# International Pacific Halibut Commission

# 77th Annual Meeting

**International Pacific Halibut Commission**
**Seventy-seventh Annual Meeting**
Four Seasons Hotel, Vancouver, B.C.
January 22 – 25, 2001

# SCHEDULE OF SESSIONS

**Monday - January 22**

| | | | |
|---|---|---|---|
| a.m. | 8:00 – 9:00 | IPHC Administrative Session | Garibaldi Room |
| | 9:30 – 1:00 | Public Session | Park B & C Ballroom |
| p.m. | 2:00 – 5:00 | IPHC Administrative Session | Garibaldi Room |
| | 2:00 – 5:00 | Processor Advisory Group (PAG) | Oak Room |
| | 2:00 – 5:00 | Conference Board (CB) | Park B & C Ballroom |
| | 7:00 – 9:00 | IPHC Reception – no host | Le Pavillion |

**Tuesday - January 23**

| | | | |
|---|---|---|---|
| a.m. | 8:30 – 5:00 | IPHC Administrative Session | Garibaldi Room |
| | 8:30 – 5:00 | Conference Board | Park B & C Ballroom |
| | 8:30 – 5:00 | Processor Advisory Group | Oak Room |
| p.m. | 5:30 – 7:00 | HANA Reception | Le Pavillion |

**Wednesday - January 24**

| | | | |
|---|---|---|---|
| a.m. | 8:30 – 9:30 | IPHC, CB, and PAG Joint Session | Park B & C Ballroom |
| | 9:30 – 5:00 | IPHC Administrative Session | Garibaldi Room |

**Thursday - January 25**

| | | | |
|---|---|---|---|
| a.m. | 8:30 – 9:30 | IPHC Administrative Session | Park Ballroom |
| | 10:00 – 12:00 | IPHC Meeting (public welcome) | Park Ballroom |
| p.m. | 1:30 – 5:00 | IPHC Administrative Session | Park Ballroom |

* The IPHC Office is located in Montague Room.

# International Pacific Halibut Commission
# Seventy-seventh Annual Meeting

Four Seasons Hotel, Vancouver, B.C.
January 22 – 25, 2001

## Public Session – January 22, 2001
## Park B&C Ballroom

| | | |
|---|---|---|
| 9:30 a.m. | **Opening of Meeting** | |
| | | Chairman's Opening Remarks |
| | | Introductions |
| | | Commissioners<br>Commission Staff<br>Distinguished Guests |
| 9:45 | **Director's Remarks** | |
| | **Staff Presentations** | |
| | | The Pacific Halibut Fishery, 2000<br>2000 Special Experiments and Chalky Fish Update<br>Survey Bait Comparison<br>Evaluation of Alternative Harvest Rates<br>Summary of the 2000 Stock Assessment<br>Staff Regulatory Proposals: 2001 |
| 10:30 | **Coffee** | |
| 11:00 | **Staff Presentations (continued)** | |
| 12:00 p.m. | **Questions and Discussions** | |
| 1:00 | **Announcements and Adjournment** | |
| 7:00 | **IPHC Reception (No Host) – Le Pavillion** | |

# Notes

# The Pacific halibut fishery, 2000

## Heather L. Gilroy

The 2000 total removals of halibut off the Pacific coast were well above the average annual removals for the last 39 years of 69 million pounds. The removals including commercial catch, sport catch, bycatch mortality, personal use and wastage totaled 92 million pounds (Table 1). These data are preliminary and the sources are the International Pacific Halibut Commission (IPHC), and federal and state agencies.

Accurate reporting of removals is essential to stock assessment and for determining the recommended allowable commercial catch. Removals are most accurately estimated using a scale weight of the halibut landings or by a scientifically-based estimation procedure. Over the years, the Commission has worked with different agencies to improve the estimation procedures and has attempted to account for all removals. The Commission attempts to estimate all significant removals, even when there is little information upon which to base the estimates. Accuracy in catch accounting is also important when instituting allocation among user groups or within management areas. The Commission does not make these allocation decisions among groups or within management areas, however, it believes that good accountability is fundamental to the success of any long-term allocation program.

Enforcement of IPHC-generated regulations ensures that proper information is available for stock management. Validation of any weights or procedures is a necessary component of accountability. In some cases, we believe improvements to the estimation procedures are needed.

The commercial fishing industry pressed the two governments to establish the IPHC in 1923 in order to manage and conserve the halibut resource. The commercial fishery still represents the largest removal (74% in 2000). Through the years the estimation of each of the other removals has been added, with bycatch mortality in the 1960s, sport catch in the late 1970s, wastage in the 1980s, and personal use in the 1990s.

Catch estimates and details of all of the removals are provided in this report. The removals for commercial catch, sport catch, incidental mortality, personal use and wastage were 68.3, 8.6, 13.2, 0.7, and 1.4 million pounds respectively (Table 1). Brief descriptions of the sources for the various data estimates and where improvement is needed are included.

The mortality of sublegal-sized halibut (as bycatch discards in other fisheries and wastage in the halibut fishery), which was deducted in setting the CEY prior to 1997, is now accounted for when setting the exploitation rate. Although the estimated amounts are no longer deducted in setting the CEY, they are included in the reporting of 2000 total removals.

## The commercial fishery

### The 2000 fishery

A detailed summary of the 2000 catch and seasons by regulatory area (Figure 1) is provided in Table 2. When comparing commercial catch tables from different reports, it should be noted that prior to 1995 the research catch was included in the commercial catch; it was not listed separately.

The commercial catch occurs in an open-access fishery and a treaty Indian fishery in Area 2A; the quota share (QS) fisheries in British Columbia and Alaska; and a Metlakatla fishery within the Annette Island Reserve. The directed commercial fishery of Area 2A had fishing period limits (Table 3).

### *Area 2A*

The one area where a comprehensive user group allocation occurs is off Washington, Oregon, and California, although sport-commercial allocations are pending in portions of Alaska. The Pacific Fishery Management Council (PFMC) allocates among commercial, sport, and treaty Indian users. The commercial fishery is open access and this is the only area with a catch limit for the sport fishery. The 2000 total catch (809,600 pounds) for commercial, sport, and treaty Indian users was under the catch limit by 2%, or 20,400 pounds.

In the incidental commercial halibut fishery conducted during the salmon troll season, the allowable incidental catch ratio was one halibut per three chinook and an 'extra' one halibut regardless of ratio, but the total number of incidental halibut landed could not exceed thirty-five. The ratio of halibut to number of chinook has increased over the last five years with one to twenty in the first year of the program (1995) and with one to three in 2000. The incidental commercial halibut catch during the May and June salmon troll fishery was estimated at over 20,000 pounds, double the 1999 catch. Since the incidental catch limit was 24,464 pounds, as directed by the PFMC, approximately 3,000 pounds were rolled into the directed commercial catch limit at the end of the June troll fishery. The total commercial catch limit was not taken during the directed July fisheries so there were two incidental halibut fisheries in August, for a total catch of 1,400 pounds.

The directed commercial fishery consisted of three 10-hour fishing periods with fishing period limits (Table 3). The first opening (July 5$^{th}$) had slightly higher fishing period limits than the previous year's first fishery but the total catch was the same (120,000 pounds). The total commercial catch for Area 2A was within 1% of the catch limit.

The treaty Indian catch of 300,100 pounds was under the catch limit by 5,000 pounds, or 2%. During the unrestricted fishery there were two fishing periods, March 15 and March 30, for a total catch of 186,000 pounds. The restricted fishery had fishing period limits of 500 pounds and a total catch of 113,400 pounds. The ceremonial and subsistence fishery remained open until December 31, 2000.

### *Quota share fisheries*

The total 2000 catch from the IFQ halibut fishery for the waters off of Alaska was 54.8 million pounds, 2% under the catch limit and approximately 4 million pounds lower than last year. For Areas 2C, 3A, and 3B, the catches were under the catch limits by 1%. The catches in the Area 4 regulatory areas were within 2 to 13% of the catch limits. The preliminary estimate of the catch from the IVQ fishery in Area 2B indicates the catch limit was taken. These estimates do not take into account the additional catch that is available from the underage programs for the quota shares fisheries (Table 2 footnotes).

The QS fishery landings are spread over nine months of the year (Table 4). The Alaska landings in March were down in 2000 with 12% of the Area 2C and 9% of the Area 3A total catch being landed in the first two weeks. This compares to March 1999 landings from Areas 2C and 3A of 18% and 13% of the total catches respectively. May was the busiest month for Alaska landings, while April was busiest for Area 2B.

***Metlakatla fishery***

The Metlakatla Indian Community was authorized by the United States government to conduct a commercial halibut fishery within the Annette Island Reserve. Fifteen 48-hour fishing periods took place between April 29 and October 13 producing a total catch of 54,026 pounds (Table 4) which is included in the Area 2C commercial catch. The catch is higher than last year's catch of 35,000 pounds, although the total catch has varied over time from a high of 126,000 pounds in 1996 to a low of 12,000 pounds in 1998.

**Data collection and validation**

The IPHC uses individual vessel landing records for tracking the total commercial removals of halibut. Accurate reporting of fishing-trip weights is necessary and is used to calculate catch per unit effort with the logbook data as well as provide the removals by location and time.

In 2000, approximately 13,000 landing records provided the commercial catch estimation. Scales were used to determine the landed weight and these scale weights were the basis of the commercial catch data. The catch per unit of effort for the commercial fishery was calculated from the fishing logbook data, which generally represents 75-80% of the catch (weight). Halibut were measured and 14,300 otoliths were collected by IPHC port samplers. The otoliths were microscopically aged and used in combination with individual fish lengths to determine the age composition and average weight at age of individuals in the stock.

IPHC currently uses fish tickets as the basis for the U.S. commercial removals. The IFQ card-swipe system tracks landings as well and is used by NMFS to track quota shares among share holders. The benefit of the fish tickets to IPHC and enforcement is they can be used as a verification of the QS system. They are a paper trail of landing records that are edited and are useful in finding recurring errors in the card-swipe information or on the tickets.

Fish tickets are completed in British Columbia but the landing records used by IPHC and DFO for quota share tracking are the validation weights that are completed by a person independent of the fisher or processing plant who is watching the offload. This weight validation program was implemented with the quota share system, was jointly agreed on by DFO and the harvesters, and is run by a consulting company hired by DFO. The enforcement and the cost of operating the IVQ program are paid for by the IVQ holders.

## The sport fishery harvest

Sport harvest estimates are provided to IPHC by state and federal agencies. One component of the harvest that should be accounted for in the future is the mortality of released halibut from hooking injuries in the sport fishery.

**Alaskan harvest**

The Alaska sport harvest estimates are derived from a statewide postal survey in conjunction with creel surveys at points of landing and lag the fishery by one year. The 2000 estimate of 6.7 million pounds is a projection based on the last five years of harvest data. Catch estimates are provided to IPHC by Alaska Department of Fish and Game (ADF&G) staff and are based on a coastwide postal survey, creel surveys in Area 2C and a port sampling program in Area 3A. The sport harvest in Areas 3B and 4 is small and is concentrated in a few ports. The harvest is estimated from average weights determined from Kodiak Island. In 1998, the ADF&G started a program to verify the information provided in the statewide postal survey. The ADF&G logbook program is in its third year but ADF&G has proposed that three years of data be collected before completing a comparison with the statewide postal survey. ADF&G does not expect the review to be complete until at least 2001. The logbook data have been used only to compare noted increases and decreases in certain areas with the postal survey estimates.

Although the estimation is scientifically-based and provides acceptable harvest estimates, it does not provide in-season catches. If in-season management were necessary for allocation and to monitor current catches, additional ADF&G staff would be needed.

**British Columbia harvest**

In 1999, the IPHC generated a sport harvest estimate based on numbers of fish from the Canadian National Survey and Alaska and Washington average weight data. The Pacific Region of DFO developed an alternate estimate based on results from creel survey and logbook programs, with expansions to cover the unsampled parts of the coast. The Commission and DFO are still reviewing the different estimation methods. The sport catch provided in this report is the IPHC estimate from the DFO National survey, although two alternate estimates were used in the stock assessment. Washington anglers landed 209,893 pounds from Canadian waters, a 10% increase from 1999. Fewer fish were landed but the increase is due to an increase in average weight.

**Washington, Oregon, and California harvest**

The Area 2A sport harvest of 340,000 pounds was under the catch limit by 3%. As previously mentioned, this is the only area on the coast with a sport fishery allocation or catch limit. In-season estimates are necessary to be able to maintain the catch but not exceed harvest allocations. This is accomplished by point intercept surveys and a follow-up telephone survey to determine the catch by anglers.

## Personal use

For a complete estimate of personal use halibut the sources would include DFO-sanctioned Indian food fish, ceremonial and subsistence fisheries, sublegal-sized halibut retained in Area 4E as part of the IPHC regulations, and illegally-retained halibut from commercial and sport fisheries. Currently, each type is not estimated for each regulatory area.

The 2000 personal use estimate (749,000 pounds) includes the value calculated in 1998 in addition to the sublegal-sized halibut retained from the Area 4E commercial fishery. Personal use or subsistence is a removal that is not recognized in the IPHC regulations (with the exception of Area 4E and the treaty Indian ceremonial and subsistence fisheries). The IPHC regulations authorized the treaty Indian ceremonial and subsistence fishery in 1986 and CDQ personal use fishery in Area 4E in 1998. The CDQ groups in Area 4E are required to report the harvest of halibut under the size limit that were retained for personal use, as well as the method of catch estimation.

Over the years, improvements have been made to these estimates however there are still examples with little documentation and without scientifically-based procedures. The Commission does currently review the Area 4E subsistence fishery. In 2001, the Commission will request information from the Northwest Indian Fisheries Commission on how the ceremonial and subsistence estimate is derived. In 2000, there was concern on whether the total amount of fish landed as part of the ceremonial treaty Indian fishery was accounted for. The governments are reviewing the personal use fisheries in Area 2B and Alaska and the Commission will work with the agencies to ensure that the programs implemented have catch accountability. The North Pacific Fishery Management Council approved a subsistence fishery for Alaska that will be implemented in 2002. The IPHC will need to adopt regulations that pertain to this fishery for 2002.

## Wastage

Wastage removals represent the mortality of legal-sized halibut due to lost or abandoned gear and of sublegal-sized halibut discarded in the halibut fishery. Information on the amount of gear lost or abandoned in the halibut longline fishery was collected through logbook interviews or from fishing logs received via mail. Fishery-wide estimates are extrapolated from qualified logbook catch and effort statistics to total catch values. Wastage is calculated from the ratio of effective skates lost to effective skates hauled, multiplied by total catch.

Since the implementation of the quota share fisheries, the ratios have fluctuated slightly among years, but are still lower than they were during the derby fisheries. The ratios for all areas were lower in 2000 with the exception of Area 2A. The Area 3A ratio of 0.002 was very low and it is difficult to tell if this is an anomaly or if in fact very few skates were lost in 2000. The ratios generally range from 0.003 to 0.008 in the quota share fisheries, with the highest ratios in Area 4. The Area 2A ratio (0.019) is still higher which is a reflection of the derby style fishery in that area.

The amount of sublegal halibut caught in the commercial fishery was estimated from the catch ratio of sublegal to legal halibut from the research survey stations that represented the highest one-third of the legal catch weighs. To calculate the pounds of sublegal-sized halibut in the commercial fishery, the ratios of sublegal:legal halibut from the surveys were multiplied by the estimated commercial catch in each regulatory area. The resulting weight was then multiplied by the discard mortality rate (16%) to obtain the estimated weight of sublegal-sized halibut killed in the commercial fishery (1.18 million pounds).

One removal that is not currently being included in the wastage estimate is the wastage that occurs when more gear is set than needed to obtain fishing period limits in Area 2A, IVQ in Area 2B, and IFQ in Alaskan regulatory areas. Also, halibut may occasionally be discarded at sea due to poor fish quality, which can occur from sand fleas. The amount of legal-sized halibut that is caught over the limits or discarded at sea is collected during logbook interviews. At this time, the amounts are being reviewed and could be included in the removal estimates.

## Bycatch

The 2000 estimate of bycatch mortality was the lowest since 1987 and was 35% lower than 20 million pounds of 1992. Bycatch estimates for most Alaskan fisheries are from the observer program overseen by NMFS. The exception is from the crab pot and shrimp trawl fisheries where the bycatch rates are from research trips, as there are no direct fishery observations available. For the trawl fishery in B.C. the bycatch is managed by an individual bycatch quota program. For the other fisheries (shrimp trawl, sablefish pot, rockfish longline) the bycatch amounts are unknown but are assumed to be very low. The Area 2A groundfish trawl bycatch estimate is from a method established in 2000 that uses the observations from the 1995-1998 voluntary observer program and commercial logbook effort data. The bycatch from the shrimp trawl fishery is estimated from gear experiments and that from the hook & line fishery is based on data from the similar Alaskan sablefish fishery.

Once bycatch is estimated, it is necessary to determine the fraction of halibut caught that will die, the discard mortality rate (DMR). In the fisheries with observers, data are collected on the condition of the halibut when they are discarded at sea. For areas with no observer coverage, the rates from similar fisheries are used. The bycatch mortality is determined from the DMRs and the estimated bycatch.

## Summary

In many instances (commercial catch, Alaska sport catch, Area 2A commercial-sport-treaty Indian catch), the removal estimates are well documented, scientifically-based and many agencies are involved in the process. The data collection process is acceptable for commercial catch. The method of determining bycatch mortality, wastage, and sport harvest are generally acceptable with the exception of a few areas. Additionally, wastage from the sport fishery will need to be estimated in the future. Personal use is the one removal where much work is needed especially with the upcoming allocation issues. The Area 2A treaty Indian ceremonial and subsistence fishery is the first personal use fishery with an allocation, and the Commission will review the estimation procedure with the Northwest Indian Fisheries Commission. There could be allocation of other personal use or subsistence fisheries in the near future. Even if there is not a direct allocation for the personal use fishery and it is deducted in setting the CEY, accountability and regulations are the next steps for all areas. It is extremely important to determine a scientifically-based estimation procedure especially if the fisheries are to occur by regulation.

**Table 1. The 2000 removals of Pacific halibut by regulatory area in net weight (thousands of pounds).**

| Area | 2A | 2B | 2C | 3A | 3B | 4 | Total |
|---|---|---|---|---|---|---|---|
| Commercial[1] | 459 | 10,781 | 8,458 | 19,331 | 15,443 | 13,800 | 68,272 |
| Sport | 340 | 1,582 | 1,978 | 4,596 | 16 | 103 | 8,615 |
| Bycatch Mortality: | | | | | | | |
| Legal-sized fish | 340 | 140 | 230 | 1,210 | 580 | 3,270 | 5,770 |
| Sublegal-sized fish | 711 | 102 | 120 | 1,513 | 778 | 4,276 | 7,500 |
| Personal Use | 10[2] | 300 | 170 | 74 | 20 | 175[3] | 749 |
| Wastage: | | | | | | | |
| Legal-sized fish | 8 | 26 | 42 | 30 | 49 | 74 | 229 |
| Sublegal-sized fish | 1 | 181 | 134 | 421 | 315 | 132 | 1,184 |
| Total | 1,869 | 13,112 | 11,132 | 27,175 | 17,201 | 21,830 | 92,319 |

[1] Commercial catch includes IPHC research catch.
[2] Treaty Indian ceremonial fish authorized in the catch sharing plan.
[3] Includes 14,000 pounds of sublegal halibut retained in the Area 4E Community Development Quota.

**Table 2. Fishing periods, number of fishing days, catch limit, commercial, research and total catch (thousands of pounds, net weight) by regulatory area for the 2000 Pacific halibut commercial fishery (preliminary, November 16, 2000).**

| Regulatory Area | Fishing Period | No. Of Days | Catch Limit | Commercial Catch | Research Catch | Total Catch |
|---|---|---|---|---|---|---|
| 2A treaty Indian | 3/15 – 3/17 | 2 | 305 | 42.7 | | 300.1 |
| | 3/30 | 1 | | 143.6 | | |
| | Restricted | | | 113.8 | | |
| 2A Commercial | | | | | | |
| Incidental | May – June | 61 | | 20.9 | | |
| | Aug1 - 4 &11-21 | 15 | | 1.4 | | |
| | | | 24.5[1] | | | 22.3 |
| Directed | July 5[2] | 10-hrs | | 120.0 | | |
| | July 19[2] | 10-hrs | | 13.0 | | |
| | Aug 2[2] | 10-hrs | | 3.7 | | |
| | | | 138.6[1] | | | 136.7 |
| Total Commercial | | | 163.1 | | | 159.0 |
| 2A Total | | | 468.1 | 459.1 | | 459.1 |
| 2B | 3/15 – 11/15 | 245 | 10,600[3] | 10,600[4] | 181 | 10,781 |
| 2C[5] | 3/15 – 11/15 | 245 | 8,400[6] | 8,279 | 179 | 8,458 |
| 3A | 3/15 – 11/15 | 245 | 18,310[6] | 18,210 | 1,121 | 19,331 |
| 3B | 3/15 – 11/15 | 245 | 15,030[6] | 14,915 | 528 | 15,443 |
| 4A | 3/15 – 11/15 | 245 | 4,970[6] | 4,850 | 194 | 5,044 |
| 4B | 3/15 – 11/15 | 245 | 4,910[6] | 4,580 | 132 | 4,712 |
| 4C | 3/15 – 11/15 | 245 | 2,030[6] | 1,746 | | 1,746 |
| 4D | 3/15 – 11/15 | 245 | 2,030[6] | 1,880 | 67 | 1,947 |
| 4E | 3/15 – 11/15 | 245 | 390[6] | 351 | | 351 |
| Alaska Total | | | 56,070 | 54,811 | 2,221 | 57,032 |
| Total | | | 67,138 | 65,870.1 | 2,402 | 68,272.1 |

[1] Pounds were carried over from the incidental to directed commercial catch limit.
[2] Fishing period limits by vessel class.
[3] An additional 145,820 pounds available as carryover from 1999.
[4] Includes the pounds that were landed by Native communal commercial licenses (F licenses).
[5] Includes 54,000 pounds taken by Metlakatla Indians during additional fishing within reservation waters.
[6] Additional net carryover pounds (thousands) from the underage/overage program were: 2C = 376; 3A = 408; 3B = 196; 4A = 39; 4B = 127; 4C = 46; 4D = 34.

**Table 3. The fishing period limits (net weight) by vessel class used in the 2000 directed commercial fishery in Area 2A.**

| Vessel Class | | Fishing Periods (Pounds) | | |
|---|---|---|---|---|
| Letter | Feet | July 5 | July 19 | August 2 |
| A | 0-25 | 310 | 200 | 200 |
| B | 26-30 | 390 | 200 | 200 |
| C | 31-35 | 620 | 200 | 200 |
| D | 36-40 | 1,715 | 325 | 230 |
| E | 42-45 | 1,845 | 350 | 250 |
| F | 46-50 | 2,205 | 415 | 300 |
| G | 51-55 | 2,460 | 465 | 335 |
| H | 56+ | 3,700 | 700 | 500 |

**Table 4. The total pounds (thousands, net weight) of 2000 commercial landings (not including research or Metlakatla fishery) of Pacific halibut for Alaska and British Columbia by regulatory area and month (preliminary).**

| Reg. Area | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 2B | 1,101 | 1,926 | 1,179 | 1,046 | 1,126 | 1,197 | 1,459 | 1,064 | 502 | 10,600 |
| 2C | 961 | 1,536 | 1,640 | 1,068 | 578 | 866 | 951 | 516 | 163 | 8,279 |
| 3A | 1,700 | 2,736 | 4,397 | 2,052 | 1,261 | 1,737 | 1,887 | 2,100 | 339 | 18,210 |
| 3B | 389 | 946 | 3,581 | 2,521 | 1,512 | 2,047 | 2,401 | 1,155 | 363 | 14,915 |
| 4A | 0 | 151 | 577 | 1,101 | 877 | 1,303 | 494 | 303 | 43 | 4,850 |
| 4B | 0 | 37 | 316 | 852 | 1,228 | 1,006 | 761 | 296 | 84 | 4,580 |
| 4C | 0 | 0 | 7 | 329 | 1,025 | 287 | 62 | 36 | 0 | 1,746 |
| 4D | 0 | 0 | 230 | 242 | 425 | 665 | 224 | 95 | 0 | 1,880 |
| 4E | 0 | 0 | 2 | 73 | 120 | 127 | 22 | 7 | 0 | 351 |
| AK Total | 3,051 | 5,407 | 10,750 | 8,239 | 7,026 | 8,038 | 6,802 | 4,506 | 993 | 54,811 |
| Total | 4,152 | 7,333 | 11,929 | 9,285 | 8,152 | 9,235 | 8,261 | 5,570 | 1,495 | 65,411 |

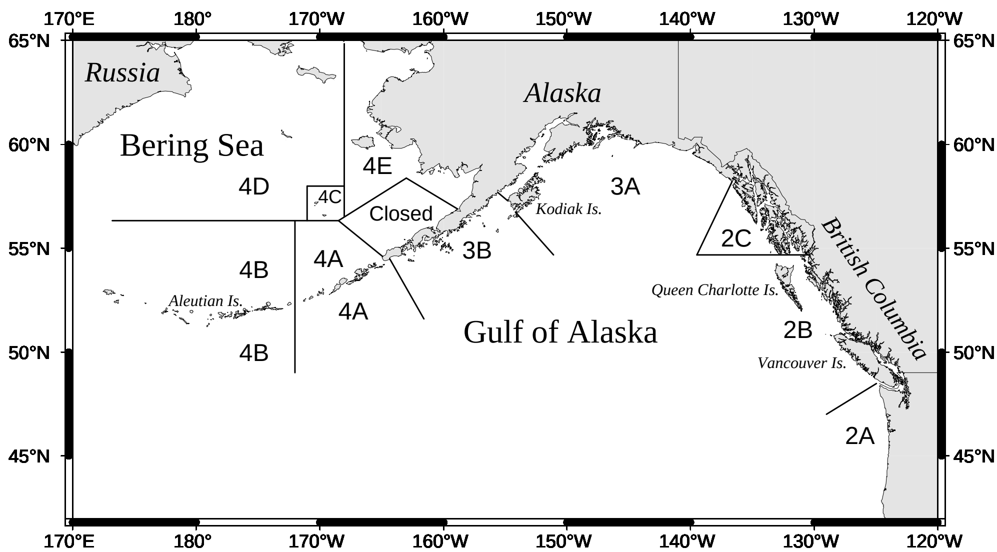


**Figure 1. IPHC regulatory areas for the 2000 fishery.**

# 2000 special experiments

## Stephen M. Kaimmer and Din G. Chen

### Introduction

During 2000, the IPHC conducted a series of special experiments to investigate factors that affect setline catch per unit of effort of Pacific halibut. We investigated the effects of hook orientation and gangion length, hook and bait size, and bait quality (Table 1). The response variables for these experiments were the catch rates for sublegal and legal-sized halibut. These were expressed as number per unit effort (NPUE) for sublegal and catch weight in pounds (CPUE) for legal-sized halibut. Each experiment was conducted as a randomized block design, with each set of gear having one skate of each treatment or treatment combination for that experiment. Each experiment was also limited to catching 40,000 pounds of halibut. We hoped that this would result in around twenty sets of gear for each experiment. The chartered vessels fished with standard 18-foot halibut gear with circle hooks, with either 83 or 100 hooks per skate. Most of the distributions of both NPUE and CPUE data were right-skewed. In order to comply with the normality assumption of the models, the data were analyzed using square-root transformations. For each experiment, an analysis of variance procedure was used to test for significant differences between the means for each treatment with $\alpha = 0.05$.

This report will also summarize results from the 1998-1999 Winter-Spring substitute bait experiment.

### Hook orientation and gangion length

The first experiment compared two factors, hook orientation ("threading") and gangion length. The interest in these factors stems primarily from the gear practices in the IPHC grid surveys. Prior to 2000, vessels conducting IPHC setline surveys were allowed to thread the gangion onto the hook either from the front or the back side of the eye (Fig. 1). Although no records were kept detailing which orientation was used, IPHC staff recollection is that most fishers threaded gangions through the front of the eye. From 2000 onwards, IPHC surveys are standardizing to a front threading. Vessels fishing IPHC surveys use their own groundline, and have been allowed some leeway in choosing gangion length. This has resulted in a wide range of gangion length in our surveys (as well as in commercial fishing). We chose lengths of 12 and 36 inches, after tying, as representative of the range of gangion length used.

Twenty-six out of 30 sets were successfully completed in two fishing trips from June 8-17. The catch per four-skate set ranged from 131 to 3,278 pounds, with an average catch of 1,651 pounds per set, or just over 400 pounds per skate.

Statistical tests showed significant differences between treatments for both CPUE and NPUE (Table 2). Generally, threading the gangion through the front of the hook eye resulted in higher catches of both size groups of halibut (Figure 2). While gangion length by itself was not significant, there was a small additive effect to the larger hook orientation effect. For legal-sized halibut, only the long gangion and front threading was significantly different from either of the back-threading treatments. For sublegals, the only significant difference was between the extreme comparison of short gangions with back threading and long gangions with front threading.

## Bait and hook size

The second experiment compared three sizes of bait and two sizes of hook. The bait sizes were chosen to bracket those most likely used in IPHC grid surveys prior to our standardization on a 3 to 5-ounce bait. The hook sizes, 16/0 and 14/0, are representative of the hooks used in the commercial fishery for Pacific halibut. The 16/0 hook size is most common in the targeted fishery for Pacific halibut and has been standard for IPHC grid surveys since their inception in 1963. Fishers targeting combinations of Pacific halibut and other species, particularly sablefish (*Anoplopoma fimbria*) or Pacific cod (*Gadus macrocephalus*), often use the hook size 14/0.

Twenty-two out of 23 sets were successfully completed for the bait and hook size experiment between July 18-26. During the first day's fishing of this experiment, the gear was set on what turned out to be particularly productive ground, and over 15,000 pounds was caught. In order to stay under the design maximum catch of 40,000 pounds, the remainder of the fishing in this experiment was conducted on grounds where low catches would be expected. Therefore, little of the fishing during this experiment was on 'average' grounds.

Tests showed a significant difference only for sublegal catches (Table 3) although this experiment was compromised by the design execution. While the trend in CPUE between bait and hook sizes suggests a relationship (Figure 3), 95% confidence limits overlap in all cases. In retrospect, a different design that allowed more replicates could have been more appropriate for testing the differences seen when allowing for the observed variance within the setline data.

## Bait quality

The third experiment investigated the effect of using different batches of chum salmon (*Oncorhynchus keta*). The IPHC uses large quantities of chum salmon as bait for survey operations. Over 300,000 pounds were purchased for the 2000 grid surveys. These baits come from many different vendors on the Pacific coast of the U.S. and Canada. Trips prior to July use bait that has been stored from the previous year. Once fresh sources of bait come available in early summer, much of our bait comes from the current year's fisheries. The bait quality experiment compared batches of bait from three runs, one each in Area 2B, 2C, and 3A. As well, the batches from 2C and 3A were obtained both as fish frozen from 1999, and as fish caught during the 2000 run. Pilot studies in 1998 suggested that bait from different batches could have significantly different catch rates. A second component of the bait quality experiment was amino acid analysis of the five bait batches. The literature on fish attractants suggests that some of the amino acids might be key attractors in the hook and line fishing process. A total amino acid concentration was determined for each sample. This was paired with a leaching extraction of dissolved free amino acids in cold seawater. Analysis of the absolute concentrations and leachates from these samples has not yet been completed.

Twenty sets were completed for the bait quality experiment from July 26-30, with catch rates ranging from 439 to 5,011 pounds per set. The overall average catch per skate was just over 380 pounds.

Tests indicate no difference in either CPUE or NPUE between the bait batches tested (Table 4, Figure 4). Although the bait which had been frozen for over a year ("1999") caught more pounds of legal halibut and more numbers of sublegal halibut than the 'fresh' year 2000 bait from the same areas ("2000"), there was a wide variability in catch rates within each treatment and differences were not significant.

## 1998-1999 winter-spring substitute bait experiment

During the winter and spring of 1999-2000, the IPHC conducted an experiment to determine the relative effectiveness of herring and squid as possible bait substitutes for the chum salmon used in IPHC grid surveys. Mainly from considerations of year-round availability, we chose Pacifc herring (*Clupea harengus pallasi*) and squid (*Illex* sp.) as our test baits. Chum baits were cut to our standard 1/4 to 1/3 pound size. Herring and squid baits were 0.22 and 0.11 pounds for large and small baits, respectively. We conducted the experiment in both Areas 2B and 3A, and during both the winter and spring seasons (Table 5). All vessels fished with standard 18-foot halibut gear with 16/0 circle hooks, with either 83 or 100 hooks per skate. The experiment used a randomized complete block design, with each set being a block, and each of the five bait descriptions included once, in random order, within each block.

Catch rates differed markedly between areas, and between fishing seasons within areas (Table 6, Figures 5 and 6). Within areas, the winter CPUEs were much higher than spring catches in Area 2B, while the spring catches in Area 3A were slightly higher than in winter. There was little change in sublegal catch between the Area 2B winter and spring fishing, and these catches were similar to the area 3A winter fishing. Sublegal numbers in 3A in the spring were about 1/3 those seen in the winter fishing. Overall, over 680,000 pounds of legal-sized halibut were caught and sold during the winter fishing, 391,000 pounds from Area 3A and 289,500 pounds from Area 2B. Spring fish sales from Area 3A totaled just over 102,000 pounds. Spring fish sales totaled almost 46,000 pounds in Area 2B, not including about 25,000 pounds which were lost from the last trip of the *F/V Royal Pursuit* when that vessel went aground, resulting in a total loss of vessel and fish. The data from this trip were not lost, and are included in the analysis.

The experiment was designed to assess the suitability of the test baits as substitutes for chum salmon in IPHC grid surveys. Most IPHC survey efforts are conducted in the months June through August. Because of this survey timing, the spring performance of the test baits is probably the more applicable. Of the baits tested, the large squid bait performed the best as a chum substitute. The catch of sublegals is higher by about 25 percent, and the catch of legals lower by about 15 to 25 percent, but these differences could be adjusted for, if necessary. The size composition of the catch on the large squid was very similar to that from the salmon bait, indicating that whatever catch factors are at work between the two baits, they appear to work equally on all sizes of halibut. The large squid also performed reasonably well in the winter comparisons.

## Discussion

The hook and line capture process for halibut includes attraction of halibut to the baited hook, the attack rate, and the hooking success for hook attacks. The IPHC is continually interested in better understanding the mechanisms of hook and line halibut catch. Catch rates by the commercial fleet, and more recently our grid survey, play an important role in our annual assessment of the halibut stock. In a time when fishers are increasingly using different gear setups, including shorter hook spacings and smaller hooks, the amount of standard gear data available for stock assessment is shrinking. Gear studies can help better understand how data from non-standard gears may be incorporated into our analysis of commercial fishing data. With an increased reliance on our grid survey data, it becomes even more important to better understand how gear or bait changes might affect survey catches.

These experiments provided useful information. The hook orientation is important, and IPHC research effort will thread hooks from the inside of the eye for all future work. Gangion length is less important, and it may be appropriate to allow fishers to continue to have leeway in using a gangion length which best suits their vessel and deck setup. The source of survey bait, and whether it is stored over the winter or is fresh from a current year's fishery, may also be important. While it would be unlikely that we can control for bait quality across a year's survey fishing, or between year, we may be able to standardize for the bait source when comparing data from different sources. We may someday be able to assay survey bait, and standardize for bait differences. Our current data, as well as pilot studies conducted in 1998, would suggest that larger baits attract attacks from more or larger fish, and in the extreme might even get in the way of successful hooking. Hook size is important in the hooking success part of the process, and is a function of the size of the hook. Smaller hooks catch smaller fish more efficiently, with a higher hooking success. A larger hook will be better catching a larger fish. Hook and bait sizes are very interesting factors in setline catch. A more extensive experiment would be required to make a definitive summary of their importance in the catch of Pacific halibut.

**Table 1. Special setline experiments conducted during 2000 using the randomized block design.**

| Experiment | Factors tested |
|---|---|
| Hook orientation and gangion length | Hook threading (inside and outside) and gangion length (12 and 36 inches) |
| Bait size and hook size | Bait size (2, 4, and 6-ounce) and hook size (14/0 and 16/0) |
| Bait quality | Bait batch (3A, 2C, and 2B), and storage time (bait from 2000 or 1999 fishery). |

**Table 2. Hook orientations and gangion lengths tested in the hook threading / gangion length experiment, with catch averages and standard deviations.**

| Gangion - | Legal pounds | | Sublegal numbers | |
|---|---|---|---|---|
| Orientation | CPUE | ± S.D | NPUE | ± S.D |
| Long - Back | 378.9 | 232.6 | 3.50 | 2.20 |
| Long - Front | 528.0 | 301.5 | 2.88 | 3.59 |
| Short - Back | 373.2 | 207.6 | 4.46 | 3.77 |
| Short - Front | 483.3 | 233.5 | 3.92 | 3.51 |
| **Significant?** | Yes | | Yes | |

**Table 3. Hook and bait sizes tested in bait and hook size experiment with catch averages and standard deviations.**

| | Legal pounds | | Sublegal numbers | |
|---|---|---|---|---|
| Hook - Bait | CPUE | ± S.D | NPUE | ± S.D |
| 14/0 - 2 oz | 215.7 | 127.5 | 12.3 | 14.0 |
| 14/0 - 4 oz | 281.5 | 187.8 | 7.3 | 9.5 |
| 16/0 - 2 oz | 231.2 | 163.5 | 7.8 | 6.5 |
| 16/0 - 4 oz | 332.0 | 214.9 | 9.6 | 10.2 |
| 16/0 - 6 oz | 329.2 | 226.7 | 7.2 | 6.5 |
| **Significant?** | No | | Yes | |

**Table 4. Bait batches tested in the bait quality experiment, with catch averages and standard deviations.**

| Bait source | Year frozen | Legal pounds | | Sublegal numbers | |
|---|---|---|---|---|---|
| | | CPUE | ± S.D | NPUE | ± S.D |
| Area 2B; Nitnak | 1999 | 434.8 | 351.7 | 5.4 | 6.4 |
| Area 3A; Cook Inlet | 1999 | 506.4 | 350.5 | 5.9 | 7.1 |
| Area 3A; Cook Inlet | 2000 | 385.0 | 309.6 | 5.2 | 9.4 |
| Area 2C; Hidden Falls | 1999 | 529.3 | 444.1 | 4.1 | 4.8 |
| Area 2C; Hidden Falls | 2000 | 394.8 | 376.6 | 4.1 | 7.2 |
| **Significant?** | | No | | No | |

**Table 5. Fishing success and average catch rate of Pacific halibut per 5-skate set by area and season during the 1998-1999 substitute bait experiment.**

| Area and season | Fishing dates | Number of sets successfully completed |
|---|---|---|
| 3A Winter | Dec 3 – 13, 1998,<br>Jan 6 – Feb 21, 1999 | 151 out of 182 |
| 3A Spring | May 2 – 20, 1999 | 32 out of 34 |
| 2B Winter | Dec 7 – 13, 1998,<br>Jan 6 - Feb 8, 1999 | 117 out of 166 |
| 2B Spring | May 4 – 30, 1999 | 83 out 96 |

**Table 6. Average catch per unit effort of legal and sublegal-sized Pacific halibut by area and season from the 1998-1999 substitute bait experiment.**

| Bait type and size | Legal CPUE: pounds per skate | | | |
|---|---|---|---|---|
| | Area 3A | | Area 2B | |
| | Winter | Spring | Winter | Spring |
| Large Chum | 649.7 | 873.2 | 428.2 | 204.7 |
| Large Herring | 409.7 | 604.5 | 357.4 | 194.8 |
| Small Herring | 371.5 | 380.4 | 242.5 | 105.7 |
| Large Squid | 583.4 | 683.7 | 369.0 | 170.4 |
| Small Squid | 531.6 | 459.2 | 350.7 | 113.0 |

| Bait type and size | Sublegal NPUE: numbers per skate | | | |
|---|---|---|---|---|
| | Area 3A | | Area 2B | |
| | Winter | Spring | Winter | Spring |
| Large Chum | 5.0 | 1.6 | 6.2 | 5.3 |
| Large Herring | 6.2 | 2.1 | 7.3 | 6.5 |
| Small Herring | 5.1 | 1.6 | 6.5 | 7.1 |
| Large Squid | 5.4 | 2.6 | 6.7 | 7.6 |
| Small Squid | 5.2 | 1.6 | 7.2 | 8.5 |

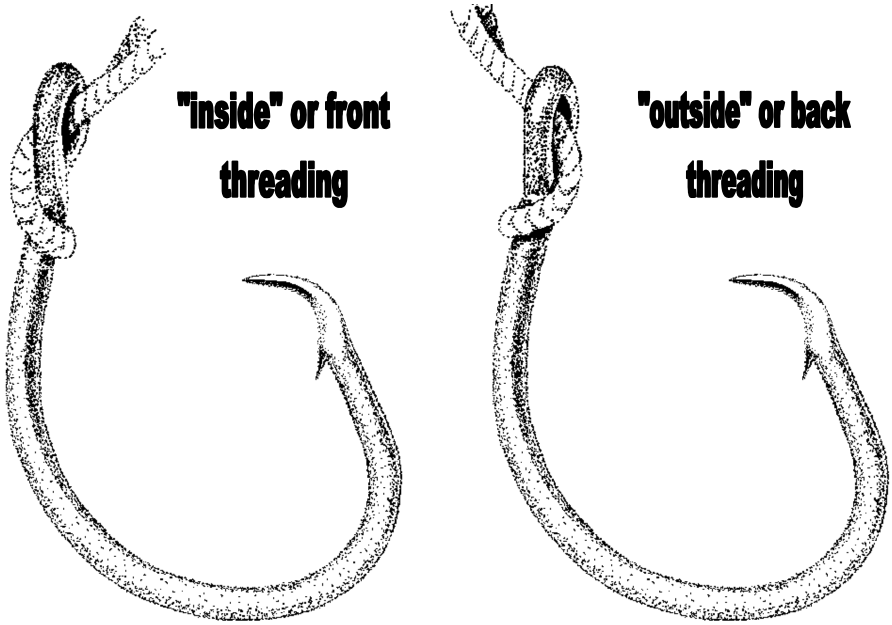


**Figure 1. Illustration showing 'inside' and 'outside' gangion threading for gangion orientation experiment.**

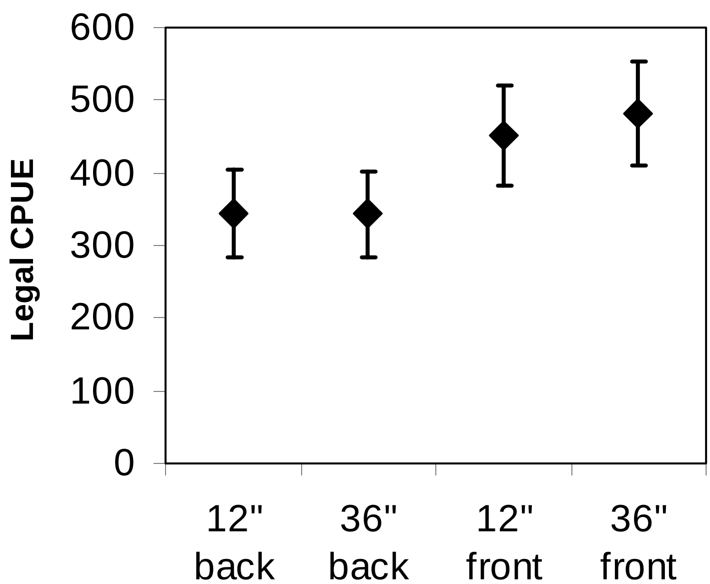


**Figure 2. Means plot of legal CPUE with 95% confidence intervals for gangion length / hook orientation experiment.**

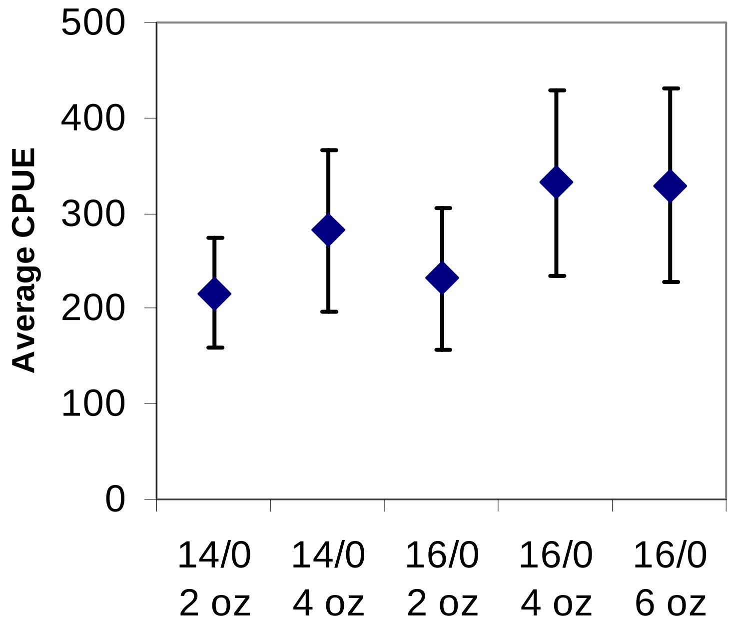


**Figure 3. Means plot for square-root transformations of legal-sized CPUE in hook size and bait size experiment using data from sets 4-22. Vertical bars indicate 95% confidence intervals.**

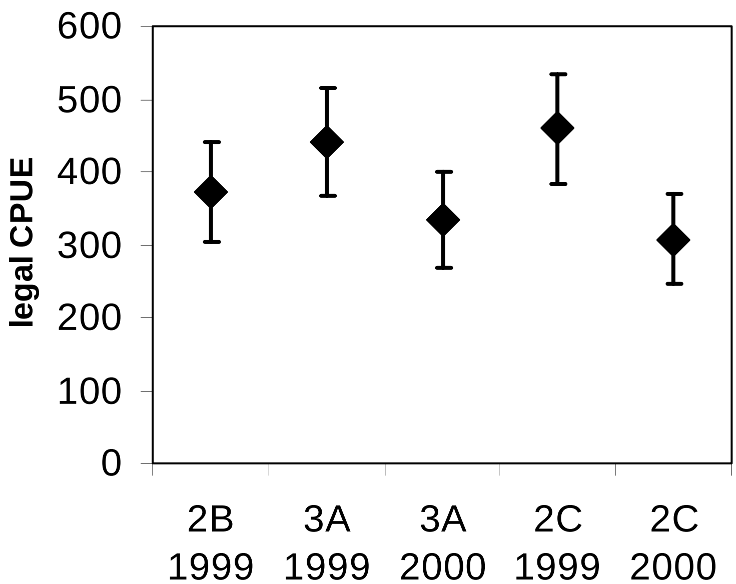


**Figure 4. Means plot for square-root transformations of legal CPUE in the bait quality experiment using data from sets 4-22. Vertical bars indicate 95% confidence intervals.**

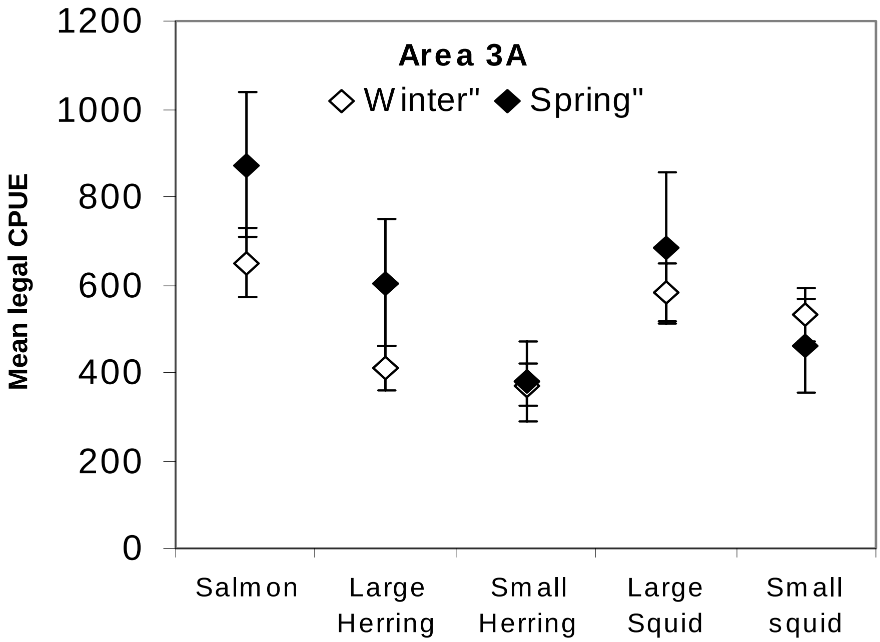


**Figure 5. Catch in pounds (CPUE) for legal sized halibut in Area 3A during the winter-spring bait comparison study. Vertical lines indicate 95% confidence limits.**

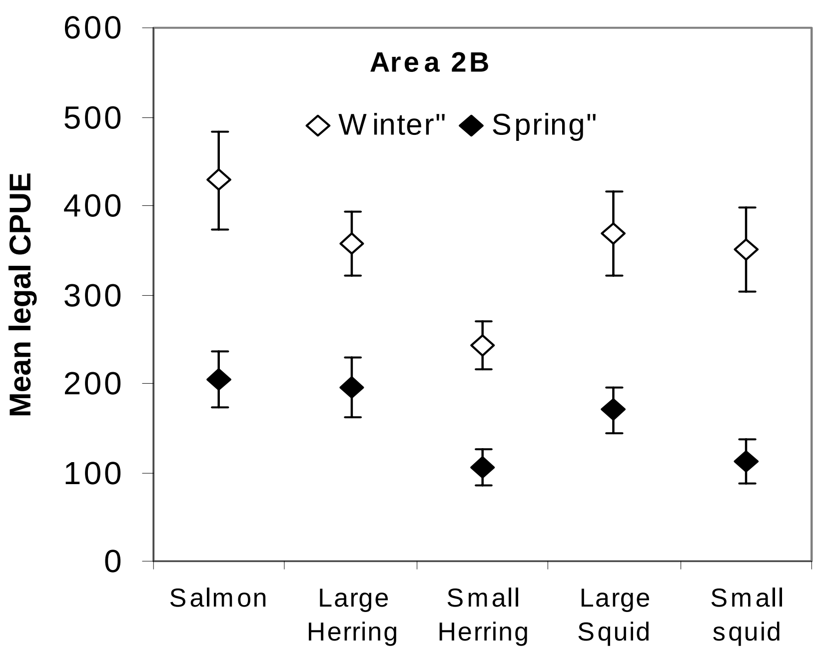


**Figure 6. Catch in pounds (CPUE) for legal sized halibut in Area 2B during the winter-spring bait comparison study. Vertical lines indicate 95% confidence limits.**

# Field Test of Robust pH Meter


## Stephen M. Kaimmer


### Introduction

The International Pacific Halibut Commission has been studying the incidence and occurrence of chalky halibut in commercial landings since 1997 (Kaimmer, 2000). Early in this study, we recognized the need for detecting chalky halibut when landed and sold by the fishers. The detection technique currently used involves a visual inspection of the flesh through a cut either into the tail or dorsal area of the fish. The flesh of chalky halibut is an opaque white, contrasting with a more translucent appearance in non-chalky fish. The visual inspection method does not detect all the chalky fish, since in some cases the visual indications of chalkiness may take three to seven days to develop after the fish is killed. The process by which halibut turns chalky was well described by four reports published in the 1960s (Tomlinson et al 1965, 1966a and 1966b, and Patashnik 1966). Normally, the pH of halibut flesh is above 6.2. In fish where the chalky condition develops, the flesh pH is lower than 6.2 (lower pH = more acidic). Fish with pH between 6.0 and 6.2 are sometimes chalky. Fish with pH below 6.0 are always chalky. The visual indications of chalkiness are the direct result of the flesh pH, and the time period associated with the appearance of visual indications are probably affected by both the holding temperature and the degree of acidity in the flesh. The change in flesh pH appears to develop within the first one or two days after death, as the result of lactic acid stored in the muscle tissue prior to death. During 2000, we contacted a number of manufacturers of pH meters. We requested to borrow pH meters and probes for a field test of their effectiveness in screening halibut for flesh pH. Three manufacturers agreed to loan us meters for testing. We received the following meters: HI 9023C meter with FC230B probe from Hanna Instruments, USA; IQ150 meter with PH07-SS probe from Cole-Parmer Instrument Company, IL; and Argus meter 5000-0001 and 2074-008 probe from Sentron, Inc., WA. The Hanna probe was a conventional glass probe and the probes from Cole-Parmer and Sentron were ISFET[1] probes. The ISFET probes were much smaller in diameter than the glass probe, and the Sentron probe had a piercing tip that most easily penetrated the halibut skin. We determined to perform the field test using the Sentron probe.

### Methods

IPHC staff visited New West Fisheries in Bellingham, Washington to field-test pH meters for use in scanning for halibut chalkiness. The plant had already started processing a load of fish that had been shipped in totes from Alaska. The fish were at least four days old when tested, since the shipping takes three days. Video and still images of the testing process were also obtained.

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[1] ISFET (Ion-Sensitive Field Effect Transistor) meters and probes use a durable membrane on the tip of the probe as a pH sensor, as opposed to conventional pH probes which use a more fragile glass bulb at the tip. This allows the ISFET probes to be smaller in diameter and to have shaped or sharpened tips, which can penetrate skin and membranes easily

The meter/probe was an “Argus” Part #5000-0001 with LanceFet probe Part #2074- 008 (Figure 1), supplied by Sentron, Inc.of Gig Harbor, Washington. The retail value on the probe and meter is $890. The probe has a sharpened stainless-steel tip designed for meat penetration.

Fish had already been visually screened for chalkiness by plant personnel, using a small cut on the dark side of the fish just below the dorsal fin. The pH probe was inserted into this same cut, to avoid further marking of the fish. However, we also probed directly into a small number of fish which had been set-aside as Number 2, and the probe penetrated the skin and flesh without problem or delay.

## Results and Discussion

We tested 33 fish, 22 that had been screened as Not Chalky, and 11 that had been screened as Chalky (Table 1). The relationship between pH range and chalkiness agreed completely with previously published data. It is interesting to note that the pH meter was in complete agreement with the visual checker on all fish with pH either less than or equal to 6.0, or greater than pH 6.2. Had these fish been screened when they were initially offloaded from the catcher vessel, we would have expected to pH readings to have been about the same on individual fish, and with less obvious visual indications of the chalky condition. These readings also suggest that some fish graded visually as Not Chalky might develop chalkiness prior to marketing.

The meter was robust and very easy to use. Readings could be obtained in a matter of seconds. The probe has a both a thermister (for temperature) and a pH-sensitive membrane, and the meter we tested automatically compensates for changes in temperature. When the probe was inserted into the first fish, it took 60 seconds for the temperature reading to stabilize from the outside ambient temperature of 11.2°C to 2.2°C, the temperature of the iced flesh. The pH reading is almost instantaneous, but changes as the probe temperature stabilizes to the flesh temperature. As the temperature of the probe drops, the internal system compensation results in an increase in pH reading. For the example here, the pH reading changed from 6.36 to 6.41 as the temperature stabilized. Therefore, it is only for fish with pH readings below 6.2 on initial insertion for which temperature compensation is important to accurate classification. From an operational perspective, temperature compensation is not a major issue. Once the probe was at the flesh temperature, it could be rinsed and inserted into another fish very quickly. Between fish, the probe temperature did not have time to rise from the flesh temperature, and the pH reading on subsequent fish was accurate within seconds following probe insertion. We were able to easily make readings on different fish about every six seconds. Further testing is necessary to determine the time sequence of post-mortem pH changes in halibut muscle, and their relationship to the development of the visual indications of chalkiness.

## Acknowledgements

We would like the thank Jim McKenzie of Hanna Instruments, Melissa Lewandowski of Cole-Parmer Instruments, and Eric Amundson of Sentron Instruments for their consideration in loaning meters for testing. I would also like to thank Vic Christensen of New West Fisheries, Bellingham, for allowing us a site for the testing.

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**Table 1. Number of observations and percent of fish visually determined to be either chalky or not chalky by range of flesh pH.**

| *Range of measured pH* | *Result of visual screening* Not chalky | | Chalky | |
|---|---|---|---|---|
| 5.70-6.00 | 0 | 0% | 8 | 100% |
| 6.07-6.11 | 2 | 40% | 3 | 60% |
| 6.20-6.70 | 20 | 100% | 0 | 0% |


**Figure 1. Sentron probe used in pH meter field test. The stabbing portion of the probe is 5 cm in length, with the last 1.7 cm tapering to a sharp point. The sensing membrane is contained in the tapered point.**

# Summary of 1960's investigations of chalky halibut


## Stephen M. Kaimmer


## Introduction

While the first records of chalky halibut investigations date from the 1950s (Bell 1950), the first published studies into chalky halibut are from the mid-1960s with reports from joint studies by the U. S. Bureau of Commercial Fisheries in Seattle, WA and the Fisheries Research Board of Canada in Vancouver, B.C. (Patashnik and Groninger 1964, Tomlinson et al. 1964, 1965, 1966a, 1966b, and Tarr 1966, 1968). These were not the first papers to mention chalkiness in halibut, but they represented a coordinated research effort to investigate the problem. Additional information is contained in unpublished reports from the period (Patashnik 1965, Myhre 1968). In 1985, Alaska Sea Grant summarized the older reports, but added no new information (Kramer and Paust 1985).

When the studies were initiated, the cause of chalkiness was unknown, and it was not known whether the condition was present in the flesh when the fish were caught or whether it developed post-mortem. The condition had been previously described as having higher oil and protein content and lower water content, but these quantitative differences were thought to be results of, rather than the causes of, the chalky condition. The chalky condition was described as one where the flesh was dull and opaque, in contrast to the shiny, semi-translucence of normal raw flesh. In addition, chalky halibut was described as softer and 'flabbier' than normal, and the myomeres of chalky flesh would tend to separate from each other more readily than in non-chalky flesh.

A series of four reports, three published by Tomlinson, Geiger, and Dollinger in 1965 and 1966 and one published by Patashnik in 1966, gave a thorough groundwork for understanding the chalky condition in halibut. The first three authors worked at the Technological Research Laboratory of the Fisheries Research Board in Vancouver, B.C., while Patashnik was at the Technological Laboratory of the U.S. Bureau of Commercial Fisheries in Seattle. While these reports are old and copies are difficult to obtain, they remain definitive works describing the development and causes of chalkiness in Pacific halibut. This paper will detail the findings of those reports in order to make these findings more readily available. In many cases, the data or text from the reports will be reproduced exactly as it appears in the source document. Due to the nature if this paper, and the number of times exact text will be quoted, quotations will not be used on these inclusions.

## Tomlinson N., Geiger, S. E., and Dollinger, E. 1965. Chalkiness in halibut in relation to muscle pH and protein denaturation.

### Summary

Trawl caught halibut and some longline halibut were examined for muscle pH, lactic acid and protein concentrations. These results were compared with visual indications of chalkiness. The authors found that chalky fish caught by either method had opaque flesh, lower pH, higher lactic acid concentrations, and lowered protein solubility than non-chalky fish. All of these indicators developed post-mortem, taking as long as three to seven days to be evident. The authors conclude that chalkiness is most likely the result of a change in muscle proteins, developing post-mortem. The change to the chalky condition was shown to be dependent on the pH of the muscle, taking place only if it fell to about 6.0 or lower. The "cooked" appearance of the chalky muscle is related to the loss in protein solubility. They further state that the quantity of lactic acid found in fish muscle post mortem and consequently the pH is related to the glycogen content of the muscle of the fish at hooking or netting, and is in turn related to the state of nutrition of the fish. They would expect well-fed fish to be more likely to become chalky. They further surmise that while both trawl and longline-caught fish undergo struggling and exhaustion during capture, that longline fish would have the opportunity to recover from this exhaustion while "resting" on the hook. This would reduce the lactic acid content prior to gear retrieval.

**Methods**

Halibut were caught by trawl. For contrast, additional samples of longline-caught fish were obtained after being held on ice for from two to three weeks. Trawls were from one to three hours duration. Once onboard, a large cut was made for visual determination of chalkiness and a similar determination was made after landing six days later. Fish were classified as being normal, moderately chalky, chalky, or very chalky. Muscle samples were taken both when the fish was caught and when the fish was fletched. In some cases, additional muscle samples were taken at periods of up to seven hours after catching and before fish were iced. Once taken, all muscle samples were frozen on dry ice and then held at -30$^{o}$C until analyses could be carried out. Flesh pH and lactic acid, protein nitrogen, and soluble protein concentrations were determined in the laboratory. After capture, fish were held on ice for six days and then landed. Since the chalky condition appeared to develop post-mortem and since the change in appearance seemed to be the result of some change in the muscle protein, the extractability of these proteins was investigated. Since the pH of the flesh was expected to exert an influence on the state of muscle proteins, pH and lactic acid content were also determined.

**Results**

***Visual screening for chalkiness***

In a pilot experiment, over 2000 halibut were visually examined during three fishing trips to determine whether chalkiness was a post-mortem development. None of the fish were visually chalky at the time of catching, but from 35-70 % of the fish were judged to be chalky when landed 5-10 days later. A number of fish found to be not chalky after being held on deck for 1 to 7 hr before being examined and iced, became chalky before being landed six days later.

***Extractability of muscle proteins***

Twenty fish were randomly selected for laboratory analyses. On being landed, 12 of the fish were normal and eight chalky. Samples were taken from individual fish when they were caught, and then when they were landed six days later. There was a pronounced decrease in the extractability of muscle protein in fish that were chalky. The authors present representative data from this part of the study (summarized in Table 1). The percentage of protein that is extractable in flesh taken just after capture was 90.3 and 90.8 percent in normal and chalky fish, respectively. When the fish were landed, those percents dropped to 86.0 for normal fish, and 51.0 for chalky fish (59.7% for moderately chalky fish and 45.6% for very chalky fish).

### *Flesh pH*

The flesh of the chalky fish had a pH below 6.0 when landed, while the flesh of normal fish was 6.0 or higher. The lower pH was related to a higher concentration of lactic acid. There was also a tendency for a greater increase in the dry weight of chalky muscle than seen in normal muscle during storage of the fish in ice. The flesh pH between fish that would be chalky and normal fish did not differ when the fish was caught.

### *Comparison of samples following thawing*

Since the flesh of normal and potentially chalky halibut was indistinguishable at catching insofar as appearance, pH, and protein extractability of samples frozen at capture were concerned, but became apparent within a few days storage on ice, a comparison of thawed samples from normal and chalky fish was made. Samples were examined while they were still frozen, immediately after being thawed, and after a further two hours storage at 20°C (Table 2). Samples frozen at catching were semi-translucent when thawed. The sample from the chalky fish became opaque within two hours, while the sample from the normal fish was partly cloudy. The marked change in appearance of the sample from the chalky fish frozen at catching was accompanied by a marked decrease in pH and in extractability of muscle proteins.

### *Examination of fish caught by longline*

Samples of six normal and six chalky fish caught by longline were obtained when the fish were landed in ice, two to three weeks after catching. The chalky samples were analyzed for soluble protein both before being frozen and again after freezing. Muscle protein and pH were determined in all fish. A marked difference between normal and chalky fish in protein extractability and muscle pH was obvious, similar in magnitude to that found between chalky and normal trawled fish (Table 3). All of the trawl samples had been frozen prior to analysis. The longline fish were tested both before and after freezing to determine whether the freezing had an effect on results. From Table 3, by far the greatest loss in protein solubility took place prior to freezing.

## Tomlinson N., Geiger, S. E., and Dollinger, E. 1966a. Free drip, flesh pH, and chalkiness in halibut.

### Summary

The authors investigated the relationship between free drip, flesh pH, and chalkiness in halibut. Free drip was found to increase continuously with decreasing pH in the range pH 6.8-5.7. Flesh pH varied somewhat with location in the body, being higher near the head. The minimum flesh pH was reached within 24-48 hours of death and increased slowly thereafter.

All fish with a flesh pH below 6.0 were chalky, those with a pH above 6.2 non-chalky, while in the pH range between 6.0 and 6.2 there was an intermingling of chalky, borderline chalky, and nonchalky.

### Methods

Trawl caught halibut were stunned, eviscerated and held on ice for 11 days. Measurement of pH was by insertion of a pH electrode into small incisions on the flesh at various locations around the body. Free drip was determined from skinned fillets as a percentage of the initial weight of the sample. Degree of chalkiness was determined by visual examination of the surface of a cut made across the wide portion of the body. Fish were rated chalky when the flesh was white, opaque, and dull in appearance, borderline when white, nearly opaque, but shiny in appearance, and not chalky when translucent and shiny in appearance. The fish examined were mostly small and medium in size (10-20 and 20-60 lb, respectively) with only a very few large (60-100 lb) fish examined.

**Results**

***Variation of pH within the flesh***

Eleven locations across the halibut body were sampled in seven different halibut (Figure 1). There was a tendency for the pH to be higher near the head of the fish and lower near the center of the body (Table 4). Maximum variations in pH encountered between any two positions were on the order of 0.3.

***Change in flesh pH with time***

In general, the minimum pH was reached within the first or second day of storage (Figure 2). Flesh pH was determined when the fish were caught, and on day one, two, eight, and thirteen after capture. Flesh pH values dropped about 0.2 to 0.4 between the first and the third day. There was a tendency for the pH to increase slowly after the initial decrease, although these increases never returned to the starting value.

***Relation between flesh pH, free drip, and chalkiness***

One hundred and twenty-two halibut were examined for flesh pH, free drip, and chalkiness (Figure 3). While there was a good deal of scatter in the free drip values observed, it is clear that there was a trend toward higher free drip values with decreasing pH, and that this trend was continuous within the pH range encountered. On average, after 11 days storage in ice, free drip from chalky fish (8.5%) was a little more than double that from nonchalky (3.8%), with that from borderline fish occupying an intermediate position (6.2%).

## Patashnik, M. 1966. New approaches to quality changes in fresh chilled halibut.

**Summary**

This study focused on defining the initial quality of landed fresh halibut in subjective and objective terms, and to relate these to the time-temperature rate of change in quality of the frozen product. The author describes both chemical and physical methods of determination. Product was held for up to 30 days, and was also submitted to a taste panel. Most of this paper discusses tests for product deterioration, particularly with respect to bacteriological growth. I will only summarize those results specific to chalkiness.

**Methods**

A hydraulic shear was used to test toughness in halibut that was cooked after two and fifteen days in iced storage. A greater shear force represents a higher textural resistance, or toughness, in the halibut sample. The author also determined pH of the interior flesh of halibut and related this to halibut weight.

**Results**

***Toughness***

There was a small but detectable difference in toughness resulting from time in storage. There was also an almost two-fold increase in toughness between high pH and low pH flesh. The author concludes that the pH is of greater significance in determining flesh toughness than storage time. He states that it is known that pH is related to the degree of struggling prior to death, and suggests that stunning a fish as it is landed to limit struggling on deck would result in a higher flesh pH.

***Chalkiness and fish weight***

The author observed the pH of halibut to decrease with fish weight, with a corresponding increase in chalkiness (Figure 4).

***Chalky condition***

The chalky condition is described. Normal halibut is described as semi-transparent. Chalky halibut is described as having a flat-chalky-white opaque color, a low pH, and a great tendency to lose water from cut tissue. Further, chalky halibut is described as having lower protein solubility and a lower protein content in the free drip. The cooked meat of chalky halibut is described as dry or tough. The causes of the chalky condition are described as involving (1) feeding halibut with high glycogen energy reserves, (2) death occurring in a frenzy of activity or a state of extreme exhaustion, with a resulting accumulation of fatigue-produced lactic acid in the muscle, (3) the inability to get rid of the lactic acid accumulation, and (4) high holding temperatures - the higher the holding temperature, the quicker the development of the chalky condition. Based on these preliminary observations, the author advises fishermen to kill or stun halibut immediately to stop all physical activity and to chill halibut immediately.

## Tomlinson N., Geiger, S.E., and E. Dollinger. 1966b. Influence of fishing methods on the incidence of chalkiness in halibut.

**Summary**

The earlier studies found a much higher degree of chalkiness in trawl caught fish than in longline caught fish. The author's suggested that this was either the result of the trawl catching heavily fed fish which might not be a susceptible to longlines, or that the longline allowed the fish a more or less lengthy recovery period following capture and prior to death. Three experiments using trawl caught halibut investigated the second hypothesis. The authors demonstrated that a recovery period following capture of trawl caught halibut resulted in an increase in post-mortem flesh pH and a decrease in post-mortem chalkiness.

**Methods**

After removal from the trawl net, halibut were either immediately killed, eviscerated, and iced, or placed into a seawater tank for various lengths of time prior to being killed, dressed, and iced.

After an 11-day storage, flesh pH was measured and fish were examined for chalkiness. Fish were classified as chalky, borderline, or nonchalky.

**Results**

Results for the first two experiments are given in Table 5. In each of these experiments, the mean flesh pH was higher, and the incidence of chalkiness lower, in the group allowed the period of recovery than in the corresponding group killed at once. A lower overall flesh pH was seen in experiment one (6.06) than in experiment two (6.35) This corresponded to a higher overall chalkiness rate in experiment one. The change in mean flesh pH with the recovery period was of about the same magnitude in both experiments. Data from the third experiment are not presented, but the authors describe it's results as being essentially the same as those of experiment two. Results were not significant in the first experiment (p=0.2) but were significant in the second and third experiments (p=0.01). Combining results across all three experiments gave significant results at p=0.01.

The authors view the results as evidence that the time that elapses between capture and killing in effect allows longline caught fish to recover from the exhaustion of the capture process.

**Discussion**

The authors of these papers expected that chalkiness would be more prevalent in fish that were well fed, with higher glycogen reserves. This has not been demonstrated, either in the experiments during the 1960s, or in subsequent experiments or observations. The authors further demonstrate an increase in chalkiness with fish size. The 1999 IPHC chalky experiment found the opposite, that chalkiness was more prevalent in small fish.

The papers summarized in this report give a clear description of the chalky condition. In short summary, the flesh of chalky halibut is a dull, 'chalky' opaque white. Non-chalky flesh is shiny and semi-translucent. The condition is usually not apparent when the fish is first caught, and may take up to seven days to become obvious. Chalky fillets have lower protein solubility and higher drip-loss, from four to as high as nine percent compared to one to two percent in non-chalky flesh. The cooked meat of chalky halibut may be dry and tough compared to non-chalky flesh, but is otherwise acceptable as a food product. The flesh of chalky halibut is more acidic. Fish with pH above 6.2 are never chalky, while those with pH below 6.0 are always chalky. Between pH 6.0 and 6.2, halibut can be chalky, not chalky, or partially chalky. The visual and pH indicators of chalkiness develop post-mortem.

The metabolic basis for the chalky condition is also clear. Muscle tissue stores energy in the form of long glucose chains called glycogen. Energy is released from glycogen by the process of glycolysis. This is the energy that fuels muscle contraction, and all other cellular energy-dependent functions. In the first stage of glycolysis, energy is produced when glycogen is converted from six-carbon molecules into three-carbon molecules called pyruvic acid, or pyruvate. Under conditions of normal activity, all the pyruvate produced is shuttled into mitochondria within the muscle tissue where oxidative breakdown produces further energy. This is the normal metabolic path for pyruvate, producing the most energy for the tissue.

Mitochondrial energy production consumes oxygen, and during periods of high-energy need the amount of oxygen available to the cell determines how much or how fast energy may be produced. When mitochondrial capacity is exceeded, energy production may continue at a lower level by allowing the first step of glycolysis to produce pyruvate faster than it can be metabolized aerobically. Extra energy can thus be made available for brief periods of high activity, like swimming away from a predator, or struggling against capture on a hook. This additional pyruvate is converted anaerobically to lactic acid, or lactate, a temporary dead end in the energy yielding process. If fish could not allow temporary accumulations of lactic acid, their ability to perform brief high intensity exercise would be almost eliminated. The cost to the fish in the short term lies in the accumulation of lactic acid, and this lactic acid must eventually be converted back to pyruvate and subsequently metabolized in the normal aerobic manner.

When the rate of conversion of lactic acid cannot keep up with its production or appearance in the blood, it accumulates and pH is lowered, which inhibits muscle contraction. The fish is therefore fatigued and muscle efficiency is reduced dramatically. A rest period following fatigue gives an opportunity for the aerobic removal of lactic acid from the system. Over time, lactic acid will diffuse from the muscle tissue into blood capillaries, and eventually to the highly aerobic heart, liver, or kidneys or into inactive muscles with higher oxygen reserves. At these locations lactic acid is converted back to pyruvic acid and metabolized by mitochondria or used by the liver as a building block to re-synthesize glucose.

A fish that dies in a state of fatigue has a high amount of stored lactic acid. The increase in lactic acid in the tissue, and corresponding decrease in pH, occurs shortly after death and takes place over a period of 12 to 24 hours or less. This lactic acid is directly responsible for the acidic denaturation of muscle proteins, and the change in visual appearance of the tissue. The denaturation of the proteins, and corresponding visual indications of chalkiness, take place over a period of a few days to a week.

The ultimate causes of pH change in Pacific halibut are less clear. Possible causes of the lowered pH include death occurring while the fish is exhausted with resultant high lactic acid concentrations, feeding differences resulting in high muscle glycogen reserves at time of capture, as well as high ambient or holding temperatures. The post-mortem pH of halibut muscle can be raised by simply allowing a rest period before death. The increase in pH is accompanied by a reduction in incidence of chalkiness. This provides support for the view that chalkiness is caused by low flesh pH and not by some unknown pathogen or abnormal condition. Two general area/time patterns for chalky occurences in Canada and Alaska have been observed. Chalkiness is generally first seen in Canada in the waters outside of Vancouver Island during mid-August and over a period of a few weeks becomes evident to the north in the waters of Hecate Strait (personal communication Blake Tipton, S.M. Products Ltd., Delta, B.C.). A similar pattern is seen in Area 3A, where first reports are often seen around the southern end of Kodiak Island in early September, then moving north and east into the waters of Cook Inlet and Prince William sound (personal communication Brad Faulkner, Alaska Custom Seafoods, Homer, AK). Although both patterns are associated with warmer summer months, it is not known if additional ecological factors such as a change in feeding patterns also play a role in these patterns.

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Tomlinson N., Geiger, S. E., and Dollinger, E. 1964. Chalky halibut. Fish. Res. Bd. Can., Vanc. Lab. Circ. 33.

**Table 1. Relation between pH, lactic acid and protein solubility (mg/gram muscle), and dry weight (% of wet weight) of halibut muscle and appearance of chalkiness (fish taken in trawls).**

| Condition when landed | No. of fish | At catching | | | | Dry wght | On landing 6 days later | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | pH | Lactic acid | Protein N Tot. | Protein N Sol. | | pH | Lactic acid | Protein N Tot. | Protein N Sol. | Dry wght |
| Normal | 12 | 6.28 | 6.0 | 27.8 | 25.1 | 21.9 | 6.17 | 6.9 | 28.4 | 24.4 | 22.5 |
| Mod. Chalky | 3 | 6.16 | 7.1 | 27.0 | 24.9 | 21.8 | 5.90 | 7.8 | 29.8 | 17.8 | 23.6 |
| Very chalky | 5 | 6.22 | 5.8 | 27.3 | 24.0 | 21.7 | 5.76 | 8.3 | 29.2 | 13.3 | 23.7 |
| *Combined chalky* | *8* | *6.19* | *6.3* | *27.2* | *24.4* | *21.7* | *5.81* | *8.1* | *29.4* | *15.0* | *23.7* |

**Table 2. Changes in pH and in extractable protein (mg/gram muscle) in frozen normal and chalky halibut muscle on thawing.**

| Condition at extraction | Frozen at catching | | | Frozen on landing | | |
|---|---|---|---|---|---|---|
| | pH | Protein N soluble in NaCl solution | Protein N soluble in KCl Solution | pH | Protein N soluble in NaCl solution | Protein N soluble in KCl Solution |
| *Normal fish* | | | | | | |
| Frozen | 6.31 | 26.8 | 5.2 | 6.25 | 25.3 | 4.4 |
| Thawed (8 min, 20°C) | 6.32 | 25.1 | 5.1 | 6.28 | 26.7 | 4.4 |
| Thawed (2 hr, 20°C) | 6.33 | 23.0 | 4.8 | 6.24 | 24.3 | 4.1 |
| *Chalky fish* | | | | | | |
| Frozen | 6.18 | 25.2 | 6.0 | 5.74 | 13.4 | 2.6 |
| Thawed (8 min, 20°C) | 6.13 | 25.7 | 5.4 | 5.74 | 13.2 | 2.5 |
| Thawed (2 hr, 20°C) | 5.79 | 12.2 | 4.0 | 5.70 | 10.3 | 2.7 |

**Table 3. Soluble protein nitrogen and pH of normal and chalky muscle from halibut caught by longline.**

| | Number | | Protein N | | | | |
|---|---|---|---|---|---|---|---|
| | | | Before freezing | | | After freezing | |
| | of fish | pH | Total | Soluble | % Sol. | Soluble | % Sol. |
| Normal fish | 6 | 6.46 | 27.9 | 25.1 | 90 | - | - |
| Chalky fish | 6 | 5.91 | 29.3 | 13.5 | 47 | 10.8 | 40 |

**Table 4. Variation in flesh pH in halibut with location of the measurement site. Each value is the mean for seven fish.**

| Position No. | Mean pH | Mean deviation from mean pH for all positions |
|---|---|---|
| 1 | 6.05 | +0.09 |
| 2 | 6.03 | +0.07 |
| 3 | 5.96 | 0.00 |
| 4 | 5.97 | +0.01 |
| 5 | 5.96 | 0.00 |
| 6 | 5.89 | -0.07 |
| 7 | 5.85 | -0.11 |
| 8 | 6.04 | +0.08 |
| 9 | 5.96 | 0.00 |
| 10 | 5.96 | 0.00 |
| 11 | 5.87 | -0.09 |

**Table 5. The influence of a recovery period between the catching and killing of halibut on flesh pH postmortem and on incidence of chalkiness.**

| | Fish killed | |
|---|---|---|
| | Immediately after being caught | After a period of recovery |
| *Experiment 1* | | |
| Recovery period | - | 10 hr |
| Number of fish | 13 | 13 |
| Mean flesh pH | 5.98 | 6.14 |
| Range of flesh pH | 5.74-6.45 | 5.78-6.66 |
| Percentage of fish chalky or borderline | 77 | 46 |
| *Experiment 2* | | |
| Recovery period | - | 9-13 hr |
| Number of fish | 21 | 21 |
| Mean flesh pH | 6.23 | 6.47 |
| Range of flesh pH | 5.90-6.64 | 6.25-6.85 |
| Percentage of fish chalky or borderline | 33 | 0 |

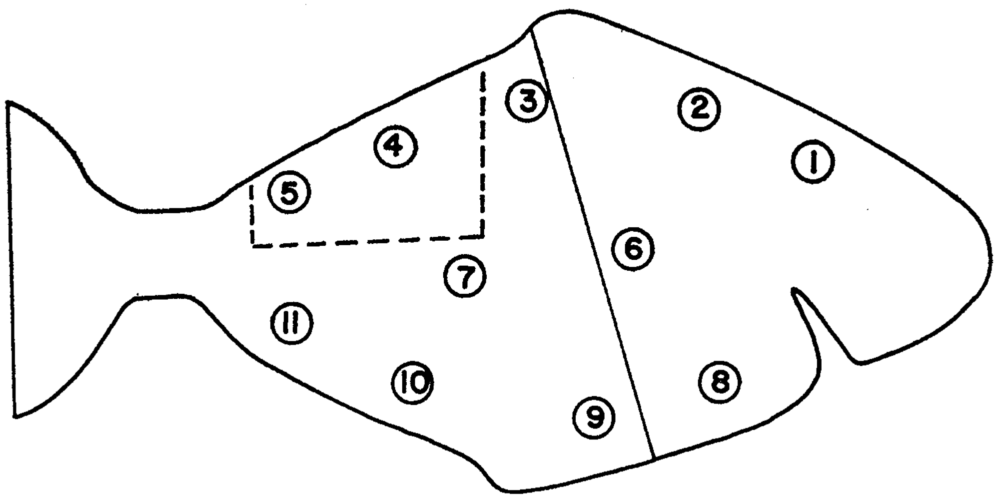


**Figure 1. Outline sketch of a halibut showing the sites at which pH measurements were made (numbered 1-11), the position of the cut made to enable visual examination of the flesh (solid line anterior to "3" and "9"), and the location of the position from which samples were taken for drip determinations (area enclosed by broken lines).**

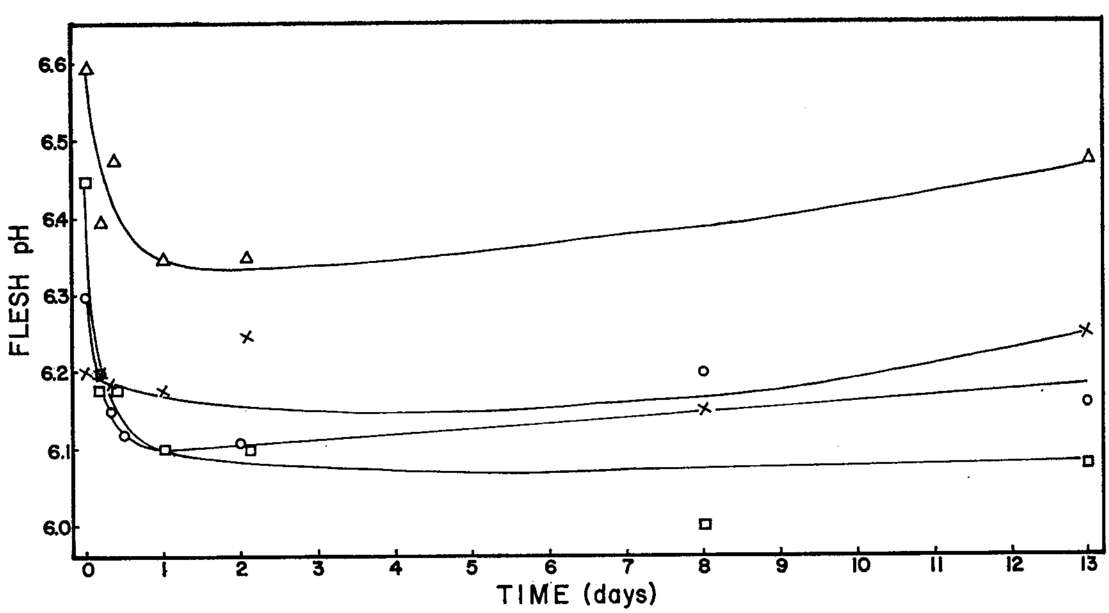


**Figure 2. Changes in halibut flesh pH with time of storage in ice. Each measurement was made in a separate, fresh incision in an area surrounding position "3", Fig. 1. The temperature of the flesh of these fish was 9-10 °C when they were killed, and 0-1 °C 4 hr after they were iced. The two small fish were in rigor within 4 hr of being killed, the medium fish within 8 hr. Small fish Δ and □, medium fish ❍ and X.**

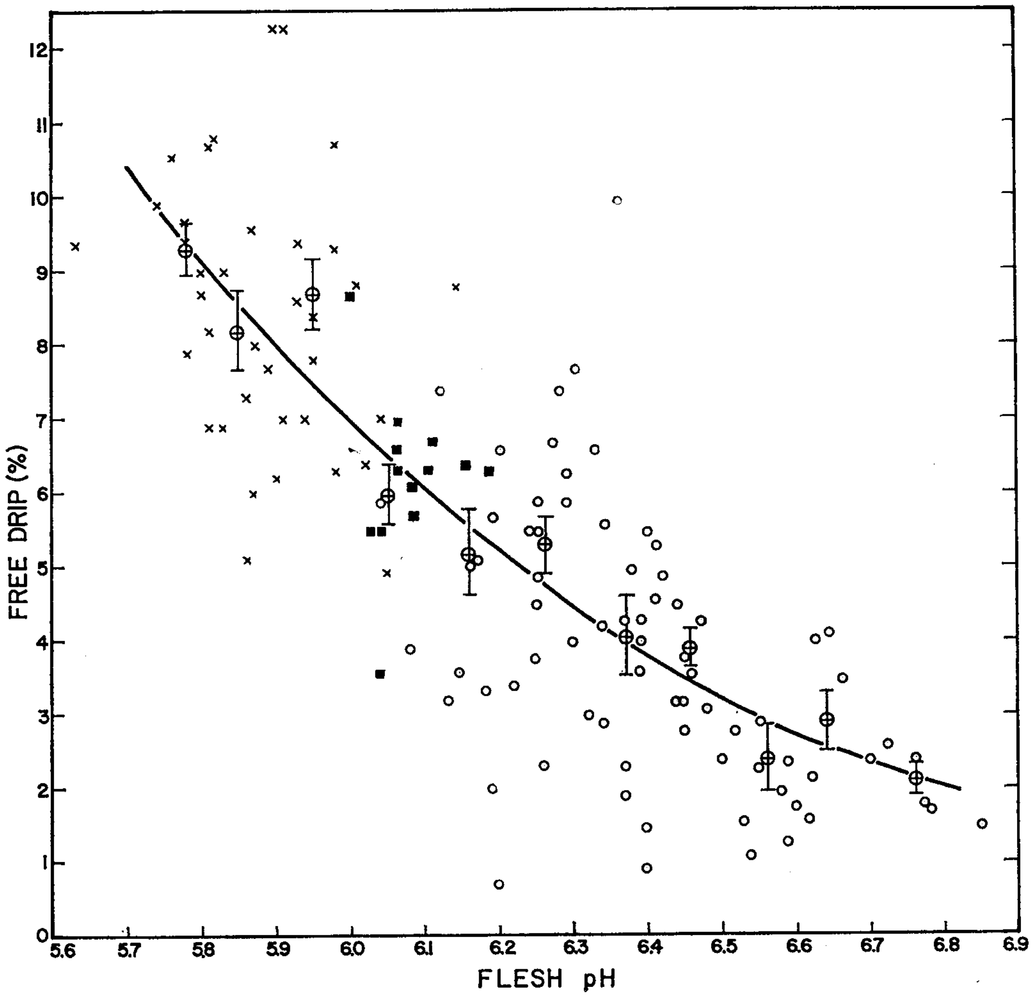


**Figure 3. Relation between free drip, flesh pH, and chalkiness in halibut. Free drip and flesh pH (position "3", Fig. 1) measurements made after the fish had been stored 11 days in ice. Chalky fish, X; borderline chalky, □; nonchalky, ❍. Mean value within each 0.1 pH unit interval, and the standard error of the mean, are indicated by ⊕ and the vertical line drawn through that symbol, respectively.**

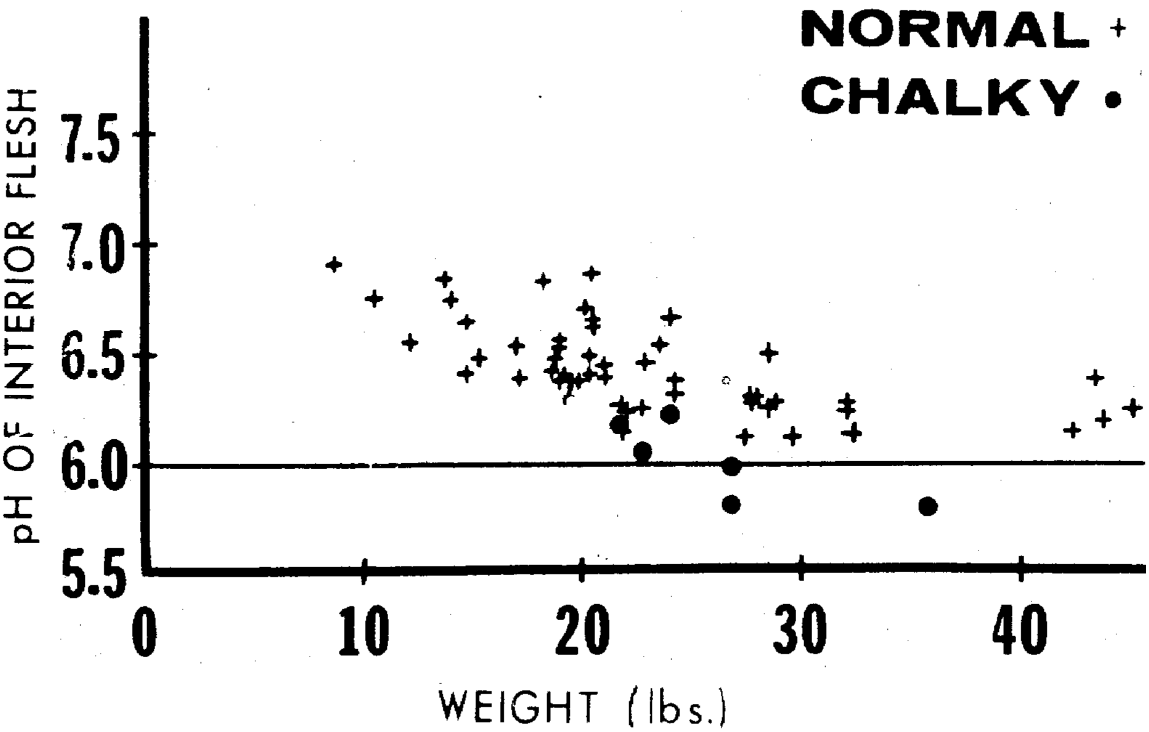


**Figure 4. Variation of interior meat pH with weight of the halibut, head on and eviscerated.**

# Survey Bait Comparison

## Din G. Chen and William G. Clark

### Summary

This paper reports the results of a statistical analysis of the bait comparison experiment done during the setline survey in summer 2000 to see whether a bait adjustment needs to be applied to recent survey catch rates in the annual stock assessment. We find there is no statistically significant difference between bait types in the survey catch per skate in total number of fish (legal and sublegal), which is the measure used in the stock assessment. However when the legal and sublegal sizes are considered separately, there is a significant difference for legal-sized fish in 3A, but not in 2B and not for sublegals in either area. Specifically, salmon baits caught 20% more legal-sized fish per skate and also slightly larger fish in Area 3A, but about 8% fewer fish per skate and slightly smaller fish in Area 2B (where the difference was not statistically significant).

### Introduction

IPHC conducted setline surveys in most years between 1976 and 1986 in Areas 2B and 3A. The surveys were discontinued after 1986 but resumed in 1993. At that time chum salmon was adopted as the standard survey bait, whereas in the mid-1980s survey gear was baited with herring and salmon on alternate hooks.

It was recognized in 1993 that the bait change might change the fishing power of the survey gear, but it was not regarded as likely, partly because of the close agreement of survey and commercial CPUE trends in 3A from the mid-1980s through the mid-1990s. Some experimental work done in 1999, however, showed that skates baited entirely with salmon caught about twice as many fish as skates baited entirely with herring. If the same bait difference occurred on skates baited with alternate salmon and herring, then a skate baited that way would catch only 75% as much fish as one baited with all salmon (because half the hooks would catch only half as many fish, for a catch reduction of 25%). The survey catch rates of the 1990s would therefore have to be scaled down by 25% to make them comparable with the catch rates of the 1980s. Pending a direct comparison of all-salmon with alternate salmon/herring baits, that adjustment was in fact applied in the 1999 assessment and biomass estimates were reduced 20-30% as a result (Clark and Parma 2000).

During the summer of 2000, the Commission performed the direct comparison of all-salmon and alternate salmon/herring baits in the course of the 2B and 3A surveys. Two strings were fished at each survey station, berthed 1-3 miles apart. All the skates on one string were baited with salmon and herring on alternate hooks, and all the skates on the other string were baited with chum salmon only. The herring used was unsalted Pacific herring, just as in the 1980s. An effort was made to use a mixture of both salmon and herring from different lots at all experimental stations to avoid the confounding effect of differences among lots of each bait type.

Only data from stations with effective sets for both salmon and salmon/herring baits were used in the analysis. The data include the catch in weight of legal-sized fish and the catch in number of both legal-sized and sublegal fish from both Area 2B and Area 3A. The analysis was done on the total number of fish caught per skate (legal and sublegal), which is the survey abundance index used in the assessment, and on the weight of legal-sized fish caught per skate, which is the familiar commercial abundance index, also used in the assessment.

## Analysis of survey CPUE in total number

The primary purpose of the experiment was to compare the catchability of salmon baits and alternate salmon/herring baits. For each bait type, catch rate data are available for the legal and sublegal fish from Area 2B and Area 3A. A three-way analysis of variance model concluded that there is no significant overall treatment difference (p-value for the F-test is 0.496). The regression estimate of the ratio of the catch rates of salmon baits and salmon/herring baits is 1.05 with a 95% confidence interval of (0.89, 1.22). This confirms that overall salmon baits caught about 5% more than salmon/herring baits at the survey stations, but the difference is not statistically significant (Table 1).

For completeness, we also conducted the test within each area to confirm there is no effect at this level either and to calculate within-area regression estimates of the ratio of catch rates. Figure 1 is the interaction plot for the data on the original scale. From this figure, we can see that the catch rates in Area 3A are generally much higher than in Area 2B, even though within each area the catch rates of the two bait types are quite close. In the analysis of variance, the interaction between the bait effect and area effect is not statistically significant, nor is the bait effect.

We also calculated separate regression estimates of the ratio of catch rates by bait type for legal-sized and sublegal fish in each area. For legal-sized fish there is a statistically significant difference between the two baits in Area 3A, but not in Area 2B (Figure 1). In Area 3A the salmon baits caught 20% more in number than the salmon/herring baits ("Legal" in Table 1). A similar analysis for the CPUE of sublegals in number shows no significant bait effect in either area ("Sublegal" in Table 1).

## Analysis of legal-sized survey CPUE in weight

Usually CPUE is reported as the weight of legal sized fish caught per skate. This section analyzes the bait comparison study using that measure.

For this analysis there is only one size group so we are considering just two factors: the bait effect (salmon and salmon/herring) and the area effect (2B and 3A). As an exploratory data analysis, we plot the means for each area for the two bait factors ( Figure 2). It can be seen from this figure that there is a significant difference between areas. Also the mean difference of CPUE in weight in 2B is smaller than that in 3A.

For Area 2B, we found that the bait effect is not significant even though the all-salmon catch rates are slightly lower. However, for Area 3A the all-salmon catch rates are significantly higher. The plots in Figure 2 also show this difference. Additionally, for both salmon and salmon/herring baits, the catch rates in Area 3A are significantly higher than in Area 2B (Figure 2). This reflects the higher abundance in Area 3A.

The regression estimates of relative catch rates between salmon baits and salmon/herring baits are summarized in Table 2. The estimated ratio in Area 3A is significantly different from one (although just barely so), which means that the catch rates with salmon baits are significantly higher (20% higher). For Area 2B, the catch rates with salmon baits are lower (8% lower), but the difference is not statistically significant.

## Discussion

The bait comparison done at survey stations in Area 2B and Area 3A in summer 2000 showed hardly any difference in catch rates between skates baited entirely with salmon and skates baited with salmon and herring on alternate hooks. This is somewhat surprising in view of the large difference in catch rates seen in 1999 between skates baited entirely with salmon and skates baited entirely with herring.

While all-salmon skates caught about 20% more legal-sized fish in Area 3A than salmon/herring skates, the effect on overall survey CPUE in number was smaller (10%) and not significant. Even if a difference of this size were statistically significant, it would not require an adjustment in the assessment data, because it is small compared with other sources of variability in survey catch rates, and small compared with the large, long-term changes in stock level that the survey aims to detect. For both reasons we intend to use the survey catch rates from the 1980s and 1990s in the stock assessment with no adjustment for the bait change in 1993.

## References

Clark, W. G., and Parma, A. M. 2000. Assessment of the Pacific halibut stock in 1999. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 1999:109-138.

**Table 1. Regression estimate of the ratio of CPUE in number with all salmon to CPUE in number with alternating salmon/herring by size and area**

| Size Class | Area | Estimate | Lower Bound | Upper Bound | Significance |
|---|---|---|---|---|---|
| All Size/Area Combined | | 1.05 | 0.89 | 1.22 | N |
| All Sizes | 3A | 1.11 | 0.93 | 1.33 | N |
| | 2B | 0.89 | 0.70 | 1.12 | N |
| Legal | 3A | 1.21 | 1.01 | 1.44 | Y |
| | 2B | 0.93 | 0.74 | 1.17 | N |
| SubLegal | 3A | 0.98 | 0.71 | 1.35 | N |
| | 2B | 0.82 | 0.54 | 1.26 | N |

**Table 2. Regression estimate of the CPUE ratio as in Table 1, but with CPUE measured as weight of legal-sized fish**

| Area | Estimate | Lower Bound | Upper Bound | Significance |
|---|---|---|---|---|
| 3A | 1.19 | 1.01 | 1.41 | Y |
| 2B | 0.93 | 0.73 | 1.18 | N |

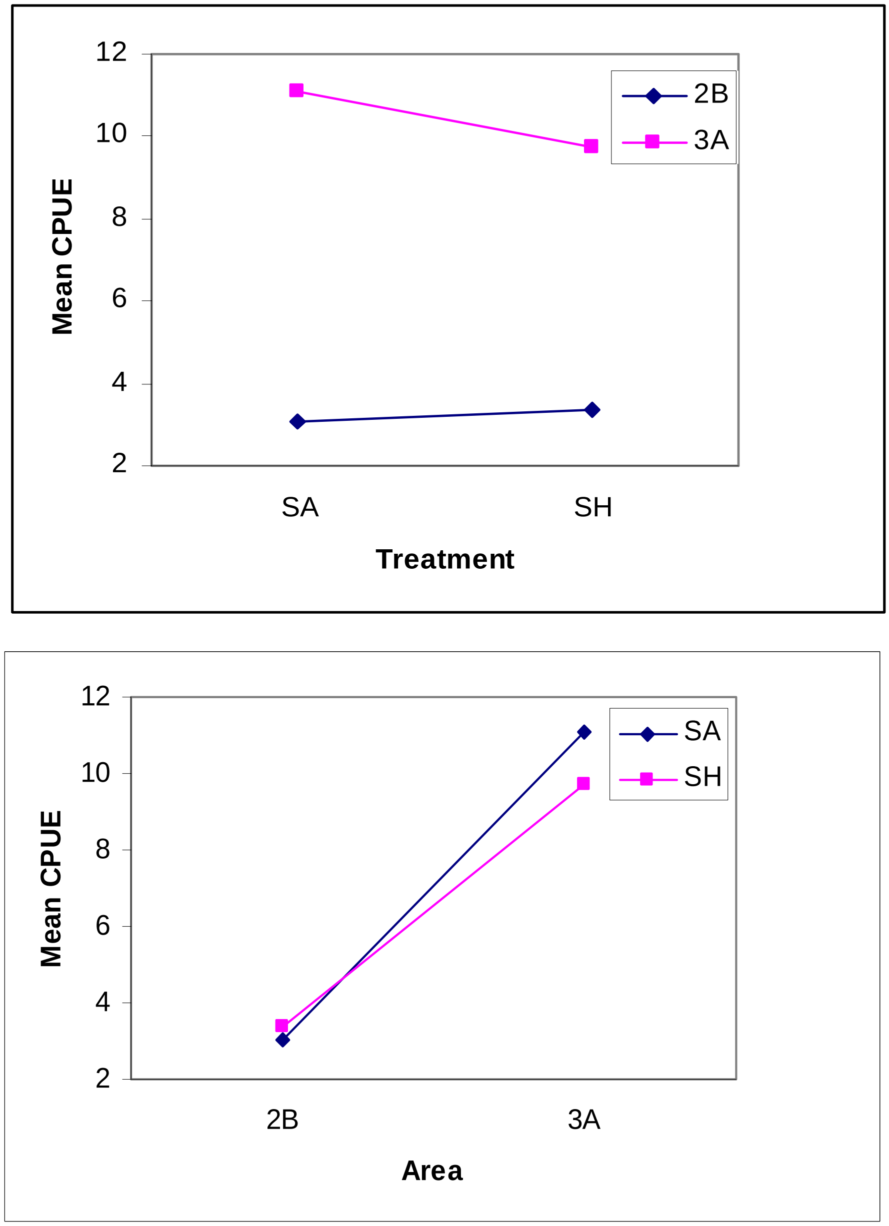


**Figure 1. Mean CPUE (total number of fish per skate by area and bait type; SA=all salmon, SH=mixed salmon/herring ).**

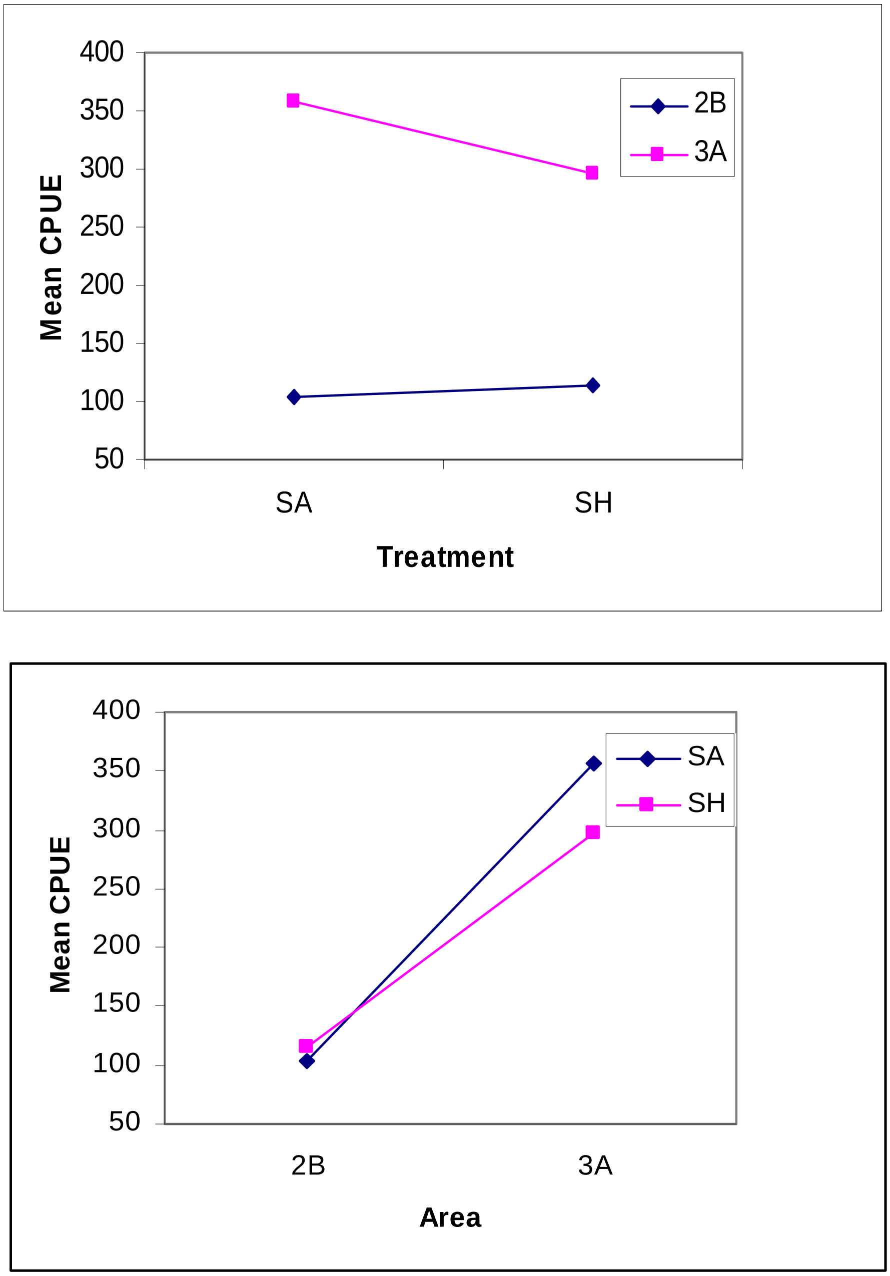


**Figure 2. Same as Figure 1, but with CPUE measured as weight of legal-sized fish per skate.**

# Evaluation of alternative harvest rates


## Steven R. Hare and William G. Clark


### Introduction

For the past 15 years, the yield of halibut has been determined on the basis of a constant harvest rate strategy, i.e., harvest of a fixed fraction of the exploitable biomass every year. The constant harvest rate was initially set at 0.35 in 1985, decreased to 0.30 in 1993 and further decreased to the present value of 0.20 in 1997. Prior to the constant harvest rate strategy, harvest levels were determined on the basis of the estimated annual surplus production (ASP), i.e., the amount of catch that could be taken in a year such that biomass levels remained constant. A strategy based on ASP was adopted during a period of very low biomass levels (mid 1970s). By setting annual catch limits less than the calculated ASP, an explicit stock rebuilding program was implemented. The change to a constant harvest rate was implemented for several reasons, including: a belief that the stock had been successfully rebuilt to the biomass level that would result from a MSY policy, that catches would rise and fall smoothly with abundance, and the exploitation fraction would be the same in all areas. Many simulation analyses over the past ten years have shown that while a constant harvest rate strategy may not always provide the maximum yield, it does appear robust to dangers of overharvesting (Hilborn and Walters 1992) and environmentally-induced recruitment variability. The most recent extensive investigation of the harvest rate strategy for Pacific halibut was conducted in 1996.

### Approaches

Two approaches were taken to determine an appropriate constant harvest rate. The first was a "per-recruit" approach in which one looks at how the population responds to different harvest levels, given the current biological and fishery conditions and an assumption of constant recruitment. These calculations are straightforward and do not involve incorporation of errors in observations or description of biology and fishing processes. Part of its value is that it allows one to see how important measures of the population, such as yield per recruit (YPR), spawning biomass per recruit (SPR) and the population sex ratio, change with the biology of the population. Size at age, for example, continued to drop after 1996 until this year and, along with it, setline selectivity at age. Because a large fraction of males are unavailable to the fishing gear, the proportion of females in the catch has almost certainly increased. This may have important ramifications for the composition of the spawning stock that remains in the ocean.

The second approach is a simulation study where the population is projected into the future under a variety of assumptions about the future biology of the population and the ability of the assessment process to accurately measure the population. The goal is to select a harvest rate that is safe even given uncertainties about the biology and assessment of the stock, as well as balancing yield and conservation of the reproductive stock. In these types of simulations, one of the most important factors is how future recruitment is modeled, though growth and selectivity can also be very important.

## Per-recruit modeling

To perform the per-recruit computations, a standard age-structured population dynamics model was used to simulate the trajectory of numbers at age from age 6 (recruitment) to a plus group at age 20. The traditional discard mortality rate of 16% for sublegal fish (<81 cm) returned to the sea was used. Model results of interest include average long term yield per recruit, exploitable biomass per recruit, and spawning biomass (per female recruit only).

The input data required for the per-recruit calculations are weight at age in the population, weight at age in the catch, commercial adult and juvenile selectivity at age for males and females, and maturity at age for females. The calculations were done for Areas 2B and 3A for 1996 and 1999. Size at age in the population for each area and year was estimated by fitting a model to setline survey data. The model required two assumptions: equal numbers of males and females at age 6 in the sea, and equal selectivity at length for both sexes, though selectivities could differ by area. To estimate the parameters, natural and historical fishing mortality rates are also required. We used values of 0.15 and 0.20, respectively, for the two mortality rates. The adjustable parameters in the model are survey selectivity at length, and mean length and standard deviation of length at age (in the sea) for both sexes. The model is fit to mean length and standard deviation of length at age in survey catches, and proportion of females in the catches. Commercial selectivity at length is then estimated by fitting a second model to mean length and standard deviation of length (sexes combined) in the commercial catch. Sex-specific selectivity at age is then computed by integrating across size at age for each sex. Age and sex-specific estimates of legal and sublegal selectivity at age are produced by integrating above and below the legal size limit (81 cm). Juvenile selectivity is the difference between total selectivity and adult selectivity and is used to estimate discard mortality in the per recruit calculations. Weight at age is computed from the distribution of length at age using the standard length-weight relationship for halibut. Maturity at age was assumed to be the same as in 1996.

Results of the yield per recruit (YPR) calculations are illustrated in Figure 1. Each of these computations illustrates the expected YPR as a function of harvest rate provided that size at age and selectivity at age do not change over time. As expected, the yield per female recruit is much greater than yield per male recruit due to the size difference. For reference, two traditional harvest reference points are shown: $F_{0.1}$ and $F_{max}$. Theoretically, $F_{max}$ is the harvest rate at which the maximum yield can be taken given present conditions, and $F_{0.1}$ is the point at which the gain in yield is reduced to 10% of what it is at extremely low harvest rates. Experience has shown that $F_{max}$ is not sustainable; $F_{0.1}$ is often applied in situations where the stock-recruitment relationship is unknown. $F_{0.1}$ is considered to be conservative when there is a strong compensatory response to low population numbers; less conservative when there is weak compensation. Except for 3A in 1999, the $F_{0.1}$ harvest rate is right around 0.20, the rate currently used for the halibut fishery. In 3A, given the 1999 biological and selectivity parameters, $F_{0.1}$ and $F_{max}$ are shifted considerably to the right, implying higher harvest rates might be warranted if conditions remained as they are in 1999.

The second important measure to consider in per-recruit computations is how the harvest rate affects spawning biomass per recruit (SPR), here measured as biomass of mature females. In Figure 2, SPR plots are given for 3A and 2B, again for the years 1996 and 1999. With conditions and selectivities as they were in 1996, a harvest rate of 0.20 would be expected to reduce SPR to around 37-42% of what it would be with no fishing. A harvest rate that reduces SPR to 35% of the no fishing level, a policy known as $F_{35\%}$, was widely adopted for Alaska groundfish in the 1990s.

Others have advocated a higher SPR be targeted, such as 45% or 50%. The changed conditions in 1999 show that a 0.20 harvest rate would reduce SPR to 51% in 3A and 44% in 2B. Thus, on the basis of per-recruit computations, it appears that a harvest rate of 0.20 continues to serve the interests of the halibut fishery well.

## Long-term simulation modeling

The second approach to choosing a harvest rate is to simulate the dynamics of the population under a set of plausible alternative states of nature, include various sources of observation and process error, and measure how the population responds to varying levels of fishing effort. For the set of simulations run here, we investigated four different recruitment scenarios. It has become well recognized that halibut recruitment is not a random process but appears to vary between productive and unproductive regimes, with regimes lasting 25-35 years. Weight at age also shows decadal scale signals but it is less clear what drives these variations. The smaller size at age in the 1990s coincides with large biomasses, however, the decreased sizes did not appear until several years after biomasses had reached current high levels. For the initial simulation results reported here, 1999 weights at age were used. A second set of simulations, incorporating a new coastwide age-specific selectivity was also computed for these simulations. This schedule is a simple average of the new selectivity-at-age schedules derived for Areas 2B and 3A. It is illustrated in Figure 3 along with the coastwide selectivity schedule used since 1996.

To provide the most accurate estimate of the stock-recruitment relationship, revised estimates of historical biomass and recruitment were computed for the period 1935-1973. Estimates of catch-at-age numbers, losses due to pre-recruit mortality in directed and bycatch fisheries, weight-at-age and effort data are also updated. A version of CAGEAN, which allows for temporal drift in catchability and selectivity, and internally estimates the stock-recruitment (S-R) relationship, is used to derive estimates of numbers at age and spawning biomass. The model forced the numbers at age projected for 1974 to match those resulting from the 2000 stock assessment. In this manner, a seamless set of biomass and recruitment numbers were generated for the period 1935-2000.

Parameter estimates for four different stock-recruitment models were made using recruitment estimates for the 1947 to 1988 year classes. Technical details on the models are available elsewhere (Hare and Clark 2001) and methodologies described in the RARA. For three of the models, an assumption was made that the year classes from 1977 to 1988 were produced in a different, more productive regime than the earlier year classes. The models are subsequently referred to as:

1. 2K model. This model assumes that there are two carrying capacities (“K”) for recruitment. The post-1977 level is set equal to mean recruitment for the 1977-1988 year classes and the pre-1977 is set equal to the mean of recruitment for the earlier year classes.
2. 2$\alpha$ model. This is a Ricker stock-recruitment model with two alpha (productivity) parameters and a single beta (density dependent) parameter. These are estimated in the usual manner for fitting a Ricker model but different alpha parameters are estimated for the two regimes.
3. 2$\beta$ model. This is much the same as the 2$\alpha$ model, except that there are instead two beta parameters.
4. AR model. This is a Ricker model with autocorrelated errors. This assumes that rather than having distinct regimes, there is a general tendency for high recruitment years to persist, and the same for low recruitment years.

Plots of the data, along with the model fits are illustrated in Figure 4. Model fitting statistics favor the two alpha model, indicating it is productivity of the stock that changes with regimes rather than the level of density dependence. Because of the uncertainty of the last several year-class estimates (i.e., post-1988), those data were not included for parameter estimation. It is informative, however, to see that the 1989-1994 estimates fall very near that predicted by the high productivity 2α model (data plotted as squares).

For the simulations, process error was incorporated into each of the stock-recruitment relationships; observation error was incorporated into the annual estimate of exploitable biomass on which yields were based. All errors were random normal variables with a mean of zero, standard deviations were 0.35 for stock-recruitment relationships and 0.2 for biomass observation error. Harvest rates from 0 to 0.70 in increments of 0.01 were investigated, with 500 Monte Carlo replicates per harvest rate increment. Simulations were run for 200 years, average long-term yield and long-term average spawning biomass were averaged over the last 100 years. The duration of productivity regimes was randomly selected to be between 25 and 35 years. The probability of going below the minimum historical spawning biomass (85 million pounds in 1974) was calculated as the fraction of times that it occurred at least once in the first 20 years across the 500 Monte Carlo replicates. Simulations begin with numbers at age in 2001 as generated from the 2000 assessment.

Three measures of stock response were considered: long-term average yield, long-term average spawning biomass, and probability of dropping below the historical minimum biomass are plotted in Figure 5. Under all but the 2K S-R model, yield is maximized at a harvest rate around 0.50.

For those same three models, harvesting at a rate of 0.20 gives approximately 75% of the maximum yield while harvesting at rates of 0.25 and 0.30 gives approximately 80% and 90% of maximum yield, respectively. The 2K model provided somewhat different results than the other models. With a fixed maximum recruitment of around 8 million 6-year olds – realized at spawning

| | | Fraction of yield at $HR_{max}$ | | |
|---|---|---|---|---|
| S-R model | $HR_{max}$ | $HR_{0.20}$ | $HR_{0.25}$ | $HR_{0.30}$ |
| AR | 0.49 | 0.76 | 0.83 | 0.89 |
| 2β | 0.49 | 0.76 | 0.84 | 0.90 |
| 2α | 0.53 | 0.73 | 0.80 | 0.83 |
| 2K | 0.34 | 0.92 | 0.96 | 0.99 |

biomasses between 150 and 250 million – this model fared poorly at the higher harvest rates the other models preferred. Examining the S-R plots in Figure 6, the peaks of the S-R curves generally occur around 120 million pounds spawning biomass which would require a high harvest rate to maintain at that level.

The long-term spawning biomasses respond similarly across recruitment scenarios to increased exploitation, showing a steady linear decline of approximately 10% per 10% increase in harvest rate.

The final measure of stock response is the probability of the spawning biomass going below the historical minimum over the next 20 years. This possibility was investigated under two assumptions, one being that we are currently in a productive regime and a second that we have entered an unproductive regime. The results are quite different for the two assumptions. In the

Appendix, we summarize the current scientific understanding of North Pacific climate, regime status and recruitment predictions. The estimated spawning biomass for 2001 is approximately 270 million pounds, or more than 300% of the 1974 minimum of 85 million. To the extent that these figures reflect reality, it would take a serious fishing effort and near collapse in recruitment to drive the spawning biomass to the 1974 level. Under the good regime assumption, none of the models show greater than a 20% probability of reaching the minimum historical biomass for harvest rates under 0.40. Under an assumption of a current unproductive regime, those probabilities climb considerably, except for the AR model which does not have a regime-specific parameter. The 2$\beta$ model shows the greatest probability of reaching a minimum with a near 100% probability at a harvest rate of 0.4. This result occurs because the last several spawning biomassess are in the region of 300 million pounds which results in extremely low recruitment in an unproductive regime.

The results discussed above were obtained under an assumption of density independent size at age. We used a constant future weight at age, set equal to 1999 sizes at age, regardless of stock size. To test the importance of this assumption, we used simple linear models to vary size at age as a function of biomass. For all ages nine and above, weight at age is negatively correlated with biomass and the amount of density dependence increases strongly with age. The general effect of incorporating simple density-dependent feedback is to increase yield and average long term spawning biomasses and further reduce the probability of reaching the historical minimum spawning biomass (Figure 7). This result occurs because average weight at all ages increases as biomass drops whereas average weight is the same as in the earlier simulations when biomass is large. A further modification that could be made, but was not extensively pursued, would be to also allow selectivity to vary as a function of size. Both sets of simulations investigated here assumed a constant selectivity at age, i.e., that computed for 1999. It is not straightforward to predict the effect this would have on the simulations and further analysis of time varying selectivity will pursued in the next year.

These results contrast somewhat with those presented the last time harvest rates were evaluated. There are at least three reasons for the tendency towards higher harvest rates suggested by this analysis:

1. Weights at age and selectivity at age have come down, particularly in Area 3A since the last analysis. Yield increases therefore by harvesting at a higher rate to capture the animals else they would avoid capture entirely.
2. The new stock-recruitment estimates show that density dependence is once again believed to be substantial for halibut. The density-dependent response, particularly the decline in recruitment at high spawning biomassess, is evident in both productive and unproductive regimes.
3. The new estimate of minimum historical biomass is 32% lower (85 million pounds compared to 125 million pounds) than in the last analysis. This has the effect of greatly reducing the probability of reaching that level and, therefore, shifting all the probability curves to the right on the harvest rate axis.

In retrospect, the combination of a harvest rate policy of 0.20 since 1996, an underharvest for several years prior to that resulting from the retrospective problem with CAGEAN, and a highly productive regime for at least a decade after 1977, illustrates that the resource will grow under that set of conditions. The two big questions, for continued investigation then, become:

1. Is density dependence in recruitment real, i.e., does too much spawning biomass actually lower recruitment?

2. If we are now in an unproductive regime, will the stock grow, or at least remain stable, under the current harvest policy?

## References

Hare, S. R., and Clark, W. G. 2001. Evaluation of alternative harvest rates. Int. Pac. Halibut Comm. Report or Assessment and Research Activities 2000: 153-167.

## Appendix – North Pacific climate, regime status, and halibut recruitment predictions

In 1999, a set of halibut stock recruitment models were fit and recruitment forecasts made for the next several years. The intent was to establish a historical record of forecasts that could eventually be used to monitor the extent to which we had identified the factors controlling recruitment. Model fits from last year, as well as the updated model fits this year, overwhelmingly favored models that incorporated some environmental component. The "best" model was, and remains, a Ricker stock recruitment model that has multiple "alpha", or productivity parameters and a single "beta", or density dependent term. All of the environmental models were based on an index of North Pacific climate variability, the Pacific Decadal Oscillation (PDO, Figure 8).

The PDO has alternated between positive and negative phases for several hundred years. The two most recent confirmed reversals were in 1947 (positive to negative) and 1977 (negative to positive). Halibut productivity is high during positive phases of the PDO and low during negative phases. The "best" stock recruitment model mentioned above had separate alpha parameters for each phase of the PDO. Several additional models were fit, using various combinations of single and phase-specific parameter estimates for the productivity and density dependent terms of the Ricker relationship. A PDO-Ricker model was also created using the PDO as a covariate.

Last year, evidence of a much weaker climatic regime shift in 1989 was published. The 1989 shift however, is separate from variability associated with the PDO and its impact on halibut recruitment has yet to be ascertained. Of perhaps more importance to halibut, the PDO index used in this study changed sign (i.e., entered a cold phase) in fall of 1998 and has remained negative through the end of 2000. The reversal of the PDO to values last seen in the 1950s and 60s, if it does turn out to be a shift and not a brief interannual departure, may well lead to a lengthy period of reduced recruitment.

Recruitment projections for the next 6 years (the longest duration for which biomass-based projections can be made) are illustrated in Figure 9. The top panel contains projections based on the assumption that halibut recruitment remains in a productive regime through the year 2000. The bottom panel shows the projections assuming that recruitment entered an unproductive phase in 1989. If 1999 is, as the PDO index now suggests, the year that witnessed a regime shift to unproductive conditions, then recruitment will follow the 1989 trajectory beginning with the 1999 year class. The "best" model fit, i.e., the 2 alpha model, forecasts recruitment of either 6-7 million (assuming a productive regime) or 2-3 million (assuming an unproductive regime) over the next several years.

Initial reports of year class strength for the post-1989 year classes, which are only now entering the commercial fishery, were quite pessimistic. This year's assessment increases estimates of those year classes. Thus, it may turn out that recruitment for the 1989-1998 year classes will not be among historical low levels. Given the large biomasses that spawned those year classes, however, they would be expected to be among the smallest of the productive regime year classes.

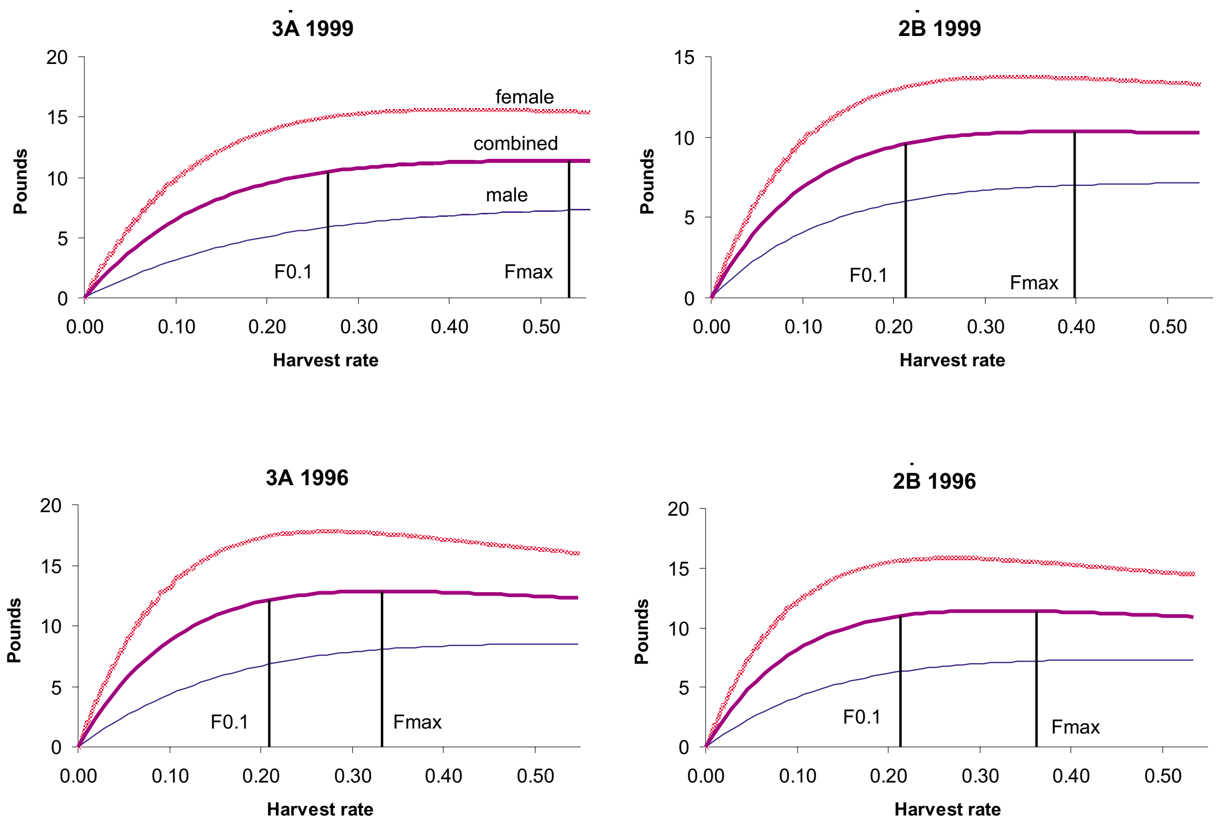


**Figure 1. Yield-per-recruit (YPR) plots for Areas 2B and 3A under prevailing sizes at age and selectivities in 1996 and 1999. Expected YPR for two different harvet policies, $F_{0.1}$ and $F_{max}$ are indicated on each plot.**

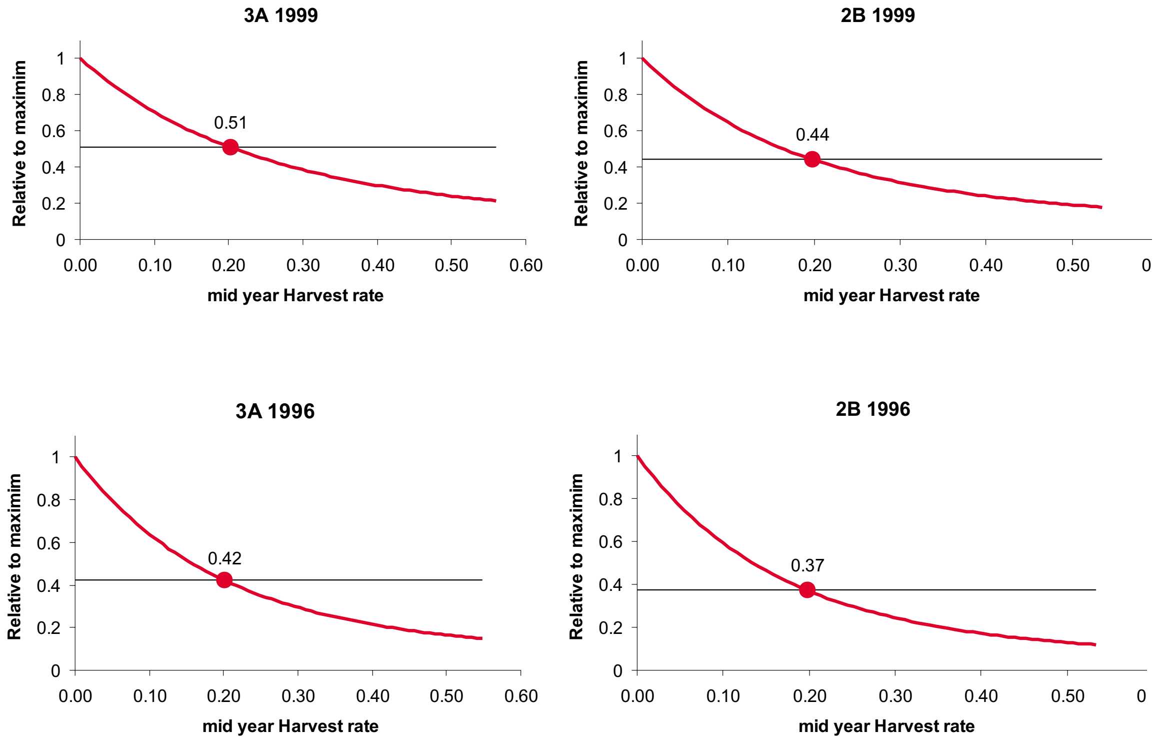


**Figure 2. Spawning biomass per recruit (SPR) plots for Areas 2B and 3A under prevailing sizes at age and selectivities in 1996 and 1999. The dot indicates a harvest rate of 0.20 and the expected SPR that would result from such a harvest policy.**

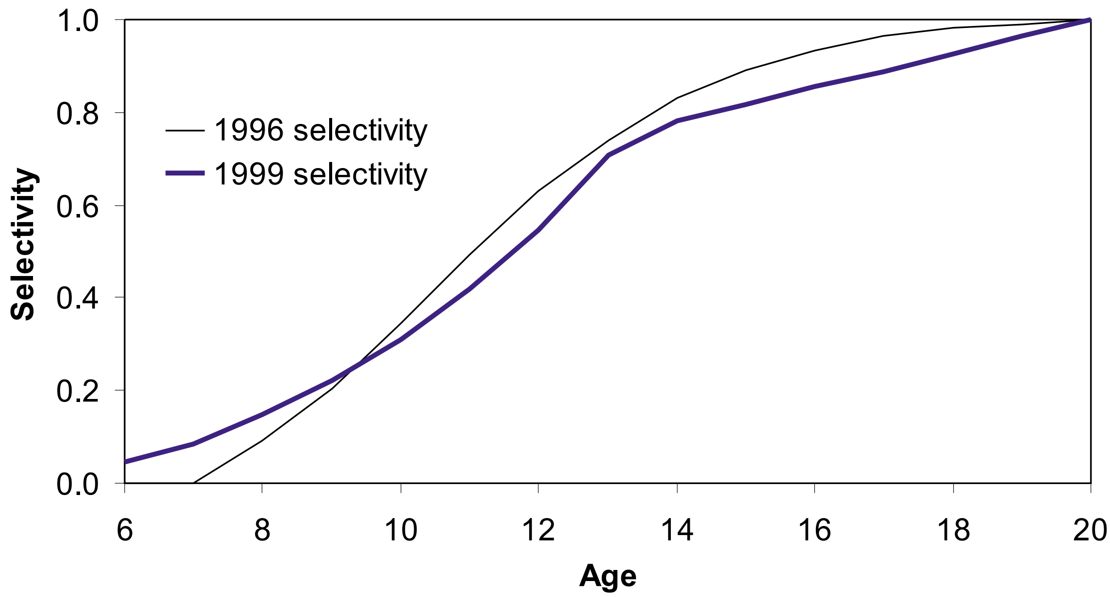


**Figure 3. Estimated coastwide selectivities estimated in this work (1999) and previously (1996).**

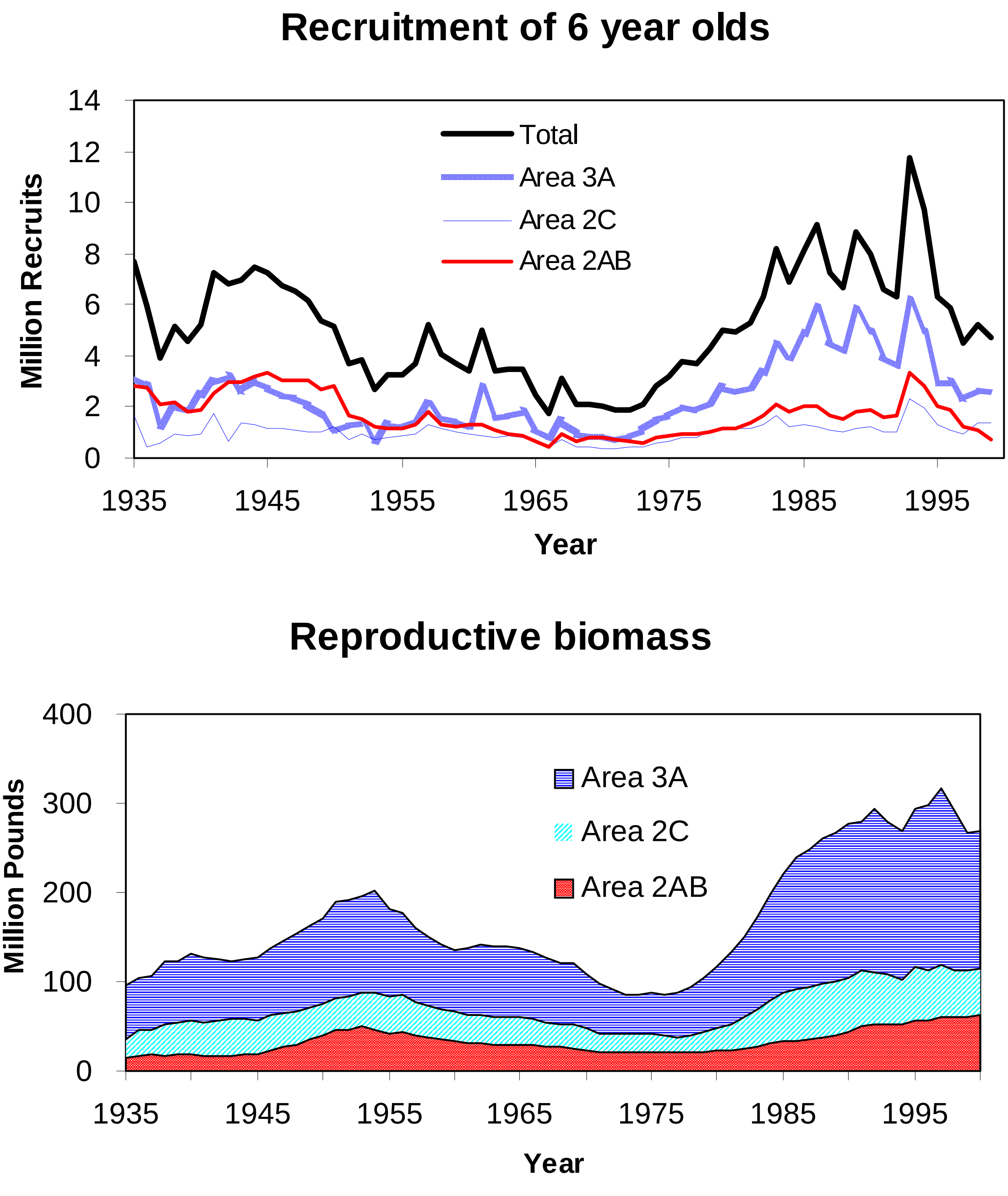


**Figure 4. Long-term trends in recruitment (measured as six-year olds) and spawning biomass of Pacific halibut from 1935 to 2000, for IPHC Areas 2AB, 2C, and 3A.**

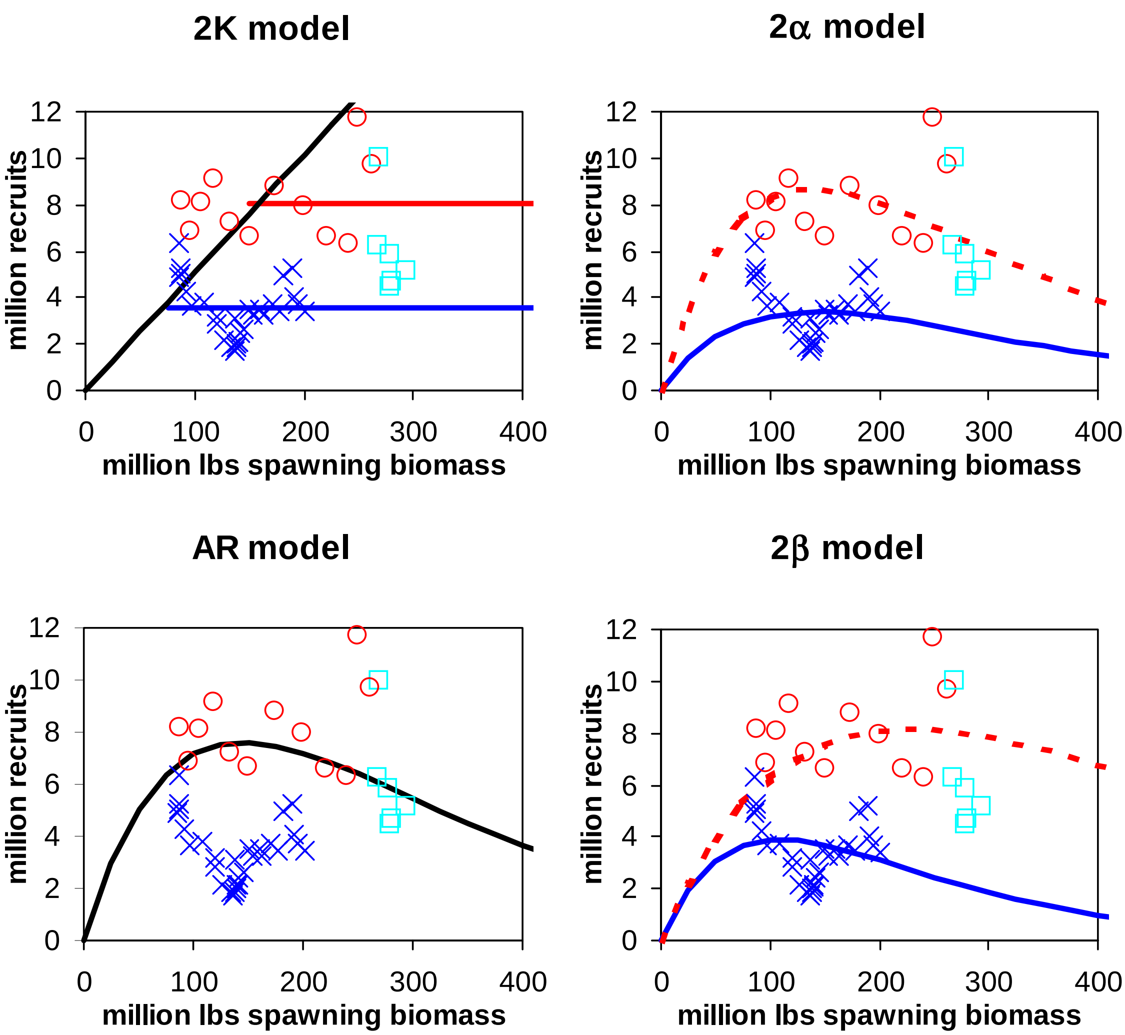


**Figure 5. Four alternate stock recruitment models for Pacific halibut. In each plot, the 1947-1976 year classes are indicated by X, 1977-1988 year classes by circles and post-1988 year classes by squares. Lines indicate various Ricker stock-recruitment fits to the data; post-1988 year classes were not used in model fitting.**

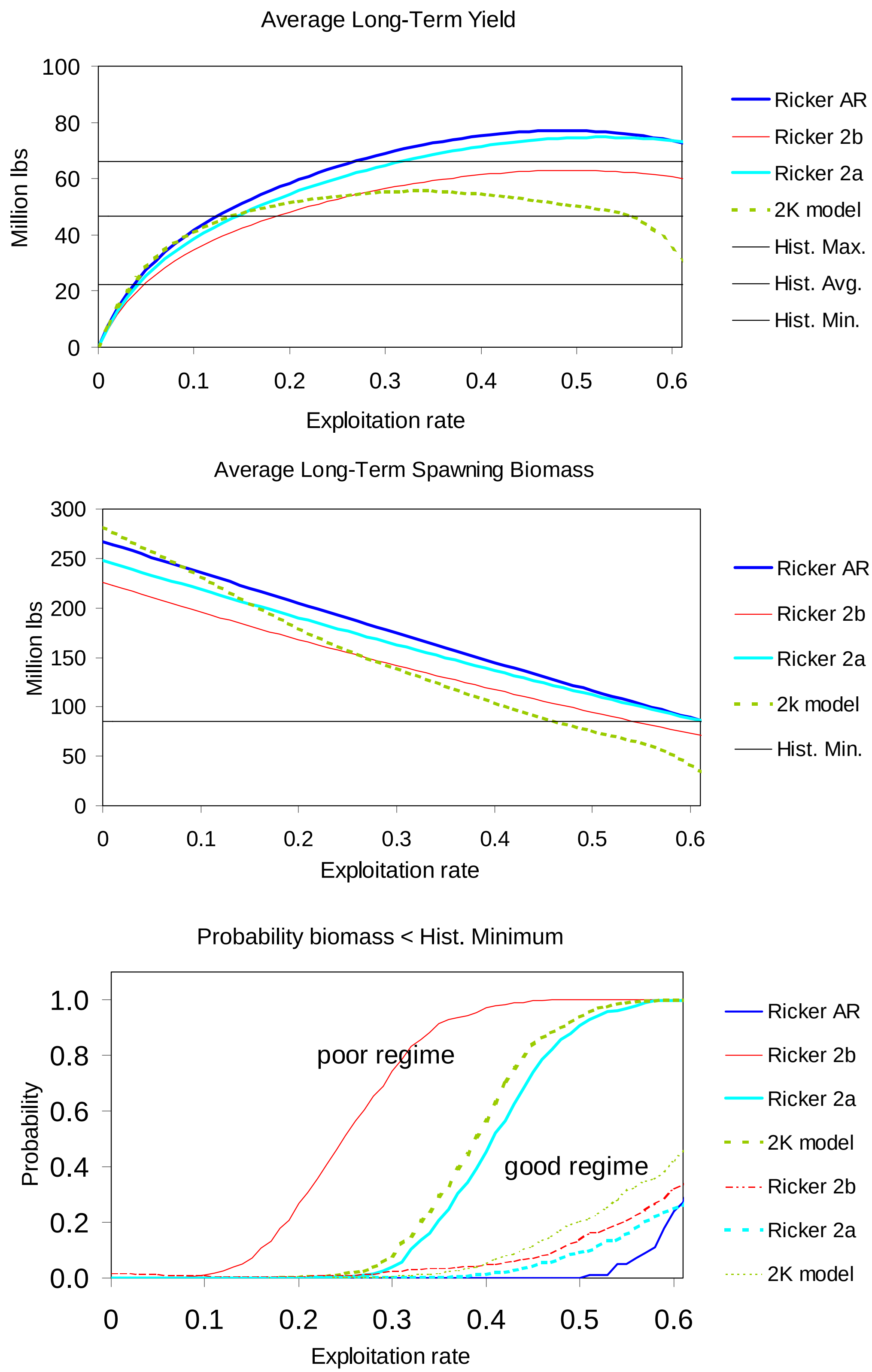


**Figure 6. Three measures of stock response to increasing harvest rates under four alternative stock-recruitment scenarios.**

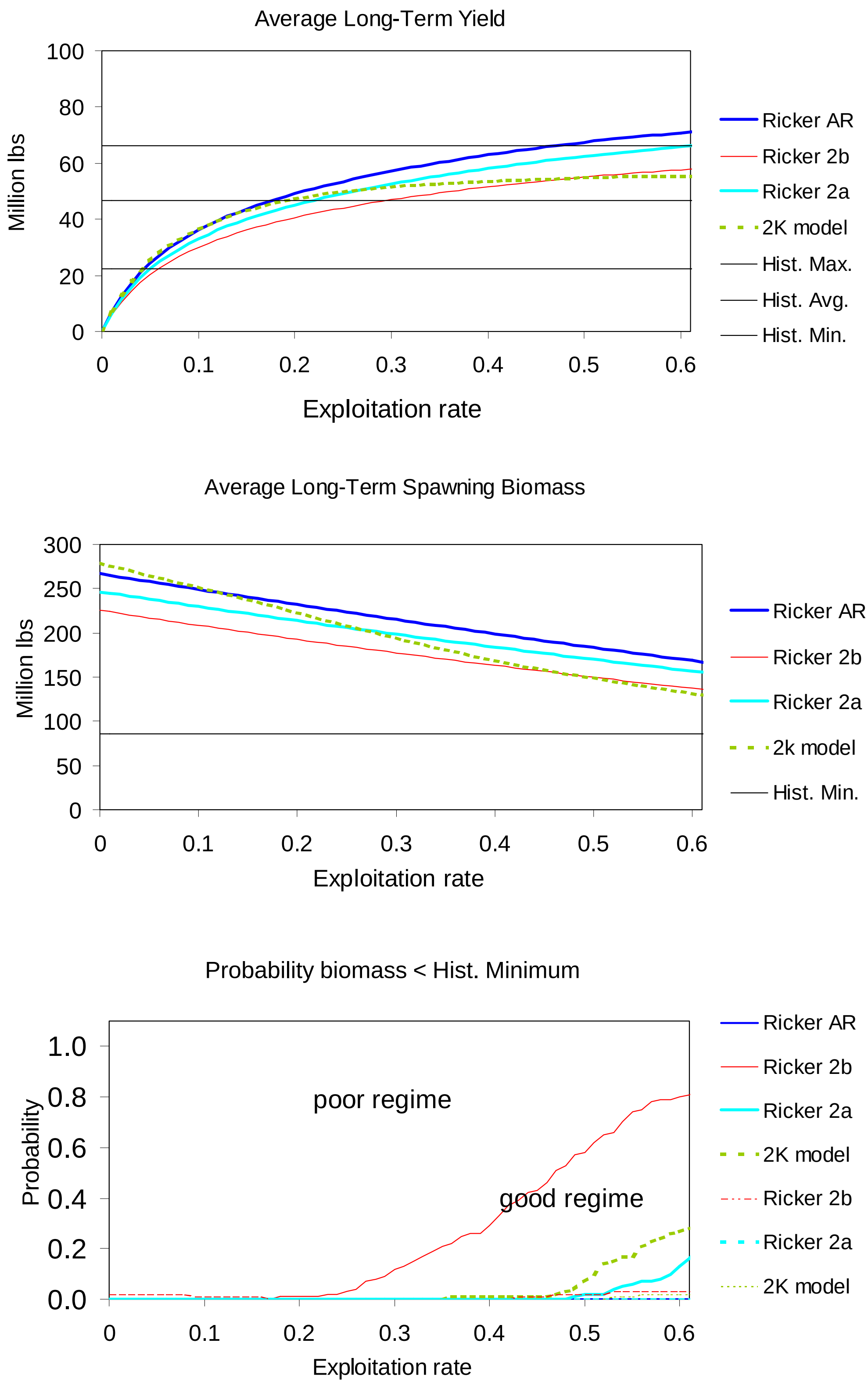


**Figure 7. Three measures of stock response to increasing harvest rates under four alternative stock-recruitment scenarios., and incorporating a size at age density-dependent response to stock biomass.**

# Pacific Decadal Oscillation

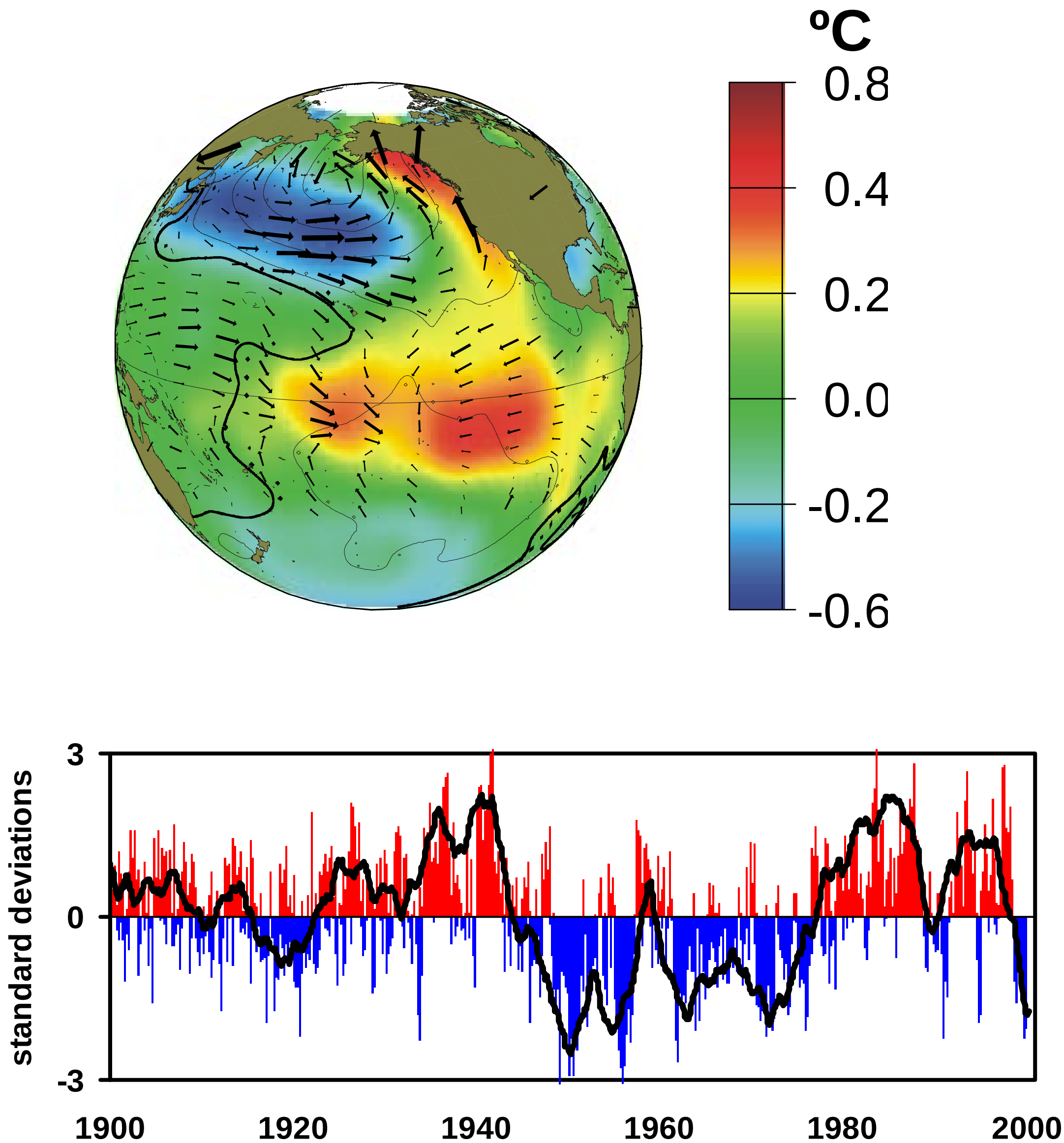


**Figure 8. The Pacific Decadal Oscillation, 1900-2000. The positive phase is illustrated, corresponding to positive values of the temporal index. The index most recently turned negative in Oct. 1998 and has remained strongly negative through the end of 2000.**

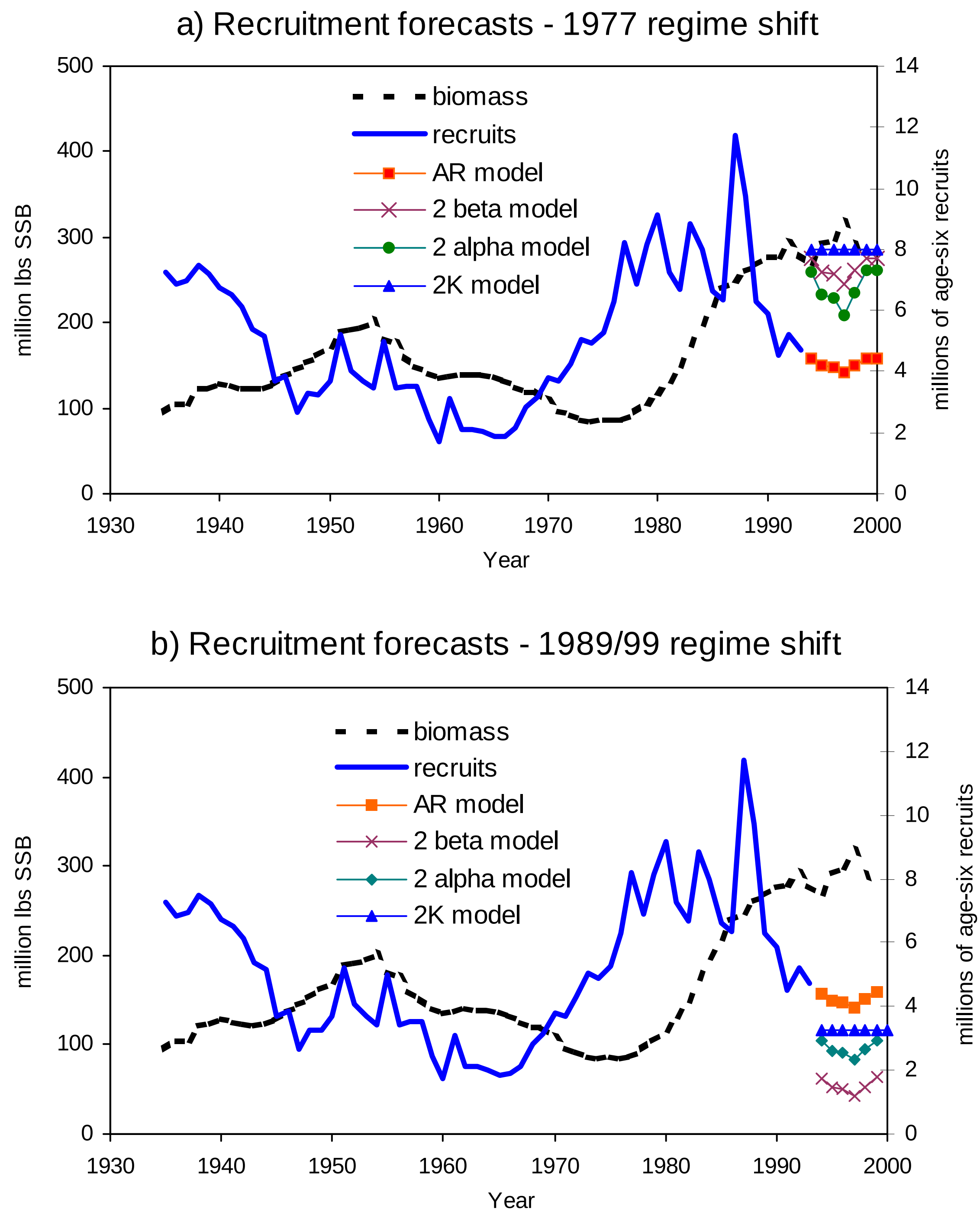


**Figure 9. Spawning stock biomass (1935-2000) and six year old recruits (brood years 1935-1993). Recruitment forecasts are shown for the four stock-recruitment models discussed in the text under the assumption of a) a 1977 regime shift and b) a subsequent regime shift in either 1989 or 1999.**

# Summary of the 2000 stock assessment


## William G. Clark and Steven R. Hare



### Summary

Biomass estimates in the 1999 assessment were sharply lower than in the 1998 assessment because of a bait adjustment to recent setline survey catch rates in all areas, lower weights at age in Alaska, and very low estimated recent recruitment in Area 3A. Since then, comparative fishing in summer 2000 has shown the bait adjustment to be unnecessary, weight at age has increased a bit, and the estimates of recent recruitment in Area 3A have come up. Although it still appears that coastwide recruitment has declined since 1996, biomass estimates are back up to approximately the level of the 1998 assessment. Coastwide setline CEY is 95 million pounds.


### Introduction

Each year the IPHC staff assesses the abundance and potential yield of Pacific halibut using all available data from the commercial fishery and scientific surveys (Appendix A). Exploitable biomass in each of IPHC regulatory areas 2AB, 2C, and 3A is estimated by fitting a detailed population model to the data from that area.

A biological target level for total removals is then calculated by applying a fixed harvest rate—presently 20%—to the estimate of exploitable biomass. This target level is called the “constant exploitation yield” or CEY for that area in the coming year. The corresponding target level for directed setline catches, called the setline CEY, is calculated by subtracting from the total CEY an estimate of all other removals—sport catches, bycatch of legal-sized fish, wastage of legal-sized fish in the halibut fishery, and fish taken for personal use.

In Areas 3B and 4 exploitation rates were low until very recently and no surveys were done before 1996. For both reasons an analytical assessment is not feasible. Instead, exploitable biomass in those areas relative to that in Area 3A is estimated from recent surveys and the analytical estimate of abundance in Area 3A is scaled accordingly to estimate exploitable biomass in Areas 3B and 4. Total and setline CEY for those areas are then calculated as explained above.

Staff recommendations for catch limits in each area are based on the estimates of setline CEY but may be higher or lower depending on a number of statistical, biological, and policy considerations. Similarly, the Commission’s final quota decisions are based on the staff’s recommendations but may be higher or lower.

This paper reports the staff’s estimates of total abundance, recruitment trends, exploitable biomass, and total and setline CEY by area, as calculated at the end of 2000 for the 2001 fishery. A more detailed account of the assessment is given elsewhere by Clark and Hare (2001).

## Assessment methods

The assessment continues to rely on commercial and survey catch rates and age compositions to estimate historical and present stock sizes. Yield recommendations are again based on a fit in which age-specific survey catchability and selectivity are held constant. Commercial catchability is still allowed to change over time, but the allowable rate of change has been reduced this year because the recent series of low survey catch rates in Area 2B, continued in 2000, now makes survey and commercial catch rate trends look quite similar in both Canada and Alaska. Because commercial catch rates are much less variable from year to year than survey catch rates, the estimated stock trends in fact tend to follow the commercial catch rates more than the survey catch rates where there is a difference (as there still is in 2B).

From 1995 through 1999 the assessment employed a population model that fitted a time-varying growth schedule to predict the observed size distribution of each age group as well as the observed age composition of survey and commercial catches. Age-specific selectivities were not estimated directly but were calculated from a fairly rigid (2-parameter) function of length. When the model was fitted, the parameters of the length-based function were required to vary over time in such a way as to keep the calculated age-specific survey selectivities constant.

This year's assessment reverts to a much simpler population model in which age-specific selectivities are estimated directly and no attempt is made to model growth or predict the distribution of size at age in the catches. Comparisons of fits of this year's model and last year's to the same data indicate that in last year's model the rigid length-based selectivity function imposed subtle constraints on the pattern of age-specific selectivities that could be achieved in the fit, with the result that in Areas 2C and 3A historical abundance tended to be overestimated and recent recruitment underestimated. Thus while the old model and the new model give similar estimates of present exploitable biomass, the long-term trends in biomass and recruitment in Alaska look more reasonable in this year's fits. There is little difference between this year's and last year's fits in Canada.

## Removal of the bait adjustment

Systematic setline surveys were suspended after 1986 and resumed in 1993. At that time chum salmon was adopted as a standard bait, whereas salmon and herring on alternate hooks had been used as bait in the 1980s.

Experiments done in 1999 showed that skates baited entirely with salmon caught about twice as many halibut as skates baited entirely with herring. These results suggested that if half of survey hooks had been baited with herring in the 1990s, catch rates would have been 25% lower. This was not certain because of the additional difference in baiting pattern (full skates vs. alternating hooks), but as a precaution the staff applied a 25% downward adjustment to recent survey catch rates when doing the 1999 assessment, and that lowered biomass estimates by 20-30%.

In summer 2000 the staff conducted a direct comparison of survey catch rates using the two bait configurations (all salmon and alternating salmon/herring) and found no practical difference between them. All-salmon skates caught about 10% more halibut (in number) than salmon/herring skates in Alaska and about 10% fewer in Canada, but the difference was not statistically significant except among legal-sized fish in Alaska. Even there it was too small (20% in both numbers and weight) to require an adjustment in the assessment (Table 1).

## Selectivities, exploitable biomass, and CEY

Younger and smaller halibut are not as catchable as older and larger ones. The relative catchability of fish at each age—a percentage or proportion—is called the selectivity at that age. The exploitable biomass of each age group is calculated by multiplying its total biomass by its selectivity. The exploitable biomass of the whole stock, summed over all ages, is therefore the biomass of fully catchable fish that would provide the same catch per effort as the mix of partly and fully vulnerable fish in the stock in any given year.

Selectivity differs among areas and changes over time. In Alaska, the selectivity of younger fish has decreased substantially because size at age has decreased. When the model is fitted, commercial selectivity is estimated year by year and exploitable biomass is calculated accordingly. Call this "variable ebio". It is this measure of exploitable biomass that should vary in proportion to commercial CPUE.

There is another measure of exploitable biomass called "fixed ebio" that is calculated with a fixed set of selectivities in all areas and years. The fixed selectivities were intermediate between the higher 2B and lower 3A estimates in 1996, and the 20% target harvest rate is based on them. To calculate CEY, the 20% harvest rate is applied to this measure.

Since 1996 estimated commercial selectivities have declined further. Fixed ebio is now only a little less than variable ebio in Area 2AB, a little more in Area 2C, and substantially more in Area 3A.

While useful for monitoring abundance and calculating CEY, exploitable biomass has little biological or intuitive meaning. This year's assessment also reports historical estimates of spawning biomass and total legal-sized biomass as more straightforward measures of abundance.

## Assessment results for Area 2AB

Stock size in 1985 is well determined by the catch at age data, because by now all the year classes that were present in the fishery have passed through it. We know how many were alive then because we have counted them as they were removed (and allowed for natural mortality). In terms of variable ebio, stock size was 53 M lb in 1985. Since 1985 commercial catch rates have increased by about 50% (Figure 1, center right panel). In the mid-1990s survey catch rates were about triple the level of survey catch rates in the mid-1980s, but the last three years have indicated a relative change of about 100%, much closer to what the commercial data indicate (Figure 1, center left panel). A commonsense estimate of present abundance would therefore be a variable ebio of 50-100% above the 1985 level. The fitted estimate is 73 M lb or about 40% above 1985, which essentially follows the commercial trend but allows for an estimated 10% increase in commercial catchability (fishing power) between 1985 and now. In terms of fixed ebio, the 2001 estimate is 68 M lb, of which 11% is assigned to Area 2A and 89% to 2B (Table 2).

This year's fit is quite pessimistic as regards recent recruitment (Figure 1, top left panel), but in this respect it is at odds with the 2C assessment. There is little doubt that the two will agree closely when the estimates firm up, because relative year-class strengths have always been similar in 2B and 2C.

## Assessment results for Area 2C

As in Area 2AB, survey catch rates have been low for the past three years after some high values in the mid-1990s (Fig. 2, center left panel). There are many fewer early survey points in 2C than in 2AB, and the recent ones are highly variable. Overall the survey results indicate little or no difference in abundance between 1985 and now, but the scatter makes any conclusion questionable. Meanwhile the commercial catch rates are very consistent in showing a decline of about one-third between 1985 and now (Fig. 2, center right panel), and this is what the model fit reflects, estimating a variable ebio of 48 M lb (56 M fixed) in 2001.

## Assessment results for Area 3A

Survey and commercial catch rates agree quite well in 3A, survey values declining 20-25% from the 1985 level of 150 M lb and commercial values 10-15% (Fig. 3, center panels). The model estimate of 111 M lb is 25% below the 1985 level. This may be a little low; on the other hand the high survey value in 2000 appears anomalously high, and it is propping up the estimate to some extent. In terms of fixed ebio, the 2001 estimate is 139 M lb.

Estimates of recent recruitment in Area 3A are still low but not dismal as in last year's fit.

## Extrapolation to Areas 3B and 4

In Areas 3B and 4, exploitation rates were very low until recently and there are no survey data before 1996. Exploitable biomass in those areas is estimated by extrapolating the analytical estimate of abundance in Area 3A to each area on the basis of total bottom area (0-500 fathoms) and a forward-weighted average of recent survey catch rates relative to 3A. The scaling factors this year are very similar to last year's, but the estimates are all substantially higher because the 3A estimate is substantially higher (Table 2).

## References


Clark, W. G., and Hare, S. R. 2001. Assessment of the Pacific halibut stock in 2000. Int. Pac. Halibut Comm. Report or Assessment and Research Activities 2000: 85-118. Also online at: http://www.iphc.washington.edu/halcom/research/sa/papers/sa00.pdf.

**Table 1. Results of the 2000 bait experiment. The value estimated is the ratio of CPUE of skates baited entirely with salmon to the CPUE of skates baited with salmon and herring on alternate hooks.**

| Size class | Area | Point estimate | Lower bound | Upper bound | Significance |
|---|---|---|---|---|---|
| **Legal sized** | **3A** | 1.21 | 1.01 | 1.44 | Y |
| | **2B** | 0.93 | 0.74 | 1.17 | N |
| **Sublegal** | **3A** | 0.98 | 0.71 | 1.35 | N |
| | **2B** | 0.82 | 0.54 | 1.26 | N |
| **Total catch** | **3A** | 1.12 | 0.93 | 1.33 | N |
| | **2B** | 0.89 | 0.70 | 1.12 | N |

**Table 2. Removals in 2000 and CEY in 2001 (in millions of net pounds).**

| Area | 2A | 2B | 2C | 3A | 3B | 4A | 4B | 4CDE | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **2000 catch limit** | 0.83[1] | 10.60 | 8.40 | 18.31 | 15.03 | 4.97 | 4.91 | 4.45 | 67.50 |
| | | | | | | | | | |
| **2000 commercial landings**[2] | 0.46 | 10.78 | 8.46 | 19.33 | 15.44 | 5.04 | 4.71 | 4.04 | 68.26 |
| **Other removals** | | | | | | | | | |
| Sport catch | 0.34 | 1.58 | 1.98 | 4.60 | 0.02 | 0.10 | — | — | 8.62 |
| Legal-sized bycatch | 0.34 | 0.14 | 0.23 | 1.21 | 0.58 | 0.52 | 0.20 | 2.55 | 5.77 |
| Personal use | 0.00 | 0.30 | 0.17 | 0.07 | 0.02 | 0.09 | 0.00 | 0.08 | 0.73 |
| Legal-sized wastage | 0.01 | 0.03 | 0.04 | 0.03 | 0.05 | 0.03 | 0.03 | 0.03 | 0.25 |
| Total other removals | 0.69 | 2.05 | 2.42 | 5.91 | 0.67 | 0.74 | 0.23 | 2.66 | 15.37 |
| **Total removals** | 1.15 | 12.83 | 10.88 | 25.24 | 16.11 | 5.78 | 4.94 | 6.70 | 83.63 |
| | | | | | | | | | |
| **2001 exploitable biomass** | 7.44 | 60.18 | 56.0 | 139.00 | 130.66 | 52.82 | 51.43 | 51.43 | 548.96 |
| **2001 total CEY** | 1.49 | 12.04 | 11.20 | 27.80 | 26.13 | 10.56 | 10.29 | 10.29 | 109.80 |
| **2001 setline CEY** | 1.14[1] | 9.99[3] | 8.78 | 21.89 | 25.46 | 9.82 | 10.06 | 7.63 | 94.77 |

[1] Catch limit and setline CEY include sport catch in Area 2A only.
[2] Includes research catches.
[3] With the lower series of 2B sport catch estimates (including 0.887 M lb in recent years), 2AB exploitable biomass is 66.71 instead of 67.62 as in the table. With 11% of the total in 2A, this change results in a 2001 setline CEY of 1.12 M lb in 2A and 10.51 M lb in 2B.

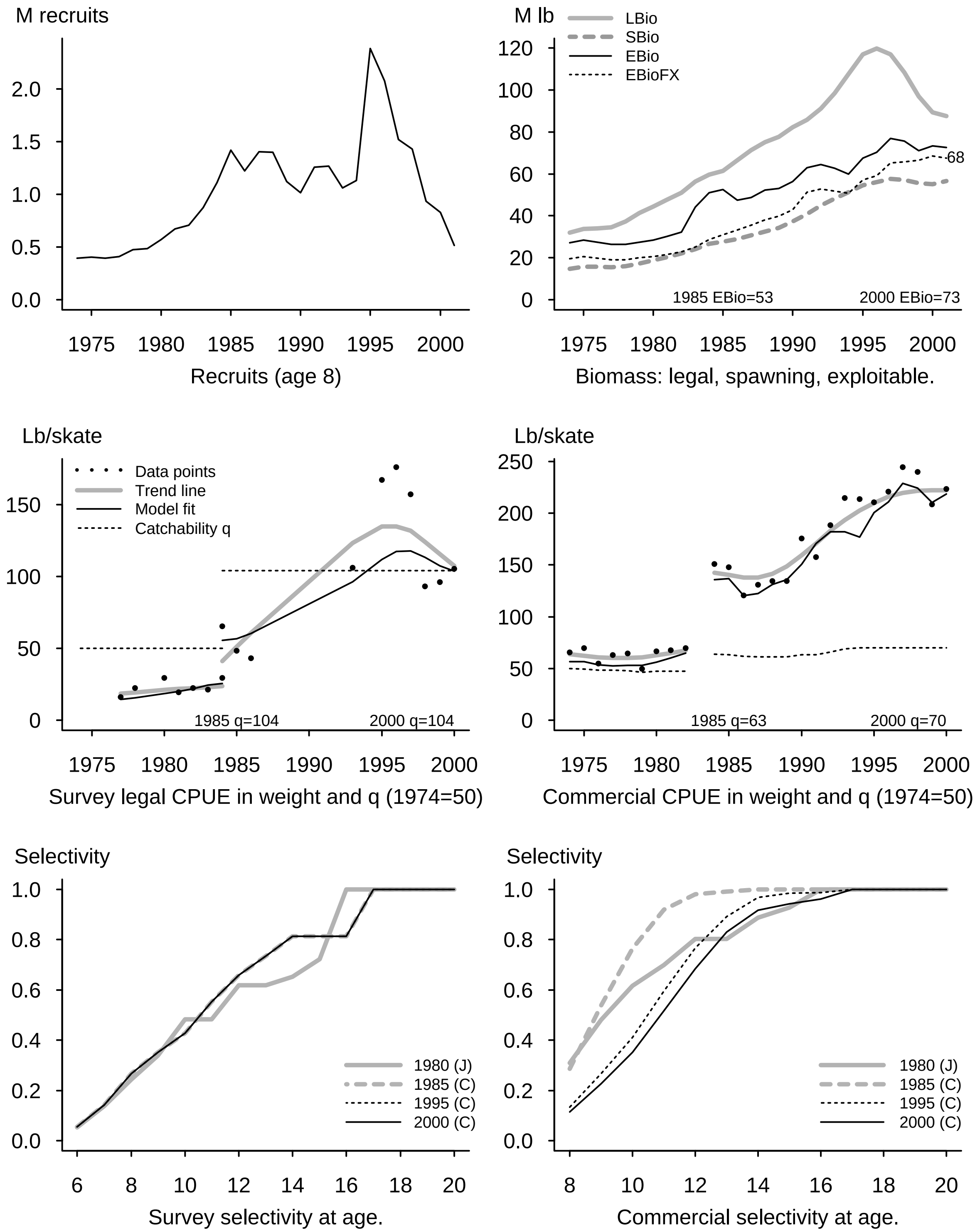


**Figure 1. Fit of the standard model in Area 2AB.**

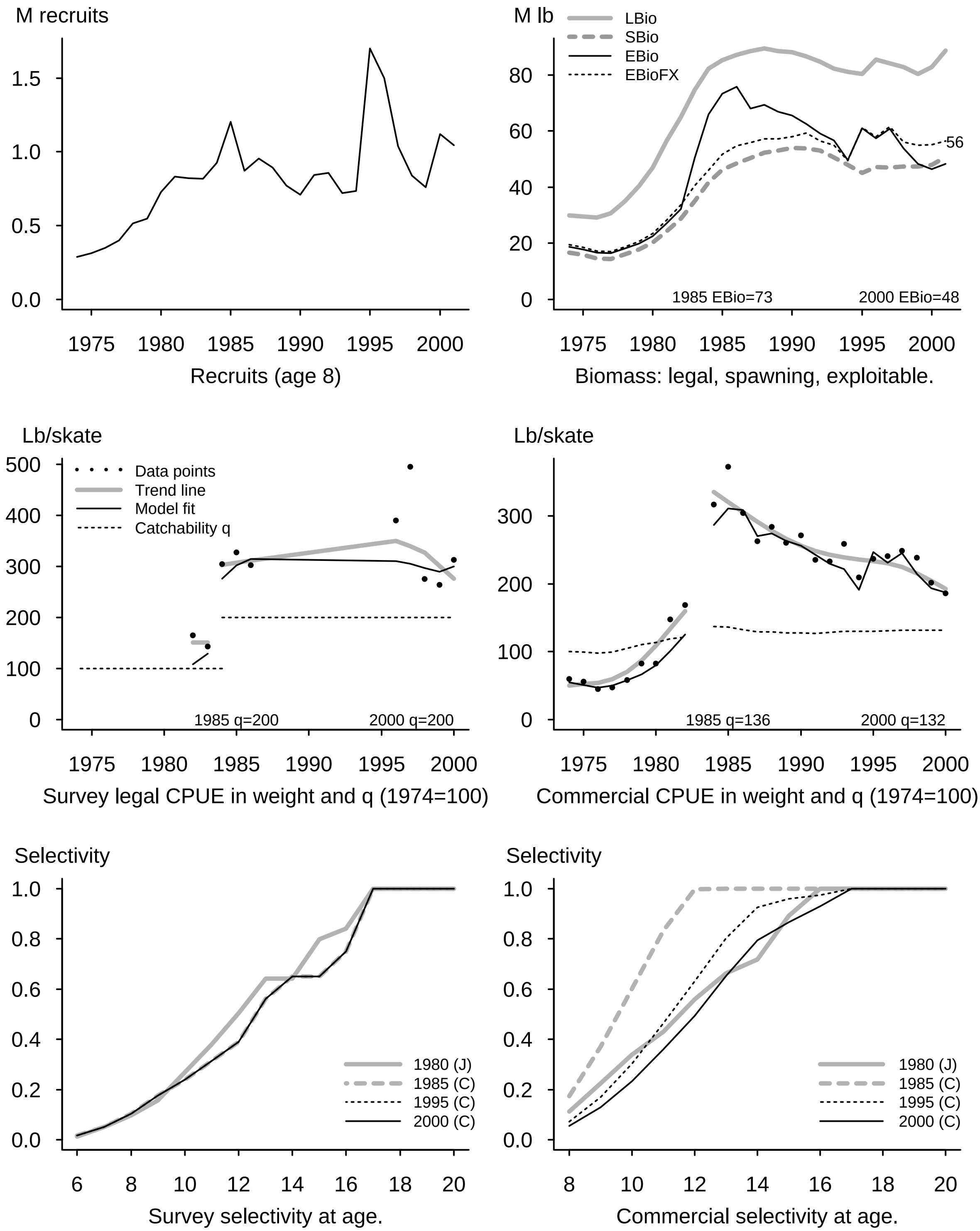


**Figure 2. Fit of the standard model in Area 2C.**

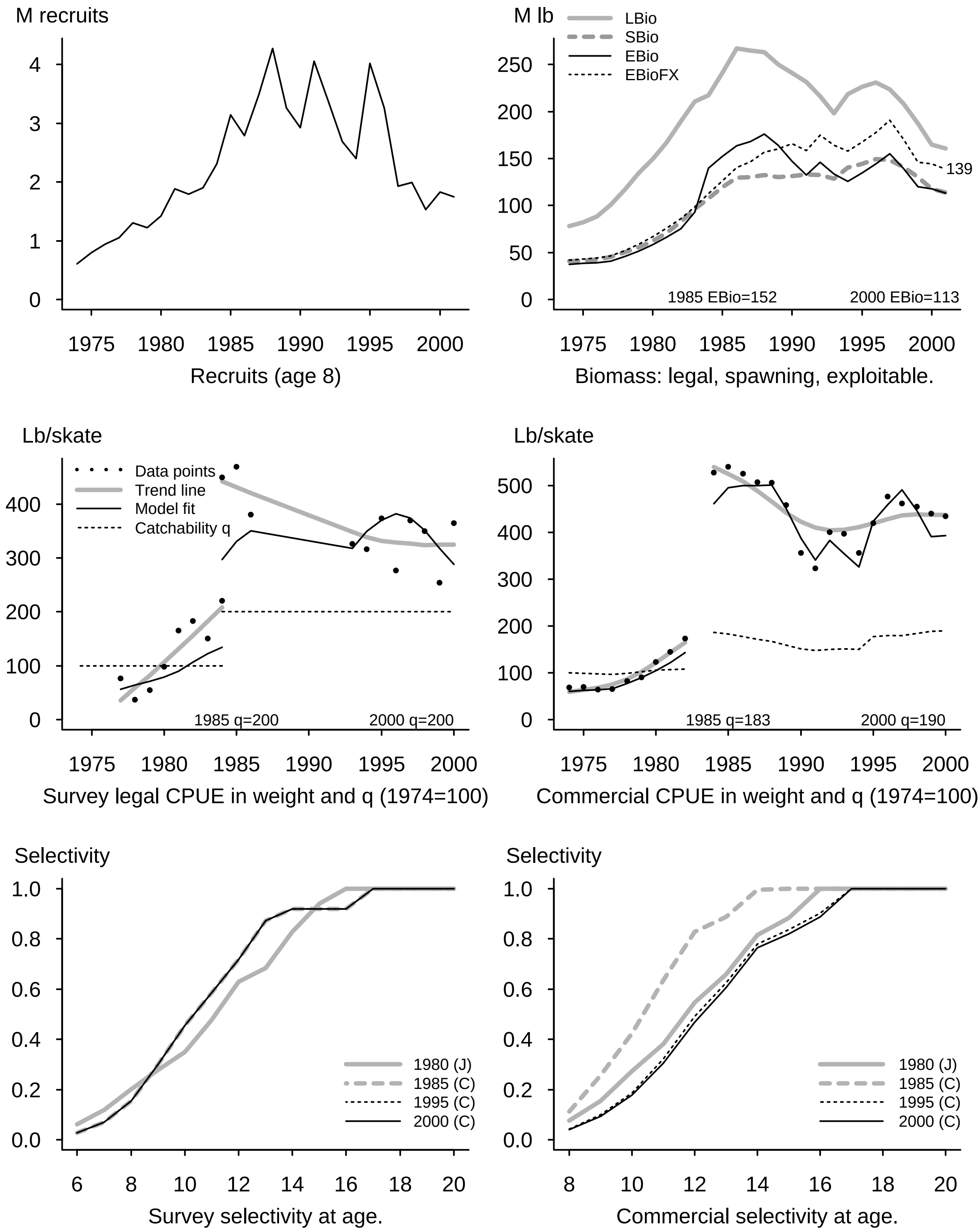


**Figure 3. Fit of the standard model in Area 3A.**

## Appendix A. Selected fishery and survey data summaries.

**Table A1. Commercial + research catch (million pounds, net weight).**

| | 2A | 2B | 2C | 3A | 3B | 4 | Total |
|---|---|---|---|---|---|---|---|
| **1974** | 0.52 | 4.62 | 5.60 | 8.19 | 1.67 | 0.71 | 21.31 |
| **1975** | 0.46 | 7.13 | 6.24 | 10.60 | 2.56 | 0.63 | 27.62 |
| **1976** | 0.24 | 7.28 | 5.53 | 11.04 | 2.73 | 0.72 | 27.54 |
| **1977** | 0.21 | 5.43 | 3.19 | 8.64 | 3.19 | 1.22 | 21.88 |
| **1978** | 0.10 | 4.61 | 4.32 | 10.30 | 1.32 | 1.35 | 22.00 |
| **1979** | 0.05 | 4.86 | 4.53 | 11.34 | 0.39 | 1.37 | 22.54 |
| **1980** | 0.02 | 5.65 | 3.24 | 11.97 | 0.28 | 0.71 | 21.87 |

| | 2A | 2B | 2C | 3A | 3B | 4A | 4B | 4C | 4D | 4E | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1981** | 0.20 | 5.66 | 4.01 | 14.23 | 0.45 | 0.49 | 0.39 | 0.30 | 0.01 | 0.00 | 25.74 |
| **1982** | 0.21 | 5.54 | 3.50 | 13.52 | 4.80 | 1.17 | 0.01 | 0.24 | 0.00 | 0.01 | 29.01 |
| **1983** | 0.27 | 5.44 | 6.38 | 14.13 | 7.75 | 2.50 | 1.34 | 0.42 | 0.15 | 0.01 | 38.39 |
| **1984** | 0.43 | 9.05 | 5.87 | 19.77 | 6.69 | 1.05 | 1.10 | 0.58 | 0.39 | 0.04 | 44.97 |
| **1985** | 0.49 | 10.39 | 9.21 | 20.84 | 10.89 | 1.72 | 1.24 | 0.62 | 0.67 | 0.04 | 56.10 |
| **1986** | 0.58 | 11.23 | 10.61 | 32.80 | 8.82 | 3.38 | 0.26 | 0.69 | 1.22 | 0.04 | 69.63 |
| **1987** | 0.59 | 12.25 | 10.68 | 31.31 | 7.76 | 3.69 | 1.50 | 0.88 | 0.70 | 0.09 | 69.45 |
| **1988** | 0.49 | 12.86 | 11.36 | 37.86 | 7.08 | 1.93 | 1.59 | 0.71 | 0.45 | 0.01 | 74.34 |
| **1989** | 0.47 | 10.43 | 9.53 | 33.73 | 7.84 | 1.02 | 2.65 | 0.57 | 0.67 | 0.01 | 66.95 |
| **1990** | 0.33 | 8.57 | 9.73 | 28.85 | 8.69 | 2.50 | 1.33 | 0.53 | 1.01 | 0.06 | 61.60 |
| **1991** | 0.35 | 7.19 | 8.69 | 22.93 | 11.93 | 2.25 | 1.51 | 0.68 | 1.44 | 0.10 | 57.08 |
| **1992** | 0.43 | 7.63 | 9.82 | 26.78 | 8.62 | 2.70 | 2.32 | 0.79 | 0.73 | 0.07 | 59.89 |
| **1993** | 0.50 | 10.63 | 11.29 | 22.74 | 7.86 | 2.56 | 1.96 | 0.83 | 0.84 | 0.06 | 59.27 |
| **1994** | 0.37 | 9.91 | 10.38 | 24.84 | 3.86 | 1.80 | 2.02 | 0.71 | 0.71 | 0.12 | 54.73 |
| **1995** | 0.30 | 9.62 | 7.77 | 18.34 | 3.12 | 1.62 | 1.68 | 0.67 | 0.64 | 0.13 | 43.88 |
| **1996** | 0.30 | 9.55 | 8.87 | 19.69 | 3.66 | 1.70 | 2.07 | 0.68 | 0.71 | 0.12 | 47.34 |
| **1997** | 0.41 | 12.42 | 9.92 | 24.63 | 9.07 | 2.91 | 3.32 | 1.12 | 1.15 | 0.25 | 65.20 |
| **1998** | 0.46 | 13.15 | 10.20 | 25.70 | 11.16 | 3.42 | 2.90 | 1.26 | 1.31 | 0.19 | 69.74 |
| **1999** | 0.45 | 12.70 | 10.17 | 25.29 | 13.83 | 4.37 | 3.57 | 1.76 | 1.89 | 0.26 | 74.31 |
| **2000** | 0.46 | 10.78 | 8.46 | 19.33 | 15.44 | 5.04 | 4.71 | 1.75 | 1.95 | 0.35 | 68.27 |

**Table A2. Bycatch mortality of legal-sized halibut (80+ cm; in million pounds, net weight).**

| | 2A | 2B | 2C | 3A | 3B | 4 | Total |
|---|---|---|---|---|---|---|---|
| 1974 | 0.25 | 0.90 | 0.37 | 4.48 | 2.82 | 1.90 | 10.71 |
| 1975 | 0.25 | 0.90 | 0.45 | 2.61 | 1.66 | 1.10 | 6.98 |
| **1976** | 0.25 | 0.94 | 0.50 | 2.74 | 1.94 | 1.18 | 7.56 |
| **1977** | 0.25 | 0.73 | 0.41 | 3.37 | 1.55 | 1.98 | 8.27 |
| **1978** | 0.25 | 0.55 | 0.21 | 2.44 | 1.31 | 3.40 | 8.16 |
| **1979** | 0.25 | 0.69 | 0.64 | 4.49 | 0.69 | 3.45 | 10.21 |
| **1980** | 0.25 | 0.51 | 0.42 | 4.93 | 0.87 | 5.71 | 12.69 |
| **1981** | 0.25 | 0.53 | 0.40 | 3.99 | 1.09 | 4.37 | 10.64 |
| **1982** | 0.25 | 0.30 | 0.20 | 3.20 | 1.68 | 2.95 | 8.58 |
| **1983** | 0.25 | 0.29 | 0.20 | 2.08 | 1.22 | 2.47 | 6.51 |
| **1984** | 0.25 | 0.52 | 0.21 | 1.51 | 0.92 | 2.29 | 5.70 |
| **1985** | 0.25 | 0.55 | 0.20 | 0.80 | 0.34 | 2.25 | 4.39 |
| **1986** | 0.25 | 0.56 | 0.20 | 0.67 | 0.20 | 2.62 | 4.50 |
| **1987** | 0.25 | 0.79 | 0.20 | 1.59 | 0.40 | 2.68 | 5.91 |
| **1988** | 0.25 | 0.77 | 0.20 | 2.13 | 0.04 | 3.27 | 6.67 |
| **1989** | 0.25 | 0.72 | 0.20 | 1.80 | 0.44 | 1.95 | 5.37 |
| **1990** | 0.25 | 1.03 | 0.67 | 2.63 | 1.21 | 4.15 | 9.96 |
| **1991** | 0.25 | 1.22 | 0.55 | 3.12 | 1.03 | 2.91 | 9.09 |
| **1992** | 0.28 | 1.02 | 0.57 | 2.65 | 1.12 | 3.34 | 8.97 |
| **1993** | 0.28 | 0.65 | 0.33 | 1.92 | 0.47 | 2.01 | 5.65 |
| **1994** | 0.28 | 0.57 | 0.40 | 2.35 | 0.85 | 3.48 | 7.93 |
| **1995** | 0.38 | 0.71 | 0.22 | 1.46 | 0.82 | 3.21 | 6.80 |
| **1996** | 0.38 | 0.17 | 0.23 | 1.40 | 0.96 | 3.57 | 6.71 |
| **1997** | 0.38 | 0.11 | 0.24 | 1.55 | 0.73 | 3.80 | 6.81 |
| **1998** | 0.38 | 0.12 | 0.24 | 1.47 | 0.73 | 3.72 | 6.66 |
| **1999** | 0.34 | 0.11 | 0.23 | 1.28 | 0.74 | 3.33 | 6.04 |
| **2000** | 0.34 | 0.14 | 0.23 | 1.21 | 0.58 | 3.28 | 5.77 |

**Table A3. Total removals: commercial catch + sport catch + legal-sized wastage + legal-sized bycatch + personal use (million pounds, net weight).**

| | 2A | 2B | 2C | 3A | 3B | 4 | Total |
|---|---|---|---|---|---|---|---|
| **1974** | 0.77 | 5.52 | 5.97 | 12.67 | 4.48 | 2.61 | 32.02 |
| **1975** | 0.71 | 8.03 | 6.69 | 13.21 | 4.22 | 1.73 | 34.60 |
| **1976** | 0.49 | 8.22 | 6.03 | 13.78 | 4.67 | 1.90 | 35.10 |
| **1977** | 0.48 | 6.17 | 3.67 | 12.20 | 4.73 | 3.20 | 30.45 |
| **1978** | 0.36 | 5.17 | 4.62 | 13.02 | 2.63 | 4.75 | 30.55 |
| **1979** | 0.32 | 5.57 | 5.34 | 16.19 | 1.08 | 4.82 | 33.32 |
| **1980** | 0.29 | 6.18 | 3.99 | 17.39 | 1.15 | 6.42 | 35.41 |
| **1981** | 0.47 | 6.21 | 4.73 | 18.96 | 1.54 | 5.57 | 37.48 |
| **1982** | 0.51 | 5.91 | 4.19 | 17.44 | 6.48 | 4.39 | 38.92 |
| **1983** | 0.58 | 5.83 | 7.15 | 17.14 | 8.97 | 6.89 | 46.56 |
| **1984** | 0.80 | 9.69 | 6.68 | 22.50 | 7.42 | 5.47 | 52.56 |
| **1985** | 0.94 | 11.57 | 10.31 | 23.79 | 11.43 | 6.69 | 64.71 |
| **1986** | 1.17 | 12.35 | 11.97 | 37.23 | 9.43 | 8.53 | 80.68 |
| **1987** | 1.29 | 13.74 | 12.03 | 36.48 | 8.50 | 9.84 | 81.88 |
| **1988** | 0.99 | 14.19 | 12.85 | 44.76 | 7.24 | 8.06 | 88.10 |
| **1989** | 1.05 | 11.83 | 11.48 | 40.00 | 8.47 | 7.03 | 79.87 |
| **1990** | 0.78 | 10.44 | 11.98 | 36.02 | 10.12 | 9.84 | 79.17 |
| **1991** | 0.77 | 9.10 | 11.96 | 32.35 | 13.46 | 9.48 | 77.12 |
| **1992** | 0.97 | 9.38 | 12.68 | 34.46 | 9.98 | 10.23 | 77.69 |
| **1993** | 1.05 | 12.33 | 13.74 | 30.59 | 8.46 | 8.55 | 74.72 |
| **1994** | 0.83 | 11.51 | 13.11 | 32.86 | 4.83 | 9.12 | 72.26 |
| **1995** | 0.92 | 12.25 | 9.79 | 24.52 | 4.01 | 8.11 | 59.60 |
| **1996** | 0.91 | 11.63 | 11.27 | 26.11 | 4.70 | 9.13 | 63.75 |
| **1997** | 1.16 | 14.45 | 12.37 | 31.86 | 9.92 | 12.83 | 82.59 |
| **1998** | 1.23 | 15.20 | 12.97 | 32.13 | 12.00 | 13.04 | 86.56 |
| **1999** | 1.14 | 14.73 | 12.48 | 30.99 | 14.69 | 15.54 | 89.57 |
| **2000** | 1.15 | 12.82 | 10.87 | 25.24 | 16.11 | 17.42 | 83.61 |

**Table A4. Commercial CPUE (net pounds per skate).**

Values before 1984 are multiplied by the J-C hook correction for catch in weight of legal-sized fish (2.2). 1983 is excluded because it consists of a mixture of J- and C-hook data. No

| | 2A | 2B | 2C | 3A | 3B | 4 |
|---|---|---|---|---|---|---|
| **1974** | 131 | 141 | 126 | 142 | 125 | 301 |
| **1975** | 131 | 149 | 117 | 145 | 149 | 211 |
| **1976** | 72 | 117 | 93 | 131 | 142 | 184 |
| **1977** | 182 | 135 | 99 | 135 | 161 | 176 |
| **1978** | 86 | 138 | 124 | 172 | 116 | 167 |
| **1979** | 110 | 106 | 177 | 189 | 81 | 146 |
| **1980** | 82 | 144 | 175 | 261 | 249 | 124 |

| | 2A | 2B | 2C | 3A | 3B | 4A | 4B | 4C | 4D | 4E |
|---|---|---|---|---|---|---|---|---|---|---|
| **1981** | --- | 146 | 318 | 312 | --- | --- | 217 | 243 | --- | --- |
| **1982** | --- | 149 | 366 | 375 | 478 | 226 | --- | 199 | --- | --- |
| **1983** | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1984** | 69 | 149 | 314 | 524 | 475 | 366 | 161 | --- | 197 | --- |
| **1985** | 69 | 146 | 370 | 536 | 602 | 333 | 234 | --- | 330 | --- |
| **1986** | 61 | 119 | 302 | 522 | 515 | 265 | --- | 427 | 238 | --- |
| **1987** | 59 | 129 | 260 | 504 | 476 | 341 | 220 | 384 | --- | --- |
| **1988** | 171 | 133 | 281 | 503 | 655 | 453 | 224 | --- | 201 | --- |
| **1989** | 124 | 133 | 258 | 455 | 590 | 409 | 268 | 331 | 384 | --- |
| **1990** | 168 | 174 | 269 | 353 | 484 | 434 | 208 | 288 | 381 | --- |
| **1991** | 164 | 156 | 233 | 319 | 466 | 471 | 329 | 223 | 398 | --- |
| **1992** | 114 | 187 | 230 | 397 | 440 | 372 | 278 | 249 | 412 | --- |
| **1993** | 155 | 213 | 256 | 393 | 514 | 463 | 218 | 256 | 851 | --- |
| **1994** | 97 | 212 | 207 | 354 | 377 | 463 | 198 | 167 | 480 | --- |
| **1995** | 132 | 209 | 234 | 416 | 476 | 349 | 189 | --- | 475 | --- |
| **1996** | 168 | 219 | 238 | 473 | 556 | 515 | 269 | --- | --- | --- |
| **1997** | 216 | 243 | 246 | 458 | 562 | 482 | 275 | 335 | 671 | --- |
| **1998** | 197 | 238 | 236 | 451 | 611 | 525 | 287 | 287 | 627 | --- |
| **1999** | 311 | 207 | 199 | 437 | 538 | 498 | 310 | 270 | 535 | --- |
| **2000** | --- | 222 | 182 | 431 | 577 | 532 | 319 | 226 | 565 | --- |

**Table A5. IPHC setline survey CPUE of legal sized fish in weight (net pounds per skate).**

Series refer to standard survey areas: all of 2A, 2B north of Vancouver Is., outside stations in 2C, 3A west of 147ºW, all of 3B, the Aleutian portion of 4A, all of 4B, 4C, and 4D. *No corrections* are applied; values before 1984 are raw J-hook catch rates.

**J-hook surveys**

| | 2A | 2B | 2C | 3A |
|---|---|---|---|---|
| **1974** | --- | --- | --- | --- |
| **1975** | --- | --- | --- | --- |
| **1976** | --- | --- | --- | --- |
| **1977** | --- | 15 | --- | 73 |
| **1978** | --- | 21 | --- | 34 |
| **1979** | --- | --- | --- | 51 |
| **1980** | --- | 28 | --- | 95 |
| **1981** | --- | 18 | --- | 162 |
| **1982** | --- | 21 | 162 | 180 |
| **1983** | --- | 20 | 140 | 147 |

**C-hook surveys**

| | 2A | 2B | 2C | 3A | 3B | 4A | 4B | 4C | 4D |
|---|---|---|---|---|---|---|---|---|---|
| **1984** | --- | 64 | 301 | 446 | --- | --- | --- | --- | --- |
| **1985** | --- | 47 | 324 | 466 | --- | --- | --- | --- | --- |
| **1986** | --- | 42 | 299 | 377 | --- | --- | --- | --- | --- |
| **1987** | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1988** | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1989** | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1990** | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1991** | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1992** | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **1993** | --- | 105 | --- | 323 | --- | --- | --- | --- | --- |
| **1994** | --- | --- | --- | 313 | --- | --- | --- | --- | --- |
| **1995** | 29 | 166 | --- | 370 | --- | --- | --- | --- | --- |
| **1996** | --- | 175 | 387 | 273 | 352 | --- | --- | --- | --- |
| **1997** | 35 | 156 | 492 | 366 | 415 | 300 | 282 | 71 | 111 |
| **1998** | --- | 92 | 272 | 346 | 436 | 394 | 216 | --- | --- |
| **1999** | 37 | 95 | 260 | 251 | 441 | 367 | 204 | --- | --- |
| **2000** | --- | 104 | 309 | 361 | 378 | 382 | 218 | --- | 212 |

# Staff Regulatory Proposals: 2001


## Bruce M. Leaman


In making catch limit recommendations for 2001, staff has considered the major elements of change in the estimated exploitable biomass noted below and evaluated their implications in relation to stock trajectories and the information on stock status available for the IPHC regulatory areas.

Setline survey catch per unit of effort has been used as an index of abundance in the halibut assessment since 1996. In order to assure that the catchability of the survey gear stays constant over time, efforts have been made to standardize fishing practices, especially since 1993 when the surveys resumed after being suspended for six years. A factor that was changed in 1993, when surveys were re-designed and expanded, was the bait: mixed salmon-herring bait used in the mid 1980s was replaced by all salmon bait, as the latter was considered to be more readily available, and using a single bait would minimize variability compared with two baits. In 1999 experiments were done that showed a substantial difference in catching power (50-150%) for the two baits, hence questions about artificial increases in survey catchability with the bait change. This difference was too large to ignore and as a precautionary measure a working value of 100% was used in for the 1999 assessment. This translated into a 33% increase in overall survey catchability between the 1980s and the 1990s. However, staff also recognized that the 1999 experiments (full skates of salmon vs. full skates of herring) did not address the exact change in survey baiting practices and that the correct experiment (full skates of salmon vs. skates of alternate salmon and herring baits) was needed. Accordingly, the recommended catch limits for 2000 stepped only 50% of the way between the CEY values that were estimated using the adjusted survey series and the previous year's quotas.

In 2000 we completed an extensive experiment comparing survey baiting practices (see Chen and Clark, this volume). The experiment indicated no overall significant difference in survey catch rates between the two baiting methods, although all-salmon baits caught slightly more legal-sized fish in Area 3A. Accordingly, the adjustment to survey catchability that was used last year was removed in this year's assessment, which increases the estimates of exploitable biomass by 20-30%.

The second major signal in this year's assessment was the general increase in survey catch rates in the central and eastern parts of the stock range, particularly in Area 3A. This increase was associated primarily with higher catches of fish up to about age 13. Weight at age also increased somewhat in Area 3A, after declining for most of the late 1980s and 1990s.

## Recruitment estimates

Recruitment to the stock has declined from the high levels seen in the 1990s, that were fueled by year classes from the late 1970s and 1980s. The 1987 and 1988 year classes were relatively strong but those resulting from spawning in 1989-1993 have been relatively poor. This means that the stock biomass will decline from the historic highs seen in recent years, as a result of these natural declines in recruitment. For 2000, recruitment estimates for 8-y old fish were similar or slightly higher than those observed last year, except for Area 2AB, where abundance of recruits continued the downward trend of recent years. Historically, the recruitment patterns have been similar in most regulatory areas and, given that abundance of 8-y olds is not well determined by a single observation, it is too soon to tell if the Area 2AB recruitment is indeed showing a different trend from that in the northern areas.

## Evaluation and future directions

We believe the trajectory of the halibut stock biomass will continue to be downward in most areas for the next several years as a result of natural declines in recruitment. This is projected to continue until improvements in recruitment occur. The rate of decline is not precipitous, in large measure because growth rate decreases over the past decade mean that the sub-legal sized component of the stock now contains more age groups than it has traditionally.

For the near future, it appears that oceanographic conditions have entered an unfavourable period for success of halibut spawning. The Pacific Decadal Oscillation oceanographic index changed from a positive to a negative value in 1998, which is associated with poor halibut recruitment, and has remained negative through 2000 (Hare and Clark, this volume).

We are mindful of the changes in the assessment model over the past several years and wish to exercise caution while we work toward stabilizing our estimation process and incorporate additional data. The assessment continues to present some symptoms of lack of fit to the data, and we have not yet been successful at including the data from trawl surveys as an additional index of relative abundance. We are also in the process of reviewing both the basis for our harvest percentage used in CEY calculations and the underlying harvest strategy. This review will examine different approaches to managing halibut stocks, with a particular emphasis on development of a strategies resulting in less variable quotas while capturing a significant proportion of available yield.

## Yield recommendations

The 2000 assessment has resulted in some substantial increases in estimated 2001 CEY over those obtained from the 1999 assessment. These changes are the result of removing the bait adjustment applied in 1999 and adding data from surveys and commercial fisheries in 2000.

For Areas 2A through 3A, we have reasonable confidence in this years' analytic results and are recommending catch limits that are the same as the estimated setline CEYs. For Areas 3B and 4, we are recommending caution in setting harvest levels because of the absence of analytic modeling for the areas and the limited historical knowledge base. Stock biomass in these areas is largely an accumulation resulting from low historical exploitation and cannot be expected to persist at current fishery levels. For Area 3B, there is somewhat more information from surveys and commercial fisheries than for Area 4. Survey catch rates in Area 3B also showed a downturn of 14% in 2000.

The recent stock assessment surveys for Area 4 show that, while the accumulated biomass of these areas is larger than was believed prior to the surveys, the biomass is spread over large areas at low density. There is considerable uncertainty about how much of this biomass is directly available to the fishery on an annual basis. Additionally, our procedure for estimating catch limits in Areas 3B and 4 results in estimates that are driven primarily by changes in Area 3A. The proportional limits for the western areas, based on bottom areas and survey catch rates, have been relatively stable but the changes in Area 3A will mean large changes in the western areas, even if survey catch rates show no change, or negative changes as in the 2000 surveys.

We have followed the 'slow-up' approach in Area 3B and the resulting catch limit recommendation is the 2000 level plus 33% of the difference between the 2000 quota and the 2001 CEY estimate (Table 1). For Area 4, we recommend keeping yields at recent levels until the effects of current exploitation levels can be evaluated and we have greater confidence in the extrapolated estimates, or we develop an improved procedure for calculating catch limits for the area.

## Fishing periods

The staff recommends maintaining the March 15 to November 15 opening and closing dates for the quota share fishing season. The treaty Indian fishery in Area 2A should also occur within this period.

In Area 2A for the directed commercial fishery, the staff recommends fishing periods similar to those in effect in 2000: a series of 10-hour periods, with fishing period limits to ensure that the catch limit is not exceeded. The size of the fishing period will be determined when more information on fleet participation is available.

The Commission does not make allocative decisions within regulatory areas or to different user groups. However, for Areas 2A and 4CDE the staff has recommended that the Commission endorse the catch sharing plan developed by the Pacific and North Pacific Fishery Management Councils for these areas, respectively.

## Proposed changes to the IPHC regulations

### Area 4 clearance requirements

The staff proposes changes to the Area 4 clearance regulations. First, we recommend adding the requirement that clearance forms must be signed either by the skipper or the officer that is confirming visual sighting. It is currently implied but not required. This will assist NMFS Enforcement if there is a question on the accuracy of the completed form. Second, to assist the fleet that fishes in Areas 4A and 4B we suggest that Nazan Bay on Atka Island be added as a port to obtain fishing clearances prior to fishing in Area 4A. Vessels would have to offload any fish caught from Area 4B prior to obtaining clearance for Area 4A, as clearances can only be obtained when no halibut is onboard the vessel.

### Fishing logbook information

We have reviewed the section of the IPHC regulations that requires the completion of fishing log information. We believe the current requirement (U.S. and Canadian) of recording locality of fishing is too general. We propose that the regulation be more specific, requiring either latitude/longitude, loran, or direction and distance from a point of land, as well as the vessel name, vessel number, amount of gear hauled and lost, and total weight of halibut taken daily or by set at each location.

The 2000 requirement was that the logbook be kept on the vessel when engaged in halibut fishing, during transit to port of landing, and for five days following offloading. The staff recommends changing "for five days following offloading" to "until the offload is completed". The five day requirement was for both countries and was necessary during the derby fisheries. IPHC issues logbooks to skippers and this allows the skipper to remove the logbook after the fishing trip.

The current requirement in B.C. is that the log sheets be mailed to IPHC within seven days of the offload. We would prefer that the log sheets be mailed at the end of the vessel's fishing season. This would allow the skipper to keep the IPHC log sheets on the vessel so that the port sampler could interview the skipper and obtain information on missed trips at anytime during the summer. This is important for cases when the samplers are unavailable during an offload. Therefore, we recommend that the regulation requires that the IPHC copy of the log sheet be mailed within seven days of their final offload for the fishing season.

**Offload weight**

The U.S. State agencies, IPHC, and NMFS reviewed the U.S. regulation that requires that all halibut must be offloaded, weighed and the weight recorded on state tickets or federal catch records. We recommend that the regulation be changed so that the weight is recorded on both the federal catch records and the fish tickets. The current wording of the regulation is unclear and unenforceable.

**Overall vessel length definition**

NMFS Alaska (Sustainable Fisheries) is proceeding with changes to the definition of overall length of a vessel. It is uncertain if the definition will be changed for 2001 but should it be determined (by the Annual Meeting) that the definition will change, then the IPHC should mirror any new length definition for U.S vessels. Overall length of a vessel is used in IPHC regulations to define logbook requirements and fishing period limits.

**Fishing gear definition**

The staff reviewed the sport and commercial gear definitions with the intent to recommend changes. However, we are not recommending changes to either of these definitions at this time. While the hook and line gear definitions by state and federal agencies are different, the staff will work with the other agencies during 2001 to determine if a common definition can be implemented. We will recommend a change in the sport gear definition when the subsistence fishery is recognized within the Commission regulations.

**Table 1. Constant exploitation yield (CEY) estimates and recommended catch limits.**

| | Millions of Pounds | | | |
|---|---|---|---|---|
| **Regulatory Area** | **2000 Setline CEY** | **2000 Setline Quota** | **2001 Setline CEY** | **2001 Setline Recommendations** |
| **2A*** | 0.83 | 0.83 | 1.14 | 1.14 |
| **2B** | 7.85 | 10.60 | 9.99 | 9.99 |
| **2C** | 6.31 | 8.40 | 8.78 | 8.78 |
| **3A** | 11.04 | 18.31 | 21.89 | 21.89 |
| **3B** | 18.36 | 15.03 | 25.46 | 18.50 |
| **4A** | 6.42 | 4.97 | 9.82 | 4.97 |
| **4B** | 6.77 | 4.91 | 10.06 | 4.91 |
| **4CDE** | 4.13 | 4.45 | 7.63 | 4.45 |
| **Total** | **62.61** | **67.50** | **94.77** | **74.63** |

*includes sport, tribal and commercial fishery

# Appendix
# IPHC research and assessment: Review of 1999/ 2000 projects and proposals for 2000/ 2001

## The International Pacific Halibut Commission Staff

### Introduction

This document reviews research conducted by the IPHC staff in the past year and proposed for the upcoming year. The report is divided into two sections, with the first section reviewing the status of research projects conducted in 1999/2000. In addition, scientific articles authored by the staff which describe results of these and other research projects are listed. Project costs are summarized at the end of the section.

The second section presents the staff research proposals for 2000/2001. Information is provided regarding when each project began, the anticipated completion date, the annual cost and total cost, a description of the costs, and the purpose of the project. This report does not include ongoing staff tasks such as data collection and processing that are necessary for the management of the fishery.

Research projects are organized into three funding categories that reflect availability and source of research funds. Very little research requiring cash outlay is possible under the basic $1.6M government appropriations, although a number of programs can be conducted using only the staff resources that are supported by the appropriations. The three funding categories are:

1) **Appropriations:** Necessary research projects of high priority that can be conducted under the basic $1.6 M budget;
2) **Supplemental:** Necessary research projects of high priority that can only be conducted with revenues generated by survey fishing in 2001, grants or contributions, or carry-over from 2000; and
3) **Contract**: Agreements to conduct specific research projects. In this report, contracts are shown for projects where the IPHC staff is the principle investigator, and projects that IPHC has contracted to other investigators.

The summary report also shows the program to which the project belongs. Internally, the staff is organized into three programs; (1) fishery statistics and regulations, (2) biological research and fisheries management, and (3) stock assessment. These programs are directed by a manager, who works with program staff to determine priorities, work objectives and staffing needs, and ensures timely project completion.

Throughout this report the status of projects is stated as being either completed, continuing, or deferred. To be completed, a project has been fully analyzed and the results reported in the Report of Assessment and Research Activities (RARA), the IPHC report series, or an outside peer-reviewed journal. Continuing projects are those which are still underway, with the staff performing analysis or writing the report. A project is deferred when it is postponed until the following or future year.

Nearly all of the research done by the staff is directed toward one of three continuing objectives of the Commission:

i) improving the annual stock assessment and quota recommendations;
ii) developing information on current management issues;
iii) adding to knowledge of the biology and life history of halibut.

In each of these areas our routine work program applies the best information and methods available, and our research program aims to improve the information and methods by answering the most important outstanding questions.

## Contents

## Section I.
## Review of research conducted in 1999/ 2000

Research conducted by the IPHC staff during 1999/2000 covered a myriad of subjects, from chalky halibut investigations to bycatch to issues that bear on the stock assessment. Most of the projects were conducted as part of the normal staff duties, with no additional funding required outside of staff salaries. Funding for projects outside of staff salaries came from the Supplemental Budget, and are outlined below.

**Staff research**

Eleven projects and two contracts are listed on the following page. Seven projects were completed in 2000, although four of those (trophic status study, NMFS trawl survey, water column profiler, and density-dependent and –independent control of growth and recruitment) are considered as ongoing research, to be conducted in 2001 and subsequent years. Four projects show zero expenditure in 2000. The halibut viability comparison (#601) was initially planned for the fall, then deferred to 2001. The project was finally cancelled when a test of a trawl gear modification to reduce bycatch was proposed for 2001 and believed to have a greater potential for success. The DNA project (#606) has been underway since FY97, but a lack of researcher time and availability resulted in no additional work in 2000. Consequently, the staff considers the project finished. Staff time to update the viability video (#608) was not available during 2000, so it is being planned for 2001 and shown as a carryover in the 2000/2001 proposals. Finally, the staff was unable to pursue filling the proposed graduate student assistantship (#607) during 2000. This also is proposed for 2000/2001 as a carryover, although at a slightly lower level.

**Contract research**

IPHC was party to two contracts with NMFS in 1999/2000. The first (Project #614) involves the IPHC port samplers picking up copies of the NMFS hook-&-line catcher vessel and sablefish logbook sheets during their dockside interviews. The samplers perform some editing to the logs, which are then sent to the Seattle office and forwarded on to the NMFS lab in Auke Bay, Alaska. IPHC was paid $6,000 in 2000, the third year in a five-year contract.

The second contract (#615) had the staff assembling information and making recommendations to NMFS on the feasibility of various options for monitoring the bycatch of short-tailed albatross in the halibut fishery off Alaska. IPHC was awarded the contract because of its knowledge of the halibut fishery and its extensive data set of fishery data. The contract for $20,000 was awarded in the spring of 2000, with the final report due on December 1, 2000. The staff expects to receive full payment following submission of the final report. Consulting work on this contract totaled $10,450 and was necessary due to the lack of staff time.

## Budget Summary for 1999/2000 Projects Funded by the Supplemental Budget

| Project Acct # | Project Title | Budget | Actual |
|---|---|---|---|
| 601 | Comparisons of halibut viability among observers | $ 50,000 | $ 0 |
| 602 | Spatial and ontogenetic variability in the trophic status of halibut | 15,000 | 11,739 |
| 603 | Amino acid content of chum salmon bait | 3,000 | 4,920 |
| 604 | NMFS trawl survey: at-sea data collection & IPHC data base mgmt. | 30,000 | 32,122 |
| 605 | Stable Isotopes (Gao) | 6,000 | 6,016 |
| 606 | DNA development and evaluation | 15,000 | 0 |
| 607 | Graduate Assistantship | 30,000 | 0 |
| 608 | Update halibut viability video used in NMFS observer training | 500 | 0 |
| 610 | Purchase and deployment of a water column profiler | 7,000 | 8,914 |
| 612 | Diet of juvenile Pacific halibut, 1957-1961 | 500 | 249 |
| 613 | Density-dependent and –independent control of halibut growth/recruit. | 1,000 | 1,558 |
| | **TOTAL** | **$ 158,000** | **$ 65,518** |

## Other 1999/2000 Research – Contracts

| Project Acct # | Project Title | Income | Expense |
|---|---|---|---|
| 614 | NMFS catcher vessel logbook and sablefish data collection | $ 6,000 | $ 0 |
| 615 | Feasibility study for monitoring bycatch of short-tailed albatross in AK | 20,000 | 10,450 |
| | **TOTAL** | 26,000 | 10,450 |

## Summary of 1999/2000 Research Projects and Status

### I. FUNDED BY APPROPRIATIONS

| Project Acct. # | Project Title | Status |
|---|---|---|
| ***Program: Biological Research and Fisheries Management*** | | |
| --- | Discard mortality estimates in Alaskan groundfish fisheries | Continuing |
| --- | Time stratified sampling by observers for halibut viability and length | Deferred |
| --- | Prior hook injury (PHI) study on SSA surveys | Continuing |
| --- | Pacific halibut aging manual | Deferred |
| --- | Monitoring changes and discrepancies in application of aging criteria using otolith images in a computer paint program | Continuing |
| --- | Break and burn percentage agreement | Continuing |
| --- | Changes in assigned ages over time due to changes in application of criteria and equipment | Continuing |
| --- | Otolith exchange with eastern Canadian branch of DFO | Deferred |
| --- | Otolith marginal increment analysis | Continuing |
| --- | Incidence of crystallized otoliths from the SSA surveys | Continuing |
| --- | Sport halibut fishery review | Deferred |
| --- | Sport tagging program | Completed |
| --- | Hook-size/bait-size comparison | Continuing |
| --- | Mixed bait (salmon-herring-P. cod vs. salmon) study | Completed |
| --- | Review and analysis of historical IPHC tagging data | Continuing |
| --- | Historical documentation of special experiments | Continuing |
| --- | Analysis of 1998-1999 special experiments | Continuing |
| --- | Chalky halibut investigations | Continuing |
| ***Program: Stock Assessment*** | | |
| --- | The 2000 stock assessment | Completed |
| --- | Development of a less variable harvest policy | Continuing |
| --- | Detailed analysis of trawl and setline survey data from Areas 2A and 3A | Deferred |
| --- | Effect of survey frequency on variability of biomass estimates | Deferred |
| --- | Misclassification of ages | Deferred |
| --- | Determination of the sex of landed halibut | Deferred |
| --- | Influence of near bottom ocean conditions on juvenile halibut growth | Continuing |
| --- | Rescue of IPHC hydrographic data back to 1935 | Continuing |
| --- | Development of a Geographic Information System (GIS) | Continuing |
| ***Program: Fishery Statistics and Regulations*** | | |
| --- | Impacts of extending the commercial fishery season | Completed |
| --- | IPHC statistical area documentation | Continuing |
| --- | Review of port sampling project, 1994 to present | Deferred |
| --- | Verification of the commercial catch database, 1974 to present | Continuing |

## Summary of 1999/2000 Research Projects and Status (cont'd)

### II. SUPPLEMENTAL FUNDING

| Project Acct. # | Project Title | Status |
|---|---|---|
| ***Program: Biological Research and Fisheries Management*** | | |
| 601 | Comparison of halibut viability data among observers | Cancelled/Redirect |
| 603 | Amino acid content of chum salmon bait | Continuing |
| 606 | DNA development and evaluation | Completed |
| 607 | Graduate assistantship | Deferred |
| 608 | Update halibut viability video used in NMFS observer training | Continuing |
| 612 | Diet of juvenile Pacific halibut, 1957-1961 | Completed |
| ***Program: Stock Assessment*** | | |
| 602 | Spatial and ontogenetic variability in the trophic status of Pacific halibut | Continuing |
| 604 | NMFS trawl survey: at-sea data collection and database mgmt. | Ongoing |
| 605 | Stable Isotopes (Gao) | Completed |
| 610 | Purchase and deployment of a water column profiler | Completed |
| 613 | Density-dependent and -independent control of halibut growth/recruit. | Continuing |

### III. CONTRACTS

| Project Acct. # | Project Title | Status |
|---|---|---|
| 614 | NMFS catcher vessel logbook and sablefish data collection | Completed |
| 615 | Feasibility study for monitoring bycatch of the short-tailed albatross in the Pacific halibut fishery off Alaska | Completed |

## 1999/2000 Research-Related Publications

Note: Current and former IPHC staff members are indicated in bold type.

**Published articles**

**Chen, D. G.** In press. A fuzzy logic view on classifying stock-recruitment relationships in different environmental regimes. Ecological Modeling.

**Chen, D. G.** and J. Irvine In press. A semiparametric approach to analyze stock-recruitment relationship with environmental effects and fishery interventions. Can. J. Fish. Aquat. Sci.

**Chen, D. G.**, B. Hargreaves, D. M. Ware, and Y. Liu. 2000. A fuzzy logic model with genetic algorithms for analyzing fish stock-recruitment relationships. Can. J. Fish. Aquat. Sci., 57(9):1878-1887.

**Clark, W. G.** 1999. Effects of an erroneous natural mortality rate on a simple age-structured stock assessment. Can. J. Fish. Aquat. Sci. 56:1721-1731.

**Clark, W. G.** In press. F35% revisited after ten years. N. Am. J. Fish. Manage.

**Clark, W. G., Vienneau, B. A., Blood, C. L., and Forsberg, J. E.** 2000. A review of IPHC catch sampling for age and size composition from 1935 through 1999, including estimates for the years 1963-1990. Int. Pac. Halibut Comm. Tech. Rep. 42.

**Geerneart, T. O. and Trumble, R. J**. 2000. A study of the dynamics of a small fishing ground in British Columbia. Int. Pac. Halibut Comm. Tech. Rep. 45.

**Hare, S. R.** and Mantua, N. J. 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. Prog. Oceanogr. 47(2-4): 103-146.

**Hare, S. R.**, Minobe, S., Wooster, W. S., and McKinnell, S. 2000. An introduction to the PICES symposium on the nature and impacts of North Pacific climate regime shifts. Prog. Oceanogr. 47(2-4): 99-102.

**International Pacific Halibut Commission.** 2000. Feasibility study that investigates options for monitoring bycatch of the short-tailed albatross in the Pacific halibut fishery off Alaska. Prepared for the Nat. Marine Fish. Serv. in completion of contract reference order number 40HANF000046.

**Kaimmer, S. M.** 2000. Chalky halibut investigations, 1997 to 1999. Int. Pac. Halibut Comm. Tech. Rep. 44.

**Kaimmer, S. M.** 2000. Pacific halibut tag release programs and tag release and recovery data, 1925 through 1998. Int. Pac. Halibut Comm. Tech. Rep. 41.

Mulligan, T. J. and **Chen, D. G.** 2000. Comment on “Can stationary bottom split-beam hydro-acoustics be used to measure fish swimming speed in situ?’ by Arrhenius et al. Fish. Res.

Parker, S. J., Berkley, S. A., Golden, J. T., Gunderson, D. R., Heifetz, J., Hixon, M. A., Larson, R., **Leaman**, **B. M**., Love, M. S., Musick, J. A., O'Connell, V. M., Ralston, S., Weeks, H. J., and Yoklavich, M. M. 2000. Management of Pacific rockfish: American Fisheries Society Policy Statement. Fisheries 25(3):22-30.

**Parma, A. M.** In press. Bayesian approaches to the analysis of uncertainty in the stock assessment of Pacific halibut. *In* Incorporating uncertainty into fisheries models. *Edited by* J. M. Berkson, L. L. Kline and D. J. Orth.

Pounds, J. G., Pokorski, P. L., **Chen**, **D. G**., and Mumtaz, M. 2000. Target organ variability in the toxicity of chemical mixtures. Toxicological Sciences 49 (1S).

Riddell, B., **Chen**, **D. G.,** and Brown, G. 2000. Stock description and biologically-based escapement goals for the Harrison River fall Chinook. Canadian Stock Assessment Secretariat Research Document 99/140, pp. 122. PASARC (Pacific Scientific Advice Review Committee) working paper S00-18.

Riddell, B., Nategaal, D. A., and **Chen, D. G**. 2000. A biological-based escapement goal for Cowichan River fall Chinook salmon (*Oncorhynchus tshawytscha*). PASARC (Pacific Scientific Advice Review Committee) working paper S00-17.

**St-Pierre, G.** and **Trumble, R. J**. 2000. Diet of juvenile Pacific halibut, 1957-1961. Int. Pac. Halibut Comm. Tech. Rep. 43.

Stanley, R. D., Kieser, R., **Leaman**, **B. M**., and Cooke, K, D. 1999. Diel vertical migration by yellowtail rockfish, *Sebastes flavidus*, and its impact on acoustic biomass estimation. Fish. Bull. 97:320-331.

**Trumble, R. J.** and **Geernaert, T. O**. In press. Results of seabird avoidance experiments and observations of bycatch reported by fishermen to IPHC samplers in Alaska and Canada ports in 1998. *In* Seabird bycatch: trends, roadblocks, and solutions. *Edited by* E. F. Melvin and J. K. Parrish. Univ. AK Sea Grant.

**Trumble, R. J., Kaimmer, S. M.,** and **Williams, G. H**. In press. Estimation of discard mortality rates for Pacific halibut bycatch in groundfish longline fisheries. N. Am. J. Fish. Manage. 20:931-939.

**Articles in review**

**Blood, C. L**. In review. Age validation of Pacific halibut. Int. Pac. Halibut Comm. Tech. Rep.

**Blood, C. L**. In review. Comparison of surface and break-burn otolith methods of aging Pacific halibut. Int. Pac. Halibut Comm. Tech. Rep.

**Chen, D. G.**, Carter, E. M., and Hubert, J. J. In review. Adjusting for historical control data in quantal bioassays by an empirical Bayes approach. Submitted to the Journal of Agriculture, Biological and Environmental Statistics.

**Chen, D. G**., Xie, Y., and Mulligan, T. J. In review. Optimal partition of effort between observations of fish density and migration speed for a riverine hydro-acoustic Duration-in-beam sampling method. Submitted to Can. J. Fish. Aquat. Sci.

Hollowed, A. B., **Hare, S. R.,** and Wooster, W. S. In review. Pacific - Basin Climate Variability and Patterns of Northeast Pacific Marine Fish Production. Submitted to Progress in Oceanography.

**Kaimmer, S. M.** In review. 1998 gear and bait experiments. Int. Pac. Halibut Comm. Tech. Rep.

Lluch-Cota, D. B., Wooster, W. S., and **Hare, S. R**. In review. Sea surface temperature variability in coastal areas of the Northeastern Pacific related to El Nino-Southern Oscillation and the Pacific Decadal Oscillation. Submitted to Geophysical Research Letters.

## Section II.
## Research proposed for 2000/2001

The staff has identified 40 research projects and two contracts for 2000/2001. Many of these projects were initiated during 1999/2000 or earlier and should be completed in 2001 or in subsequent years. Others are recurring projects conducted by staff annually, e.g., the stock assessment or prior hook injury data collection.

The staff is proposing 12 projects for 2000/2001 that require funding totaling $356,500. Three projects are being carried over from 1999/2000 totaling $70,500, resulting in a total funding for new projects of $286,000. The remainder are accomplished as part of regular staff research, which are covered by staff salaries. Projects scheduled for 2000/2001 which require funding are summarized in the table on the next page. The table also shows Line Numbers and page numbers for quick reference to the detailed descriptions which follow. Project Account Numbers are provided which link back to budgetary information provided by Administration.

## Budget Summary For Projects Proposed For 2000/2001 Requiring Funding
## (Funds from Supplemental Budget)

| Project Acct # | Project Title | Proposed |
|---|---|---|
| ***New Funding*** | | |
| 410 | Chalky halibut investigations – time development of pH changes | $ 2,000 |
| 411 | PIT Tagging Study – tag selection & retention | 75,500 |
| 412 | PIT Tagging Study – field experiment | 60,000 |
| 413 | PIT Tagging Study – field detection equipment | 10,000 |
| 602 | Spatial and ontogenetic variability in the trophic status of Pacific halibut | 30,000 |
| 604 | NMFS trawl survey: at-sea data collection & IPHC data base management | 35,000 |
| 609 | Post-doctoral fellowship | 52,000 |
| 610 | Deployment of a water column profiler | 1,500 |
| 618 | Undergraduate internships | 20,000 |
| | **Sub-Total** | **$ 286,000** |
| ***Carryover from 1999/2000*** | | |
| 607 | Graduate student | 20,000 |
| 608 | Update halibut viability video used in NMFS observer training | 500 |
| 616 | Field testing of halibut excluder gear for cod trawls (Groundfish Forum) | 50,000 |
| | **Sub-Total** | **$ 70,500** |
| | **GRAND TOTAL** | **$ 356,500** |

## Other 2000/2001 Research – Contracts

| Project Acct # | Project Title | Income | Expense |
|---|---|---|---|
| 611 | Description of 1963-1999 setline charters from IPHC data base | $ 0 | $ 20,000 |
| 614 | NMFS catcher vessel logbook and sablefish data collection | 7,000 | 0 |
| | **TOTAL** | 7,000 | 20,000 |

## Summary List of Proposed 2000/2001 Research

### I. FUNDED BY APPROPRIATIONS

| Line No. | Project Title | Page |
|---|---|---|
| ***Program: Biological Research and Fisheries Management*** | | |
| A.1 | Pacific halibut aging manual | 98 |
| A.2 | Monitoring changes and discrepancies in application of aging criteria using otolith images in a computer paint program | 98 |
| A.3 | Otolith break-and-burn percentage agreement | 98 |
| A.4 | Changes in assigned ages over time due to changes in application of criteria and equipment | 99 |
| A.5 | Otolith exchange with eastern Canadian branch of DFO | 99 |
| A.6 | Otolith marginal increment analysis | 99 |
| A.7 | Incidence of crystallized otoliths from the SSA surveys | 100 |
| A.8 | Sport halibut fishery review | 100 |
| A.9 | Prior hook injury (PHI) study on setline surveys | 100 |
| A.10 | Hook-size/bait-size comparison | 101 |
| A.11 | Documentation of historical special setline experiments | 101 |
| A.12 | Analysis of 1998-1999 special setline experiments | 101 |
| A.13 | Time stratified sampling by observers for halibut viability and length | 102 |
| ***Program: Stock Assessment*** | | |
| A.14 | The 2001 stock assessment | 102 |
| A.15 | Development of a less variable harvest policy | 103 |
| A.16 | Review and analysis of historical IPHC tagging data | 103 |
| A.17 | Investigation of changes in setline survey selectivity | 103 |
| A.18 | Influence of near bottom ocean conditions on juvenile halibut growth | 104 |
| A.19 | Rescue of IPHC hydrographic data back to 1935 | 104 |
| A.20 | Density-dependent and –independent control of halibut growth and recruitment | 104 |
| A.21 | Bait and hook effects on setline catchability and selectivity | 105 |
| A.22 | Misclassification of ages | 105 |
| A.23 | Development of a Geographic Information System (GIS) | 106 |
| A.24 | Discard mortality rates and bycatch length frequency estimates | 106 |
| A.25 | Halibut bycatch mortality and length composition, 1974-2000 | 106 |
| ***Program: Fishery Statistics and Regulations*** | | |
| A.26 | The effects of changing gear in the halibut fishery following IQs | 107 |
| A.27 | Impacts of extending the commercial fishery season | 107 |
| A.28 | IPHC statistical area documentation | 107 |
| A.29 | Review of port sampling, 1994 to present | 108 |
| A.30 | Verification of the commercial catch database, 1974 to present | 108 |

**II. SUPPLEMENTAL FUNDING**



**III. CONTRACTS**

## Description Of Proposed Research Projects For 2000/2001

*Funded By Appropriations*

**Program: Biological Research and Fisheries Management**
***Program Manager: Williams***

### A.1 Pacific halibut aging manual

Status: Continuing
Cost: Staff Salaries
Start Date: 1999
Anticipated ending: 2001
Personnel: Forsberg

This will be a descriptive document, detailing procedures, materials and criteria used in determining ages of Pacific halibut. Document will be illustrated with otolith photographs and will be useful both in training new readers and as a reference for experienced readers.

### A.2 Monitoring changes and discrepancies in application of aging criteria using otolith images in a computer paint program

Status: Continuing
Cost: Staff Salaries
Start Date: 2000
Anticipated ending: 2001
Personnel: Forsberg, Kong, Blood

This study will compare between and within reader consistency in application of aging criteria. There is no permanent record of any particular age interpretation. A reader cannot replicate 100% of his or her own ages, let alone another reader's. In these cases of disagreement, whether with oneself or another reader, the reader(s) must be interpreting the growth patterns differently, and it may not be clear why, or where the discrepancy(s) occur(s). Even when two readers assign the same age to a given otolith, it cannot be assumed that they have "read" or interpreted the same marks as annuli. A series of scanned otolith photos and a computer paint program will be used. For each image, readers will mark what they are interpreting as annuli and save the marks in an overlay. Each reader would repeat the process after a period of time and the overlays would be compared within and between readers for discrepancies in application of aging criteria.

### A.3 Otolith break-and-burn percentage agreement

Status: Continuing
Cost: Staff Salaries
Start Date: 2000

Anticipated ending: 2001
Personnel: Forsberg, Kong

Repeat of Bill Clark's 1995 break and burn study. Double blind readings of broken and burnt otolith sections will be compared for percent agreement. Sample will be a subset of the 1999 survey otolith collection. Percent agreement values will be incorporated into IPHC aging quality control standards.

### A.4 Changes in assigned ages over time due to changes in application of criteria and equipment

Status: Continuing
Cost: Staff Salaries
Start Date: 1999
Anticipated ending: 2001
Personnel: Forsberg, Blood, Kong

Current readers will age a set of archived otoliths that were originally aged 20-25 years ago and current and original ages will be compared and examined for changes/shifts in the age distribution due to different aging practices. These otoliths will then be aged again using an old Bausch & Lomb microscope to test for differences in ages due to equipment.

### A.5 Otolith exchange with eastern Canadian branch of DFO

Status: Continuing
Cost: Staff salaries
Start Date: 2000
Anticipated ending: 2001
Personnel: Blood, Williams

IPHC has been involved with several otolith exchanges over the years to compare aging methods with various agencies. The Committee of Age Reading Experts (CARE) encourages age determination units to regularly exchange otoliths to gain new perspectives on age reading. Atlantic halibut otoliths were provided for IPHC age-readers in the early 1980s, but a larger scale exchange would be useful to compare the aging methods, criteria, and time of formation of annuli between Atlantic and Pacific halibut. Otolith exchange will occur in 2000/2001, but reading and analysis will not be complete until 2001.

### A.6 Otolith marginal increment analysis

Status: Continuing
Cost: Staff salaries
Start Date: 1999
Anticipated ending: 2001
Personnel: Blood, Williams

This project is being initiated to improve reliability of the age determination for Pacific halibut. Timing of annulus formation was first studied in the 1930s by Dunlop. Recent research on halibut age validation suggests Dunlop's early results were incomplete. Otoliths are being collected coast wide by IPHC surveys and domestic observers. Timing of annulus formation is critical to assigning accurate age and prevent smearing of strong year classes over weak ones. For this study, we are collaborating with observer programs in both Canada and the United States. Selected observers on board groundfish vessels will collect several halibut otoliths per month. Data collection and otolith processing will occur in 1999 and 2000. Analysis will occur in 2001. We will use the otoliths collected to observe when during the year the halibut deposit annual growth rings. We will also investigate whether the timing varies by area and sex.

### A.7 Incidence of crystallized otoliths from the 1998-99 setline surveys

Status: Continuing
Cost: Staff salaries
Start Date: 2000
Anticipated ending: 2001
Personnel: Kong, Forsberg

Crystallization of the otolith, a defect that occurs throughout the range of Pacific halibut, impairs the readability of the earbone to the point of rejection from the age reading collection. The cause of crystallization is unknown though various hypotheses have been suggested ranging from pollution effects to genetic defects. In 1998 and 1999 the incidence of crystallized otoliths was recorded during otolith collection on the stock assessment surveys. This project will examine the occurrence rate among areas and years, and with sex and age of fish.

### A.8 Sport halibut fishery review

Status: Continuing
Cost: Staff salaries
Start Date: 2000
Anticipated ending: 2002
Personnel: Blood

This report will document the changes in the sport halibut fishery since Skud's report which identified the process which recognized the sport fishery in 1973. Topics will include early attempts to estimate the catch in Alaska and British Columbia, voluntary log book program, sport fish questionnaires, Area 2A catch sharing plan, and separation of allocation from IPHC regulations. This project was postponed from 1998-1999.

### A.9 Prior hook injury (PHI) study on setline surveys

Status: Continuing
Cost: Staff Salaries
Start Date: 1996
Anticipated ending: Ongoing
Personnel: Williams

Data on the presence and severity of prior hook injuries on halibut caught on the 1999 setline surveys will be analyzed. This continues the data collection and analysis which began with the 1997 surveys. This work will continue for several years to see if the incidence of prior hooking injuries decreases, as the halibut careful release program for longline fisheries should cause fewer release injuries of bycaught halibut.

### A.10 Hook-size/bait-size comparison

Status: Continuing
Cost: Staff salaries
Start Date: 2000
Anticipated ending: 2001
Personnel: Kaimmer

This project will follow up on work conducted in 2000, which was spoiled by extremely high catch rates on the first day, necessitating fishing the remainder on very poor ground. The project compares halibut catches (CPUE) on two sizes of hook (14/0 and 16/0) with two sizes of chum bait (2.5 oz and 5 oz). This project will require two vessel charters, one in Area 3A and one in Area 2B. We learned from the 1998 special experiments that bait size affects CPUE and hook size affects size distribution. This project will give a definitive estimate of the combined effects of bait and hook size on halibut CPUE and size composition. There may not be staff time available for this in 2001, but it may piggyback on the tagging experiment.

### A.11 Documentation of historical special setline experiments

Status: Continuing
Cost: Staff salaries
Start Date: 2001
Anticipated ending: 2002
Personnel: Kaimmer

The Commission has conducted a number of special experiments – those with specific objectives separate from stock assessment surveys – over the years. We will consolidate into a single source the objectives, results, data formats, and caveats for each experiment, and evaluate the overall performance of the special experiments. The report will also summarize or give references to any written reports resulting from the experiments. This effort will include an investigation of the IPHC database, and more properly archiving some data sets which do not fit into the current IPHC data format (including camera observations, hook timer data, and mortality study information).

### A.12 Analysis of 1998-1999 special setline experiments

Status: Continuing
Cost: Staff salaries
Start Date: 1998
Anticipated ending: 2001
Personnel: Kaimmer, Williams

The first phase summarizes fishing effort and results from special setline experiments conducted during the summer of 1998. These experiments included bait size, bait type, bait quality and gear type comparisons. The report will include analyses of catches by numbers, pounds, and size of fish caught. The second phase summarizes the winter/summer experiment comparing a standard chum salmon bait to two sizes each of squid and pollock bait, and discussing the usefulness of these baits as possible alternates to the chum currently used in the grid surveys.

### A.13 Time stratified sampling by observers for halibut viability and length

Status: deferred from 1999
Cost: Staff salaries
Start Date: 1999
Anticipated ending: 2001
Personnel: Williams

The objective of this project is to collect halibut bycatch length and viability data independent of species composition sampling on trawl catcher/processors. This information will improve the accuracy of halibut viability data collected by observers. Observers will be tasked with conducting special halibut length/viability (L/V) sampling during a portion of their vessel assignment in lieu of their regular (traditional) sampling for halibut length and viability. During a special sampling period, sampling the catch from an individual haul for species composition will occur from basket samples, as has been past practice. L/V sampling of halibut bycatch will be conducted from the same hauls as the basket samples, but during specific separate time intervals, rather than at the observer's discretion. This project was postponed from 1999 because it conflicted with the Observer Program workload.

## Program: Stock Assessment

***Program Manager: Clark***

### A.14 The 2001 stock assessment

Status: New
Cost: Staff salaries
Start Date: 2000
Anticipated ending: 2001
Personnel: Clark, Hare, Chen

The annual stock assessment process comprises a large amount of work including preparation of IPHC data, estimation of bycatch by length in other fisheries, model development and validation, model fitting, examination of residuals, comparison of alternative model specifications, sensitivity tests, evaluation of harvest strategy, incidental analyses, and reporting.

## A.15 Development of a less variable harvest policy

Status: Continuing
Cost: Staff salaries
Start Date: 2001
Anticipated ending: 2002
Personnel: Hare, Clark

Staff quota recommendations are calculated by applying a judiciously chosen harvest rate to an estimate of present exploitable biomass. In principle this policy should result in relatively stable quotas, but in recent years both the target harvest rate and the biomass estimates have fluctuated substantially because of changes in assessment methods. Short-term quota recommendations have therefore gone up and down dramatically even though there has been little change in real stock size or in the staff's estimate of average long-term yield. The aim of this project is to develop a procedure for calculating quota recommendations that is based less on short-term biomass estimates and more on estimates of medium-term productivity. These quotas should be more stable over time, and it may be possible to provide at least tentative recommendations for 3-5 years into the future.

## A.16 Review and analysis of historical IPHC tagging data

Status: New
Cost: staff cost
Start Date: 2001
Anticipated ending: 2003
Personnel: Chen

The IPHC has conducted many tagging programs since the 1920s. The IPHC has also conducted at least five reviews of these programs, again with differing objectives. However, many of these reviews did not account for the issues of non-reporting or differential reporting of tags by areas, fishing effort effects on recovery probabilities, the relationship of initial tag releases and the density of fish in given areas, and the effect of seasonal migratory patterns on the analysis of recoveries were not always considered. A changed paradigm for the area-specific impacts of juvenile bycatch, questions concerning the effects of changing seasonal distribution of fishing effort, potential halibut distribution changes with climatic shifts, and the utility of juvenile surveys in specific areas have all prompted concerns about halibut movements. During 1997 and 1998 IPHC staff assembled the first complete summary of IPHC tagging programs. We propose to use this summary as a starting point to conduct a more comprehensive review of halibut migration. Candidate data sets for inclusion in revised analysis will be identified and, depending on availability of a new analyst, a new analytic framework will be developed. This project will also compile information on selectivity available from tagging programs, to assist in the evaluation of the potential tagging program in Areas 3A/B and 2B.

## A.17 Investigation of changes in setline survey selectivity

Status: Continuing
Cost: Staff salaries
Start Date: 2000

Anticipated ending: ongoing
Personnel: Clark

Trawl survey data compiled for the 2000 assessment indicate a decline in the setline selectivity of 60-90 cm halibut in Area 3A in the 1990s. If the full assessment tends to confirm that, the evidence and findings will be written up and published.

## A.18 Influence of near-bottom ocean conditions on juvenile halibut growth

Status: Nearly Completed
Cost: Staff salaries
Start Date: 2000
Anticipated ending: 2001
Personnel: Hare, Blood, Hagen, Quinn

In year 2000, dual readings were made of growth increments on 700 otoliths as part of a study to better understand the factors controlling early ocean growth rates of halibut and several other species of flatfish from the north Pacific. This work extends, with an additional 12 years of data, a line of research begun by Hagen and Quinn, and includes them as co-analysts. Initial analyses of these data have been undertaken and it is anticipated that a journal paper will be produced during 2001. The data collected as part of the ocean bottom properties database is critical to this study.

## A.19 Rescue of IPHC hydrographic data back to 1935

Status: Nearly Completed
Cost: Staff salaries
Start Date: 2000
Anticipated ending: 2001
Personnel: Hare

Historical IPHC hydrographic data have been conveyed to NOAA/PMEL where it is currently undergoing transcription and analysis. NOAA has provided funding for a qualified oceanographer to assist in the rescue, quality control and cataloging of these data as part of a broader data rescue effort. It is anticipated that the data rescue will be completed and the data incorporated into federal databases by mid-year.

## A.20 Density-dependent and independent control of halibut growth and recruitment

Status: Continuing
Cost: Staff salary, some travel
Start Date: 1998
Anticipated ending: ongoing
Personnel: Hare, Clark

The specific mechanisms driving the observed interdecadal trends in halibut growth and recruitment remain largely unexplained though more specific hypotheses have been developed in the past two years. Work towards better understanding whether density dependent (intra- or inter-specific) or density independent factors are responsible continues and remains the core research focus of the fisheries oceanography project. Progress in this area will require examination of all potential influences and collaborative research. Several recent collaborations have helped shape the regime shift hypothesis and demonstrated that many components of the north Pacific marine ecosystems respond synchronously to these shifts. A recent analysis of groundfish, salmonid and pelagic recruitment time series, however, show that there are distinct differences among groups of species. There are several ongoing investigations that will continue through the next year, including: how have oceanographic conditions on the continental shelf differed from surface conditions; has there been a regime shift since the 1976/77 event; is halibut growth affected by the density of other flatfish populations; are there basin-wide patterns in zooplankton population variability. In keeping with the NOAA movement towards ecosystem considerations in fisheries management, we will attempt to derive a framework whereby the results of fisheries oceanography investigations can provide useful input for management purposes, such as determining safe harvest levels or forecasting near-term recruitment. Part of this project includes maintenance of the near bottom "Ocean Bottom Properties" database, first assembled in 1997 (and described in the 1997 RARA) and maintained and updated as additional data become available. This database has proven to be extremely useful to researchers around the north Pacific.

## A.21 Bait and hook effects on setline catchability and selectivity

Status: Continuing
Cost: Staff salaries
Start Date: 2000
Anticipated ending: 2001
Personnel: Kaimmer, Chen

A number of recent experiments comparing different baits and hooks (including the 2000 survey bait comparison) will be described and analyzed in an IPHC Scientific Report.

## A.22 Misclassification of ages

Status: New
Cost: Staff salaries
Start Date: 2000
Anticipated ending: 2001
Personnel: Chen, Forsberg

Halibut age readings (either surface or break-and-burn) are somewhat variable, and using them at face value misrepresents the age composition of the landings. In particular, it leads to underestimates of the strength of large year-classes. The error can be corrected by estimating a misclassification matrix and incorporating it into the assessment model. We have assembled datasets of independent readings by both methods for this purpose, but the analysis has not been done.

## A.23 Geographic Information System

Status: Continuing
Cost: staff salaries
Start Date: 2000
Anticipated ending: Ongoing
Personnel: Leickly, Gilroy, Kong

Geographical information systems (GIS) have been successfully used elsewhere in the analysis of fishery stock distributions, satellite imagery, demographics, and physical phenomenon such as depth and temperature. This project will develop a GIS system which will link habitat information with IPHC database records and develop a dynamic system for assessing habitat that can be compared with historical habitat measures previously developed using pencil and paper plotting techniques. Currently logbook location data are coded in an IPHC statistical area by hand, for example latitude and longitude are plotted on the chart and the statistical area is determined. When this project is completed, IPHC statistical areas would be computer generated from the latitude/longitude location entered into the database. The definitions necessary for this project were completed in 1999 (statistical area documentation).

## A.24 Discard mortality rates and bycatch length frequency estimates

Status: Continuing
Cost: Staff salaries
Start Date: 1991
Anticipated ending: ongoing
Personnel: Chen, Williams, Hare

The IPHC staff assembles halibut bycatch data from the NMFS observer program and calculates discard mortality rates by gear, area, and target fishery for the groundfish fisheries in Alaskan waters. NMFS applies these values to total halibut bycatch to calculate total halibut bycatch mortality. DFO supplies this information for Canadian groundfish fisheries, and IPHC staff reviews the information. Estimates of the size composition of the bycatch mortality are also estimated from the collected data. Bycatch estimates are now routinely input to the annual stock assessment. The IPHC has long emphasized methods of reducing bycatch, and the staff works with the NPFMC process to assist with information and evaluation of potential programs such as VBA. Staff members train and debrief observers from the Alaskan fisheries, and work with the Observer Program to improve halibut bycatch sampling procedures. This year, the duty of computing bycatch mortality rates will be transferred to the new biometrician.

## A.25 Halibut bycatch mortality and length composition, 1974-2000

Status: Nearly Completed
Cost: Staff salaries
Start Date: 1999
Anticipated ending: 2001
Personnel: Hare, Williams

This report will document the changes in procedures used to tabulate estimates of bycatch discard mortality as well as to compile the bycatch mortality length compositions used in the annual stock assessment. The last IPHC Technical Report on bycatch estimates was produced over 10 years ago, thus this report will provide a timely update of the official IPHC bycatch estimates for the past 25 years.

**Program: Fishery Statistics and Regulations**
***Program Manager: Gilroy***

### A.26 The effects of changing gear in the halibut fishery following IQs

Status: New
Cost: Staff salaries
Start Date: 2001
Anticipated ending: 2002
Personnel: Leaman, Gilroy

Many more vessels now fish for combinations of sablefish and halibut, and to a much lesser extent, Pacific cod and rockfish. This has resulted in associated changes in the type and quantity of gear used in harvesting halibut, particularly as it concerns hook size and spacing. The second major issue is the distribution and timing of fishing effort within the 8-month season. These issues have been previously examined for the Area 2B fishery after Canada implemented IVQs, but it is time to examine the impact of these changes on data obtained from the fishery off Alaska and used in the stock assessment. Associated with this is the issue of having skippers identify the target species for each set when interviewed by our port samplers.

### A.27 Impacts of extending the commercial fishery season

Status: Initial report - completed
New report – ongoing
Cost: Staff Salaries
Start Date: 1999
Anticipated ending: 2001
Personnel: Leaman, Gilroy, Sadorus, Clark, other agency and industry personnel

The initial report was presented to the Commissioners and industry at the 2000 Annual Meeting. The Commission staff was asked to continue to review the possibilities of an extended fishing season. The Conference Board acknowledged that the interception of migrating fish during winter fishing is a serious concern to the staff but requested that further measures be reviewed to allow partial winter fishing. Report to be provided at the 2002 Annual Meeting.

### A.28 IPHC statistical area documentation

Status: continuing
Cost: Staff salaries
Start Date: 1999

Anticipated ending: 2001
Personnel: Kong, Gilroy, Wade

The project is to document the baseline and finer resolution IPHC statistical areas, especially from the inside areas of British Columbia and SE Alaska. The finer resolution statistical areas are now being used to provide more detailed commercial catch data to the industry. The definitions are needed to accompany the data. Defined polygons and lines for the statistical areas can be used in the Geographic Information Systems database.

Part 1: Document the finer resolution and baseline statistical areas and the changes that have occurred to the definitions through the years.

Part 2: (Completed). Polygons for each statistical area have been defined by latitude and longitude. This project was the first stage of the long-term implementation of geo-referenced data for analysis by many IPHC programs.

### A.29 Review of port sampling, 1994 to present

Status: continuing
Cost: staff salaries
Start Date: 2001
Anticipated ending: 2001
Personnel: Wade

Report on the changes that have occurred in the commercial catch sampling and port sampling program from 1994 to the present. For example, the report will review the changes made to the program due to the implementation of the IFQ fishery in Alaska, the changes in the method of logbook data collection in the U.S., as well as changes in the Canadian program. This is an update of Technical Report 32.

### A.30 Verification of the commercial catch database, 1974 to present

Status: continuing
Cost: staff salaries
Start Date: 1999
Anticipated ending: Ongoing
Personnel: Gilroy, Geernaert, Taheri

The project is to make available for stock assessment records of the commercial landing and fishing logbook data in an on-line log-dealer relational database system and to update commercial-catch databases (and all databases) with current and historical statistical areas. The project includes summarizing data and providing tables of commercial catch by year, fishing period, regulatory area, detailed statistical area, and landing port in a report and on the IPHC homepage. In 2000, several earlier years' data were validated and more recent data were reviewed relative to statistical areas and log records. Completed data includes the years from 1978 to present.

## *Funded By Supplemental Budget*

**Program: Biological Research and Fisheries Management**
***Program Manager: Williams***

### S.1 Chalky halibut investigations – time development of pH changes

Project Account No.: 410
Status: New
Cost: $ 2,000
Start Date: 2001
Anticipated ending: 2001
Personnel: Kaimmer, Leaman, Williams

The staff has investigated the causes of chalkiness in halibut for the past two years, discovering that a change in the pH of the tissue is indicative of the onset of chalk. In 2001, the staff proposes to further examine the development of the pH change over time by using commercial pH meters on a setline survey cruise in the late summer. The funds for this project will go towards the purchase of the meters and fish lost to sampling.

### S.2 PIT Tagging study: 2001 field trials

Project Account No.: 411-413
Status: New
Cost: $145,500
Start Date: 2001
Anticipated ending: 2001
Personnel: Geernaert, Kaimmer, Chen, Leaman

The staff will be undertaking a large-scale marking experiment using PIT (passively induced transponder) tags in 2002. We will undertake pilot work in 2001 to evaluate the appropriate tag shape and insertion point, conduct tests of tagging mortality and tag retention, and the configuration of detection equipment in the fish plants. We will also conduct one tagging charter to establish baseline tagging capability and rates, and use one of the survey vessel trips to insert tags on landed fish and evaluate detection capability under normal offloading conditions.

### S.3 Graduate student

Project Account No.: 607
Status: Carryover from 1999/2000
Cost: $20,000
Start Date: 2001
Anticipated ending: 2001
Personnel: Leaman, Clark

We propose to hire a graduate student (Master's degree candidate) in FY 2000/2001 to assist staff in project analyses. The specific assignment will be determined based on staff needs.

### S.4 Update Halibut Viability Video Used in NMFS Observer Training

Project Account No.: 608
Status: Carryover from 1999/2000
Cost: $500
Start Date: 2001
Anticipated ending: 2001
Personnel: Williams, Kaimmer

A training video was prepared several years ago by IPHC staff with the purpose of improving consistency in observer determination of viability of halibut bycatch on longlines. Changes in viability categories which will be implemented in 2000 render the video ineffective as a training tool. Staff will revise the audio portion of the tape, and add additional video footage taken on trawlers to expand the usefulness of the tape.

### S.5 Post-doctoral fellowship

Project Account No.: 609
Status: New
Cost: $52,000
Start Date: 2001
Anticipated ending: 2002
Personnel: Leaman, Clark

The Commission has lost several senior staff in recent years. While recruitment of replacements is underway, the loss of these staff highlights the lack of breadth in the Commission's analytic capacity. Historically, the Commission has been able to supplement its in-house expertise by funding graduate students working on halibut projects. This approach serves the dual purpose of acquiring relatively inexpensive expertise as well as providing stimulation and challenge to existing staff. We propose to fund a two-year post-doctoral fellowship leading to permanent employment beginning in FY 2000/2001. The subject matter of the fellowship will be negotiated with prospective candidates, but will involve elements from a suite of projects proposed by the staff.

### S.6 Field testing of halibut excluder gear for cod trawls

Project Account No.: 616
Status: Carryover from 1999/2000
Cost: $50,000
Start Date: 2001
Anticipated ending: 2001
Personnel: Williams, Gauvin (Groundfish Forum), Rose (NMFS)

The Alaskan trawl industry has been experimenting with new designs for devices that would exclude halibut in bottom trawls for the past few years. The design tested in late 2000 under experimental conditions produced results of a 20% decrease in the catch of Pacific cod for a 70-80% drop in halibut bycatch. The trawl industry group Groundfish Forum needs to test the design under fishery conditions to demonstrate the effectiveness, and has requested funding from IPHC for their 2001 project from IPHC.

### S.7 Undergraduate internships

Project Account No.: 618
Status: New
Cost: $20,000 for two interns, staff support
Start Date: 2001
Anticipated duration: May-August
Personnel: Leaman, Sadorus, survey manager, Van Wormer

Two undergraduates will be selected through the co-op programs at University of Victoria, University of Washington, or Simon Fraser University to do a combination of office and at-sea work during the summer months. The program will include various pre-determined office projects, planning of a research project with staff support, execution of the project while deployed on the setline survey, and a final report by the end of the employment term.

**Program: Stock Assessment**
***Program Manager: Clark***

### S.8 Spatial and ontogenetic variability in the trophic status of Pacific halibut

Project Account No.: 602
Status: Ongoing
Cost: $30,000, staff salaries, and sample collection during assessment survey
Start Date: 1999
Anticipated ending: ongoing
Personnel: Hare, Kline

This project will attempt to define spatial and ontogenetic variability in the trophic status of Pacific halibut using natural stable isotope abundance of carbon and nitrogen which is hypothesized to vary over its distribution in the northeast Pacific. Natural stable isotope abundance is a useful research tool for fish ecology because of the predictable relationships of isotope signatures among food web constituents and isotopic gradients existing in the study area. Increase in trophic level is hypothesized to explain the large decrease in growth rate exhibited by halibut since the 1976-1977 regime shift that also affected many species in the region. Ontogenetic shifts in isotope signature are expected to indicate a shift to feeding offshore as adults. This will provide a linkage to the regime shift because changes in zooplankton abundance have been noted offshore near the continental shelf break. Showing a relationship to this carbon source through isotope matching will provide the first line of evidence for a mechanism for explaining changing halibut growth patterns.

A second set of flesh samples were obtained and freeze dried during the IPHC 2000 survey. The first of the 1999 samples were processed and initial results are encouraging. Significant difference in trophic level were found by region (Areas 2B and 3A), sex and age. Due to the high cost and long turnaround time of extracting isotope ratios, the number of processed samples was relatively small. In 2001, we will collect a third year of samples and begin analysis of the year 2000 samples. We anticipate at least one journal paper will arise from this project during this year with more to follow as this project reaches fruition. This project is especially timely as a sudden shift in the forage fish community of the Gulf of Alaska appears to have begun in 1999, with large numbers of eulachon appearing for the first time since the late 1970s.

### S.9 NMFS trawl survey: at-sea data collection and data base management

Project Account No.: 604
Status: ongoing
Cost: Staff salaries for database work, $30,000 for at-sea otolith collection
Start Date: 1996
Anticipated ending: ongoing
Personnel: Sadorus, Ranta, Clark

A series of NMFS trawl survey data on halibut, parallel to our setline data, would be extremely valuable to IPHC as a second fishery-independent data source for stock assessment. Trawl data are particularly useful because they include large numbers of juveniles (ages 3-7) that do not appear in large numbers in the setline survey. Since 1996 IPHC staff have collected otoliths on the triennial surveys and on the Bering Sea annual survey since 1998. The halibut age data are incorporated into a copy of the NMFS haul data, expanded to estimates of relative abundance and age/size composition by IPHC area (NMFS calculates estimates by INPFC area), and stored in a database at IPHC. The task in this project is to add recent data. Summer 2001 includes the Gulf of Alaska and Bering Sea shelf surveys.

### S.10 Deployment of a water column profiler

Project Account No.: 610
Status: Ongoing
Cost: Staff salaries, $1,500 for service and additional equipment
Start Date: 2000
Anticipated ending: Ongoing
Personnel: Hare

The IPHC maintains one of the most extensive sampling platforms in the north Pacific. This platform offers enormous potential for collection of valuable oceanographic data. In particular, understanding the dynamics of the structure of the mixed layer depth – a major GLOBEC goal - requires *in situ* vertical profiling. Use of this platform for oceanographic data collection capabilities not only would benefit the scientific community at large, but demonstration of sampling feasibility may also create other funding opportunities for collaborative research.

In 2000, the IPHC purchased and successfully deployed a SeaBird SBE-19 water column profiler. A total of 110 profiles were collected (out of a possible 120) aboard the F/V *Bold Pursuit*. In the long term, the IPHC would like to expand this form of data collection to a larger part of the survey effort. Before doing so, however, we plan on testing the profiler under somewhat more adverse conditions in 2001 as well as modify the design slightly in response to the results obtained in 2000. If deployment of a water profiler continues to prove feasible, we anticipate obtaining external funding to purchase additional profilers in the future and making their use an integral part of the assessment survey, much like the present collection of bottom temperatures.

## *Contract Projects*

### C.1 Description of 1963-1999 setline charters from IPHC database

Project Account No.: 611
Status: New
Cost: $20,000
Start Date: 2001
Anticipated ending: 2001
Personnel: Clark, Randolph

The project describes all IPHC setline charters that are represented in the setline database. The information will be ordered by year and vessel for easy reference and published in the IPHC report series. For each charter, and to the extent that the information can be located, the report will include: (1) purpose of the charter; i.e., general nature of the project and survey objectives; (2) how fishing locations were chosen; (3) gear, bait, and fishing procedures; (4) number of stations fished and skates hauled; and (5) catch sampling and data recording protocol. The information will be obtained from records and reports of the Commission and personal interviews, and will attempt to check the information by examining the data actually present in the database. The report will include an annotated list of the documents from which the information came, and those documents will be turned over to the Commission to preserve as an archive.

### C.2 NMFS catcher vessel logbook and sablefish data collection

Project Account No.: 614
Status: Ongoing
Revenue: $7,000
Start Date: 1998
Anticipated ending: 2003
Personnel: Wade, port samplers

IPHC and NMFS have a joint IFQ catcher vessel logbook program for vessels 60 ft and greater. NMFS contracted IPHC staff to interview the IFQ fishers to review and collect the sablefish information in addition to the halibut information. Copies of the log sheets are sent to the NMFS scientists at the lab in Auke Bay, Alaska.