The Pacific Halibut Fishery:

Success and Failure Under Regulation

1930-1960,

The Canadian Experience

By

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Abstract

At the 1996 World Fisheries Congress, Donald A. McCaughran declared seventy-five years of regulatory success for the International Pacific Halibut Commission. The Commission's mandate was to reverse the precipitous decline in halibut stocks that had become apparent in the 1910's, and save this fishery from economic extinction. The biologists and fishermen who sat on the Commission assumed that the appropriate biological target was the one that yielded the maximum sustainable harvest. Using a bioeconomic model of the fishery and regression analysis, I argue the Commission's use of global quotas to achieve its biological goal of maximum sustained yield was most certainly an economic failure. I also argue its policies were very likely a biological failure, as well. While arguably accomplishing its biological goal of the maximum sustainable yield in 1960, dynamic bioeconomic theory indicates their policies probably destabilized the biological fishery. The paper will first sketch the historical background of the industry. Then the regulatory history will be discussed. Then the economic literature will be reviewed as it applies to the Pacific halibut industry. Finally, the historical data will be examined and the proposition that the regulatory management of the halibut fishery was a success will be tested. The period 1928 to 1960 is covered as it provides both reliable data and a continuous period of regulation, at the end of which the biological goal of maximum sustainable yields was apparently achieved. In conclusion, I find that statistically the fishermen were insensitive to the direct effects of the quota and the total quantity of fish available, and instead responded to the quota's indirect effects on the fishermen's costs, which induced the inflow of greater fishing capital than otherwise would have occurred.

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Thanks, Hazel

"Seventy-five years of regulatory success" is what Donald A. McCaughran declared at the 1996 World Fisheries Congress, for the International Pacific Halibut Commission's management of the US-Canada fishery.[1] On the surface, his claim seems sound. The commercial fishery did recover rapidly from near extinction shortly after IPHC regulations enforced quotas in the 1930's. As well, the Commission's goal also seemed reasonable: to achieve and then maintain the halibut stock at a level that generated the greatest maximum sustainable yield. In this sense, McCaughran was declaring success for the Commission in terms of both the biology and the economics of the Pacific halibut fishery.

However, not everyone agreed. By the 1950's and 1960's the ocean fishery became the specific subject of economic theory and investigation. Paul Crutchfield and Arnold Zellner's 1962 study of the Pacific halibut fishery was particularly critical of the IPHC's emphasis on biological targets.[2] They argued the problem facing the halibut fishery was primarily economic, and in particular an over-capacity of fishing power, exacerbated by the Commission's policies. Any potential gains to society resulting from the Commission's conservation efforts were soon lost as extra fishermen chased, and dissipated, these benefits as soon as they appeared. The result was a fishery that, while increasingly fertile biologically, became increasingly costly in terms of society's scarce economic resources. Crutchfield and Zellner concluded that until this problem of entry-and-exit of fishing effort was addressed, "the job must be considered only half done."[3]

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[1] Donald A. McCaughran, "Seventy-Five Years of Halibut Management Success," *Developing and Sustaining World Fisheries Resources: The State of Science and Management, 2nd World Fisheries Congress Proceedings* (Brisbane, Australia: CSIRO, 1996) 680-686.
[2] James Crutchfield and Arnold Zellner, "Economic Aspects of the Pacific Halibut Fishery," *Fishery Industrial Research* Vol. 1, no. 1 (April, 1962), 102.
[3] Crutchfield and Zellner, 102.

The response of the Commission and its supporters to this outside criticism was defensive. The Commission, which was made up of fishery biologists and halibut fishermen, never seriously questioned whether its biological target of maximum sustainable yield was also the appropriate economic target, and no doubt felt it was self-evident.[4] When faced with criticism, the Commission lashed out. It publicly chastised H. Scott Gordon, the leading economic theorist of the ocean fishery at the time, after he ventured to point out these problems.[5] And one-time Commission member F.H. Bell, in his seminal history of the Pacific halibut industry, argued that the economists prejudged the Commission's regulatory success by relying on "hearsay" to confirm their theories about "the common property character of the fisheries generally and of the Pacific halibut fishery in particular."[6]

Bell makes two claims in order to contradict the fishery economists' conclusions of over-capacity. First, he asserts, "there was little evidence of fleet increases tying up resources to any consequential degree." Second, he argues, "by 1965 all productivity measures per crew member had about doubled over what they were immediately prior to regulation."[7] Bell argues from the statistics of the fishery "and other facts of the fishery

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[4] Indeed, so unexamined was this notion of managing the fishery to annually produce the greatest sustainable harvest that it was only made explicit as the Commission's policy in the 1953 Convention, after more than thirty years. As long-time Commission member F. Heward Bell notes about the 1953 Convention, the commission "was charged with the responsibility of developing and maintaining the halibut stocks at levels which would provide the maximum sustained yield. While this directive had been implied in earlier conventions it was not explicitly stated." Bell, F. Heward. *The Pacific Halibut: the resource and the fishery* (Anchorage: Alaska Northwest Publishing Company, 1981), 153.

[5] The transcripts of the expert panel Gordon was sitting on show an interesting end to the exchange. "GORDON withdrew his strictures on the Commission. They have done a good job. The complaint must be against the economists and others who did not succeed in having the Commission's terms of reference made wider." The irony of this comment seems particularly pointed. J.A. Crutchfield, "Regulation of the Pacific Coast Halibut Fishery" *Expert Meeting on the Economic Effects of Fishery Regulation, Ottawa, Canada, 12 to 17 June 1961* (May, 1961), "Panel IV Discussion," 7.

[6] Bell, 120.

[7] Bell, 121.

that management of the resource by the Halibut Commission has not been the disaster that many economists claimed it to be."[8]

But even in terms of the biology of the resource, it appears the Commission's policies were also less than successful. The fishery did make a remarkable turn-around shortly after the quota system was brought in, leading regulators to declare that "by the late 1950s most segments of the [Pacific halibut] population appeared to have reached levels of their maximum sustainable yields."[9] However, there was also a sharp and prolonged slump in the halibut catch in the late 1960s, out of which the fishery did not emerge until the mid-1980s.[10] Bell attributed this decline to factors outside of the control of the Commission, such as foreign fleets and environmental conditions. It is this account of the regulated fishery that has been picked up by current historical writers, but it is only part of the story.[11] Instead, there is good reason to believe that the recurrent problems of the Pacific halibut fishery are rooted in the very nature of the Commission's regulatory efforts.

Some form of unitary control is needed to manage common property resources. But it will be argued that the regulatory instruments chosen by the IPHC were the wrong instruments on both economic and biological grounds. Although earlier writers, notably Crutchfield and Zellner, have used descriptive statistics to make their arguments, the economic effects of these regulations have never been statistically tested. We will take advantage of the large amount of statistics complied by the IPHC to test the causality of

[8] Bell, 122.
[9] Bell, 210.
[10] Patrick J. Sullivan, Ana M. Parma, and William G. Clark. *Scientific Report No. 79, The Pacific Halibut Stock Assessment of 1997,* (Seattle: IPHC, 1999), 10.
[11] "By the 1960s, environmental degradation and larger incidental catches by foreign high-seas trawling fleets further reduced stocks." Dianne Newell, *Tangled Webs of History: Indians and the Law in Canada's Pacific Coast Fisheries,* (Toronto: University of Toronto, 1993), 186.

IPHC policies on capital investment in the fishery using regression analysis. The period 1928 to 1960 is of particular interest as it provides both reliable data and a continuous period of regulation at the end of which, according to the Commission, the biological goal of the greatest maximum sustainable yield was reached.[12] We will also use recent economic theory to suggest that the IPHC policies may have also exposed the halibut fishery to extinction once again. In doing so, we gain a fuller understanding of the effects of regulatory management of a natural resource that is being commercially exploited, and move closer to taking the proper steps to conserve and husband our resources.

Background to Regulation

The Pacific halibut is particularly vulnerable to commercial depletion. It is slow to mature sexually, females sexually maturing around 12 years while males sexually mature by the time they are 8 years old. The halibut life cycle is depicted on page 36.[13] By the age of 3 years, halibut move from the shallow inner waters to the deeper waters of the continental shelf, and are exposed to capture by both halibut fishermen and to incidental capture by trawlers fishing for other species of groundfish. Adult halibut move seasonally from the shallow banks to the deeper ocean during the winter breeding season. Juvenile halibut can also migrate annually 100's of miles along the coast, moving from the northeast to the southwest. However, most Halibut are found within 60 miles of their

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[12] Area 2 (BC coast) was believed to be operating at its greatest maximum sustainable yield of 32 million pounds by 1950. Area 3 (Alaskan panhandle) reached its greatest maximum yield of 36 million pounds by 1959. Douglas G. Chapman, Richard J. Myhre, and G. Morris Southward, "Utilization of Pacific Halibut Stocks: Estimation of Maximum Sustainable Yield, 1960," *Report of the International Pacific Halibut Commission, No. 31 (Seattle, Washington: IPHC, 1962),* 30

[13] Trumble, R.J. et al. *Canadian Bulletin of Fisheries and Aquatic Sciences 227* (Ottawa: NRC, 1993), 11.

original breeding grounds along the continental shelf, and it is there, on the inner and outer banks, that fishing effort is brought to bear.[14]

The Pacific halibut is the largest of all flatfish and lives near the bottom of the ocean. Consequently, the fishery was and is a hook and line fishery. Early attempts at trawling for halibut proved unsuccessful. Fishing gear was set and retrieved using either small two-man dories, which were carried by a mothership, or else by "longliners" that set the gear behind them.[15] By the 1930's, dory fishing was no longer practised and longlining had become the standard method. Halibut fishing gear was standardised early in the history of fishery. The figures on pages 37-39 show the standard method of setting gear, and the technical aspects of the gear itself.[16] The standard unit of gear was an 1800-foot groundline with hooks on five-foot gangings attached every nine feet for dory fishing and every thirteen feet for longlining. Once set into place along the fishing banks, the gear was allowed to "soak" for around twelve hours. The differences in placement between dory fishing and longlining were due entirely to differences in the speed that the groundline could be moved in and out of the boat. These differences in placement apparently had no real effect upon productivity.[17] This allowed the Commission to convert all gear into one standard unit, regardless of differences in groundline length or hook spacing. The Commission was thus able to collect and collate all ship's logs and express total fishing productivity in terms of one standard unit of effort of 120 hooks per

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[14] The International Pacific Halibut Commission, "The Pacific Halibut: Biology, Fishery, and Management," *Technical Report No. 22*, (Seattle, Washington: 1987), 5-12.
[15] Bell, 57.
[16] Diagrams on pages 37 and 38 are from IPHC Technical Report No. 22, *The Pacific Halibut: Biology, Fishery, and Management* (Seattle, Washington: 1987), 22-23. Diagram on page 39 is from William F. Thompson and Norman L. Freeman, "History of the Pacific Halibut Fishery," *Report of the International Fisheries Commission, No. 5*, (Vancouver, BC: Wrigley Printing Co, 1930), 21.
[17] However, see Bernard Skud and John M. Hamley, "Factors Affecting Longline Catch and Effort" *IPHC Scientific Report No. 64* (Seattle, Washington: 1978), for their cautions on pre-1928 statistics.

1800-foot skate. This statistic will be used here to indicate the catch per unit of effort, or CPUE.[18]

Halibut is a delicious white meat fish. The market for Pacific coast halibut during this period was essentially the east coast of both Canada and the United States. The halibut were eviscerated, heads off, and then packed in ice, or, later frozen solid, for shipment by rail east. Other methods of preservation were canning and smoking, but by far the preponderant method was freezing. The enormous potential of the fishery was clear to fishermen early on; the waters were reportedly "teeming" with halibut. However, the commercial halibut fishery did not really begin until the last decade of the 19th century. As an early Commission report states,

> What is evident now should have been evident then, that the limit of the area fished was fixed, not by the presence or absence of halibut, but by the commercial practicability of establishing a paying fishery.[19]

The completion of the Northern Pacific railroad in 1887 and the Canadian Pacific in 1885 opened up markets to the east. However, high freight charges, ice costs, and wastage due to handling, served to keep entry into the fishery at a low level until the depletion of stocks in the Atlantic fishery pushed Atlantic halibut prices up. As transportation costs fell, prices rose, and trade connections improved, men and boats were attracted into the Pacific fishery from both the older Atlantic fishery as well as from the local area.[20]

The period 1888 to 1910 was one of intensive growth for the fishery. More effort, in terms of boats and men, were brought to bear on local fishing banks. These banks were in the sheltered areas close along the coast and were easily accessible with the existing

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[18] Bell, 57-66.
[19] Thompson and Freeman, 23.

sail-based technology. In the first half of this period, activity was centred on the grounds near Puget Sound, which also enjoyed the closest rail connections to the eastern markets. With the introduction of steamer ships in the late 1890's greater intensity of effort became possible on the existing British Columbia and Alaska grounds. Activity on these grounds was initially during the winter season, even though the catch was at its poorest at this time. Atlantic halibut landings were at their seasonal low, and halibut prices were at their seasonal high. Once Pacific halibut became established on its own in the marketplace, fishing became a year-round activity. The exploitation of the fishery during this period was dictated by the development of, and access to, the market and not by resource abundance.[21]

Towards the end of this period, around 1910, depletion became a concern for the first time. The southern grounds around Puget Sound became virtually exhausted. Consequently, gas powered schooners from the south entered the abundant British Columbia fishery and put pressure on the slow-growing halibut. Catch per unit of effort on these grounds peaked in 1904 and 1905.[22] Up until 1909 or 1910, the fishing fleet became technically more adept at exploiting the existing banks. Gains in productivity were created as the fleet learned how best to organize and to apply its inputs. But at the same time fish were becoming scarcer, negating these gains. These forces combined to push fishing effort out beyond the protected inner waters, resulting in a period of extensive growth.[23]

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[20] Thompson and Freeman, 16-18.
[21] Thompson and Freeman, 23-29.
[22] Crutchfield and Zellner, 6.
[23] Thompson and Freeman, 29.

These deeper and more distant fishing grounds came to be exploited in and after 1910. Depletion on the inner grounds was one factor, but technical change was another. By 1910 the fleet was mostly gasoline powered. Vessels became larger and better able to navigate the more northerly waters. Longlining with power winches became more widespread, making fishing safer and speeding up the loading and unloading of fish. Electric lights had also been introduced, permitting night fishing. Oil and gas supplies were improved. Fishing was now possible 24 hours a day. Cold storage was improved upon and became more widespread. Increases in the catch, made possible by the improvements in motive power, could now be stored for long periods of time. Broken trips were made possible by the ability to store partial catches. As a result, the range of fishing vessels was extended and the ability to market the catch was improved.[24]

The completion of the Grand Trunk Railway terminus at Prince Rupert in 1908 also enabled the fishery to extend itself further north and west by providing a more northerly port. Its completion was also accompanied by the building of more cold storage facilities. The Canadian government's encouragement of American landings duty free at the newly completed port accelerated this outward and northward shift of fishing effort. By April 1915 American landings at Prince Rupert had begun in earnest.[25] The northern and western expansion of the fishery was well under way.

Subsequent overproduction and concerns over depletion combined to produce calls for a winter closure of the halibut fishery. Production from the newly exploited grounds made it difficult to market the resultant frozen fish surpluses, and consensus was built to discontinue the winter fishery, which produced small inferior fish due to the

[24] Thompson and Freeman, 45-47.
[25] Thompson and Freeman, 40-41.

winter spawning season. Thus, under the guise of conservation, the first effort at regulating the fishery was made. After several false starts, the International Fisheries Commission was finally formed by treaty in 1923 between the United States and Canada to study the halibut life cycle and to regulate the winter season closure.[26] This closed season in turn accelerated the movement of fishing effort outward from the southern banks and into the more northerly and westerly outer banks. The regulatory era of the halibut fishery had thus begun.

Regulatory History

Concerns over depletion were the public justifications for regulating the Pacific halibut fishery. Statistics indeed showed a precipitous decline in landings in just a few years off the southern banks from their peak in 1904/1905. This led to two reports on the state of the halibut in 1916 and 1917 by W.F. Thompson of the BC Fisheries Department. The statistics compiled by Thompson showed both biological and economic signs of depletion. The numbers clearly showed a decline in both abundance and average size of halibut caught on the older banks. Fishermen responded with longer voyages and more man-hours. Thompson emphasised the distinct possibility that the halibut fishery was in, at the very least, danger of economic extinction. He thus called upon industry, in his 1917 report, to create a regulatory body whose aim would be to conserve the commercial halibut fishery.[27]

Thompson's 1916 report identified early the biological characteristics that made the Pacific halibut particularly vulnerable to depletion. These characteristics are a slow growth rate of the fish stock, a large size relative to the small extent of the banks, and a

[26] Thompson and Freeman, 55.

late sexually mature female.[28] Furthermore, the bulk of the commercially valuable fishery is made up of medium-sized fish, whose age range is from 7 to 18 years, while females are not sexually mature until twelve years of age. As the grounds contain all age ranges, this means many sexually immature fish are caught. In addition, halibut are relative immobile. They tend to stay on certain banks. These sub-groupings made the more accessible grounds especially vulnerable.[29] Very quickly, depletion manifested itself in these close-in southern grounds.

The Pacific coast halibut fishery is an international fishery. The first halibut commission was provided for in 1923 by treaty between the United States and Canada – the first international treaty signed by Canada without British participation.[30] In 1924, the Commission was established, and named the International Fisheries Commission, until its name was changed in 1953 to the International Pacific Halibut Commission. The four man Commission's mandate was to rehabilitate the halibut stocks, initially by the enforcement of a winter season closure, as well as to study the biology of the halibut. By 1928 it was clear that the closed season had little impact upon depletion of the fishery. And even though new areas were expanded into, the catch per unit of effort continued to fall. The total landed was maintained year after year, but at greater and greater levels of fishing effort. In 1915 the amount of fish caught per skate was 183 pounds. In 1928 the

[27] William F. Thompson, "The Problem of the Halibut" *1915 Report of the Commissioner of Fisheries* (Victoria, BC: 1916), S133-S136.
[28] Thompson, S136.
[29] Crutchfield and Zellner, 5.
[30] Bell, 149.

amount was 62 pounds per skate.[31] On the basis of this research, the Commission called for more effective measures to rehabilitate the stock.

The regulatory history of the halibut industry to 1960 has been punctuated by several regulatory conventions between the US and Canada. Major treaties or treaty changes were made in 1930, 1937 and 1953. In 1930 (effective 1932) regulatory areas were created, catch limits within those areas were set, gear type was specified, and the licensing of vessels was required for statistical purposes. The original mandate to do scientific research was also retained.[32] In 1937 early season closures were also provided for. Of the various provisions made (see Table 1), the regulation with the most biological and economic impact was catch limits.[33] It was through the power of catch limits that the Commission attempted to achieve the maximum sustainable yield.

Table 1: IPHC Regulations

Table 1. Chronology of IPHC regulations, 1932-1975. X = year introduced, O = year deleted.

Regulation	1932 - 1945	1946 - 1960	1961 - 1975
Area Definition	X		
Closed Season	X		
Catch Limit	X		
Dealer Record	X		
Closed Area	X		O X
Licensing	X		
Log Book	X		
Validation	X		O
Catch Report	X		O
Dory Gear	X		O
Departure Control	X O		
Incidental Catch	X		O
Nets Prohibited	X		
Size Limit	X		
Landing Control	X		
Sealing of Gear			X O
Sport Fishery			X

Source: B.E. Skud.

[31] William F. Thompson, Henry A. Dunlop, and F.Heward Bell, "Biological Statistics of the Pacific Halibut Fishery," *Report of the International Fisheries Commission, No. 6,* (Vancouver, BC: Wrigley Printing Co, 1931), 14-15.
[32] Bernard Einar Skud, "Regulations of the Pacific Halibut Fishery, 1924-1976," *International Pacific Halibut Commission Technical Report No. 15*, (Seattle, Washington: 1977), 7.
[33] Table 1 is taken from Skud, 19.

The quota gave the Commission the means to reduce the harvest to below its expected annual recruitment and thereby return more fish to the population, allowing the parent population to expand. The degree to which the Commission could restrict the harvest was constrained by the fishermen's willingness to forgo income for the sake of the fishery.[34] However, the Commission was greatly aided by the Great Depression, and the general collapse of prices that coincided with the setting of quotas. Landings were already at their lowest level in years. Thus, quotas allowing for significant biological investment in the halibut stock were accepted without resistance.[35]

Since their introduction, the Commission has set quotas according to the eventual achievement and then maintenance of a biological stock that yields the maximum sustainable yield. While such a target was perhaps achievable, whether it was the appropriate target is problematic. In the 1950's economic theorists turned their attention to the fishery. Their premise was that the fishery not only involved biology, but also necessarily involved the exertion of human effort. As such, it seemed reasonable to turn the economists' gaze upon the fishery.

Economic Theory of the Fishery

The ocean fishery is a classic example of a resource that is held in common and the general problem with such resources in a market-oriented society is that "everybody's property is nobody's property."[36] As such, no one in such a society places any economic value on unharvested common resources; "the fish in the sea are valueless to the fisherman, because there is no assurance that they will be there for him tomorrow if they

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[34] See J.E. Wilen and F.R. Homans, "What do regulators do? Dynamic behaviour of resource managers in the North Pacific Halibut Fishery," *Ecological Economics*, (March 1998), v. 24, no. 2-3, 289-298.
[35] Crutchfield and Zellner, 8.

are left behind today."[37] To the fisherman, the only cost of the fish is the cost of going out and getting it. Unharvested fish are an investment that cannot be protected.

Natural resources held in common are thus "free goods for the individual and scarce goods for society."[38] H. Scott Gordon's classic 1954 paper discusses the ocean fishery as a particularly good example of this situation, and the problems that economic forces can cause in this situation. Thus, Gordon explains "overexploitation" in terms of the economic forces that work themselves out in the situation where resources are held in common but exploited individually. To the fishermen, the value of the fish, over and above the costs of getting it, represents a rent that is available to anyone willing to make the effort. This rent is a signal for either more fishermen to enter the industry, or for existing fishermen to commit more resources, or both. But, because no one owner controls access to the resource, these gains will be dissipated and, at the limit, dissipated completely in the form of the cost of the extra effort spent trying to capture them.[39]

Thus, economic equilibrium occurs when total profit equals zero. Only then does effort cease entering the fishery. From society's standpoint, a larger stock of boats and men end up harvesting a fish population that is much smaller than it otherwise could have been under a single owner. Society is clearly worse off, because the higher costs per pound of fish represent the waste of human resources. And the biology of the fishery is worse off, because the stock of fish is smaller than otherwise. Clearly, the ocean fishery was not a good candidate for the emergence of private property rights. [40] Only a private or

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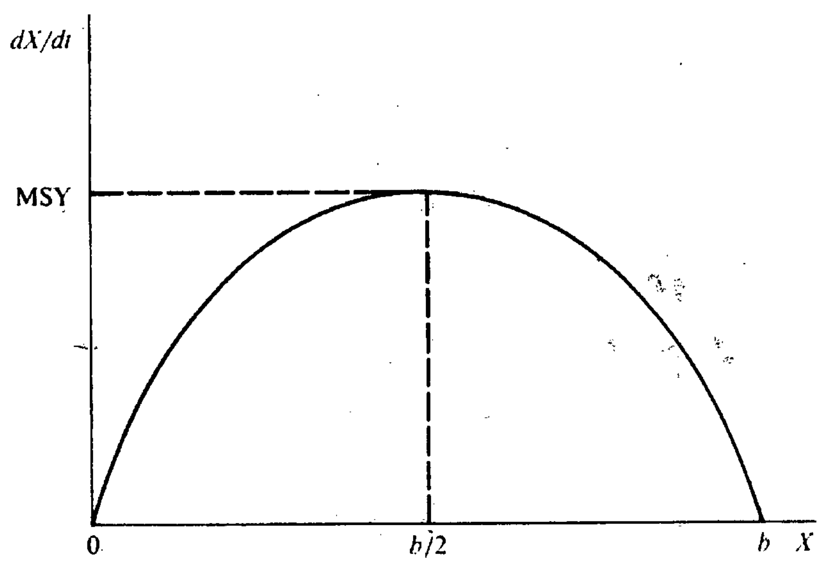
[36] H. Scott Gordon, "The Economic Theory of a Common-Property Resource: The Fishery," *Journal of Political Economy*, v. 62 (1954) 135.
[37] Gordon.
[38] Gordon.
[39] Gordon, 124-144.
[40] As Harold Demsetz notes in his 1967 paper, private property rights only emerge to internalise these valuable externalities when "the gains of internalisation become larger than the cost of

public monopoly can capture for society the value of such resources and prevent their depletion.[41] If it is in society's interests to allocate efficiently both fishing effort and fish, then somehow there must be some form of unitary control over the fish.

Gordon further argued that the ocean fishery is really the interaction of both biological and economic forces, and it is in terms of these two forces that any solution must be expressed. This "bioeconomic" equilibrium is where the natural biology of the fish population equilibrates with human fishing effort. Sustainable harvest from the ocean fishery can be described by a simple quadratic equation. This equation describes the various levels of net recruitment to the biological population according to the size of the various levels of the parent stock.[42] The figure below shows this relationship.[43]

Figure 1: Maximum Sustainable Yields



Source: F.J. Anderson

internalisation."Harold Demsetz, "Toward a Theory of Property Rights," *The American Economic Review*, vol. 57, (1967), 350.

[41] Gordon, 124-144.

[42] Such as the Schaefer logistic which relates the natural growth of a biomass to the animal population, $F(X) = aX - aX^2/b$, where a is the (exponential) growth rate, and b is the maximum biomass. As the biomass approaches its maximum capacity (as X approaches b) growth slows down. The biomass is in a natural equilibrium when X=b. F.J. Anderson, *Natural Resources in Canada,* (Scarborough, Ontario: Nelson Canada, 1991), 217-218.

Recruitment to the population is on the vertical axis and the size of the population is on the horizontal axis. Each point on the curve represents the maximum sustainable yield for a given parent population. There is no new recruitment when the population is either extinct (point 0) or when it has completely filled the environment (point b). Thus, recruitment to the fishery is at its maximum possible at point MSY_{max}. It should be noted that net recruitment to the left of MSY_{max} exactly mirrors net recruitment to the right, except that it occurs with a smaller parent stock (MSY_{max} = b/2). If harvesting, for any given parent population, occurs within the curve, then the parent population will rise. If harvesting occurs outside of the curve, then the parent population will decline. Overexploitation can be thought of in terms of fishing efforts that result in populations that are to the left of MSY_{max}. These populations are nearer to the extinction point, 0, and thus are in greater danger.

Populations are stable when recruitment is on this curve. When harvests are not equal to recruitment then the parent stock changes. Because the fish are held in common, the fishery is in economic equilibrium when total harvesting revenue (TR) of the fishery is equal to total harvesting costs (TC). At this point all economic rents derivable from the common resource are completely dissipated in the form of extra costs.[44] Total harvesting revenue can be obtained from figure 1 by multiplying the landed price of the fish times the recruitment function. Again, total revenue is maximized at point MSY_{max}.

Total harvesting costs are derived from the production function of the fishery. Simply, the size of the harvest is related to the size of the fishing stock and to the amount of fishing effort applied to that stock in the form of boats, men, gear, etc. Thus,

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[43] Figure taken from Anderson, 219.

$$h = h(E,X)$$

where h is the harvest rate, E is the amount of effort, and X is the stock of fish. A simple form of this relationship is

$$h = e \cdot E \cdot X$$

where e is the catchability coefficient. This coefficient relates how productive a unit of effort is on any given stock of fish. If this e is constant, then catch per unit of effort (h/E) simply depends on the density of the fish population, X. Thus, a doubling in the density of fish will double the productivity of the fishing effort.

If we assume that effort can move freely in and out of the fishery at constant prices then the cost of one unit of fishing effort can be aggregated into one variable, w. This variable also includes the opportunity cost of using the inputs in some other employment. Thus total costs can be simply written as

$$TC = w \cdot E$$

In terms of our fish population diagram, the costs will range between zero effort, at which the population is undisturbed, and some high level of effort where the population is driven to extinction.

[44] Economic rents are the payments to factors over and above the payment necessary to induce them to engage in that employment.

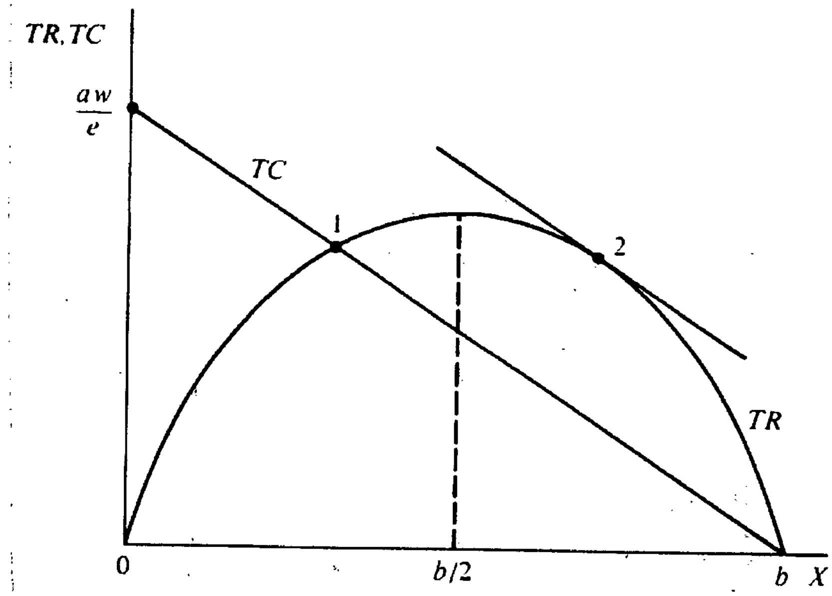

Figure 2: Bioeconomic Equilibrium

Source: F.J. Andersen

Point 1 is where the equilibrium exists in a competitive fishery. Here *TR=TC*. All economic rent is dissipated and there is no more incentive to enter the fishery. To the left of this point, *TR<TC* and fishermen will exit. To the right of this point, *TR>TC* and fishermen will enter. At point 2 is where the difference *TR-TC* is maximum (where the TC curve would be tangent to the TR curve). Here is where the economic rent of the resource is fully captured and profit is at a maximum. It is at this point that a monopoly owner would operate. It should be noted that point 1 is to the left of MSY_{max} and point 2 is to the right. Again, MSY_{max} is possible at parent population b/2, (which is where the curve climbs the highest on the vertical net recruitment axis). It should be noted that there is nothing economically special about the MSY_{max}. Economic equilibrium at this point would be simply coincidental.[45]

The greatest maximum sustainable yield is not necessarily the best economic objective and the application of capital theory tells us why. Stocks of fish are like any capital asset. A given stock of fish yields income in the future in terms of its progeny. If alternative rates of return are high enough, it makes economic sense to "thin" the stock beyond the MSY_{max} and earn interest on the money. Alternatively, it can often make sense to catch fish below the MSY_{max}, and thus lower search costs by "thickening" the fish stock. Thickening the stock makes sense as long as the reduction in search costs offsets the reduction in the catch.[46]

Bioeconomic Dynamics

Subsequent economic theory also incorporates dynamic models to explain the possible transition paths that can occur when moving from one bionomic equilibrium to another. In particular, this theory seeks to understand how extinction paths can be created. Extinction paths can be explained both by the various characteristics some populations could have and by the potentially explosive effects of fixed investment. Robert McKelvey nicely shows how different population parameters can result in different possible extinction paths.[47]

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[45] Anderson, 218-220. Figure is taken from page 220.
[46] Philip A. Neher, *Natural Resource Economics: Conservation and Exploitation*, (Cambridge University Press: 1990), 17-20.
[47] Robert McKelvey, "Fur Seal and Blue Whale: The Bioeconomics of Extinction," *Lecture Notes in Biomathematics: Applications in Control Theory in Ecology* ed. Y. Cohen, (Berlin: Springer-Verlag, 1986), 57-82. Figure 3 is taken from page 63.

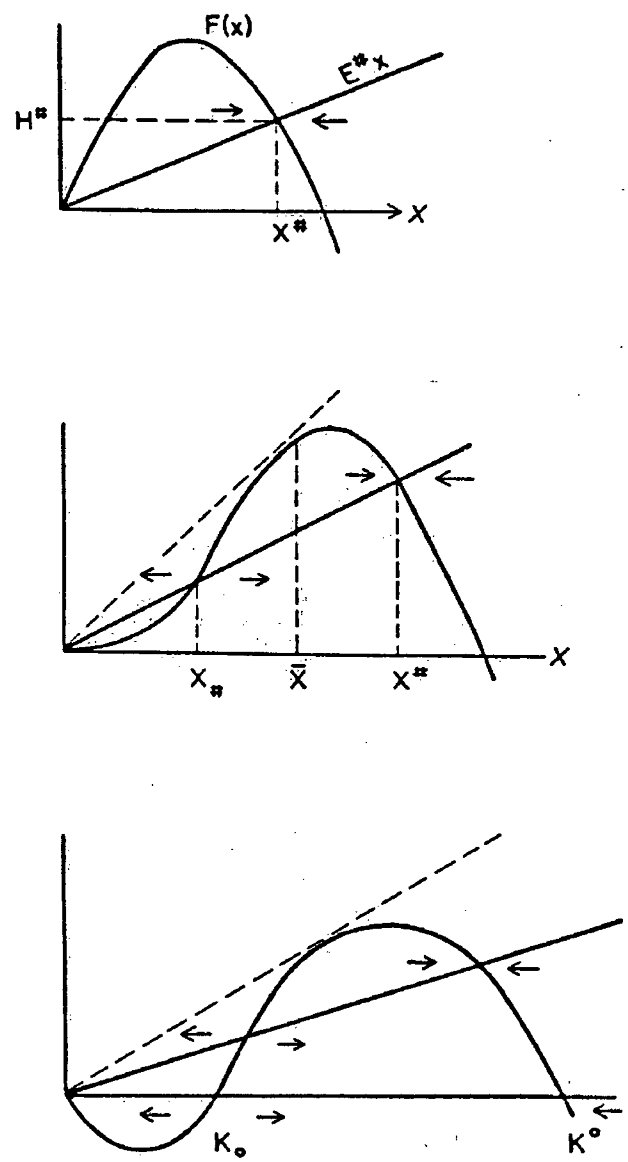

Figure 1. Growth curves *F(x)* : (a) compensatory, (b) depensatory, and (c) over-depensatory. Equilibrium under constant-effort harvest *E* is at intersection of the graph of *F(x)* with the straight line *qxE* . Arrows show non-equilibrium direction of motion.

Figure 3: Stable and Unstable Bioeconomic Equilibria

Source: R. McKelvey

Paterson and Wiley nicely show how different paths (in capital-biostock space) are dependent upon the varying explosiveness of "sunken" capital investment. Note paths A and B result in a positive solution, while path C results in extinction.[48]

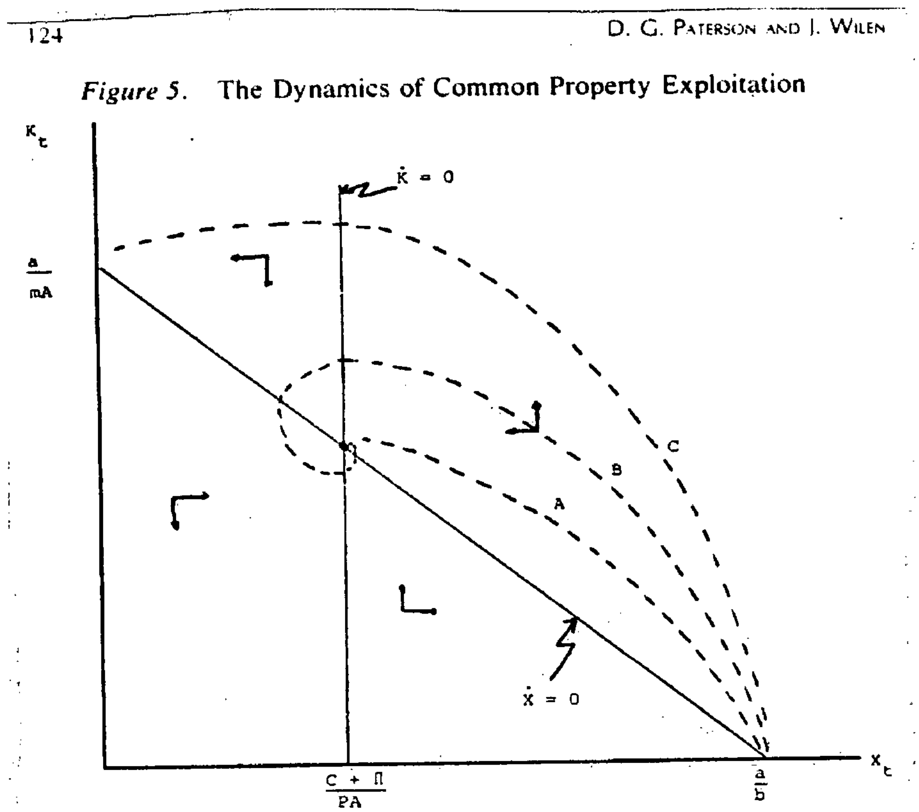

Figure 4: Dynamic Bioeconomic Solution Paths

Philip Neher presents an elegant synthesis of the static and dynamic equilibrium models.[49] The linear cost function is line *a*, the non-linear growth function is *b* (the axis has been changed so the parent population decreases as we move further out). The stable path towards equilibrium is indicated by the arms EE, the model "explodes" when values for *a* and *b* stray to far from the stable path of EE.[50] What these models underline is that

[48] D.G. Paterson and J. Wilen, "The North Pacific Seal Hunt, 1886-1910," *Research in Economic History*, vol. 2, (Greenwich Connecticut: JAI Press, 1977), 124. Figure is taken from 124.
[49] Figure 4 is taken from Neher, 211.
[50] Neher, 209-212.

extinction paths could be started upon in a variety of situations. In general, all these models indicate the more capital invested, the more explosive the outcome.

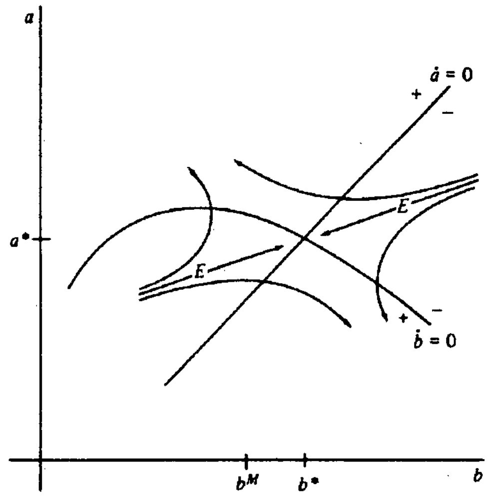

Figure 11.7. The synthesized solution of the same model depicted in Figure 11.4, but (a, b) are both observable variables.

Figure 5: Dynamic and Static Bioeconomic Solutions

Source: P. Neher.

Given the sudden decline in halibut stocks, shortly after the declared achievement of MSY by the Commission, these models indicate that Commission policy may have pushed the fishery into a situation where it was exposed to moving onto an extinction path, if environmental or biological conditions were to change. This is consistent with the account of the sudden decline of the halibut fishery in the 1960's to the 1980's being due to "environmental degradation." But it is a degradation that is intrinsic to biological systems. Consequently, when the system is taxed to its maximum, it is at most risk. The target of maximum sustained yield, combined with the regulatory effects on capital investment in the fishing fleet, appears to have exposed the halibut fishery to precisely this risk.

The Regulated Fishery

The 1930 halibut treaty, which first brought in annual quotas for the fishery, was intended to rehabilitate halibut stocks. The centrepiece of the treaty was an agreement on an annual catch quota for the entire fishery. Four regulatory areas were defined and quotas for each were introduced in 1932. Area 2 corresponds to the BC coast and was where the great majority of BC's fishing effort occurred.

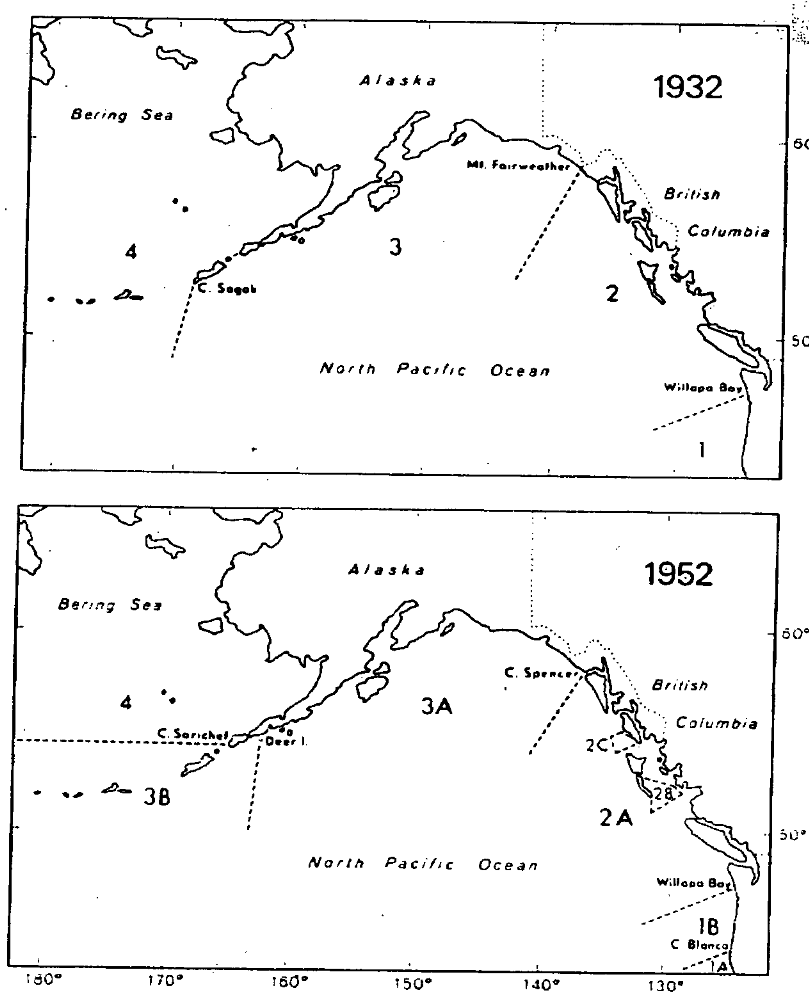

Figure 1. Regulatory areas for the halibut fishery, 1932 and 1952.

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Figure 6: Halibut Fishery Regulatory Areas

Source: IPHC Technical Report No. 15.

Quotas were initially set according to "the approximate level of the catch in the previous years."[51] In fact, as this was the time of the Great Depression, prices were depressed and landings were historically low. This gave regulators both a lower than normal base of landings on which to set their quotas and facilitated fishermen's acceptance of the quota at this historically low level.

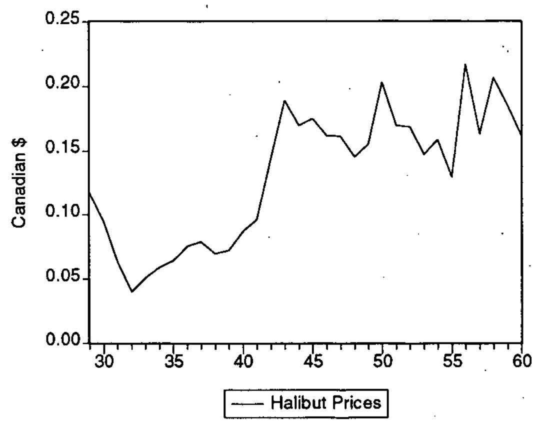


Figure 7

Source: Historical Statistics of Canada

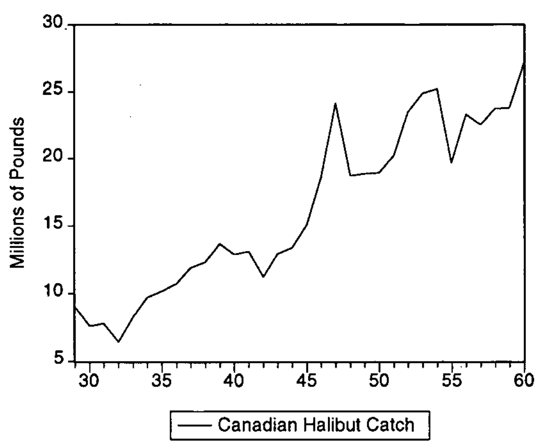


Figure 8

Source: IPHC Technical Report No. 14

[51] Skud, 14.

As catch-per-unit-effort (CPUE) improved for the entire fishery, quotas were periodically reset at higher levels, as the maximum sustainable yield was presumably approached. Whether the quotas were responsible for the subsequent increase in CPUE, or whether natural cycles were at work, was and still is debatable.[52] Nonetheless, CPUE for the entire fishery began to improve immediately and dramatically as stocks apparently thickened.[53]

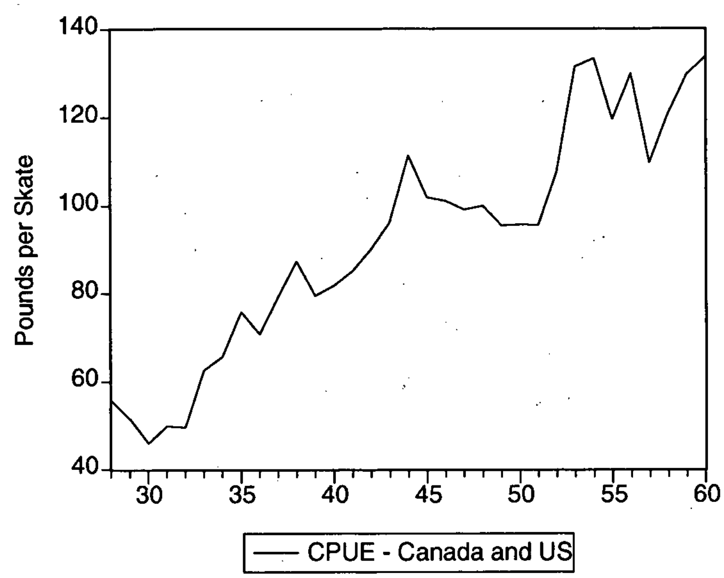


Figure 9: Catch per unit of Effort

Source: IPHC Technical Report No. 14

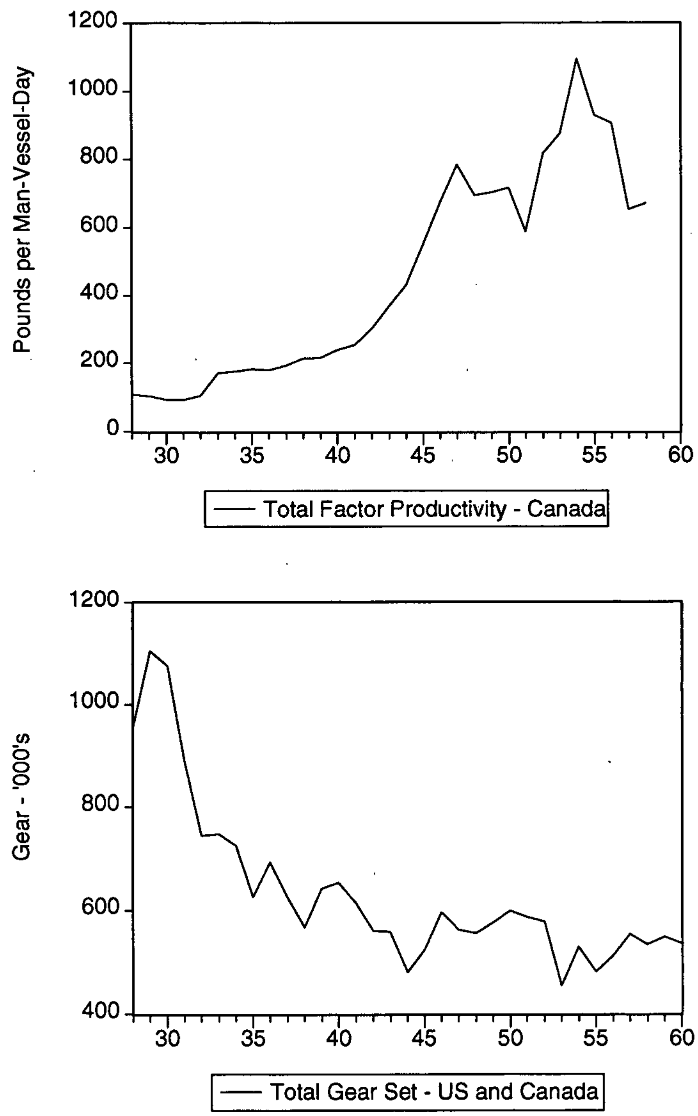
Total factor productivity calculations, in terms of man-vessel-days, also clearly reveal the same improving trend.[54] Every year less and less effort was required to catch a given amount of fish. And as total factor productivity increased, there was a steady

[52] This is the so-called Burkenroad debate. See M.D. Burkenroad, "Fluctuations in Abundance of Pacific Halibut," *Bulletin of the Bingham Oceanographic Collection*, May, 1948.

[53] See appendix A for an annotated bibliography of statistical sources.

[54] A rough index of the amount of halibut caught per man-vessel-month. A simple Cobb-Douglas production function was used, $X = K^{\alpha}L^{\beta}$, where K is vessel-months, L is man-months, α is the share to vessels, and β is the share to men. The assumed factor shares were .25 and .75 respectively. Total factor productivity is calculated as $X/ K^{\alpha}L^{\beta}$. Statistics from Crutchfield (1960) were used for the calculations.

decline in the total number of units of gear (skates) that were set in the water each year to take each the quota. Clearly, the general trend was less fishing power was needed each year to take the catch.



Figures 10 and 11

Sources: IPHC Report No. 17 and
IPHC Technical Report No. 14

Improvements in productivity and a reduction in the amount of gear set are economic improvements, and it is this evidence that Bell and McCaughran refer to, when they conclude that the IPHC's regulations were a success. However, this higher productivity of labour and capital, induced by regulation, and enforced by fiat, also encouraged the entrance of more fishing boats and more fishermen to take what was essentially the same mandated quantity of fish each year, a quantity that changed only gradually and conservatively over this time period.

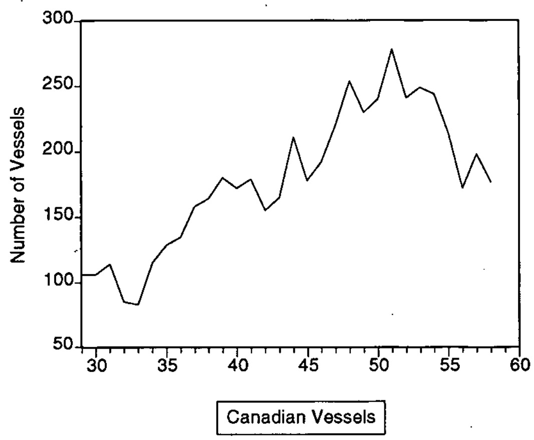
This is because the quota regime devised by the Commission was a *global* quota, meaning restrictions were placed on the industry catch but not on any *individual* fisherman's catch. Individuals were still free to enter the fishery or increase their effort. As the productivity of fishing increased, so too did its profitability. Statistics show consequent dramatic rise in both the number of fishing vessels and fishermen in the halibut fishery. By 1937 the number of regular halibut fishing vessels surpassed its previous high of 1929. By 1951 the fleet was double its 1932 size, while the total catch only increased 20%.

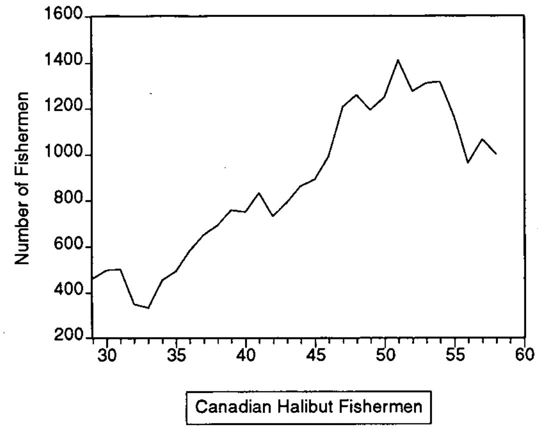
Table 2

Source: Crutchfield and Zellner

Number of Cnd Halibut Vessels

Year	Vessels	Year	Vessels
1928	421	1943	519
1929	474	1944	573
1930	459	1945	591
1931	437	1946	681
1932	407	1947	689
1933	384	1948	796
1934	438	1949	753
1935	432	1950	816
1936	470	1951	820
1937	531	1952	670
1938	509	1953	661
1939	515	1954	654
1940	549	1955	617
1941	576	1956	556
1942	497	1957	659
		1958	574





Figures 12 and 13

Source: Statistics from Crutchfield and Zellner

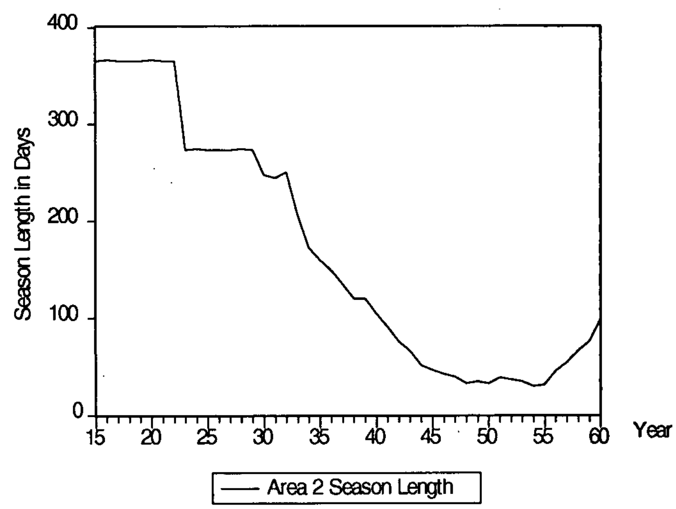
As more vessels and fishermen entered the industry, the increase in fishing power was greater than the increase in the total amount of fish available each year. Consequently, the length of the fishing season rapidly contracted as each year it took less and less time to catch the quota. Figures for the BC coast (Area 2) starkly show that each year it took less and less time to catch that year's quota.

Table 3

Season Length A2-BC Coast

Year	Fishing Days	Year	Fishing Days
1923	273	1942	75
1924	274	1943	66
1925	273	1944	51
1926	273	1945	46
1927	273	1946	42
1928	274	1947	39
1929	273	1948	32
1930	247	1949	34
1931	244	1950	32
1932	250	1951	38
1933	206	1952	36
1934	172	1953	34
1935	159	1954	29
1936	148	1955	31
1937	135	1956	45
1938	120	1957	54
1939	120	1958	66
1940	104	1959	75
1941	91	1960	98

Figure 14



Source: IPHC statistics

As the season length contracted and the off-season expanded, fishing capital was left idle. Continuous efforts at self-regulation were made to counter the shortening of the season through voluntary layovers and maximum catch limits per trip.[55] Fisherman also began to invest in hybrid boats that could participate in several fisheries throughout the year. But the decline in the season length was precipitous and the waste of capital due to the off-season could only have been partly offset. The Commission described the resultant problems for the fishermen in one of their many technical reports: "During the early 1950's, competition among halibut fishermen was so keen that the catch limit was taken in less than 2 months. Fishermen had no rest periods between trips and the processors occasionally had difficulty handling the volume of the catch."[56]

Exactly as economic theory would predict. Clearly the Commission did not anticipate this tendency for the season to contract, as indicated by its hasty revision of the 1930 Convention in 1937, only five years after the quotas had been put in place in 1932.The only revision of substance: the power to close the season early once the quota had been taken. In the 1953 Convention the Commission again tried to deal creatively with the same problem of the intensity of fishing effort by creating multiple start dates to ease pressure on the close-by areas versus the more distant areas.[57]

In 1933 the quota in Area 2, which cover the halibut grounds off the coast of British Columbia, was 46 million pounds and took 205 days to take. By 1954 the quota in the same area was 54.5 million pounds, and took only 29 days to take. In 1933 the number of Canadian halibut fishing vessels was 83. In 1954 there were 244. Expressed in

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[55] Skud, 24-25.
[56] Skud, 25.
[57] Skud, 7, 17.

percentages, from 1933 to 1954 the quota in Area 2 increased about 18.5 %, the length of the season plunged 86%, and the number of vessels rose over 190%.

Inspection of our statistics at a descriptive level seems to confirm the predictions of the economic theory. Increases in, or thickening of, the fish population led to increases in productivity that raised the profitability of halibut fishing. This in turn led to the entry of men and vessels until the fishery was no longer profitable. This greater effort, increasingly productive due to the thickening fish population, took less and less time to catch the Commission's quotas. The costs to society were thus twofold. The rents that otherwise could have accrued to society (in this case, privately) were completely dissipated in the form of excess costs and underemployed capital. And the net income of fishermen did not improve. . A regression analysis will show us how strongly the relationship was between the Commission's policy and the economic response of the fishery, and further help us decide whether the Commission's policies were a regulatory success or not.

Regression Analysis

There are two broad categories of inputs that are used in the fishery: fishing boats and fishermen. Technological change in the 1920's had altered drastically how the halibut fishery put these inputs together. By 1930 these technical changes had reduced the necessary manpower per vessel by 30 percent.[58] But, by the 1930's all vessels were using the same longlining techniques and fishing gear had become standardised. Little significant technological change occurred after this period to at least the end of the 1950's. The type of gear and vessels and the relationship of this capital to fishermen saw

[58] The International Pacific Halibut Commission, *The Pacific Halibut: Biology, Fishery, and Management, Technical Report No. 22* (Seattle, Washington: 1987), 17.

little change. We thus expect that the relationship between vessels and men to be quite stable.[59]

Of particular interest to us is the entry and exit of fishing vessels. Vessels represent a particularly "sticky" form of capital in the sense that they cannot be easily moved out of fishing and into another occupation. The effects of such fixed capital investment can be quite explosive, as indicated in the discussion of dynamic models above. This long-term commitment of society's resources, and the negative effects it can have on the fish population, makes the relationship of regulation to vessel entry and exit particularly important.

Recall that the intended effect of regulation was to keep the harvest below recruitment. In terms of our biological model, the Commission wants

$$F(X) - h > 0,$$

$$\text{where } F(X) = aX - aX^2/b.$$

$F(X)$ gives the annual recruitment to a given population of fish, and h is the annual harvest. The intention of the Commission was to invest a proportion of the annual recruitment back into the stock. In the next period, the larger fish stock would then yield a greater recruitment. The goal was to reinvest in stocks until the greatest maximum sustained yield was reached. Recalling the figure above, the Commission is trying to move the parent population to the point at b/2 where recruitment is at MSY.

This forced investment in the halibut stock raised productivity by increasing the population density. The resultant thickening of the stock thus lowered fishermen's search costs. The greater profitability of fishing should then lead to the entry of extra effort until these economic rents are dissipated. Recall total costs,

[59] The ratio of men to vessels over the relevant time period is about 5.

$$TC = w \cdot h/e \cdot X$$

where w is the cost of a fishing unit, h is the harvest, e is the catchability coefficient, and X is the fish stock. Productivity is here defined as h/E, where E is total effort. Recall that

$$h = e \cdot E \cdot X, \text{ or}$$

$$h/E = e \cdot X$$

Thus we expect our calculated total factor productivity to be directly related to $e \cdot X$ and inversely related to costs. We therefore expect total factor productivity (TFP) to be positively related to vessel entry in our model.[60]

Gross National Product provides a rough proxy of the opportunity cost of being in the fishery, or staying out of it. When GNP is growing, there are opportunities for employment elsewhere, and we would expect fishermen to move out of the fishery. Total revenue is,

$$TR = p \cdot h$$

where p is the price of halibut, and h is the harvest. We expect that entry into the fishery will be positively related to halibut pricing. The stronger the relation of halibut prices is to vessel entries and exits, the weaker the effect of regulation. The Commission also controlled the total amount that could be taken from the fishery. Over the period of study, quotas were increased 20%. We expect the effect of increases in the annual catch to be positive on vessel entry. Lastly, we expect capital is sticky, and thus if a vessel was in the fishery one year, we expect it tends to remain the following year.

We regress the entry of Canadian vessels, ***V***, against the number of vessels in the fishery the year before, ***V(-1)***, versus the previous year's total factor productivity, ***TP(-1),***

[60] We assume e is constant throughout. This is not an unwarranted assumption, as the technology of halibut fishing was little changed through this period.

the Canadian landed halibut prices at that time, ***P(-1)***, the amount of fish Canadian fishermen landed that year, ***Q(-1)***, and the previous year's Canadian GNP, ***Y(-1)***. We take logs on both sides to smooth out the non-linearity of each series. The model is thus,

$$Log\ V = C + \beta_1 Log\ V_{(-1)} + \beta_2 Log\ TP_{(-1)} + \beta_3 Log\ P_{(-1)} - \beta_4 Log\ Y_{(-1)} + \beta_5 Log\ Q_{(-1)} + \varepsilon_1$$

The null hypothesis is that entry and exit of vessels were unaffected by any of our four variables,

$$\textbf{Ho: } \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0.$$

The results of our tests are:

Table 4: First Regression Results

Dependent Variable: Log V
Method: Least Squares
Date: 07/25/01 Time: 14:58
Sample(adjusted): 1929 1958
Included observations: 30 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Log V (-1)	0.492258	0.115617	4.257650	0.0003
Log TP (-1)	0.287572	0.062978	4.566247	0.0001
Log P (-1)	0.233492	0.074995	3.113438	0.0047
Log Y (-1)	-0.311594	0.067412	-4.622203	0.0001
Log Q (-1)	0.131303	0.248542	0.528294	0.6021
C	3.872667	0.808891	4.787628	0.0001

R-squared	0.930202	Mean dependent var	5.134000
Adjusted R-squared	0.915660	S.D. dependent var	0.328217
S.E. of regression	0.095318	Akaike info criterion	-1.686330
Sum squared resid	0.218055	Schwarz criterion	-1.406090
Log likelihood	31.29495	F-statistic	63.96962
Durbin-Watson stat	1.994319	Prob(F-statistic)	0.000000

Surprisingly, *Q*, the quantity of fish landed in the previous year, must be rejected as an explanatory variable in this model, falling well outside the 5% confidence interval. Instead, it seems our other variables (or ones not specified) explain the observed changes in Canadian halibut vessels over time. We accordingly accept the null hypothesis, and respecify the model, dropping Canadian catch statistics from our list of explanatory variables. Our new model is:

$$Log\ V = C + \beta_1 Log\ V_{(-1)} + \beta_2 Log\ TP_{(-1)} + \beta_3 Log\ P_{(-1)} - \beta_4 Log\ Y_{(-1)} + \varepsilon_1$$

The null hypothesis again is that entry and exit of vessels were unaffected by any of our four variables,

$$\textbf{Ho: } \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0.$$

The results of our tests are:

Table 5: Second Regression Results

Dependent Variable: Log V
Method: Least Squares
Date: 07/29/01 Time: 13:06
Sample(adjusted): 1929 1958
Included observations: 30 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Log V (-1)	0.506479	0.110807	4.570834	0.0001
Log TP (-1)	0.294102	0.060856	4.832751	0.0001
Log P (-1)	0.226801	0.072844	3.113510	0.0046
Log Y (-1)	-0.298296	0.061629	-4.840208	0.0001
C	4.056509	0.719604	5.637139	0.0000

R-squared	0.929390	Mean dependent var	5.134000
Adjusted R-squared	0.918092	S.D. dependent var	0.328217
S.E. of regression	0.093934	Akaike info criterion	-1.741435
Sum squared resid	0.220590	Schwarz criterion	-1.507902
Log likelihood	31.12152	F-statistic	82.26444
Durbin-Watson stat	1.972413	Prob(F-statistic)	0.000000

We now have a very good model for the entry of fishing vessels into the halibut fishery. All the signs are as expected, and our chosen variables explain over 90% of the observed variation in Canadian halibut vessel well within accepted confidence levels. We have the expected signs for prices and GNP, with vessels entering the fishery when prices rise, and leaving when GNP rises, confirming our expectation that when alternative economic activity increases, fishing power leaves the fishery. Total factor productivity is clearly a significant element in the entry of fishing vessels into the fishery, inducing a

29% change in the fleet. The largest explanatory variable in our model is the previous year's supply of fishing vessels, accounting for 50% of the following year's vessels. This result underlines the stickiness of fishing capital and its vulnerability to explosive changes in its bioeconomic equilibrium.

Conclusions

In terms of the economics of the fishery, what the Commission ultimately affected was the level of total costs expended. By raising productivity the Commission induced more fishing effort to enter the fishery and catch essentially the same amount of fish. Before the Commission regulated the Pacific halibut fishery all the economic rents of the fishery were dissipated, and after regulation economic rents were still being dissipated. The Commission's use of a global quota, a type of quota that still allows for competitive rent seeking, exacerbated the tragedy of the commons. Unfortunately, there was no economic theory of the fishery in the 1920's to guide the Commission's policies.

In terms of biology, the Commission's actions appear to have greatly improved halibut stocks shortly after the imposition of quotas. However, the induced growth of the halibut fleet, and consequent rapid exhaustion of the allowable quota, increasingly exposed the fishery to the danger of moving on to an extinction path. As the Commission came nearer to achieving the maximum sustained yield, and the time it took to catch this maximum fell, it seems likely underlying changes in environmental and biological variables, which were beyond the control of the regulators, pushed the fishery into another crisis, as predicted by the dynamic models we explored earlier.

Our attempt to model the participation of fishermen in the halibut fishery yielded a most intriguing result. The lack of significance of the total quantity of fish landed by the fishery in our entry-exit model indicates Canadian fishing boat owners were not consistently sensitive to this statistic. Instead, it seems Canadian fishermen were consistently sensitive to the thickening of the fish stock, as revealed by total factor productivity, than they were to the total amount of fish available to catch each year. Given the relatively slow and conservative changes in the quotas, versus the continuous and dramatic changes in productivity, it is perhaps not surprising that the decision to enter the halibut fishery was based on steadily improving chances of beating your neighbour to a season's worth of fish by getting your boat in the water early, and then keeping it there.

Our entry and exit regression clearly supports the hypothesis that a large amount of the growth in the Pacific halibut fishing fleet was caused by the actions of the Commission, who by restricting the catch and thereby causing productivity to rise induced more men and capital into the fishery. The result was a much higher stock of fishing effort operating over fewer and fewer fishing days. From the standpoint of society, the success or failure of conservation efforts must be judged in terms of both its biological and economic dimensions. To ignore the economics of the fishery is to ignore the actions of the human actors. But it is these actions that allocate and consume society's scarce resources. And it is presumably the welfare of these human actors that we should first and foremost consider. From this standpoint, contrary to the assertions of Bell and McCaughran, the Commission's efforts must be judged a failure, because of the waste of society's resources, and the undoubted human hardship.

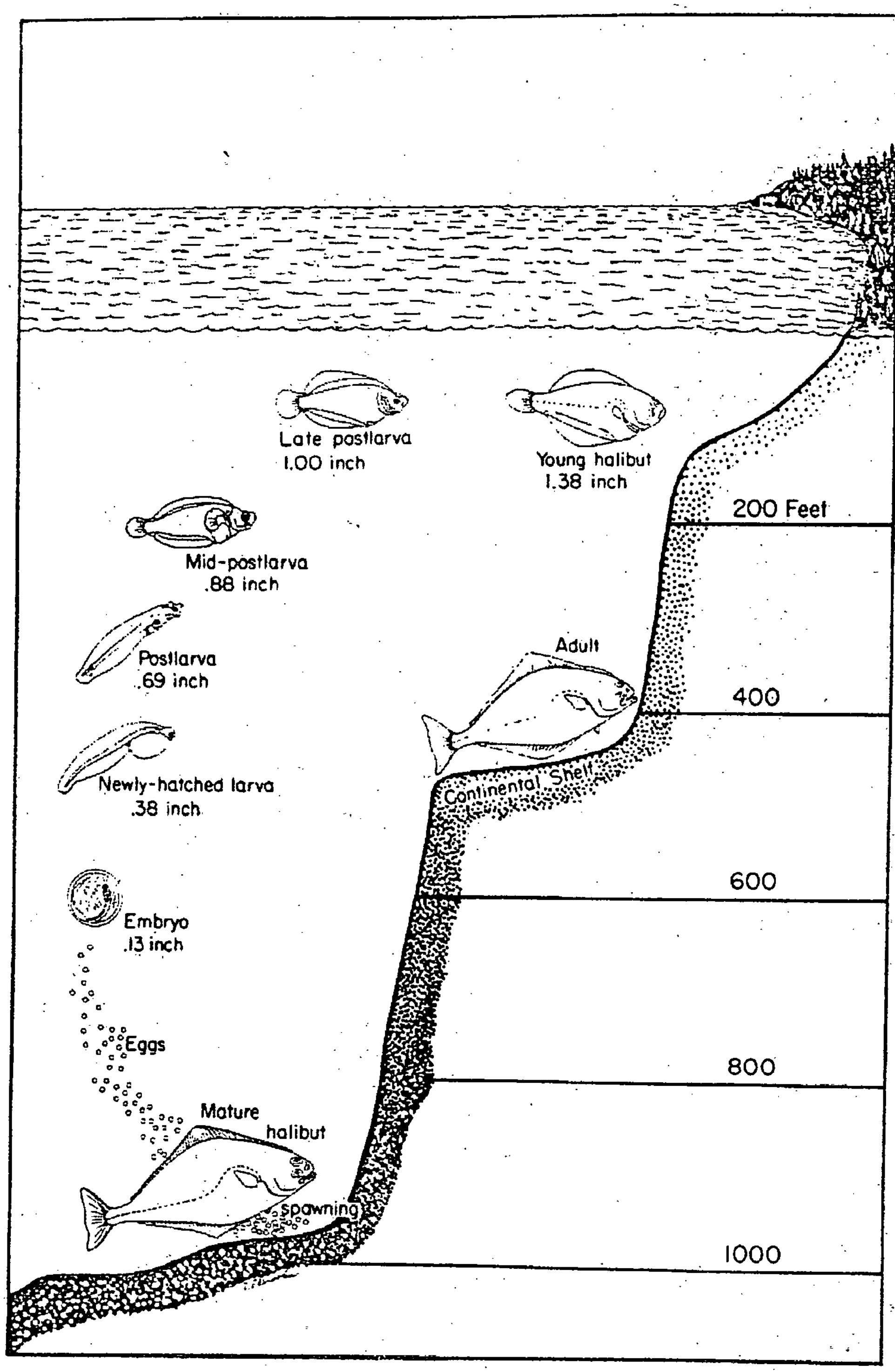

Figure 4. Life cycle of Pacific halibut.

Figure 15: Pacific Halibut Life Cycle

Source: IPHC Report No. 5

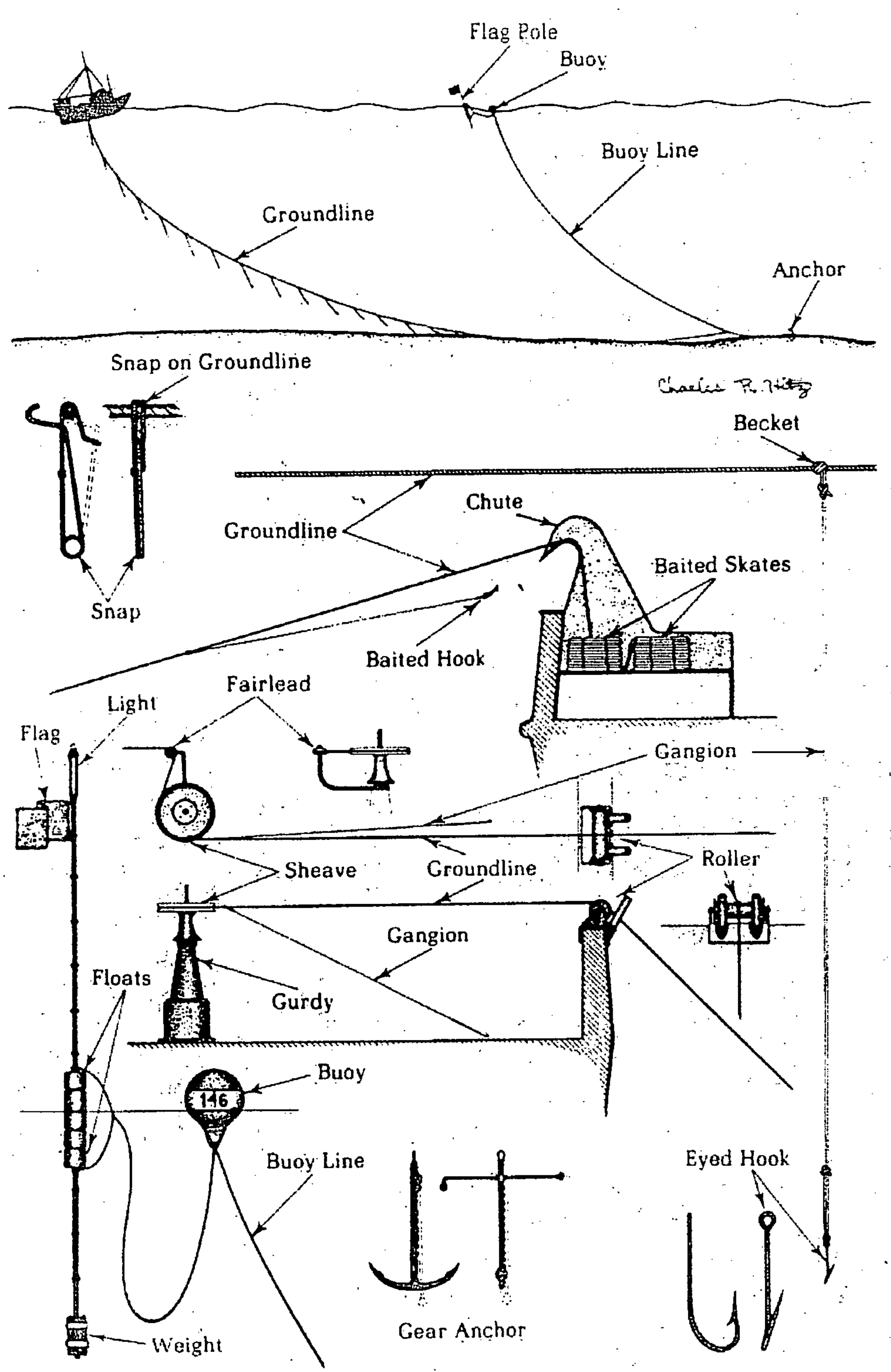

Figure 13. Halibut fishing gear and deck equipment. (Drawings by Charles R. Hitz)

Figure 16: Halibut Fishing Gear

Source: IPHC Report No. 5

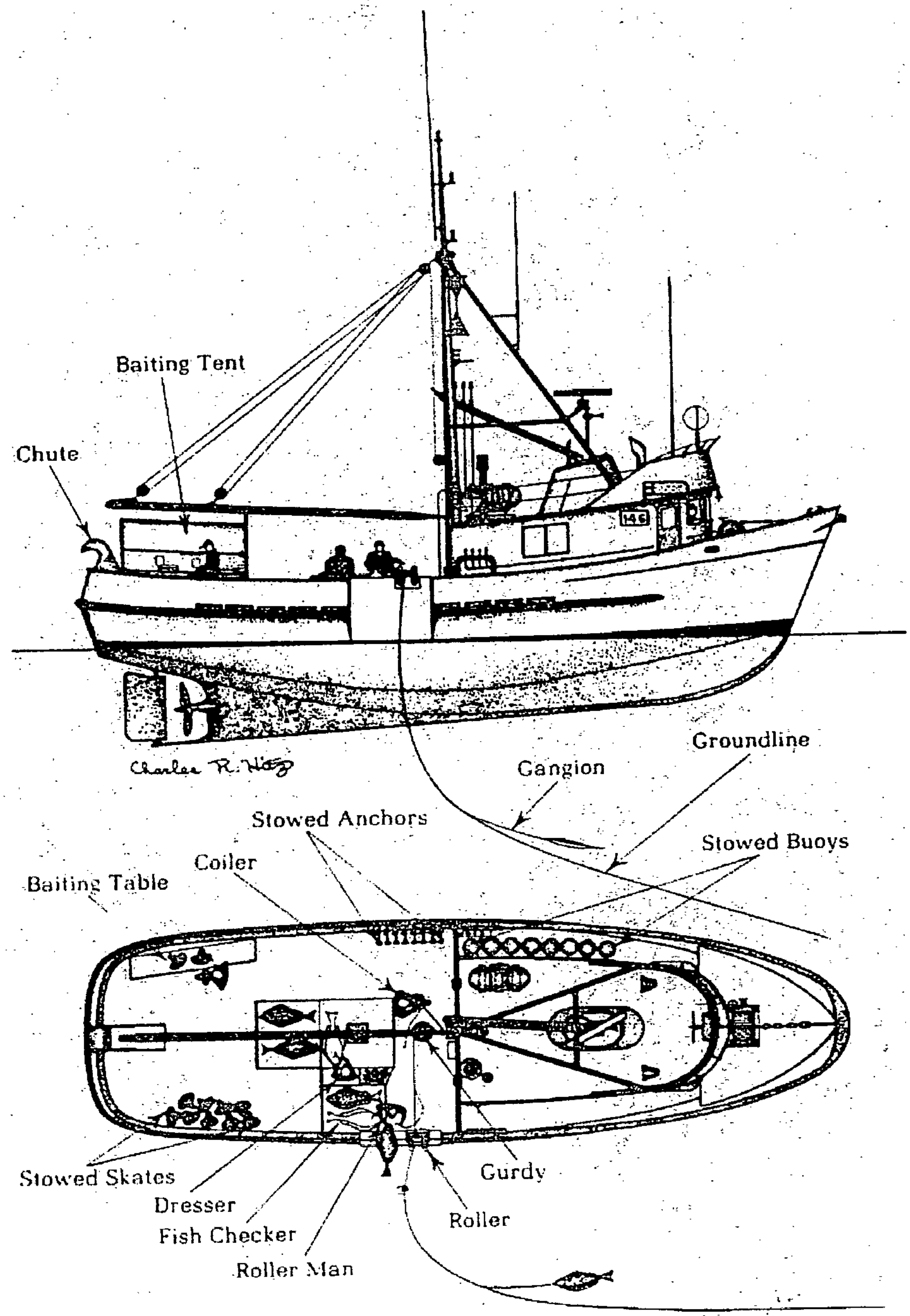

Figure 12. Deck layout and fishing arrangement. (Drawings by Charles R. Hitz)

Figure 17: Halibut Fishing Boat

Source: IPHC Report No. 5

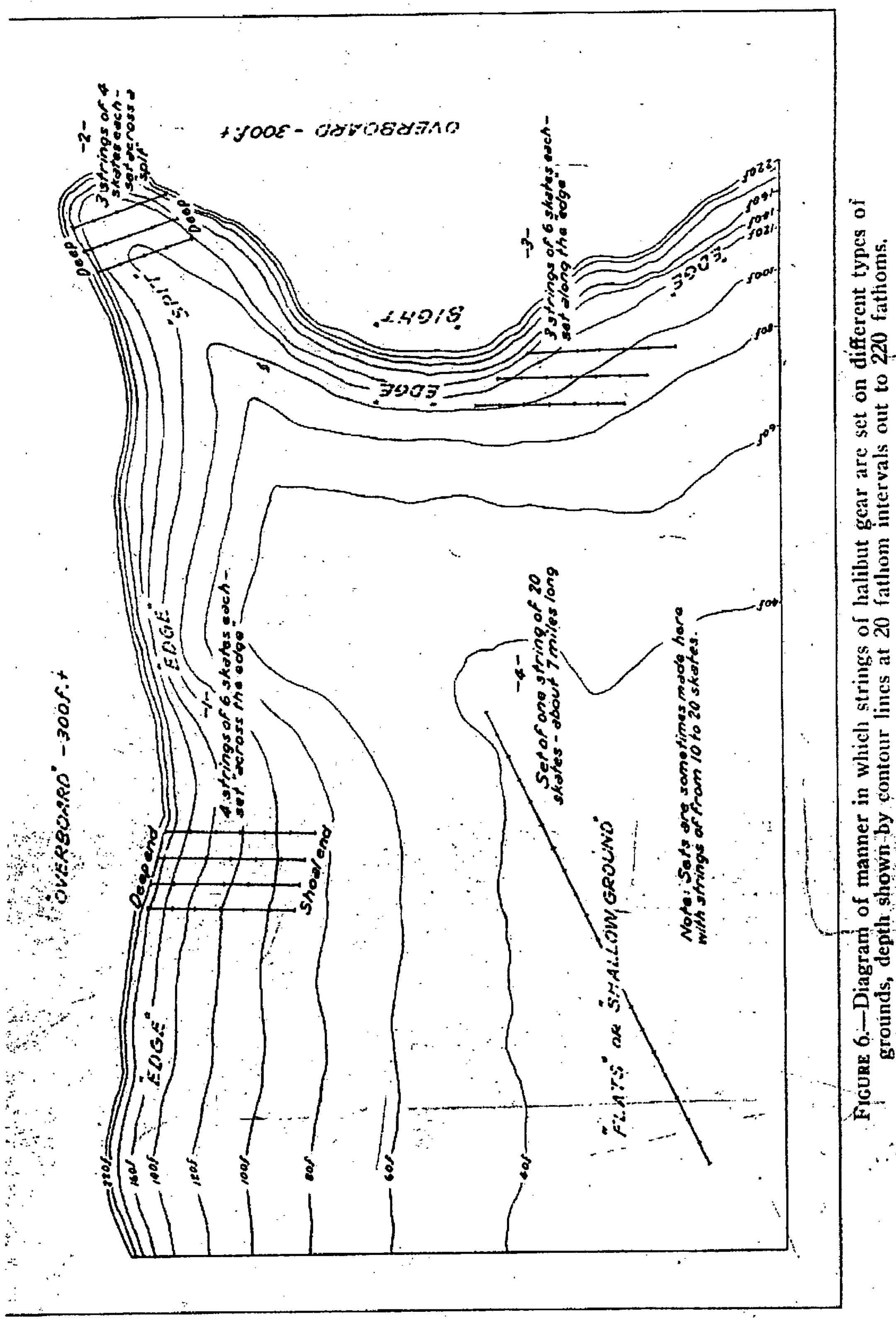

Figure 18: Halibut Fishing Methods (Source: IPHC Report No. 5)

Appendix
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Landed halibut prices and GNP for Canada. Halibut prices go back to 1915.

Bell, F. Heward, Henry A. Dunlop and Norman L. Freeman. "Pacific Coast Halibut Landings, 1888 to 1950, and Catch According to Area of Origin." *Report of the International Fisheries Commission No. 17*. Seattle, Washington: 1952.

Total catch, effort in terms of gear set, and catch per unit of effort are given for the US and Canada, 1888-1950. Continuous data is available only from 1888 to 1950 for the total catch along the BC. US figures are not split out until 1915, and the Canadian catch data is missing from 1898 to 1914. Pacific coast totals are discontinuous until 1911. See table 1, page 10 in their report.

Chapman, Douglas G., Richard J. Myhre and G. Morris Southward. "Utilization of Pacific Halibut Stocks: Estimation of Maximum Sustainable Yield, 1960." *Report of the International Pacific Halibut Commission, No. 31*. Seattle, Washington: 1962.

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Crutchfield, James and Arnold Zellner. "Economic Aspects of the Pacific Halibut Fishery," *Fishery Industrial Research* vol. 1, no. 1 (April, 1962). Washington, DC: United States Government Printing Office, 1963.

Size of the regular halibut fleet and number of fisherman, by country of origin (US or Canada). Their source for data is the *Pacific Fisherman Yearbook.*

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Total catch, gear set, and CPUE for Canada and the US, 1929-1960. The report breaks the numbers down into a number of regulatory sub-areas, as well.

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Both the Halibut Commission and the Canadian Fisheries Department have other interesting halibut fishery statistics, which were not used directly in the writing of this paper. Number of vessels and men operating in each regulatory area are available from IPHC reports. The Fisheries department's data goes back to 1915. Its call number is SH 37.C2 A12.

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