	10,757	--	10,757
Quota leases	23,051	334	23,385
Bait	6,147	--	6,147
Gear maintenance/ Replacement	11,200	--	11,200
Total fishery specific expenses ($)	64,884	408	65,292
Net revenue (net stock) ($)	73,424	4,174	77,598
Less:			
Crew and captain shares ($)	29,369	1,670	31,039
Fishery contribution ($)	44,055	2,504	46,559
Vessel fixed expenses ($)			
Insurance			4,000
Repairs and maintenance			12,000
Moorage			1,200
Miscellaneous			2,000
Total vessel			19,200

Bottom tier (1/3) Individual vessel	Sablefish (K)	Other groundfish	Total
expenses ($)			
Earnings (EBITDA) ($)			**27,359**
Opportunity cost of owned quota ($)			53,786
Net earnings if opportunity cost is accounted for ($)			**-26,427**

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Reproduced from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 71), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd. except for last two rows.

For the bottom tier, Table 10 closely resembles reality in 2007, as during this year fishers had to lease-in 30% of their sablefish quotas. They were able to generate a reasonable profit of $27,359. However, Tables A4, A5 and A6 illustrate the differential effects of having to pay for 60%, 100% and none of their quotas. Earnings plunge to $4,308 when fishers purchase 60% of their quotas and to a loss of $26,428 when fishers must purchase all of their quotas. In scenarios where fishers need not purchase any quotas – as would be the case if they had been allocated ITQs equivalent to what they actually catch – vessel profits could reach as high as $50,410.

The bottom tier business is usually composed of 2 to 3 fishers who use longline gear and have a more diversified portfolio than fishers in the other tiers. They usually fish halibut and groundfish in addition to sablefish. When fishers account for the opportunity cost of their assets, the net earnings figures change drastically. Depending on what the fisher considers to be the opportunity cost of his or her assets, or how much he/she decides to account for, the numbers can change. In the above examples, I assumed the opportunity cost would be equivalent to ongoing lease rates in 2007, especially since they are the only opportunities for such an asset to be leased out to other fishers or sold. I also assumed that the fishers chose to fully account for the opportunity cost. The results were revealing. It seems that fishers in this tier of production face tight cost structures that would eventually force them to exit the industry. However, they have various other considerations that help them to rationalize their decision to remain in the business. For example, the crew share is divided among family members, so it is considered to be income derived from the fishing operation. The increase in quota value expectation is also an important factor; fishers who remain in business make some assumptions about the expected rate of growth in the quota value. The fact that the crew of the bottom tier is mostly composed of family members has value in itself to the fishers.

We turn now to the middle tier of production. Tables 11, A7, A8 and A9 show how vessel profitability changes in scenarios where these vessel owners pay for 30%, 60%, 100%, and none of their quotas, assuming that all other costs remain at observed 2007 levels:

Table 11 *Cost Structure of Middle Tier Representative Firm When Leasing 30% of Quotas*

Middle tier (1/3) Individual vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	106,731	12,871	119,602
Vessel price ($ per lb)	4.50	1.24	4.15
Gross revenue (gross stock)($)	**480,292**	**15,912**	**496,204**
Fishery specific expenses ($)			
Fuel	26,683	--	26,683
At sea monitoring	6,226	--	6,226
Offload monitor	1,334	161	1,495
Licence / co-management fees	37,356	--	37,356
Quota leases	80,048	1,158	81,206
Bait	21,346	--	21,346
Gear maintenance/	11,200	--	11,200

Middle tier (1/3) Individual vessel	Sablefish (K)	Other groundfish	Total
replacement			
Total fishery specific expenses ($)	184,193	1,319	185,512
Net revenue (net stock) ($)	296,099	14,593	310,692
Less:			
Crew and captain shares ($)	118,439	5,837	124,276
Fishery contribution ($)	177,660	8,756	186,416
Vessel fixed expenses ($)			
Insurance			8,000
Repairs and maintenance			25,000
Moorage			1,200
Miscellaneous			2,000
Total vessel expenses ($)			36,200
Earnings (EBITDA) ($)			**150,216**
Opportunity cost of owned quota			186,779
Net earnings if opportunity cost is accounted for ($)			**-36,563**

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Reproduced from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 70), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd. except for last two rows.

Table 11, in which fishers purchase approximately 30% of their quotas, closely reflects the reality of 2007. Individual vessels in this tier of production would earn profits of $150,216. Tables A7, A8 and A9 illustrate the differential effects of purchasing 60%, 100%, and none of their quotas. Profitability drops considerably to $70,168 when fishers purchase 60% of their quotas and to a loss of $36,564 when fishers must purchase all of their quotas. In scenarios where fishers need not purchase any quotas—as would be the case for those whose ITQs equate to what they actually catch—vessel profits can increase to $230,264.

Middle tier businesses are usually composed of three to four crew members who can either be family members or hired employees. This tier usually uses trap gear to fish. The net earnings of the fisher, if the opportunity cost of his/her quota is fully accounted for, could still be negative. However, the net earnings are not significant and can be mitigated by considering various factors; for example, the value of the opportunity cost can have a significant effect on the net earnings value. As is the case for the bottom tier, being in the fishing business would still have value for fishers and they might increase or reduce their crew share (i.e., their personal income) or their anticipated value with regard to the expected growth of quota values over time. All these factors help explain why fishers would remain in business.

We turn finally to the top tier of production. Tables 12, A10, A11 and A12 show how vessel profitability changes in scenarios where vessel owners in this tier pay for 30%, 60%, 100%, and none of their quotas**,** assuming that all other costs remain at observed 2007 levels.

Table 12 *Cost Structure of Top Tier Representative Firm When Leasing 30% of Quotas*

Top tier (1/3) Individual vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	460,343	55,513	515,856
Vessel price ($ per lb)	4.50	1.24	4.15
Gross revenue (gross stock)($)	**2,071,546**	**68,631**	**2,140,177**
Less: Fishery specific expenses ($)			
Fuel	131,527	--	131,527
At sea monitoring	18,414	--	18,414

Top tier (1/3) Individual vessel	Sablefish (K)	Other groundfish	Total
Offload monitor	3,453	416	3,869
Licence / co-management fees	161,120	--	161,120
Quota leases	345,257	4,996	350,253
Bait	92,069	--	92,069
Gear maintenance/ replacement	11,200	--	11,200
Total fishery specific expenses($)	763,040	5,412	768,452
Net revenue (net stock)($)	1,308,506	63,219	1,371,725
Less: Crew and captain shares ($)	523,402	25,287	548,690
Fishery contribution ($)	785,104	37,932	823,035
Vessel fixed expenses ($)			
Insurance			15,000
Repairs and maintenance			125,000
Moorage			2,000
Miscellaneous			10,000
Total vessel expenses ($)			152,000
Earnings (EBITDA) ($)			**671,035**
Opportunity cost of owned quota			805,600
Net earnings if opportunity cost is accounted for ($)			**-134,566**

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Reproduced from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 69), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd. except for last two rows.

Not surprisingly, the same observations hold for the top tier of production. Table 12, showing a scenario in which fishers purchase approximately 30% of their quotas, closely reflects the reality of 2007. Individual vessels in this tier of production would earn profits of $671,035. Tables A10, A11 and A12 illustrate the differential effects of purchasing 60%, 100%, and none of their quotas, which is similar to the lower and middle tiers. Earnings decline to $325,779 when vessel owners must purchase 60% of their quotas and vessel owners actually suffer a loss of $134,565 when they must purchase all of their quotas. In scenarios where fishers need not purchase any quotas—as would be the case for those whose ITQs equate to what they actually catch—vessel profits increase to $1,016,293.

Top tier fishers use trap gear and are usually composed of four to five fishers; the owner may or may not be one of them. The settlement arrangements of crew shares may be different. It may be more like a wage as opposed to the crew share percentage system used by fishers in the middle and bottom tier businesses. Alternatively, the crew share may be lower than it is for the other tiers. One explanation for this difference is the low risk associated with catching fish. These fishers have both larger boats and larger gear, which increases the chance of catching the targeted quantity of fish.

When accounting for the opportunity cost of their quotas, fishers have net earnings that show negative figures. However, given the capitalization of the quota value and its historical growth rate, fishers could easily mitigate this negative figure by accounting for the growth in their capital asset – the value of their quotas.

One way of looking at the highly stratified nature of cost structures in the sablefish fleet is by considering the averages for individual vessels within each tier. It is important to note that the cost structure shown below is based on an assumption that quota holders lease-in 30% of their quotas. This cost structure is shown below in Table 13:

Table 13 *Aggregate of Cost Structures of Individual Representative Firms of All Tiers When Leasing 30% of Quotas*

Sablefish fleet Individual vessels	**Top 1/3**	**Middle 1/3**	**Bottom 1/3**	**Fleet average**
Landings (total lbs in $)	515,856	119,602	34,441	223,300
Vessel price ($ per lb)	4.15	4.15	4.15	4.15
Gross revenue (gross stock) ($)	**2,140,177**	**496,204**	**142,890**	**926,423**
Less: Fishery specific expenses ($)				
Fuel	131,527	26,683	10,245	56,152
At sea monitoring	18,414	6,226	2,869	9,169
Offload monitor	3,869	1,495	689	2,018
Licence / co-management fees	161,120	37,356	10,757	69,744
Quota leases	350,254	81,207	23,385	151,615
Bait	92,069	21,346	6,147	39,854
Gear maintenance/ replacement	11,200	11,200	11,200	11,200
Total fishery specific expenses ($)	768,452	185,513	65,291	339,752
Net revenue (net stock) ($)	1,371,724	310,691	77,598	586,671
Less: Crew and captain shares ($)	548,690	124,276	31,039	223,737
Fishery contribution ($)	823,034	186,414	46,559	362,934
Vessel fixed expenses ($)				
Insurance	15,000	8,000	4,000	9,000

Sablefish fleet Individual vessels	Top 1/3	Middle 1/3	Bottom 1/3	Fleet average
Repairs and maintenance	125,000	25,000	12,000	54,000
Moorage	2,000	1,200	1,200	1,467
Miscellaneous	10,000	2,000	2,000	4,667
Total vessel expenses ($)	152,000	36,200	19,200	69,133
Earnings (EBITDA) ($)	**671,034**	**150,214**	**27,359**	**293,801**

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Reproduced from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 72), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Having offered a picture of a representative firm's profitability in 2007, I will aggregate the cost structures for each tier in order to provide a full industry outlook. I have chosen to aggregate the cost structure of an assumed 30% quota lease, which is presented in Tables A13, A14 and A15 below.

Tables A13, A14 and A15 reveal the breakdown of revenue and expenses as they relate to sablefish and other groundfish for each production tier in the aggregate.

The sablefish fishery is frequently characterized as "lucrative" and Table 13 below shows why. The far right-hand column of Table 13 reveals fleet-wide revenues and expense totals in aggregate; the middle three columns reveal aggregate values by production tier. As seen, the 33 active K-licenced vessels depicted in the table collectively landed more than $30.5 million worth of fish.

Table 14 *Summary of All Three Production Tiers in Sablefish*

Sablefish fleet totals	Top 1/3	Middle 1/3	Bottom 1/3	Total
Landings (total lbs in $)	5,674,417	1,315,624	378,855	7,368,896
Vessel price ($ per lb)	4.15	4.15	4.15	4.15

Sablefish fleet totals	Top 1/3	Middle 1/3	Bottom 1/3	Total
Gross revenue (gross stock) ($)	**23,541,942**	**5,458,241**	**1,571,786**	**30,571,970**
Less: Fishery specific expenses ($)				
Fuel	1,446,794	293,512	112,695	1,853,000
At sea monitoring	202,551	68,486	31,555	302,592
Offload monitor	42,558	16,445	7,577	66,581
Licence / co-management fees	1,772,322	410,916	118,330	2,301,568
Quota leases	3,852,791	893,277	257,233	5,003,301
Bait	1,012,760	234,809	67,617	1,315,186
Gear maintenance/ replacement	123,200	123,200	123,200	369,600
Total fishery specific expenses ($)	8,452,976	2,040,645	718,206	11,211,827
Net revenue (Net stock) ($)	15,088,966	3,417,597	853,580	19,360,142
Less: Crew and captain shares ($)	6,035,582	1,367,037	341,434	7,744,053
Fishery contribution ($)	9,053,384	2,050,560	512,146	11,616,090
Vessel fixed expenses ($)				
Insurance	165,000	88,000	44,000	297,000
Repairs and maintenance	1,375,000	275,000	132,000	1,782,000
Moorage	22,000	13,200	13,200	48,400
Miscellaneous	110,000	22,000	22,000	154,000
Total vessel expenses ($)	1,672,000	398,200	211,200	2,281,400
Earnings (EBITDA) ($)	**7,381,384**	**1,652,360**	**300,946**	**9,334,690**

Note. Number of vessels in each tier = 11. Total number of vessels = 33. Crew shares from other groundfish have been added to original source. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Reproduced from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 76), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Table 15 below shows the approximate number of active sablefish vessels that were also engaged in the halibut and tuna fisheries in 2007. The highest percentage of participation in these other fisheries is thought to come from the lower production tiers (Nelson, 2009, p. 78).

Table 15 *Approximate Number of Active Sablefish Vessels Also Engaged in the Halibut and Tuna Fisheries in 2007*

Sablefish fleet Include other fisheries	Sablefish[a]	Halibut[b]	Tuna[c]	Total
Landings (total lbs in $)	7,368,896	957,186	770,200	9,096,282
Vessel price ($ per lb)	4.15	4.27	1.55	3.94
Gross revenue (gross stock)($)	**30,571,970**	**4,088,622**	**1,193,810**	**35,854,401**
Less: Fishery specific expenses ($)				
Fuel	1,853,000	102,814	151,335	2,107,149
At sea, offload monitoring and licence / co-management fees	2,670,740	222,347	5,000	2,898,088
Stacked licence/quota lease	5,003,301	711,435	--	5,714,736
Bait	1,315,186	74,795	--	1,389,981
Gear maintenance/ replacement	369,600	14,959	15,833	400,392
Total fishery specific expenses ($)	11,211,827	1,126,350	172,168	12,510,346
Net revenue (net stock) ($)	19,360,142	2,962,272	1,021,642	23,344,056
Less: Crew and captain shares ($)	7,383,319	1,184,909	459,739	9,027,966
Fishery contribution ($)	11,976,824	1,777,363	561,903	14,316,090
Vessel fixed expenses				
Insurance				297,000

Sablefish fleet Include other fisheries	Sablefish[a]	Halibut[b]	Tuna[c]	Total
Repairs and maintenance		37,500	20,000	1,839,500
Moorage				48,400
Miscellaneous				154,000
Total vessel expenses ($)				2,338,900
Earnings (EBITDA) ($)				**11,977,190**

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Reproduced from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 78), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.
[a]Number of vessels = 33. [b]Number of vessels = 15. [c]Number of vessels = 10.

The foregoing tables illustrate that the free initial allocation of quotas has not in itself created significant wealth among fishing firms. Profitability is not correlated with the benefits of having received free gifts of quotas so long as fishers account for the opportunity cost of those quotas. From a profitability point of view, the ITQ system has resulted in an economically viable industry. However, it is important to remember that the cost structure is different for each of the three tiers.

For example, at 2007 market rates for the quotas, firms in the lowest tier of production would be just barely in business if they had to purchase 60% of their quotas. In both the middle and top tiers of production, firms that paid for 60% of their quotas would still be generating considerable profits. For these firms, the break-even point rests somewhere in between 60% and 100%. If all firms were required to purchase their entire quotas at 2007 market rates, none of the firms would be viable. The most salient conclusion is that the amount which fishers deem to be the opportunity cost of the quotas they own along with other factors relative to each tier determines the net earnings of their businesses.

There are several caveats to the foregoing discussion. First, as previously mentioned, Nelson Bros Fisheries Ltd. data does not include capital or debt-service costs, so these have not been included. Furthermore, Nelson (2009) cautions that estimates of crew shares may be generous and notes that industry data was collected from very small sample sizes (in some cases, less than three). Second, due to a lack of available data, the foregoing analyses have excluded a significant portion (up to 28%) of the industry in 2007. This portion is composed of the 13 firms that chose not to fish with sablefish licences. Their profits, some or all of which would have been earned from leasing sablefish quotas and not having to pay the expenses associated with fishing for sablefish, have not been factored into the profitability analysis; therefore, I used the ongoing lease rate as the opportunity cost to capture this portion of returns.

An important question needs to be addressed before concluding the discussion on cost structures. That is: could the lease rates be overstated? To answer this question, it is important to consider that as the sablefish industry is relatively small, both active and inactive fishers have to preplan their season. Those who decide to be inactive would lease their available quotas and those who decide to fish would have an opportunity to lease in additional quotas and increase their capacity in a given year. This preplanning is likely to involve direct mutual agreements between the fishers. However, brokers provide another mechanism for leasing quotas. There are various reasons why fishers who choose to use brokers do not have an opportunity to secure their quotas earlier in the season. For example, fishers might secure quotas for unexpected amounts which exceed their allowed catch. This situation could account for a possible difference between the quota lease rates fishers would be willing to pay to lease in quotas in order to cover their excess catch and the quota lease rates they would be willing to pay if they plan their season in order to increase catch capacity. If fishers decide to lease out their quotas, they would either lease them out at a lower rate to a peer ahead of the season or lease them out through a broker at higher rates. This could give rise to a situation in which fishers obtain their leased in quota at a price higher than the price they would receive if they leased out their entire quotas, which means that the opportunity cost of the quota could be severely overstated. Another possible reason for overstated lease rates is that the fishers would like to demonstrate low returns because they are concerned about policy changes. The low returns would put fishers in a position that could discourage the DFO from implementing regulating schemes that might reduce their profit margins. This would be more likely in the Canadian sablefish fishery than other Canadian fisheries because it is among the most lucrative ITQ fisheries in the country.

I now turn to an analysis of the replacement cost of assets. The assets that will be examined are: the K-licence, quotas, and vessels. The K-licence value is $250,000 dollars per licence, and is required, along with a quota, for a fisher to fish. The quota value is based on a per pound dollar value; in 2007, the average purchase rate was $ 25/lb. The quota is a secured percentage of the TAC, not a guarantee for a fixed amount of fish, and TACs can and do change on year-to-year basis. In other words, there are risks associated with changes to the TAC. A fisher's portfolio could potentially include a portion of each of the following: quotas initially allocated at no cost; quotas purchased, and; quotas leased.

Table 16 below describes different vessels used by sablefish fishers and provides an estimated value for each type:

Table 16 *Vessel Classification and Estimated Values*

Vessel type		**Classic style**			**Modern style**		**Total / Average**
		Wood	*Aluminum/ Fibreglass*	*Steel*	*Aluminum/ Fibreglass*	*Steel*	
Inside waters / Smaller vessel	**Est # vessels**	1	2	--	4	--	7
	Unit value ($)	25,000	125,000	--	300,000	--	210,714
	Aggregate value ($)	25,000	250,000	--	1,200,000	--	1,475,000
Outside waters / Larger vessel	**Est # vessels**	7	7	6	6	13	39
	Unit value ($)	65,000	175,000	200,000	400,000	500,000	302,051
	Aggregate value ($)	455,000	1,225,000	1,200,000	2,400,000	6,500,000	11,780,000
Total / average	**Est # vessels**	8	9	6	10	13	46

Average value ($)	60,000	163,889	200,000	360,000	500,000	288,152
Aggregate value ($)	480,000	1,475,000	1,200,000	3,600,000	6,500,000	13,255,000

Notes. Reproduced from *Commercial fishing licence, quota, and vessel values: As at March 31, 2007* (Prepared for DFO, Pacific Region, p. 38), by S. Nelson, 2007, Vancouver, British Columbia, Canada, Nelson Bros Fisheries Ltd.

Table 17 below analyzes the replacement cost of assets for each production tier. The vessel costs include gear and are based on the purchase of used vessels. This analysis assumes that 50% of the assets' value is borrowed.

Table 17 *Asset Valuation Based on 50% Loan and 15 Years Amortization Period*

Sablefish replacement cost of assets ($)	**460,343 lb Sablefish quota**	**106,731 lb Sablefish quota**	**30,735 lb Sablefish quota**
Licence cost	250,000	250,000	250,000
Quota	11,508,586	2,668,286	768,375
Vessel cost	1,000,000	500,000	250,000
Replacement cost	12,758,586	3,418,286	1,268,375
Amortization cost (annual at 5%)	637,929	170,914	63,419
Loan considerations if 50% borrowed:			
Loan amount	6,379,293	1,709,143	634,188
Interest (1st year)	510,343	136,731	50,735
Principal (1st year, 15-yr amortization)	425,286	113,943	42,279
1st year pmt (principal + interest):	**935,630**	**250,674**	**93,014**
Earnings (EBITDA) ($)	1,016,293	230,264	50,410
Net Earnings ($)	**80,663**	**-20,410**	**-42,604**

Note. Adapted from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 78), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

As shown in the table above, 1st year payment amounts are well above the yearly earnings of the middle and bottom tier. However, it is interesting to note that for bottom tier businesses, the 1st

year payment is 185% above the earnings in 2007, while for middle tier businesses, the 1st year payment is 109% above the 2007 earnings. The 1st year payment amount is reasonably below the yearly earnings of the top tier, which would result in a surplus of $80,663. This clearly highlights the challenges that new bottom tier entrants can face as compared to new top tier entrants.

For new bottom and middle tier entrants to consider entering the fishing business, having a down payment of 50% is not sufficient to break even. A higher down payment would be required to lower the monthly payment to a level below earnings. Table 18 below shows the changes in figures for a 35-year amortization period.

Table 18 *Asset Valuation Based on 50% Loan and 35 Years Amortization Period*

Sablefish replacement cost of assets ($)	**460,343 lb Sablefish quota**	**106,731 lb Sablefish quota**	**30,735 lb Sablefish quota**
Licence cost	250,000	250,000	250,000
Quota	11,508,586	2,668,286	768,375
Vessel cost	1,000,000	500,000	250,000
Replacement cost	12,758,586	3,418,286	1,268,375
Amortization cost (annual at 5%)	637,929	170,914	63,419
Loan considerations if 50% borrowed:			
Loan amount	6,379,293	1,709,143	634,188
Interest (1st year)	510,343	136,731	50,735
Principal (1st year, 35-yr amortization)	182,266	48,833	18,120
1st year pmt (principal + interest):	**692,609**	**185,564**	**68,855**
Earnings (EBITDA) ($)	1,016,293	230,264	50,410
Net Earnings	**323,684**	**44,700**	**-18,445**

Note. Adapted from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 78), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

The above table shows lower figures for the 1st year payment amount. For the bottom tier, the 1st year payment amount is now 137% above the earnings in 2007, while for the middle and top tier; the 1st year payment amounts is lower than the 2007 earnings. Once again, the financial challenges facing new bottom tier entrants are clearly greater than those encountered by new middle and top tier entrants.

I now would like to consider the option that new entrants would be financing quotas only, at 2007 rates. This could be the case for: a) active fishermen who would be increasing their quotas; b) the fishers of other fisheries, or; c) new entrants who already have their own vessels. Table 18 below presents the figures for a 50% loan on quotas, for 35-year amortization periods:

Table 19 *Asset Valuation for Quotas Only Based on 50% Loan and 35 Years Amortization Period*

Sablefish replacement cost of assets ($)	**460,343 lb Sablefish quota**	**106,731 lb Sablefish quota**	**30,735 lb Sablefish quota**
Quota	11,508,586	2,668,286	768,375
Replacement cost	11,508,586	2,668,286	768,375
Amortization cost (annual at 5%)	575,429	133,414	38,419
Loan considerations if 50% borrowed:			
Loan amount	5,754,293	1,334,143	384,190
Interest (1st year)	460,343	106,731	30,735
Principal (1st year, 35-yr amortization)	164,408	38,118	10,977
1st year pmt (principal + interest):	**624,751**	**144,849**	**41,712**

Note. Adapted from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 78), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

The above figures reiterate the overall challenges facing the bottom production tier. Given that all the figures are based on a 50% loan to purchase quota, new entrants in that tier would have to own at least all of the other assets outright in order to enter the industry.

Although earnings of the bottom tier in the sablefish industry do not seem to support the purchase or financing of 50% of all assets, it is important to note that in 2007 the TAC and the vessel price per pound were both at a low level. A more detailed cash flow would be required in order to examine the ability of new entrants to enter the industry. An important issue to study would be the ability of different production tiers to borrow money to cover possible negative return during the initial investment period. However, from an economics point of view, the industry is profitable on the long run.

The Policy Analysis Matrix

What does all of the above tell us about industry efficiency? At this point I will use a simplified version of the PAM model to quantify the impact of quota values on efficiency. To do this, I will first compute "private profit" by subtracting actual, observed costs from actual, observed revenues for the tiers of production already examined. Then, I will compute "social" profits by running the same calculations, this time removing the amounts of all known taxes or subsidies that would change the equation. By deducting social revenues, social costs, and social profits from private revenues, private costs, and private profits, I will quantify a divergence between profitability under a system that is subsidized and a system that is not subsidized. The amount of this divergence is considered the cost to the economy of efficiency lost in order to serve whatever goal motivated the subsidy or tax. A positive number would represent a net loss of efficiency to the economy, while a negative number would represent a net gain. A divergence of zero would describe a completely competitive and efficient industry in which all production inputs command their full market value.

It should be noted at this point that a comprehensive PAM analysis would factor in and itemize all costs and revenues and all sources of subsidy and/or tax. However, time and resource constraints, along with the difficulties of gathering what firms consider to be competitive information, make this impossible. To simplify the analysis, I will assume that all revenues from sablefish fishing are purely market-determined (which they probably are) and that all other factors of production, including quotas (when opportunity cost is fully accounted for) and labour, are purchased at market-determined prices (which is assuredly not the case, considering the many ways that government programs affect the prices of factors such as labour and fuel). All of these other factors are held constant simply to quantify any divergence from a pure state of efficiency in which subsidies might be a factor.

Using data from the previous tables, I have constructed a PAM analysis to show how the industry would look if it were paying for a portion of the quotas and accounting for all of the owned portions at 2007 market rates. Tables 20 through 22 illustrate this for firms representing the bottom, middle and top tiers of production and Table 23 presents an aggregate for the entire industry:

Table 20 *PAM Analysis for an Individual Representative Firm of Bottom Tier (1/3) of Producers*

		Cost						
	Gross revenues ($)	Quota lease value ($)	Fishery specific expenses ($)	Crew share ($)	Co-management fees ($)	DFO contribution ($)	Vessel fixed expenses ($)	Profit ($)
Private	142,890	77,172	31,150	31,039	10,757	0	19,200	–26,428
Social	142,890	77,172	31,150	31,039	10,757	1,290	152,000	–27,718
Divergence	0	0	0	0	0	-1,290	0	1,290

Table 21 *PAM Analysis for an Individual Representative Firm of Middle Tier (1/3) of Producers*

		Cost						
	Gross revenues ($)	Quota lease value ($)	Fishery specific expenses ($)	Crew share ($)	Co-management fees ($)	DFO contribution ($)	Vessel fixed expenses ($)	Profit ($)
Private	496,204	267,986	66,950	124,276	37,356	$0	36,200	–36,564
Social	496,204	267,986	66,950	124,276	37,356	4,483	36,200	-41,047
Divergence	0	0	0	0	0	-4,483	0	4,483

Table 22 *PAM Analysis for an Individual Representative Firm of Top Tier (1/3) of Producers*

		Cost						
	Gross revenues ($)	Quota lease value ($)	Fishery specific expenses ($)	Crew share ($)	Co-management fees ($)	DFO contribution ($)	Vessel fixed expenses ($)	Profit ($)
Private	2,140,177	1,155,854	257,079	548,690	161,120	0	152,000	-134,566
Social	2,140,177	1,155,854	257,079	548,690	161,120	19,334	152,000	-153,910
Divergence	0	0	0	0	0	-19,334	0	19,334

The above tables reiterate what was observed in the financial analysis above: if all factors of production were being purchased at full market-determined rates, all observed costs do not appear to be subsidized (with the exception of the DFO's contribution to research). Since the DFO's contribution benefits the fishers directly by contributing to a healthy fishery, it is in this case seen as a subsidy.

Table 23 *Aggregate PAM Analysis of the Sablefish Industry in 2007 Over All Tiers and Firms*

		Cost						
	Gross revenues ($)	Quota lease value ($)	Fishery specific expenses ($)	Crew share ($)	Co-manageme nt fees ($)	DFO contribution ($)	Vessel fixed expenses ($)	Profit ($)
Private	30,571,970	16,511,132	3,906,959	7,744,053	2,301,568	$0	2,281,400	-2,173,142
Social	30,571,970	16,511,132	3,906,959	7,744,053	2,301,568	308,900	2,281,400	-2,482,042
Divergence	0	0	0	0	0	-308,900	0	308,900

Although the market appears to be unprofitable, the above profit figures are based on the assumption that certain portions of the quotas are leased and others are accounted for as an opportunity cost equivalent to the ongoing lease rate in 2007. Other factors have been discussed in the previous section that could alter the amount of opportunity cost that makes this industry profitable enough for fishers to remain in the business. If all fishers had to lease-in a high portion of their quotas and markets determined lease prices, quota lease rates would drop well below 2007 market rates. If the subsidy alone were to be addressed, it would be apparent that in all situations, the industry seems to some extent subsidized.

The DFO's contributions have been identified as a subsidy for the purpose of this analysis. It is important to note that the amount of this divergence is considered to be the cost to the economy of efficiency lost in order to serve the sustainability goals that motivated the subsidy – which means that a decrease in efficiency is by no means the economic death-knell of the industry.

The PAM analysis proves that the industry is not heavily subsidized as a result of the free initial quota allocation – as the critics of the ITQ system claim. As Munro (2009) has described, the issues raised by ITQ critics mainly concern distribution. The financial analysis and the PAM tables above show that: a) the industry is profitable, b) under certain quota lease percentages, profitability decreases, and c) under situations where quotas have to be entirely leased, there can be negative profitability. Under certain circumstances, the industry is economically viable and lucrative. For example, it is more lucrative for those who are in the top tier than for those who are in the middle and bottom tiers, providing that other factors remain constant. It is also more lucrative for those who lease fewer quotas than for those who lease more quotas.

Does this mean that the existence of zero profits in the state of efficiency described in Tables 19 through 21 indicates that all quest for efficiency ought to be jettisoned? The answer is, not at all. If markets were more accessible to new entrants and the prices of quotas were determined by markets, quota prices would drop considerably, settling at a level where firms would continue to make "normal" profits (that is, profits sufficient to cover actual and opportunity costs).

Inaccessibility to the market is at the heart of the efficiency argument. It is a source of inefficiency on its own and is also tied to the property rights of ITQs and more specifically, to ITQ bankability. New entrants would be able to enter the market if they were able to acquire bank loans for business startup costs, including the purchase or lease of quotas (Bruce Turris, personal communication, May 3, 2010).

Contrary to claims made by critics of the ITQ system, the free initial allocation of quotas has not mounted considerable barriers to new firms' entrance into the market. Two other factors contribute to the barriers facing new entrants: cost structure of different tiers of production and the ability of new entrants to acquire funding using quotas as a collateral security. A new entrant would have to consider the cost structure of the tier they would fit-in before making a decision to enter this industry.

In Chapter 5 I will relate and discuss the findings of my analysis in light of six topics raised by the critics of ITQs: whether subsidies exist in the sablefish fishery and to what extent; whether there is evidence of extra-competitive economic returns; whether armchair fishing exists in the sablefish fishery and whether ITQs inhibit technical efficiency; whether ITQs pose barriers to new sablefish industry entrants; whether the extent of the earned rents resulting from the free initial allocation of quotas is as large as the critics claim, and; whether or not ITQs inhibit innovation.

Chapter 5: Discussion

The foregoing analysis has revealed that differences in industry participants' production costs are not related to whether they own their quotas or must lease them to cover their catch, providing that they account for the opportunity cost of their assets. What, then, do these differences mean?

Subsidy Sources

There is no evidence that ITQs heavily subsidize fishers by offering free access to a resource in the sablefish fishery, as suggested by Bromley(2009) in his criticism of the ITQ system. I would argue that the cost of leasing quotas on a temporary, per-pound basis throughout the year is most appropriately viewed as a cost of doing business. In my view, the market value of owned quotas is an accrued value of the fisher's investment, a risk of being in business, and a resource rent not collected by the public. I do not consider quota values a subsidy, as suggested by ITQ critics. The fact that fishers include the opportunity cost of the quota value in their financial planning means that they have accounted for this value. As a result, the quota value is included as a private cost and not a social one. The question of whether the quotas are truly owned does not change the fact that the cost has been accounted for in the assessment of private costs. As shown in the financial analysis section, whether the owner leases the quotas from the DFO or from a fisher does not change his/her cost structure. Therefore, the free initial allocation causes a distributional effect and not an efficiency one. Had the quota price been determined by industry participants themselves through a market mechanism such as an auction, it would have arrived at a level which would still have allowed firms to earn the same profits when the opportunity cost was taken into account. However, we must acknowledge that quota values are not the only possible source of subsidies, which, as defined by Sumaila et al. (2009), are "financial transfers, direct or indirect, from public entities to the fishing sector, which help the sector make more profit than it would otherwise" (p. 2). A thorough accounting would consider *all* of the ways in which the industry (as individual participants or in aggregate) contributes to government 'in-kind' and in cash through fees and taxes. It would also tally all taxpayer financed supports to sablefish fishing firms, such as grants (e.g., the $225,000 from Agriculture Canada to assist the Canadian Sablefish Association with marketing activities in 2006-2007), tax deductions (e.g., the $212,000 that came back to the Canadian Sablefish Association as a tax credit for having spent about $500,000 on research; R. Macdonald, personal communication, April 13, 2010), and income-support programs (e.g., Employment Insurance, which arguably makes it viable for fishers to remain in a highly seasonal industry and effectively reduces firms' labour recruitment, training, and wage costs). It must also be said that subsidies are by no means the only cause of departures from economic efficiency, particularly if efficiency is defined, as it usually is, without reference to sustainability over the long term: "efficiency is the extent to which a given set of resources is being allocated across uses or activities in a manner that maximizes whatever value they are intended to produce, such as output, market value, or utility" (Deardorff, 2001) or simply "getting the most out of resources used" (Matthew Bishop, as cited in The Economist.com, n.d.). Government-imposed restrictions on where fishing can proceed (marine protected areas) and on how fishing is to be done (gear) can also be impediments to efficiency in the sablefish fishery. Further, efficiency in sablefish harvesting can suffer when sablefish are harvested as bycatch by vessels directed at other species. (B. Turris, personal communication, May 03, 2010)

Extra-competitive Economic Returns

Those who own quotas can and do generate wealth from them without producing or fishing; they need only lease them out. Such wealth is correctly viewed as economic rents; leasing quotas is rational behaviour and the wealth is simply a return on the fisher's assets. The need to diversify portfolios is one of the various reasons why fishers lease out quotas and the rate of return from leasing out may in fact be higher than fishing in a given season. Many factors could contribute to the different rate of return, including the tier of production, the previous year's prices, or expected return from other fishing opportunities.

Armchair Fishing and Technical Efficiency

Quota holders who receive such rents transfer the quotas to those who can fish more efficiently than themselves. Quota owners decide to lease their quotas as part of managing their own portfolios (R. MacDonald, personal communication, April 13, 2010). However, there is no evidence to suggest that the phenomenon known as "armchair fishing" exists in the sablefish fishery at this time. This observation leads me to suggest that Pinkerton and Danielle's (2009) argument about B.C.'s halibut fishery does not hold true for the sablefish fishery. These authors argue that:

> . . . the assumption that quota will gravitate toward the most efficient units of production is clearly problematic. Vessels leasing most of their quota may have a very high level of technical efficiency (defined as using the least cost gear, most fuel-efficient engine, lowest ratio of crew to catch, etc.) and still not be financially viable, while vessels fishing their own quota are so highly profitable that they are under little pressure to be technically efficient. (p. 710)

Barriers to New Entrants

Quota rents created by high quota values do not pose significant barriers to new industry entrants. The free initial quota allocation also did not cause barriers. It is the bankability of the quotas along with other economic factors specific to each tier that causes these barriers. As illustrated in chapter 4, each production tier faces different expected earnings depending on the percentage of quota and assets leased or financed. In order to discuss barriers facing new entrants, we would need to analyze the specific factors relevant to the tier in discussion and not generalize over all tiers.

Initial Quota Allocation

When distributed, the value of the quotas was much lower than their value today. Had the quotas been auctioned at the time of allocation, the value received by the seller (i.e., the public) would have been much lower than today's value. For example, the quota value was $18.82 per kg in 1990 and $76.05 per kg in 2009. To examine the extent of the distributional effect, researchers would therefore need to take the 1990 quota price into account.

Innovation

As the foregoing discussion has shown, the ITQ system in the sablefish fishery has created an economically profitable industry. However, the industry is by no means efficient. Still, it would not be accurate to say that the protection afforded by ITQs has discouraged management innovation in the sablefish sector**.** To the contrary, several initiatives being explored by the Canadian Sablefish Association suggest that adept management is adding value to the resource.

Savvy marketing appears to have been the key. For example, the vast majority of sablefish harvested since the 1970s has been exported to Japan. This is changing; with matching funding from government, the CSA is finding and developing new international markets and new niches:

> . . . in four years we've probably taken 25% of the fish, found new higher-end markets, such as Dubai, such as Paris, such as selected cities in China. And we've been able, as the stocks have declined, through new market development, to put pressure on the market, so that the price [of sablefish] at one time went over $7.50 a pound from about $4.20. So the marketing program was meant to completely separate the brand and quality from the larger Alaskan blackcod fleet, which is only 8% frozen at sea. So we did it on a quality basis, and we did it through aggressive niche marketing. (R. MacDonald, personal communication, April 13, 2010)

Tables A16 and A17 below shows that significant inroads have been made into new markets, with particularly robust market development in the United Kingdom, the United Arab Emirates, Italy, and France.

Cooperation Among Fishers

In addition, several licence holders are investing in Wild Canadian Sablefish Ltd., a commercial venture that is owned by the Canadian Sablefish Association. The company's president, who is also Executive Director of the CSA, has indicated that its business plan is still under development but will be defined by a very key set of economic and trade objectives that are focused on adding more value per pound of fish. The company's plans include the processing and marketing of sablefish as a pre-portioned, smoked, and filleted product to previously identified markets in France and the Middle East, as well as other countries. Potential locations for processing facilities are currently being determined and include China and Dubai. Members of the "sellers' group" will be asked to guarantee that a percentage of their quotas will be put into the system to ensure continuity of supply.

The CSA has also been successful at trimming co-management costs. This has been primarily accomplished by negotiating Joint Project Agreements that have returned enforcement costs, some scientific expenses and a portion of government fishery staff salaries back to the taxpayers, as well as by eliminating activities that had been specified in Joint Project Agreements but actually weren't carried out (R. MacDonald, personal communication, April 13, 2010). Such management initiatives have proven to be very successful in terms of adding value, raising prices, and lowering costs. According to the CSA, the negotiation of more industry-friendly agreements with the DFO has left at least $700,000 more in the sector than would previously have been available under co-management.

The CSA's "voluntary" industry contributions to stock assessment and research have been cited as evidence, albeit fragmentary (Munro, 2009, p. 25), that in sablefish ITQ fisheries at least, fishing firms are now behaving as cooperative game theory would predict: "coalescing and attempting to enhance the long-term value of the resource" (Munro, 2009, p. 25).

Certainly, CSA contributions to science, plus initiatives that seek to add value to the resource, strengthen the argument that the implementation of ITQs in the sablefish fishery has substantially reduced the "incentive gap". At the same time, Munro (2009) concedes that "one cannot argue convincingly that the incentives of the sablefishers and those of DFO are necessarily perfectly aligned" (p. 25).

Evidence from this study supports the characterization of the DFO-CSA relationship as one of principal and agent. It actually resembles reality enough to be useful as an analogy that can predict behaviour. In true principal-agent relationships, the agent is hired by a principal to achieve the principal's objectives. The management dilemma arises when the agent chooses to favour his or her own interests at the expense of the principal's interests. This study clearly shows that fishers, represented by the agent, have the incentive to cooperate. The evidence provided in this study demonstrates that this cooperation has assumed various forms, one of which is CSA contributions to science, research and enforcements; these contributions have sustainable spillovers whereby the agents are acting to maintain the resource for the future capitalization of benefits.

However, according to the Sablefish Advisory Committee and Commercial Industry Caucus meeting minutes, sablefish fishers resemble their counterparts in other fisheries in that they first and foremost maintain businesses that have profit as their primary objective. Conservation of the resource is a corollary objective, providing that profits in the sector remain at levels sufficient to maintain fishers' investment. By continuing to resist tighter regulations and seeking to reduce or offload conservation-related responsibilities wherever possible, fishing firms act not as conservation-focused agents but as the profit-maximizers that they really are.

There is nothing remotely mysterious or sinister about this, but it has important implications for sustainability. As Clark, Munro, and Sumaila (2008) have argued, there are circumstances in which the profit-maximizing owners (be they public or private) of destructible resources can be expected to conclude that it is economically optimal to drive a resource to the brink of biological extinction. In addition, unregulated, "rational" profit-making behaviour has no particular allegiance to the long-term sustainability of resources in one sector over those in another.

Finally, it is clear that ITQs resulted in an economically viable sablefish industry. That is, the industry produces positive rents. What this means and the question of how these rents should be collected, distributed, and/or directed remains the subject of continuing debate. At the heart of this debate is yet another, which focuses on the meanings of terms such as resource rent and economic rent. For example, Munro (2009) has suggested that “a clear distinction does not exist” (p. 8) between the two terms; resource rent is synonymous with the “economic returns on natural capital assets” (p. 6) and the “net economic benefits” (p. 11) from the resource. Munro (2009) has further argued that:

> the proper definition of resource rent to be employed is a broad one. If, for example, society gains satisfaction from knowing that a fishery resource is there and safe from extinction, what is commonly referred to as existence value, this can be encompassed within a broad definition of resource rent. (p. 5)

In contrast, Bromley (2009) defines economic rent as “extra-competitive profit” and “the net revenue to a firm that is in excess of what would be necessary to keep the firm engaged in its current activity” (p. 286)**.** He makes a clear distinction between economic rent and resource rent, which is payable by resource users to resource owners and which has monetary value as well as value in itself:

> A market economy requires that all owners of factors of production—and fish in the EEZ are a factor of production to fishing firms—must receive a payment for their relative contribution to the value of the total product of the firm using those factors. In this case, fish are the raw material (similar to gold, silver, timber, and oil) gathered up by the private sector and delivered to the market ready for further processing. Payment for this raw material is correctly understood to be *resource rent.* (Bromley, 2009, p. 287)

In Munro's (2009) opinion, the primary challenge for resource managers is to “design management schemes that will lead to the generation of resource rent” (p. 11); determining how such rents should be distributed is a secondary concern. Should rents be appropriated by the public in the form of taxes or royalties, or left with the private sector? Munro has argued that there is, in fact, “a case to be made for appropriating a share of the fishery resource rent for the public purse,” (p. 32) as is done in Canada with forest and petroleum resources. I consider the question of rent distribution to be a political question. The answer to that question is outside the scope of this paper and arguably best determined by the democratic process.

Chapter 6: Conclusion

This thesis has undertaken a financial analysis and PAM analysis of the Pacific sablefish fishery in order to evaluate its economic viability. It has focused on efficiency as a critical dimension of that economic viability and the fisher's competiveness. One of the key findings of my study is that the free initial quota allocation does not constitute a source of subsidy that serves to degrade the efficiency, and thus the economic viability, of the industry. Second, the study reveals that: a) the industry is economically viable under the ITQ system; b) differences in costs of production by industry participants are not related to whether they own or lease their quotas in order to cover their catch, so long as they account for the opportunity cost of their assets, and; c) the current perception, or structure, of quota access rights limits the quotas' bankability and thus reduces efficiency by posing considerable barriers to new industry entrants.

Third, the study has demonstrated that if the ITQ system was meant to correct market failures in the sablefish industry, it has partially succeeded in doing so. However, it is also demonstrated that ITQs in combination with co-management and the introduction of a robust, adequately-funded system of enforcement constitute a significant improvement over the two systems that preceded ITQs: the poorly-designed Limited Entry system that existed from 1981 to 1990 and the state of unregulated open access that preceded it. Furthermore, CSA initiatives suggest that although ITQs may not have completely eliminated inefficiency in the sablefish industry, they have not squelched management innovation.

Fourth, the study has clearly demonstrated that rents are to some degree a result of the free free initial allocation of quotas, as is true for ITQs in other fisheries. The question of who should be receiving these rents is a distributional one that remains hotly debated: Should these rents be left in the private sector, where they constitute "true economic profit" (i.e., Munro, 2009) or "extra-competitive" or "supernormal" profit, as suggested by Bromley (2009)? Or, should they be recouped by governments for resource owners (the public) as “resource rent” through taxes or auctioned royalties (which could underwrite the cost of transparent and accountable management of the resource and/or provide an investment dividend)? Although this question merits consideration, addressing it is beyond the scope of this paper.

It is also salient to note that when quota values pose prohibitive barriers to entry for new industry participants, it has social as well as economic impacts. Although my focus has been on economic effects, the social effects that ITQs and the barriers to market entry posed by quota bankability have on the culture of fishing communities, is a subject that is equally worthy of research.

Recommendations for Future Research

Finally, the results of this study infer several additional questions that merit further investigation (by students of economics, law, and sociology) before firm conclusions can be drawn about the total impact of ITQs in the Pacific sablefish industry. These questions concern distributional effects, accessibility to the market, and the access rights structure of the ITQ system. The issues they encompass include: whether ITQs are privileges or property; armchair fishing; enforcement or cooperative games; resource rent or subsidies; quota values and policy risk; and the DFO’s mandate.

ITQs: Privilege or Property?

Officially, ITQs are seen as privileges that are renewed annually. However, some claim that they are a form of “de facto” property because they can be bought, sold, traded and leased. As it happens, an October 2008 Supreme Court of Canada decision in *Saulnier v. Royal Bank* determined that de facto property rights are inherent in fishing licences and quotas (Ecotrust, 2009). Given this stance, what are the implications of ITQs assuming the legal status of private property? Turris (2009) has stated that fishing firms’ inability to use ITQs to access capital—as can be done with other assets—poses a barrier to new fishing industry entrants and is an issue that "representatives from the commercial fishing industry in Canada have been asking government to address for several years" (p. 5). If quotas became fully "bankable," would this mitigate or exacerbate barriers to new market entrants? If ITQs are a form of property, could they potentially expose taxpayers to lawsuits from corporations if the revocation of fishing quotas was seen as necessary in order to serve the public interest? If quotas were a private property, what would this imply for public oversight, transparency, and accountability in resource management? And who would be expected to bear the cost of resource management (including monitoring and enforcement), and why?

Armchair Fishing

The CSA has declared that armchair fishing is not currently a problem in the sablefish fishery, but acknowledged that it could become one in future—specifically, a problem of access. The CSA claims that armchair fishing is not necessarily practiced by semi-retired fishers, but by active, full-time fishers who shrewdly manage their "portfolio of investments" by dividing their efforts between more than one licence. This practice invites further investigation: How *is* armchair fishing defined by different industry observers and how *should* it be defined? What is the nature and extent of armchair fishing in the sablefish fishery? And do all industry players agree that it is a benign practice?

Enforcement or Cooperative Games

How should conservation-friendly behaviour (such as financial and in-kind contributions to management) among sablefish fishers be explained? The explanation might consider all of the following points: game theory, which suggests that fishers' incentives have become aligned with those of government; de facto property ownership, which delivers the long-term benefits of investing in the resource; the necessity of employing conservation-friendly techniques in order to maintain the lucrative ITQ system; robustly enforcing the system, and; whether "cooperative fisher games" actually are causing the system to evolve into one that is “self-enforcing”. Munro (2009) affirms the latter point in stating that: “Wasteful fishing practices by one fisherman that potentially affects the overall health of the sablefish resource will have a direct negative impact on other sablefish fishermen and will mobilize opposition and corrective action” (Canadian Sablefish Association, para. 6).

An explanation of conservation-friendly behavior in the sablefish fishery would also benefit from a consideration of the following questions. In what ways does this corrective action play out in the Pacific sablefish fishery? To what extent is it reducing the need for the pervasive and costly enforcement that is common for ITQ systems? What are the economic arguments for socializing the majority of the costs needed to ensure that the private use of a public resource remains sustainable (i.e., the true costs, in environmental terms, of production), while simultaneously allowing all profits generated by the allocation of free quotas to remain in the private sector?

Resource Rent or Subsidies

Munro (2009) states that, “In the case of the British Columbia groundfish fisheries discussed, licence holders do pay license fees based upon the amount of quota by species held” (p. 34, footnote 15) According to Munro, the fees collected by government have risen substantially and “whether the fees collected more than cover the resource management costs incurred by government remains to be seen. (p. 34, footnote 15). Further, Table 4 in Chapter 2 indicates that while licence fees collected by the government have generally risen over the period under study in this thesis, landed values (adjusted into 2007 dollars) peaked in 1997 and have remained high ever since.

If the fees collected do cover the resource management costs incurred by government, it might be possible to conclude that the industry is in fact paying resource rent – at least in the way that Bromley (2009) uses the term. However, correctly answering this question might demand that *all* forms of government assistance to the industry, from all levels of government, are factored in, including all the subsidies enumerated by Sumaila et al. (2009). If these forms of assistance are taken into account, the following question would be raised: is the sablefish fishery generating more wealth for the economy than it receives through cash and in-kind contributions of government?

Pricing the Resource

Critics of the ITQ system such as Bromley (2009) have decried the policy of giving fishing firms free access to a valuable public resource because of the corresponding loss of resource rent that could be collected for its owners. If fishing firms were asked to pay for access, how would the price of the resource be determined? If fishing firms were compelled to pay for opportunities to "make a living off the public's endowment of fisheries wealth in the EEZ [Exclusive Economic Zone]" (Bromley, 2009, p. 288), what would be the effects on industry efficiency? Alternatives to ITQs and modifications to the system that aim to address these effects have been proposed. For example, Bromley and Macinko (2007) present a hypothetical allotment-share fishery that would address the race-to-fish and overcapitalization problems by offering time-limited (i.e., 5 or 10 years) catch shares. The price of access to the resource would be determined through an auction which would require fishing firms to submit royalty bids indicating what fraction of annual gross landings receipts they are willing to pay government in order to make a profit from the use of a public resource. Would such a scheme work in British Columbia? Would auctioning quotas at their current price be "fair", considering that the quotas were distributed in 1990?

Quota Values and Policy Risk

Although some see individual transferable quotas as de facto property, technically they are not owned. Rather, they are agreements that are renewed annually by government, conditional to the minister's approval. However, as Table 4 has shown, they command considerable value in the marketplace. To what extent is this value dependent upon quota holders' expectations that the ITQ-supporting policy regime will continue? Barichello (1996) used the "policy risk" model he developed to analyze this question as it relates to quotas in the dairy industry and the results were revealing. That is, Barichello found that quantifying the effect of “policy risk” on quota values is important because identifying the extent to which industry profitability depends on support from a given policy regime concurrently reveals the extent to which that industry can be considered internationally competitive. Barichello observed:

> Understanding how government program benefits are capitalized holds more than academic interest. . . . it allows one to move from knowing the value of some protective asset (for example, a quota) to its otherwise unobserved annual income flows. Policy makers distinguish between protected industries which are high cost or inefficient and those with low costs that receive large economic rents due to the protection. This knowledge may allow us to estimate the annual benefits of protection from capital value of a quota, when the capital value alone normally conceals such information. (p. 283)

To the best of my knowledge, Barichello’s model has not yet been applied to fisheries. However, this study has demonstrated that it is useful to test Barichello’s model on the sablefish fishery because it is an example of a public resource that displays the characteristics of common property. As such, the model has helped shed further light on the economic viability of the sablefish fishery.

The DFO’s Mandate

Two final questions remain and they should be addressed not only by economists, but also by students of law, political science and sociology. First, do ITQs constitute unnecessary interference by government in the workings of markets or an over-correction for the so-called market failure that led to their implementation? Second, is the goal of enhancing industry profitability appropriate for a government agency that is entrusted with safeguarding the harvesting of sustainable resources and perhaps generating a return to its owners at the same time?

Policy Recommendations

Several key lessons can be learned from this research. In discussing these lessons, it is important to distinguish between lessons for fisheries that have not yet utilized ITQs as a management tool and fisheries that are already under an ITQ management scheme.

Recommendations for Fisheries Yet to Utilize ITQ

As demonstrated by this research, the ITQ system is a superior tool in the management of fisheries. The government body that is mandated to oversee the fishery assumes the responsibility of setting TACs that consider the fishery's sustainability and biological characteristics. Once TACs have been established, a management body can utilize ITQs as an effective management tool. For an ITQ system to be applied successfully to a new fishery, fishery managers need to address two main issues (which have been noted in criticisms of ITQ systems): the property right attached to the quotas and the initial allocation of the quotas. First, the property rights need to be well defined, which would mitigate the public's and fishers' concern about the ownership of the resource. It is therefore important to address the question of whether these quotas are a form of ownership and how long they will remain as such. Further, well-defined property rights would enable fishers to gain access to capital and thus remove industry barriers to new entrants.

Second, the initial allocation of the quota needs to be handled by a mechanism that is fair. The public should be receiving a return on a resource that they own and fishers should be able to obtain their quotas at a fair price. It is likely that a fishery which utilizes ITQs will have fishers who have been active for several years. New management schemes commonly take **such** historical catch data into consideration when they distribute quotas. It has been suggested that the distribution of these quotas to fishers should be based on historical catch data and include a buy-back period during which fishers would be able to purchase the quotas (if they do not do this, management authority could regain access to their quota shares and sell the shares in the market). For example, fishers would have an opportunity to buy 5% of their quota each year through either a market determined price mechanism or through an auction. This suggested initial allocation scheme would benefit both the public and the fishers as the public would receive a return on a resource which they own and fishers would transition smoothly from one management scheme to another.

Recommendations for Fisheries Already Utilizing ITQ

Several recommendations can be derived from this research. The first is to increase the quota renewal period. Currently, sablefish quotas are renewed annually by the DFO. A longer renewal term would encourage fishers to participate in research that aims to preserve the fishery by anticipating the capitalization of future benefits. As explained by Munro et al (2009), these future benefits are essential to keeping the fishers' objectives aligned with the resource managers' objectives. A longer renewal period would serve as a guarantee against any immediate changes in government policy and therefore reduce the risk faced by fishers due to their anticipation of policy changes – which would mean that biological factors are the main source of risk.

Second, the research indicates that the armchair fishing phenomena would need to be addressed. The research shows that there are reasons to believe that this phenomenon is going to increase as active fishers age and retire. Consequently, the term armchair fishing needs to be properly defined and various regulations can be implemented to prevent it from occurring. For example, the fishery management can utilize an *Owner on Board* scheme mandating that quota owners be active in the industry to a certain extent. However, this scheme could devastate active fishers who diversity their portfolio by choosing not to fish one type of fish and to instead dedicate their efforts to a different type. These fishers are not considered inactive in the sense of armchair fishing. Since these fishers hold more than one quota, the move to multi-species management would enable regulator to carry out such scheme across various fisheries allowing some flexibility to these fishers.

I hope to engage in future research that investigates these questions in the public interest. And in closing, I acknowledge that the thesis may have generated more questions than answers and reiterate that future research that addresses these questions is critical to the health of the sablefish industry and the protection of sablefish as a resource.

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Appendix: Technical Appendix

Table A1 *Calculated Risk Parameter Using 7, 8 and 9 years Annual Growth Rate, 1997 to 2009*

Year	Pq ($)	R ($)	r	R/Pq	g	d
1997	53.56[a]	10.88	4.88	0.20	0.16	0.27
1998	56.50	5.38	5.41	0.10	0.15	0.17
1999	66.15	7.28	5.20	0.11	0.15	0.19
2000	92.68	10.94	4.55	0.12	0.18	0.23
2001	91.10	10.39[a]	4.61	0.11	0.17	0.21
2002	93.35	9.83	4.48	0.11	0.14	0.18
2003	103.89	8.79	3.34	0.08	0.13	0.17
2004	93.88	7.98	2.58	0.08	0.08	0.13
2005	80.31	5.74	2.18	0.07	0.05	0.10
2006	66.08	5.46	1.90	0.08	0.02	0.08
2007	71.00	4.85	1.87	0.07	0.03	0.07
2008	54.56	5.25	1.76	0.10	-0.02	0.05
2009	76.05	9.25	1.69	0.12	-0.02	0.07

Notes: Annual growth rate for 1997 = 1997 price / 1990 price raised to the power of 1/7, then subtract 1. Annual growth rate for 1998 = 1998 price / 1990 price raised to the power of 1/8, then subtract 1. Annual growth rate for all other years = quota price / quota price 9 years earlier raised to the power of 1/9, then subtract 1. Pq = quota value / KG (expressed in 2007 dollars); R = quota lease rate / KG (expressed in 2007 dollars); r = 5 year average real interest rate (converted to decimals by dividing by 100); R/Pq = the ratio of lease rate to the quota value; g = expected growth rate in quota values; d = policy risk parameter.
[a]Calculated values have been linearly interpolated, i.e., calculated by averaging the previous and following two years.

Table A2 *Calculated Risk Parameter Using 7 years Annual Growth Rate and averaged quota values (Pq) as well as averaged lease rates (R), 1998 to 2008*

Year	Pq ($)	R ($)	r	R/Pq	g	d
1998	58.74	7.85	5.41	0.13	0.16	0.21
1999	71.78	7.87	5.20	0.11	0.18	0.22
2000	83.31	9.54	4.55	0.11	0.16	0.21
2001	92.38	10.39[a]	4.61	0.10	0.15	0.20
2002	96.11	9.67	4.48	0.09	0.11	0.15
2003	97.04	8.86	3.34	0.08	0.10	0.14
2004	92.70	7.50	2.58	0.08	0.08	0.13
2005	80.09	6.39	2.18	0.08	0.05	0.10
2006	72.46	5.35	1.90	0.07	0.00	0.05
2007	63.88	5.19	1.87	0.08	-0.04	0.02
2008	67.20	6.45	1.76	0.10	-0.04	0.03

Notes: Annual growth rate = quota price / quota price 7 years earlier raised to the power of 1/7, then subtract 1. Pq = quota value / KG (expressed in 2007 dollars and averaged over three years); R = quota lease rate / KG (expressed in 2007 dollars and averaged over three years); r = 5 year average real interest rate (converted to decimals by dividing by 100); R/Pq = the ratio of lease rate to the quota value; g = expected growth rate in quota values; d = policy risk parameter.
[a]Calculated values have been linearly interpolated, i.e., calculated by averaging the previous and following two years.

Table A3 *Calculated Risk Parameter Using 8 and 9 years Annual Growth Rate, averaged quota values (Pq) as well as averaged lease rates (R), 1998 to 2008*

Year	Pq ($)	R ($)	r	R/Pq	g	d
1998	58.74	7.85	5.41	0.13	0.15	0.21
1999	71.78	7.87	5.20	0.11	0.16	0.20
2000	83.31	9.54	4.55	0.11	0.17	0.21
2001	92.38	10.39[a]	4.61	0.10	0.17	0.22
2002	96.11	9.67	4.48	0.09	0.14	0.18
2003	97.04	8.86	3.34	0.08	0.12	0.17
2004	92.70	7.50	2.58	0.08	0.08	0.12
2005	80.09	6.39	2.18	0.08	0.05	0.10
2006	72.46	5.35	1.90	0.07	0.03	0.08
2007	63.88	5.19	1.87	0.08	0.01	0.07
2008	67.20	6.45	1.76	0.10	-0.01	0.06

Notes: Annual growth rate for 1998 = 1998 price / 1990 price raised to the power of 1/8, then subtract 1. Annual growth rate for all other years = quota price / quota price 9 years earlier raised to the power of 1/9, then subtract 1.Pq = quota value / KG (expressed in 2007 dollars averaged over three years); R = quota lease rate / KG (expressed in 2007 dollars averaged over three years); r = 5 year average real interest rate (converted to decimals by dividing by 100); R/Pq = the ratio of lease rate to the quota value; g = expected growth rate in quota values; d = policy risk parameter.
[a]Calculated values have been linearly interpolated, i.e., calculated by averaging the previous and following two years.

Table A4 *Cost Structure of Bottom Tier Representative Firm When Leasing 60% of Quotas*

Bottom tier (1/3) Individual vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	30,735	3,706	34,441
Vessel price ($ per lb)	4.50	1.24	4.15
Gross revenue (gross stock) ($)	138,308	4,582	**142,890**
Fishery specific expenses ($)			
Fuel	10,245	--	10,245
At sea monitoring	2,869	--	2,869
Offload monitor	615	74	689
Licence / co-management fees	10,757	--	10,757
Quota leases	46,103	334	46,437
Bait	6,147	--	6,147
Gear maintenance/ Replacement	11,200	--	11,200
Total fishery specific expenses ($)	87,936	408	88,344
Net revenue (net stock) ($)	50,373	4,174	54,547
Less:			31,039
Crew and captain shares ($)	29,369	1,670	
Fishery contribution ($)	21,004	2,504	**23,508**
Vessel fixed expenses ($)			
Insurance			4,000
Repairs and maintenance			12,000
Moorage			1,200

Bottom tier (1/3) Individual vessel	Sablefish (K)	Other groundfish	Total
Miscellaneous			2,000
Total vessel expenses ($)			19,200
Earnings (EBITDA) ($)			**4,308**
Opportunity cost of owned quota ($)			30,735
Net earnings if opportunity cost is accounted for ($)			**-26,427**

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Adapted from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 71), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Table A5 *Cost Structure of Bottom Tier Representative Firm When Leasing 100% of Quotas*

Bottom tier (1/3) Individual vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	30,735	3,706	34,441
Vessel price ($ per lb)	4.50	1.24	4.15
Gross revenue (gross stock) ($)	**138,308**	**4,582**	**142,890**
Fishery specific expenses ($)			
Fuel	10,245	--	10,245
At sea monitoring	2,869	--	2,869
Offload monitor	615	74	689
Licence / co-management fees	10,757	--	10,757
Quota leases	76,838	334	77,172
Bait	6,147	--	6,147
Gear maintenance/ Replacement	11,200	--	11,200
Total fishery specific expenses ($)	118,671	408	119,079
Net revenue (net stock) ($)	19,638	4,174	23,812
Less:			
Crew and captain shares ($)	29,369	1,670	31,039
Fishery contribution ($)	-9,732	2,504	-7,228
Vessel fixed expenses ($)			
Insurance			4,000
Repairs and maintenance			12,000
Moorage			1,200
Miscellaneous			2,000
Total vessel expenses ($)			19,200

Bottom tier (1/3) Individual vessel	Sablefish (K)	Other groundfish	Total
Earnings (EBITDA) ($)			**-26,428**

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Adapted from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 71), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Table A6 *Cost Structure of Bottom Tier Representative Firm When Leasing 0% of Quotas*

Bottom tier (1/3) Individual vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	30,735	3,706	34,441
Vessel price ($ per lb)	4.50	1.24	4.15
Gross revenue (gross stock) ($)	**138,308**	**4,582**	**142,890**
Fishery specific expenses ($)			
Fuel	10,245	--	10,245
At sea monitoring	2,869	--	2,869
Offload monitor	615	74	689
Licence / co-management fees	10,757	--	10,757
Quota leases	0	334	334
Bait	6,147	--	6,147
Gear maintenance/ Replacement	11,200	--	11,200
Total fishery specific expenses ($)	41,833	408	42,241
Net revenue (net stock) ($)	96,475	4,174	100,649
Less:			
Crew and captain shares ($)	29,369	1,670	31,039
Fishery contribution ($)	67,106	2,504	69,610
Vessel fixed expenses ($)			
Insurance			4,000
Repairs and maintenance			12,000
Moorage			1,200
Miscellaneous			2,000

Bottom tier (1/3) Individual vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Total vessel expenses ($)			19,200
Earnings (EBITDA) ($)			**50,410**
Opportunity cost of owned quota ($)			76,837
Net earnings if opportunity cost is accounted for ($)			**26,427**

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Adapted from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 71), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Table A7 *Cost Structure of Middle Tier Representative Firm When Leasing 60% of Quotas*

Middle tier (1/3) Individual vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	106,731	12,871	119,602
Vessel price ($ per lb)	4.50	1.24	4.15
Gross revenue (gross stock)	**480,292**	**15,912**	**496,204**
Fishery specific expenses ($)			
Fuel	26,683	--	26,683
At sea monitoring	6,226	--	6,226
Offload monitor	1,334	161	1,495
Licence / co-management fees	37,356	--	37,356
Quota leases	160,097	1,158	161,255
Bait	21,346	--	21,346
Gear maintenance / replacement	11,200	--	11,200
Total fishery specific expenses ($)	264,242	1,319	265,561
Net revenue (net stock) ($)	216,051	14,593	230,644
Less:			
Crew and captain shares ($)	118,439	5,837	124,276
Fishery contribution ($)	97,612	8,756	106,368
Vessel fixed expenses ($)			
Insurance			8,000
Repairs and maintenance			25,000
Moorage			1,200
Miscellaneous			2,000
Total vessel expenses ($)			36,200

Middle tier (1/3) Individual vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Earnings (EBITDA) ($)			**70,168**
Opportunity cost of owned quota ($)			106,731
Net earnings if opportunity cost is accounted for ($)			**-36,564**

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Adapted from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 70), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Table A8 *Cost Structure of Middle Tier Representative Firm When Leasing 100% of Quotas*

Middle tier (1/3) Individual vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	106,731	12,871	119,602
Vessel price ($ per lb)	4.50	1.24	4.15
Gross revenue (gross stock) ($)	**480,292**	**15,912**	**496,204**
Fishery specific expenses ($)			
Fuel	26,683	--	26,683
At sea monitoring	6,226	--	6,226
Offload monitor	1,334	161	1,495
Licence /co-management fees	37,356	--	37,356
Quota leases	266,828	1,158	267,986
Bait	21,346	--	21,346
Gear maintenance / Replacement	11,200	--	11,200
Total fishery specific expenses ($)	370,973	1,319	372,292
Net revenue (net stock) ($)	109,320	14,593	123,913
Less:			
Crew and captain shares ($)	118,439	5,837	124,276
Fishery contribution ($)	-9,120	8,756	-364
Vessel fixed expenses			
Insurance			8,000
Repairs and maintenance			25,000
Moorage			1,200
Miscellaneous			2,000
Total vessel expenses			36,200

Middle tier (1/3) Individual vessel	Sablefish (K)	Other groundfish	Total
Earnings (EBITDA) ($)			**-36,564**

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Adapted from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 70), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Table A9 *Cost Structure of Middle Tier Representative Firm When Leasing 0% of Quotas*

Middle tier (1/3) Individual vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	106,731	12,871	119,602
Vessel price ($ per lb)	4.50	1.24	4.15
Gross revenue (gross stock) ($)	**480,292**	**15,912**	**496,204**
Fishery specific expenses ($)			
Fuel	26,683	--	26,683
At sea monitoring	6,226	--	6,226
Offload monitor	1,334	161	1,495
Licence /co-management fees	37,356	--	37,356
Quota leases	0	1,158	1,158
Bait	21,346	--	21,346
Gear maintenance/ replacement	11,200	--	11,200
Total fishery specific expenses ($)	104,145	1,319	105,464
Net revenue (net stock) ($)	376,147	14,593	390,740
Less:			
Crew and captain shares ($)	118,439	5,837	124,276
Fishery contribution ($)	257,708	8,756	266,464
Vessel fixed expenses			
Insurance			8,000
Repairs and maintenance			25,000
Moorage			1,200
Miscellaneous			2,000
Total vessel expenses ($)			36,200
Earnings (EBITDA)			**230,264**

Middle tier (1/3) Individual vessel	Sablefish (K)	Other groundfish	Total
($)			
Opportunity cost of owned quota ($)			266,827
Net earnings if opportunity cost is accounted for ($)			**-36,564**

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Adapted from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 70), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Table A10 *Cost Structure of Top Tier Representative Firm When Leasing 60% of Quotas*

Top tier (1/3) Individual Vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	460,343	55,513	515,856
Vessel price ($ per lb)	4.50	1.24	4.15
Gross revenue (gross stock) ($)	**2,071,546**	**68,631**	2,140,177
Less: Fishery specific expenses ($)			
Fuel	131,527	--	131,527
At sea monitoring	18,414	--	18,414
Offload monitor	3,453	416	3,869
Licence/co-management fees	161,120	--	161,120
Quota leases	690,515	4,996	695,511
Bait	92,069	--	92,069
Gear maintenance/ replacement	11,200	--	11,200
Total fishery specific expenses ($)	1,108,298	5,412	1,113,710
Net revenue (net stock) ($)	963,249	63,219	1,026,468
Less: Crew and captain shares ($)	523,402	25,287	548,689
Fishery contribution ($)	439,847	37,932	477,779
Vessel fixed expenses ($)			
Insurance			15,000
Repairs and maintenance			125,000
Moorage			2,000
Miscellaneous			10,000
Total vessel expenses ($)			152,000

Top tier (1/3) Individual Vessel	Sablefish (K)	Other groundfish	Total
Earnings (EBITDA) ($)			**325,779**
Opportunity cost of owned quota ($)			460,343
Net earnings if opportunity cost is accounted for ($)			**-134,566**

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Adapted from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 69), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Table A11 *Cost Structure of Top Tier Representative Firm When Leasing 100% of Quotas*

Top tier (1/3) Individual vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	460,343	55,513	515,856
Vessel price ($ per lb)	4.50	1.24	4
Gross revenue (gross stock) ($)	**2,071,546**	**68,631**	2,140,177
Less: Fishery specific expenses	131,527	--	131,527
Fuel			
At sea monitoring	18,414	--	18,414
Offload monitor	3,453	416	3,869
Licence/co-management fees	161,120	--	161,120
Quota leases	1,150,858	4,996	1,155,854
Bait	92,069	--	92,069
Gear maintenance/ replacement	11,200	--	11,200
Total fishery specific expenses ($)	1,568,641	5,412	1,574,053
Net revenue (net stock) ($)	502,906	63,219	566,125
Less: Crew and captain shares ($)	523,402	25,287	548,689
Fishery contribution ($)	-20,497	37,932	17,436
Vessel fixed expenses ($)			
Insurance			15,000
Repairs and maintenance			125,000
Moorage			2,000
Miscellaneous			10,000
Total vessel expenses ($)			152,000
Earnings (EBITDA)			**-134,565**

Top tier (1/3) Individual vessel	Sablefish (K)	Other groundfish	Total
($)			

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Adapted from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 69), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Table A12 *Cost Structure of Top Tier Representative Firm When Leasing 0% of Quotas*

Top tier (1/3) Individual vessel	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	460,343	55,513	515,856
Vessel price ($ per lb)	4.50	1.24	4.15
Gross revenue (gross stock) ($)	**2,071,546**	**68,631**	**2,140,177**
Less: Fishery specific expenses ($)			
Fuel	131,527	-	131,527
At sea monitoring	18,414	-	18,414
Offload monitor	3,453	416	3,869
Licence / co-management fees	161,120	-	161,120
Quota leases	0	4,996	4,996
Bait	92,069	-	92,069
Gear maintenance/ Replacement	11,200	-	11,200
Total fishery specific expenses ($)	417,783	5,412	423,195
Net revenue (net stock) ($)	1,653,763	63,219	1,716,982
Less: Crew and captain shares ($)	523,402	25,287	548,690
Fishery contribution ($)	1,130,361	37,932	1,168,293
Vessel fixed expenses ($)			
Insurance			15,000
Repairs and maintenance			125,000
Moorage			2,000
Miscellaneous			10,000
Total vessel expenses ($)			152,000
Earnings (EBITDA) ($)			**1,016,293**
Opportunity cost of owned quota ($)			1,150,857
Net earnings if opportunity cost is accounted for ($)			**-134,566**

Note. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Adapted from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 69), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Table A13 *Aggregate of Cost Structures of All Bottom Tier Firms When Leasing 30% of Quotas*

Bottom tier (1/3) aggregate	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	338,085	40,770	378,855
Vessel price ($ per lb)	$4.50	$1.24	$4.15
Gross revenue (gross stock) ($)	**$1,521,383**	**$50,404**	**$1,571,786**
Less: Fishery specific expenses ($)			
Fuel	112,695	--	112,695
At sea monitoring	31,555	--	31,555
Offload monitor	6,762	815	7,577
Licence / co-management fees	118,330	--	118,330
Quota leases	253,564	3,669	257,233
Bait	67,617	--	67,617
Gear maintenance/ replacement	123,200	--	123,200
Total fishery specific expenses ($)	713,722	4,485	718,206
Net revenue (net stock) ($)	807,661	45,919	853,580
Less: Crew and captain shares ($)	323,064	18,370	341,434
Fishery contribution ($)	484,596	27,549	512,146
Vessel fixed expenses ($)			
Insurance			44,000
Repairs and maintenance			132,000
Moorage			13,200
Miscellaneous			22,000
Total vessel expenses ($)			211,200

Bottom tier (1/3) aggregate	Sablefish (K)	Other groundfish	Total
Earnings (EBITDA) ($)			**300,946**

Note. Number of vessels = 11. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Reproduced from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 75), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Table A14 *Aggregate of Cost Structures of All Middle Tier Firms When Leasing 30% of Quotas*

Middle tier (1/3) aggregate	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	1,174,046	141,578	1,315,624
Vessel price ($ per lb)	4.50	1.24	4.15
Gross revenue (gross stock)	**5,283,207**	**175,034**	**5,458,241**
Less: Fishery specific expenses ($)	293,512	--	293,512
Fuel			
At sea monitoring	68,486	--	68,486
Offload monitor	14,676	1,770	16,445
Licence/co-management fees	410,916	--	410,916
Quota leases	880,535	12,742	893,277
Bait	234,809	--	234,809
Gear maintenance/ Replacement	123,200	--	123,200
Total fishery specific expenses ($)	2,026,133	14,512	2,040,645
Net revenue (Net stock) ($)	3,257,074	160,523	3,417,597
Less: Crew and captain shares ($)	1,302,830	64207	1,367,037
Fishery contribution ($)	1,954,244	96,316	2,050,560
Vessel fixed expenses ($)			
Insurance			88,000
Repairs and maintenance			275,000
Moorage			13,200
Miscellaneous			22,000
Total vessel expenses ($)			398,200
Earnings (EBITDA) ($)			**1,652,360**

Note. Number of vessels = 11. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Reproduced from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 74), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Table A15 *Aggregate of Cost Structures of All Top Tier Firms When Leasing 30% of Quotas*

Top tier (1/3) aggregate	**Sablefish (K)**	**Other groundfish**	**Total**
Landings (total lbs in $)	5,063,778	610,639	5,674,417
Vessel price ($ per lb)	4.50	1.24	4.15
Gross revenue (gross stock) ($)	**22,787,001**	**754,941**	**23,541,942**
Less: Fishery specific expenses ($)			
Fuel	1,446,794	--	1,446,794
At sea monitoring	202,551	--	202,551
Offload monitor	37,978	4,580	42,558
Licence / co-management fees	1,772,322	--	1,772,322
Quota leases	3,797,834	54,958	3,852,791
Bait	1,012,760	--	1,012,760
Gear maintenance/ replacement	123,200	--	123,200
Total fishery specific expenses ($)	8,393,439	59,537	8,452,976
Net revenue (Net stock) ($)	14,393,562	695,404	15,088,966
Less: Crew and captain shares ($)	5,757,425	278157	6,035,582
Fishery contribution ($)	8,636,137	417,247	9,053,384
Vessel fixed expenses ($)			
Insurance			165,000
Repairs and maintenance			1,375,000
Moorage			22,000
Miscellaneous			110,000
Total vessel expenses ($)			1,672,000

Top tier (1/3) aggregate	Sablefish (K)	Other groundfish	Total
Earnings (EBITDA) ($)			**7,381,384**

Note. Number of vessels = 11. Table ignores capital costs to acquire vessel, gear, licences and quotas, as well as the cost of servicing any debt incurred in purchasing capital assets. Reproduced from *Pacific commercial fishing fleet: Financial profiles for 2007* (Prepared for DFO, Pacific Region, Revised April 2009, p. 73), by S. Nelson, 2009, Vancouver, British Columbia, Canada: Nelson Bros Fisheries Ltd.

Table A16 *Canadian Sablefish Value Export Data, 2005–2009*

Canada's Sablefish, frozen, excluding heading 03.04, livers and roes					
Exports to All Countries					
HS CODE:	VALUE ($ Can)				
0303.7916	2005	2006	2007	2008	2009
TOTAL:	19,324,850	23,309,586	17,208,399	18,931,573	19,426,643
Japan	15,265,420	19,703,900	14,358,967	15,685,134	16,776,525
United States	2,869,100	2,283,016	1,954,609	1,740,908	1,342,798
United Kingdom	122,766	74,365	177,535	620,269	680,054
Hong Kong	711,618	681,185	90,206	532,978	271,646
United Arab Emir.	0	0	0	127,409	172,607
Italy	0	0	17,518	165,050	120,197
France	0	1,452	25,130	59,552	50,516
Germany	0	226,465	0	0	10,955
Malaysia	0	0	0	0	1,020
Taiwan	0	4,641	17,498	0	325
Mexico	0	2,085	0	0	0
China, P. Rep.	224,573	98,084	52,370	0	0
Jordan	0	0	215,931	0	0
Korea, South	8,723	5,926	29,339	0	0
Ukraine	0	0	124,336	0	0
Philippines	0	26,158	0	0	0
Thailand	0	50,352	0	0	0
Bermuda	0	0	0	273	0
Singapore	122,650	151,957	144,960	0	0

Note. Reproduced from “Canada’s sablefish, frozen, excluding heading 03.04, livers and roes ($CND),” by Agriculture and Agri-Food Canada Fish and Seafood Online, 2010, *Export reports—2010 by species,* Ottawa, Ontario, Canada:Statistics Canada. Retrieved from http://www.ats-sea.agr.gc.ca/sea-mer/03037916-eng.pdf

Table A17 *Canadian Sablefish Quantity Export Data, 2005–2009*

Canada's Sablefish, frozen, excluding heading 03.04, livers and roes					
Exports to All Countries					
HS CODE:	QUANTITY (KGM)				
0303.7916	2005	2006	2007	2008	2009
TOTAL:	2,130,837	2,417,630	1,897,482	1,817,133	1,533,217
Japan	1,688,458	2,075,930	1,634,831	1,549,329	1,334,415
United States	338,957	229,841	183,195	146,473	100,800
United Kingdom	8,505	5,013	14,209	54,092	55,044
Hong Kong	64,017	58,767	10,331	40,254	18,810
United Arab Emir.	0	0	0	9,117	10,604
Italy	0	0	1,361	13,084	8,718
France	0	90	2,661	4,761	3,722
Germany	0	16,254	0	0	980
Malaysia	0	0	0	0	99
Taiwan	0	341	1,156	0	25
Mexico	0	137	0	0	0
China, P. Rep.	19,490	13,577	8,119	0	0
Jordan	0	0	21,126	0	0
Korea, South	2,429	625	3,033	0	0
Ukraine	0	0	8,199	0	0
Philippines	0	2,041	0	0	0
Thailand	0	4,990	0	0	0
Bermuda	0	0	0	23	0
Singapore	8,981	10,024	9,261	0	0

Note. Reproduced from “Canada’s sablefish, frozen, excluding heading 03.04, livers and roes ($CND),” by Agriculture and Agri-Food Canada Fish and Seafood Online, 2010, *Export reports—2010 by species,* Ottawa, Ontario, Canada:Statistics Canada. Retrieved from http://www.ats-sea.agr.gc.ca/sea-mer/03037916-eng.pdf