11. TABLES AND FIGURES

Table 3.1 Mortality, growth and maturity parameter estimates for five populations from Warner (1975) and Cowen (1990). See the text for a description of how the parameters were determined. Parameters for Catalina (in bold) were used in the baseline model and the other parameter estimates were used for sensitivity analyses.

	POPULATION					
PARAMETER	***Catalina Island(Warner)***	***Guadalupe Island (Warner)***	***San Benitos Island (Cowen)***	***Guadalupe Island (Cowen)***	***Cabo Thurloe (Cowen)***	***San Nicolas Island (Cowen)***
Mortality	**0.35**	0.46	0.43	0.55	0.41	0.29
Maximum age in the sample	**20**	12	10	9	12	21
Estimated L_{inf}	**83.86**	46.03	83.85	45.46	464.16	85.19
k growth	**0.068**	0.064	0.064	0.064	0.007	0.064
L1 (age 1)	**12.92**	14.76	10.93	10.93	10.93	16.40
L2 (age 13)	**52.60**	31.47	49.91	29.39	49.84	53.17
L50 maturity	**25.24**	20.55	33.65	23.44	18.76	31.33
L50 sexchange	**36.77**	24.71	31.77	36.12	26.35	34.64
k maturity (slope)	**1.060**	4.169	0.190	1.506	1.338	0.152
k sexchange (slope)	**0.32**	0.33	3.75	0.81	0.31	0.23

Table 4.1 Historical California Sheephead landings (mtons) by fishery, 1916-2003.

	Hook & Line	Trap	Setnets	Total Commercial	Recreational	TOTAL
1916	1.61	0.00	0.00	1.61	0.00	1.61
1917	2.68	0.00	0.00	2.68	0.00	2.68
1918	10.42	0.00	0.00	10.42	0.00	10.42
1919	8.15	0.00	0.00	8.15	0.00	8.15
1920	6.61	0.00	0.00	6.61	0.00	6.61
1921	10.85	0.00	0.00	10.85	0.00	10.85
1922	8.26	0.00	0.00	8.26	0.00	8.26
1923	14.35	0.00	0.00	14.35	0.00	14.35
1924	11.01	0.00	0.00	11.01	0.00	11.01
1925	22.14	0.00	0.00	22.14	0.00	22.14
1926	63.02	0.00	0.00	63.02	0.00	63.02
1927	72.30	0.00	0.00	72.30	0.00	72.30
1928	169.04	0.00	0.00	169.04	0.00	169.04
1929	130.83	0.00	0.00	130.83	0.00	130.83
1930	110.54	0.00	0.00	110.54	0.00	110.54
1931	89.97	0.00	0.00	89.97	0.00	89.97
1932	40.64	0.00	0.00	40.64	0.00	40.64
1933	26.58	0.00	0.00	26.58	0.00	26.58
1934	65.11	0.00	0.00	65.11	0.00	65.11
1935	85.29	0.00	0.00	85.29	0.00	85.29
1936	58.32	0.00	0.00	58.32	0.00	58.32
1937	36.95	0.00	0.00	36.95	0.00	36.95
1938	32.67	0.00	0.00	32.67	0.00	32.67
1939	32.37	0.00	0.00	32.37	0.00	32.37
1940	28.28	0.00	0.00	28.28	0.00	28.28
1941	22.28	0.00	0.00	22.28	0.00	22.28
1942	22.80	0.00	0.00	22.80	0.00	22.80
1943	68.51	0.00	0.00	68.51	0.00	68.51
1944	76.50	0.00	0.00	76.50	0.00	76.50
1945	113.21	0.00	0.00	113.21	0.00	113.21
1946	121.17	0.00	0.00	121.17	0.00	121.17
1947	87.77	0.00	0.00	87.77	21.03	108.79
1948	45.46	0.00	0.00	45.46	27.91	73.37
1949	28.81	0.00	0.00	28.81	24.97	53.78
1950	30.03	0.00	0.00	30.03	23.09	53.13
1951	27.86	0.00	0.00	27.86	33.01	60.87
1952	16.43	0.00	0.00	16.43	26.65	43.08
1953	16.07	0.00	0.00	16.07	28.05	44.12
1954	13.24	0.00	0.00	13.24	34.77	48.00
1955	5.97	0.00	0.00	5.97	26.64	32.61
1956	2.98	0.00	0.00	2.98	27.75	30.73
1957	5.00	0.00	0.00	5.00	28.26	33.27
1958	5.16	0.00	0.00	5.16	33.14	38.29
1959	4.64	0.00	0.00	4.64	31.56	36.21
1960	2.15	0.00	0.00	2.15	22.50	24.65

(cont.)	Hook & Line	Trap	Setnets	Total Commercial	Recreational	TOTAL
1961	5.72	0.00	0.00	5.72	28.43	34.15
1962	9.22	0.00	0.00	9.22	25.65	34.87
1963	12.71	0.00	0.00	12.71	33.66	46.37
1964	8.13	0.00	0.00	8.13	47.21	55.34
1965	5.51	0.00	0.00	5.51	71.19	76.70
1966	7.25	0.00	0.00	7.25	89.49	96.74
1967	8.90	0.00	0.00	8.90	72.85	81.75
1968	5.78	0.00	0.00	5.78	57.32	63.10
1969	6.03	0.00	0.00	6.03	84.09	90.11
1970	1.73	0.00	0.00	1.73	67.65	69.38
1971	4.02	0.00	0.00	4.02	65.77	69.79
1972	3.21	0.00	0.00	3.21	58.08	61.29
1973	1.39	0.00	0.00	1.39	78.60	79.99
1974	1.69	0.00	0.00	1.69	52.96	54.65
1975	2.74	0.00	0.00	2.74	53.15	55.89
1976	3.78	0.00	0.00	3.78	57.08	60.86
1977	2.91	0.00	0.00	2.91	49.94	52.85
1978	0.94	0.49	3.63	5.05	59.48	64.53
1979	0.23	0.45	3.32	4.00	55.58	59.57
1980	0.85	1.08	2.20	4.13	143.57	147.69
1981	0.36	0.36	5.13	5.86	106.97	112.83
1982	0.44	0.82	4.08	5.34	92.03	97.37
1983	0.88	0.34	4.50	5.73	155.35	161.08
1984	1.96	0.28	9.15	11.40	131.20	142.59
1985	0.17	0.08	12.67	12.93	200.20	213.12
1986	0.39	0.00	12.88	13.27	223.30	236.57
1987	2.76	0.00	12.16	14.92	108.09	123.01
1988	2.84	0.00	10.47	13.31	178.84	192.15
1989	7.84	0.00	7.25	15.09	64.64	79.73
1990	49.60	0.00	6.54	56.14	60.00	116.14
1991	80.43	0.00	6.66	87.09	73.63	160.72
1992	111.20	0.00	6.14	117.34	45.50	162.84
1993	127.11	11.88	4.33	143.31	78.24	221.56
1994	27.06	89.92	0.72	117.70	121.12	238.81
1995	26.40	88.20	0.47	115.08	54.52	169.60
1996	20.89	92.83	0.68	114.40	81.22	195.62
1997	22.02	115.69	1.28	138.98	59.81	198.79
1998	24.79	93.32	0.94	119.04	76.51	195.55
1999	11.24	46.68	0.90	58.82	84.94	143.76
2000	15.16	62.31	1.21	78.68	100.09	178.77
2001	10.96	55.78	1.39	68.13	58.85	126.98
2002	10.34	43.71	0.66	54.71	60.26	114.96
2003	10.87	36.98	0.15	48.00	68.51	116.51
TOTAL	2512.47	741.20	119.50	3373.17	3924.88	7298.05
AVERAGE	28.55	8.42	1.36	38.33	44.60	82.93

Table 4.2 Initial sample sizes used for length composition data in the baseline model.

		SAMPLE SIZE (n)	
		Available	Used
Commercial			
	Hook and Line	162	119
	Trap	1072	1064
	Setnet	67	58
	Commercial Subtotal	1301	1241
Recreational			
	Hook and Line	8004	7294
TOTAL*		**9305**	**8535**

•Source data did not overlap between years. Source with larger sample size in a year was used. No year was used that had < 5 samples.

Table 5.1 A description of the parameters and variables in the Single-Sex Approximation Model.

Parameter	Description
L(a)	Length at age
k	Growth rate
L_∞	Asymptotic size
ε_g, ε_m, ε_f, ε_r	Error and uncertainty terms
W(a)	Weight at age
c	Weight to length scalar
d	Weight to allometry
M(t)	Auto-correlated mortality term
ρ	Auto-correlation term
θ_i	Selectivity for fishery, i
T_i	Scaling factor for selectivity
β_{1i}, β_{3i}	Steepness for fishing selectivity
β_{2i}, β_{4i}	Midpoint size for selectivity curves
F(a)	Fishing mortality
E_i	Effort for fishery, i
C(t)	Catch at time, t
$p_m(a)$	Proportion of age class mature
L_{50m}	Size at which 50% of individuals mature
$p_f(a)$	Proportion of age class still female
L_{50f}	Size at which 50% of individuals are female
r	Rate of maturity or sex change
$p_s(a)$	Proportion of age class able to produce eggs
$\varphi(a)_{sex\ change}$, $\varphi(a)_{single\ sex}$	Number of eggs produced by age class
σ	Eggs produced per kg body weight
h	Steepness of recruitment curve at 20% of virgin SSB
R_0	Recruitment at virgin SSB
S_0	Virgin SSB
a	Maximum number of recruits produced
b	SSB needed to produce half of a
ϕ_0	Lifetime eggs per recruit without fishing

Table 6.1 Likelihood components, emphasis levels and their relative values in the final fit of the baseline model.

Likelihood component	Emphasis	Value
hook and line landings	1	-0.06
hooks and line length composition	1	-32.07
trap landings	1	0.00
trap length compositions	1	-42.90
setnet landings	1	0.00
setnet length composition	1	-12.87
recreational landings	1	-0.06
recreational length composition	1	-189.17
CPFV logbook CPUE (1947-1961)	1	-12.40
CPFV logbook CPUE (1960-1981)	1	-16.93
CPFV logbook CPUE (1980-2003)	1	10.10
CalCOFI SPB	1	-46.22
spawned-recruit curve- individual	0	-2450.28
recruit-recruit curve- mean	0	-267579.98
ending biomass	0	1036.96
total log-likelihood:		-342.5729

T**able 6.2** The parameter values and estimation status for the baseline model.

PARAMETER	**VALUE**	**ESTIMATED?**
Natural mortality	0.35	no
Maturity		
L_{50} Maturity	25.24	no
K (slope) maturity	1.06	no
L_{50} sex change	36.7	no
k (slope) sex change	0.32	no
Growth		
L_1	12.92	no
L_2	52.6	no
K	0.068	no
CV_1	0.14	yes
CV_2	0.26	yes
Recruitment		
Virgin recruitment (SR curve)	1.39	yes
Steepness parameter (SR curve)	0.70	yes
Standard deviation of recruitment	0.61	yes
Background recruitment	0.88	yes
Selectivities		
Hook and line: initial selectivity	0.0058	yes
Hook and line: inflection	1.0000	yes
Hook and line: slope	0.3081	yes
Traps: initial selectivity	0.0055	yes
Traps: inflection point	0.3506	yes
Traps: slope	0.6895	yes
Setnet: initial selectivity	0.0019	yes
Setnet: inflection	1.0000	yes
Setnet: slope	0.2549	yes
Recreational: initial selectivity	0.0012	yes
Recreational: inflection	0.3089	yes
Recreational: slope	0.5369	yes

Table 6.3 Sensitivity analyses on growth: The effect of allowing the growth parameters to be estimated within the Synthesis model.

PARAMETER	Baseline model	Growth parameters estimated
L_1	12.92 (fixed)	12.92 (fixed)
L_2	52.60 (fixed)	51.79 (estimated)
K	0.068 (fixed)	0.099 (estimated)
CV_1	0.14 (estimated)	0.13 (estimated)
CV_2	0.26 (estimated)	0.24 (estimated)
log-likelihood	-342.57	-340.57

Table 7.1 The effect of the coefficient of variation in growth on the estimated status of the stock as measured by the spawning potential ratio. The coefficient of variation in growth parameters (CV_1 and CV_2) were assumed to be equal and affect the estimated total biomass which therefore leads to different estimates of current exploitation among runs of the model that differ in CV_1 and CV_2.

CV	current exploitation	relative female SPR	relative male SPR	relative total SPR
0.10	0.07	0.87	0.54	0.77
0.20	0.11	0.80	0.39	0.70
0.30	0.20	0.68	0.19	0.59

Table 8.1. We refitted the length and maturity data from the Warner and Cowen theses for all nearshore data sets. The life history parameters in this table were also used to calculate relative SPR in figure 8.17.

	Population			
Parameter	*Catalina Island (Warner)*	*San Benitos Island (Cowen)*	*Cabo Thruloe (Cowen)*	*San Nicolas Island (Cowen)*
Estimate L_{inf}	83.86	130	145.86	85.19
k growth	0.068	0.026	0.028	0.064
L_1 (age 1)	12.92	7.35	10.16	16.4
L_2 (age 13)	52.49	40.22	49.38	53.3
L_{50} maturity	25.24	26.9	21.8	33.3
L_{50} sex change	36.77	33.4	30.9	54.5
k maturity (slope)	1.06	0.88	0.52	0.78
k sex change (slope)	0.32	0.46	0.21	0.54

Table 8.2 Likelihood components, emphasis levels and their relative values in the final fit of the baseline model with M=0.20. Other options for M are shown for comparison.

		M=0.20	**M=0.15**	**M=0.30**
Likelihood component	**Emphasis**	**Value**	**Value**	**Value**
hook and line landings	1	0.00	0.00	0.00
hook and line length compositions	1	-46.78	-47.83	-45.49
trap landings	1	0.00	0.00	0.00
trap length compositions	1	-50.69	-51.82	-49.96
setnet landings	1	0.00	0.00	0.00
setnet length compositions	1	-24.77	-24.31	-26.15
recreational landings	1	0.00	0.00	0.00
recreational length compositions	1	-238.95	-245.74	-237.56
CPFV logbook CPUE (1947-1961)	1	-12.26	-12.29	-12.27
CPFV logbook CPUE (1960-1981)	1	-16.82	-16.96	-16.78
CPFV logbook CPUE (1980-2003)	1	4.56	-0.10	6.99
CalCOFI SPB	1	-34.43	-34.90	-34.44
Spawner-recruit curve - individual	0.01	-31.06	-19.57	-32.49
Spawner-recruit curve - mean	0.01	-312.35	-10.91	-344.13
Total log-likelihood		-423.57	-434.26	-419.42

Table 8.3 The parameter values and estimation status for the final Sheephead stock assessment model with M= 0.20. Other options for M are shown for comparison.

		M=0.20	**M=0.15**	**M=0.30**
PARAMETER	**STATUS**	**VALUE**	**VALUE**	**VALUE**
Natural Mortality	FIXED	0.2	0.15	0.3
Maturity				
L50 Maturity	FIXED	25.24	25.24	25.24
k (slope) maturity	FIXED	1.06	1.06	1.06
L50 sex change	FIXED	36.7	36.7	36.7
k (slope) sex change	FIXED	0.32	0.32	0.32
Growth				
L1	FIXED	12.92	12.92	12.92
LINF	FIXED	52.6	52.6	52.6
K	FIXED	0.068	0.068	0.068
CV1	FIXED	0.11	0.11	0.11
CV1	FIXED	0.11	0.11	0.11
Recruitment				
Virgin recruitment (SR curve)	ESTIMATED	0.219875	0.2	0.63445662
Steepness parameter (SR curve)	FIXED	0.99	0.99	0.99
Standard deviation of recruitment	FIXED	0.8	0.8	0.8
Background recruitment	FIXED	1.163816	1.163816	1.163816
Selectivities				
Hook and line: initial selectivity	ESTIMATED	0.007365	0.00939618	0.00381731
Hook and line: inflection point	ESTIMATED	0.520713	0.50218018	0.55852208
Hook and line: slope	ESTIMATED	0.302354	0.32276091	0.25454652
Traps: initial selectivity	ESTIMATED	0.011185	0.0115224	0.00705048
Traps: inflection point	ESTIMATED	0.178	0.17580839	0.1829147
Traps: slope	ESTIMATED	0.752285	0.76223522	0.7069142
Setnet: initial selectivity	ESTIMATED	0.000612	0.00082801	0.0002709
Setnet: inflection point	ESTIMATED	0.656452	0.6313351	0.68210677
Setnet: slope	ESTIMATED	0.179861	0.18568015	0.17189107
Recreational: initial selectivity	ESTIMATED	0.002149	0.00245944	0.00139085
Recreational: inflection point	ESTIMATED	0.14896	0.14578432	0.15768232
Recreational: slope	ESTIMATED	0.562873	0.57434163	0.54215113

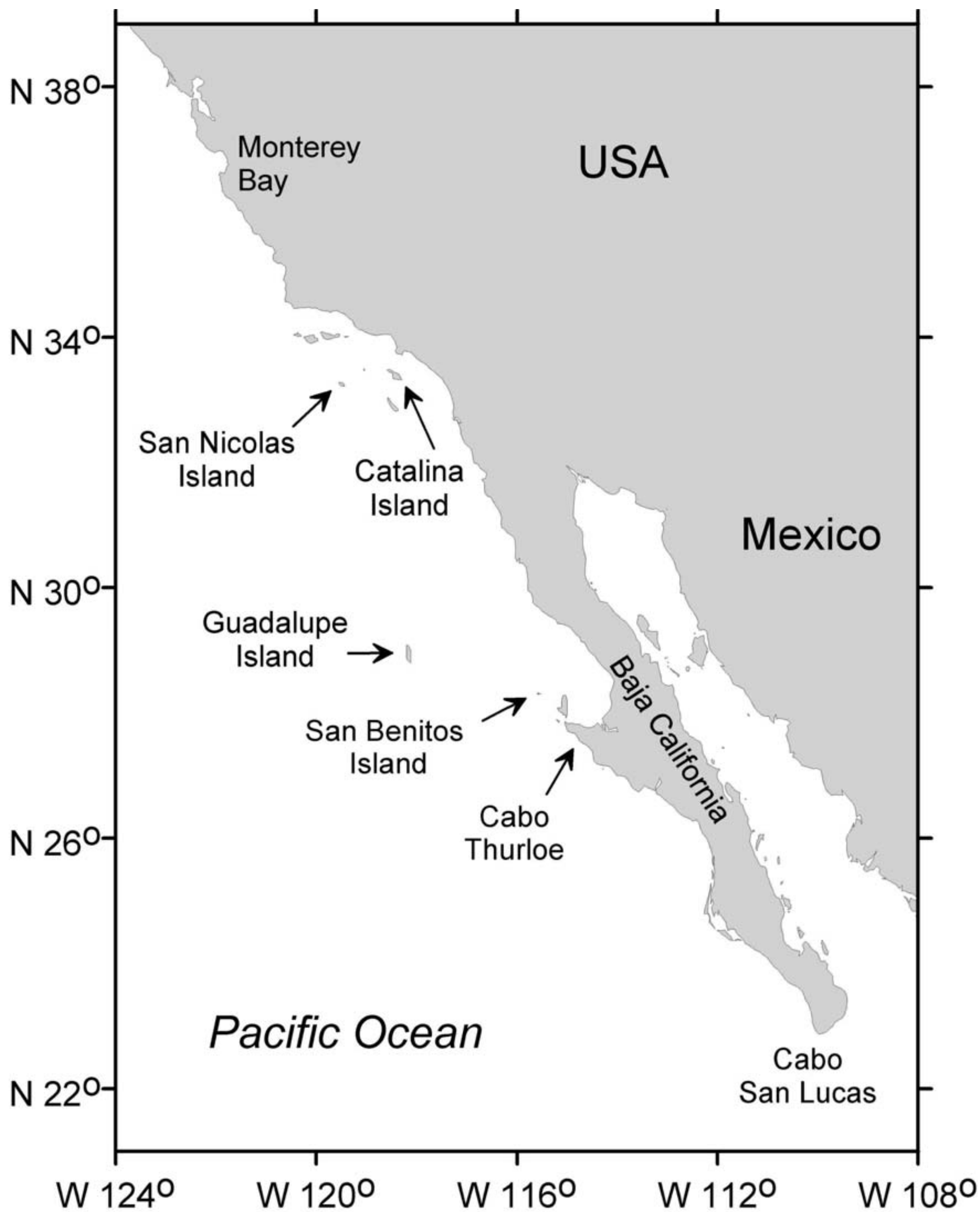


Figure 1.1 California Sheephead are found from Monterey Bay, CA to Cabo San Lucas, Mexico. The study areas from Warner (1975) and Cowen (1990) are also shown here.

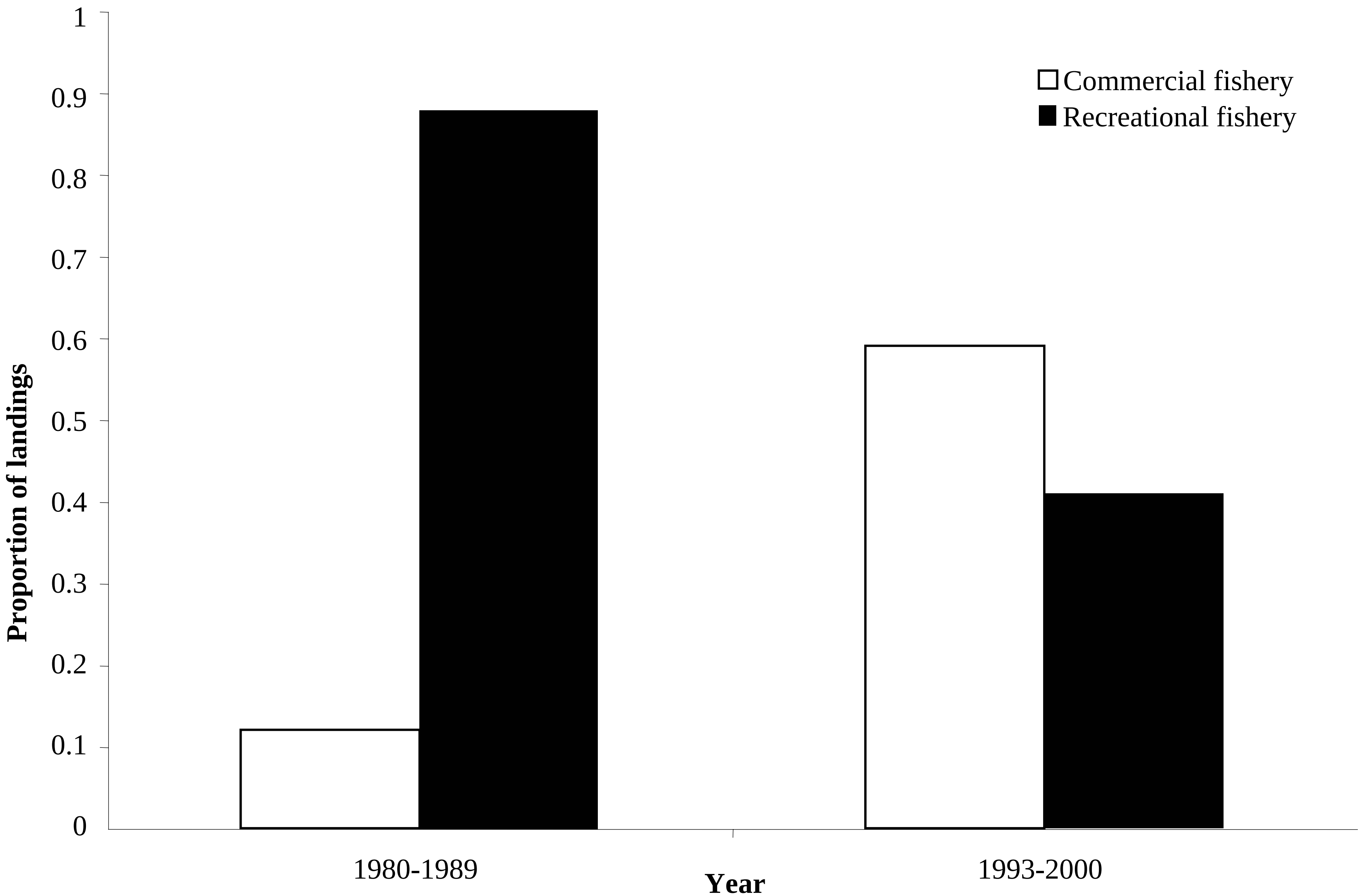


Figure 2.1 Proportion of total landings from the commercial and recreational fisheries during two periods from Schroeder and Love 2002.

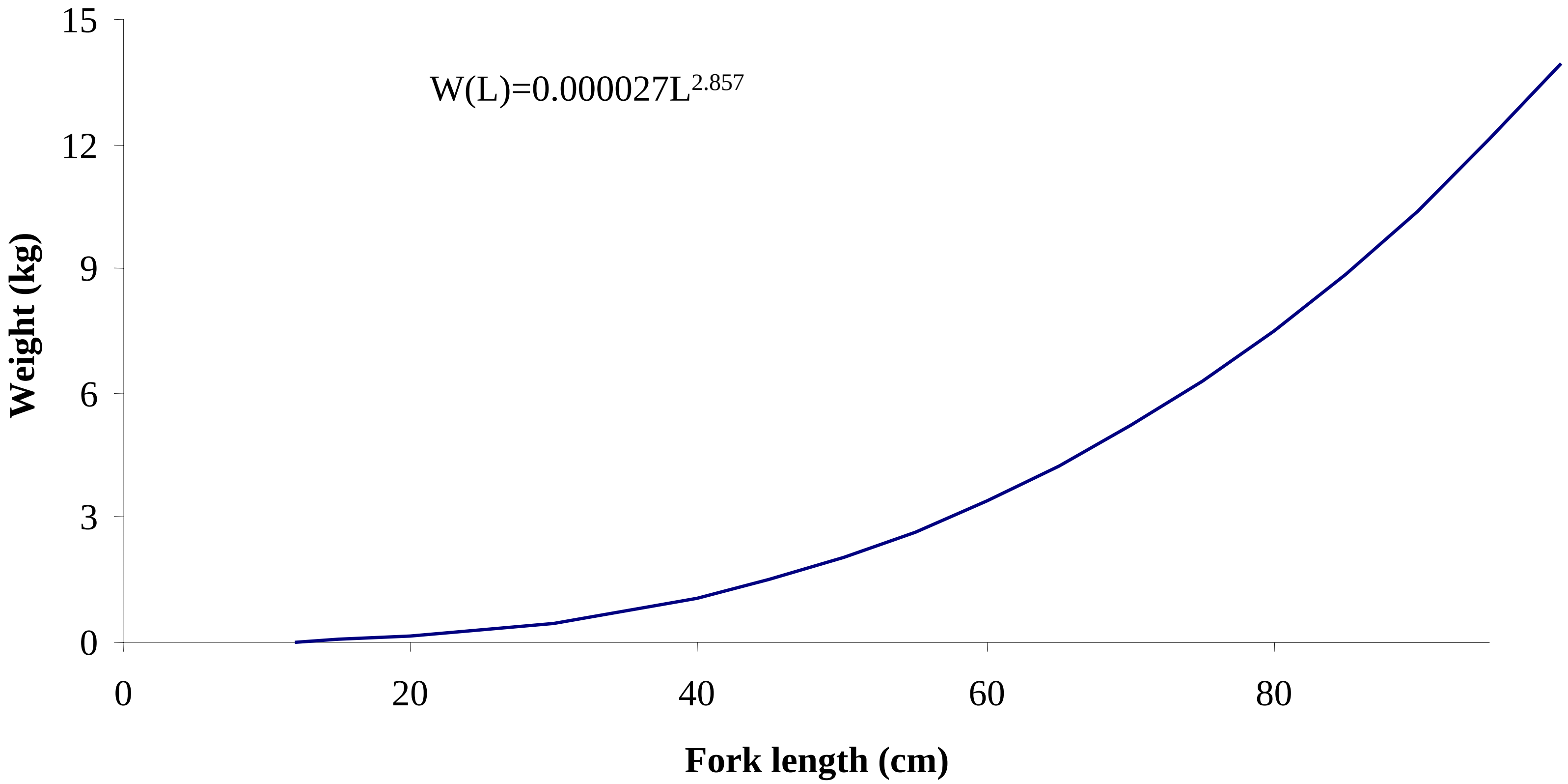


Figure 3.1 The power relationship between length in cm and weight in kg (converted from DeMartini et al. 1994).

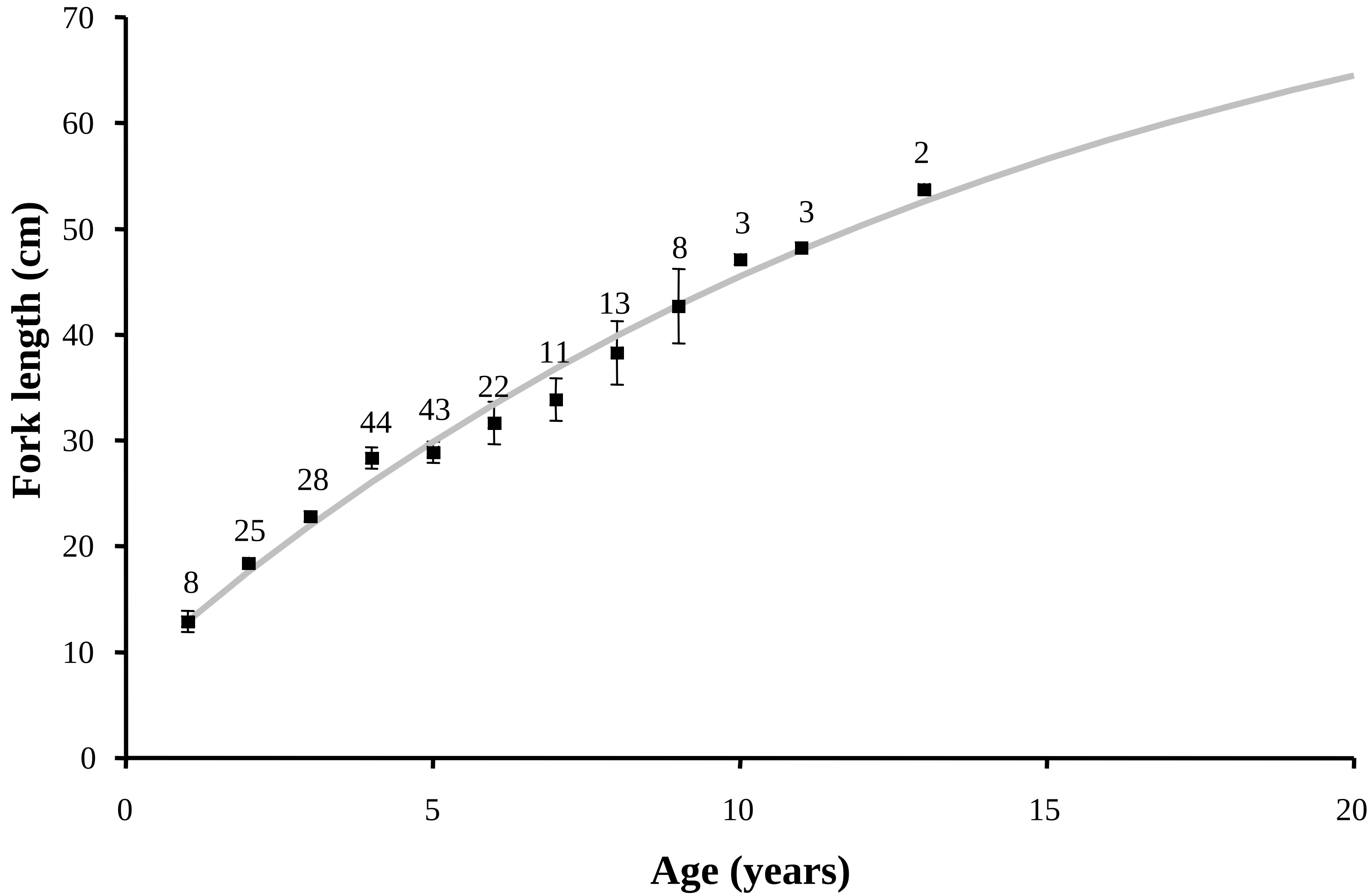


Figure 3.2 Predicted size at age using the best-fit growth parameters compared with the observed mean size at age data from Warner (1975). Error bars show the 95% confidence interval around the mean size at age and sample sizes per age are also given.

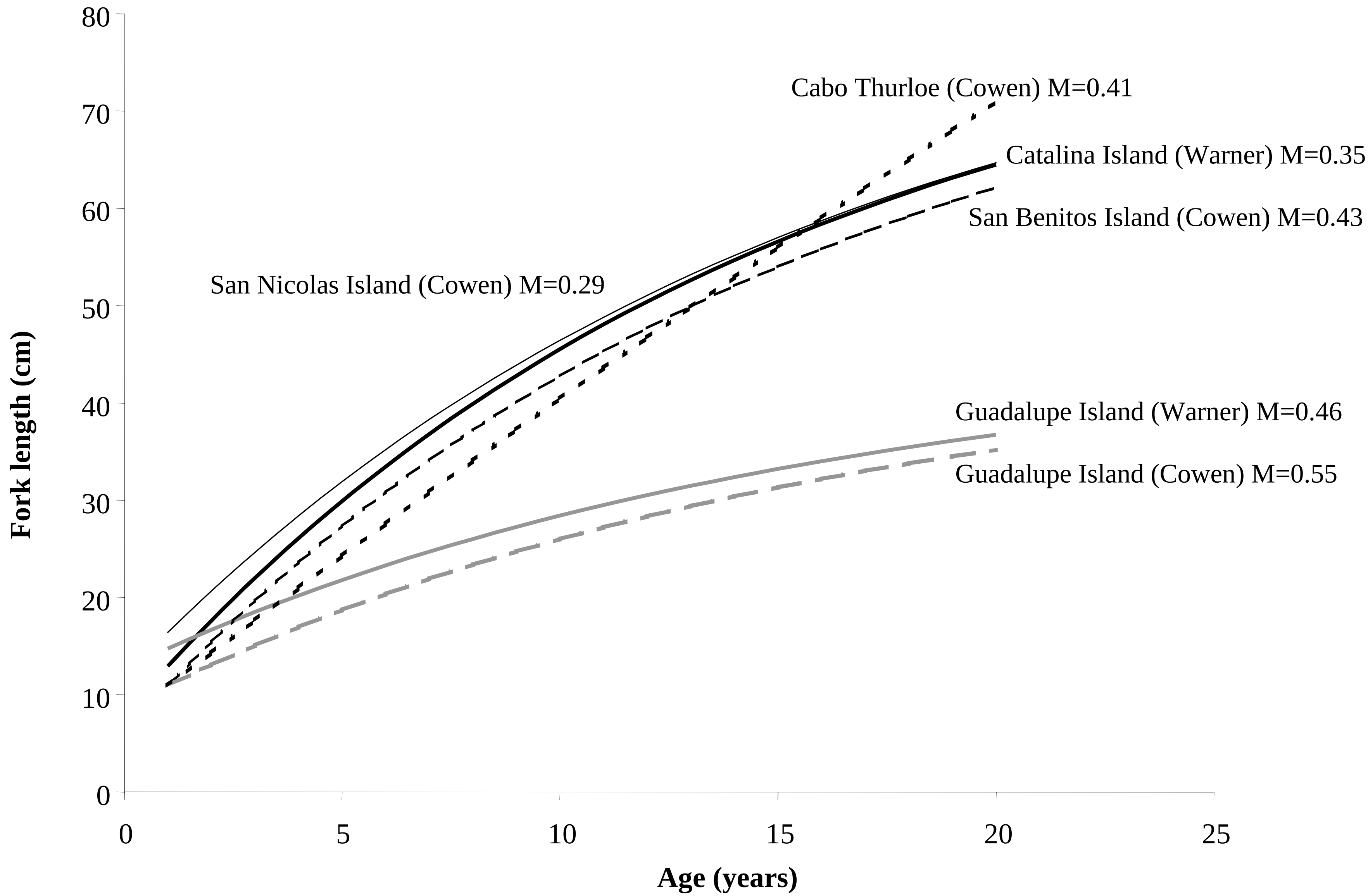


Figure 3.3 Variation among populations in growth. The parameter values for each population are given in Table 3.1.

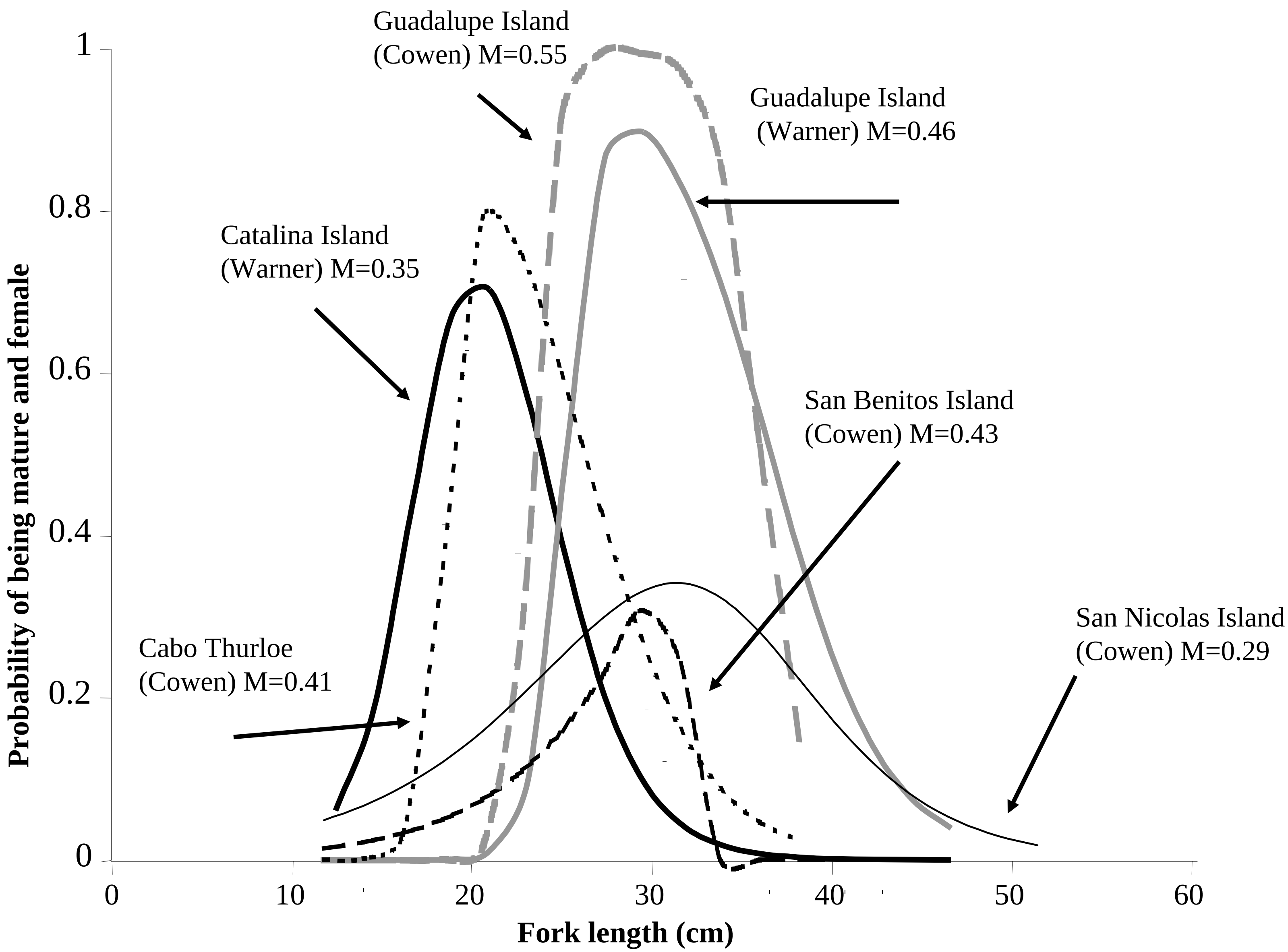


Figure 3.4 Variation among populations in maturity and sex change. Parameter values are given in Table 3.1.

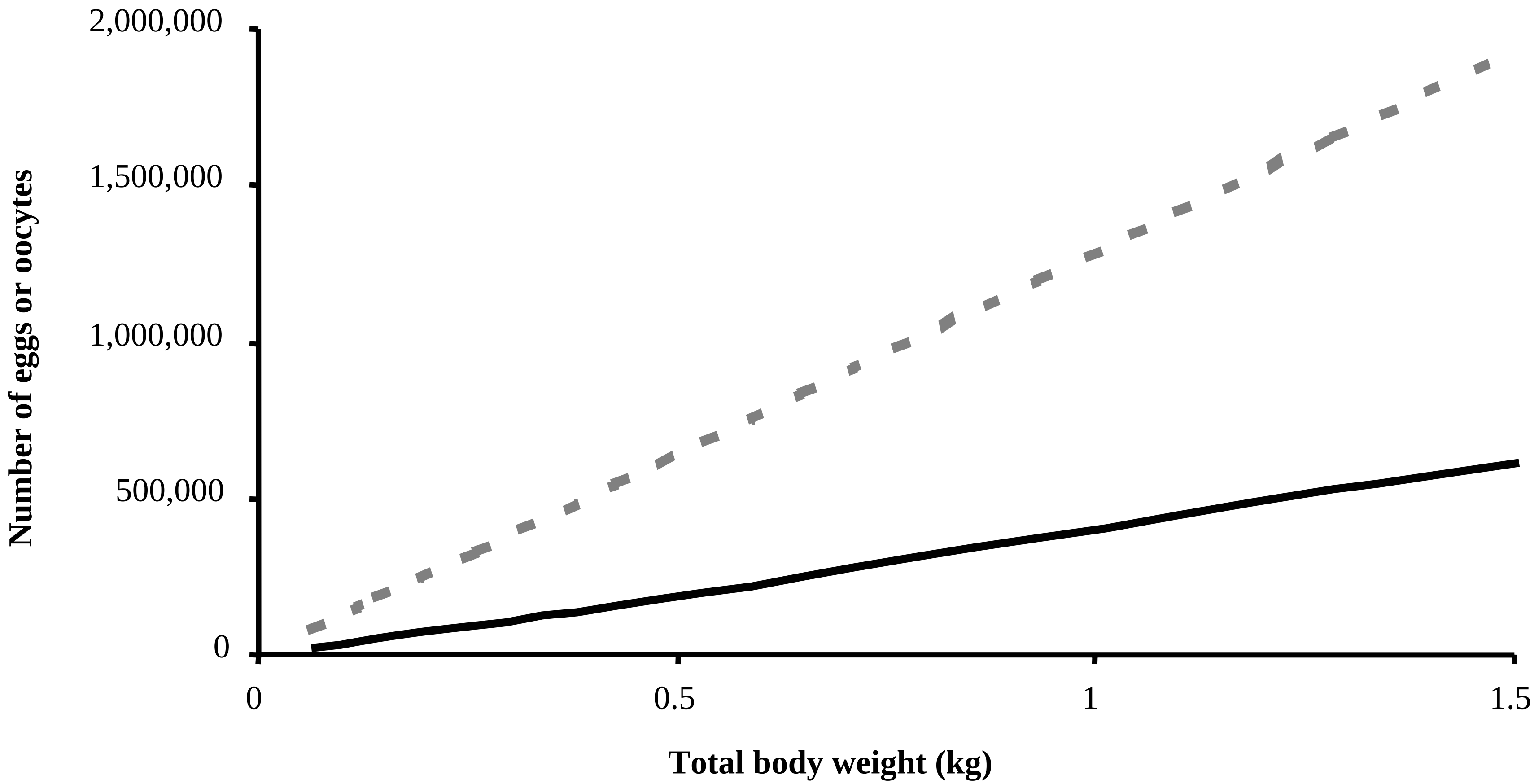


Figure 3.5 The relationship between annual egg production or the estimated number of oocytes per female as a function of total body weight in kilograms. The dashed gray line shows the estimated total egg production of females as a function of their body weight (data for the estimate taken from DeMartini et al. 1994). We use this relationship in the baseline Synthesis model. The solid black line shows the number of oocytes per female as a function of female body weight (data for the estimate taken from Warner 1975 and the weight/length relationship published in DeMartini et al. 1994). We used this relationship in a sensitivity analysis.

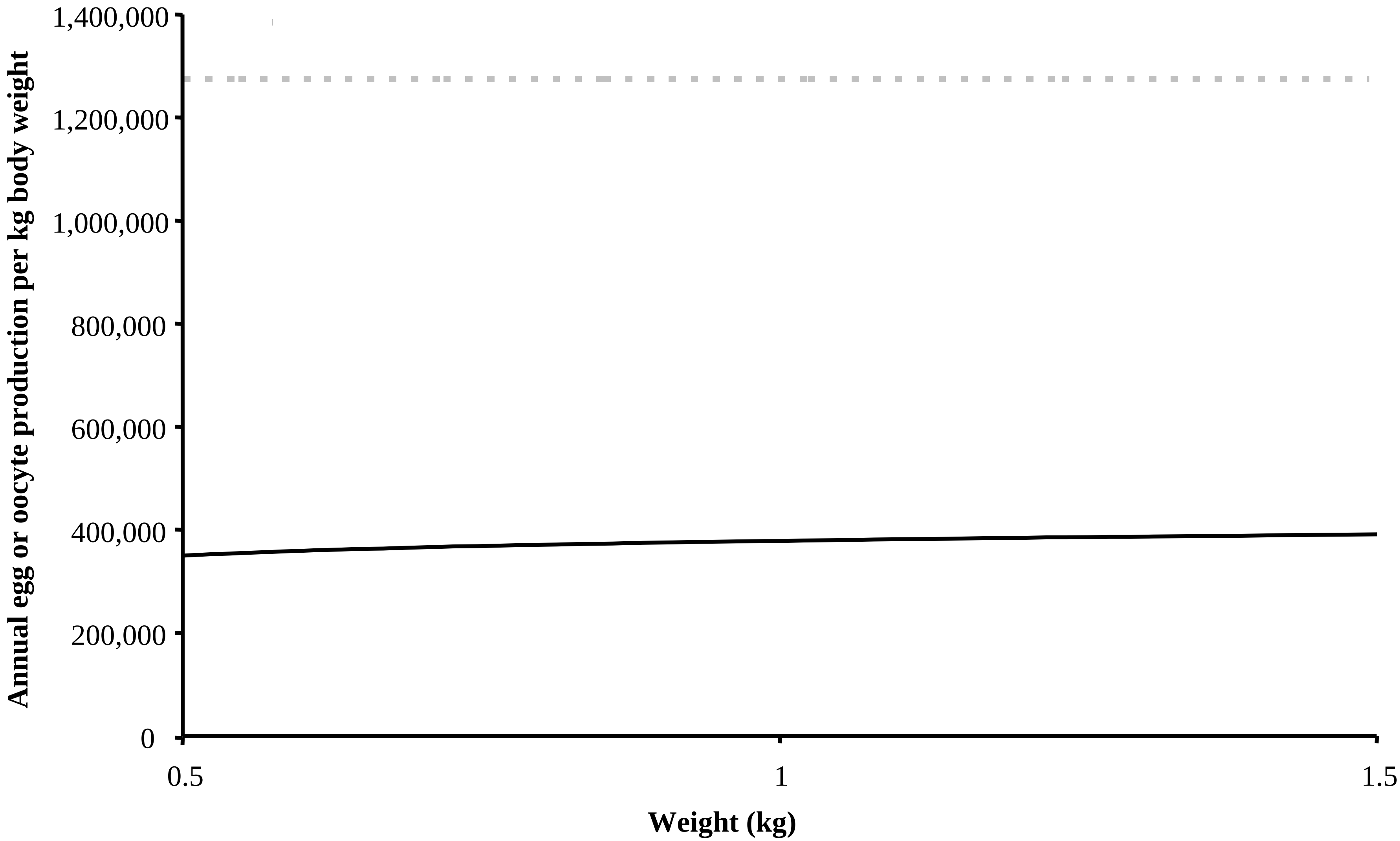


Figure 3.6 Weight-specific egg production did not increase with individual body weight. The weight range shown is for the weights and lengths (15cm to 50 cm approximately) in which some individuals might be mature and female. The dashed gray line shows the expected number of eggs produced annually per kilogram of female body weight (data for the estimate taken from DeMartini et al. 1994). The solid black line shows the expected number of oocytes per kilogram of female body weight (data for the estimate taken from Warner 1975 and the weight/length relationship published in DeMartini et al. 1994). We used the data from DeMartini et al (1994) for the baseline model (slope=0 intercept=129,000) and the Warner derived slope and intercept (slope=55,000 and intercept=341,000) as a sensitivity analysis.

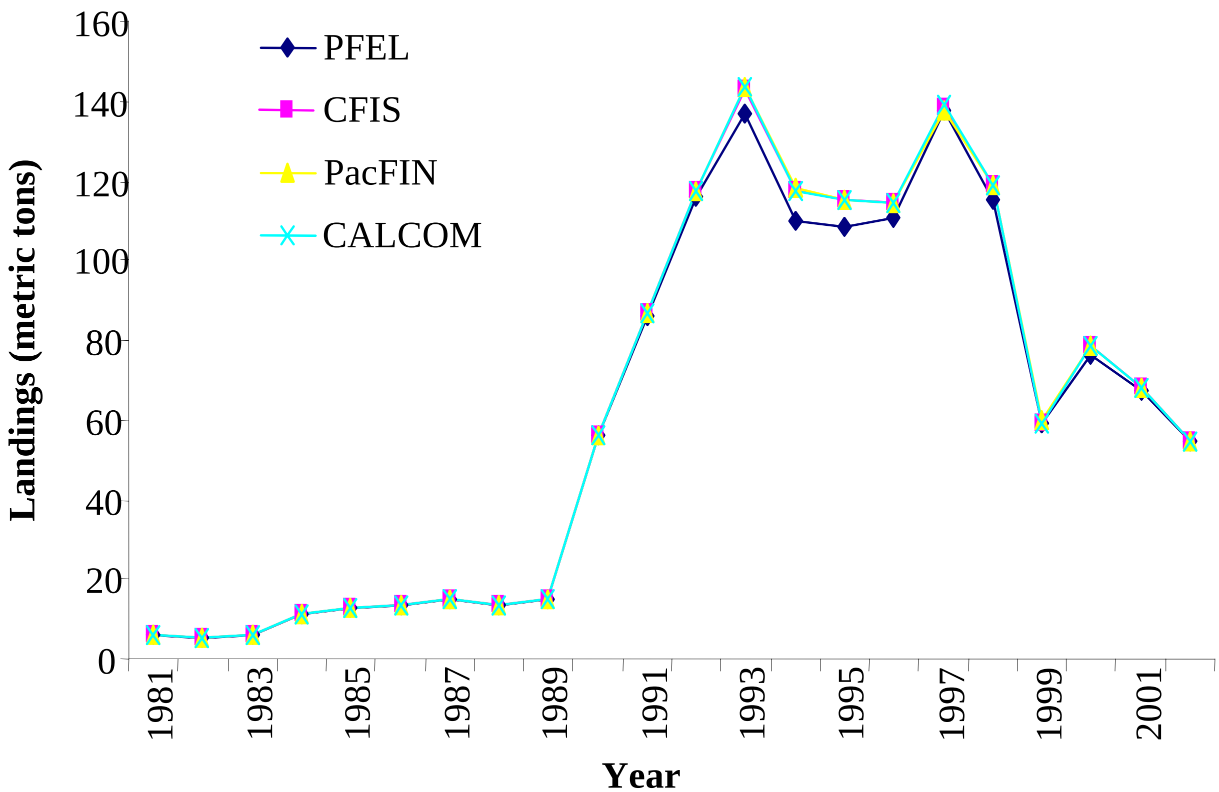


Figure 4.1a Comparing commercial landings (metric tons) by data source for overlapping time periods (1981-2002). No significant differences were detected (p=0.999).

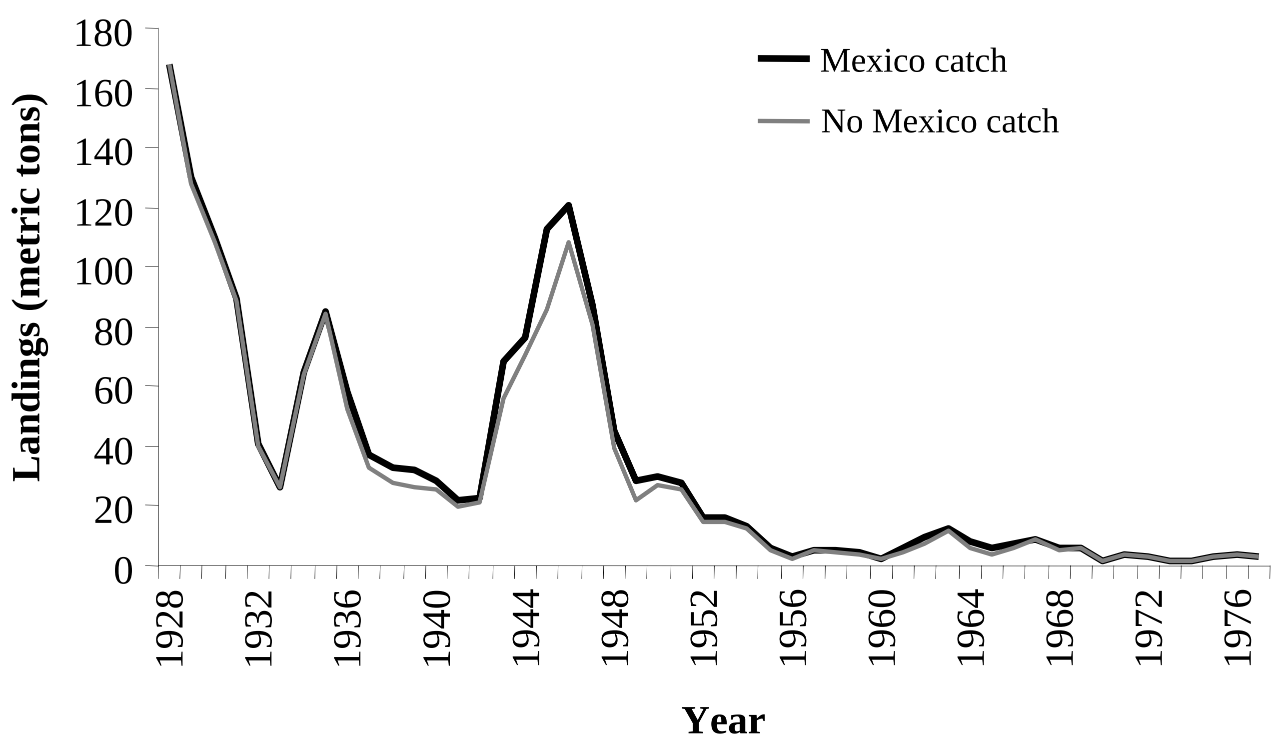


Figure 4.1b Comparing total Sheephead removals between two data sources; one including catch in Mexico (California's Living Marine Resources - CLMR) and the other not including Mexico catch (PFEL). We used landings caught in Mexico and brought into California for total removals in our baseline model.

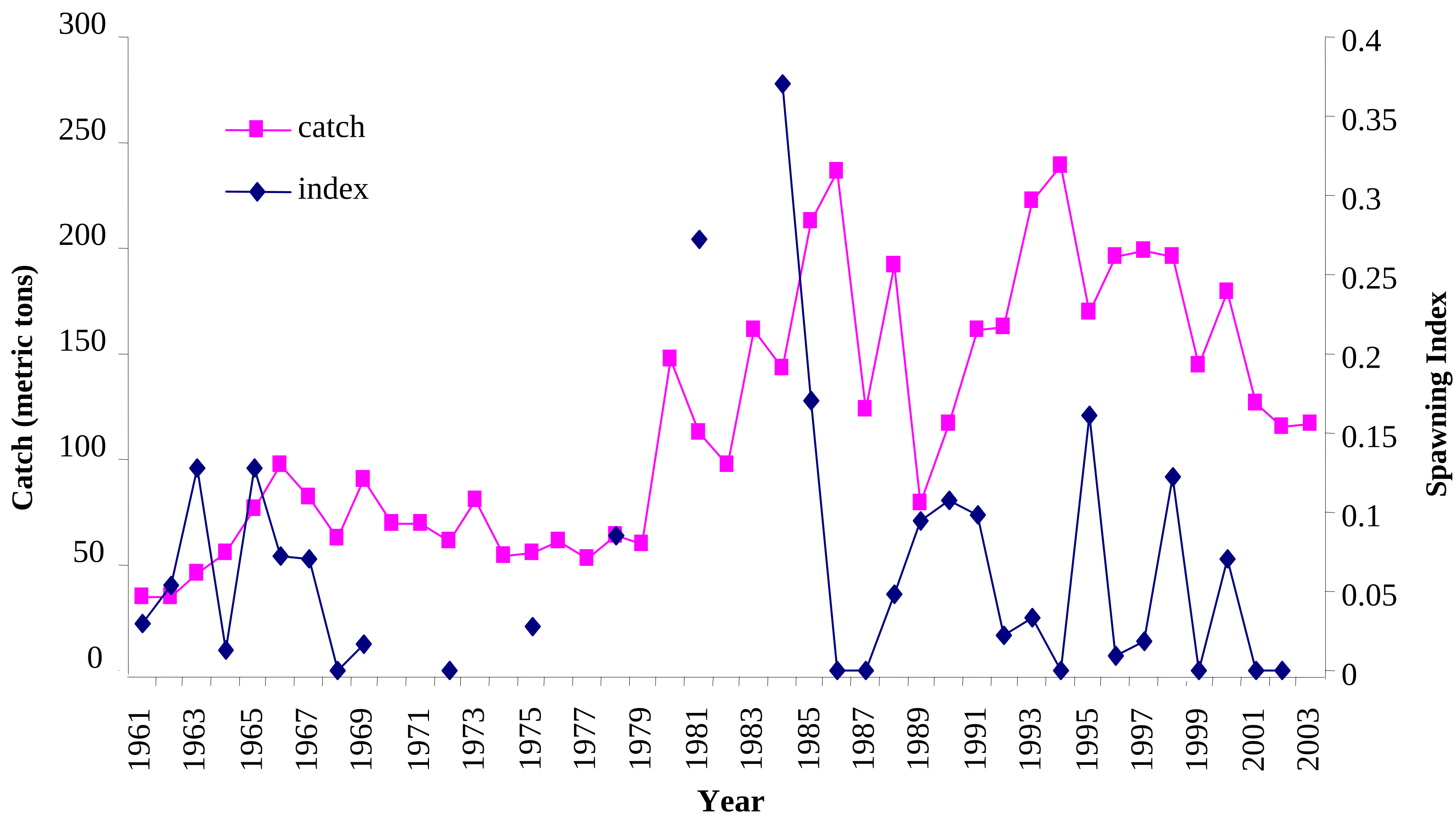


Figure 4.2 Comparing the annual variation (1961-2003) of landings (p<0.001) and the index of abundance (p=0.032) from CalCOFI larval surveys. Sheephead larvae appeared in the CalCOFI survey in 1961.

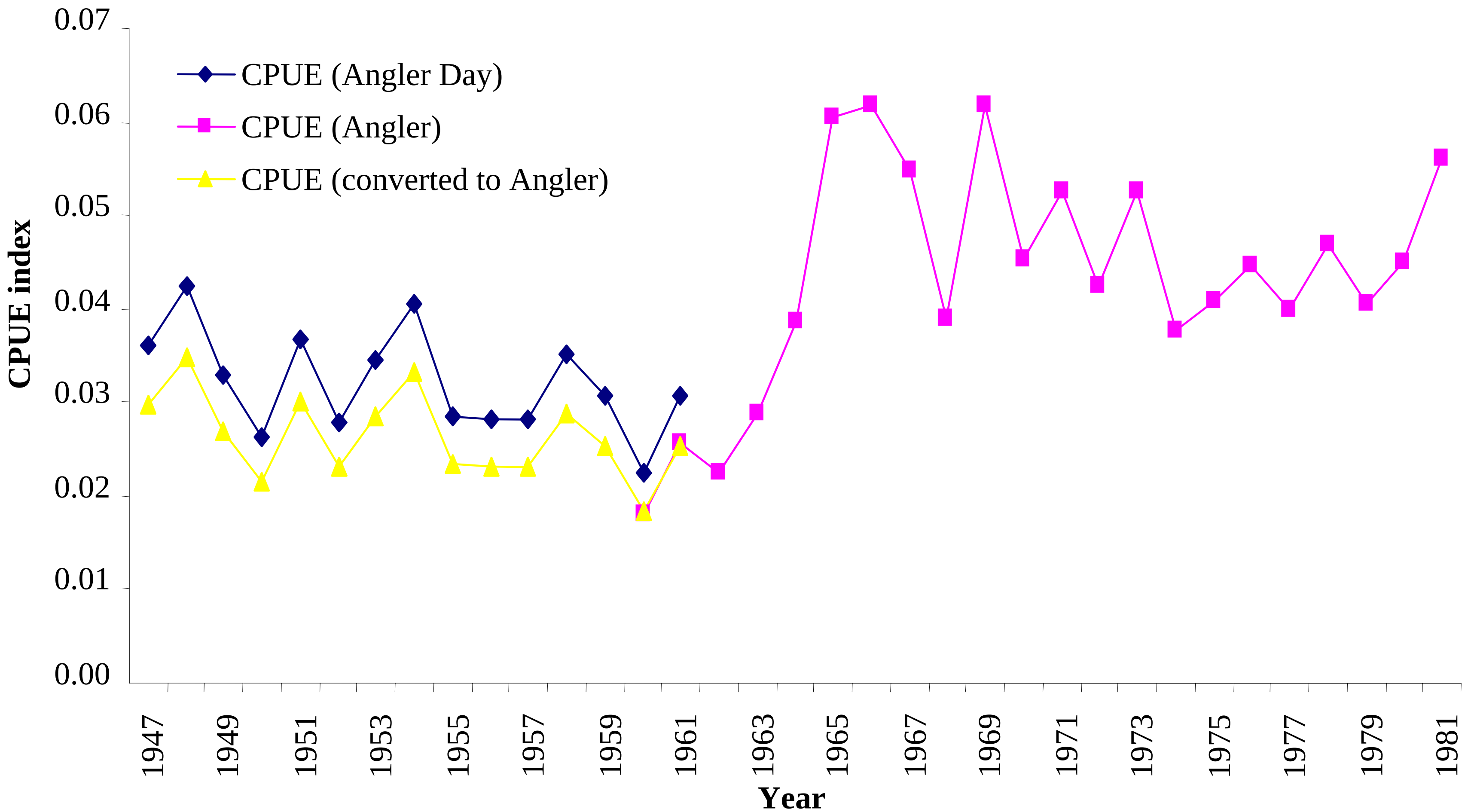


Figure 4.3 Comparing units of catch per unit effort from 1947-1981from CPFV logbooks. Converting catch per angler day to make one series of catch per angler does not change the general trend in those years; however, there is a difference between the two indices (p=0.004). We used the separated time series of differing units in the baseline model; catch per angler day from 1947-1961 and catch per angler from 1960-1981.

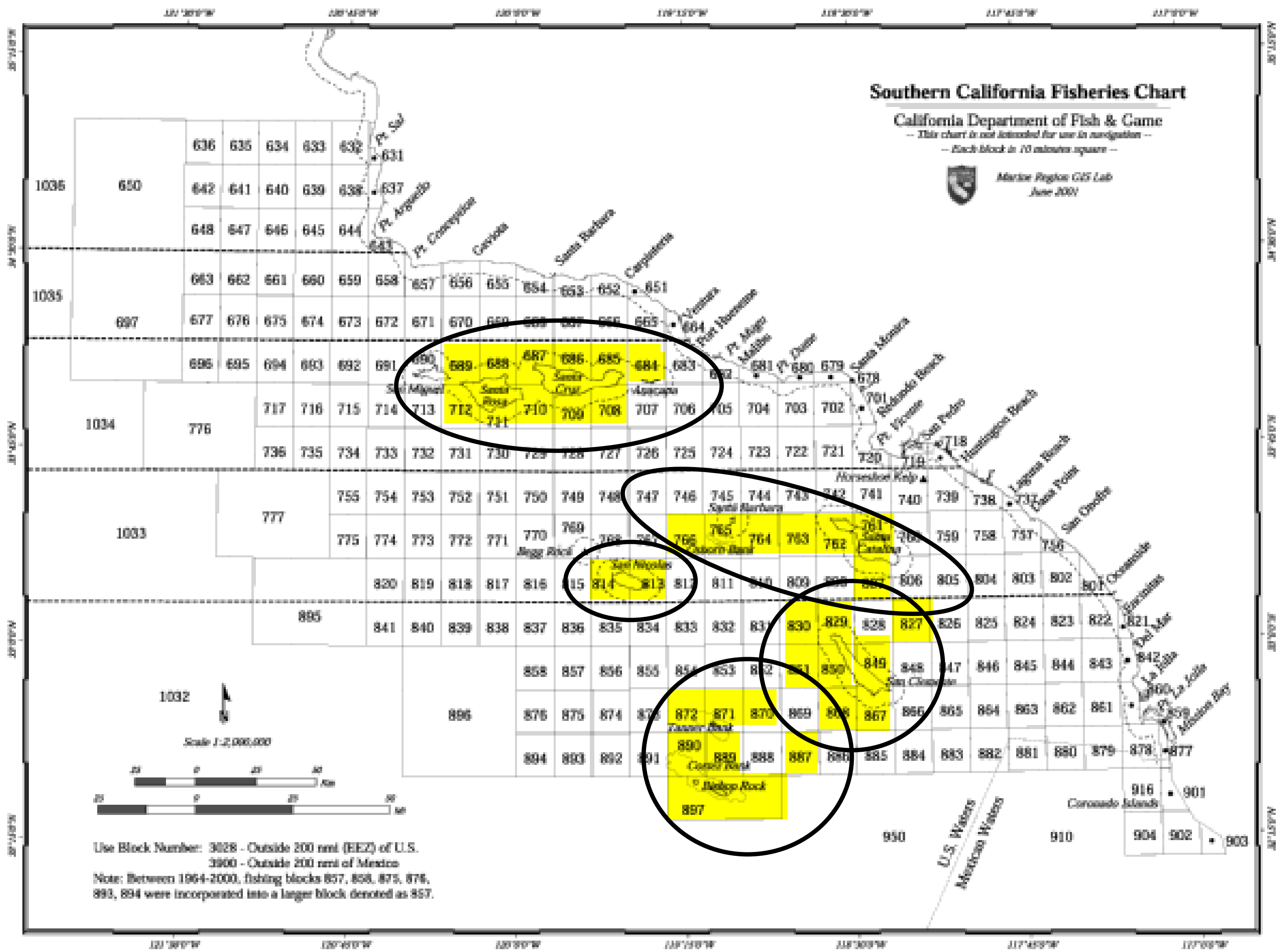
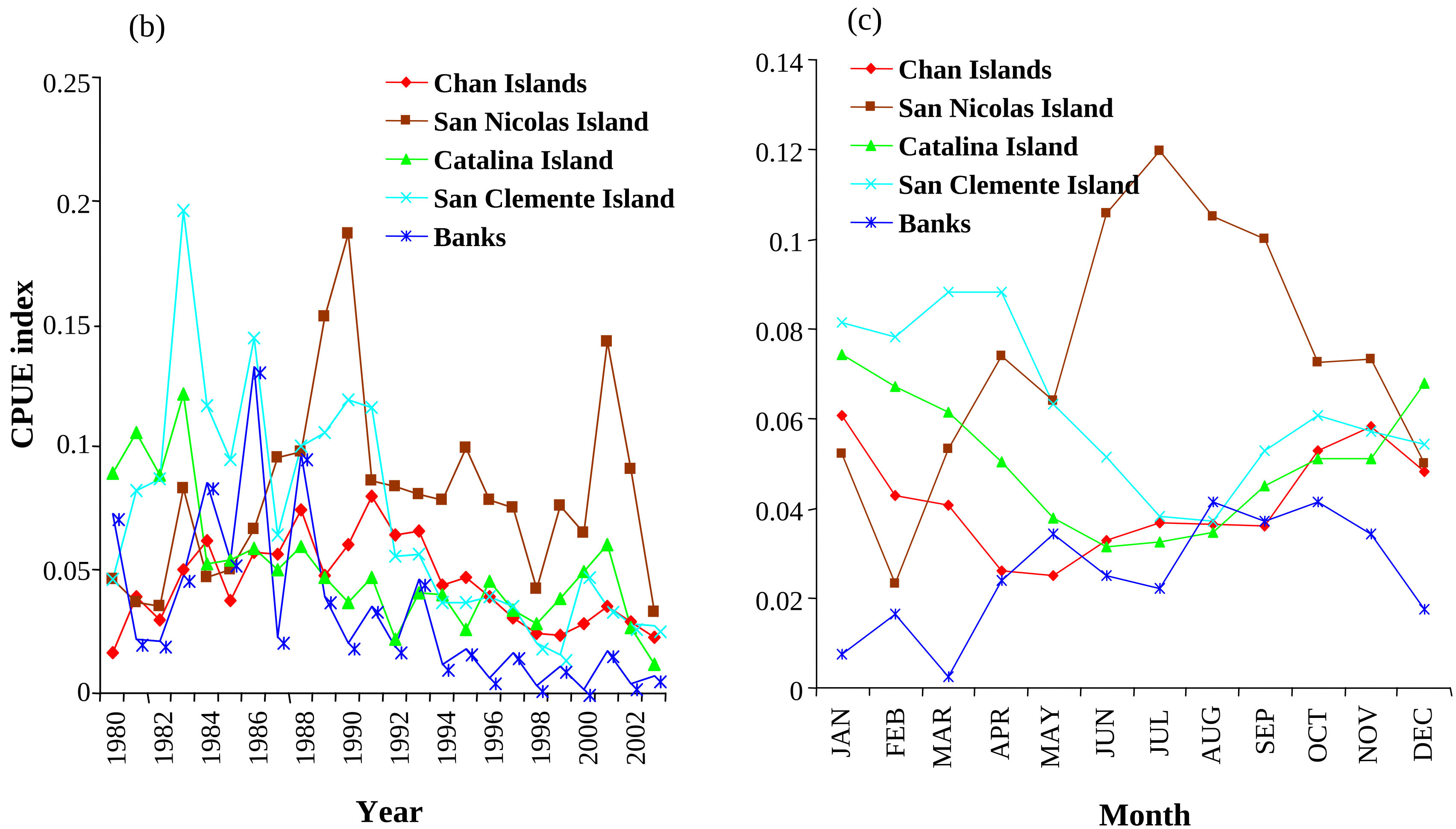


Figure 4.4a The CPUE index from 1980-2003 was calculated using logbook block information. Once run through a GLM, we found that 70% of the cumulative block values were in the following five geographic regions: Northern Channel Islands, San Nicolas Island, Santa Catalina Island, San Clemente Island, and Tanner and Cortez Banks.



Figures 4.4 (b) shows the variability in the CPUE Index and (c) monthly effects for each Geographic Fishing Area. A separate glm was run for each area considering the interactions shown here.

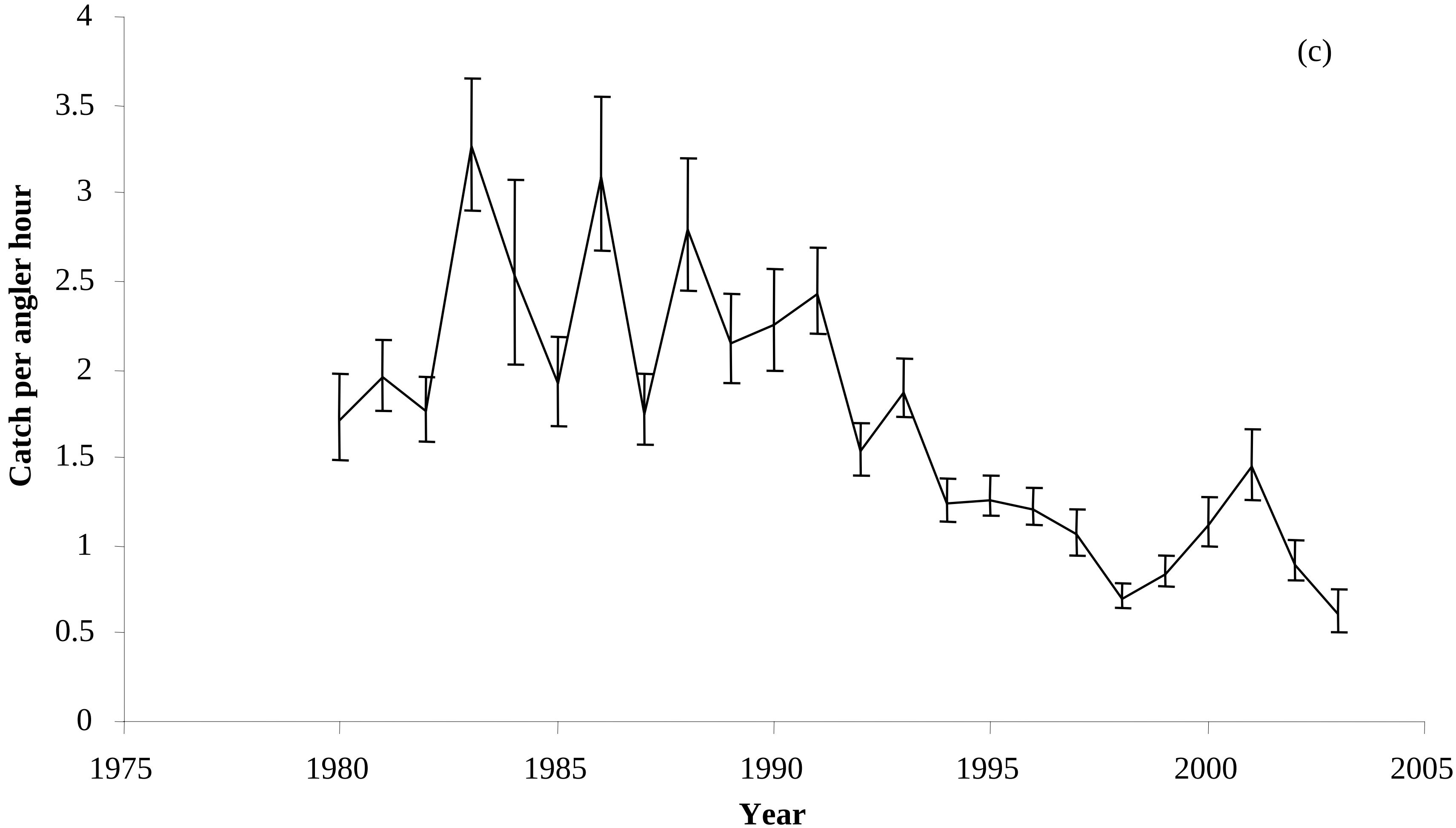
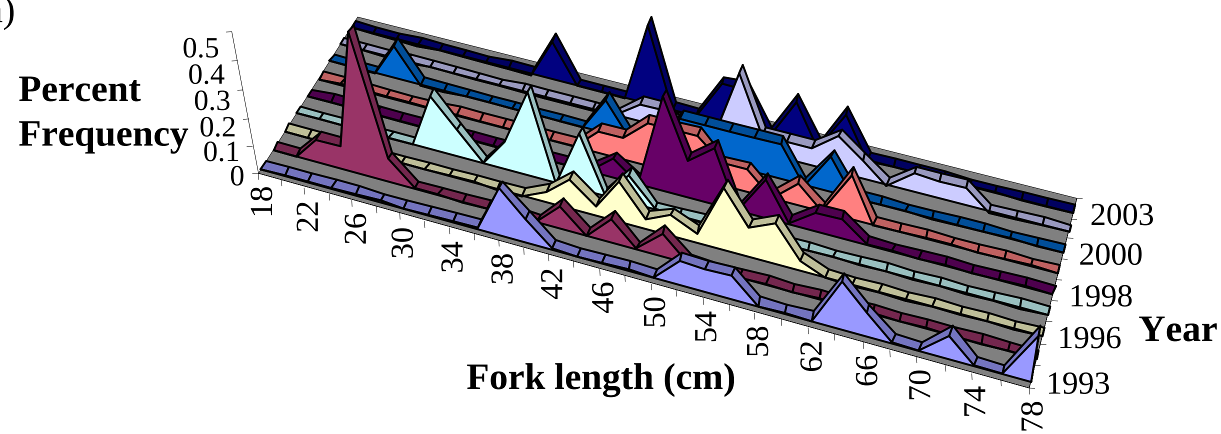
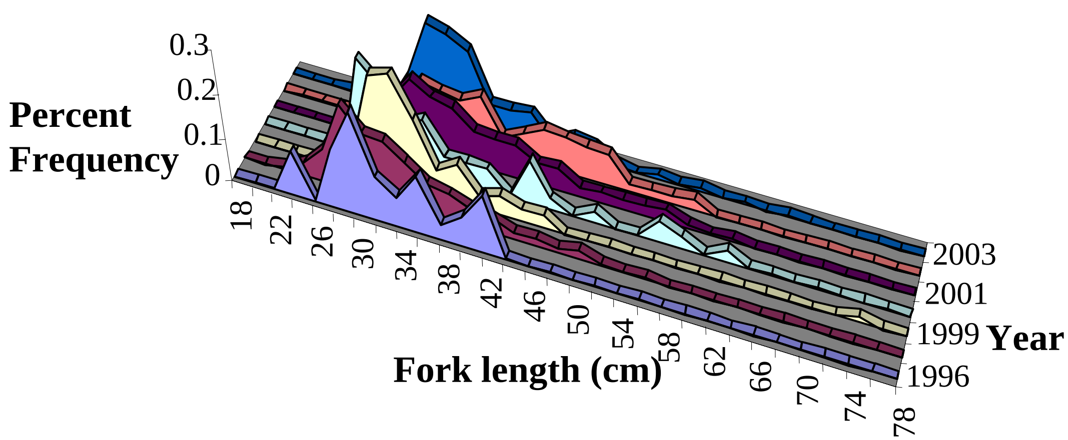


Figure 4.4d Southern California CPFV logbook index (1980-2003) calculated using block information from 5 separate geographic areas (+-1SE).

(a)

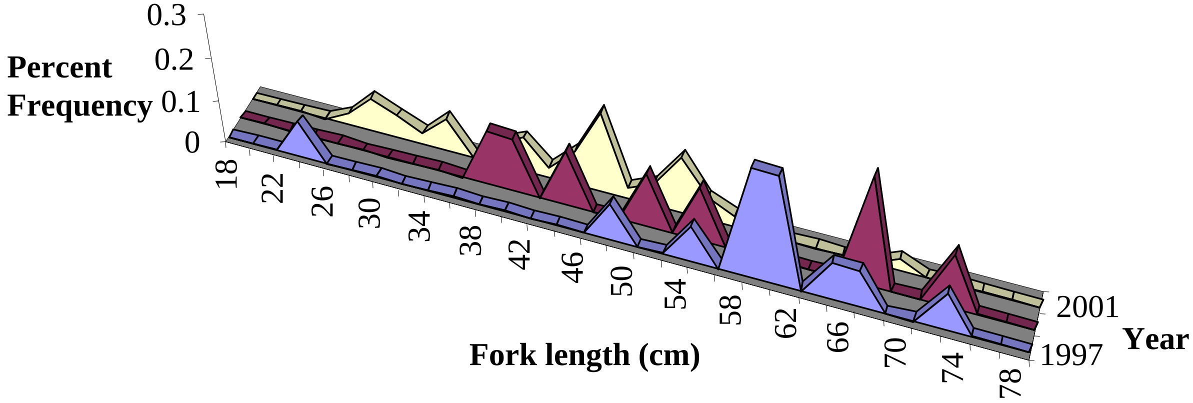


(b)

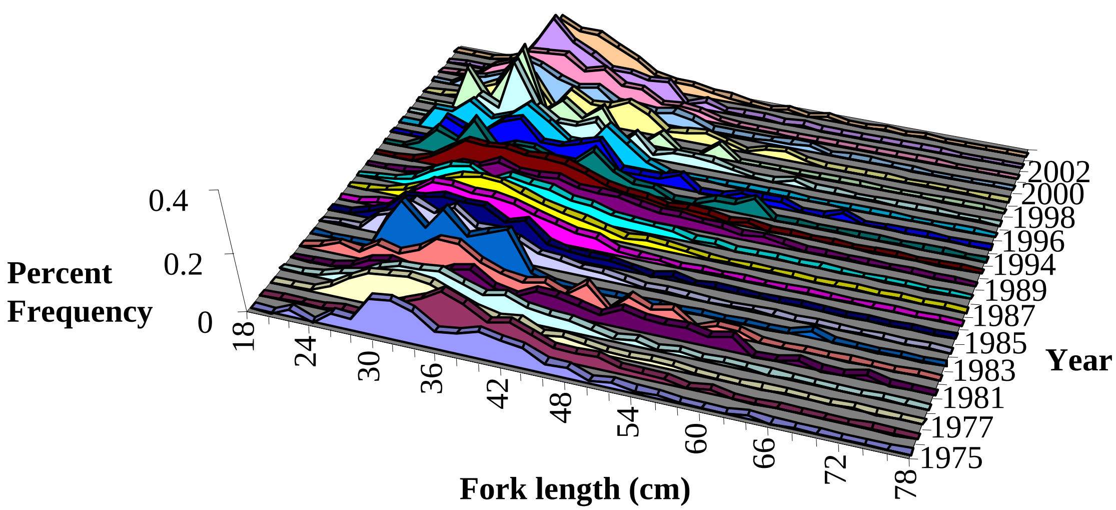


Figures 4.5 shows length compositions for the commercial (a) hook-and-line and (b) trap fisheries.

(c)



(d)



Figures 4.5 shows length compositions for the (c) setnet and (d) recreational fisheries.

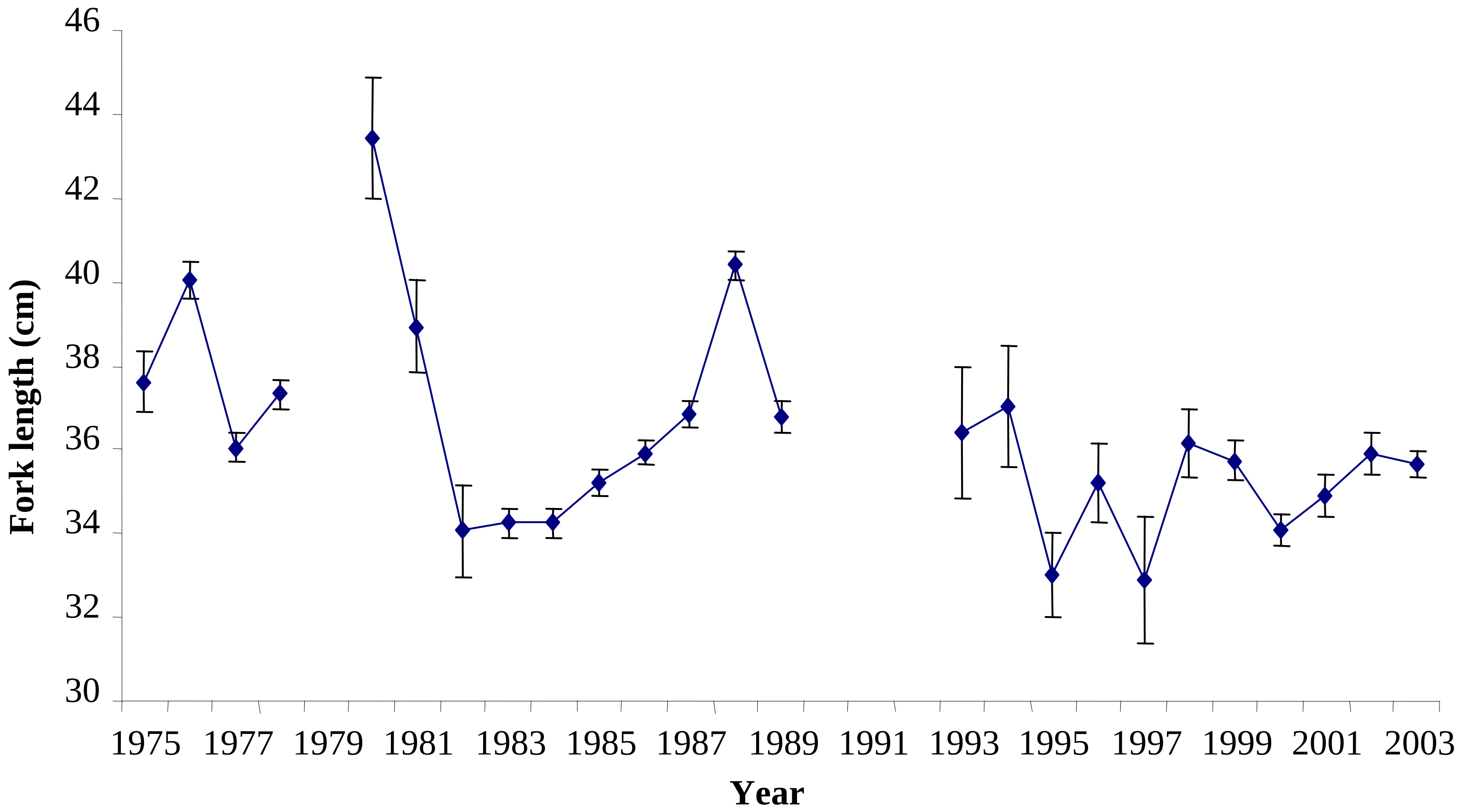


Figure 4.6 Average lengths of California Sheephead landed on CPFV's, 1975-2003 (some years missing). Data for the 1975-1978 sample period are from Collins and Crooke, 1984-1989 sample period are from Ally et al, and all other years are from RecFIN (+- 1SE).

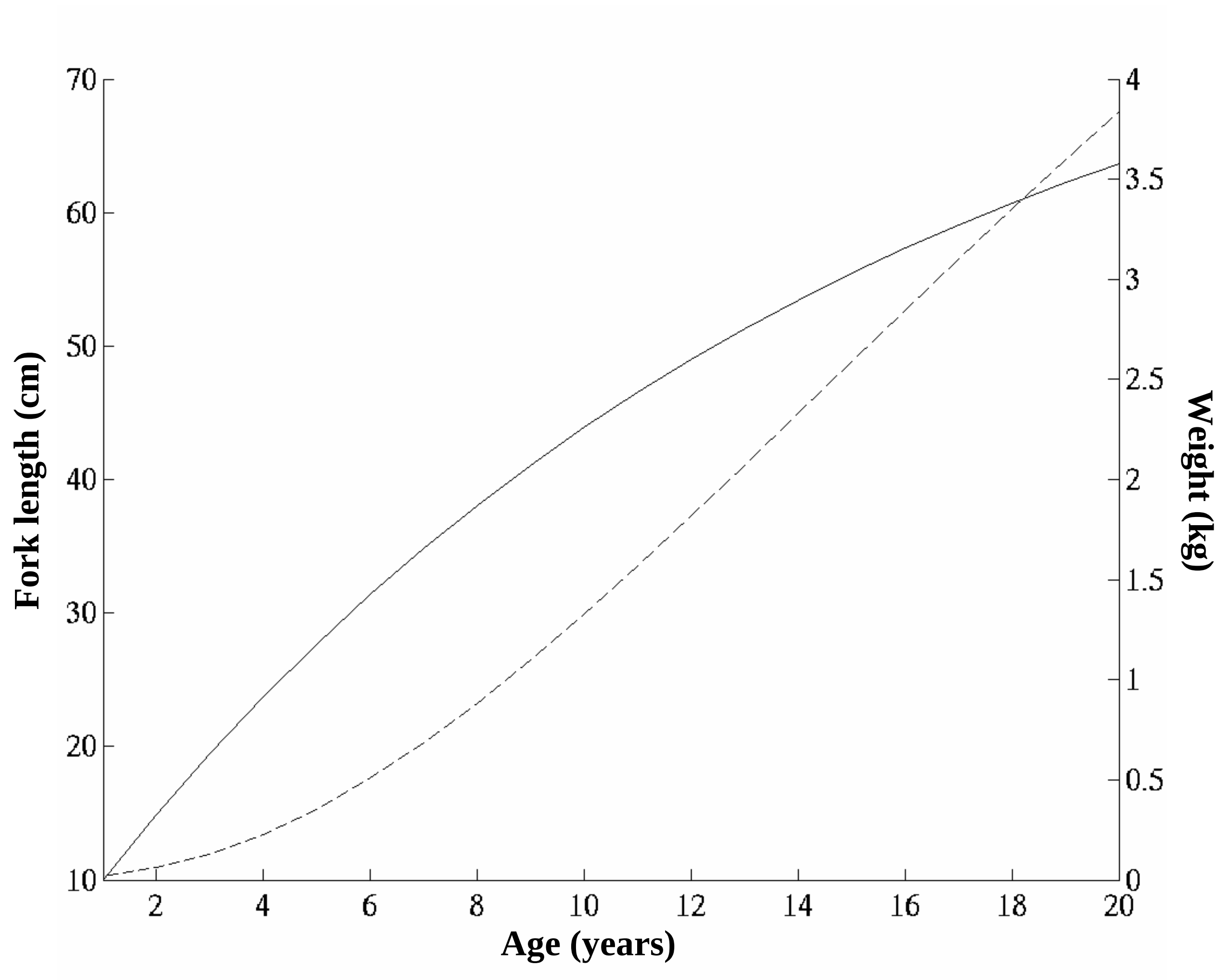


Figure 5.1 Sheephead size-at-age from the Catalina Island population used in the model. Fork length in cm (solid) and weight in kg (dashed).

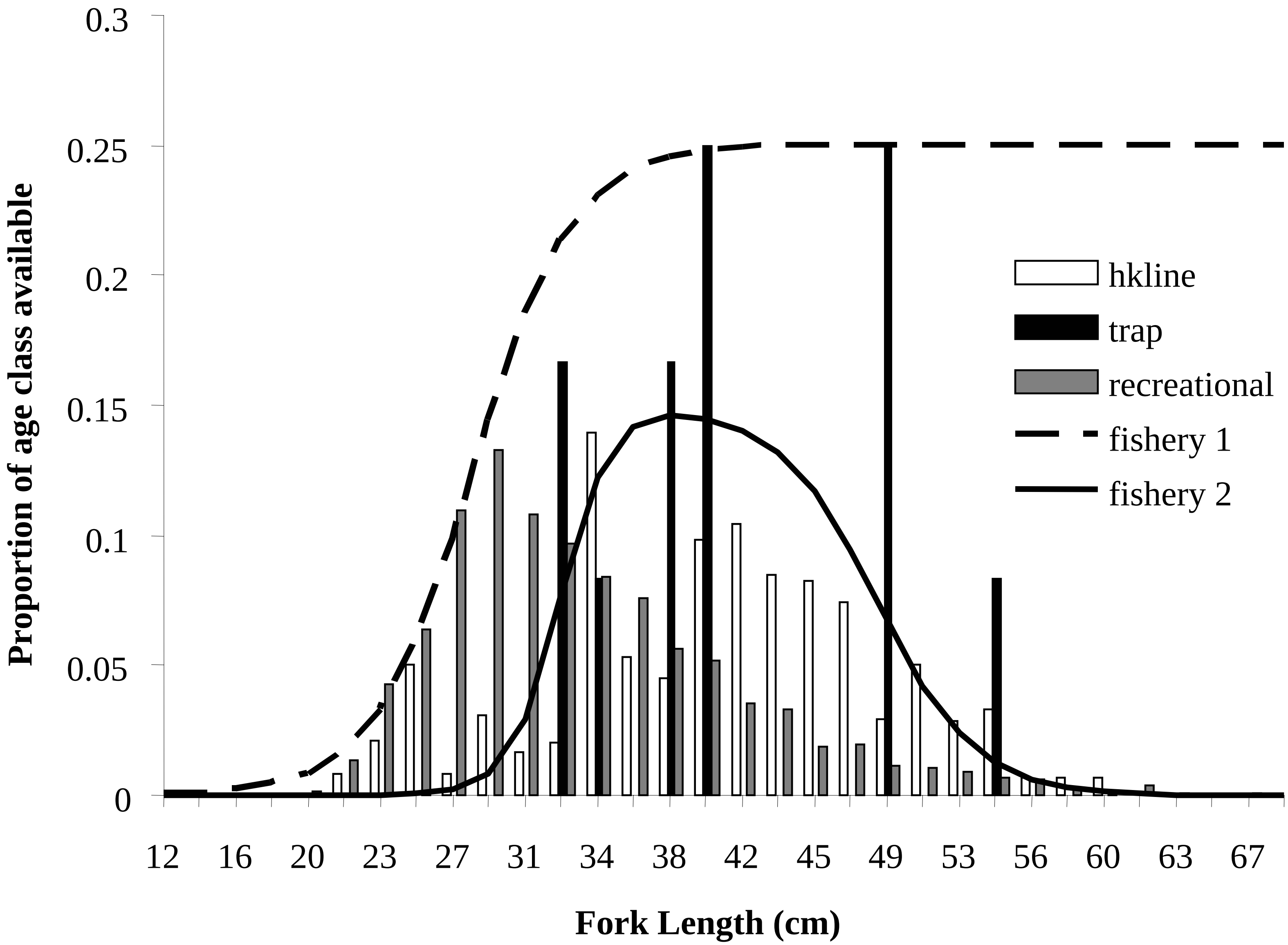


Figure 5.2 Selectivities used in the single-sex approximation model (lines) and size distribution of the trap (black bars), recreational (grey bars), and hook and line (white bars) fisheries for Sheephead.

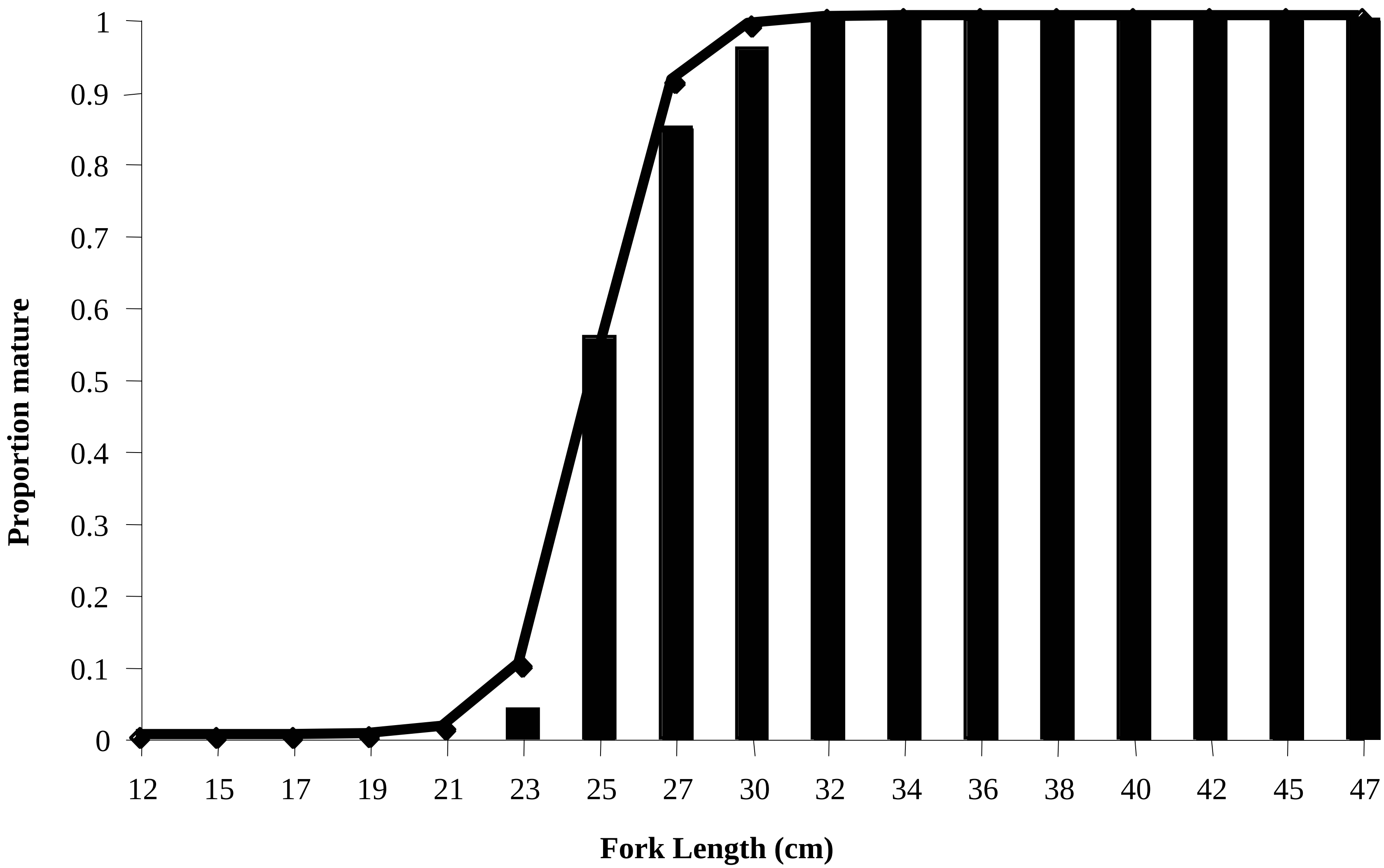


Figure 5.3a Proportion of length class mature, regardless of sex. The bars show maturity data from Warner (1978), and the fitted line is calculated from Equation 5.6.

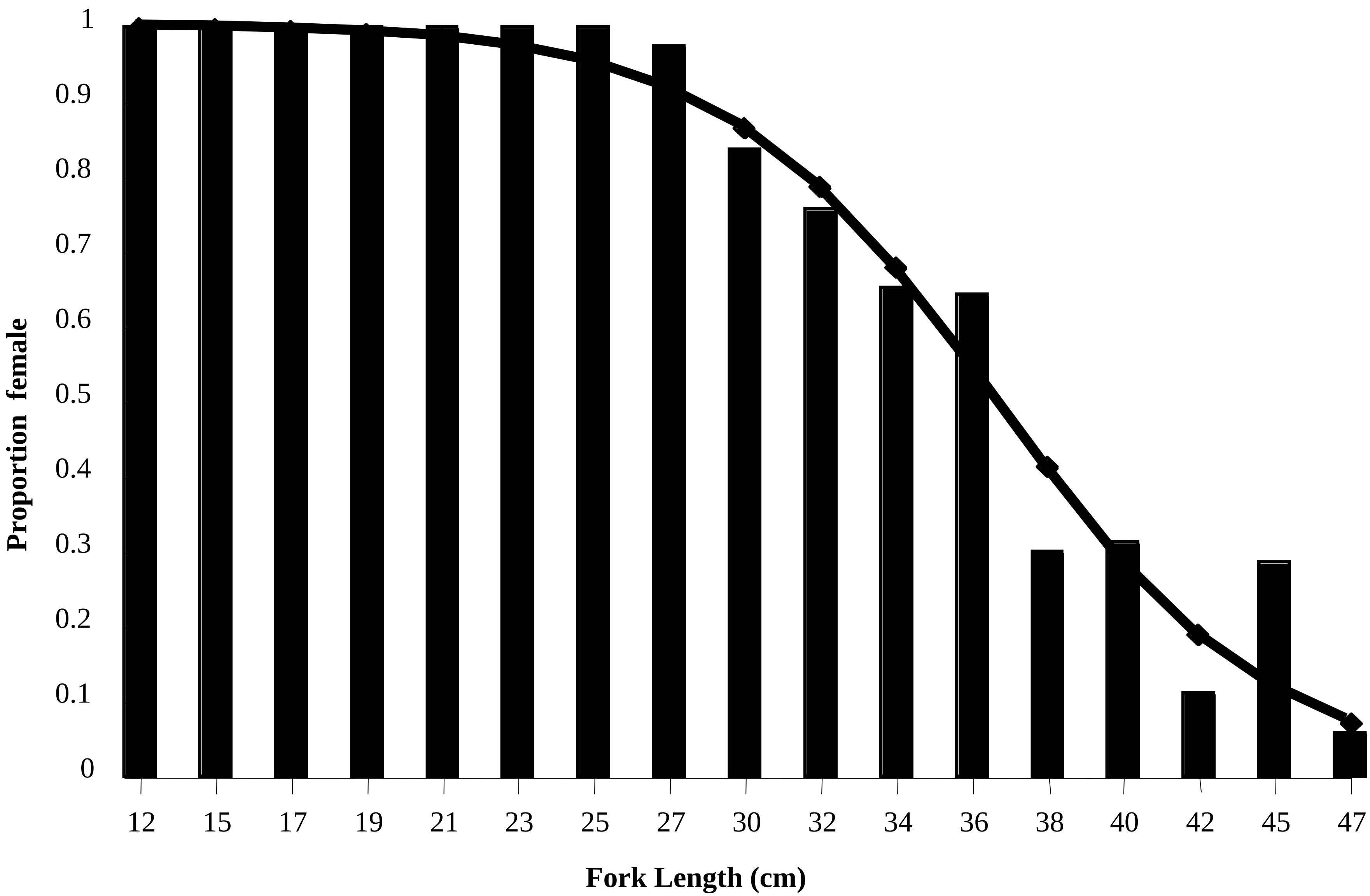


Figure 5.3b Proportion of length class female, regardless of maturity. The bars show sex-change data from Warner (1978), and the fitted line is calculated from Equation 5.6.

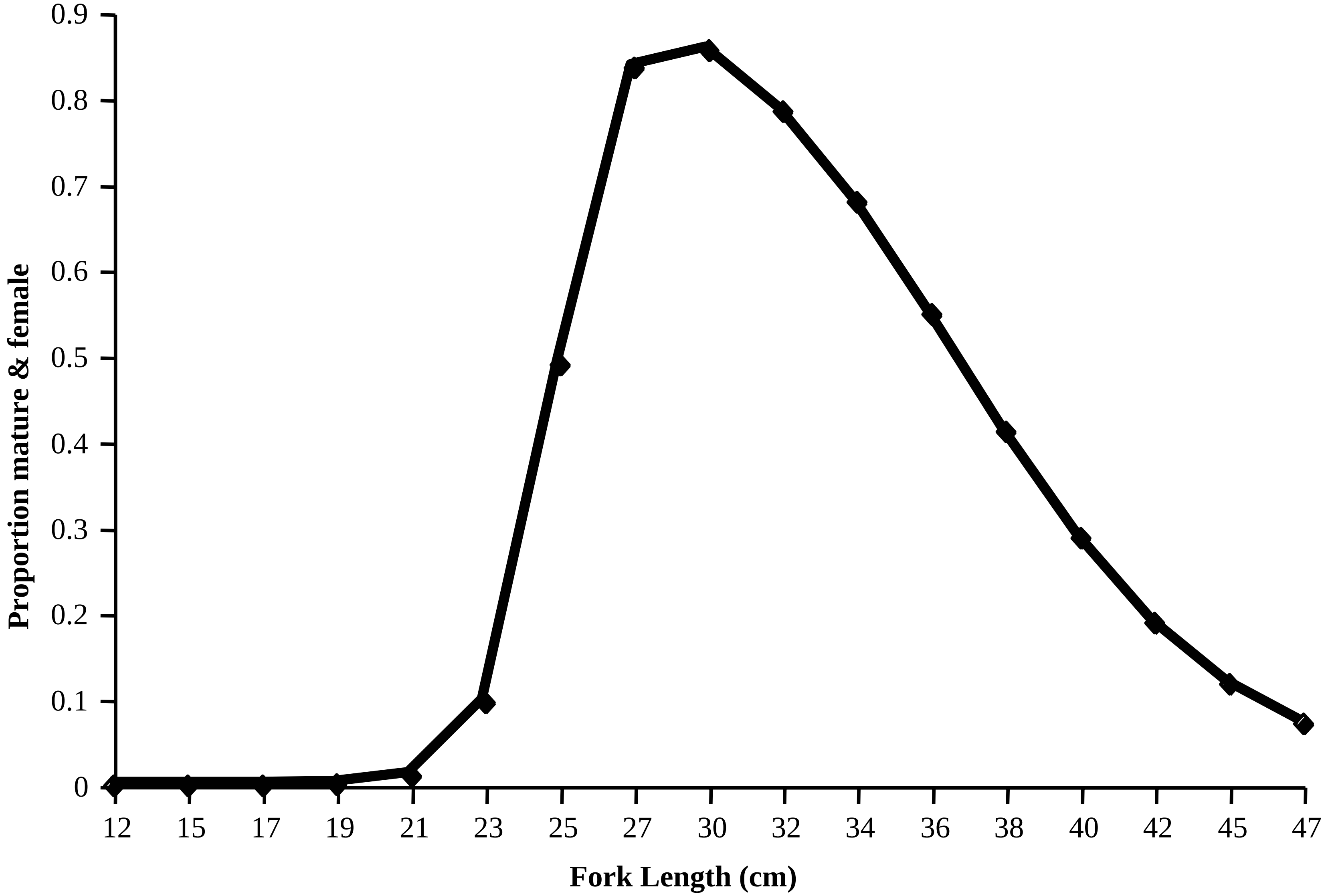


Figure 5.4 Proportion of length class mature and female for the single-sex model calculated from Equation 5.7.

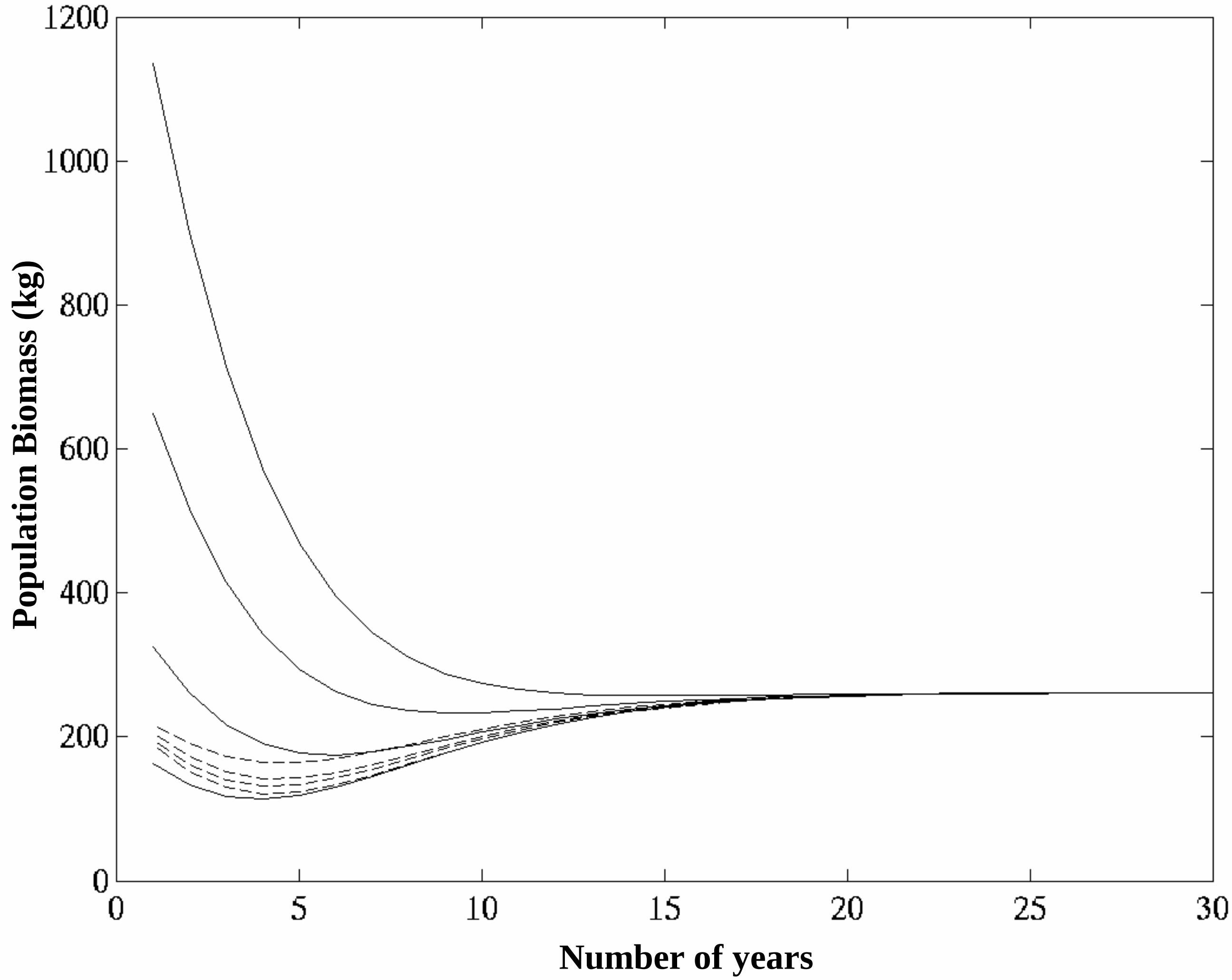


Figure 5.5 Population dynamics of the single-sex and sex-changing models from the model start with arbitrary population sizes. The single-sex model (dashed) started with a larger population than the sex-changing model (solid) and they converge.

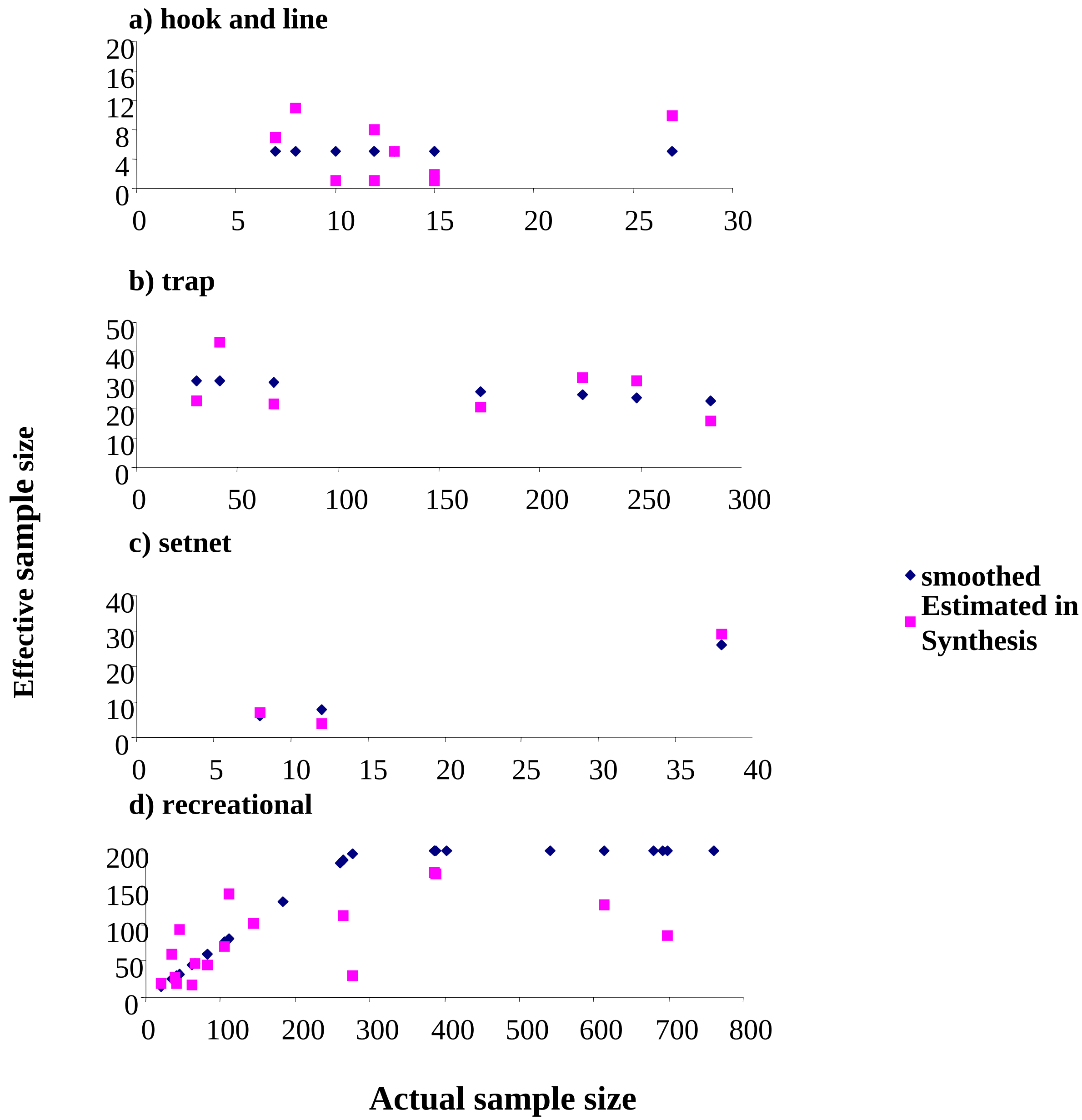


Figure 6.1 Effective sample sizes used in the Synthesis model.

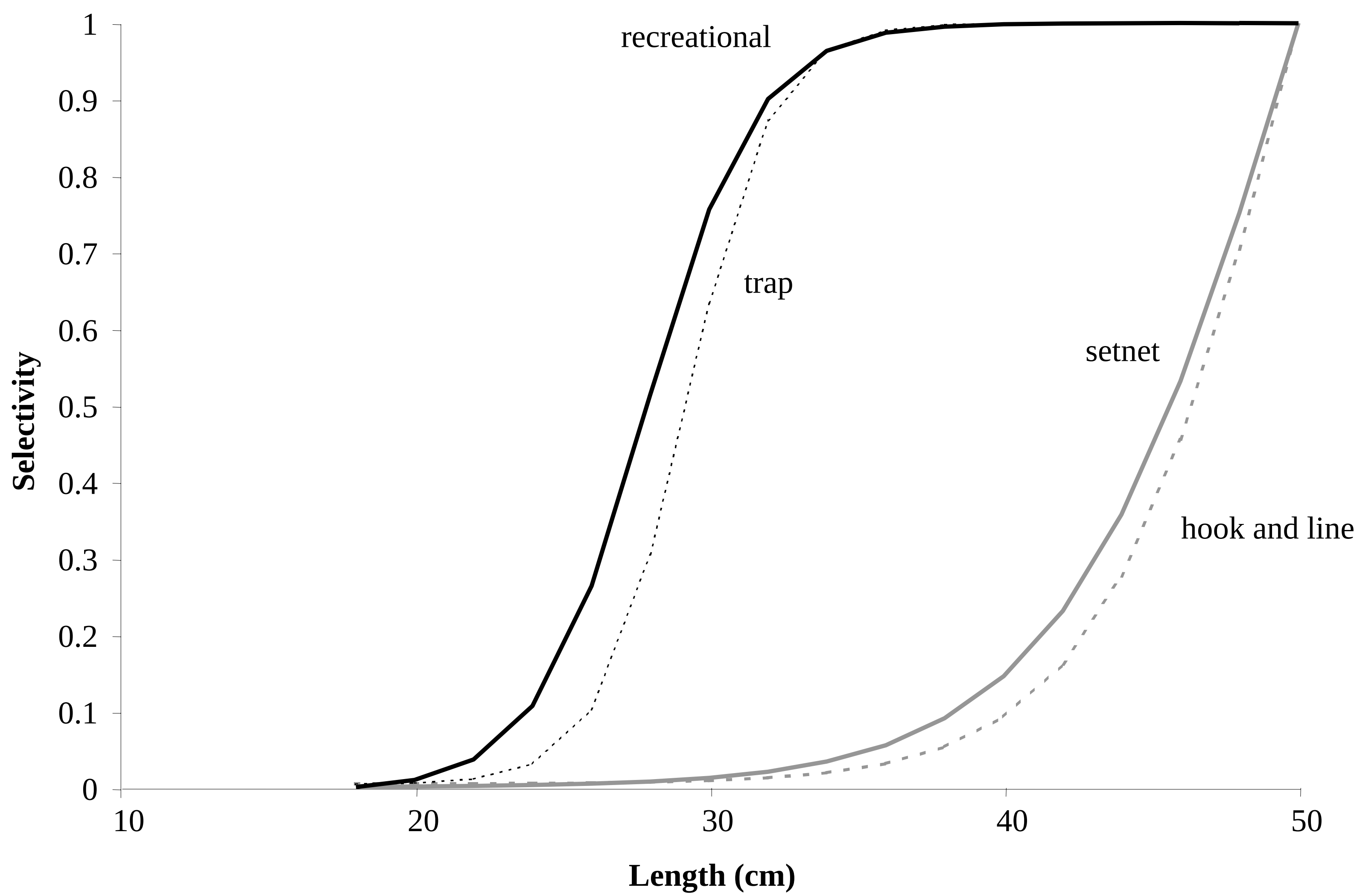


Figure 6.2 The selectivities for each of the four fisheries in the best-fit Synthesis model.

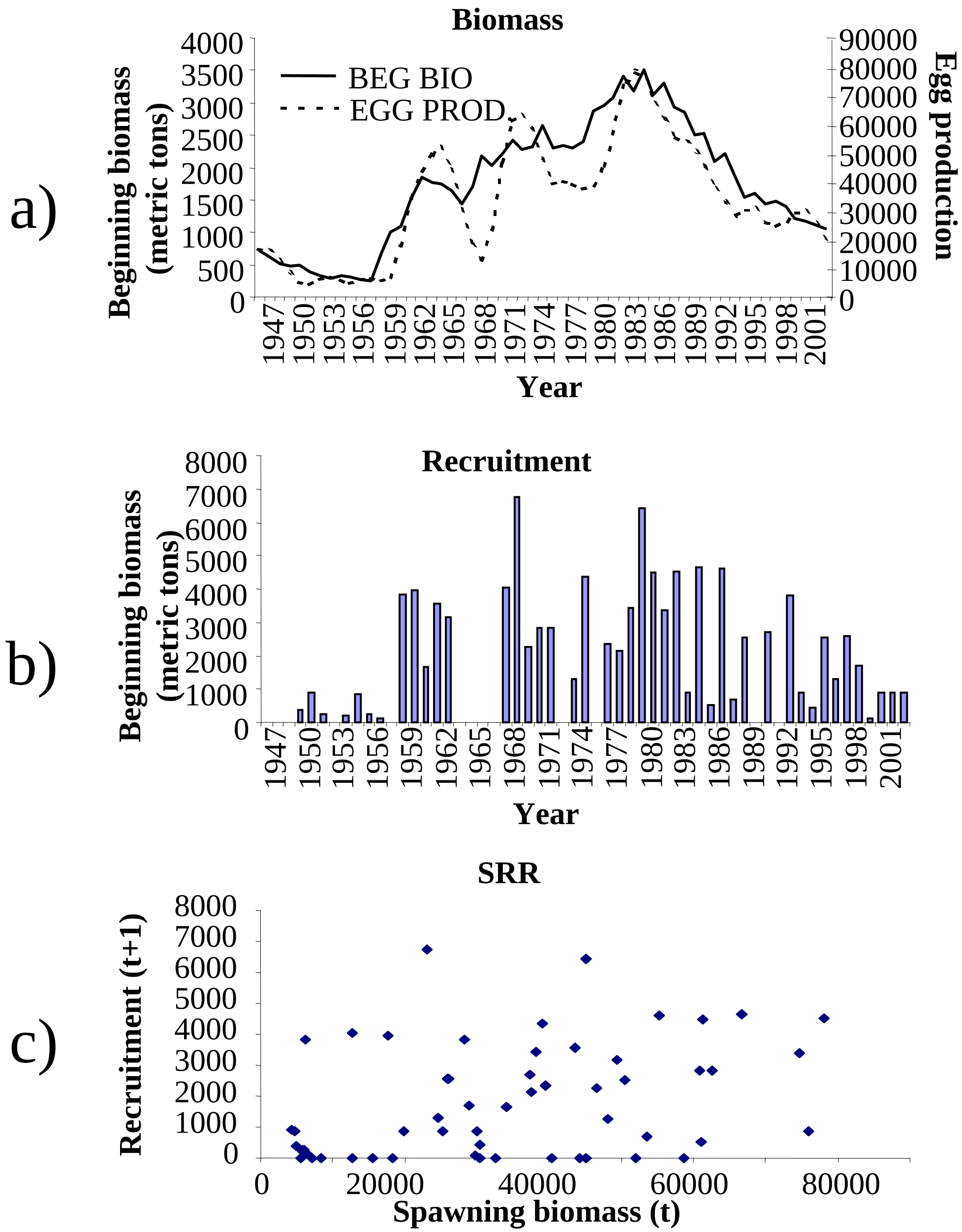


Figure 6.3 (a) The historical total biomass and female spawning biomass (b) recruitment, and (c) the relationship between recruitment and spawning biomass estimated by the baseline Synthesis model.

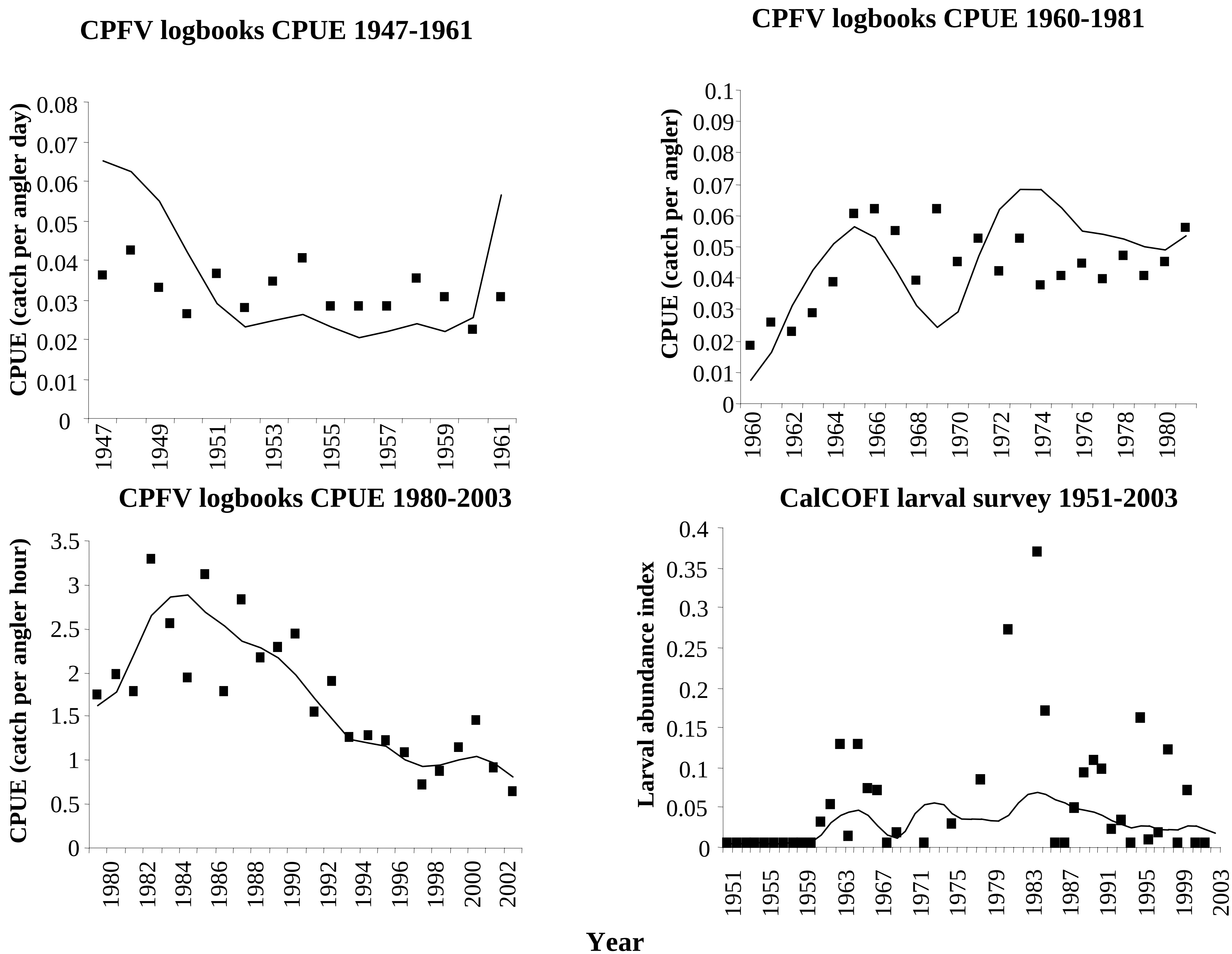


Figure 6.4 The estimated (solid line) and observed (black squares) abundance indices for the baseline Synthesis model.

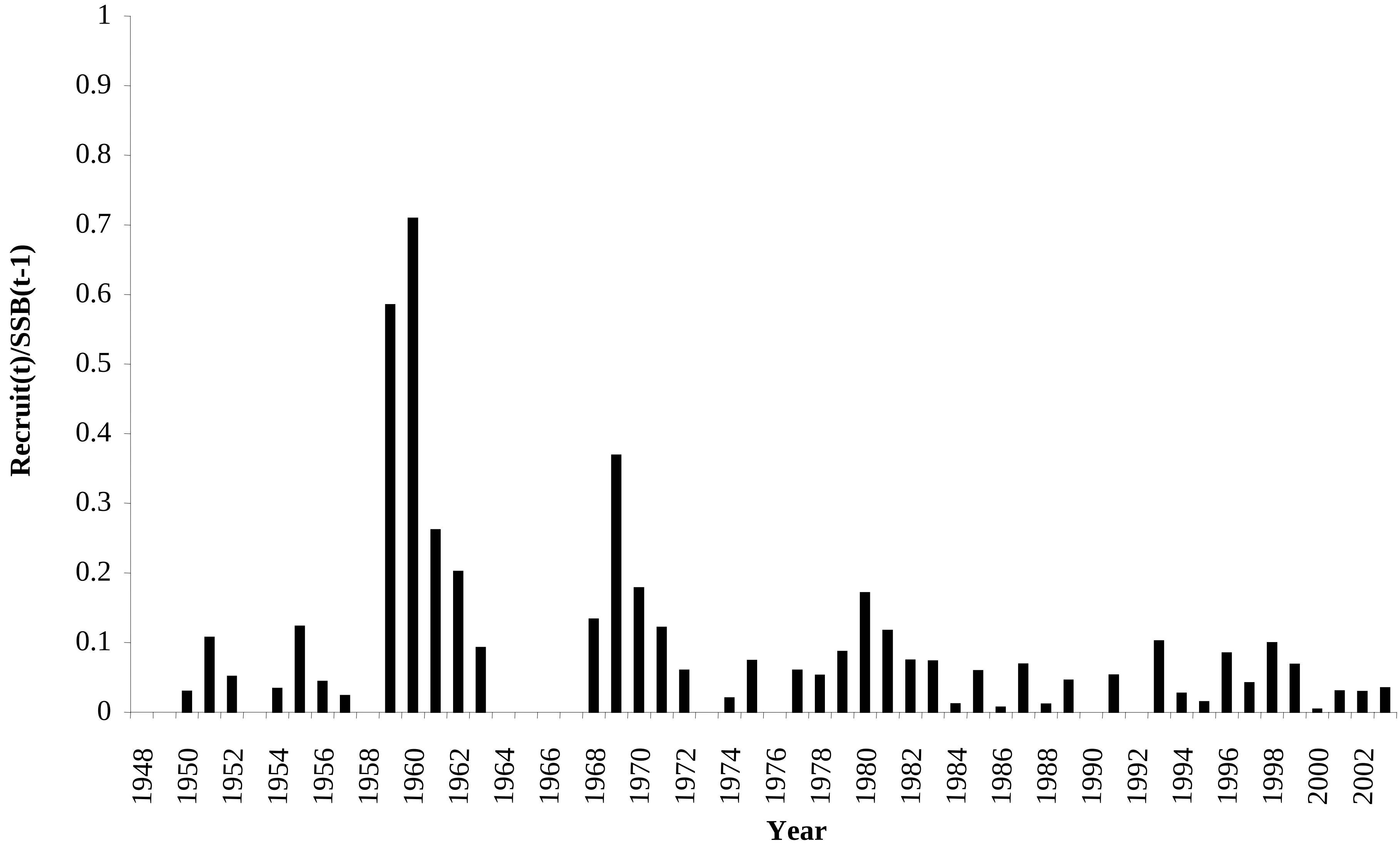


Figure 6.5 Recruit per spawning biomass was estimated to be variable through time in the baseline Synthesis model.

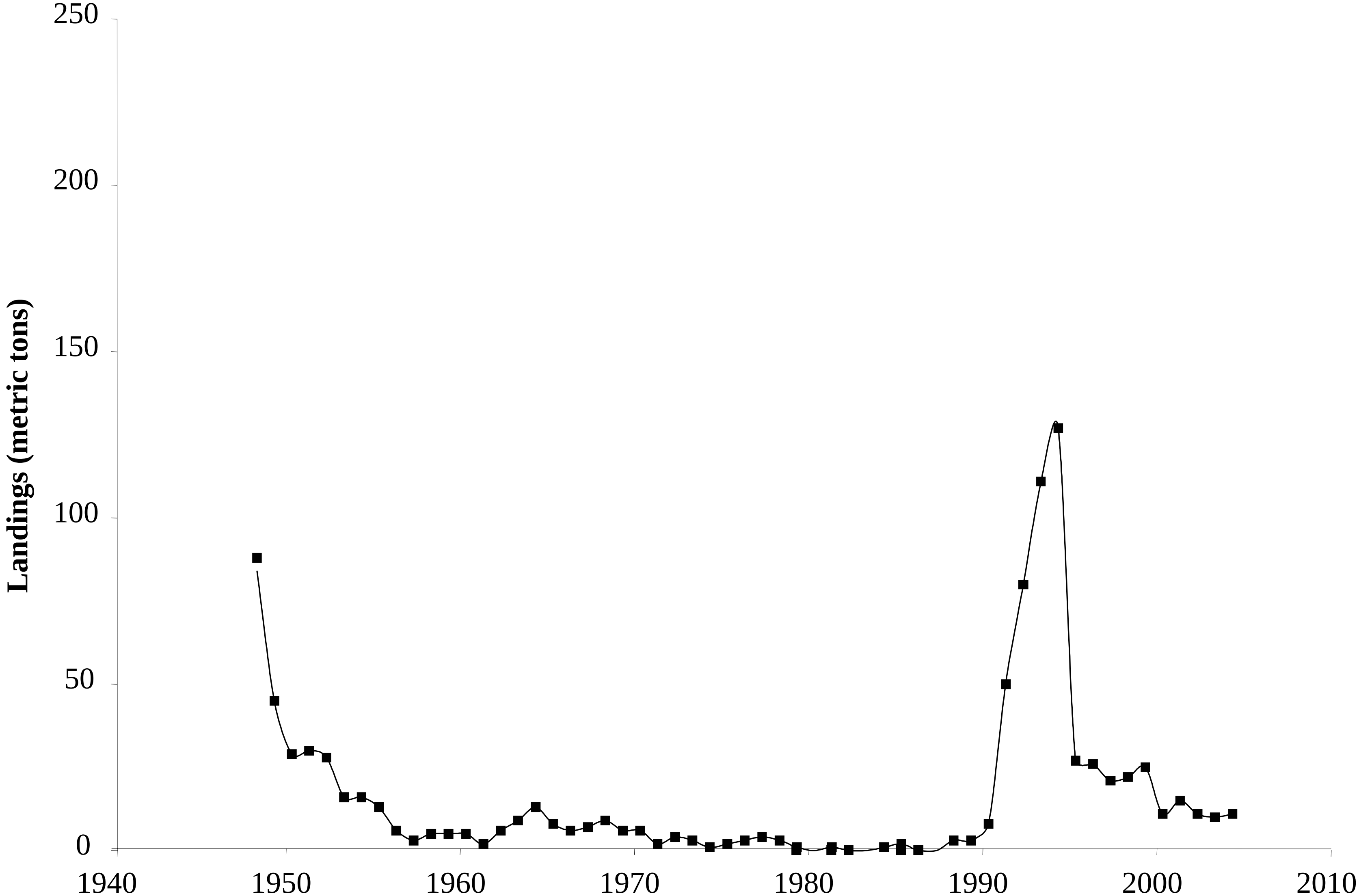


Figure 6.6 Landings for the hook and line commercial fishery in the Synthesis model.

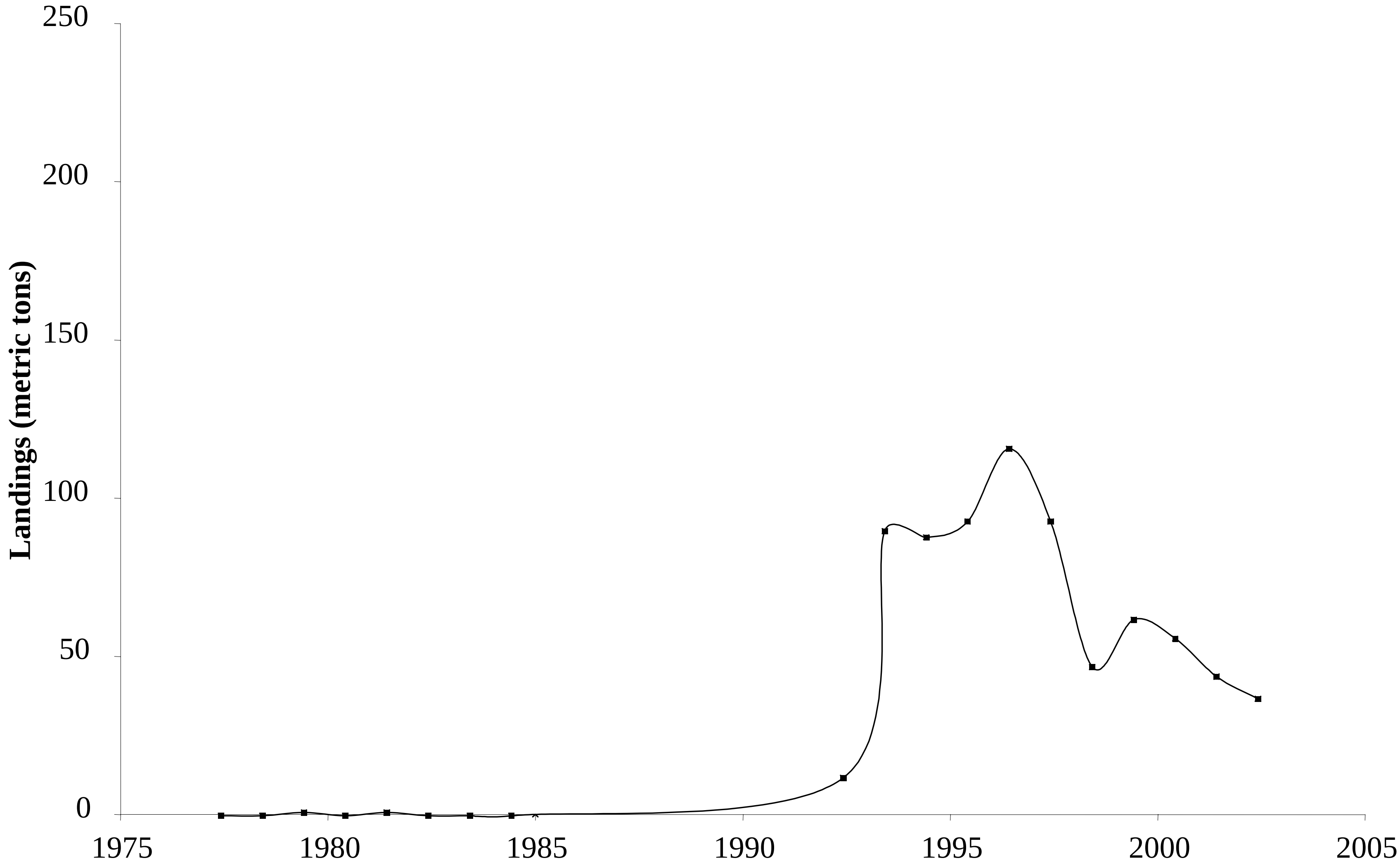


Figure 6.7 Landings for the trap commercial fishery in the Synthesis model.

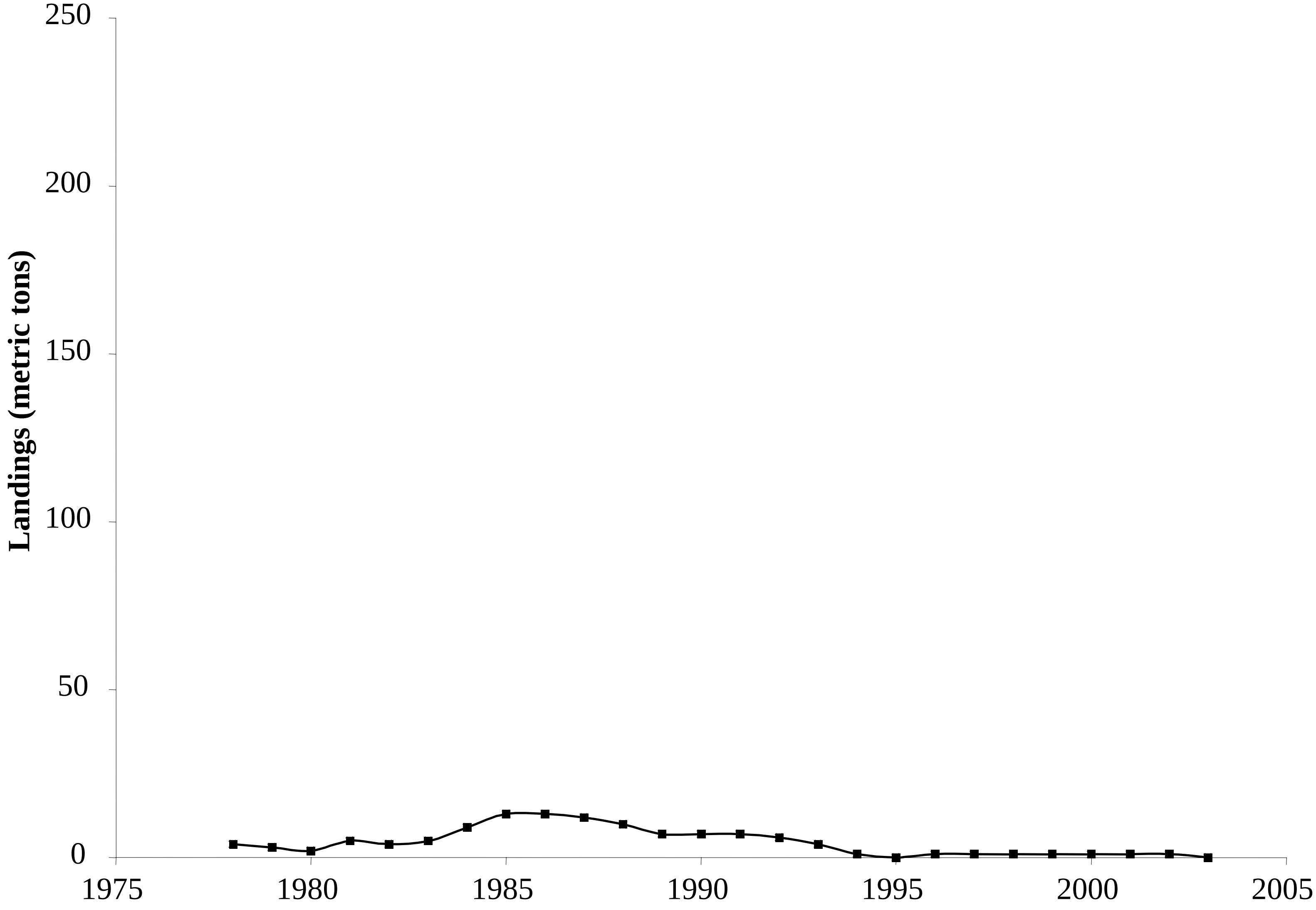


Figure 6.8 Landings for the setnet commercial fishery in the Synthesis model.

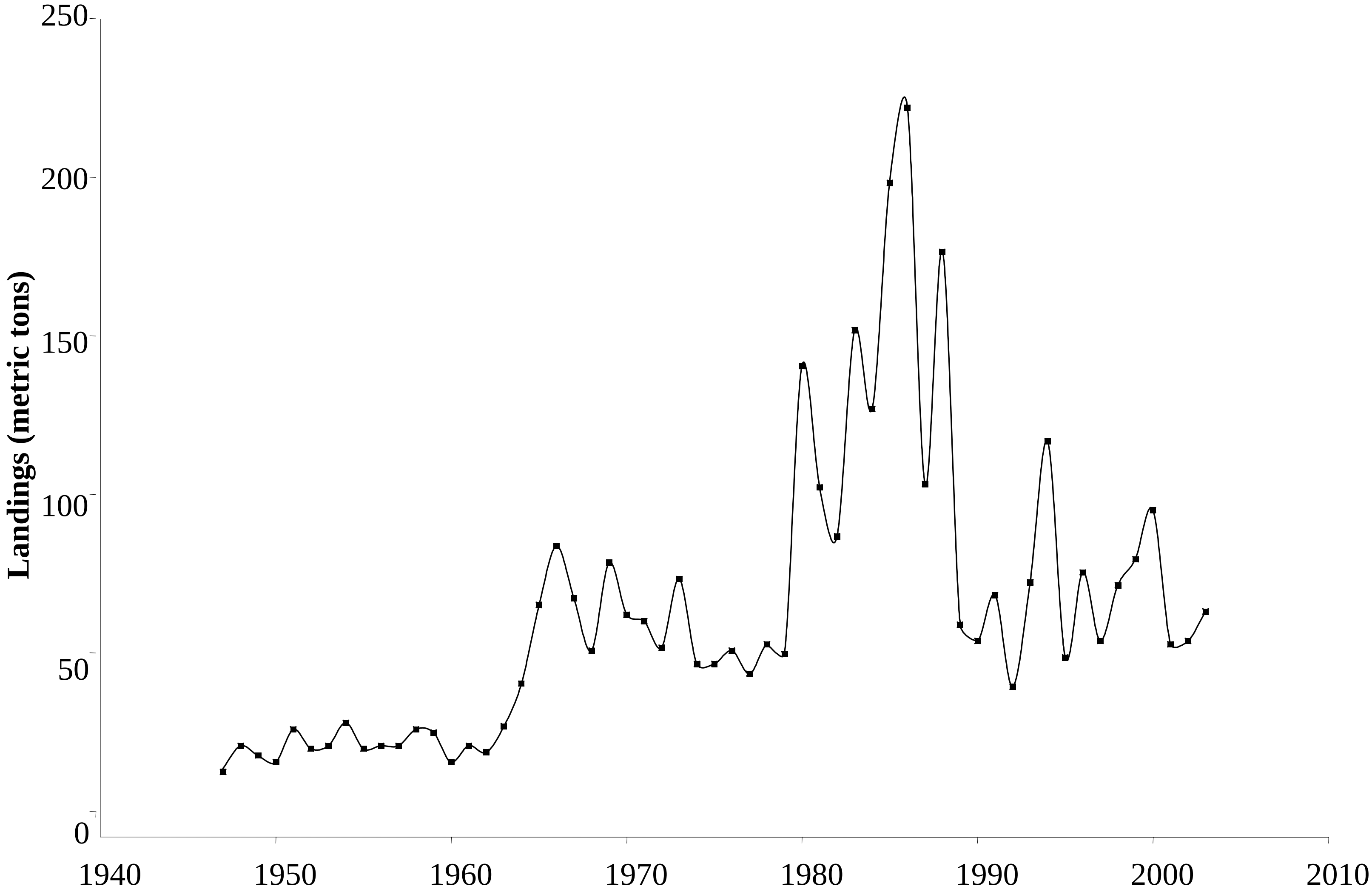


Figure 6.9 Landings for the recreational fishery in the Synthesis model.

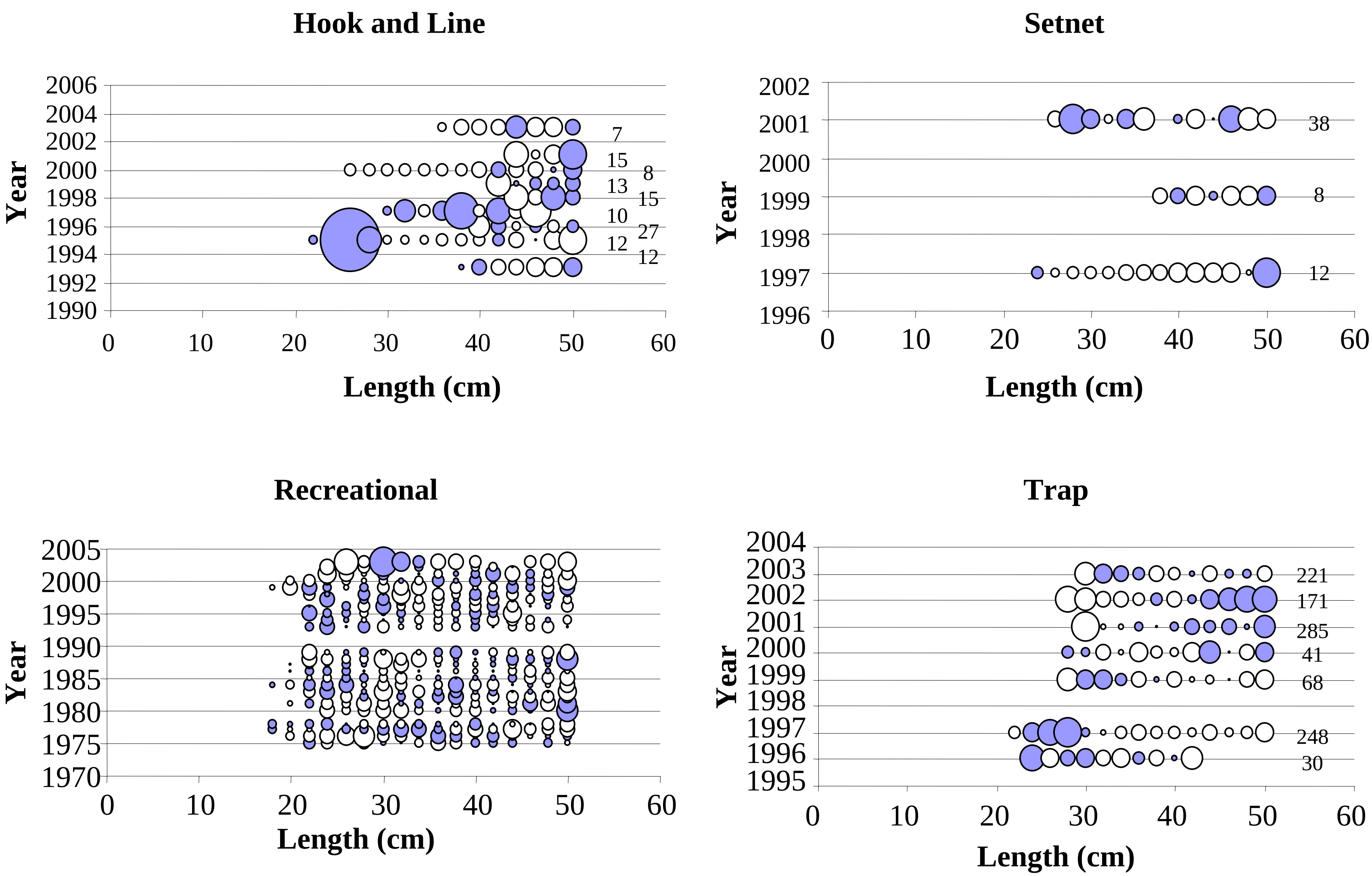


Figure 6.10 Bubble plots representing the fit between the observed and estimated length compositions for the baseline Synthesis model. The area of the circle indicates the deviation between the observed and estimated values. Filled circles represent a positive deviation and empty circles represent a negative deviation. Sample sizes are also given for the commercial fisheries.

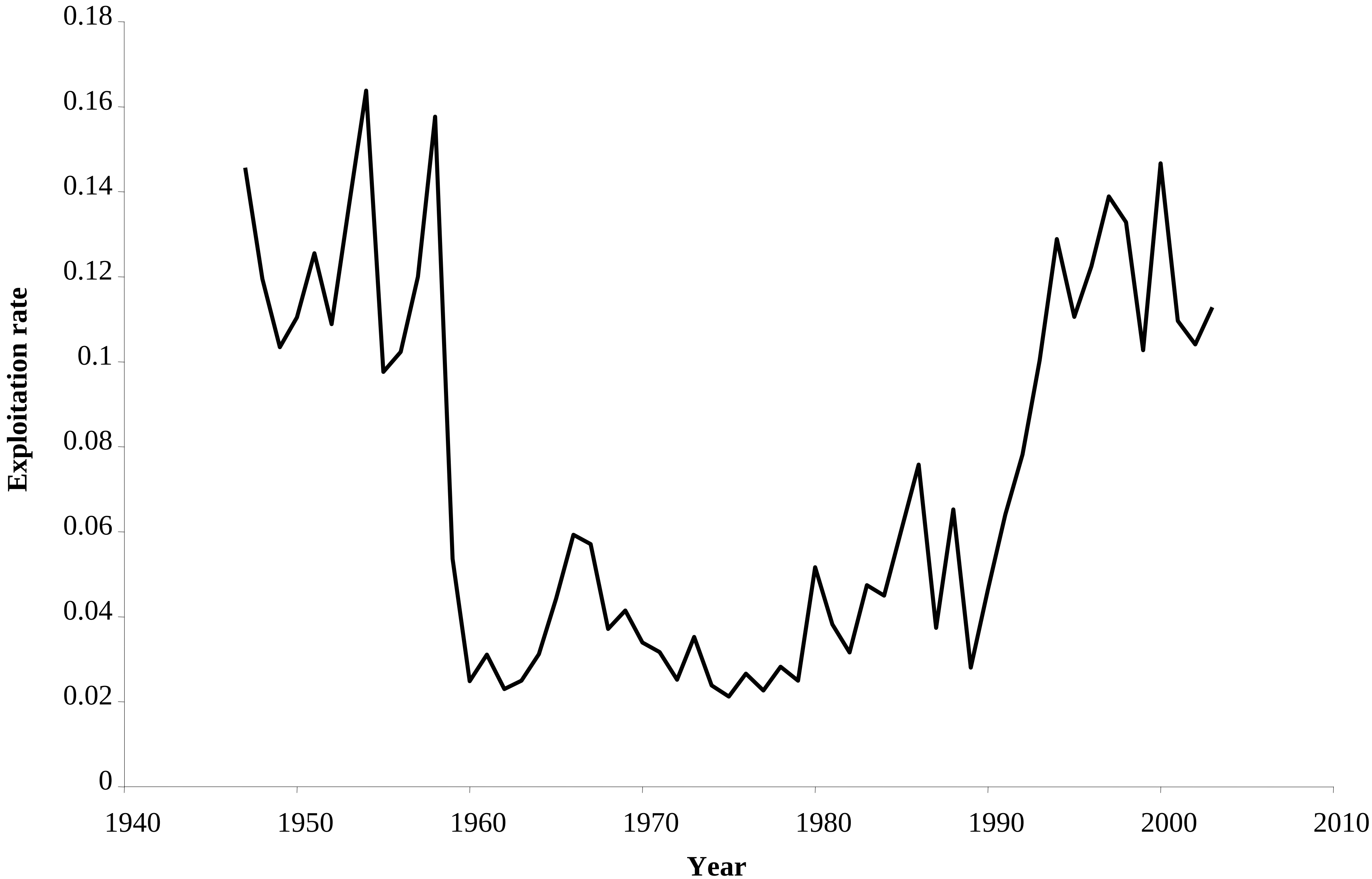


Figure 6.11 Historical exploitation rate of Sheephead as estimated by the baseline Synthesis model.

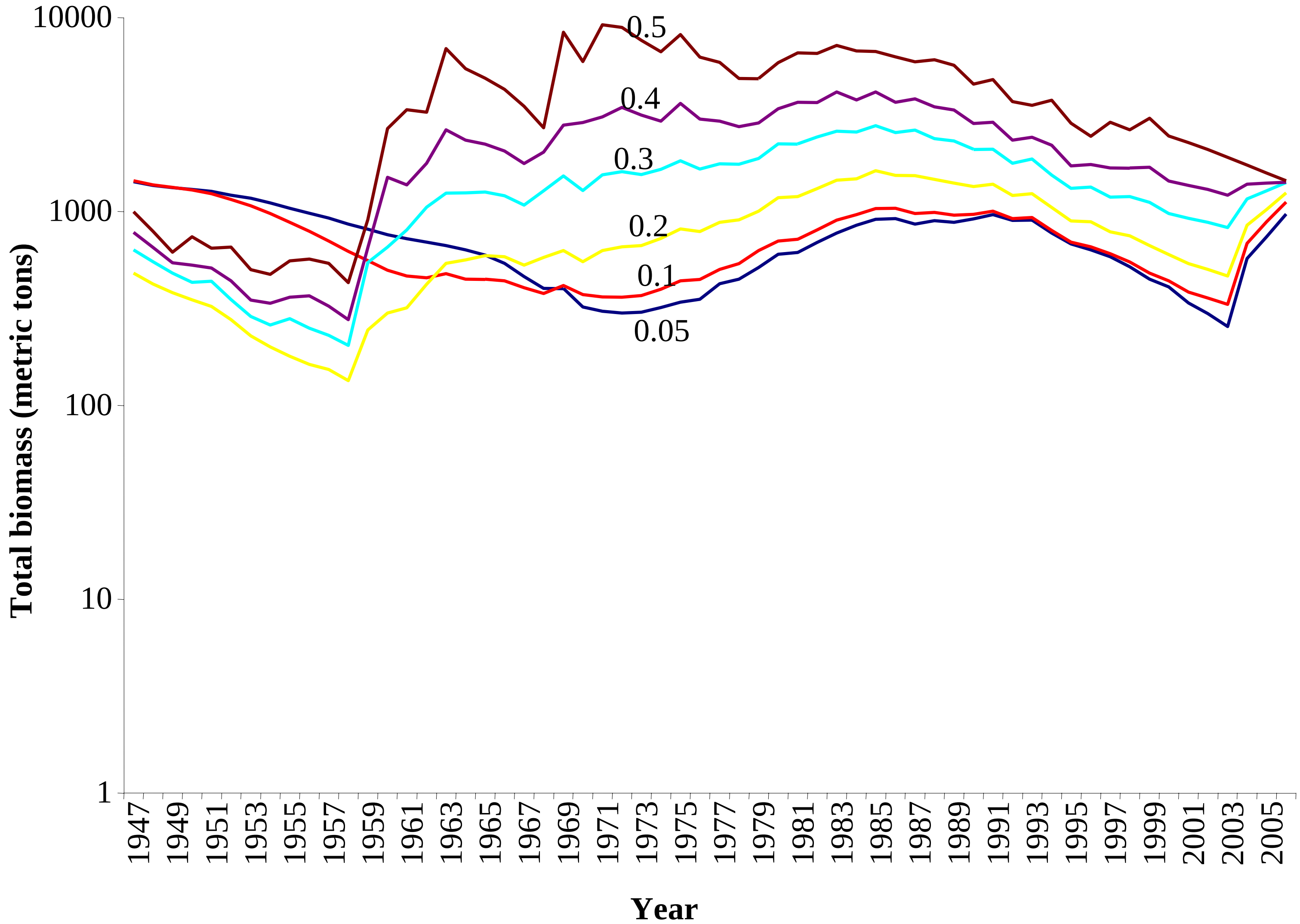


Figure 6.12 The predicted effect of natural mortality on the estimated total biomass. As M increases from 0.05 to 0.5 the estimated total biomass increases. Spawning biomass and recruitment exhibit similar patterns.

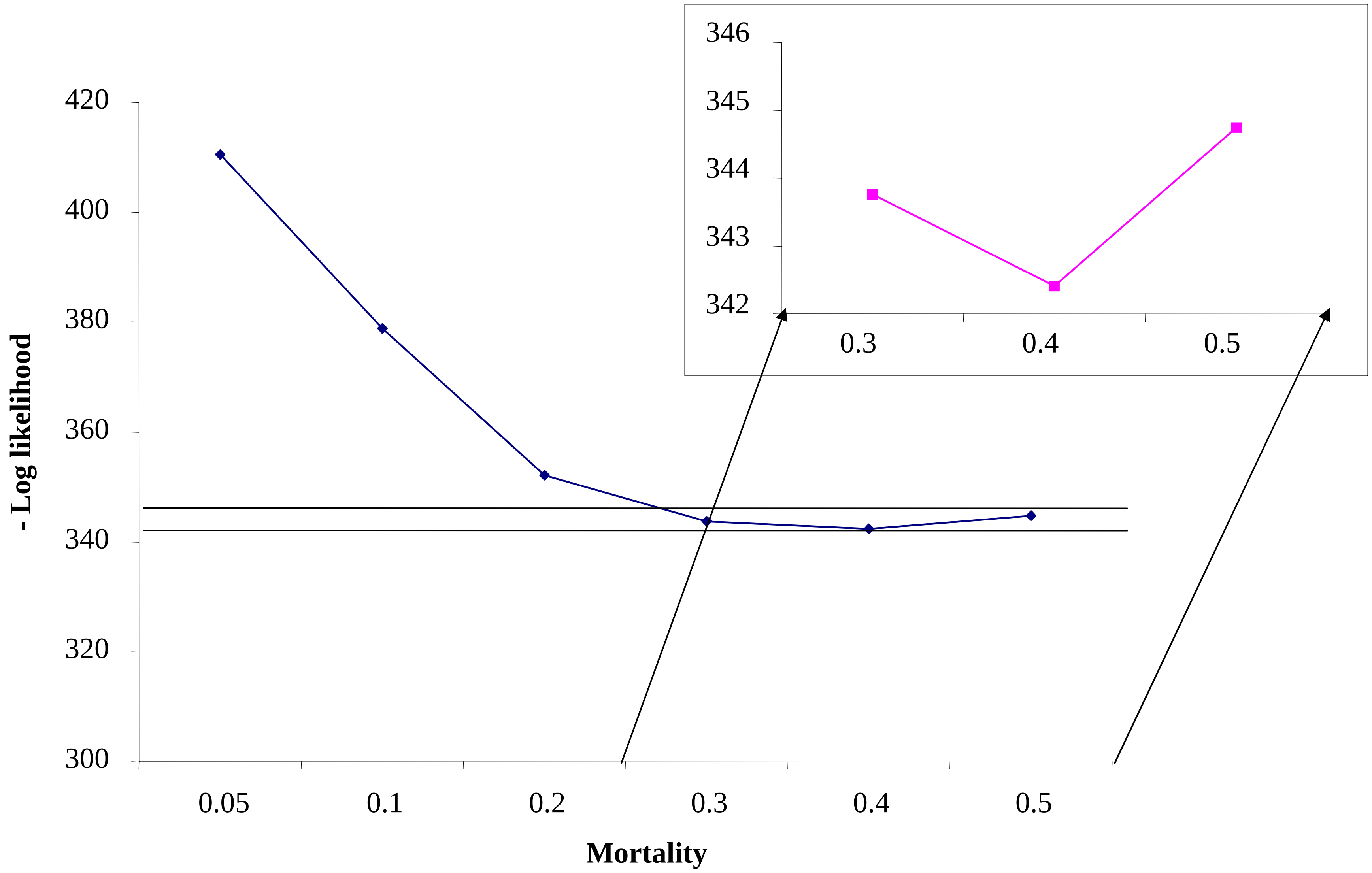


Figure 6.13 The total (negative) log-likelihood of the model for a sensitivity analyses of natural mortality rate as mortality varies from 0.05 to 0.5.

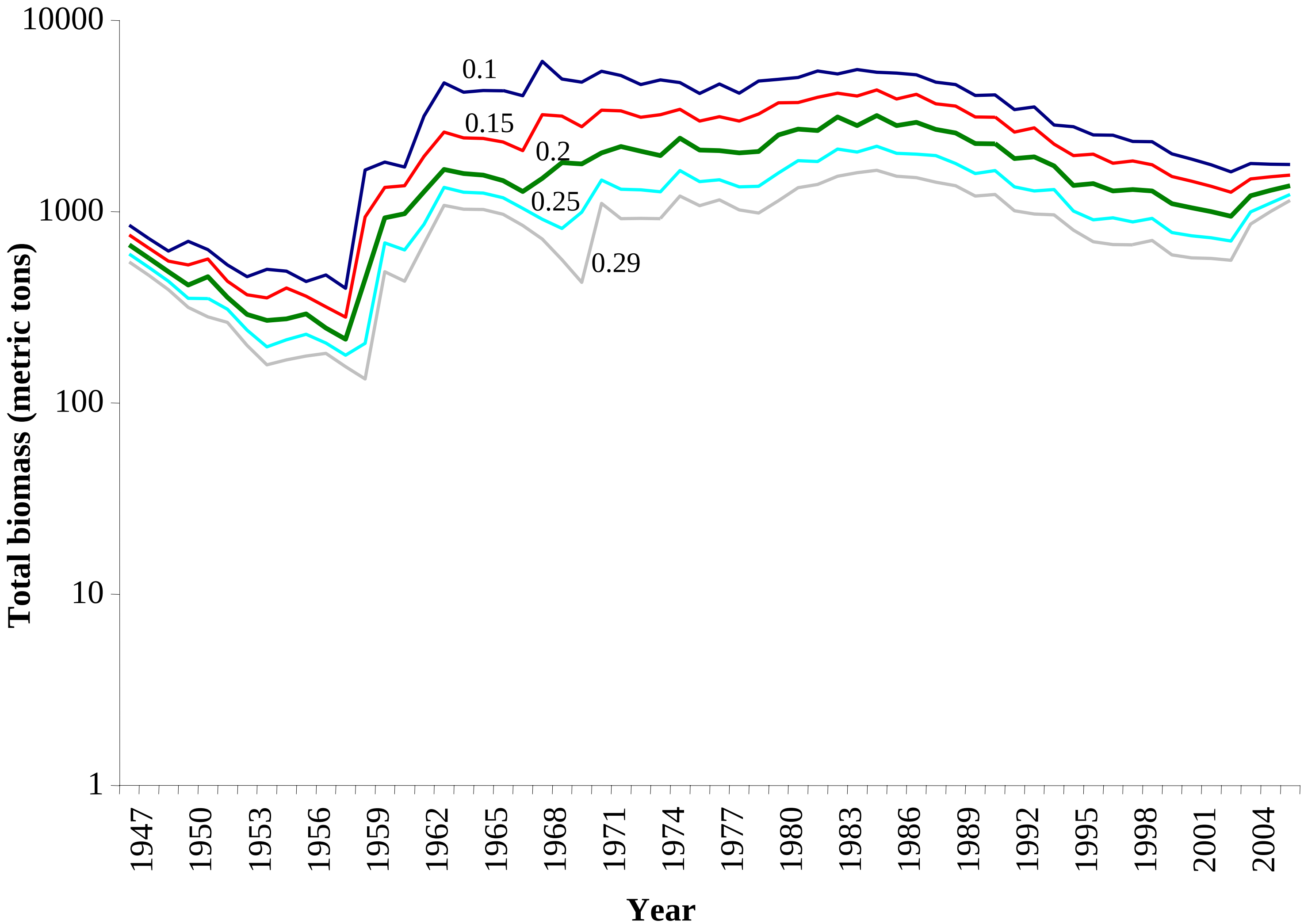


Figure 6.14 The effect of the coefficient of variation in growth (CV_1 and CV_2) on the estimated total biomass. As CV_1 and CV_2 increase from 0.10 to 0.29, the estimated total biomass decreases. Spawning biomass exhibits a similar pattern.

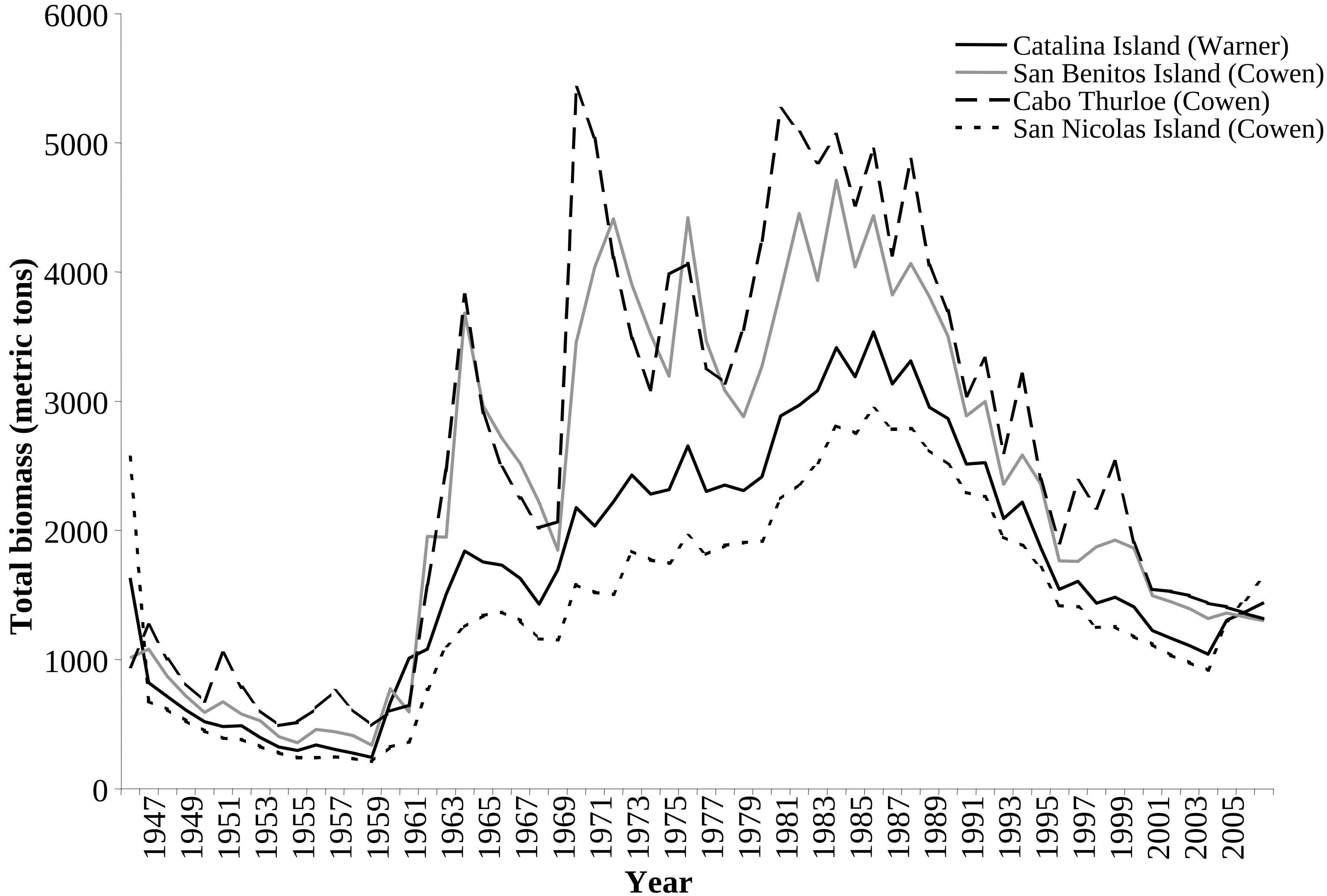


Figure 6.15 The predicted total biomass for the four sets of California life history parameters from Table 3.1. Spawning biomass and recruitment exhibit similar patterns.

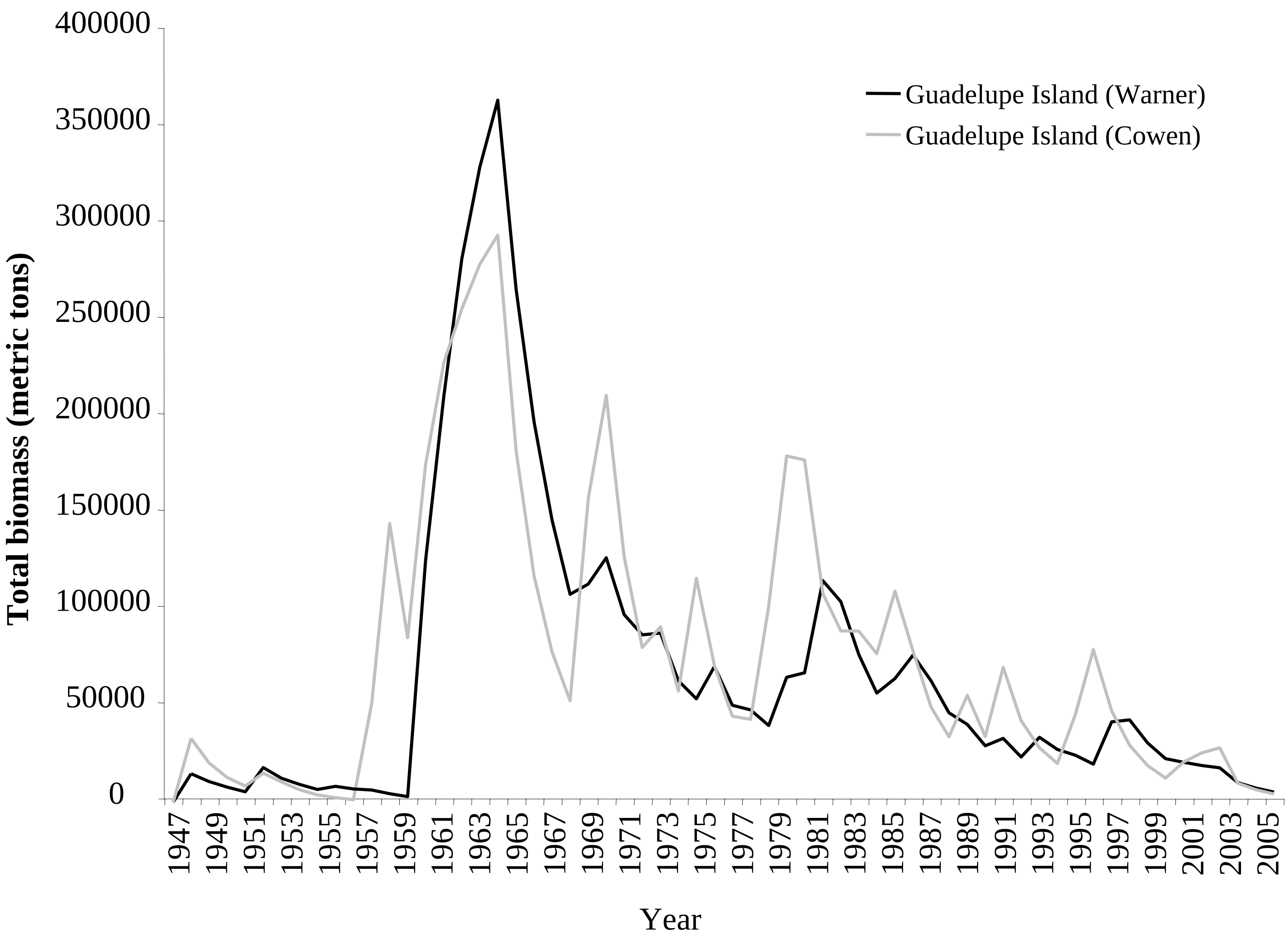


Figure 6.16 The predicted total biomass for the two sets of Guadelupe Island, Mexico life history parameters from Table 3.1. Spawning biomass and recruitment exhibit similar patterns.

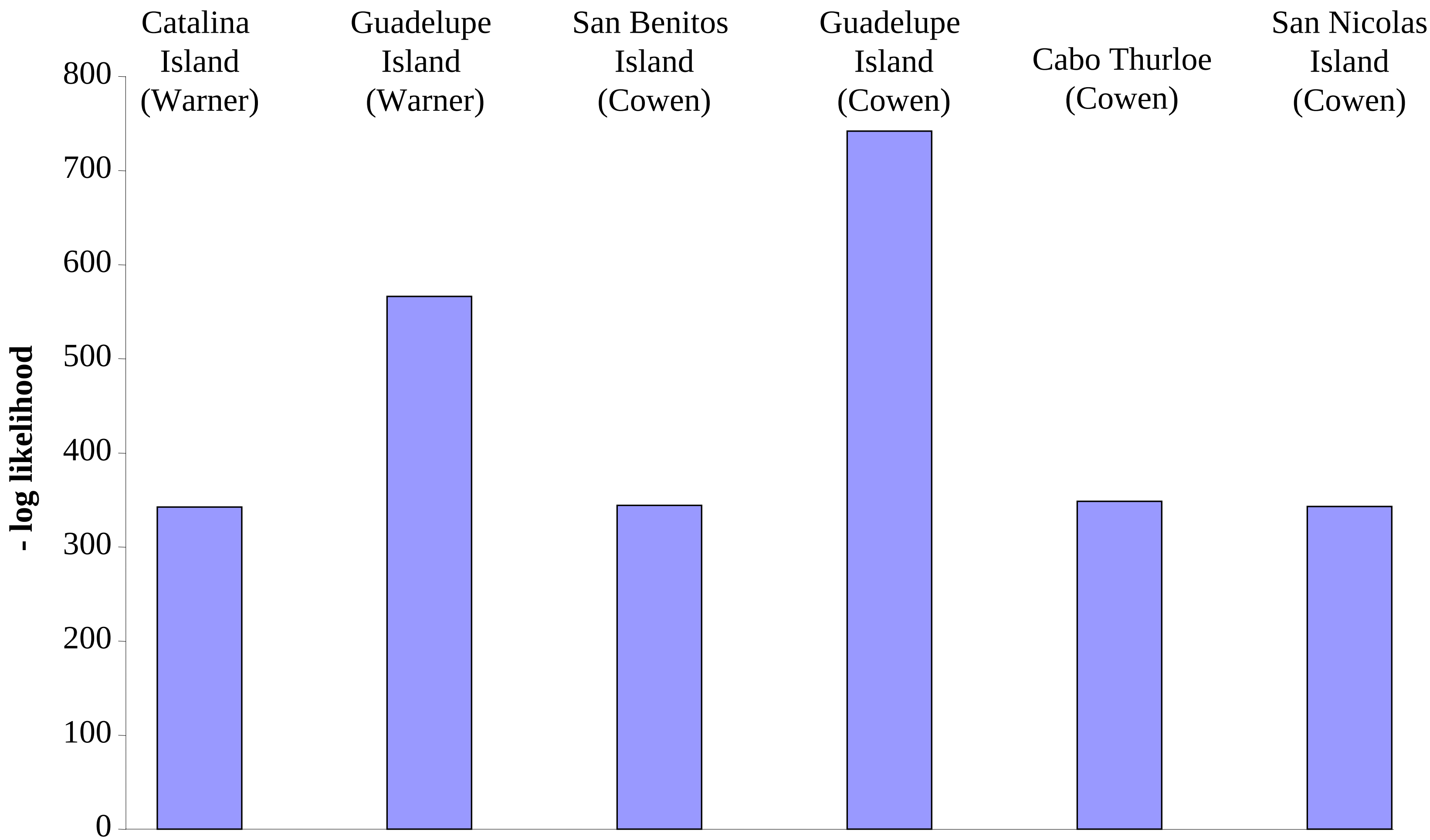


Figure 6.17 The negative log likelihood of the model as the life history parameters are varied. The Guadelupe parameters do not lead to a good fit with the data while the parameters from the four California populations fit the data similarly. The parameters used for the baseline model were based on the Catalina data from Warner (1975) which lead to the best fit between the data and the model.

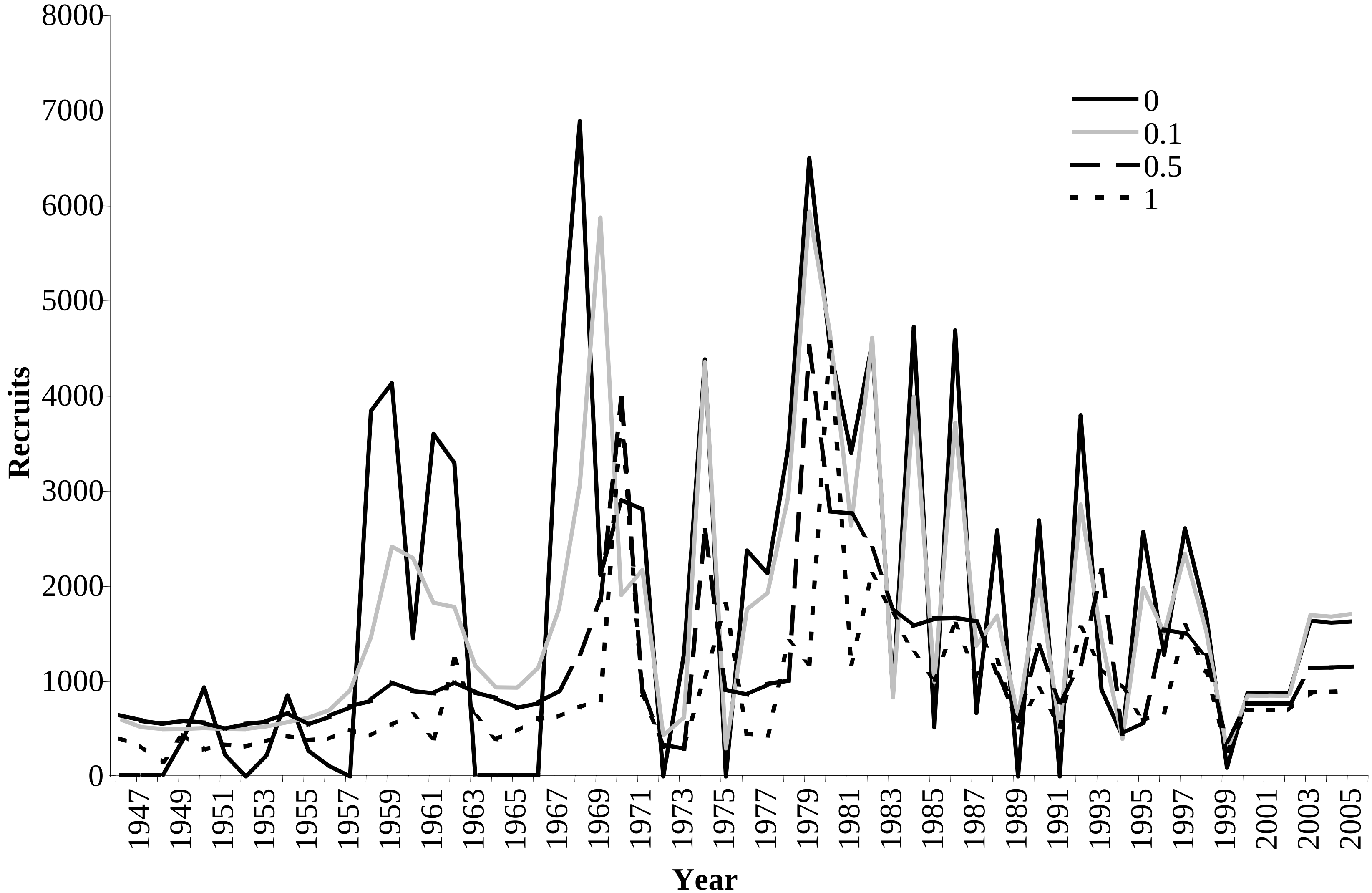


Figure 6.18 The effect of increasing the likelihood weights on the stock recruitment curve from zero to one on the estimated recruitment in the model. The freely estimated values (zero weight on the curve), show greater temporal variation but a similar trend to the other values.

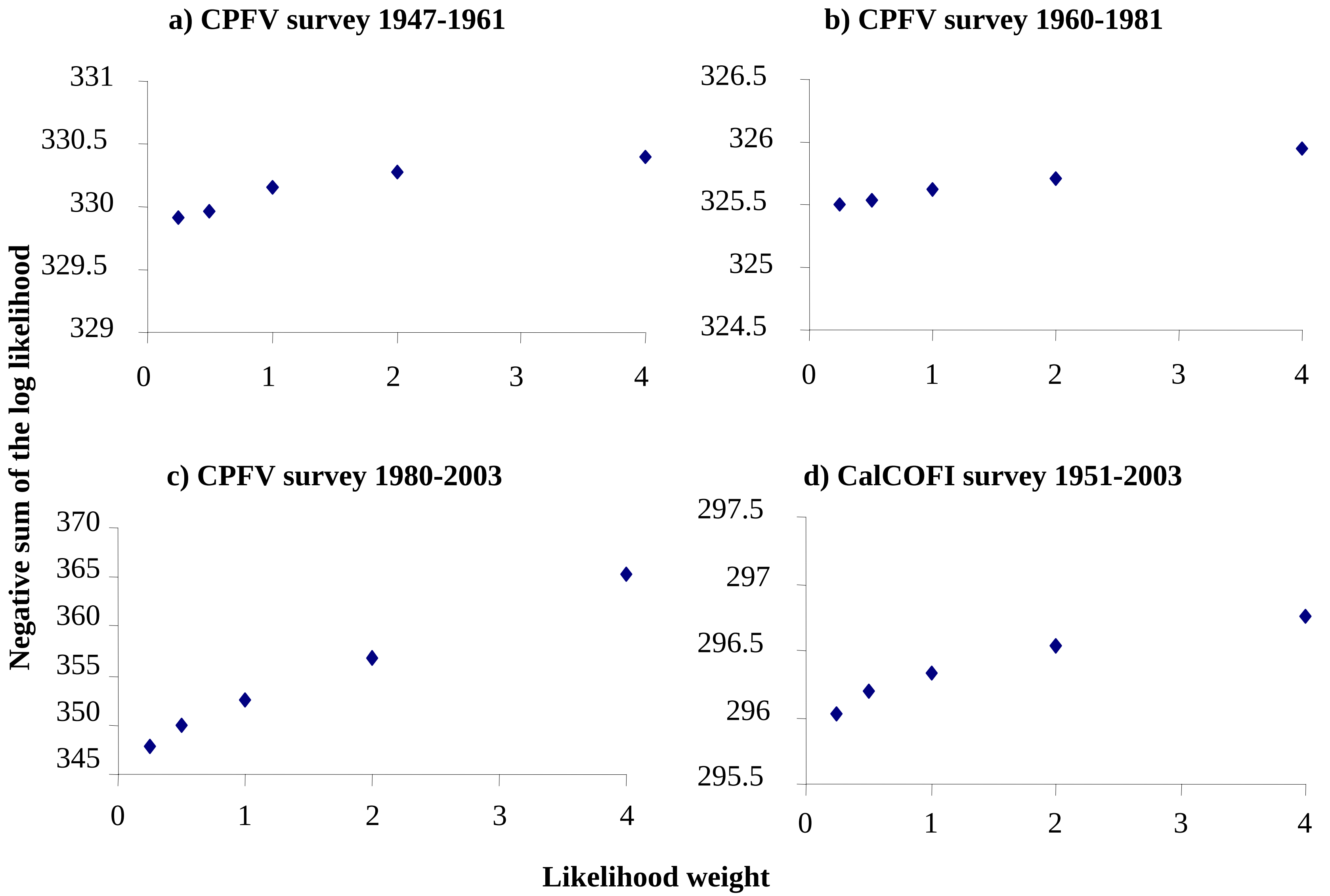


Figure 6.19 a-d A sensitivity analyses on data sources. For each of the four abundance indices we varied the individual likelihood weight from 0.25 to 4 and took the sum of all of the likelihood weights except the survey of interest. The CPFV logbook survey that covers 1980-2003 shows a decrease in the sum of the rest of the negative log likelihood components indicating that it does not necessarily agree with other data sources. However the other three surveys show an increase with the likelihood meaning they are in agreement with the other data sources.

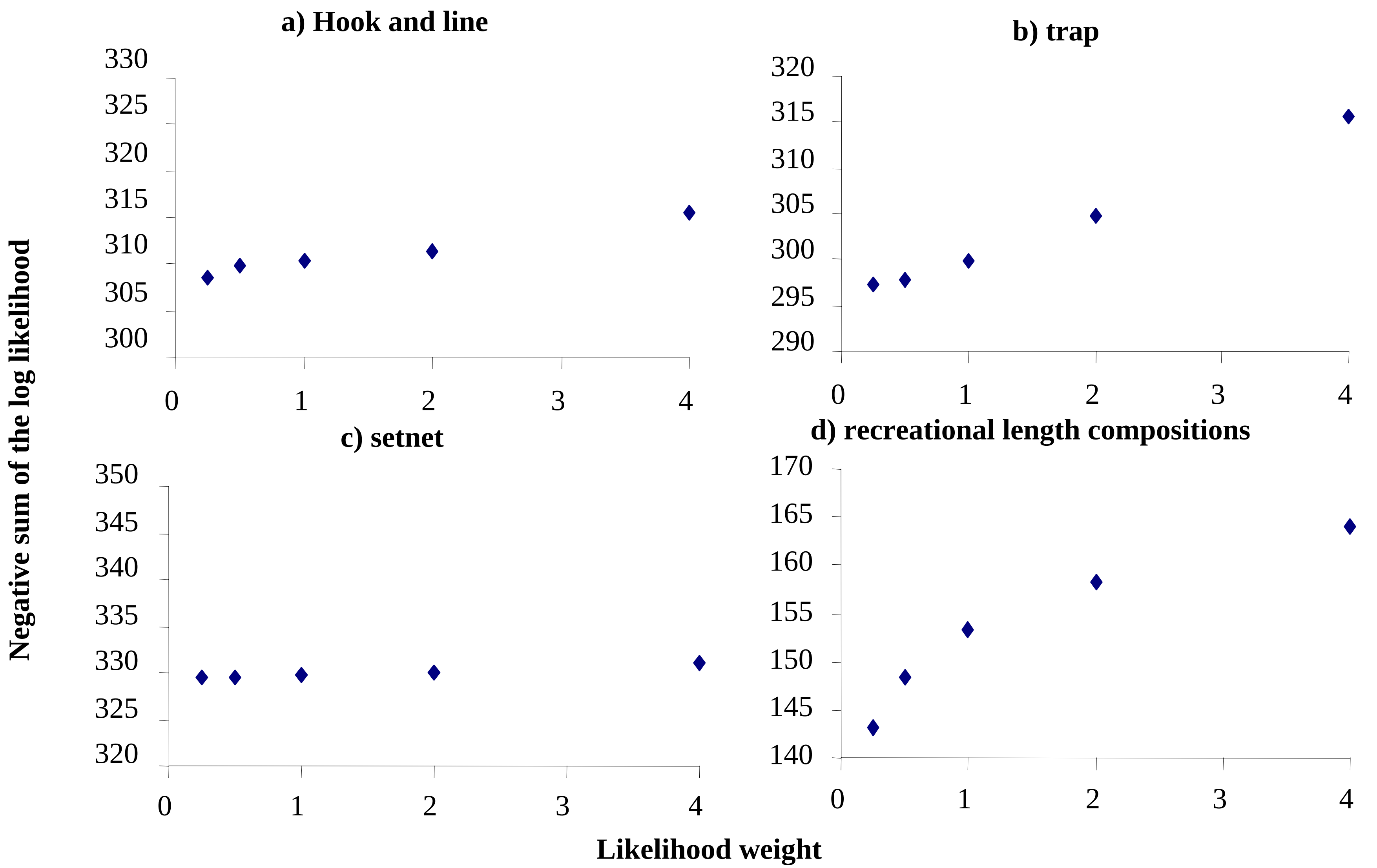


Figure 6.20 a-d A sensitivity analyses on data sources. For each set of length compositions associated with one of the four fisheries, we varied the individual likelihood weight from 0.25 to 4 and took the sum of all of the likelihood components except the length composition being varied. They all tend to increase with the likelihood weight indicating that they tend to be in agreement with the other data sources.

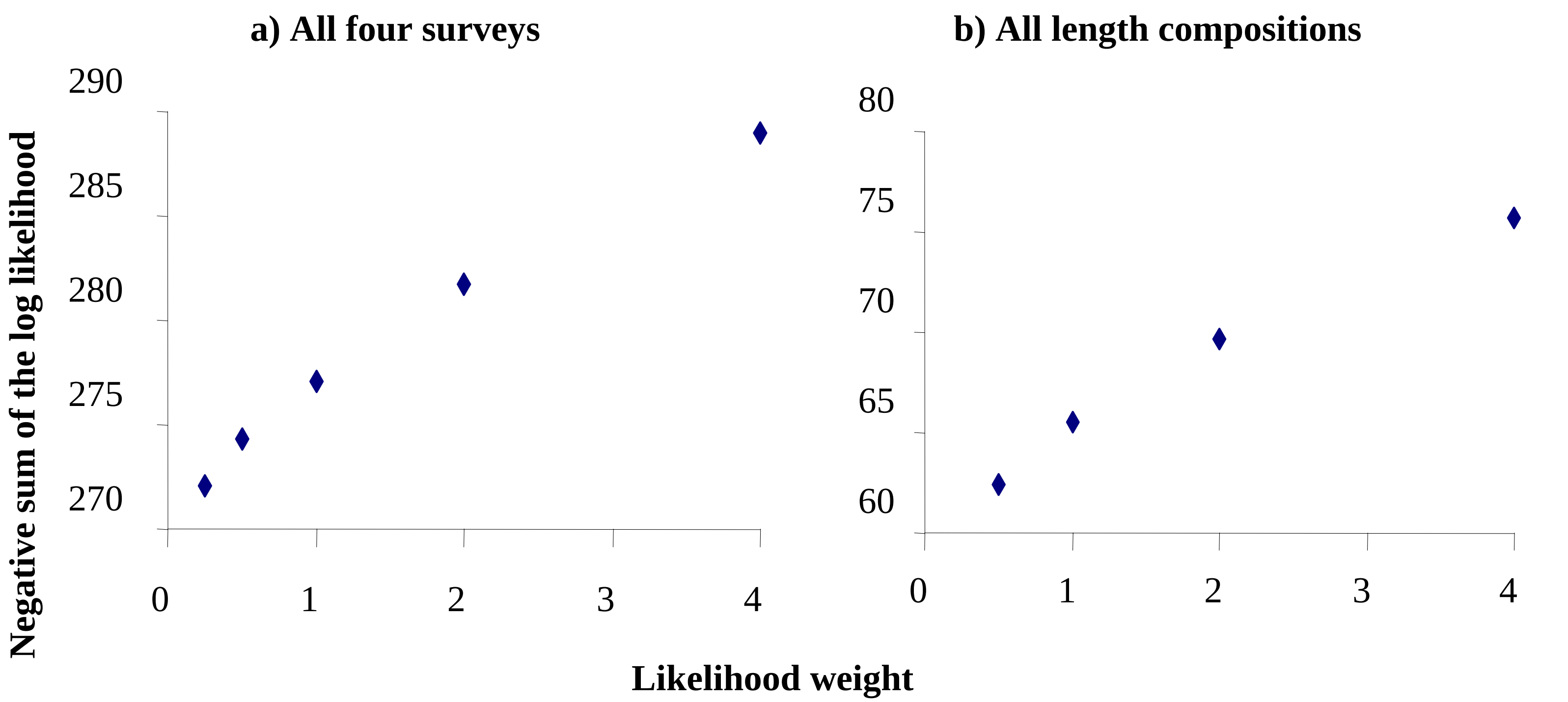


Figure 6.21 Sensitivity analysis on data sources. We give the total log-likelihood of the model when we (a) varied the likelihood weight of all four surveys simultaneously while keeping all other likelihood weights constant (and equal to 1.0) and (b) varied the likelihood weight of all four sets of length compositions while keeping all other likelihood weights constant.

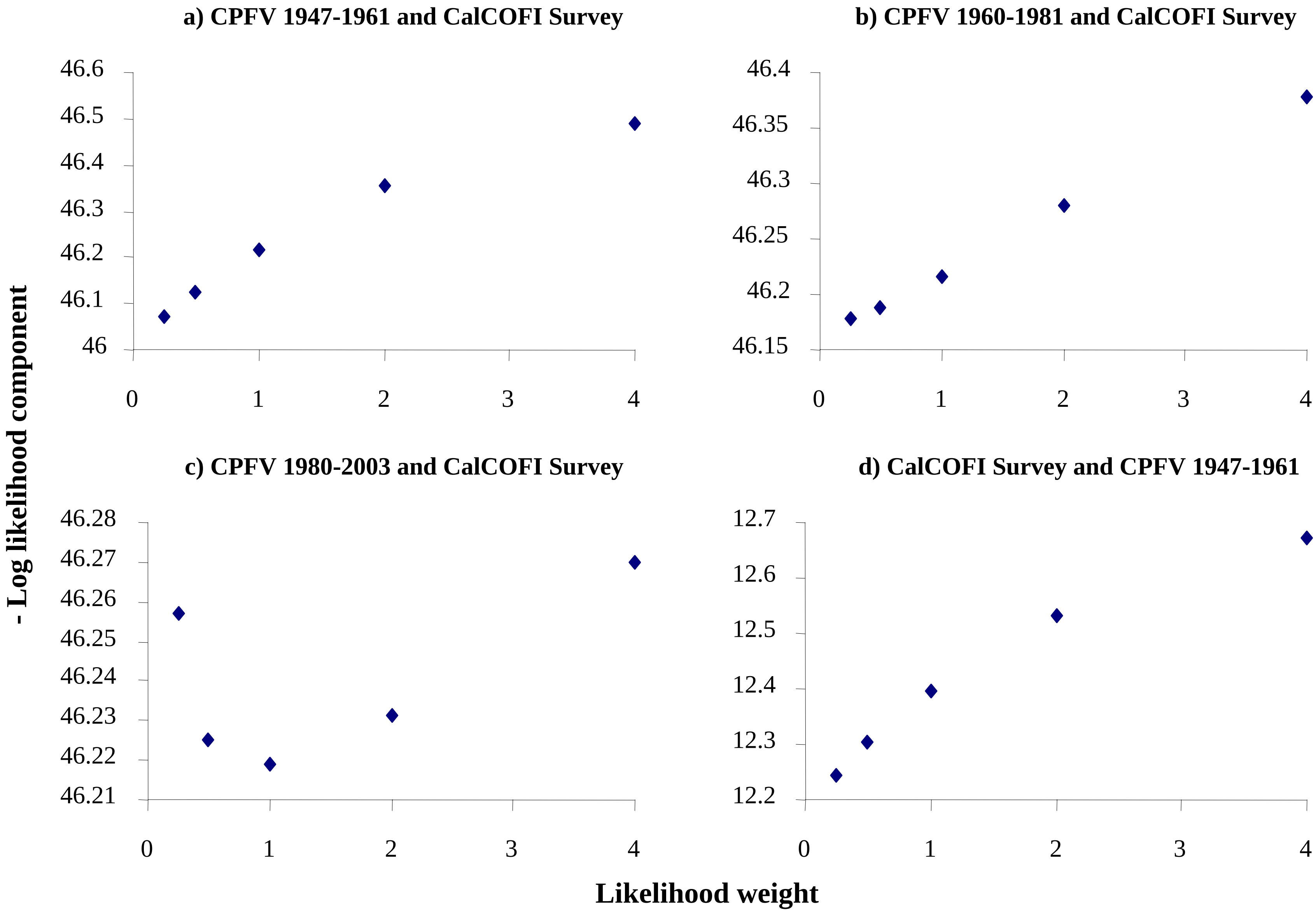


Figure 6.22 a-d We varied the likelihood weight of each of the four surveys individually while holding all other likelihood weights at the baseline level at one. In each panel, the likelihood component of one survey is shown as another survey's likelihood weight is varied. We focus on comparing the CPFV surveys with the CalCOFI survey.

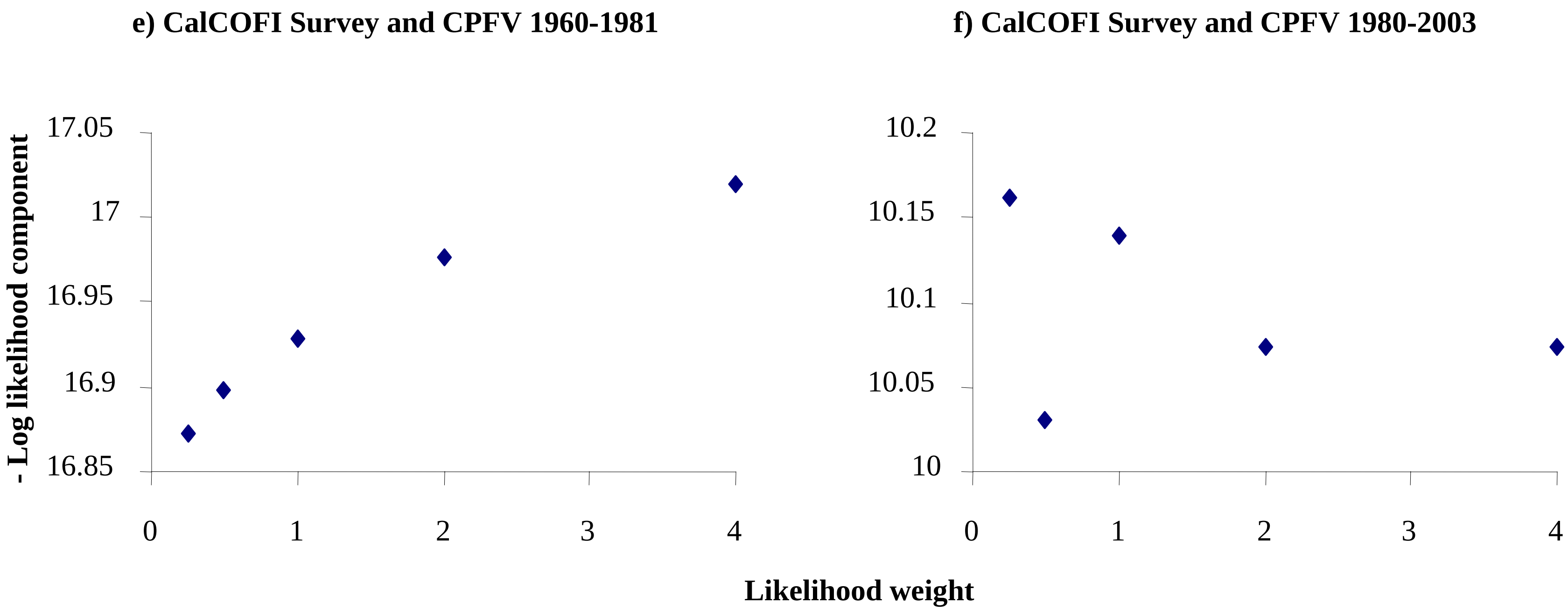


Figure 6.22 e-f Continued. We varied the likelihood weight of each of the four surveys individually while holding all other likelihood weights at the baseline level of one. In each panel, the likelihood component of one survey is shown as another survey's likelihood weight is varied. We focus on comparing the CPFV surveys with the CalCOFI survey.

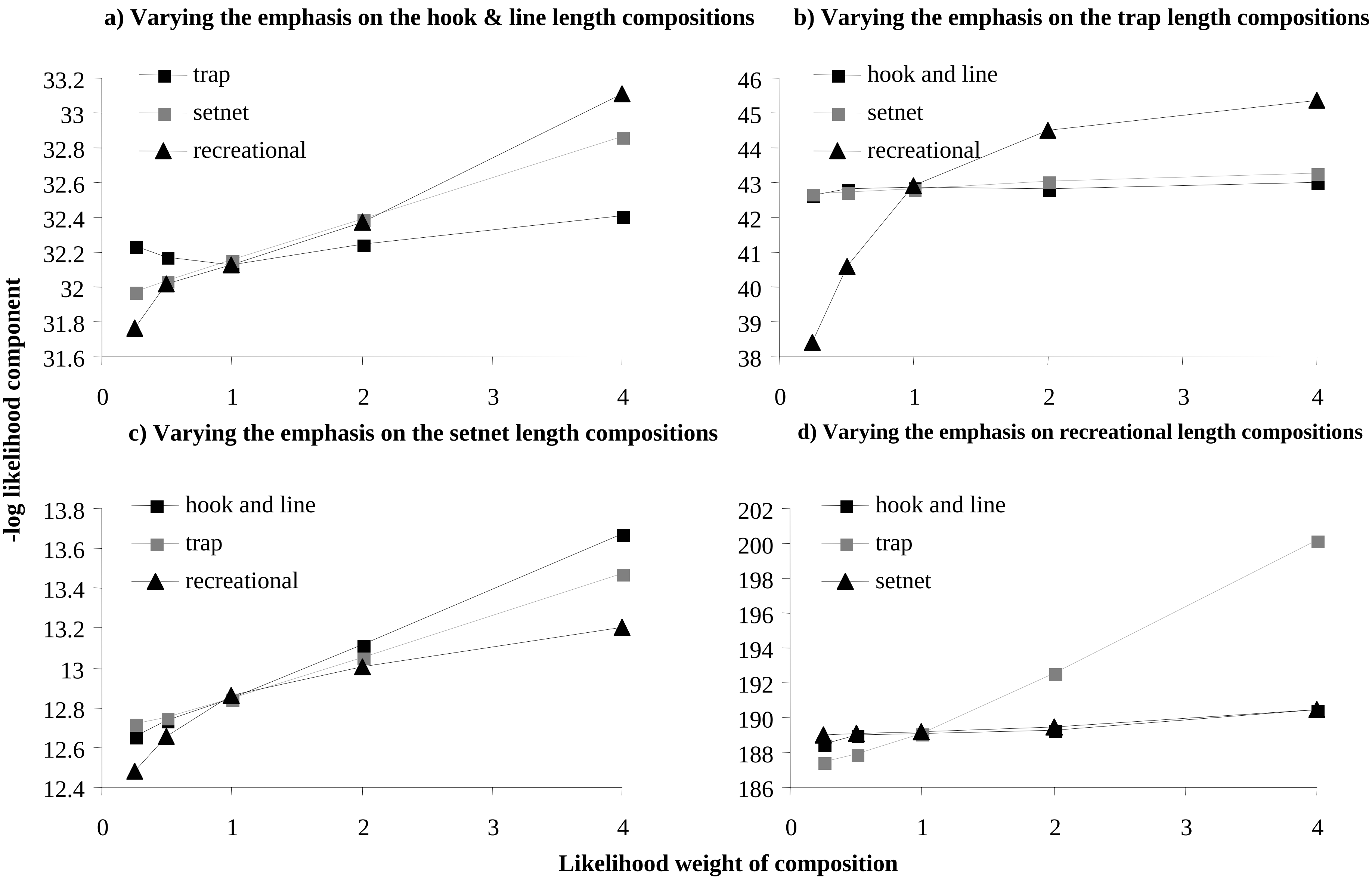


Figure 6.23 a-d Sensitivity analyses on data sources. We varied the individual likelihood weights of each length composition while holding all other likelihood weights at the baseline level of one. Each panel represents the change in the individual likelihood component of the three length compositions while the weight of the fourth set of length compositions is varied.

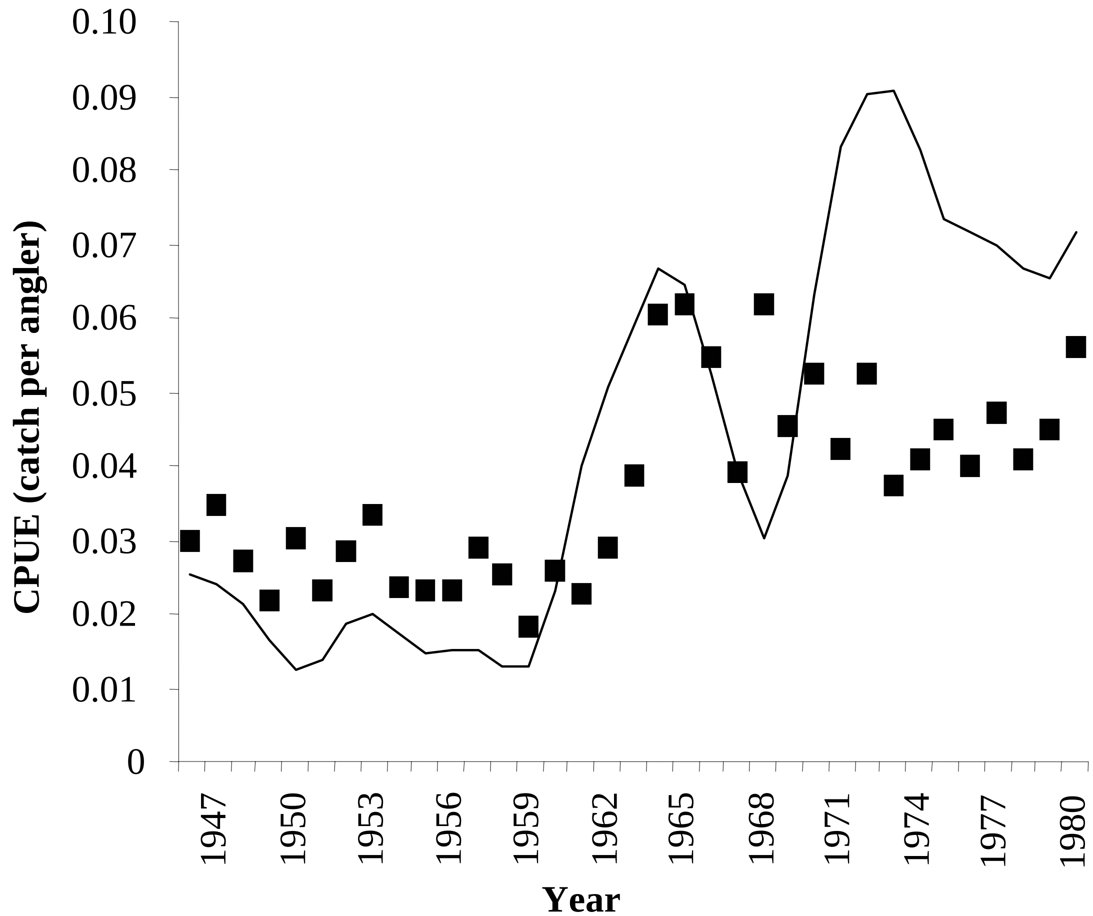


Figure 6.24 Sensitivity analysis on the fit to the combined CPFV (1947-1981) survey. Black squares are the observed values and the solid line is the estimated abundance index.

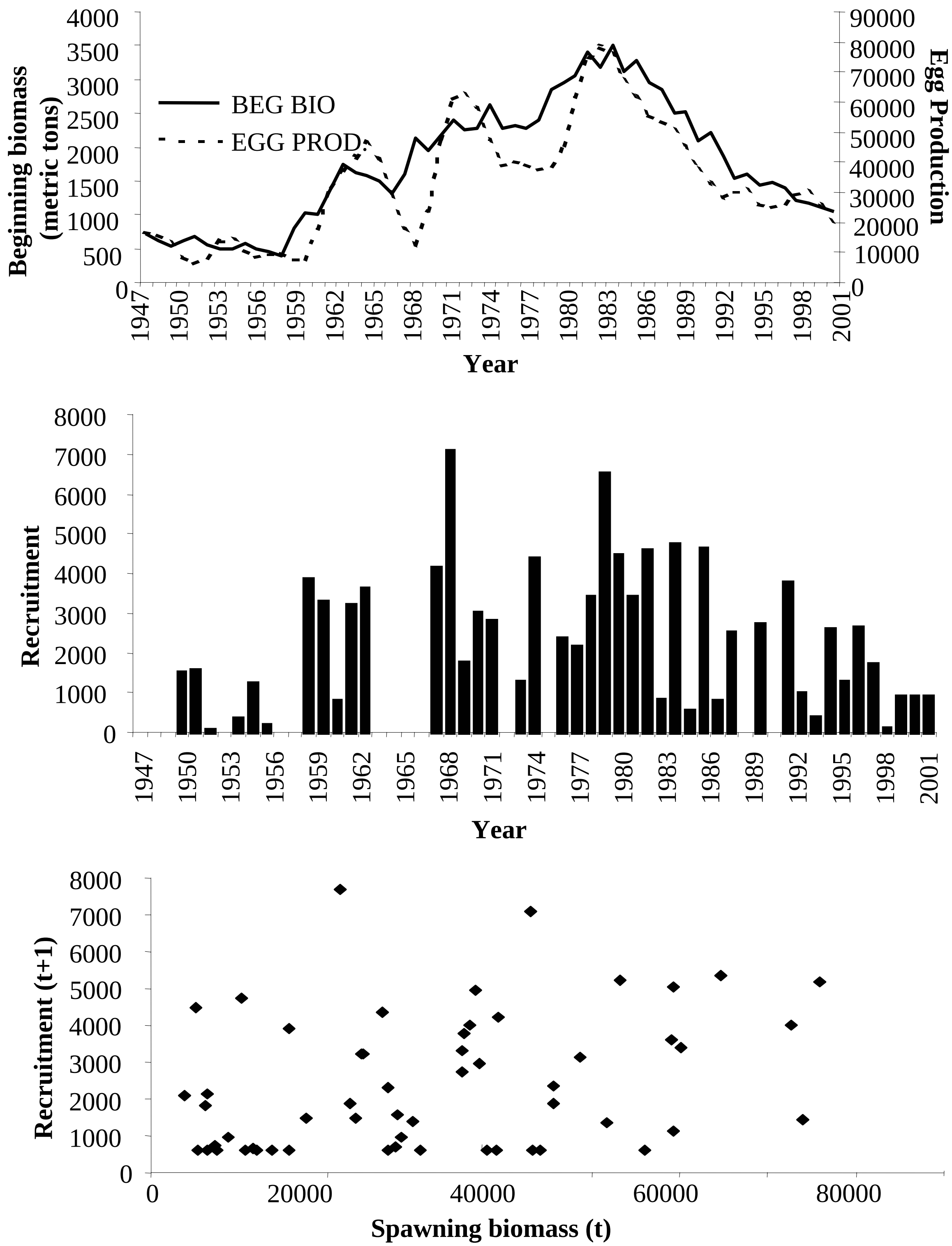


Figure 6.25 Sensitivity analysis on data: The predicted biomass, recruitment and stock/recruitment pattern using the calibrated CPFV survey as one index 1947-2003.

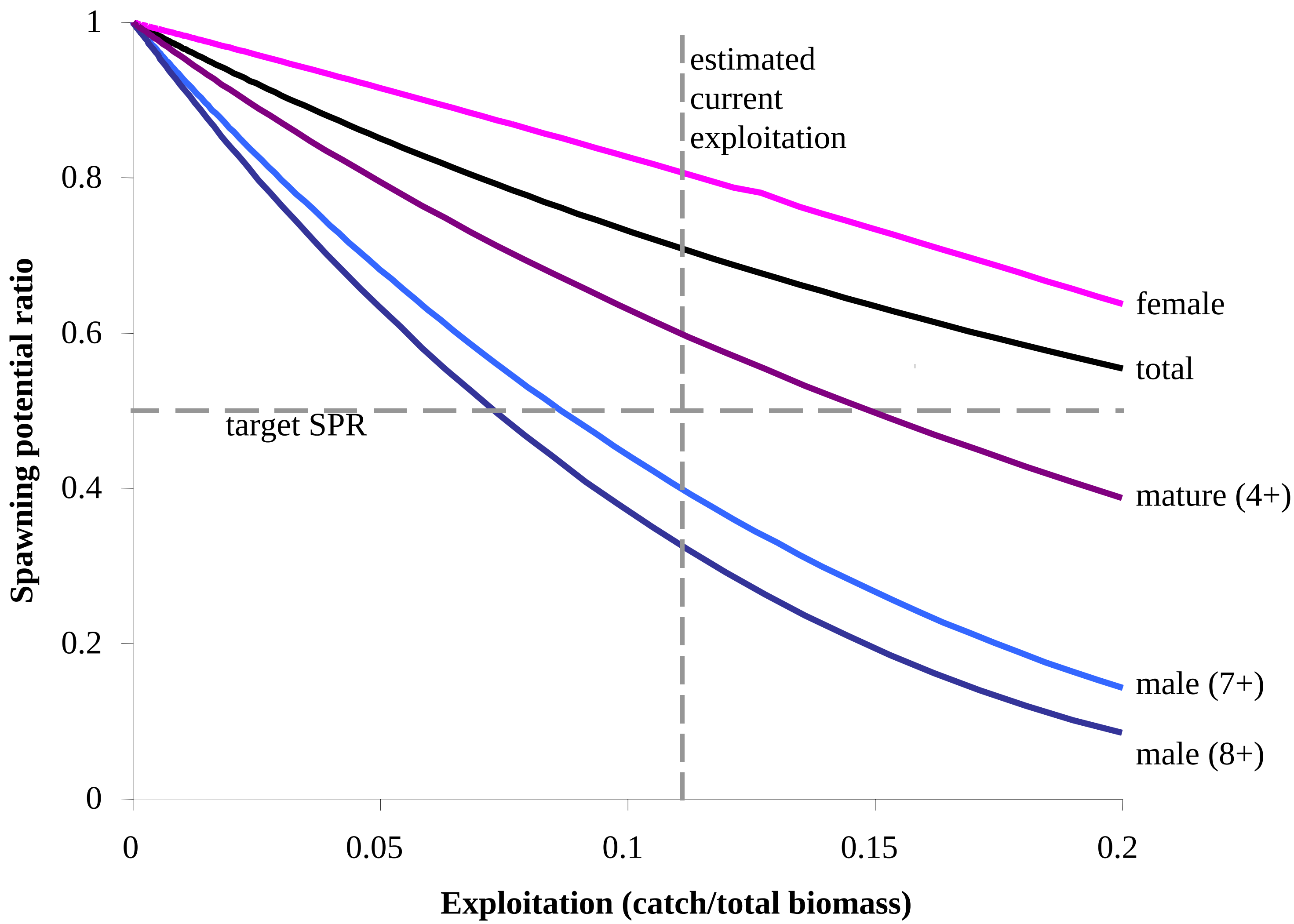


Figure 7.1 Estimated status of the stock as predicted by the baseline model. We give the relative spawning potential ratio (SPR) for female, mature (age 4 and above), male (age 7 and above or age 8 and above) and total biomass. Current exploitation is shown with the dashed vertical line. Female spawning potential ratio is estimated to be reduced to 80% of unfished levels while relative male spawning potential ratio is estimated to be reduced by about 65%. Equilibrium calculations are based on current (2003) fishing mortality associated with each fishery.

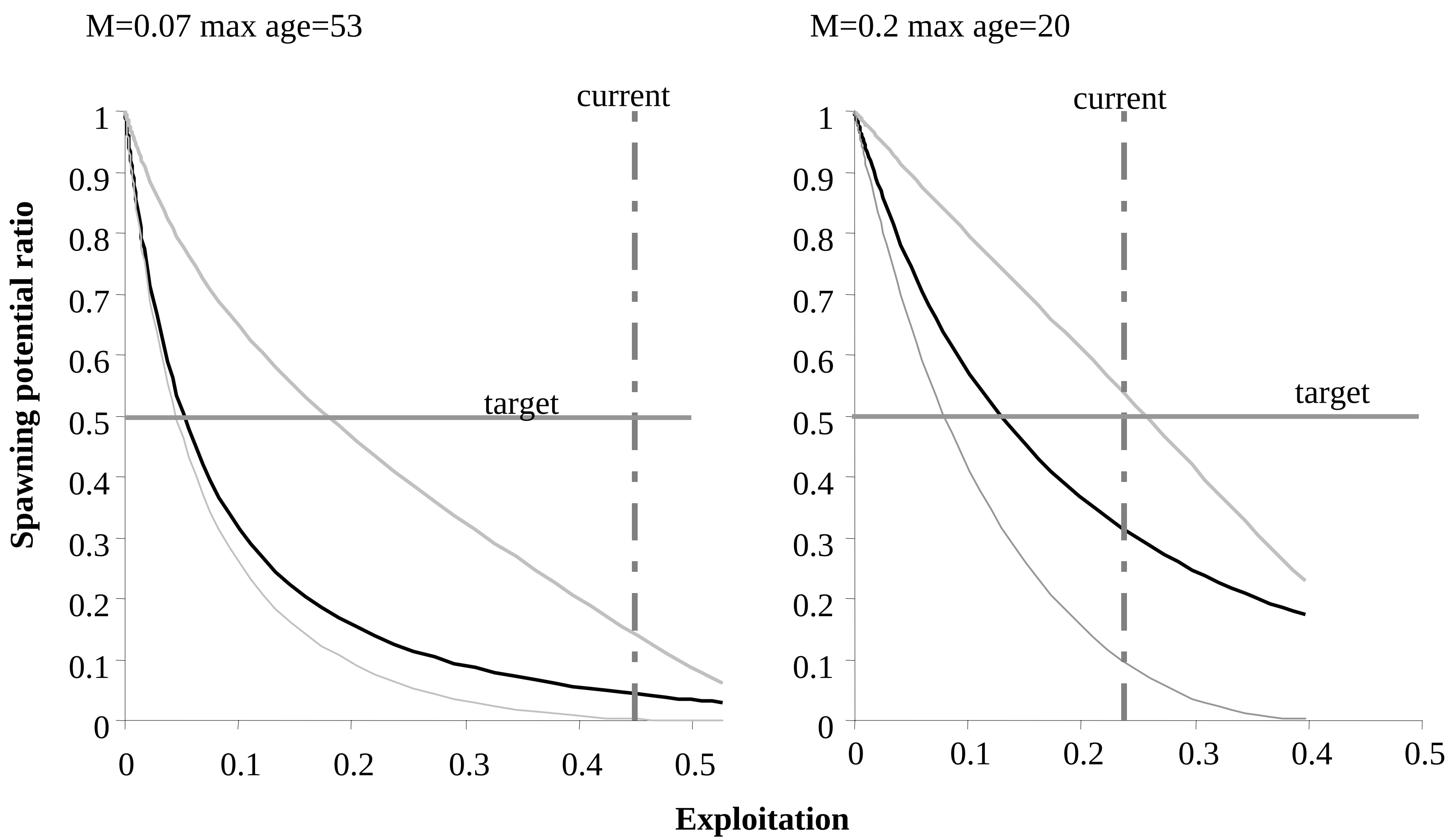


Figure 7.2 Natural mortality affects the estimated status of the stock. We give the relative spawning potential ratio (SPR) for female (thick grey line), male (age 7 and above, thin grey line) and total biomass (black line) for two additional natural mortality values. Natural mortality was estimated using Hoenig (1983) and the observed maximum age of Sheephead from two different sources. For further details see the text. Current estimated exploitation differs between the models as natural mortality changes because the estimated total and spawning biomass are affected by natural mortality. Equilibrium calculations are based on current (2003) fishing mortality associated with each fishery.

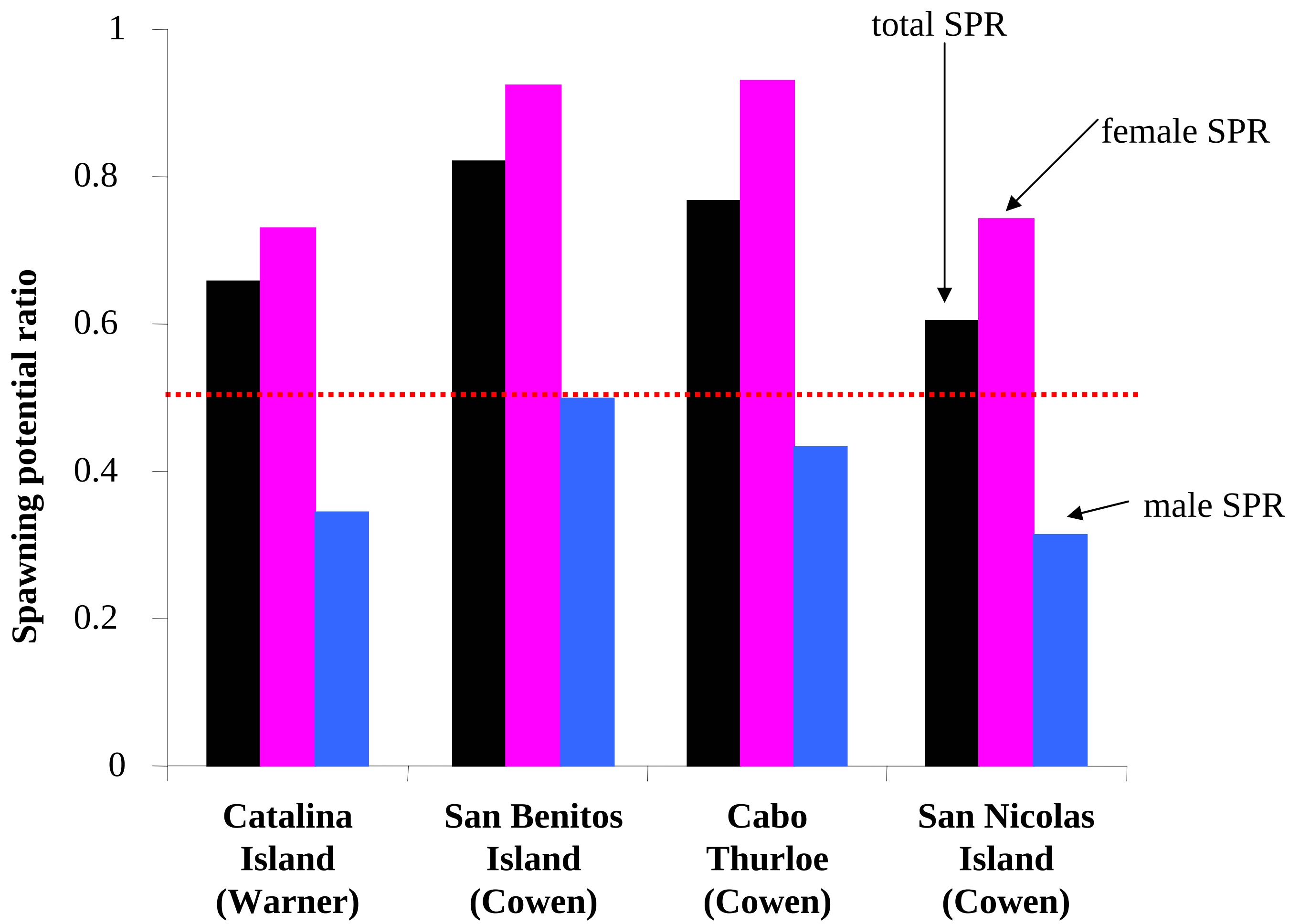


Figure 7.3 The estimated current status of the stock is also affected by the combination of life history parameters used. We ran the model with each of the six sets of parameters given in Table 3.1 and calculated the estimated relative spawning potential ratios (total, female and male) for each model, this figure shows only the four nearshore populations. Equilibrium calculations are based on current (2003) fishing mortality associated with each fishery.

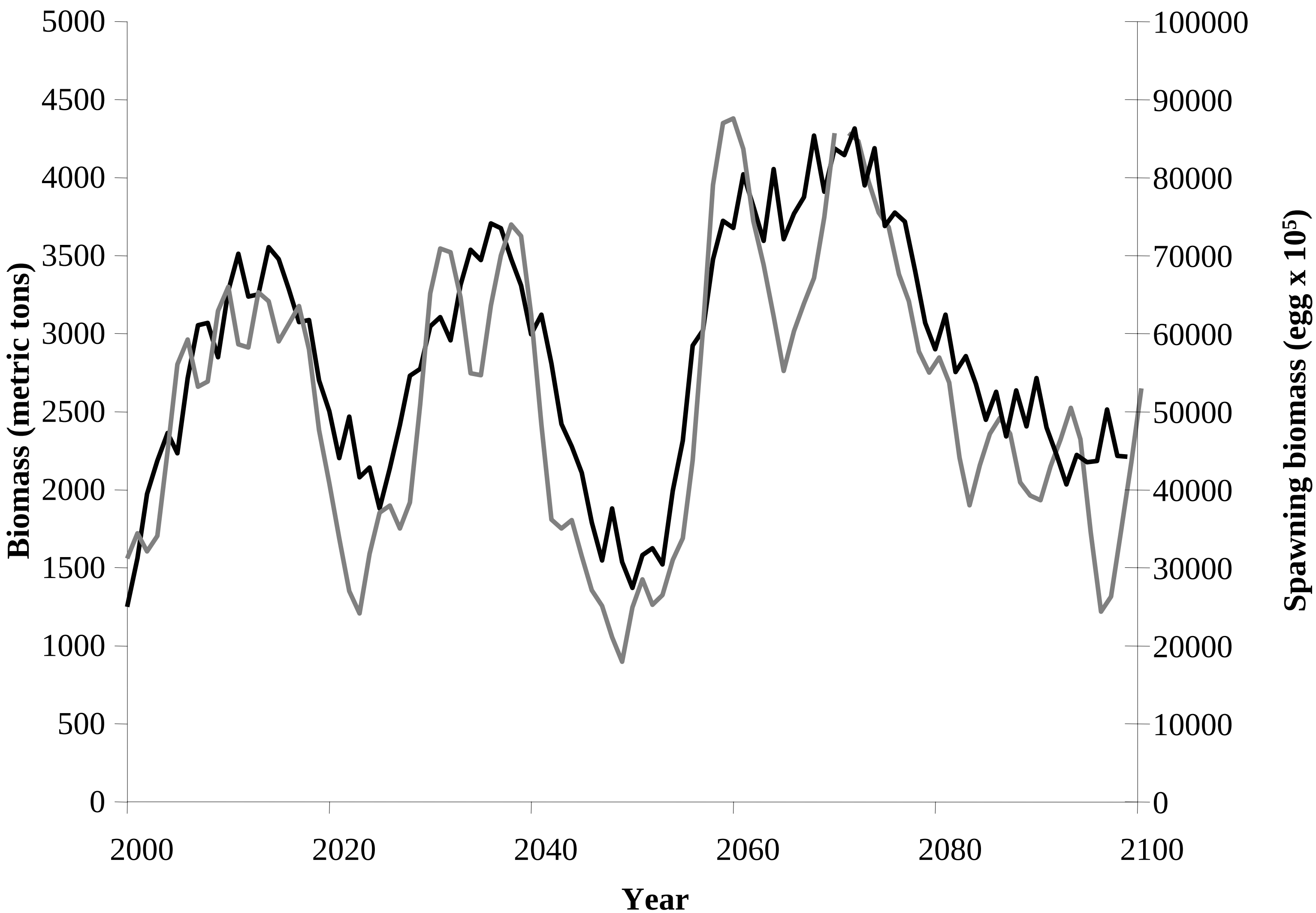


Figure 7.4 Variable recruitment leads to temporal variation in expected total and spawning biomass even in the absence of fishing mortality. The results presented here are based on a single projection showing for total (black line) and female (grey line) spawning biomass in the absence of fishing assuming that recruitment is selected randomly from model estimated recruitment from 1970-1995.

Figure 7.5 Projections of the 10^{th}, 25^{th}, 50^{th} and 90^{th} percentiles for projected total biomass when fishing mortality is zero. The results presented here are based on 100 projections for 100 years in the absence of fishing assuming that recruitment is selected randomly from model estimated recruitment from 1970-1995.

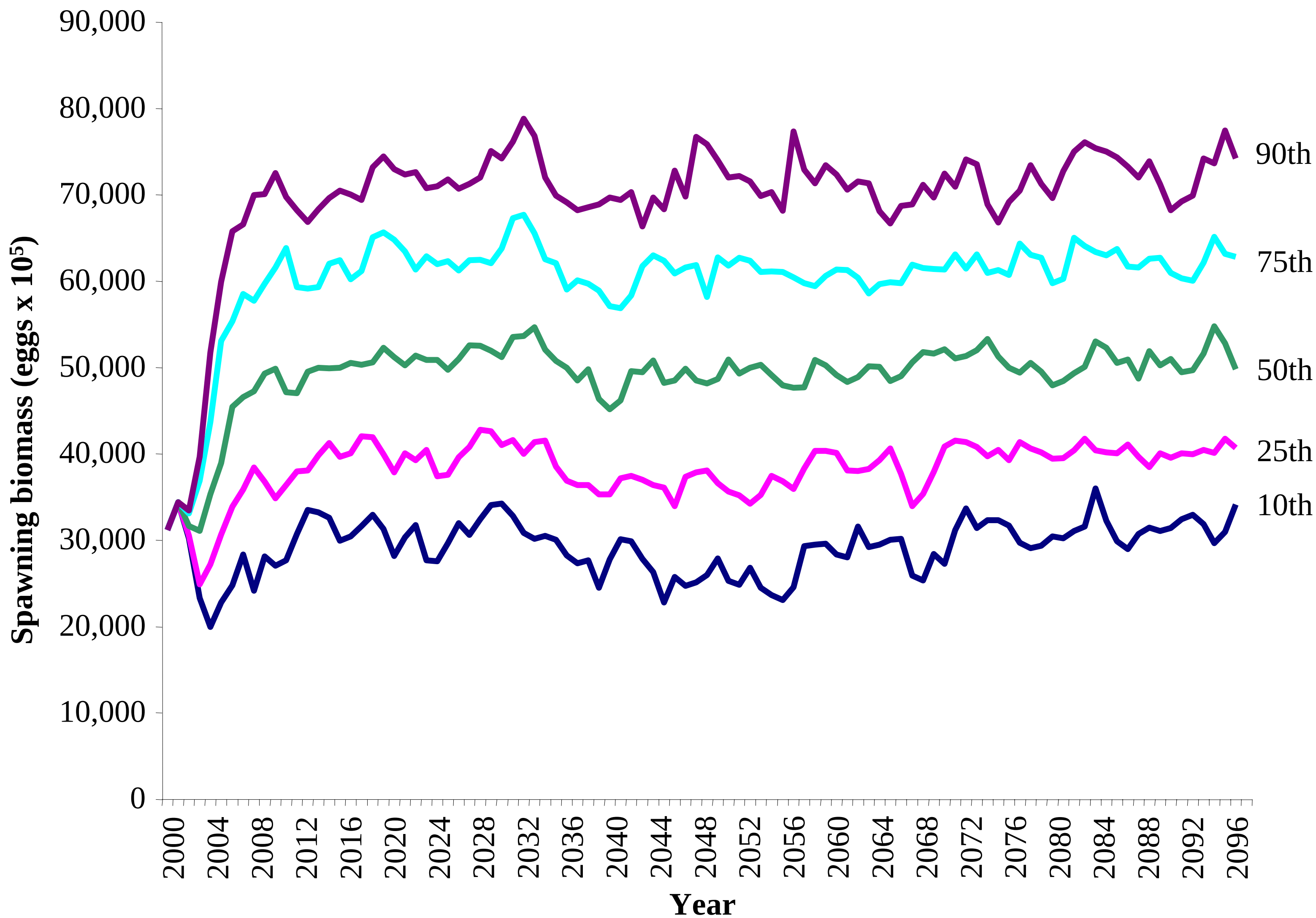


Figure 7.6 Projections of the 10th, 25th, 50th and 90th percentiles for projected spawning biomass when fishing mortality is zero. The results presented here are based on 100 projections for 100 years in the absence of fishing assuming that recruitment is selected randomly from model estimated recruitment from 1970-1995.

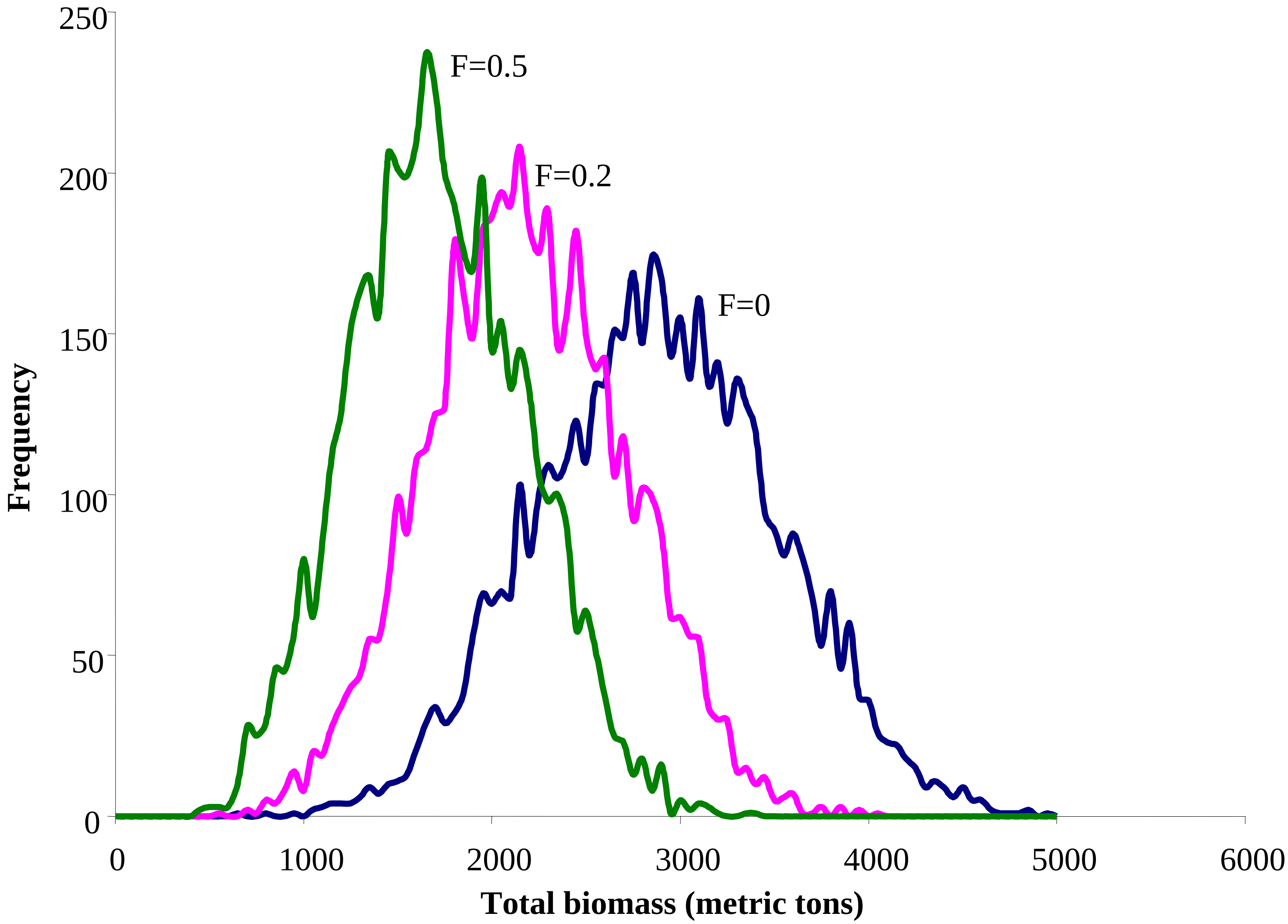


Figure 7.7 Frequency distributions of projected total biomass in the future (of the baseline model) when future fishing mortality is fixed at 0, 0.2 and 0.5. The distribution of total biomass is based on projections over 50 years after having allowed the projections to stabilize. The results presented here are based on 100 projections for 100 years assuming that recruitment is selected randomly from model estimated recruitment from 1970-1995.

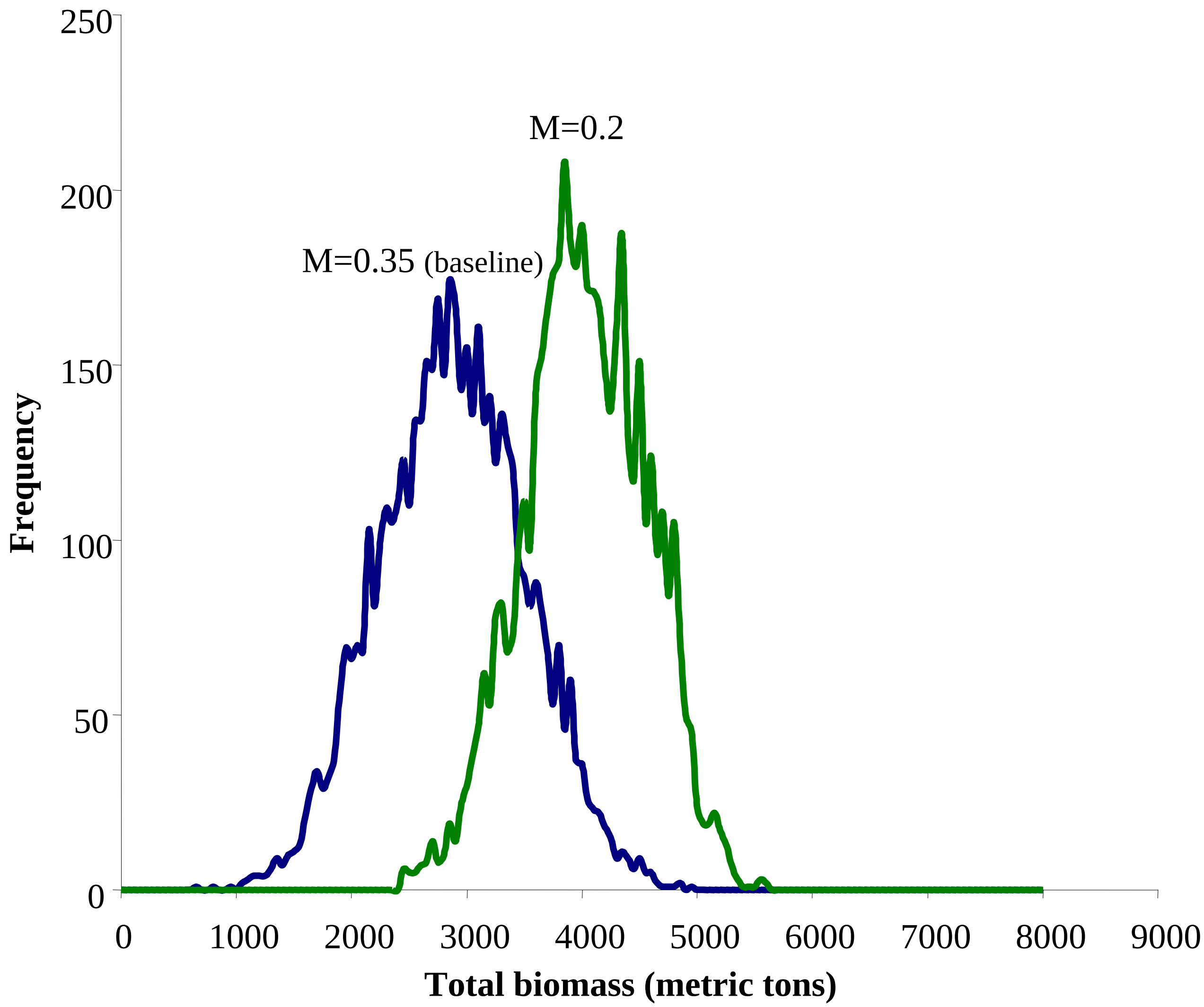


Figure 7.8 Frequency distributions of projected total biomass in the future (of the baseline model) when fishing mortality is zero (F=0) and natural mortality is 0.35 (baseline case) and 0.2. The distribution of total biomass is based on projections over 50 years after having allowed the projections to stabilize. The results presented here are based on 100 projections for 100 years assuming that recruitment is selected randomly from model estimated recruitment from 1970-1995.

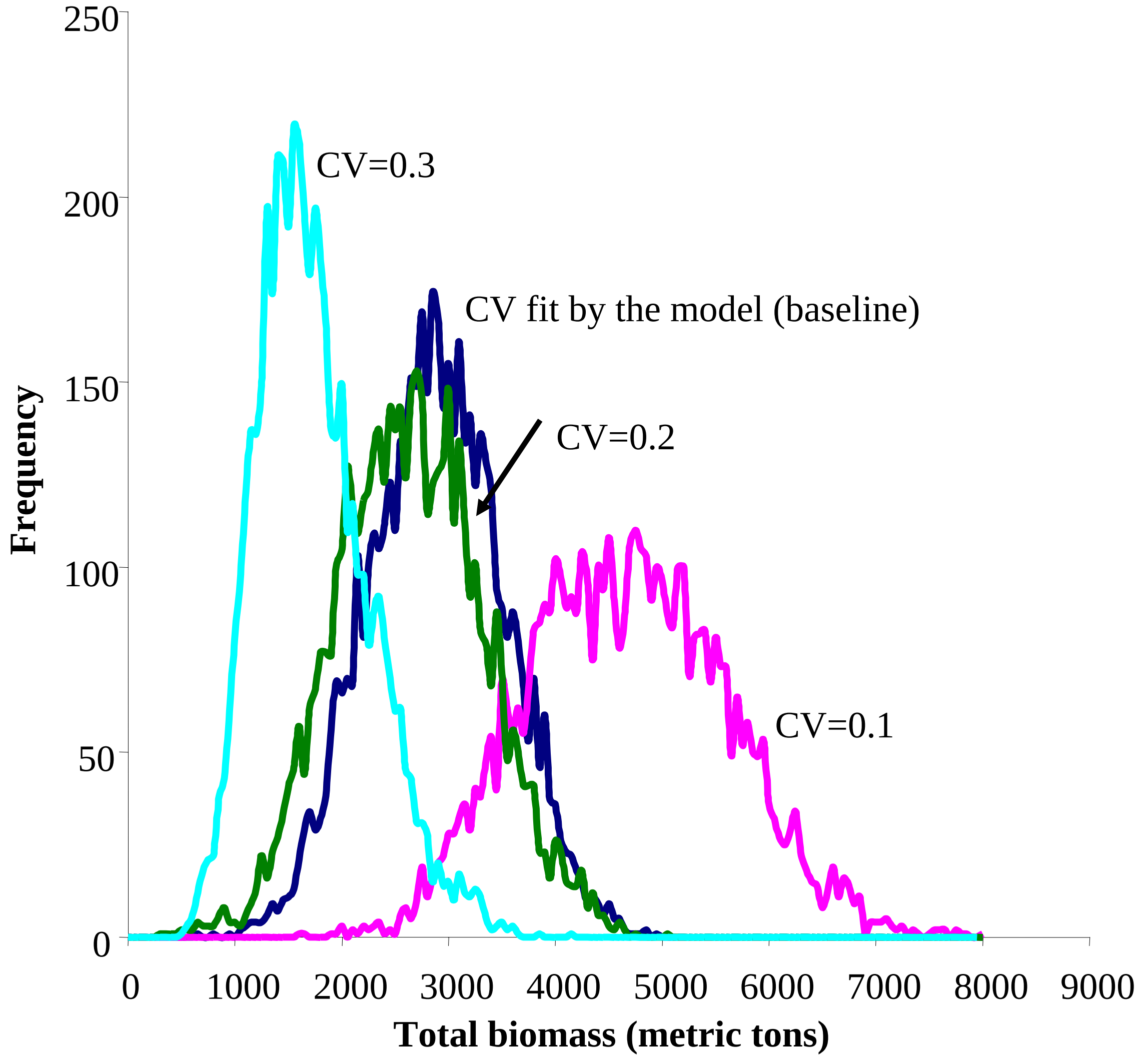


Figure 7.9 Frequency distributions of projected total biomass in the future (of the baseline model) when fishing mortality is zero and the coefficient of variation is estimated by the model (baseline case), 0.1, 0.2 and 0.3. The distribution of total biomass is based on projections over 50 years after having allowed the projections to stabilize. The results presented here are based on 100 projections for 100 years assuming that recruitment is selected randomly from model estimated recruitment from 1970-1995.

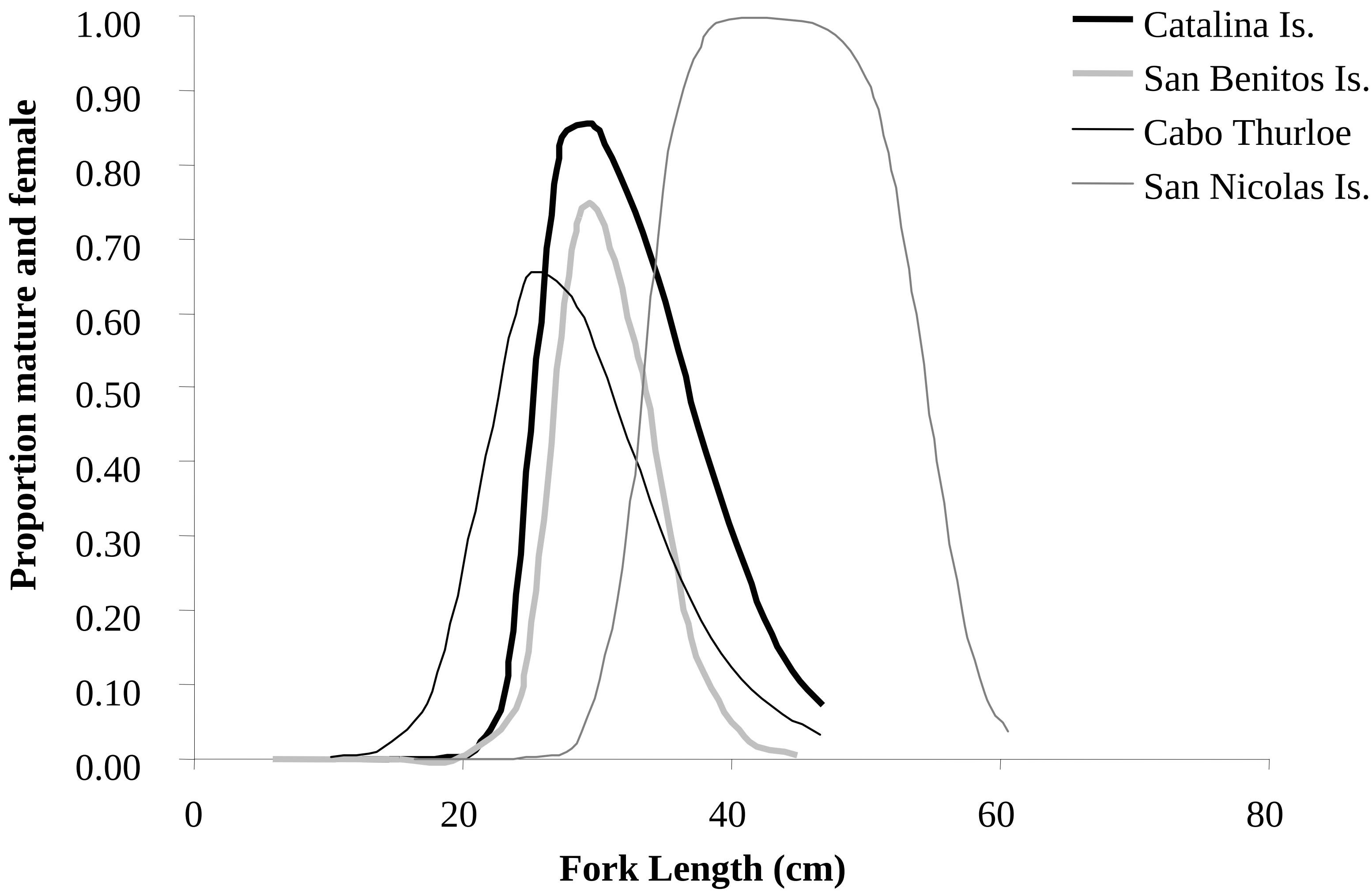


Figure 8.1 The maturity and sex change combined function for each of the refitted length and maturity data for the four nearshore populations.

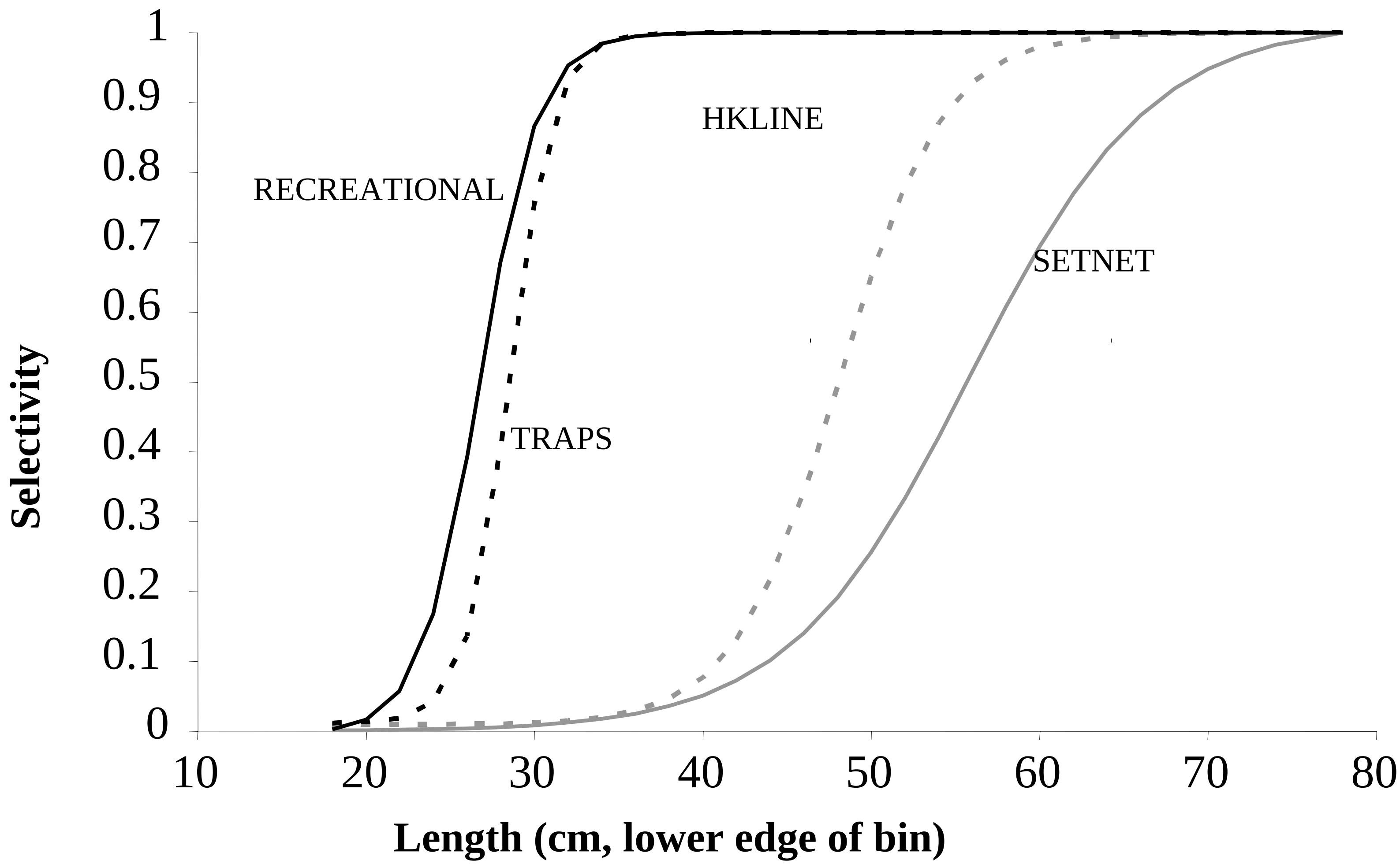


Figure 8.2 Estimated selectivities for each of the four fisheries in the final Synthesis model. Results are shown for the case where M=0.2. However, alternative natural mortality values (M=0.15 and M=0.3) lead to the same pattern.

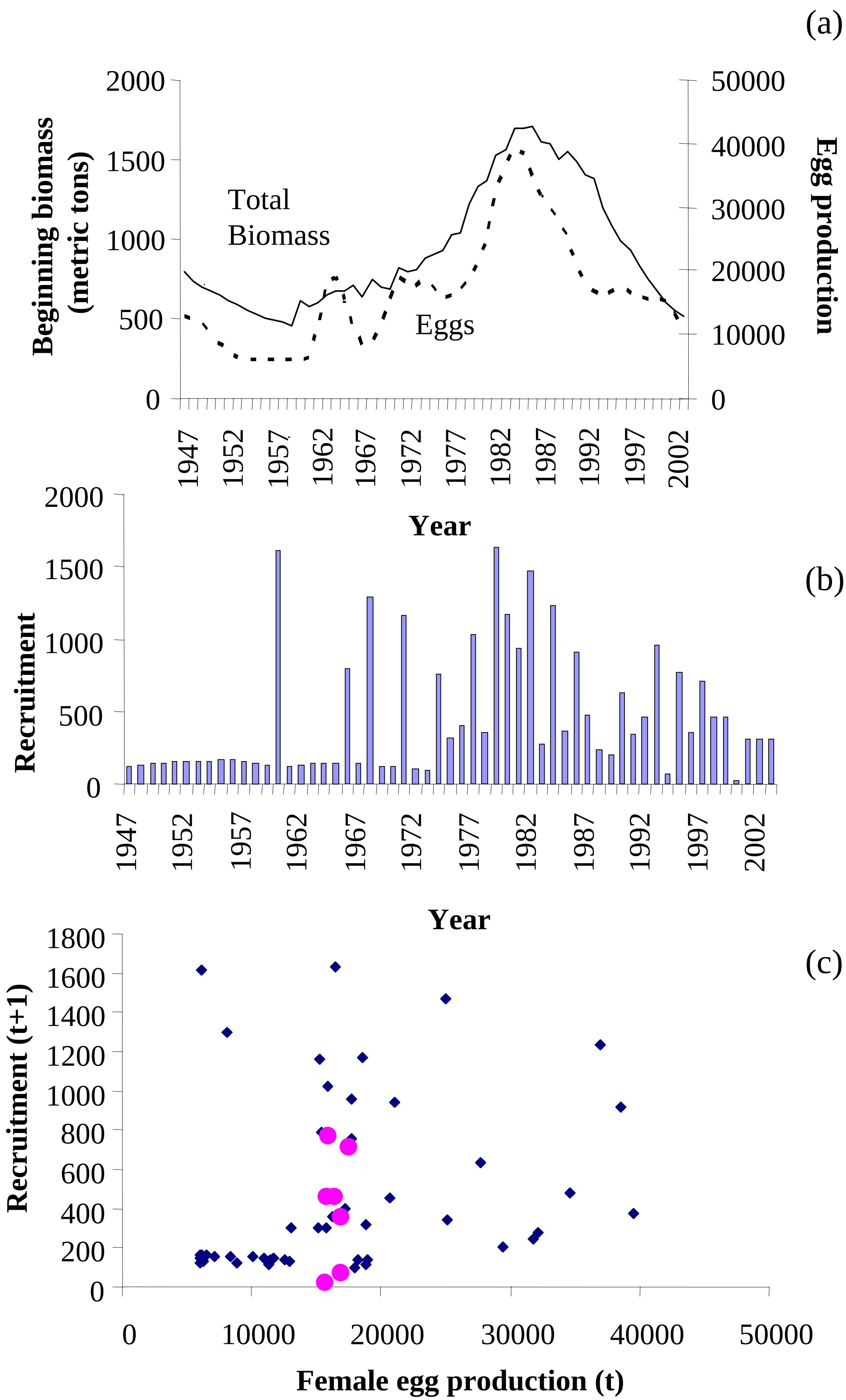


Figure 8.3 (a) The historical total biomass and spawning biomass (b) recruitment, and (c) the relationship between recruitment and spawning output estimated by the final Synthesis model when M=0.2. The round markers indicate recruitment between 1993-2000.

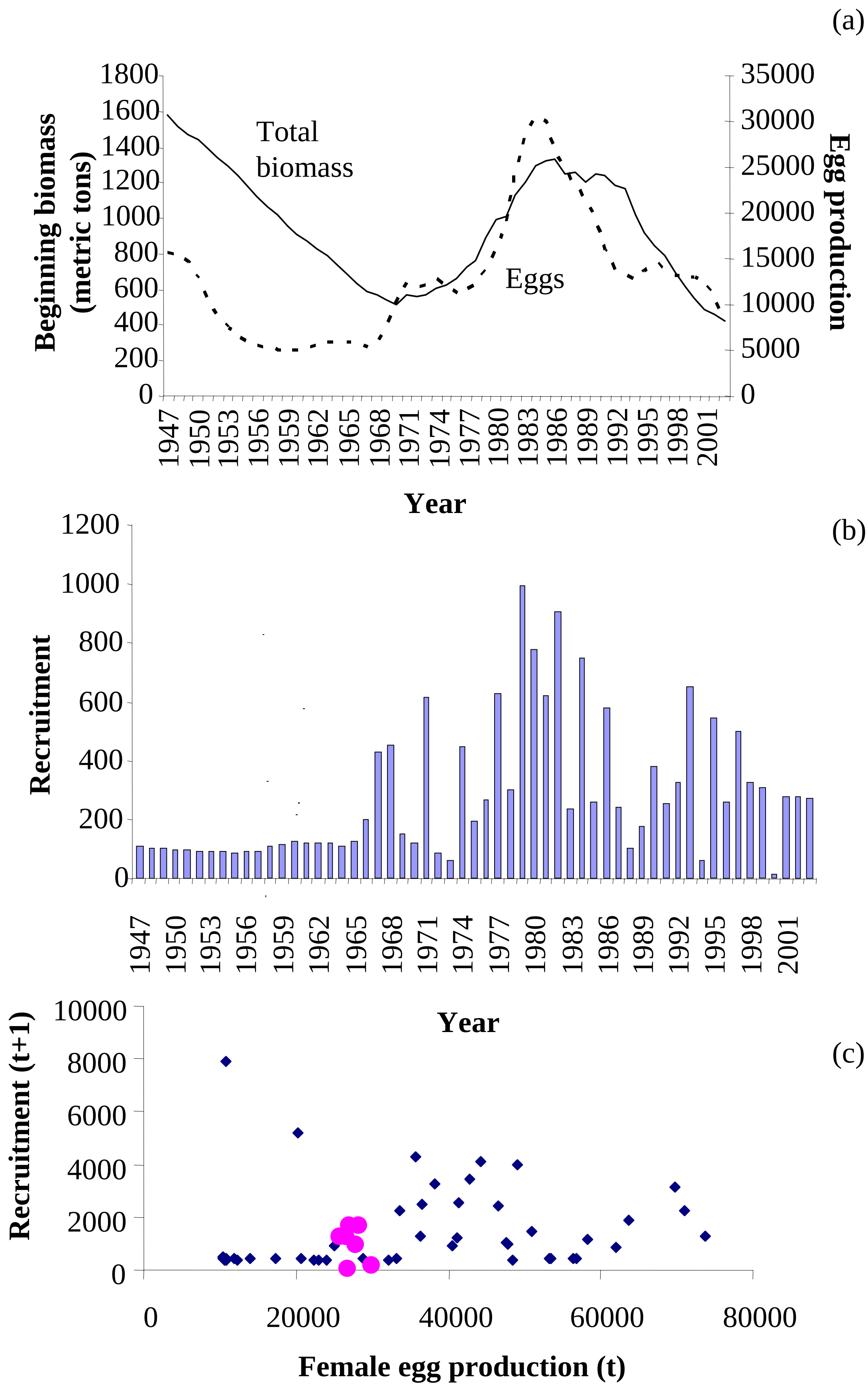


Figure 8.4 (a) The historical total biomass and spawning biomass (b) recruitment, and (c) the relationship between recruitment and spawning output estimated by the final Synthesis model when M=0.15the round markers indicate recruitment between 1993-2000.

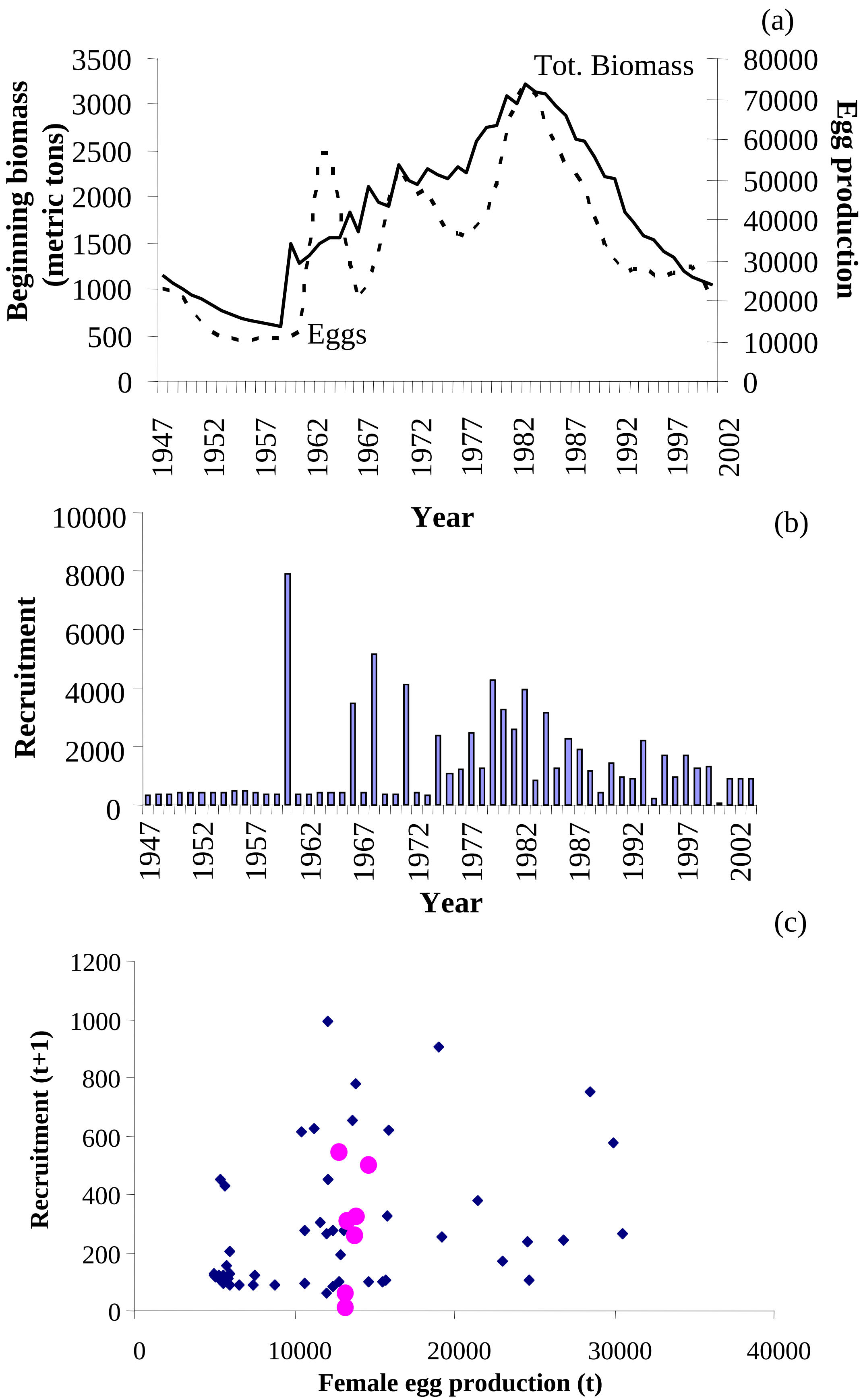


Figure 8.5 (a) The historical total biomass and spawning biomass (b) recruitment, and (c) the relationship between recruitment and spawning output estimated by the final Synthesis model when M=0.3 the round markers indicate recruitment between 1993-2000.

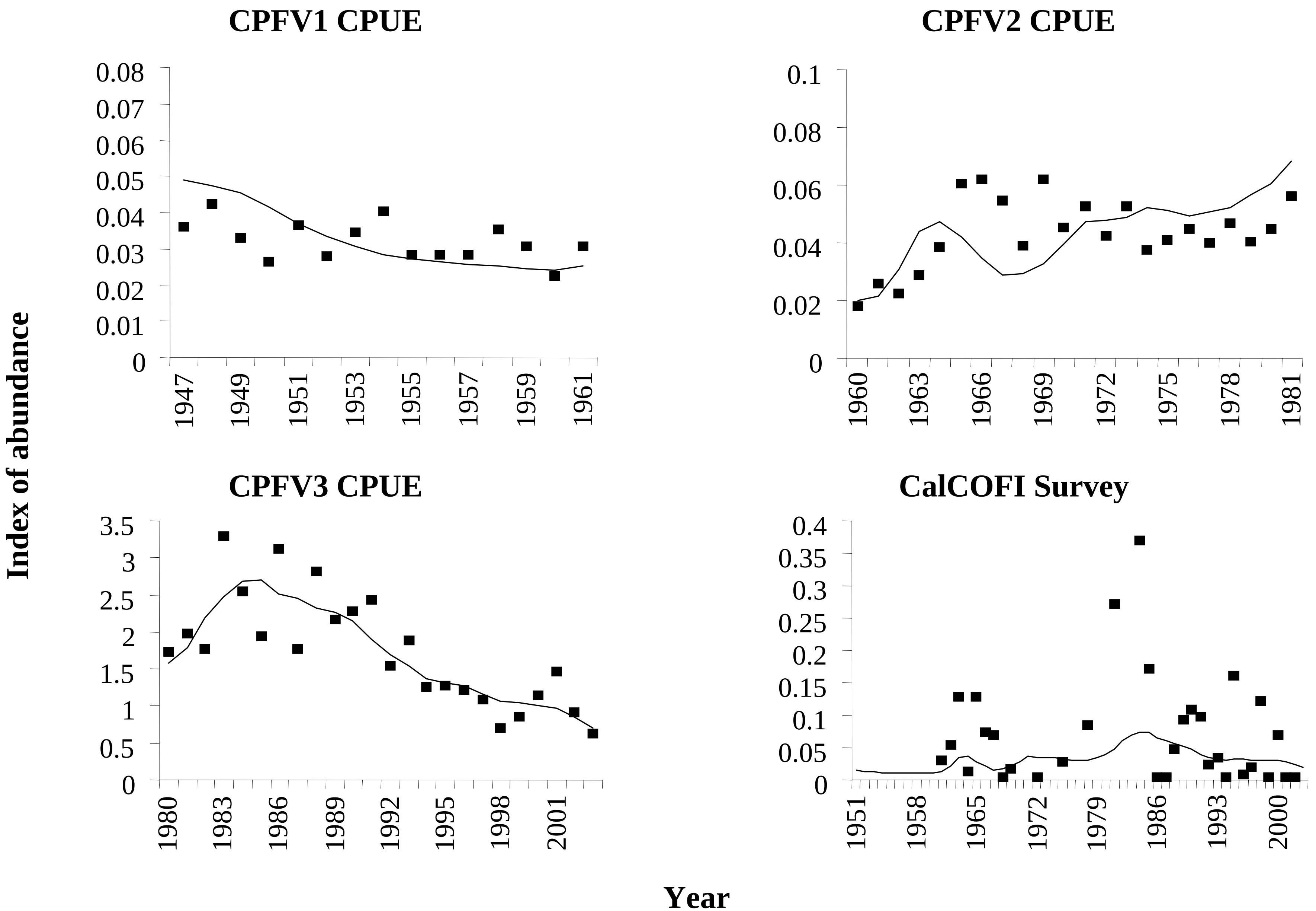


Figure 8.6 The estimated (solid line) and observed (black squares) abundance indices for the final Synthesis model when M=0.2.

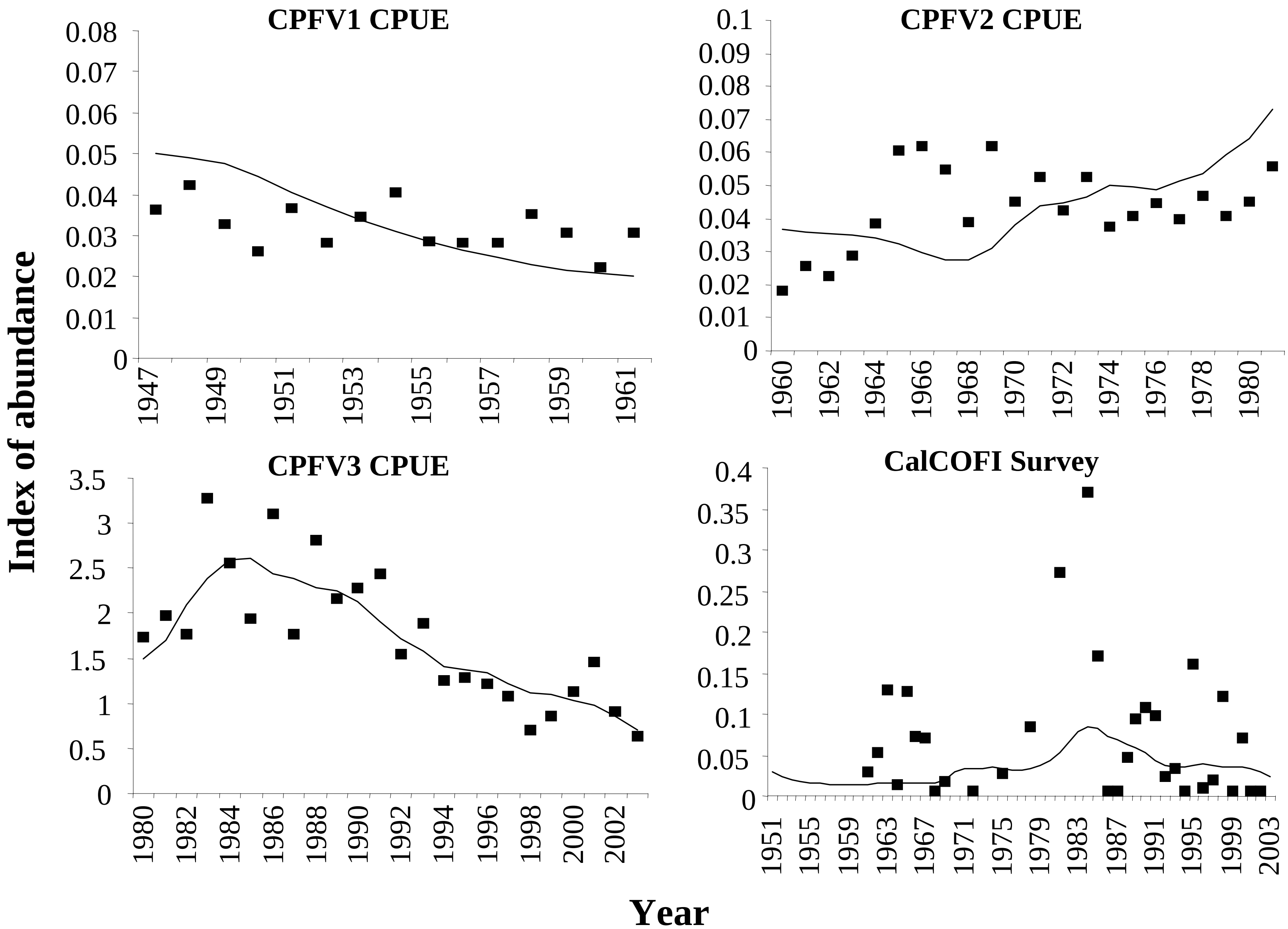


Figure 8.7 The estimated (solid line) and observed (black squares) abundance indices for the final Synthesis model when M=0.15.

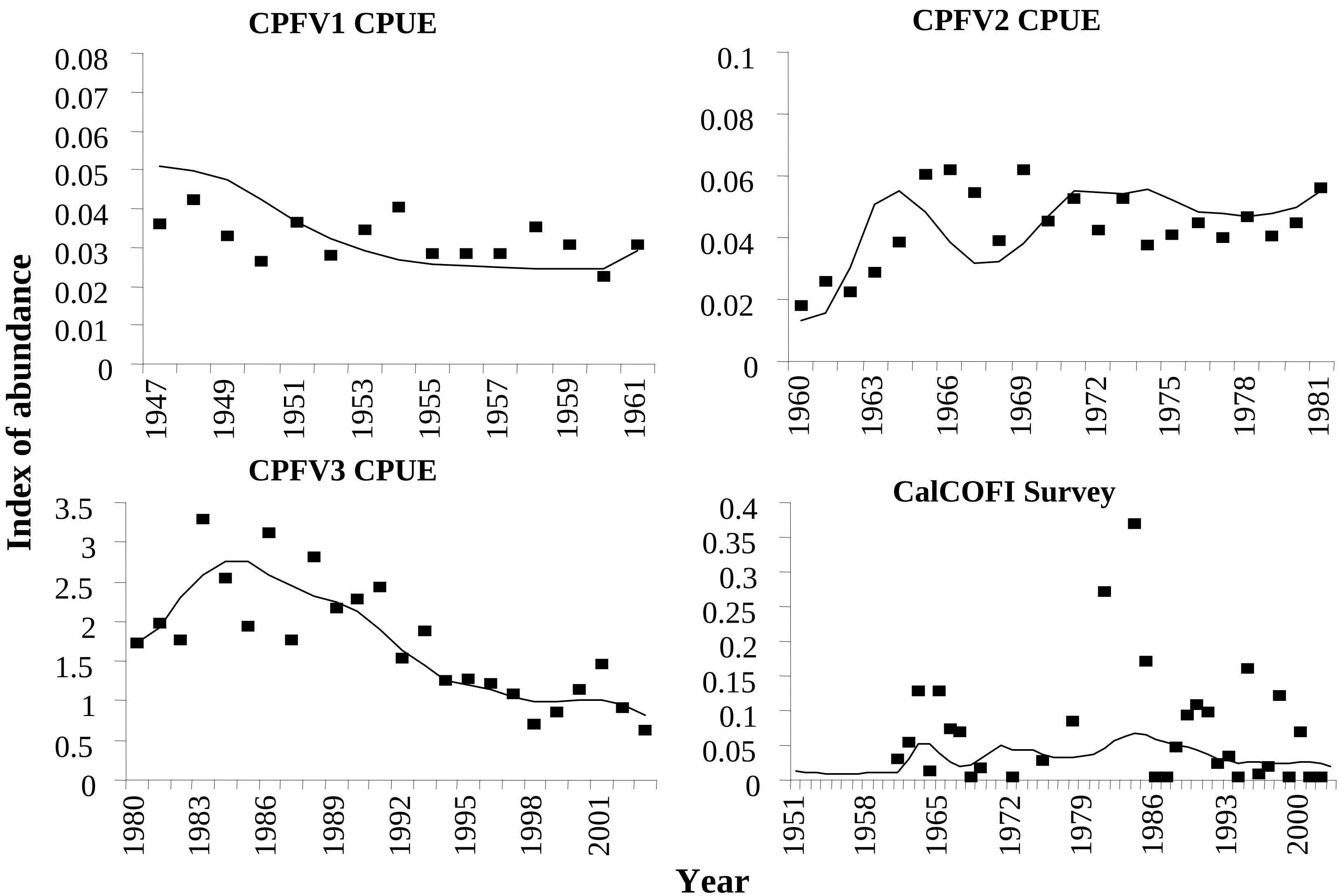


Figure 8.8 The estimated (solid line) and observed (black squares) abundance indices for the final Synthesis model when M=0.3.

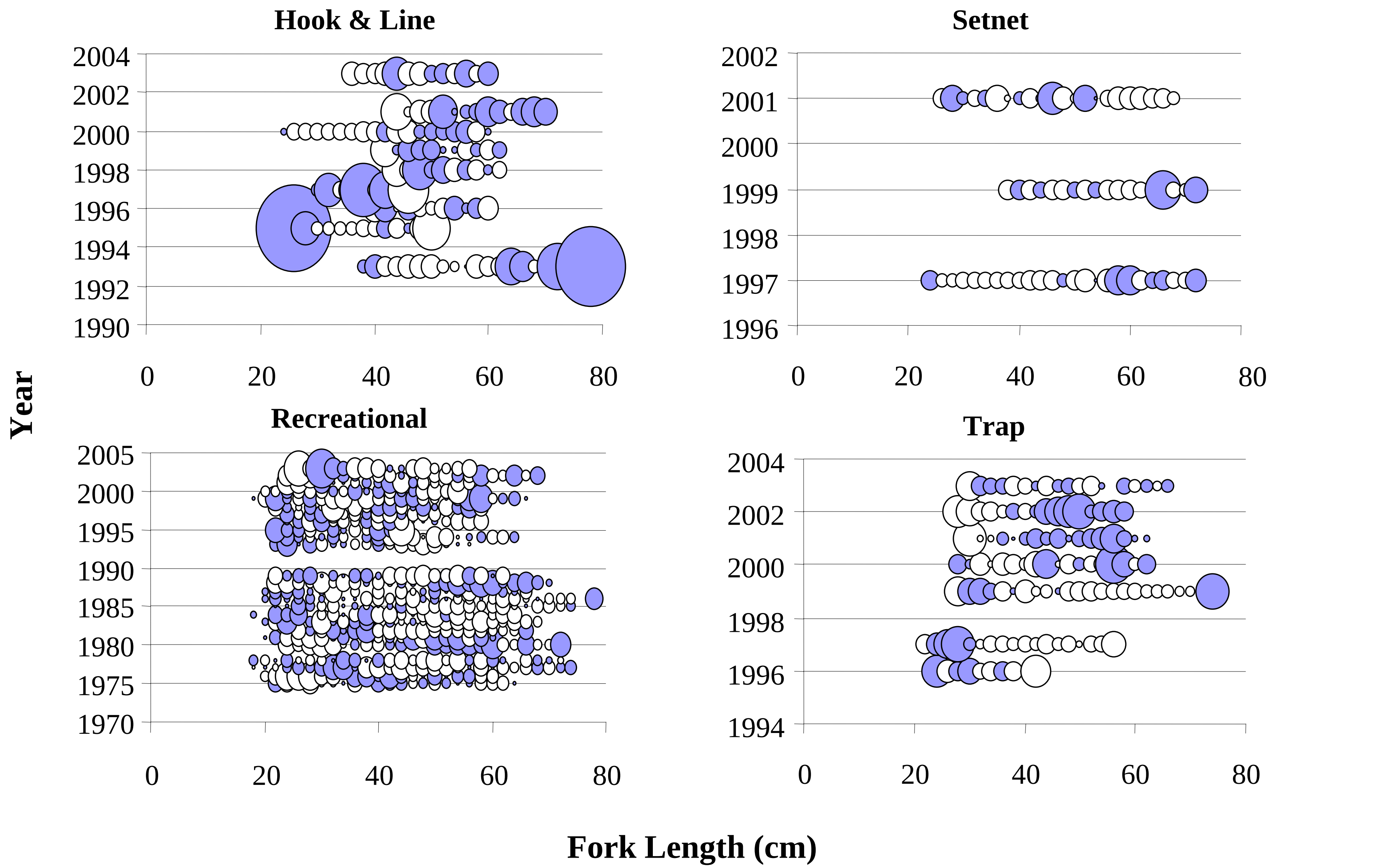


Figure 8.9 Bubble plots representing the fit between the observed and estimated length compositions for the final Synthesis model when M=0.2. However, alternative estimates of natural mortality (M=0.15 and 0.3) lead to identical patterns. The area of the circle indicates the deviation between the observed and estimated values. Filled circles represent a positive deviation and empty circles represent a negative deviation.

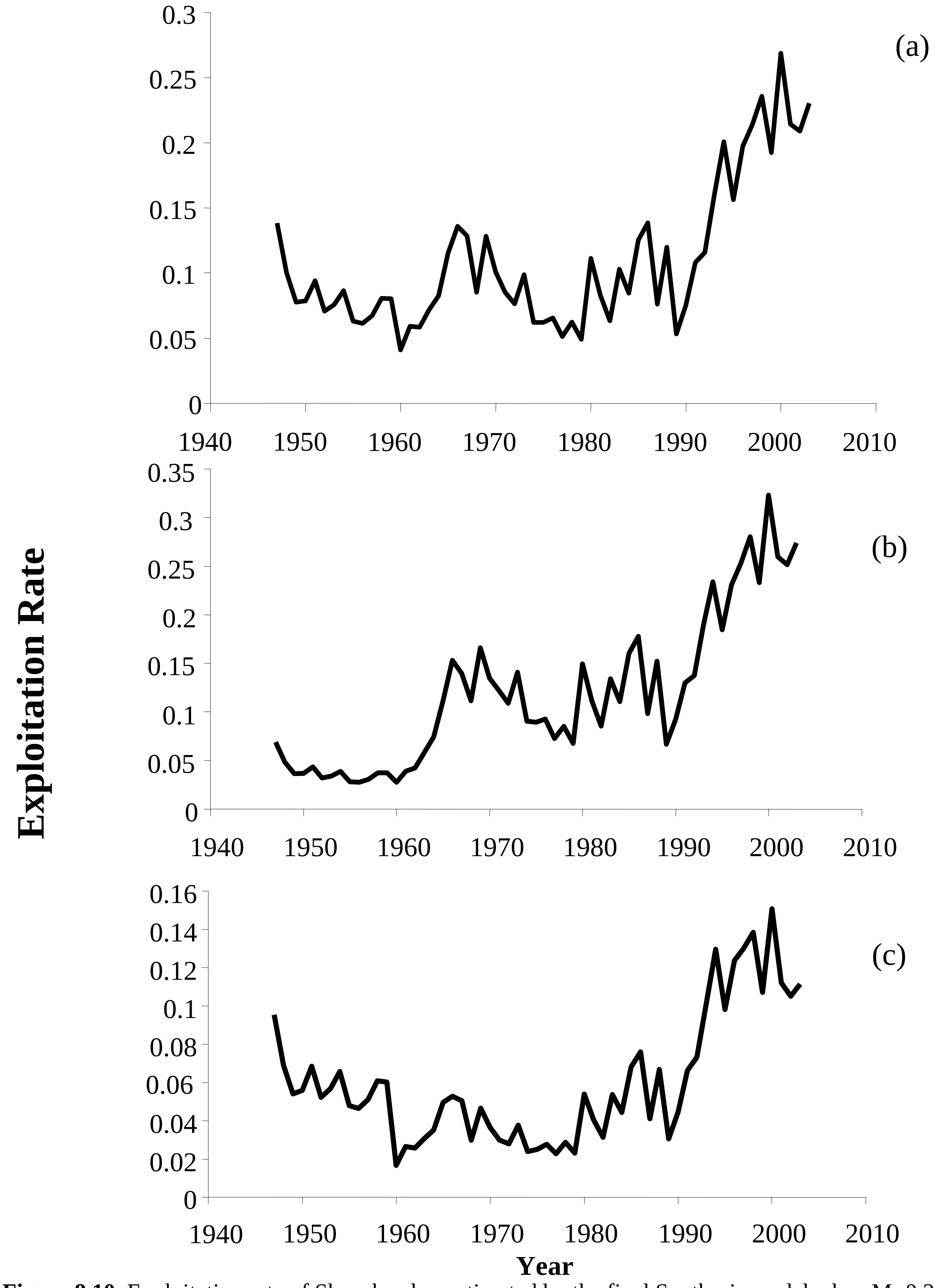


Figure 8.10 Exploitation rate of Sheephead as estimated by the final Synthesis model when M=0.20 (a), M=0.15 (b), and M=0.30 (c).

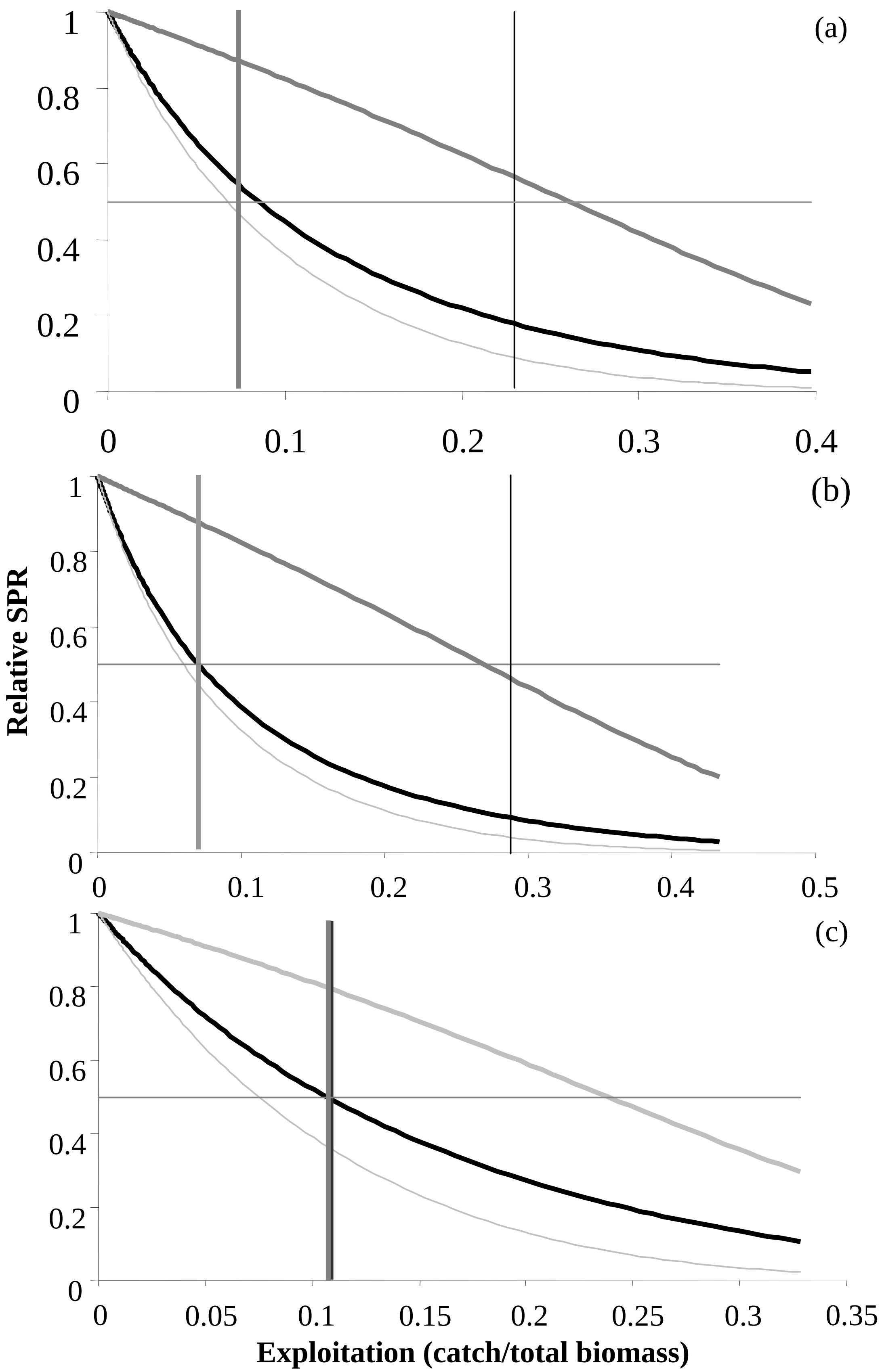


Figure 8.11 Relative spawning potential ratio (SPR) for female (upper curve), mature (middle curve), and male (lower curve) biomass based on the final model when M=0.2 (a), M=0.15 (b), and M=0.30 (c). Current exploitations are shown with the vertical thin black line, target exploitations are shown with the vertical solid grey line, and target levels are shown by the horizontal grey line.

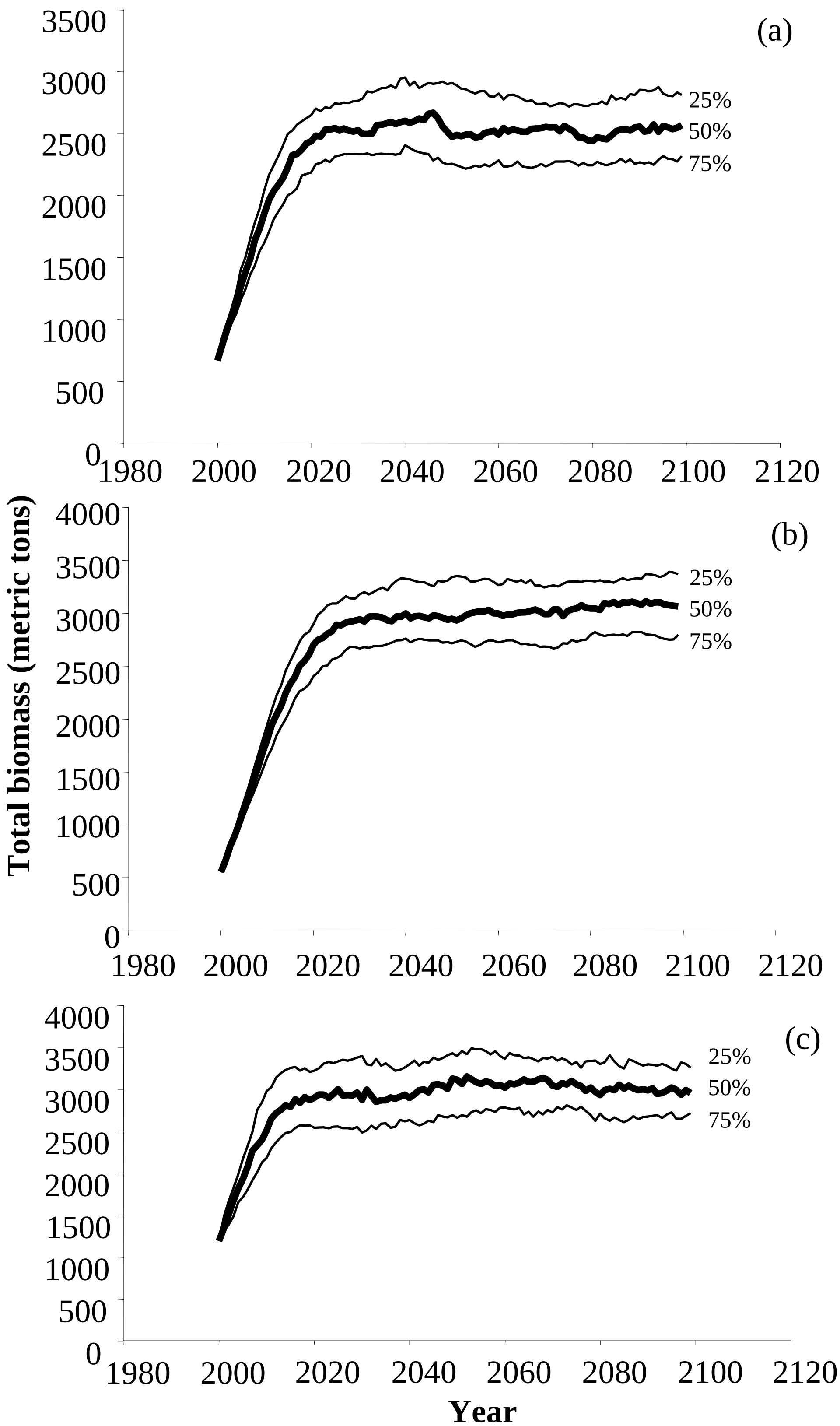


Figure 8.12 Projections of the 25th, 50th and 75th percentiles for projected total biomass when fishing mortality is zero for M=0.20 (a), M=0.15 (b), and M=0.30 (c). The results presented here are based on 100 projections for 100 years in the absence of fishing assuming that recruitment is selected randomly from model estimated recruitment from 1970-1995.

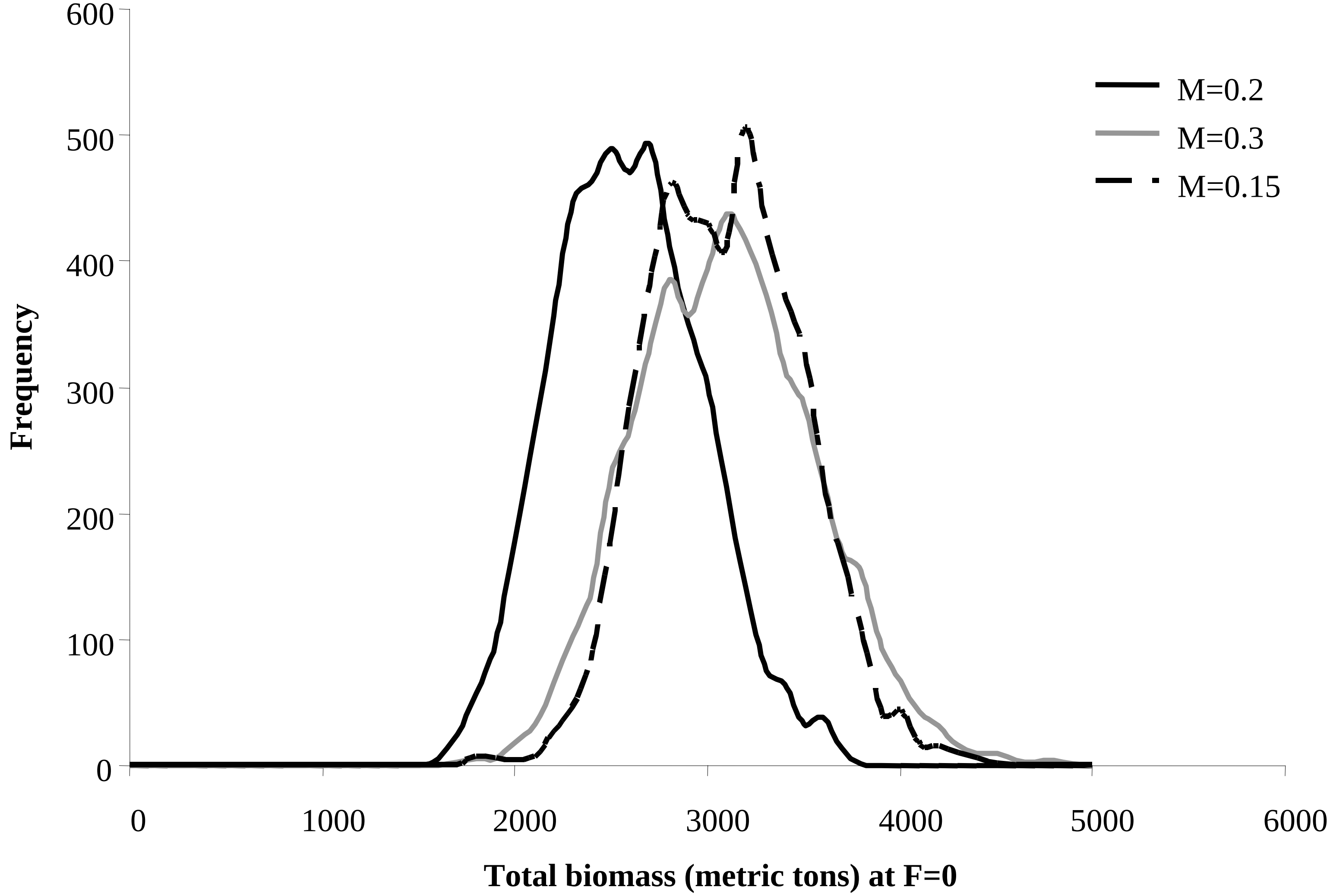


Figure 8.13 Expected frequency distributions of future total biomass (for the final model) in the absence of fishing if M=0.2. The distribution of total biomass is based on projections over 50 years after having allowed the projections to stabilize for 50 years. The results presented here are based on 100 projections for 100 years assuming that recruitment is selected randomly from model estimated recruitment from 1970-1995.

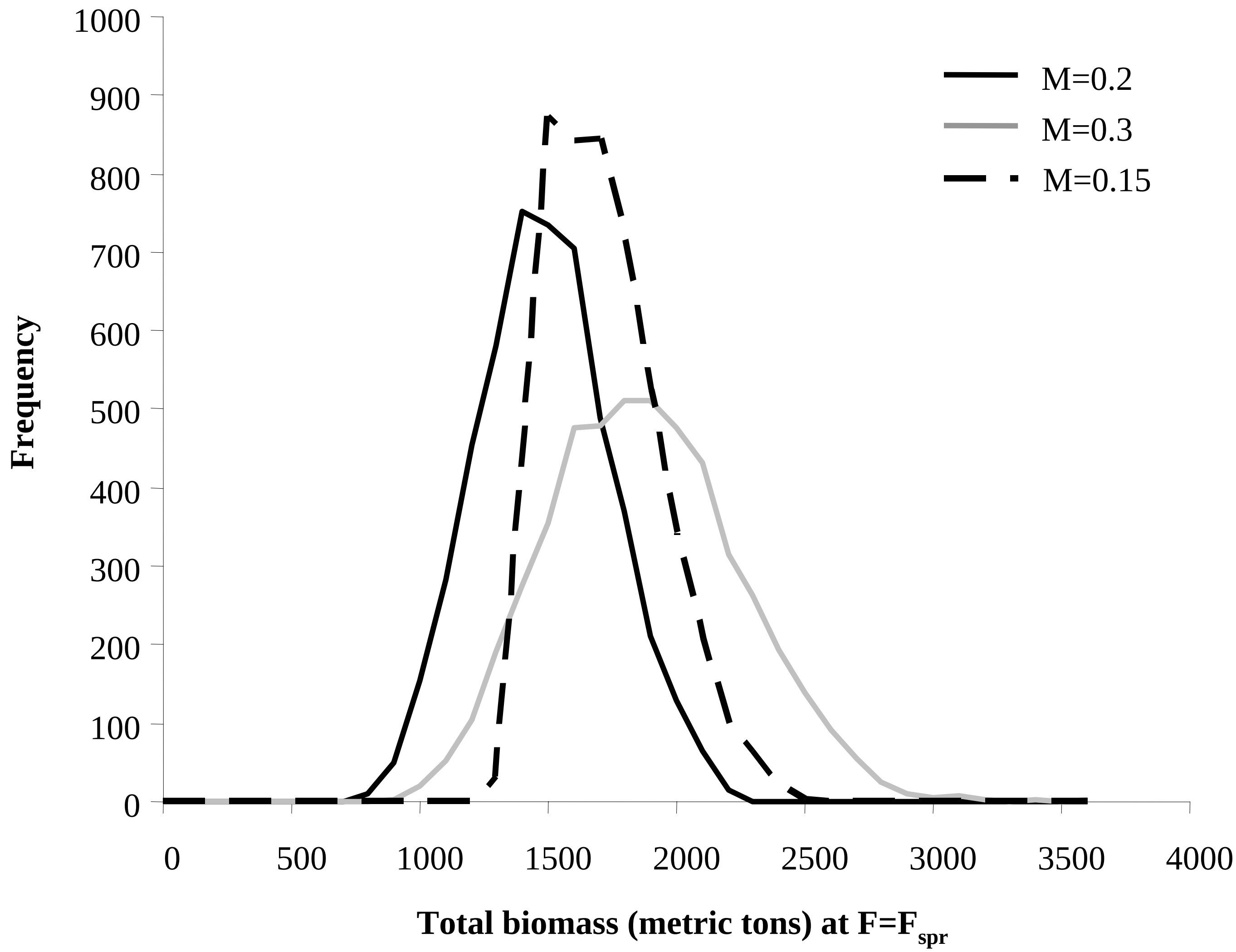


Figure 8.14 Expected frequency distributions of future total biomass (for the final model) when future fishing mortality adopts the 60/20 plan outlined by the NFMP and is set at the target level which allows the spawning potential ratio based on mature biomass to be reduced to 50% of the estimated unfished situation (CDFG 2002). The distribution of total biomass is based on projections over 50 years after having allowed the projections to stabilize for 50 years. The results presented here are based on 100 projections for 100 years assuming that recruitment is selected randomly from model estimated recruitment from 1970-1995.

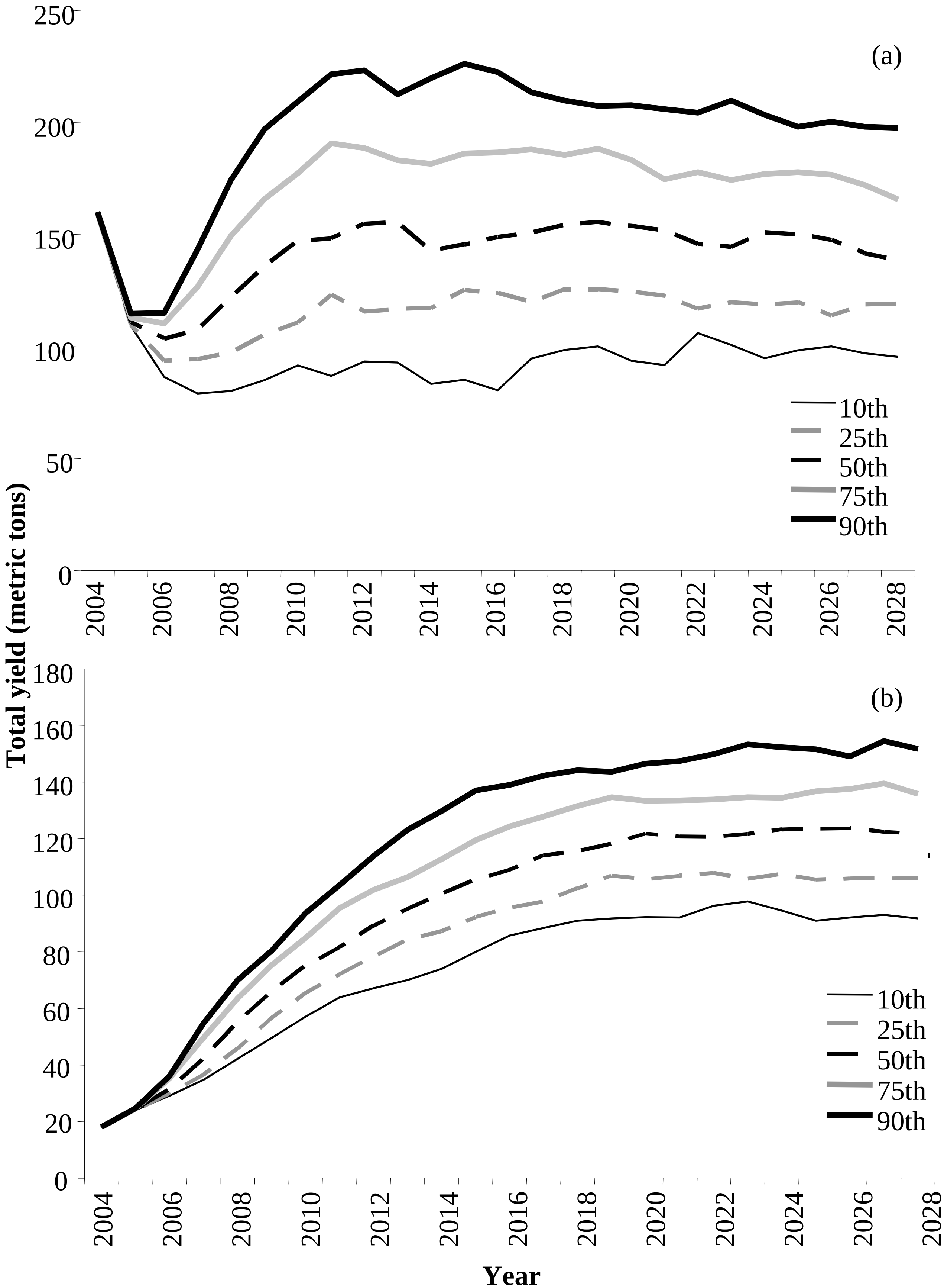


Figure 8.15 Allowable catch under NFMP 60/20 policy (CDFG 2002) for California Sheephead for the final model when M=0.2 for females only (a) and the total mature population (b). Projection assumptions are the same as described in Figure 8.13.

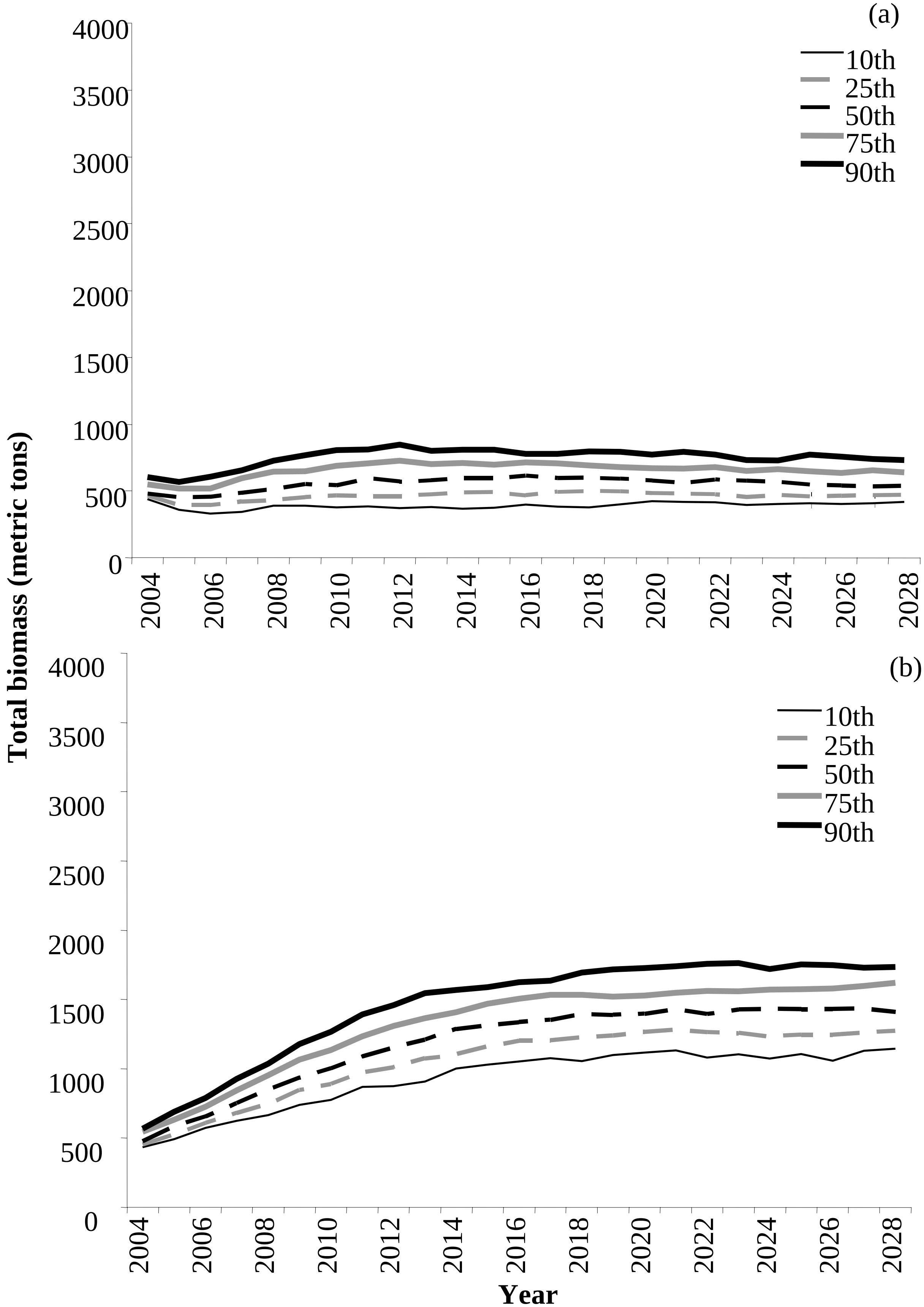
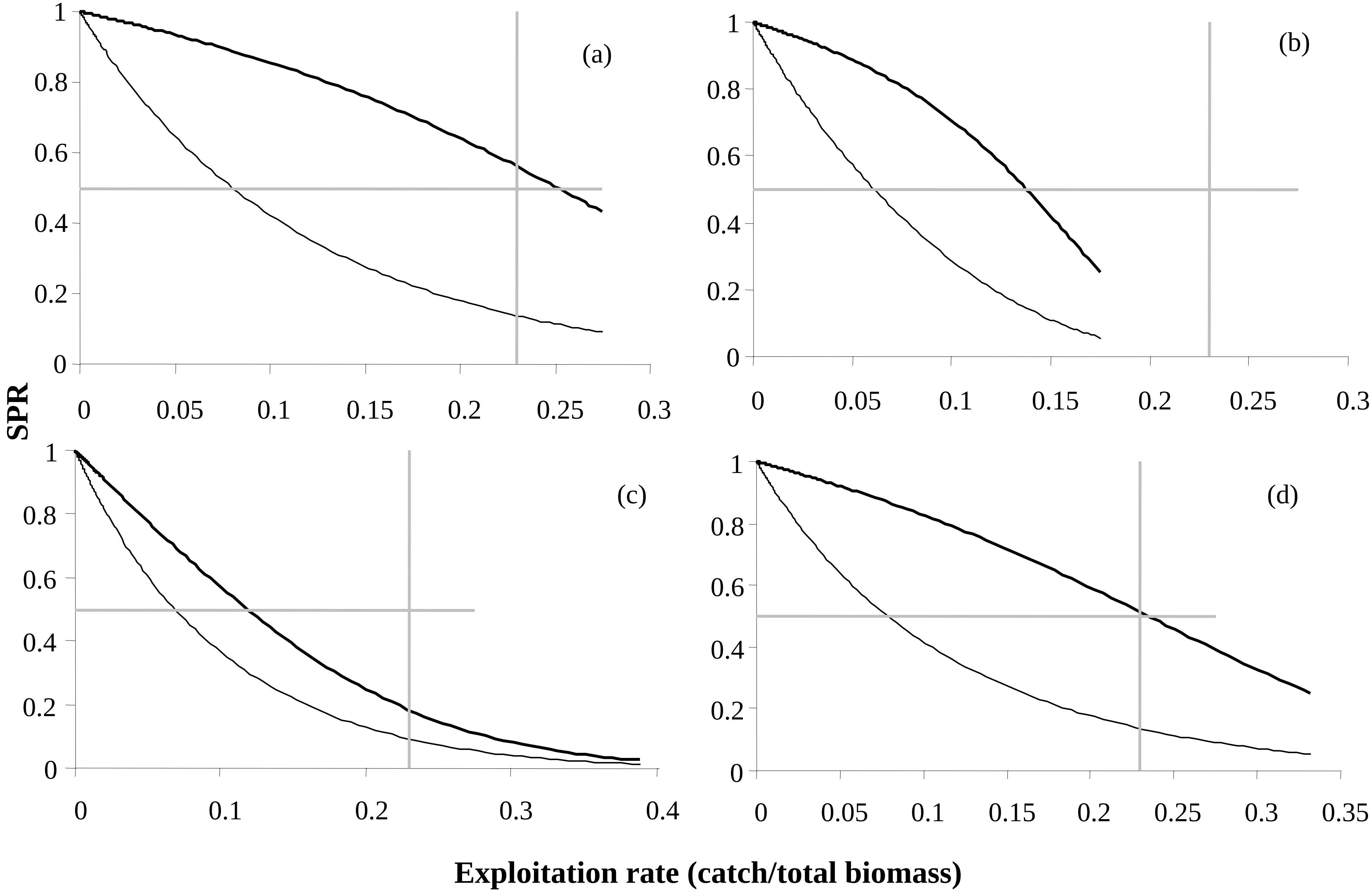


Figure 8.16 Projected population bioamass under NFMP 60/20 policy (CDFG 2002) for California Sheephead for the final model when M=0.2 for females only (a) and the total mature population (b). Projection assumptions are the same as described in Figure 8.13.



8.17 Relative SPR with life history characteristics for Cabo Thurloe (a), San Benitos Island (b), San Nicolas Island (c), and Catalina Island (d). The upper curve is female biomass, the lower curve is mature biomass, the vertical line is an estimate for current exploitation and the horizontal line is 0.50 relative SPR.