Section C: Assessment of California halibut north of Point Conception.

C1. Model

The assessment model is identical to that used for the southern stock with the following features:

1) Growth parameters of the Richards growth curve are estimated while fitting to age–conditioned- on-length data. This is to accommodate the San Francisco Bay Delta (Bay Delta) trawl survey data that captures young fish and provides information on growth. The length at age zero is assumed to be the same for males and females.
2) Variation of length-at-age is modeled assuming the Coefficient of Variation (CV) is constant over age and the parameters are estimated for males and females.
3) All the selectivity parameters are fixed at the values estimated for the southern stock except the width of the mode and the descending limb of the Commercial Passenger Fishing Vessel (CPFV) recreational fishery (the other recreational fishery in the model, which combines all remaining recreational fishing modes, uses the same selectivity parameters as the CPFV fishery) and the parameters of the bottom trawl fishery selectivity.
4) Initial equilibrium fishing mortality rates are estimated for five of the fisheries and the model is fit to the catch averaged over the first 5 years by fishery.
5) The model is fit to the swept area estimate of abundance with the catchability fixed at one because without this data the model cannot estimate reasonable values for absolute abundance.
6) The composition sample sizes are not reweighted.

C1.1. Summary of data used in the assessment

Data used in the assessment are only from north of Point Conception. Catch by fishery is shown in Table C1.6.1. and in Figures C1.6.1 and C1.6.2. The model is fit to indices of relative abundance based on standardized catch-per-unit-effort (CPUE) from CPFV log books, trawl logbook CPUE, the Bay Delta trawl survey, and to an estimate of absolute abundance based on a swept area trawl survey. The model is fit to retained catch length and weight composition data for the CPFV/charter boat and private/rental boat fisheries. Length composition data for the other recreational fisheries (shore-based fisheries) are not used because the sample sizes are small and the catch by those fisheries is small. Length composition data for only the bottom trawl commercial fisheries are used because the sample sizes are small for the other fisheries

and they are only available for a few years. Only one year of length composition data is used for the trawl fishery, but the selectivity is very different from the southern stock. The model is also fit to length composition data for the Bay Delta trawl survey and sex-specific age composition from the swept area trawl survey. A multinomial likelihood with the recorded sample sizes is used for the likelihood function. Years with sample sizes less than 20 fish were excluded from the analysis.

C2. Data

C2.1. CPFV logbook

Only data from CPFV trips that were considered to target California halibut based on expert judgment about associated species are used to create the index, which extends from 1980 to 2010. Data is also available prior to 1980, but lack detail to identify the target species. The catch of California halibut per angler hour for inshore blocks separated into north (Pigeon Point to Point Arena), central (Lopez Point to Pigeon Point), and south (Point Conception to Lopez Point). Sub-areas were standardized separately for the categorical variables year, month, and block using a delta-lognormal regression (Table C2.1.1, Figure C2.1.1). The combined year effect from the binomial and lognormal components of the regression was used as the index of relative abundance. A combined index was created as the average weighted by the number of blocks in each sub-area. This index is assumed proportional to the number of fish selected by the CPFV fishery. The index was used in the assessment model. The index is fit using a lognormal likelihood function with a standard deviation for the logarithm of the index set to 0.3 (approximately equivalent to a CV).

C2.2. Trawl logbook data

See the southern stock assessment for details. Depth was not used as an explanatory variable because categorizing the data by depth generated too many records for the software used to do the analysis. Jackknife estimates of uncertainty were not calculated due to the large size of the data set. This index was used in the assessment model (Table C2.2.1, Figure C2.2.1).

C2.3. San Francisco Bay Estuarine Complex (Bay Delta) Study

The Bay Delta Study (http://www.dfg.ca.gov/delta/projects.asp?ProjectID=BAYSTUDY) was established in 1980 to determine the effects of freshwater outflow on the abundance and distribution of fish and mobile crustaceans in the Bay Delta. The catch of California halibut (primarily young-of-the-year) per trawl was standardized for the categorical variables year and station using a delta-lognormal regression (Table C2.3.1, Figure C2.3.1). The combined year effect from the binomial and lognormal components of the regression was used as the index of

relative abundance. The data from three regions (West Delta, Sacramento River, and San Joaquin River) were eliminated from the analysis due to very low occurrence of California halibut. The survey has associated length composition data that can be used to estimate a selectivity curve to determine the component of the population it relates to. Standard errors were calculated using a jackknife procedure. This index was used in the assessment model.

C2.4. Length composition data

Length composition data is available from several sources. Commercial length composition by gear and sex come from the California Department of Fish and Game's (CDFG) State Finfish Management Project (2007-2010) database (Table C2.4.1, Figure C2.4.1). Some data is not available by sex. Recreational length composition data of the retained catch comes from the Recreational Fisheries Information Network (RecFIN) (1993-2010) databases (Table C2.4.2, Figure C2.4.2). Weight frequency data is available for 1980-1989 from the RecFIN database. Length composition data is also available for the Bay Delta trawl survey (Table C2.4.2, Figure C2.4.3) .

C2.5. Age composition data

Sex-specific age composition data is available for the swept area survey and is used in the model to estimate the selectivity for this survey (Table C2.5.1).

C2.6. Age conditioned on length data

Length-at-age data is available for the swept area trawl survey (MacNair et al. 2001) and for fish collected from the commercial fisheries (Reilly and Tanaka pers com). These data were used in the model as age conditioned on length to provide information on growth and variation of length-at-age.

C3. Results

C3.1. Model fit

The stock assessment model provides reasonable fits to the CPFV index of relative abundance (Figure C3.1.1a) and the recreational fisheries length composition data (Appendix). The commercial fisheries length composition data are highly variable and the commercial fishery selectivities are fixed based on the southern stock assessment (except for bottom trawl), therefore the fit to the composition data for these fisheries is poor for some fisheries (Appendix). The root mean square error (RMSE) (0.35) of the fit to the CPFV index is higher

(Table C3.1.2) than the assumed standard error (SE) for this index (0.3). The fit to the other indices is worse in terms of RMSE (Table C3.1.2), but their trends are generally consistent (Figures C3.1.1b and c). The effective sample sizes for the length composition data are all smaller than the input sample size (Table C3.1.1). The model fits the age-length data reasonably well (Figure C3.2.5). The stock assessment model's biomass estimate of 832 metric tons (mt) is larger than the swept area trawl survey biomass estimate of 707 mt.

The model had difficulty converging and was sensitive to starting values and phases of parameter estimation.

C3.2. Estimates

The stock is estimated to have increased rapidly starting in 1995 (Figure C3.2.1). The increase in abundance is due to large recruitments, which appear to occur in a cyclic pattern, and the magnitude of the cycles increased after 1990 (Figure C3.2.2).

The estimated selectivity curve for the recreational fisheries appears reasonable (Figure C3.2.4), but differs somewhat from that estimated for the southern stock. The estimated male selectivity curve for the bottom trawl fishery is somewhat unusual (Figure C3.2.4b).

C3.3. Management quantities

The population is estimated to be well above the biomass associated with maximum sustainable yield (Bmsy) and fishing mortality is well below the fishing mortality rate associated with maximum sustainable yield (Fmsy) either using the estimated MSY quantities or the 25% proxy (Table C3.3.1; Figure C3.3.1).

C3.4. Sensitivity analyses

No sensitivity analyses were carried out with the updated data.

C3.5. Discussion

The stock assessment results are consistent with the data. The estimated abundance trend is consistent with the trends in the indices of abundance. The model is only able to provide reasonable estimates of the absolute abundance if the swept area trawl survey estimate of absolute abundance is used in the model. However, the trends in abundance are robust and follow from the recruitment estimates. These results suggest the stock abundance is driven by recruitment, which is probably environmentally driven, and fishing is not currently a major factor in controlling the abundance level.

Tables

Table C1.6.1. Catch for each of the fisheries used in the assessment. Catch is in kg except for the recreational fisheries, which are in number of fish.(Comm = commercial; Rec = recreational)

Year	Comm bottom trawl	Comm single rigged trawl	Comm trawl with footrope < 8 inches	Comm hook and line	Comm gill net	Rec CPFV	Other recreational
1980	0	0	0	4,396	74,937	4,057	7,148
1981	0	0	0	5,485	123,326	270	4,423
1982	123,300	119	0	19,155	154,646	1,403	12,234
1983	159,167	1,206	0	11,986	92,791	2,906	10,835
1984	84,365	1,861	0	3,362	91,759	949	4,438
1985	56,159	444	0	9,152	128,118	896	2,416
1986	66,531	152	0	18,203	139,665	396	4,931
1987	82,020	12	0	17,900	114,393	2,192	22,448
1988	143,390	0	0	12,845	49,497	616	19,289
1989	115,789	0	0	57,133	108,685	529	9,076
1990	81,860	0	0	35,484	58,490	779	5,328
1991	142,446	0	0	31,772	31,014	666	4,554
1992	190,832	0	0	35,030	12,550	1,522	10,409
1993	151,727	50	0	33,974	8,130	0	31,070
1994	94,188	365	0	48,112	12,431	0	51,907
1995	122,948	792	0	69,269	23,264	0	267,007
1996	158,251	1,958	0	62,921	34,071	3,177	83,613
1997	293,311	1,321	0	65,024	67,524	1,657	44,678
1998	270,559	2,763	0	51,702	43,638	2,789	41,086
1999	239,640	483	176	47,179	67,992	1,333	23,429
2000	89,095	3,126	31,825	36,690	21,592	11,754	47,387
2001	67,522	5,440	54,212	42,608	12,583	10,111	90,903
2002	46,510	1,527	95,700	56,047	9,041	5,708	117,708
2003	55,715	6,676	73,587	83,669	5,429	7,638	99,499
2004	84,179	16,256	135,976	61,543	2,416	3,445	13,907
2005	39,566	13,353	228,151	45,846	2,648	5,423	16,625
2006	8,655	12,621	173,187	26,407	3,992	296	15,648
2007	3,500	379	50,317	19,271	3,441	3,590	11,713
2008	2,904	0	49,488	52,481	588	11,653	42,941
2009	10,914	8,215	80,017	59,986	133	6,626	37,652
2010	16,038	7,877	61,559	46,889	49	5,413	17,081

Table C2.1.1. Indices of relative abundance for the CPFV logbook data Sub-areas were standardized separately for the categorical variables year, month, and block using a delta-lognormal regression . The combined year effect from the binomial and lognormal components of the regression was used as the index of relative abundance.

	North (31 blocks)		Central (16 blocks)		South (20 blocks)		Combined
Year	Index	Obs	Index	Obs	Index	Obs	Index
1980	0.04211	171		1	0.016354	12	0.03201
1981	0.043015	304		4	0.019191	11	0.033672
1982	0.040673	302		3	0.038948	3	0.039997
1983	0.032612	431			0.011899	13	0.024489
1984	0.018461	337	0.032283	1	0.015768	16	0.020958
1985	0.019972	290	0.069428	1	0.016564	22	0.030765
1986	0.028487	342	0.034097	33	0.010553	29	0.024473
1987	0.020075	314	0.020569	14	0.018631	24	0.019762
1988	0.019972	306	0.024009	21	0.034382	33	0.025237
1989	0.024359	156	0.032291	21	0.053697	84	0.035011
1990	0.025289	212	0.018412	19	0.045728	71	0.029748
1991	0.024012	217	0.030454	15	0.023228	57	0.025316
1992	0.033869	304	0.046852	27	0.026565	79	0.034789
1993	0.035134	180	0.036202	16	0.022069	51	0.031489
1994	0.051983	294	0.039799	21	0.024814	59	0.040963
1995	0.074953	565	0.037184	16	0.023098	49	0.050454
1996	0.078742	912	0.082046	7	0.026502	39	0.063937
1997	0.05969	630	0.056769	18	0.01559	39	0.045829
1998	0.048823	906	0.031681	12	0.020247	39	0.036199
1999	0.039988	667	0.067272	43	0.013602	29	0.038627
2000	0.037415	863	0.052554	75	0.01462	53	0.034226
2001	0.050125	969	0.103309	122	0.024532	21	0.055186
2002	0.059647	825	0.040965	52	0.016092	21	0.042184
2003	0.06466	830	0.079167	87	0.013084	24	0.052729
2004	0.037941	510	0.08573	53	0.020156	49	0.044045
2005	0.032745	487	0.068603	32	0.012583	11	0.035289
2006	0.040895	438	0.056673	27	0.014903	10	0.036904
2007	0.035081	511	0.07059	12	0.009702	11	0.035985
2008	0.097407	1147	0.074059	15	0.051792	4	0.078215
2009	0.075961	1087	0.070474	28	0.008455	14	0.054499
2010	0.048034	779	0.077621	26	0.009093	10	0.043475

Table C2.2.1. Index of relative abundance for the trawl logbook data. Catch of California halibut per tow from the trawl logbook were standardized using the categorical variables year, month, and block using a delta-lognormal regression. The data were aggregated by these categories for analysis. The data was limited to trips that caught California halibut and/or species associated with California halibut (based on expert opinion).

Year	Value	Records	Year	Value	Records	Year	Value	Records
1980	NA	17	1990	0.014928	1050	2000	0.026356	919
1981	0.013732	1140	1991	0.018283	1110	2001	0.04385	913
1982	0.01626	1170	1992	0.021501	1148	2002	0.019049	833
1983	0.035055	1122	1993	0.031341	1116	2003	0.02278	766
1984	0.012106	1017	1994	0.031503	1075	2004	0.047837	647
1985	0.006249	1125	1995	0.07465	1068	2005	0.044951	630
1986	0.016498	1116	1996	0.082036	1138	2006	0.036874	620
1987	0.009477	1026	1997	0.061686	1321	2007	0.005095	624
1988	0.011007	1067	1998	0.10178	1121	2008	0.012863	642
1989	0.010145	1128	1999	0.054556	1057			

Table C2.3.1. Index of relative abundance for the Bay Delta Study.

Year	Value	CV	Year	Value	CV	Year	Value	CV
1980	0.139475	0.390538	1990	0.610589	0.216796	2000	1.789739	0.130929
1981	0.137945	0.365893	1991	0.991783	0.183	2001	0.72248	0.215699
1982	0.150038	0.373409	1992	1.49521	0.168135	2002	0.532378	0.257612
1983	0.141367	0.387906	1993	5.251172	0.109299	2003	0.345227	0.272975
1984	0.309449	0.278367	1994	2.412884	0.140306	2004	0.54411	0.228041
1985	0.547773	0.212229	1995	1.57715	0.145671	2005	3.119688	0.133646
1986	0.510471	0.225285	1996	0.596945	0.20528	2006	4.773427	0.118914
1987	0.524927	0.219851	1997	0.465569	0.222999	2007	1.959884	0.13709
1988	0.279271	0.259298	1998	2.807679	0.155505	2008	0.923466	0.177272
1989	0.200589	0.374596	1999	5.587436	0.113545			

Table C2.4.1. Number of fish sampled for commercial length composition data.

	Bottom trawl		Hook and line		Single rigged trawl		Trawl with footrope diameter < 8 inches	
Year	Sex combined	Sex specific	Sex combined	Sex specific	Sex combined	Sex specific	Sex combined	Sex specific
2007	16	151	2	2	1	29	9	97
2008			40	112			23	195
2009				29			16	
2010				3				

Table C2.4.2. Number of fish sampled for recreational and Bay Delta Study length and weight composition data.

	Length			Weight	
Year	CPFV	Other recreational	Bay study	CPFV	Other recreational
1980			9	6	17
1981			9	1	9
1982			9		26
1983			7	2	28
1984			21	7	10
1985			32	6	8
1986			31	3	11
1987			29	12	35
1988			19	1	15
1989			8	3	20
1990			28		
1991			42		
1992			62		
1993		126	230		
1994	3	246	109		
1995	158	428	89		
1996	67	523	49		
1997	17	165	37		
1998	29	189	212		
1999	18	136	321		
2000	48	246	126		
2001	90	291	38		
2002	82	326	24		
2003	147		17		
2004	96	824	26		
2005	43	891	168		
2006	35	1026	251		
2007	86	806	109		
2008	210	2501	50		
2009	105	2529			
2010	30	1161			

Table C2.5.1. Sex-specific numbers at age sampled in the swept area trawl survey.

Age	Female	Male
1	0	0
2	12	15
3	46	46
4	35	26
5	17	9
6	4	20
7	2	13
8	5	13
9	7	3
10	1	1
11	0	1
12	2	0
13	0	0

Table C3.1.1. Input and effective samples sizes (number of fish measured) for the length composition data.

Fleet	mean_effN	mean(inputN*Adj)	HarMean(effN)	Mean(effN/inputN)	MeaneffN/ MeaninputN
BT	148	151	148	0.98	0.98
HL	19	60	19	0.42	0.31
SRT	22	29	22	0.76	0.76
TF	60	105	24	0.59	0.57
CPFV	63	88	49	0.81	0.72
RecOther	411	730	241	0.70	0.56
BayStudy	46	88	18	0.59	0.53

Table C3.1.2. Root mean square error of the fit to the indices of relative abundance.

Fleet	RMSE
BT	0.52
CPFV	0.35
BayStudy	0.61
SweptArea	0.16

Table C3.3.1. Management quantities. MSY is the maximum sustainable yield in metric tons. B2011 is the spawning biomass at the start of 2011. B0 is the average spawning biomass in the absence of fishing (virgin spawning biomass). Bmsy is the spawning biomass corresponding to MSY. Fmult is the multiplier on the current fishing mortality (fishing effort) that would produce maximum sustainable yield.

	Base Model
MSY (mt)	950
B2011/B0	1.22
Bmsy/B0	0.12
B2011/Bmsy	10.21
Fmult	36.76

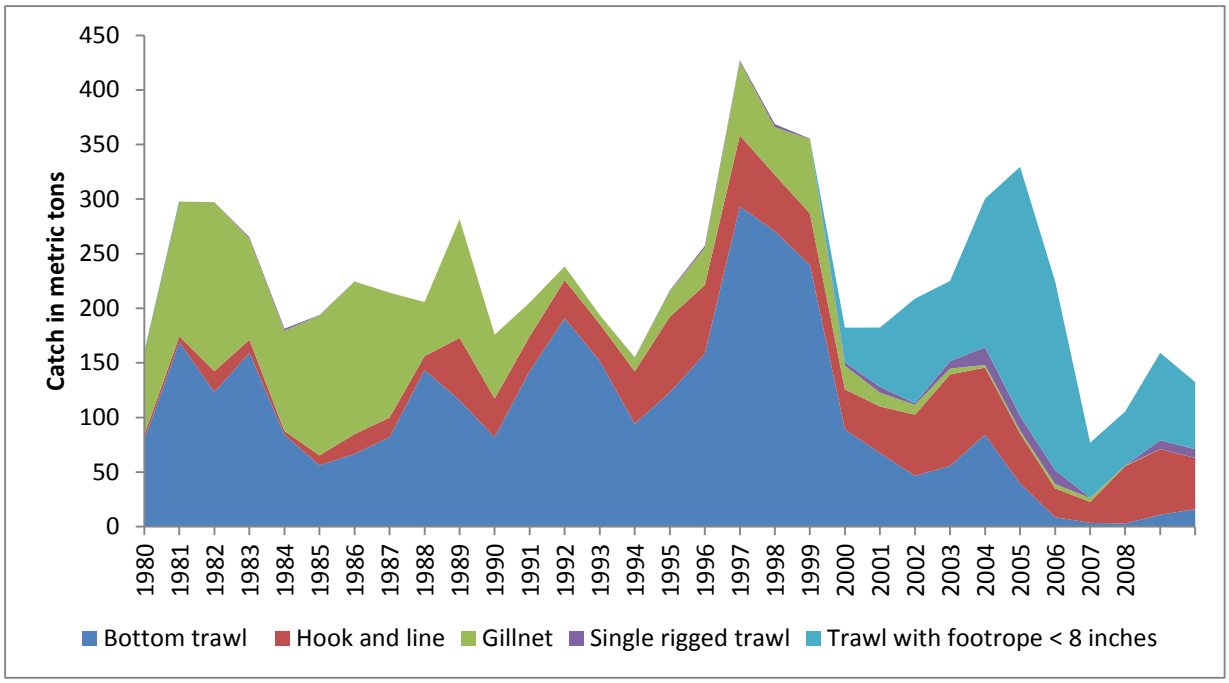


Figure C1.6.1. Commercial catch north of Point Conception in metric tons by gear type.

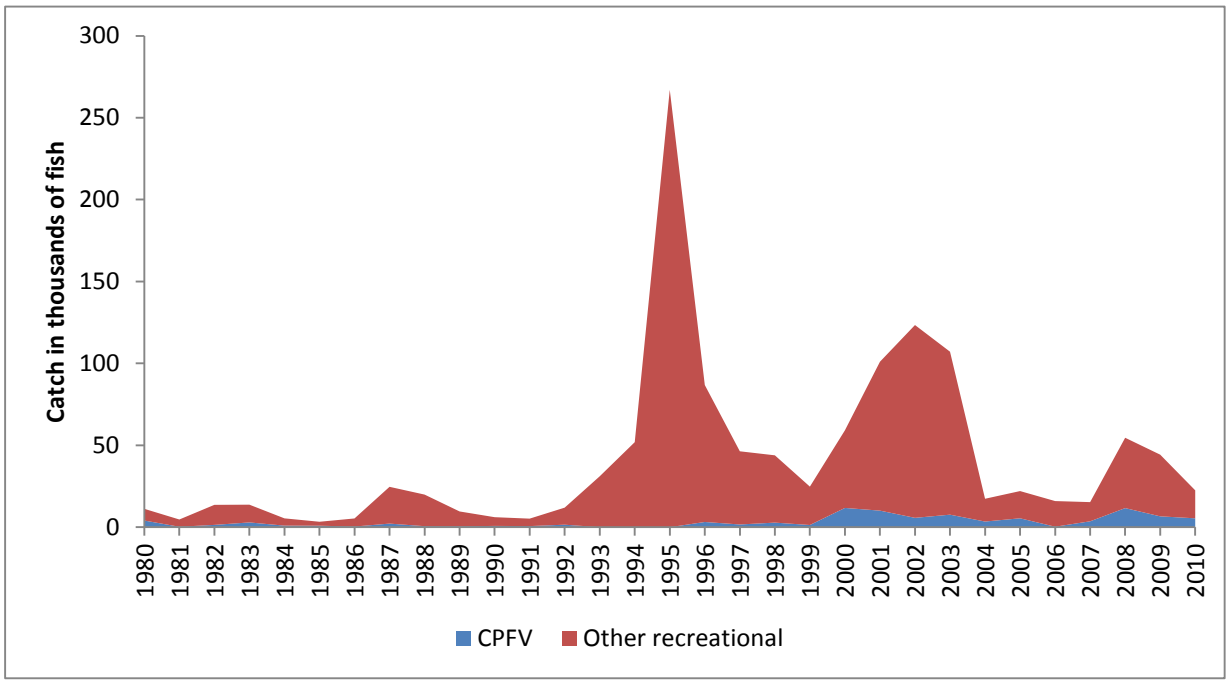


Figure C1.6.2. Recreational catch north of Point Conception by fishing mode in thousands of fish.

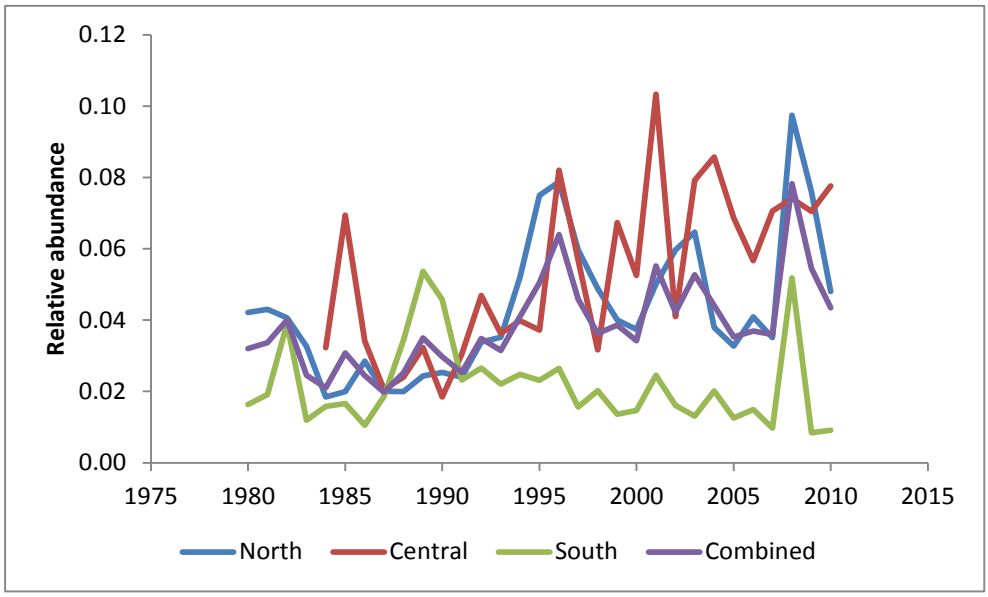


Figure C2.1.1. Index of relative abundance for the CPFV logbook data for three sub-areas north of Point Conception.

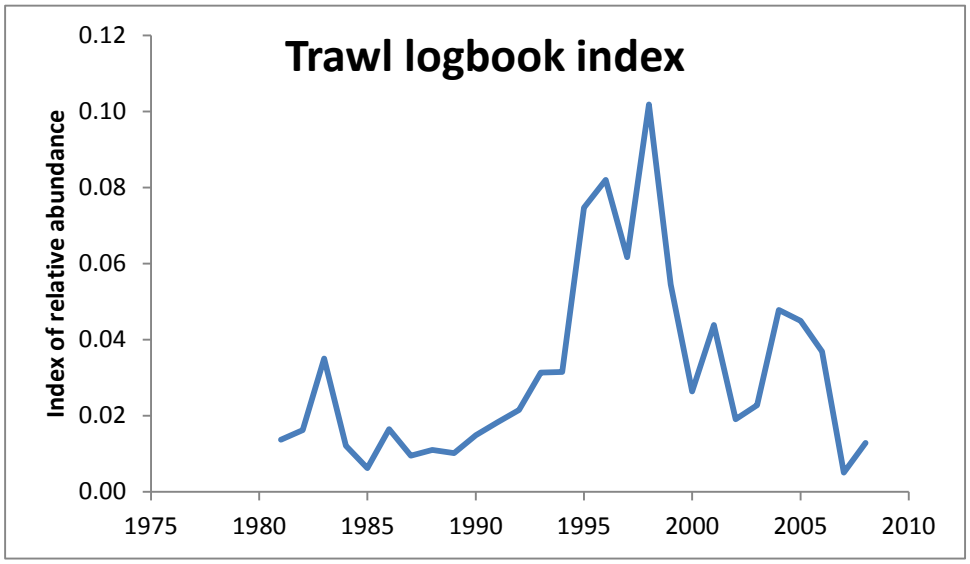


Figure C2.2.1. Index of relative abundance for the trawl logbook data north of Point Conception.

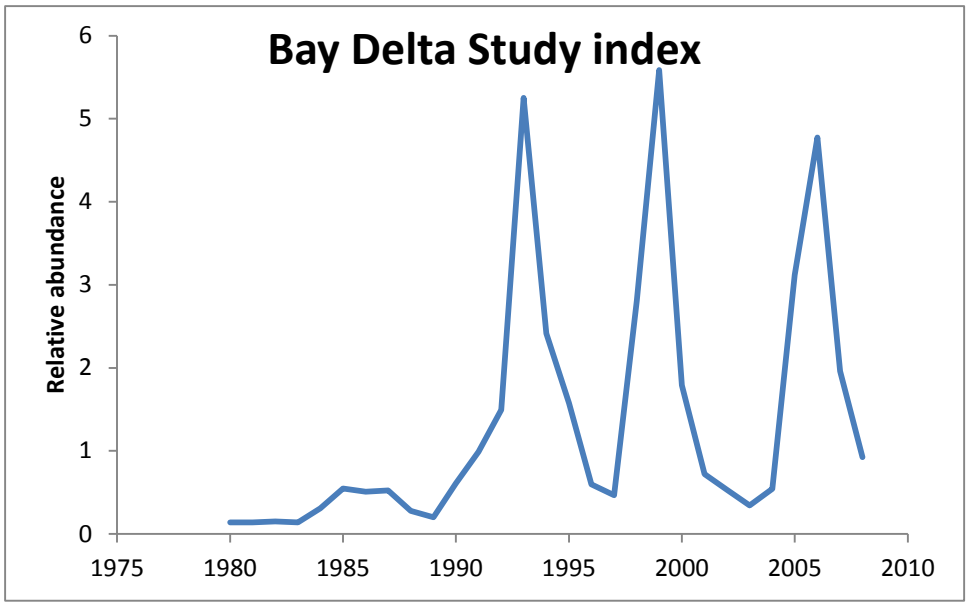


Figure C2.3.1. Index of relative abundance for the Bay Delta Study data.

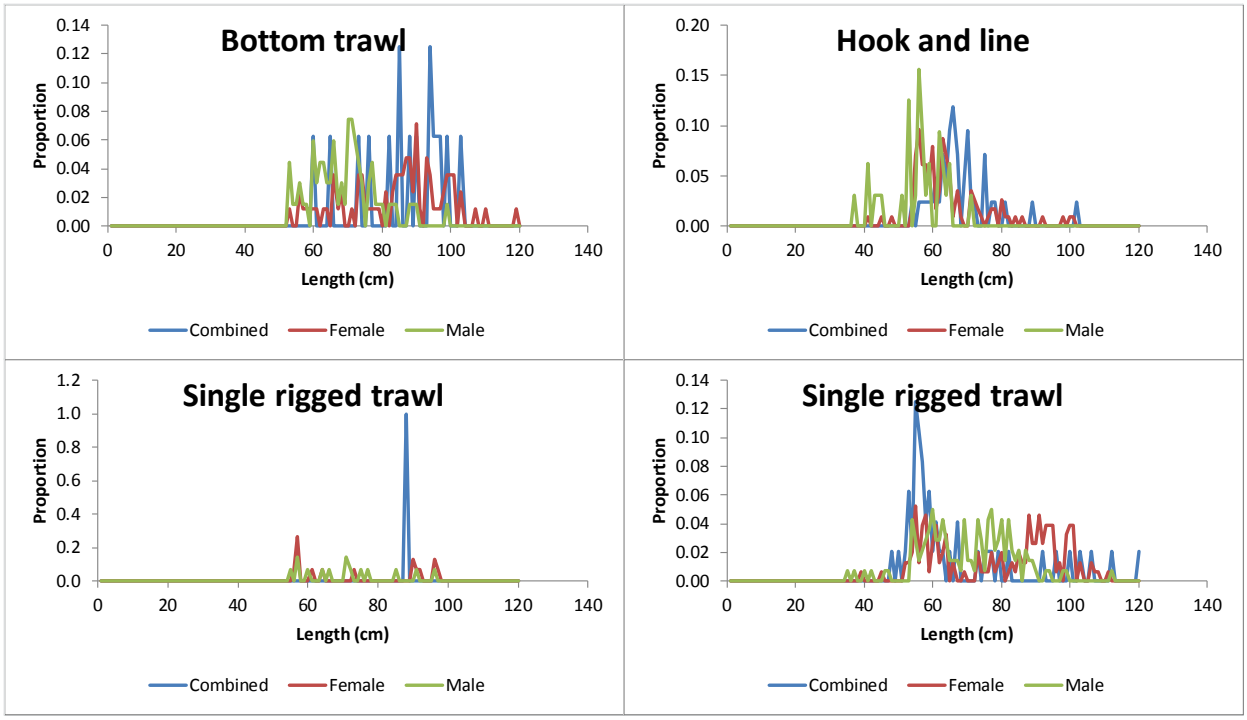


Figure C2.4.1. Commercial fishery average length compositions. (note years differ among fisheries and data types. Male and female data not included in combined and don not sum to one together)

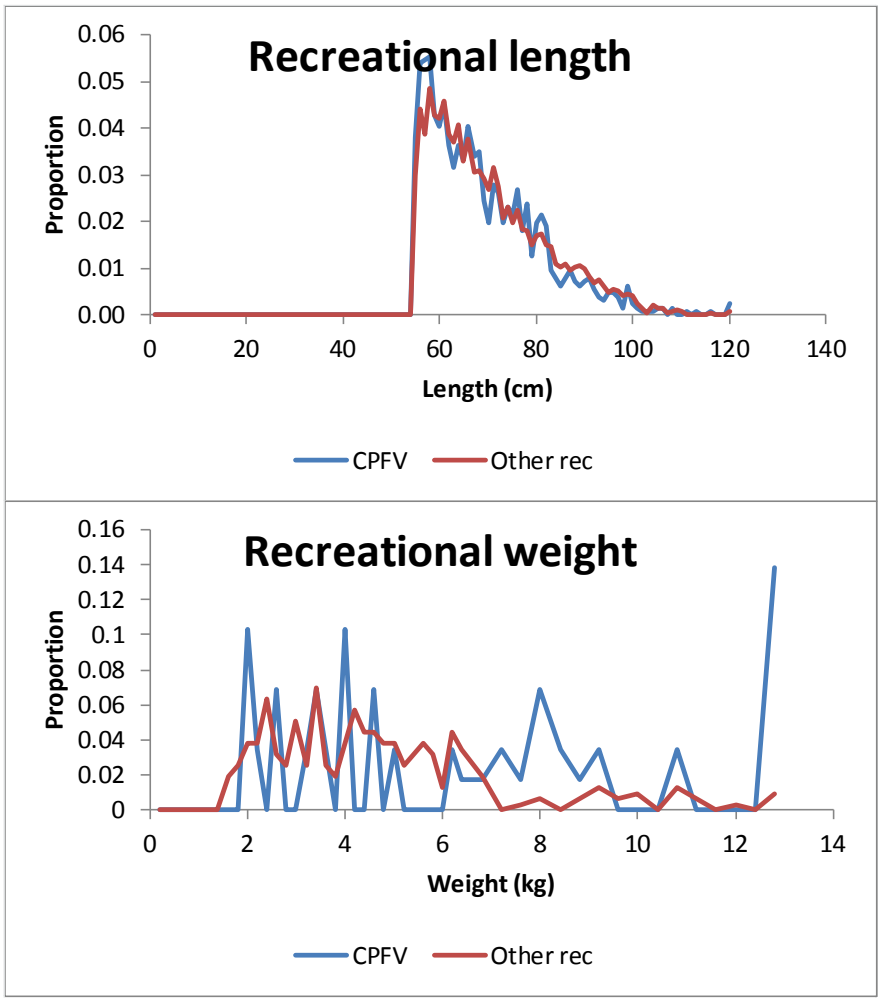


Figure C2.4.2. Recreational fishery average length and weight compositions. (note years differ among fisheries and data types)

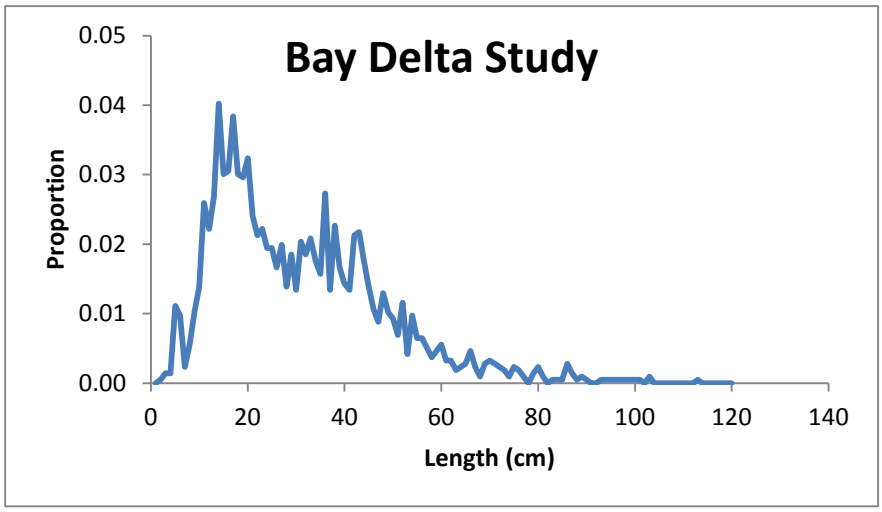


Figure C2.4.3. Bay Delta Study average length compositions. (note years differ among fisheries and data types and fish smaller than 10 cm are grouped at 10 cm.

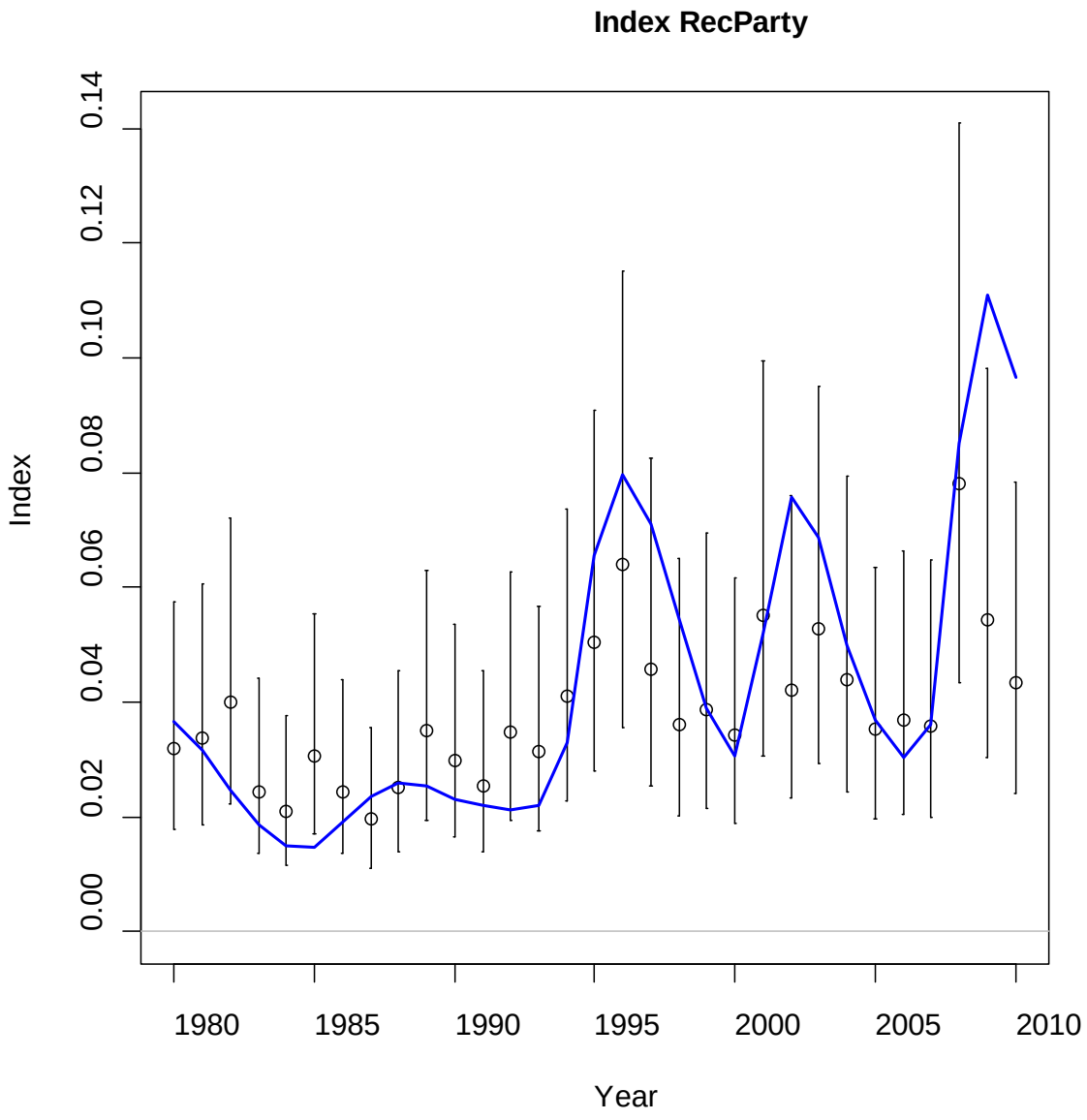


Figure C3.1.1a. Fit of the model to the CPFV index of relative abundance.

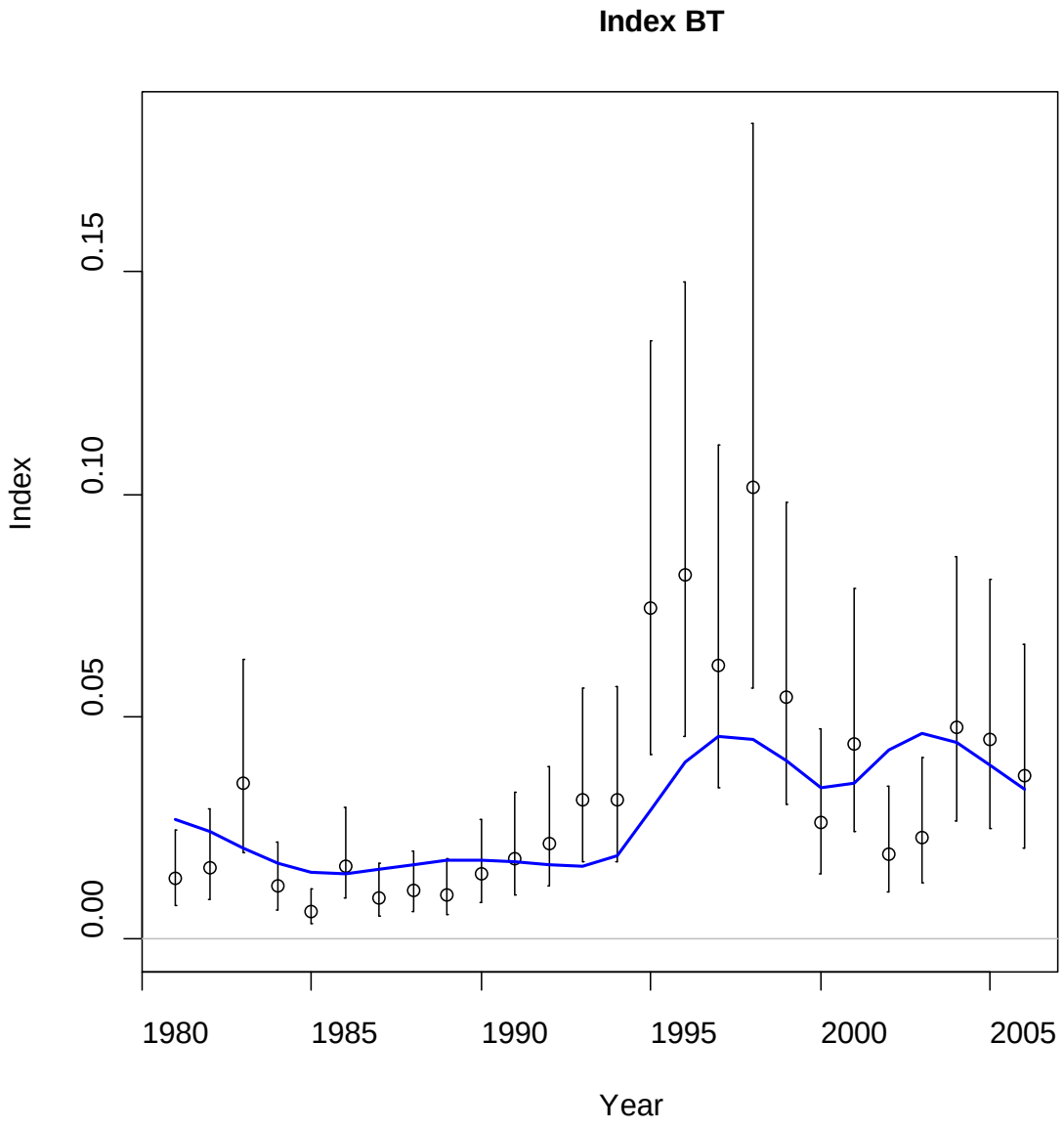


Figure C3.1.1b. Fit of the model to the trawl logbook index of relative abundance

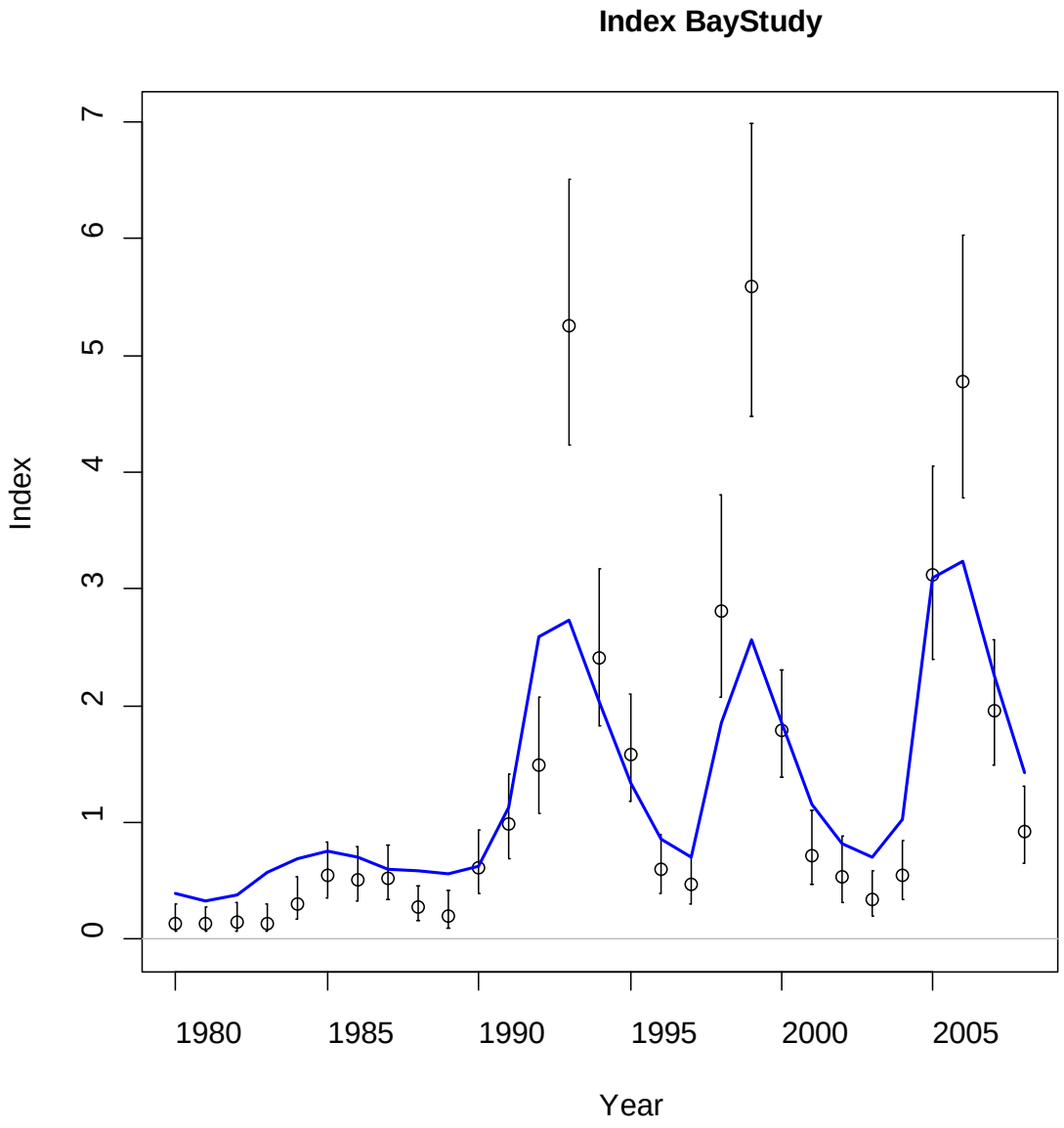


Figure C3.1.1c. Fit of the model to the Bay Delta Study index of relative abundance .

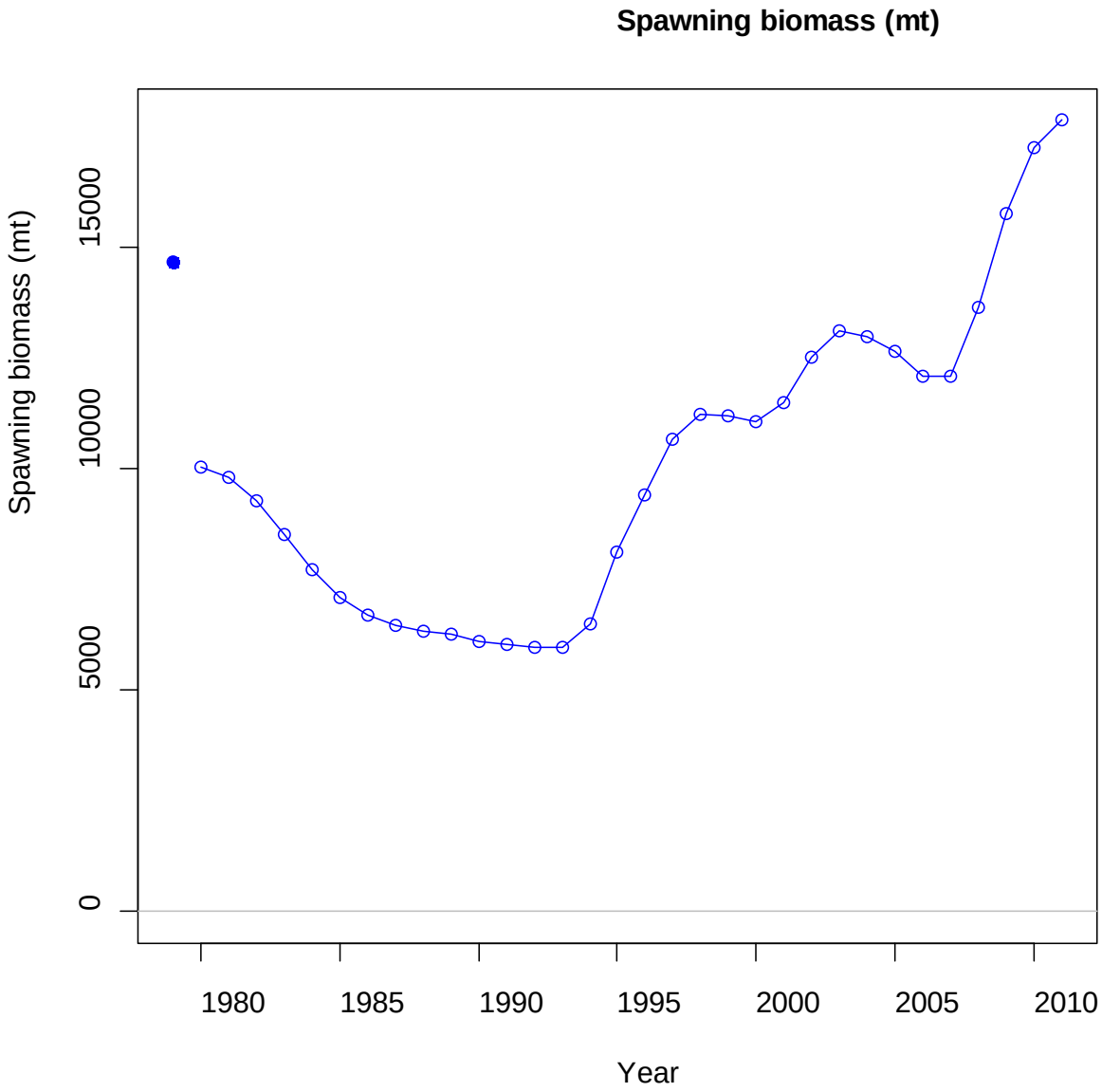


Figure C3.2.1. Estimated spawning biomass.

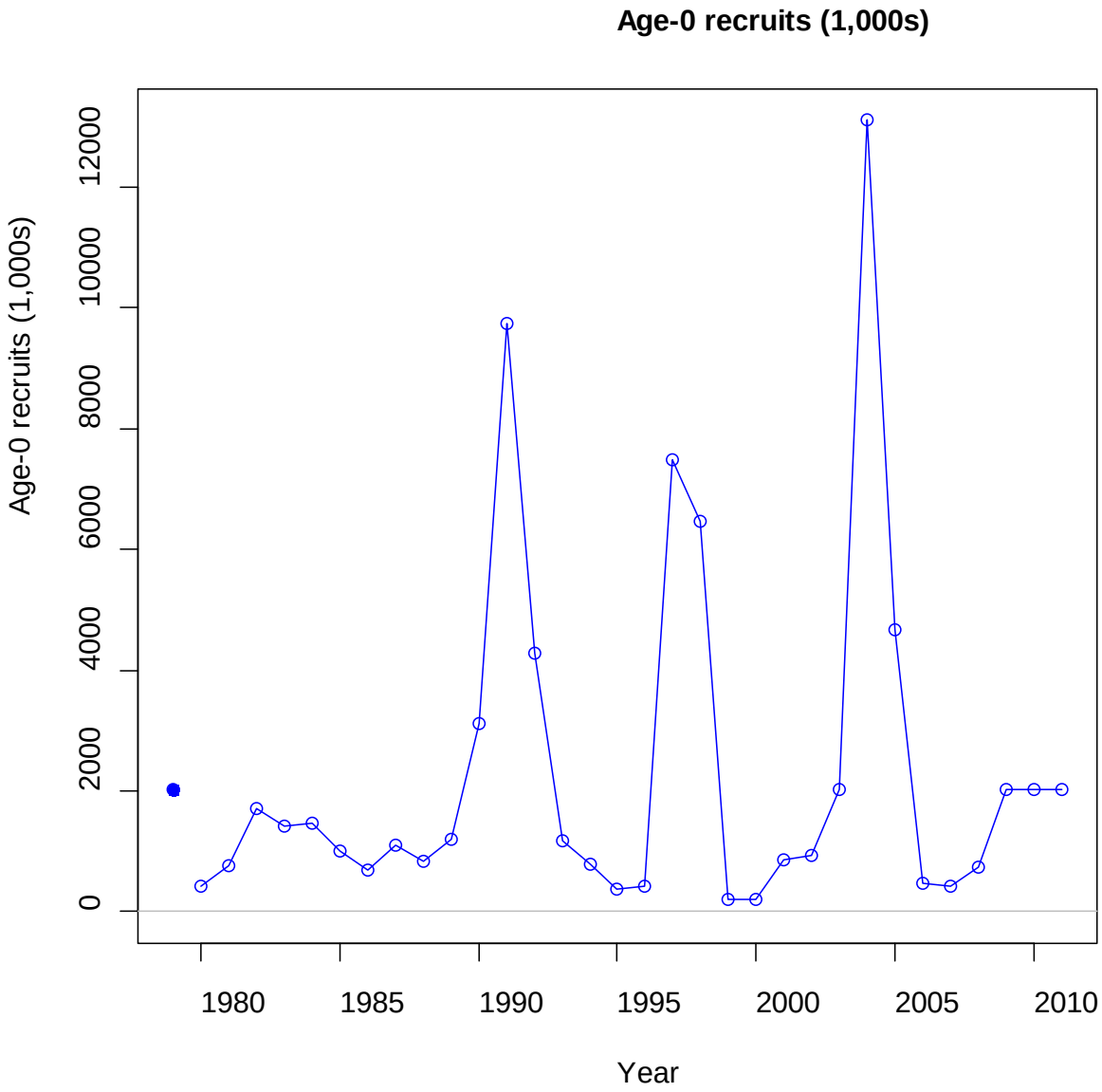


Figure C3.2.2. Recruitment estimates

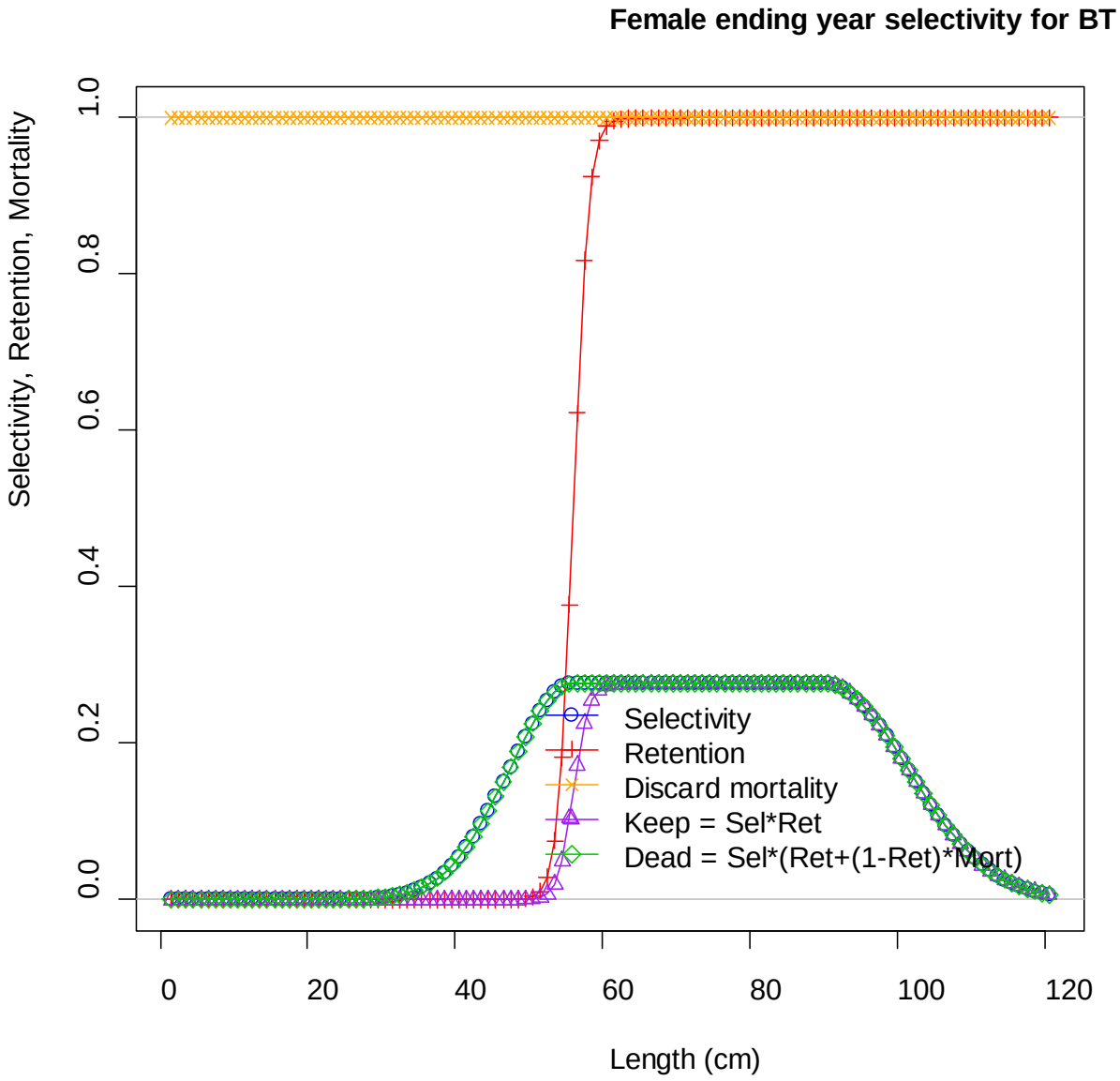


Figure C3.2.4a. Bottom trawl (BT) female selectivity.

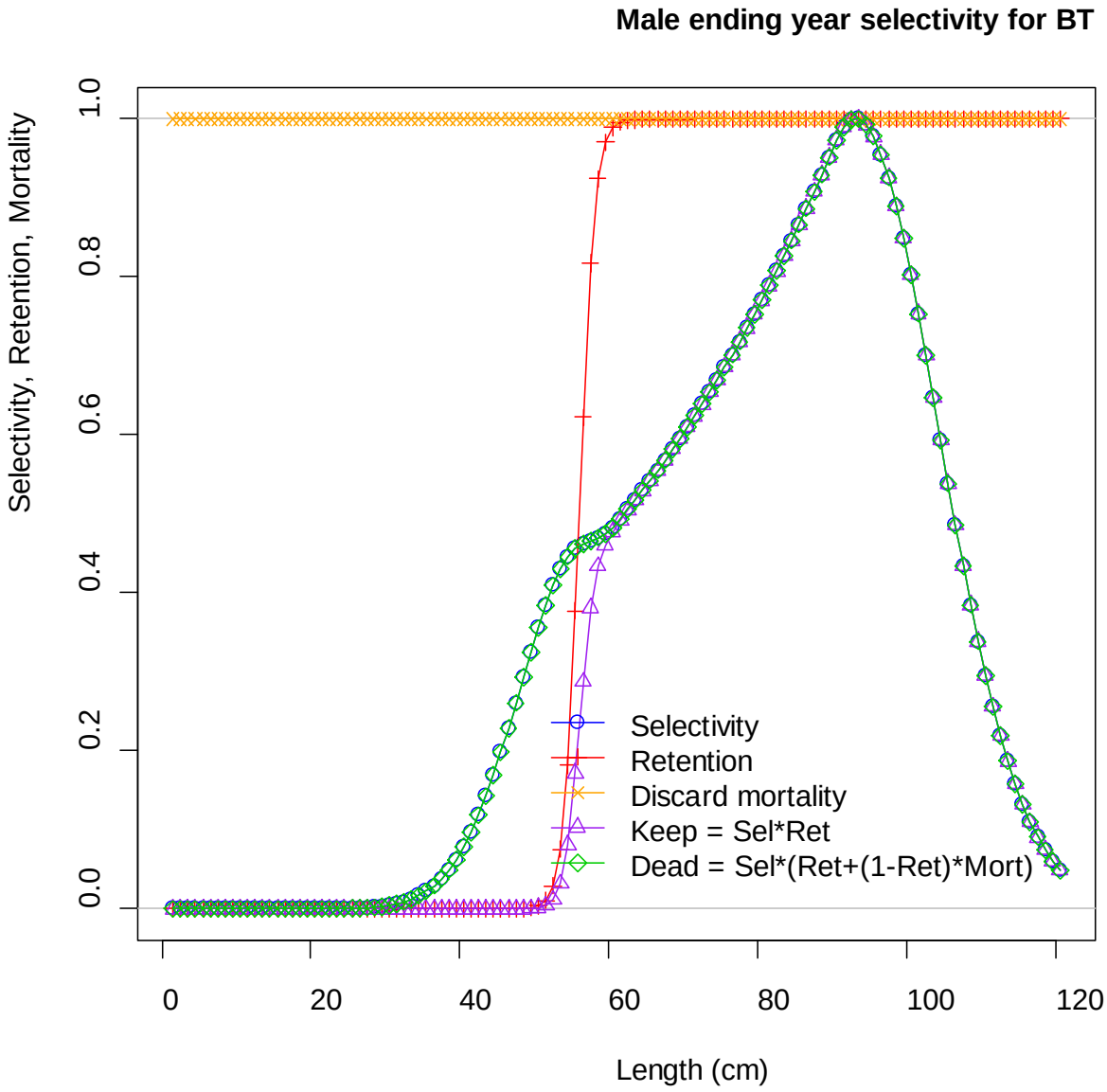


Figure C3.2.4b. Bottom trawl (BT) male selectivity.

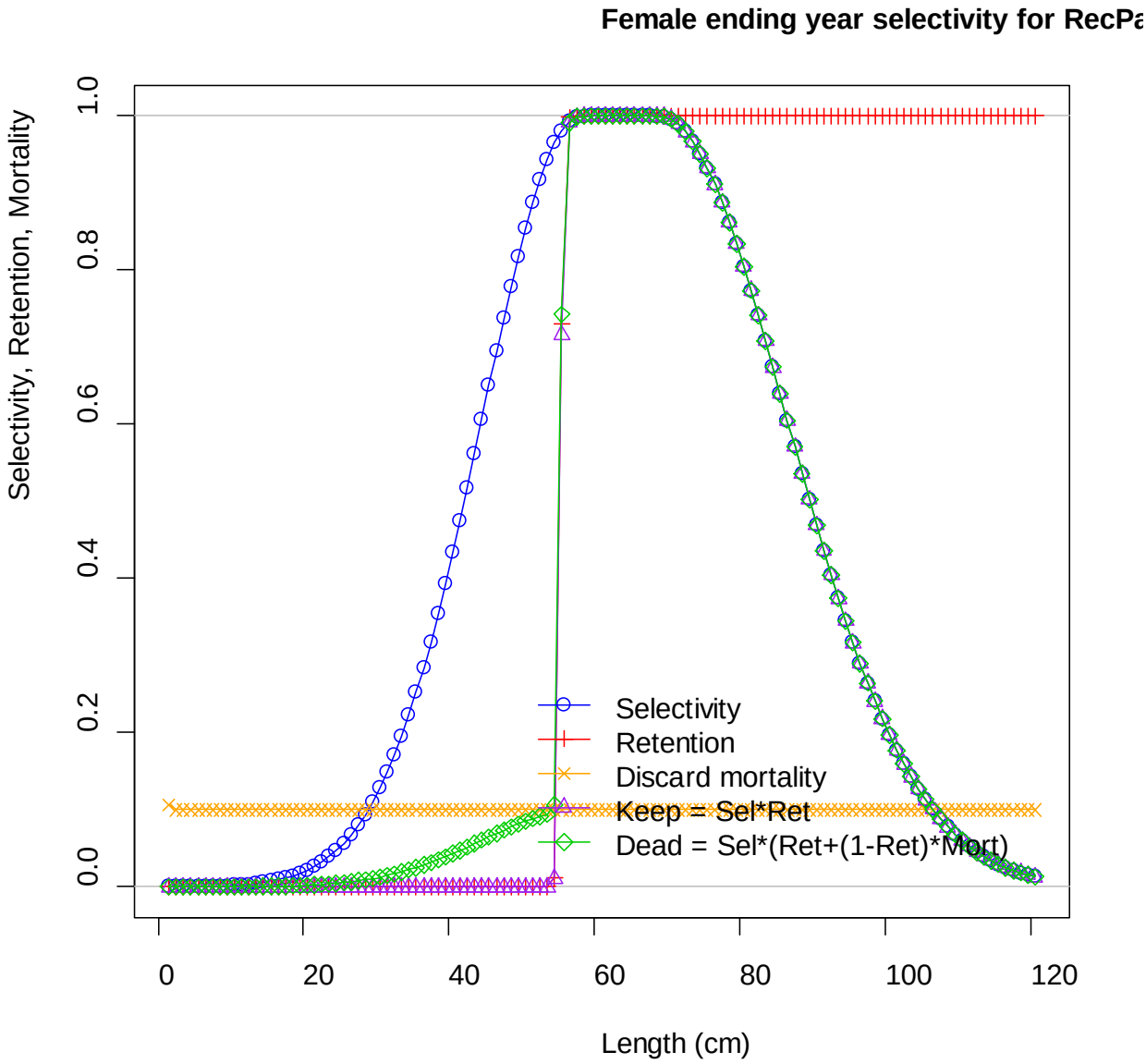


Figure C3.2.4c. CPFV female selectivity. (Also used for the "other" (non-CPFV) recreational fishery)

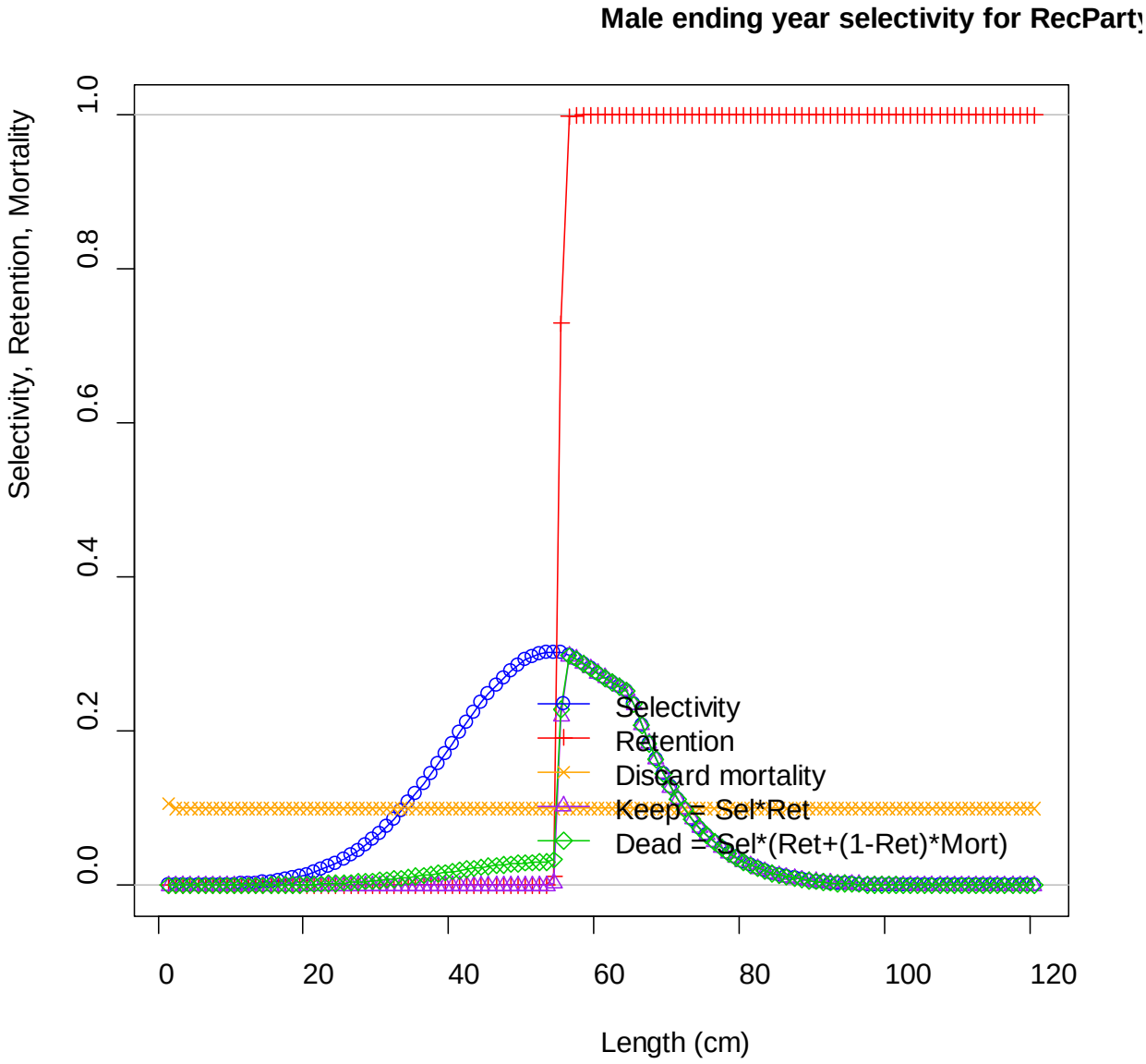


Figure C3.2.4f. CPFV male selectivity. (Also used for the other recreational fishery)

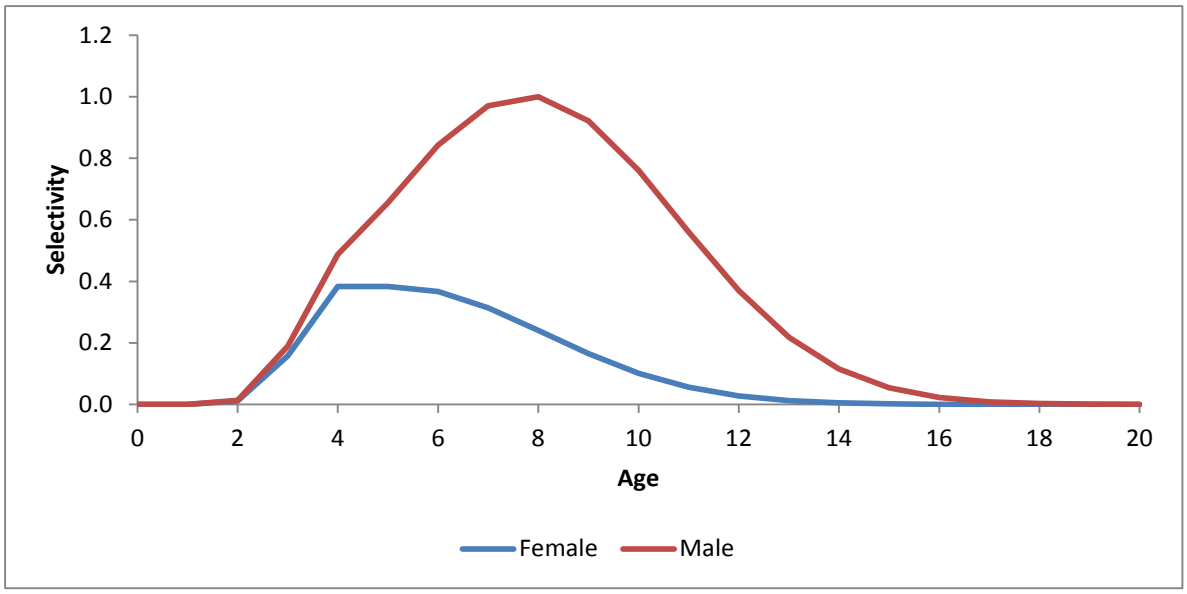


Figure C3.2.4g. Swept area trawl survey selectivity. Age is in years.

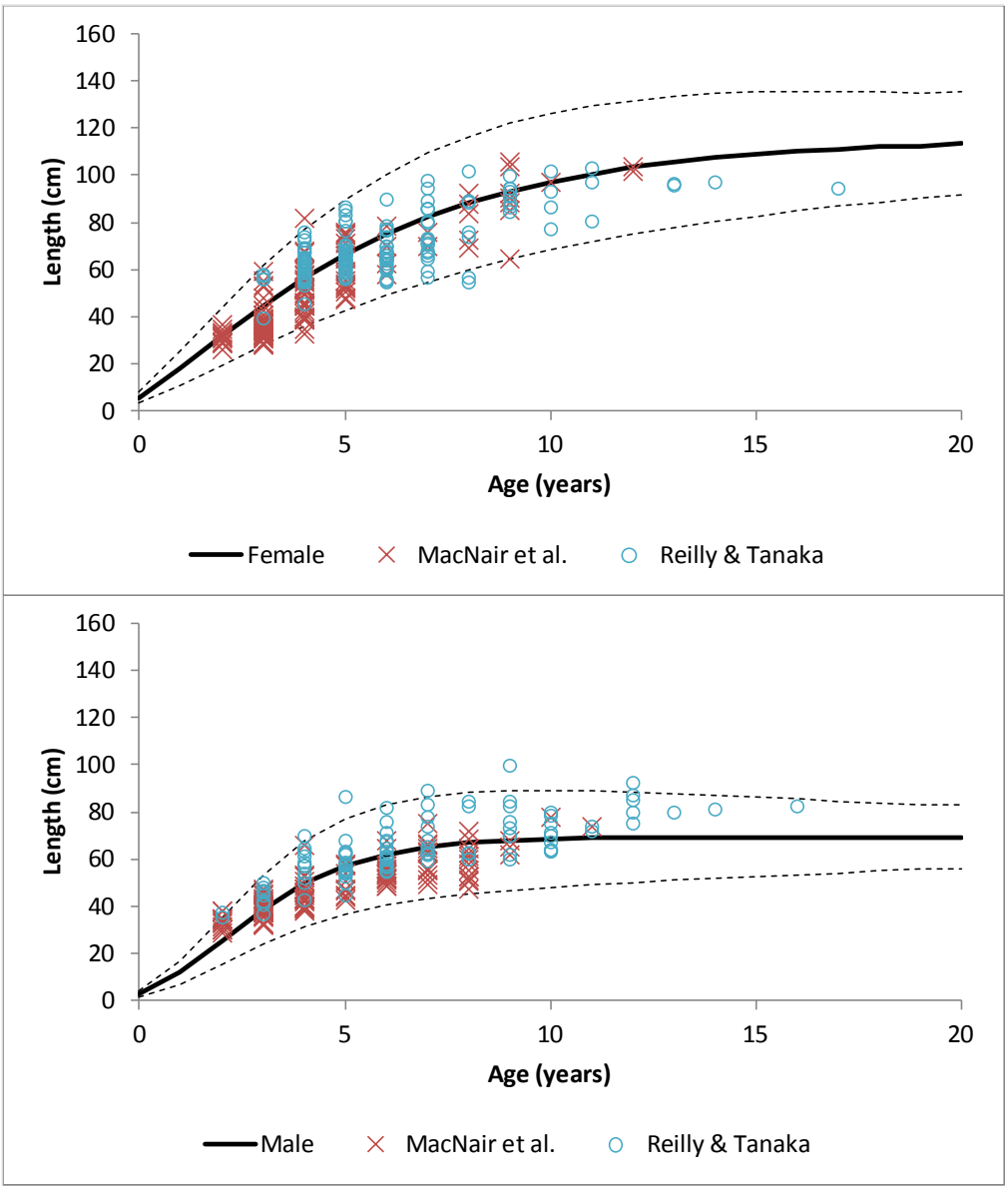
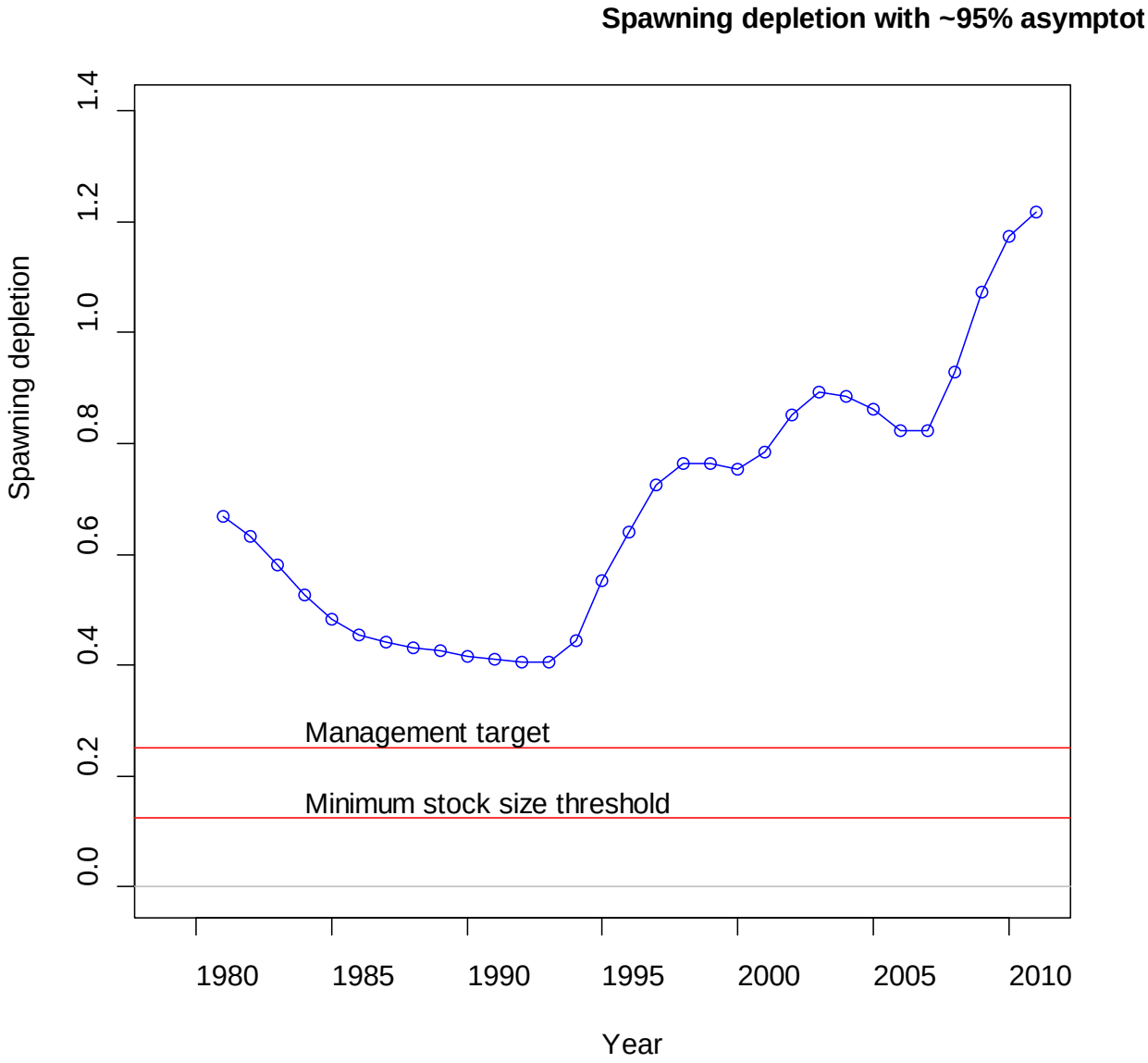
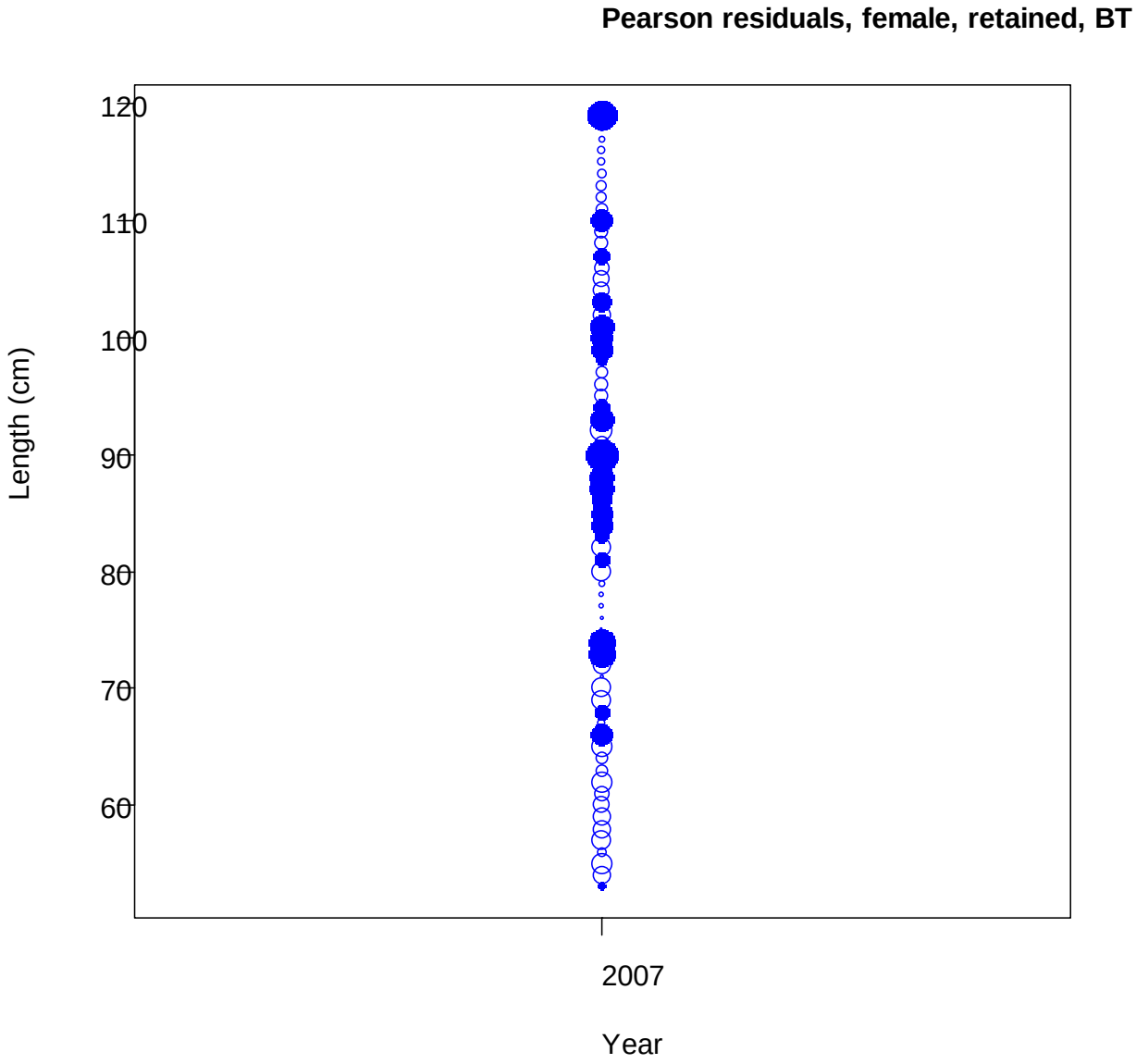
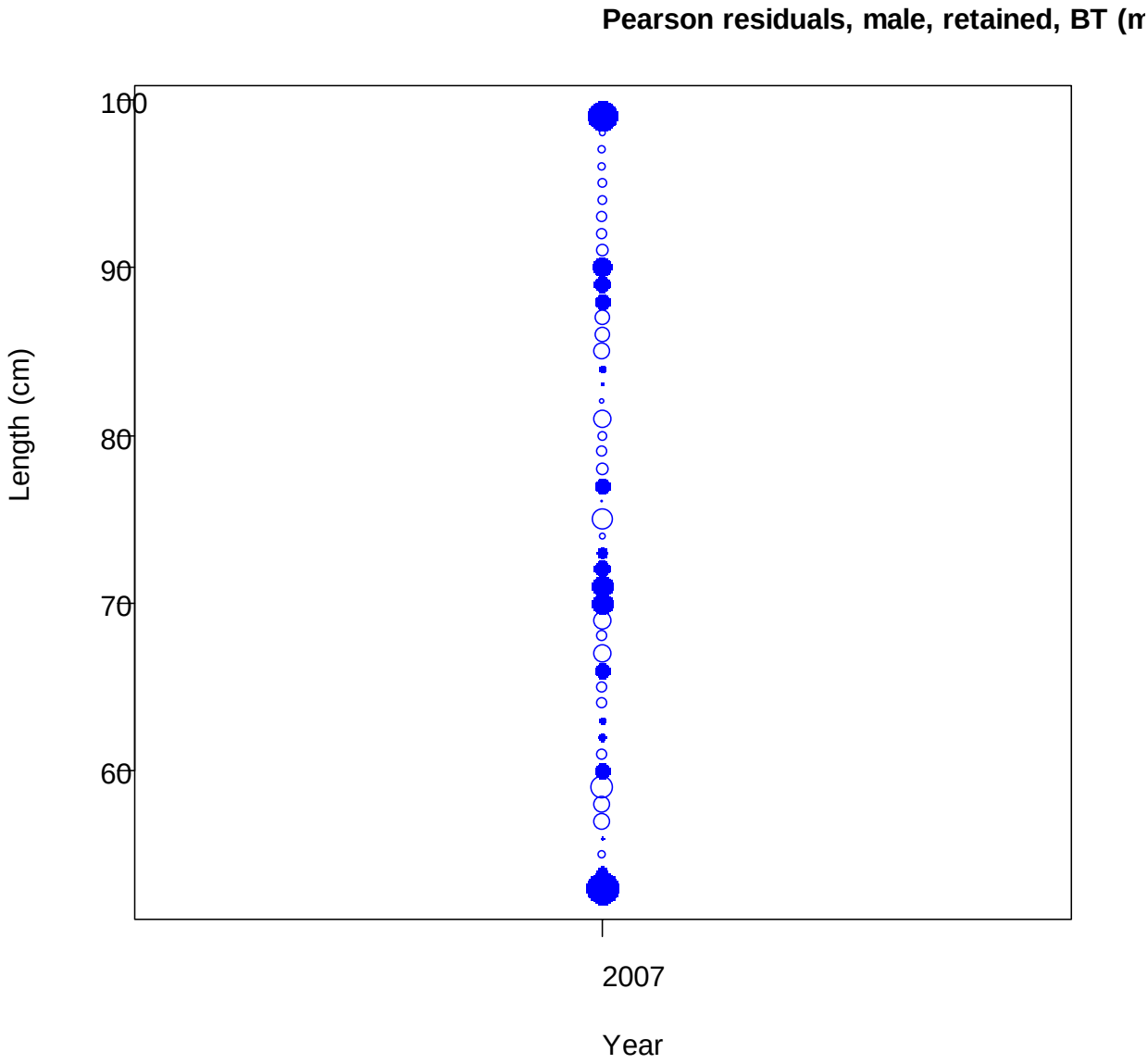


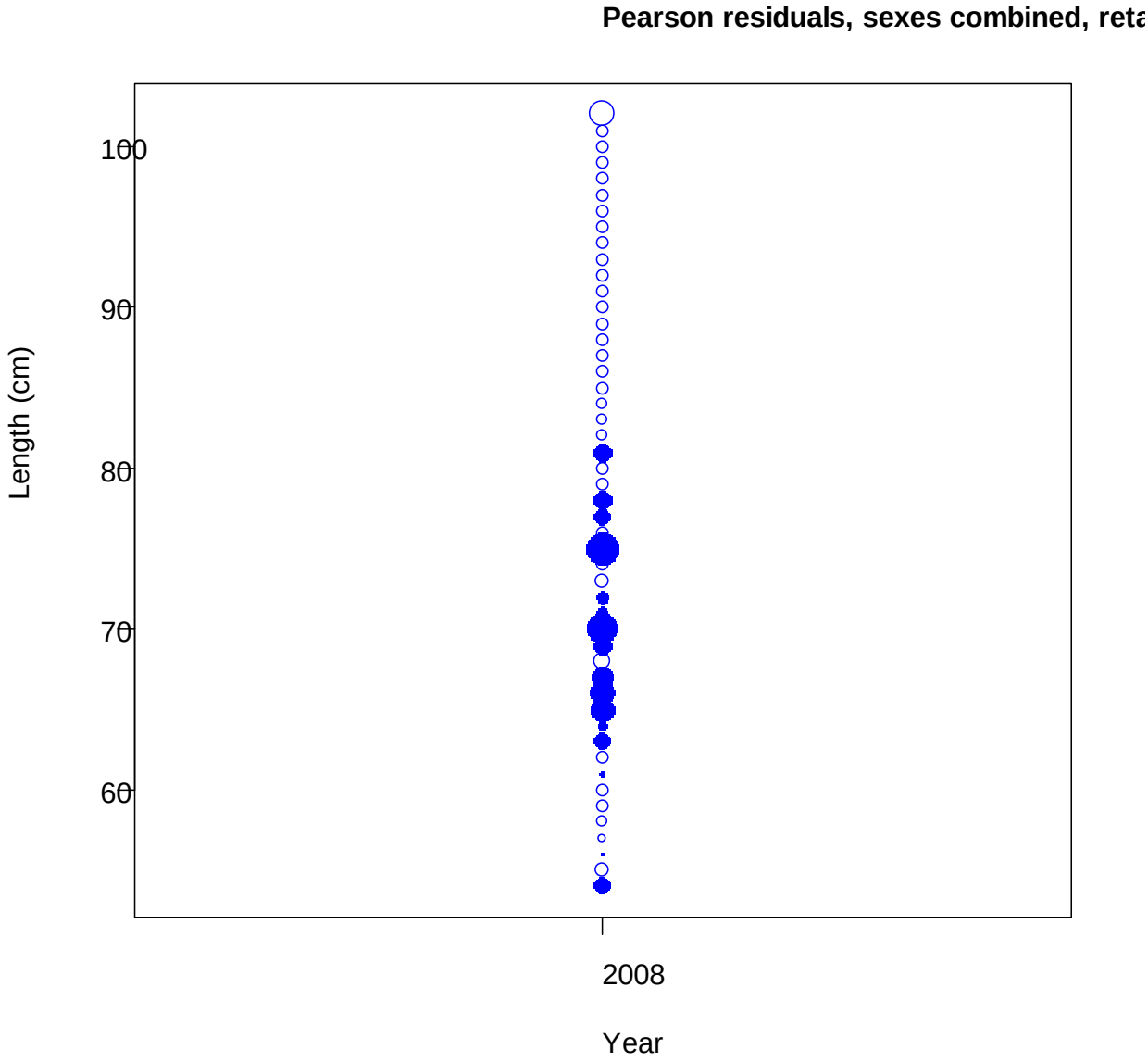
Figure C3.2.5. Estimated growth and variation of length-at-age (dashed lines).

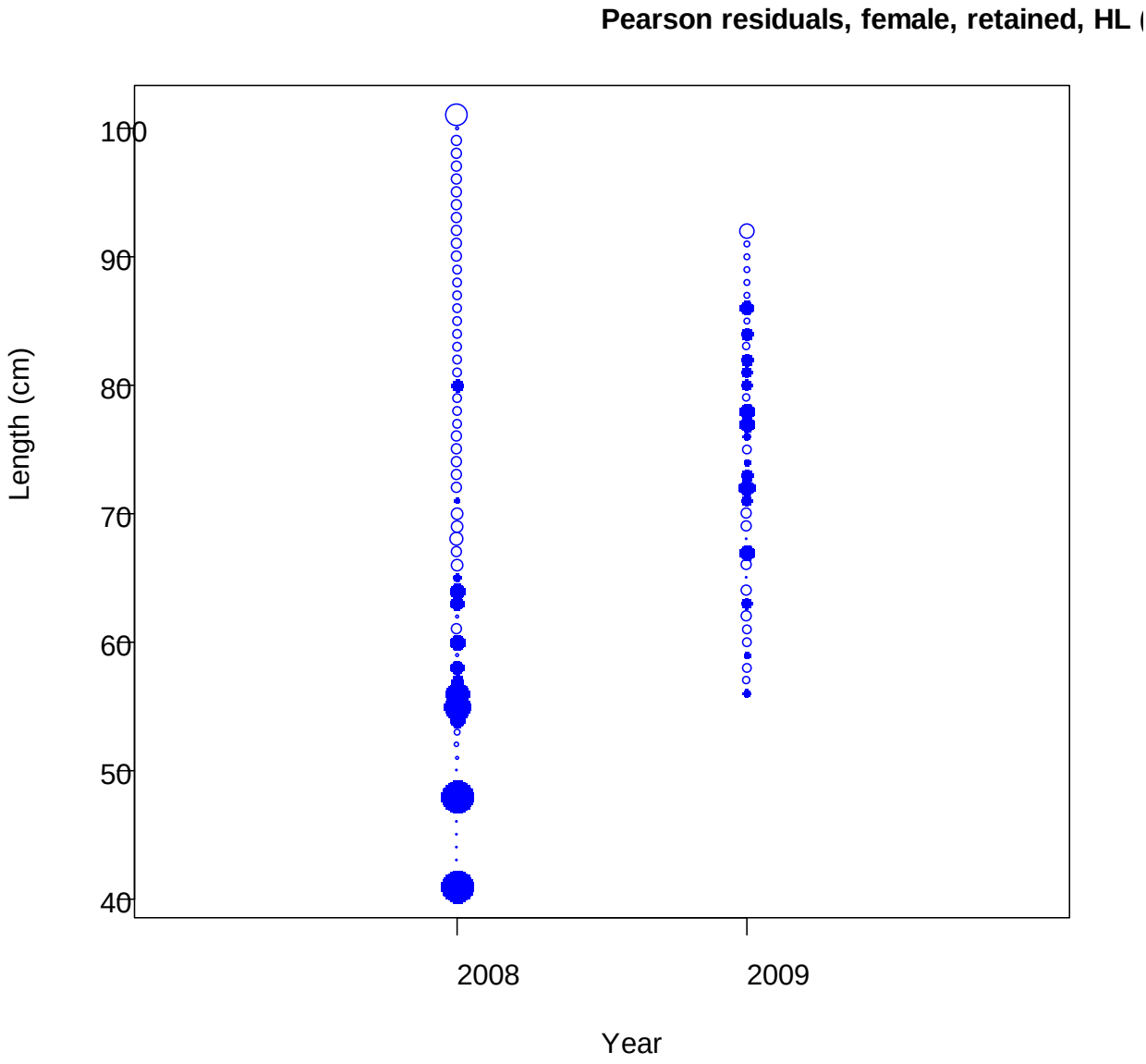

Spawning depletion with ~95% asymptot
Spawning depletion
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Management target
Minimum stock size threshold
1980
1985
1990
1995
2000
2005
2010
Year

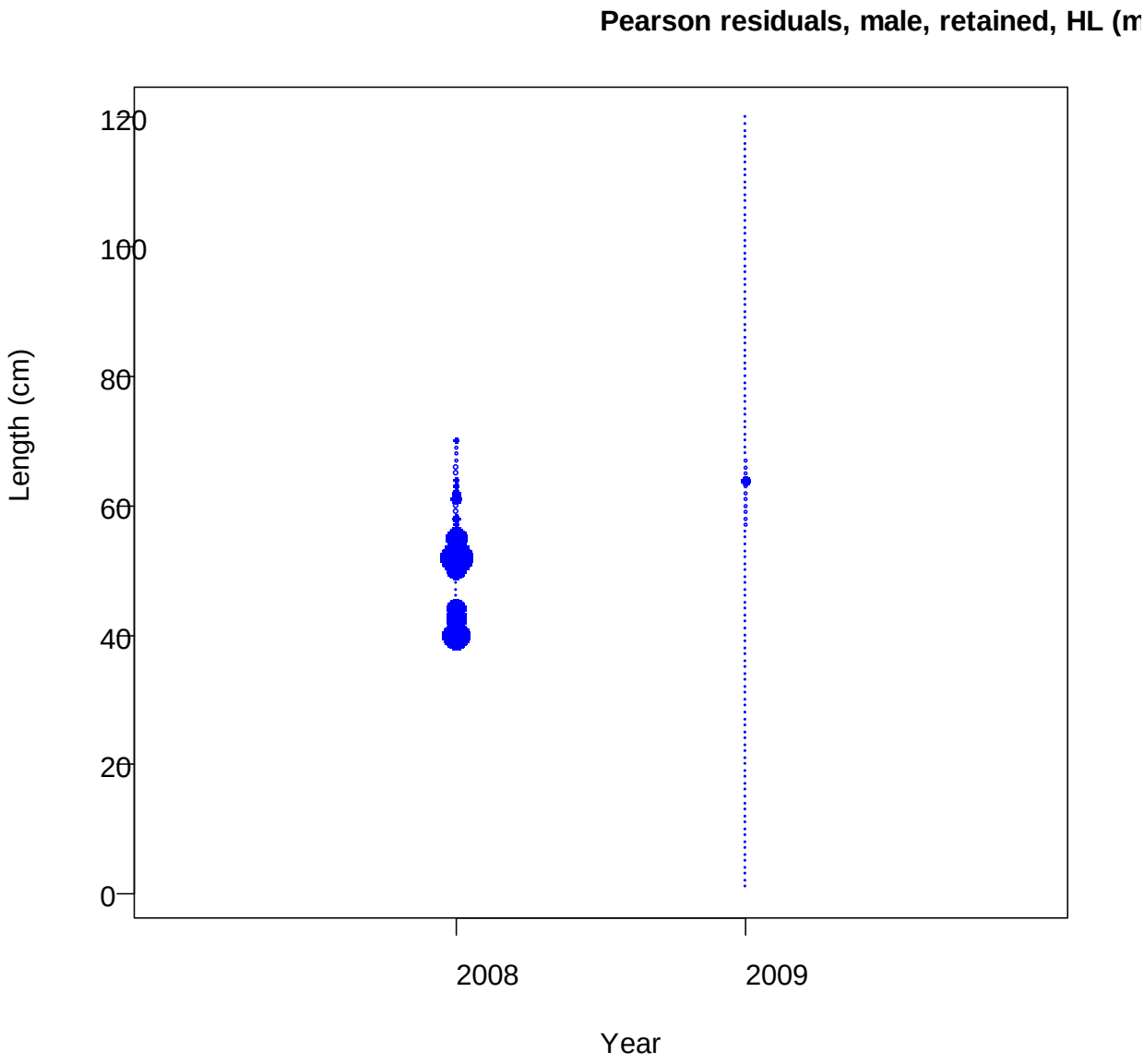
Appendix: Fit to the length and age composition data.

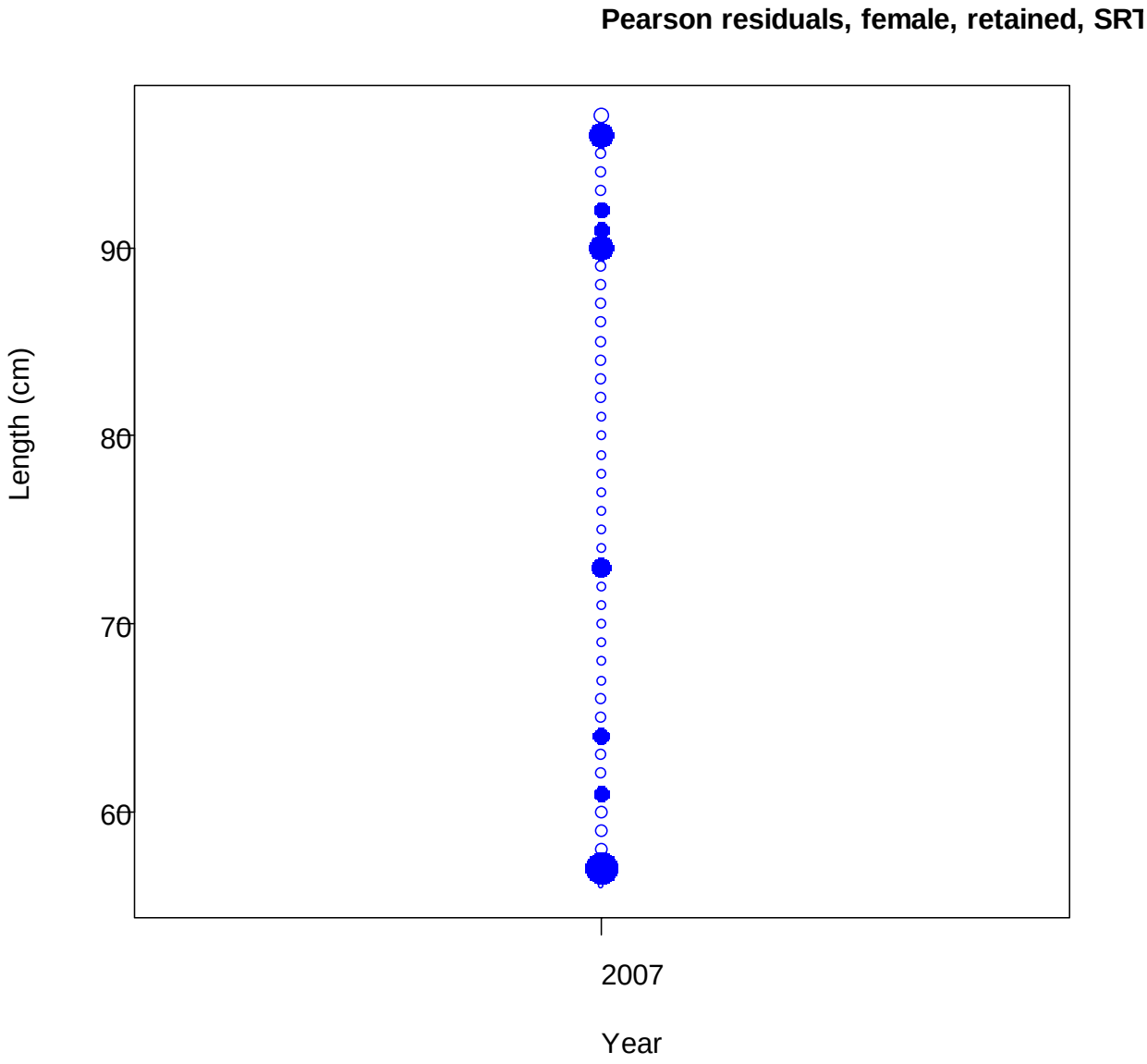


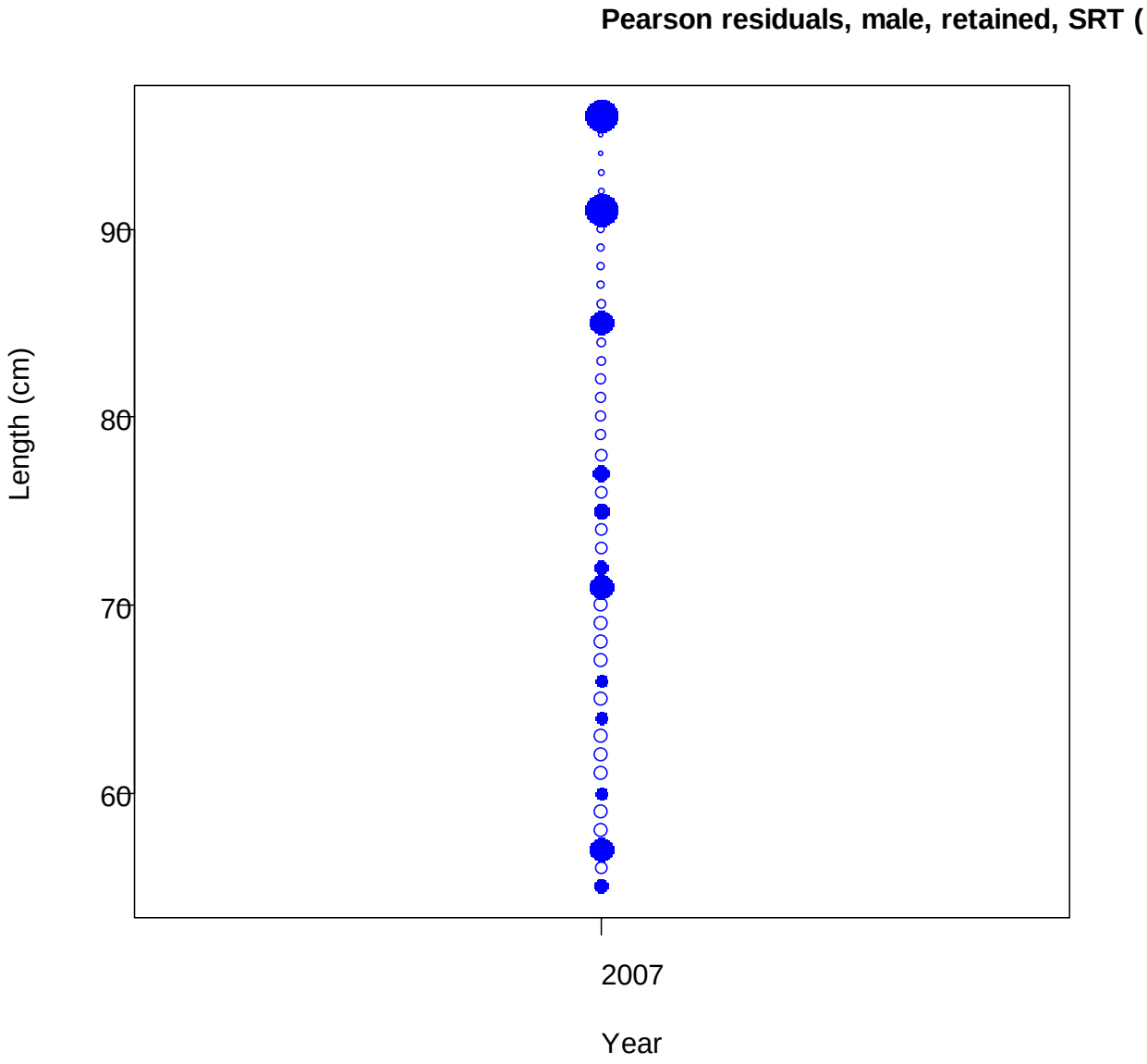

Pearson residuals, male, retained, BT (m
100
90
80
70
60
Length (cm)
2007
Year

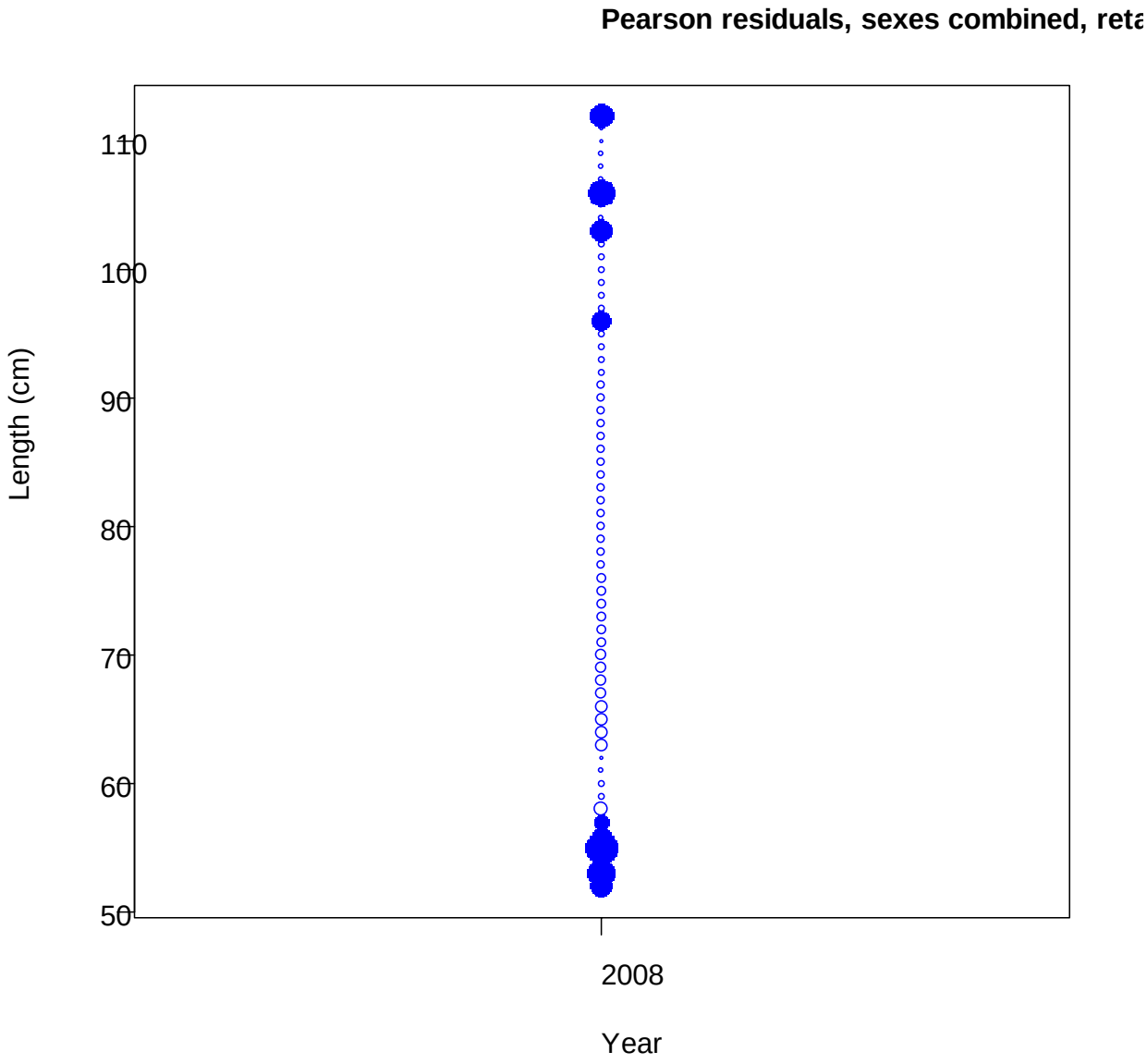

Pearson residuals, sexes combined, reta
100
90
80
70
60
Length (cm)
2008
Year

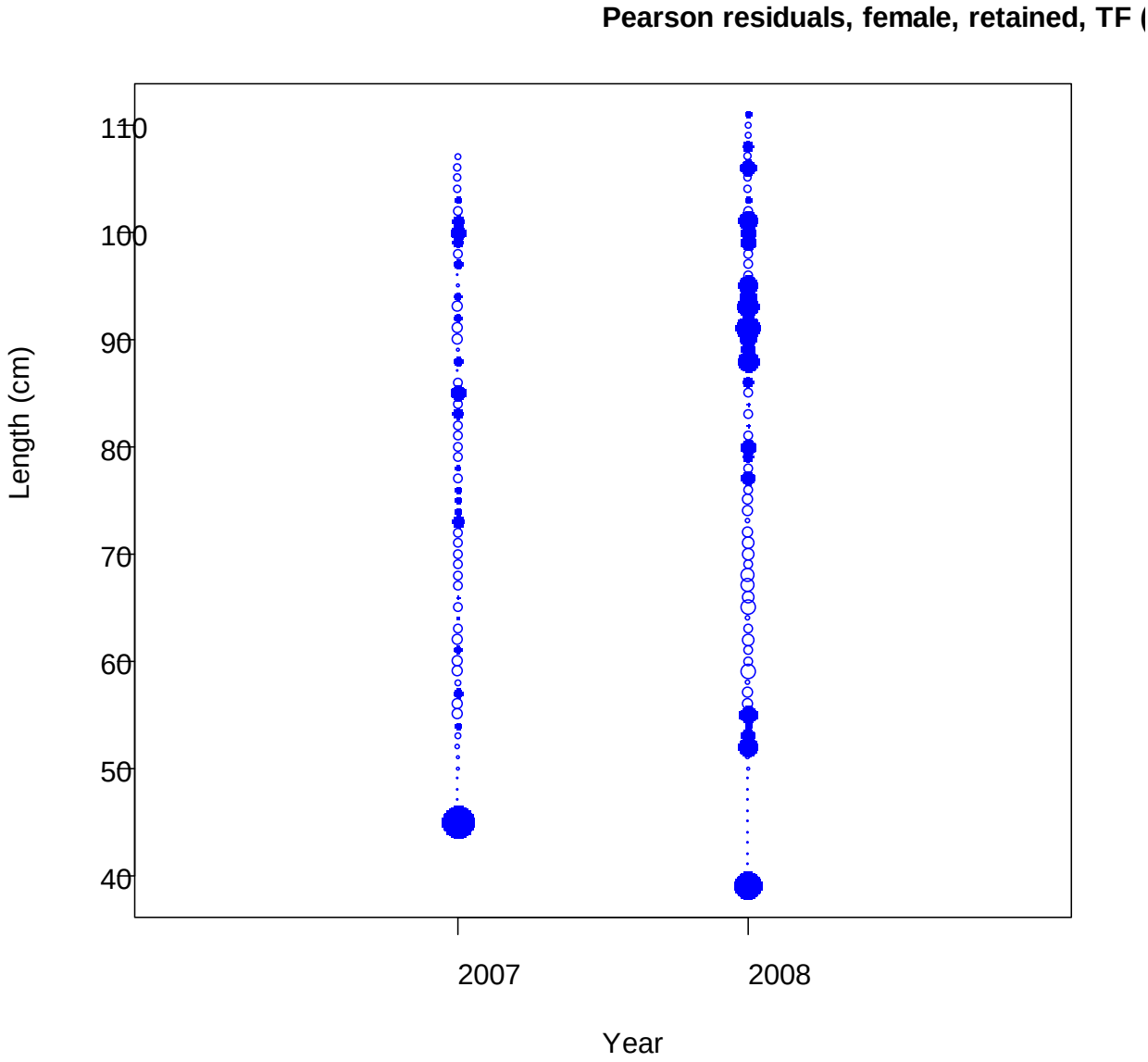

Pearson residuals, female, retained, HL
Length (cm)
100
90
80
70
60
50
40
2008
2009
Year

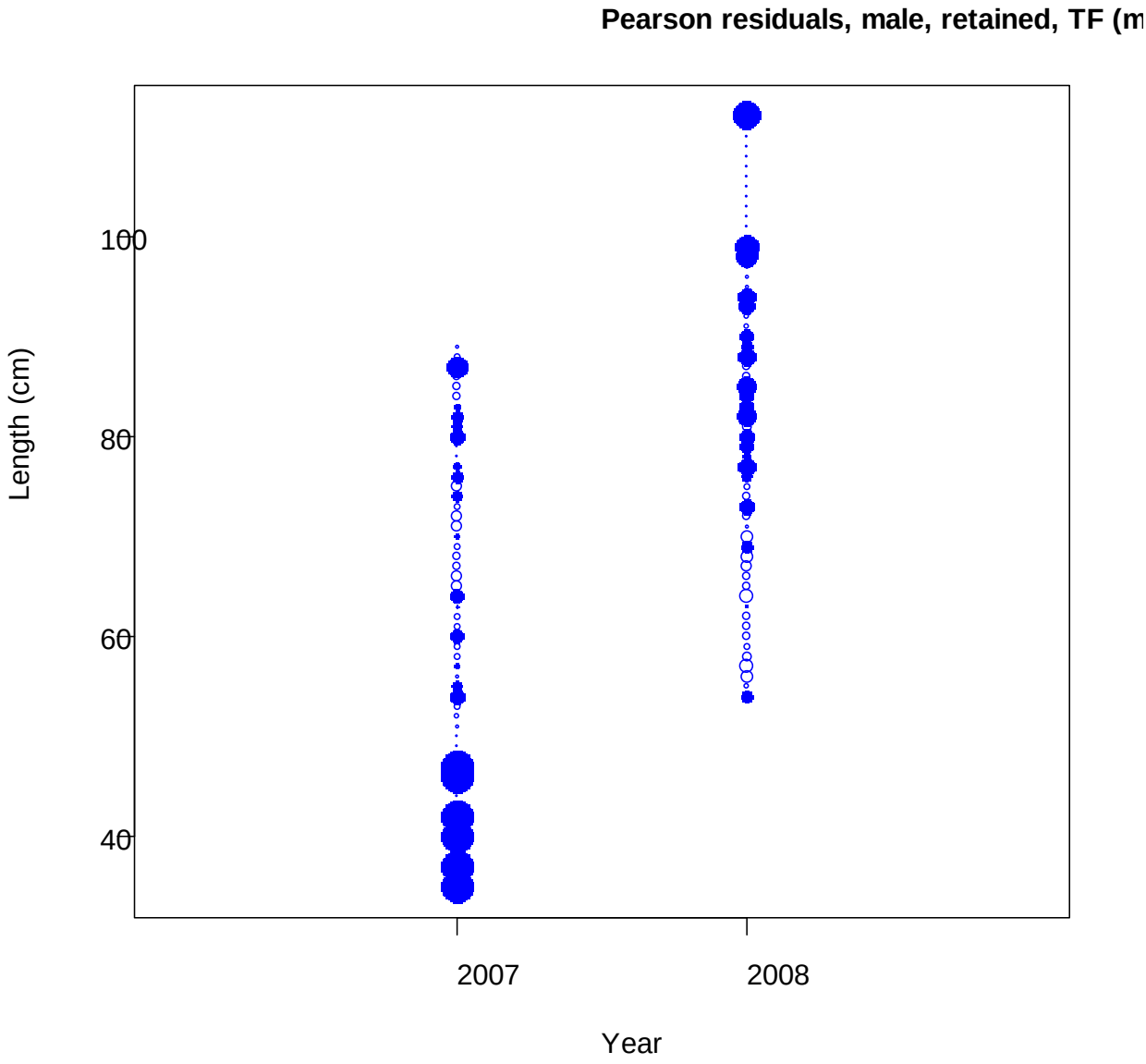

Pearson residuals, male, retained, HL (m
Length (cm)
120
100
80
60
40
20
0
2008
2009
Year

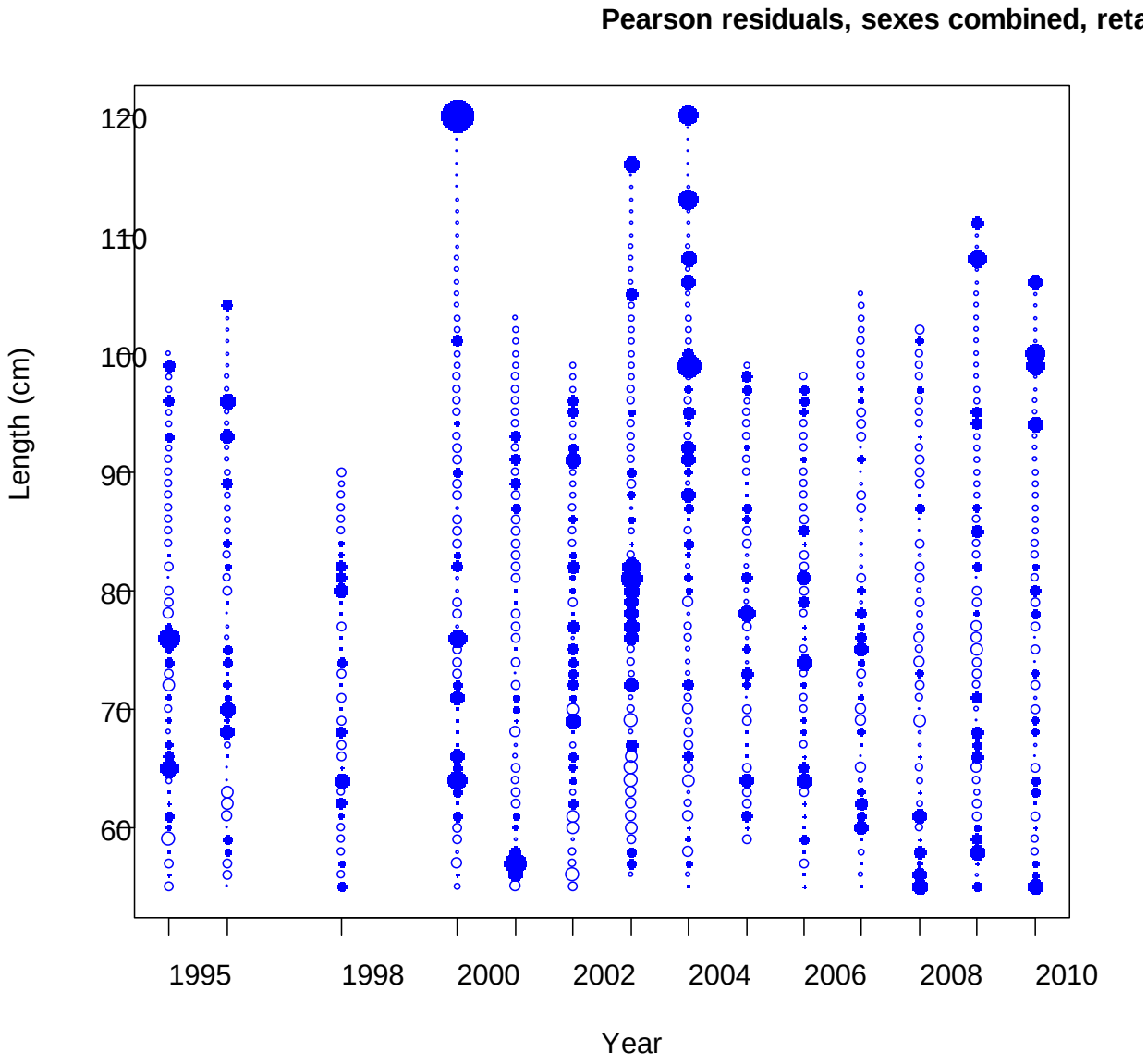

Pearson residuals, female, retained, SR1
Length (cm)
90
80
70
60
2007
Year

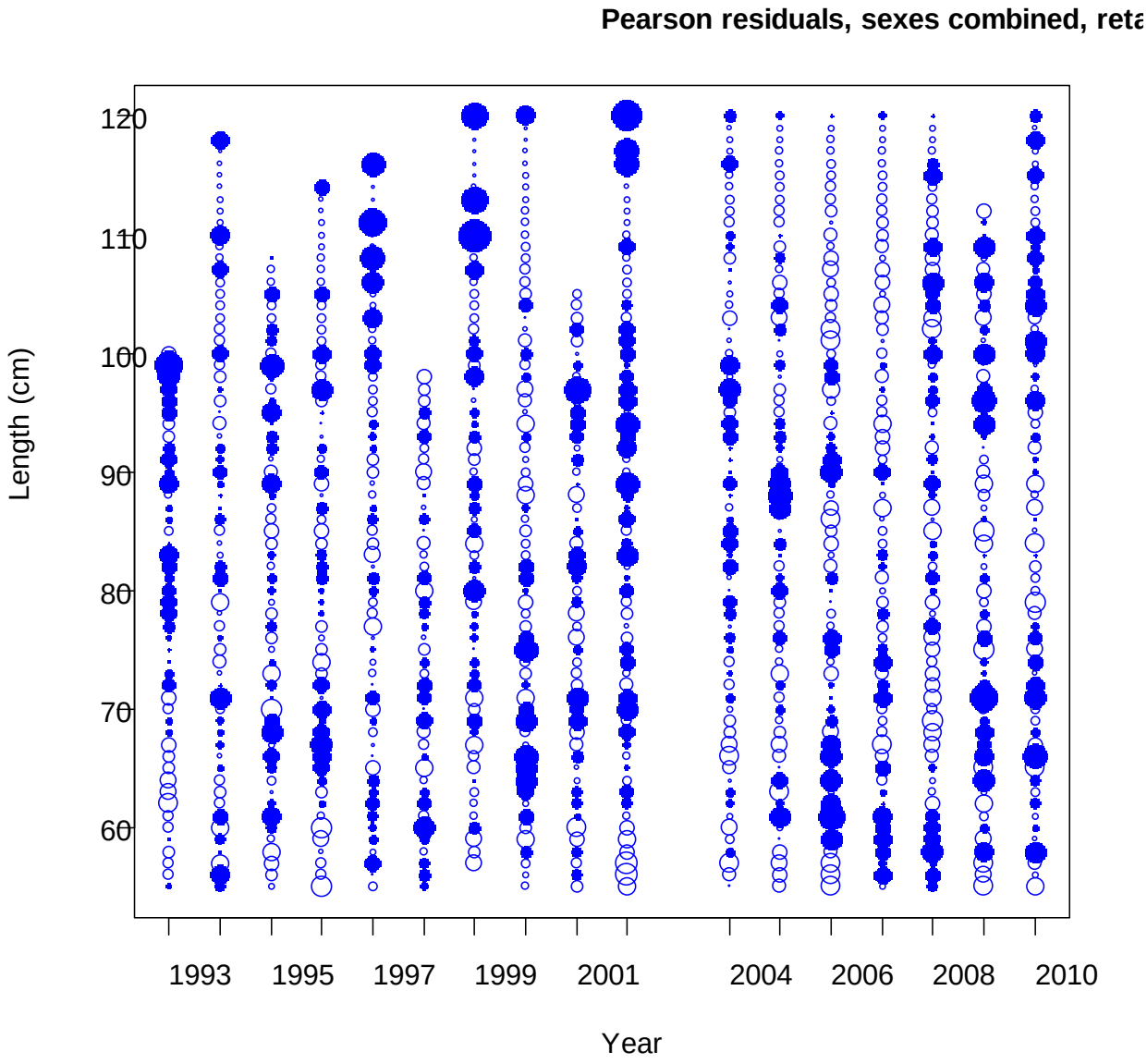

Pearson residuals, male, retained, SRT (
Length (cm)
90
80
70
60
2007
Year

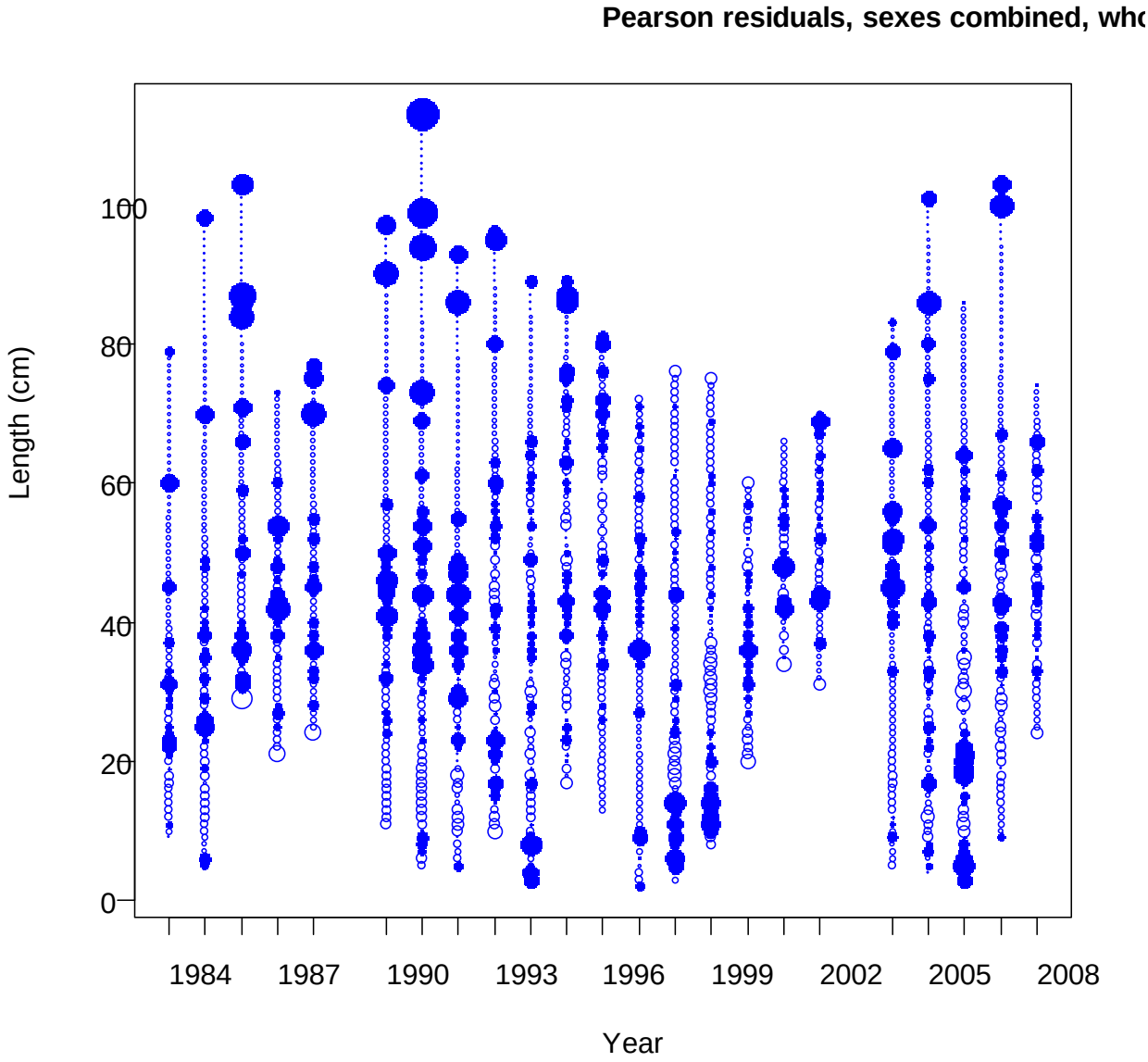

Pearson residuals, sexes combined, reta
Length (cm)
110
100
90
80
70
60
50
2008
Year

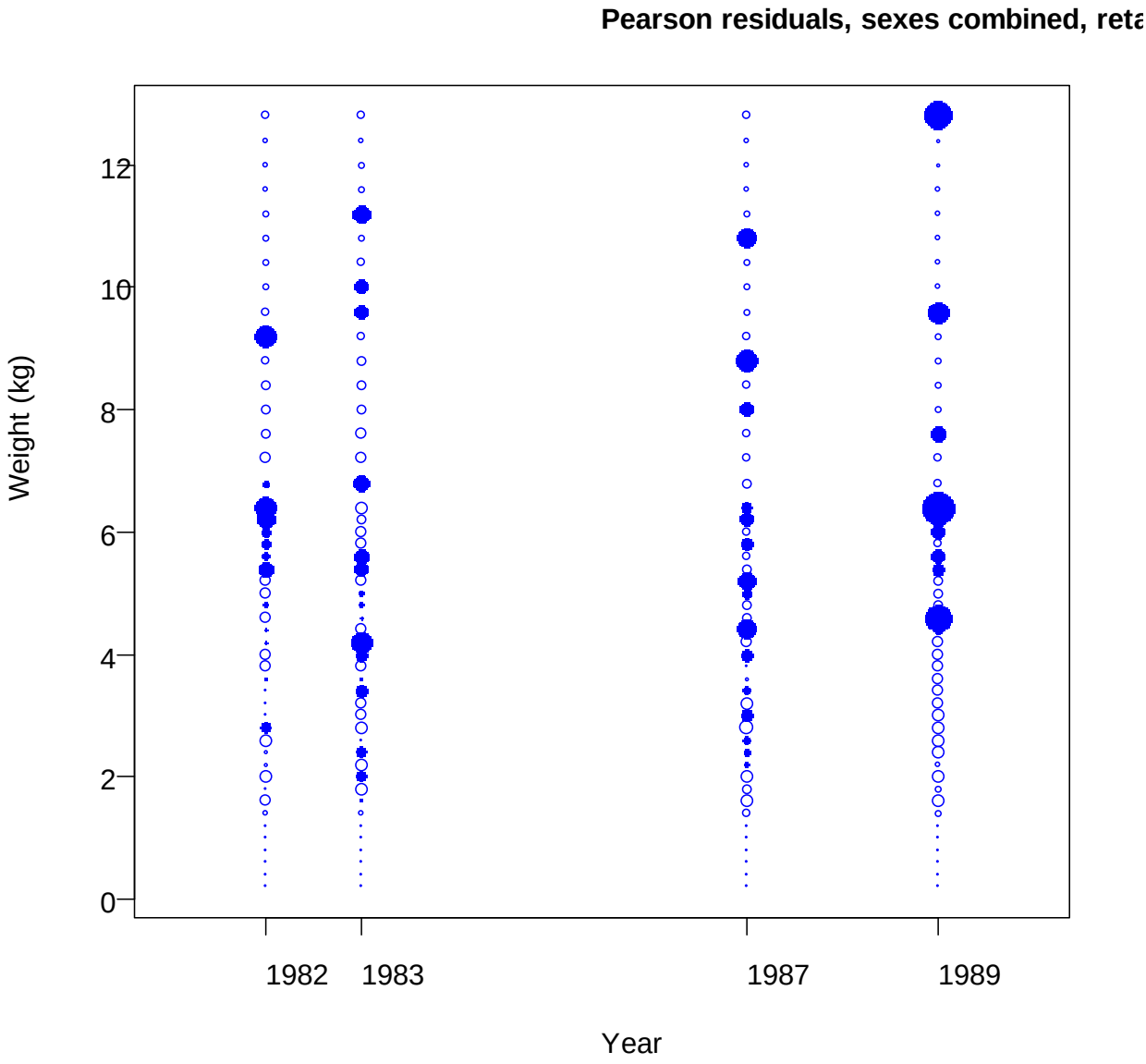

Pearson residuals, female, retained, TF (
Length (cm)
110
100
90
80
70
60
50
40
2007
2008
Year


Pearson residuals, male, retained, TF (m
Length (cm)
100
80
60
40
2007
2008
Year

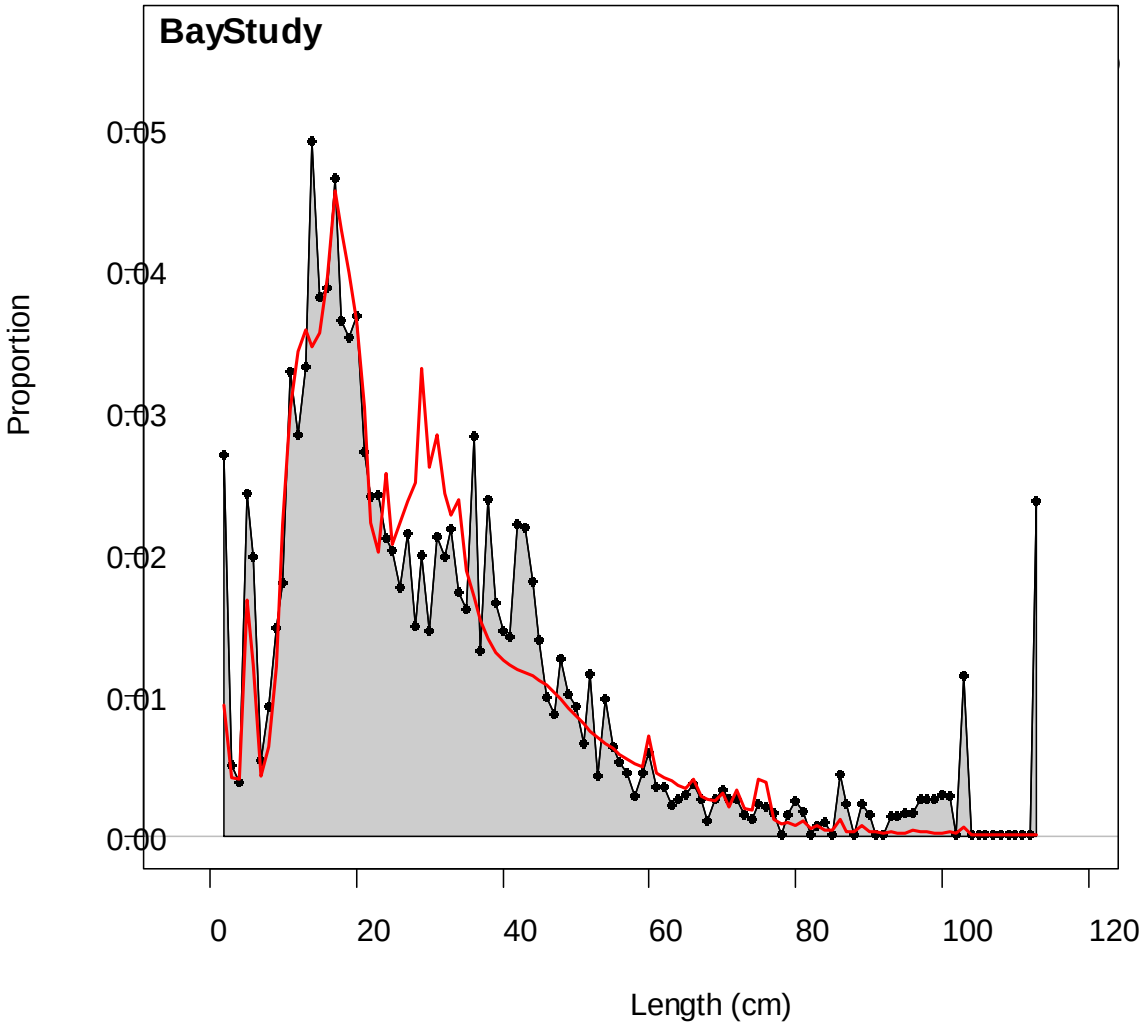

Pearson residuals, sexes combined, reta
Length (cm)
120
110
100
90
80
70
60
1995
1998
2000
2002
2004
2006
2008
2010
Year

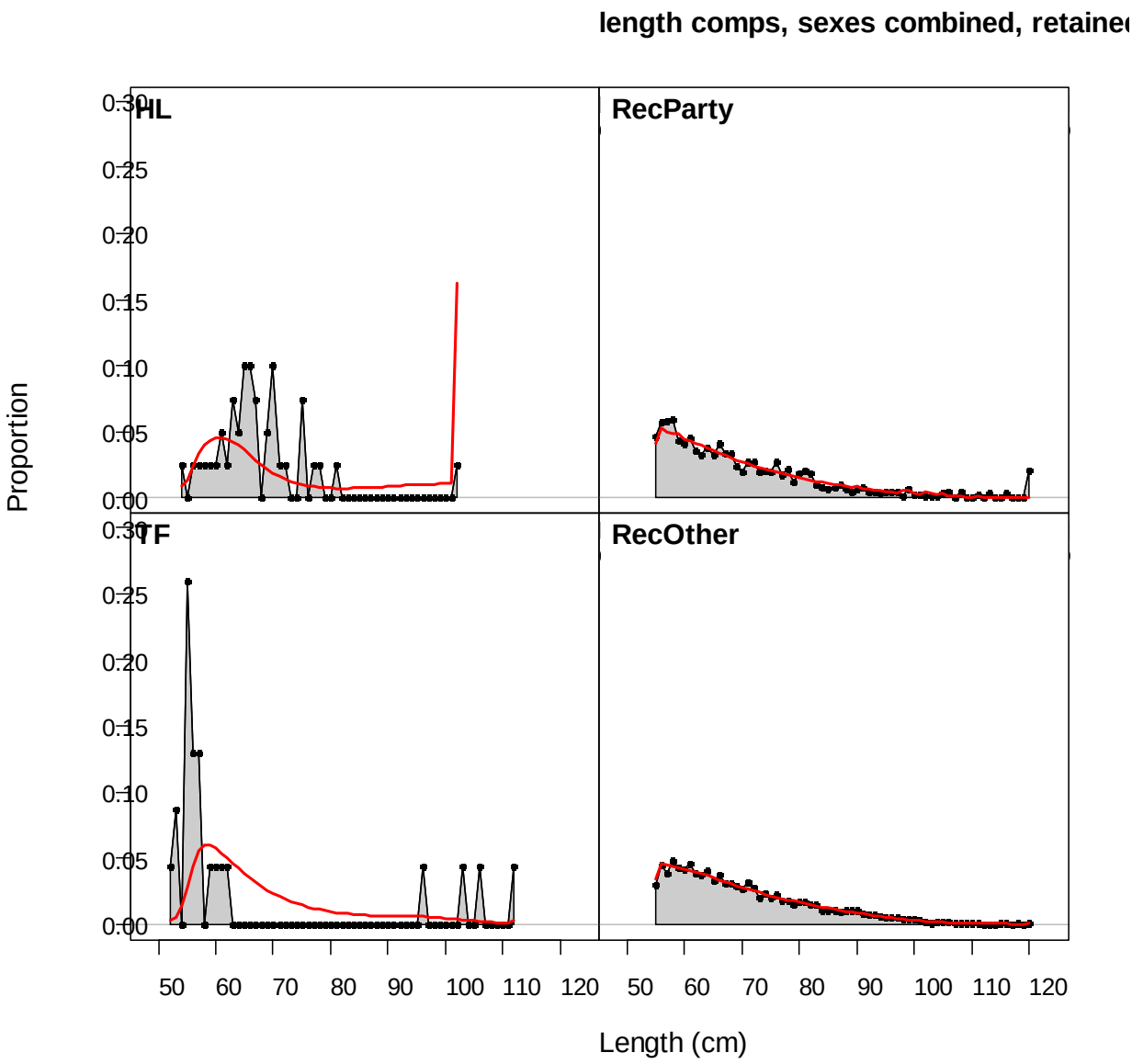

Pearson residuals, sexes combined, reta
Length (cm)
120
110
100
90
80
70
60
1993
1995
1997
1999
2001
2004
2006
2008
2010
Year

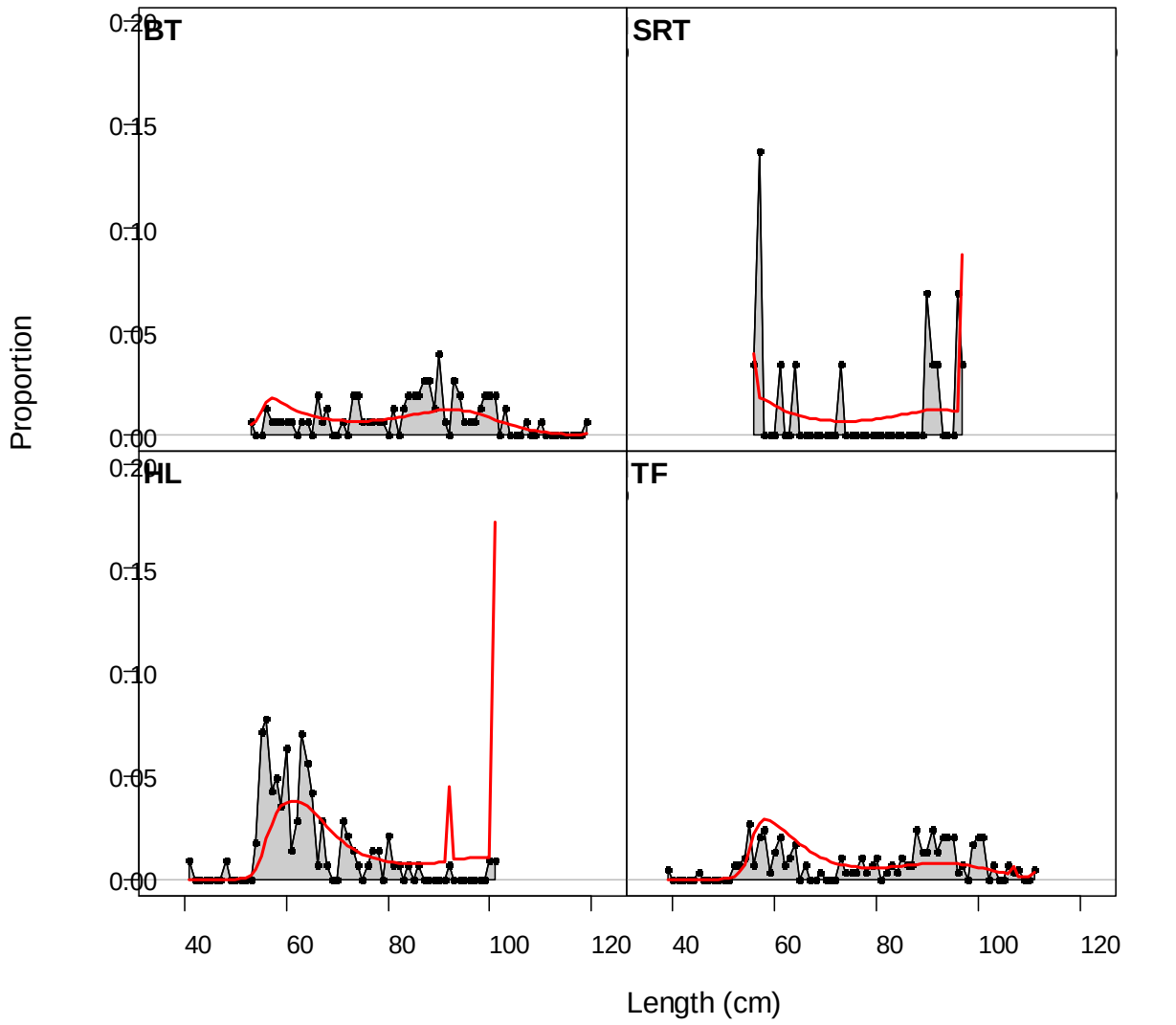

Pearson residuals, sexes combined, who
Length (cm)
0
20
40
60
80
100
1984
1987
1990
1993
1996
1999
2002
2005
2008
Year

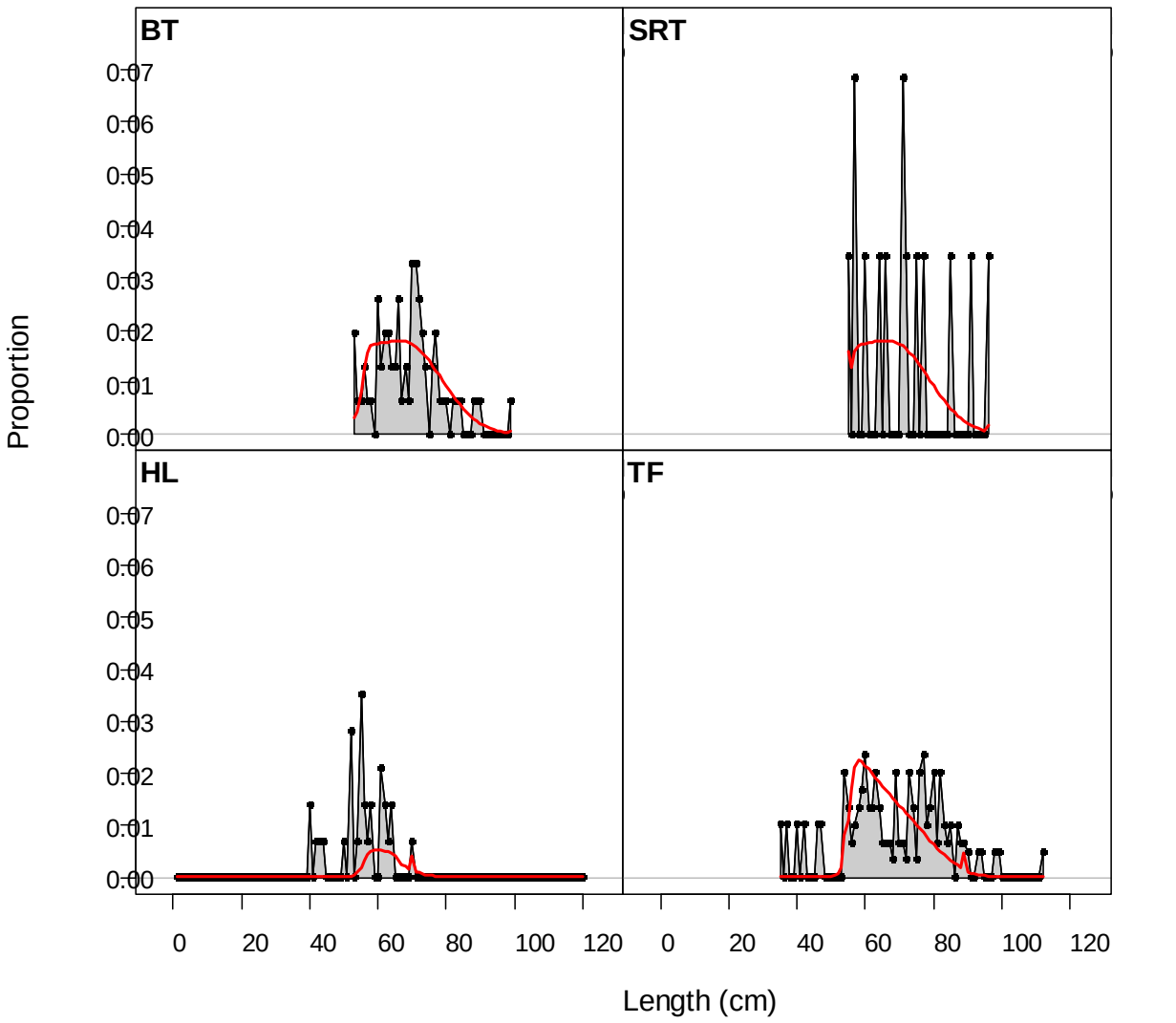

Pearson residuals, sexes combined, reta
Weight (kg)
0
2
4
6
8
10
12
1982
1983
1987
1989
Year

length comps, sexes combined, whole




length comps, sexes combined, retaine
HL
RecParty
TF
RecOther
Proportion
0.30
0.25
0.20
0.15
0.10
0.05
0.00
50
60
70
80
90
100
110
120
Length (cm)


length comps, female, retained, aggrega
BT
SRT
HL
TF
Proportion
0.20
0.15
0.10
0.05
0.00
40
60
80
100
120
Length (cm)


length comps, male, retained, aggregate
BT
SRT
HL
TF
Proportion
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0
20
40
60
80
100
120
Length (cm)