

Pacific Halibut Bycatch in IPHC Area 2A in the 2003 Groundfish Trawl Fishery

John Wallace
Jim Hastie

NOAA Fisheries
Northwest Fisheries Science Center
Seattle, WA

August 2004

ABSTRACT

This report updates the estimate of Pacific halibut bycatch and mortality in the bottom trawl fishery through the calendar year 2003. The estimate of halibut bycatch and mortality in the bottom trawl fishery is based upon the method developed in the report for 1999 (Wallace, 2000). The current report uses halibut bycatch rates observed from 01 September 2002 thru 31 August 2003 by the West Coast Groundfish Observer Program. These rates are stratified by season, depth, latitude, and amount of arrowtooth flounder catch, then multiplied by the amount of trawl effort in each stratum determined from Oregon and Washington trawl logbooks in 2003. Estimated halibut bycatch and mortality in other gear types has not been updated for 2003. The estimate for the 2003 bottom trawl fishery is 462,000 lbs net weight of total halibut bycatch mortality, of which 367,000 lbs is legal-sized. The net weight is 9.8 percent lower than in 2002. As in past reports, forecast of bycatch for the current year (2004) or future years is not attempted.

GROUND FISH FISHERY BACKGROUND

Changes in the groundfish fishery and its management affect not only the amount of groundfish fishing effort, but also its geographic and temporal distribution. Since halibut bycatch rates vary among time and area strata, changes in the amount and distribution of effort will alter the amount of halibut bycatch that is estimated for the trawl fleet. Here we briefly describe the management changes that occurred in 2003.

In 2003, for the first time, the trawl fishery was managed using closed Rockfish Conservation Areas (RCA) throughout the entire year. North of 40°10' N. Lat., the closed area during the first 4 months was demarcated by lines approximating the 100 fm and 250 fm depth contours. In January 2003, new NMFS observer data from the trawl fleet were published. These data indicated higher rates of bycatch for some shelf rockfish species than had previously been assumed. As a result, the RCA was expanded shoreward from May through December in order to reduce bycatch impacts. The shoreward boundary was 50 fm in May-June and September-October, and 75 fm in July-August. The seaward boundary was set at 200 fm throughout May-December. Unexpectedly high catches of canary rockfish and lingcod reported by the Marine Recreational Fisheries Statistical Survey (MRFSS) in the California recreational fishery led to a coast-wide closure of groundfish trawling inside 200 fm during November and December. Special areas for winter petrale fishing were designated outside of 150 fm during the first and last 2-month periods of the year. The use of small footrope gear (rollers of 8" or less) was required for all fishing shoreward of the RCA. Also, from May through October, reduced 2-month limits were implemented for flatfish, thornyheads, and sablefish when small footrope gear was used at any time during the period. This differential limit was implemented in order to reduce effort on the shelf, and in turn the bycatch of several rebuilding species.

In accordance with the rebuilding mandate for widow rockfish, no mid-water fishing for widow or yellowtail rockfish was allowed in 2003, except through a short-lived yellowtail Exempted Fishing Permit (EFP) program operated by the state of Washington. As a result of changes in the ability to target these species with large footrope or mid-water gear, widow landings in 2003 were lower than 2002 by an order of magnitude, and were two orders of magnitude less than in 2001. Yellowtail landings in 2003 were less than 20 percent of the 2002 amount, and less than 10 percent of the amount landed in 2001.

Two other trawl EFPs operated throughout much of the year off Oregon and Washington. Both of these EFPs required the use of trawl gear containing modifications intended to more selectively retain flatfish. Participation in the EFPs provided fishers with access to some fishing grounds located within the RCA. Washington's EFP also provided higher trip limits for arrowtooth flounder. The reduction in the bycatch rates of most shelf rockfish species was dramatic enough that the Council voted in June 2004 to require use of selective flatfish gear shoreward of the RCA and north of 40°10' N. Lat. beginning in January 2005. Landings of arrowtooth and petrale each increased by at least 10 percent from 2002 to 2003, however, arrowtooth landings remained somewhat less than in 2001. The increases in landings of these flatfish were offset, somewhat, by reductions in the landings of nearer-shore flatfish, such as English sole and sanddabs. Landings of the deeper-water species sablefish and grenadiers were both up by more than 50 percent from 2002, while Dover sole was nearly 30 percent higher.

HISTORICAL BYCATCH ESTIMATES

Bottom Trawl Fishery for Groundfish

Estimated bycatch and mortality of halibut in 1987, 1992, and 1995 are summarized in Table 1. As described by Williams, et al. (1998), these halibut bycatch and mortality estimates were based upon catch rates observed during a voluntary fisheries observer program conducted during the late 1980s.

Approximately 1,062 tows by bottom trawl fisheries off Oregon and Washington were observed during

1985-1987. An additional 65 tows were observed off California during 1988-1990. Catch rates were stratified by fishing strategy, depth, season, and area as described by Pikitch, et al. (1998).

Analysis of Enhanced Data Collection Program

From November 1995 through December 1998, observers quantified halibut catches on the west coast bottom trawl fisheries during the Enhanced Data Collection Program (EDCP). In addition, skippers participating in the EDCP filled out enhanced logbooks on which aggregate halibut catch information was recorded. During the program, when no observer was onboard, skippers continued to fill out the enhanced logbooks.

In the 1,825 EDCP tows from both Washington and Oregon, an estimated 11,434 halibut were caught. However, using only observed EDCP tows with complete strata information, 4,816 halibut were measured by observers. Wallace (2000) used similar methods to those in Pikitch (1998) to analyze the EDCP data and identify appropriate strata for bycatch estimation. These strata are season (Jan-Aug and Sept-Dec), depth (0-100, 100-300, 300-700 fm), area (five latitude ranges) and catch of arrowtooth flounder (0-20 lbs per hour and >20 lbs). These methods and preliminary results were reviewed and approved by the Pacific Fishery Management Council's Scientific and Statistical Committee during the June and September 2000 meetings.

Shrimp Trawl

Halibut bycatch in shrimp trawls in 1987, 1992, and 1995 was reported by Williams, et al (1998) and are presented in Table 4. For 1998, Bob Hannah (ODFW, personal communication) produced estimates of halibut bycatch in Oregon shrimp trawls for PSMFC Areas 2B-3C (Table 5). He used three data sources: 1) bycatch rates observed during 128 tows by Pikitch, et al., during 1985-87; 2) control net catch rates from 166 tows observed by Hannah, et al.; and 3) data compiled from shrimp fishing trips observed during 1996-99 by the EDCP, combined with control net catches from ODFW research charters during the same time period (for a total of 203 observed tows). The approximate number of tows in the 1998 Oregon shrimp fishery was over 10,000. The halibut bycatch estimates for this fishery are based on expanding the encounter rates (pounds of halibut per single-rig equivalent hour (sreh)) by the effort expended by vessels landing shrimp in Oregon ports only. The estimates are not stratified by depth because the depth range of the shrimp fishery is very restricted and the amount of data is very limited. The percent legal-sized (62 percent) and the percent survival (50 percent) was assumed to be the same as in the bottom trawl fishery. Given the range of estimates and the data limitations, Hannah estimates that the 1998 bycatch mortality of legal-sized halibut from Oregon is about 16,000 lbs, net weight and about 25,000 lbs. round weight. Halibut bycatch from vessels landing shrimp into Washington and California ports is not included.

Analysis of data collected during first year of the West Coast Groundfish Observer Program (WCGOP)

The WCGOP began collecting at-sea trawl discard data in September of 2001. Data collected through August 2002 were checked and evaluated in the winter of 2002. A report of findings from the first year of observation was published at the NMFS Northwest Fisheries Science Center website in January 2003. Estimates of halibut bycatch in the 2002 trawl fishery were developed in the summer of 2003 using observer data from the first year of collection. Because observer data from the last four months of 2002 were not yet available, halibut bycatch during that period was estimated using data collected during the last four months of 2001.

A total of 2,812 observed bottom trawl tows off Washington and Oregon were included in the estimation of 2002 halibut bycatch. Methods similar to those in Pikitch (1998) were used to analyze the observer data and identify appropriate strata for bycatch estimation. The strata used to estimate 2002 halibut bycatch were: season (Jan-Aug and Sept-Dec), depth (0-100, 100-300, 300-700 fm), area (four latitude ranges) and catch of arrowtooth flounder (0-20 lbs per hour and >20 lbs). The correlation between

arrowtooth and halibut witnessed in the observer data was also confirmed by an examination of bottom trawl survey data. Bycatch rates for these strata were, in turn, applied to trawl effort summarized from logbooks, and the resulting bycatch amounts expanded to account for landings not captured in logbooks. The total estimated halibut mortality for 2002 was 512,000 net pounds, which was a 36 percent reduction from the estimate for 2001.

BYCATCH ESTIMATES FOR 2003

Analysis of data from the West Coast Groundfish Observer Program's second year

The second year of data released by the West Coast Groundfish Observer Program (WCGOP) includes observations from 01 September 2002 through 31 August 2003. Because of the current unavailability of observer data from the last four months of 2003, the September-December 2002 data were included to form a 12-month bycatch data set. There were 2,770 bottom trawl tows between 48.667 and 40.667 degrees latitude (all of Washington to just north of the Oregon-California border) used for this study. An estimated total weight of 163,363 lbs of halibut was caught in those tows. The vast majority of these weights are 'actual weights' from the entire catch, i.e. not estimated or extrapolated. The number of halibut in a tow was also recorded, but those data were not used in this report. In the observer program, lengths are taken when halibut are selected as 'biological samples'. For the data used in this report, on a tow basis, halibut were selected to be a biological sample 41 percent of the time when Pacific halibut were caught in the tow. Halibut have a lower priority for biological sampling than groundfish species that have been declared overfished. Additionally, crews attempt to return halibut to the ocean as quickly as possible, in order to promote survival of the discards. As a consequence, it can be difficult for observers to obtain length measurements for all discarded halibut.

The WCGOP observed all the 2003 Oregon Flatfish Trawl EFP trips; hence the halibut discard observed during this program is a census. However, WCGOP data from September-October 2003 has not yet been released (the EFP did not operate after October). Consequently, EFP bycatch for these two months was extrapolated using the mean rate (sum of halibut weight over sum of hours) from the available EFP data and the PacFIN logbook effort (hours) from the Oregon EFP trips during those months. The total Oregon EFP bycatch (Table 6) is the sum of the September-October extrapolations and the halibut discard observed during the remainder of 2003.

For the remainder of Limited-Entry groundfish trawl activity, including the Washington Arrowtooth EFP (which was not fully observed), methods similar to those in Pikitch (1998) were used to analyze the observer data and identify appropriate strata for bycatch estimation. These strata are season (Jan-Aug and Sept-Dec), depth (0-75, 75-150, 150-250, 250-700 fm), area (four latitude ranges) and catch of arrowtooth flounder (0-20 lbs per hour and >20 lbs). Depth strata were adjusted from previous years, so as to better align with management boundaries for the RCA. Numbers of tows, halibut catches, halibut catch rates, and the proportions of legal-sized halibut (>81 cm) are listed for each of these strata in Table 3.

Bottom Trawl Effort from Logbooks

Logbook data for Oregon and Washington in 2003 were obtained from PacFIN. Since ODFW collects logbook data for only 70-80 percent of the trawl deliveries during a typical year, Oregon logbook effort (hours towed) was expanded with fish tickets by port and month, in order to avoid any potential bias created by unequal collection of logbooks in the three major ports (Astoria, Newport, and Coos Bay). WDFW's "extrapolated and expanded" trawl effort was used for Washington trips.

Total trawl effort (hours) for the entire Oregon fleet was based on expanding the groundfish catch in logbook data by the total groundfish catch reported on fish tickets, as follows. Expansion ratios, by port and month, were derived by dividing aggregate catch on fish tickets by aggregate catch in the logbook

data. These expansion ratios were applied to the tow effort (hours) to arrive at the expanded effort for Oregon's trawl fleet. The expanded effort was then combined into the strata based on the observer data analysis. A similar effort expansion was not conducted for the Washington fleet because WDFW expands their effort, so total fleet effort is equal to reported logbook effort. The total fleet effort for each stratum in 2003 is reported in Table 3.

Halibut bycatch for each stratum was estimated by multiplying total (expanded) effort by the halibut bycatch rate for that stratum. Bycatch by the bottom trawl fleet is estimated by summing across strata. If there was effort within a strata, but no observer tows, the coast wide average bycatch rate was used: 15.083 kg per hour for weight. This value is calculated as the unweighted average of the stratum means.

As in earlier years, half of the released halibut are assumed to survive capture (Gregg Williams, IPHC, personal communication). Therefore, bycatch mortality of halibut is assumed to be 50 percent of total bycatch. The proportion of legal-sized halibut (> 81cm) is estimated from the length frequencies of halibut measured in the observer data (Table 2). The Limited Entry program and the Washington Arrowtooth EFP measurements of fish lengths were converted to fish weight based on a length-weight relationship for Pacific halibut (IPHC, personal communication), and the proportion of legal-sized fish (by weight) was computed for each stratum (Table 3). Average proportion legal (calculated as the unweighted average of the stratum means) was used when no other estimate was available: 67.20 percent by weight. A more sophisticated approach of imputing the missing data shows that the unweighted average is more appropriate than weighting either by effort or weight. This compares favorably with an average proportion legal of 74.44 percent and weighted logbook estimate of 67 percent that were found in the EDCP data. A value of 62 percent was estimated in early studies (Williams et al., 1998) and used for 1977-1997. Since all tows that were part of the Oregon Flatfish EFP were observed, the proportion of legal-sized fish for that group was calculated separately. Within that EFP 40.7 percent of the halibut caught were of legal size.

For comparison purposes, the 2003 column totals from Table 6 are shown together with annual totals since 1998 in Table 7. Estimated mortality of all and legal-sized halibut since 1977 are listed in Tables 8 and 9, respectively. Total discard mortality of halibut during 2003 is estimated to be 9.8 percent lower than in 2002, even though the trawl effort increased by 10.6 percent. The decrease in halibut bycatch is principally due to the movement of trawl effort to deeper water where halibut bycatch is lower. However, the total amount and percentage of discard comprised by legal-sized fish increased dramatically in 2003. Nearly 70 percent of the estimated discard of legal-sized fish occurred in just three of the 64 strata used in the analysis. All three strata were for the January-August time period, the area between 47.67° and 48.67° N. lat., and depths shallower than 150 fm.

It is not possible to make a forecast for the 2004 fishery given lack of a methodology to project the distribution of effort among model strata prior to the complete availability of a year's logbook data.

REFERENCES

- Pikitch, E.K., Wallace, J.R., Babcock, E.A., Erickson, D.L., Saelens, M., and Oddsson, G. (1998) Pacific halibut bycatch in the Washington, Oregon, and California groundfish and shrimp trawl fisheries. *North American Journal of Fisheries Management*. Volume 18, pp. 569-586.
- Wallace, J.R. (2000) Unpublished report. Pacific halibut discard in the EDCP Observer Program. June 2000. 18 pg.
- Williams, G. H., G. Stauffer, H. Weeks, M. Saelens, J. Scordino, D. Bodenmiller, and T. Northup (1998). Pacific halibut bycatch in Area 2A: Bycatch rates and current estimates of bycatch mortality. *Int. Pac. Halibut Comm. Rep. of Assess. and Res. Activ.* 1998: 269-282.

Table 1. Halibut bycatch and mortality in the bottom trawl fisheries for groundfish off the west coast, estimated from Pikitch et al., (1998) and reported by Williams et al., (1998).

Year	Trawl Effort (hours)	Estimated Halibut Bycatch (numbers)	Estimated Halibut Bycatch (kg., round)	Estimated Halibut Bycatch (lbs, net)	Estimated Total Halibut Mortality (lbs, net)	Estimated Legal-Sized Halibut Mortality (lbs, net)
1987	135,075	78,765	372,911	616,702	308,351	191,178
1992	182,155	89,756	465,595	769,979	384,989	238,693
1995	72,295	113,702	663,262	1,096,870	548,435	340,030

Note: For 1995, bycatch estimates for Areas 1B-2A off California are not included. Mortality estimated at 50% of bycatch. Legal-sized mortality (>81 cm) estimated at 62%, by weight, of total mortality. 1 kg, round = 1.65375 lbs, net weight.

Table 2. Length frequency for Pacific halibut from the West Coast Groundfish Observer Program data. (The upper limits on the length intervals are inclusive, the lower limits are not.)

Length Interval (cm)	Length Freq.	Percent Length Freq.
25-30	1	0.04
30-35	1	0.04
35-40	2	0.07
40-45	2	0.07
45-50	6	0.22
50-55	10	0.37
55-60	50	1.84
60-65	183	6.75
65-70	395	14.56
70-75	511	18.84
75-80	444	16.37
80-85	356	13.13
85-90	241	8.89
90-95	155	5.72
95-100	117	4.31
100-105	68	2.51
105-110	61	2.25
110-115	34	1.25
115-120	16	0.59
120-125	17	0.63
125-130	19	0.70
130-135	9	0.33
135-140	5	0.18
140-145	5	0.18
145-150	1	0.04
150-155	1	0.04
155-160	0	0.00
160-165	1	0.04
165-170	0	0.00
170-175	0	0.00
175-180	0	0.00
180-185	1	0.04
Total	2712	100.00

Table 3. Numbers of tows, halibut catches, halibut catch rates and effort, by strata, observed in the bottom trawl fishery by the West Coast Groundfish Observer Program. The last two columns, from 2002, are for comparison purposes. (The upper limits are inclusive for all intervals; the lower limits are not.)

SEASON: JANUARY - AUGUST

Arrowtooth Catch (lbs/h)	Latitude	Depth (Fathoms)	Number of Observed Tows	Number of Tows with ≥ 1 Halibut	Wgt. (kg., rnd) Halibut per Hour	Trawl Effort (hours) from OR & WA	Proportion Legal by Weight	Number of Observed Tows 2002	Wgt. (kg., rnd) Halibut per Hour 2002
≤ 20	40.667 - 42.667	0 - 75	6	0	0.00	69		137	2.64
		75 - 150	1	1	12.48	6		39	5.28
		150 - 250	6	0	0.00	289		45	0.62
		250 - 700	109	1	0.05	4097	0.230	190	0.02
42.667 - 46.667		0 - 75	154	50	4.83	2528	0.756	447	3.33
		75 - 150	46	30	10.27	964	0.550	143	4.28
		150 - 250	78	21	2.15	2859	0.765	64	1.58
		250 - 700	282	12	0.10	9836	0.648	164	0.38
46.667 - 47.667		0 - 75	36	17	6.03	1184	0.775	211	13.45
		75 - 150	6	5	15.24	55		13	14.40
		150 - 250	44	6	1.24	701	0.000	6	1.53
		250 - 700	50	2	0.13	1331	0.925	21	0.32
47.667 - 48.667		0 - 75	105	84	25.64	3018	0.871	263	32.17
		75 - 150	29	25	26.73	991	0.763	93	61.59
		150 - 250	23	6	3.39	790	0.598	40	23.73
		250 - 700	49	4	0.45	2389	0.706	30	2.27
> 20	40.667 - 42.667	0 - 75	0	0		8		16	0.98
		75 - 150	1	1	9.50	2		11	8.31
		150 - 250	0	0		18		2	0.00
		250 - 700	0	0		7		0	
42.667 - 46.667		0 - 75	25	13	7.30	582	0.859	10	3.33
		75 - 150	54	45	10.96	1117	0.485	43	10.86
		150 - 250	78	38	2.66	2658	0.729	29	3.89
		250 - 700	59	4	0.88	1279	0.000	15	4.94
46.667 - 47.667		0 - 75	27	19	13.75	489	0.838	14	20.32
		75 - 150	12	9	137.85	106	0.780	12	11.17
		150 - 250	16	12	18.05	302	0.506	6	2.52
		250 - 700	3	1	2.37	115		2	1.94
47.667 - 48.667		0 - 75	123	121	62.37	1558	0.906	104	72.44
		75 - 150	31	25	130.67	1179	0.903	40	159.64
		150 - 250	27	18	16.78	850	0.597	89	69.46
		250 - 700	16	6	6.37	539	0.585	29	65.47

Table 3. Continued.

SEASON: SEPTEMBER - DECEMBER

Arrowtooth Catch (lbs/h)	Latitude	Depth (Fathoms)	Number of Observed Tows	Number of Tows with ≥ 1 Halibut	Wgt. (kg., rnd) Halibut per Hour	Trawl Effort (hours) from OR & WA	Proportion Legal by Weight	Number of Observed Tows 2002	Wgt. (kg., rnd) Halibut per Hour 2002
≤ 20	40.667 - 42.667	0 - 75	0	0		15		94	0.81
		75 - 150	0	0		0		20	0.31
		150 - 250	0	0		144		3	0.23
		250 - 700	5	0	0.00	1075		11	0.00
	42.667 - 46.667	0 - 75	144	23	1.24	292	0.862	70	1.22
		75 - 150	15	5	1.98	68	1.000	69	4.02
		150 - 250	12	2	2.46	1368		25	4.67
		250 - 700	104	6	0.25	2510	1.000	50	0.09
	46.667 - 47.667	0 - 75	9	6	3.48	68		4	0.00
		75 - 150	0	0		0		12	0.00
		150 - 250	0	0		344		0	
		250 - 700	4	0	0.00	383		3	0.00
	47.667 - 48.667	0 - 75	86	40	4.02	1549		29	3.73
		75 - 150	7	1	16.96	1		25	0.44
		150 - 250	17	17	69.34	228	0.507	6	59.99
		250 - 700	16	4	0.79	545		0	
> 20	40.667 - 42.667	0 - 75	0	0		6		1	6.10
		75 - 150	0	0		0		0	
		150 - 250	0	0		19		0	
		250 - 700	0	0		35		0	
	42.667 - 46.667	0 - 75	14	7	5.48	82		3	8.17
		75 - 150	24	8	1.54	61		36	10.93
		150 - 250	2	0	0.00	2018		8	145.44
		250 - 700	2	1	3.14	528		0	
	46.667 - 47.667	0 - 75	13	10	28.20	6		0	
		75 - 150	0	0		3		0	
		150 - 250	0	0		200		0	
		250 - 700	0	0		82		0	
	47.667 - 48.667	0 - 75	0	0		93		2	199.06
		75 - 150	4	2	2.14	3		6	2.38
		150 - 250	11	11	48.72	607		7	65.47
		250 - 700	1	1	5.99	166		0	

Table 4. Halibut bycatch and mortality in the bottom trawl fishery for pink shrimp off the west coast, reported by Williams et al. (1998).

Year	Trawl Effort (hours)	Estimated Halibut Bycatch (numbers)	Estimated Halibut Bycatch (kg., round)	Estimated Halibut Bycatch (lbs, net)	Estimated Total Halibut Mortality (lbs, net)	Legal-sized Bycatch Mortality (lbs, net)
1987	193,694	20,536	98,983	163,693	81,847	50,745
1992	107,015	10,244	51,671	85,450	42,725	26,490
1995	----	----	----	100,000	50,000	31,000

Note: For 1995, bycatch estimates for Areas 1B-2A off California are not included. Mortality estimated at 50% of bycatch. Proportion of legal-sized mortality (>81 cm) is assumed to be 62% by weight. 1 kg, round = 1.65375 lbs, net weight.

Table 5. Estimated 1998 halibut bycatch and mortality in the bottom trawl fishery for pink shrimp (landings into Oregon ports only). (Bob Hannah, personal communication, October 8, 1999 memo). The data sources numbered 1-3 are described in the text.

Data Source	Single-rig Equivalent Hours (sreh) Observed	Bycatch Rate (lbs/sreh)	Fishing Effort (sreh) in Oregon Landings	Bycatch Estimate (kg., round)	Bycatch Mortality (lbs, net)	Legal-sized Bycatch Mortality (lbs, net)
1 - Pikitch	---	1.22	34,543	19,155	15,839	9,820
2 - Hannah	236.5	2.60	34,543	40,824	33,756	20,929
3 - EDCP	551.1	2.12	34,543	33,287	27,524	17,065

Note: Mortality estimated at 50% of bycatch. Proportion of legal-sized mortality (>81 cm) is assumed to be 62% by weight, as in the bottom trawl fishery. 1 kg, round = 1.65375 pounds, net weight.

Table 6. Halibut bycatch and mortality in the Oregon and Washington bottom trawl fisheries for groundfish off the west coast. The 2003 Oregon Flatfish Trawl EFP is a census. The Limited Entry and Washington Arrowtooth EFP data are estimated from bycatch rates observed by the West Coast Groundfish Observer Program and applied to annual total groundfish bottom trawl effort (Table 3).

Program	Trawl Effort (hours)	Estimated Halibut Bycatch (kg., round)	Estimated Halibut Bycatch (lbs, net)	Estimated Total Halibut Mortality (lbs, net)	Estimated Legal-Sized Halibut Mortality (lbs, net)
Oregon Flatfish Trawl EFP	3,926	16,808	27,797	13,899	5,654
Limited Entry & Washington Arrowtooth EFP	54,413	541,736	895,896	447,948	361,091
Total	58,339	558,544	923,693	461,847	366,745

Note: Halibut bycatch by California bottom trawl fishery is not included. Mortality estimated at 50% of bycatch. Proportion of legal-sized mortality (>81 cm) estimated from length frequencies of fish measured by the West Coast Groundfish Observer Program. 1 kg, round = 1.65375 pounds, net weight.

Table 7. Halibut bycatch and mortality in the Oregon and Washington bottom trawl fisheries for groundfish off the west coast. The new 2003 data are estimated from bycatch rates observed by the West Coast Groundfish Observer Program and applied to annual total groundfish bottom trawl effort (Table 3). All estimates in this table (except the last column) are derived from a sum over strata cells; see the text for details.

Year	Trawl Effort (hours)	Estimated Halibut Bycatch (numbers)	Estimated Halibut Bycatch (kg, round)	Estimated Halibut Bycatch (lbs, net)	Estimated Total Halibut Mortality (lbs, net)	Estimated Legal-Sized Halibut Mortality (lbs, net)	Estimated Legal-Sized divided by Total Halibut Mortality
1998	92,294	164,961	1,259,374	2,082,690	1,041,345	691,755	0.6643
1999	81,420	147,995	1,144,236	1,892,280	946,140	638,091	0.6744
2000	70,363	122,234	944,120	1,561,338	780,669	523,097	0.6701
2001	67,199	124,969	962,348	1,591,482	795,741	532,912	0.6697
2002	52,168	NA	618,913	1,023,527	511,764	286,221	0.5593
2003	58,339	NA	558,544	923,693	461,847	366,745	0.7941

Note: Halibut bycatch by California bottom trawl fishery is not included. Mortality estimated at 50% of bycatch. Proportion of legal-sized mortality (>81 cm) estimated from length frequencies of fish measured by the West Coast Groundfish Observer Program. 1 kg, round = 1.65375 pounds, net weight.

Table 8. Summary of total estimated bycatch mortality of Pacific halibut, in thousands of pounds, net weight, by fishery in 2A. Bycatch mortality estimates for 1977-1997 are reported from Table 6 in Williams, et al. 1998.

Year	Foreign, JV & Catcher-Proc.	Groundfish Trawls	Shrimp Trawls	Hook & Line	TOTAL
1977	3	308	82	16	409
1978	2	308	82	16	408
1979	1	308	82	16	407
1980	1	308	82	16	407
1981	Trace	308	82	16	406
1982	Trace	308	82	16	406
1983	1	308	82	16	407
1984	Trace	308	82	16	406
1985	Trace	308	82	16	406
1986	1	308	82	16	407
1987	1	308	82	16	407
1988	1	308	82	16	407
1989	2	308	82	16	408
1990	2	308	82	16	408
1991	2	308	82	16	408
1992	0	385	43	16	444
1993	0	385	43	16	444
1994	0	385	43	16	444
1995	0	548	50	16	614
1996	0	548	50	16	614
1997	0	548	50	16	614
1998	0	1,041	25	---	---
1999	---	946	---	---	---
2000	---	781	---	---	---
2001	---	796	---	---	---
2002	---	512	---	---	---
2003	---	462	---	---	---

Note: Bycatch mortality by groundfish trawls in 1998-2003 does not include fisheries off California. Bycatch mortality by shrimp trawls in 1998 does not include fisheries off California and Washington.

Table 9. Summary of estimated mortality of legal-sized Pacific halibut, in thousands of pounds, net weight, by fishery in 2A. The bycatch mortality estimate for legal-sized halibut for 2002 is from this report. (Sums across fisheries may not always equal the TOTAL due to rounding.)

Year	Foreign, JV & Catcher-Proc.	Groundfish Trawls	Shrimp Trawls	Hook & Line	TOTAL
1977	2	191	51	10	254
1978	1	191	51	10	253
1979	0.6	191	51	10	252
1980	0.6	191	51	10	252
1981	Trace	191	51	10	252
1982	Trace	191	51	10	252
1983	0.6	191	51	10	252
1984	Trace	191	51	10	252
1985	Trace	191	51	10	252
1986	0.6	191	51	10	252
1987	0.6	191	51	10	252
1988	0.6	191	51	10	252
1989	1	191	51	10	253
1990	1	191	51	10	253
1991	1	191	51	10	253
1992	0	239	27	10	275
1993	0	239	27	10	275
1994	0	239	27	10	275
1995	0	340	31	10	381
1996	0	340	31	10	381
1997	0	340	31	10	381
1998	0	692	16	---	---
1999	---	638	---	---	---
2000	---	523	---	---	---
2001	---	533	---	---	---
2002	---	286	---	---	---
2003	---	367	---	---	---

Note: Bycatch mortality by groundfish trawls in 1998-2003 does not include fisheries off California. Bycatch mortality by shrimp trawls in 1998 does not include fisheries off California and Washington.