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Title : The Degree of Market Power Exerted by Pacific Halibut Processors

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A structural model of the Pacific halibut fishery is developed. Hypothesis tests are developed within the framework of the "new empirical industry organization" for the exertion of market power by Pacific halibut processors in both the exvessel market and the wholesale market. The relationship of market power exertion and IPHC's regulatory instrument--season length--is featured. The results indicate that both the United States and Canadian processors exert market power in the exvessel market when the season length is short. The United States also exerts a moderate degree of market power in the wholesale market while Canada does not. The exvessel price distortion from the imperfect competition leads to the transfer of economic rent from the fishermen to the processors.

The Degree of Market Power Exerted by Pacific Halibut Processors

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The Degree of Market Power Exerted by Pacific Halibut Processors

I. INTRODUCTION

In studying the fishery, most economic modeling works have been focused primarily on the harvesting sector for analyzing the well known common-property resource problems. In contrast, there has been far less analysis on the processing sector. Crutchfield and Pontecorvo (1969) state that most of the world's fishing industries typically consist of highly competitive harvesting sectors that confront oligopsonistic processing sectors. They further assert that if an oligopsonistic processing sector is able to exercise effective monopsony power, the fishery will be managed in a socially optimal manner even if the processing and harvesting sectors are unintegrated. Their assertion has been examined theoretically by Clark and Munro (1980), Schworm (1983), and Stollery (1987). These studies have helped provide new insight about alternatives in managing a common-property resource. Clark and Munro (1980) suggested using tax polices on landings or processed fish to turn the weak oligopsony processors into strong monopsonist. Capalbo and Hatti's (1984) empirical work on Pacific halibut is cast in a monopoly/monopsony model and their results support Clark's and Munro's proposition.

To date, if regulators managing the halibut fishery presume that markets are competitive, when they are not, realized policy outcomes will be suboptimal. Yet, analysis of the fishery market structure and its policy implication studies remain conceptual. No empirical study has attempted to measure actual processor market power exertion. However, unique characteristics of fishery may allow processors to exert market power. These features include: 1) numerous fisherman, 2) few geographically disperse processors, 3) high degree of control by the public sector, and 4) the vast array of regulatory instruments used to regulate the fishery. The sellers' problem is generally compounded by the perishable nature of their product and their inability-financial, technical, or both- to provide storage capacity. Additional problems may arise from the seasonal nature of production and from severe fluctuations in harvest over time.

Recent developments in industry organization, or what is called "the new empirical industry organization" (NEIO), provide new opportunities for empirically estimating market structure (Bresnahan, 1982). The purpose of this study is to empirically test the processor market power assertion using the technique of NEIO. The specific objectives are:

(1) to develop a structural model of the pacific halibut processing industry, in which the market structure can be identified and estimated,

(2) to test the hypothesis of market power exertion by the Pacific halibut processing industry, and,

(3) to investigate the relationship between market power and regulatory instruments.

There are several other reasons why the Pacific halibut industry is selected for this analysis. First, there is development of new management schemes--Individual Transferable Quota System in British Columbia and in U.S. Under the individual quota system, season length and timing of landing are expected to change. A study of the halibut industry will help in understanding the past management performance. It also will provide a highlight to other fisheries. Second, the compact and homogeneous character of the halibut fishery, together with its long management history makes it possible to draw factual data of much greater reliability and coverage than most other fisheries. Third, other fisheries including salmon, now facing similar problems with declining stocks and declining length of the fishing season. The study of the halibut fishery can provide important insights for analysis of management strategies in Pacific halibut fishery as well as other fisheries.

II. REVIEW OF LITERATURE

This section first briefly summarizes the literature of economic models that have been primarily focused on the harvesting sector. These "management models" have focused on regulating the harvesting sector directly via restrictions on the number of fishing licenses, catch quotas, gear type, season controls, etc. In early 1950's, the problems of common-property fishery were first analyzed by Gordon (1954) and Scott(1955) who highlighted the inefficiency of common property fisheries. Crutchfield and (1969) empirically estimated the losses due to this inefficiency. Schaefer(1957) developed a biological model and the biological growth equation and production function have since served as the basic structure for the traditional fishery model. Dynamic models were then developed by Bell (1972), Clark (1976), and Quirk and Smith (1970) who explored developing optimal harvest rates through use of corrective taxes or quotas to achieve them. Stollery(1986) developed a short-run competitive fishery model and applied the model to the Pacific halibut fishery to determine the effects of regulations in that fishery. Stolery (1986) found that per-boat labor productivity was less strongly affected by season-length restrictions than by increases in the halibut price resulting from the quotas. Cook and Copes (1987) applied the conventional bioeconomic analysis, within a static microeconomic framework to Area 2 of the halibut fishery to estimate the optimal harvesting levels for the area. Androkovich and Stollery (1989) modeled the Pacific halibut fishery by a dynamic programming to characterize the various policy options that are available to the authority for regulation. Their stochastic model is calibrated from the Schaefer function with the focus on the effects of season restrictions. The analysis concluded that "direct controls over either the season length or the number of boats in the fishery are typically ineffective, in the sense that the level of expected net social benefits generated when either is implemented is almost identical with that under a competitive environment."

Crutchfield and Pontecorvo (1969) are among the first to explore the structure of Pacific halibut fisheries. They asserted that "at the level of the primary producer we usually find atomistic sellers facing oligopsonistic buyers." Crutchfield and Pontecorvo (1969) further asserted that if the oligopsony processors are collusive and act as a monopsonist, they would impose a rational solution on the fishery, i.e., they would capture the rent by offering sellers a price that would permit only the most efficient exploitation of the resource to take place. The malallocation of resources, which resulted from the combination of free entry and common property, would be avoided. If in turn, the product market in which the processors sell is highly competitive, the monopsonist could provide a near-optimal level of output and real costs. The monopsonist would impose a price that would yield competitive returns to fisherman only if factor combinations and total inputs were optimal. Monopsony might, still, involve exploitation of the immobility of fisherman and therefore a transfer of real income from fisherman to consumers, if the product market is atomistic.

Clark and Munro (1980), explicitly incorporated the processing sector into a bioeconomic model of fishing to examine Crutchfield and Pontecorvo's (1969) assertion. Their theoretical single-sector fishery model was based on Schaefer, Pella and Tomlinson's general production fishery model with the addition of a processing sector. The industry structure and its implication to resource management were theoretically analyzed. They found that if both the harvesting and processing sectors are competitive, the fishery will expand up to the point where net economic rents equal to zero. Therefore, the common property fishery will lead to overexploitation of the resource. In the case of a competitive harvesting sector facing a monopsonistic processing sector, the monopsonist will be more conservationist than socially optimal, since the monopsonist is able to control completely the harvest rate by setting the exvessel price. If the monopsonist was able to integrate backward, his optimal biomass target would be the same as that of the social manager. If the competitive harvesting sector confronts a monopsonist/monopolist processing sector, Clark and Munro (1980) showed that the result will be inconclusive: stock of the resource or biomass will be greater than, equal to or less than the social optimal no matter whether the fishery is backward integrated or not. They suggested that if the fish products are consumed domestically, the existence of a product demand function with finite price elasticity will increase the probability that the long-run harvest will be larger and the long-run price will be lower than would be the case under a socially optimal regime. They then showed that taxes/subsidies could in most cases be used to drive the monopsonist/monopolist toward the social optimum.

Schworm (1983) went one step further by taking account of the static externality that assumes the harvest of one firm affects the current profit of another firm to generalize the Clark and Munro's (1980) model. Schworm (1983) modeled the fishery by allowing the harvesting costs to depend on the harvest rate and the stock of the resource. Therefore, the harvesting costs are consistent with the existence of both the static and intertemporal externalities that can arise from common resources. He theoretically modeled the dynamics harvesting and processing of a common-property renewable resource under three forms of market structures. Those structures (similar to Clark and Munro) hypothsised as: a competitive harvesting sector and the processing sector, a competitive harvesting sector and a monopsonistic processing sector, and an integrated single-owner of the processing and harvesting sector. He argues that only under certain conditions Crutchfield's and Pontecorvo's conjectures is valid. One sufficient condition is that the harvesting sector consists of a large number of firms with identical convex technologies. Yet, Schworm (1983) suggested that this condition is not very restrictive given the fact that it is a common practice to model a competitive industry as a large number of identical firms with convex technologies. Alternatively, if the monopsonist can charge a lump sum fee (fees will be different to different fisherman) to harvests, the monopsonist harvests efficiently under more general conditions. If neither of the above condition is met, then the monopsonist's policy generally will diverge from the policy of the sing-owner (the same as the social optimal).

Capalbo and Howitt (1984) presented a nonlinear optimal control model, which is characterized by a competitive harvesting sector, a monopsonistic or oligopsonistic/monopoly processing sector, and a transboundary resource stock. The empirical analysis of the Pacific halibut fishery was featured. The so called "processor allocation model" comprised of a set of wholesale demand relations, a set of fishermen's supply functions and a set of biological relationship describing the dynamics of the biomass and a criterion function. The wholesale demand was specified as a price dependent model where price in country i is a function of quantity consumed in country i and processed in country j, and consumer income in country i. The fisherman's supply response functions, which assumed to be based on profit maximizing behavior, were specified to reflect the theoretical properties of supply functions. The biological relationship was adopted from Deriso (1981), which features traditional stock-production and age-structure model. The criterion function was specified in terms of maximizing the present value of net returns to the processing sector over the infinite horizon. The wholesale demand and input supply were estimated by Zellner's seemingly unrelated regression technique. The result showed own-price elasticities of demand are elastic and input supply responses were inelastic while the elasticities of supply with respect to changes in biomass were elastic. The estimates were then incorporated into the processor allocation model. The empirical results suggested strict conservation of the resources by the oligopsonist/monopolist. This is achieved via the market price offered to fishermen.

Stollery (1987) argued that the slope of the long-run fishing supply curve, and consequently the ability of the monopsonist to depress the price paid to the fisherman depends critically on the ease of entry and exit in the competitive fishery. Stollery (1987) included a constant returns to scale monopsonist processing sector in a standard dynamic fishing model. He then modified the models to include the cost of new capacity and derived the equilibrium conditions. The relationship between the cost of capacity, speed of entry and exit, equilibrium price and resource stock were then derived based on the equilibrium conditions. Simulation employing parameters generated from the previous studies in Area 2 of the Pacific halibut fishery is done in support his argument. The simulated optimal solution is compared with the benchmark competitive solution. The competitive open-access fishery results in excessive vessel numbers, dissipation of nearly $3 million resource rents and an exvessel prices above the social optimal, resource stock that is less than half of the optimal equilibrium stock size. The simulated monopsony processor equilibria was showed for different values on the speed of entry and exit. The results also showed that for a very elastic supply curve of the new capacity and very high speed of entry and exit, monopsony equilibrium stock, landed price, and catch size approach the optimum solution. However, as the rate of exit decrease, there are conflicting forces operating on the processing cash flow. The processor is able to lower the landed price below the competitive equilibrium, extracting a combination of resource rent and monopsony profit only indirectly through fishermen agents. Since the harvesting sector is a competitive open-access sector, the resource is for the most part still dissipated. The degree in which the monopsonist can collect resource rent depending on the speed of entry or exit. High speed of entry/exit represents greater control over the number of vessels and indirectly over the resource stock, allowing the monopsony to collect more rents. Lower entry/exit speed means greater monopsony power due to in mobility of the fleet, lowering resource rents due to over-conservation of the stock. This over conservation of the stock is the results of the monopsonist perceiving its marginal harvesting cost above social marginal cost.

In summary, management models, which focued on the harvesting sector, are relatively rich in both conceptual and empirical findings. Most bioeconomic models incorporating the processing sector and attempt to link the market structure to resource management remain conceptual. Although Capalbo and Howitt 's (1984) work is empirical, they presumed the market structure strictly based on the industry concentration ratio. The traditional model characterized by the competitive harvesting sector assumes that the processing sector is characterized by atomistic competitive structure. Others, including Crutchfield and Pontecorvo (1969), Clark and Munro (1980), Schworm (1983), Capalbo and Howitt (1984) and Stollery (1987), argue that in most fisheries, the atomic competitive processing sector assumption is invalid. Therefore, they suggest that instead of managing the harvesting sector, the policy maker might consider managing processing sector by turning weak oligopsonist into a strong monopsonist.

No empirical study to date has attempted to measure actual processor market power exertion. Although Crutchfield and Pontecorvo (1969) argue and later Capablo

(1984) did some primary analysis of the industry structure, their primary evidence was a mere high concentration ratio which alone is an inadequate indication of any market structure. High concentration ratios imply nothing with respect to control over prices except in conjunction with an explicit analysis of entry conditions and the degree to which the individual firm's ability to control or to differentiate their products successfully. For example, in both the Pacific salmon fishery and Pacific halibut fishery there is and has been relatively high concentration among the buyers of raw fish. Yet, instead of a tendency toward rational exploitation, these fisheries have become increasingly overcapitalized.

III. PACIFIC HALIBUT FISHERY

Resource and the Commercial Fishery

According to the Scientific Reports (IPHC), Pacific halibut (Hippoglossus Stenolepis) lives near the bottom depth from 15 to 250 fathoms and is distributed 3500 miles along the North American Cost from northern California to the Bering Sea. The growth rate and increase in size with age ranges widely from one section of the Pacific Coast to another. The average age of first maturity for female is 12 years and 7-8 years for males. Halibut is the largest of all flat fish and one of the largest species of fish in the world. The largest halibut ever recorded from the North Pacific was 495 pounds. The North American catch of Pacific halibut, caught mostly by setline gear in the regulated fishery, consists of fish ranging from 5 to over 200 pounds. The average size is 30 to 35 pounds. The estimated exploitable biomass by the International Halibut Commission from 1949 to 1987 increased steadily during the 1950's, reaching a record of 307.15 million pounds in 1959, decreased during the 1960's and 1970's to a low of 124.97 in 1975, and then gradually increasing during 1980's. In the past decade, most of the fish stock and catches are the gulf of Alaska, the Bering Sea area, and British Columbia.

Today's Pacific halibut fishery consists of a commercial fishery, an Indian fishery, and a sport fishery. The Indian fishery is mainly a subsistence fishery. Sport fishery is relatively small and limited by regulation. Neither of these fisheries is considered to significantly impact stock abundance or commercial landings. Therefore, this study will concentrate only on commercial fishery.

The commercial fishery[1] began capture of significant quantities of halibut in 1895 when the efficient large steamer fleets were introduced. During the 1920's smaller independently-owned schooner vessels entered the fishery. The vessels that were powered by gasoline or diesel engines operated more efficiently and economically than the steamer fleet. Schooners were originally designed to fish dories but converted to setlining for safety reasons. Although schooners were very efficient at halibut fishing, the vessels were not easily adopted in other fisheries. In recent years, the fishing season for many species has become increasingly shortened due to advances in technology and excessive amount of fishing effort. As a result, fishermen are forced to participate in more than one fishery. Today's halibut fishermen may use their boat for seining or trawling for salmon, pot fishing for king or tanner crab, trawling for flounders and groundfish, longlining for sable fish, or even chartering the vessels for private sport fishing. The Schooners, many built before 1930's, have remained in the fishery. The home port of most of the schooners is Seattle but the vessel can be found longlining off Alaska for halibut and other species. Many large vessels, which were built in the 1970's for pot fisheries for king and Tanner crab, have successfully adapted to longlining. Table 1 shows the number of vessels and catches classified by net tonnage in 1986 and 1987.

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[1]. 100 Years of Fishing, International Pacific halibut Commission (IPHC), Annual Report 1986.

Table 1. No. of Vessels and Catches by Class (1986-1987)

Vessels Class	1986		1987	
	No. of Vessels	Catch (000's lbs)	No. of Vessels	Catch (000's lbs)
Unkn. Tons	582	2,625	657	3,042
1-4 Tons	803	1,874	893	2,044
5-19 Tons	1,820	19,649	2,116	23,049
20-39 Tons	754	16,729	835	18,139
40-59 Tons	260	12,402	305	11,702
60+ Tons	238	14,079	264	11,505
Total	4,457	53,279	5,070	69,481

Source: IPHC: Annual Report: 1987

Although number of vessels operating from year to year is of significant interest from an economic perspective, it is not a satisfactory measure of fishing effort unless adjusted at least for changes in average size, technology and length of season. Unfortunately, the adjustment is not possible because of the inconsistencies in IPHC's vessel statistics.

The Pacific halibut fishery is one of the most valuable fisheries in the northwestern U.S. and Canada. The catch distribution and real exvessel price from 1950 to 1986 are graphed in Figure 1 and Figure 2 respectively. Over time, halibut landed by US and Canada have followed the similar pattern. Total Pacific halibut harvesting has been as high as 60 million pounds during 1950s when the biomass was abundant. Harvesting decreased in 1960's and dropped below 30 million in the 1970's. Both the biomass and harvesting increase in 1980's and gradually reach the level experienced during the 1950's and 1960's.

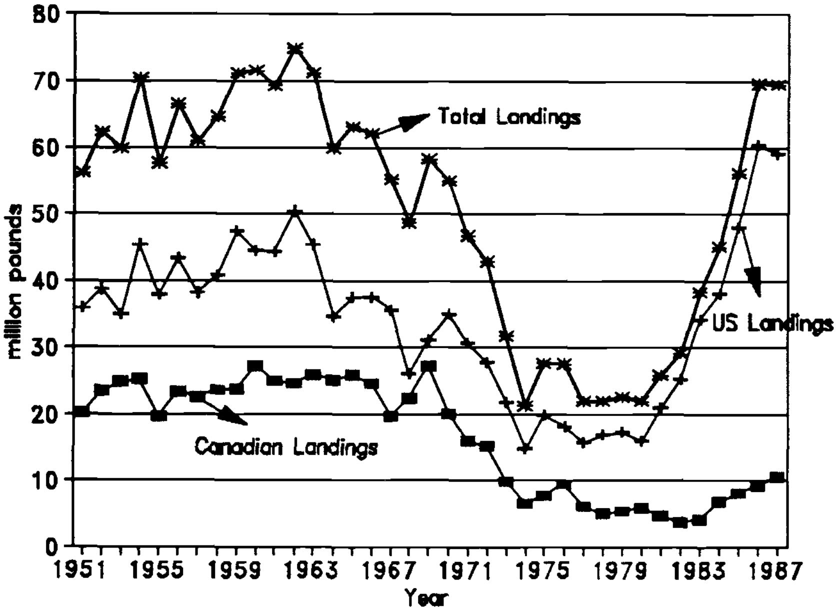

Figure 1: Historic Landings

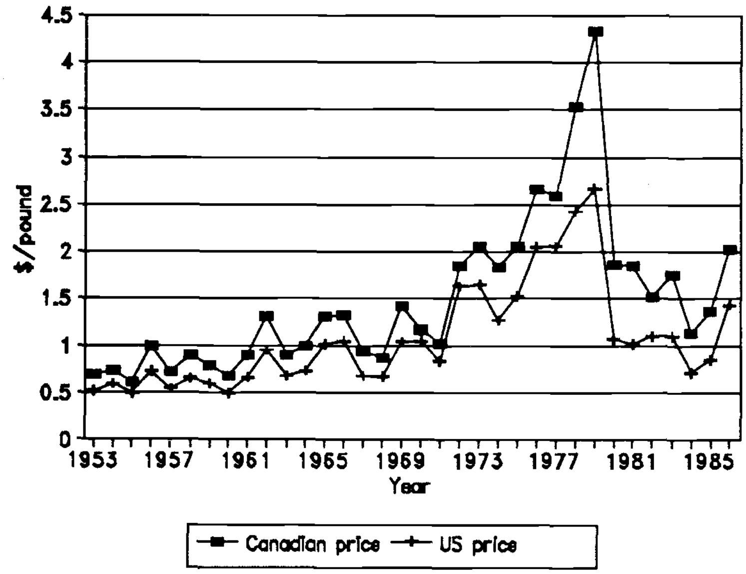

Figure 2: Real Exvessel Price

The current US dollar value per pound landed halibut (exvessel price) ranged from $0.14 to $2.09. Real exvessel price (1986 as base year) is featured in Figure 2. Real halibut exvessel prices in both U.S. and British Columbia show the similar pattern over time. Price stayed relatively low and stable prior to 1970's. Price began to rise rapidly during 1970's when the stock and landings declined. In the early 1980's, US catches of halibut increased sharply and the price dropped accordingly. Over time, there is pretty strong evidence of economic relationship between price and quantity.

History of Regulation and IPHC

The initial 25 years of the Pacific halibut fishery was a period of unrestricted exploitation, limited only by technology and market demands. In the early 1920's, heavy U.S. and Canadian fishing pressure led to significant reductions in fish stocks and catch-per-unit-effort. This resulted in the formation of International Pacific Halibut Commission (IPHC), which was established in 1923 by a convention between Canada and the United States for the preservation of the halibut fishery of the North Pacific Ocean and Bering Sea. The only regulatory measure included in the Convention of 1923 was the establishment of a winter closed season, running from November 16 to February 15, or as modified by the commission. A closed season proved ineffective in halting the decline in the resource and a new Convention was signed in 1930 to broaden the Commission's regulatory powers. Commission studies indicated overfishing was the cause of resource depletion. As the stocks were rebuilding, the

Conventions of 1937 and 1953, which were amended by the Protocol of 1979, further expanded IPHC's authority. The Convention specifically required that all Commission regulations be based on scientific studies, and that the resource stocks be developed and maintained at levels that would permit the maximum sustained yield (MSY).

The IPHC was given no authority to manage according to economic considerations and could not regulate fleet size (Cook and Copes, 1987). IPHC has used season length, area deregulation, catch quota, gear restriction, and licensing fee to regulate Pacific halibut fishery. Longlining is the only method allowed to fishing halibut. Catch quota and season length control are often initiated together. For example, if the quota is met, then the season in an area will be closed. The length of the season for Area 2 and Area 3 from 1949 to 1989 are shown in Figure 3. These areas were selected to provide an overview of the change in length of season because they are the major producing area (over 99% of the total halibut harvests are in Area 2 and Area 3).

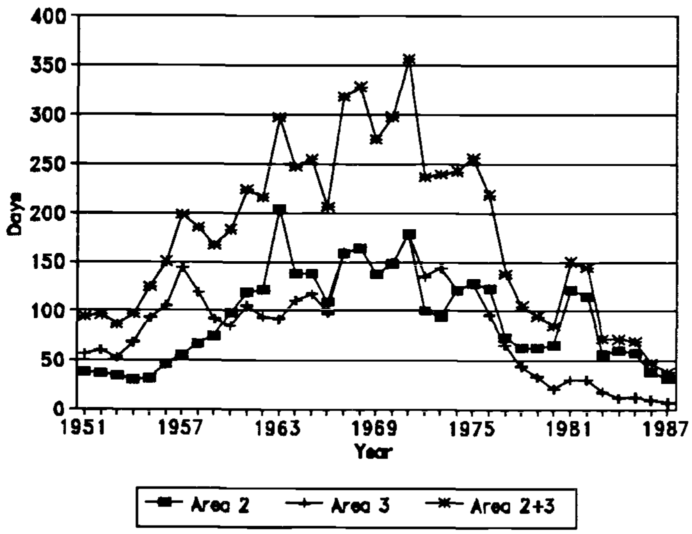

Figure 3 IPHC Regulated Season length

The open season for Area 2 and Area 3 were added together to illustrate that IPHC sometimes stack the opening season in different areas as a management tool. Since 1981, IPHC divided Area 2 into three sub Areas: 2A (Washington, Oregon and California), 2B (British Columbia), and 2C (Southeastern Alaska). Also, starting in 1981, U.S. and Canadian fishermen have been phased out each others' fishing water according to a reciprocal agreement between Canada and the United States.

To understand the relationship of fishing effort and IPHC's season regulation the historical season length and effort as well as the exvessel price are plotted over time on the semi-log graph. From Figure 4, it appears that fishing effort and season

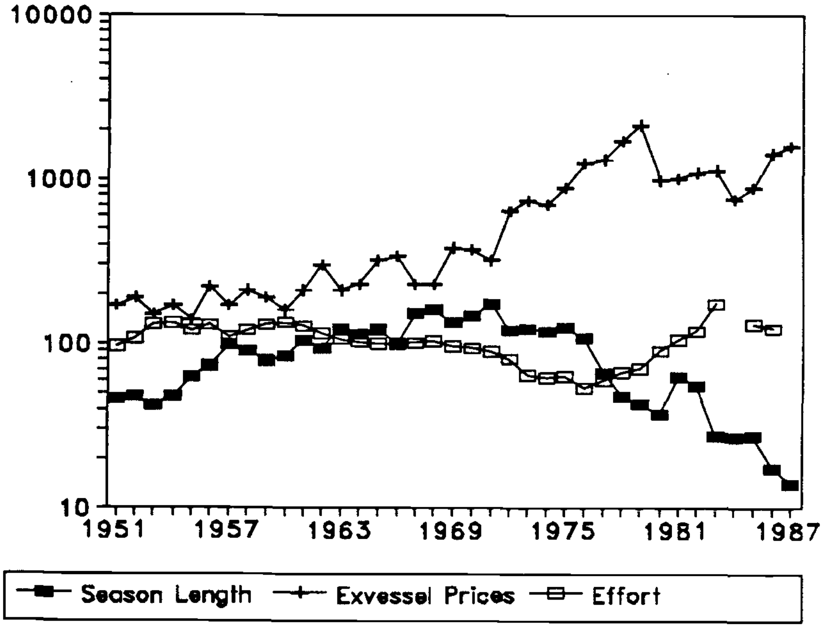

Figure 4: **Season Length, Exvessel Price and Effort**

length are negatively correlated. IPHC was somewhat successful in conserving the stocks through use of harvest quotas in their early days, but open-access fishery regulation led to increased fishing effort, resulting in shortened seasons during 1950's as showed in Figure 2. As the stock recovered and harvesting picked up in the 1960's, the fishing effort slowly declined and season lengthened. By the 1970's, over-harvesting by traditional setline fishermen and heavy foreign and American trawler by-catch led to severe stock reductions and limited seasons. With passage of the Magnuson Conservation and Fisheries Act in 1977, foreigners were excluded (including Canadians) from American waters (This act was implemented in 1981 between U.S. and Canada according to a reciprocal agreement: Starting in 1981, U.S. and Canadian fishermen's operation in other nations water phased out each others fishing water) and increased IPHC conservation measures, halibut stocks recovered. Yet, fishing effort in U.S. and Canada continued to increase and by the 1980's fishing seasons were reduced to a handful of daily or weekly openings along the Pacific coast.

Industry Organization

The organization of the Pacific halibut industry has remained relatively stable over the last forty years. Many small vessels using set-hook and line-gear deliver product to processors scattered along the Pacific Northwest coast. The product undergoes primary processing and is then sold fresh or inventoried as frozen product for later sales and distribution to secondary processors and distributors. Smaller vessels tend to be based in Alaskan ports and large vessels are based in Seattle. Most of the processors are located in coastal communities port communities throughout of Alaska, British Columbia, Washington and Oregon (FCFF).

Most halibut is frozen in dressed form after landed and graded. Inventories of frozen halibut are drawn down during the course of a year as the market dictates. Most are processed into steaks and the rest into fillets, roasts, breaded portions, and pre-cooked specialty foods. Secondary processing usually take place at distribution centers near major markets. Trade in fresh halibut is restricted by the very short season of the fishery.

The halibut fishery has been characterized as many small fishermen facing highly concentrated processors. In 1990, 3,620 American vessels fishing off Alaska delivered 53 million pounds of whole product to 176 processors (NPFMC). While individual processors vary greatly by amount of fresh and frozen halibut handled due to the fact of multi-species processing, the concentration ratio of halibut processors has been very high. Based on Alaska Department of Fish and Game data (Capalbo, 1979), In the south-eastern section of Alaska, four firm concentration increased from about 46% in the later 50's to over 62% in the 1970's although this period exhibited a 68% decrease in overall production and a 32% decrease in the number of processing facilities. Although central Alaska's concentration ratio had actually decreased, the largest four firms processing halibut products in whole Alaska still accounted for 55% of production during 1973-75. For frozen halibut production, Pacific Packers Report (Capalbo, 1979) showed even higher concentration ratio in later 1970's. Shares of production by the four Processing companies for 1976, 1977 and 1978 were 70%, 73%

and 86% respectively and the eight companies shares were all above 90% (Capalbo, 1982). From 1984 to 1990, although the number processors increased, more than threefold of the increases purchasing less than 10,000 pounds of halibut. Processors purchasing over one million pounds handled 48% and 51% of the entire Alaska catch in 1984 and 1990.

The industry organization in British Columbia is of the similar pattern. In 1987, 430 Canadian vessels (Canada has had a limited entry program since 1980) landed 5.4 million pounds of halibut. British Columbia processors handled 4.7 million pounds with the remainder landed in US ports. In that year, forty-one BC processing plants produced fresh product (32% of total landed product). The dominant firm accounted for 29% of total volume. Overall, BC's ten largest processors accounted for 27% of fresh product but over 55% of frozen product (PCVOG).

In summary, the problems and issues associated with the halibut industry including concentration in the processing sector and the limited fishing season has attracted significant amount of economic analysis. Yet, most of this work has not directly addressed the issue of the relationship of market power and regulatory controls. Where results are available, they are often contradictory. Crutchfield and Zellner (1963) conclude that license programs can be used to reduce effort and increase economic returns from the halibut fishery. Using a short run competitive model, Stollery (1989) finds that price may be more important than season length in determining the level of inputs into the halibut fishery. Lin et. al. (1988) develop a price-dependent demand model and show that season length is a significant factor in determining output price. Therefore, this thesis will empirically study the market structure of Pacific halibut fishery. This study also will address the relationship between regulatory controls and the market structure.

IV. THEORETICAL MODEL

In this chapter, a theoretical framework of the "NEIO" technique is summarized and adapted to the assessment of Pacific halibut processor's monopolistic and monopsonistic performance. The model that allows one to test the hypothesis that processor may exert market power at both the exvessel and wholesale level is developed. Unlike others (Clark and Munro, 1980; Stollery, 1987) who presumed market structure, the "NEIO" technique allows one to develop a model that the hypothesis of monopoly and monopsony power exerted by the processor can be empirically tested. The processor model is specified so that industry wide monopoly and monopsony powers are incorporated explicitly through the pure middleman profit maximizing solution (Lerner, 1934). The model is then parameterized to allow independent measurement of monopoly and monopsony power.

Consider the Pacific halibut processing industry in which **N** firms produce a homogeneous output using **K** inputs. In view of the intended application, assume that the production technology is characterized by fixed proportions of output (dressed frozen halibut) and a single material input (exvessel fresh fish):

$$q_j = \delta h_j \tag{1}$$

Where $\mathbf{q}_j$ is the output produced (processed halibut in this case), $\mathbf{h}_j$ is the unprocessed halibut, and δ is a conversion factor from the whole dressed (head-off eviscerated) fish to wholesale product. Assume a constant marginal processing cost, $\mathbf{m}_j$ (per unit processing cost including transportation cost to wholesale market). Furthermore assume each processor exercise some market power in purchasing fish and in selling its processed fish but is a price taker in the market for other inputs. Let the inverse wholesale market demand curve facing the industry in the processed halibut market be given by:

$$Pw = f(Q) \tag{2}$$

Where **Pw** is market price and $\mathbf{Q=\sum q_j}$ **(for j=1,2, . . ., N)** is industry output. The inverse market supply function for the unprocessed fish is given by:

$$P_x = f(h) \tag{3}$$

Where Px is exvessel price of halibut and $\mathbf{h=\sum h_j}$ **for (j=1,2, . . ., N)** is total industry inputs of halibut to be processed. Assume each firm is a profit maximizer, the firm's profit maximization problem is:

$$\underset{h_j}{Max} \; \prod_j = P_w(Q(h)) \cdot \delta h - P_x(h) \cdot h_j - mh_j \tag{4}$$

The first term in equation 4 represents revenue from processed halibut sales. The second term represents firms's cost in purchasing halibut. The third term represents processor's processing and transportation costs, which are assumed to be proportional to amount of fish processed. Processor's profit maximizing solution is given by:

$$\frac{\partial \Pi_j}{\partial h_j} = \lambda_{wj}\frac{\partial P_w}{\partial Q}\frac{\partial q_j}{\partial h_j}\delta h_j + P_w \delta - \lambda_{xj}\frac{\partial P_x}{\partial h}h_j - P_x - m_j = 0 \tag{5}$$

Where $\partial P_w/\partial Q$ is wholesale demand slope; $\partial Q/\partial h$ is δ; and $\partial P_x/\partial h$ is exvessel supply slope. Equation 5 states that, at equilibrium, processor's marginal revenue equals marginal cost. In theory, market power parameters λ_{wj} and λ_{xj} (also called conjectural variation parameter) provide useful bench-marks for testing for price-taking behavior or degree of competitiveness (Appebaum, 1982). When both λ_{wj} and λ_{xj} equal zero, we have the perfect competitive case where each firm equates the marginal product of each input to its real price. In the extreme case where both market power parameters λ_{wj} and λ_{xj} are one, we obtain pure middlemen case, i.e., monopsonist and monopolist where the firm equates the marginal revenue product to the marginal inputs costs. When λ_{wj} is zero and λ_{xj} is one, processor is a monopsonist. When λ_w is one and $\lambda_x(\theta)$ is zero, processor is a monopolist. Alternatively, one can identify the location of the firm on the continuum between the two poles of market structure as λ_{wj} and λ_{xj} can take the values between zero and one, which represent less restrictive solutions than perfect monopoly, monopsony, or pure middleman solutions (oligopoly and oligopsony solutions).

Lack of panel data on firm level, however, leads one to consider the problem at the industry level. One approach (Appelbaum, 1979; Porter, 1984) is to rewrite Equation 5 in aggregate form:

$$\lambda_w \frac{\partial P_w}{\partial Q} \frac{\partial Q}{\partial h} \delta h + P_w \delta - \lambda_x (d) \frac{\partial P_x}{\partial h} h - P_x - m = 0 \tag{6}$$

In doing above aggregation, one has to made additional assumptions. There are two different versions of these assumptions. One approach is that in equilibrium, the market power parameters and marginal processing cost are invariant across firms (Appelbaum, 1979; Porter, 1984). Another interpretation (Cowling and Waterson, 1976) is that the aggregate λ_w and λ_x and as the industry average conduct and *m* as the industry average processing cost. Since there is nothing in the logic of oligopsony /oligopoly theory to force all firms to have the same conduct and the same marginal cost, this paper takes the second approach. Therefore, Equation 8, generally will be interpreted as the industry profit maximization solution and the market parameters λ_w and λ_x are the industry average conduct respectively.

V. EMPIRICAL MODEL AND ESTIMATION

Before the market power parameters can be estimated, Equation 2 and 3 in the previous section have to be specified. Equation 2 is the inverse wholesale market demand and wholesale demand is a derived demand from retail demand. Since direct estimation of retail demand is not possible and we are only interested in the market structure of vessel and wholesale level, a wholesale demand is specified based on the following two assumptions: (1) processors do not change the level of their inventory in the short run, and, (2) the wholesale-retail margin only reflects the handling and transportation cost, not pure profit. Thus, wholesale demand of halibut can be specified as a function of its own price, price of its substitutes, and disposable income. Salmon is chosen as a substitute[2] for Pacific halibut following Stollery (1986), and, Cook and Copes (1987). Primary data analysis showed that most of the halibut are sold in frozen form (over 70%). Price-dependent wholesale demand is specified in semi-log form as a function of wholesale halibut and salmon prices and income. Wholesale demand is given by:

$$P_w = a_0 + a_1 lnQ + a_2 lny + a_3 lnP_s + \epsilon_{P_w} \tag{7}$$

Where ε_{P_w} is a random error term.

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[2] Stollery, Cook and Copes specified salmon as the closest substitutes of Pacific halibut with and found an statistical significant relationship. A market survey by B.C. based Don Ference & Associates LTD. found that salmon is only secondary substitutes, while the primary substitutes being cod and other white flesh fish such as sole and turbot.

Fisherman's supply curve can be obtained by standard competitive profit maximization. The primary approach requires the correct specification of harvesting production technology. The harvesting technology can be described as a function of current biomass (B) and some measure of the amount of fishing effort (E). The harvest function or the fishery production function h(B, E) has been modeled in various ways, or treated simply as a "policy variable" subject to direct control. The most widely used specification is h(B,E)=qBE, where q is the catchability coefficient, which is the well know "Schaffer" production function used by Clark and Munro (1980), Stollery (1987), and others in modeling Pacific halibut fishery. This production function is based on the assumption that effort E can be measured as a rate, in term of the area (or volume) swept by the harvests per unit of time, and that biomass is distributed homogeneously respective to area or volume. Catch per unit effort is, therefore, linearly related to stock size.

Although used extensively, the Schaefer production function has been widely criticized, because harvesting effort is seldom applied at random with respect to the stock distribution. As Walters discussed, catch ability coefficient q tends to change over time as harvesting technologies improve. For example, in the halibut fishery, adoption of fish finders radios and circle hooks have improved catchability dramatically. Thus, it seems plausible that a nonlinear relationship may characterize the production function. This paper uses the duality principle of microeconomic theory (Varian, 1978), which allow the choice of a flexible cost function instead of a production function. Unlike Clark and Munro (1980) who assumed effort as comprising the service of both labor and capital devoted to fishing, and Stollery (1987) who specifies per-boat effort(e) as the services of labor and materials in fishing given a fixed number of boats (capital) in the fishery, this paper defines effort as consisting of fuel and capital. Labor is not included because crew and capital are paid by share of net catch (Crutchfield and Zellner, 1962; Bell, 1981; Stollery, 1986) that is part of profit rather than input cost. Because Pacific halibut has long been a regulated fishery, the biomass at any time t, Bt, is estimated by IPHC using scientific method (B is predetermined by the catch in previous years and the environment. B is accessed each year by IPHC using the CPUE data). The total allowable catch quota is allocated based on the estimated total exploitable stock, therefore, we further assume the cost of effort is conditioned on the biomass. Take the industry cost function to be of the generalized Leontief (GL) form[3] conditioned on biomass. Specifically, let:

$$C(h,W,T;B) \equiv \sum c^{i}(h^{i},W,T;B) = \frac{h}{\frac{B}{h}-\gamma_0 T-a_{00}}\left(b_{01}w_1^{\frac{1}{2}} + b_{02}w_2^{\frac{1}{2}}\right)^2 + h\left(b_{11}w_1 + 2b_{12}w_1^{\frac{1}{2}}w_2^{\frac{1}{2}} + b_{22}w_2 + \gamma_1 w_1 T + \gamma_2 w_2 T\right) \tag{8}$$

N

where i = 1,2, . . .,M of individual fisherman

B = biomass

h = harvest(landings)

w1 = fuel price

w2 = cost of capital (commercial bank interest rate)

T = technology progress

[3] See Diewert (1974) for a discussion of the GL cost function and its properties. See Lopes (1988) for a discussion of conditional GL cost function and its application.

Parameter r_0 measures the effect of technological change on biomass intensity and r_1 and $_{r2}$ measures similar effects for fuel and capital inputs.

The net revenue (profit) flow to the harvesting sector is therefore given by:

$$\Pi = p_x h - C(h,W,T;B) \tag{9}$$

Where P_x is the exvessel price of halibut which the fisherman is taken if we assumed competitive market behavior in the harvesting sector. Take the partial derivative of Equation 9 respect to h and solve for P_x to get exvessel market inverse supply function of halibut[4] as:

$$P_x = \frac{\frac{2B}{h} - \gamma_0 T - a_{00}}{(\frac{B}{h} - \gamma_0 T - a_{00})^2}(b_{01}w_1^{\frac{1}{2}} + b_{02}w_2^{\frac{1}{2}})^2 + (b_{11}w_1 + 2b_{12}w_1^{\frac{1}{2}}w_2^{\frac{1}{2}} + b_{22}w_2 + \gamma_1 w_1 T + \gamma_2 w_2 T) \tag{10}$$

Finally, since the market power in the vessel market is related to regulatory measure such as season length. Fishermen have few market alternatives when the season is short. Once caught, fishes are either sold to processors or they spoil. Therefore, processor market power should be highest when season duration is shortest. Further, market power estimates should be a priori on the unit interval. To facilitate estimation of the changing market power parameters a functional form must be specified for $\lambda_x(d)$. A reasonable function form is:

[4] Aggregation consistency is assured by the homogeneous product (unprocessed halibut) and the constant return to scale assumption of the harvesting production.

$$\lambda_x = \exp(\frac{-\lambda d}{365}) \tag{11}$$

Market power parameters and demand and supply parameters can be jointly estimated by forming equations 6, 7, and 10 into a simultaneous system of equations and using a nonlinear simultaneous equations estimator. The oligopoly and oligopsony markup terms, $\partial P_w/\partial Q$ and $\partial P_x/\partial h$, are replaced by a_1/Q and $\{2B^2/[(B/h-\gamma_0 T-a_{00})^3 h^3]\}(b_{01}w_1^{1/2}+b_{02}w_2^{1/2})^2$ respectively, from equation 6. Monoposony market power index $\lambda_x(d)$ in Equation 6 is substituted with Equation 11. Nonlinearity of demand in quantity (equation 7) and supply (equation 10) in harvest insures λ_w and $\lambda_x(\theta)$ are econometrically identified (Bresnahan, 1982).

Identification of the structural parameters can be checked by determining the rank of the information matrix augmented with the Jacobian matrix, calculated in the neighborhood of the parameter estimates, is equal to the number of unknown parameters. This condition was numerically checked using TSP4.1B (Hall, Schnake and Cummins, 1987).

Nonlinear three-stage least squares (NL3LS) developed by Amemiya (1977) and implemented in the TSP4.1B is used to obtain the parameter estimates. Full information Maximum Likelihood (FIML) estimator in TSP4.1B was tried but did not converge. Efficiency and consistency Comparison of the NL3LS and FIML is featured by Amemiya.

DATA

Data required for the developed model include exvessel price (P_x), exvessel quantity (h), biomass (B), and the input prices of w_1 and w_2 on halibut harvesting sector. Data required for estimation of the processing sector include wholesale price (P_w), wholesale quantity (Q), processing cost (r), transportation cost (t), and the substitute price (P_s) as well as income level(Y). Open season days(d) for halibut fishing are also required to estimate the market power parameters.

All the prices and costs data are presented in normal currencies and (U.S. dollar for US and Canadian Dollar for Canada). They have been transformed to real term during the estimation using PPI, and CPI. All the quantities are expressed in thousand pounds units. The sources, transformations and the descriptions are outlined below. A list of the data is provided in appendix.

<u>Exvessel prices (P_x) and quantities (h)</u>: The total US's and Canada's exvessel quantities, values and the average exvessel prices have been reported by *IPHC: Annual Reports*. The corresponding data for Canada were obtained from *Fisheries Production Statistics of British Columbia*. U.S. data were computed as the following way: U.S. exvessel quantities equals to the total quantities minus Canadian exvessel quantities, U.S. exvessel price are calculated by subtracted the Canadian exvessel value (converted to U.S. dollar) from the total landed value. The quantities are expressed as whole, dressed and in thousands pounds. The prices are in normal US and Canadian dollars.

Halibut stock or biomass (B): IPHC has played a major emphasis on timely assessment of the population status of the Pacific Halibut. Methods used by IPHC to assess biomass have evolved with the advent of better mathematical and statistical procedures. More recent method, catch-age data are judged to be of adequate precision and accuracy. In this report, the estimates of exploitable biomass by subarea using cohort analysis with CPUE partitioning and fixed age selectivity from catch age analysis, are obtained from *IPHC: Scientific Report No. 72*. These estimates cover the year from 1949 to 1984 in our model. The estimates, then, have been updated for the year 1985 to 1987 from the *IPHC: Annual Reports*.

Since U.S. and Canadian fishermen had been fishing in any area that was open before 1981, the exploitable halibut stock available for US and Canadian fishermen should be the same. Starting in 1981, U.S. and Canadian fishermen have been phased out each others, fishing water according to a reciprocal agreement between Canada and the United States. In this report, we used the total exploitable biomass for both U.S. and Canada before 1981. Then, data for area 2B were used for Canada and sum of area 2A, 2C, 3A, 3B and area 4 were used for the United States.

Input prices of harvesting (w_1, w_2): Costs of capital and fuel are believed to be significantly affect the harvesting yield and fishing revenue/profits. Labor was not used as an input for the following reasons: 1) a share system has been found traditional in the halibut fishery and the system has been consistent since 1934, and, 2) the Norwegian culture tradition has made the entry to halibut fishery as a family tradition rather than the market reason. The wholesale fuel/gas index for both Canada and the

United States are obtained and transformed to the same base year (1986=1). Various sources of the above data are listed in the miscellaneous data section.

Wholesale prices (P_w) and quantities (Q): Wholesale prices for Canada are the average annual prices reported by Bureau of Canadian Fisheries: *Fisheries Production Statistics of British Columbia (Fisheries Statistics of British Columbia).* The monthly wholesale prices of U.S. are reported by the National Marine Fisheries Service and the U.S. Bureau of Labor Statistics: *Fisheries Statistic of the United States and PPI/Wholesale Price and Index.* The wholesale prices are for over 20 lbs., frozen dressed whole pacific halibut pricing at New York wholesale markets. Some years' data are calculated from the indices. A verification found that the two publications used the same sources of the data. Since most of the pacific halibut have been transported to the east in the frozen dressed form. We used these prices as our overall wholesale prices for the united Staes. Data used in this report are the 12 month average of the monthly data. Our primary examination of the prices and prior study (Stollery, 1986) has suggested Salmon been the closest substitute for halibut. Wholesale Quantites fo the United States computed from the landings directly by a conversion factor of 0.9. This conversion factor represents the weight loss from the dressed halibut to frozen halibut. Canada's wholesale quantities are obtained directly from Bureau of Statistics Canada, *Fisheries Statistics of British Columbia.*

Computed Processing cost (r) and Transportation cost (t): There are very limited time series cost data and cost analysis available in the processing sector. Until recently, North Pacific Fishery Management Council and National Marine Fisheries Service(NPFMC) did a joint study that include some analysis of the processing cost of halibut in Gulf of Alaska and Bering Sea/Aleutian Islands. According to the study, the contributors of the variable processing costs are as the following:

Direct labor	0.1
Utilities	0.06
Fright	0.08
Other cost	0.02
Taxes	4.5% of exvessel price.

The index for wage rate, PPI electricity, and PPI are used to deflate and inflate the above figures and the exvessel prices are used to calculate the taxes. By sum up those results we got our total variable cost per pounds.

"The cost of transporting fish from west cost ports to converters in the east, range from $0.7 to $0.9 per pound" (FCFF). We used the average of $0.825 per pound, and then used PPI to deflate and inflate them to generate the time series transportation data.

Season length (d): Season length regulated by IPHC has been strictly enforced by both Canada and the United States. Historically, those regulations are by IPHC's regulation areas. Our initial investigation found that over 99% of halibut have been consistently caught in Area 2 and Area 3 from 1949 to 1987. IPHC regulated season length data for Area 2 and Area 3 are collected from *IPHC: Annual Reports* (various issues). Consider also the reciprocal agreement of 1981 that we mentioned before. Starting in 1981, data for Canada is IPHC's regulated Area 2B (British Columbia).

Import and export: Most of the export or import are in the processed form such as fillets and steaks (for interested readers, this data can be found at Current

Fishery Statistics: Fishery of The United States by the National Marine Fisheries Service, thus are not included in our analysis.

Miscellaneous Data series and Source:

(a). Disposable personal Income: U.S. Dept. of Commerce, Bureau of Economic Analysis, *Survey of Current Business Statistics;* Statistics Canada, *Canadian Statistic Review*, and *Historic Statistics of Canada.*

(b). Producer/Consumer price index: U.S. Bureau of Labor Statistics, *Producer/Consumer Price Index*; *Canadian Statistic Review*, and *Historic Statistics of Canada.*

(c). Foreign exchange rate and Interest rate: International Monetary Fund, *International Financial Statistics Year Book.*

VI. RESULTS

Results using data between 1953 and 1986 are reported in the table 3. Separate estimates were obtained for the United States and Canada. Estimated conditional cost functions satisfy required regularity conditions for most observations. Out of 34 observations, estimated US cost is increasing in w_1 (34 observations), increasing in w_2 (19 observations), decreasing in B (34 observations), and increasing in h (34 observations). Second-order conditions are satisfied for 19 observations in the US. Canadian cost is increasing in w_1 (34 observations), increasing in w_2 (25 observations), decreasing in B (34 observations), and increasing in h (34 observations). Second-order conditions are satisfied for 16 observations in Canada.

A noteworthy difference in the two countries is the differing effect of technological change on cost. Biomass productivity growth in Canada appears to have been double the US's (k_0 significant in both countries but twice as large for Canada). Further, the direct effects of technological change (i.e., constant price effects) lead to increasing fuel share in the US (k_1 significantly positive), but not in Canada (k_1 zero). The estimates suggest that fuel and capital are strong complement in Canada (b_{12} significantly negative) but not in the US (b_{12} not significant).

Market power parameters show similar processor market power exertion in both countries. Processor market power exertion at the wholesale level is modest but significant in the US ($\lambda_w = 0.131$), but is inconsequential in Canada ($\lambda_w = 0.05$). This suggests the wholesale market in Canada is competitive and is weakly oligopolistic in

Table 2. Parameter Estimates from Nonlinear Three-Stage-Least-Squares Estimation

Coefficient	United States	Canada
a_0	-3.967	5.192
	(-1.22)*	(0.89)
a_1	-0.835	-0.663
	(-5.42)	(-2.31)
a_2	0.557	-0.235
	(2.65)	(-0.52)
a_3	0.388	1.809
	(2.37)	(3.23)
γ_0	2.579	5.065
	(4.43)	(27.43)
a_{00}	-188.915	-370.460
	(-4.26)	(-26.05)
b_{01}	-0.002	0.002
	(-0.82)	(0.06)
b_{02}	1.392	0.352
	(4.22)	(2.31)
b_{11}	-0.008	0.029
	(-1.67)	(1.38)
b_{12}	-0.009	-0.096
	(-0.87)	(-3.48)
b_{22}	-0.064	0.604
	(-0.20)	(1.08)
γ_1	0.0002	0.00001
	(3.518)	(0.05)
γ_2	0.0014	-0.001
	(0.39)	(-0.10)
λ_w	0.131	0.053
	(1.85)	(0.57)
λ	8.64	19.524
	(6.42)	(8.10)

* Asymptotic t-ratio.

the US. Since λ is highly significant in both country, Processor market power at the vessel level, which is functionalized as $\lambda_x(\theta)$ (= $e^{-\lambda d/365)}$ must be significant too. Direct interpretation of λ_x is difficult. To help interpretation, the functionalized market power parameter $\lambda_x(\theta)$ (= $e^{-\lambda d/365)}$ is plotted in figure 5 for the US and figure 6 for Canada. Monopsony power scale is on the right of each graph and IPHC regulated fishing season days are on the left. The smaller dotted lines paralleling market power designate one standard deviation around market power. It appears that in recent years, processor market power has reached its maximum value of about .45 in both countries as seasons have diminished. Interestingly, US processors appear to have exerted limited market power in the fishery during the early 1950's while Canadian processors did not. During the 1960-75 period, processors exerted minimal (close to zero) market power at the fishery level in either country.

Table 3 presents the price flexibility of wholesale demand and exvessel supply calculated at the mean value. The own price flexibility of wholesale demand for U.S. is estimated to be -0.4910. The reciprocal of that is -2.036 that is not far from Capalbo(1986) of -1.48. The own price flexibility of wholesale demand for Canada is estimated to be -0.3294. The reciprocal of that is -3.036 that is close to Capalbo of -3.72. The estimated price flexibility at mean value of exvessel supply of 0.02756 for U.S. and 0.0037036 for Canada are relatively too small. This implies that the exvessel supply curve is very flat. Since, the exvessel supply is conditioned on the level of biomass, for a given level of biomass, a big increase in the quantity supplied is required to have any impact on the level of exvessel price. In other words, the price flexibility of supply is relatively inflexible.

Figure 5: Duration and Market Power
United States

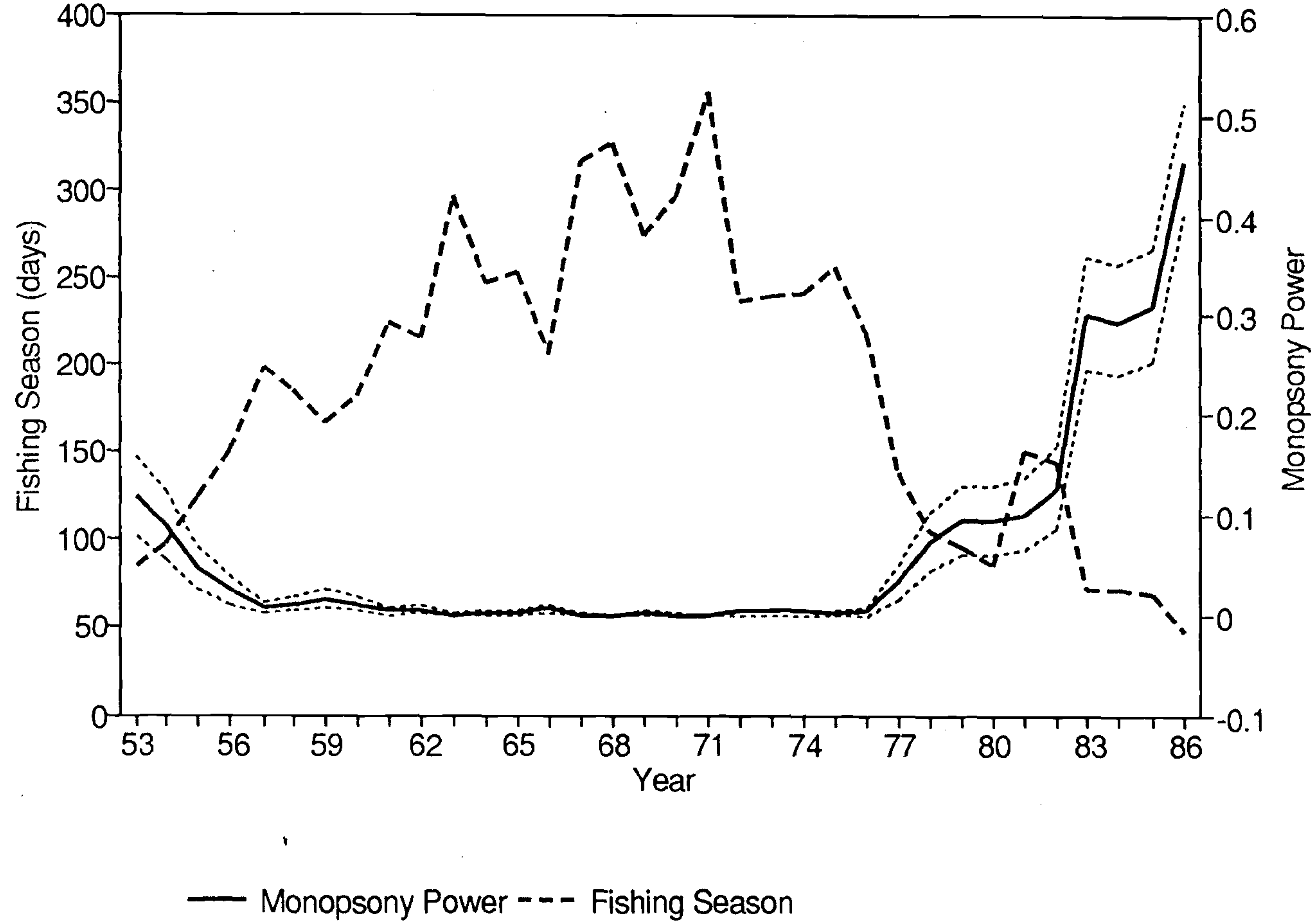

Figure 6: Duration and Market Power
Canada

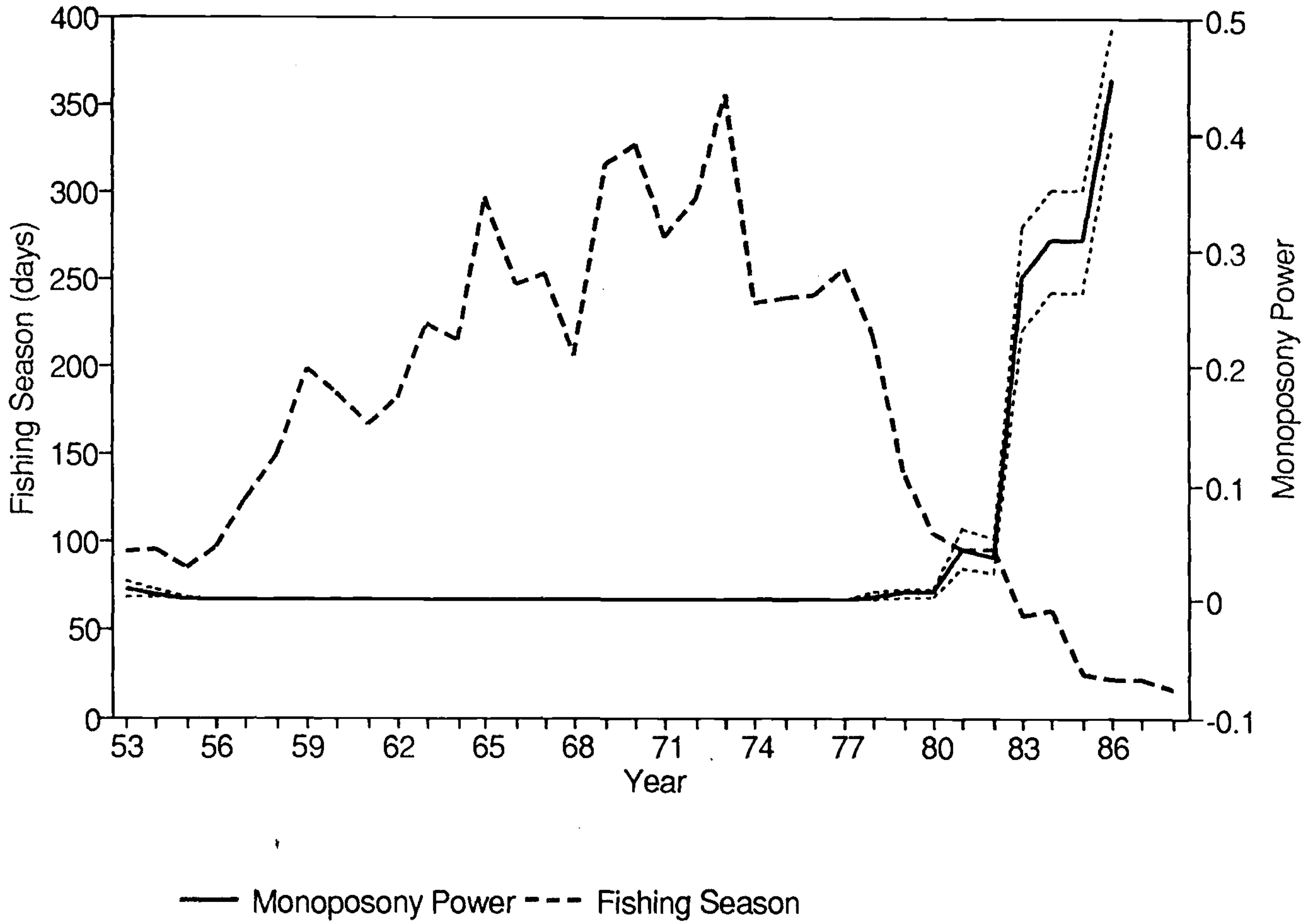

Table 3. Price Flexibility at the Mean Value

	Wholesale Demand	Exvessel Supply
United States	-0.49102	0.02756
Canada	-0.32941	0.0037036

The effective price distortion from the imperfect behavior is the product of market power parameter and price flexibility. For the U.S., The monopsony price distortion ranges from 1.26% when the season length at its shortest period to zero when the season at its longest. For Canada, the monopsony price distortion ranges from 0.166% to zero respectively. The transfer of the short-run rent from the harvesting sector to the processing sector is as high as $109,307 for US and Canadian $30,055 respectively when the season length was set at its shortest period by IPHC.

VII. CONCLUSION

The empirical evidences, for the first time, show that the halibut market structure in exvessel market is not perfect competitive. The apparent tendency, in recent years, is toward less competitive performance. However, there is no strong evidence of imperfect behavior in the wholesale market. Regulatory control of fisheries for the purpose of conservation, especially, IPHC's season length control have affected the market power exertion in the exvessel market. However, the effective market price distortion, from the imperfect performance is rather moderate as measured by the transfer of short-run fishery rent from fisherman to processors. Crutchfield- and Pontecorvo, Schworm, Clark and Munro, and Stollery asserted that under certain conditions a collusive processing sector, able to exercise completely effective monopsony power, would manage the fishery in a socially optimal manner. However, they have also suggested that the necessary conditions for socially optimal management are more restrictive and are unlikely to be met. The empirical result, for the first time, showed that this certainly appears the case for the Pacific halibut fishery and may help explain the biomass reduction throughout the 1960's and 1970's as well as ever increasing fishing effort. Pacific halibut processing industry, which appeared to be a monopolized/monopsonist economic structure, did not control the fishery in which the purely private monopoly/monopsony control would have operated. The empirical results also demonstrated that peculiar nature of the supply function in open access fishery. Whenever the fishing effort is carried to the limit of a quota imposed by a regulatory commission, the market supply function becomes very inelastic or negatively sloped in some years. Therefore any increase in demand will attract more entry to the processing and the fishing industry, therefore overcapacity.

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APPENDIX

Data: Exvessel Prices and Quantities

	Canada		United States		Total	
Year	Landings (million lbs.)	Exvessel Price (CA$/lb)	Landings (million lbs.)	Exvessel Price (US$/lb)	Landings (million lbs.)	Average Exv. Price (US$/lb)
1951	20.214	0.1696	35.831	0.1750	56.045	0.17
1952	23.489	0.1683	38.773	0.2010	62.262	0.19
1953	24.882	0.1471	34.955	0.1503	59.837	0.15
1954	25.260	0.1581	45.323	0.1742	70.583	0.17
1955	19.679	0.1298	37.842	0.1443	57.521	0.14
1956	23.316	0.2173	43.272	0.2196	66.588	0.22
1957	22.647	0.1632	38.207	0.1699	60.854	0.17
1958	23.707	0.2068	40.801	0.2082	64.508	0.21
1959	23.798	0.1848	47.406	0.1887	71.204	0.19
1960	27.162	0.1612	44.443	0.1562	71.605	0.16
1961	24.951	0.2131	44.323	0.2098	69.274	0.21
1962	24.526	0.3169	50.336	0.3019	74.862	0.30
1963	25.933	0.2206	45.304	0.2134	71.237	0.21
1964	25.124	0.2495	34.660	0.2294	59.784	0.23
1965	25.783	0.3374	37.393	0.3255	63.176	0.32
1966	24.511	0.3544	37.505	0.3480	62.016	0.34
1967	19.671	0.2576	35.551	0.2254	55.222	0.23
1968	22.507	0.2501	26.087	0.2288	48.594	0.23
1969	27.196	0.4257	31.079	0.3680	58.275	0.38
1970	20.062	0.3610	34.876	0.3846	54.938	0.37
1971	15.950	0.3269	30.704	0.3181	46.654	0.32
1972	15.187	0.6200	27.695	0.6478	42.882	0.64
1973	9.892	0.7400	21.848	0.7401	31.740	0.74
1974	6.493	0.7300	14.813	0.6796	21.306	0.70
1975	7.793	0.9100	19.823	0.8882	27.616	0.89
1976	9.511	1.2600	18.024	1.2506	27.535	1.26
1977	6.207	1.3300	15.661	1.3335	21.868	1.31
1978	5.053	1.9700	16.935	1.6919	21.988	1.70
1979	5.308	2.6400	17.219	2.0919	22.527	2.13
1980	5.877	1.2500	15.989	0.9609	21.866	0.99
1981	4.756	1.3900	20.976	0.9884	25.732	1.02
1982	3.722	1.2700	25.286	1.0989	29.008	1.09
1983	4.108	1.5500	34.276	1.1147	38.384	1.13
1984	6.850	1.0500	38.120	0.7391	44.970	0.75
1985	8.121	1.3200	47.991	0.8770	56.113	0.89
1986	9.253	2.0300	60.377	1.4368	69.632	1.44
1987	10.465	2.3200	59.015	1.5500	69.482	1.58

Data: Wholsale Prices and Disposable Income

	Canada			United States		
Year	Halibut Wholesale Price (CA $/lb)	Salmon Wholesale Price (CA $/lb)	Disposable Personal Income (million CA $)	Halibut Wholesale Price (US$/lb)	Salmon Wholesal Price (US$/lb)	Disposable Personal Income (millions US $)
1951	0.2772	0.2976	15435	0.3280	0.5410	227600
1952	0.2355	0.2656	16922	0.3698	0.5187	239800
1953	0.2232	0.2484	17718	0.3277	0.4963	255100
1954	0.2367	0.2722	17868	0.3243	0.5641	260500
1955	0.1994	0.3121	19331	0.2814	0.5656	278800
1956	0.2846	0.3737	21307	0.3704	0.6348	297500
1957	0.2480	0.3253	22714	0.3360	0.6437	313900
1958	0.2822	0.4013	24313	0.3488	0.7328	324900
1959	0.2620	0.4959	25440	0.3305	0.7742	344600
1960	0.2406	0.4556	26567	0.3104	0.8495	358900
1961	0.2845	0.4543	26904	0.3448	0.8618	373800
1962	0.3797	0.4115	29340	0.4268	0.9495	396200
1963	0.3082	0.3904	31168	0.3884	0.9153	415800
1964	0.3206	0.4808	33049	0.3848	0.8815	451400
1965	0.3953	0.5354	36263	0.4495	0.8655	486800
1966	0.4382	0.5514	39901	0.4790	0.9375	525900
1967	0.3738	0.5569	43123	0.4107	0.9673	562100
1968	0.3726	0.5286	46820	0.3819	1.0342	609600
1969	0.5079	0.6622	50911	0.5369	1.2033	656700
1970	0.5322	0.5948	54009	0.5949	1.3392	715600
1971	0.5293	0.6602	59943	0.5483	1.2433	776800
1972	0.8300	0.6122	68100	0.8219	1.3035	839600
1973	0.9700	0.9512	79719	0.9603	1.1742	949900
1974	0.9700	1.1093	94545	1.0367	1.8917	1038400
1975	1.2600	1.4387	110996	1.2433	1.8900	1142800
1976	1.6100	1.2280	125510	1.6133	2.8458	1252600
1977	1.5700	1.4492	138515	1.7392	3.4104	1379300
1978	2.5400	1.7601	153954	2.1300	3.5292	1551200
1979	3.3300	1.9807	172308	2.6000	3.2825	1729300
1980	1.7000	2.0566	192572	2.4650	1.5325	1918000
1981	2.2200	1.9412	232439	1.9492	1.9458	2127600
1982	1.4700	2.0480	255954	1.8492	2.2275	2261400
1983	2.2600	1.6518	270056	2.1492	1.8643	2428100
1984	1.7000	2.3742	300835	1.5725	2.6758	2668600
1985	1.9400	2.0600	325909	1.7909	4.8701	2838700
1986	2.7600	2.2311	343455	2.6040	6.1079	3019600
1987	3.2400	2.7906	352920	2.7091	6.5096	3209700

Data: Exploitable Biomass (million of pounds)

Year	Total	2A	2B	2C	3A	3B	4	BUS	BCA
1951	289.305	3.351	61.065	49.745	104.579	44.622	25.682	289.305	289.305
1952	289.698	3.331	63.178	50.848	102.051	43.921	25.704	289.698	289.698
1953	291.635	3.405	66.475	52.526	98.587	43.784	25.785	291.635	291.635
1954	294.499	3.580	69.498	54.252	97.120	43.992	25.939	294.499	294.499
1955	298.445	3.707	70.589	54.921	97.977	44.842	26.174	298.445	298.445
1956	302.911	3.734	69.832	54.166	101.690	46.291	26.432	302.911	302.911
1957	305.811	3.674	67.150	51.472	108.750	47.882	26.607	305.811	305.811
1958	306.918	3.527	63.259	47.525	116.732	49.304	26.695	306.918	306.918
1959	307.150	3.385	59.939	44.180	122.085	50.540	26.775	307.150	307.150
1960	305.811	3.248	57.588	41.947	123.660	51.096	26.739	305.811	305.811
1961	298.540	3.054	55.525	40.175	122.500	50.645	26.261	298.540	298.540
1962	284.449	2.836	52.981	38.202	117.526	48.420	25.067	284.449	284.449
1963	262.981	2.626	49.682	35.958	107.774	44.208	23.165	262.981	262.981
1964	238.208	2.432	46.026	33.848	95.687	39.349	20.967	238.208	238.208
1965	215.519	2.281	42.482	32.089	84.374	35.287	18.969	215.519	215.519
1966	196.117	2.200	39.071	30.329	74.879	32.197	17.267	196.117	196.117
1967	179.579	2.188	35.949	28.399	67.244	29.776	15.814	179.579	179.579
1968	167.602	2.239	33.740	26.785	61.985	28.074	14.760	167.602	167.602
1969	159.415	2.318	32.579	25.639	58.426	26.701	14.030	159.415	159.415
1970	151.517	2.353	31.929	24.581	54.887	24.961	13.299	151.517	151.517
1971	142.816	2.275	31.426	23.464	50.890	22.728	12.478	142.816	142.816
1972	134.419	2.054	31.021	22.345	47.096	20.469	11.706	134.419	134.419
1973	128.217	1.808	30.684	21.274	44.671	18.871	11.181	128.217	128.217
1974	125.441	1.645	30.446	20.339	43.979	18.174	10.977	125.441	125.441
1975	124.965	1.521	30.271	19.636	44.334	18.043	10.958	124.965	124.965
1976	125.793	1.395	29.953	19.263	45.883	18.148	11.028	125.793	125.793
1977	128.902	1.274	29.147	19.600	49.067	18.529	11.266	128.902	128.902
1978	135.104	1.540	27.914	21.447	53.406	19.386	11.767	135.104	135.104
1979	144.365	1.024	27.028	25.159	58.170	20.851	12.553	144.365	144.365
1980	157.347	0.927	26.796	29.968	63.606	23.079	13.677	157.347	157.347
1981	175.692	0.896	27.676	34.788	71.084	26.273	15.288	148.016	27.676
1982	202.018	0.908	31.072	39.095	82.483	30.761	17.677	170.946	31.072
1983	232.241	0.944	36.192	42.406	96.280	35.835	20.471	196.049	36.192
1984	257.609	0.994	40.732	44.495	108.272	40.074	22.865	216.877	40.732
1985	229.430	1.040	28.069	50.129	113.927	28.134	8.131	201.361	28.069
1986	237.304	0.895	28.400	50.909	125.736	23.353	8.011	208.904	28.400
1987	252.100	0.775	33.600	45.365	128.650	35.500	11.950	218.5	33.600

Data: Calculated Variable Processing Cost and Transportation Cost

Year	Freight Cost ($/lb)	Direct Labor ($/lb)	Utility Cost ($/lb)	Other Cost ($/lb)	Taxes (for US only)	Total VC ($/lb)	Transpot cost ($/lb)
1951	0.0243	0.0160	0.0129	0.0061	0.0079	0.0671	0.0256
1952	0.0236	0.0169	0.0130	0.0059	0.0090	0.0684	0.0249
1953	0.0233	0.0178	0.0130	0.0058	0.0068	0.0667	0.0246
1954	0.0234	0.0183	0.0133	0.0058	0.0078	0.0687	0.0246
1955	0.0234	0.0191	0.0127	0.0059	0.0065	0.0675	0.0247
1956	0.0242	0.0200	0.0130	0.0061	0.0099	0.0732	0.0255
1957	0.0249	0.0210	0.0124	0.0062	0.0076	0.0721	0.0262
1958	0.0254	0.0217	0.0131	0.0063	0.0094	0.0758	0.0267
1959	0.0253	0.0225	0.0131	0.0063	0.0085	0.0757	0.0266
1960	0.0253	0.0232	0.0133	0.0063	0.0070	0.0751	0.0267
1961	0.0254	0.0238	0.0133	0.0063	0.0094	0.0783	0.0267
1962	0.0253	0.0245	0.0134	0.0063	0.0136	0.0831	0.0266
1963	0.0252	0.0252	0.0133	0.0063	0.0096	0.0796	0.0265
1964	0.0252	0.0260	0.0132	0.0063	0.0103	0.0810	0.0266
1965	0.0257	0.0268	0.0131	0.0064	0.0146	0.0867	0.0271
1966	0.0266	0.0278	0.0131	0.0067	0.0157	0.0898	0.0281
1967	0.0267	0.0289	0.0131	0.0067	0.0101	0.0855	0.0281
1968	0.0273	0.0309	0.0132	0.0068	0.0103	0.0886	0.0288
1969	0.0284	0.0327	0.0134	0.0071	0.0166	0.0981	0.0299
1970	0.0294	0.0344	0.0139	0.0074	0.0173	0.1024	0.0310
1971	0.0304	0.0366	0.0149	0.0076	0.0143	0.1038	0.0320
1972	0.0318	0.0392	0.0159	0.0079	0.0292	0.1240	0.0335
1973	0.0359	0.0420	0.0169	0.0090	0.0333	0.1371	0.0378
1974	0.0427	0.0454	0.0214	0.0107	0.0306	0.1507	0.0450
1975	0.0466	0.0496	0.0253	0.0117	0.0400	0.1732	0.0492
1976	0.0488	0.0536	0.0273	0.0122	0.0563	0.1981	0.0514
1977	0.0518	0.0583	0.0305	0.0129	0.0600	0.2135	0.0546
1978	0.0558	0.0632	0.0328	0.0140	0.0761	0.2419	0.0588
1979	0.0629	0.0688	0.0354	0.0157	0.0941	0.2769	0.0663
1980	0.0718	0.0746	0.0421	0.0179	0.0432	0.2497	0.0756
1981	0.0783	0.0821	0.0481	0.0196	0.0445	0.2725	0.0825
1982	0.0798	0.0873	0.0533	0.0200	0.0495	0.2898	0.0842
1983	0.0808	0.0907	0.0548	0.0202	0.0502	0.2966	0.0852
1984	0.0828	0.0943	0.0576	0.0207	0.0333	0.2887	0.0873
1985	0.0824	0.0979	0.0594	0.0206	0.0395	0.2998	0.0868
1986	0.0800	0.1000	0.0600	0.0200	0.0647	0.3247	0.0843
1987	0.0821	0.1018	0.0000	0.0205	0.0697	0.2742	0.0866

Data: Wholesale Fuel Prices and IPHC Regulated Season Lengt

	Canada		United States	
Year	Fuel price Index (1986=100)	Saeson Length (Days)	Fuel price Index (1986=100)	Season Length (Days)
1951	15.4736	94	28.8064	94
1952	14.5753	96	28.7426	96
1953	14.2172	86	29.5401	86
1954	13.9910	97	29.1254	97
1955	14.1983	124	29.0935	124
1956	14.6821	150	29.9867	150
1957	15.3204	198	31.6137	198
1958	14.9508	185	30.4015	185
1959	14.8836	167	30.4015	167
1960	14.8164	183	30.6567	183
1961	14.7997	225	31.0076	225
1962	14.6821	216	30.8481	216
1963	14.2621	297	30.7205	297
1964	14.2957	247	29.8910	247
1965	14.0437	254	30.4653	254
1966	14.0773	206	31.1990	206
1967	14.2117	318	31.9008	318
1968	14.5141	328	31.5499	328
1969	14.8164	275	32.2198	275
1970	15.2532	298	33.8786	298
1971	16.7987	356	36.4307	356
1972	17.2523	237	37.8343	237
1973	19.6881	239	42.8428	239
1974	26.7771	242	66.4494	242
1975	30.8592	256	78.1570	256
1976	38.0304	219	84.8561	219
1977	41.0728	138	96.3404	138
1978	46.2636	105	103.0396	105
1979	53.9742	95	130.1552	95
1980	67.9675	95	118.6246	95
1981	92.6784	58	143.5530	92
1982	106.5709	61	143.2665	83
1983	113.3576	24	137.3926	48
1984	118.3300	22	135.8166	49
1985	124.4671	22	130.9456	47
1986	100.0000	15	100.0000	32

Data: Miscellaneous Data

	Canada				United States				
Year	PPI 1986=1	CPI 1986=1	Interest Rate Annu. %	Hourly Earnings 1986=1	PPI 1986=1	CPI 1986=1	Interest Rate Annu. %	Hourly Earnings 1986=1	Exchange Rate CA$/US$
1951	0.23	0.21	2.00	0.094	0.30	0.24	1.75	0.160	1.0530
1952	0.22	0.22	2.00	0.105	0.30	0.24	1.75	0.169	0.9790
1953	0.21	0.21	2.00	0.110	0.29	0.24	2.00	0.178	0.9830
1954	0.21	0.21	2.00	0.114	0.29	0.24	1.50	0.183	0.9730
1955	0.21	0.22	2.75	0.117	0.29	0.24	2.50	0.191	0.9860
1956	0.22	0.22	3.92	0.122	0.30	0.25	3.00	0.200	0.9840
1957	0.25	0.23	3.87	0.130	0.31	0.26	3.00	0.210	0.9588
1958	0.25	0.23	3.74	0.134	0.32	0.26	2.50	0.217	0.9708
1959	0.25	0.23	5.37	0.139	0.32	0.27	4.00	0.225	0.9592
1960	0.26	0.24	3.50	0.143	0.32	0.27	3.00	0.232	0.9695
1961	0.26	0.24	3.24	0.147	0.32	0.27	3.00	0.238	1.0131
1962	0.26	0.24	4.00	0.152	0.32	0.28	3.00	0.245	1.0701
1963	0.26	0.25	4.00	0.157	0.31	0.28	3.50	0.252	1.0811
1964	0.26	0.25	4.25	0.163	0.32	0.28	4.00	0.260	1.0811
1965	0.27	0.26	4.75	0.171	0.32	0.29	4.50	0.268	1.0811
1966	0.28	0.27	5.25	0.181	0.33	0.30	4.50	0.278	1.0811
1967	0.28	0.28	6.00	0.193	0.33	0.30	4.50	0.289	1.0811
1968	0.29	0.29	6.50	0.208	0.34	0.32	5.50	0.309	1.0811
1969	0.30	0.30	8.00	0.224	0.35	0.33	6.00	0.327	1.0811
1970	0.30	0.31	6.00	0.242	0.37	0.35	5.50	0.344	1.0475
1971	0.31	0.32	4.75	0.264	0.38	0.37	4.50	0.366	1.0098
1972	0.32	0.33	4.75	0.285	0.40	0.38	4.50	0.392	0.9908
1973	0.36	0.36	7.25	0.310	0.45	0.41	7.50	0.420	1.0002
1974	0.43	0.40	8.75	0.352	0.53	0.45	7.75	0.454	0.9779
1975	0.48	0.44	9.00	0.407	0.58	0.49	6.00	0.496	1.0172
1976	0.50	0.47	8.50	0.464	0.61	0.52	5.25	0.536	0.9860
1977	0.54	0.51	7.50	0.514	0.65	0.55	6.00	0.583	1.0635
1978	0.59	0.56	10.75	0.551	0.70	0.59	9.50	0.632	1.1407
1979	0.68	0.61	14.00	0.598	0.79	0.66	12.00	0.688	1.1714
1980	0.77	0.67	17.26	0.659	0.90	0.75	13.00	0.746	1.1692
1981	0.85	0.75	14.66	0.738	0.98	0.83	12.00	0.821	1.1989
1982	0.90	0.84	10.26	0.824	1.00	0.88	8.50	0.873	1.2337
1983	0.93	0.88	10.04	0.882	1.01	0.91	8.50	0.907	1.2324
1984	0.97	0.92	10.16	0.934	1.04	0.95	8.00	0.943	1.2951
1985	0.99	0.96	9.49	0.970	1.03	0.98	7.50	0.979	1.3655
1986	1.00	1.00	8.49	1.000	1.00	1.00	5.50	1.000	1.3895
1987	1.03	1.04	8.66	1.026	1.03	1.04	6.00	1.018	1.3260