Section B: Assessment of California halibut from the US-Mexico border to Point Conception.

B1. Model

A sex-structured model with different growth, natural mortality, and selectivity for males and females developed using Stock Synthesis (Methot 2009) is used to assess California halibut from the US-Mexico border to Point Conception. Sex-specific length composition data are not available for all fisheries, are not available for the fishery-independent surveys, and the sample sizes are low for many of the fisheries for which sex data is available. Therefore, selectivity is shared among some fisheries and several assumptions are made when defining selectivity.

B1.1. Fisheries

Seven fisheries are modeled. These fisheries were selected because they represent the majority of the fish caught and because they have length composition data. The fisheries include 1) bottom trawl; 2) single-rigged trawl; 3) trawl with a footrope diameter less than 8 inches; 4) commercial hook-and-line; 5) gill net; 6) Commercial Passenger Fishing Vessel (CPFV)/charter boats; and 7) private/rental boats. Other recreational catch (e.g., shore-based fishing) is combined with fishery 7. There is ambiguity in some of the definitions of the trawl gear and which gear is recorded on catch reports. Despite these ambiguities, the three trawl gears are kept separate to allow comparison of length composition data. There is a large amount of catch for which the fishing method is unrecorded. This catch is proportionally applied to the fisheries based on detailed investigation of the gear type for a subset of the data. The commercial catch from fisheries other than hook-and-line and trawl is added to the gill net fishery. Since, the hook-and-line and gill net gears are assumed to have the same selectivity, these other gear types are assumed to have the same selectivity as these two gears.

B1.2. Initial conditions

The stock is modeled starting in 1971 because this is when the minimum legal size (MLS) was introduced, which would have substantially changed the behavior of the fisheries, and there is a lack of information on the amount of discarded fish, the size of discards, and the discard mortality rate. Length composition, abundance, and detailed catch data is also lacking from the early period. The historical catch data starts in 1916 when the commercial fishery was already substantial, so even if the population was modeled starting in 1916 it would have to be modeled from an exploited state. The initial age-structure of the population is constructed using a parameter to scale the average equilibrium recruitment, fishing mortality parameters for the CPFV fishery, and cohort strength deviates for ages zero to six with tapering bias correction. The initial equilibrium catch is not fit in the model due to the change in MLS. The initial condition setup is just a way to parsimoniously parameterize the initial conditions and does not represent any particular population dynamics processes.

B1.3. Growth and fecundity

Growth is fixed in the model using the von Bertalanffy growth curve following estimates based on recent age-length data provided by Reilly and Tanaka (Table B1.3.1). Variation of length-at-age is fixed in the model as a linear function of length based on estimates of variation of length-at-age from randomly sampled fish presented in Pattison and McAllister (1990) and MacNair et al. (2001). Weight-at-length is fixed in the model based on parameters presented in Reed and MacCall (1988). Maturity-at-length is modeled using a logistic curve and fixed in the model based on data from Love and Brooks (1990). Fecundity is assumed to be proportional to weight.

B1.4. Natural mortality

Natural mortality (M) is fixed at 0.2 for females and 0.3 for males based on assumptions made for summer flounder. However, recent work suggests M may be higher for summer flounder than assumed in the summer flounder assessment. These values are essentially arbitrary since there are no reliable data to estimate natural mortality for California halibut. However, for this stock and other flatfish it is clear natural mortality is higher for males compared to females.

B1.5. Recruitment

Recruitment is assumed to be independent of stock size (i.e., steepness = 1). This is essentially arbitrary since there are no reliable data to estimate steepness for this stock. The sex ratio at birth is assumed to be 1:1. Recruitment deviates are estimated for all years and the standard deviation of the logarithm of the recruitment deviates is assumed equal to 1.0. This is higher than the typical 0.6 because recruitment appears to be more variable for this stock. Most of the information on annual recruitment variation comes from the length composition data. A ramped recruitment deviate bias correction factor was used with full bias correction starting in 1973 and ending in 2006.

B1.6. Catch

Commercial catch by fishery in metric tons (Table B1.6.1; Figure B1.6.1) and recreational catch in thousands of fish (Table B1.6.1; Figure B1.6.2) are included in the model.

B1.7. Selectivity

The Stock Synthesis double normal selectivity option is used for all fisheries, including the gill net fishery, which is assumed to have asymptotic selectivity (i.e. reaching a maximum finite level). Some of the six parameters are fixed to simplify the model assumptions due to the limited availability of composition data and the final selectivity parameter is ignored (option -999). Male selectivity is modeled as a dogleg offset of the female selectivity. Discards are modeled using a logistic retention curve. Selectivity is length specific to better reflect the differences in growth rates between males and females.

All trawl fisheries are assumed to have the same selectivity due to low length composition sample sizes and limited years of data for the single-rigged trawl and trawl with a footrope less than 8 inches fisheries. The selectivity at the lower length bin (lower bound of 1 cm) is assumed to be zero since trawl gear does not catch these very small fish. The length at the peak and the width of the ascending limb is fixed to represent the federal observer program discards (annual raw data was not available). Retention is fixed using a steep logistic curve with the inflection at the minimum legal size of 22 inches (559 mm). All discarded fish are assumed to die. Male selectivity is estimated as an offset from females with the dogleg set at 559 mm and the offset at the dogleg and largest length bin estimated.

Hook-and-line selectivity is set equal to the gill net selectivity due to lack of length frequency data. An assumption of 10% of discarded fish dying is used based on data from mortality experiments for California halibut.

The gill net fishery selectivity is assumed to be logistic as it is difficult to estimate the model parameters unless at least one selectivity curve is asymptotic and the gill net fishery tends to catch the larger fish. The selectivity at the lower length bin is assumed to be zero. Retention is estimated using a logistic curve since there are length composition data on discards from an observer program and a management allowance for some retention of undersized fish in the commercial fishery. An assumption of 30% of discarded fish dying is used based on data from mortality experiments for California halibut. Male selectivity is estimated as an offset from females with the dogleg set at 650 mm and the offsets at the dogleg and largest length bin estimated.

The CPFV fishery selectivity at the lower length bin is assumed to be zero. The logistic retention curve is estimated since there is length composition data for both the whole catch and the retained catch. The asymptotic retention level was initially allowed to differ between 1971-1990 and 1991-2008 because of the two periods of discard data (logbooks and observer. The recreational survey estimates were considered unreliable). However, initial runs estimated retention of legal sized fish to be 100% so the asymptotic retention parameter was fixed at 1.0 for both periods. No male offset is calculated for retention since there is no sex-specific composition data and male and female small fish are assumed to behave the same. Discard mortality is assumed to be 10% based on data for summer flounder and mortality experiments for California halibut. The male selectivity offset is assumed to be similar to that estimated for the commercial gears (25% of females at 650 mm and 0.03% at the largest size) because there is no sex-specific length composition data for the recreational fishery.

Due to similar length composition data and lack of length composition for the discarded fish in the other recreational fishery, the selectivity is set equal to that estimated for the CPFV fishery.

There is no sex-specific size composition data for the fishery-independent indices of abundance, so sex-specific selectivities cannot be estimated. When included in the model (during initial sensitivity runs not shown here), length based selectivities are used in an attempt to account for differences in growth between males and females, but this would not account for any age-specific differences in selectivity between males and females (e.g., due to differences in ontogenetic movement). A double normal is used to model the selectivity with selectivity at the largest size in the model set to zero. The length based selectivity assumption may be adequate for indices that relate to mostly juveniles.

The selectivity of the swept area survey, when included in the model (during initial sensitivity runs not shown here), is modeled using an age-based double normal with male offset for the peak, width of ascending limb, width of descending limb, and selectivity at final size bin.

B1.8. Summary of data used in the assessment

The model is fit to an index of relative abundance (index) based on standardized catch-per-unit effort (CPUE) from CPFV logbooks. 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. The data was split into two inshore areas separated at Palos Verdes and an island area before standardizing and then a composite index was created using an average weighted by the number of blocks in each area. 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 coefficient of variation (CV)).

The model is fit to CPFV discard catch estimates from observer data (1986-1989) and logbooks (1995-2007). The discard data is fit using a normal likelihood function with standard deviations based on an assumed CV of 0.6 to limit their influence on the estimates of abundance.

The model is fit to bottom trawl and gill net length composition data for both combined sexes and for proportions of males and females that sum to one. Years with sample sizes less than 20 fish were excluded from the analysis. Data from hook-and-line, and the two other trawl methods were excluded because the samples sizes are small and it is considered better to remove fish at somewhat wrong sizes than to mix length composition samples from gears that may have different selectivities. Length composition data of retained and discarded halibut from a gill net observer program were included in the model to estimate the gill net retention curve. The model is fit to both whole catch and to retained catch length (or weight) composition data for the CPFV fishery and to retained catch length (or weight) composition for the private/rental boat fishery. Length composition data for the other recreational fisheries (shore based fisheries) is not used because the sample sizes are small and the catch by those fisheries is small. A multinomial likelihood with the recorded sample sizes is used for the likelihood function.

Other data are available and the results are compared to these data, but the data are not used to estimate the parameters in the assessment except in sensitivity analyses.

B2. Data

B2.1. 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 lacks details to identify the target species. The catch of California halibut per angler hour for inshore blocks separated into north and south of Palos Verdes and blocks around islands were standardized separately for the categorical variables year, month, and block using a delta-lognormal regression (Table B2.1.1, Figures B2.1.1 and B2.1.2). 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. The 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).

B2.2. California Cooperative Oceanic Fisheries Investigations

The catch of California halibut larvae per volume of water strained in the oblique tows was standardized for the categorical variables year, month, and station using a delta-lognormal regression. The data was restricted to tows conducted between Point Conception and the US-Mexico border and that started at 76.2 m (approximately 250 ft) deep or less as a proxy for ocean depth and is related to where most California halibut larvae are found. Pelagic larvae occur over the shelf with greatest densities in water less than 250 ft deep and within 4 miles of shore. The combined year effect from the binomial and lognormal components of the regression was used as the index of relative abundance (Table B2.2.1, Figure B2.2.1). The index is assumed proportional to spawning biomass rather than recruitment since there is a shorter time period between spawners and eggs/larvae than there is between eggs/larvae and recruitment to the fishery. Therefore, there is a lower probability that external factors can influence the relationship between spawners and eggs/larvae. The index is highly variable from one year to the next, has high coefficients of variation, and includes several zero observations that cannot be included directly in the lognormal likelihood function commonly used to fit indices of abundance. Therefore, it is considered an unreliable index of abundance and not used in the assessment model. Similar results were obtained if the data was not restricted by depth at the start of the tow.

B2.3. Ocean Resources Enhancement Hatchery Program gill net survey

The OREHP gill net surveys for juvenile white seabass also catch California halibut. The gill nets were set overnight and floated with the lead lines about 1 m above the bottom so they may not be an optimal halibut sampling gear. Two surveys were conducted. The California State University of Northridge (CSUN) survey (data provided by Dr. Larry G. Allen, Southern California Marine Institute) covered the northern two-thirds of the Southern California Bight from

Newport Beach to Santa Barbara including Catalina Island. The San Diego State [Hubbs-Sea World Research Institute (HSWRI)] survey (data provided by Michael A. Shane, HSWRI) covered the stations south to the US-Mexico border. HSWRI has been deploying multiple mesh gill nets since 1988, but the mesh sizes and panel lengths in the nets varied until June 1992 when the nets were standardized. Hence only data starting in June 1992 from nets with similar design (mesh and panel sizes) were used. The CSUN survey had different mesh sizes, which varied over time. Therefore, the data was used to create two indices of abundance. Each 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.

The catch of California halibut per length of net in the CSUN survey was standardized for the categorical variables year and month using a linear regression. The year effect was used as the index of relative abundance (Table B2.3.1, Figure B2.3.1). The data was provided with all stations combined so area or station effects could not be used in the standardization.

The catch of California halibut per length of net in the HSWRI survey was standardized for the categorical variables year, month, and site 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 (Table B2.3.1, Figure B2.3.1). Jackknife estimates of error were calculated for the HSWRI survey.

Each of these indices is only from a part of the coast, there is no sex-specific length composition information, they were not designed to capture halibut (lead lines about 1 m above the bottom), the CSUN survey has inconsistent mesh sizes, and the CV for the HSWRI survey was large in many years. Therefore, they are considered unreliable indices of abundance and not used in the assessment model. Length composition data is available for the surveys (Table B2.8.3).

B2.4. Impingement and associated trawl survey

Monitoring has been carried out since 1972 at all electricity generating coastal facilities built by Southern California Edison. Three operational survey types are used: normal operation, heat treatment, and fish chase. A trawl survey is also conducted. The impingement number per unit of volume data (provided by Eric Miller), which includes both heat treatment and fish chase surveys, was standardized for the categorical variables year, month, survey type, and station using a delta-lognormal regression. The trawl data was standardized for the categorical variables year, month, site, and station 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 (Table B2.4.1, Figure B2.4.1). A jackknife procedure was used to estimate standard errors, but it did not work for the trawl data. Each 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. The indices represent a small spatial area, there is no sex-specific length composition information, and the CV for the impingement index is moderately high for many years. Therefore, they are considered unreliable indices of abundance and not used in the assessment model.

B2.5. Sanitation district data

Records of California halibut catch and length composition data were obtained from three sanitation districts (Table B2.5.1, Figure B2.5.1). None of these had details about the trawl tows that did not catch California halibut. Therefore, indices of abundance were calculated by assuming the stations were sampled the same number of times each year. The sanitation data is from a limited area, there is no sex-specific length composition information, and therefore they are not used in the assessment.

B2.6. Trawl logbook data

Attempts were made to standardize the catch of California halibut per tow from the trawl logbook data using the categorical variables year, month, block, and depth 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). The analysis was unstable with wide fluctuations in the index of abundance depending on the covariates included. The regression did not converge with some combinations of covariates. Therefore, the results did not appear to be reasonable. Therefore, unstandardized data (using tows targeting halibut) was considered as an index of abundance and assumed proportional to the fish vulnerable to the bottom trawl fishery (Table B2.6.1., Figure B2.6.1). Due to the issues in standardizing the index it is considered an unreliable index of abundance and not used in the assessment model.

B2.7. Swept area trawl estimate of abundance

A trawl survey was carried out in the southern area during 1994 (Domeier). The data was used to generate a swept area estimate of abundance. The fish were weighed after their gonads were removed so the estimates of number of fish are more reliable than estimates of biomass. The estimated number of fish in the southern area, including islands, was 3,862,104 with 90% confidence intervals (CI) ± 712,740. Sex-specific age-length data is also available for this survey. However, the codend mesh size of the 400-mesh Eastern trawl used was 85 mm (3.34 inches) and was likely responsible for the scarcity of larger, older fish and the relatively low proportion of aged halibut that were females (31 per cent). Swept area survey estimates are notoriously biased due to invalid assumptions about the proportion of fish within the trawls path that are caught and the distribution of fish outside the trawled areas. It is not possible to estimate the catchability coefficient from a single biomass estimate. Therefore, this abundance estimate was not used in the model.

B2.8. Length composition data

Length composition data is available from several sources. Commercial length composition by gear and sex come from California Department of Fish and Game's (CDFG) State Finfish Management Project (2007-2010) and market sampling (1983-2006) databases (Table B2.8.1, Figure B2.8.1). The length composition data on the retained and discarded halibut that are available from the gill net observer program (1983-1989) were included in the model to estimate the gill net retention curve. Some data is not available by sex. Recreational length composition data (unsexed) of the whole catch (retained plus discarded) in the CPFV fishery comes from the observer sampling (1975-1978 and 1986-1989) and retained catch comes from the Recreational Fisheries Information Network (RecFIN) (1993-2010) database (Table B2.8.2, Figure B2.8.2). Weight composition data from the retained catch for the recreational fisheries is also available from the RecFIN (1980-1989) database. Length composition data is also available for the fishery-independent surveys (impingement, impingement trawls, sanitation trawls, and gill net surveys; Table B2.8.3, Figure B2.8.3). The composition data were reweighted by estimating the effective sample size using a Michaelis–Menton (Beverton-Holt) equation in a single iteration (Figure B2.8.4).

B2.9. Age composition data

Randomly collected age data is available from 1985-1988 (Sunada et al. 1990; Table B2.9.1). It is from both gill net and trawl fisheries combined. Therefore, it is not used in the assessment.

Sex-specific age composition data is available for the trawl survey (MacNair et al. 2001; Table B2.9.2). Since the trawl survey is not used in the assessment model and the length-at-age data may be biased due to selectivity of the trawl codend mesh size, the corresponding age data is not used.

B2.10. Discards

Estimates of recreational discard rates are available from RecFIN, CPFV observers, and CPFV logbooks (Table B2.10.1, Figure B2.10.1). The total discards can be calculated by applying these ratios to the retained catch (Table B2.10.2). Initial analyses estimated the retention rate of legal sized fish to be 100%, so the asymptotic retention value was set at 1.0.

Commercial discards are available from the federal observer program on halibut trawl trips, both limited entry and open access (Table B2.10.3, Figure B2.10.2). However, most of the data is from north of Point Conception and samples sizes are low. Limited data is available on the size composition of the discards (Figure B2.10.3.). An annual series of discard rates is available (e.g., see Bellman et al. 2010). Discard length composition data is available for the gill net fishery from the gill net observer program (see above).

B3. Results

B3.1. Model fit

Visually, the stock assessment model provides a poor fit to the CPFV index of relative abundance due to temporal correlation in the residual pattern (Figure B3.1.1a). However, the fit is quite good statistically and the root mean square error (RMSE) (0.22) of the fit to the CPFV index is lower than the assumed standard error (SE) for this index (0.3), which can be seen visually as the predicted time series lies within the 95% confidence intervals of the observed index points for all years. The low RMSE is due to the lack of variation in the observed index.

The model fits the length composition data (Appendix B.1), and the CPFV discard data (Figure B3.1.2) reasonably well. The reweighted sample sizes for the length composition data are all smaller than the input sample size (Figure B2.8.4). The model provides poor fits to the trawl logbook and CalCOFI indices of abundance (Figures B3.1.1b, c; note they are not used in estimating the model parameters). However, the trend in the trawl logbook index is similar to that estimated by the model. The fit to the other indices of abundance are not meaningful since the selectivities are not estimated in the base case assessment.

B3.2. Estimates

The stock is estimated to be depleted with the start of year 2011 spawning biomass estimated to be only 14% of the unexploited spawning biomass (Figure B3.3.1). This is not completely unexpected since the population was already exploited at the start of the modeling period in 1971 (16% of the unexploited level) and the CPFV index of relative abundance is relatively flat. There was substantial catch prior to 1971, but changes in the management (e.g., minimum legal size) and lack of data prior to 1971 prevent adequate assessment of the abundance prior to 1971. The assessment is able to estimate the depletion level in 1971 by calculating the abundance at age that is consistent with the length composition data seen in the fisheries compared to what would be expected in the absence of fishing. It is not unusual for a fish stock to be sustainably fished at high fishing levels and low abundance levels for decades. There has been a series of low recruitments in recent years (since 1999; Figure B3.2.2). Recruitment does not appear to be related to spawning stock size (Figure B3.2.3).

The estimated selectivity curves appear reasonable (Figure B3.2.4). Male selectivity is estimated to be substantially less than female selectivity.

B3.3. Management quantities

Maximum sustainable yield (MSY) is estimated to occur at a very low fraction of the unexploited spawning biomass (Table B3.3.1). Therefore, even though the population is estimated to be depleted, it is still estimated to be above the spawning biomass level that would produce MSY and the fishing mortality is lower than the level that would produce MSY. This is partly due to the assumption recruitment is independent of stock size, at least at the abundance levels observed, which is not contradicted by the data. In other words, halibut as a species, like many other flatfishes, are prolific enough, and have a high reproductive potential, such that when environmental conditions are favorable, biomass can increase relatively quickly in a short time frame. MSY and related quantities are also dependent on the size of fish caught, natural mortality, and growth. There is substantial uncertainty about many of the biological and fishing processes including the stock-recruitment relationship, natural mortality, growth, and the survival of discarded fish. Despite the resilience of flatfish and the fact that California halibut have sustained high exploitation rates for several decades, the uncertainty in the biological and fishing processes and the recent series of low recruitments indicate that management action may be needed to reduce the risk of fishery collapse.

B3.4. Sensitivity analyses

Several analyses were carried out to evaluate the sensitivity of the results to model assumptions: 1) using the longer time frame aggregated CPFV CPUE index of abundance, 2) steepness of the stock-recruitment relationship equal to 0.75, 3) the average length of age 20 females equal to 100 cm, 4) natural mortality for females and males fixed at 0.3 and 0.4, respectively, and 5) not reweighting the composition data (Table B3.4.1). The RMSE for the aggregated CPFV CPUE (0.39) is much worse than for the detailed logbook targeting based index. However, visually the model appears to fit the index better and shows a decline in recent years consistent with the estimated low recruitments (Figure B3.4.1). The likelihood is worse when the steepness of the stock-recruitment relationship is fixed at 0.75 and the population is more depleted. Both reduced average length at age 20 and increased natural mortality have better likelihood values and lower depletion levels. Using the original samples sizes for the composition data has a higher RMSE for the CPFV index of abundance and the population is slightly less depleted.

B3.5. Discussion

The stock assessment estimates the California halibut population south of Point Conception has been depleted during the whole time frame modeled (1971-2011). The depletion level is somewhat sensitive to uncertainties in several important biological processes (e.g., growth and natural mortality) and data (e.g., method used to standardize the CPFV index of abundance). CPFV CPUE data suggests the status of the stock may differ among locations in the southern region and it is unclear if these should be treated as separate stocks.

The stock assessment results are somewhat consistent with the alternative data sets. Although the CalCOFI data was not used in the model, the CalCOFI index was low in the late 1990s and early 2000s suggesting low egg production or some oceanographic process may have generated low recruitment (Figure B3.1.1c). The gill net surveys, which catch small halibut, were low in the north in the late 1990s and early 2000s, but not in the south (Figure B2.3.1). The raw bottom trawl catch per tow is consistent with the biomass trend (Figure B3.1.1b). The impingement heat treatment and fish chase (HTFC) and trawl surveys, which catch small halibut, were also generally lower in the early 2000s (Figure B2.4.1). The sanitation surveys, which also catch small fish, were lower in the mid 2000s (Figure B2.5.1). These all generally support a low recruitment level in the late 1990s and early 2000s.

Tables and Figures

Table B1.3.1. Growth, variation in length-at-age, length-weight, and maturity parameters used in the assessment. K, L1 and L20 are the parameters for the version of the von Bertalanffy growth equation used in stock synthesis. Lsd1 and Lsd20 are the parameters of the linear relationship between the standard deviation of the variation in length at age and age. The quantities a and b are the parameters of the length-weight relationship. The quantities alpha and beta are the parameters of the logistic maturity curve and L50 is the length at 50% maturity.

Growth	Females	Males
K	0.095	0.112
L1	22.1	15.3
L20	114.5	107.3
Variation		
Lsd1	17.6	13.8
Lsd20	161.9	140.3
Length weight		
a	7.77E-06	9.22E-06
a	3.0496	3.0165
Maturity		
alpha	-0.15	-0.34
beta	7.02	7.77
L50	47.1	22.7

Table B1.6.1. Catch for each of the fisheries used in the assessment of the stock south of Point Conception. Catch is in kg for commercial fisheries (Comm) and in number of fish for the recreational fisheries (Rec).

Year	Comm bottom trawl	Comm single rigged trawl	Comm trawl with footrope diameter < 8 inches	Comm hook-and-line	Comm gill net	Rec CPFV	Other recreational
1971	30	0	0	1,251	55,745	22	82,269
1972	15,456	0	0	2,488	40,775	13,915	54,913
1973	24,075	660	0	3,972	44,000	16,162	66,304
1974	24,899	0	0	2,729	33,245	16,992	72,530
1975	18,417	0	0	3,539	66,383	16,978	75,485
1976	3,274	0	0	1,983	89,245	18,394	85,269
1977	0	0	0	4,106	77,730	13,868	67,112
1978	1,145	8	0	4,758	107,130	10,955	55,411
1979	1,538	0	0	4,300	152,779	10,562	55,909
1980	1,117	0	0	2,436	57,250	8,007	107,440
1981	501	0	0	4,994	259,933	16,495	54,098
1982	1,450	0	0	2,634	229,117	15,280	68,831
1983	2,491	0	0	1,902	148,949	3,662	26,822
1984	4,591	0	0	2,605	193,923	2,011	32,524
1985	14,963	0	0	885	307,947	11,539	57,164
1986	22,567	0	0	3,577	223,533	11,014	109,374
1987	27,758	27	0	6,729	230,296	26,825	135,664
1988	16,182	5	0	9,507	220,219	18,049	67,562
1989	12,198	0	0	4,950	196,432	22,420	91,224
1990	20,063	0	0	5,040	187,683	12,152	67,424
1991	18,300	0	0	6,932	219,303	11,004	61,054
1992	23,383	164	0	3,138	126,953	5,041	27,968
1993	11,668	543	0	3,596	110,854	7,432	27,643
1994	10,751	19,686	0	3,805	50,085	13,699	39,712
1995	6,502	44,912	0	8,399	71,718	8,897	61,328
1996	2,782	59,351	0	6,686	86,625	10,468	49,664
1997	2,384	34,556	0	10,406	127,192	4,853	40,753
1998	24,949	35,870	0	8,739	105,065	4,657	57,689
1999	26,689	42,311	0	15,890	173,664	16,656	88,556
2000	6,517	25,891	0	16,676	156,946	10,955	96,319
2001	46,298	24,876	0	14,257	138,008	8,616	82,485
2002	61,096	23,642	414	20,404	111,356	3,379	113,070
2003	24,314	27,310	18	14,402	82,620	6,074	85,875
2004	1,552	47,861	20	21,407	83,576	3,325	25,284

2005	320	34,848	786	16,591	48,583	4,218	22,959
2006	367	32,354	17	19,782	47,824	912	31,718
2007	1,937	12,452	21,925	18,542	44,827	918	19,159
2008	541	1,186	37,486	19,394	50,959	784	19,154
2009	677	5,251	41,268	19,835	54,472	1,145	16,252
2010	2,093	5,226	41,859	9,743	45,026	775	17,331

Table B2.1.1. Indices of relative abundance for the CPFV logbook data. Data from CPFV trips that were considered to target California halibut were standardized for the categorical variables year, month, and block using a delta-lognormal regression. Obs is the number of trips used to generate the index in that year. The combined index was created as the average weighted by the number of blocks in each sub-area. The indices are assumed proportional to the number of fish selected by the CPFV fishery and the combined index is used in the stock assessment model.

	Islands (30 blocks)		North (19 blocks)		South (16 blocks)		Combined
Year	Index	Obs	Index	Obs	Index	Obs	Index
1980	0.017115	305	0.035399	872	0.018452	483	0.022789
1981	0.015183	337	0.030275	1182	0.017866	511	0.020255
1982	0.016472	388	0.033123	1222	0.020209	800	0.022259
1983	0.012964	213	0.024025	367	0.016575	438	0.017086
1984	0.011143	199	0.023579	519	0.015963	271	0.015965
1985	0.01294	324	0.03183	915	0.0205	547	0.020323
1986	0.01695	292	0.031045	981	0.018236	473	0.021387
1987	0.016431	191	0.031139	1010	0.017472	489	0.020987
1988	0.016061	368	0.037645	1233	0.016629	858	0.02251
1989	0.017003	287	0.037751	967	0.019839	746	0.023766
1990	0.012096	332	0.031195	940	0.019556	767	0.019515
1991	0.014484	357	0.030539	929	0.019893	693	0.020508
1992	0.012773	193	0.023876	590	0.020425	322	0.017902
1993	0.012671	252	0.034648	651	0.020883	477	0.021117
1994	0.013861	292	0.033804	506	0.018499	677	0.020832
1995	0.013734	478	0.035383	848	0.016999	1295	0.020866
1996	0.017066	460	0.032702	1052	0.015085	1523	0.021149
1997	0.018835	609	0.031563	1572	0.013466	1593	0.021234
1998	0.016078	527	0.03525	1064	0.015656	1138	0.021579
1999	0.018712	1006	0.042284	1125	0.024838	1393	0.02711
2000	0.019247	1070	0.037333	1280	0.017214	1459	0.024033
2001	0.023191	1011	0.034015	1063	0.012601	1531	0.023748
2002	0.020954	746	0.03518	639	0.012594	1201	0.023054
2003	0.019786	676	0.035241	581	0.014642	1051	0.023038
2004	0.01973	302	0.034929	365	0.01362	731	0.022669
2005	0.018311	432	0.029208	287	0.014332	719	0.020517
2006	0.020774	610	0.035425	242	0.014879	799	0.023605
2007	0.022194	480	0.030721	117	0.013107	736	0.02245
2008	0.018328	573	0.027432	155	0.015126	775	0.020201
2009	0.020833	552	0.027779	89	0.014904	519	0.021404
2010	0.018569	316	0.030412	95	0.018278	384	0.021959

Table B2.2.1. Indices of relative abundance for the CalCOFI data. CV is the coefficient of variation.

Year	Index	CV	Tows	Year	Index	CV	Tows
1972	0	NA	12	1992	0.038693	0.80	19
1974	0.018859	0.62	27	1993	0.03897	0.56	22
1975	0.012978	0.35	146	1994	0.029065	0.75	21
1977	0.466019	0.86	8	1995	0.023834	0.78	20
1978	0.040799	0.39	53	1996	0.04538	0.54	21
1979	0	NA	9	1997	0.014875	0.89	22
1980	0	NA	11	1998	0.030408	0.45	32
1981	0.076255	0.62	25	1999	0	NA	22
1982	0	NA	2	2000	0.006177	0.80	15
1983	0	NA	3	2001	NA	NA	19
1984	0.009529	0.86	34	2002	0	NA	20
1985	0.067349	0.87	22	2003	0	NA	18
1986	0.070915	0.72	25	2004	0.030546	0.51	36
1987	0.009168	0.77	22	2005	0.008459	0.52	52
1988	0.006997	0.97	21	2006	0.012075	0.48	49
1989	0.03171	0.52	22	2007	NA	NA	42
1990	0.018648	0.72	23	2008	0	NA	12
1991	0.011487	0.68	21				

Table B2.3.1. Indices of relative abundance for the gill net survey data. CV is the coefficient of variation.

	CSUN		HSWRI		
Year	Index	Records	Index	Records	CV
1992			1.682454	29	1.22
1993			2.699604	48	0.80
1994			3.861616	45	0.41
1995	1	5			
1996	1.178555	5	3.836322	18	0.31
1997	0.78079	4	2.802623	36	0.27
1998	0.593652	4	1.607183	36	0.76
1999	0.384474	4	2.015596	34	0.54
2000	0.332923	4	2.988562	36	0.32
2001	0.525439	4	2.849381	37	0.51
2002	0.34695	4	2.339514	36	0.57
2003	0.19787	4	3.06859	36	0.58
2004	0.154064	4	2.495822	35	0.37
2005	0.824833	2	2.522458	30	0.80
2006	0.891373	2	2.323233	11	0.35
2007	0.463029	3	2.408852	27	0.39
2008	0.446826	2	2.446496	15	0.28

Table B2.4.1. Indices of relative abundance for the impingement and related trawl survey data. "Records" refers to the number of samples or tows. CV is the coefficient of variation.

	Impingement			Trawl	
Year	Index	Records	CV	Index	Records
1971				0.00029	13
1972	0.004793	38	0.42	0.000952	35
1973	0.004449	35	0.45		
1974	0.010468	44	0.36		
1975	0.010419	42	0.36	0.003932	12
1976	0.002647	62	0.52	0.005684	6
1977	0.006571	43	0.43	0.211718	6
1978	0.014879	39	0.42	0.060024	88
1979	0.022858	60	0.39	0.067532	74
1980	0.037106	51	0.27	0.194794	174
1981	0.021018	53	0.33	0.213707	122
1982	0.032267	48	0.26	0.060432	675
1983	0.031276	48	0.37	0.046349	651
1984	0.012374	41	0.43	0.050408	619
1985	0.00948	56	0.30	0.064645	672
1986	0.024196	56	0.37	0.07943	708
1987	0.007125	47	0.45	0.066321	48
1988	0.007863	45	0.39	0.064792	142
1989	0.004012	51	0.42	0.036098	6
1990	0.005151	57	0.36	0.06511	46
1991	0.002992	45	0.49	0.16979	33
1992	0.005175	72	0.40	0.034103	46
1993	0.008333	53	0.32	0.035666	46
1994	0.007652	66	0.30	0.032544	46
1995	0.016498	50	0.32	0.066913	74
1996	0.00909	63	0.32	0.062444	78
1997	0.014222	57	0.28	0.047757	97
1998	0.028455	54	0.26	0.058338	78
1999	0.021596	35	0.44	0.054064	117
2000	0.002396	56	0.40	0.028838	112
2001	0.006602	60	0.31	0.040556	118
2002	0.007913	55	0.34	0.068121	112
2003	0.001797	49	0.43	0.03551	85
2004	0.005297	40	0.50	0.032246	117
2005	0.017568	49	0.34	0.067046	112
2006	0.005159	33	0.51	0.084118	112
2007	0.004783	50	0.45	0.062724	118
2008	0.00387	43	0.45	0.03533	106

2009	0.001232	35	0.62	0.020396	118
2010				0.013234	38

Table B2.5.1. Indices of relative abundance for the sanitation district trawl data. LACSD is the Los Angeles County Sanitation District, OCSD is the Orange County Sanitation District.

Year	LACSD	OCSD	LA2
1972	3		
1974	6		
1975	1		
1976	4		
1977	23		
1978	5		
1979	31		
1980	16		
1981	66		
1982	71		
1983	90		
1984	54		
1985	113	4	
1986	62	2	
1987	76	5	
1988	85	14	
1989	59	11	24
1990	65	14	57
1991	41	7	86
1992	54	13	8
1993	64	4	48
1994	45	13	81
1995	76	1	109
1996	85	1	75
1997	105	9	70
1998	124	12	61
1999	127	7	64
2000	143	13	55
2001	105	21	56
2002	46	6	65
2003	4	1	52
2004	30	1	58
2005	28	1	31
2006	32	7	29
2007	23	3	48
2008	31	4	31
2009		5	11

Table B2.6.1. Indices of relative abundance for the trawl logbook data.

Year	Index	Records	Year	Index	Records	Year	Index	Records
1981	13.13068	56	1991	2.173588	28	2000	8.213026	226
1982	1.287888	92	1992	2.003135	30	2001	12.75801	307
1983	0.117583	30	1993	1.261276	62	2002	9.819932	147
1984	0	4	1994	9.765941	82	2003	9.587504	243
1985	3.755854	89	1995	8.999438	151	2004	12.34795	211
1986	3.986667	25	1996	20.457	110	2005	5.514078	195
1987	9.615522	35	1997	12.16804	317	2006	6.474595	152
1988	2.59459	45	1998	18.1296	322	2007	1.834771	136
1989	0.684957	102	1999	15.68217	260	2008	6.954767	135
1990	1.051019	56						

Table B2.8.1. Sample size (number of fish measured) for commercial length composition data.

	Bottom trawl		Hook-and-line		Gill net				Single-rigged trawl		Trawl with footrope diameter < 8 inches	
Year	Retained Sex aggregated	Sex specific	Retained Sex aggregated	Sex Specific	Whole catch Sex aggregated	Sex specific	Retained Sex aggregated	Sex specific	Retained Sex aggregated	Sex specific	Retained Sex aggregated	Sex specific
1975												
1976												
1977												
1978												
1980												
1981												
1982												
1983	215				652		594					
1984	538		25		1542		2000					
1985	807	6			1525	245	2705	782				
1986	69	166		24	1284	666	2097	4835				
1987	50	497	33	47	760	868	1988	3604				
1988	17	391	32	175	802	164	1618	4099				
1989	17	339	5	81	191	25	992	4349				
1990	2	92		7			354	1508				
1991	3	33	14	1			417	943				
1992	30	95	14				1748	1694				
1993	8						1496	437				
1994	15		4	3			73	3	26	18		
1995	227						49	6	15			
1996	64		2				136	4	56			
1997							1	1				

1998										
1999					2					
2000			1		24					
2001			39		15		5			
2002			43		491	1	15			
2003			38		74	5	46			
2004					38		1			
2005			7		23					
2006			7							
2007	4	8	8		2	1	6		58	1
2008			132	3	110	32	17	20	300	96
2009	32		54	2	27	94	12	20	67	108
2010	29		24		43	50	36		4	1

Table B2.8.2. Sample size (number of fish measured or weighed) for recreational length and weight composition data. Males and females are aggregated.

	CPFV			Other recreational	
	Length	Length	Weight	Length	Weight
Year	Whole catch	Retained	Retained	Retained	Retained
1975	118				
1976	208				
1977	352				
1978	406				
1980			12		102
1981			45		89
1982			27		110
1983			12		45
1984			7		45
1985			40		67
1986	922		37		134
1987	752		43		62
1988	795		28		89
1989	756		43		100
1990					
1991					
1992					
1993		3		46	
1994		24		55	
1995		13		91	
1996		25		139	
1997		11		99	
1998		26		168	
1999		105		430	
2000		47		232	
2001		38		102	
2002		80		260	
2003		106		308	
2004		42		646	
2005		43		676	
2006		35		872	
2007		36		655	
2008		37		808	
2009		48		672	
2010		35		343	

Table B2.8.3. Sample size (number of fish measured) for survey length composition data.

Year	Gill net Survey HSWRI	Gill net Survey CSUN	Impingement HTFC	Impingement Trawl
1971				
1972				
1973				
1974			1	
1975			4	
1976				
1977				
1978			1	
1979				
1980				
1981			197	
1982			79	
1983			90	
1984			72	
1985			46	
1986			80	
1987			26	
1988			27	
1989			24	
1990			22	
1991			10	
1992	43		20	
1993	120		30	
1994	157		75	
1995		119	102	
1996	58	139	63	
1997	85	115	73	
1998	40	107	88	
1999	53	69	40	
2000	95	66	11	
2001	69	92	21	
2002	67	70	33	
2003	70	35	9	
2004	73	33	23	67
2005	56	74	43	134
2006	18	77	26	197
2007	60	63	30	159

2008	32	29	22	88
2009			12	62
2010				17

Table B2.9.1. Percent age composition data from Sunada et al. (1990) N = number of fish aged.

N	95	344	565	330
Age	1985	1986	1987	1988
4	8.4	4.4	0.3	0.3
5	28.4	19.2	11.5	19.4
6	28.4	32	33.8	35.5
7	22.1	25	32.4	32.7
8	4.2	9.6	12.5	8.5
9	1.1	4.4	4.4	2.4
10	2.1	0.6	1.8	0.9
11		2.3	1.2	
12	4.2	0.9	1.2	0.3
13		1.1	0.7	
14		0.3		
15+		0.3		

Table B2.9.2. Age composition data (number of fish aged) from the trawl survey (MacNair et al. 2001).

Age	Female	Male
1	1	5
2	22	104
3	42	178
4	55	109
5	58	106
6	68	92
7	41	96
8	25	39
9	10	22
10	10	4
11	2	1
12	0	1
13	1	0

Table B2.10.1. Ratio of discards to retained recreationally caught fish in numbers of fish.

Year	CPFV RecFIN	Logbook	Observer	Other RecFIN
1980	3.126219			5.421364
1981	2.739227			8.653592
1982	9.435152			7.000156
1983	9.342324			9.707031
1984	14.5061			13.17026
1985	9.400688			12.85084
1986	7.601768		2.120172	10.37773
1987	4.850019		2.189922	9.266473
1988	7.255059		2.214286	20.41673
1989	6.189065		3.130631	14.245
1990				
1991				
1992				
1993	2.161651			8.828594
1994	2.771594			10.21362
1995	3.017931	0.745753		7.837356
1996	3.362679	0.786168		8.422285
1997	4.416503	0.874393		8.695001
1998	2.694001	0.535598		3.606764
1999	2.400497	0.974563		6.010149
2000	5.674797	1.737543		8.383372
2001	4.241324	1.206122		9.891615
2002	4.154036	0.909103		8.190336
2003	1.582726	0.409591		6.211792
2004	1.349514	0.317965		6.541289
2005	1.316633	0.26268		11.28617
2006	1.820902	0.661114		10.61169
2007	2.842799	1.204752		8.492012
2008	2.073493			10.72115
2009	0.771462			12.00346

Table B2.10.2. Discard catch estimates (number of fish observed) used in the model.

Observer based		Logbook based	
Year	Discards	Year	Discards
1986	23,352	1995	6,635
1987	58,745	1996	8,230
1988	39,965	1997	4,244
1989	70,189	1998	2,494
		1999	16,233
		2000	19,035
		2001	10,392
		2002	3,072
		2003	2,488
		2004	1,057
		2005	1,108
		2006	603
		2007	1,106

Table B2.10.3. Proportion of the catch, by weight, discarded in the limited entry and open access trawl fisheries with standard errors (from Bellman et al. 2010 and earlier reports). Data is from both north and south of Point Conception.

	Limited entry		Open access	
Year	Estimate	SE	Estimate	SE
2002	0.3454	0.0885		
2003	0.1788	0.0271	0.1091	0.0264
2004	0.0334	0.0041	0.1008	0.0141
2005	0.0266	0.0037	0.0835	0.0142
2006	0.091	0.0172		
2007	0.206	0.047	0.5691	0.0723
2008	0.373	0.5785	0.2602	0.2632
2009	0.0749	0.1475	0.0419	0.1268

Table B3.3.1. Management quantities for the base case and sensitivities. 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. nlnL is the negative log-likelihood of the model fit to the data.

	Base Model
MSY	392
B2011/B0	0.14
Bmsy/B0	0.07
B2011/Bmsy	2.19
Fmult	4.49
nlnL	3567.46

Table B3.4.1. Negative log-likelihood values, current depletion level (B2011/B0), and root mean squared error (RMSE) of the fit to the CPFV index of abundance for the sensitivity analyses.

	TOTAL	Survey	Discard	Length comp	Weight comp	Recruitment	B2011/B0	RMSE CPFV
Base	3567.46	-28.89	51.20	3311.89	227.53	5.73	0.14	0.22
Aggregated CPUE	3584.15	-13.91	48.29	3311.23	227.84	10.68	0.04	0.39
h75 (not converge)	3571.91	-28.79	51.10	3311.76	227.49	10.35	0.05	0.22
L2=100	3550.80	-25.61	48.57	3292.73	228.97	6.14	0.21	0.26
M=0.3 0.4	3541.92	-23.83	50.00	3283.03	226.97	5.75	0.25	0.28
No reweight	9183.08	-25.81	50.29	8735.76	415.81	7.02	0.16	0.26

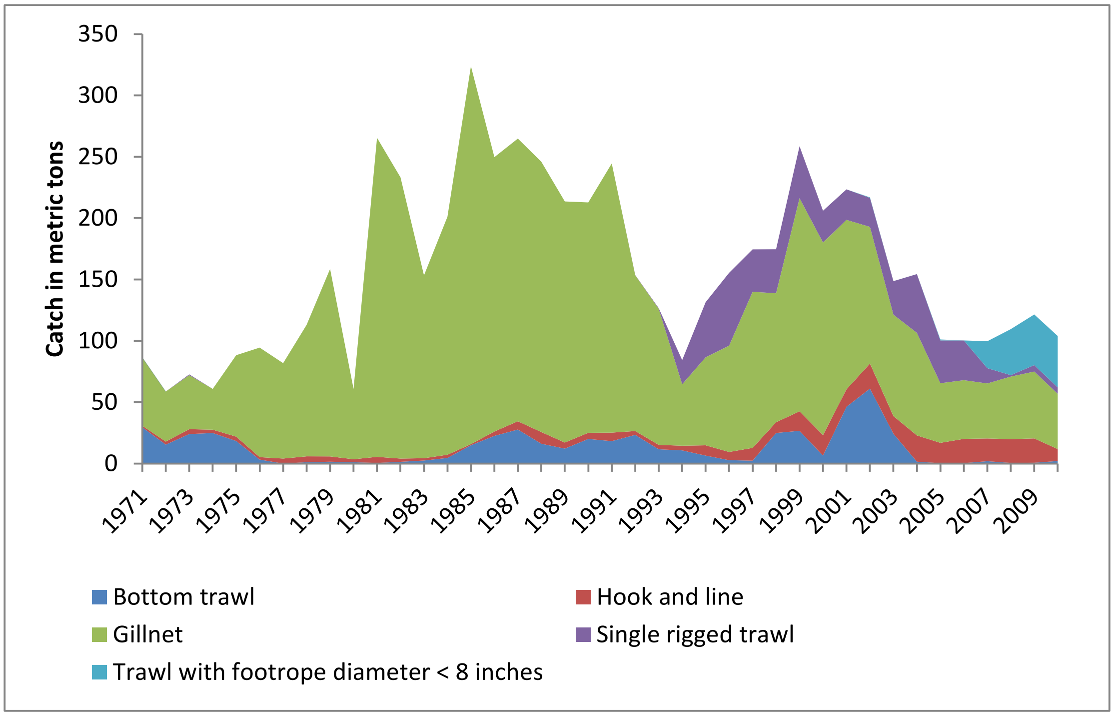


Figure B1.6.1. Commercial catch in metric tons by gear type.

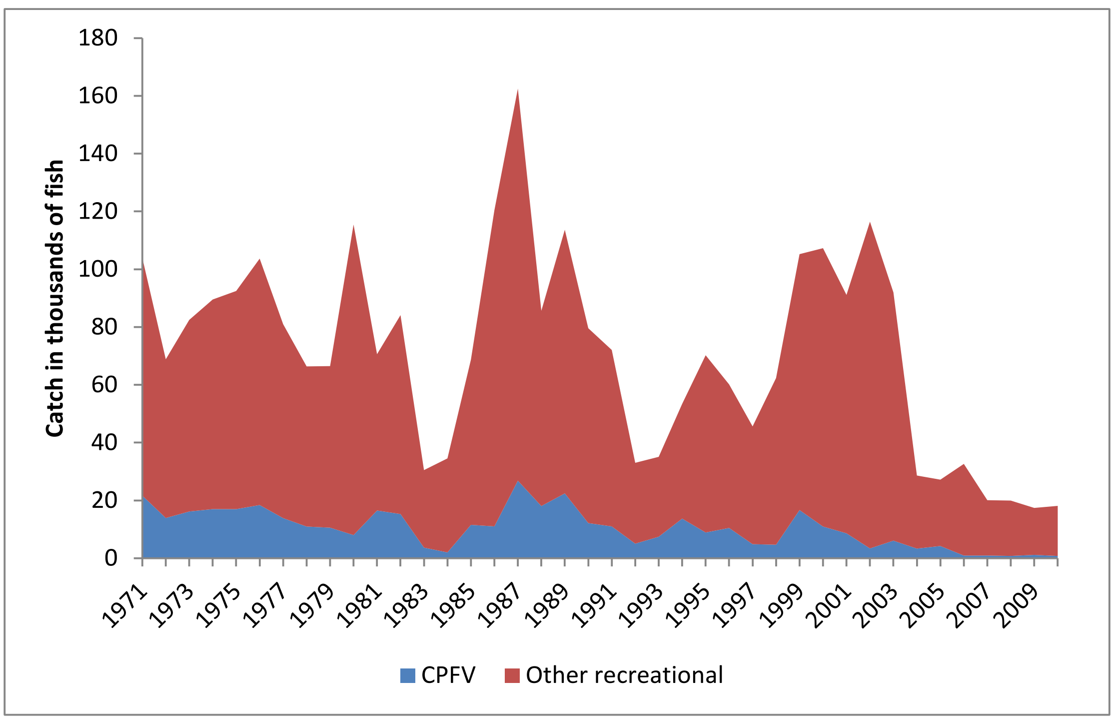


Figure B1.6.2. Recreational catch by fishing mode in thousands of fish.

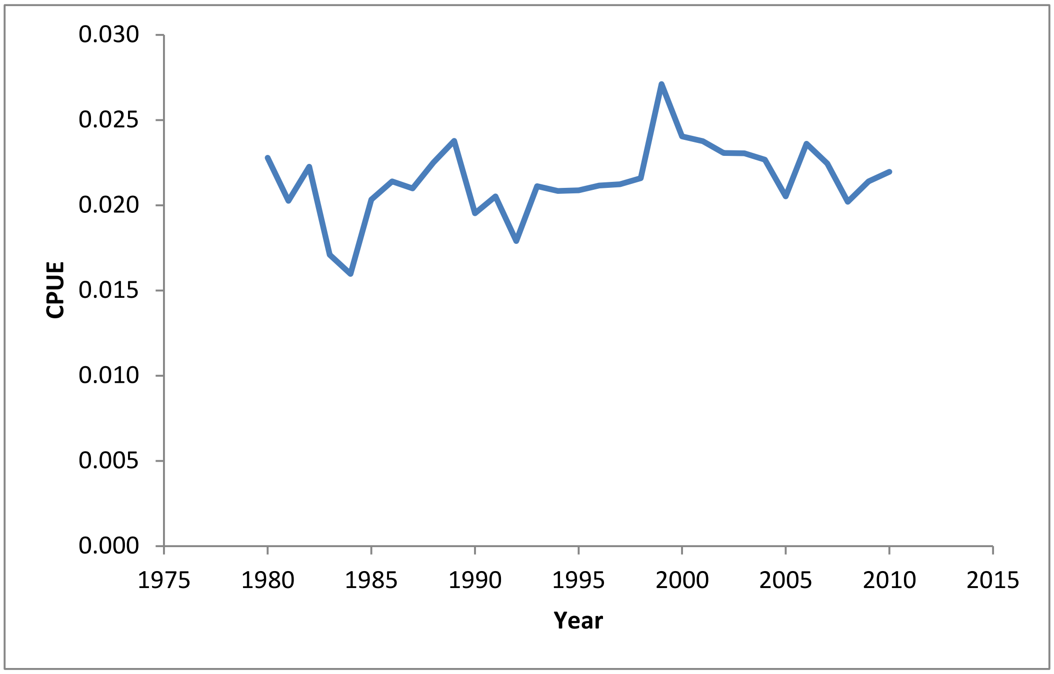


Figure B2.1.1. Index of relative abundance for the CPFV logbook data.

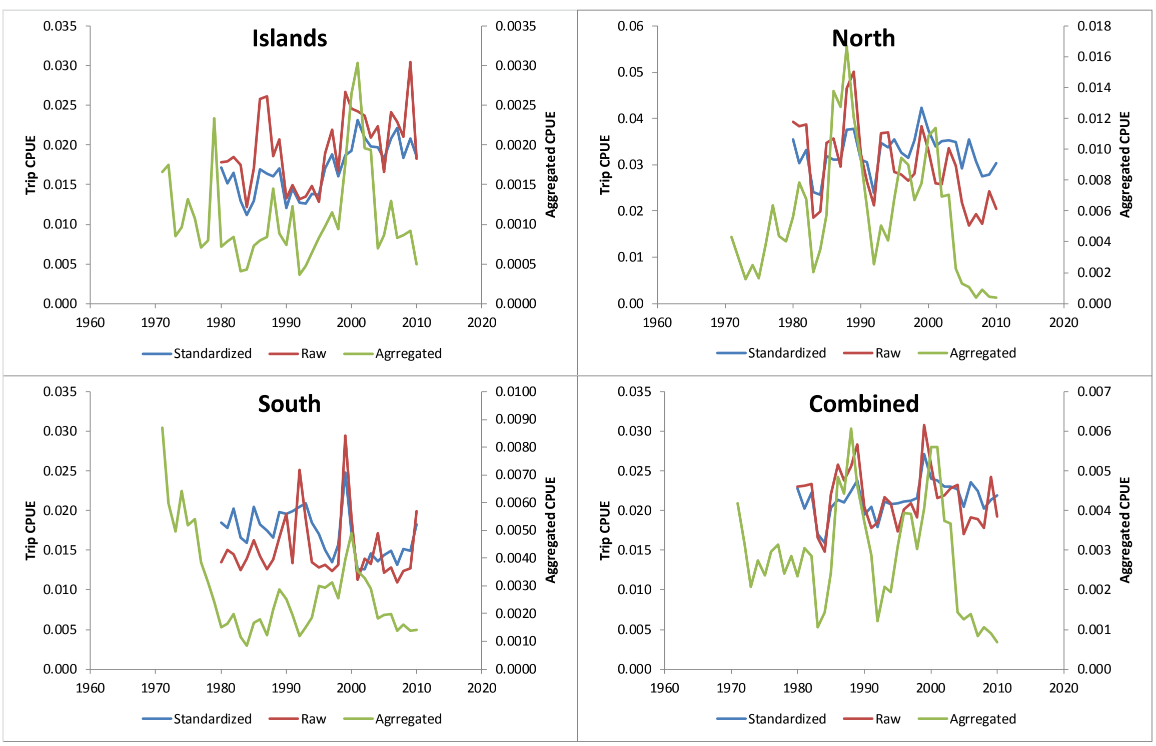


Figure B2.1.2. Index of relative abundance for the detailed trip targeting CPFV logbook data standardized and unstandardized compared to the aggregated data.

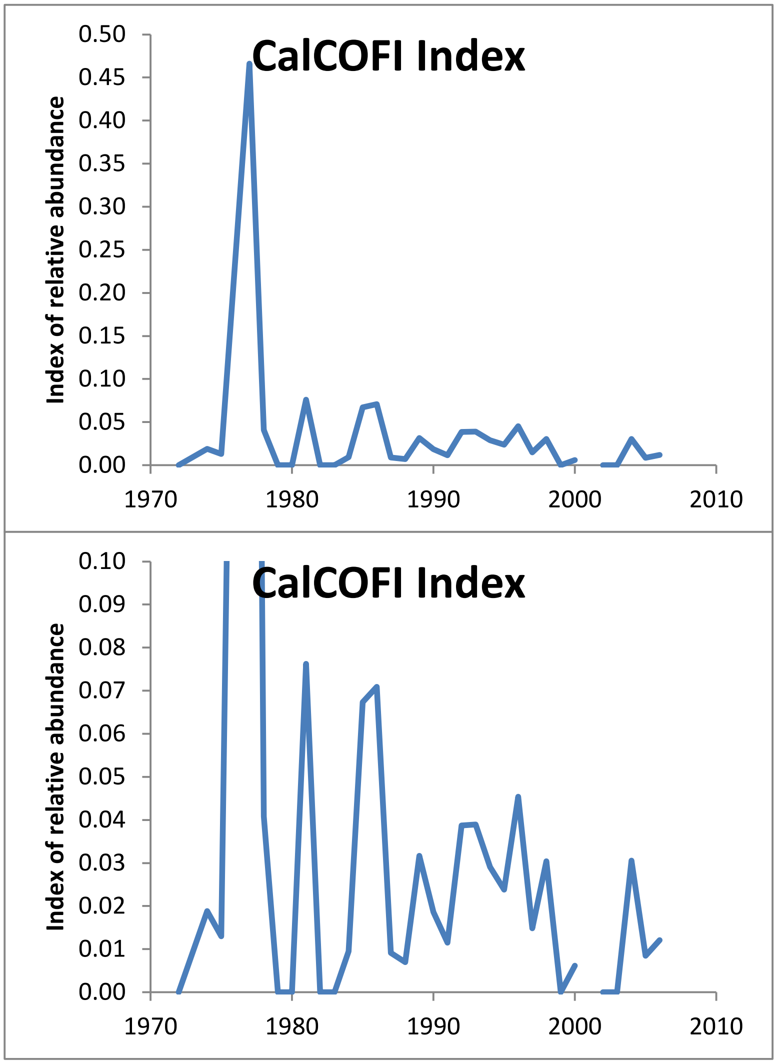


Figure B2.2.1. Index of relative abundance for the CalCOFI data. The lower figure differs from the upper figure only in the range of the y-axis.

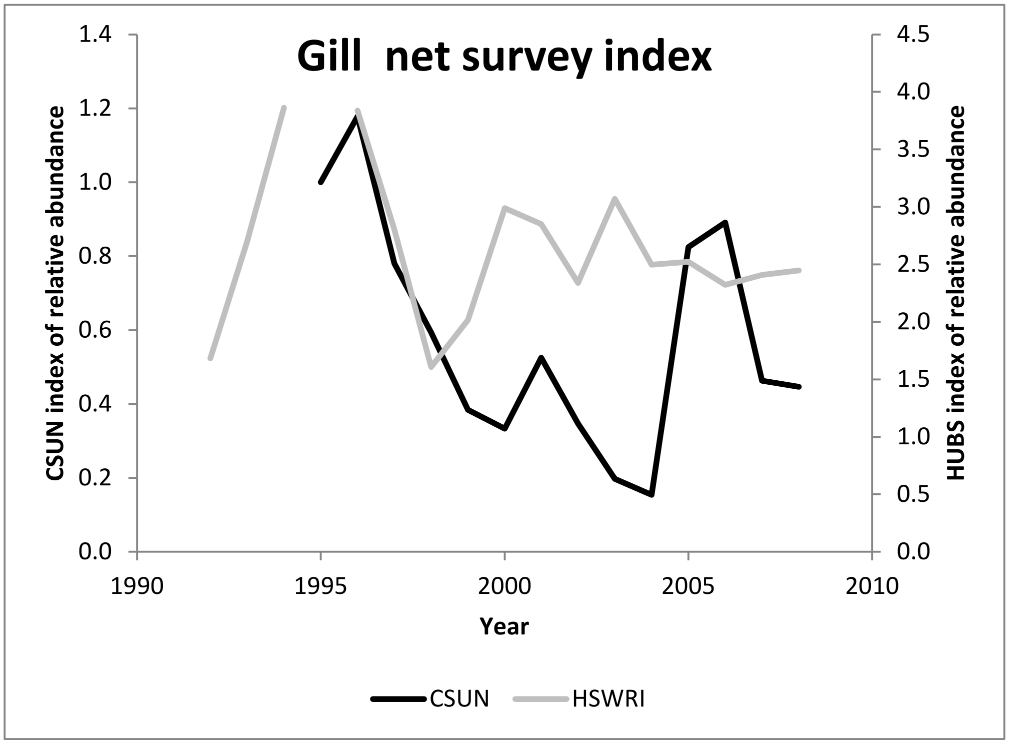


Figure B2.3.1. Gill net survey indices of relative abundance for the gill net survey data.

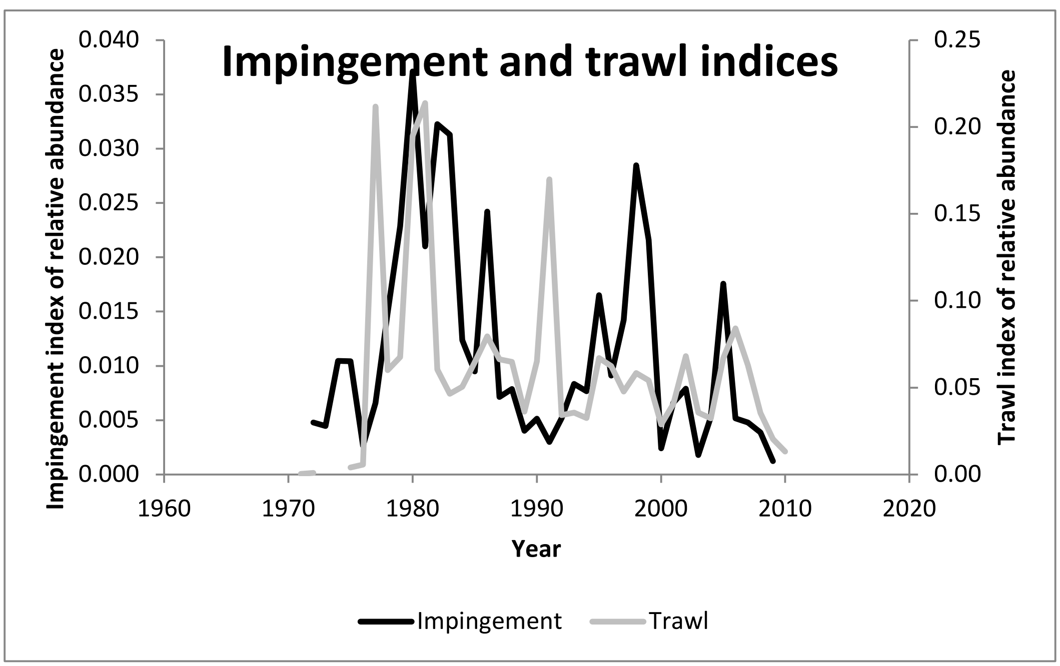


Figure B2.4.1. Indices of relative abundance for the impingement and related trawl survey data.

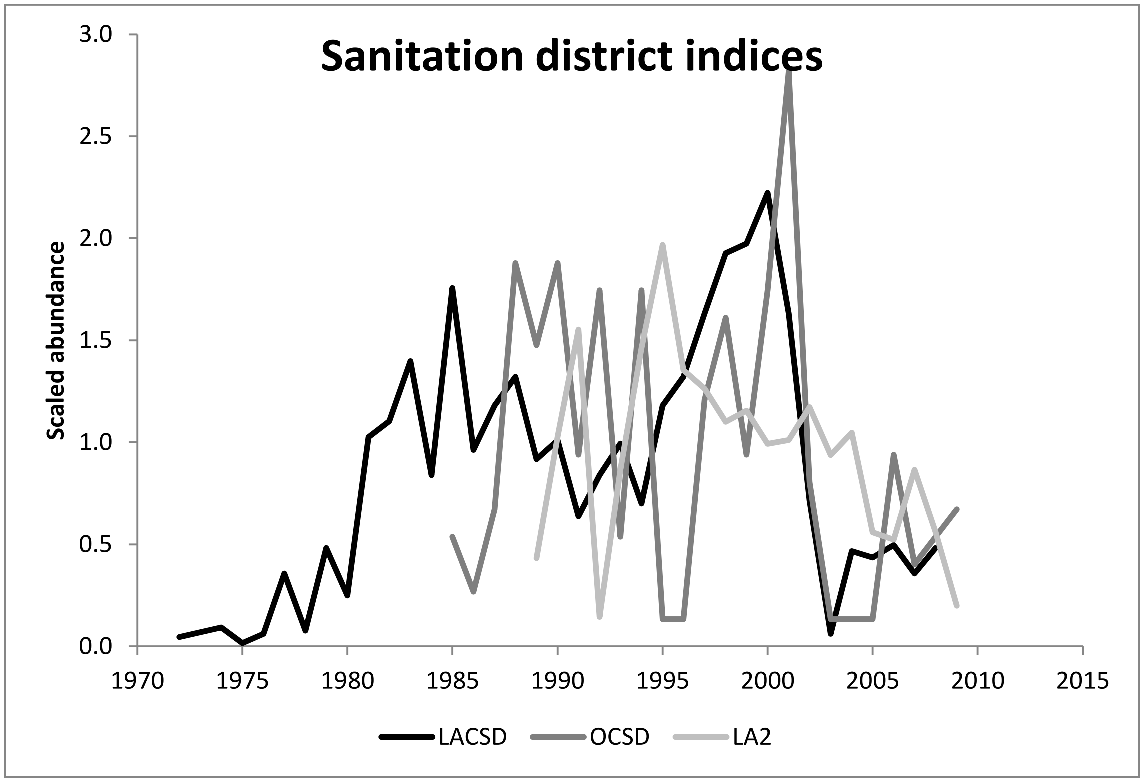


Figure B2.5.1. Scaled indices of relative abundance for the sanitation district trawl data.

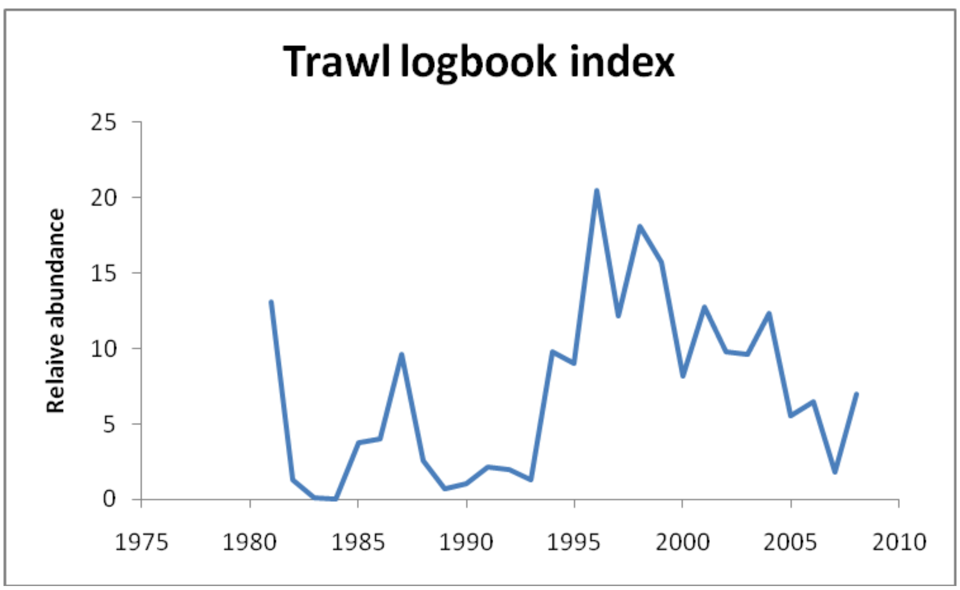


Figure B2.6.1. Index of relative abundance for the trawl logbook data. (Note that there was very little data in 1984 when the index is estimated to be zero).

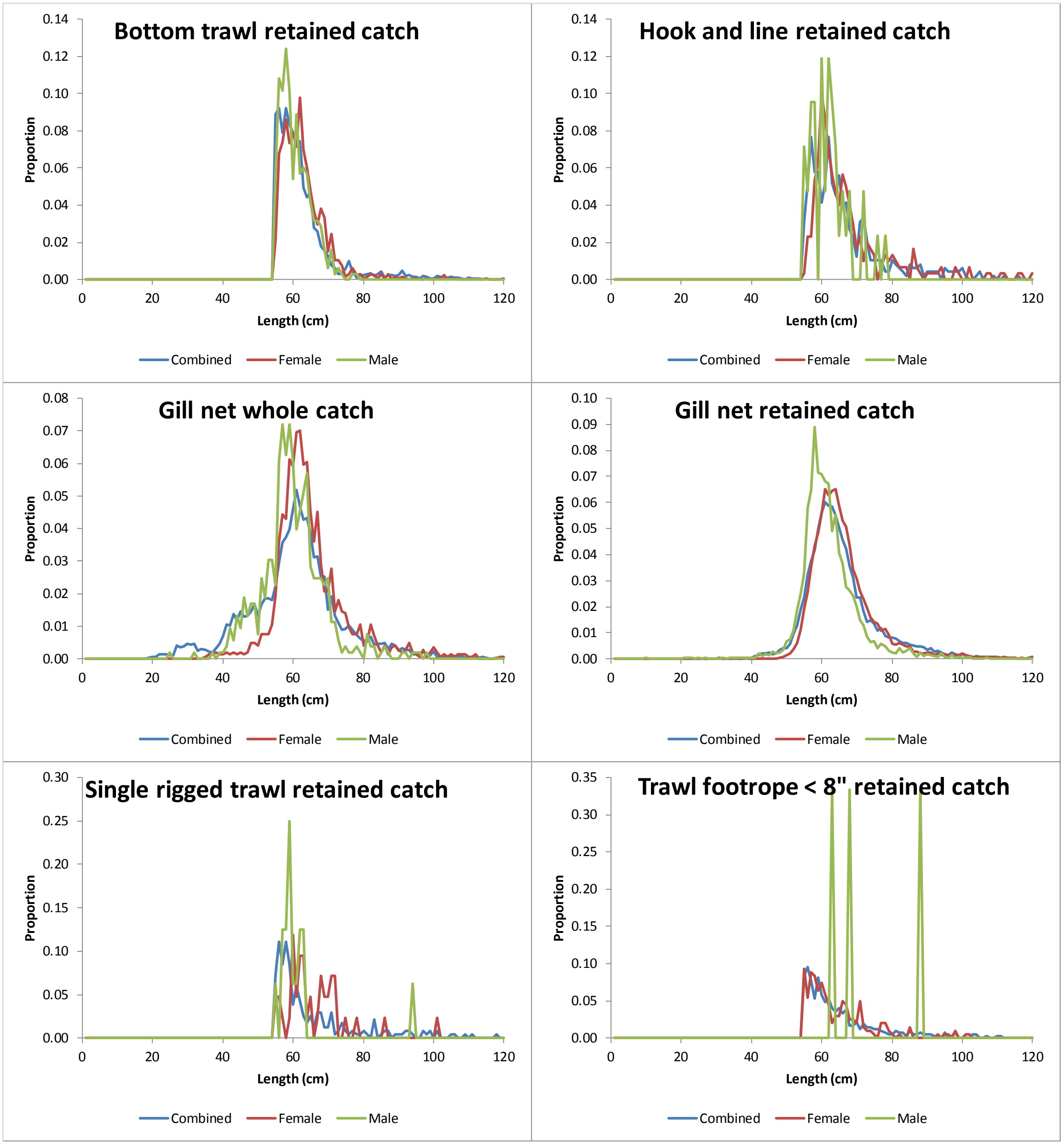


Figure B2.8.1. Commercial fishery average length compositions. (note years differ among fisheries and data types. Male and female data not included in combined and do not sum to one together)

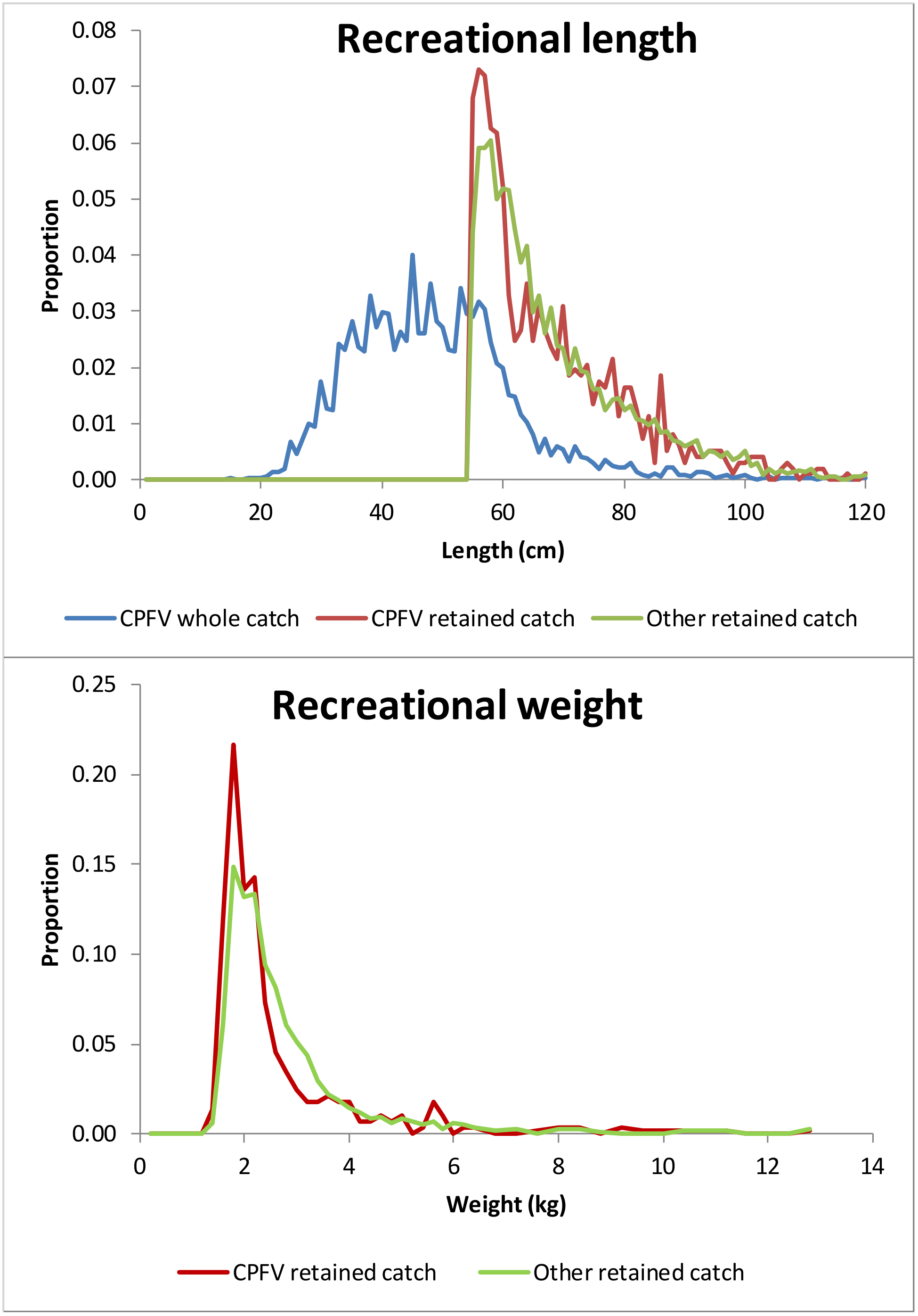


Figure B2.8.2. Recreational fishery average length and weight compositions. (note years differ among fisheries and data types)

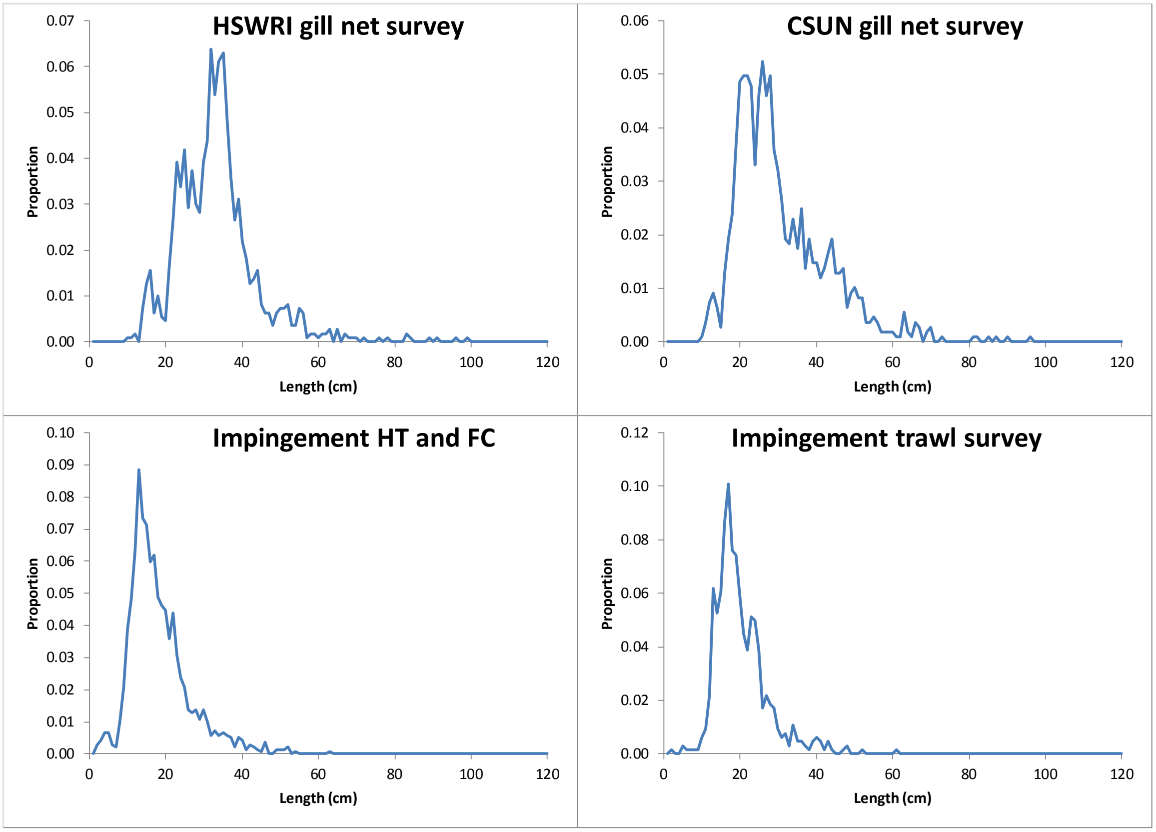


Figure B2.8.3. Survey average length compositions. (note years differ among surveys) Lengths less than 10 cm are grouped at 10 cm.

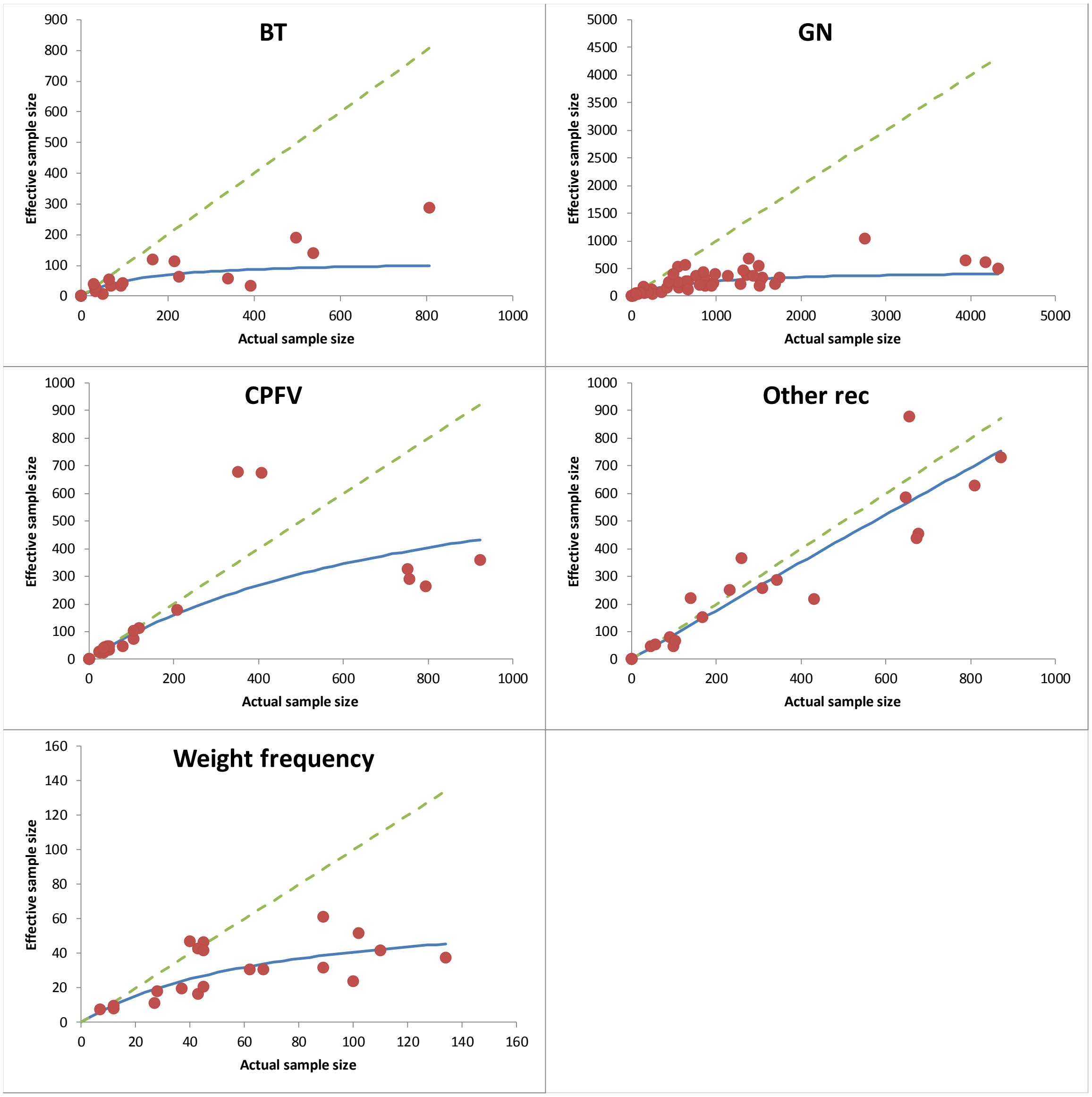


Figure B2.8.4. Reweighting of the composition sample size in number of fish.

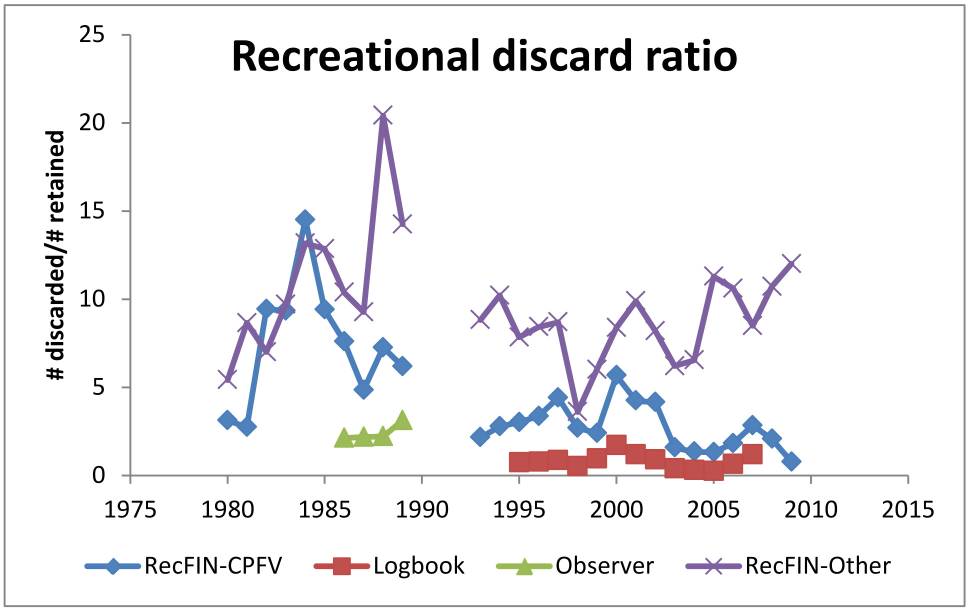


Figure B2.10.1. Ratio of discards to retained recreational catches in numbers of fish.

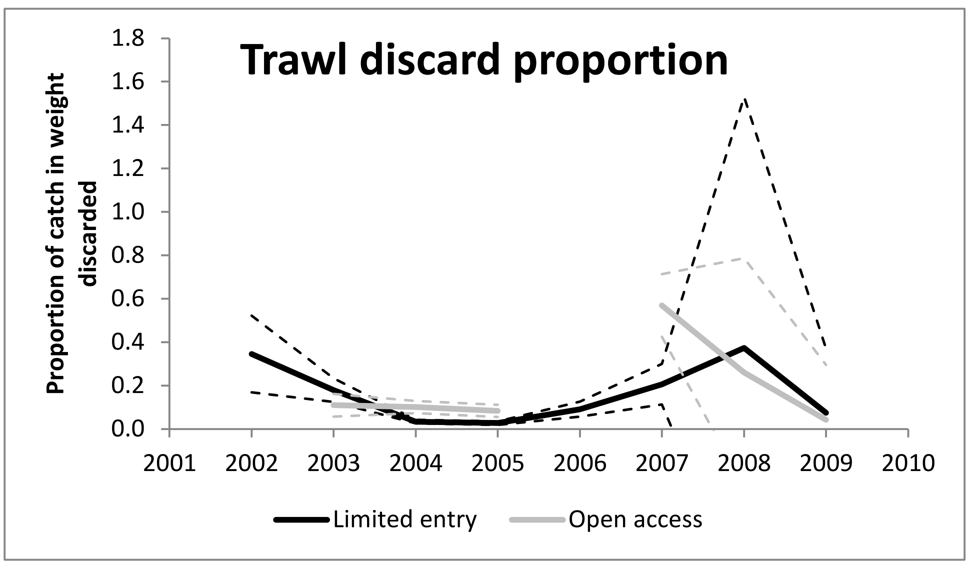


Figure B2.10.2. Proportion of the catch in weight discarded in the limited entry and open access trawl fisheries with 95% confidence intervals (from Bellman et al. 2010) and earlier reports). Data is from both north and south of Point Conception due to the lack of data in the south and the inability to separate some of the data.

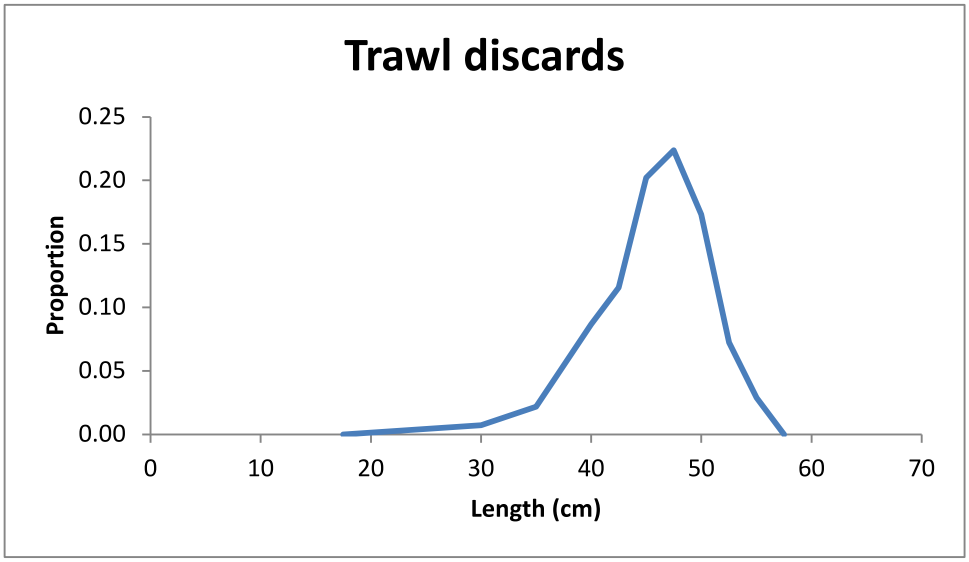


Figure B2.10.3. Length composition for halibut trawl reconstructed from Figure 1 of Bellman et al. (2010). Data is from 2003-2010 and includes 341 individuals. Proportion refers to the proportion that length bin comprises of the total discards.

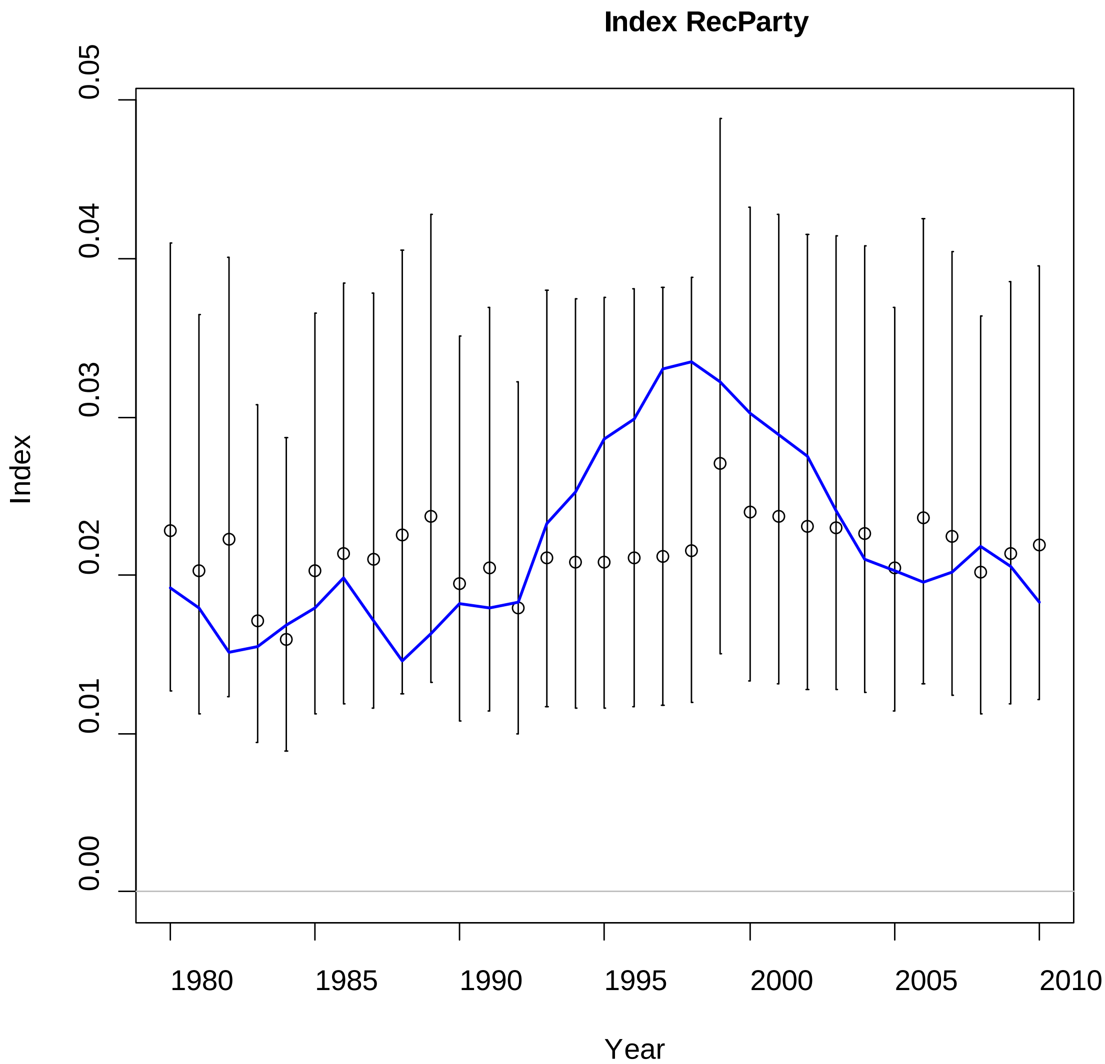


Figure B3.1.1a. Fit of the model to the CPFV index of relative abundance.

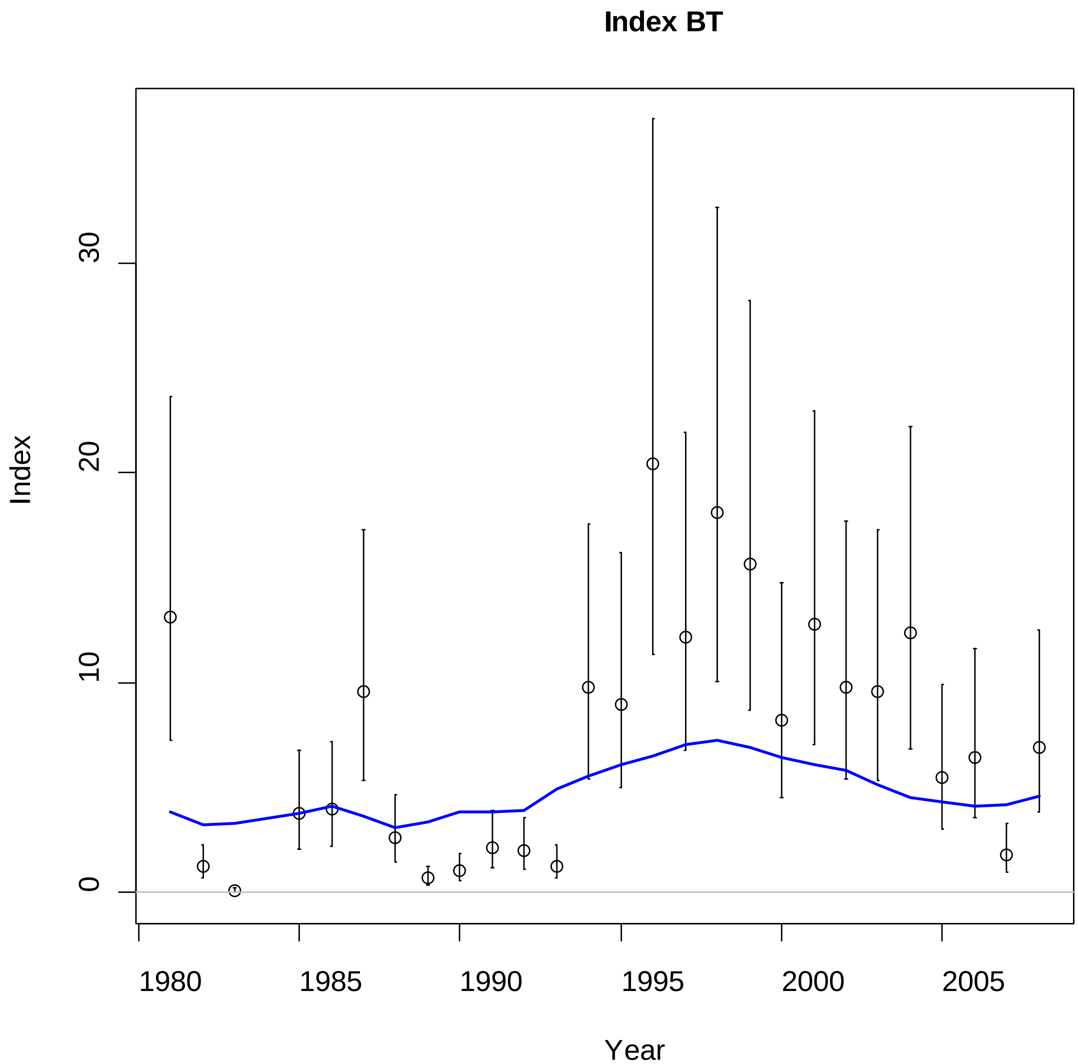


Figure B3.1.1b. Fit of the model to the trawl logbook index of relative abundance (note that data is not used to estimate parameters)

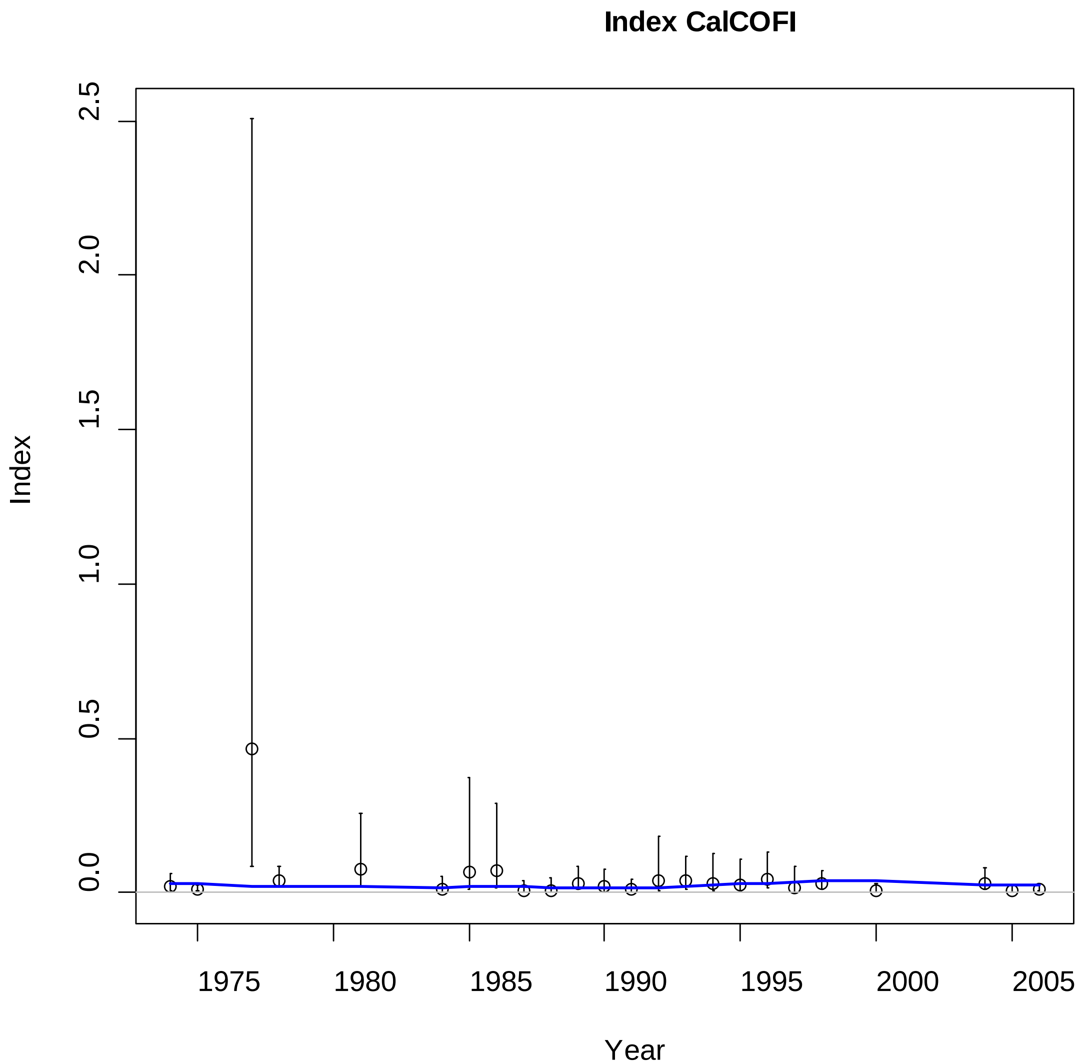


Figure B3.1.1c. Fit of the model to the CalCOFI index of relative abundance (note that data is not used to estimate parameters)

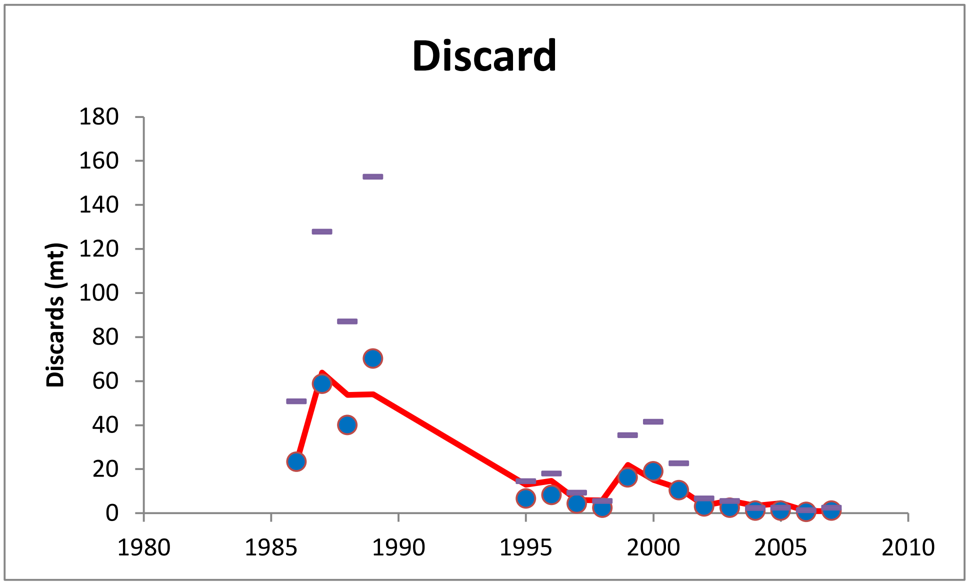


Figure B3.1.2. Fit to the CPFV discard data.

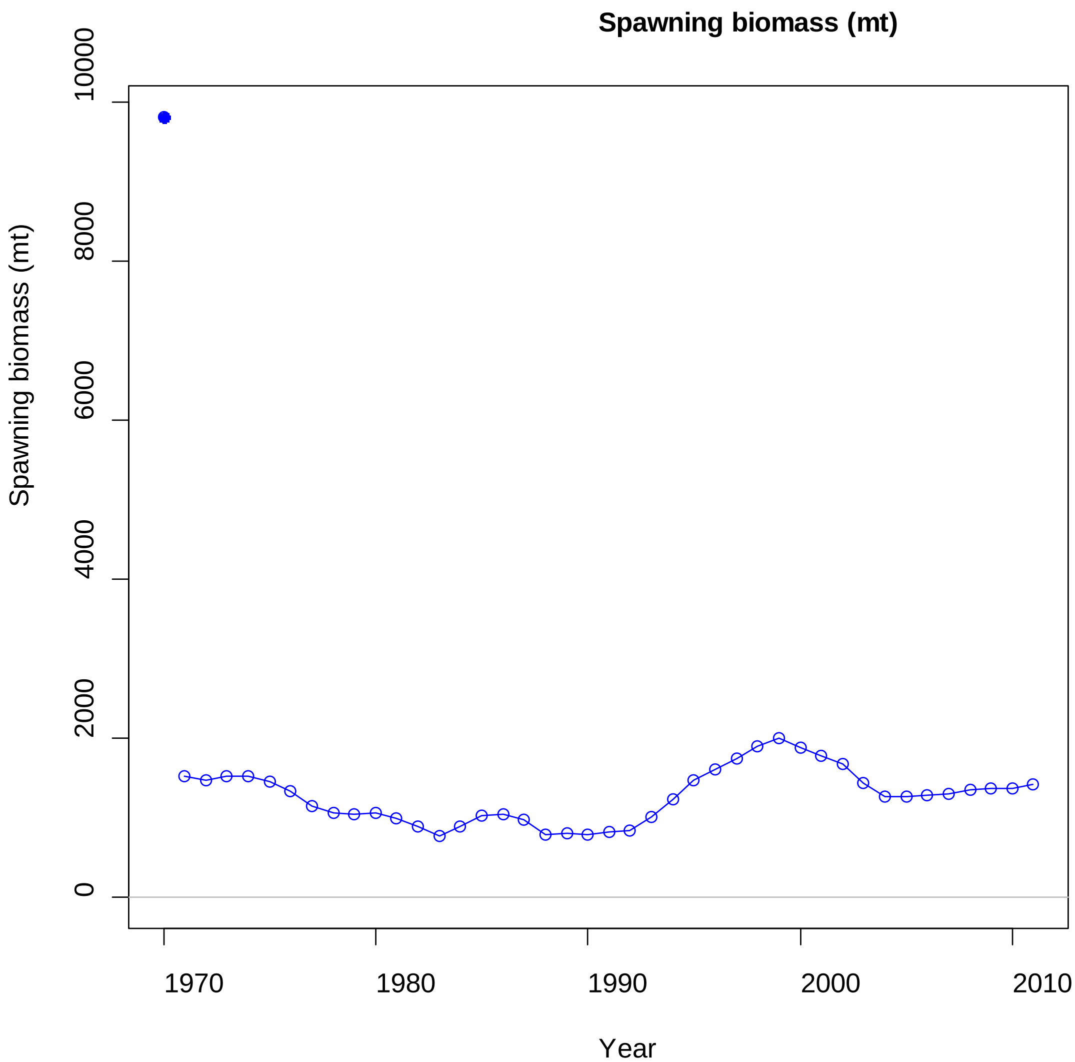


Figure B3.2.1. Estimated spawning biomass.

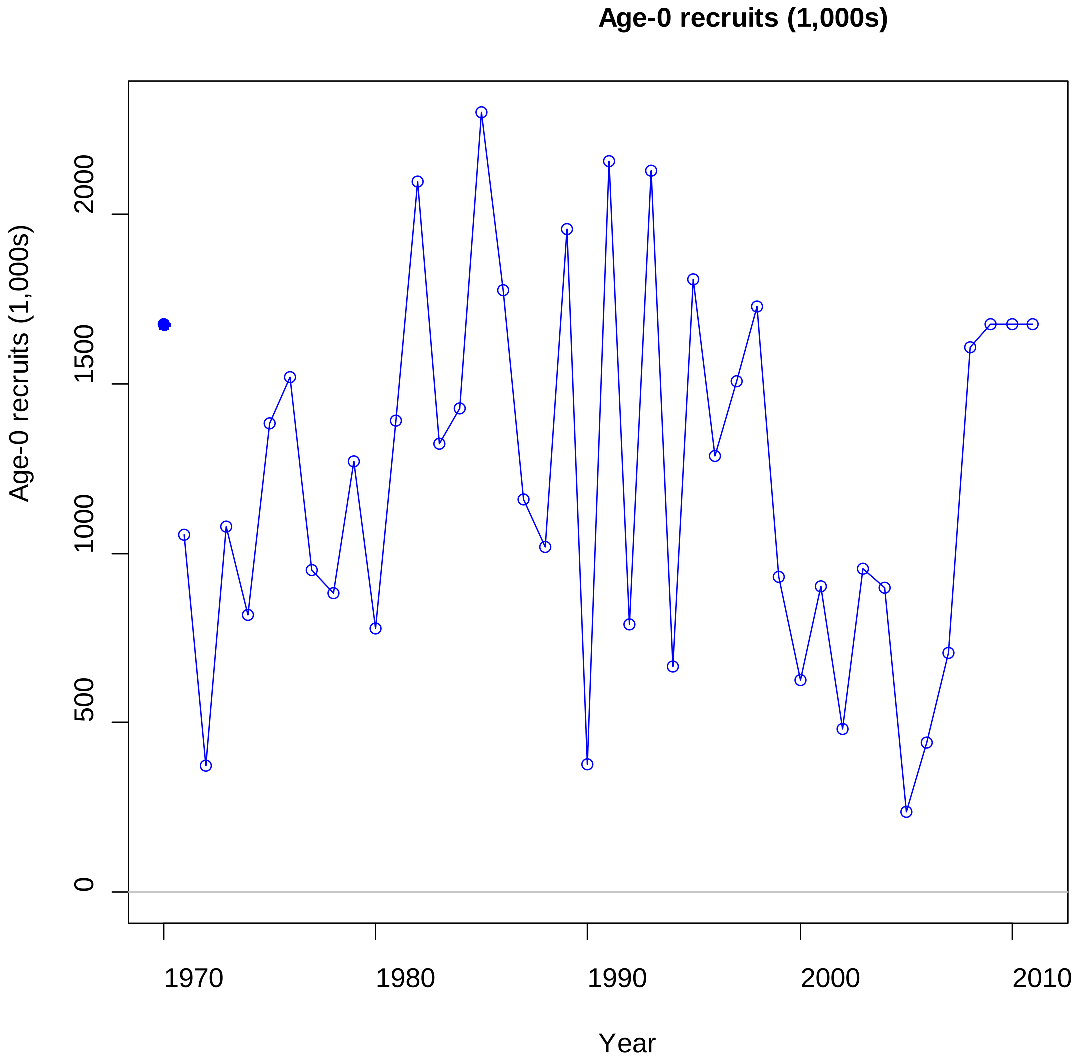


Figure B3.2.2. Recruitment estimates.

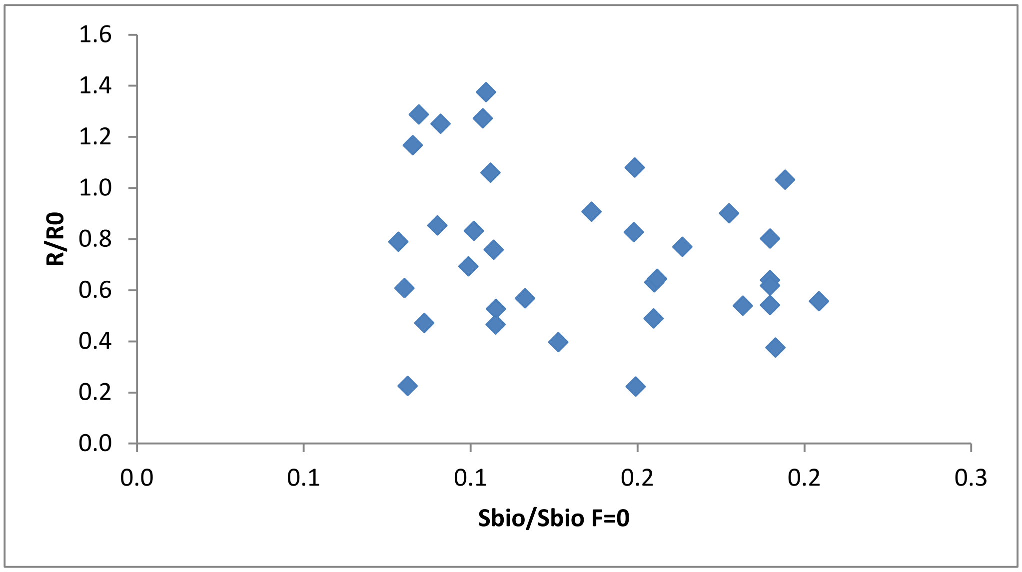


Figure B3.2.3. Relationship between recruitment and spawning stock size.

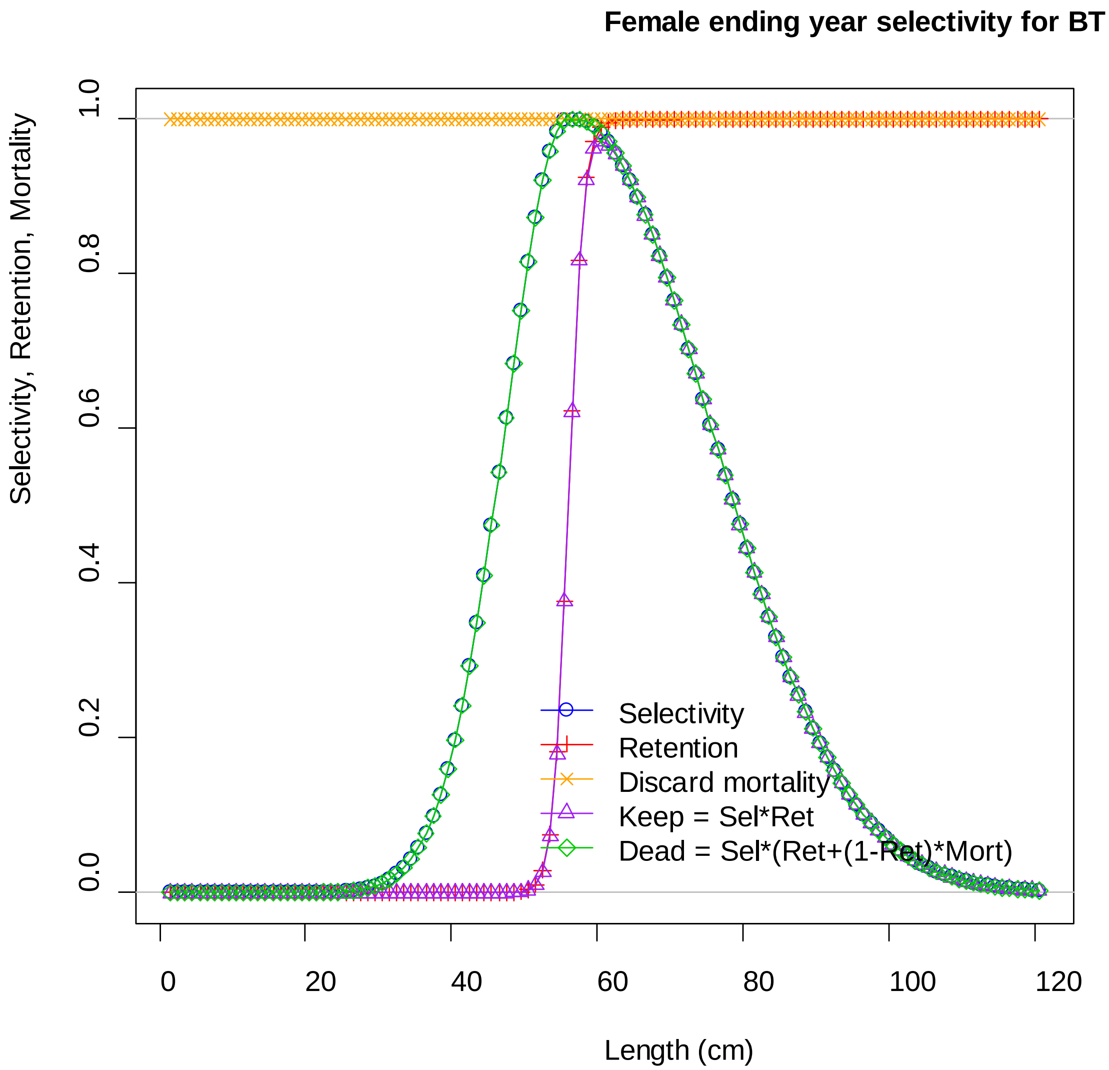


Figure B3.2.4a. Bottom trawl (BT) female selectivity. (Also used for the single-rigged trawl and trawl with a footrope less than 8 inches)

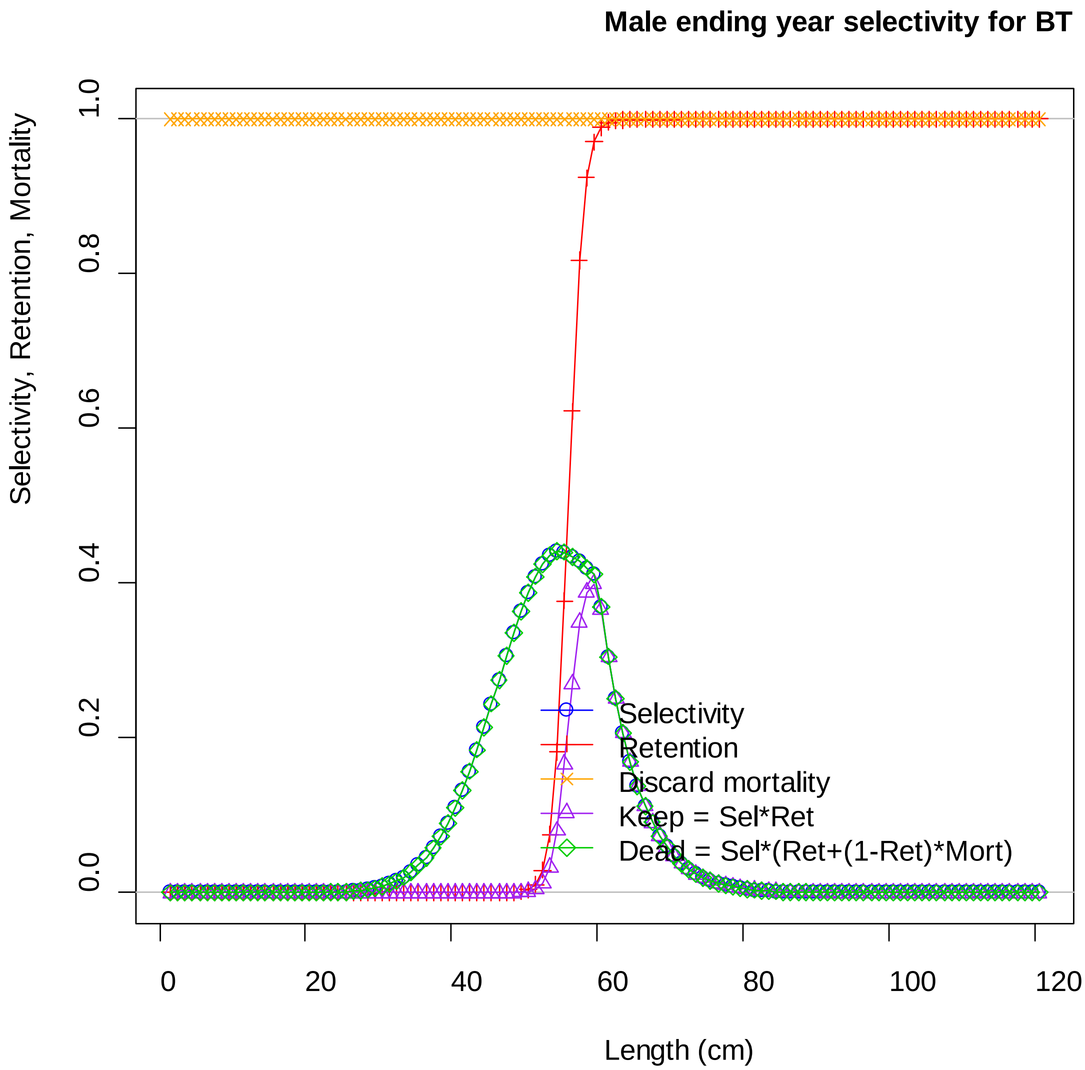


Figure B3.2.4b. Bottom trawl male selectivity. (Also used for the single-rigged trawl and trawl with a footrope less than 8 inches)

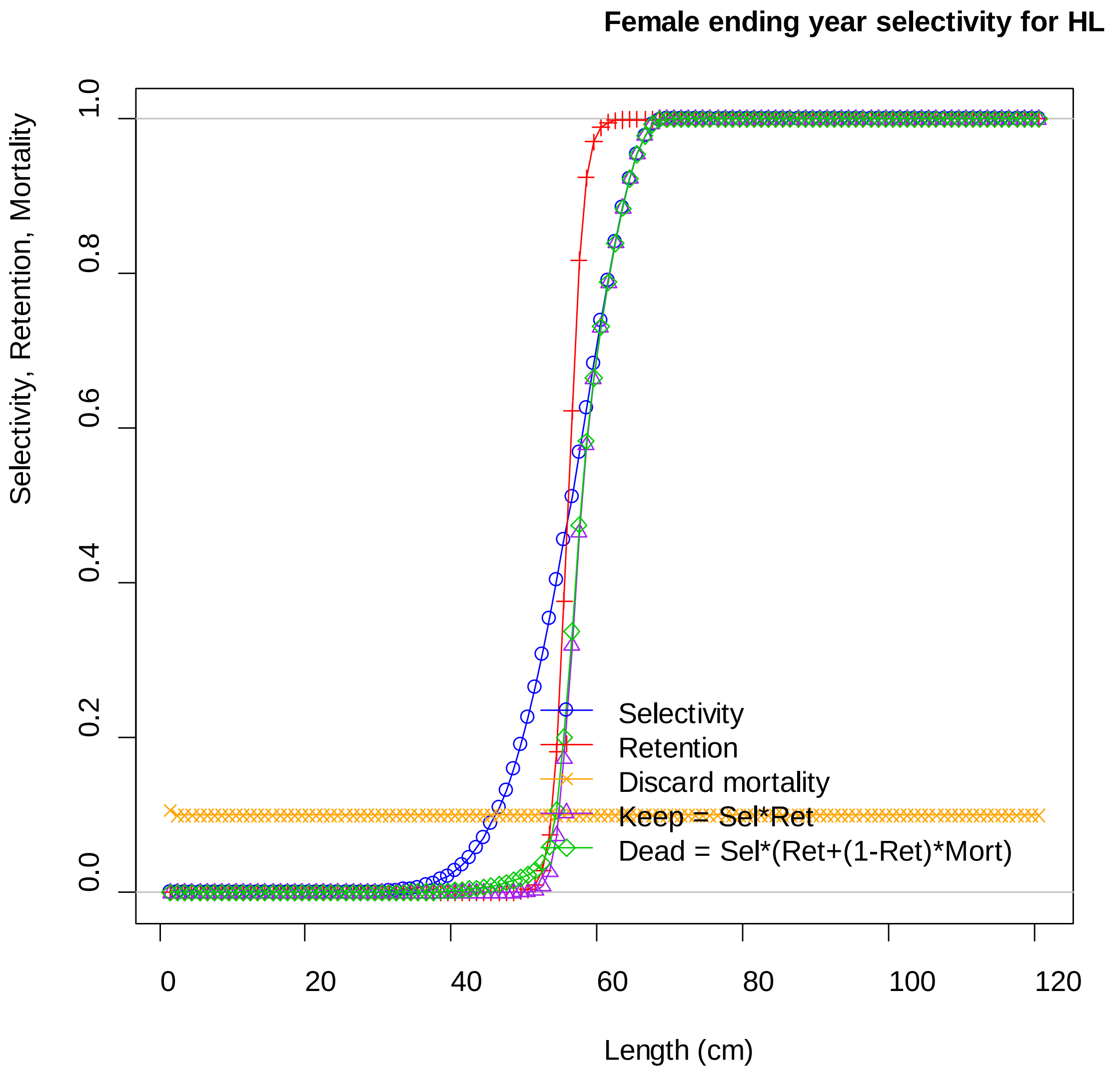


Figure B3.2.4c. Hook-and-line (HL) female selectivity.

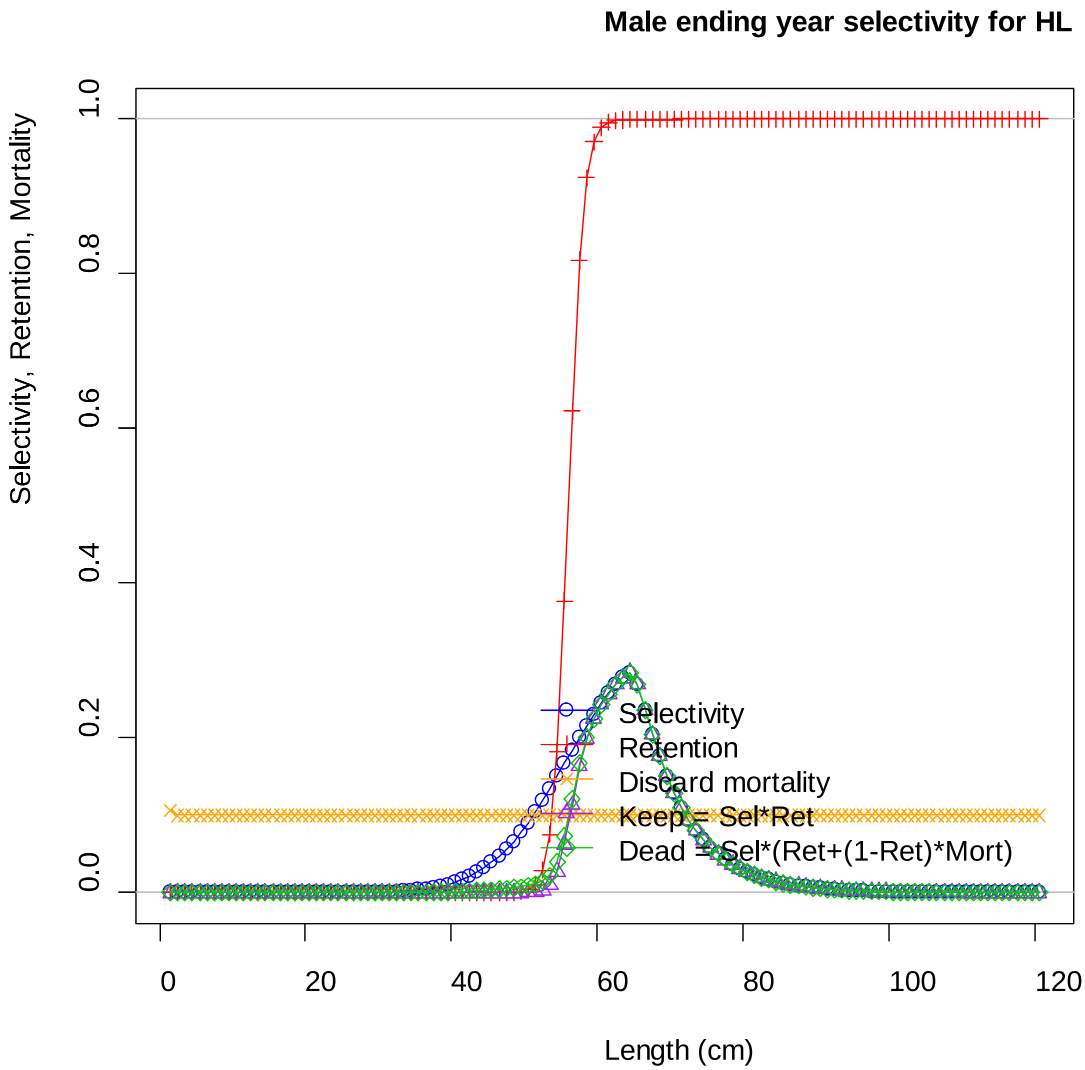


Figure B3.2.4d. Hook-and-line male selectivity.

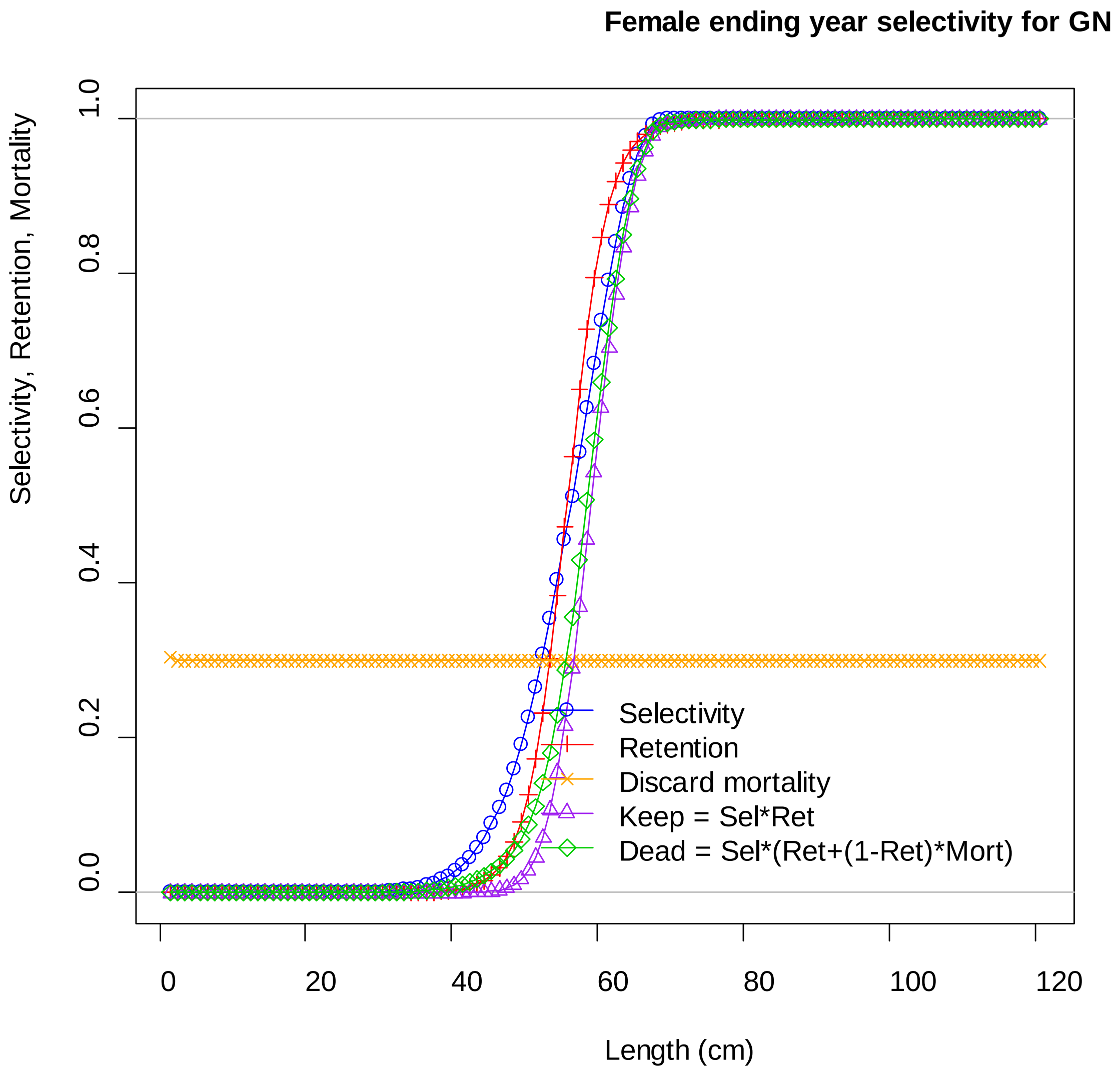


Figure B3.2.4e. Gill net (GN) female selectivity.

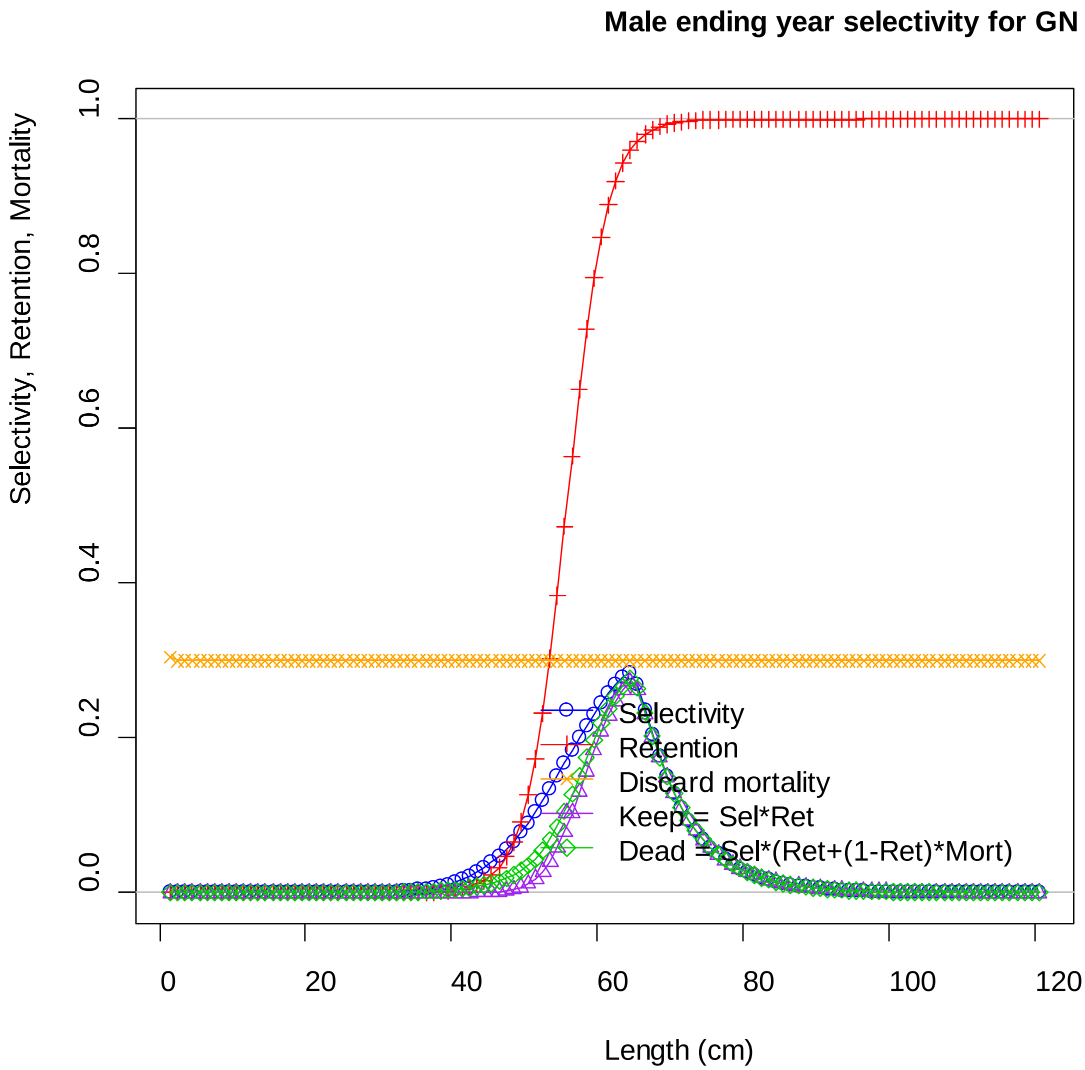


Figure B3.2.4f. Gill net male selectivity.

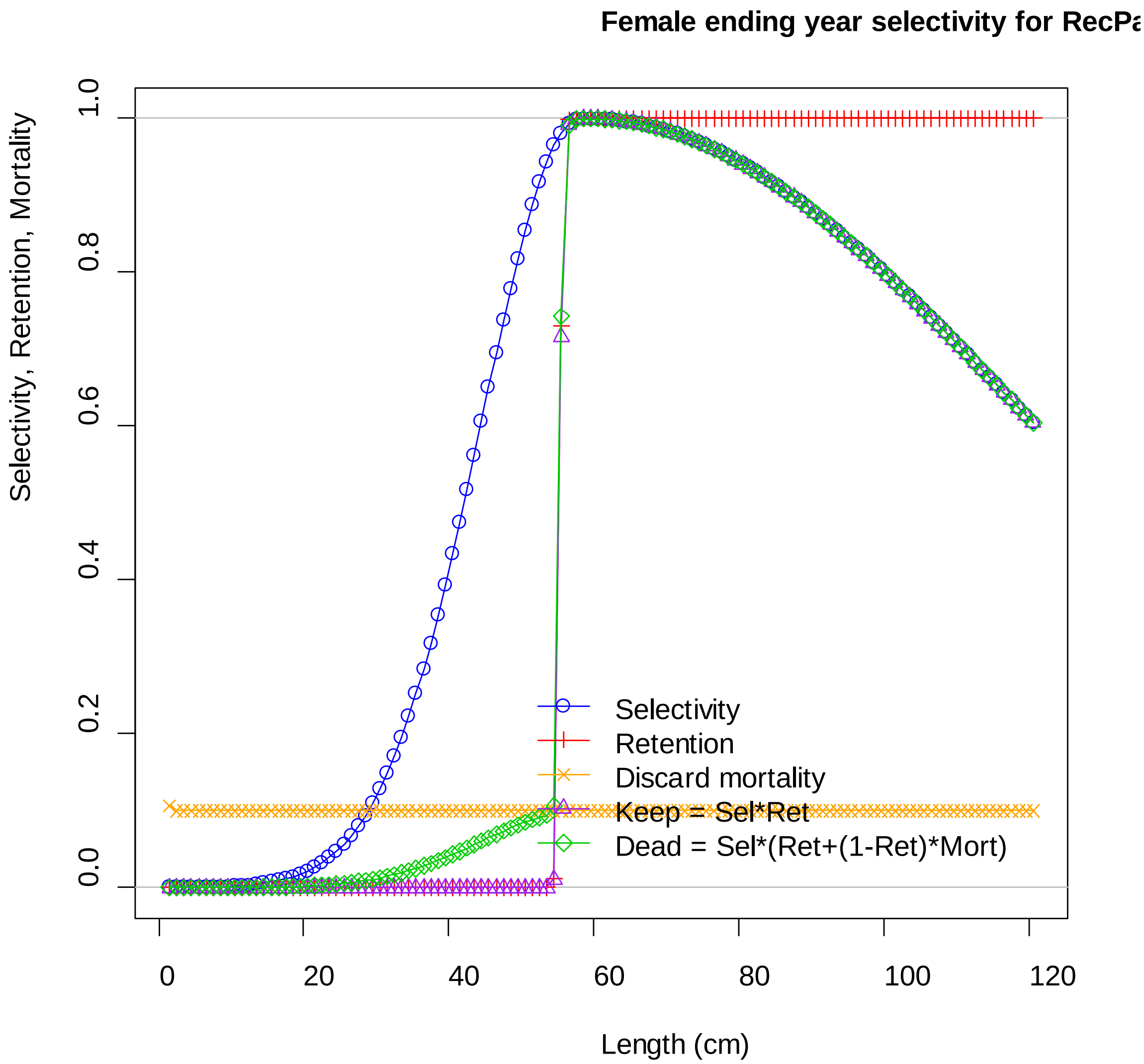


Figure B3.2.4g. CPFV (RecParty) female selectivity. (Also used for the other recreational fishery)

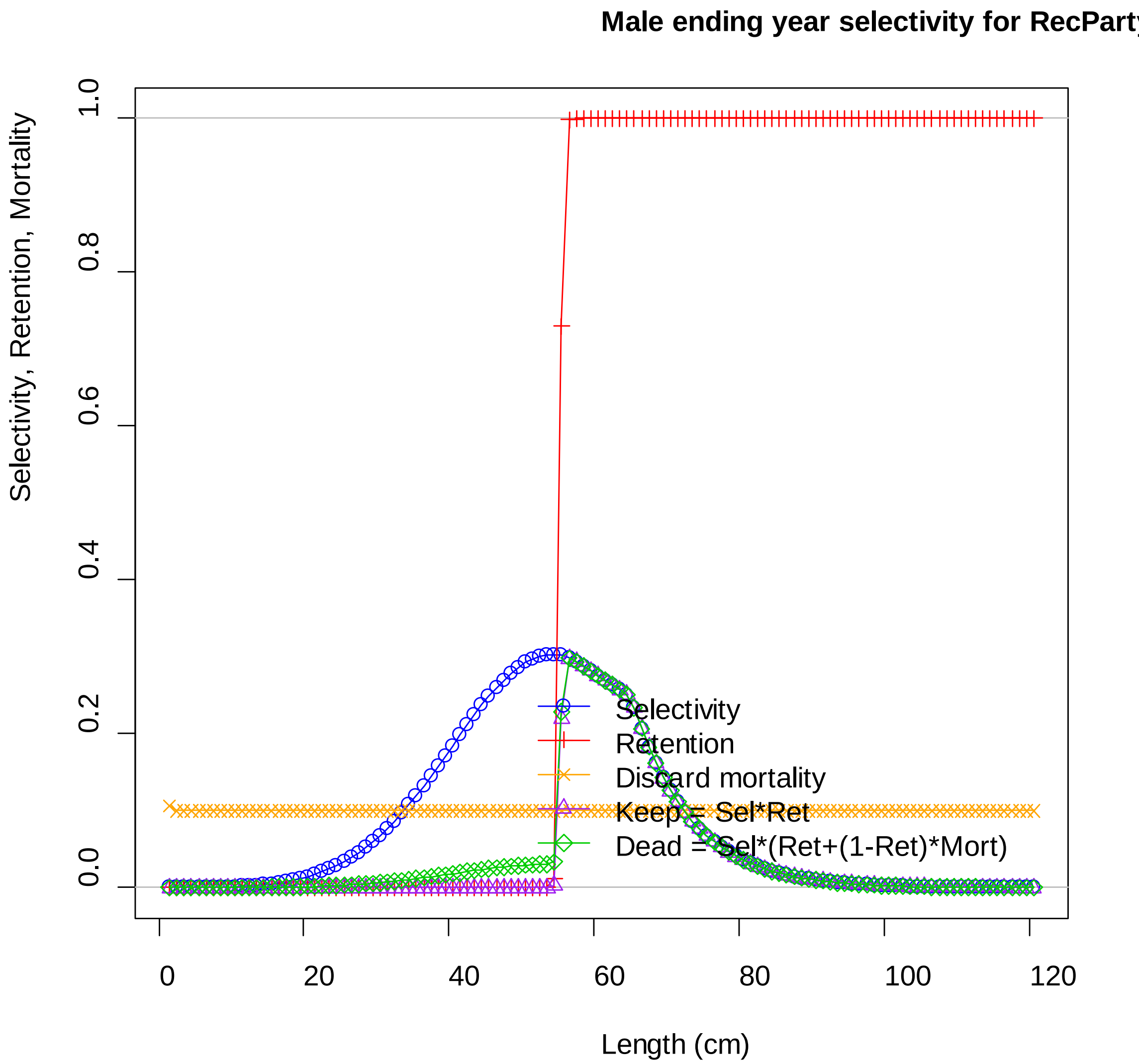
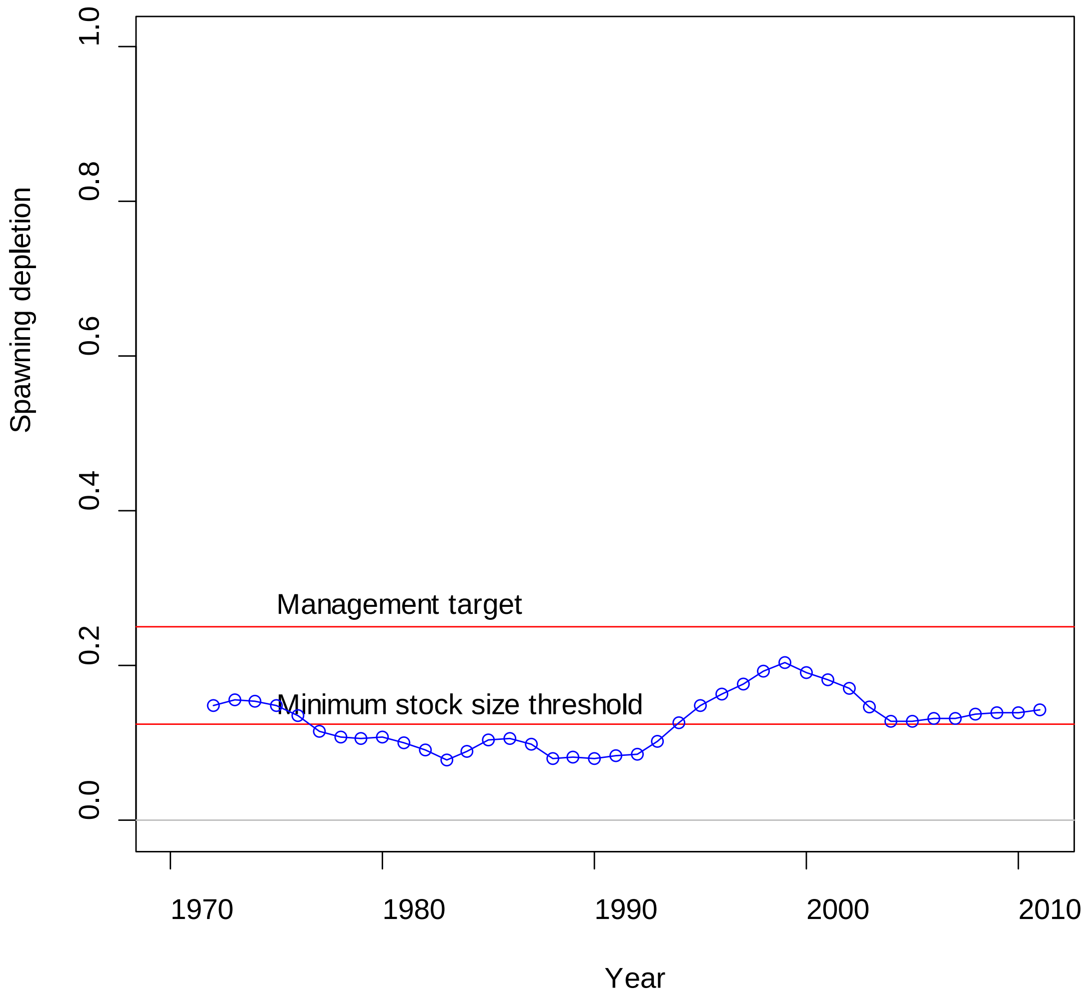


Figure B3.2.4h. CPFV (RecParty) male selectivity. (Also used for the other recreational fishery)

Spawning depletion with ~95% asymptot



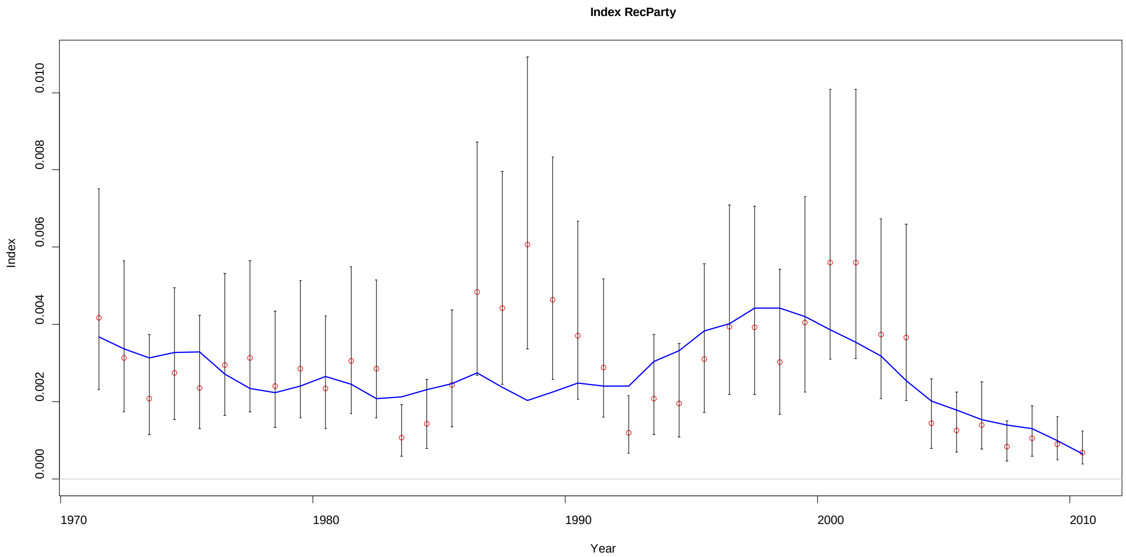
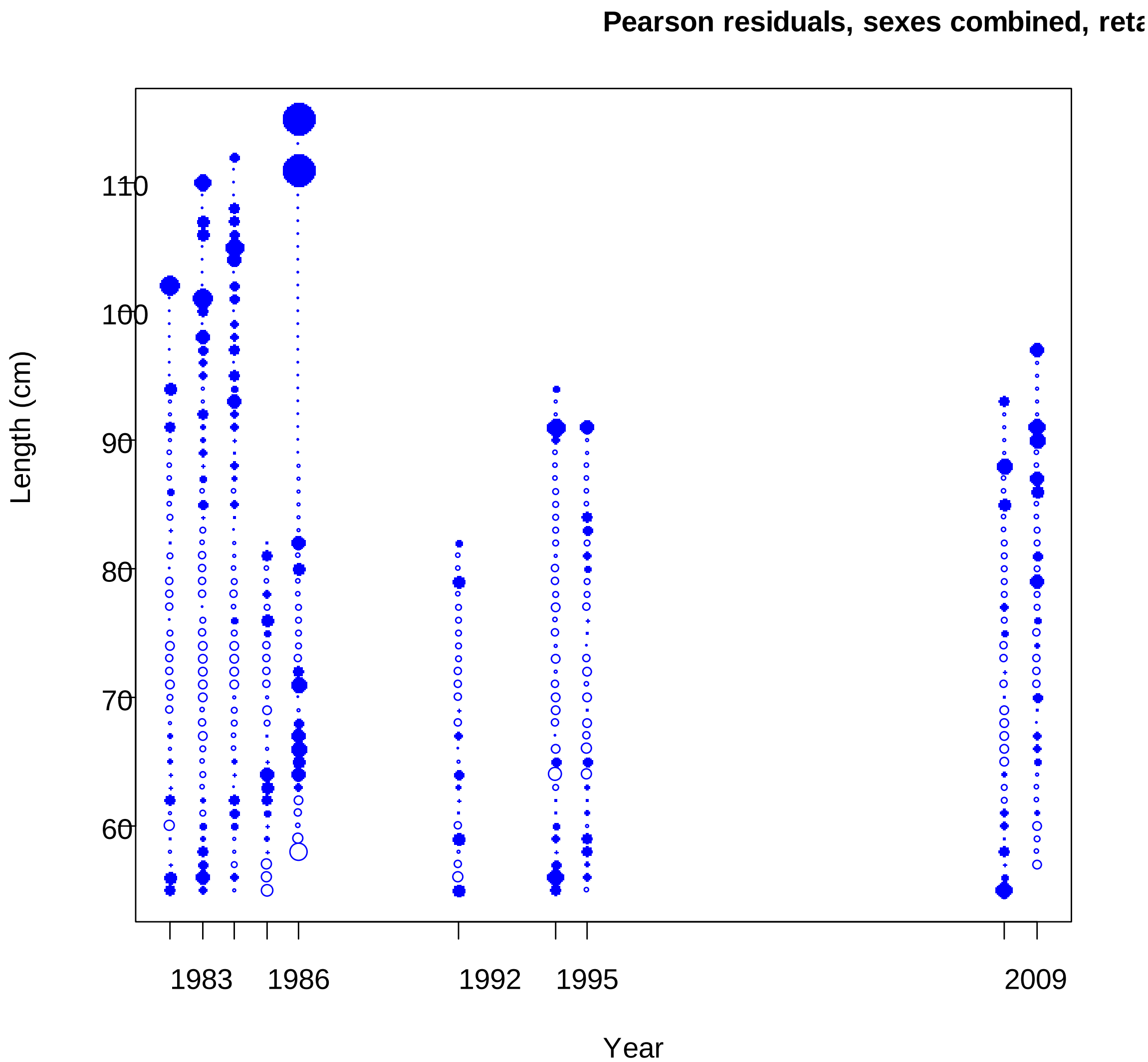
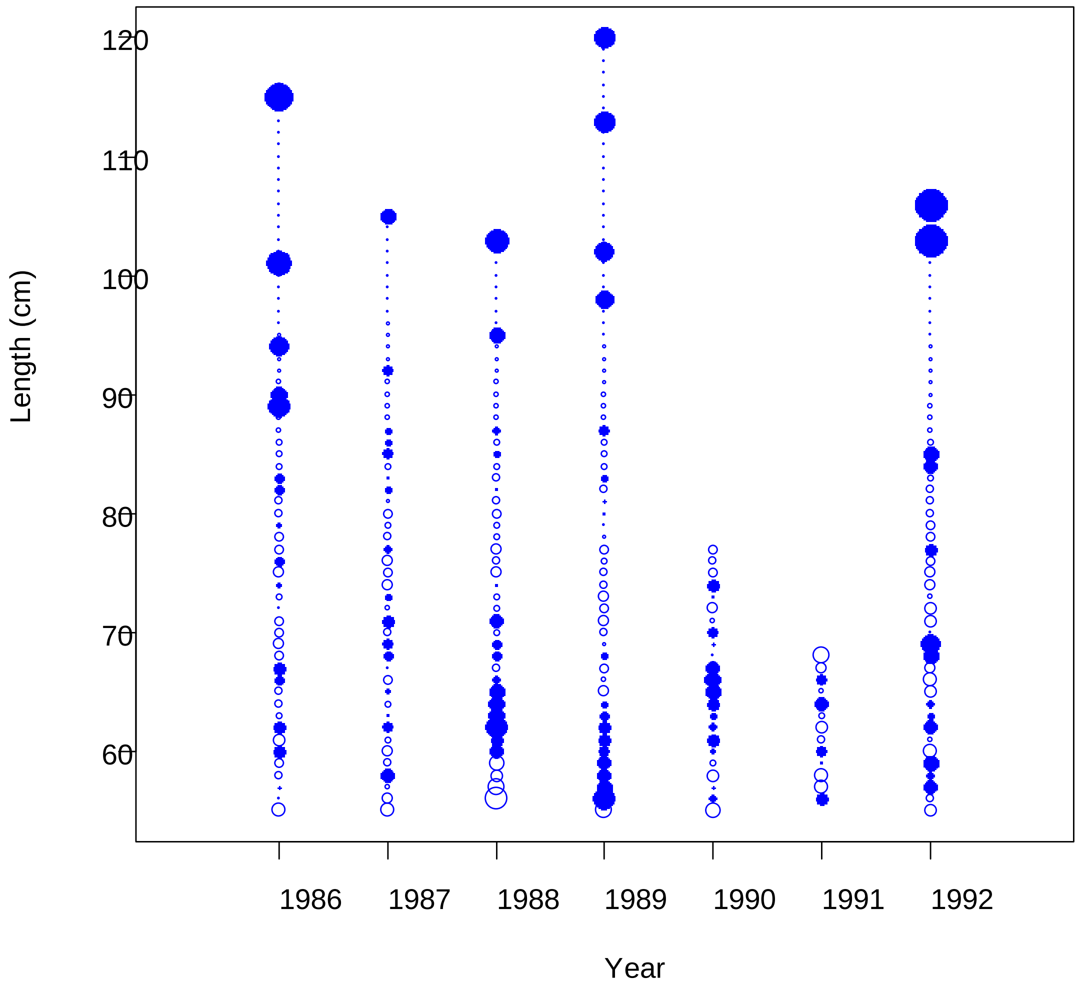


Figure B3.4.1. Model fit to the aggregated CPFV index that is not filtered for targeting.

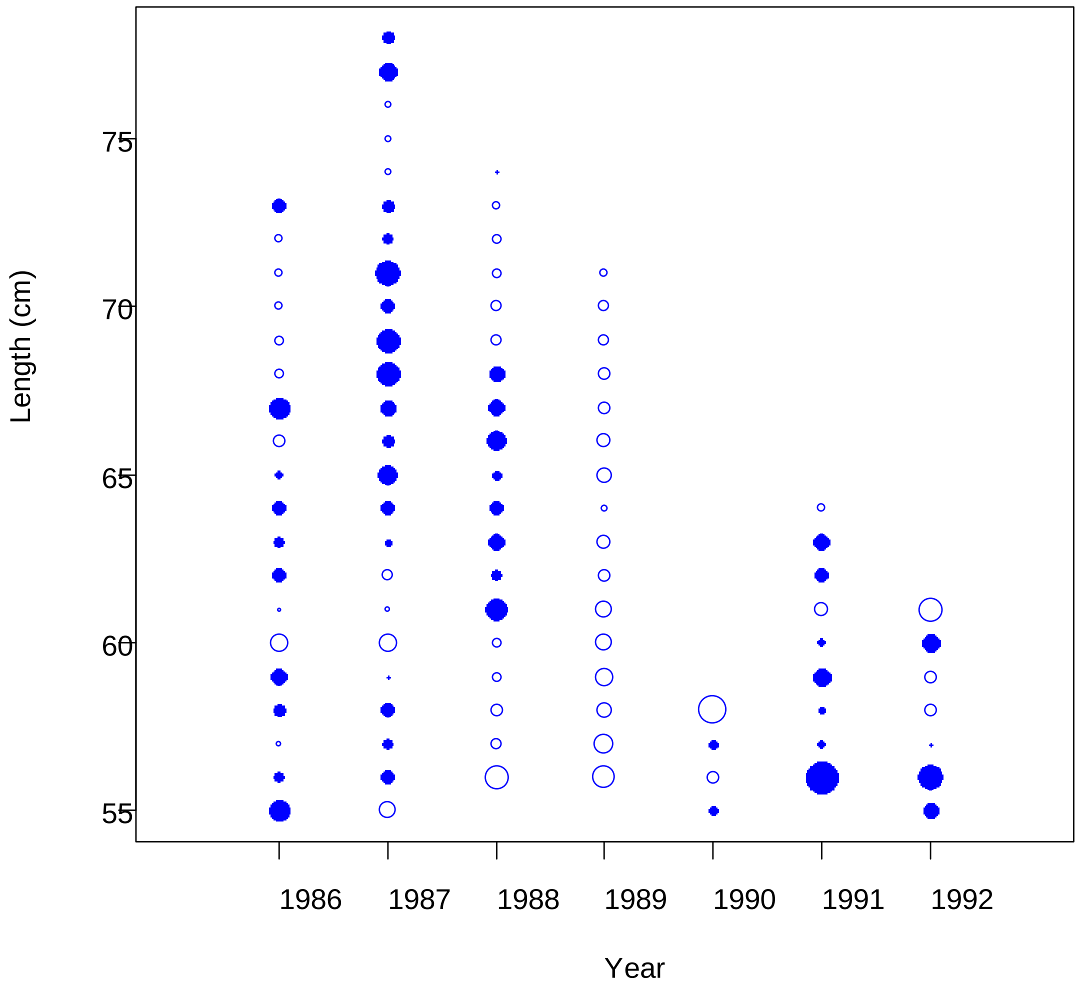
Appendix B.1: Fit to the length composition data.



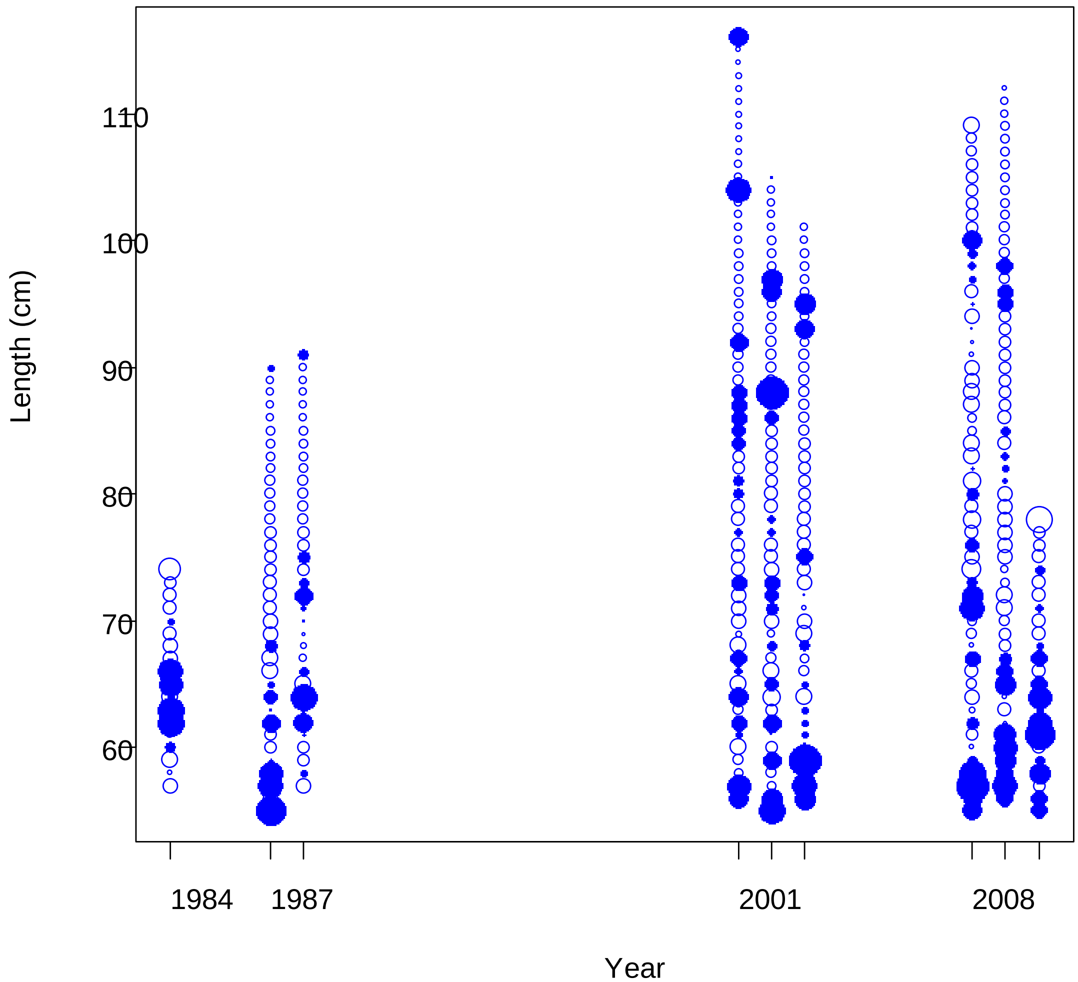
Pearson residuals, female, retained, BT

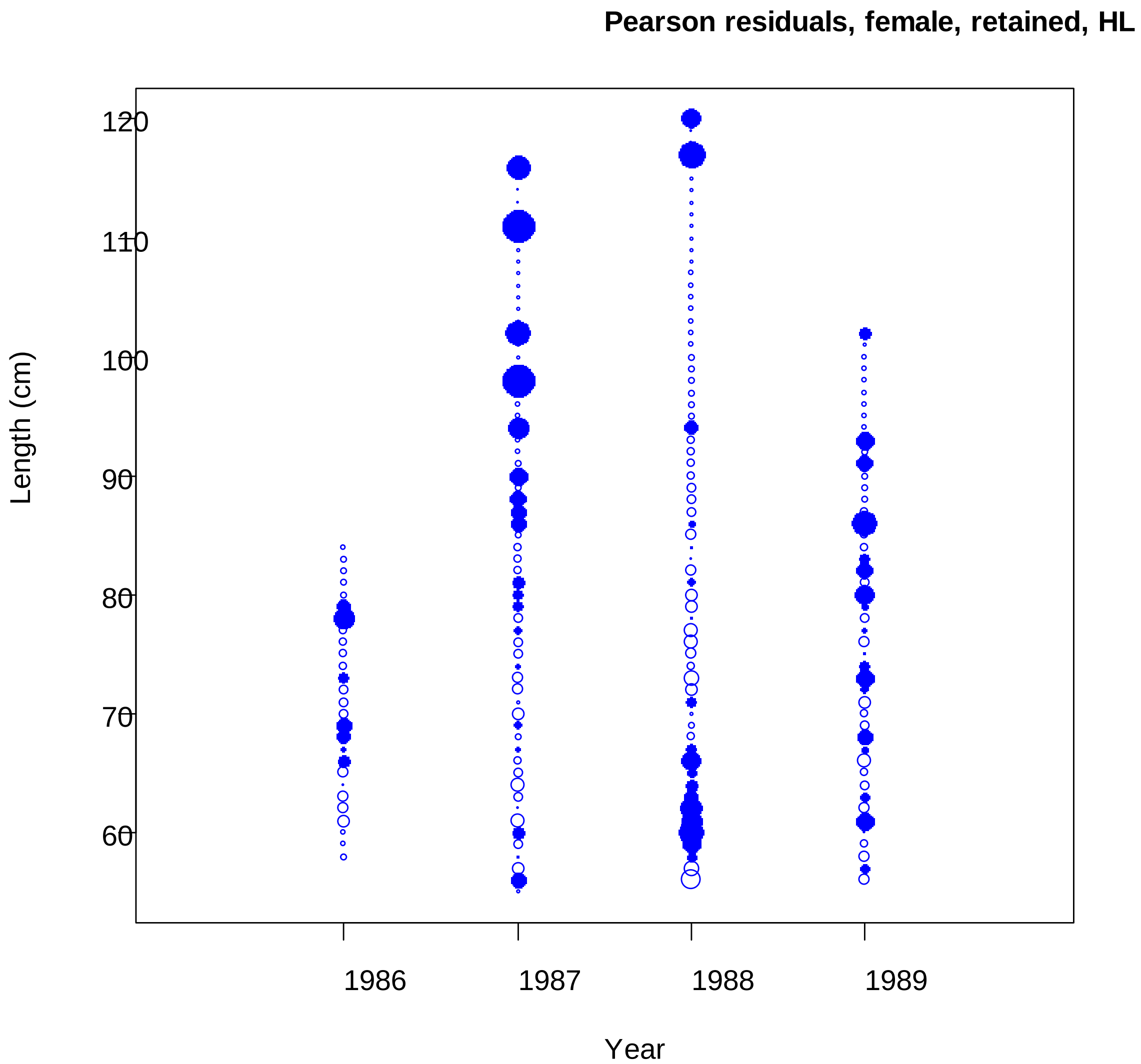


Pearson residuals, male, retained, BT (m

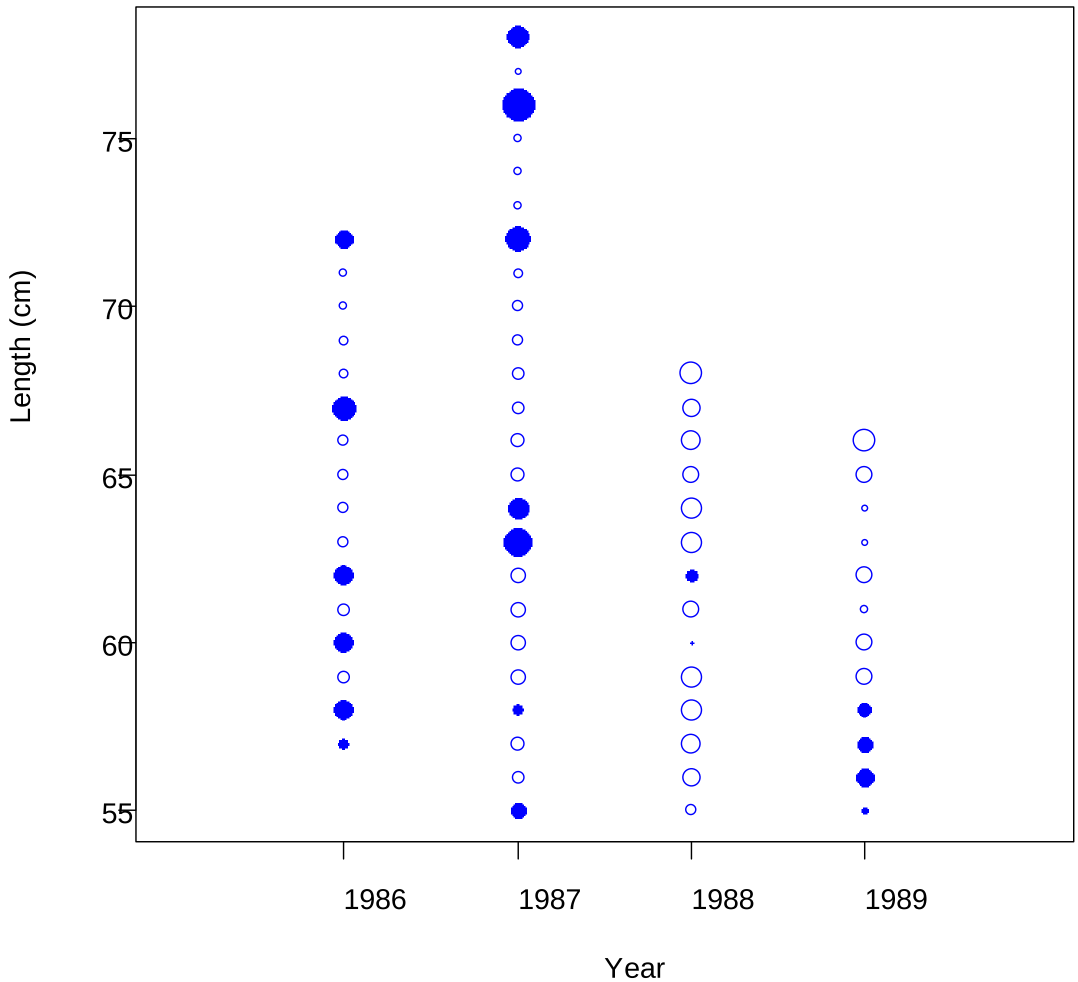


Pearson residuals, sexes combined, reta

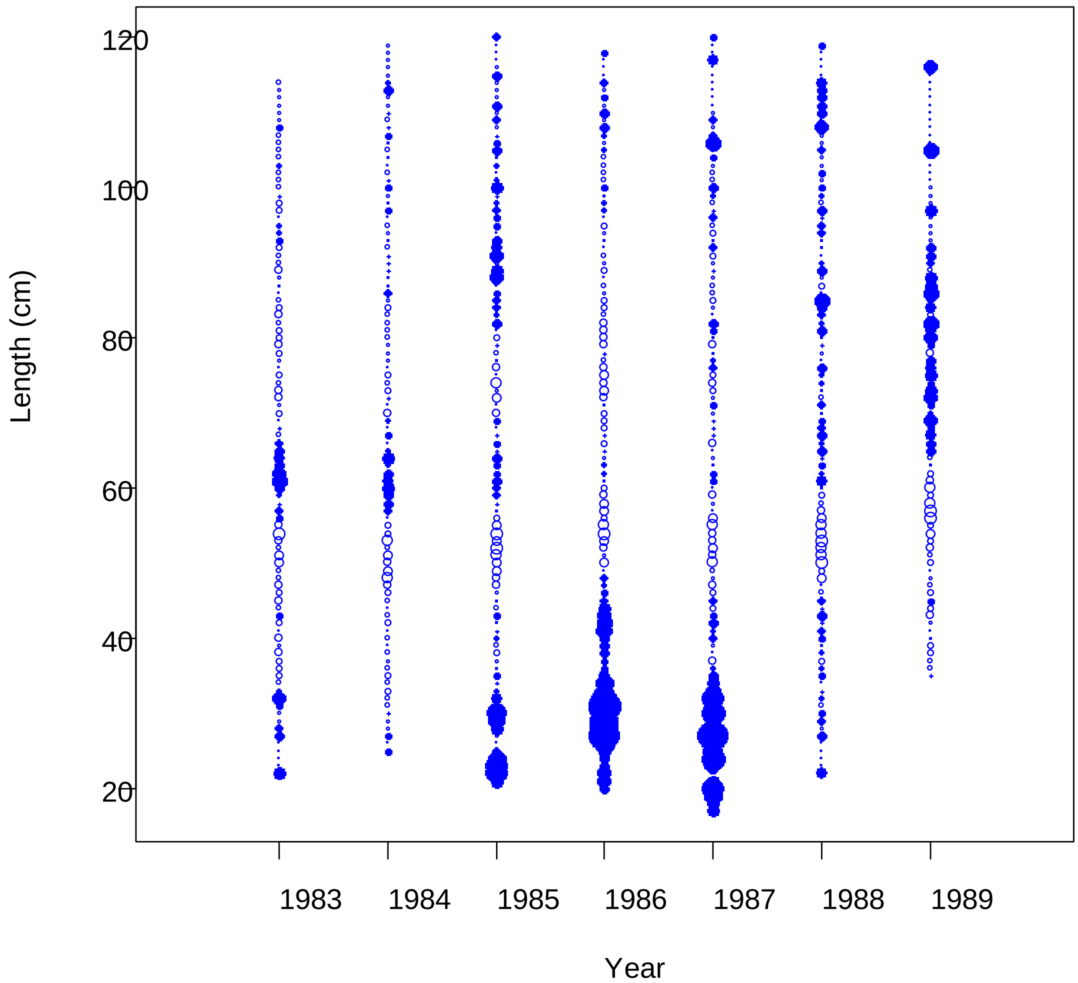



Pearson residuals, female, retained, HL (
Length (cm)
120
110
100
90
80
70
60
1986
1987
1988
1989
Year

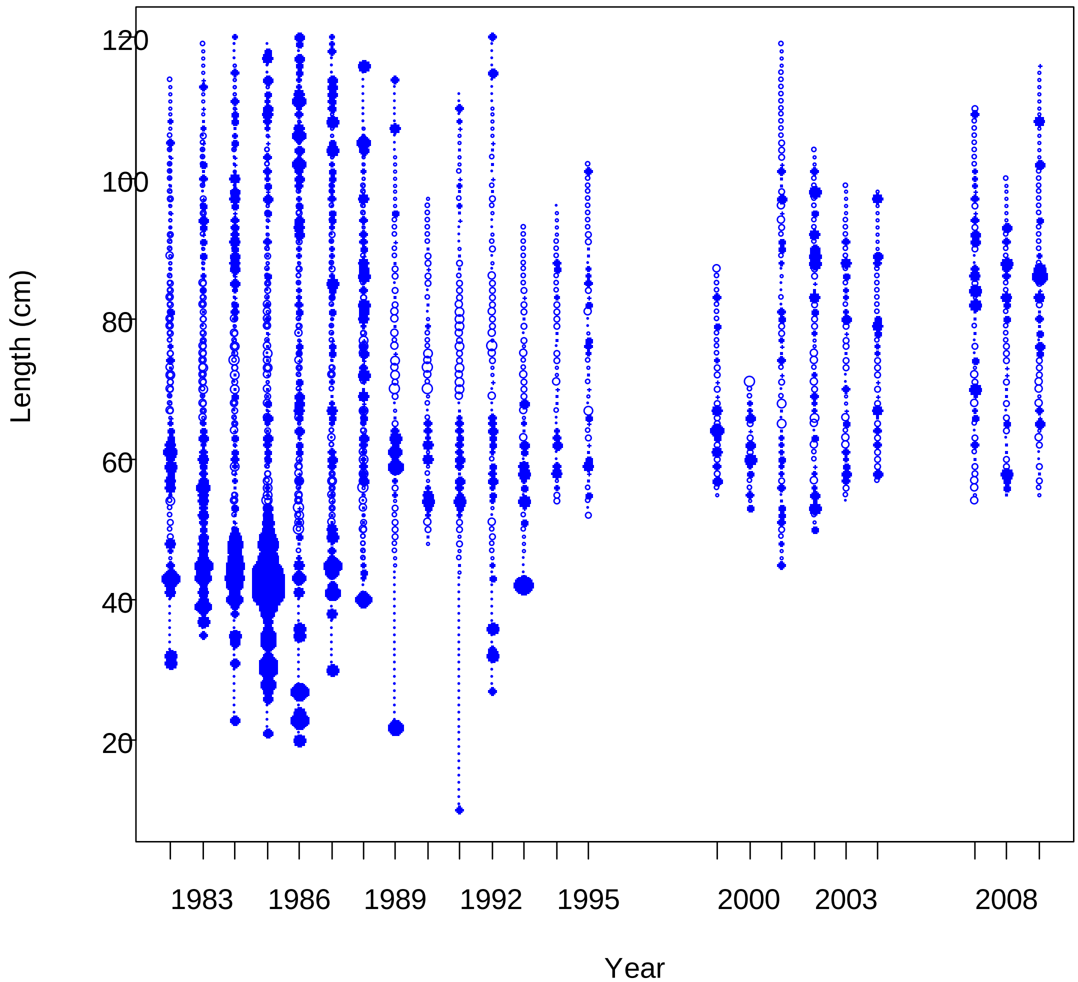
Pearson residuals, male, retained, HL (m



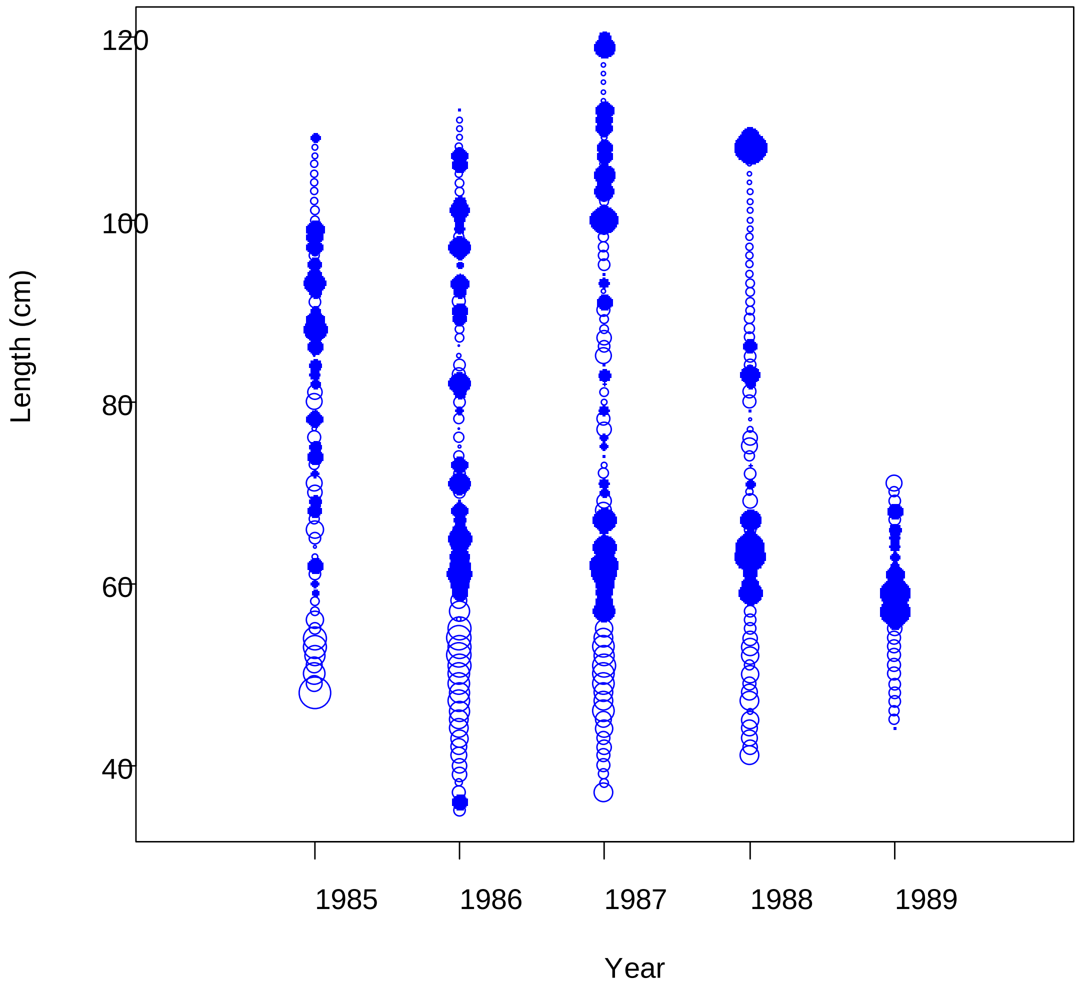
Pearson residuals, sexes combined, who

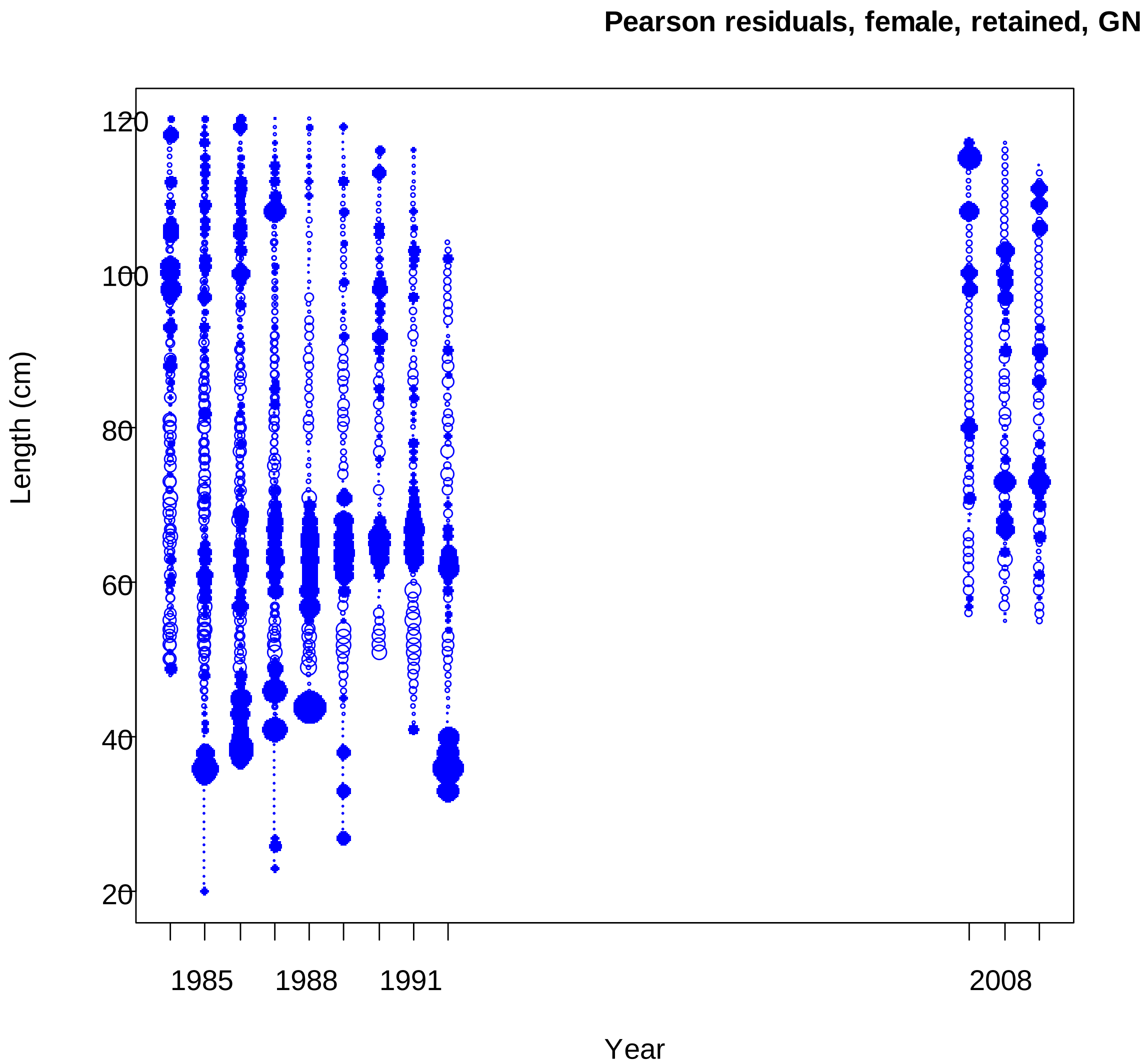


Pearson residuals, sexes combined, reta



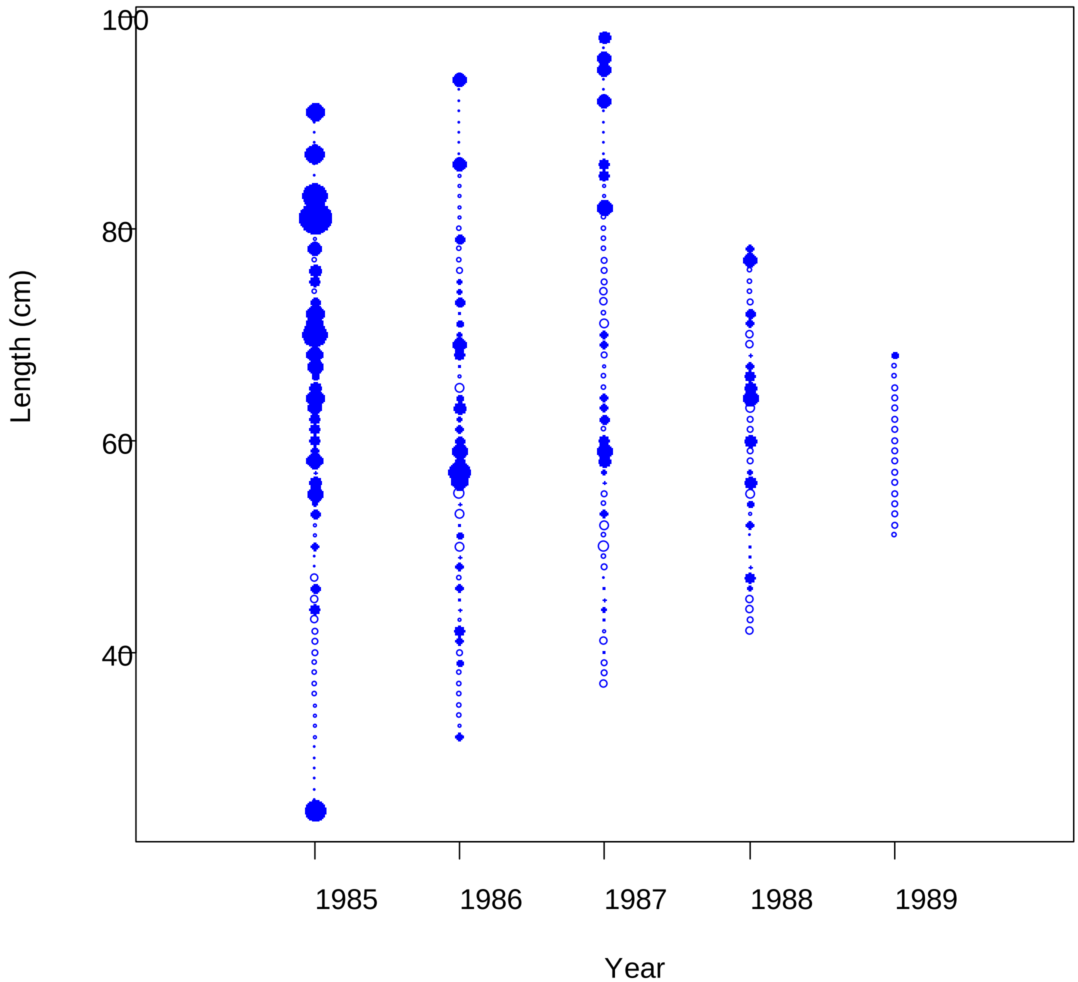
Pearson residuals, female, whole catch,



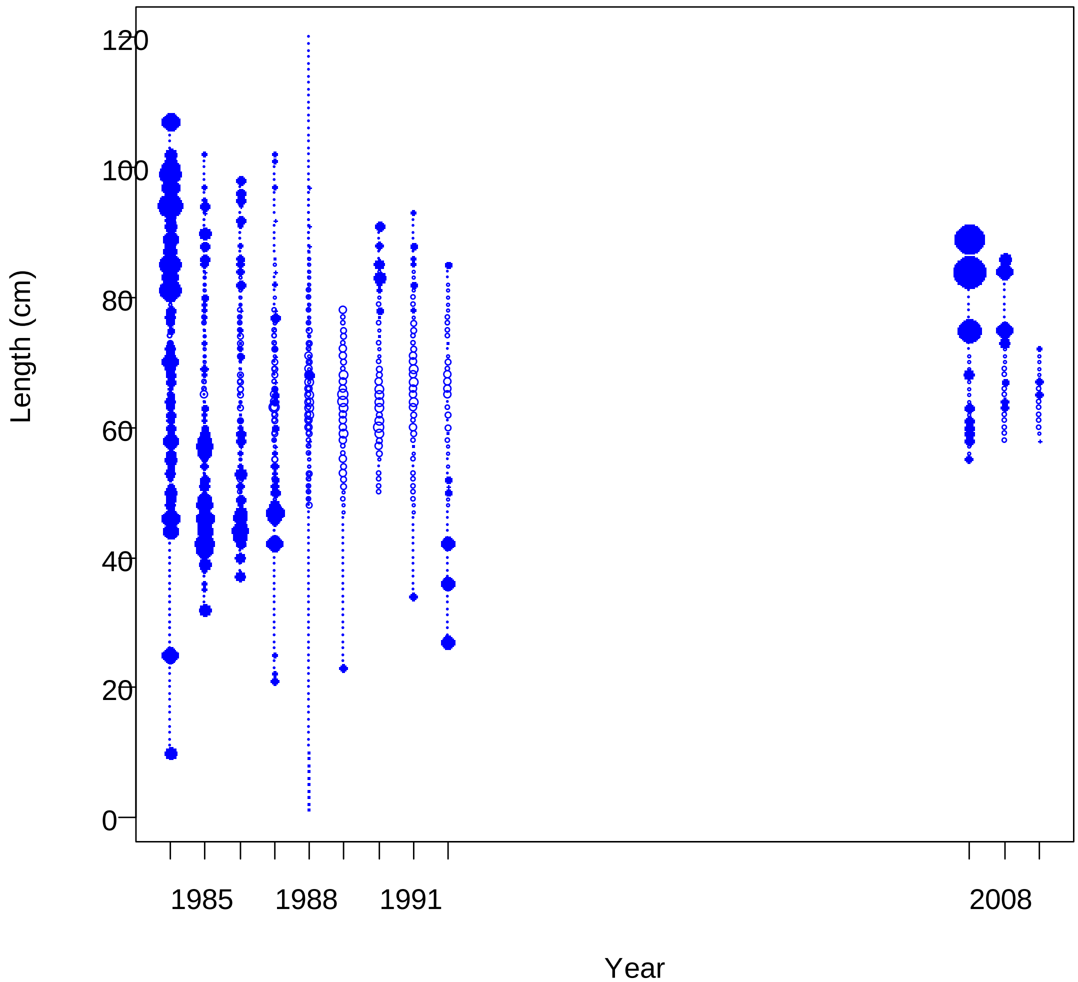


Pearson residuals, female, retained, GN
120
100
80
60
40
20
Length (cm)
1985
1988
1991
2008
Year

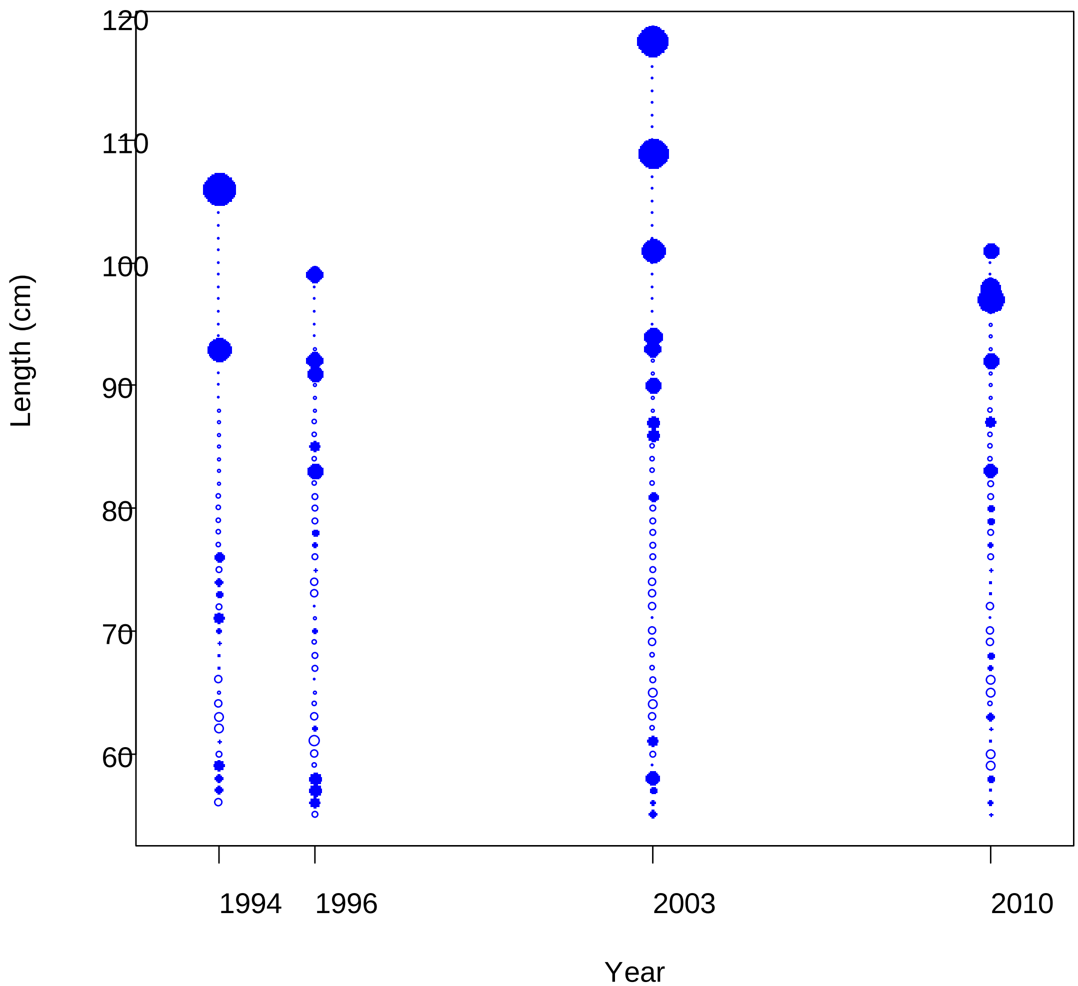
Pearson residuals, male, whole catch, G

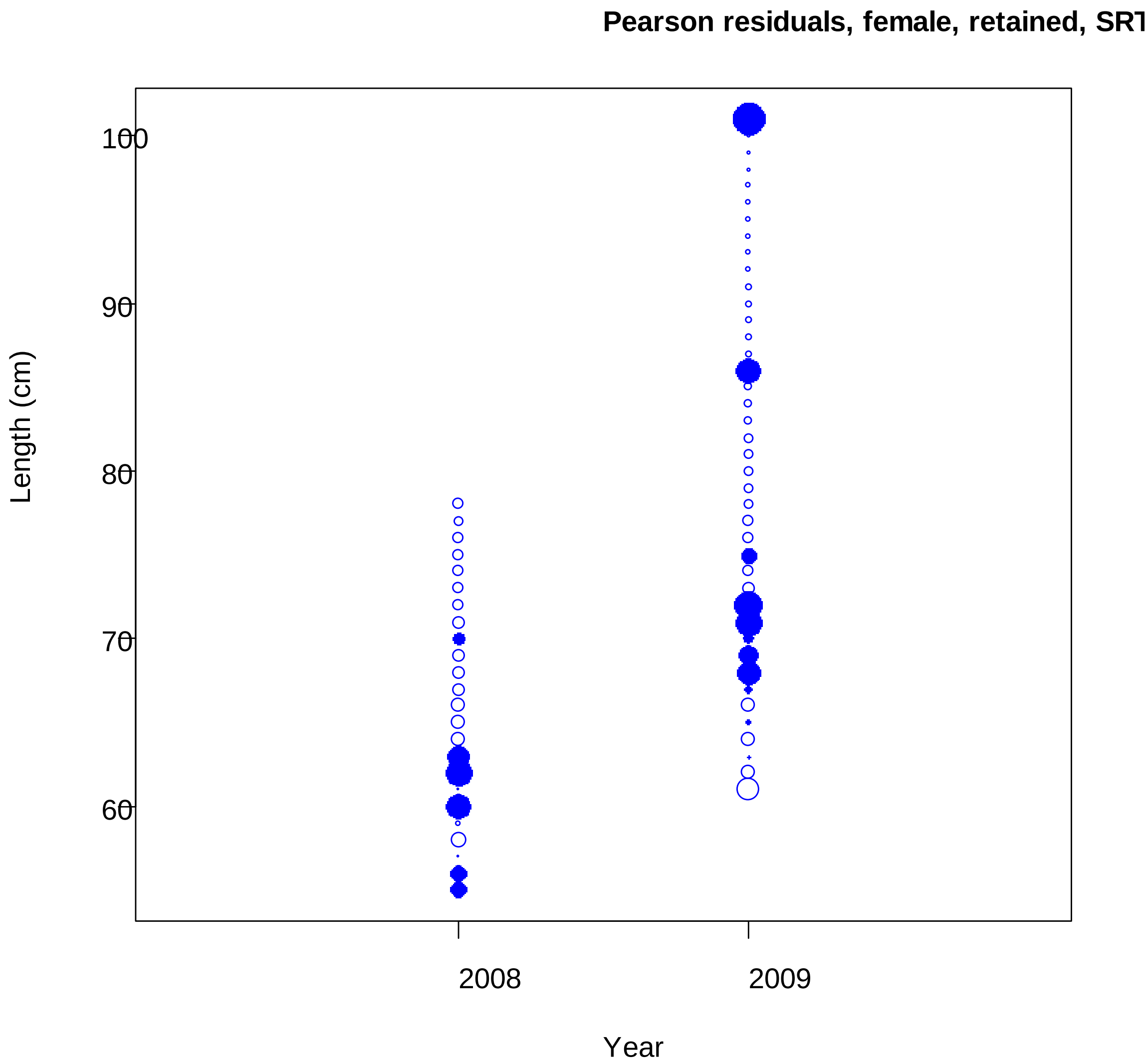


Pearson residuals, male, retained, GN (m



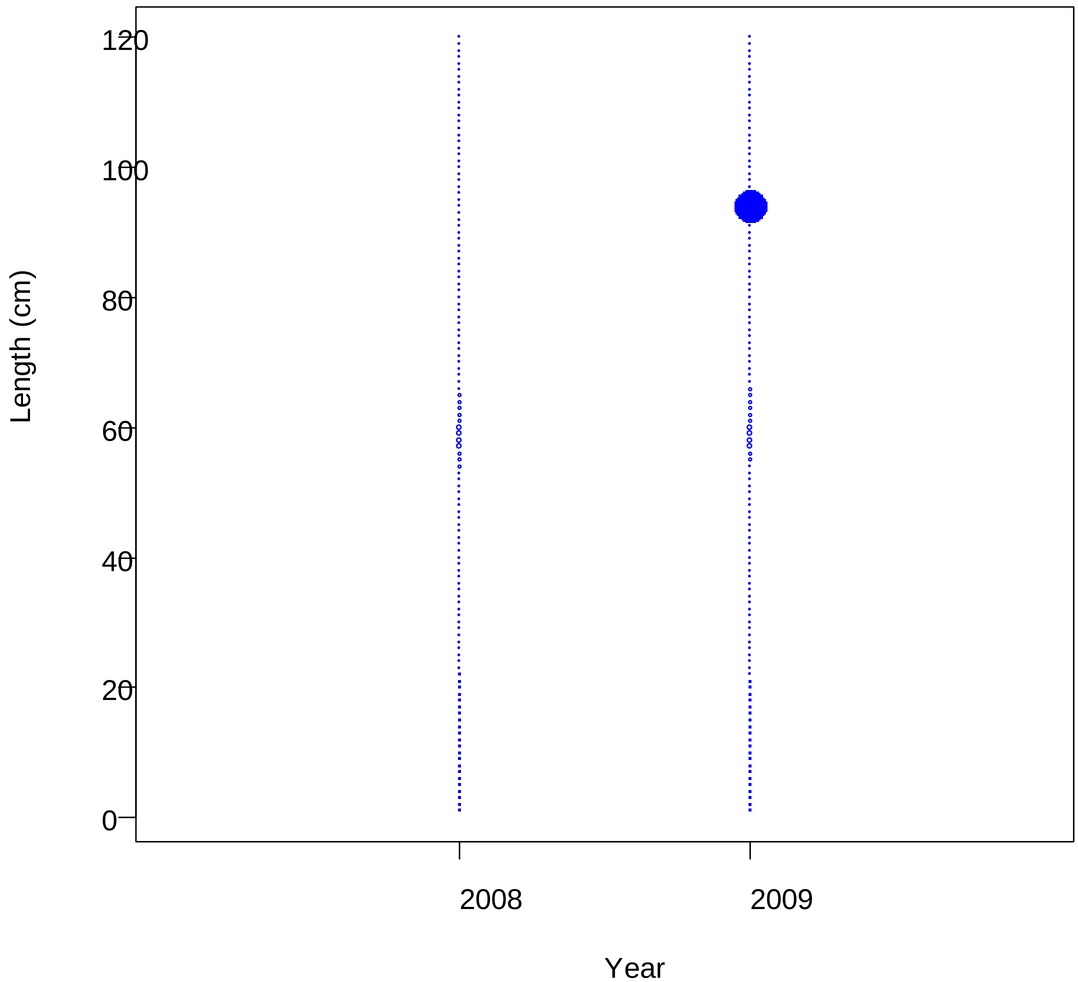
Pearson residuals, sexes combined, reta

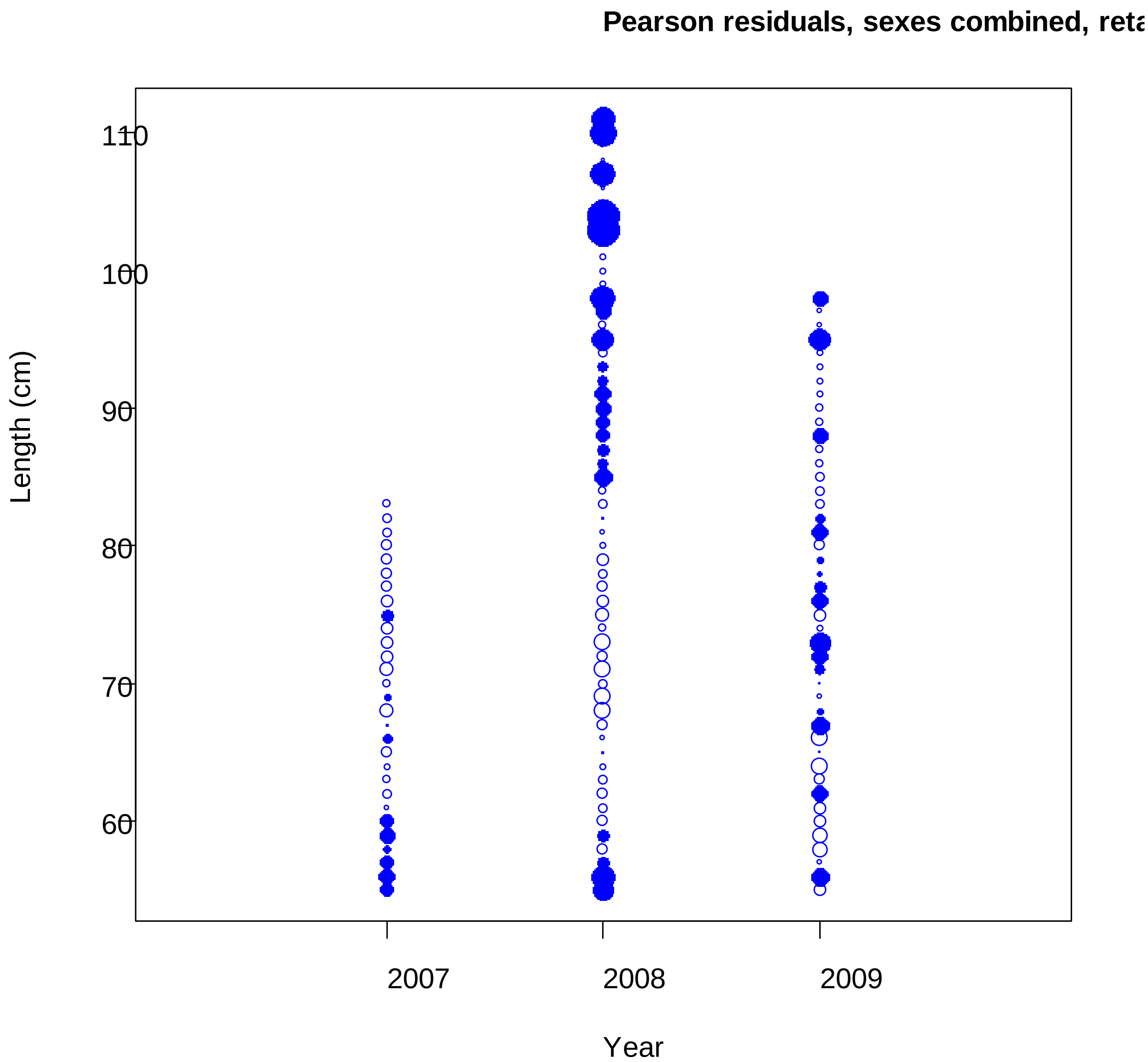




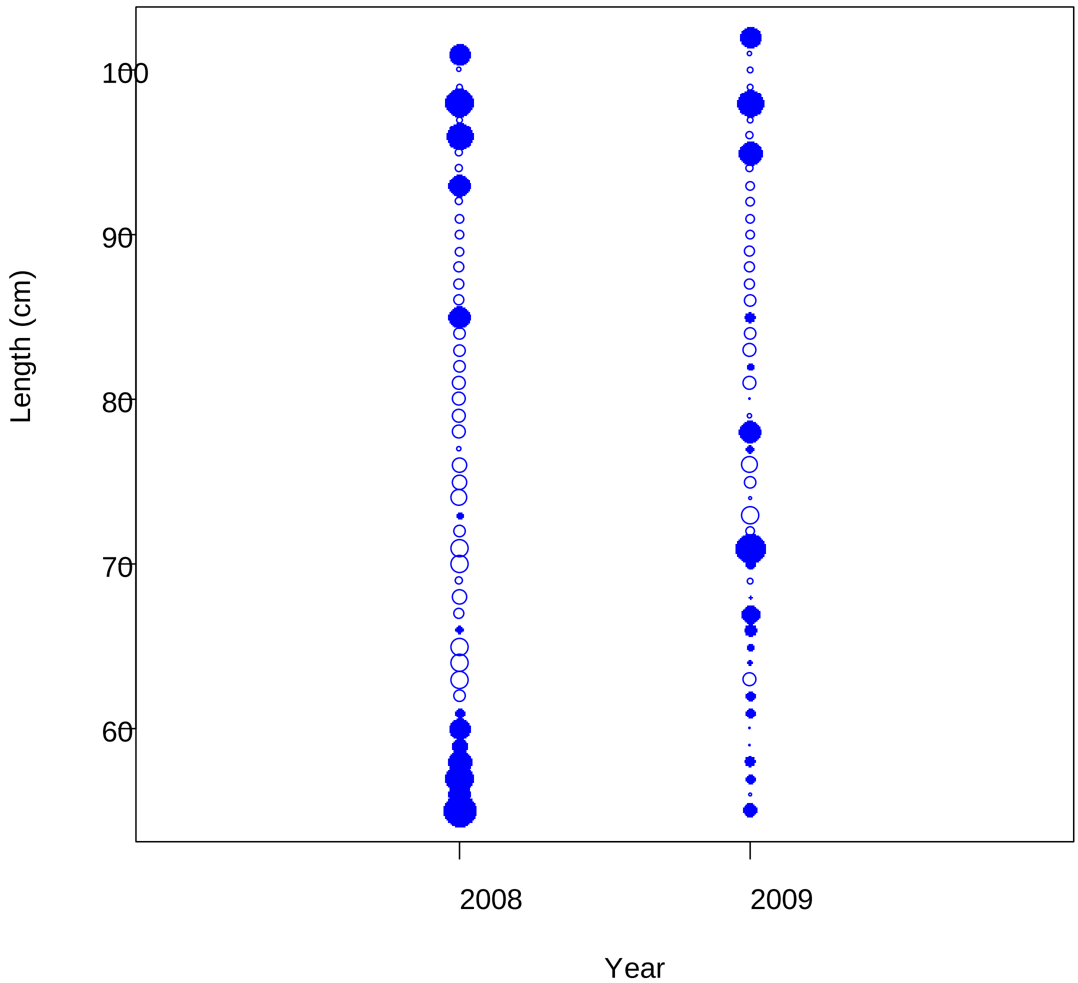
Pearson residuals, female, retained, SR1
100
90
80
70
60
Length (cm)
2008
2009
Year

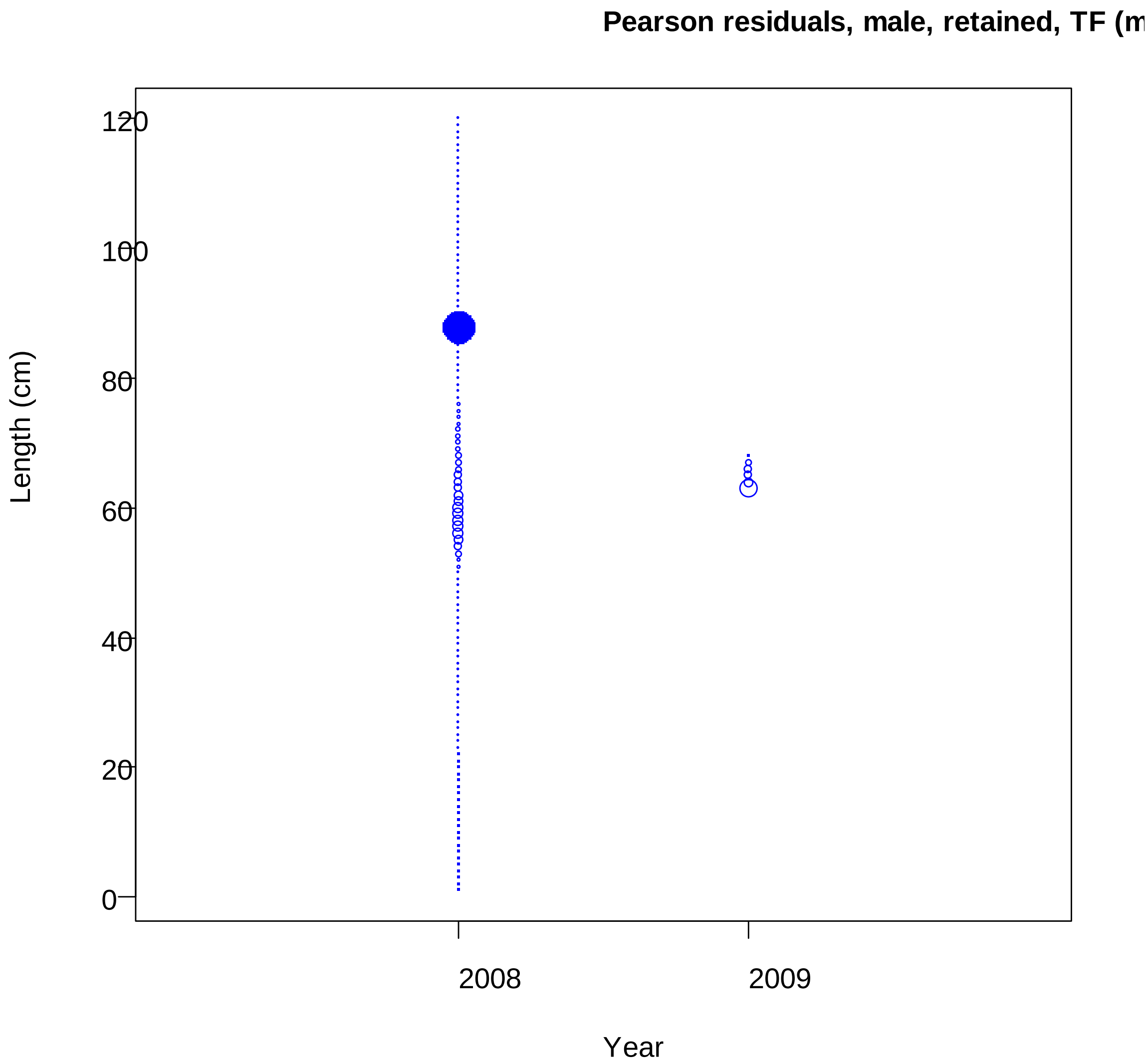
Pearson residuals, male, retained, SRT (



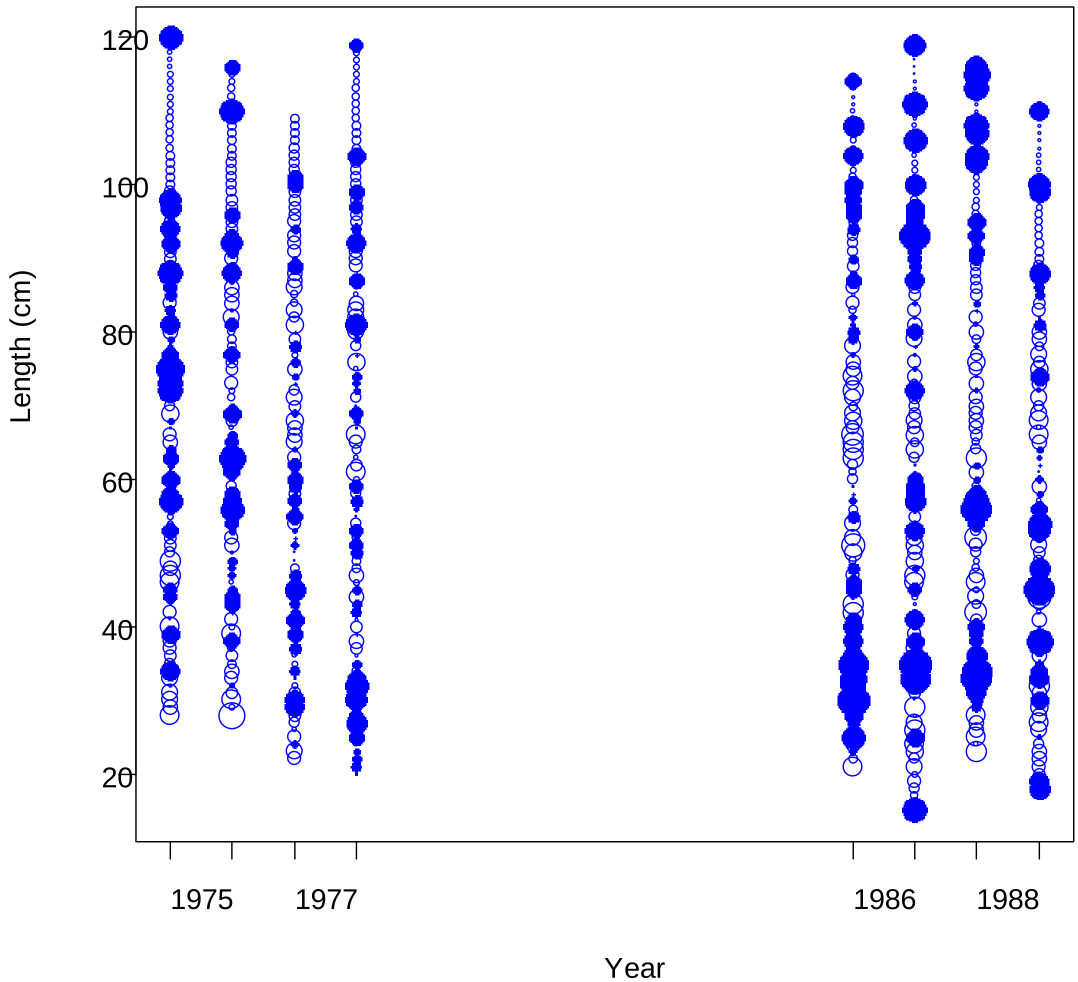

Pearson residuals, sexes combined, reta
Length (cm)
110
100
90
80
70
60
2007
2008
2009
Year

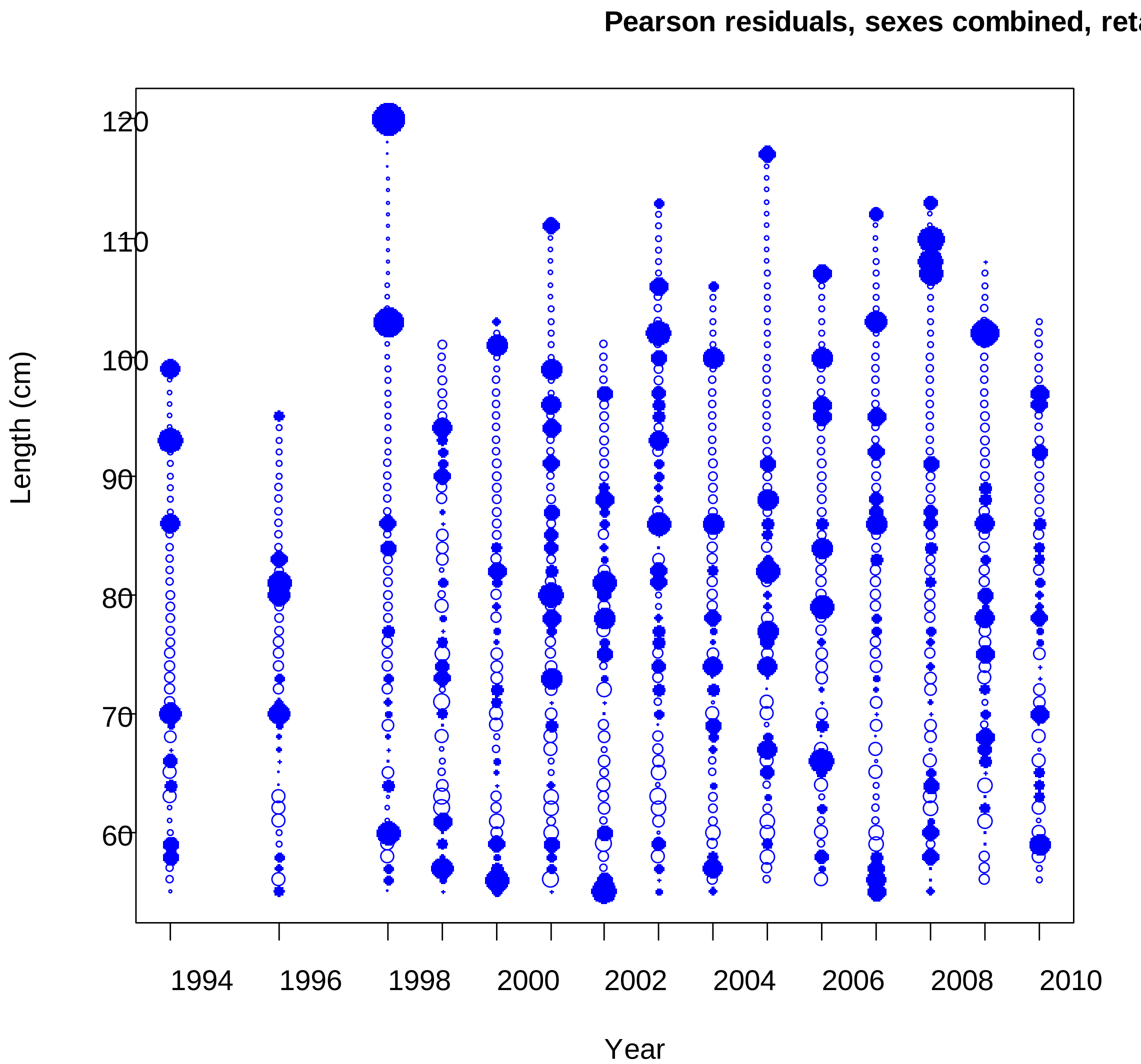
Pearson residuals, female, retained, TF (



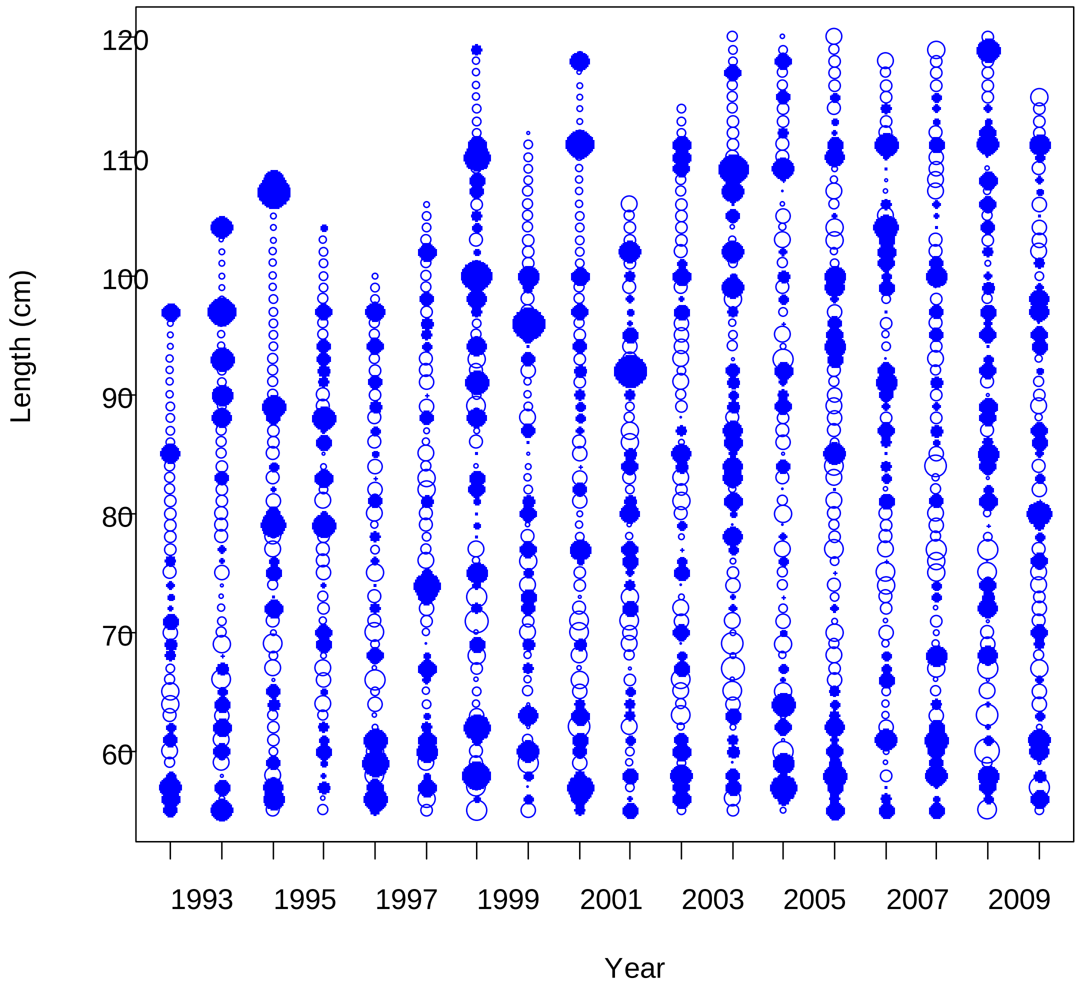

Pearson residuals, male, retained, TF (m
Length (cm)
120
100
80
60
40
20
0
2008
2009
Year

Pearson residuals, sexes combined, who

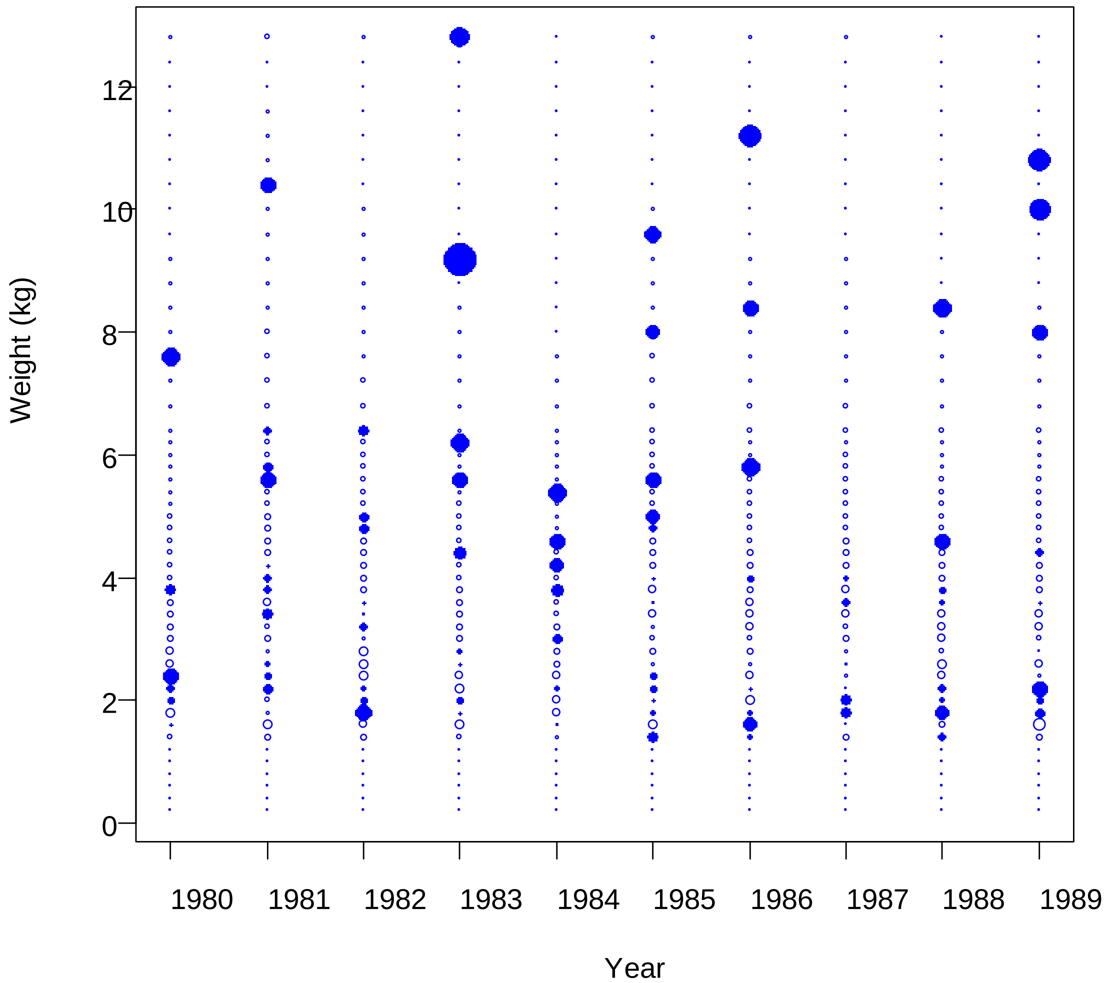



Pearson residuals, sexes combined, reta
Length (cm)
120
110
100
90
80
70
60
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

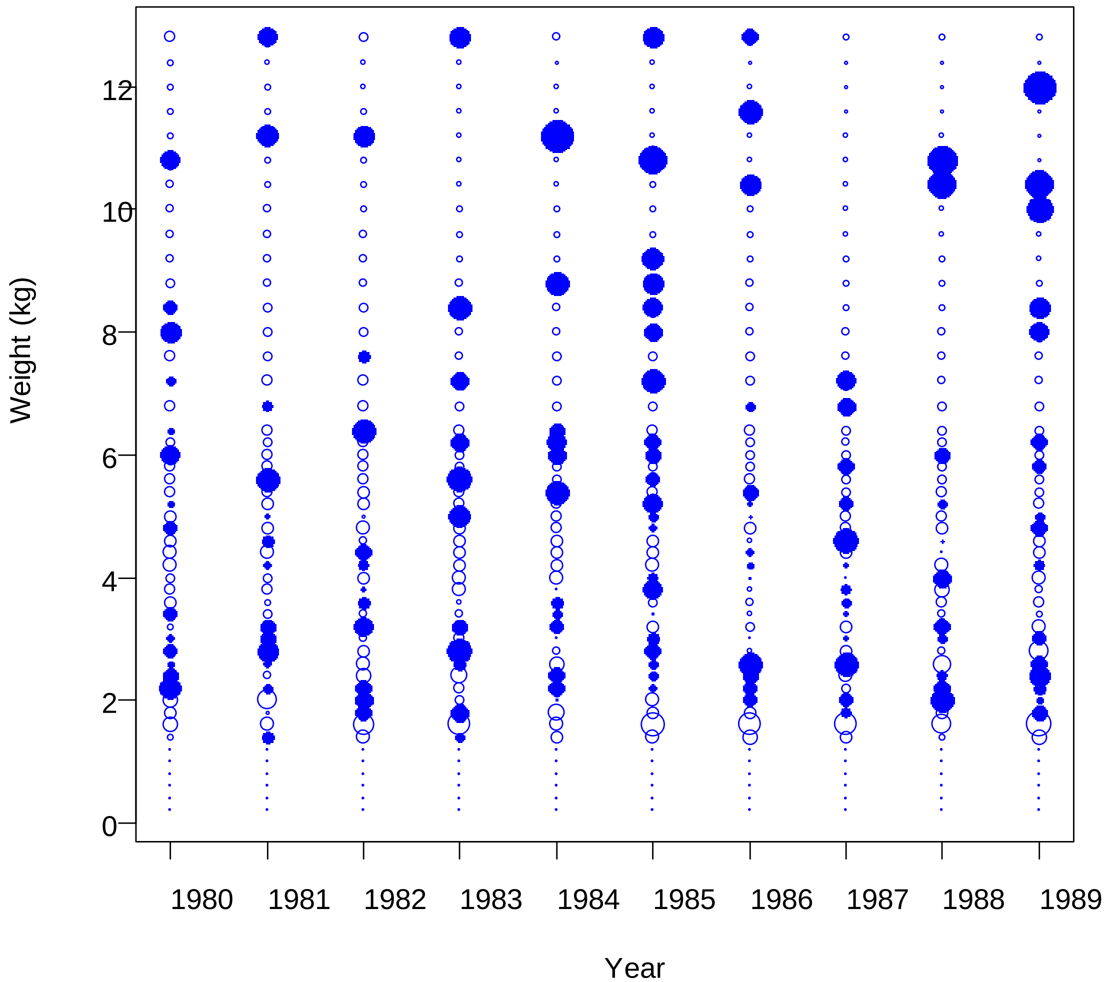
Pearson residuals, sexes combined, reta



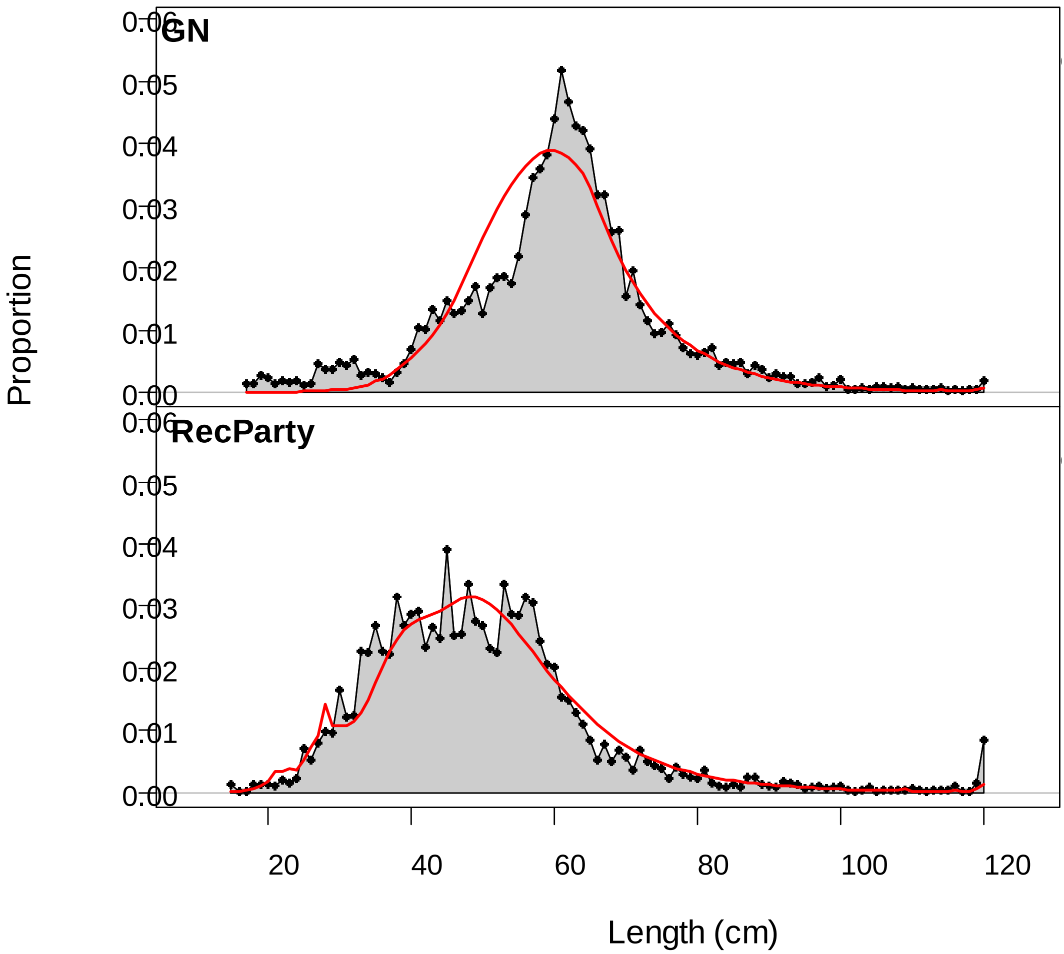
Pearson residuals, sexes combined, reta

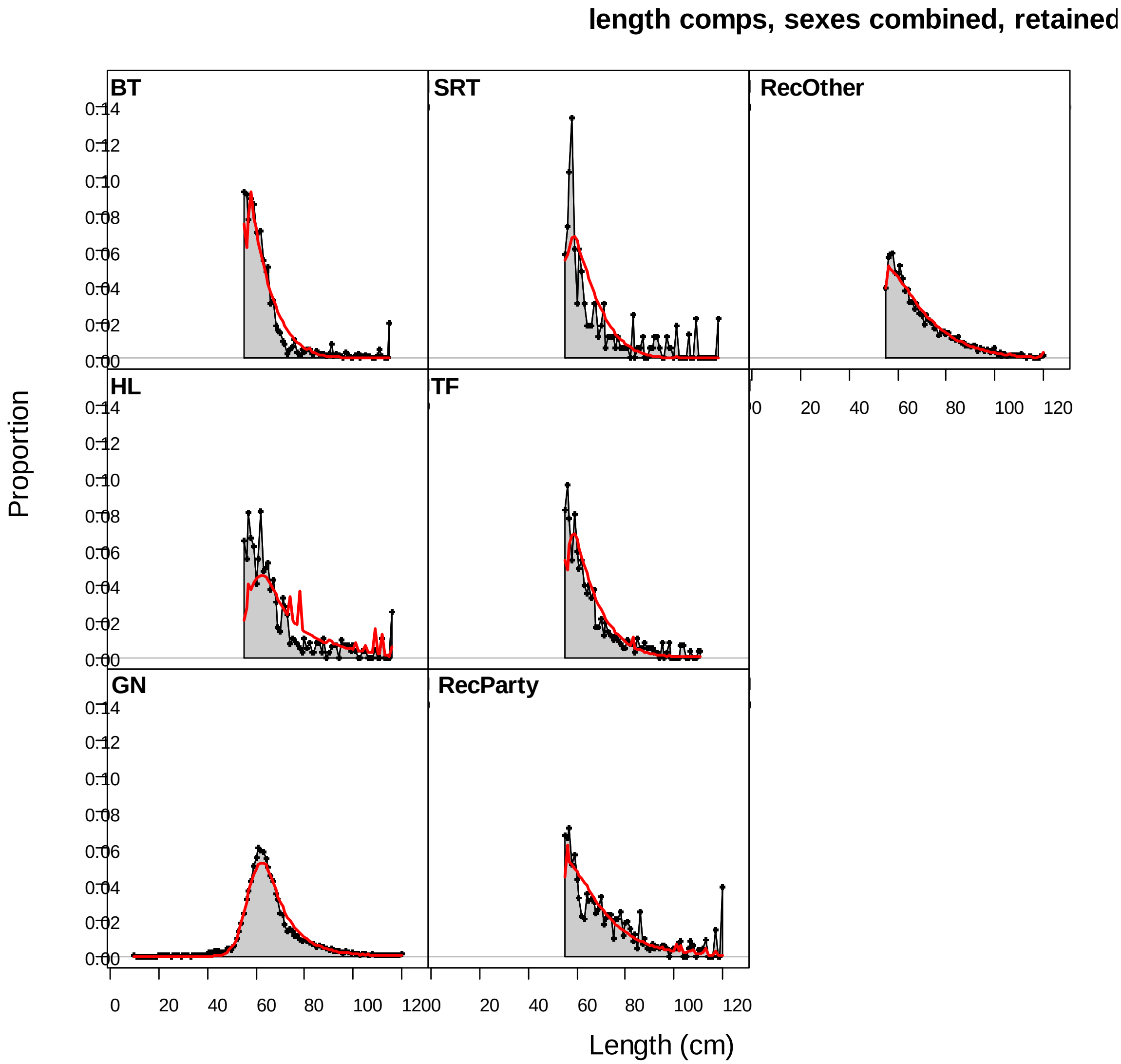


Pearson residuals, sexes combined, reta

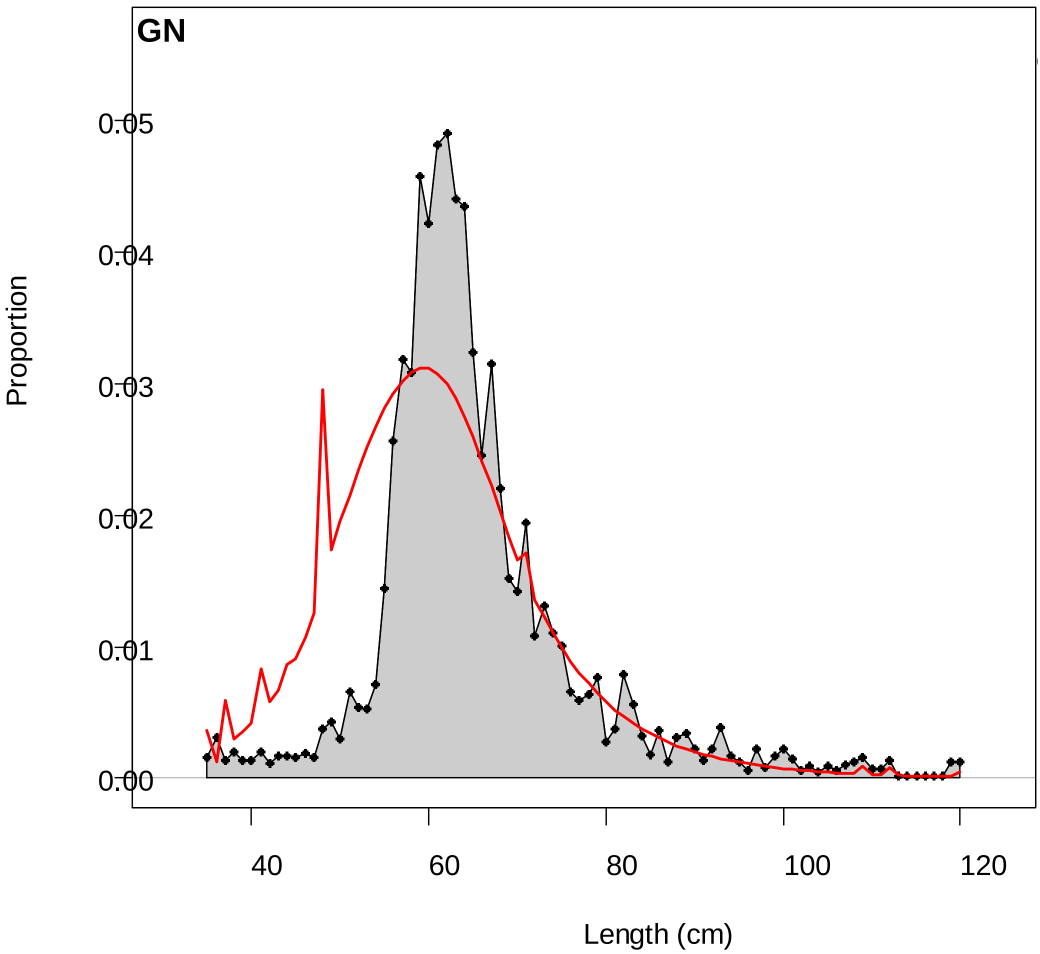


length comps, sexes combined, w

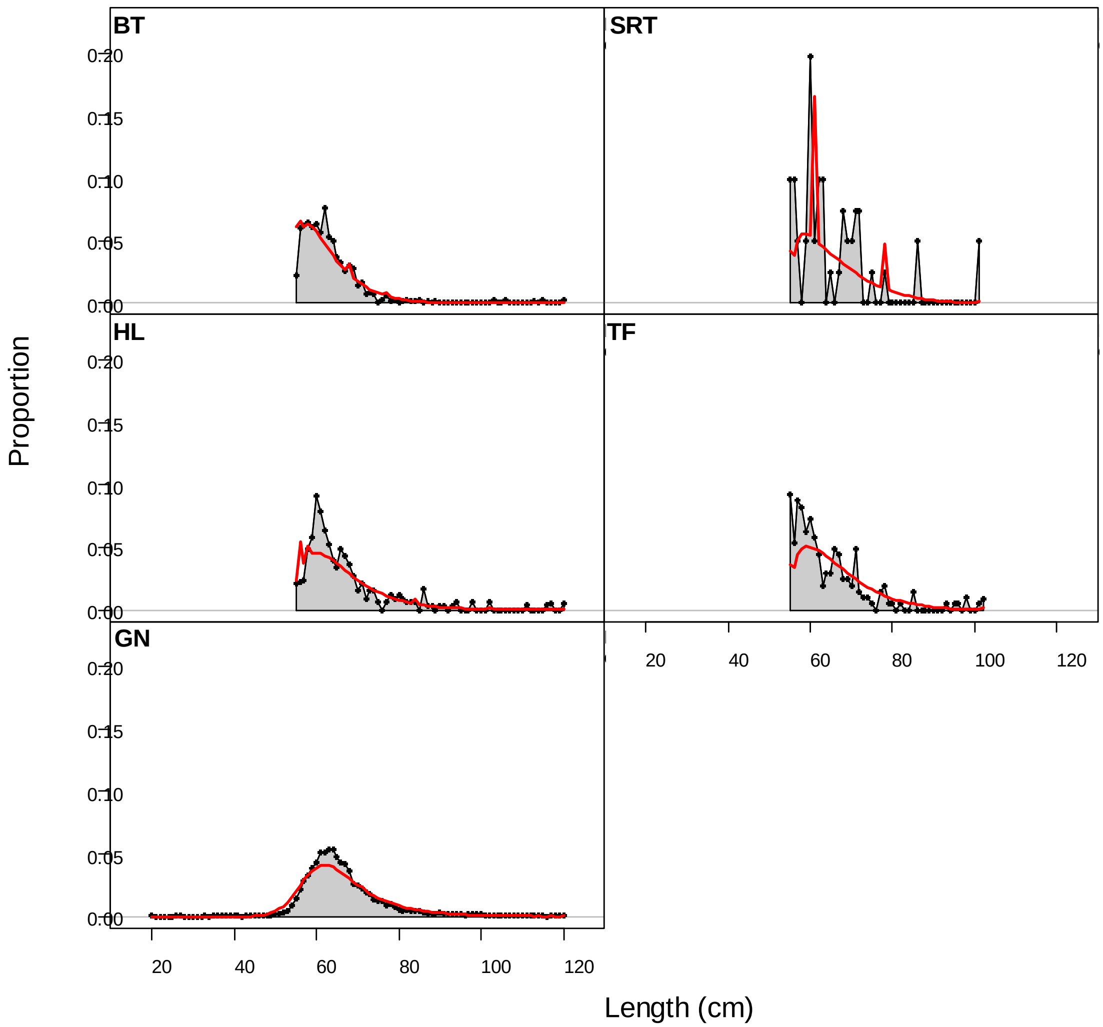



length comps, sexes combined, retained
BT
SRT
RecOther
HL
TF
GN
RecParty
Proportion
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0
20
40
60
80
100
120
Length (cm)

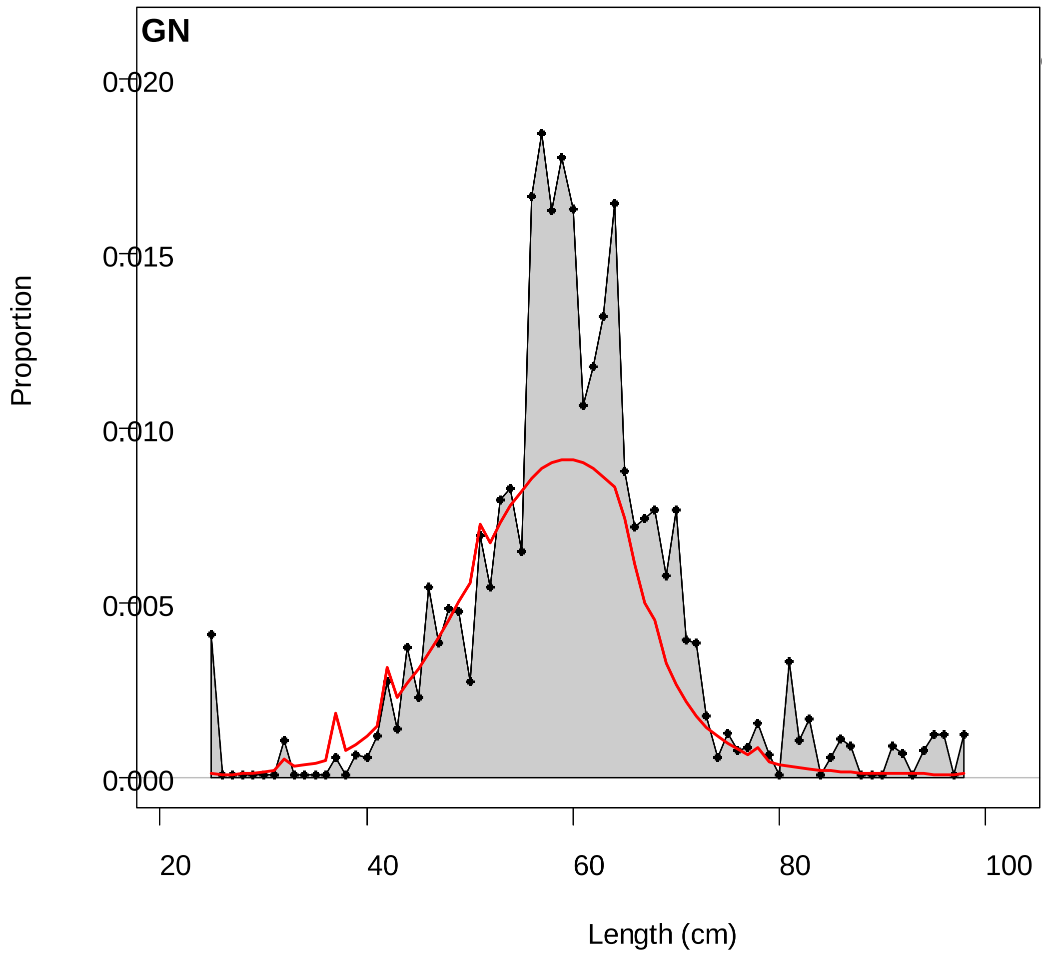
length comps, female, whole catch, agg



length comps, female, retained, aggrega



length comps, male, whole catch, aggr



length comps, male, retained, aggregate