

# Age-structured model for swordfish in the Indian Ocean

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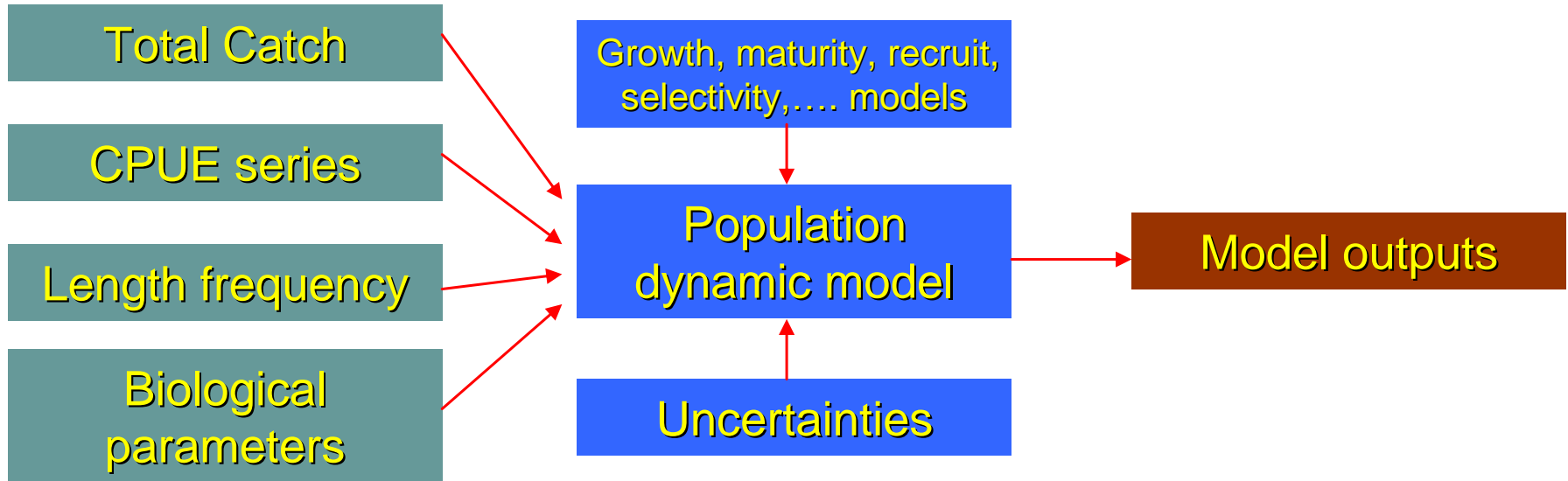


# Age-structured model



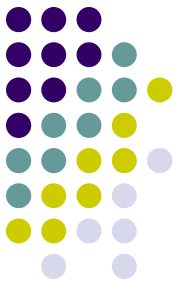
- Due to absence of sex-specific information, an age-structured assessment model without sex factor was conducted for evaluating the population status of the swordfish in the Indian Ocean.
- The model is modified based on the “Sex-specific age-structured model” conducted by Wang *et al.* (2005) and Wang *et al.* (2007).

# Age-structured model

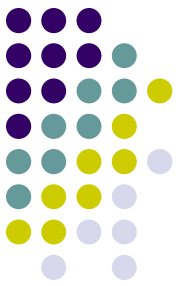


# Data used

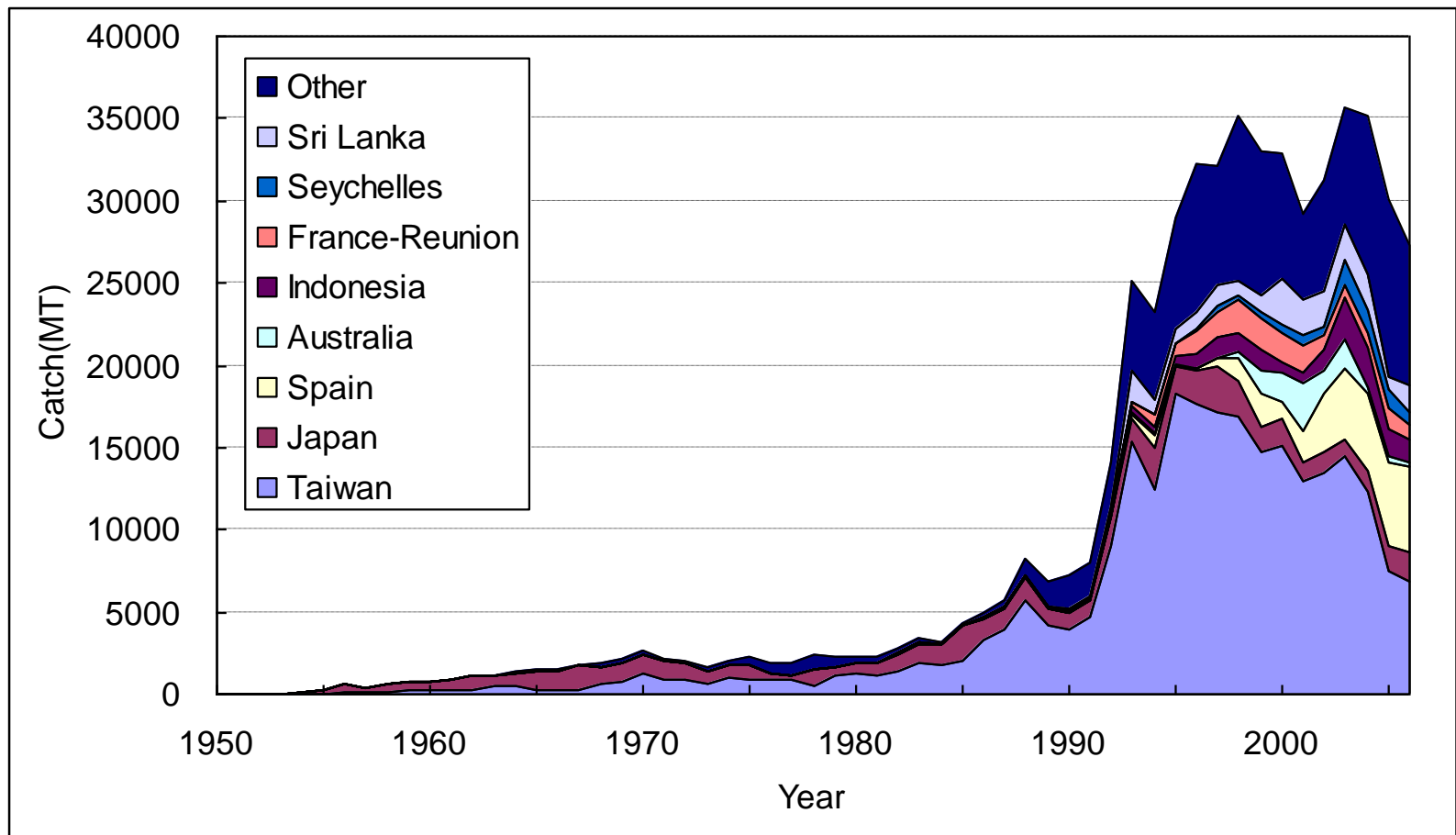
- Catch data
- Standardized CPUE
- Length frequency data
- Biological parameter



# Data used

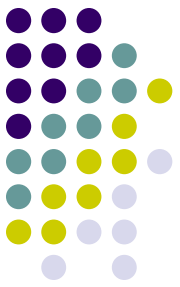


- Total Catch



Fleet	Gear	Code	Catch	Length Frequency	CPUE
Taiwan	Longline	TWNW	1954-2006 (number)	1980-2005	1980-2006
	Longline	TWSW	1954-2006 (number)	1980-2005	1980-2006
	Longline	TWNE	1954-2006 (number)	1980-2005	1980-2006
	Longline	TWSE	1954-2006 (number)	1980-2005	1980-2006
Japan	Longline	JPNW	1954-2006 (number)	1970-2004	1980-2006
	Longline	JPSW	1955-2006 (number)	1970-2004	1980-2006
	Longline	JPNE	1952-2006 (number)	1970-2001	1980-2006
	Longline	JPSE	1952-2006 (number)	1970-2004	1980-2006
Spain	Longline	SPNW	1993-2006 (number)	1993-2005	–
	Longline	SPSW	1994-2006 (number)	1994-2005	
	Longline	SPNE	1997-2006 (number)	1999-2005	
	Longline	SPSE	1997-2006 (number)	1998-2005	
Australia	Longline	AULL	1989-2006 (weight)	2000-2005	–
Indonesia	Longline	INDLL	1974-2006 (weight)	2002-2005	–
France- Reunion	Longline	REULL	1991-2006 (weight)	1997-2005	–
Seychelles	Longline	SYCLL	1995-2005 (weight)	1995-2005	–
Other	Other	OTHLL	1964-2005 (weight)	1998-2005	–
Sri Lanka	Gillnet	SLGN	1986-2005 (weight)	1988-2005	–





# Data used

- Biological parameters

(Poisson *et al.* (2001), Young *et al.* (2004), Ariz *et al.* (2006))

Parameter	Females	Males
Asymptotic size, $L_{\infty}$ ( cm )	323.4	260.47
95% C.I.	(57.39)	(46.22)
Growth parameter, K ( year <sup>-1</sup> )	0.08148	0.1096
95% C.I.	(0.0145)	(0.0194)
Age-at-zero-length, $a_0$ ( year )	-3.413	-3.3808
95% C.I.	(0.6056)	(0.5999)
Length-weight,A	1.839x10 <sup>-6</sup>	
Length-weight,B	3.3921	
Maturity slope, $r_m$	0.0953	
Length-at-50%-maturity, $L_m$ ( cm )	170.4	
Maximum age, $\lambda$ ( year )	15	15

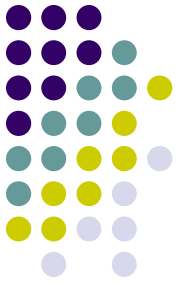


# Data used

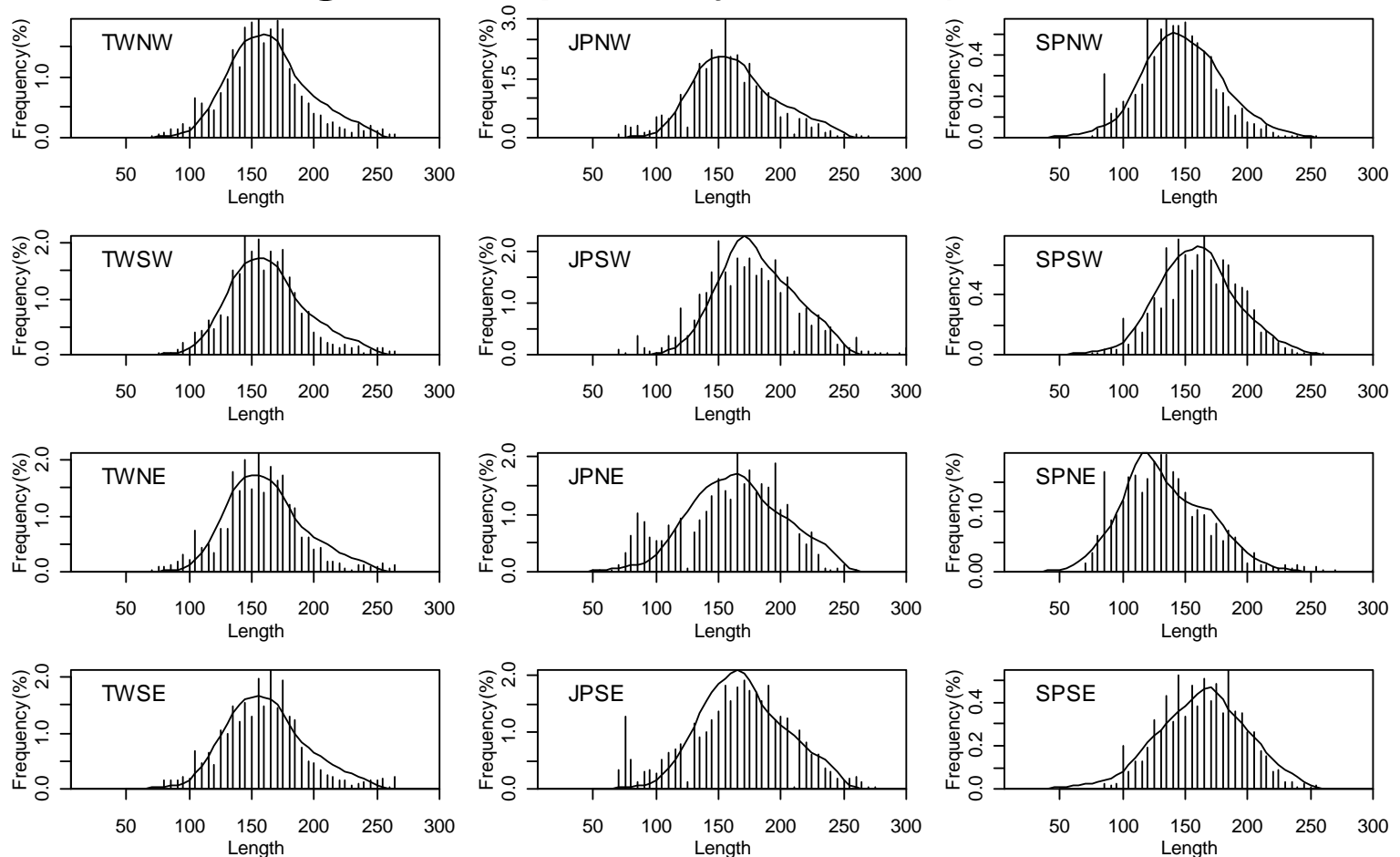
- Pre-specified parameters
  - Base-Case
    - Natural mortality ( $M$ ) = 0.25
    - Steepness ( $h$ ) = 0.9
    - Variation in recruitment ( $\sigma_v$ ) = 0.4



# Results



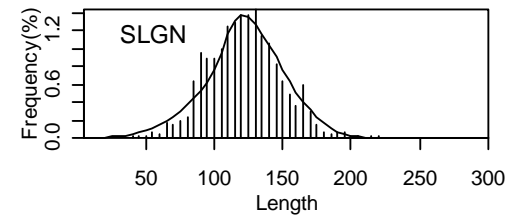
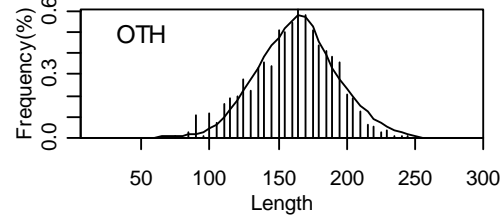
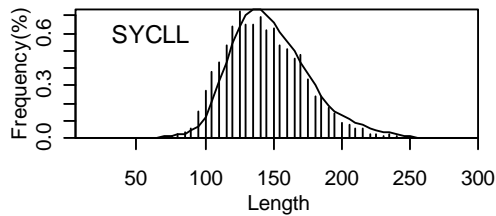
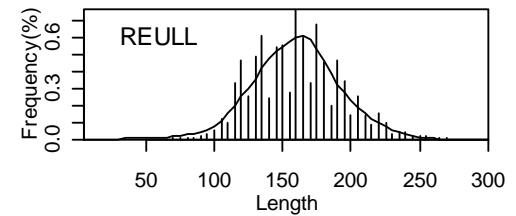
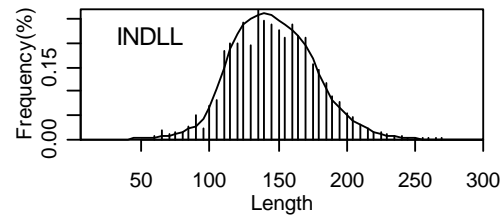
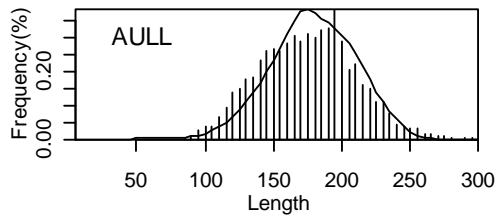
- Fits of length frequency data (Base-Case)



# Results



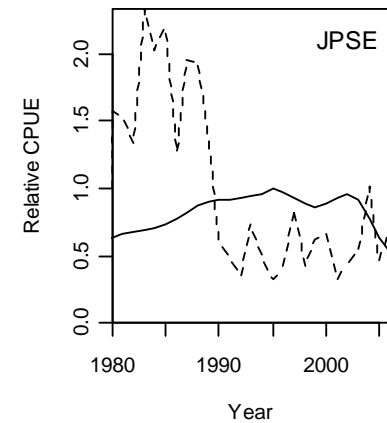
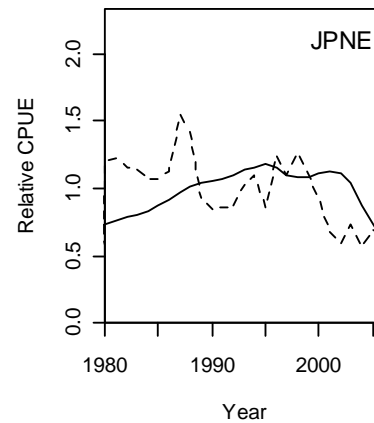
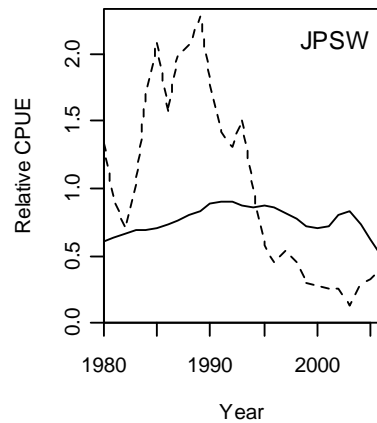
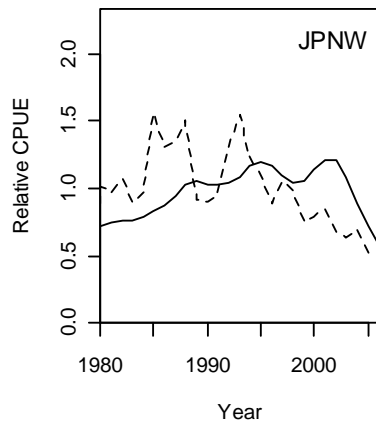
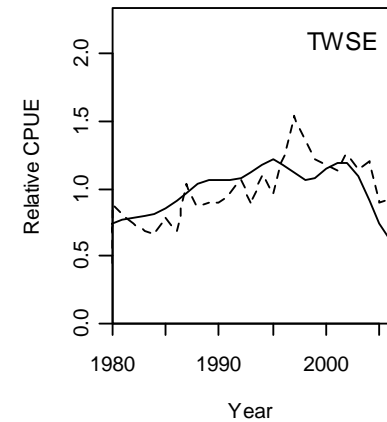
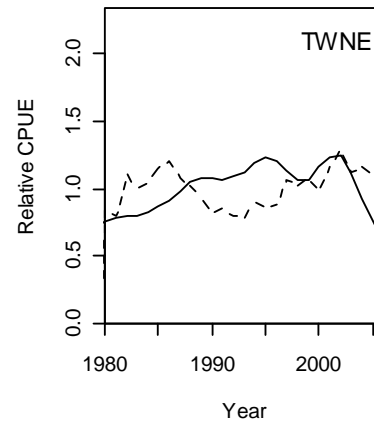
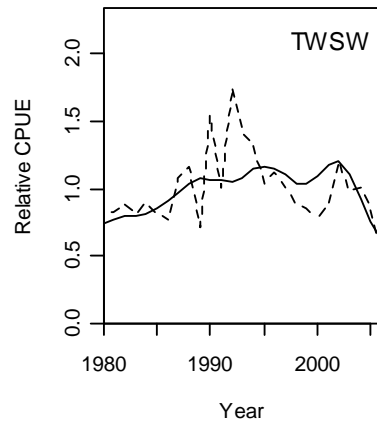
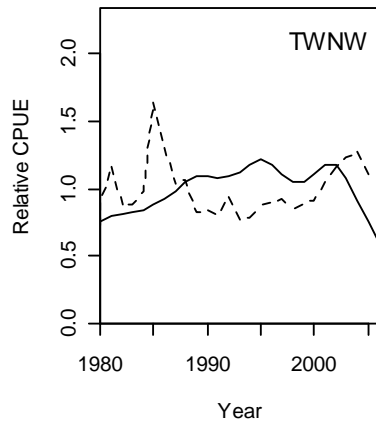
- Fits of length frequency data (Base-Case)



# Results



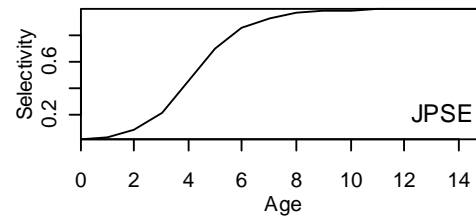
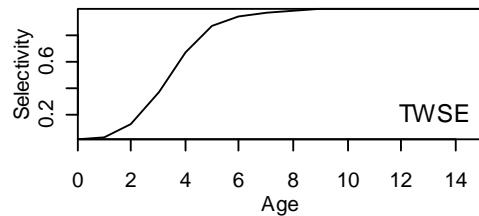
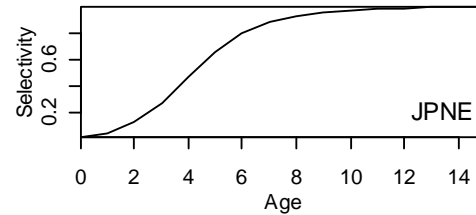
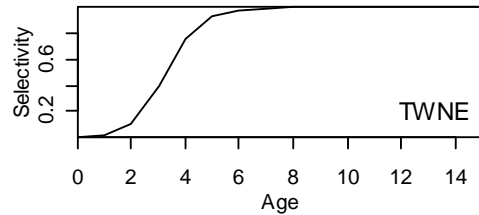
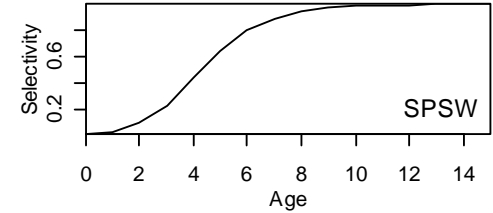
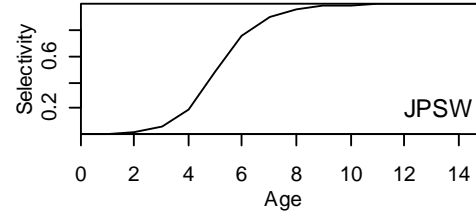
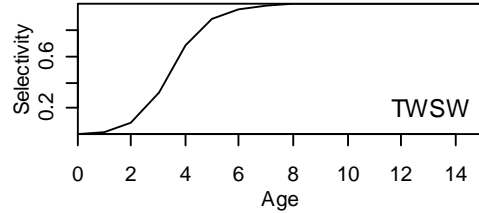
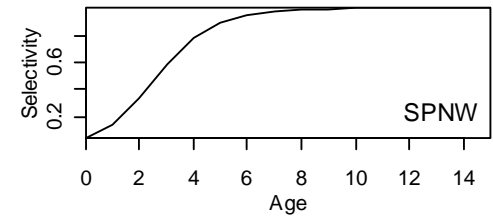
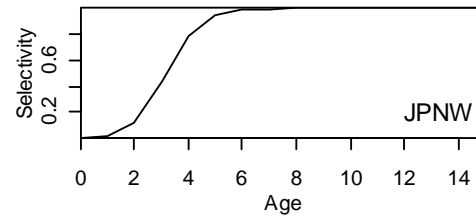
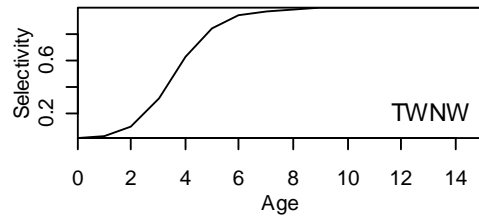
- Fits of CPUE (Base-Case)



# Results



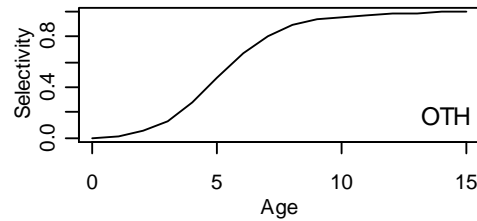
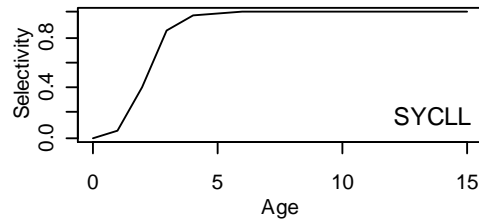
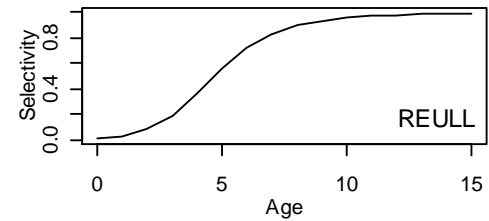
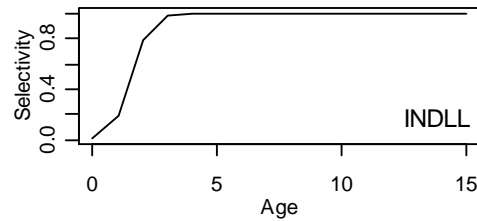
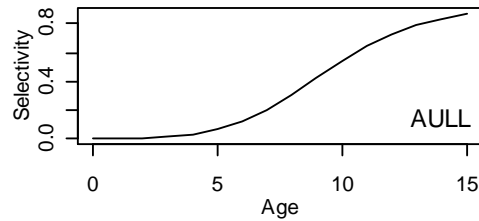
- Estimated selectivity (Base-Case)



# Results



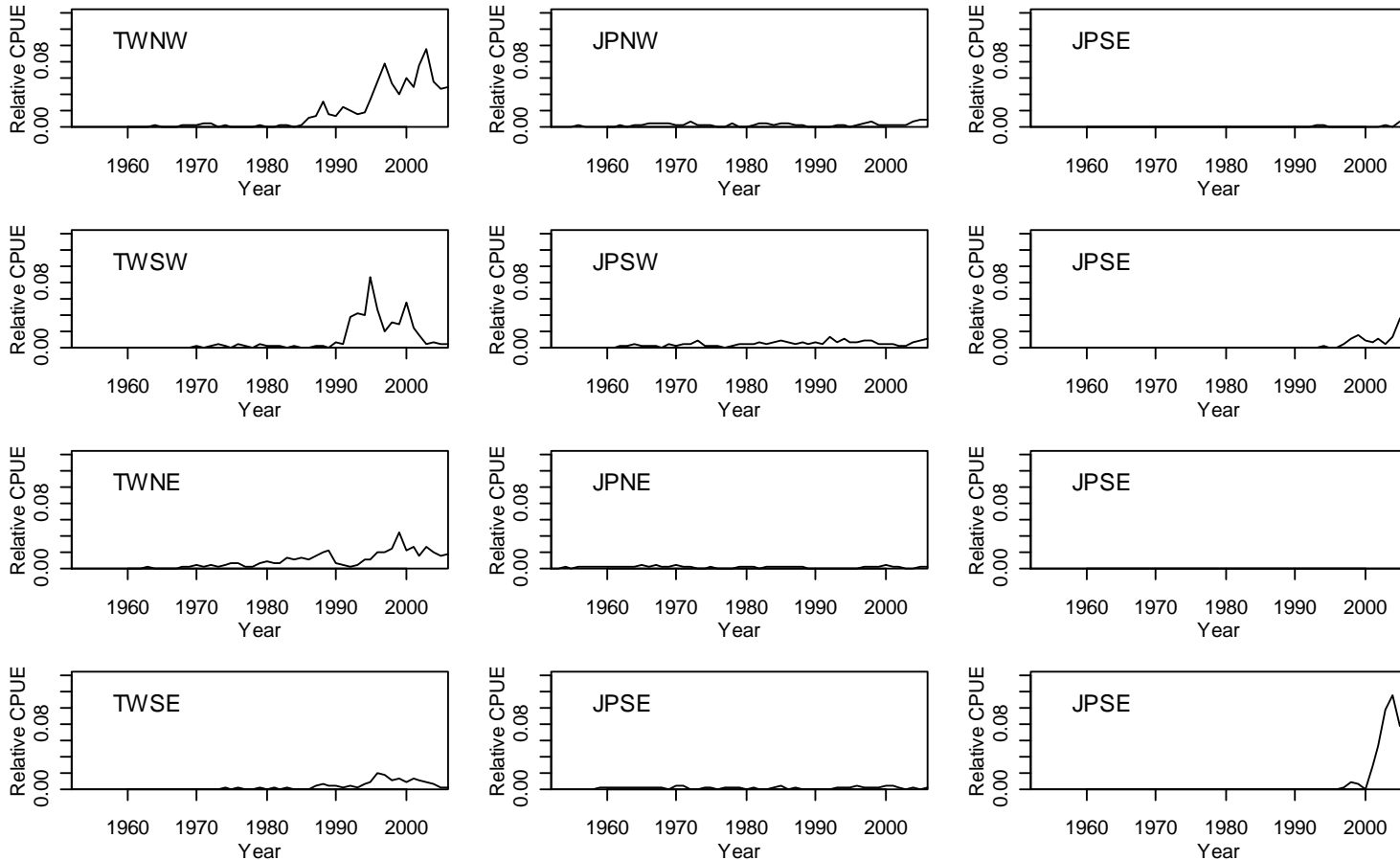
- Estimated selectivity (Base-Case)



# Results



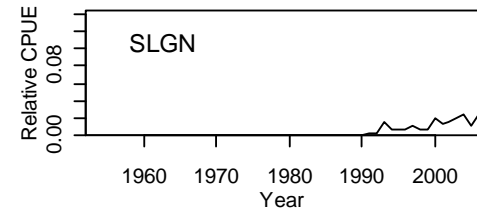
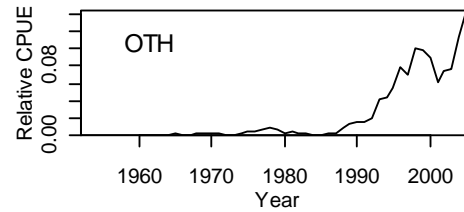
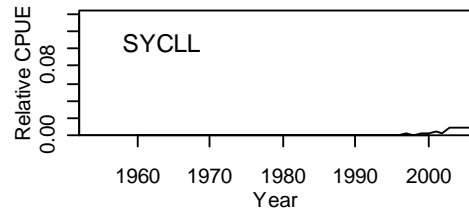
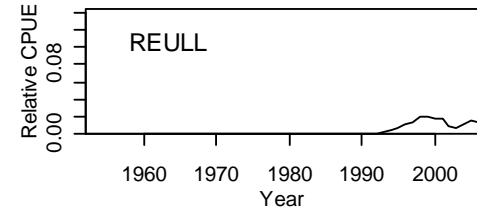
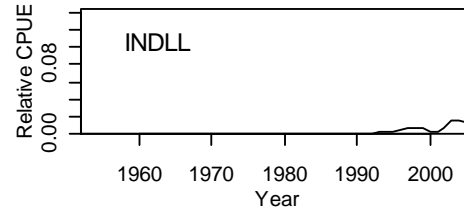
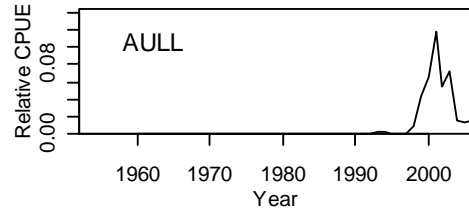
- Estimated exploitation rate (Base-Case)



# Results



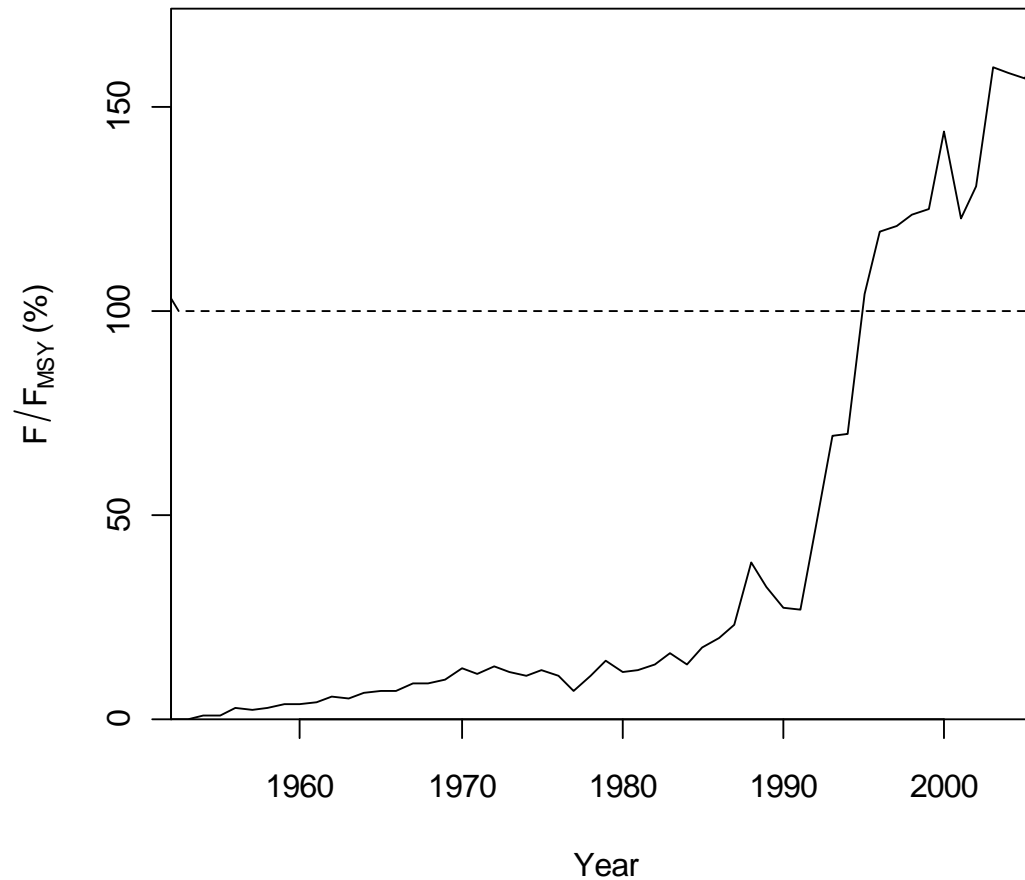
- Estimated exploitation rate (Base-Case)



# Results

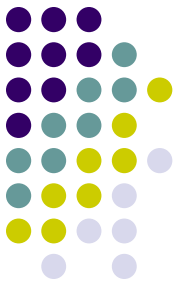


- Exploitation rate ( $F/F_{MSY}$ ) (Base-Case)

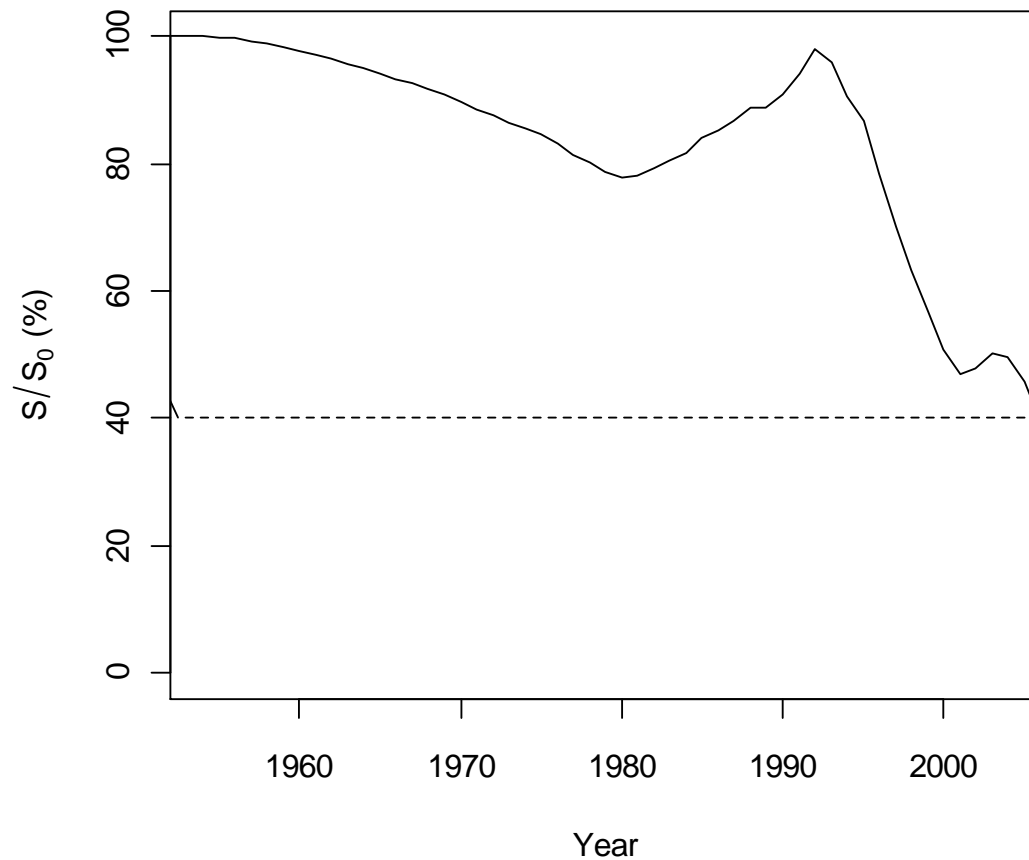




# Results



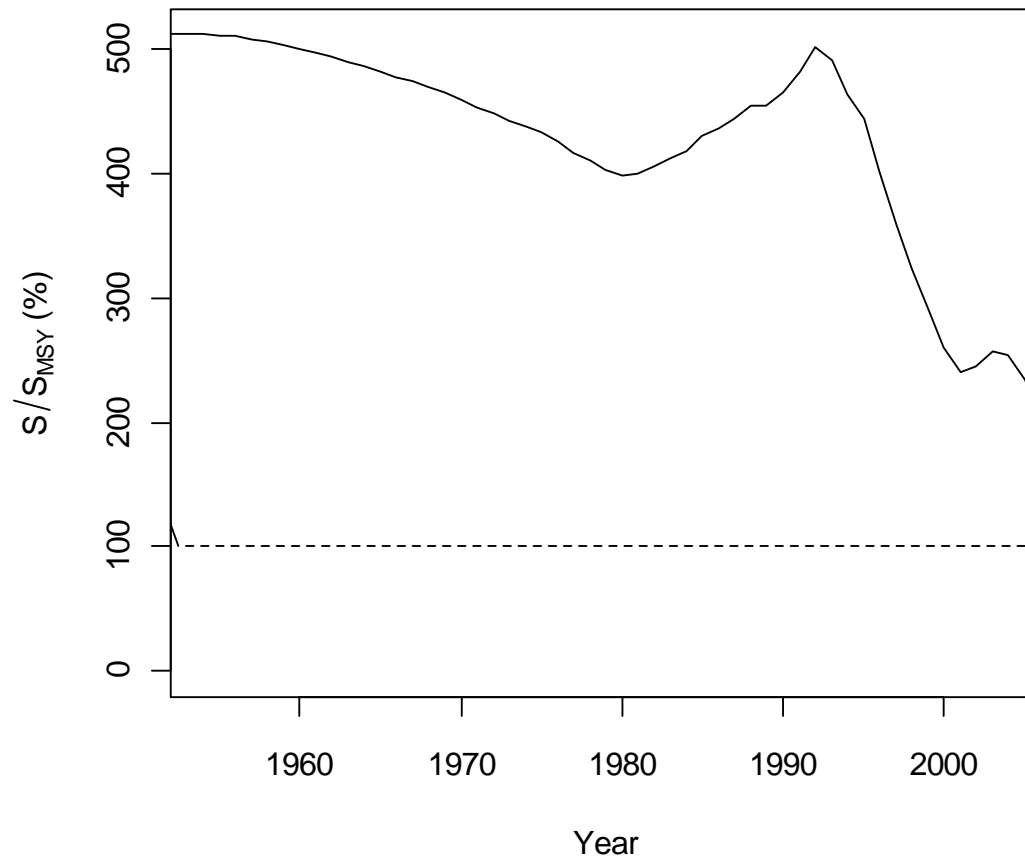
- Spawning biomass ( $S/S_0$ ) (Base-Case)



# Results



- Spawning biomass ( $S/S_{MSY}$ ) (Base-Case)



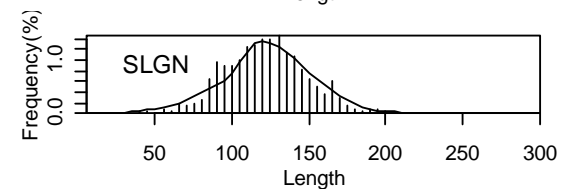
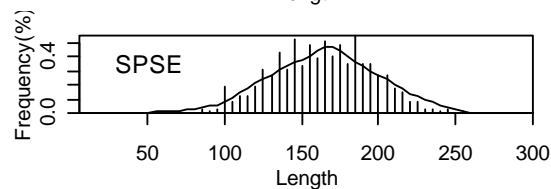
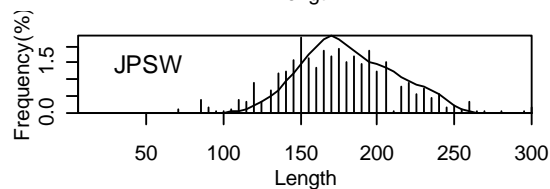
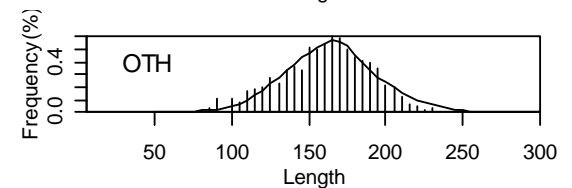
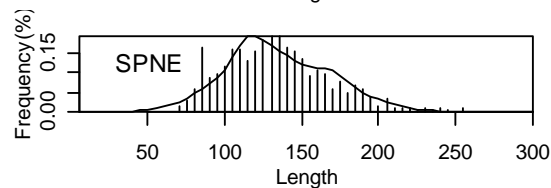
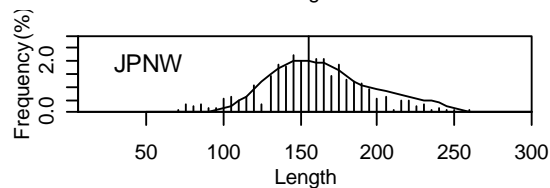
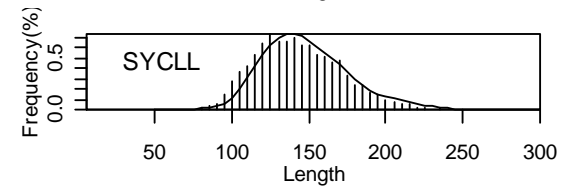
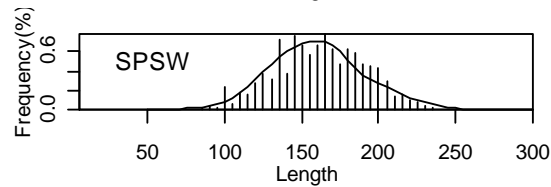
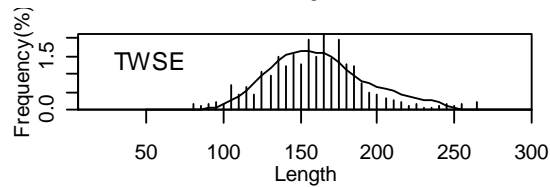
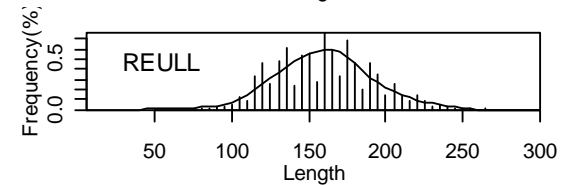
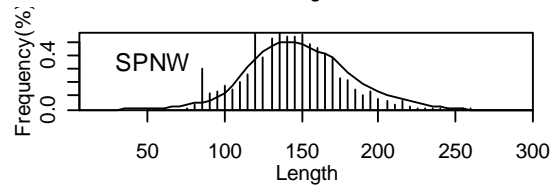
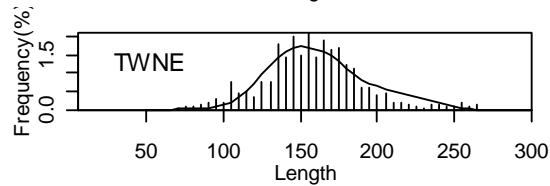
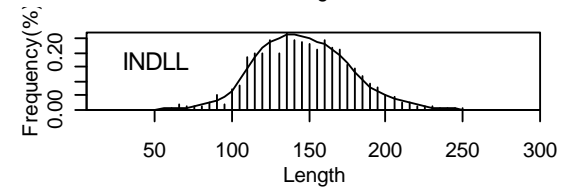
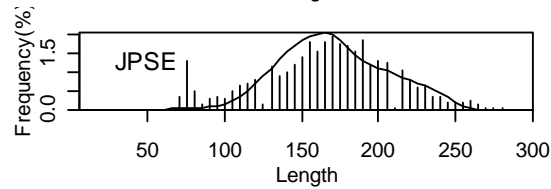
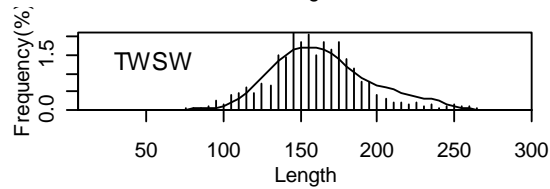
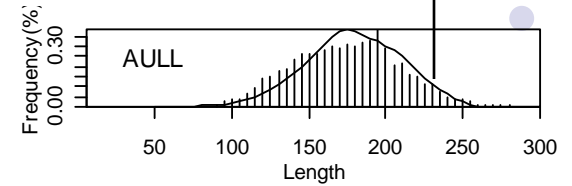
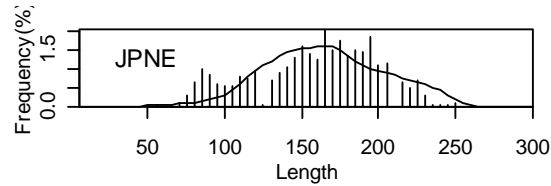
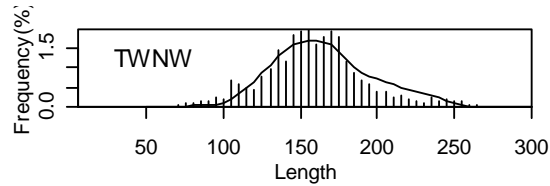
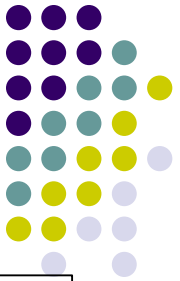
# Results



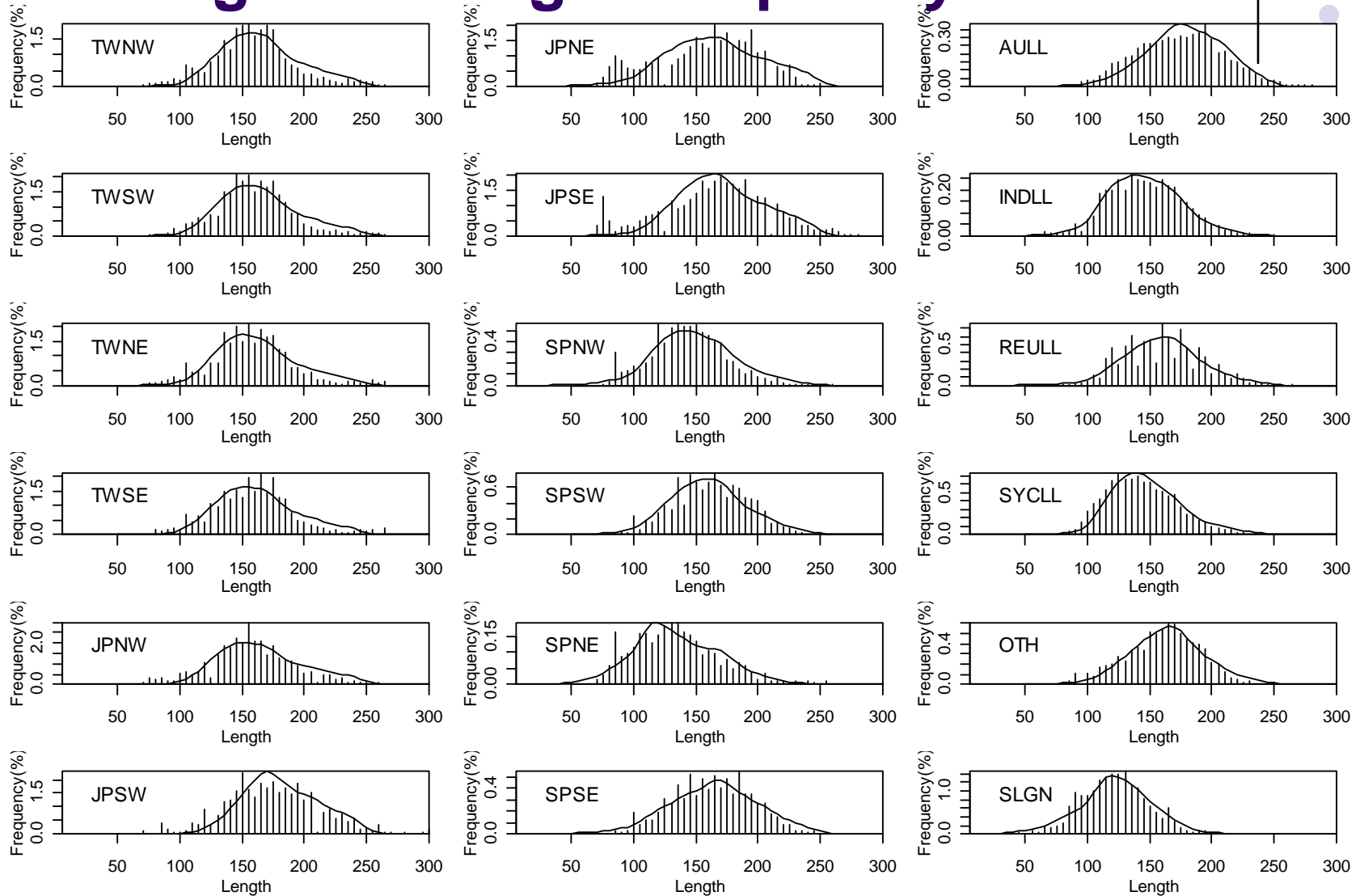
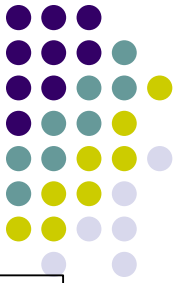
- Sensitivity analyses

	$S_{2006}/S_0$	$S_{2006}/S_{MSY}$	$F_{2006}/F_{MSY}$
Base-case	0.40	2.03	1.74
<i>M</i>			
0.2	0.32	1.53	3.13
0.3	0.48	2.61	1.08
<i>h</i>			
0.6	0.41	1.29	3.40
0.8	0.40	1.65	2.21
0.95	0.40	2.41	1.49
$\sigma_v$			
0.2	0.30	1.51	1.59
0.6	0.50	2.57	1.81

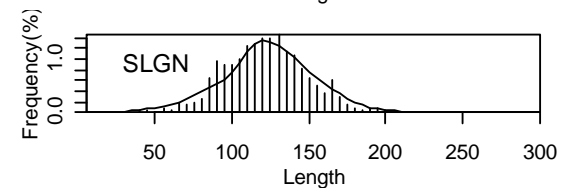
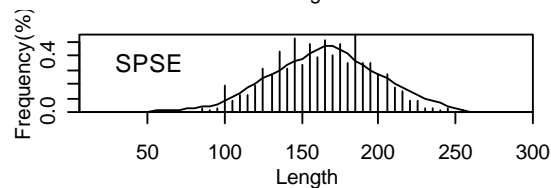
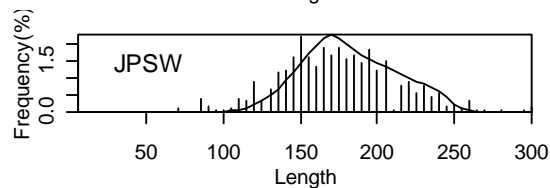
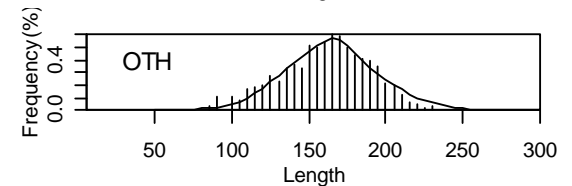
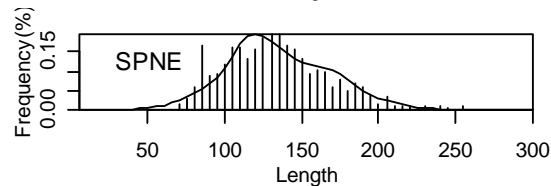
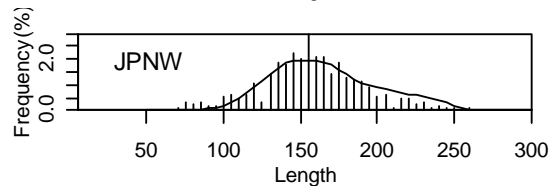
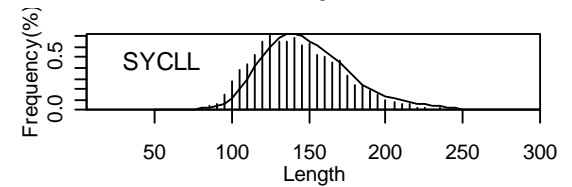
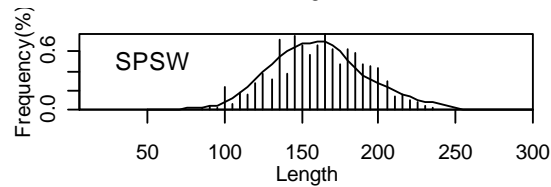
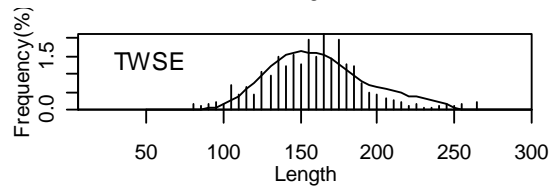
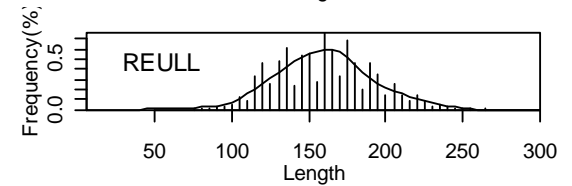
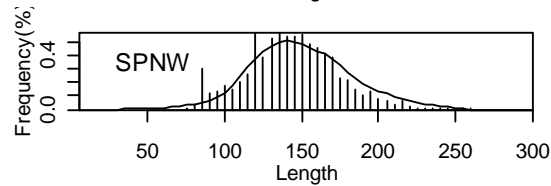
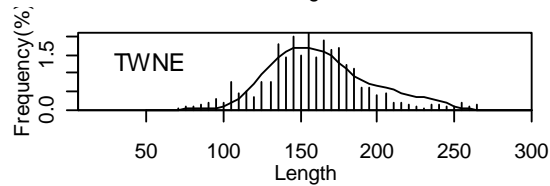
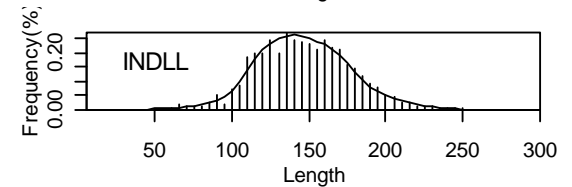
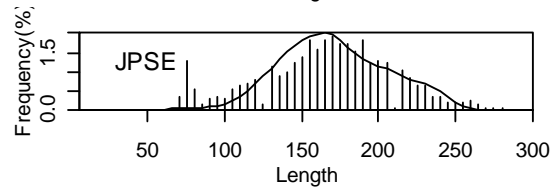
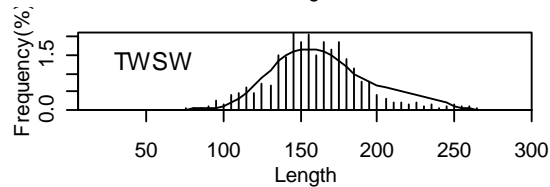
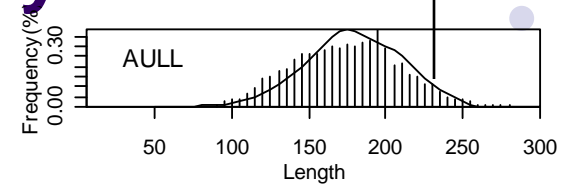
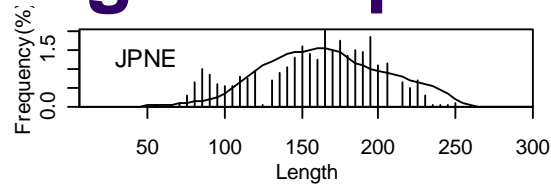
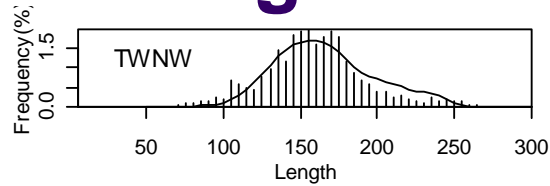
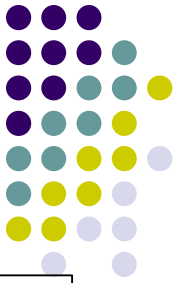
# Base-Case



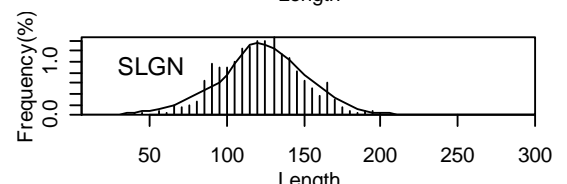
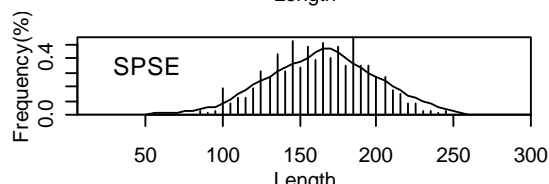
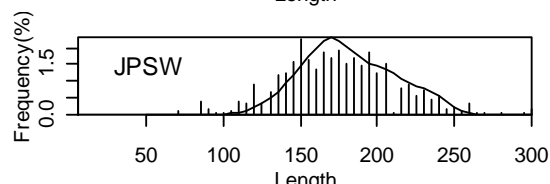
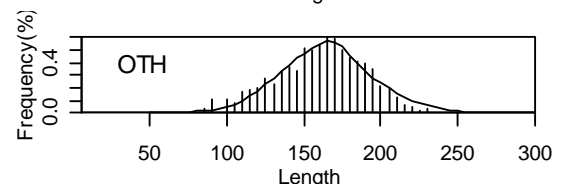
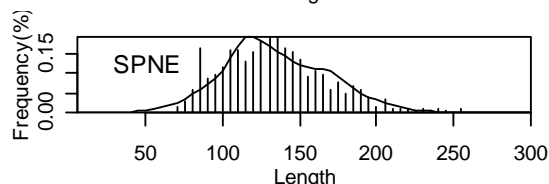
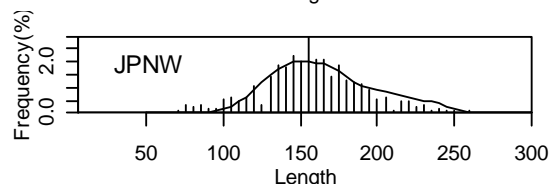
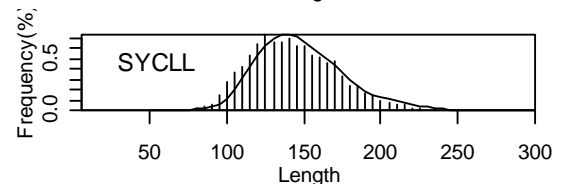
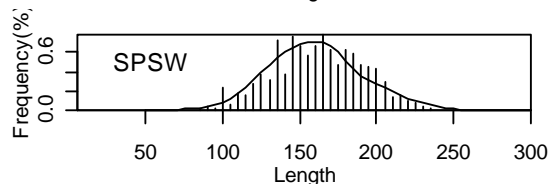
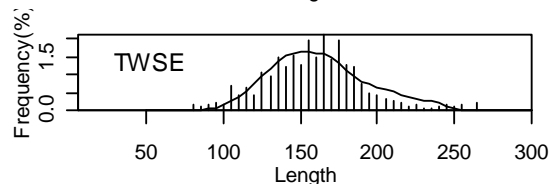
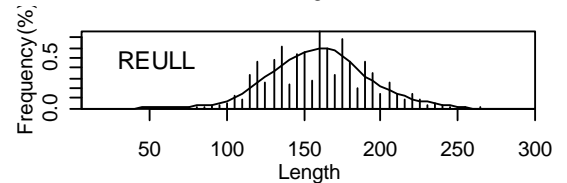
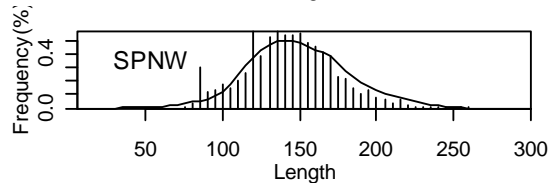
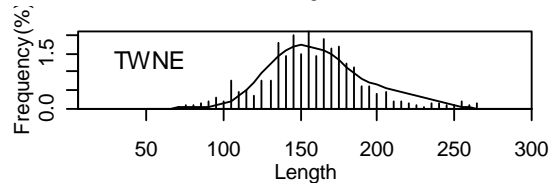
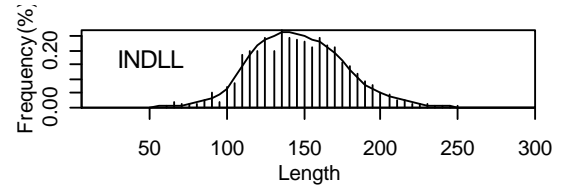
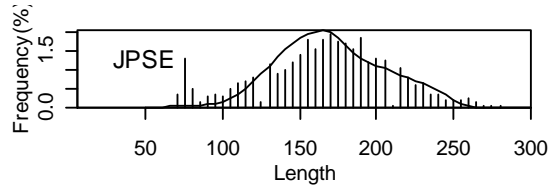
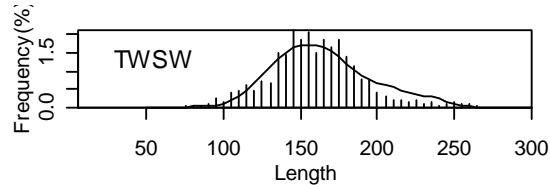
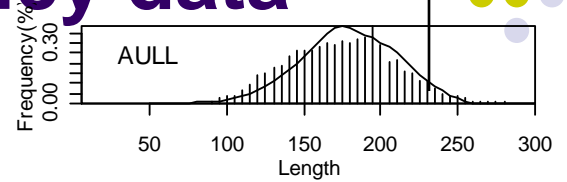
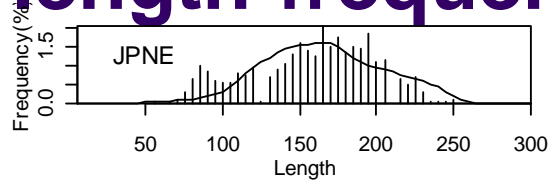
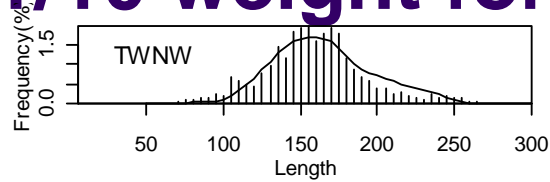
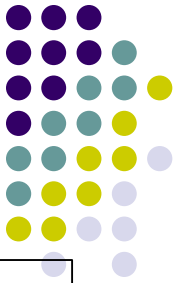
# 1/2 weight for length-frequency data



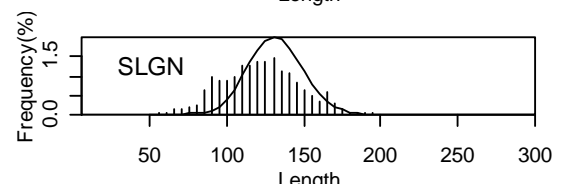
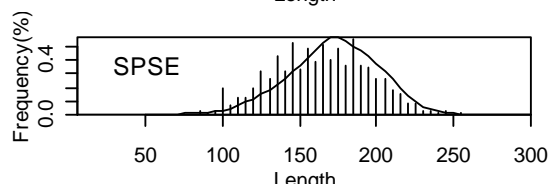
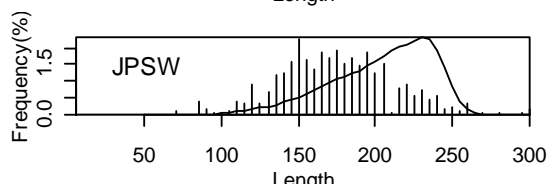
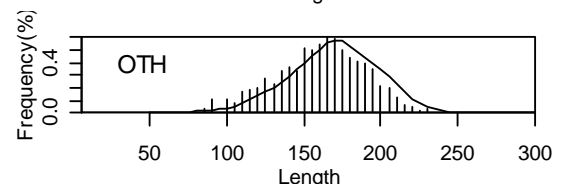
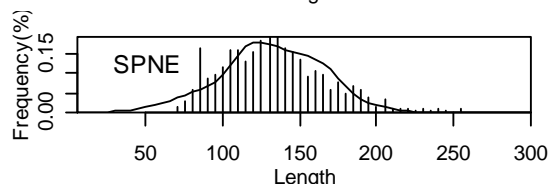
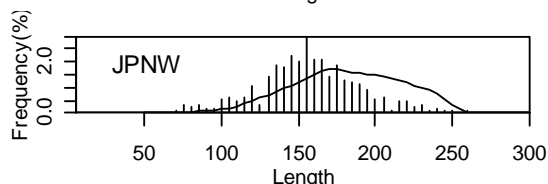
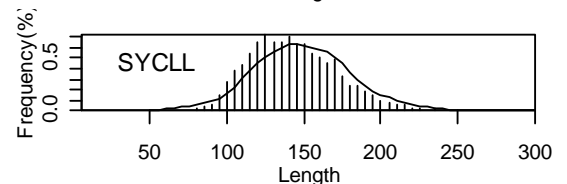
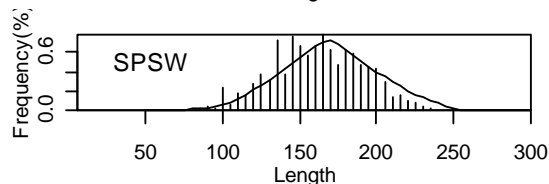
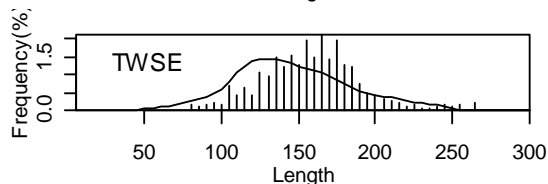
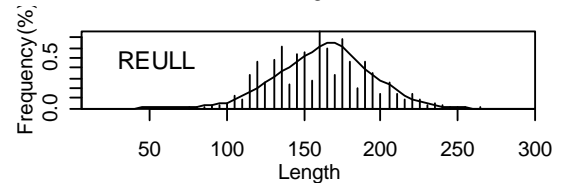
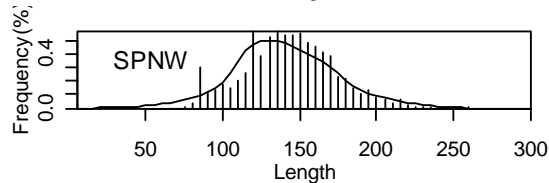
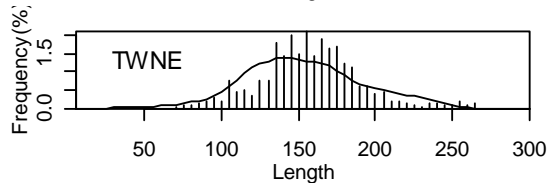
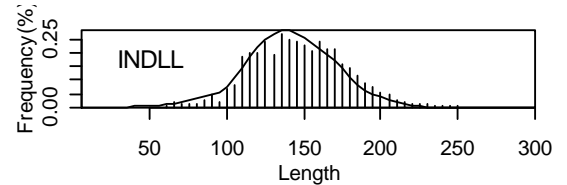
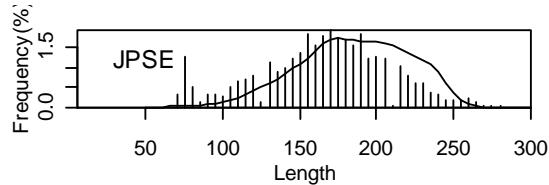
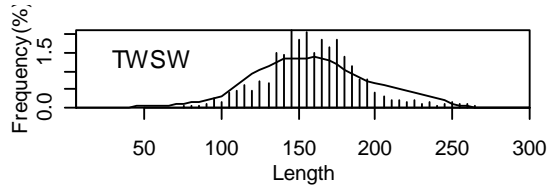
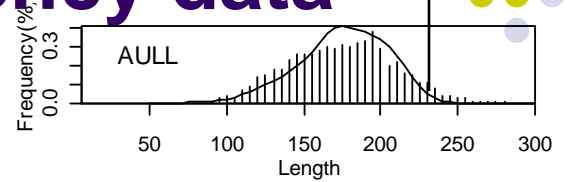
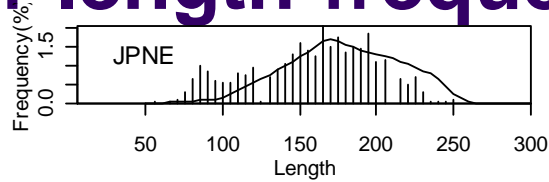
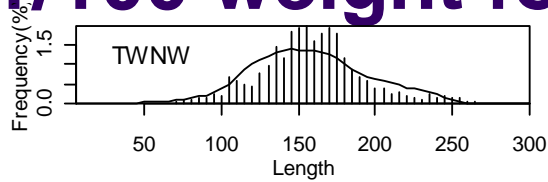
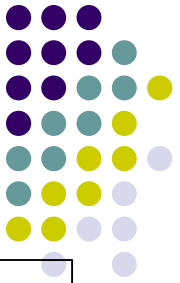
# 1/5 weight for length-frequency data



# 1/10 weight for length-frequency data

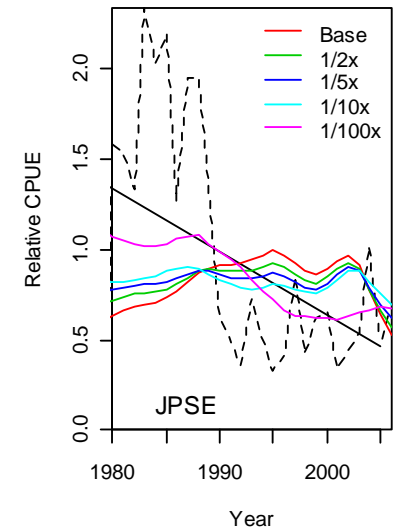
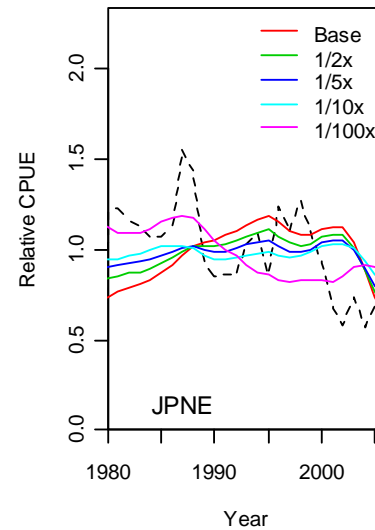
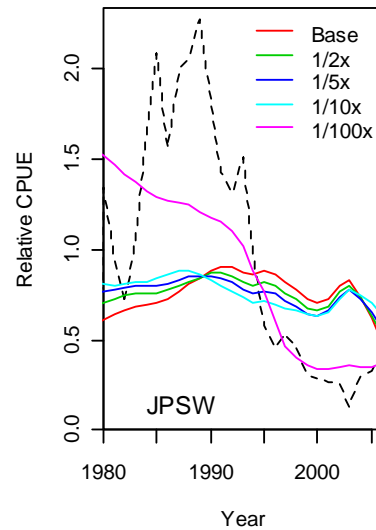
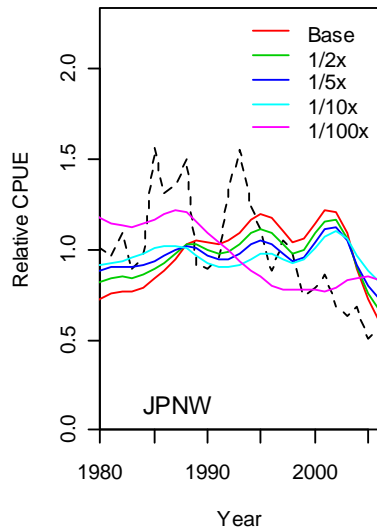
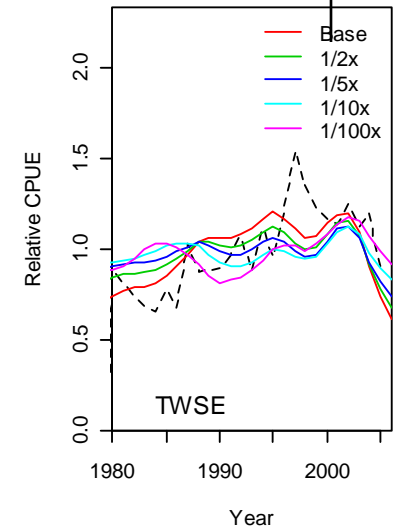
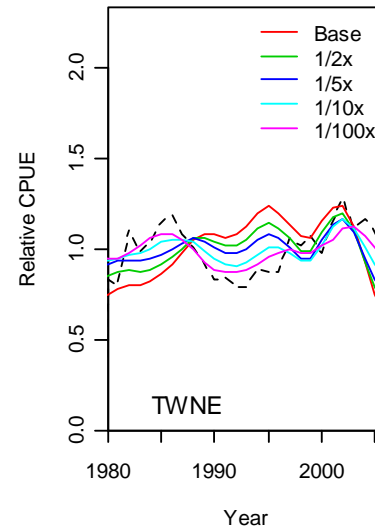
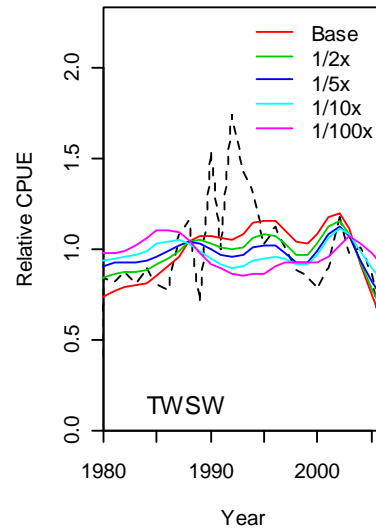
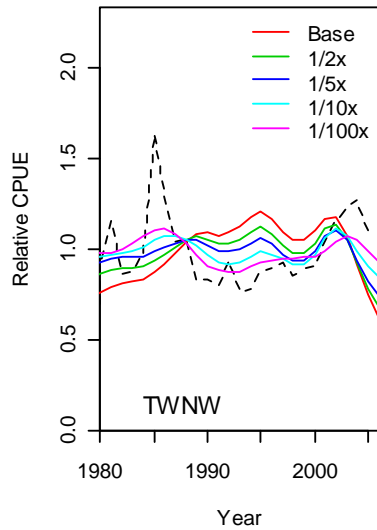
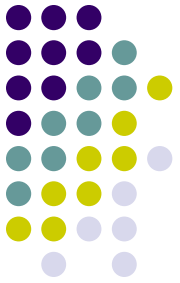


# 1/100 weight for length-frequency data





# Fits of CPUE





# Estimations of quantities

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	$S_{2006}/S_0$	$S_{2006}/S_{MSY}$	$F_{2006}/F_{MSY}$
Base-case	0.40	2.03	1.74
Weight for Length-frequency			
1/2x	0.35	1.80	1.45
1/5x	0.37	1.72	1.21
1/10	0.36	1.83	1.36
1/100	0.23	1.14	1.61

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The set of weight of length-frequency does not seem to change the estimations of relative quantities unless very low value of weight is used