

# Bycatch mortality and size distribution extrapolation methodology

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## Abstract

Bycatch mortality of Pacific halibut in non-target fisheries has been a substantial source of mortality since the 1960's. In this report, we present estimates of bycatch mortality and the size distribution of the bycatch mortality, for the period 1990-2002 and describe the extrapolation methodology. The greatest amount of the bycatch mortality occurs in the groundfish fisheries off Alaska. Because of onboard observer programs, the groundfish fishery related bycatch mortality and its length composition are well estimated. For a number of other bycatch fisheries, sporadic sampling has resulted in less precise estimates.

## Introduction

The incidental catch ("bycatch") of Pacific halibut (*Hippoglossus stenolepis*) in non-directed fisheries has been a significant source of mortality to the coastwide population since the early 1960s. Until the early 1980s, most of the bycatch occurred in foreign groundfish fisheries. Bycatch mortality generally decreased during the transition to entirely domestic groundfish fisheries (in both the U.S. and Canada), a goal that was fully attained by 1990. In the decade since complete domestication, bycatch mortality has averaged around 16 million pounds (net weight), i.e., a level similar to that seen during much of the foreign fishing era.

As a fraction of total halibut removals (including commercial catch, sport catch, and wastage), bycatch mortality has fluctuated between 10 and 37 percent, totaling 21 percent of total removals (mortality) during the 1974-2002 period. However, the bycatch fraction has shown extreme variability by area and year. We estimate that bycatch mortality accounted for more than 60% (on occasion, more than 80%) of the total removals in Areas 4 and 2A between the mid-1970s and mid-1980s. By contrast, Area 2C bycatch mortality has averaged less than 10% of total removals in that area. Over the last decade, bycatch removals for all areas combined have slowly decreased from 20% to 15% of total removals, although most of this decrease resulted from increased other removals over the same period. There is no clear indication that bycatch levels will decrease substantially in the near future.

The Alaska groundfish fisheries account for about 80% of the total halibut bycatch mortality. Using data collected by observers, an elaborate extrapolation procedure has been developed to produce bycatch mortality and size distribution estimates. Because of the importance of bycatch in Alaska, the methodology employed to produce the estimates is reviewed in detail.

## Summary of Alaska observer bycatch sampling and extrapolation methodology

The estimates of bycatch mortality and its size distribution are based on data collected from the groundfish observer program. In Alaska, a domestic observer program has been in place since 1990. Observers are trained to estimate the viability of halibut after capture and prior to

being returned to sea. They also collect length frequencies of the bycatch halibut. The halibut are not sexed or aged. A summary of the number of halibut sampled by groundfish observers is given in Table 1. The numbers of halibut sampled annually are very large providing a solid basis for the extrapolations. In the U.S. program, every halibut that is sampled is assigned to a region and gear specific target fishery. This allows proper weighting of the samples during the extrapolation procedure that results in total mortality and size distribution estimates. Because there is unequal sampling effort among the different target fisheries, this weighting is a critical step. Tables 2 and 3 provide a more detailed breakdown of the raw data collected for the year 2002. Discard mortality rates (DMRs) for each area/gear/target fishery are computed using the extrapolated viability data. These data are the number of halibut in “excellent”, “poor” and “dead” condition sampled and returned to the sea by observers. Because observers generally measure only a fraction of the halibut within each haul, these sample numbers are expanded to give the total number of halibut within each viability category for each haul. The three viability categories are then summed within region/gear/target category. Regions are Bering Sea/Aleutian Islands, Gulf of Alaska, and Southeast Alaska; gears are trawl, longline, pot; and there are approximately 15 groundfish target fisheries. The discard mortality rate (DMR) for each year/gear/target is computed using the following gear specific formulas (Clark et al. 1993, Williams 1996.)

$$\begin{aligned} \text{DMR}_{\text{trawl}} &= (0.2 * E + 0.55 * P + 0.9 * D) / (E + P + D) \\ \text{DMR}_{\text{longline}} &= (0.035 * E + 0.52 * P + 1.0 * D) / (E + P + D) \\ \text{DMR}_{\text{pot}} &= (0.0 * E + 1.0 * P + 1.0 * D) / (E + P + D) \end{aligned}$$

where E, P, D are numbers of halibut in Excellent, Poor, and Dead condition, respectively. Estimates of bycatch mortality are then computed by multiplying each target fisheries estimated total bycatch times its computed DMR.

To produce the mortality size distributions, the following steps are taken.

1. Raw length frequencies are expanded within each haul by the ratio of halibut caught to halibut sampled within that haul.
2. The extrapolated length frequency numbers for each haul are assigned to a target fishery.
3. Extrapolated length frequency distributions are summed for each region/gear/target fishery and **viability** category.
4. Within each region/gear/target category, mortality length frequency distributions are formed by applying the gear specific mortality formulas (shown above) to the viability categories.
5. Within each region/gear category, the individual target fishery distributions are combined using the target fishery bycatch mortality to weight the individual distributions.

When combining different length frequency distributions, weighted averages of individual distributions were used. Some clarification of what is meant by weighted average is in order. As an example, assume that two fisheries had accounted for halibut mortality as follows:

Fishery A - 60 mt  
 Fishery B - 40 mt.

From each fishery there is a bycatch mortality size distribution that is in numbers at length. The procedure we followed was to calculate the estimated total numbers at length for each fishery by expanding the sample numbers using the ratio of the weight of fishery bycatch mortality to sample weight:

$$N_{i,j} = \frac{W_j}{w_j} * n_{i,j}$$

$$w_j = \sum_{i=1}^{l_{\max}} n_{i,j} * .00000692 * l^{3.24}$$

where  $N$  refers to number,  $W$  refers to weight and  $l$  refers to length. The upper case symbols refer to the fishery and lower case symbols to the sample. The length weight relationship is taken from Quinn et al. (1983). Following computation of total numbers by length interval per fishery, the numbers are summed and the new proportions by length interval computed. It is important to note that this method produces substantially different results than the incorrect method of simply weighting each length interval by the ratio of fishery mortalities, i.e., in this example 60:40 for Fishery A lengths to Fishery B lengths.

Examples of unweighted bycatch size distributions for three example fisheries – 1998 Gulf of Alaska Pacific cod, 1999 Bering Sea yellowfin sole, and 2001 British Columbia groundfish – are illustrated in Figure 1. These plots show the raw size distributions before mortality computations are made and mortality size distribution numbers extrapolated by sample rate and target fishery mortality.

## Bycatch in other fisheries

In Canada, observers have collected halibut bycatch data in the groundfish trawl fisheries since 1991. There are no bycatch mortality estimates for other fisheries in Area 2B. Observers collect the same halibut data as the U.S. observers. Since 1996, the groundfish trawl fisheries in Canada have had 100% observer coverage. Observers collect viability and length information on every halibut that is captured. Thus, no extrapolation procedures are required to produce the Area 2B estimates of trawl bycatch mortality and size distribution.

As noted, the other bycatch fisheries are responsible for a much smaller fraction of the total bycatch mortality. Since 1990, the only other target fisheries with measurable amounts of halibut mortality are king and tanner crab fisheries in Alaska, and shrimp fisheries in Area 2A and Alaska. The methods used to estimate bycatch mortality and size distributions in these other fisheries is being documented (Hare and Williams, in revision) and will not be summarized here.

## Total mortality and size distribution estimates

The end result of this data compilation and processing exercise is the generation of mortality and size distribution numbers by IPHC regulatory area for input to the annual stock assessment. Table 4 contains a summary of total bycatch mortality by weight for each regulatory area for 1990-2003 as well as the estimated numbers of sublegal and legal halibut that die as bycatch. Figures 2a-g illustrate the bycatch mortality size distributions by regulatory area.

## References

Clark, W.G., Hoag, S.H., Trumble, R.J. Williams, G.H.. 1993. Re-estimation of survival for trawl caught halibut released in different condition factors. Int. Pac. Halibut Comm. Report. of Assessment and Research Activities 1992: 197-203.

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Quinn, T. J. II, Best, E.A. Bijsterveld, L. and McGregor, I.R.. 1983. Sampling Pacific halibut (*Hippoglossus stenolepis*) landings for age composition: History, evaluation, and estimation. Int. Pac. Halibut Comm. Sci. Rpt. 68. 56 p.

Williams, G.H. 1996. Pacific halibut discard mortality rates in the 1994 Alaskan groundfish fisheries, with recommendations for monitoring in 1996. Int. Pac. Halibut Comm. Report. of Assessment and Research Activities 1995: 173-183.

**Table 1. Number of halibut sampled for length and viability in each IPHC regulatory area, 1990-2002.**

<b>Area/Gear/Target</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>
<i>Area 2A</i>	-	-	-	-	-	-	-	-	-	-	-	-	1,882
<i>Area 2B</i>	-	2,103	10,696	2,892	2,712	7,642	18,461	11,142	13,671	33,595	32,429	27,867	40,040
<i>Areas 2C/3A/3B Longline</i>													
Pacific cod	4,533	9,676	9,607	1,513	1,833	3,054	734	552	1,361	1,159	384	631	1,017
Sablefish	26,136	4,223	4,210	2,850	1,401	1,860	1,656	-	-	-	-	-	-
Rockfish	480	-	-	16	-	4	70	-	17	-	-	-	-
<i>Areas 2C/3A/3B Pot</i>													
Pacific cod	1,599	1,210	3,726	718	712	2,070	464	252	588	3,690	1,322	501	430
<i>Areas 2C/3A/3B Trawl</i>													
Atka mackerel	998	82	540	227	59	-	155	-	-	-	-	-	-
Bottom pollock	9,143	2,500	3,000	479	1,688	2,569	872	842	1,363	459	1,281	856	91
Pacific cod	37,691	30,141	14,484	7,789	4,182	12,268	6,707	7,889	6,832	5,743	2,416	3,458	2,550
Deepwater flatfish	6,694	7,273	7,722	7,154	370	693	1,030	327	217	220	279	158	75
Shallow water flatfish	5,217	782	1,938	4,729	2,681	1,815	4,743	3,761	1,774	452	2,320	2,167	2,377
Rockfish	23,749	6,637	2,816	1,192	1,721	1,944	1,509	907	1,057	1,674	960	1,174	641
Flathead sole	-	-	-	-	568	367	337	551	275	22	114	439	206
Other sp.	-	-	-	-	-	-	-	-	-	-	65	73	108
Pelagic pollock	168	346	99	121	183	232	130	202	293	279	328	74	34
Sablefish	1,334	485	101	172	814	262	118	58	-	24	150	17	21
Arrowtooth flounder	-	-	-	-	-	-	319	154	526	94	996	443	832
Rex sole	-	-	-	-	1,749	1,118	1,624	609	826	737	396	322	799
<b><i>Areas 2C/3A/3B TOTAL</i></b>	<b>117,742</b>	<b>63,355</b>	<b>48,243</b>	<b>26,960</b>	<b>17,961</b>	<b>28,256</b>	<b>20,468</b>	<b>16,104</b>	<b>15,129</b>	<b>14,553</b>	<b>11,011</b>	<b>10,313</b>	<b>9,181</b>
<b>AREA 2 &amp; 3 TOTAL</b>	<b>117,742</b>	<b>65,458</b>	<b>58,939</b>	<b>29,852</b>	<b>20,673</b>	<b>35,898</b>	<b>38,929</b>	<b>27,246</b>	<b>28,800</b>	<b>48,148</b>	<b>43,440</b>	<b>38,180</b>	<b>51,103</b>

...continued

**Table 1. (cont'd) Number of halibut sampled for length and viability in each IPHC regulatory area, 1990-2002.**

<b>Area/Gear/Target</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>
<b>Area 4 Longline</b>													
Pacific cod	48,547	55,047	35,388	19,895	45,964	37,350	42,510	31,721	35,856	14,093	18,924	20,296	15,265
Rockfish	27	15		10	27	-	170	23	11	-	41	-	-
Sablefish	1,489	814	239	197	171	338	212	-	-	-	-	-	-
Turbot	1,723	1,338	354	1,456	296	1,375	669	407	594	20	771	92	240
<b>Area 4 Pot</b>													
Pacific cod	773	2,339	4,640	430	2,258	3,294	6,838	3,405	993	1,421	102	681	532
<b>Area 4 Trawl</b>													
Atka mackerel	3,755	2,252	979	420	192	114	525	125	353	405	158	73	150
Bottom pollock	42,177	29,896	23,908	11,620	8,149	5,555	6,506	5,937	4,875	4,567	3,299	2,834	2,809
Pacific cod	72,544	61,719	24,722	12,244	18,166	18,426	21,846	11,947	13,535	11,680	9,983	4,356	7,361
Other flatfish	1,569	2,571	595	1,100	187	246	375	1,230	1,302	910	516	467	818
Rockfish	5,392	1,676	1,081	1,836	210	125	197	33	34	135	81	72	60
Flathead sole	-	-	-	-	686	1,509	1,245	919	1,425	2,976	1,826	1,034	685
Pelagic pollock	5,647	2,679	4,530	1,953	3,328	3,099	4,143	4,449	4,485	7,208	6,409	14,170	8,049
Rock sole	14,062	20,489	10,363	6,211	3,063	7,459	4,591	6,632	5,725	6,261	5,108	2,593	4,622
Sablefish	157	39	-	6	5	-	-	-	-	15	6	-	4
Turbot	7,207	4,135	-	-	242	1,119	37	58	39	80	209	71	92
Yellowfin sole	6,080	5,206	4,481	3,652	2,891	1,910	1,841	2,345	3,675	1,560	1,995	2,101	2,154
<b>Area 4 TOTAL</b>	<b>211,149</b>	<b>190,215</b>	<b>111,280</b>	<b>61,030</b>	<b>85,835</b>	<b>81,919</b>	<b>91,705</b>	<b>69,231</b>	<b>72,902</b>	<b>51,331</b>	<b>49,428</b>	<b>48,840</b>	<b>42,841</b>
<b>GRAND TOTAL</b>	<b>328,891</b>	<b>255,673</b>	<b>170,219</b>	<b>90,882</b>	<b>106,508</b>	<b>117,817</b>	<b>130,634</b>	<b>96,477</b>	<b>101,702</b>	<b>99,479</b>	<b>92,868</b>	<b>87,020</b>	<b>93,944</b>

**Table 2. Information on observer coverage, sampling, and size composition of the halibut bycatch in 2002.**

<b>Area/Gear /Target</b>	<b>No. of Vsls Observed</b>	<b>No. of Smpld hauls</b>	<b>No. of fish measured</b>	<b>Mean Length (cm)</b>	<b>Percent &lt;65 cm</b>	<b>Percent &lt; 82 cm</b>
<i>BSAI Longline</i>						
Pacific cod	40	817	15,265	69.8	0.398	0.808
Other sp.	6	23	20	81.3	0.050	0.600
Turbot	9	246	240	93.0	0.017	0.258
<i>BSAI Pot</i>						
Pacific cod	47	135	558	66.8	0.387	0.953
<i>BSAI Trawl</i>						
Atka mackerel	13	365	150	79.1	0.427	0.647
Bottom pollock	89	441	2,809	52.0	0.787	0.927
Pacific cod	80	565	7,361	50.6	0.844	0.961
Other flatfish	24	491	818	72.6	0.435	0.647
Rockfish	11	171	60	81.3	0.300	0.583
Flathead sole	15	472	685	67.0	0.458	0.819
Other sp.	5	18	57	63.0	0.561	0.912
Pelagic pollock	99	1292	8,049	65.7	0.470	0.778
Rock sole	22	516	4,622	47.8	0.855	0.931
Turbot	7	105	92	91.8	0.022	0.174
Yellowfin sole	24	984	2,154	69.2	0.441	0.725
<i>GOA Longline</i>						
Pacific cod	13	291	1,017	71.7	0.331	0.784
<i>GOA Pot</i>						
Pacific cod	24	111	430	72.4	0.240	0.770
<i>GOA Trawl</i>						
Bottom pollock	37	68	91	61.7	0.604	0.835
Pacific cod	50	136	2,550	51.5	0.834	0.936
Dp wtr flatfish	3	14	75	57.7	0.680	0.800
Shall wtr flatfish	29	131	2,377	48.8	0.803	0.939
Rockfish	42	310	641	85.6	0.154	0.438
Flathead sole	8	40	206	56.6	0.655	0.927
Other sp.	4	21	108	66.0	0.481	0.880
Pelagic pollock	42	114	34	50.1	0.824	0.912
Sablefish	1	4	21	69.8	0.476	0.810
Arrowtooth flndr	9	289	832	70.2	0.407	0.775
Rex sole	7	294	799	69.7	0.389	0.820

**Table 3. Distribution of halibut viability data by condition factor and target fishery during 2002.**

Target	Raw Data				Extrapolated Data					
	Exc	Poor	Dead	DMR	Exc	Poor	Dead	DMR	SE	
<b>Area 4 Trawl</b>										
Atka mackerel	8	7	149	0.851	286	251	5,401	0.852	0.0624	
Bottom pollock	475	391	3,085	0.781	15,168	14,140	103,902	0.783	0.0531	
Pacific cod	1,402	2,122	4,415	0.683	35,635	45,355	109,632	0.686	0.0342	
Other flatfish	163	185	459	0.678	2,186	2,421	13,469	0.768	0.0845	
Rockfish	12	7	37	0.706	678	213	2,369	0.731	0.1244	
Flathead sole	144	171	264	0.623	4,305	3,172	6,295	0.601	0.1183	
Other sp.	16	19	25	0.603	389	666	803	0.628	0.2407	
Pelagic pollock	20	42	9,641	0.897	34	69	19,368	0.898	0.0034	
Rock sole	270	283	3,562	0.830	14,683	18,410	212,847	0.832	0.0251	
Turbot	15	21	40	0.665	210	481	1,345	0.745	0.1338	
Yellowfin sole	212	278	1,437	0.772	7,418	3,833	38,553	0.769	0.0403	
<b>Area 4Pot</b>										
Pacific cod	609	20	16	0.056	1,876	66	40	0.053	0.0661	
Sablefish	140	16	12	0.167	264	24	15	0.129	0.4166	
<b>Area 2C/3Trawl</b>										
Bottom pollock	8	8	76	0.809	131	58	130	0.549	0.1809	
Pacific cod	870	801	976	0.564	17,358	20,097	23,794	0.587	0.0600	
Deepwater flatfish	50	27	16	0.422	549	387	289	0.476	0.0907	
Shallow water flatfish	646	814	1,273	0.630	13,424	22,740	37,117	0.663	0.0584	
Rockfish	148	113	263	0.627	4,354	1,542	7,815	0.638	0.1013	
Flathead sole	57	42	105	0.632	775	573	3,228	0.738	0.2083	
Other sp.	10	18	63	0.754	85	296	3,186	0.854	0.1338	
Pelagic pollock	-	-	104	0.900	-	-	105	0.900	0.0000	
Sablefish	-	19	3	0.598	-	237	55	0.616	.	
Arrowtooth flounder	91	182	365	0.700	1,524	3,282	10,905	0.759	0.1113	
Rex sole	192	190	308	0.609	3,909	3,206	4,398	0.565	0.1179	
<b>Area 2C/3 Pot</b>										
Pacific cod	356	58	35	0.207	693	87	74	0.188	0.1023	

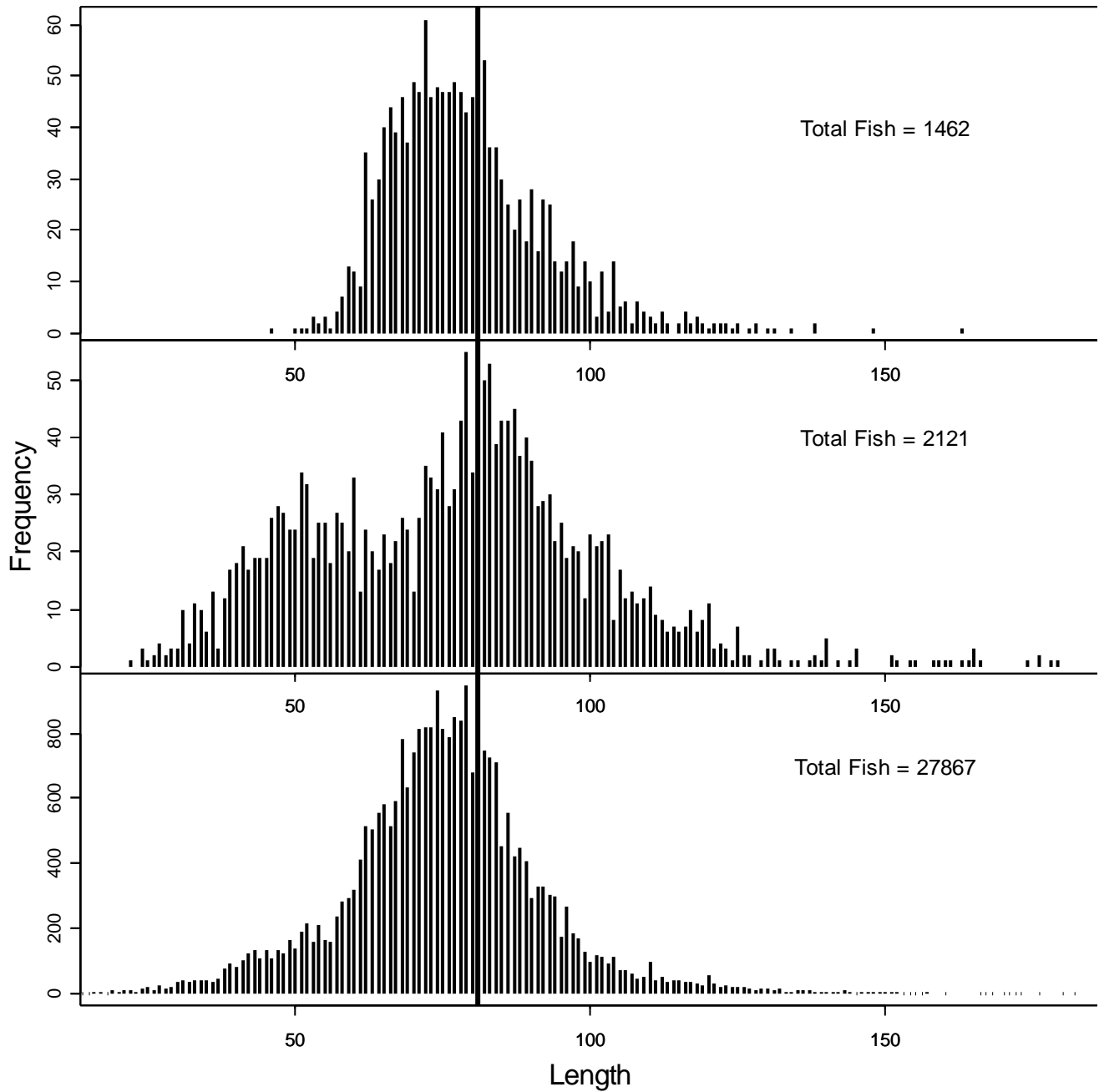
Target	Raw Data					Extrapolated Data					
	Minor	Mod	Severe	Dead	DMR	Minor	Mod	Severe	Dead	DMR	SE
<b>Area 4 Longline</b>											
Pacific cod	13,596	1,762	416	339	0.107	260,402	30,141	5,996	4,644	0.095	0.0113
Rockfish	7	-	-	-	0.035	16	-	-	-	0.035	.
Other sp.	18	4	3	3	0.252	596	74	150	79	0.252	0.1111
Turbot	293	35	14	22	0.149	4,103	523	182	809	0.225	0.0949
<b>Area 2C/3 LL</b>											
Pacific cod	1,001	135	24	38	0.115	52,745	7,250	1,504	1,469	0.110	0.0195

**Table 4. Summary of halibut bycatch mortality 1990-2003.**

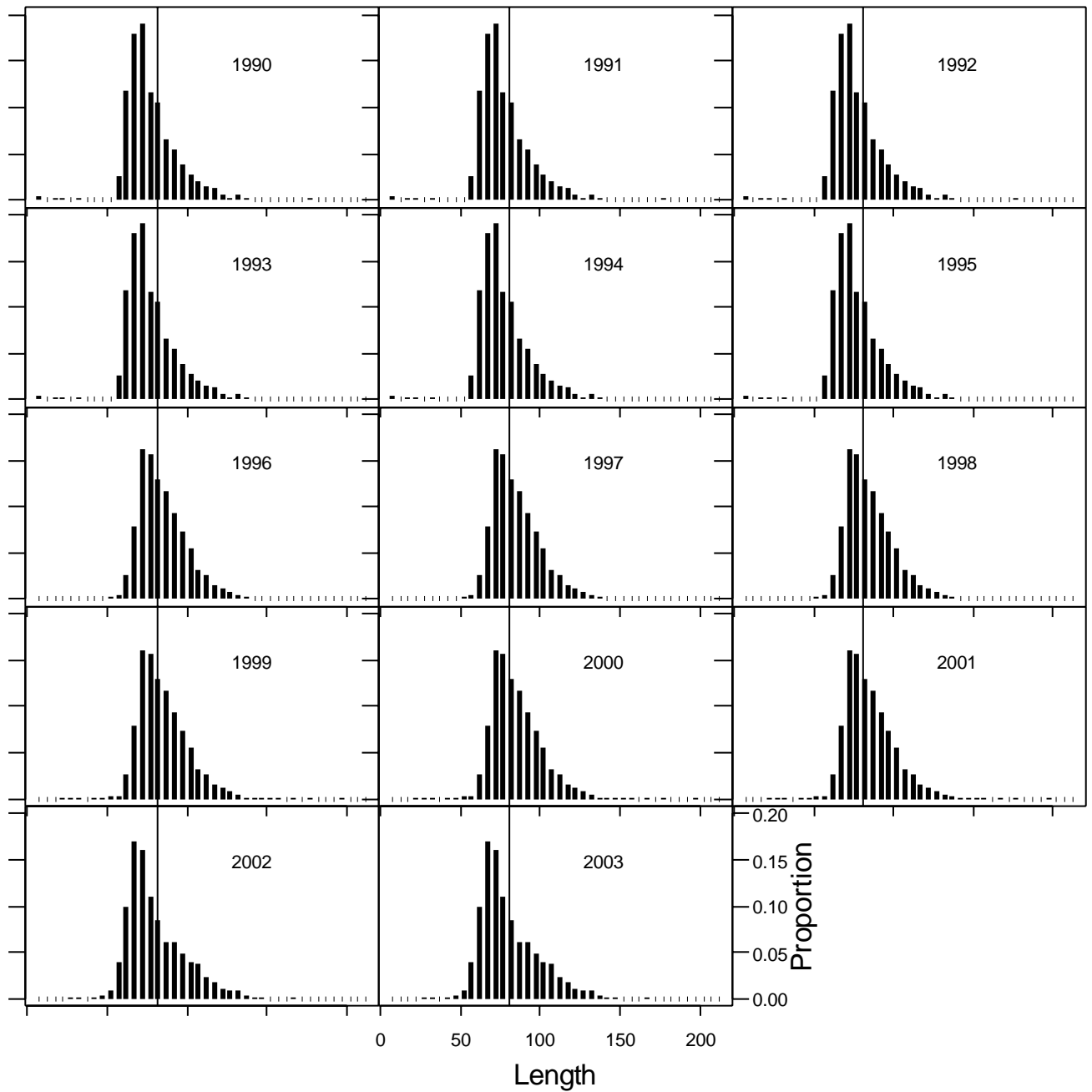
<b>Total bycatch mortality (million net pounds)</b>								
Year	2A	2B	2C	3A	3B	4A	4B	4C
1990	0.408	1.679	0.856	4.111	2.045	2.164	0.482	5.935
1991	0.408	1.993	0.734	4.841	1.671	2.850	0.345	6.839
1992	0.444	1.744	0.736	4.666	1.980	2.760	0.963	7.000
1993	0.444	1.660	0.742	4.292	1.061	1.831	0.789	5.147
1994	0.444	1.218	0.523	3.907	1.386	2.906	0.656	5.899
1995	0.614	1.522	0.342	2.957	1.745	3.770	0.256	4.696
1996	0.614	0.299	0.344	2.699	1.931	2.176	0.618	5.699
1997	0.614	0.215	0.397	2.964	1.443	2.388	0.296	5.194
1998	1.082	0.213	0.361	2.662	1.388	2.489	0.484	4.755
1999	0.987	0.193	0.358	2.885	1.736	2.495	0.408	4.782
2000	0.822	0.230	0.395	2.892	1.509	2.144	0.686	4.609
2001	0.691	0.180	0.340	2.195	1.926	1.529	0.539	5.148
2002	0.691	0.180	0.340	2.194	1.924	1.530	0.539	5.157
2003	0.691	0.180	0.340	2.194	1.924	1.530	0.539	5.157

<b>Sublegal bycatch mortalities (millions of halibut)</b>								
Year	2A	2B	2C	3A	3B	4A	4B	4C
1990	0.025	0.177	0.033	0.321	0.188	0.617	0.026	1.328
1991	0.025	0.211	0.031	0.425	0.162	1.282	0.017	2.933
1992	0.027	0.172	0.029	0.524	0.222	0.925	0.055	2.054
1993	0.027	0.229	0.095	0.654	0.163	0.884	0.065	1.365
1994	0.027	0.112	0.023	0.344	0.115	0.500	0.025	1.249
1995	0.037	0.154	0.023	0.366	0.224	0.909	0.022	0.785
1996	0.019	0.022	0.020	0.359	0.269	0.419	0.029	0.752
1997	0.019	0.017	0.029	0.398	0.212	0.566	0.018	0.772
1998	0.034	0.017	0.023	0.292	0.163	0.397	0.029	0.846
1999	0.031	0.014	0.025	0.333	0.197	0.604	0.016	0.942
2000	0.026	0.016	0.027	0.334	0.172	0.446	0.023	0.917
2001	0.022	0.004	0.047	0.301	0.307	0.223	0.027	0.744
2002	0.034	0.012	0.062	0.397	0.558	0.494	0.028	1.027
2003	0.034	0.012	0.062	0.397	0.558	0.494	0.028	1.027

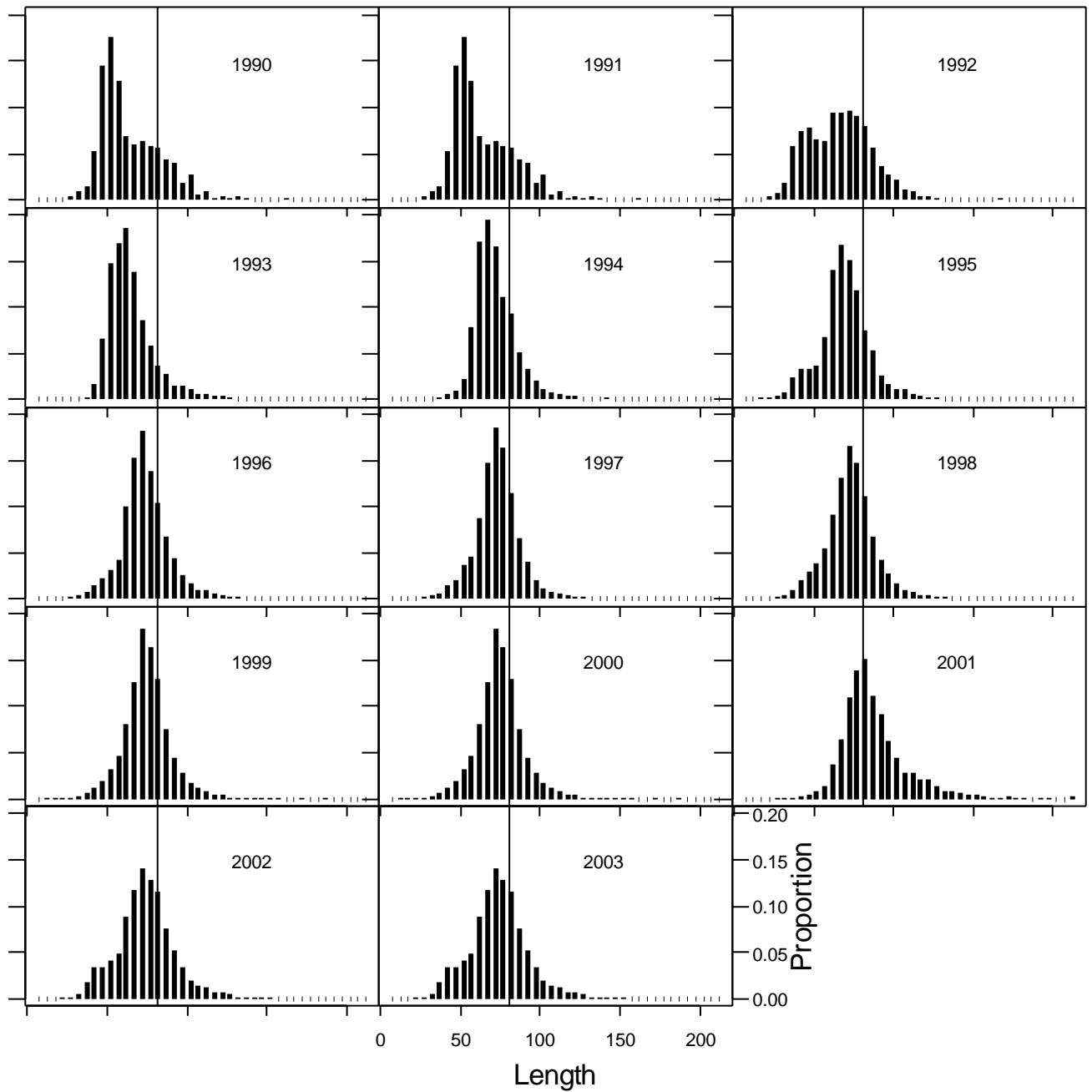
<b>Legal bycatch mortalities (millions of halibut)</b>								
Year	2A	2B	2C	3A	3B	4A	4B	4C
1990	0.014	0.049	0.034	0.121	0.054	0.03	0.011	0.112
1991	0.014	0.059	0.029	0.151	0.049	0.036	0.012	0.102
1992	0.015	0.059	0.028	0.135	0.057	0.042	0.031	0.098
1993	0.015	0.034	0.016	0.094	0.023	0.008	0.017	0.057
1994	0.015	0.035	0.023	0.116	0.042	0.057	0.013	0.093
1995	0.020	0.041	0.012	0.067	0.039	0.047	0.006	0.088
1996	0.025	0.010	0.013	0.069	0.048	0.038	0.015	0.134
1997	0.025	0.007	0.013	0.069	0.033	0.049	0.008	0.146
1998	0.045	0.007	0.013	0.078	0.039	0.067	0.014	0.138
1999	0.041	0.007	0.012	0.068	0.042	0.054	0.011	0.121
2000	0.034	0.008	0.013	0.068	0.037	0.052	0.020	0.113
2001	0.029	0.007	0.010	0.062	0.042	0.039	0.016	0.132
2002	0.023	0.006	0.009	0.056	0.038	0.022	0.016	0.139
2003	0.023	0.006	0.009	0.056	0.038	0.022	0.016	0.139



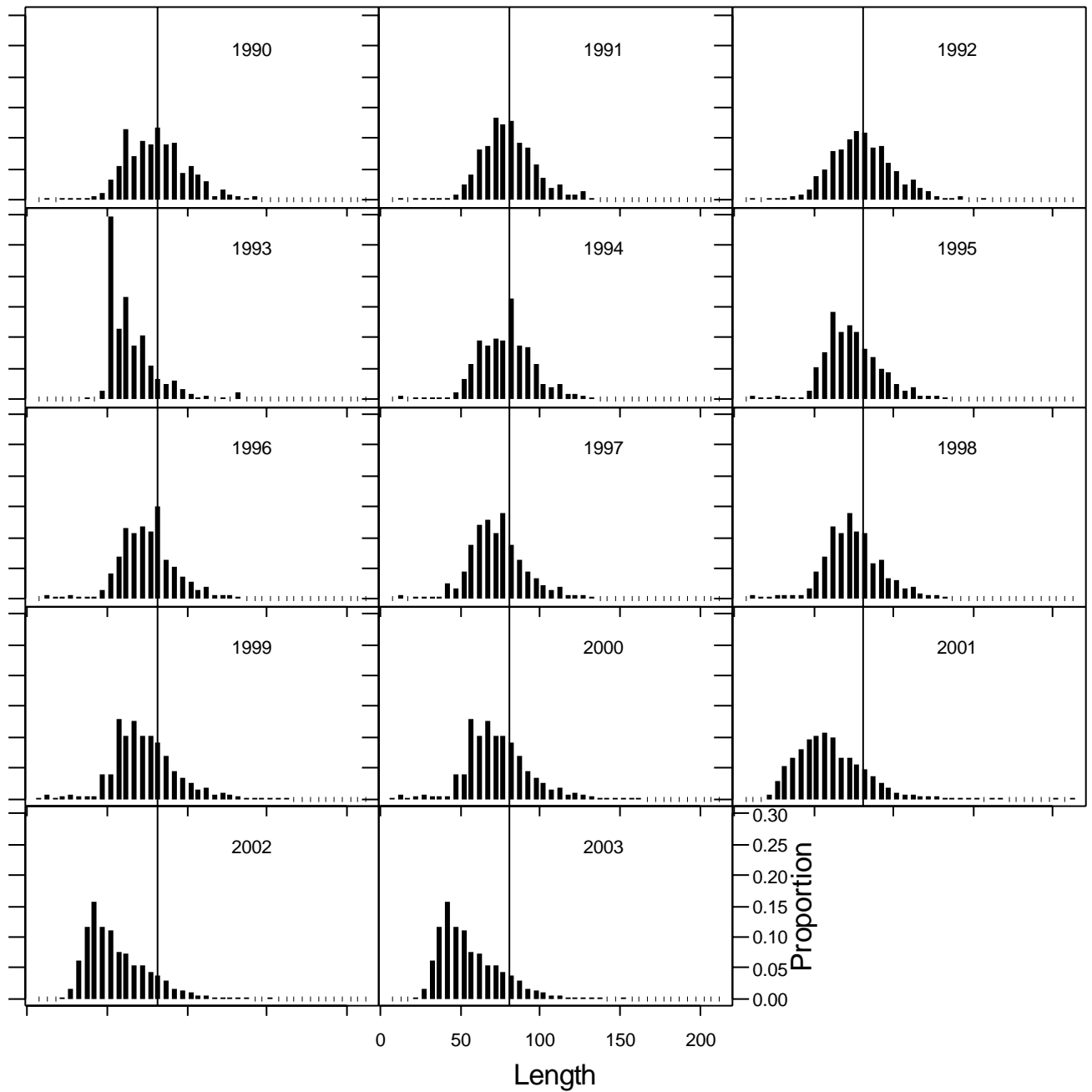
**Figure 1. Bycatch size distributions and sample sizes for three example fisheries. The top panel is bycatch in the 1998 Gulf of Alaska longline Pacific cod fishery, the middle panel is the 1999 Bering Sea trawl yellowfin sole fishery and the bottom panel shows all length frequencies collected in the 2001 British Columbia groundfish fisheries where sample rates are 100%. The vertical line through all three plots shows the 81 legal cm size limit.**



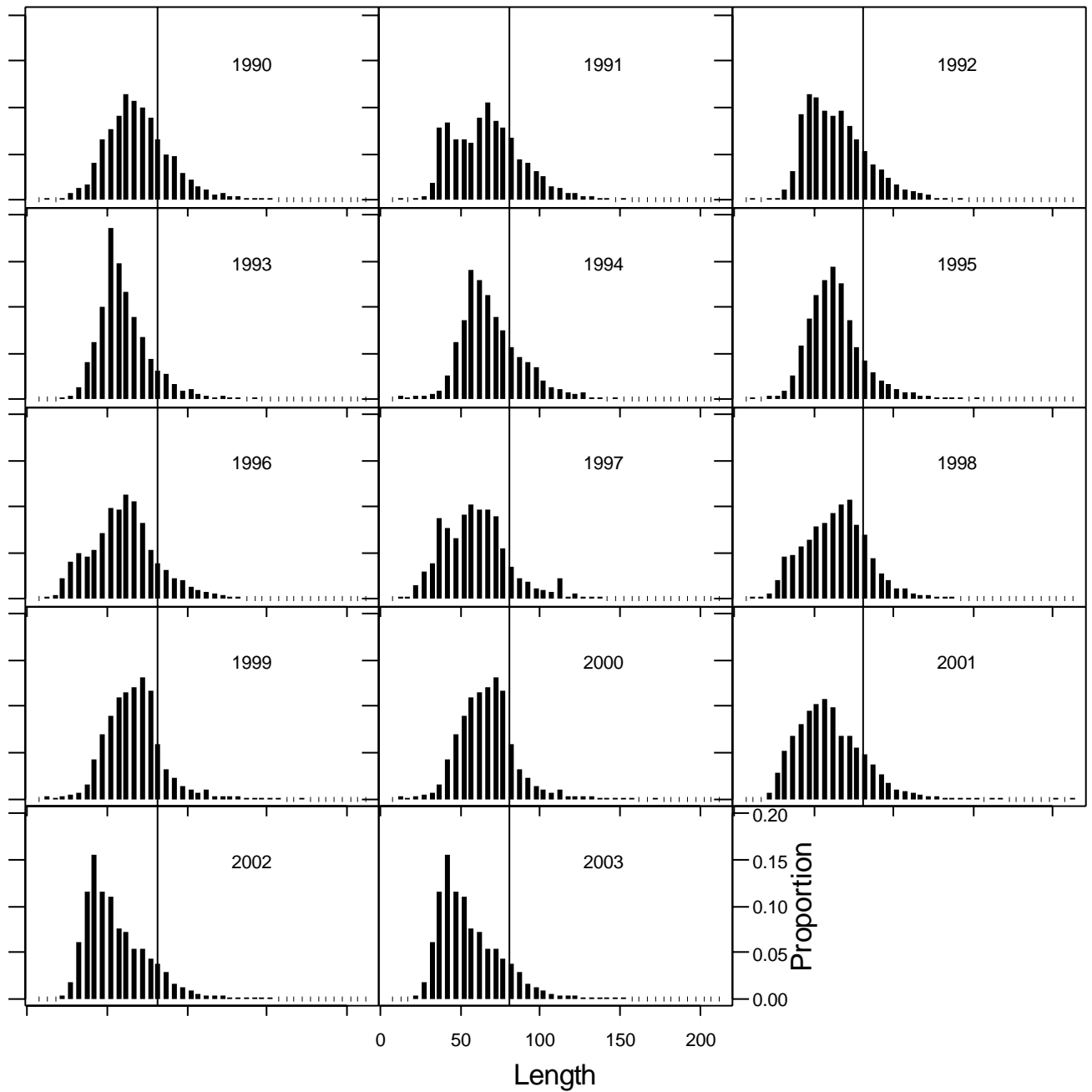
**Figure 2a. Bycatch mortality size distributions for Area 2A, 1990-2003. The legal size limit (81 cm) is indicated by the vertical line in all plots.**



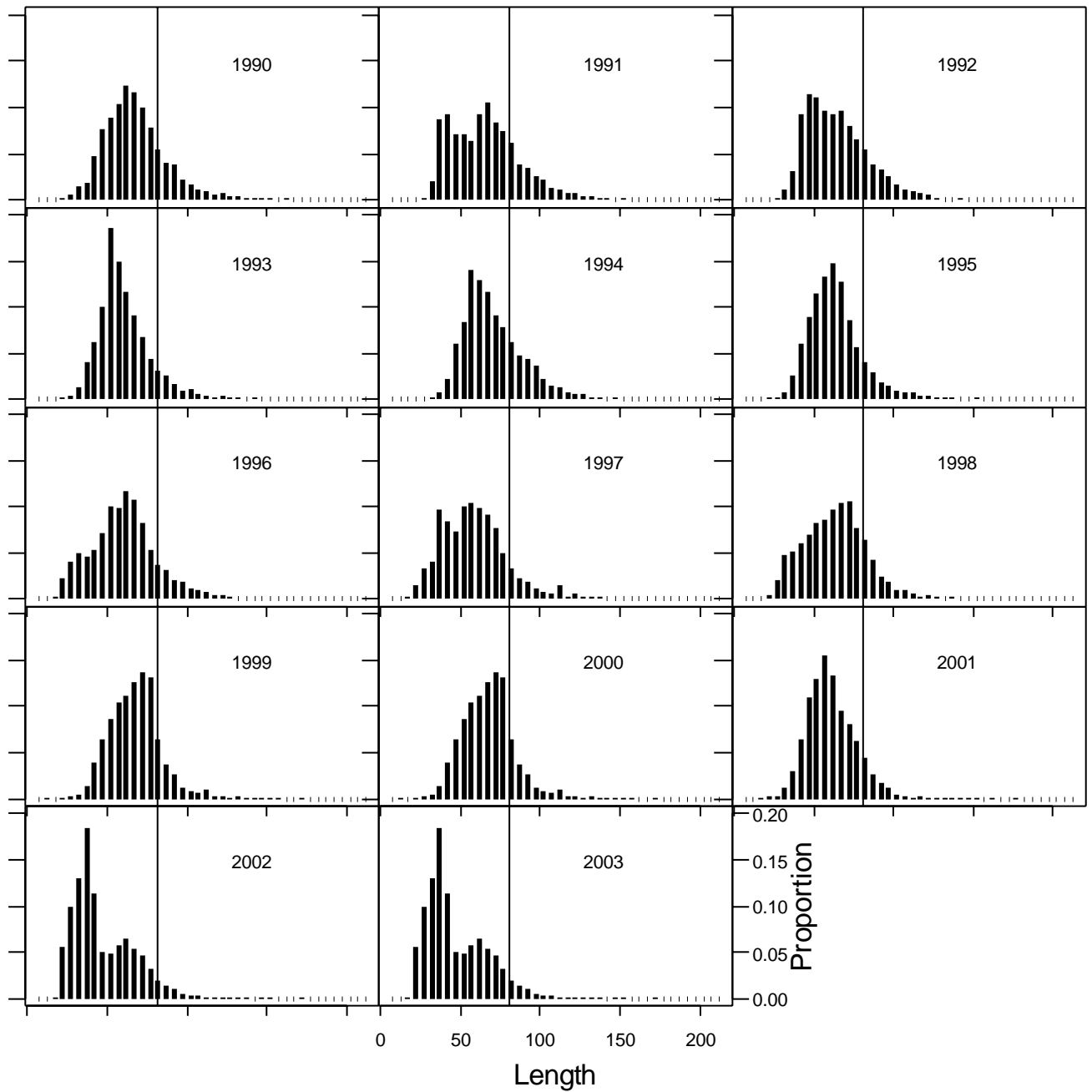
**Figure 2b. Bycatch mortality size distributions for Area 2B, 1990-2003. The legal size limit (81 cm) is indicated by the vertical line in all plots.**



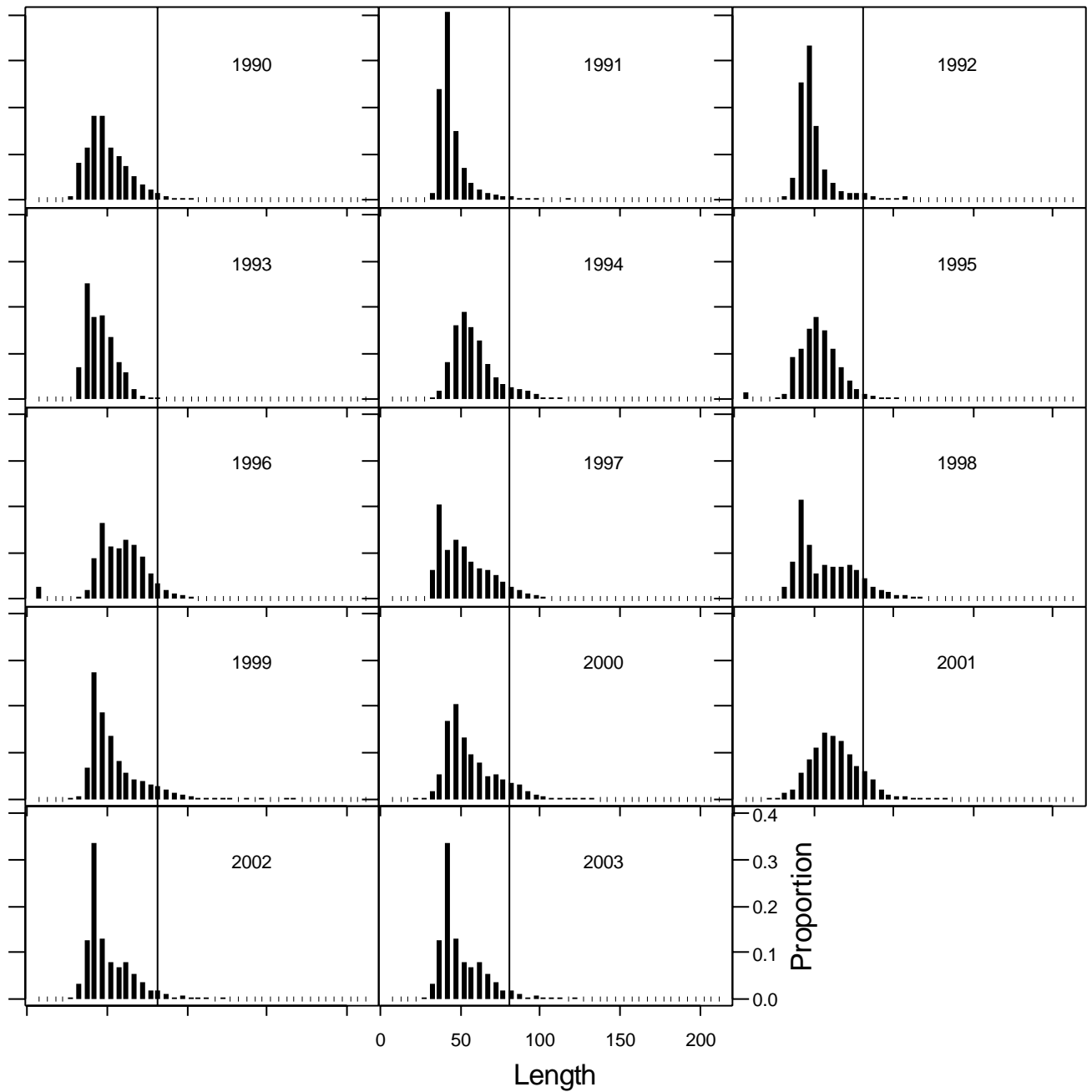
**Figure 2c. Bycatch mortality size distributions for Area 2C, 1990-2003. The legal size limit (81 cm) is indicated by the vertical line in all plots.**



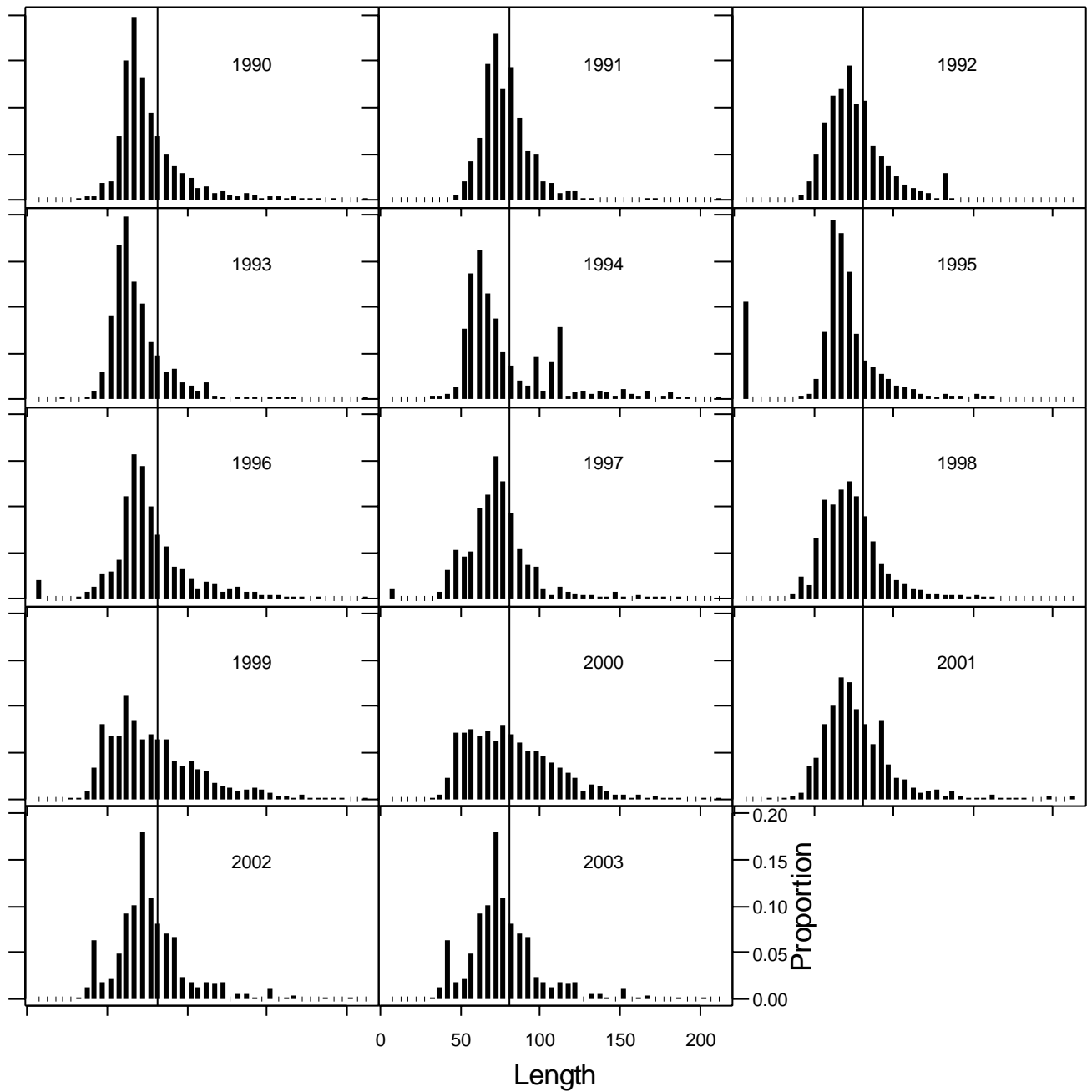
**Figure 2d. Bycatch mortality size distributions for Area 3A, 1990-2003. The legal size limit (81 cm) is indicated by the vertical line in all plots.**



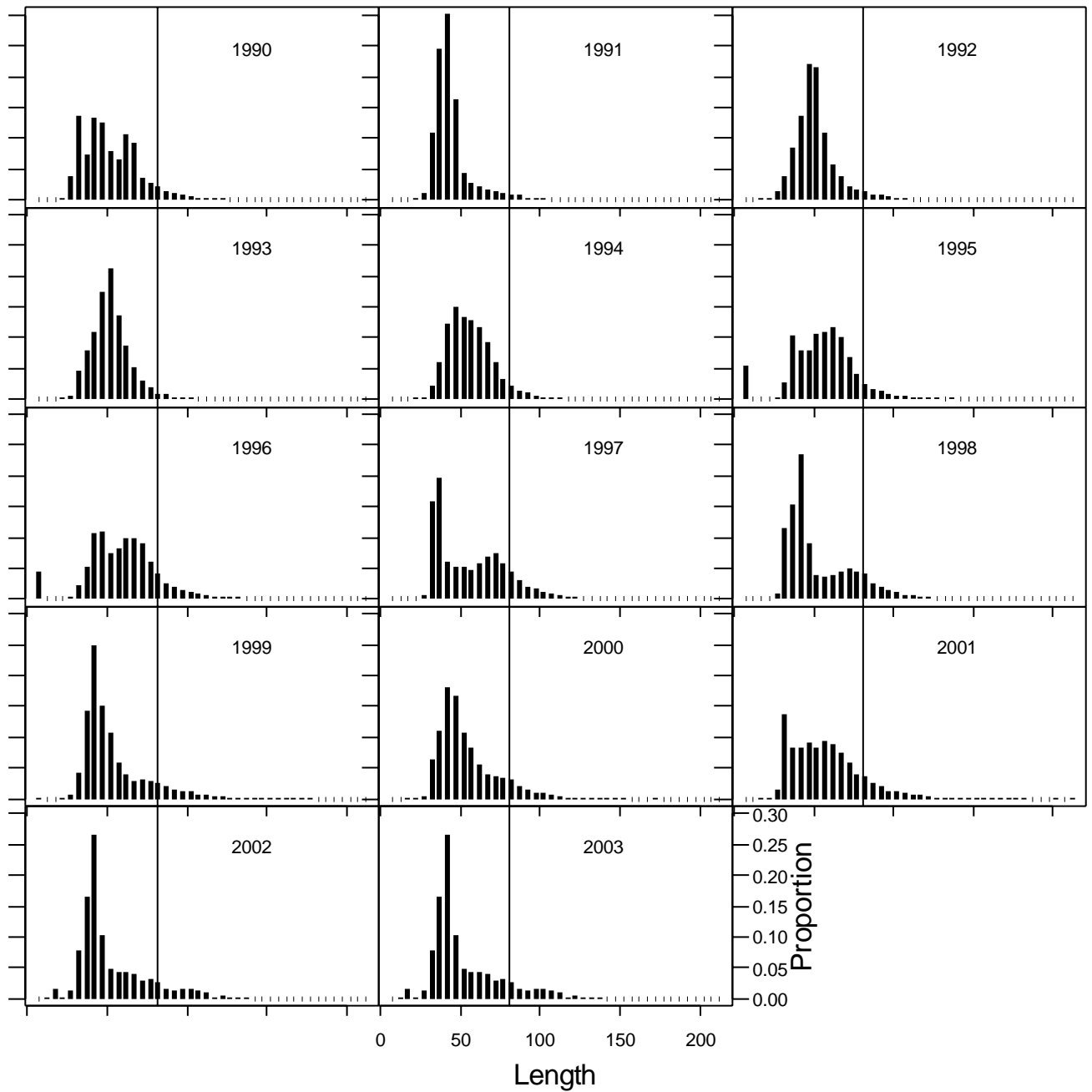
**Figure 2e. Bycatch mortality size distributions for Area 3B, 1990-2003. The legal size limit (81 cm) is indicated by the vertical line in all plots.**



**Figure 2f. Bycatch mortality size distributions for Area 4A, 1990-2003. The legal size limit (81 cm) is indicated by the vertical line in all plots.**



**Figure 2g. Bycatch mortality size distributions for Area 4B, 1990-2003. The legal size limit (81 cm) is indicated by the vertical line in all plots.**



**Figure 2h. Bycatch mortality size distributions for Area 4CDE, 1990-2003. The legal size limit (81 cm) is indicated by the vertical line in all plots.**