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# Evaluation of Pacific Halibut Management for Regulatory Area 2A

## I. Review of the Pacific Halibut Fishery in Area 2A

by

Robert J. Trumble, Gilbert St-Pierre, and Ian R. McGregor

## II. Critique of the Area 2A Stock Assessment

by

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INTERNATIONAL PACIFIC HALIBUT COMMISSION
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# EVALUTION OF PACIFIC HALIBUT MANAGEMENT FOR REGULATORY AREA 2A

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## FOREWORD

The International Pacific Halibut Commission staff was asked by the Oregon Department of Fish and Wildlife to provide catch information of Pacific halibut in Area 2A for the purpose of examining the distribution of the catch within the Area. The Department is considering making a recommendation that the Commission subdivide Area 2A to distribute the harvest proportionally to biomass within the Area. Similarly, halibut catch data are frequently requested by the Washington Department of Fisheries, the treaty Indian tribes in the State of Washington, the Pacific Fishery Management Council, and U.S. government agencies. Such data could be of help as background information in formulating policies. The data are used to develop allocative proposals or catch sharing plans for all user groups in Area 2A. This report is partly in response to their requests.

# I. Review of the Pacific Halibut Fishery in Area 2A

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## ABSTRACT

This report chronologically reviews the regulatory measures used to conduct the management of the fishery in Area 2A and documents their application. Information on the 1929-1988 catches is provided for statistical areas and fisheries of Area 2A. The total bottom area estimated as halibut habitat and the prime areas where higher concentrations are found are given for each statistical area. Tagging recovery data is presented to illustrate the close relationship of Area 2A stocks with those in all other Regulatory Areas. Difficulties in obtaining adequate and useful data for stock assessment are explained and management implications for this Area are enumerated.

# I. Review of the Pacific Halibut Fishery in Area 2A

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## INTRODUCTION

The International Pacific Halibut Commission (IPHC), formerly the International Fisheries Commission (IFC), was established in 1923 by a Convention between Canada and the United States for the preservation of the Pacific halibut (*Hippoglossus stenolepis*) fishery of the North Pacific Ocean and the Bering Sea. The Commission's authority was gradually expanded and revised by successive Conventions: namely the 1930, 1937, and 1953 Conventions (Bell 1969, Skud 1977b). The 1953 Convention was amended by the Protocol of 1979 (IPHC 1987b). Each Convention broadened the Commission's regulatory authority and enumerated the types of measures that could be introduced, subject to the approval of both governments. A brief review of the several Conventions and other treaties relating to Pacific halibut is provided by the IPHC (1987b).

The Halibut Convention requires that the Commission allocate halibut between U.S. and Canadian fisheries, but is not explicit on domestic allocation. The Commission assumed limited allocative responsibility, but made allocative decisions only after consulting with representatives of the national governments. In 1987, the U.S. National Oceanic and Atmospheric Administration (NOAA) determined that regional fishery management councils should undertake allocating halibut among various domestic user groups.

In Area 2A, allocation recommendations to the Secretary of Commerce are made by the Pacific Fishery Management Council (PFMC) for treaty Indian fisheries and non-treaty sport and commercial fisheries. Representatives of the tribes, the states of Washington and Oregon, the U.S. government, and the IPHC participate in work groups to develop recommendations to the Council. Council recommendations pass through the IPHC for approval. Information on distribution and movement of halibut within Area 2A has been requested of the IPHC by other participants in the allocation process. Oregon Department of Fish and Wildlife staff plans to evaluate separate areas for Oregon and Washington for effects on harvests in Oregon waters. Treaty tribes are negotiating with state and federal agencies for a settlement of treaty rights to halibut, and may ask the federal courts to decide the question. Data in this report have been compiled to assist in resolution of allocation issues.

## HISTORICAL REVIEW

### Regulatory Background

No legal restriction on the Pacific halibut fishery existed during the early exploitation of the stocks off the North American Pacific coast. The 1923 Convention

established a coast-wide winter closed period during the spawning season, in an attempt to avoid overharvest. Thompson et al. (1931) indicated that fishing off the coast of Oregon and Washington was not affected by the winter closed period because the then current fishery was only occurring from spring to fall. Thompson and Freeman (1930) stated that the arguments for a closed season were largely economic in nature, and Babcock et al. (1931) concluded that the closure ". . . merely shortened the period within which the catch has been taken."

The coast was divided in 1925 into statistical areas or units, originally numbered from 1 at Cape Blanco in Oregon to 35 in western Alaska, now extended to 50. The statistical units were delineated by lines spaced 60 nautical miles apart and drawn at right angles to a base line following the trend of the coast. The statistical areas were not designed to contain an equal surface area of actual fishing ground but were designed for convenience in statistical analysis (Thompson et al. 1931). The statistical areas were soon subdivided with letter designators. During the 1950's, use of computers for data processing led to replacement of the letters with a third digit to subdivide statistical areas (Figure 1). The statistical areas off Washington, Oregon, and Califor-

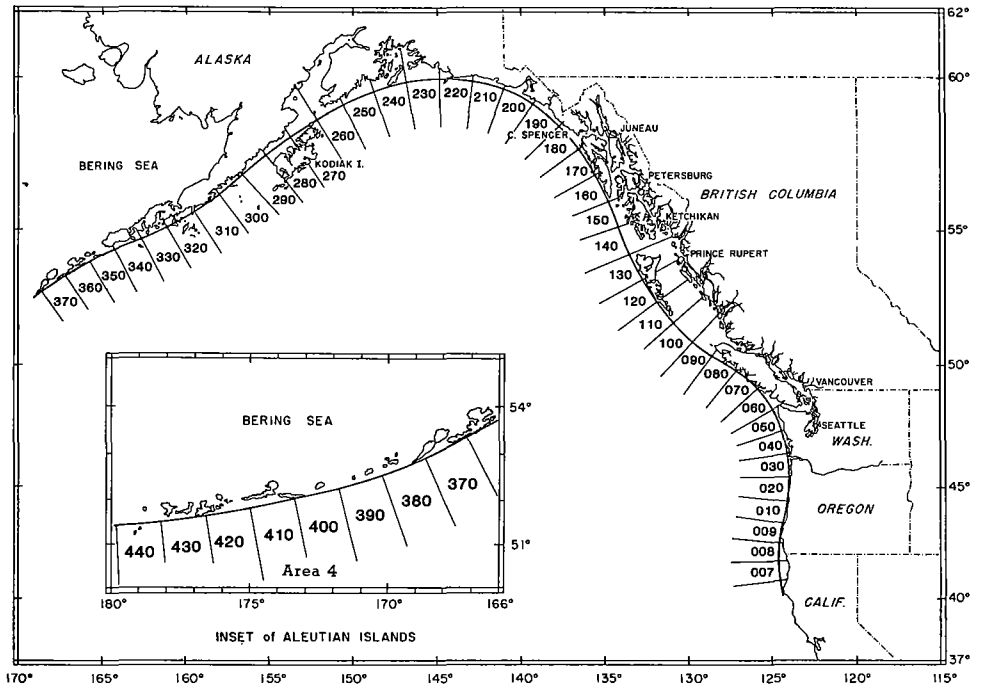


**Figure 1. Statistical areas used in data collection for Pacific halibut.**

nia range from 007 off northern California to the southern part of 060 off the northern Washington coast (Figure 2); because 060 is so small off Washington, it has been combined with 050 in this report.

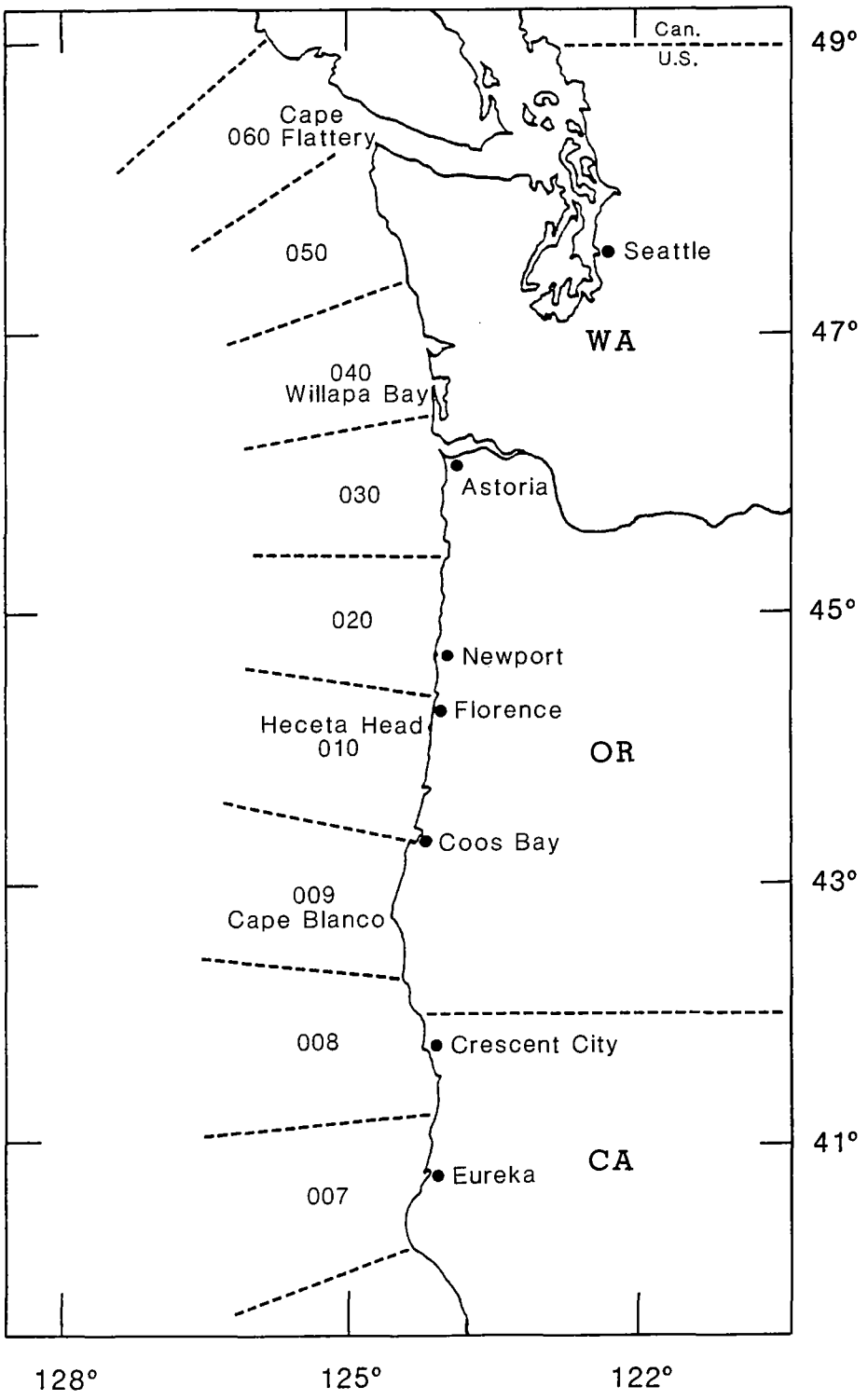


**Figure 2. Statistical areas that comprise IPHC Regulatory Area 2A.**

The 1930 Convention authorized the Commission to divide the convention waters into areas, to change and suspend the closed season, and to limit the catch of halibut during fishing seasons. The convention waters were divided into four large regulatory areas in 1932 and the areas have been subsequently subdivided and regrouped. The current regulatory areas are depicted in Figure 3. In 1932, Regulatory Area 1 included

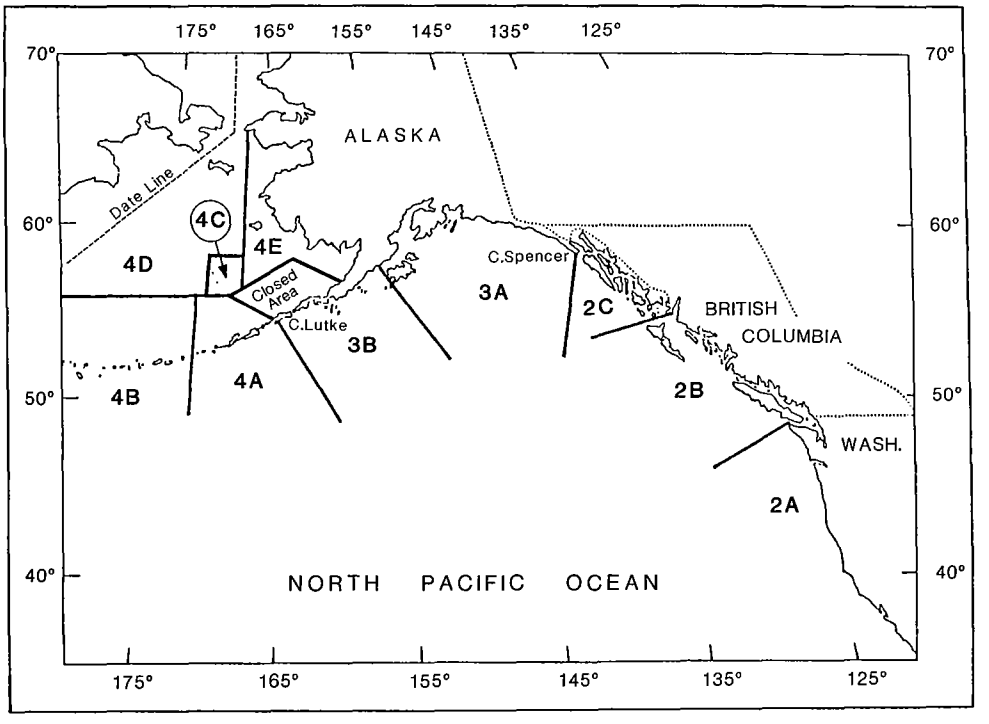


**Figure 3. IPHC regulatory areas in the North Pacific Ocean.**

all convention waters south of a line running through Willapa Bay, Washington. Regulatory Area 2 included all convention waters between Area 1 and a line running south from the highest point on Mount Fairweather. Regulatory Area 3 included all convention waters between Area 2 and a line running south from Cape Sagak on Umnak Island. Finally, Regulatory Area 4 included all convention waters not included in Regulatory Area 1, 2, or 3.

The boundaries and the number of regulatory areas were changed from time to time to reflect changes in the fishery. The following quotation (IPHC 1963), reviews why boundaries were changed and subdivisions were established within the convention waters:

> "The dividing lines between the above sections of the convention waters except that at Cape Spencer are not biological. They are designed to provide practical management divisions that may be opened or closed to

fishing at different times in order to secure the amount of fishing appropriate to the productivity of the various grounds and with recognition of the seasonal differences in availability of halibut. The foregoing method is necessary because in the United States and Canada the principle of free entry precludes control of the fishing intensity in an area by restricting the number of licenses or by allotting of catch quotas to individual vessels."

This management method is as much in use today as it was when the regulatory areas were first introduced as management tools. Although limited entry in the Canadian halibut fishery took effect in 1979, no such program limits the participation of United States vessels. As stated earlier, the separation of convention waters at Cape Spencer was, in part, arrived at from biological data obtained from early tagging experiments which suggested, according to Kask[1] that " . . . the halibut on banks south of Cape Spencer and the halibut on banks north and west of Cape Spencer form separate and distinct stocks." He indicated that although both areas needed to be protected, the "halibut in heavily fished Area 2 needed more protection than the fish in Area 3, [and] the Commission was forced to regulate the areas separately." Presently, the Commission considers the halibut resource inside the convention waters to form one homogeneous population. Since 1932, the Commission has published an annual document titled "Pacific Halibut Fishery Regulations." It lists and describes the Regulatory Areas, the catch limits, the seasons, and fishing regulations which apply to commercial halibut fishing. A section with sport fishery regulations has been included since 1973.

**Convention Waters South of Cape Flattery**

The convention waters off Washington, Oregon, and northern California have been managed either under Regulatory Area 1 and part of the southernmost portion of Regulatory Area 2, as an integral part of Regulatory Area 2, or as Regulatory Area 2A. Many of the regulatory changes in the 1930's and 1940's were designed to combat illegal fishing in closed areas. The IPHC adjusted catch statistics for illegal fishing to correct landings according to the area of origin (Bell et al. 1952). A summary of season length by management area and distribution of catch is presented in Table 1, and the historical changes in regulatory areas, in what is now 2A, are presented in Figure 4.

The area south of a line running through Willapa Bay Light was designated as Area 1 in 1932. The portion of the coast north of this line was part of Area 2. Area 1 was effectively managed by controlling the length of the season and a catch limit was not deemed necessary. The closure date for Area 1 was the same as for Area 2 to facilitate enforcement of the closure in Area 2, so as not to jeopardize the effectiveness of management in that more productive region of the coast (Bell and Best 1968).

However, Bell and Best (1968) indicated that the trend was towards shorter seasons in Area 2 and since a reasonable length of season was needed to assess the stock condition in Area 1, it was provided that Area 1 would close with Area 2 or Area 3 in 1934, whichever closed later. Area 1 closed 69 days later than Area 2 in 1934 prompting a number of Seattle vessels to fish in Area 1. This development led to the Commission amending the 1934 Regulations to include an Area 1 catch limit

[1]Kask, J.L. Halibut tagging experiments. Internat. Fish. Comm. Circular No. 6. 1937.

**Table 1. Area 2A commercial catches and length of season in days, 1929-1989.**

| | SOUTH OF WILLAPA BAY | | | | NORTH OF WILLAPA BAY | |
|---|---|---|---|---|---|---|
| | | Length of Season | | | | |
| Year | Catch (000 lbs) | Combined Area | Area 1B | Area 1A | Catch (000 lbs) | Length of season |
| 1929 | 1,228 | 273 | - | - | 336 | 273 |
| 1930 | 822 | 260 | - | - | 345 | 260 |
| 1931 | 921 | 242 | - | - | 358 | 242 |
| 1932 | 869 | 250 | - | - | 385 | 250 |
| 1933 | 741 | 206 | - | - | 375 | 206 |
| 1934 | 1,614 | 241 | - | - | 370 | 172 |
| 1935* | 1,492 | - | 159 | 270 | 278 | 159 |
| 1936 | 714 | 148 | - | - | 187 | 148 |
| 1937 | 714 | 135 | - | - | 203 | 135 |
| 1938 | 718 | 120 | - | - | 233 | 120 |
| 1939 | 1,091 | 120 | - | - | 272 | 120 |
| 1940 | 825 | 104 | - | - | 156 | 104 |
| 1941 | 349 | 91 | - | - | 160 | 91 |
| 1942 | 290 | 75 | - | - | 428 | 75 |
| 1943 | 428 | 66 | - | - | 809 | 66 |
| 1944 | 326 | 51 | - | - | 571 | 51 |
| 1945 | 443 | 46 | - | - | 286 | 46 |
| 1946 | 574 | - | 42 | 111 | 326 | 42 |
| 1947 | 409 | - | 39 | 109 | 163 | 39 |
| 1948 | 259 | - | 32 | 72 | 148 | 32 |
| 1949 | 385 | - | 34 | 73 | 233 | 34 |
| 1950 | 377 | - | 32 | 66 | 326 | 32 |
| 1951 | 289 | - | 28 | 56 | 296 | 38 |
| 1952 | 320 | - | 26 | 60 | 297 | 36 |
| 1953 | 210 | - | 24 | 52 | 292 | 34 |
| 1954 | 551 | - | 29 | 117 | 302 | 29 |
| 1955 | 377 | - | 31 | 132 | 235 | 31 |
| 1956 | 325 | - | 45 | 156 | 204 | 45 |
| 1957 | 296 | - | 54 | 168 | 300 | 54 |
| 1958 | 212 | - | 66 | 165 | 311 | 66 |
| 1959 | 129 | - | 75 | 168 | 540 | 75 |
| 1960 | 238 | - | 98 | 168 | 647 | 98 |
| 1961 | 223 | - | 120 | 144 | 274 | 120 |
| 1962 | 275 | 122 | - | - | 174 | 122 |
| 1963 | 169 | 205 | - | - | 243 | 205 |
| 1964 | 104 | 137 | - | - | 176 | 137 |
| 1965 | 98 | 137 | - | - | 116 | 137 |
| 1966 | 81 | 108 | - | - | 102 | 108 |
| 1967 | 74 | 159 | - | - | 125 | 159 |
| 1968 | 51 | 164 | - | - | 87 | 164 |
| 1969 | 72 | 137 | - | - | 158 | 137 |

*In 1935 only, Area 1B was designated as Area 1, and Area 1A as Area 4.

continued...

**Table 1. (continued)**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1970 | 47 | 149 | - | - | 112 | 149 |
| 1971 | 112 | 178 | - | - | 206 | 178 |
| 1972 | 104 | 101 | - | - | 265 | 101 |
| 1973 | 6 | 95 | - | - | 219 | 95 |
| 1974 | 68 | 121 | - | - | 447 | 121 |
| 1975 | 38 | 128 | - | - | 422 | 128 |
| 1976 | 48 | 123 | - | - | 190 | 123 |
| 1977 | 56 | 73 | - | - | 151 | 73 |
| 1978 | 32 | 62 | - | - | 65 | 62 |
| 1979 | 14 | 23 | - | - | 32 | 23 |
| 1980 | 6 | 10 | - | - | 16 | 10 |
| 1981 | 52 | 56 | - | - | 150 | 56 |
| 1982 | 76 | 49 | - | - | 135 | 49 |
| 1983 | 133 | 26 | - | - | 132 | 26 |
| 1984 | 159 | 35 | - | - | 272 | 35 |
| 1985 | 129 | 31 | - | - | 364 | 31 |
| 1986 | 282 | 19 | - | - | 299 | 19 |
| 1987 | 261 | 12 | - | - | 331 | 12 |
| 1988 | 197 | 5 | - | - | 289 | 5 |
| 1989 | 148 | 2 | - | - | 342 | 2 |

of 1.4 million pounds. In 1935, the grounds south of Cape Blanco were designated as Area 4 and were closed at the same time as Area 3, whereas Area 1 closed with Area 2. This proved only partly effective in controlling illegal fishing and in 1936 the Commission returned to the design of 1932, i.e. closing all the waters south of Willapa Bay at the same time as Area 2.

The regulatory boundaries for the waters south of Cape Flattery remained the same from 1936 through 1945. As the number of days when fishing took place in Area 2 steadily decreased, operators of the few local halibut setline vessels fishing the grounds of Area 1 demanded more fishing time. Although the halibut fishery was mostly incidental to other species, the market demand for fresh halibut in Oregon was good both on the local market and at larger population centers within overnight trucking from the ports. A five pound minimum weight limit for dressed head-off halibut was introduced in 1940 and a head-on length limit of 26 inches (66 cm) was added in 1944 for the convenience of the fishermen (Myhre 1974). Also, the retention of halibut caught by trawlers or other net gear was prohibited in the convention waters in 1944 (Skud 1977b).

Bell and Best (1968) suggested that the low level of halibut production in Area 1 provided little justification for the expenditure of public funds for enforcement and indicated that the landing of illegally caught halibut increased sharply because of the strong demand for halibut following World War II. Area 1 was divided into Areas 1A and 1B in 1946 to permit a longer opening in the southern region (1A) and to reduce the amount of illegally landed halibut. The general objectives of the 1948 regulations as stated in IFC Report #14 (IFC 1949) explain well the use of regulations in Area 1:

> "The closure of Area 1B with Area 2, as in the case of Area 4 with Area 3, is necessary for enforcement purposes. Experience has shown that without such a provision vessels would fish in Area 2 after closure and declare

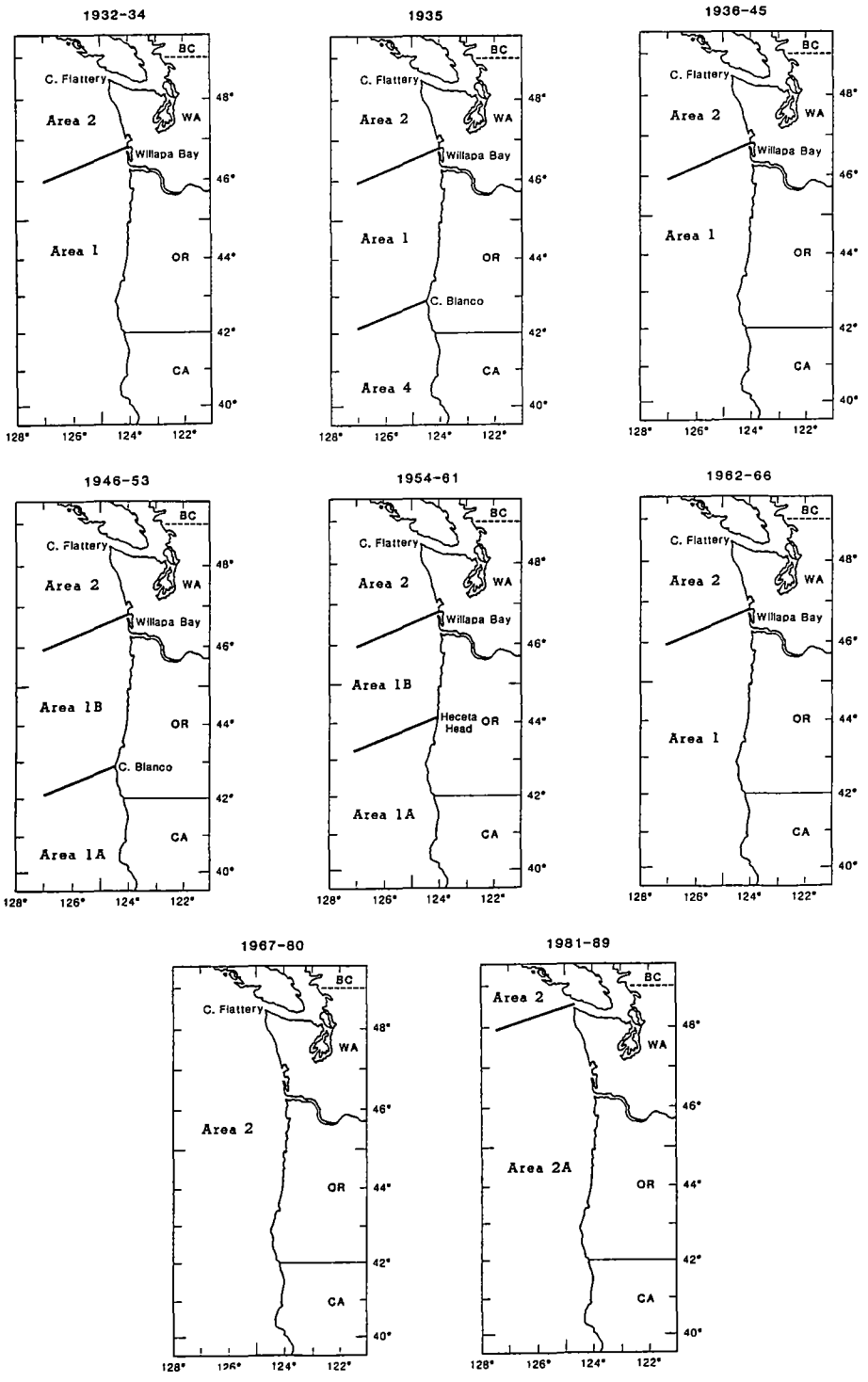


**Figure 4. Historical changes in management boundaries in the present IPHC Regulatory Area 2A.**

their catches from the adjoining Area 1B. With the greater remoteness of Area 1A, such a practice is less likely. It is further discouraged by requiring vessels fishing in Area 1A after closure of Areas 1B and 2 to have their licenses validated at a port in Area 1A prior to each trip."

The boundary between Area 1A and Area 1B was moved northward from Cape Blanco to Heceta Head, Oregon in 1954 (Bell and Best 1968). This boundary remained at that location until 1962 when Areas 1A and 1B were recombined into Area 1, with the same season length as Area 2. This was made possible because of continued improvement of enforcement conditions. Surveillance was further increased in 1964 (Bell and Best 1968) when the state of Oregon included significant features of the Pacific Halibut Fishery Regulations in their General Orders (now Administrative Rules or Oregon Revised Statute). This permitted the Oregon State Police to actively enforce halibut regulations.

Area 1 was incorporated into Area 2 in 1967, a natural and inevitable denouement since for "all practical purposes the two areas had been managed as a unit for many decades" (Bell and Best 1968). This proved possible due to the gradual lengthening of the fishing season in Area 1 compared to the early 1950's, and with the more effective enforcement of halibut regulations. A change to the size limit, from 26 inches to 32 inches (81.3 cm), occurred in 1973 to maximize yield per recruit (Myhre 1974). The convention waters south of Cape Flattery continued to be managed as an integral part of Area 2 through 1980. However, the catch limit in Area 2 was reached in fewer fishing days because of the strong effort in southeastern Alaska. By 1980, the number fishing days in the waters south of Cape Flattery was reduced drastically (Table 1), and resulted in underharvest of the resource for this region.

Therefore, Area 2 was divided into three subareas in 1981 and the convention waters off Washington, Oregon, and California became known as Area 2A. A catch limit was set for Area 2A and because the area was again being managed apart from the rest of Area 2, the number of fishing days increased from 10 in 1980 to 56 in 1981. Increased effort and efficiency and decreased catch limits caused the catch limit to be reached in progressively fewer days. The non-Indian commercial fishery lasted for only two days in 1989, and in 1990 for one 12-hour period with several subsequent fishing periods with a 250 pound fishing period limit.

## CATCH HISTORY

### The Commercial Fishery

Pacific halibut were harvested by members of Indian tribes for use in what is now Washington for hundreds of years before early explorers reached the Pacific northwest. The modern commercial halibut fishery is considered to have begun with a landing from the northern Washington coast in 1888. The commercial fishery soon expanded to Oregon waters. Gradual declines in landings, probably from reduced stock abundance, caused the fishery to spread to the north into more productive grounds off British Columbia and Alaska.

The decline in the catch from fishing grounds in Area 2A has generally resulted in the shortening of the fishing season (Bell and Best 1968). Halibut harvest has fluctuated substantially in this area, but with an overall downward trend (Table 2). The greatest decline occurred off Oregon, while harvest off Washington fluctuated with little pattern. Table 2 shows the percentage of the catch in Area 2A from the

**Table 2. Summary of commercial catch (thousands of pounds) by 60-mile statistical area in Area 2A and the percentage of the catch taken in Area 2A versus the whole of Area 2 (Areas 2A + 2B + 2C). (Area 050 includes the U.S. portion of statistical area 060 since 1979).**

| Year | Total Catch | Area 2A catch as a % of Area 2 | Catch by Statistical Area | | |
|---|---|---|---|---|---|
| | | | 007-030 | 040 | 050 |
| 1929 | 1,564 | 6.1 | 1,228 | 38 | 298 |
| 1930 | 1,167 | 5.2 | 822 | 19 | 326 |
| 1931 | 1,279 | 5.7 | 921 | 141 | 217 |
| 1932 | 1,254 | 5.5 | 869 | 37 | 348 |
| 1933 | 1,116 | 4.8 | 741 | 41 | 334 |
| 1934 | 1,984 | 8.3 | 1,614 | 13 | 357 |
| 1935 | 1,770 | 7.5 | 1,492 | 12 | 266 |
| 1936 | 901 | 3.9 | 714 | 22 | 165 |
| 1937 | 917 | 3.8 | 714 | 7 | 196 |
| 1938 | 951 | 3.9 | 718 | 15 | 218 |
| 1939 | 1,363 | 5.3 | 1,091 | 44 | 228 |
| 1940 | 981 | 3.7 | 825 | 17 | 139 |
| 1941 | 509 | 2.1 | 349 | 7 | 153 |
| 1942 | 718 | 3.1 | 290 | 130 | 298 |
| 1943 | 1,237 | 4.9 | 428 | 55 | 754 |
| 1944 | 897 | 3.4 | 326 | 168 | 403 |
| 1945 | 729 | 3.1 | 443 | 67 | 219 |
| 1946 | 900 | 3.1 | 574 | 130 | 196 |
| 1947 | 572 | 2.1 | 409 | 73 | 90 |
| 1948 | 407 | 1.5 | 259 | 8 | 140 |
| 1949 | 618 | 2.3 | 385 | 13 | 220 |
| 1950 | 703 | 2.6 | 377 | 3 | 323 |
| 1951 | 585 | 1.9 | 289 | 9 | 287 |
| 1952 | 617 | 2.0 | 320 | 7 | 290 |
| 1953 | 502 | 1.5 | 210 | 28 | 264 |
| 1954 | 853 | 2.3 | 551 | 37 | 265 |
| 1955 | 612 | 2.2 | 377 | 22 | 213 |
| 1956 | 529 | 1.5 | 325 | 9 | 195 |
| 1957 | 596 | 2.0 | 296 | 12 | 288 |
| 1958 | 523 | 1.7 | 212 | 43 | 268 |
| 1959 | 669 | 2.2 | 129 | 62 | 478 |
| 1960 | 885 | 2.8 | 238 | 110 | 537 |
| 1961 | 497 | 1.7 | 223 | 69 | 205 |
| 1962 | 449 | 1.6 | 275 | 31 | 143 |
| 1963 | 412 | 1.6 | 169 | 39 | 204 |
| 1964 | 280 | 1.4 | 104 | 29 | 147 |
| 1965 | 214 | 0.9 | 98 | 6 | 110 |
| 1966 | 183 | 0.8 | 81 | 1 | 101 |
| 1967 | 199 | 1.0 | 74 | 7 | 118 |
| 1968 | 138 | 0.8 | 51 | 9 | 78 |
| 1969 | 230 | 1.0 | 72 | 17 | 141 |

continued...

**Table 2. (continued)**

| | | | | | |
|---|---|---|---|---|---|
| 1970 | 159 | 0.8 | 47 | 7 | 105 |
| 1971 | 318 | 1.9 | 112 | 10 | 196 |
| 1972 | 369 | 2.3 | 104 | 3 | 262 |
| 1973 | 225 | 1.7 | 6 | 5 | 214 |
| 1974 | 515 | 4.8 | 68 | 0 | 447 |
| 1975 | 460 | 3.3 | 38 | 1 | 421 |
| 1976 | 238 | 1.8 | 48 | 5 | 185 |
| 1977 | 207 | 2.3 | 56 | 16 | 135 |
| 1978 | 97 | 1.1 | 32 | 6 | 59 |
| 1979 | 46 | 0.5 | 14 | 10 | 22 |
| 1980 | 22 | 0.2 | 6 | 6 | 10 |
| 1981 | 202 | 2.0 | 52 | 2 | 148 |
| 1982 | 211 | 2.3 | 76 | 18 | 117 |
| 1983 | 265 | 2.2 | 133 | 8 | 124 |
| 1984 | 431 | 2.8 | 159 | 13 | 259 |
| 1985 | 493 | 2.4 | 129 | 25 | 339 |
| 1986 | 581 | 2.6 | 282 | 41 | 258 |
| 1987 | 592 | 2.5 | 261 | 74 | 257 |
| 1988 | 486 | 2.0 | 197 | 36 | 253 |
| 1989 | 490 | 2.4 | 148 | 18 | 324 |
| **Average** | **621** | **2.8** | **354** | **31** | **235** |

combined catch of Areas 2A, 2B, and 2C. The Area 2A catch averaged 2.8 percent and ranged from a high of 8.3 in 1934 to a low of 0.2 in 1980.

The commercial halibut fishery has traditionally focused uniquely on halibut. During the past few years, however, an increasing number of vessels have combined halibut with fishing for other species. Especially off the northern Washington coast, a portion of the production is taken with rockfish and sablefish.

### The Sport Fishery for Halibut

The earliest reported sport fishing in Area 2A came from the 1915 Pacific Fisherman Magazine describing the construction in Florence, Oregon of a 55-ft vessel to be used "especially for taking fishing parties to the halibut banks that lie northwest of here" (Bell and Best 1968). Skud (1975) reported that the recreational use of halibut was non-existent when the halibut Convention was ratified in 1924, but that subsistence fishing was not uncommon. Skud (1975) indicated that the Convention implied that the signatories were concerned only with the commercial exploitation of the halibut fishery and no attempt was made to define the term "fishery." The 1953 revision of the Convention uses the term "stocks" instead of the term "fishery" and, in this context, the Convention can be interpreted to apply to commercial, recreational, or subsistence fisheries.

Skud (1975) reviewed the recreational fishery for halibut and indicated that the Commission was uncertain as to whether it had the authority to manage the sport fishery. The Commission periodically reviewed the sport fishery and considered sport fishery management as a low priority because the catch was insignificant relative to the commercial landings. Prior to 1973, recreational fishing for halibut was permitted only during the commercial season and all out-of-season landings were unlawful. The

regulations were enforced by federal agents and as the commercial seasons became shorter, the numbers of infractions increased.

In 1970, after numerous yearly requests by the U.S. National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game to IPHC to institute sport fishery regulations, the Commission asked the two federal governments for legal interpretations as to the Commission's authority relative to sport fishing (Skud 1975). The federal governments indicated that the Commission's authority was wide enough to justify implementing sport regulations. After consultations with federal and state agencies, the first sport fishery regulations were adopted by the Commission in 1973 and approved by the governments of Canada and the United States.

The first season was set from March 1 to October 31. The daily catch limit was three fish of any size in 1973, one fish in 1974, and two fish since 1975. Skud (1975) estimated the coast-wide catch of sport caught halibut at 250,000 pounds annually (1973-1974), and the effect on the stock abundance to be of minimal importance. The IPHC supported uniform regulations for all Convention waters. As IPHC regulations were adopted by U.S. states, they in turn assumed the responsibility of enforcement with the Canadian and United States agencies (Skud 1975). The Commission relied on U.S. states and the Canadian Department of Fisheries and Oceans (DFO) for the estimates of annual sport catch of halibut.

In Area 2A, Skud (1975) estimated the 1973-1974 annual sport catch to be 2,500 fish (30,000 lb) off Washington and a combined catch of 1,000 fish (12,000 lb) off Oregon and California. From 1975 to 1980, years of low halibut abundance coast-wide, the sport catch of halibut remained essentially unchanged in Area 2A and, at this level of recreational fishing, required little regulation.

The sport fishery for halibut has enjoyed a sharp gain in popularity in recent years due mostly to the increase in abundance of halibut during the early 1980's, the hope of catching trophy size fish, and the reduced opportunities for recreational salmon fishing. The estimated sport catch of halibut in the Convention waters quintupled between 1981 and 1989 to over five million pounds (Table 3).

**Table 3. Catch (thousands of pounds, net weight) of Pacific halibut by the sport fishery, 1981-1989.**

| Area | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |
|---|---|---|---|---|---|---|---|---|---|
| 2A | 20 | 49 | 66 | 129 | 238 | 339 | 415 | 246 | 317 |
| 2B | 23 | 66 | 103 | 124 | 525 | 372 | 329 | 508 | 598 |
| 2C | 318 | 489 | 553 | 621 | 682 | 730 | 780 | 1,076 | 1,559 |
| 3A | 765 | 732 | 957 | 1,042 | 1,227 | 1,924 | 2,045 | 3,336 | 3,297 |
| 3B | - | - | - | - | - | - | - | - | - |
| 4 | - | - | - | - | 10 | 13 | 15 | 18 | 20 |
| Coastwide Total | 1,126 | 1,336 | 1,679 | 1,916 | 2,682 | 3,378 | 3,584 | 5,184 | 5,791 |

In Area 2A, the harvest increased 25 fold since 1981 to 415,000 pounds in 1987. Table 4 gives the estimated sport catch of halibut in Area 2A from 1975 to 1989. An attempt, which failed, was made in 1987 to limit the sport catch to 200,000 pounds by setting a September 30 closure and by establishing a minimum size limit of 30 inches (IPHC 1988b). In 1988 and 1989, the Commission adopted catch sharing

**Table 4. Commercial, sport and treaty Indian catches (thousands of pounds, net weight) in Areas 2A-1 and 2A for 1975-1989.**

| | AREA 2A-1 | | | | AREA 2A | | | |
|---|---|---|---|---|---|---|---|---|
| | Non-Treaty | | Treaty | | Non-Treaty | | Treaty | TOTAL |
| Year | Comm. | Sport | Comm. | C&S | Comm. | Sport | | |
| 1975 | 421.8 | 12.3 | - | - | 460.0 | 17.3 | - | 477.3 |
| 1976 | 189.0 | 5.3 | - | - | 238.0 | 10.3 | - | 248.3 |
| 1977 | 147.8 | 8.6 | - | - | 207.0 | 14.6 | - | 221.6 |
| 1978 | 63.8 | 5.0 | - | - | 97.0 | 10.0 | - | 107.0 |
| 1979 | 30.0 | 10.0 | - | - | 46.0 | 15.0 | - | 61.0 |
| 1980 | 14.8 | 11.2 | - | - | 22.0 | 16.2 | - | 38.2 |
| 1981 | 149.6 | 12.9 | - | - | 202.0 | 20.2 | - | 222.2 |
| 1982 | 131.4 | 36.0 | - | - | 211.0 | 48.8 | - | 259.8 |
| 1983 | 130.4 | 56.4 | - | - | 265.0 | 66.0 | - | 331.0 |
| 1984 | 269.4 | 123.5 | - | - | 431.0 | 129.0 | - | 560.0 |
| 1985 | 355.1 | 226.7 | 3.9 | 10.5 | 489.0 | 237.8 | 14.4 | 741.2 |
| 1986 | 273.4 | 301.3 | 17.4 | 10.0 | 564.0 | 338.6 | 27.4 | 930.0 |
| 1987 | 272.5 | 334.8 | 43.7 | 10.9 | 548.0 | 415.2 | 54.6 | 1,017.8 |
| 1988 | 187.8 | 168.2 | 94.0 | 9.2 | 392.0 | 245.6 | 103.2 | 740.8 |
| 1989 | 196.4 | 177.1 | 142.0 | 10.0 | 330.0 | 316.9 | 152.0 | 798.9 |

plans developed for Area 2A by the Pacific Fishery Management Council (PFMC) that included deliberation between commercial and sport fishermen. Under the catch sharing plan, PFMC allocated sport harvest to Washington and Oregon waters. The 1988 sport fishery was allocated 270,000 pounds, a decrease of almost 50 percent from the 1987 harvest. The 1989 allocation decreased slightly to 224,000 pounds. Catch division is presented in Table 5.

**Table 5. Distribution of recreational halibut catch (pounds, net weight) within Area 2A, 1981-1989.**

| YEAR | OREGON | WASHINGTON | | GRAND TOTAL |
|---|---|---|---|---|
| | | Coastal | Puget Sound | |
| 1981 | 6,600 | 2,565 | 10,995 | 20,160 |
| 1982 | 7,100 | 9,525 | 32,205 | 48,830 |
| 1983 | 7,900 | 12,705 | 45,420 | 66,025 |
| 1984 | 5,100 | 70,455 | 53,415 | 128,970 |
| 1985 | 8,700 | 51,300 | 177,750 | 237,750 |
| 1986 | 35,000 | 99,570 | 204,000 | 338,570 |
| 1987 | 78,200 | 189,975 | 147,015 | 415,190 |
| 1988 | 74,300 | 134,316 | 37,083 | 245,699 |
| 1989 | 135,000 | 149,078 | 32,866 | 316,944 |

### Allocation of Halibut to Treaty Indian Tribes

Each year from 1979 to 1984, the Makah Indian Tribe had requested changes in the regulations that would increase their opportunity to participate in the halibut fishery. The Commission regarded such requests as an allocation issue between the Tribe and the United States government. The Commission felt that it did not have the authority to allocate quotas. In 1985, a request was made by the NMFS to allow Makah tribal members to fish with handline gear on fishing grounds for which they have historic treaty fishing rights. With the recommendation of the Conference Board (IPHC 1986), the Commission recommended that the United States government authorize a tribal fishery. The fishing took place between the Area 2A all-citizen commercial seasons, with 3,900 pounds landed commercially and 10,500 pounds landed for the ceremonial and subsistence (C&S) use (Table 4).

A portion of the Area 2A catch limit was allocated by the United States government to northwest Washington Indian tribes beginning in 1986. Treaty halibut fishing was restricted to Subarea 2A-1 (Figure 5), the composite of tribal usual and accustomed fishing areas (U&A) previously determined for other species. The Commission retained overall management authority in the Convention waters and continued to set catch limits based upon biological assessment in the area. The position of the Commission was to facilitate obligations that the United States government may have to northwest Indian tribes with historic treaties containing fishery provisions (IPHC 1987a).

In 1986, the IPHC recommended a commercial season for the Quileute, Hoh, Quinault, and Makah Tribes, which was allocated to the Tribes by the United States government (IPHC 1987a). A 50,000 pound quota to be taken by hook and line gear was set, which included a two fish per day subsistence fishery after the commercial season. The treaty tribes had a 184-day commercial season (Apr.30-Oct.31) and landed 17,400 pounds in the commercial fishery and 10,000 pounds in the C&S fishery.

In 1987, the Lummi, Swinomish, Tulalip, Skokomish, Port Gamble Klallam, Jamestown Klallam, and Lower Elwha Klallam tribes were included as participants in the treaty fishery in Subarea 2A-1 (IPHC, 1988). A commercial allocation of 150,000 pounds was set for the 11 northwest Washington Indian treaty tribes by the United States government. The treaty tribes caught about 43,700 pounds during a 214-day commercial season and 10,900 pounds in the C&S fishery.

The Suquamish tribe was included in 1988 (IPHC, 1989). The 12 northwest Washington Indian treaty tribes were allocated 150,000 pounds under the PFMC catch sharing plan and landed 94,000 pounds during a 214-day commercial season, and 9,200 pounds in the C&S fishery. In 1989, the tribes caught the 152,000 pound allocation that included 10,000 pounds for C&S harvest. The tribal commercial fishery was closed prior to the date set in the regulations, for the first time, to prevent exceeding the catch limit.

## THE FISHING GROUNDS

Several fishing grounds with high concentrations of halibut are located in the waters south of Cape Flattery. However, most of the grounds in Area 2A are very small in area and therefore support only a limited population of halibut. Fishing in Area 2A is a spot fishery, i.e., if the gear is set off the spot the catch per unit of effort falls dramatically, often approaching zero. The bottom area between these hot spots

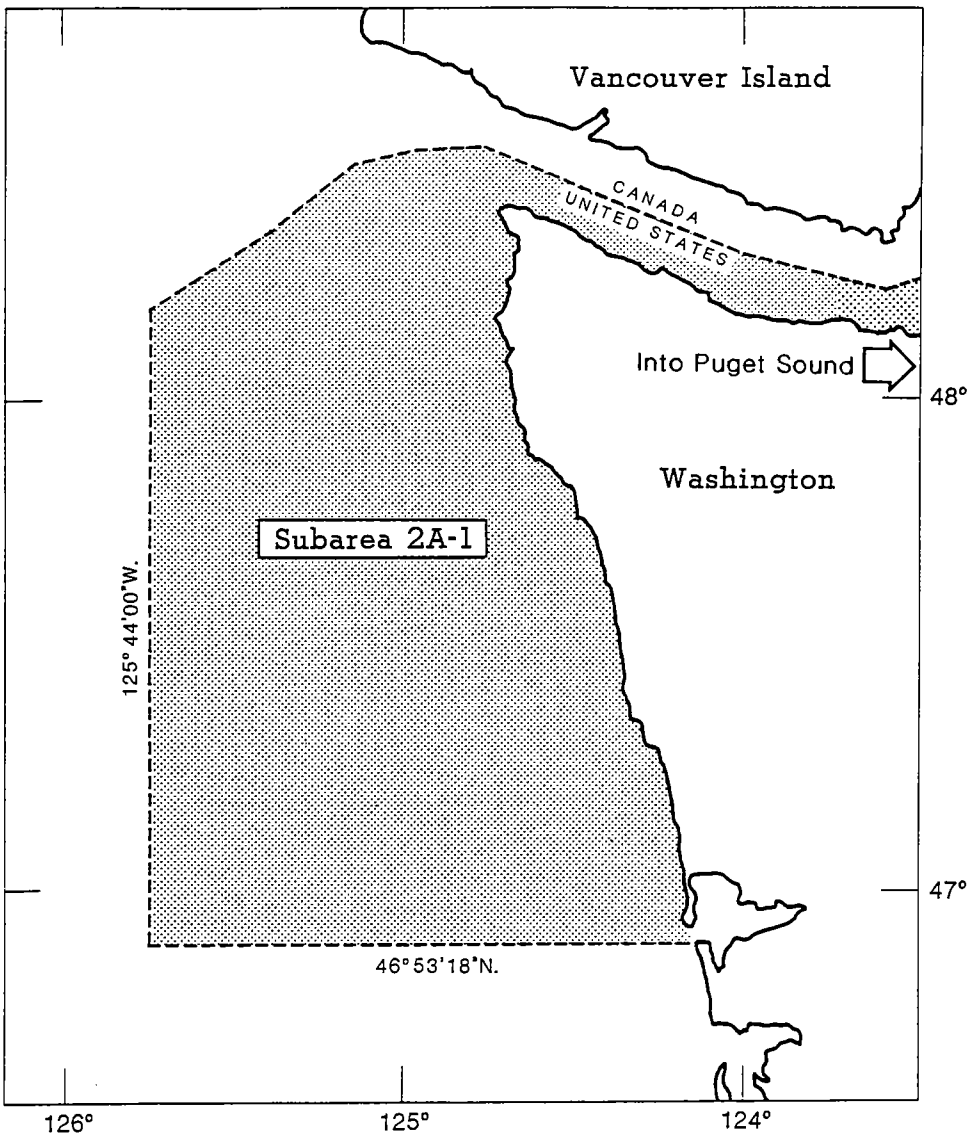


**Figure 5. Treaty Indian fishing areas (Subarea 2A-1) currently used in IPHC Regulatory Area 2A.**

consists of grounds sparsely populated with halibut.

Some very high catches were taken from Area 2A grounds in past years. Bell and Best (1968) documented the catch of 50,000 pounds on 25 units of gear fished by one vessel in 1915. The same vessel had slightly more than 100 pounds per unit fished on the same ground in 1916 and considerably less than 100 pounds in 1917. In May 1915, catches of over 3,000,000 pounds were reported off the Columbia River mouth (Bell and Best 1968). They indicated that such fishing results did not last long since it was reported the following month that halibut were scarce on the grounds.

Table 6 shows the bottom area and the halibut habitat area in square miles for Area 2A, including the Puget Sound area of Washington. The bottom area is defined

**Table 6. Bottom area and bottom habitat in nautical square miles for Area 2A.**

| Statistical Area | Bottom Area | Halibut Habitat |
|---|---|---|
| 000* | 2534 | 153 |
| 010 | 1671 | 196 |
| 020 | 1282 | 358 |
| 030 | 1596 | 193 |
| 040 | 1671 | 70 |
| 050 | 1558 | 323 |
| 060** | 356 | 56 |
| Strait*** | 981 | 80 |

* South of statistical area 010 to Cape Mendocino
** Portion of statistical area 060 in U.S. waters
*** U.S. portion of Strait of Juan de Fuca

as the area, in nautical square miles, from the shoreline to the depth of 150 to 175 fathoms, except to a greater depth where fishing is known to have occurred. The combined compilation of daily fishing locations using log data from 1930 to 1988, plotted on a chart and measured with a planimeter, was updated from Hoag et al. (1983) and used to calculate the halibut habitat. The locations obtained from logbooks are confidential, and are not presented in this report. Thus the halibut habitat is based on grounds where the commercial fleet fished or is presently fishing. No evaluation of the relative quality of habitat has been done, and all habitat is considered equal for the purposes of this report.

## MOVEMENT OF AREA 2A HALIBUT

The International Pacific Halibut Commission manages the Pacific halibut resource as a single stock, because egg and larval drift and counter migration by juvenile fish apparently cause homogeneity in the resource that prevents development of separate populations. Spawning occurs primarily during winter from northern British Columbia through the Gulf of Alaska into the Bering Sea, at depths of 150 to 250 fathoms (St-Pierre 1984). Eggs and larvae at depth drift passively with the ocean currents and gradually rise toward the ocean surface (Thompson and Van Cleve 1936).

Prevailing currents at spawning depth and near the surface tend to flow counterclockwise, paralleling the British Columbia and Alaska coastline (Figure 6). Eggs and larvae drift for hundreds or thousands of miles before reaching shallow water where the larvae can settle to the bottom. The Commission has not identified spawning grounds in Area 2A; if spawning occurred in Area 2A, however, prevailing currents would carry the eggs and larvae in the same general pattern as eggs spawned further north. There is no apparent oceanographic mechanism to either retain eggs and larvae off Washington and Oregon, or to otherwise separate them from eggs and larvae of other spawning grounds, other than drift into Grays Harbor or Willapa Bay.

Continuity of the halibut resource requires that the progeny move back to the east and south at some stage in the life history to counter the drift of eggs and larvae. Under this hypothesis, virtually all halibut off the coast of British Columbia,

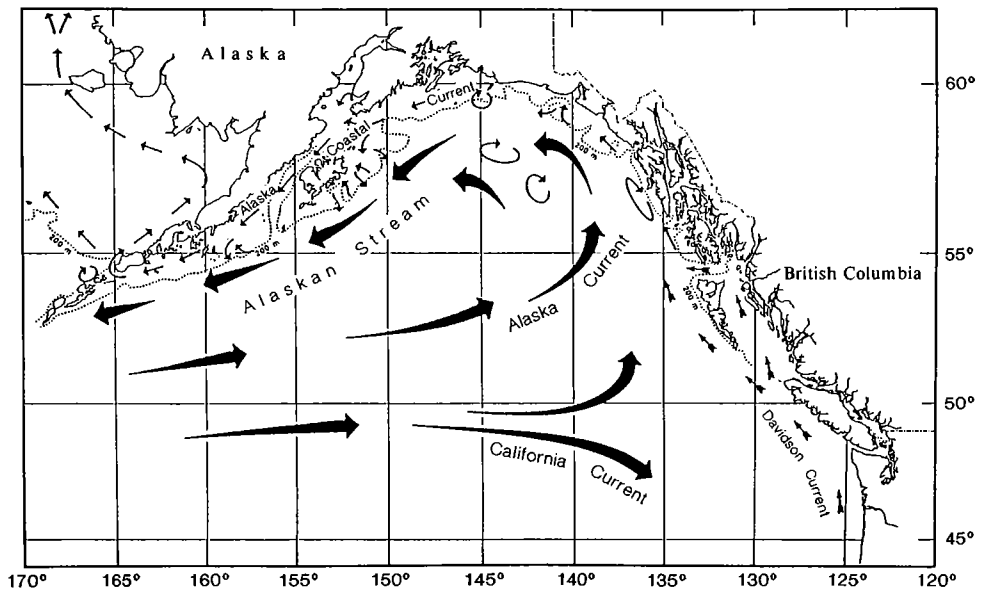


**Figure 6. Prevailing ocean surface currents that affect drift of Pacific halibut eggs and larvae.**

Washington, Oregon, and California migrated through Alaska. Best (1977) and Skud (1977a) present evidence that the counter migration occurs primarily during the juvenile stage, and that most juveniles migrate while 2 through 6 years of age. Most migration takes place by fish smaller than 65 cm, although migration at larger sizes does occur.

Skud (1977a) concluded that adult halibut undergo a feeding-spawning migration, with autumn migration to winter spawning grounds and spring migration to summer feeding grounds. Recovery data for halibut released or recovered in Area 2A were summarized to evaluate the extent of such migration. Summer was considered to be May through September, winter to be the peak spawning months of December to February, and March-April and October-November are transition months. Recovery data are divided by size at release. Halibut smaller than 65 cm are considered to have a higher migration rate than do larger halibut. Once halibut reach legal size (82 cm), summer to summer migration appears to be greatly reduced relative to fish smaller than 65 cm.

The IPHC has tagged Pacific halibut coast-wide since the 1920's. Over 250,000 tagged fish have been released, and more than 25,000 have been recovered (Trumble et al. 1990). Migration rates between IPHC regulatory areas have been calculated from tagging data, but are not currently used because tag releases have not been randomly distributed, fishing effort varies considerably over the range of the fish, tags are captured by trawls, longline, and sport gear which select for different sized fish, and tag reporting rates vary with time and area. Most recovery data are available for Area 2A since 1960. However, little tagging was conducted in Area 2A until a 1989 pilot experiment off central Oregon to evaluate the potential of tagging for halibut stock assessment. Tag recovery data, summarized for 1960 through 1986 in Tables 7, 8, and 9, provide qualitative information on the origin of halibut in Area 2A, and quantify where possible the distribution of halibut within Area 2A. These

halibut tagging data must be used with caution, for reasons given above. Additionally, tagging in Area 2A is limited relative to other areas of the coast. Winter releases, winter recoveries, and recoveries of releases made in winter are rare.

### Halibut Tagged Outside of Area 2A

Tag recovery data for 100 fish released outside of Area 2A but recovered within Area 2A show that the origin of Area 2A halibut extends from British Columbia into the Bering Sea and along the Aleutian Islands. Recoveries in Area 2A of fish released at sizes 65 cm or larger occurred mostly in the summer (Table 7). All but eight of 36 summer recoveries that were released in summer outside of Area 2A came from British Columbia waters, and 26 of the recoveries were made in northern Washington (Statistical Area 050) waters. Too few winter releases were recovered to draw firm conclusions about winter migration to Area 2A. Transition period releases show movement from Area 2B to Area 2A. The 15 transition period releases recovered during the summer were of legal size when released, and were released in Area 2B. These few available data are consistent with migration from Area 2B spawning grounds to Area 2A feeding grounds.

Most of the Area 2A recoveries of fish released at sizes less than 65 cm came from the region near Kodiak Island (Table 8). Most summer releases were recovered in summer, primarily off Washington. Three summer releases were recovered during winter and five during the transition period. No recoveries were obtained from winter releases.

### Halibut Tagged in Area 2A

One important consideration for evaluating a possible separation of Area 2A is the degree of redistribution of adult halibut within the area. From 1960 through 1986, 110 tag recoveries have been made of halibut released within Area 2A, plus 241 tag recoveries through April, 1990 from the 1989 central Oregon tagging experiment. The 1989 Oregon tagging results cannot yet be used to address redistribution within 2A because all commercial and a portion of recreational landings occurred within several weeks of release of tagged fish. Redistribution did not have a chance to occur. The following discussion is based on the historical data unless the central Oregon experiment is specifically stated.

Recoveries from 1960 through 1986 of 80 tagged fish 65 cm or longer, released during summer in Area 2A, suggest that redistribution occurs only to a limited degree in Area 2A (Table 9). Of 59 summer recoveries, most relevant to inter-annual redistribution between fishing areas, all but seven were recovered within one statistical area of release. One Oregon release was recovered in Washington, and no Washington releases were recovered in Oregon. Four of the distant movements were recovered between northern British Columbia and Southeast Alaska, two in May and one each in August and September.

Summer releases recovered during the transition period have a pattern similar to summer releases-summer recoveries, but with slightly higher northward movement. Thirteen (68.4%) of 19 tags recovered were recovered within one statistical area of release. One Oregon release was recovered in Washington, and no Washington releases in Oregon. Five (26.3%) recovered fish moved to between Vancouver Island and Southeast Alaska.

Fish released during the transition period showed some tendency to remain near

**Table 7. Tag recovery data summary for halibut 65 cm or larger recovered but not released in Area 2A, 1960-1986.**

**Summer recoveries from summer releases**

| Area Released | Area Recovered | | | | | | |
|---|---|---|---|---|---|---|---|
| | 007 | 008 | 010 | 020 | 030 | 040 | 050 |
| 060 | | | | | 1 | | 17 |
| 091 | | | | 1 | | | |
| 102 | 1 | | | | | | 3 |
| 112 | | 1 | | 1 | | | 1 |
| 132 | | | | | | 1 | |
| 133 | | | | 1 | | | |
| 142 | | | | | | | 1 |
| 230 | | | | | | | 1 |
| 270 | | | | 1 | | | |
| 290 | | | 1 | | | | |
| 340 | | | | | | | 1 |
| 410 | | | 1 | | | | |
| B. Sea | | | | | | | 2 |

**Summer recoveries from transition period releases**

| Area Released | Area Recovered | | |
|---|---|---|---|
| | 009 | 030 | 050 |
| 100 | | 1 | 6 |
| 102 | 2 | 1 | 5 |

**Summer Recoveries from Winter Releases**

| Area Released | Area Recovered | |
|---|---|---|
| | 020 | 050 |
| 160 | 1 | 1 |
| B. Sea | 1 | 1 |

**Transition period recoveries from summer releases**

| Area Released | Area Recovered | |
|---|---|---|
| | 007 | 050 |
| 060 | | 1 |
| 102 | | 1 |
| 113 | | 1 |
| 133 | 1 | |

**Transition period recoveries from transition period releases**

| Area Released | Area Recovered |
|---|---|
| | 007 |
| 340 | 1 |

**Transition period recoveries from winter releases**

| Area Released | Area Recovered |
|---|---|
| | 050 |
| B. Sea | 1 |

**Winter recoveries from summer releases**

| Area Released | Area Recovered |
|---|---|
| | 008 |
| 112 | 1 |

**Table 8. Tag recovery data summary for halibut smaller than 65 cm recovered but not released in Area 2A, 1960-1986.**

**Summer recoveries from summer releases**

| Area Released | Area Recovered | | | | | | |
|---|---|---|---|---|---|---|---|
| | 007 | 008 | 009 | 010 | 020 | 040 | 050 |
| 060 | | | | | | | 1 |
| 091 | | | | 1 | | | 1 |
| 112 | | | | | | | 1 |
| 132 | | | | | | 1 | 2 |
| 170 | | | | | | | 1 |
| 220 | | | | 1 | | | |
| 261 | 1 | | | | 1 | | 1 |
| 270 | 1 | 1 | 1 | 1 | | 4 | 7 |
| 290 | | | | | | | 1 |
| B. Sea | | | | 1 | 1 | | |

**Summer recoveries from winter releases**

No Recoveries from Winter Releases

**Transition period recoveries from summer releases**

| Area Released | Area Recovered | | | |
|---|---|---|---|---|
| | 007 | 008 | 030 | 040 |
| 112 | 1 | | | |
| 261 | | | 1 | |
| 270 | 1 | 1 | | 1 |

**Winter recoveries from summer releases**

| Area Released | Area Recovered | | |
|---|---|---|---|
| | 007 | 050 | 060 |
| 220 | | 1 | |
| 270 | 1 | | 1 |

**Winter recoveries from winter releases**

No Recoveries from Winter Releases

the area of release, but with a higher degree of movement. Ten (52.6%) of 19 recoveries stayed within one statistical area of release, two moved south from Washington to Oregon, and seven (36.8%) moved north from Oregon to between northern Vancouver Island and central Alaska. Only two tags were recovered during winter, both released and recovered in central Oregon; one fish was sublegal when released and recovered within a year, and the other was legal and recaptured after three months.

Fish smaller than 65 cm tagged in Area 2A during summer provide little information, as only 11 tags were recovered. Nine tags were recovered within one statistical area of release, one released in Oregon was recovered in Washington, and one released in Washington was recovered in the Gulf of Alaska.

The paucity of historical winter tagging data makes conclusions on spawning/feeding migrations hard to evaluate for Area 2A, although winter recoveries from the central Oregon tagging experiment provide additional information. Twenty winter recoveries were made in Oregon, and one was made in Washington. These recoveries suggest that spawning may occur in Oregon or Washington. Such a conclusion is very weak, as no sexual maturity information was collected with the tag recoveries.

**Table 9. Tag recovery data summary for halibut 65 cm or larger released in Area 2A, 1960-1986.**

**Summer recoveries from summer releases**

| Area Released | Area Recovered | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 007 | 008 | 009 | 010 | 020 | 030 | 050 | 060 | 102 | 130 | 141 |
| 007 | 16 | | 1 | | | | | | | 1 | |
| 008 | | 5 | 1 | | | | | | 1 | | 1 |
| 009 | 1 | | 1 | | | | | | | | |
| 020 | | | | 2 | 1 | | | | | | |
| 030 | | | | | | 1 | | 1 | | | |
| 050 | | | | | | | 17 | 8 | 1 | | |

Summer recoveries from transition period releases

| Area Released | Area Recovered | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 007 | 008 | 010 | 020 | 050 | 090 | 102 | 150 | 170 | 200 |
| 008 | 1 | | | | | | | | | |
| 009 | | | | | | 1 | | 2 | | 1 |
| 010 | | | 6 | | | 1 | 1 | | 1 | |
| 020 | | | | 1 | | | | | | |
| 050 | | 1 | | 1 | 1 | | | | | |

**Transition period recoveries from summer releases**

| Area Released | Area Recovered | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 007 | 008 | 009 | 010 | 030 | 050 | 070 | 090 | 110 | 140 |
| 007 | 2 | | | | | | | 2 | | |
| 008 | | 3 | | | | 1 | | | | |
| 009 | | | 1 | | | | | | | |
| 010 | | | | 2 | | | | | 1 | 1 |
| 020 | | | | | 1 | | | | | |
| 030 | | | | | 3 | | | | | |
| 050 | | | | | | 1 | 1 | | | |

**Winter recoveries from summer releases**

| Area Released | Area Recovered |
|---|---|
| | 007 |
| 007 | 2 |

**Transition period recoveries from transition period releases**

| Area Released | Area Recovered |
|---|---|
| | 009 |
| 009 | 1 |

Of the winter recoveries, only eight were legal-sized, and most of these were of a size that could either be mature or immature. St-Pierre (1984) referenced a report by a halibut fisherman of spawning off Destruction Island, Wash. in 1925. Two years of ichtyoplankton surveys near the end of the halibut spawning season (March-April in 1984 and April-May in 1985) off the coast of Washington and Oregon found several halibut eggs (David S. Savage, National Marine Fisheries Service, Seattle, unpublished data). Collection of maturity data from halibut during winter would help resolve the issue.

In spite of inconclusive tagging data, minimal previous observations of spawning

grounds or nursery grounds in Area 2A support a conclusion that most adult halibut in Area 2A migrate to British Columbia waters for spawning. Even though no active search for halibut spawning or nursery grounds has been conducted in Area 2A, research and commercial fishing activities have had opportunity to find and report such grounds. For example, six years of research trawling in Grays Harbor, Willapa Bay, and adjacent coastal waters found no halibut larvae or young of the year (Gunderson et al. 1990).

### Movement of Halibut through Subarea 2A-1

No studies have been conducted for Pacific halibut to determine the path of seasonal migrations. However, information from the general biology may be used to provide a probable pattern. Halibut tend to move from summer feeding grounds on the continental shelf to deeper water on the continental slope, usually during the autumn. In spring, halibut return from deeper water to the shelf. The spring and autumn periods are most likely periods for the halibut to migrate between summer feeding grounds and winter spawning grounds. In general, then, one would expect the majority of the seasonal migration to occur along the continental slope. Seven tags from the 1989 central Oregon tagging experiment were recovered during the transition period, all but one at depths greater than 130 fathoms. While these data are too few to establish a migratory route, they are consistent with an hypothesis of migration on the continental slope.

Whether the halibut migrate along the slope or shelf, the distance travelled from central Oregon to the spawning grounds off British Columbia is substantial. We have no conclusive data that the fish move quickly through the areas in between, or move slowly over a longer period of time during the transition period. One halibut tagged during the 1989 central Oregon tagging experiment was recovered four months later near the north end of Vancouver Island (almost 400 nm), and another was recovered off Cape Spencer (almost 800 nm) five months later. Movement from summer grounds in statistical areas 020 or 030 to spawning grounds in statistical area 110 (most spawning areas are substantially further north) would pass nine or 10 other statistical areas, two of which (040 and 050) are in Subarea 2A-1. About 20 per cent of the migratory time could be expected to occur in Subarea 2A-1.

## EFFECT OF BYCATCH

Pacific halibut spawn along the upper continental slope. Spawning grounds extend from the coast of British Columbia into the Bering Sea, but are most concentrated in the central Gulf of Alaska. Eggs and larvae drift with ocean currents to the north and west of the spawning grounds. Larvae settle to the ocean floor in shallow water and metamorphose into the typical form. Subsequently, the juvenile halibut migrate to the east and south, countering the effects of egg and larval drift. During the countermigration, the juvenile halibut are vulnerable to interception by fisheries targeting other species. Details of the biological and management impacts of migration are provided in a document prepared by the IPHC staff for the North Pacific Fishery Management Council[2]. Although the procedures for calculating impacts of bycatch

[2]Juvenile halibut migration and bycatch management implications. Unpublished report by the IPHC staff to the North Pacific Fishery Management Council. 1988.

have been revised, the report contains necessary concepts and entry to the literature.

Migratory juvenile halibut are vulnerable to bycatch in fisheries directed at other species. Bycatch mortality currently amounts to about 21 million pounds of lost yield to the directed halibut fishery (bycatch mortality of 13.2 million pounds in 1989, times 1.6 to account for growth of the juveniles and lost reproductive value). Of that quantity, some portion will be lost to the fisheries in Area 2A. Migration rates of juvenile halibut are not well enough known to precisely apportion the effects of lost yield to the management area in which the loss will occur. The IPHC currently apportions bycatch loss in proportion to the exploitable biomass in each management area, using the rationale that most juveniles must go to areas with the largest biomass to maintain the abundance, and fewer will go to less populated areas. The apportionment process is under evaluation for future improvements.

It is very difficult to make precise estimates of the effects of bycatch on the commercial-sized component of halibut stocks because bycatch is largely made up of younger migrating halibut. Growth, mortality, and migration greatly complicate the estimation procedures. Migration rates of juvenile halibut are not well known, so the impact of bycatch of juvenile halibut from specific areas on adult populations in those or other areas must be estimated indirectly.

Bycaught halibut are generally smaller than those harvested by the directed fishery. Consequently, factors such as maturity, reproductive capacity, survivorship, and growth substantially affect stock productivity. By allowing small halibut to remain at large for a longer period of time, a net gain in stock biomass occurs due to the greater cumulative gain in individual weight relative to losses incurred due to mortality. Smaller fish are less likely to be reproductively mature, and have less reproductive capacity. Those harvested earlier in their life history not only contribute less in terms of short term yield, but they also contribute less to the maintenance of future stock biomass or to future yields. Bycatch losses affect recruitment, future catch, and future reproductive potential of the stock.

In 1990, the IPHC staff improved its method of compensating for bycatch[3]. The new approach is to reduce harvest in the directed fishery such that the reproductive potential of the exploitable component of the stock would be the same after bycatch as it would have been if bycatch had not occurred. The compensation factor, which is multiplied times bycatch to calculate the amount of catch limit reduction in the directed halibut fishery, was determined to be 1.0.

Impact on the directed halibut fishery consists of two parts: (1) the catch limit reduction to maintain reproduction, and (2) reduced recruitment to the directed halibut fishery from bycatch of pre-recruits.

> (1) Catch limit reduction to compensate for bycatch immediately deprives the directed fishery of one mt of yield for each mt of bycatch the previous year. But this amounts to leaving fish in the stock rather than catching them right away, and some are caught in later years. On the average, about 0.6 mt of each mt reduction in catch limit is eventually caught, so the net impact of reproductive compensation is 0.4 mt of lost harvest per mt of bycatch.

[3]Sullivan, P.J. Bycatch and adult reproductive compensation. Internat. Pac. Halibut Comm. 1989 Stock Assessment Document III. 1990.

(2) Bycatch eventually reduces recruitment to the directed fishery, and amounts to 1.2 mt of lost yield for each mt of bycatch.

The combined effects of reproductive compensation and lost recruitment shows a net loss to the directed fishery of 1.6 mt for each mt of bycatch: 0.4 mt from reproduction compensation and 1.2 mt from reduced recruitment.

If the reproductive compensation is done correctly and if the bycatch is estimated correctly, the halibut spawning stock size will remain in the same condition whether bycatch occurs or not. The directed halibut fishery pays for maintenance of the resource through lower catches.

For the 1990 fishery in Area 2A, preliminary values are 0.09 million pounds in catch limit reduction for reproductive compensation, but 0.14 million pounds of loss to fishermen.

With existing summer fishing seasons, the directed halibut longline fishery in Alaska or British Columbia has little effect on the abundance in Area 2A because legal-sized halibut migrate only to a limited degree from summer to summer. However, tagging data indicate that the interception of adults migrating to or from spawning grounds could occur if longline fishing occurred during the transition and winter periods.

## STOCK ASSESSMENT

The basic methods of stock assessment for Pacific halibut are presented in Quinn et al. (1985). Updated assessments are provided annually in an IPHC Stock Assessment Document[4]. Data from Area 2A are weak because only small quantities of fish are involved and only a small number of observations are available. Although Area 2A data are statistically adequate, the data are combined with Area 2B data for assessment purposes to increase reliability of the estimated exploitable biomass. Area 2A is apportioned from the Area 2A-2B pool using habitat area weighted by CPUE.

Results of IPHC stock assessment for Area 2A have not been well accepted because the quantity of fish in the harvest seemed too high to be compatible with estimated exploitable biomass. A review of stock assessment methodology applied separately to Area 2A (Clark, Section II of this report) concluded that any estimation errors were likely small, and that harvest has been higher than the acceptable rate set for the stock as a whole. Clark determined that, given existing fishery data, exploitable biomass cannot be significantly higher than 1.5 million pounds. At the standard exploitation of 0.35, resulting harvest is 525,000 pounds. Actual exploitable biomass and appropriate harvest are probably lower, in the vicinity of one million pounds and 350,000 pounds, respectively.

Of the available data, commercial fishery catch per unit effort (CPUE) is the best proxy for recent values of exploitable biomass, but is not exactly proportional to the exploitable biomass calculated from the IPHC stock assessment model. CPUE is calculated as pounds per standard skate of longline gear. The CPUE values, uncorrected to standard skates, by statistical area in Area 2A from 1981 to 1988 are presented in Table 10. Because of the low amount of logbook catch data used to

[4]e.g. Sullivan, P.J., P.R. Neal, and B. Vienneau. Population assessment, 1989. Internat. Pac. Halibut Comm. 1989 Stock Assessment Document IV. 1990.

**Table 10. Commercial CPUE (not standardized) and logbook catch by statistical area in Area 2A and part of Area 2B.**

**a. CPUE by statistical area**

| YEAR | REGULATORY AREA 2A | | | | | PART OF 2B | |
|---|---|---|---|---|---|---|---|
| | 010 | 020 | 030 | 040 | 050 | 060 | 070 |
| 1981 | 85.8 | 22.3 | 24.7 | | 103.1 | 104.8 | 214.1 |
| 1982 | | 12.9 | 17.2 | 38.7 | 86.0 | 117.8 | 153.0 |
| 1983 | 179.1 | 55.4 | 60.9 | 71.9 | 102.3 | 145.0 | 78.2 |
| 1984 | 100.3 | 90.6 | 22.1 | 45.4 | 47.7 | 92.9 | 14.0 |
| 1985 | 56.4 | 63.8 | | | 59.8 | 101.0 | 189.8 |
| 1986 | 106.1 | 108.8 | 15.5 | 38.0 | 42.3 | 149.5 | 89.0 |
| 1987 | 50.0 | 63.2 | 29.8 | 25.8 | 5.2 | 105.6 | |
| 1988 | 50.9 | 31.7 | 84.9 | 42.0 | 30.6 | 95.7 | 85.5 |

**b. Logbook catch (in pounds) used to calculate CPUE**

| YEAR | REGULATORY AREA 2A | | | | | PART OF 2B | |
|---|---|---|---|---|---|---|---|
| | 010 | 020 | 030 | 040 | 050 | 060 | 070 |
| 1981 | 2,489 | 201 | 1,505 | | 20,208 | 13,524 | 26,550 |
| 1982 | | 103 | 310 | 620 | 19,783 | 49,229 | 15,601 |
| 1983 | 5,553 | 776 | 670 | 1,798 | 15,246 | 24,212 | 4,690 |
| 1984 | 44,914 | 22,555 | 951 | 1,862 | 77,226 | 97,450 | 126 |
| 1985 | 24,364 | 9,375 | | | 110,319 | 46,370 | 16,136 |
| 1986 | 49,102 | 60,180 | 170 | 12,419 | 30,738 | 118,980 | 62,401 |
| 1987 | 26,593 | 23,384 | 1,910 | 2,171 | 145 | 71,178 | |
| 1988 | 25,286 | 81,509 | 19,361 | 9,034 | 16,561 | 105,377 | 32,650 |

calculate CPUE, and because logbook effort has not been standardized, caution must be used in application of the values. The relatively small number of commercial fishermen in Area 2A and fishing success that depends to a large degree on finding a "hot" spot cause CPUE data to be more variable than in other IPHC management areas. Therefore, as data are subdivided, they become increasingly more inaccurate as an indicator of abundance. However, statistical areas 010 and 020 tend to have higher CPUE values than those found in statistical areas 040 and 050 in recent years during the period of high exploitation. The southern part of Area 2A has CPUE values roughly comparable to CPUE in the southern part of Area 2B.

CPUE in the recreational fishery (Table 11) has been monitored most accurately only since 1987, so time trends are not available. Recreational fishing tends to occur at selected spots rather than being widespread throughout the region, and is unlikely to represent the resource distribution for the subarea as a whole. Therefore, recreational CPUE data may not be a good indicator of overall abundance. The limited available data suggest that 1987-1989 average CPUE in the recreational fishery is highest off the north coast of Washington, followed by Oregon, with Puget Sound the lowest. In 1989, the Oregon sport fishery was managed with a 32 in minimum size limit with a second fish allowed if larger than 50 in. These Oregon restrictions reduced the 1989 CPUE below that of an unconstrained fishery.

According to the model results presented by Clark in Section II, recruitment, which nearly tripled since 1974, and increased fishing mortality have maintained the fishery. Fishery production can withstand the high exploitation rate if recruitment

**Table 11. Recreational catch of halibut (fish) per angler trip for Oregon and Washington, 1987-1989.**

| YEAR | OREGON | WASHINGTON | |
|---|---|---|---|
| | | Puget Sound | North Coast |
| 1987 | 0.71 | 0.14 | 1.25 |
| 1988 | 0.94 | 0.05 | 1.20 |
| 1989 | 0.89* | 0.05 | 1.23 |

* minimum size limits applied in Oregon.

continues at recent levels. However, decreased recruitment, which may or may not result from the high exploitation, would lead to declining production and lower catches if biomass is to remain near the same level. In Alaska waters, strong recruitment was a primary cause in the rapid increase in exploitable biomass which supported near-record harvest levels. High exploitation in Area 2A has prevented the recruitment from leading to an increased exploitable biomass. Recruitment peaked in 1985, was stronger from 1984 to 1988 than during other recent years, and dropped substantially in 1989[4]. Exploitable biomass also decreased slightly in 1987 and 1989 from a peak in 1986.

## POSSIBILITY OF LOCAL DEPLETION

High exploitation rates in Area 2A tend to prevent strong recruitment from building up stock abundance, and will deplete the stock when recruitment declines. Area 2A exploitable biomass is currently about half the biomass at MSY, and likely to decline further. Thus, local depletion in this area is a management concern.

The larval drift-countermigration hypothesis and limited tagging data suggest that recruitment of halibut to Area 2A depends on migration from Alaska and British Columbia waters. One may speculate that nursery grounds in the Gulf of Alaska are the predominant source. Travel through Alaska and British Columbia waters poses an interception hazard to migrating halibut. No information exists to suggest that halibut in Area 2A are separate from halibut in other areas. In the long term, productivity of Area 2A is largely dependent on the amount of recruitment originating in other areas.

Once halibut arrive in Area 2A, they appear to establish a home ground during summer, from which straying is typically less than 100 miles: tagging data show that most tags released in summer are recovered during summer within one statistical area of release. The tagging data suggest that a redistribution over a small scale (<100 miles) occurs throughout the season, but that redistribution within the whole of Area 2A is unlikely. Because fishing occurs in the summer, local depletion is a high probability if harvest is disproportionate to biomass distribution. The degree of harvest imbalance will determine the degree of local depletion.

Within Area 2A, fishing effort is concentrated rather than spread evenly, and local depletion of subareas seems probable. The most intensively fished areas are off northern Washington and off central Oregon. We have examined data on historical catch, habitat distribution, recent commercial CPUE, and recent sport CPUE to evaluate the probability of local depletion within Area 2A. While these data must be used cautiously, all but sport data indicate that higher than proportional harvest is

occurring off northern Washington.

Habitat distribution and long term catch records suggest that approximately 60% of the halibut resource is distributed off central Oregon, with 40% off northern Washington (Table 2). The Halibut Commission has not evaluated quality of habitat that may affect the distribution of resource. Plots of fishing locations used to define habitat may include areas of exploratory fishing with little or no catch as well as prime fishing grounds. Consequently, all habitat is considered equal, even though variable quality is likely the case. Averages of the historical catch records are a good representation of long term resource distribution if exploitation patterns are comparable for the entire period. Comparability may not be entirely the case, as exploitation began earlier off the northern Washington coast than off Oregon. This difference may not be significant because the catch off Washington has fluctuated without trend since the data series began, while Oregon catch declined consistently.

National Marine Fisheries Service triennial bottom trawl surveys off Washington, Oregon, and California also suggest lower quantities of halibut off northern Washington than in the remainder of Area 2A for survey years 1980, 1983, 1986, and 1989[5]. The trawl survey estimates total biomass, including sublegal halibut, while IPHC stock assessment estimates exploitable biomass. In both 1986 and 1989 trawl surveys, about 30 percent of the total Washington-Oregon biomass was in northern Washington. Biomass distribution was more variable in 1980 and 1983, at 20 and 40 percent, respectively.

Commercial CPUE data in Area 2A are inherently variable and only a small amount of unstandardized logbook data are available (Table 10). CPUE data since 1981 suggest that halibut density is higher off Oregon than off Washington, especially during most recent years, although high variability means that differences cannot be shown statistically significant. CPUE in the recreational fisheries is available for Oregon only since 1987, and is most reliable in Washington during these years (Table 11). However, recreational fishing tends to occur at selected spots rather than being widespread throughout the region, and is unlikely to represent the resource distribution for the subarea as a whole. The Oregon sport fishery is centered off Newport, and CPUE there is comparable to the CPUE off northern Washington where the sport fishery is longest established. Within Washington, popular sport fishing areas off Neah Bay and in the Strait of Juan de Fuca appear to have greatly different fishing success, with recreational CPUE about 20 times higher at Neah Bay, and declining in the Strait. However, many halibut in the Strait of Juan de Fuca are caught incidentally when fishing for other species, so CPUE values are not exactly comparable to directed sport harvest values.

The IPHC policy of distributing harvest proportionally to biomass in management areas specifically works to minimize local depletion. Local depletion in an area with a mobile fleet is of little management concern, because the fleet will redistribute to higher density regions while migration fills in the depleted localities. However, fleets with little or no mobility depend on management and regulation to keep stock abundance in balance. In the case of Area 2A, sport and treaty Indian fisheries have limited mobility. Some components of the non-treaty commercial fishery are highly mobile, but many of the small boats are unable to effectively move between regions

[5]Coleman, B.A. 1988. Pacific west coast survey of groundfish resources: estimates of distribution, abundance, length and age composition. NOAA Tech. Memo. NMFS/NWC 152; and unpublished results from National Marine Fisheries Service.

of Area 2A. Similarly, sport fisheries are locally mobile. For example, the sport fishery in Washington moves between Puget Sound and the north Washington coast, and to Canadian waters near the British Columbia-Washington boundary. The Washington sport fishery, however, appears to have little exchange with Oregon.

Harvest quantities by region within Area 2A by treaty Indians and the sport fisheries can be controlled through existing allocation procedures. The Indian fisheries occur in a usual and accustomed area (U&A) tentatively based on previous court rulings. Allocation to the sport fishery is subdivided into several regions by the Pacific Fishery Management Council. Only the non-treaty commercial fishery is able to harvest halibut in Area 2A without regard to region.

The treaty Indian fisheries and a major component of the sport fishery take place off the northern Washington coast (Area 2A-1) with a predetermined harvest allotment. Depending on the magnitude of these fisheries and the proportion of the non-treaty commercial fishery that occurs off the northern Washington coast, this is the most likely area to experience local depletion. Within Area 2A-1, the Strait of Juan de Fuca may experience even higher exploitation, based on the very low recreational CPUE values there. For the northern Washington coast, historical harvests (Table 2) and habitat area (Table 6) indicate that about 40% of the resource during the time of traditional harvest may be in Area 2A-1 (80% of statistical area 04, 05 including Puget Sound, and the U.S. portion of 06). CPUE is also lower in Area 2A-1 than in waters to the south (Table 10). However, since 1985, about two thirds of the removals have been from Area 2A-1 (Table 4).

Stock assessment for Area 2A was conducted separately from Area 2B in 1988, but no analyses have been done for subareas of Area 2A. Data are inadequate for separate subarea analyses, and would be marginal even with substantially enhanced monitoring of catch per effort and age composition. Such enhancement would add major costs to Area 2A stock assessment. No information is currently available to determine if the northern Washington coast is actually experiencing local depletion, although commercial CPUE appears lower off Washington than off Oregon. Stock assessment results show that overfishing has occurred in Area 2A (exploitation rates significantly higher than 0.35), and that stock abundance levels have been maintained by high recruitment. The combination of high exploitation and high recruitment to Area 2A may confound interpretations of abundance patterns in subareas.

## SUMMARY AND MANAGEMENT IMPLICATIONS

The IPHC is not directly involved with domestic allocation in the U.S., for which NOAA assigned responsibility to the applicable regional fishery management council. Allocation requirements are incorporated in IPHC regulations. The IPHC has authority to establish management areas, which could apply to allocation-based areas if determined necessary.

Current IPHC management areas are not established to separate stock components, although the Area 2-Area 3 boundary was originally thought to do so. The Areas have biological implications, and are used to distribute harvest in proportion to the distribution of harvestable biomass. Local depletion is possible by over exploitation.

Management areas have varied off Washington-Oregon-California according to management philosophy of the time. A line at Willapa Bay has been inserted and deleted several times. The justification was largely for enforcement or management purposes.

Commercial catch has a long history in Area 2A. A long term decline has occurred, with most of the reduction occurring off Oregon. Sport and modern tribal harvest has occurred mostly in the past 10 years.

The average historical commercial catch is distributed roughly the same as the fishing grounds, with an important area on the northern Washington coast, and an important area off central Oregon. A clear break occurs in both fishing grounds and catch in the vicinity of Willapa Bay, including southern Washington and northern Oregon.

Tag recovery data shows a widespread origin of halibut in Area 2A, and includes tags released in the Bering Sea and the Aleutian Islands. The majority of recovered fish released at less than 65 cm length were released in the Kodiak Island area, while many recovered fish released at larger sizes were released in British Columbia waters.

Once in Area 2A, little summer to summer movement is evident between statistical areas. However, movement is evident within a subarea. Halibut apparently do not redistribute between Washington and Oregon areas, so local depletion is possible. Available data do not allow firm conclusions on spawning migrations; Area 2A halibut probably spawn in Area 2B or further north, but a weak case may be made for spawning in Area 2A.

Distribution of harvest in Area 2A has not been proportional to the average productivity of subregions estimated from habitat and historical catch. However, there is little basis for assessing current resource distribution.

The limited mobility of most of the Area 2A fisheries and the harvests that resulted from allocation decisions based on non-biological factors suggest that disproportional harvest is likely unless the area is subdivided. However, any increase in total yield from the resource as a result of subdivision is probably small. Subdivision of Area 2A would add additional costs associated with management and reduce precision of stock assessment, particularly if separate stock assessment were required for the subareas. The data for stock assessment are poor relative to data in other areas, but adequate for a pooled assessment with Area 2B. Separate stock assessments within Area 2A would have inadequate data. A separate stock assessment for Area 2A may be feasible, but stock assessment for subareas is not.

If Area 2A were to be subdivided, the most appropriate location would be within statistical area 040, which represents a low density region in the halibut distribution. Selection of a specific boundary may depend on the justification for a subdivision, so a boundary recommendation is not given in this report.

Historical catches or habitat are reasonable measures of long term resource distribution until better assessment data are available. Catch limits based on long term distribution may prevent serious local depletion even though the historical division is not necessarily appropriate at all times.

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## LITERATURE CITED


Babcock, J.P., W.A. Found, M. Freeman, and H. O'Malley. 1931. Report of the International Fisheries Commission appointed under the Northern Pacific Halibut Treaty. Internat. Fish. Comm., Rept. No. 1. 31 pp.

Bell, F.H. 1969. Agreements, conventions and treaties between Canada and the United States of America with respect to the Pacific halibut fishery. Internat. Pac. Halibut Comm., Rept. No. 50. 102 pp.

————, and E.A. Best. 1968. The halibut fishery south of Willapa Bay, Washington. Internat. Pac. Halibut Comm., Rept. No. 48. 36 pp.

Bell, F.H., H.A. Dunlop, and N.L. Freeman. 1952. Pacific coast halibut landings 1888 to 1950 and catch according to area of origin. Internat. Fish. Comm., Rept. No. 17. 47 pp.

Best, E.A. 1977. Distribution and abundance of juvenile halibut in the southeastern Bering Sea. Internat. Pac. Halibut Comm., Sci. Rept. No. 62. 23 pp.

Gunderson, D.R., D.A. Armstrong, Y. Shi, and R.A. McConnaughey. 1990. Patterns of estuarine use by juvenile English sole (*Parophrys vetulus*) and Dungeness crab (*Cancer magister*). Estuaries 13(1): 59-71.

Hoag, S.H., R.J. Myhre, G. St-Pierre, and D.A. McCaughran. 1983. The Pacific Halibut resource and fishery in Regulatory Area 2: 1. Management and biology. Internat. Pac. Halibut Comm., Sci. Rept. No. 67. pp. 5-54.

International Fisheries Commission. 1949. Regulation and investigation of the Pacific halibut fishery in 1948. Internat. Fish. Comm., Rept. No. 14. 30 pp.

International Pacific Halibut Commission. 1963. Regulation and investigation of the Pacific halibut fishery in 1962. Internat. Pac. Halibut Comm., Rept. No. 33. 27 pp.

————. 1986. Annual Report 1985. 59 pp.

————. 1987a. Annual Report 1986. 73 pp.

————. 1987b. The Pacific halibut: Biology, fishery and management. Internat. Pac. Halibut Comm., Tech. Rept. No. 22. 59 pp.

————. 1988. Annual Report 1987. 51 pp.

————. 1989. Annual Report 1988. 62 pp.

Myhre, R.J. 1974. Minimum size and optimum age of entry for Pacific halibut. Internat. Pac. Halibut Comm., Sci. Rept. No. 55. 15 pp.

Quinn, T.J. II, R.B. Deriso, and S.H. Hoag. 1985. Methods of population assessment of Pacific halibut. Internat. Pac. Halibut Comm., Sci. Rept. No. 72. 52 pp.

Skud, B.E. 1975. The sport fishery for halibut: development, recognition and regulation. Internat. Pac. Halibut Comm., Tech. Rept. No. 13. 19 pp.

————. 1977a. Drift, migration, and intermingling of Pacific halibut stocks. Internat. Pac. Halibut Comm., Sci. Rept. No. 63. 42 pp.

————. 1977b. Regulations of the Pacific halibut fishery, 1924-1976. Internat. Pac. Halibut Comm., Tech. Rept. No. 15. 47 pp.

St-Pierre, G. 1984. Spawning locations and season for Pacific halibut. Internat. Pac. Halibut Comm., Sci. Rept. No. 70. 46 pp.

Thompson, W.F., H.A. Dunlop, and F.H. Bell. 1931. Biological statistics of the Pacific halibut fishery. Internat. Fish. Comm., Rept. No. 6. 108 pp.

————, and N.L. Freeman. 1930. History of the Pacific halibut fishery. Internat. Fish. Comm., Rept. No. 5. 61 pp.

————, and R. Van Cleve. 1936. Life history of the Pacific halibut. (2) Distribution and early life history. Internat. Fish. Comm., Rept. No. 9. 184 pp.

Trumble, R.J., I.R. McGregor, G. St-Pierre, D.A. McCaughran, and S.H. Hoag. 1990. Sixty years of tagging Pacific halibut: a case study. [IN] Proceedings of the International Symposium and Educational Workshop on Fish Marking Techniques. Amer. Fish. Soc. Sympos. 7: 831-840.

# II. Critique of the Area 2A Stock Assessment

by

William G. Clark

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## INTRODUCTION

For the last year or two, the staff's assessment of halibut in Area 2A has been received with great skepticism, because it appeared that the estimates of exploitable biomass and potential yield were unreasonably low in comparison with historical and recent catches. The purpose of this section is to make an exhaustive appraisal of every factor that could possibly produce an underestimate of exploitable biomass in Area 2A, both to provide some measure of the credibility of the staff's point estimates and to indicate what the upper limits must be on any credible estimates.

As in other areas, the stock assessment is performed by fitting an age-structured model of the stock and the fishery to time series of catch, catch per effort, and age composition data for the years 1974-1988. During that period, commercial catches declined from a few hundred thousand pounds per year to practically nil in 1980. The decline was caused by management practices. From 1967 to 1980, all of Area 2 was managed as a single unit that closed together. The best fishing occurred in the northern part of Area 2, where mobile fishermen participated. The relatively few days of fishing caused the area to close before fishermen had an opportunity to move to the slower fishing in what is now Area 2A. Since Area 2A was separated from the northern areas in 1981, commercial catch has recovered. Setline catch per effort has been steady. At the beginning of the series the age composition resembled areas to the north, with good numbers of older fish, but in recent years the age compositions have been increasingly dominated by young fish. Sport catches have increased dramatically since about 1983.

The model reconciles the changing age composition and unchanging catch per effort by estimating higher levels of both recruitment and fishing mortality in recent years, and only a slightly lower level of exploitable biomass. This is also the common sense implication of the data. Three closely related methods of estimation produce an average estimate of not much more than a million pounds of exploitable biomass at the beginning of 1988, implying total yields of 300-500,000 pounds.

There are a number of features of the data and the estimation procedure that could bias the estimates. These are considered in detail below, and their possible effects are determined by recomputing the estimates. All of the estimates in this paper are obtained with closed area catch-at-age analysis using only data from Area 2A.

## TREATMENT OF RECREATIONAL CATCHES

In all of the Commission's standard assessments, sport catches are simply ignored when exploitable biomass is estimated, which is reasonable so long as they are small in relation to commercial catches and natural mortality. In Area 2A, they have become significant in the last few years, so one must expect the standard biomass estimates to be significantly lower than they would be if sport catches were considered along with commercial removals.

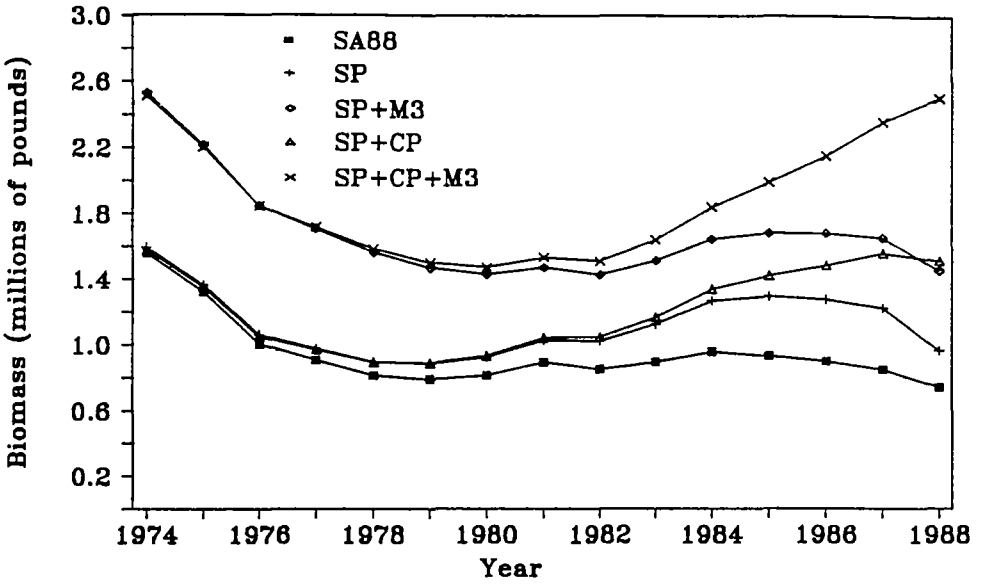


**Figure 1. Area 2A exploitable biomass.**

The size of this effect is shown in Figure 1. There the lower line, labeled "SA88" (for Stock Assessment 1988) is the stock history estimated by the standard closed area analysis which shows an exploitable biomass at the start of 1988 of only about 800,000 pounds, hardly more than the estimated 1988 removals of 750,000 pounds. The next line up, labeled "SP" (Sport), is the fit obtained when 75 percent of the sport catch (the proportion above 32″ in length) is added to the commercial catch and effort is increased proportionately so as to preserve the value of catch per effort. The age composition of the commercial fishery is used for the sport fishery, as no age structures are collected. However, the size composition of the two fisheries is similar, except for about 25 percent of the sport catch that would be sublegal size for the commercial fishery. The majority of this smaller category is close to the 32 in minimum commercial size. As expected, this effect of including sport catch is significant, but it is not large.

## CHOICE OF SELECTIVITIES

Part of the estimation procedure is determining age-specific selectivities. In practice one set of selectivities is estimated when fitting the model to each area's data, but another, standard set is used to compute exploitable biomass. Since young fish are so common in Area 2A catches, it seems likely that the standard selectivities could be understating the actual Area 2A values and therefore producing an underestimate of the exploitable biomass.

This is not the case. The estimated selectivities for Area 2A are nearly identical to the standard set, so the biomass estimate is the same. Selectivities are unlikely to be affected by use of sport harvest data, because there is less deviation in the size composition between the sport fishery and commercial fisheries in Area 2A than between the commercial fisheries in Area 2A and the coast-wide average.

## CHANGE IN SELECTIVITIES

The age-structured model is fitted on the assumption that age-specific selectivities were constant throughout the period covered by the data. In Area 2A there has been an increase in the use of sablefish gear in recent years, and 1988 data shows a higher frequency of young fish in catches by sablefish gear in Area 2A. The shift in age composition may therefore be an artifact of change in fishing gear or fishing practices. (The only other area where sablefish gear is important is Southeast Alaska, and in the much larger sample from that area there is no difference in catch composition by gear type).

A change in selectivities can be accommodated by dividing the data series and estimating different selectivities for each part. Doing so in the case of Area 2A does in fact produce higher estimated selectivities for younger fish in recent years, but hardly any increase in the estimate of 1988 exploitable biomass computed with those selectivities, because now the estimated level of recruitment is lower.

It is also significant that the biomass estimate in 1980 obtained from the early data alone is almost the same as the estimate obtained from the entire undivided 1974-88 data set. This means that the data from the years with a consistent fishery indicate the same level of stock biomass as is indicated by the 1988 assessment.

## CHANGE IN CATCHABILITY

The model assumes constant catchability. In recent years there have been new entrants into the fishery, an increase in the use of sablefish gear, and some trips in which both halibut and sablefish were target species. In these conditions, there could be a drop in halibut catch per effort in the absence of a real decline in abundance or, equivalently, a failure of catch per effort to increase despite a real increase in halibut abundance.

To check on the last possibility, logbook data were assembled on all vessels that fished the same gear and strategy in Area 2A in two or more of the years 1974-1988, and a generalized linear model (GLM) was fitted to the data to determine year-to-year changes in CPUE adjusted for the effects of vessel, gear, and fishing strategy. The CPUE values so obtained are shown as "2A GLM" along with the standard CPUE values ("2A") in Figure 2. The two series are in close agreement for 1984-1987. Both roughly double in 1988 with the linear model CPUE rising to a level exceeding the highest catch rates ever observed (in the 1950s). Since there is no sign of an upsurge in catch rates in Area 2B, which still has a consistent halibut fishery, it is very unlikely that this 1988 value from the linear model is correct.

The standard CPUE appears much more credible in comparison. It should be noted that the parameter estimates from the linear model have a coefficient of variation of about 30%, and the standard CPUE is somewhat different.

While a careful examination of the CPUE data does not suggest any undetected increase in CPUE in the last few years, it is of interest to determine what effect such an increase would have on the estimate of exploitable biomass in 1988. The CPUE values labeled "2A ART" (for ARTificial) in Figure 2 suppose a linear increase in CPUE from 1986 to the historic high of about 200 lbs/skate in 1988. The corresponding fit of the age-structured model is labeled "SP+CP" in Figure 1. Evidently, a sharp increase in CPUE in recent years would increase the 1988 biomass estimate by about 400,000 pounds.

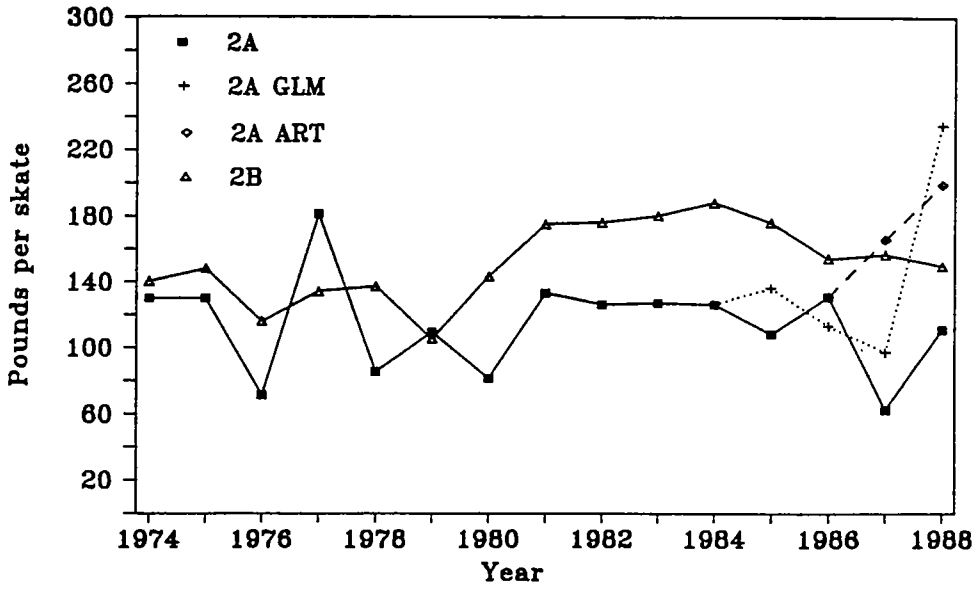


**Figure 2. Area 2A/B catch per effort.**

## DIFFERENT VALUE OF NATURAL MORTALITY

The model is fitted using a natural mortality of 0.2. The fish in Area 2A, at the southern end of the species' range, may well experience a higher rate, which would imply higher levels of abundance.

The line labeled "SP+M3" in Figure 1 shows the effect of using a natural mortality rate of 0.3. By itself, this change raises the 1988 biomass estimate by the same amount as the artificial increase in CPUE, that is about 400,000 pounds. In conjunction with the artificially increased CPUE, it raises the 1988 estimate dramatically, to 2.5 million pounds or so (line labeled "SP+CP+M3"). Of all the possibilities considered, this is the only one that produces an estimate above the range of the other four estimates. It must be considered a remote possibility in view of the actual CPUE data, which does not show a sustained increase over the last few years.

The true rate of natural mortality in Area 2A in unknown and likely to remain so. Even if it were known to be higher, there is no assurance that quota recommendations would increase, since the quotas are based on a 35% exploitation rate which was chosen on the basis of a natural mortality rate of 0.2, among other things. Given the same spawner-recruit relationship, a higher rate of natural mortality in Area 2A would imply a smaller margin of density dependent increase in reproductive success and a lower optimum exploitation rate. Whether 0.2 is the correct value or not, therefore, the yield calculations based on it probably are correct.

## CHANGE IN MEAN WEIGHTS

The model uses smoothed annual estimates of mean weights to calculate biomass. A spurious change in these could be masking an increase in biomass.

This effect could not be large in any case. In this case, fitting the model with constant (average) weights throughout produces the same 1988 biomass estimate.

## CHOICE OF LAMBDA

In fitting the model, more or less influence can be given to the catch per effort data by varying a weighting parameter named lambda in the age structured model. A poor choice of lambda may be producing bad estimates.

Not so. The biomass estimates are only slightly affected by the choice of lambda in this case.

## DISCUSSION

There are a number of valid criticisms that can be made of the Area 2A assessment. Age composition samples are fewer than desirable. Logbook data is less than in other areas, although by no means an inadequate sample from a statistical viewpoint. Changes in fishing gear and strategies make the catch per effort suspect. Sport catches are neglected although they are not negligible. The deviations of the observed data from model predictions are larger than for other areas, which is to say that the estimates have a larger variance.

But the assessment is not flawed in any fundamental way, and as explained above, downward bias in the estimate of exploitable biomass is not likely and certainly not large. There is no reasonable possibility, given the data from the fishery, that exploitable biomass could exceed about 1.5 million pounds. At a 35% rate of exploitation, therefore, the catch should be no more than 525,000 pounds, and a lower figure would be more consistent with the data and with practice in other areas.

Continued high rates of exploitation in Area 2A will not necessarily lead to lower yields there in the future, because the yield per recruit of halibut increases asymptotically with fishing mortality. The critical question is whether recruitment will hold up when spawning biomass per recruit is reduced to such low levels.

The reason for limiting the harvest rate to 35% on the stock as a whole is to avoid recruitment over-fishing, and the policy has been to apply this rate uniformly so that all areas contribute proportionally to total spawning biomass. This policy is rational whether the recruits in each area are the progeny of that area's spawners, or some share of a broadcast recruitment from a common source. As a matter of principle, therefore, the exploitation rate in Area 2A should be limited to the overall target rate. As a practical matter, of course, the contribution of the fish in Area 2A to total spawning biomass, like their contribution to the total catch, is so small as to be negligible, regardless of how the fishery is managed. The policy adopted for Area 2A will therefore have no noticeable effect on the stock as a whole.