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CANADA AND THE UNITED STATES OF AMERICA

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A Reassessment of Effort in the Halibut Fishery

by

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PREFACE

The International Pacific Halibut Commission was established in 1923 by the Convention between Canada and the United States for the preservation of the halibut fishery of the North Pacific. The Convention was the first international agreement providing for joint management of a marine fishery. The Conventions of 1930, 1937, and 1953 extended the Commission's authority and specified that the halibut stocks be developed and maintained at levels consistent with the maximum sustained yield.

Three Commissioners are appointed by the Governor General of Canada and three by the President of the United States. The Commissioners appoint the Director of Investigations who supervises the scientific and administrative staff. The scientific staff collects and analyzes statistical and biological data to manage the halibut fishery. The headquarters and laboratory are located at the University of Washington in Seattle, Washington. Each country provides one-half of the Commission's annual appropriation.

The Commissioners meet annually to review the regulatory proposals made by the scientific staff and consider advice from the Conference Board that represents vessel owners and fishermen. The regulatory measures are submitted to the two governments for adoption, and the fishermen of both nations are required to observe these regulations.

CONTENTS

ABSTRACT

In the early years of managing the halibut resource, a standard length of groundline was used as the basic unit of effort. In 1943 a new measure of effort was introduced – the 120-hook "standard skate" – which assumed that effort was proportional to the number of hooks and that catch per hook did not change with hook-spacing. Recent test-fishing and a re-examination of past log data show that catch per hook increases as the interval between hooks increases. When most of the fleet used hook-spacing of 13 feet, the estimates of catch per unit effort (CPUE) based on the "standard skate" were representative of stock abundance. As fishermen changed their gear to wider hook-spacing, the abundance of halibut was over-estimated by the standard CPUE. The new measure of effort must account for the differences in the catch per hook by gear type and, if changes in hook-spacing continue, must be adjusted accordingly.

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INTRODUCTION

The traditional measure of effort in the Pacific halibut fishery has been a skate of setline gear. The groundline in a skate of gear is usually 250 to 300 fathoms long. Short lines called gangions are attached to the groundline at regular intervals and each gangion carries a hook. The distance between gangions determines the interval between hooks and each skate is rigged for a uniform hook-spacing. Until the 1920s fishermen consistently spaced their hooks at 9-foot intervals. By 1930 the most popular rig was 13-foot gear and by the late 1950s most of the gear was rigged at 18-foot intervals. More recently, 21-, 24-, and 26-foot gear have been introduced in the fishery.

Thompson, Dunlop and Bell (1931) studied the relative efficiency of the 9- and 13-foot gear. When corrections were made for a "standard" length of groundline (300 fathoms), the average catch of both rigs was nearly the same and the authors concluded that the length of groundline, alone, could be used as the basic unit of effort. Though 9-foot gear had more hooks per skate than 13-foot gear, adjustments for the number of hooks or the hook-spacing were not considered necessary. The study was conducted on particular fishing grounds in the Gulf of Alaska and the results were applied to all areas in the fishery.

When fishermen began using 18-foot gear, Bell (unpublished) found that the catch per skate of this gear was less than that of the 13-foot rig of the same length. He attributed the difference in catch to the difference in hook count and concluded that *effort was proportional to the number of hooks.* Bell's data were from Southeastern Alaska. The basic unit of effort was redefined and 13-foot gear with 120 hooks was adopted as the "standard skate" for all areas. Theoretically, a 6-line or 300 fathom (1800 feet) skate of 13-foot gear would have 138 hooks (1800 divided by 13), but, in practice, the number was less and varied considerably because of different rigging techniques. The modal number was usually 120 hooks and this was selected as the standard skate. Since 1943, all rigs, regardless of hook-spacing or length of groundline, were adusted to this standard; for example, 13-foot gear with 120 hooks would be credited as 1.00 skate, 18-foot gear with 80 hooks as 0.67 skate, 21-foot gear with 70 hooks as 0.58 skate, and 24-foot gear with 60 hooks as 0.50 skate. Other minor adjustments were also made between classes of vessels, area fished, and fibers used in the groundline (Bell, personal communication).

Recent changes in the spacing of hooks on the longline gear prompted a re-examination of effort data and the results showed that the method of measuring CPUE must be revised. These findings and their implications are summarized in this paper. Additional studies are planned to review other aspects of CPUE in the halibut fishery.

RECENT GEAR CHANGES

Changes in the hook-spacing on longline gear since 1950 have been dramatic (Figure 1). The 13-foot gear has all but disappeared in Area 3A (Cape Spencer to Shumagin Islands) and only 20% of the fleet uses this gear in Area 2 (Southeastern Alaska and British Columbia). The 18-foot gear was dominant in both areas by 1960 and continues so in Area 2. In Area 3A, the fleet has rapidly changed to 21-foot gear; from 10% in 1968 to 70% in 1971; whereas, in Area 2 only 15% of the gear is now rigged at 21-foot intervals. A few fishermen also have introduced 24- and 26-foot gear. The vessels usually did not change their gear in a single season, rather vessels would fish a mixture of rigs — 13- and 18-, 18- and 21-foot, etc. — until the old gear was replaced with wider-spaced rigs. During the early 1960s, over 90% of the fleet was fishing one rig; by 1971, 30% of the fleet had mixed rigs. The analyses of log records in this report have been restricted to those vessels using a single rig.

The International Pacific Halibut Commission continued using the 120-hook "standard skate" during this period of gear change, and the wider-spaced gear was equated to this standard on the basis of hook number. It is important to note that the change to wider-spaced gear occurred, for the most part, during a period (1961-1971) of declining stock abundance.

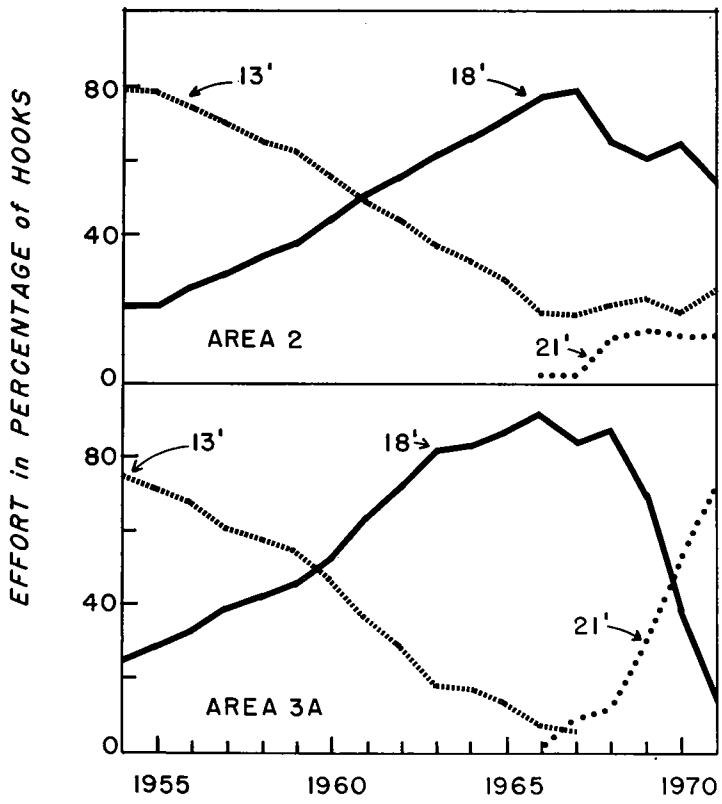

Figure 1. Changes in the percentage of effort by gear type (hook-spacing), 1954-1971.

CATCH PER UNIT EFFORT (CPUE)

In the late 1960s fishermen voiced the opinion that the CPUE based on the "standard skate" no longer reflected the catch rates on the fishing grounds and in 1971 the Commission decided to re-examine the calculation of CPUE. A longline vessel was chartered for test-fishing and the log records of the fleet from 1954 to 1971 were reviewed.

Hook-Spacing Experiment

The chartered vessel, *Chelsea*, made three trips near Kodiak Island (Area 3A) in July and August, 1971. The vessel carried ten skates each of 12-, 18-, 21-, and 24-foot gear all of the same length (250 fathoms). Fishing was conducted as a regular commercial operation, except that the rigs were set on a rotating schedule, i.e. 12-, 18-, 21-, and 24-foot gear on the first day, 18-, 21-, 24-, and 12-foot gear on the next day and so forth. All skates were baited uniformly with herring and cod. Approximately 100,000 pounds of halibut were caught in the 32-day period and the average catch per skate and catch per hook were calculated for each rig (Table 1). The catch per skate decreased as the hook-spacing increased; however, the decrease was not proportional to the number of hooks as previously assumed in the standardization of fishing effort. *The catch per hook increased with hook-spacing, contrary to the assumption that catch per hook was the same regardless of the space between hooks.*

Table 1. Hook-spacing experiment

	Gear			Catch (in pounds)			Catch (in number of fish)		
	Hook-spacing in feet	Average No. of hooks per skate	No. of skates fished	Total	Per skate	Per hook	Total	Per Skate	Per hook
Area 3	12	121.1	385	27,942	73	0.60	749	1.95	.016
	18	81.9	382	26,492	69	0.85	664	1.74	.021
	21	72.1	372	23,505	63	0.88	577	1.55	.022
	24	60.8	387	23,262	60	0.99	551	1.42	.023
Area 2	12	110.2	150	23,799	159	1.44	2,067	13.78	.125
	18	88.9	80	11,601	145	1.63	1,035	12.94	.146

A fishing captain who conducted similar tests in 1965 made his data available to me and these data also showed that catch per hook increases with spacing for 18-, 21-, 33-, and 42-foot gear. Data also was collected by a Commission observer aboard a vessel in Area 2. Only 12- and 18-foot gear was used on this trip. The catch per hook of the 18-foot gear was 1.63 pounds whereas the 12-foot gear was only 1.44 pounds.

The results from the Area 3A charter also indicated that the mean weight of halibut increased as the hook-spacing increased. Fish captured on 12-foot gear averaged 38 pounds; on 18- and 21-foot gear, 40 pounds; and on 24-foot gear, 43 pounds. Additional data are needed to confirm and evaluate this finding, for the suggestion that wide-spaced gear is selective for larger fish would be of particular importance to estimates of CPUE.

Examination of Data from Log Records

Each year the captains of halibut setline vessels are interviewed and their fishing logs are copied. The information collected includes hook-spacing and the number of hooks per skate. The analysis of CPUE was concentrated on the log records from 1954 to 1971 which were available on IBM cards.

The data from Area 3A (Cape Spencer to Shumagin Islands) are presented in Table 2 and show the consistency of catch per hook increasing with hook-spacing. In years when particular rigs were not fished extensively, the precise values of the data may be questionable, but the general magnitude was considered adequate for this comparison. For example, 13-foot gear was used by only a few vessels in 1968-1970 and the low catch per hook is not considered comparable to the other years. The same limitation applies to the wider-spaced gear in its first years of introduction.

Table 2. Catch per hook by different rigs in Area 3A

	Hook-spacing in feet				
	13	18	21	24	26
Year	Catch in pounds per hook				
1954	1.06	1.27	—	—	—
1955	0.94	1.20	—	—	—
1956	1.02	1.29	—	—	—
1957	1.01	1.20	—	1.78*	—
1958	1.16	1.46	—	2.03*	—
1959	1.31	1.69	—	—	—
1960	1.41	1.72	—	—	—
1961	1.38	1.67	—	—	—
1962	1.23	1.45	—	—	—
1963	1.16	1.28	—	—	—
1964	1.14	1.24	—	—	—
1965	1.01	1.13	—	1.98*	—
1966	1.12	1.17	1.20*	—	—
1967	1.17	1.17	1.20*	1.49*	—
1968	0.69*	1.15	1.19*	—	1.63*
1969	0.63*	1.07	1.20*	—	1.28*
1970	0.70*	0.99	1.21	1.51*	1.46*
1971	—	0.89	1.10	1.24*	1.58*

* These data are based on limited amounts of effort and though useful for this comparison are not considered precise.

During this 18-year period in Area 3A, the average catch per hook was 1.07 pounds for 13-foot gear and 1.28 pounds for 18-foot gear. During the last five years when most of the rigs were being fished, the average catch per hook was 0.80 for 13-foot gear; 1.05 for 18-foot gear; 1.18 for 21-foot gear; 1.41 for 24-foot gear and 1.49 for 26-foot gear. These data have been compared with the results from the test-fishing which was done in the same regulatory area (Figure 2). The slopes of the lines are similar and both the experimental fishing and the log records indicate that catch per hook increases with hook-spacing.

The data in Table 2 also indicate that the difference in catch rates between rigs is not constant. The ratio of catch per hook for 18- and 13-foot gear generally declines from 1959 to 1967. Apparently, this change is related to the declining abundance of halibut during this period, but the individual capabilities of fishermen who have retained the 13-foot gear may also contribute to this change.

The log records from Area 2 (Southeastern Alaska and British Columbia) also indicated that catch per hook increased with hook-spacing, but the difference between rigs was less pronounced than in Area 3A. There are several plausible reasons for the difference: the fish in Area 2 are smaller and more abundant and fishing often is conducted on small grounds, "spots", inhabited by dense concentrations of halibut. A fishing experiment is planned in 1972 to obtain more information on the relationship of catch and hook-spacing in this area.

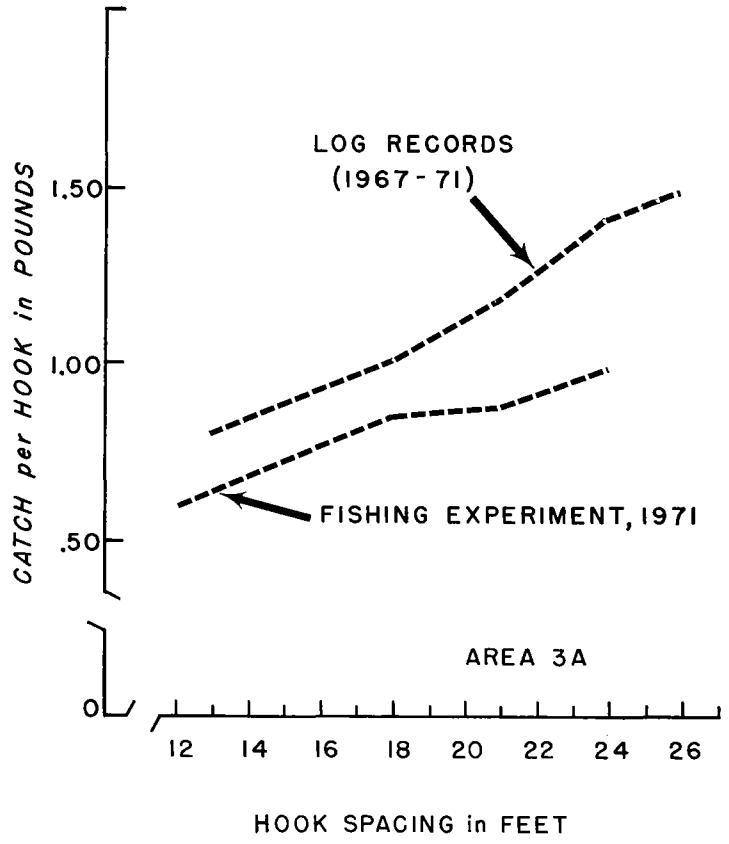

Figure 2. Comparison of catch per hook by rig from log records and test-fishing.

SIGNIFICANCE OF CATCH PER HOOK STUDY

A suitable measure of effort requires that each additional unit of gear should increase the instantaneous rate of fishing by the same amount (Ricker, 1958). With the 120-hook "standard skate", it was assumed that every hook – regardless of hook-spacing – met this criterion. The recent study shows that the instantaneous rate of fishing is dependent on the hook-interval and invalidates the adjustment that was made to calculate the old standard.

When effort was assumed to be proportional to the number of hooks and all rigs were adjusted to the 120-hook standard, the effective effort of wider-spaced gear was underestimated and the catch per skate was over-estimated, indicating a higher abundance of halibut than actually existed. This underestimation of effort was evident

in the catches of the charter vessel, *Chelsea,* during the hook-spacing experiment. Based on the 120-hook standard, 18-foot gear with 81.9 hooks would be recorded as 0.676 skate; 21-foot gear (72.1 hooks) as 0.595 skate; and 24-foot gear (60.8 hooks) as 0.502 skate; whereas the catches show that the effective effort of these three rigs would be 0.945, 0.863, and 0.822 skate. The under-estimation of effort based on the standard was 28%, 31%, and 38% for the 18-, 21-, and 24-foot gear respectively. In the fishery, this error increased as wider-spaced gear was added to the fleet. The magnitude of the problem is clearly seen when the old measure of CPUE is compared with the CPUE of 18-foot gear – the dominant rig during the past 18 years (Figure 3). Before 1960, gear changes were gradual and the old CPUE provided an adequate interpretation of stock abundance. After 1960 and especially since 1965 when the change to wider-spaced gear was rapid, the over-estimation of CPUE became critical. In recent years the old "standard" CPUE indicated a somewhat stable condition, whereas, the CPUE of 18-foot gear declined sharply after 1968.

Discovering that catch per hook changes with hook-spacing has clarified the problem with the old "standard skate" and has confirmed the experience of the fishermen who had increased their effort substantially to maintain their catch levels. The changes in hook-spacing are expected to continue and must be followed closely to maintain a valid assessment of stock condition. If a new standard is adopted, it must account for differences caused by hook-spacing, and may have to be adjusted periodic-

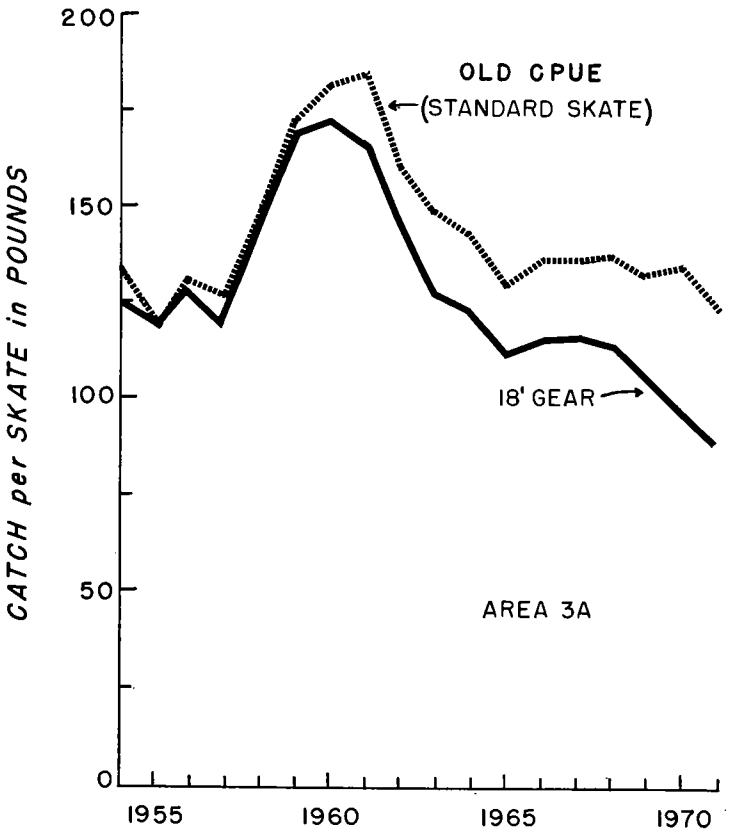

Figure 3. Comparison of CPUE based on the "standard skate" and CPUE of 18-foot gear.

ally because the relative effectiveness of different rigs apparently changes with the abundance or size of fish or the fishing area. Alternatively, estimates of CPUE may be based on the single rig that is most frequently used during a given period. With the excellent data-base maintained by the Halibut Commission, the new concept of CPUE can be used to review past estimates of stock abundance and to interpret changes that occur in the years ahead. For a more complete understanding of the relationship of CPUE to hook-spacing, more extensive analyses of log records and more fishing experiments are necessary. There also is need to examine CPUE in terms of number of fish as well as weight – such as suggested by Murphy (1960) for the tuna longline fishery. The impact of gear competition has not received adequate attention in the past and the rapid changes in hook-spacing necessitate an evaluation of these effects.

The new findings on catch per hook also have economic implications which may be of interest and use to the fishermen. During the test-fishing experiment, the time required to bait and haul each rig was measured. For example, the average time to bait a skate of 12-foot gear was 21.2 minutes and for 24-foot gear was only 13 minutes. The average time for hauling 12-foot gear was 14.6 minutes and for 24-foot gear 13.5 minutes. If these operations are calculated on the basis of hooks rather than skates, however, the time required per hook increases as the hook interval increases. The advantage of wide-spaced gear – fewer hooks, less bait, higher catch per hook, and faster baiting and hauling time per skate – must be weighed against costs of additional groundline and other factors to determine the optimum operation for any vessel.

SUMMARY

The "standard 120-hook skate" was established as the basic measure of effort in the halibut setline fishery in 1943. Effort was assumed to be proportional to the number of hooks and all gear regardless of hook-spacing was adjusted to the "standard" on this basis. A fishing experiment and a re-examination of past effort data in 1971 showed that catch per hook increases with hook-spacing. As a result, it is now evident that the "standard skate" under-estimated effort and over-estimated CPUE.

Temporarily, stock conditions now are being assessed by the CPUE of 18-foot gear which has been used more extensively since 1950 than other gear rigged with different hook-spacing. The trend toward wider hook-spacing is expected to continue and the relationship of catch per hook by rig must be monitored and evaluated.

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