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Impacts of harvesting rights in Canadian Pacific fisheries

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IMPACTS OF HARVESTING RIGHTS
IN CANADIAN PACIFIC FISHERIES

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ABSTRACT

This report assesses the move to harvesting rights (ITQs) management schemes in three British Columbia fisheries, the B.C. Pacific Halibut fishery, the B.C. Sablefish fishery, and the B.C. Groundfish Trawl fishery respectively. In so doing, the report examines the question of whether the move toward harvesting rights schemes represented an improvement over the previous management scheme, described by the report as limited entry, combined with Olympic style TAC harvesting. The report concludes that, while the harvesting rights scheme are not flawless, they represent a dramatic improvement, both in terms of enhancing the economic viability of the fisheries, and in terms of ensuring the sustainability of the fishery resources providing the basis of the fisheries. Key to the improvement lies in transforming the interaction among the relevant fishers from competition to cooperation.

PREFACE

Clark, Munro and Associates, working in cooperation with Professor Ussif Rashid Sumaila of the UBC Fisheries Centre, and Mr. Bruce Turris of Pacific Fisheries Management Inc., were called upon by the Department of Fisheries and Oceans (DFO) to make an assessment of harvesting rights schemes in Canadian Pacific fisheries. Due to the short term nature of the project, the assessment has been confined to three B.C. fisheries operating under Individual Harvest Quota (IQ) schemes, namely Pacific halibut, sablefish and the groundfish trawl fishery. These fisheries are by no means insignificant. Combined, they account for approximately 40 per cent of the annual harvests, in value terms, of the B.C. commercial capture fisheries (Table A16 – Appendix).

The focus of this project, on IQ fisheries alone, must not be seen as implying that the authors of the report have come to the conclusion that IQ fisheries are to be preferred over other harvesting rights schemes, such as community based fisheries management schemes (also referred to as territorial use rights) and fishers' cooperatives. To the contrary, the authors are of the view that the relative merits of different harvesting rights schemes constitute a question of such magnitude that it deserves a project unto itself.

INTRODUCTION

The terms of reference for the project, set forth by DFO, imply that the goals of Canadian Pacific fisheries management can be described as follows: (i) enhancing the economic viability of the fisheries; and (ii) ensuring the sustainability of the fishery resources that provide the basis of these fisheries.

Placing these goals in the context of modern fisheries economics, it can be said that fisheries management is fundamentally an exercise in asset management. Fishery resources can be viewed as “natural” capital assets that would, in an ideal world, be managed in such a manner that they would make the maximum economic contribution (broadly defined to include non-market benefits) to society *through time*. Since the resources are renewable, the flow of net economic benefits to be derived from them should be expected to continue over an indefinite period of time.

Fishery resources that are not sustained are incapable of making the aforementioned maximum economic contribution to society. Indeed, in the case of fishery resources that were overexploited in the past, sustaining the resources is not sufficient. Sound economic management of the resource would almost certainly call for a program of positive investment in the resource stocks, i.e. a program of stock rebuilding.

Interaction between and among fish species is commonplace, either because the species are linked to one another for biological reasons and/or because of the nature of the fisheries (e.g. inescapable by-catches). Effective management of these natural capital assets is, therefore, not to be thought of in terms of managing single assets, but rather is to be thought of in terms of management of portfolios of assets, with many of the assets being interrelated.

Capture fisheries worldwide have historically been “common pool” in nature, in the sense that the resources are open to exploitation by all fishers. It has been well known for over half a century (Gordon 1954) that this “common pool” nature of the resources works directly counter to the goal of effective economic management of the resources, in that it leads to fishers being confronted with a set of incentives that are perverse from society’s point of view.

The rational fisher has no incentive to conserve the resources. If any fisher refrains from harvesting, for the purpose of ensuring that the resources will be there for future generations, the fisher is likely to find that he/she has done no more than increase the harvests of his or her competitors. If left unchecked, or unaltered, these incentives can lead (and have led) to a disorderly mining of the resources.

The baleful effects of “common pool” resources are not unique to fisheries, but are to be found in other sectors of the economy, where “common pool” conditions have, from time to time prevailed, e.g. oil and gas, water, atmosphere/pollution, radio spectrum (Libecap 2006). As Libecap points out, the initial reaction to the losses arising from the “common pool” nature of the resources is the imposition of state (top down) control.

There are, Libecap continues, good reasons for this. Imposing direct government regulations is less complex than attempting to create a system of exploiters “rights.” It is also consistent with the view that many natural resources are properly regarded as being inherently “public” in nature, and that ownership should be seen to rest firmly with the state, and not the private sector (Libecap 2006, p. 5).

In the case of Canada’s fisheries, or at least certainly Canada’s Pacific fisheries, the top down approach came into full flower in the form of licence limitation/limited entry schemes, combined with an Olympic style “total allowable catch” (TAC) harvesting (or equivalent thereof). The schemes were designed to prevent the build up of excess capacity in fisheries with TACs. Every participating vessel was required to have a licence. The number of licences was strictly limited.

The TAC harvests were Olympic in style, in the sense that the limited number of licensed vessels competed with one another for shares of the global quotas. The fishers that were the fastest, most aggressive, and best equipped “won the race”.

Far from being opposed by economists, these limited entry, plus Olympic style TAC harvests, schemes were at first welcomed by economists, with some enthusiasm (e.g. Crutchfield 1979). Indeed, the first fully developed plan for the implementation of such limited entry schemes in B.C. fisheries can be traced back to the 1960 report by the economist Sol Sinclair (Sinclair 1960).

Canada’s first experiment with such a limited entry scheme was in the Pacific salmon fishery, which came about as a delayed response to the Sinclair report. Sinclair had advocated the same form of limited entry scheme for Canada’s share of the Pacific halibut fishery, as well, but implementation of the scheme had to await the advent of Canada’s Economic Exclusive Zone (EEZ) regime, in the second half of the 1970s.

The UN Third Conference of on the Law of the Sea, 1973-1982 brought forth the UN Convention on the Law of the Sea. The 1982 UN Convention enabled coastal states, such as Canada and the USA, to establish 200 nautical mile Exclusive Economic Zones (EEZs), within which the coastal states have sovereign rights for managing the fishery resources contained therein (UN 1982, Article 56). In the UN Third Conference on the Law of the Sea, the fisheries issues were more or less settled by the mid-1970s. Several coastal states, including Canada and the USA, implemented EEZ regimes in the second half of the 1970s, in anticipation of the UN Convention on the Law of the Sea. Canada and the USA implemented their regimes in 1977.

The advent of the EEZ regime was also to lead to the implementation of limited entry schemes (with Olympic style TAC harvesting) in other B.C. fisheries. Two of these were the B.C. sablefish fishery and the B.C. groundfish trawl fishery.

As will be discussed in the following section, the three groundfish limited entry schemes with Olympic style TAC harvests had remarkably similar outcomes. To all intents and purposes, they disintegrated. The schemes proved totally ineffective in preventing the emergence of excess fleet capacity over time. The excess capacity had severe economic and resource conservation consequences. The schemes were replaced by limited entry/IQ schemes (referred to, hereafter, simply as IQ schemes), under which vessels were granted specific individual harvest quotas, with the hope that the individual harvest quotas would remove the incentive to race for the fish. In time, these IQs were to become transferable, and thus ITQs. As Bruce Turris notes, drawing upon his experience as an official with DFO, Pacific Region, the shift to IQ schemes in the three fisheries was not driven by ideology. Rather, it was driven by desperation (Turris 2000).

There is nothing particularly unique about the B.C. groundfish experience. A report recently released by the American non-government organization (NGO), Environmental Defense, draws upon a study of some ten North American fisheries (including the three B.C. groundfish fisheries under examination in this report) that shifted from the old style limited entry schemes to limited entry/harvesting rights schemes, which Environmental Defense refers to as Limited Access Privilege Programs (LAPPS) (Environmental Defense 2007; Redstone Strategy Group, LLC and Environmental Defense 2007). The experiences of the other seven fisheries discussed in the Environmental Defense report were similar to those of the three B.C. groundfish fisheries.

The questions to be addressed are why the earlier limited entry schemes produced such dire results, and whether the IQ schemes hold promise of long term improvement, or whether they are no more than a temporary palliative. What the question is not, is whether the IQ schemes are free from flaws, because the answer to that question is already known. To paraphrase Winston Churchill, the hope held out for the IQ schemes is, not that they will take us to Heaven, but rather that they will prevent us from going to the other place.

In order to answer the questions, a broad analytical framework is required, even though admittedly this framework may, in part, be sketchy. There is the obvious issue of incentive structures confronting fishers, an issue that is highlighted by the Environmental Defense report (2007). It is well known that the perverse incentives confronting fishers in "common pool” fisheries continue unabated under limited entry schemes, with Olympics style TAC harvesting. It was the hope of such schemes that they would effectively block the fishers as they attempted to respond to these incentives. It is also hoped that IQ schemes plus other harvesting rights based management schemes (LAPPS), will adjust fishers incentives, so that they are more closely aligned with the best interests of society, in that the fishers will be given the incentive to invest in the resources, and work towards fisheries that will provide sustainable economic benefits through time (see also: Grafton et al. 2006). This, however, is not entirely adequate.

One should commence by recognizing another obvious fact, namely that, regardless of the resource management scheme in place, there is an ongoing strategic interaction between and among the relevant fishers, and between the fishers and the resource managers (DFO). Hence, one should properly draw upon the theory of strategic interaction, more commonly known as game theory. While once regarded as highly esoteric, game theory has come to play a major role in economics (and many other fields). It is worth noting in passing that, since 1994, the Nobel Prize in Economic Sciences has twice been awarded to specialists in game theory, the second time being 2005.

With respect to fisheries, economists have, for almost 30 years, made extensive use of game theory in analysing the management of internationally shared fish stocks (e.g., Bjørndal and Munro, 2003). They are now beginning to apply game theory to the analysis of domestic fisheries (e.g. Sumaila 1997; Krønbak and Lindroos 2006; Clark 2006).

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" non-compliance (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).

LIMITED ENTRY SCHEMES WITH OLYMPIC STYLE GLOBAL QUOTAS

Having talked about the usefulness of game theory in analysing the issues at hand, we run the risk of appearing to contradict ourselves by commencing the discussion of the earlier limited entry schemes with another analytical framework, namely Principal-Agent analysis. In fact, Principal-Agent analysis is very closely related to a class of non-cooperative games, known as leader-follower games (Mesterton-Gibbons 1993; Krønbak and Lindroos 2006).

The principal, be it a person, a firm, a country or a province, wishes to see undertaken certain tasks that it is unable to do itself, and so acquires the services of one, or more, agents to undertake these tasks. Classic examples are an owner of a firm hiring a manager, and a landlord leasing farm land to a tenant farmer. The Principal-Agent analysis has application far beyond these simple examples, e.g. industry regulators and the firms being regulated (Sappington 1991).

In any event, in the context of Canadian fisheries, the resource managers (DFO) can be seen as constituting the principal, while the fishers constitute the agents. The Principal-Agent paradigm can be formally described as follows (see Clarke and Munro 1987, pp. 83-86).

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.

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 and Munro 1987).

An example of non-fishery resource management, to which Principal-Agent analysis obviously applies, and in which the results are reasonably satisfactory, is that of the management of British Columbia's forests. Some 96 per cent of B.C.'s commercially exploitable forest land is crown land. The B.C. provincial government grants forest tenure rights to forest companies, under a set of schemes. Basically, the companies are given the right to harvest timber under a set of regulations, and are called upon to assume various resource management responsibilities. Thus the B.C. government is the principal, while the forest companies harvesting the resources are the agents. That an incentive gap exists is undeniable. The companies are, for example, called upon by the province to engage in the re-planting of harvested forest land, and to engage in silviculture, once the re-planting has been completed. This requirement, however, produces less than fully satisfactory results, because of inadequate incentives (Haley and Luckert 1995). That being said, the incentive gap is at a tolerably low level.

With all of this in mind, the three limited entry schemes are now considered in detail.

Pacific Halibut Fishery

Pacific halibut, deemed to be one of the more valuable commercial species in the North Pacific, is a transboundary resource, shared by Canada and the United States (B.C. and Alaska). The Pacific halibut fishery has existed for over a century.

By the end of the First World War, there were clear signs that the resource was being overexploited. In response to the growing danger, the two coastal states came together and developed a cooperative management program, resulting in the establishment of the International Pacific Halibut Commission (IPHC) in 1923. In terms of conservation of the resource, the cooperative fisheries game that is the IPHC must be seen as having been remarkably stable and successful.

Following the implementation of EEZs by both Canada and the United States in 1977, an adjustment was made to the convention underlying the IPHC, which resulted in the elimination of American harvesting within the Canadian Pacific EEZ (and the corresponding elimination of Canadian harvesting within American waters). The adjustment to the convention enabled Canada to implement its own set of Pacific halibut fishery regulations, with the proviso that the regulations were not to contravene the conservation regulations of the IPHC. Canada responded to the opportunity by introducing a limited entry scheme in 1979.

At the time of the implementation of the limited entry scheme, there was already evidence of excess capacity (Crutchfield 1981). The IHPC had laid down an annual season maximum of approximately 240 days. Table 1 shows that in 1980 the season length was 65 days per year, far below the IHPC maximum.

In any event, at the outset of the limited entry scheme, the government of Canada issued 435 vessel ("L") licences, accompanied by some limitations on their transferability, e.g. the licence of a small vessel could not be transferred to a larger vessel. During the first year of operation, not all vessel licences were used. Some 102 licensed vessels did not participate.

The limited entry Principal-Agent relationship – leader-follower game – was accompanied by what turned out to be an insuppressible competitive sub-game among the fishers, as they struggled for shares of the limited harvest. The authors would be hard pressed to come up with Principal-Agent relationships outside of fisheries, in which such competitive sub-games emerge.

The inter-fisher competitive game was an example of what is arguably the most famous of all competitive games, and one which has proven to have very wide applicability. The game is known as the “Prisoner’s Dilemma”, with the name coming from a story developed to illustrate a key point about the nature of competitive games. In the story, two partners in crime are arrested on (justified) suspicion of grand larceny. The prisoners are kept in separate cells, so that cooperation between them is impossible. Each prisoner is interviewed, in turn, by the Crown prosecutor, who admits that, if both plead not guilty, the Crown can only hope to convict the two on a lesser charge, carrying a light sentence. If the “players” could cooperate, and enter into a binding agreement, they would obviously plead not guilty. The story goes on to demonstrate that, with cooperation being impossible, each player will be driven to adopt the strategy of pleading guilty, with the result that both end up serving long sentences – a decidedly inferior outcome. The key point is that, in competitive games, the “players” will be forced to adopt strategies that all recognize as inferior, if not destructive.

Consider now the 1979 Pacific halibut limited entry scheme. In the pre-limited entry era, there had been a competitive free for all, as more and more Canadian and American fishers competed for shares of the TAC. The limited entry scheme was supposed to bring this free for all to halt, in the newly established Canadian EEZ.

If the vessels plus crew had been identical, if input substitution in the fishing fleet had been impossible, and if the technology had been frozen, the competition (interaction) among vessels and fishers might have been virtually eliminated, given, of course, that the fleet size was appropriate for the TAC. None of these conditions held. Technology, for example, was anything but frozen. The result was that circumvention of the intent of the limited entry scheme was entirely feasible, which meant, in turn, that competition among the licence holders was definitely possible. Even if all fishers had been aware that such competition was mutually harmful, in terms of their economic returns from the fishery, each and every fisher would, in the absence of scope for meaningful cooperation, have had no option but to compete. Any fisher, who held back from competing, was all but guaranteeing the loss of a part, if not all, of his/her share of the TAC – a perfect Prisoner’s Dilemma.

It was remarked earlier that economists had originally welcomed limited entry schemes, like the 1979 Pacific halibut one, with enthusiasm. In reading what these economists wrote at the time, it is clear that, while they did not deny the possibility of inter-vessel competition, they thought that such competition would, in practical terms, be very limited, and readily controllable by the resource managers (see, for example, Crutchfield 1979). History was to prove them spectacularly wrong.

Return now to the B.C. Pacific halibut fishery, and consider Table 1, and the effects of the competitive race. The hitherto inactive licences were fully activated over the decade. Even though the TAC more than doubled between 1980 and 1988, the rapidly declining season length gives a clear indication of steadily increasing excess capacity. The ceiling of 435 licences proved to be a wholly ineffective barrier to the growth of capacity. The growth in capacity was fuelled in part by a steady technological advance in fishing electronics and gear (e.g. circle hooks, snap on gear, power drums, hook strippers and automatic baiting machines), over which the resource managers had no effective control.

While there were some limitations on licence transfers, as noted earlier, licence transfers were not banned. To the extent that a market for licences emerged, it can be argued that the market worked against conservation and economic sustainability. The licences, through the market, would tend to come into the hands of the most innovative and aggressive fishers, thereby intensifying the competitive game.

Table 1. British Columbia Pacific halibut fishery 1980-1990

Year	Active vessels (no.)	Season length (days)	Catch (tonnes)	TAC (tonnes)	TAC overage / underage (tonnes)
1980	333	65	3 305	2 721	584
1981	337	58	2 456	2 414	42
1982	301	61	2 382	2 458	-76
1983	305	24	2 398	2 414	-16
1984	334	22	4 033	4 082	-49
1985	363	22	4 704	4 564	140
1986	417	15	5 390	5 135	255
1987	424	16	5 444	5 266	178
1988	433	14	5 866	5 749	117
1989	435	11	4 659	4 564	95
1990	435	6	3 783	3 555	228

The increasing competition among the fishers had both resource, economic and safety consequences. With respect to conservation, it can be noted that, while the TAC overages were not large, they did, after the mid decade become persistent, and a matter of concern. There was also growing concern about unreported at-sea mortality, due, for example, to wastage, and lost fishing gear (often the result of gear wars on the fishing grounds) (B. Turris, Pacific Fisheries Management, pers. comm.).

The consequences for safety and economic viability of the fishery were severe. The risk to vessel and life grew as vessels were compelled to fish in unsafe conditions, as they competed for catch during an increasingly narrow window of opportunity. The economic returns from the fishery declined as large volumes of fish were landed over a short period of time, glutting the market. By 1990, the entire catch for fresh, halibut was landed around a six day season.

By the end of the decade, it was obvious to both government and industry that the situation was wholly unsatisfactory, and that it could not be allowed to continue. From the point of view of the principal, DFO, one could say that the consequence of the uncontrollable competitive fisher game was to produce a large incentive gap, in the sense that the resources offered a poor, if not negative, economic return to the public, and in which the future sustainability of the resources was thrown into question. One could go further and state that the incentive gap was, not merely large, but of overwhelming proportions.

B.C. Sablefish Fishery

Sablefish (black cod), like halibut, is today a high-valued groundfish species, with the unit landed value of the two species roughly comparable. In contrast to the Pacific halibut fishery, however, the British Columbia sablefish fishery is a relatively young one.

In the 1950s, 60s and 70s sablefish had been primarily a low valued bycatch in the halibut and groundfish trawl fisheries. Some enterprising fishermen experimented with longline and trap gear for the purpose of catching sablefish in the mid-1970s and developed lucrative markets in Japan for their catch. Concerned about the increasing effort directed towards sablefish, DFO limited entry to the fishery in 1981 to 48 longline and trap vessels (a limited entry “K” license) in an attempt to curtail further increases in fishing capacity and improve the management of the commercial fishery.

Exactly the same type of competitive fisher sub-game, witnessed in the case of Pacific halibut, played itself out, producing a history strikingly similar to that of the Pacific halibut fishery. Consider Table 2.

The number of active vessels steadily grew through the decade and approached the 48 vessel ceiling. Although the TAC increased by some 42 per cent, evidence of excess capacity grew as the season length steadily declined. Vessels deployed more gear, used better fish finding electronic devices, fished in all weather conditions, added crew, fished around the clock, increased the holding capacity of their vessels, bait loaded traps and hooks, and, in some cases, cheated by fishing before and after openings (B. Turris, Pacific Fisheries Management, pers. comm.).

The emergence of an active market in licences exacerbated the competitive fisher game. The explanation is the same as that given in the discussion of the Pacific halibut fishery. The market directed licences into the hands of the aggressive and innovative.

The consequences for conservation, economic viability of the fishery, and safety differed from the Pacific halibut fishery experience, only in that they were, if anything more pronounced. With respect to conservation, TAC overages based upon reported landings did, after 1981 become chronic and most definitely not trivial. The overage for 1989, for example, was in excess of 20 per cent of the TAC. Similar to the case of Pacific halibut, there was growing concern about unaccounted for at sea mortality associated with discarded small fish, hook and trap predation, and lost fishing gear.

Regarding economic viability and safety, the steadily declining season length resulted in poor product quality (vessels did not waste time dressing and freezing product at sea), supply gluts, increased operating costs, and poor safety practices, as boats overloaded with fishing gear and catch operated in poor weather conditions (B. Turris, Pacific Fisheries Management, pers. comm.).

Table 2. British Columbia sablefish fishery 1981-1989

Year	Active vessels (no.)	Season length (days)	Catch (tonnes)	TAC (tonnes)	TAC overage / underage (tonnes)
1981	n/a	148	2 636	3 190	-554
1982	n/a	181	3 628	3 190	438
1983	23	95	4 123	3 190	933
1984	20	63	3 824	3 190	634
1985	27	45	3 951	3 650	301
1986	41	20	3 900	3 650	250
1987	43	14	4 178	3 740	438
1988	45	20[a]	5 075	4 015	1 060
1989	47	14[b]	4 722	4 015	707

[a] In 1988 there were seven 20-day fishing periods during the year. Each vessel was allowed to fish in one.
[b] In 1989 there were eight 14-day fishing periods during the year. Each vessel was allowed to fish in one.

In late 1989, it had become obvious to both industry and DFO that the existing management measures were not working. Yet again, from the point of view of the principal, DFO, the incentive gap proved to be overwhelming.

Groundfish Trawl Fishery

The British Columbia commercial groundfish trawl fishery has existed since the1940s. Groundfish are caught in nets (trawls) towed behind the vessel along the seafloor (bottom trawling) or off bottom (midwater trawling). The fishery is an extremely complex one, with more than 50 different stocks being harvested (various rockfish, cod, flatfish, lingcod, and elasmobranch stocks).

In the 1960s and 1970s, prior to the implementation of Canada’s Pacific EEZ, Canadian groundfish trawl vessels had found themselves in competition with large foreign trawlers. With the advent of Canada’s EEZ regime most foreign fishing inside of Canada’s EEZ was eliminated, which created the opportunity for the introduction of a limited entry scheme.

Concerns about increased harvesting capacity (partially fuelled by government ship building subsidies aimed at increasing the utilization of fish resources within

Canada's EEZ) led to this opportunity being realized. A limited entry licensing scheme in the groundfish trawl fishery was introduced in 1976, in anticipation of the EEZ regime, resulting in 142 groundfish trawl (T) licenses. Fewer than one half of the licenses were initially activated, and fishing was relatively unrestricted. The first management plan was introduced in 1980.

Following this, a pattern similar to that of Pacific halibut and sablefish developed (the emergence of a competitive sub-game among fishers). More and more licenses were activated. Better and better gear and equipment were introduced. The overall length of the season remained a twelve month one, which was necessary, if domestic processors were to maintain market access. Trip limits, and limits on number of trips, were used to keep harvests within the bounds of the TAC. The results were the same as shortened seasons. Trip limits shrank steadily; at-sea discarding and misreporting increased dramatically (Turris 2000). Reduced trip limits did not mean vessels caught less in their nets. It meant they could only retain less fish and were required to discard a greater proportion of the catch. In an attempt to reduce discarding and fishing costs, fishermen would often misreport the species of catch (i.e. report it as another species caught or as the correct species but from an incorrect area). Once again, tradability of the licences served to exacerbate the problem.

The groundfish trawl species were, and are, much more difficult to manage than Pacific halibut or sablefish. Pacific halibut and sablefish are each managed as single coastwide stocks encompassing the entire West coast of British Columbia. This means that no matter where halibut or sablefish are caught (West coast of Vancouver Island, Hecate Strait, or Dixon Entrance) the catch comes out of the coastwide TAC for that species. This is not the case, however, for many other groundfish species. There are, for example some 20 different species of rockfish. Each species may have several different stocks (resident in different locations). The commercially most important of the rockfish species, Pacific Ocean Perch (POP), is a case in point. Off British Columbia, there are five different POP stocks (3C stock-lower West Coast Vancouver Island, 3D stock-upper West Coast Vancouver Island, 5A/B stock-Queen Charlotte Sound, 5C/D stock-Hecate Strait, and 5E stock-West Coast Queen Charlotte Islands and Dixon Entrance), with each having a separate TAC. During a groundfish trawl trip, a vessel may catch POP from all 5 stocks as well as a multitude of others species and stocks. The management challenge is to be able to account accurately for total catch mortality (this includes catch kept by the vessel as well as released at sea) on a stock basis (by species and area).

In the pre-ITQ era, DFO, while employing the imposition of trip limits, limits on the number of trips, log books, dockside monitoring, and vessel and gear restrictions, found itself incapable of meeting the management challenge. Trawl vessels would exceed trip limits, misreport the area and species of catch and the amount of discards. As the species trip limits declined the amount of overages, misreporting and discarding increased. One aspect of the management scheme that seriously aggravated the problem of misreporting and discarding were the facts that trip allocations were non-transferable, and that there were individual species limits. The consequence was that legally a fisher was required to curtail his/her trip, if just one of the many individual limits was exceeded (Grafton et al. 2007).

With inaccurate information, DFO was unable to manage on a stock specific basis and was forced to group stocks into coastwide species TACs (for example, combine all 5 POP stock TACs into one coastwide POP TAC), increasing the likelihood that specific stocks were being seriously overharvested. Since at-sea mortality was not known but increasing, coastwide TACs were being managed to and exceeded by landed catch alone.

Table 3. Pacific ocean perch TAC overage/underage 1980-1995

Year	Catch (tonnes)	TAC (tonnes)	Total TAC overage / underage (tonnes)	Overages as a percentage of TAC
1980	5 325	3 400	1 925	57 %
1981	5 108	4 400	708	16 %
1982	6 031	4 350	1 681	39 %
1983	5 705	3 750	1 955	52 %
1984	6 774	3 550	3 224	91 %
1985	6 119	3 500	2 619	75 %
1986	5 947	2 950	2 997	102 %
1987	6 383	2 950	3 433	116 %
1988	7 037	4 150	2 887	70 %
1989	6 127	4 800	1 327	28 %
1990	5 807	4 250	1 557	37 %
1991	4 408	3 800	608	16 %
1992	4 139	4 050	89	2 %
1993	4 624	4 200	424	10 %
1994	5 788	4 917	871	18 %
1995	6 311	4 234	2 077	49 %

The problems being faced by DFO are illustrated by Table 3, on Pacific Ocean Perch TAC overages and underages, from 1980 to 1995. Note that the TAC overages are based on reported landings, and thus underestimate the true overages, probably by a considerable margin, particularly in the later years as the trip limits decline in quantity and discarding increased. Note further that the TACs are the combined TAC for all five stocks, with all that that implies.

While the overages fluctuated substantially over the period, the overall impression given by Table 3 is essentially that of a fishery out of control.

The conservation problems were matched by increasing economic distress, for reasons similar to the halibut and sablefish fisheries (Turris 2000). By 1995, the incentive gap had become so massive that, in September of 1995, DFO felt compelled to take the unprecedented step of shutting down the groundfish trawl fishery down – an historical first. The fishery remained closed for five months, until an entirely new program could be introduced. It had taken a greater number of years for the groundfish trawl limited management scheme to fail, than it had for the Pacific halibut and sablefish programs. When the collapse of the groundfish trawl limited entry scheme came, however, the collapse was particularly dramatic.

The history of the three limited entry schemes, while varying in detail, had the same general pattern. Seen in the context of Principal-Agent (leader-follower game) analysis, the limited entry schemes gave rise to difficult monitoring problems, which led, in turn, to the emergence of unsustainable, and indeed intolerable, incentive gaps. The incentive was to maximize catch at the lowest cost to the vessel by misreporting discards, area of catch, and species of catch. DFO did not have in place at-sea monitoring to provide independent catch and mortality information.

This raises a question. As will be seen, a key component of the post-ITQ groundfish fish fishery, and the more recent integrated ITQ scheme, has been the implementation of at-sea-monitoring. Why was at-sea-monitoring not introduced before the implementation of the ITQ schemes? The basic reason is that lack of individual accountability would have made such a program extremely difficult to implement.

Consider the case of groundfish, and the bycatch constraint. With at-sea monitoring to accurately account for total mortality and without individual accountability and incentives, fishers would race to catch as much from an area as they could before the TAC for the most limiting bycatch species had been reached. Once a bycatch species TAC was reached, the fishery managers would then have been required to close the area to all groundfish trawl fishing, even if TACs for other groundfish species had not yet been caught. For example, the current coastwide sablefish TAC is 328 tonnes. Sablefish is a common bycatch, when fishing many other groundfish species (especially deeper water rockfishes and soles). Fearing that the sablefish TAC would be reached before the end of the season, fishers would have had a powerful incentive to race out to the grounds to maximize their catch, while showing little concern for minimizing their sablefish bycatch. The result would have been predictable. The sablefish TAC would be quickly caught (as bycatch) and the fishery would be closed down, leaving significant portions of other groundfish TACs uncaught. Markets would not be properly serviced (inconsistent supply, poor quality, supply gluts), the value of the available catch would not be maximized, and the economic viability of the fishery would be compromised.

There is another aspect, as well. The scenario described carries with it the assumption that fishery managers would have had the political will to shut down the other portions of groundfish fishery with TACs not fully caught. Realism suggests that the fishery managers would have been under immense and likely irresistible, pressure to keep the fisheries open regardless.

Data are not available that would enable one to obtain a precise estimate of the economic state of the three fishing industries at the close of their respective post-EEZ limited entry schemes. Nonetheless, the following conjecture can be advanced. It is that, taking into account the DFO costs of administering the fisheries, the fisheries were, at the end of their pre-ITQ management schemes, making negative contributions to the Canadian GDP.

THE SHIFT TO ITQ SCHEMES

The post EEZ incentive scheme developed by the principal (DFO) had produced wholly unsatisfactory results – yawning incentive gaps. A new scheme was called for, one that would hopefully narrow, if not close, these gaps. The scheme adopted was that of individual harvest rights – IQs.

The Pacific halibut industry, facing growing economic distress, approached DFO in 1988 to discuss the opportunity for implementing an IQ scheme in the fishery. The sablefish industry followed suit the following year. After extensive consultations with the two industries, DFO introduced experimental IQ schemes to the Pacific halibut fishery and the sablefish fishery, in 1991 and 1990 respectively. DFO implemented an individual transferable quota (ITQ) scheme in the groundfish trawl fishery in 1997. The rationale for the IQ schemes can be traced back to the Commission on Pacific Fisheries Policy, which brought down its final report in 1982 (Pearse 1982)

In the report, Commissioner Peter Pearse had recommended the introduction of harvest quotas for the three fisheries being investigated in this project (recommendations that were greeted with little or no enthusiasm by industry, at the time). Pearse observed that the precedent had been set in other Canadian renewable natural resource industries, where the resources are owned by the Crown. He cited, with approval (having a first degree in forestry) the British Columbia forest industry, as an example of a reasonably successful harvester quota scheme. As has been noted, forest companies are granted harvesting rights, and are assigned management duties, under various lease programs. The property rights to the resource remain firmly in the hands of the Crown (provincial government).

Forest resources are, however, visible and stationary. Harvesting rights can be assigned to companies in specific, and divisible, areas. In terms of harvesting, one would be hard pressed to find any significant strategic interaction between, and among, the forest companies holding harvesting rights, because they are not exploiting a resource in common, in contrast to the fisheries, under investigation.

In the three fisheries under investigation, strategic interaction among the fishers is an inescapable fact of life, regardless of the resource management regime (primarily because they fish the same species, and the same areas; furthermore, in some cases, the vessels are multi-licensed for all three fisheries). If the IQ schemes do no more than re-establish a competitive sub-game among fishers, under somewhat different rules perhaps, little or nothing will be gained. Success will be achieved (the incentive gap reduced to tolerable proportions), if and only if, the IQ scheme leads to the fisher sub-game being transformed from a competitive to cooperative one.

In order for there to be a cooperative game, there must first be in place a workable mechanism for the sharing of the economic benefits among the “players”. IQ schemes provide such a mechanism (but IQs are by no means the only possible mechanism). The existence of the sharing mechanism, in of and by itself, is, however, not sufficient.

A fundamental condition that must be satisfied, if a cooperative game is to have a stable solution, is that each and every player must be convinced that it will receive a return – a payoff – at least as great as it would under competition (see, for example: FAO 2002). If non-compliance (cheating) is left unchecked, or, if free riding (poaching) is rampant, this condition, known as the Individual Rationality Constraint, will not be met, even if the allocated shares appear to be “fair”. Hilborn et al. (2004) give the example of an abalone fishery in B.C. that was transformed into an IQ fishery. The scheme collapsed and fisher competition resumed, because compliance proved to be unenforceable.

Let us next ask, if achieving a stable cooperative fisher game, demands that firm property rights be established for the quota holders. It has become almost dogma among economists that, when an IQ scheme has been put in place, fisher property rights are created, at least to the harvests, if not to the resources themselves. The stronger these private property rights are, the argument continues, the better – the more stable is the fisher cooperative game (e.g. Bjørndal and Munro 1998).

The implication is, of course that the public property rights to the fishery resources are thereby diminished, if not extinguished. This, in turn, leads to great controversy about IQ schemes, with charges of public resource “giveaways” being levelled by IQ critics.

The dogma can, and should be, challenged. It is not at all clear that the establishment of harvesting rights, in of and by themselves, leads to the creation of private property rights in any true sense. To return to the example of the B.C. forest industry, the companies are granted harvesting permits or rights, but no one seriously argues that these permits or rights give the relevant forest companies meaningful property rights to the forest lands, or the trees upon the stump. For an argument against the aforementioned dogma, put forth with vigour by an American geographer and economist see: Seth Macinko and Daniel Bromley 2002. In any event, this is an issue to be debated by legal experts (as opposed to economists).

Indeed, upon examining the issue within the Principal-Agent framework, one can go farther and argue that the introduction of IQs may actually enhance the value of the public property rights to the resources. Return to the often cited example of a principal-agent relationship: the owner of a firm and the hired manager. If the owner finds a means of reducing the incentive gap, which he/she faces, the legal nature of the owner’s property rights to the firm will not change. The value of these rights (firm shares) will, however, obviously be increased. Thus, if the introduction of IQs leads to a marked reduction in the aforementioned massive incentive gap, and turns the fishery resources into economically productive assets, from the point of view of Canadian society, one could then maintain that the IQ schemes have, in fact, enhanced the value of the public property rights to the resources.

THE NATURE OF THE ITQ SCHEMES

The three ITQ schemes have recently been integrated. Prior to integration, the Pacific halibut and sablefish fisheries IQ schemes were relatively straightforward, while the groundfish trawl scheme was remarkably complex. The simplicity of the first two schemes reflects the fact that they were and are applied to single species fisheries. Both halibut and sablefish quotas are issued on an annual basis, are expressed in terms of percentages of the TACs, and both became genuine ITQs, i.e. transferable. There was initially a ban on trade on halibut quotas, but this ban was relaxed over time (Munro 2001).

While the halibut and sablefish quotas are legally very short term, there is evidence that fishers regard them as de facto being much longer in term. Turris, for example, reported that, while DFO only allowed sablefish quotas to be transferred only on an annual basis, legal agreements between “K” licence holders resulted in de facto longer term quotas (Turris 2000).

The argument made on behalf of the single species ITQs, given that they are perceived by the fishers as being long term, is that with a clearly identified share of the TAC, fishers are able 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.

Furthermore, the market value of the ITQs reflects 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. If the resource is not managed to be sustainable, future TACs will decline as will the value of the ITQ. Thus, fishers have an incentive to ensure the resource is not over-exploited. In this sense, the fishers’ long-term objectives are brought into line with those of the government – to make certain the annual removals are stable and sustainable. Having similar long-term objectives, the fishers begin to work collectively and cooperatively with government in support of better monitoring, management, research, and science.

The groundfish trawl ITQ scheme is of particular interest for at least two reasons, the first being that even strongly pro-ITQ economists had, until the last decade, serious doubts about the efficacy of ITQ schemes in multi-species fisheries (see, for example: Macgillivray 1996; Squires et al. 1998). Following the experience of the evolution of the B.C. groundfish trawl fishery IQ scheme, several of these hesitant economists recanted, and began arguing that IQs do, in fact, come into their own in multi-species fisheries, given that they are transferable (i.e. ITQs) (Grafton et al. 2007).

Secondly, 20 per cent of the quota is set aside for Code of Conduct Quota and Groundfish Development Quota, administered by the Groundfish Development Authority. The significance of this is that it demonstrates that non-vessel owner, non-government players, having significant bargaining power, can be incorporated into the cooperative game.

In any event, when the groundfish trawl ITQ scheme was introduced in 1997, fifty-five different stock specific TACs were allocated to all T license holders, as ITQs based primarily on their historical catch of all groundfish combined. License holders then transferred stock specific quota amongst themselves based on the business strategy that best fit their individual operation. Some vessels wanted to specialize by area (south vs. north coast), or depth (deepwater vs. inshore fishing), or gear (bottom vs. midwater trawl), or species (rockfish vs. cod and flatfish), or market (fresh vs. frozen). Many vessels stayed diversified in their ITQ holdings, moving fish annually on a temporary basis to other vessels as needed. Some operators chose to exit the fishery, while others expanded their operations to improve economies of scale (B. Turris, Pacific Fisheries Management, pers. comm.).

An additional component of the groundfish trawl ITQ plan was the implementation of 100 per cent at-sea observer coverage on all groundfish trawl trips. Any vessel participating in the bottom trawl fishery would have to have a trained and certified observer on board to record the total catch mortality (kept and released) by species and area for each bottom trawl tow. The vessel owners are required to cover the full cost of the observers (Grafton et al. 2007).

The information from the at-sea observer as well as the information from the dockside monitor is tabulated in an efficient and timely manner at the end of the trip (within 24 hours) so that the vessel operator knows the status of the vessel's ITQ holdings. If a vessel has exceeded its ITQ for a specific species in an area, it is required to stop fishing in that area. In stark contrast to the pre-ITQ management scheme, the vessel owner can surmount the constraint by transferring additional ITQ to the vessel through the market. If the vessel is finished fishing for the season, and is in an overage situation for a stock, the vessel owner can transfer quota on to cover the overage, or see the overage deducted from the vessel's ITQ for the following year. To remove the incentive for the vessel always to catch the entire ITQ, the plan allows vessels to carry forward up to 30 per cent of their ITQs to the following year (B. Turris, Pacific Fisheries Management, pers. comm.).

While DFO must approve the transfer of fish from one vessel to another, this is a simple administrative function carried out electronically. There are approximately 2500 to 3000 ITQ transfers in the groundfish trawl fishery annually. To facilitate the clearing of the ITQ market, private quota trading companies have emerged. The companies have become so efficient that vessels can call from their vessels, immediately after realizing the need for additional quota, and arrange for and complete the transfer of ITQ by the time that they reach port to offload their catch (B. Turris, ibid.).

It is argued that the addition of at-sea observers allows for ITQs to operate successfully on a multi-species and stock specific basis, when combined with individual quotas. Of critical importance for the system to work is that the quotas be transferable. Individualizing the quota allocation makes the fishers accountable for their own actions, as opposed to becoming a fleet responsibility, resulting in shutting down the entire fleet or implementation of management measures that further restrict all vessels. If vessel owners exceed their individual allocations they cannot continue to fish, until they have acquired additional quota through the market. Transferability allows individuals to adapt to changing circumstances in a very dynamic business. The incentives are to fish safely, selectively, minimize wastage and costs, and maximize the landed and long-term value of the ITQ (B. Turris, ibid.).

In 2006, DFO moved to the integrated ITQ scheme encompassing the three fisheries and being examined in this report. That transferability of quota is central to the effectiveness of the integrated program will be obvious from the discussion to follow.

While the move to integration occurred in 2006, the thinking that lay behind the move can be traced back to the mid-1990s. For years, single species limited entry groundfish fisheries for sablefish, halibut, rockfish, dogfish and lingcod have been releasing at-sea catch that their licenses prohibit them from retaining. Needless to say, there is some level of mortality associated with the bycatch and release of groundfish. For rockfish, the mortality rate is very high (virtually 100 per cent), while for other more resilient species, such as halibut, the mortality rate is lower (around 20 percent). By the mid-1990s managers started to become concerned about the health of various groundfish stocks, especially some stocks of rockfish (i.e. yelloweye, quillback, copper, china, and tiger rockfish). Adding to the problem was the unaccounted-for discard bycatch mortality occurring in the various limited entry groundfish fisheries. Throwing back fish at-sea was wasteful, impaired the proper management of the resource, and threatened the long-term viability and sustainability of the fishery (B. Turris, ibid.).

Almost all fisheries are, in fact, multi-species by nature. The management regime must provide for the harvest of more than one species of fish. Realizing that limited entry had created species specific management regimes to the detriment of many bycatch species, DFO worked closely with industry on the development of a multi-species ITQ program for all groundfish fisheries that operates very similar to the groundfish trawl ITQ program. In 2006, following more than three years of planning, design and consultation, DFO implemented the integrated groundfish management plan. All groundfish fisheries (sablefish, halibut, groundfish trawl, rockfish, dogfish and lingcod) are managed under ITQs and can trade quota between licensed vessels to cover bycatch mortality (retained or released). To ensure accurate recording of catch and releases at sea by species and area, all sablefish, halibut, rockfish, dogfish and lingcod vessels must be equipped with electronic monitoring equipment (cameras). Groundfish trawl vessels continue to use at-sea observers.

Under the integrated groundfish management plan, a limited entry licensed sablefish vessel that catches halibut while fishing for sablefish must transfer halibut from a halibut license onto their sablefish license to cover the halibut bycatch. Similarly, a vessel licensed to fish dogfish that catches rockfish as bycatch, must transfer rockfish ITQ onto their dogfish license to cover bycatch. Just as in the trawl fishery, large data systems and computer programs have been developed (by both government and the private sector) to facilitate the trading of ITQ and allow for the timely entry of data and updating of each vessel's quota holdings.

Consistent with the principles of sustainable management, all groundfish mortality incurred in the various limited entry groundfish fisheries is accounted-for against established stock specific TACs. All groundfish fishermen now have incentives to fish selectively, minimize mortality of released fish and the costs of fishing, and maximize the revenue from their total catch (B. Turris, ibid.).

One final comment is in order. In the discussion of the pre-ITQ limited entry management scheme, the point was made over and over that transferability of licences exacerbated the economic and conservation problems of the fisheries. The market was the enemy of effective resource management. Transferability of licences fuelled the intra-fisher competitive game, putting licences in the hands of the most efficient and aggressive. By way of contrast, under the ITQ schemes the market, by facilitating the allocation of harvests among fishers, by reducing fisher risk through allowing fishers to diversify their ITQ asset portfolios, and by directing harvesting to the most efficient, magnifies the returns from the cooperative fisher games to the benefit of the fishers, and to the benefit of the public at large.

ANALYSIS

A properly functioning, stable cooperative fisher game should see the "players" working towards the maximization of the net economic returns from the fishery through time, while bargaining over the division of these returns. We now turn to the available data to see what evidence, if any, can be obtained on whether the cooperative fisher games are, or are not, yielding the hoped for results, and thus, whether or not, the destructive consequences of the pre-ITQ Prisoner's Dilemma type of competitive games have been eliminated.

Figure 1. Pacific Halibut Season Length: 1980-2005

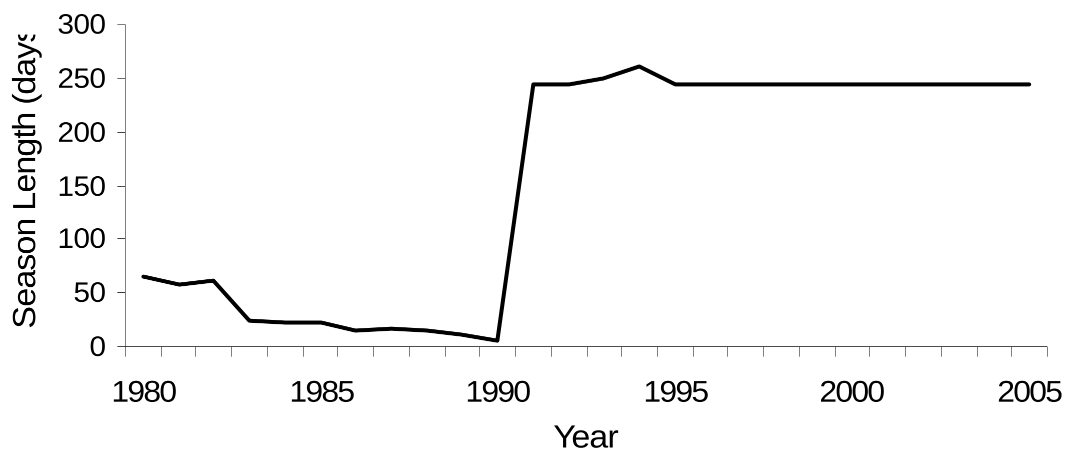
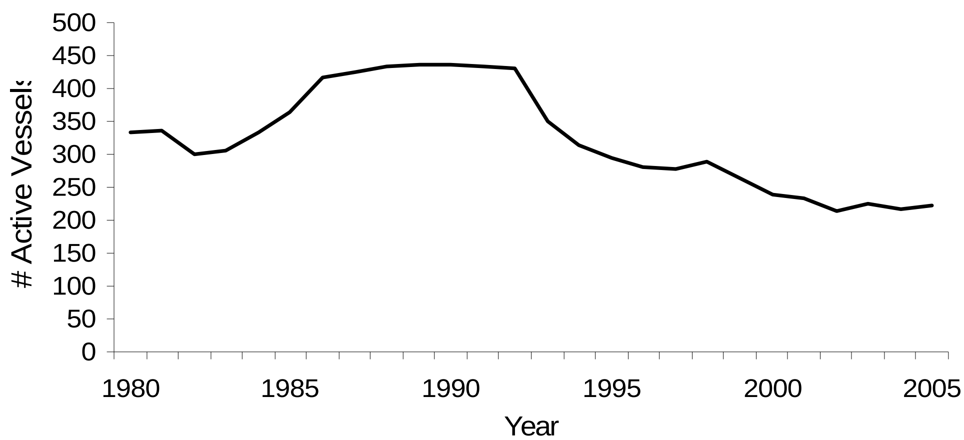


Table 4. Pacific halibut fishery TAC overage/underage: 1988-2005

Year	Catch (tonnes)	TAC (tonnes)	TAC overage / underage (tonnes)
1988	5 866	5 749	117
1989	4 659	4 564	95
1990	3 783	3 555	228
1991	3 241	3 364	-123
1992	3 441	3 636	-195
1993	4 796	4 836	-40
1994	4 498	4 564	-66
1995	4 320	4 387	-67
1996	4 321	4 379	-58
1997	5 601	5 719	-118
1998	5 859	5 924	-65
1999	5 552	5 554	-2
2000	4 832	4 884	-53
2001	4 638	4 819	-180
2002	5 448	5 510	-62
2003	5 328	5 397	-69
2004	5 494	5 768	-275
2005	5 568	5 700	-132

Figure 2. Pacific Halibut: Number of Active Vessels 1980-2005



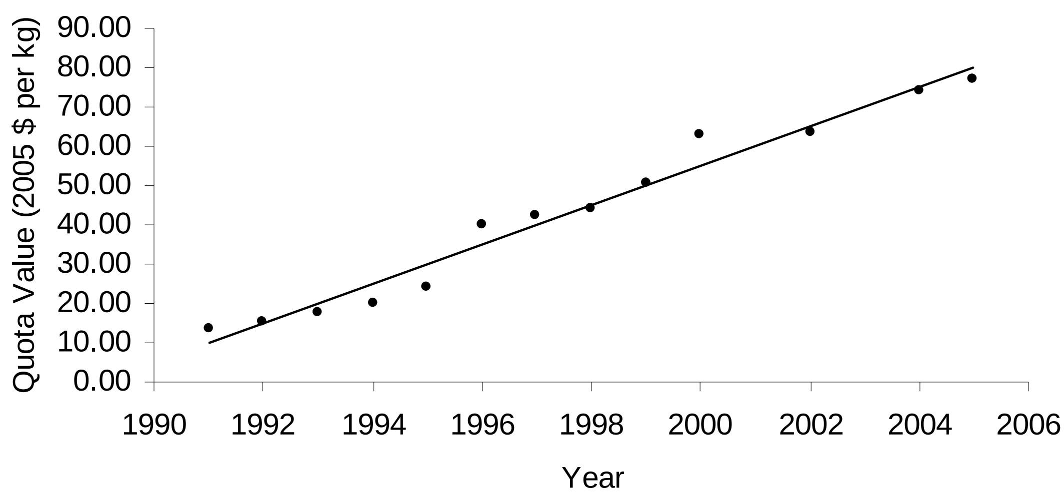
Since the integrated ITQ scheme has been in place for a very short period of time, this segment of the ITQ history of the fisheries cannot be assessed. Thus, the search for evidence will, of necessity, proceed on a fishery by fishery basis, up to the introduction of the integrated scheme. It will come as no surprise that the Pacific halibut and sablefish experiences are much easier to assess than is that of the groundfish trawl fishery.

In turning first to Pacific halibut, it will be recalled that, in the years leading up to the introduction of the IQ scheme, the fishery was characterized by excess capacity, rapidly declining seasons, chronic TAC overages, and economic distress. Consider now Table 4, and Figures 1 and 2.

The chronic overages (based on reported catch) disappeared after the introduction of IQs. The steady decline in active vessels is encouraging. What is particularly striking is the dramatic increase in season length, up to the IPHC maximum, and the fact that it has remained at, or close to, that maximum, ever since.

Detailed data on the industry’s costs are not available, so that it is not possible to obtain estimates of the industry’s profits through time. What is available, however, is the market value of quota over time. Given that quotas are perceived by fishers as being de facto long term, the quota values will, if the fishers are rational, reflect, albeit imperfectly, the market’s perception of the flow of net economic returns from the fishery through time. Consider now Table 5, which presents the halibut quota values in constant 2005 dollars, and the accompanying Figure 3, in which a trend line is plotted.

Figure 3. Pacific Halibut: Quota Values and Trend Line



The quota values reflect the market’s perception of the returns from the fishery to the industry, not to the economy as a whole. Since the introduction of the ITQ scheme can be expected to have increased DFO’s management costs, it is important to know whether the government received compensation through increased licence fees. Hence the quota value series is accompanied by a series on licence fees, also in constant dollars.

Table 5. Pacific halibut fishery quota and licence values in constant (2005) dollars 1988-2005

Year	Quota value[a] (2005 $ per kg)	Licence fees ('000s of 2005 $)
1988		6.5
1989		6.2
1990		5.9
1991	13.52	993.2
1992	15.41	974.5
1993	17.89	135.7
1994	19.93	135.6
1995	24.20	132.0
1996	39.73	128.8
1997	42.36	126.8
1998	43.85	125.4
1999	50.74	121.9
2000	62.94	2,126.3
2001	n/a	1,192.9
2002	63.59	1,332.5
2003	n/a	1,289.8
2004	74.25	1,321.1
2005	77.00	1,083.0

[a] Annual average

The quota values, in real terms, show a steady, and indeed unbroken, increase, since the inception of the IQ scheme, in spite of sharply increasing licence fees. Given the fluctuations in the halibut market, the unbroken nature of the increase is surprising. In any event, the quota values increased some five fold in real terms, over the last decade and a half. This can be taken as a measure, albeit crude, of the market's perception of the steadily increasing economic health of the fishery.

With regards to licence fees, the licence fees collected were trifling prior to the introduction of IQs. They remained decidedly modest during the 1990s, but reached a more healthy state after 2000, when DFO began to undertake a serious cost recovery program.

The same exercise is now undertaken for the sablefish fishery. Consider Tables 6 and 7, and Figures 3 and 4.

Table 6. Sablefish fishery TAC overage/underage 1988-2005

Year	Catch (tonnes)	TAC (tonnes)	TAC overage / underage (tonnes)
1988	5 075	4 015	1 060
1989	4 722	4 015	707
1990	4 275	4 260	15
1991	4 532	4 560	-28
1992	4 557	4 560	-3
1993	4 546	4 560	-14
1994	4 533	4 521	12
1995	3 709	3 709	0
1996	3 168	3 169	-1
1997	3 893	4 023	-130
1998	4 164	4 023	141
1999	6 323	6 394	-71
2000	3 532	3 646	-114
2001	2 753	2 812	-58
2002	1 894	1 928	-34
2003	2 591	2 675	-84
2004	3 859	4 088	-229
2005	3 822	4 213	-391

Figure 4. Sablefish Season Length: 1981-2005

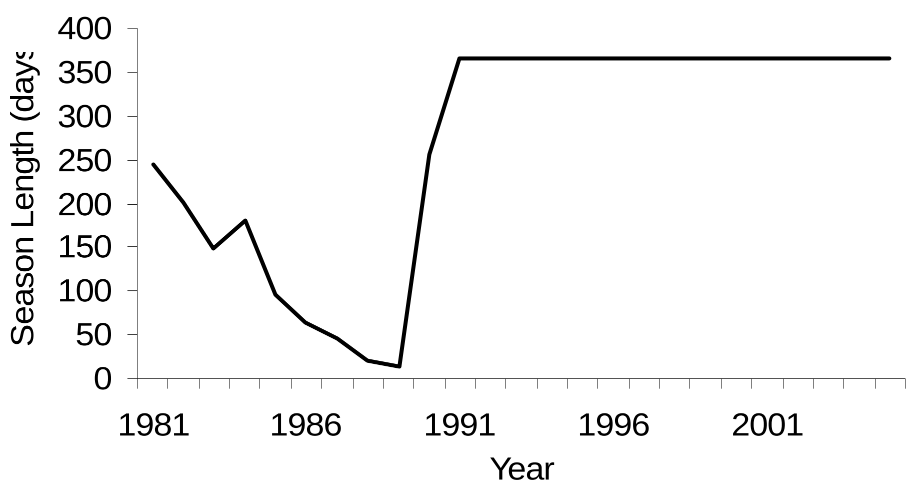


Figure 5. Sablefish: Number of Active Vessels: 1983-2005

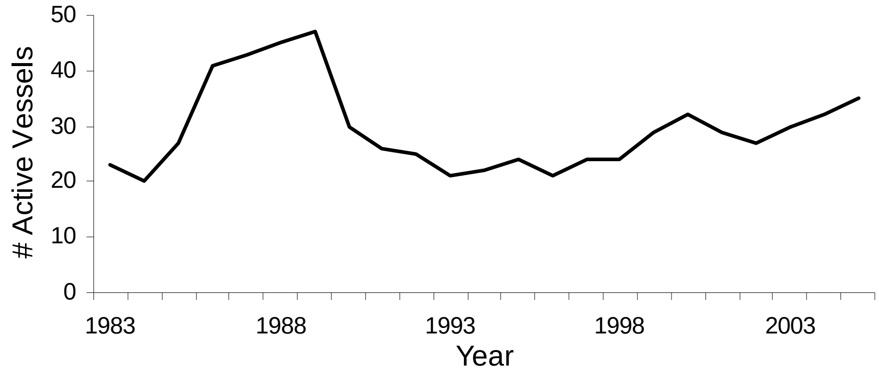
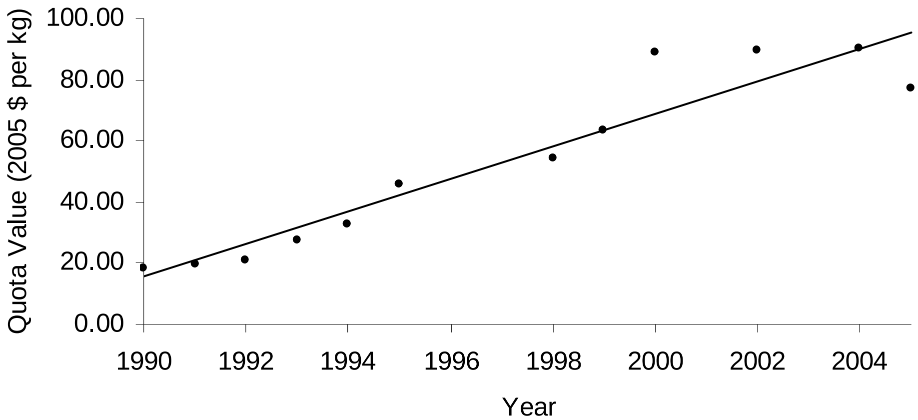


Table 7. Sablefish quota values and licence fees in constant (2005) dollars 1988-2005

Year	Quota value[a] (2005 $ per kg)	Licence fees (‘000s of 2005 $)
1988		0.7
1989		0.7
1990	18.04	0.7
1991	19.93	0.6
1992	21.01	0.6
1993	27.52	0.6
1994	32.99	0.6
1995	45.71	0.6
1996	n/a	484.5
1997	n/a	605.4
1998	54.17	599.1
1999	63.42	1,512.4
2000	88.86	920.0
2001	n/a	838.3
2002	89.50	179.7
2003	n/a	613.9
2004	90.01	988.0
2005	77.00	911.0

[a] Annual average

Figure 6. Sablefish: Quota Values and Trend Line



The pattern exhibited by the sablefish fishery, after the introduction of IQs differs only in minor detail from that of the Pacific halibut fishery. The same conclusions hold.

The data that are available for the groundfish trawl fishery are, due to the complexity of the fishery, less complete than are those for halibut and sablefish. There are, for example no useful quota value data for the fishery available, at the time of writing. Nonetheless, it is possible to draw some inferences from what data there are. Consider now Tables 8 and 9.

Table 8. Groundfish trawl fishery number of active vessels and number of tows per annum 1996-2005

Year	Active Vessels (no.)	Tows (‘000s)
1996	112	19.7
1997	92	16.3
1998	88	17.2
1999	89	17.4
2000	82	18.2
2001	83	16.7
2002	79	17.8
2003	78	15.5
2004	72	14.8
2005	75	14.4

Table 8 gives some indication that there was a steady decrease in active capacity in the fishery, after the advent of ITQs, and a corresponding decrease in fishing effort.

Table 9 on Pacific ocean perch, the fishery described as having been out of control in the pre-ITQ era (see: Table 3), is revealing. The massive overages disappeared after the 1997 implementation of the new regime. The appendix contains a set of tables on the other main groundfish trawl fishery species and species groups. Pre-ITQ TAC data are not available for these species, but post-ITQ TAC data are. It will be seen that the post-ITQ overage/underage pattern is virtually identical to that of Pacific ocean perch.

Table 9. Pacific ocean perch TAC overage/underage 1995-2005

Year	Catch (tonnes)	TAC (tonnes)	TAC overage / underage (tonnes)
1995	6 311	4 234	2 077
1996	6 490	6 884	-394
1997	6 016	6 481	-465
1998	5 947	6 147	-200
1999	6 222	6 147	75
2000	5 967	6 147	-180
2001	5 823	6 147	-324
2002	5 897	5 847	50
2003	6 228	6 146	82
2004	5 971	6 146	-175
2005	5 152	6 146	-994

The economic data on the groundfish trawl fishery are fragmentary. Having said this, history has carried out a useful experiment for us. The American groundfish trawl fishery, off Washington, Oregon and California, is very similar in nature to that off B.C. When the B.C. fishery moved to ITQs, the West Coast American fishery continued with the same management scheme that Canada had used prior to 1997. A detailed comparative study of the two fisheries was published in 2006, by Trevor Branch, now with the University of Miami (Branch 2006). Branch concludes that, were the US to adopt the management scheme used for the B.C. groundfish trawl fishery, including the use of 100 per cent at sea observer coverage to be paid for by the fishers, the per annum net incomes of the American fishers would be increased by many millions of dollars (Branch ibid.).

Finally, it needs to be asked whether there is any evidence of the fishers, in the fisheries in question, coalescing and attempting to enhance the long term value of the resource, as cooperative game theory would lead us to expect. Once again, the evidence is very fragmentary, but there is some. No hard evidence is available, at the time of writing, on the Pacific halibut fishery. There is some, however, on the other two fisheries. The Canadian Sablefish Association has been making voluntary contributions to stock assessment and research in the order of $800,000 per year (L. Budden, Canadian Sablefish Association, pers. comm. 2007). The groundfish trawl fishers have made comparable voluntary annual contributions to research (Grafton et al. 2007).

DISCUSSION

The task set before the consultants was to assess the move towards harvest rights (ITQ) schemes in the three groundfish fisheries, and to determine whether or not they represented an advance over the previous management scheme, which this report has described as limited entry combined with Olympic style TAC harvesting. That there may be flaws in the present ITQ schemes cannot be denied. Nonetheless, the general conclusion is that the ITQ schemes represent a marked advance over the previous management scheme.

In part, this general conclusion arises from the fact that the previous management scheme became increasingly untenable. The relationship between DFO and the fishers has been described in terms of a Principal-Agent relationship. Due to the fact that previous scheme resulted in what has been described as a classic Prisoner's Dilemma competitive game among the fishers, the so called "incentive gap" became intolerably large. The economic returns from the fisheries to the true principal (the people of Canada) were probably negative.

It was argued that the only solution was to institute a management scheme that would transform the fisher competitive game into a cooperative one. What evidence there is suggests that this has been achieved, to the benefit of both the long term sustainability of the resources, to the long term economic viability of the fisheries, and to the long term benefit of the Canadian economy. The move to an integrated ITQ scheme is particularly innovative and encouraging.

There is nothing particularly novel or surprising about this conclusion. It is essentially the same conclusion arrived at by Environmental Defense, in its review of North American fisheries (Environment Defense, 2007), and its insistence on the importance of what it terms Limited Access Privilege Programs, "LAPPS", which includes (but is not restricted to ITQs)..

Finally, in the case of the three fisheries under investigation, the "LAPPS" have taken the form of ITQs. We would cheerfully concede that in other fisheries the same results could be achieved through the implementation of "LAPPS", in the form of fisher cooperatives, territorial use rights, or combinations of different forms of "LAPPS".

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Table A1. Pacific halibut fishery catch, TAC, landed value and price: 1980-2005

Year	Catch (tonnes)[a,b]	TAC (tonnes)[b,c]	Overage / underage (tonnes)	Landed value ('000s 2005 $)[a]	Price per kg (2005 $)	Landed value ('000s 2005 US$)[d]	Price per kg (2005 US$)
1980	3 305	2 721	584	22 083	6.68	18 885	5.71
1981	2 456	2 414	42	15 663	6.38	13 065	5.32
1982	2 382	2 458	-76	13 843	5.81	11 220	4.71
1983	2 398	2 414	-16	15 305	6.38	12 417	5.18
1984	4 033	4 082	-49	16 643	4.13	12 850	3.19
1985	4 704	4 564	140	23 423	4.98	17 149	3.65
1986	5 390	5 135	255	39 836	7.39	28 664	5.32
1987	5 444	5 266	178	44 263	8.13	33 378	6.13
1988	5 866	5 749	117	34 871	5.94	28 329	4.83
1989	4 659	4 564	95	26 755	5.74	22 556	4.84
1990	3 783	3 555	228	28 787	7.61	24 667	6.52
1991	3 241	3 364	-123	28 173	8.69	24 589	7.59
1992	3 441	3 636	-195	27 413	7.97	22 682	6.59
1993	4 796	4 836	-40	37 869	7.90	29 357	6.12
1994	4 498	4 564	-66	46 794	10.40	34 263	7.62
1995	4 320	4 387	-67	41 685	9.65	30 374	7.03
1996	4 321	4 379	-58	40 642	9.41	29 808	6.90
1997	5 601	5 719	-118	47 830	8.54	34 545	6.17
1998	5 859	5 924	-65	37 045	6.32	24 972	4.26

Year	Catch (tonnes)[a,b]	TAC (tonnes)[b,c]	Overage / underage (tonnes)	Landed value (‘000s 2005 $)[a]	Price per kg (2005 $)	Landed value (‘000s 2005 US$)[d]	Price per kg (2005 US$)
1999	5 552	5 554	-2	46 552	8.39	31 334	5.64
2000	4 832	4 884	-53	44 705	9.25	30 098	6.23
2001	4 638	4 819	-180	42 048	9.07	27 149	5.85
2002	5 448	5 510	-62	45 121	8.28	28 735	5.27
2003	5 328	5 397	-69	50 429	9.46	35 998	6.76
2004	5 494	5 768	-275	39 978	10.00[e]	30 725	7.69[e]
2005	5 568	5 700	-132	39 659	10.36[e]	32 740	8.55[e]

[a] Pacific Region, Fisheries and Oceans Canada. Commercial halibut landings in B.C. [online]. Available from www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/Summaries/Halibut/comhal_e.htm [1980-1990].
[b] Archipelago Marine Research Ltd. Commercial fisheries summaries [online]. Available from www-ops2.pac.dfo-mpo.gc.ca/xnet/content/groundfish/halibut/default.htm [1991-2005].
[c] Turris, B.R., and Sporer, C. 1994. Halibut IVQ Program. *In* Experience with individual quota and enterprise allocation (IQ/EA) management in Canadian fisheries 1972-1994. Policy and Economics Branch Working Group Report, Department of Fisheries and Oceans, Halifax.
[d] Pacific Exchange Rate Service, Sauder School of Business, University of British Columbia. Historic exchange rates [online]. Available from fx.sauder.ubc.ca.
[e] B. Turris. 2007. Pacific Fisheries Management, pers. comm.

Table A2. Pacific halibut fishery season length, active vessels, quota values and licence fees: 1980-2005

Year	Season length (days)[a,b]	Active vessels (no.)[a,b]	Quota value (2005 $ per kg)[c,d]	Quota lease rate (2005 $ per kg)[c]	Licence fees ('000s of 2005 $)[e]	Licence value (2005 $ per foot)[b]
1980	65	333				
1981	58	337				
1982	61	301				
1983	24	305				
1984	22	334			0.1	
1985	22	363			7.4	
1986	15	417			7.0	
1987	16	424			6.8	
1988	14	433			6.5	
1989	11	435			6.2	
1990	6	435			5.9	
1991	245	433	13.52		993.2	
1992	245	431	15.41		974.5	
1993	250	351	17.89		135.7	
1994	260	313	19.93		135.6	
1995	245	294	24.20		132.0	
1996	245	281	39.73		128.8	
1997	245	279	42.36		126.8	
1998	245	288	43.85	4.64	125.4	768

Year	Season length (days)[a,b]	Active vessels (no.)[a,b]	Quota value (2005 $ per kg)[c,d]	Quota lease rate (2005 $ per kg)[c]	Licence fees (‘000s of 2005 $)[e]	Licence value (2005 $ per foot)[b]
1999	245	265	50.74	4.57	121.9	1 038
2000	245	238	62.94	5.80	2 126.3	1 290
2001	245	234	n/a	n/a	1 192.9	n/a
2002	245	214	63.59	5.89	1 332.5	1 178
2003	245	225	n/a	n/a	1 289.8	n/a
2004	245	218	74.25	6.53	1 321.1	1146
2005	245	221	77.00	4.95	1 083.0	1330

[a] Munro, G.R. 2001. The effect of introducing individual harvest quotas upon fleet capacity in the marine fisheries of British Columbia. *In* Case Studies on the Effects of Transferable Fishing Rights on Fleet Capacity and Concentration of Quota Ownership, FAO Fisheries Technical Paper 412. *Edited by* R. Shotton. Food and Agriculture Organization of the UN, Rome, pp. 208-220.

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[d] B. Turris. 2007. Pacific Fisheries Management, pers. comm.

[e] D. Collister, personal communication, 2007. Fisheries and Oceans Canada, Ottawa.

Table A3. Halibut industry contribution to management

Year	Fisheries management fees (current 000's $)
1997	843[a]
2001	1 400[b]
2003	1 300[c]

[a] Gardner Pinfold Consulting Economists Limited and GSGislason & Associates Ltd. 1999. Cumulative impact of federal user fees on the commercial fish harvesting sector [online]. Available from www.dfo-mpo.gc.ca/communic/reports/fee-droit_e.htm.

[b] Pacific Region, Fisheries and Oceans Canada. 2001 Halibut integrated fisheries management plan. Available from www-ops2.pac.dfo-mpo.gc.ca/xnet/content/mplans/archive.

[c] Pacific Region, Fisheries and Oceans Canada . 2003/04 Halibut integrated fisheries management plan. Available from www-ops2.pac.dfo-mpo.gc.ca/xnet/content/mplans/archive.

Table A4. Sablefish fishery catch, TAC, landed value and price: 1981-2005

Year	Catch (tonnes)[a,b]	TAC (tonnes)[a,b]	Overage / underage (tonnes)	Landed value (‘000s 2005 $)[c]	Price per kg (2005 $)	Landed value (‘000,000s 2005 ¥)[d]	Price per kg (2005 ¥)
1981	2 636	3 190	-554	13 281	5.04	2 437	924
1982	3 628	3 190	438	12 430	3.43	2 503	690
1983	4 123	3 190	933	10 727	2.60	2 066	501
1984	3 824	3 190	634	11 408	2.98	2 091	547
1985	3 951	3 650	301	19 581	4.96	3 392	859
1986	3 900	3 650	250	18 729	4.80	2 259	579
1987	4 178	3 740	438	22 305	5.34	2 427	581
1988	5 075	4 015	1060	26 221	5.17	2 727	537
1989	4 722	4 015	707	20 432	4.33	2 375	503
1990	4 275	4 260	15	23 667	5.54	2 925	684
1991	4 532	4 560	-28	33 543	7.40	3 934	868
1992	4 557	4 560	-3	29 456	6.46	3 084	677
1993	4 546	4 560	-14	27 073	5.96	2 325	511
1994	4 533	4 521	12	35 926	7.93	2 683	592
1995	3 709	3 709	0	32 521	8.77	2 177	587
1996	3 168	3 169	-1	32 202	10.16	2 567	810
1997	3 893	4 023	-130	39 270	10.09	3 431	881
1998	4 164	4 023	141	31 083	7.46	2 729	655
1999	6 323	6 394	-71	38 074	6.02	2 904	459

Year	Catch (tonnes)[a,b]	TAC (tonnes)[a,b]	Overage / underage (tonnes)	Landed value (‘000s 2005 $)[c]	Price per kg (2005 $)	Landed value (‘000,000s 2005 ¥)[d]	Price per kg (2005 ¥)
2000	3 532	3 646	-114	35 904	10.17	2 606	738
2001	2 753	2 812	-58	31 589	11.47	2 477	900
2002	1 894	1 928	-34	26 318	13.90	2 096	1107
2003	2 591	2 675	-84	22 872	8.83	1 892	730
2004	3 859	4 088	-229	19 007	4.92	1 580	409
2005	3 822	4 213	-391	31 476	8.24	2 854	747

Note. Prior to 1996, Fisheries and Oceans Canada aggregated sablefish landed value over all gears, including trawl. Sablefish trawl landings (tonnes) are reported in Table A9.

[a] Pacific Region, Fisheries and Oceans Canada. Sablefish fishery quotas and catches 1979-1999 [online]. Available from www.pac.dfo-mpo.gc.ca/sci/sa-mfpd/sablefish/Sable_QuotaCatch.htm [1981-1998].
[b] Pacific Region, Fisheries and Oceans Canada. 2005/2006 Sablefish Season Summary [online]. Available from www-ops2.pac.dfo-mpo.gc.ca/xnet/content/groundfish/sablefish/default.htm [1999-2005].
[c] Pacific Region, Fisheries and Oceans Canada. Commercial catch statistics [online]. Available from www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/default_e.htm.
[d] Pacific Exchange Rate Service, Sauder School of Business, University of British Columbia. Historic exchange rates [online]. Available from fx.sauder.ubc.ca.

Table A5. Sablefish industry (K-Fleet) and DFO (Minister) contribution to management 2002-2006[a]

Joint project agreement	Minister	K-Fleet to DFO	K-Fleet in-kind	Total
2002	97 849	359 521	1 879 061	2 336 431
2003	98 249	352 461	2 070 617	2 521 327
2004	81 000	263 008	1 763 945	2 107 953
2005	153 120	362 188	2 181 300	2 696 608
TOTAL	629 755	1 672 265	10 347 310	12 649 330

[a] L. Budden, personal communication, 2007. Canadian Sablefish Association, Vancouver.

Table A6. Sablefish fishery season length, active vessels, quota values and licence fees: 1981-2005

Year	Season length (days)[a,b]	Active Vessels (no.)[c]	Quota value (2005 $ per kg)[d,e]	Quota lease rate (2005 $ per kg)[d]	Licence fees (000's 2005 $)[f]	Licence value (2005 $ per foot)[d]
1981	245	N/A				
1982	202				N/A	
1983	148	23				
1984	181	20			0.02	
1985	95	27	N/A		0.78	
1986	63	41			0.77	
1987	45	43			0.73	
1988	20	45		N/A	0.71	
1989	14	47			0.69	N/A
1990	255	30	18.04		0.66	
1991	365	26	19.93		0.62	
1992	365	25	21.01		0.61	
1993	365	21	27.52		0.60	
1994	365	22	32.99		0.60	
1995	365	24	45.71		0.59	
1996	365	21	n/a		484.53	
1997	365	24	n/a	10.43	605.41	
1998	365	24	54.17	5.16	599.08	768
1999	365	29	63.42	6.98	1 512.37	1 038
2000	365	32	88.86	10.49	920.01	1 290
2001	365	29	n/a	n/a	838.29	n/a
2002	365	27	89.50	9.42	179.75	1 178
2003	365	30	n/a	n/a	613.85	n/a
2004	365	32	90.01	7.65	988.04	1 146
2005	365	35	77.00	5.50	911.01	1 330

[a] Munro, G.R. 2001. The effect of introducing individual harvest quotas upon fleet capacity in the marine fisheries of British Columbia. *In* Case Studies on the Effects of Transferable Fishing Rights on

Fleet Capacity and Concentration of Quota Ownership, FAO Fisheries Technical Paper 412. *Edited by* R. Shotton. Food and Agriculture Organization of the UN, Rome, pp. 208-220.

[b] Pacific Region, Fisheries and Oceans Canada. Sablefish fishery management history 1981-1999 [online]. Available from www.pac.dfo-mpo.gc.ca/sci/sa-mfpd/sablefish/Sable_Mgmnt.htm [1981-1998]

[c] Pacific Region, Fisheries and Oceans Canada. Sablefish commercial fishery summaries [online]. Available from www-ops2.pac.dfo-mpo.gc.ca/xnet/content/groundfish/sablefish/default.htm [1990-2005].

[d] Nelson Bros. Fisheries Ltd. 2006. An analysis of commercial fishing licence, quota, and vessel values as of March 31, 2006: west coast fishing fleet. Pacific Region, Fisheries and Oceans Canada, Vancouver.

[e] B. Turris. 2007. Pacific Fisheries Management, pers. comm.

[f] D. Collister, personal communication, 2007. Fisheries and Oceans Canada, Ottawa.

Table A7. Groundfish trawl fishery catch and landed value: 1980-2005

Year	Catch (tonnes)[a]	Landed value ('000s 2005 $)[a]	Average price per kg (2005 $)
1980	32 990	51 816	1.57
1981	26 054	37 466	1.44
1982	28 111	31 469	1.12
1983	31 577	33 740	1.07
1984	33 800	37 561	1.11
1985	40 588	31 214	0.77
1986	47 394	41 616	0.88
1987	64 665	57 588	0.89
1988	59 961	51 350	0.86
1989	57 719	43 824	0.76
1990	65 004	52 306	0.80
1991	80 819	55 653	0.69
1992	86 222	55 853	0.65
1993	78 863	53 190	0.67
1994	85 600	58 816	0.69
1995	79 025	65 615	0.83
1996	77 921	49 466	0.63
1997	91 793	49 342	0.54
1998	89 814	56 178	0.63
1999	115 295	74 172	0.64
2000	51 853	63 256	1.22
2001	86 596	64 194	0.74
2002	105 571	66 644	0.63
2003	118 605	66 701	0.56
2004	111 558	66 134	0.59
2005	143 884	70 117	0.49

[a] Pacific Region, Fisheries and Oceans Canada. Commercial catch statistics [online]. Available from www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/default_e.htm.

Table A8. Lingcod catch, TAC and landed value: 1980-2005

Year	Catch (tonnes)[a,b]	TAC (tonnes)[c]	TAC Overage/under age (tonnes)	Landed value ('000s 2005 $)[b]
1980	1 315			2 892
1981	1 739			3 612
1982	2 878			4 759
1983	2 992			3 956
1984	2 971			3 857
1985	4 853			5 846
1986	2 925			4 977
1987	2 400			5 172
1988	2 521			3 938
1989	3 059			4 106
1990	4 048			5 011
1991	4 211			4 894
1992	3 248			4 179
1993	3 764			5 552
1994	3 431			5 841
1995	3 110			5 727
1996	1 761			2 425
1997	1 086	2 887	-1 801	1 851
1998	1 101	2 500	-1 399	1 897
1999	958	2 462	-1 504	2 049
2000	1 854	3 154	-1 300	4 034
2001	1 373	3 031	-1 658	2 187
2002	1 813	3 151	-1 338	3 726
2003	1 747	3 024	-1 277	2 846
2004	1 776	3 027	-1 251	3 484
2005	1 702	3 084	-1 382	3 263

Note. Prior to 1997, Fisheries and Oceans Canada did not separate lingcod TACs by gear (which included trawl and hook and line), and annual landed value was aggregated across all gear.

[a] King, F.R., and Surry, A.M. 2001. Lingcod stock assessment and recommended yield options for 2001. Canadian Stock Assessment Secretariat Research Document 2000/164, Fisheries and Oceans Canada, Ottawa [1980-1999].

[b] Pacific Region, Fisheries and Oceans Canada. Commercial catch statistics [online]. Available from www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/default_e.htm.

[c] Pacific Region, Fisheries and Oceans Canada. Fisheries management plans [online]. Available from www-ops2.pac.dfo-mpo.gc.ca/xnet/content/MPLANS/MPlans.htm.

Table A9. Sablefish

Year	Catch (tonnes)[a,b]	TAC (tonnes)[a,c]	TAC Overage / underage (tonnes)	Landed value ('000s 2005 $)[b]
1981	541	310	231	
1982	418	310	108	
1983	279	310	-31	
1984	185	310	-125	
1985	229	350	-121	
1986	550	350	200	
1987	421	360	61	
1988	636	385	251	N/A
1989	627	385	242	
1990	457	410	47	
1991	385	440	-55	
1992	451	440	11	
1993	541	440	101	
1994	481	433	48	
1995	427	356	71	
1996	211	304	-93	973
1997	285	386	-101	1 666
1998	328	386	-58	2 250
1999	403	386	17	2 312
2000	326	339	-13	1 964
2001	298	339	-41	2 104
2002	269	206	63	1 520
2003	228	206	22	1 039
2004	344	384	-40	1 860
2005	279	389	-110	1 474

Note. Prior to 1996, Fisheries and Oceans Canada aggregated sablefish landed value over all gears, including trawl. Aggregated landed values prior to 1996 are reported in Table A4.

[a] Pacific Region, Fisheries and Oceans Canada. Sablefish fishery quotas and catches 1979-1999 [online]. Available from www.pac.dfo-mpo.gc.ca/sci/sa-mfpd/sablefish/Sable_QuotaCatch.htm [1981-1998]
[b] Pacific Region, Fisheries and Oceans Canada. Commercial catch statistics [online]. Available from www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/default_e.htm [1999-2005].
[c] Pacific Region, Fisheries and Oceans Canada. Fisheries management plans [online]. Available from www-ops2.pac.dfo-mpo.gc.ca/xnet/content/MPLANS/MPlans.htm.

Table A10. Pacific cod catch, TAC and landed value: 1980-2005

Year	Catch (tonnes)[a,b]	TAC (tonnes)[c]	TAC Overage / underage (tonnes)	Landed value ('000s 2005 $)[a]
1980	8 662			8 077
1981	6 688			6 040
1982	4 797			4 096
1983	4 496			3 932
1984	3 458			2 954
1985	2 318			2 089
1986	3 642			3 532
1987	13 937	N/A		13 403
1988	11 078			8 661
1989	9 146			6 467
1990	6 446			4 612
1991	11 918			7 848
1992	10 331			6 974
1993	8 099			5 743
1994	3 541			2 822
1995	2 343	1 870	473	2 663
1996	891	by-catch only		1 163
1997	1 507	2 574	-1 067	1 817
1998	1 381	1 954	-573	1 764
1999	824	1 954	-1 130	1 490
2000	695	2 517	-1 822	1 312
2001	641	1 432	-791	740
2002	548	753	-205	1 260
2003	1 100	1 260	-160	1 137
2004	1 322	1 572	-250	1 814
2005	1 537	1 980	-443	2 066

Note. Prior to 1995, TACs were area-specific and not coast-wide. Prior to 1996. Fisheries and Oceans aggregated landed value across gear (including gillnet, longline and troll).

[a] Pacific Region, Fisheries and Oceans Canada. Commercial catch statistics [online]. Available from www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/default_e.htm.

[b] Sinclair, A., Martell, S., and Boutillier, J. 2001. Assessment of Pacific cod off the west coast of Vancouver Island and Hecate Strait. Canadian Stock Assessment Secretariat Research Document 2001/159, Fisheries and Oceans Canada, Ottawa [1980-2000].

[c] Pacific Region, Fisheries and Oceans Canada. Fisheries management plans [online]. Available from www-ops2.pac.dfo-mpo.gc.ca/xnet/content/MPLANS/MPlans.htm.

Table A11. Pacific ocean perch catch, TAC, and landed value: 1980-2005

Year	Total catch (tonnes)[a,b]	TAC (tonnes)[c]	Total TAC overage / underage (tonnes)	Landed value ('000s 2005 $)[a]
1980	5 325	3 400	1 925	5 325
1981	5 108	4 400	708	5 108
1982	6 031	4 350	1 681	6 031
1983	5 705	3 750	1 955	5 705
1984	6 774	3 550	3 224	6 774
1985	6 119	3 500	2 619	6 119
1986	5 947	2 950	2 997	5 947
1987	6 383	2 950	3 433	6 383
1988	7 037	4 150	2 887	7 037
1989	6 127	4 800	1 327	6 127
1990	5 807	4 250	1 557	5 807
1991	4 408	3 800	608	4 408
1992	4 139	4 050	89	4 139
1993	4 624	4 200	424	4 624
1994	5 788	4 917	871	5 788
1995	6 311	4 234	2 077	6 311
1996	6 490	6 884	-394	6 490
1997	6 016	6 481	-465	6 016
1998	5 947	6 147	-200	5 947
1999	6 222	6 147	75	6 222
2000	5 967	6 147	-180	5 967
2001	5 823	6 147	-324	5 823
2002	5 697	5 847	-150	5 697
2003	6 228	6 146	82	6 228
2004	5 971	6 146	-175	5 971
2005	5 152	6 146	-994	5 152

[a] Pacific Region, Fisheries and Oceans Canada. Commercial catch statistics [online]. Available from www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/default_e.htm.

[b] Schnute, J.T., Haigh, R., Krishka, B.A., and Starr, P. 2001. Pacific ocean perch assessment for the west coast of Canada in 2001. Canadian Stock Assessment Secretariat Research Document 2001/138, Fisheries and Oceans Canada, Ottawa [1980-2000].

[c] Pacific Region, Fisheries and Oceans Canada. Fisheries management plans [online]. Available from www-ops2.pac.dfo-mpo.gc.ca/xnet/content/MPLANS/MPlans.htm.

Table A12. Pollock catch, TAC and landed value: 1980-2005

Year	Catch (tonnes)[a]	TAC (tonnes)[b]	TAC overage / underage (tonnes)	Landed value ('000s 2005 $)[a]
1980	2 179	3 400	-1 221	1 059
1981	1 130	3 400	-2 270	523
1982	911	3 400	-2 489	445
1983	1 092	3 400	-2 308	473
1984	596	3 400	-2 804	240
1985	1 689	3 400	-1 711	609
1986	598	3 400	-2 802	245
1987	861	3 400	-2 539	392
1988	460	3 400	-2 940	134
1989	434	3 400	-2 966	90
1990	676	3 400	-2 724	253
1991	2 580	3 700	-1 120	776
1992	3 249	3 700	-451	1 253
1993	8 121	3 700	4 421	3 273
1994	4 609	no report	4 609	1 884
1995	3 295	6 910	-3 615	1 672
1996	2 147	6 578	-4 431	1 155
1997	1 826	4 000	-2 174	345
1998	822	3 730	-2 908	458
1999	1 233	4 225	-2 992	470
2000	1 044	4 225	-3 181	525
2001	1 746	4 225	-2 479	1 097
2002	3 606	4 225	-619	354
2003	5 395	4 225	1 170	2 241
2004	2 932	4 225	-1 293	1 388
2005	1 878	5 408	-3 530	869

Note. The reported TAC for years 1980 to 1993 is only for area 4B Strait of Georgia.

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[a] Pacific Region, Fisheries and Oceans Canada. Commercial catch statistics [online]. Available from www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/default_e.htm.

[b] Pacific Region, Fisheries and Oceans Canada. Fisheries management plans [online]. Available from www-ops2.pac.dfo-mpo.gc.ca/xnet/content/MPLANS/MPlans.htm.

Table A13. Rockfish (not including Pacific ocean perch) catch and landed value: 1980-2005

Year	Catch (tonnes)[a]	Landed value (‘000s 2005 $)[a]
1980	9 203	7 533
1981	9 460	6 782
1982	10 366	7 614
1983	12 126	9 396
1984	7 489	7 029
1985	11 481	10 683
1986	18 781	19 296
1987	17 857	21 723
1988	20 016	20 313
1989	18 388	17 322
1990	22 143	21 131
1991	19 127	18 894
1992	21 792	21 732
1993	20 034	19 349
1994	17 662	20 903
1995	15 393	22 455
1996	16 728	19 773
1997	14 148	18 208
1998	15 151	22 397
1999	17 296	26 635
2000	16 039	26 777
2001	15 316	23 641
2002	15 409	20 892
2003	14 843	19 193
2004	13 565	18 839
2005	13 113	17 721

[a] Pacific Region, Fisheries and Oceans Canada. Commercial catch statistics [online]. Available from www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/default_e.htm.

Table A14. Petrale sole catch, TAC and landed value: 1980-2005

Year	Catch (tonnes)[a,b]	TAC (tonnes)[c]	TAC overage / underage (tonnes)	Landed value (‘000s 2005 $)[b]
1980	223	N/A		N/A
1981	289			
1982	366			590
1983	439			690
1984	417			667
1985	336			623
1986	416			839
1987	446			1 054
1988	793			1 921
1989	953			2 131
1990	1 066			2 381
1991	795			1 668
1992	609			1 313
1993	581			1 215
1994	485			1 076
1995	672			1 373
1996	276	by-catch only		751
1997	511	479	-155	866
1998	355	479	-125	752
1999	378	479	-101	1 328
2000	455	583	-128	1 168
2001	474	560	-85	1 338
2002	458	528	-69	1 215
2003	492	522	-30	1 298
2004	586	617	-31	1 342
2005	625	625	0	1 596

Note. Fisheries and Oceans Canada did not set petrale sole TACs prior to 1996.

[a] Starr, P.J., and Fargo, J. 2004. Petrale sole stock assessment for 2003 and recommendations for management in 2004. Canadian Science Advisory Secretariat Research Document 2004/036 [1980-2002]

[b] Pacific Region, Fisheries and Oceans Canada. Commercial catch statistics [online]. Available from www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/default_e.htm.

[c] Pacific Region, Fisheries and Oceans Canada. Fisheries management plans [online]. Available from www-ops2.pac.dfo-mpo.gc.ca/xnet/content/MPLANS/MPlans.htm.

Table A15. Dover sole catch, TAC, and landed value: 1980-2005

Year	Catch (tonnes)[a]	TAC (tonnes)[b]	TAC overage / underage (tonnes)	Landed value ('000s 2005 $)[a]
1980	1 241			N/A
1981	1 138			
1982	880			783
1983	841			724
1984	1 137			966
1985	955			740
1986	1 140			835
1987	627	N/A		584
1988	1 259			1 009
1989	2 102			1 709
1990	2 383			1 865
1991	2 220			1 771
1992	2 686			2 152
1993	4 054			3 132
1994	4 010			3 427
1995	3 140	2 650	490	3 408
1996	2 760	2 913	-153	2 911
1997	2 031	3 073	-1 042	2 274
1998	2 741	3 073	-332	2 373
1999	2 867	3 073	-206	3 333
2000	3 040	3 073	-33	3 367
2001	2 735	3 073	-338	2 575
2002	3 302	3 073	229	3 308
2003	2 928	3 073	-145	2 866
2004	2 810	3 073	-263	2 788
2005	2 577	3 073	-496	2 499

Note. Prior to 1995, TACs were area-specific; however, catch was coast-wide.

[a] Pacific Region, Fisheries and Oceans Canada. Commercial catch statistics [online]. Available from www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/default_e.htm.

[b] Pacific Region, Fisheries and Oceans Canada. Fisheries management plans [online]. Available from www-ops2.pac.dfo-mpo.gc.ca/xnet/content/MPLANS/MPlans.htm.

Table A16. Reedi catch, TAC and landed value: 1980-2005

Year	Catch (tonnes)[a]	TAC (tonnes)[b]	TAC Overage/under age (tonnes)	Landed value ('000s 2005 $)[a]
1980	N/A	N/A		N/A
1981				
1982	722			417
1983	987			718
1984	727			541
1985	1 351			1 153
1986	2 276			2 033
1987	1 731			1 911
1988	1 243			1 120
1989	1 596			1 192
1990	1 607	1 380	-88	1 190
1991	1 217	1 380	-108	881
1992	1 424	1 380	44	1 078
1993	1 142	1 380	-238	786
1994	1 229	N/A		1 189
1995	955			1 065
1996	1 435			1 442
1997	2 085	2 430	-345	2 405
1998	1 836	2 385	-549	2 355
1999	1 734	2 407	-673	2 422
2000	2 041	2 408	-367	3 024
2001	1 848	2 365	-517	2 610
2002	2 011	2 365	-354	2 801
2003	1 912	2 365	-453	2 326
2004	1 901	2 365	-464	2 419
2005	1 961	2 365	-404	2 551

Note. From 1982 to 1989 TACs were area specific; from 1994-1996 TACs were aggregated with Pacific Ocean perch and redstripe rockfish.

[a] Pacific Region, Fisheries and Oceans Canada. Commercial catch statistics [online]. Available from www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/default_e.htm.

[b] Pacific Region, Fisheries and Oceans Canada. Fisheries management plans [online]. Available from www-ops2.pac.dfo-mpo.gc.ca/xnet/content/MPLANS/MPlans.htm.

Table A17. Groundfish trawl effort data

Year	Active vessels (no.)[a]	Trips (no. per year)[1a]	Tows (no. per Year)[b]	Licence fees ('000s 2005 $)[c]
1980	N/A			
1981	111	825		N/A
1982	105	755		
1983	103	807		
1984	111	869		0.05
1985	138	1 007		2.41
1986	138	968		2.32
1987	99	1 236	N/A	2.20
1988	111	1 437		2.13
1989	112	1 632		2.03
1990	112	1 632		1.94
1991	112	2 052		1.84
1992	123	2 524		1.81
1993	118	2 664		1.78
1994	117	2 143		1.77
1995	122	2 465		2.33
1996	112	1 947	19 665	86.08
1997	92	2 332	16 314	83.53
1998	88	2 319	17 233	101.63
1999	89	2 920	17 409	380.55
2000	82	1 703	18 203	927.01
2001	83	2 406	16 687	862.90
2002	79	2 602	17 801	687.86
2003	78	2 593	15 471	713.55
2004	72	2 433	14 776	736.91
2005	75	2 578	14 377	895.43

[a] B. Ackerman, personal communication, 2007. Pacific Region, Fisheries and Oceans Canada, Vancouver.
[b] B. Turris. 2007. Pacific Fisheries Management, pers. comm.
[c] D. Collister, personal communication, 2007. Fisheries and Oceans Canada, Ottawa.

Table A18. Groundfish trawl quota and licence values: 1997-2005

Year	Uncut quota value (2005 $/kg)[a]	Coast-wide hake quota Value (2005 $/kg)[a]	Gulf hake quota value (2005 $/kg)[b]	Uncut quota lease rate (2005 $/ft)[a]	Licence valuation (2005 $/ft)[a]
1997	3.08	2.87			
1998	3.79	0.64			1 172
1999	3.89	0.71	0.25	0.16	1 384
2000	5.05	0.62	0.25	0.22	1 459
2001	6.02				
2002	6.92	0.71	0.24	0.27	1 392
2003	7.39				
2004	7.25	0.56	0.25	0.26	1 330
2005	7.15	0.77	0.24	0.18	1 500

[a] Nelson Bros. Fisheries Ltd. 2006. An analysis of commercial fishing licence, quota, and vessel values as of March 31, 2006: west coast fishing fleet. Fisheries and Oceans Pacific Region, Vancouver.
[b] Laing Management Consultants Inc, unpublished data. Laing Management Consultants Inc.

Table A19. BC IQ fisheries as a percent of total landed value (TLV) of BC commercial fisheries

Year	Pacific halibut (% of TLV)	Sablefish (% of TLV)	Groundfish trawl (% of TLV)	Total IQ fisheries (% of landed value)	Total landed value of BC commercial fisheries ('000,000's 2005 $)[a]
1980	12.11		28.42	40.54	182.3
1981	6.78	5.75	16.21	28.74	231.1
1982	5.84	5.25	13.28	24.37	236.9
1983	7.47	5.24	16.47	29.19	204.8
1984	6.99	4.79	15.78	27.56	238.1
1985	6.24	5.22	8.32	19.78	375.3
1986	10.02	4.71	10.47	25.21	397.4
1987	10.19	5.14	13.26	28.59	434.3
1988	6.64	4.99	9.78	21.41	525.1
1989	6.04	4.61	9.89	20.53	443.2
1990	6.14	5.05	11.16	22.35	468.8
1991	7.65	9.11	15.12	31.89	368.1
1992	6.78	7.29	13.82	27.89	404.2
1993	8.28	5.92	11.64	25.84	457.1
1994	8.38	6.43	10.53	25.33	558.7
1995	9.94	7.75	15.64	33.33	419.5
1996	9.64	7.64	11.73	29.00	421.7
1997	12.20	10.01	12.58	34.79	392.2
1998	12.52	10.51	18.99	42.02	295.8
1999	16.01	13.09	25.51	54.61	290.8
2000	12.45	10.00	17.61	40.05	359.2
2001	12.38	9.30	18.90	40.59	339.6
2002	13.18	7.69	19.47	40.34	342.3
2003	14.27	6.47	18.87	39.62	353.4
2004	11.72	5.57	19.39	36.69	341
2005	12.44	9.87	21.99	44.29	318.9

Note. Prior to 1996, Fisheries and Oceans Canada aggregated sablefish landed value over all gears, including trawl. Tonnage of sablefish trawl landings is reported in Table A9.

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[a] Pacific Region, Fisheries and Oceans Canada. Commercial catch statistics [online]. Available from www-sci.pac.dfo-mpo.gc.ca/sa/Commercial/default_e.htm. [1980-2005]