

Large Coastal Shark Complex Assessment

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This presentation

- Brief review of definitions
- Data inputs
- Stock assessment modeling approaches
- Baseline results
- Continuity and retrospective analyses
- Sensitivity analyses
- Discussion / Summary

Management history of LCS complex

- LCS complex established in 1993 FMP because of lack of species-specific data (consisted of 22 spp)
- First 5 (formerly LCS) Prohibited Species designated in 1997 (white, whale, basking, sand tiger, and bigeye sand tiger)
- Additional 6 (formerly LCS) Prohibited Species designated in 1999 FMP
- 1999 FMP also proposed distinction between “ridgeback” (sandbar, silky, tiger) and “non-ridgeback” (blacktip, bull, spinner, lemon, nurse, and three hammerhead spp), but did not pass

The LCS groupings in this assessment

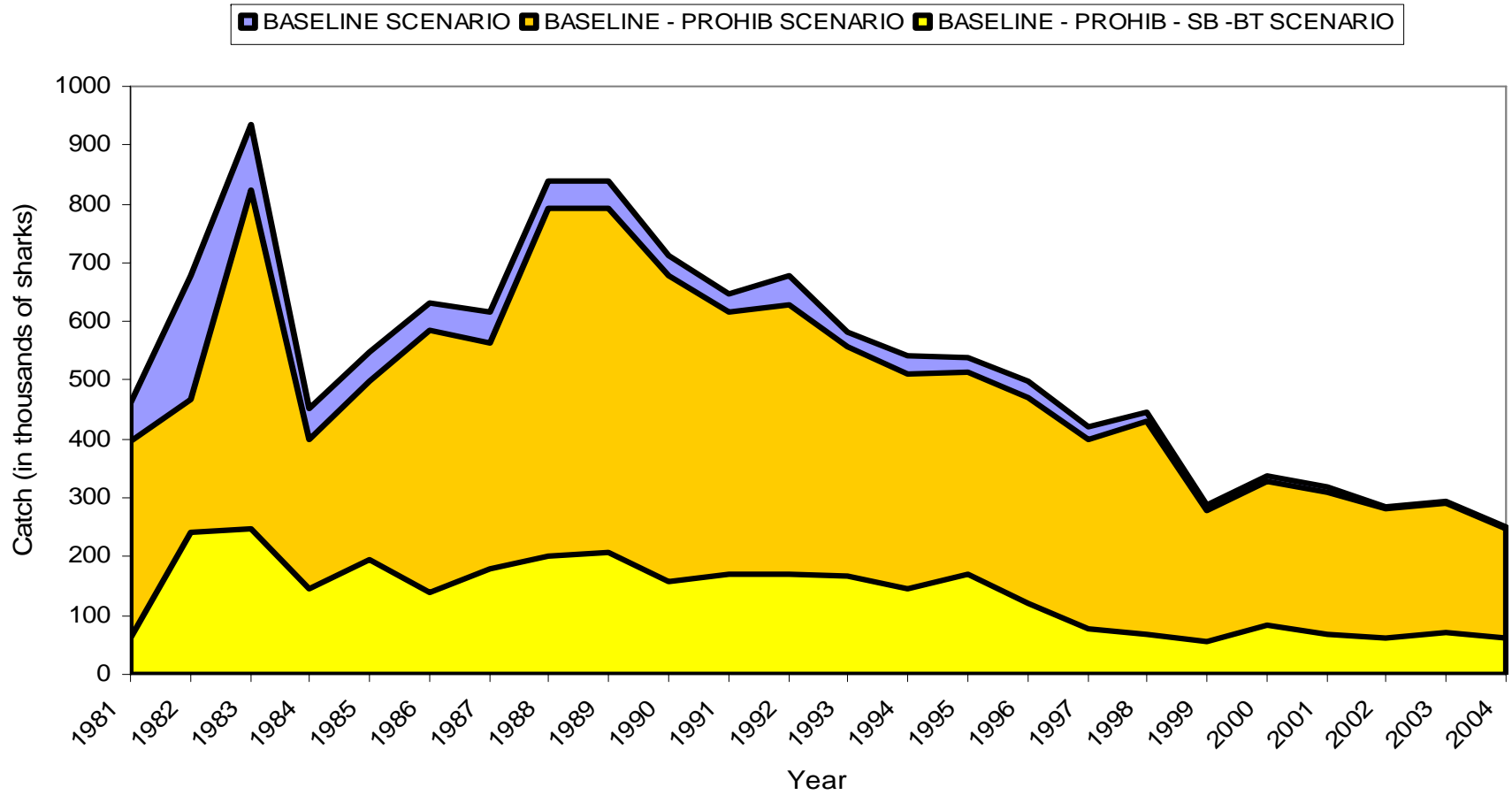
- LCS: 22 species
- LCS – Prohibited (11 species; prohibited spp are: dusky, night, sand tiger, bigeye sand tiger, whale, basking, bignose, Galapagos, Caribbean reef, narrowtooth, white)
- LCS – Prohibited – sandbar – blacktip (9 species)

Why these groupings?

- To try and reconcile the results of the 2002 assessment, which at the time showed that the LCS complex (~22 spp) was overfished with overfishing occurring, whereas the two main spp in the complex (blacktip and sandbar) showed healthy status (blacktip) or overfishing only (sandbar)
- So the DW considered that removing prohibited spp and (blacktip+sandbar) could help clarify situation and alleviate industry concerns

Total Catches

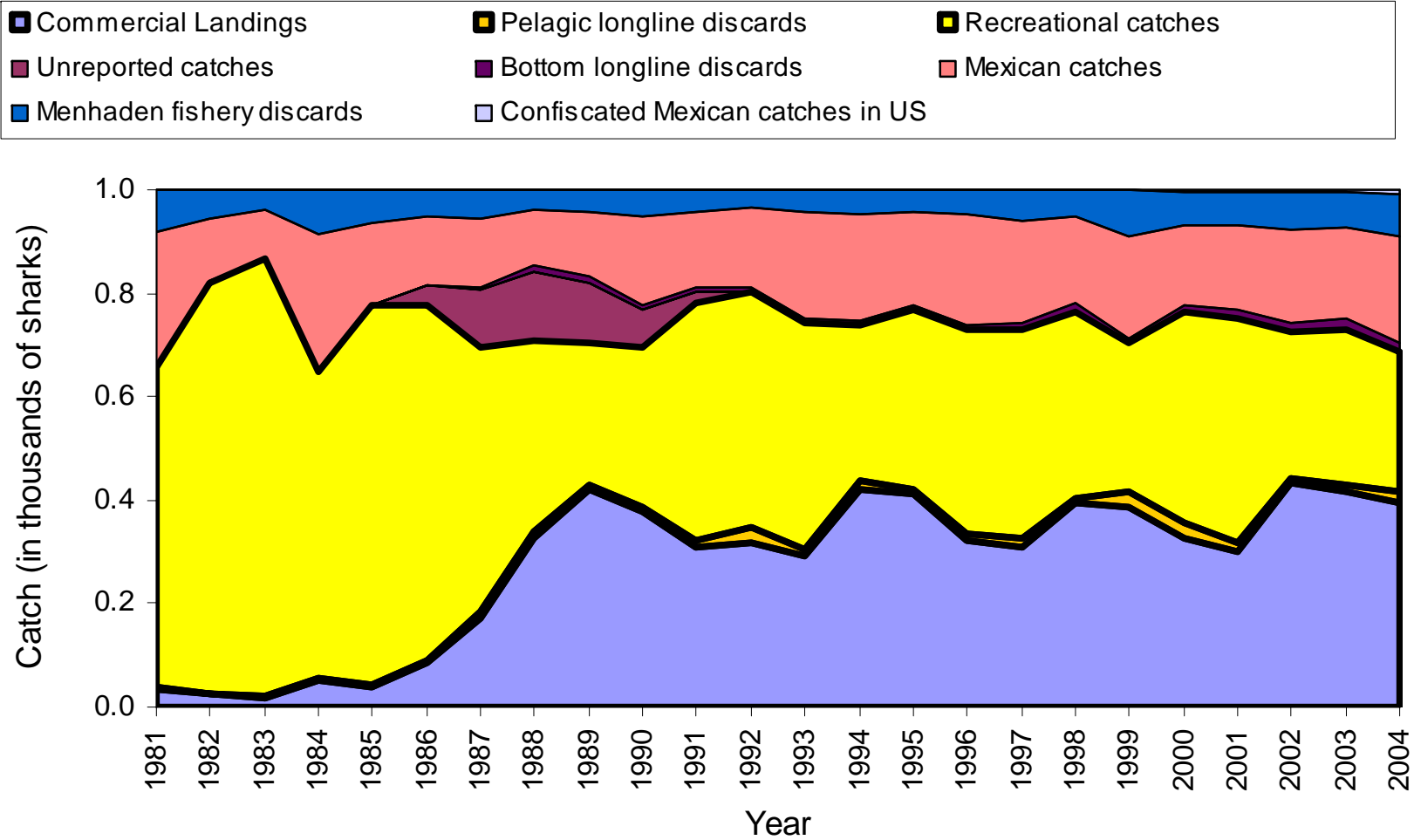
LCS



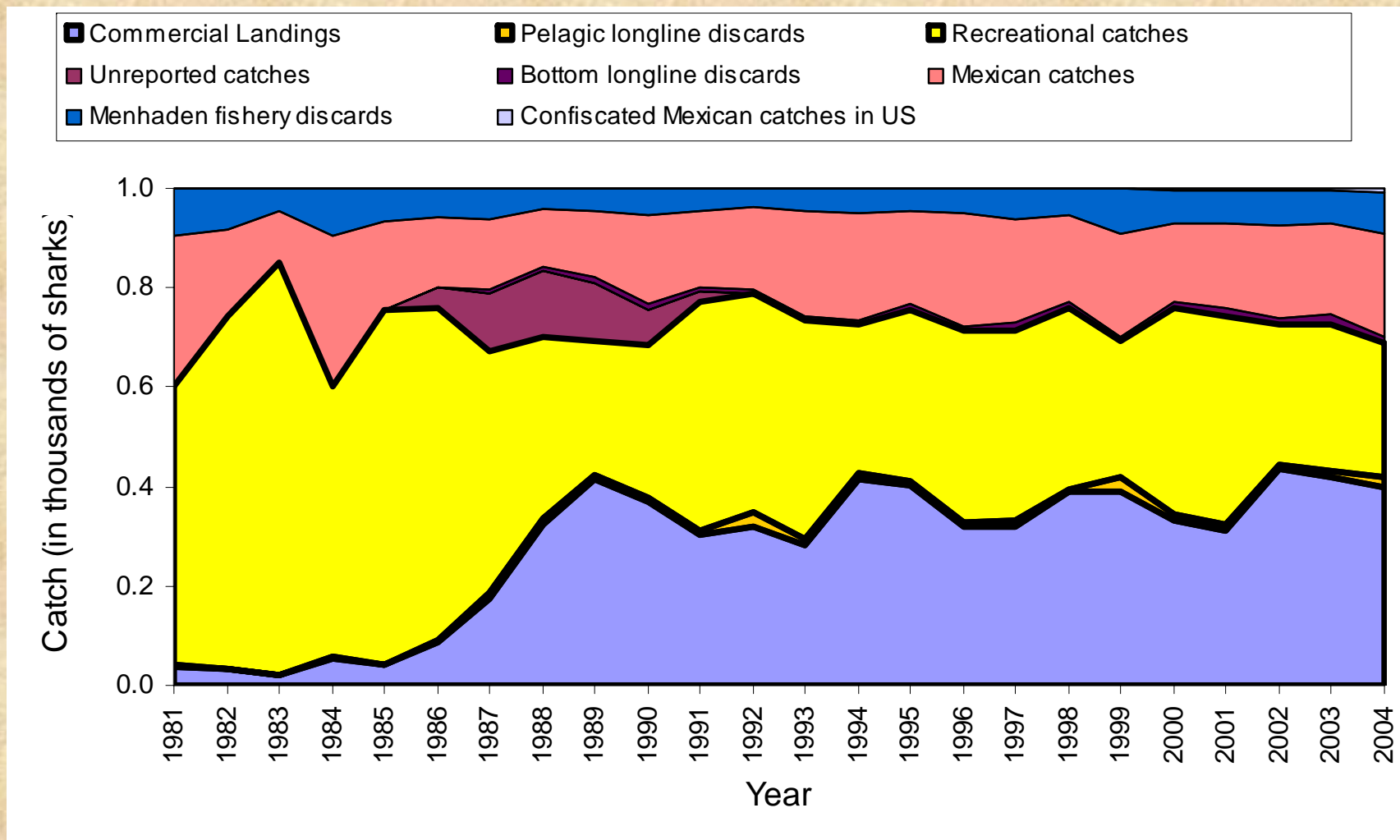
Catches by sector: why numbers?

- Commercial (in weight; use average weights from observer program to estimate numbers)
- Pelagic longline discards (in numbers and weight)
- Recreational (MRFSS + Headboat + TXPWD; in numbers)
- Unreported commercial catches (a proportion)
- Bottom longline discards (a proportion)
- Mexican (artisanal) catches (in numbers)
- Gulf menhaden fishery discards (in numbers)
- Confiscated Mexican catches in US (in numbers + proportion)

Catches by sector: LCS-Baseline



Catches by sector: LCS-Prohibited spp-Baseline

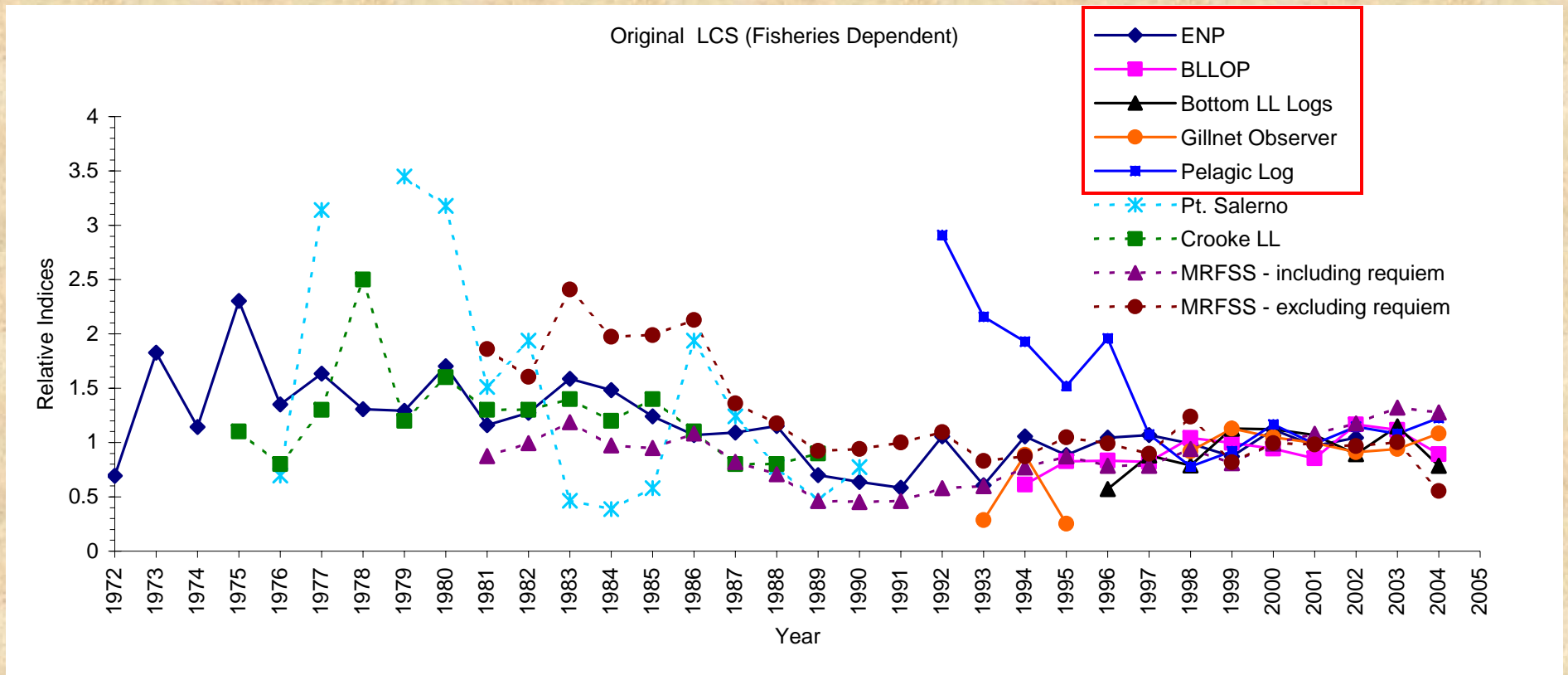


CPUE series: LCS-Baseline

- **FISHERY-DEPENDENT:** ENP, BLLOP, Bottom LL Logs, Gillnet Observer, Pelagic Log (Pt. Salerno, Crooke LL, MRFSS-incl. Requiem, MRFSS-excl. Requiem)
- **FISHERY-INDEPENDENT:** PC Gillnet, NMFS LL SE, SC LL Recent, VA LL, NMFS LL NE, SC LL Early (PC LL, MS Gillnet)

CPUE series: LCS-Baseline (F-D)

Baseline Indices

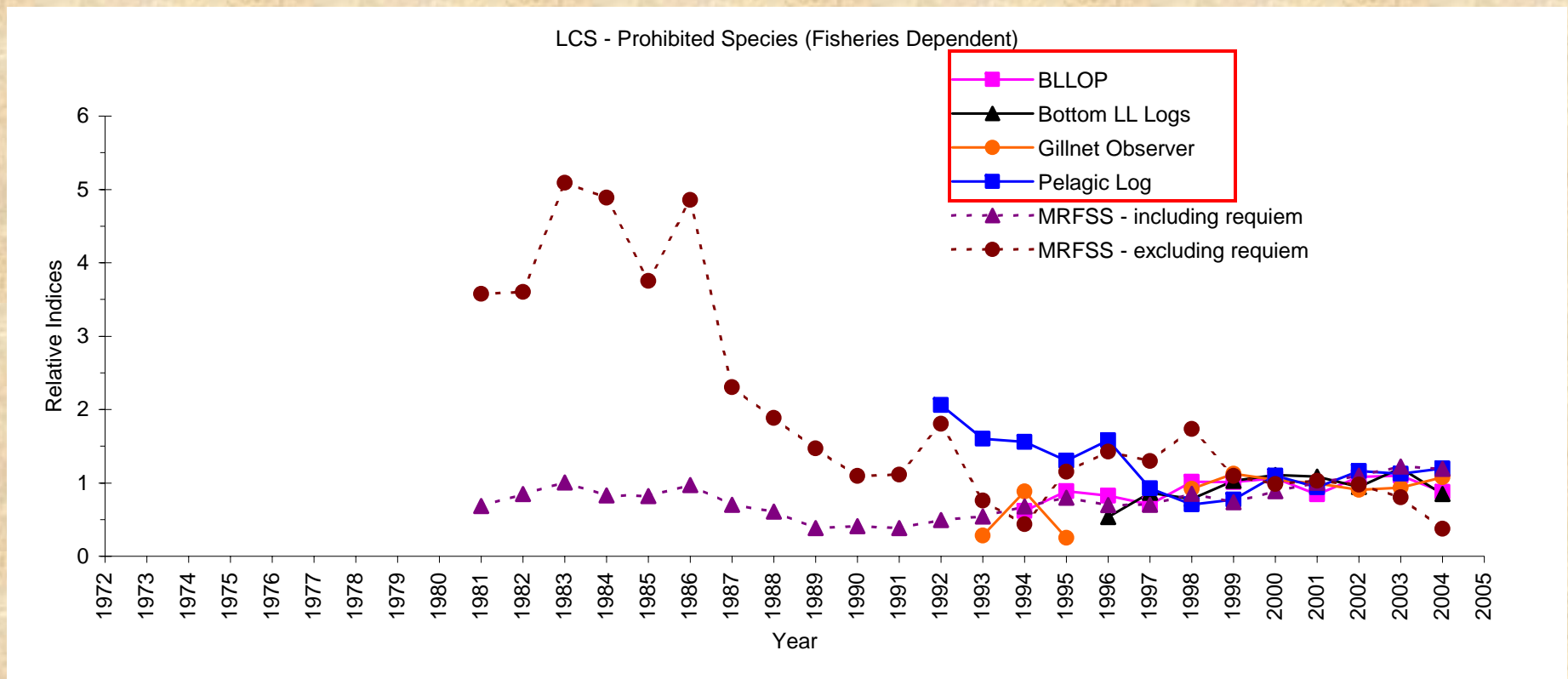


CPUE series: LCS-Prohibited spp-Baseline

- **FISHERY-DEPENDENT:** BLLOP, Bottom LL Logs, Gillnet Observer, Pelagic Log (MRFSS-incl. Requiem, MRFSS-excl. Requiem)
- **FISHERY-INDEPENDENT:** PC Gillnet, NMFS LL SE, NMFS LL NE (PC LL, MS Gillnet)

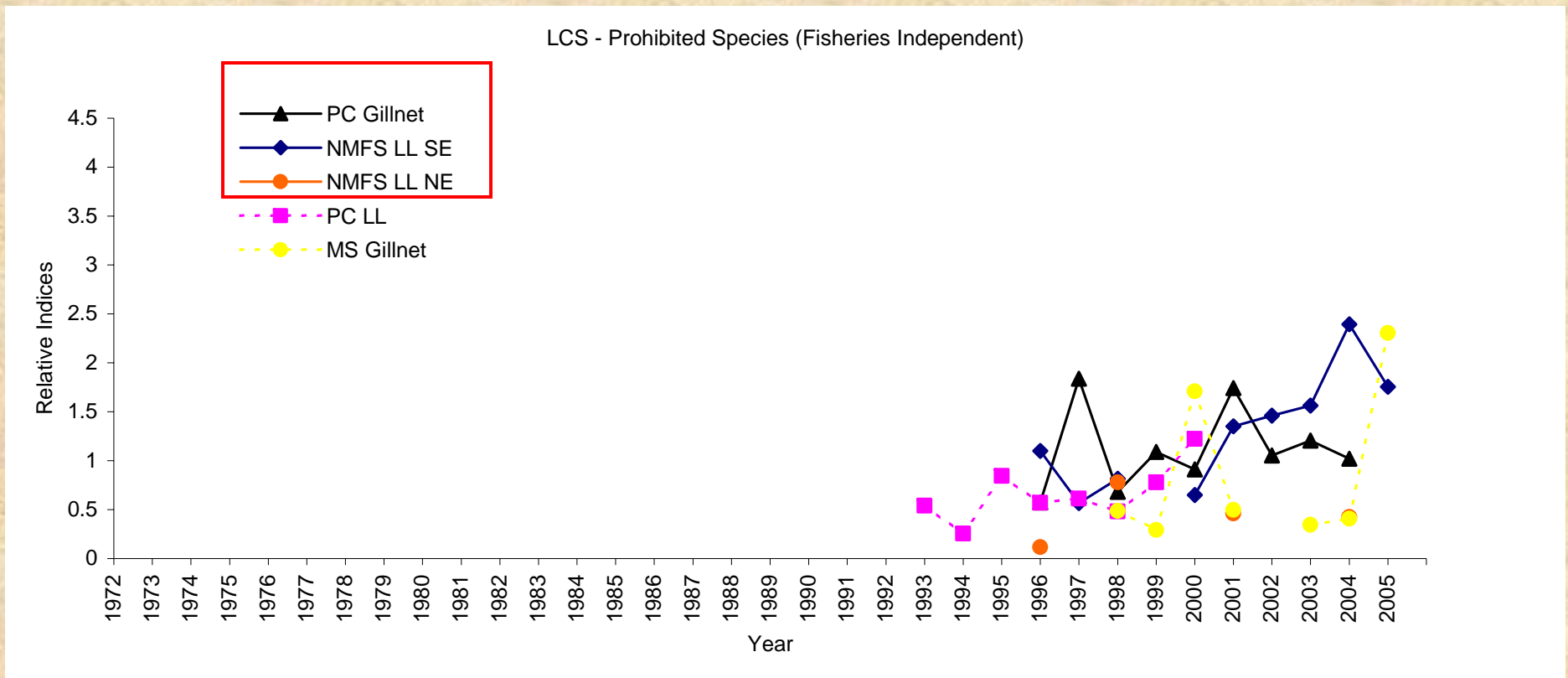
CPUE series: LCS-Prohibited spp- Baseline (F-D)

Baseline Indices



CPUE series: LCS-Prohibited spp- Baseline (F-I)

Baseline Indices

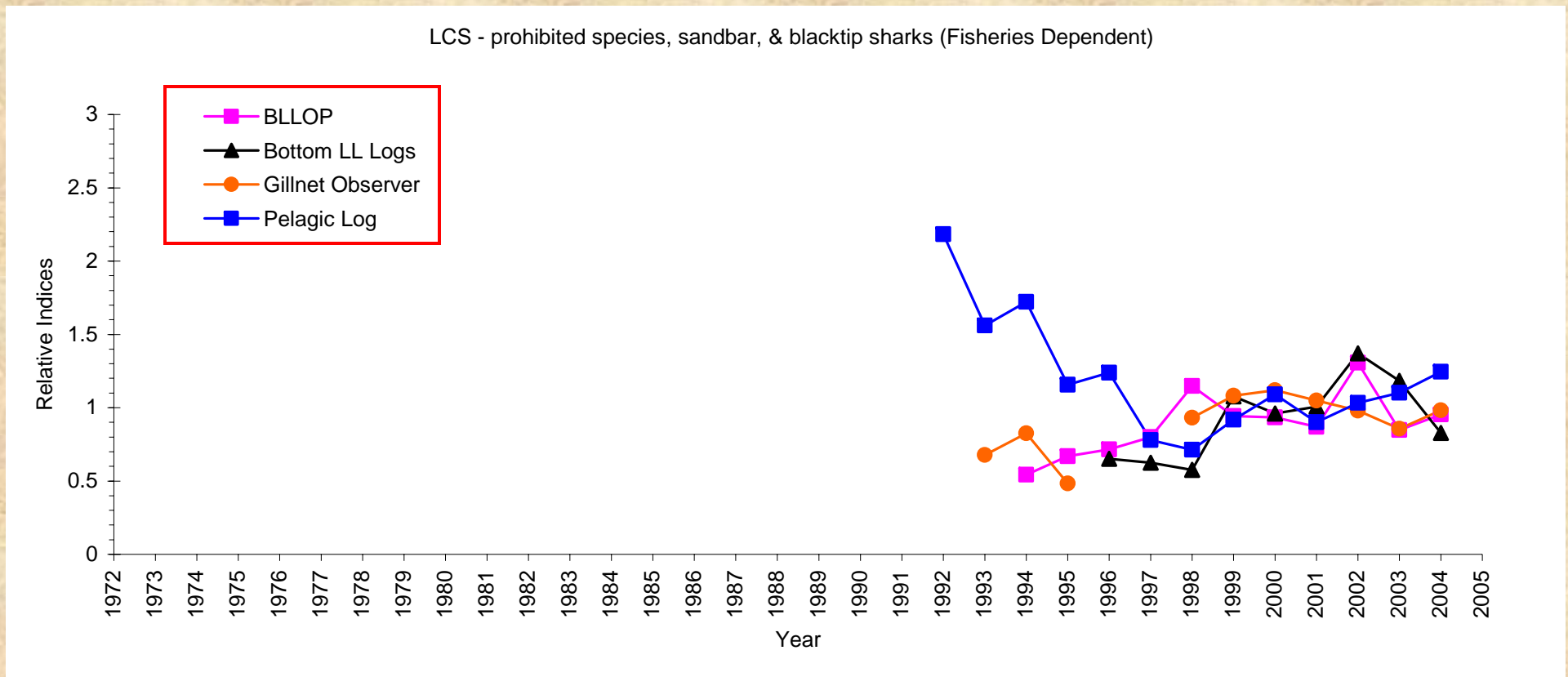


CPUE series: LCS-Prohibited spp-BT-SB-Baseline

- **FISHERY-DEPENDENT:** BLLOP, Bottom LL Logs, Gillnet Observer, Pelagic Log
- **FISHERY-INDEPENDENT:** PC Gillnet, NMFS LL SE, NMFS LL NE

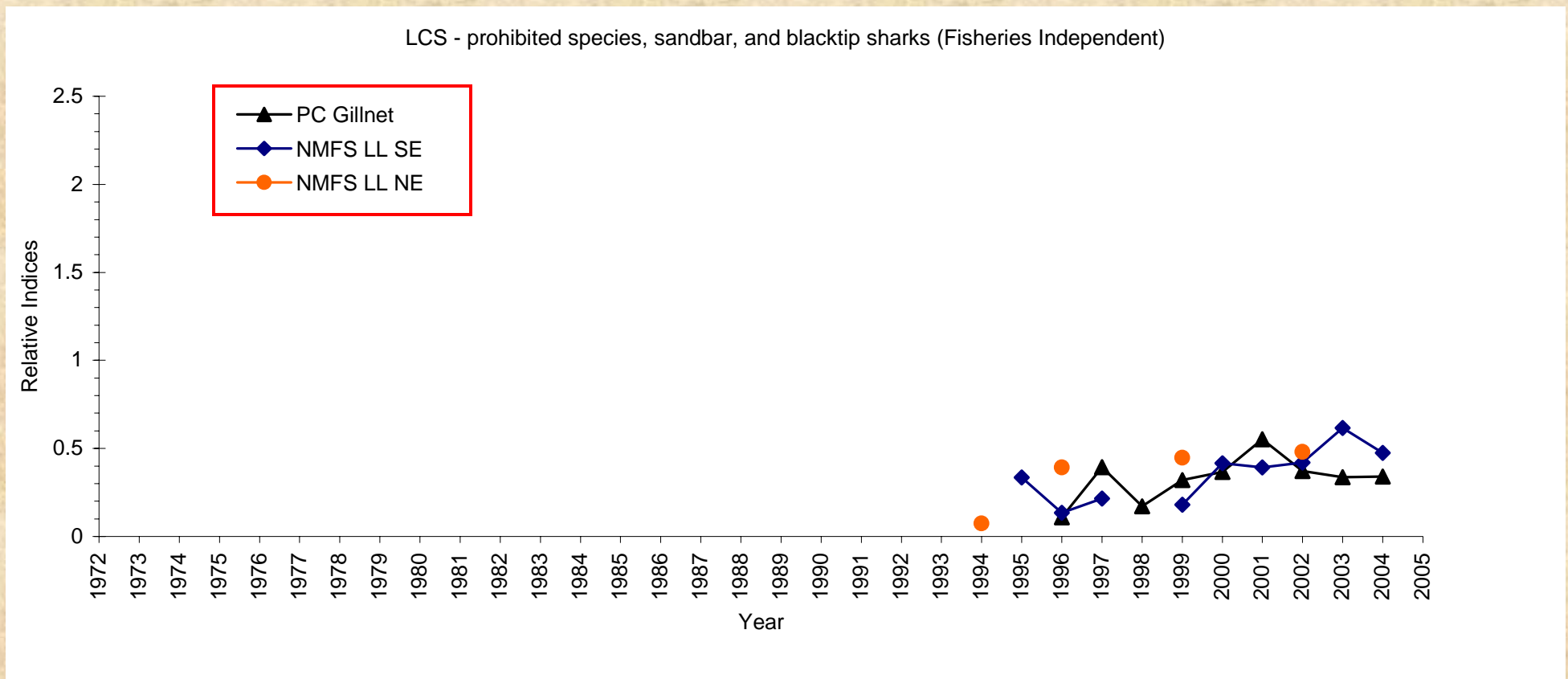
CPUE series: LCS-Prohibited spp-BT-SB-Baseline (F-D)

Baseline Indices



CPUE series: LCS-Prohibited spp-BT-SB-Baseline (F-I)

Baseline Indices



Inputs-Priors for LCS-Baseline

- Model started in 1972 (first year of Indices)
 - Catches for 1972-1980 = $C_0 \sim \text{LN}(534.9, 1)$
 - $r \sim \text{LN}(0.045, 0.44, 0.001, 2.0)$
 - $N_{72/K} \sim \text{LN}(1, 0.2, 0.2, 1.1)$
 - $K \sim \text{U}$ on $\log K$ (10^5 - 10^9)
- ↑
Mean (1981-2004)

Inputs-Priors for LCS-Prohibited spp- Baseline

- Model started in 1972 (first year of Indices was 1992)
 - Catches for 1972-1980 = $C_0 \sim \text{LN}(494.6, 1)$
 - $r \sim \text{LN}(0.046, 0.45, 0.001, 2.0)$
 - $N_{72/K} \sim \text{LN}(1, 0.2, 0.2, 1.1)$
 - $K \sim U$ on $\log K$ (10^5 - 10^9)
- ↑
Mean (1981-2004)

Inputs-Priors for LCS-Prohibited spp- BT-SB-Baseline

- Model started in 1972 (first year of Indices was 1992)
 - Catches for 1972-1980 = $C_0 \sim \text{LN}(136.1, 1)$
 - $r \sim \text{LN}(0.043, 0.43, 0.001, 2.0)$
 - $N_{72/K} \sim \text{LN}(1, 0.2, 0.2, 1.1)$
 - $K \sim U$ on $\log K$ (10^5 - 10^9)
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Mean (1981-2004)

Surplus production modeling approaches

1) **Bayesian SPM**

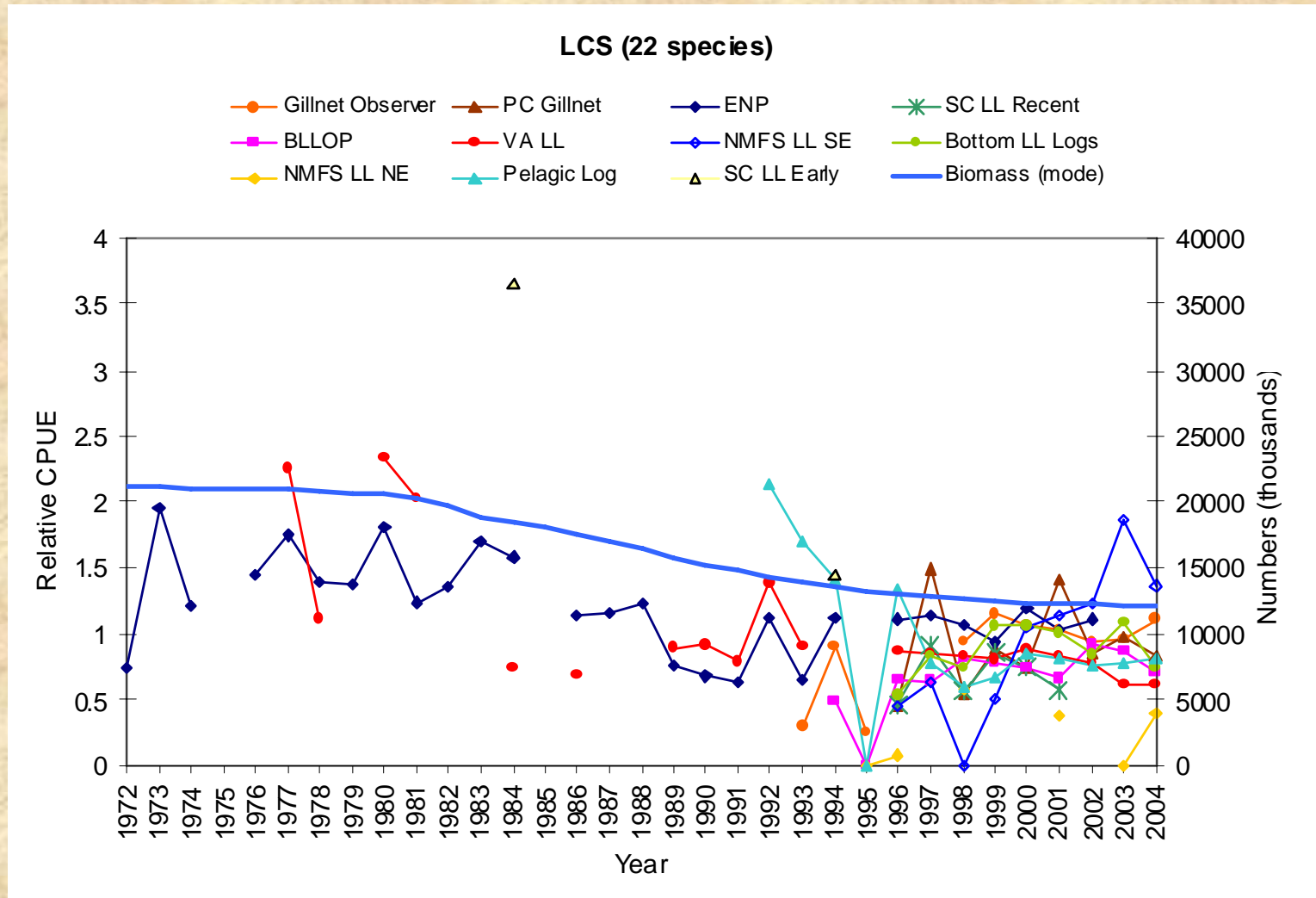
- Observation error in CPUE
- SIR algorithm for numerical integration
- Implemented in VB

2) **State-space Bayesian SPM**

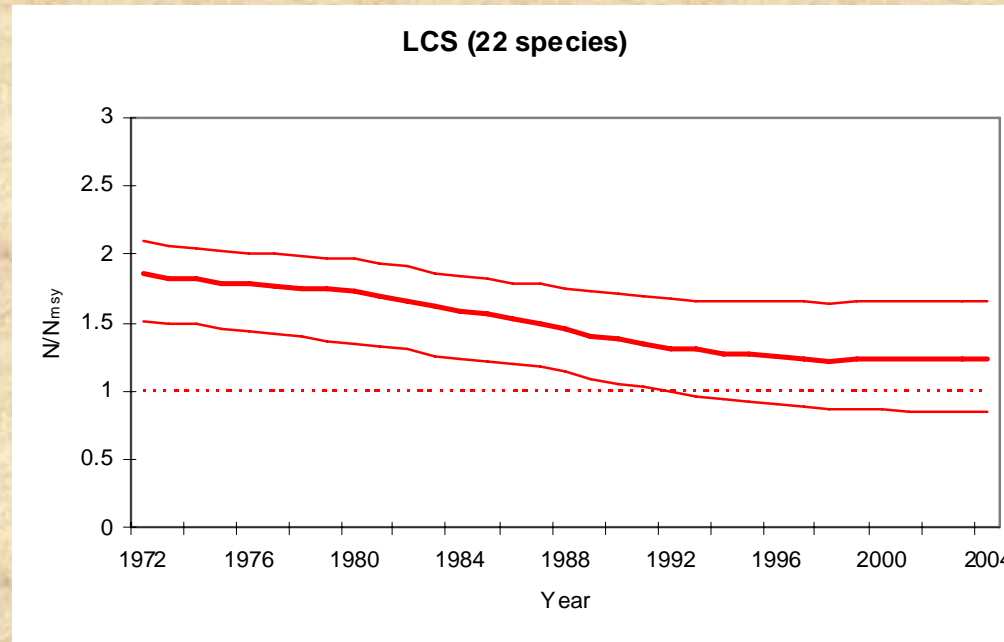
- Observation error in CPUE
- Process error in biomass (unobserved state)
- MCMC for numerical integration
- Implemented in WinBUGS

	LCS		LCS-PROH		LCS-PROH-SB-BT	
	EV	CV	EV	CV	EV	CV
Importance function	priors		priors		priors	
K	35677	0.5	51387	0.45	31534	0.8
r	0.048	0.47	0.05	0.47	0.046	0.46
MSY	395.5	0.59	621.4	0.62	347.7	0.96
N ₂₀₀₄	24133	0.71	40500	0.56	27899	0.88
N₂₀₀₄/K	0.63	0.25	0.75	0.19	0.81	0.2
N _{init}	32578	0.52	45485	0.46	27944	0.82
N ₂₀₀₄ /N _{init}	0.69	0.23	0.85	0.21	0.92	0.21
C ₂₀₀₄ /MSY	0.8	0.47	0.56	0.61	0.37	0.87
F₂₀₀₄/F_{MSY}	0.74	0.7	0.44	0.95	0.29	1.32
N₂₀₀₄/N_{MSY}	1.26	0.25	1.49	0.19	1.61	0.2
C ₂₀₀₄ /repy	0.927	0.37	0.792	0.39	0.66	35.39
N _{MSY}	17839	0.5	25693	0.45	15767	0.8
F _{MSY}	0.024		0.025		0.023	
repy	299.2	0.3	351.2	0.33	115.9	0.56
C ₀	421.7	1	467	1.11	137.1	1.24
Diagnostics						
CV (Wt) / CV (L*p)	0.58		0.54		0.32	
%maxpWt	0.006		0.002		0.003	

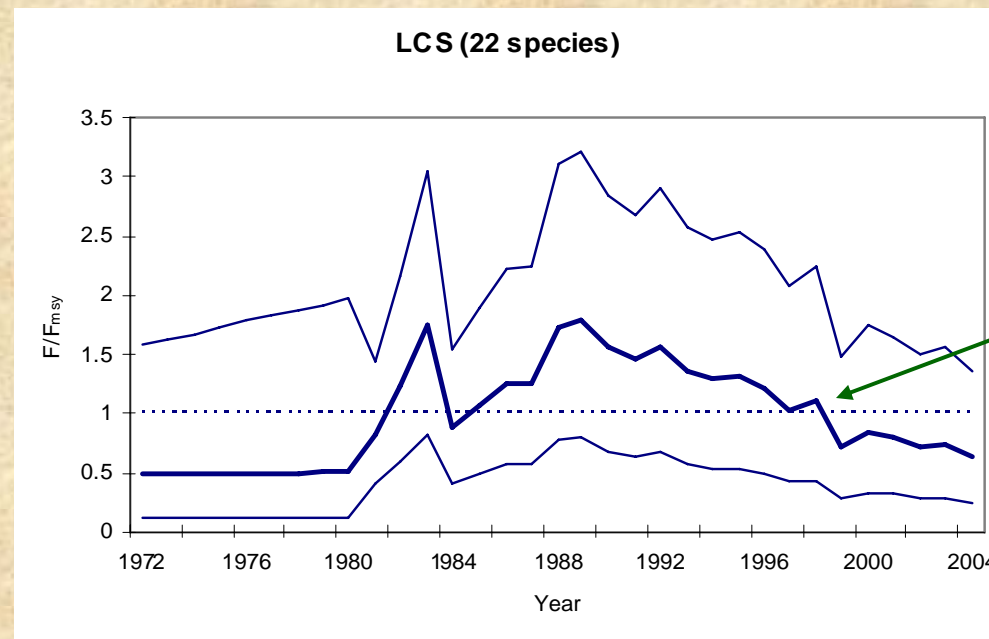
SPM results for LCS-Baseline: Predicted biomass trend at posterior mode of the BSP model fitted to catch and CPUE data



SPM
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BSP
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N/N_{MSY}

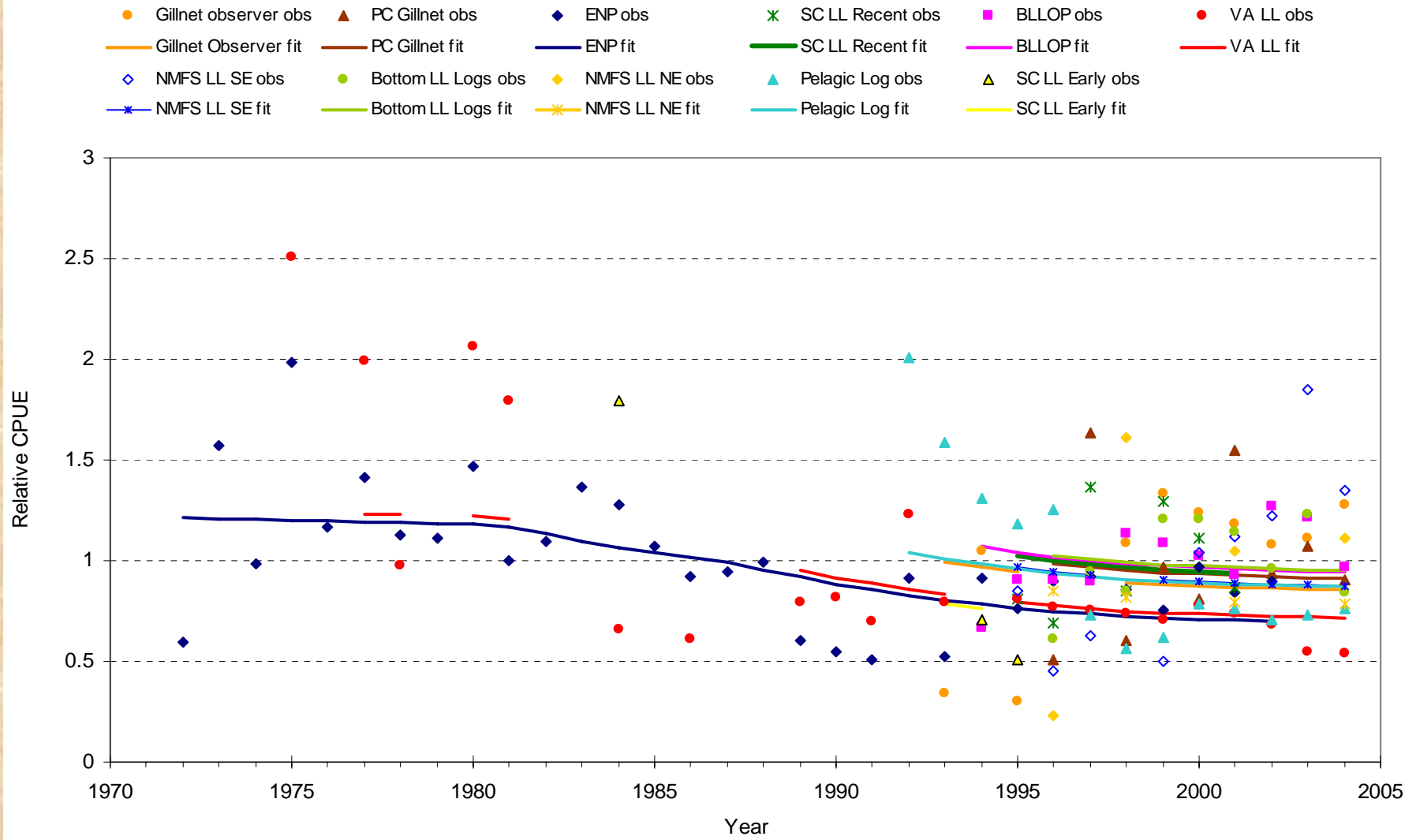


F/F_{MSY}

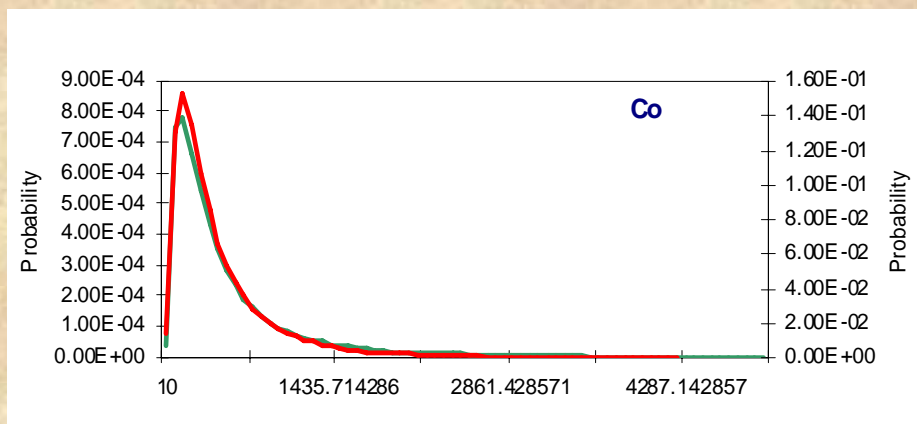
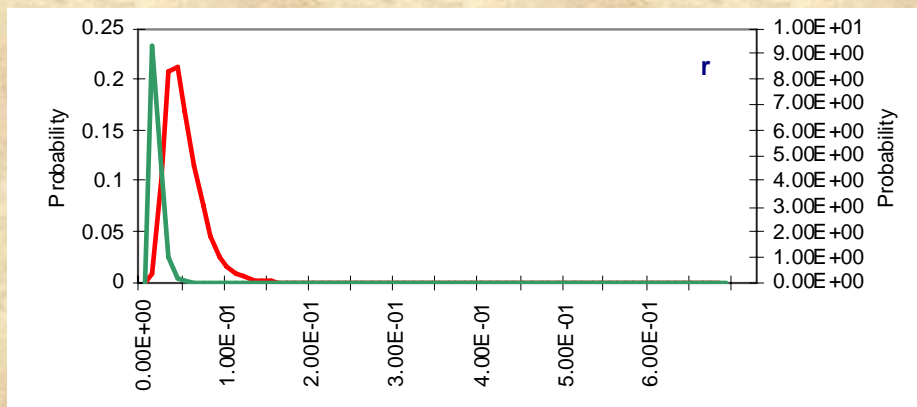
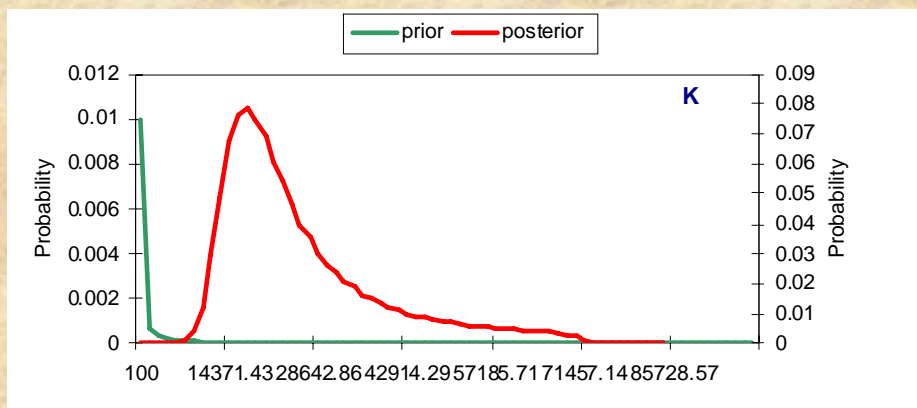
No overfishing
from 1999

SPM results for LCS-Baseline: Model fits to the individual CPUE series

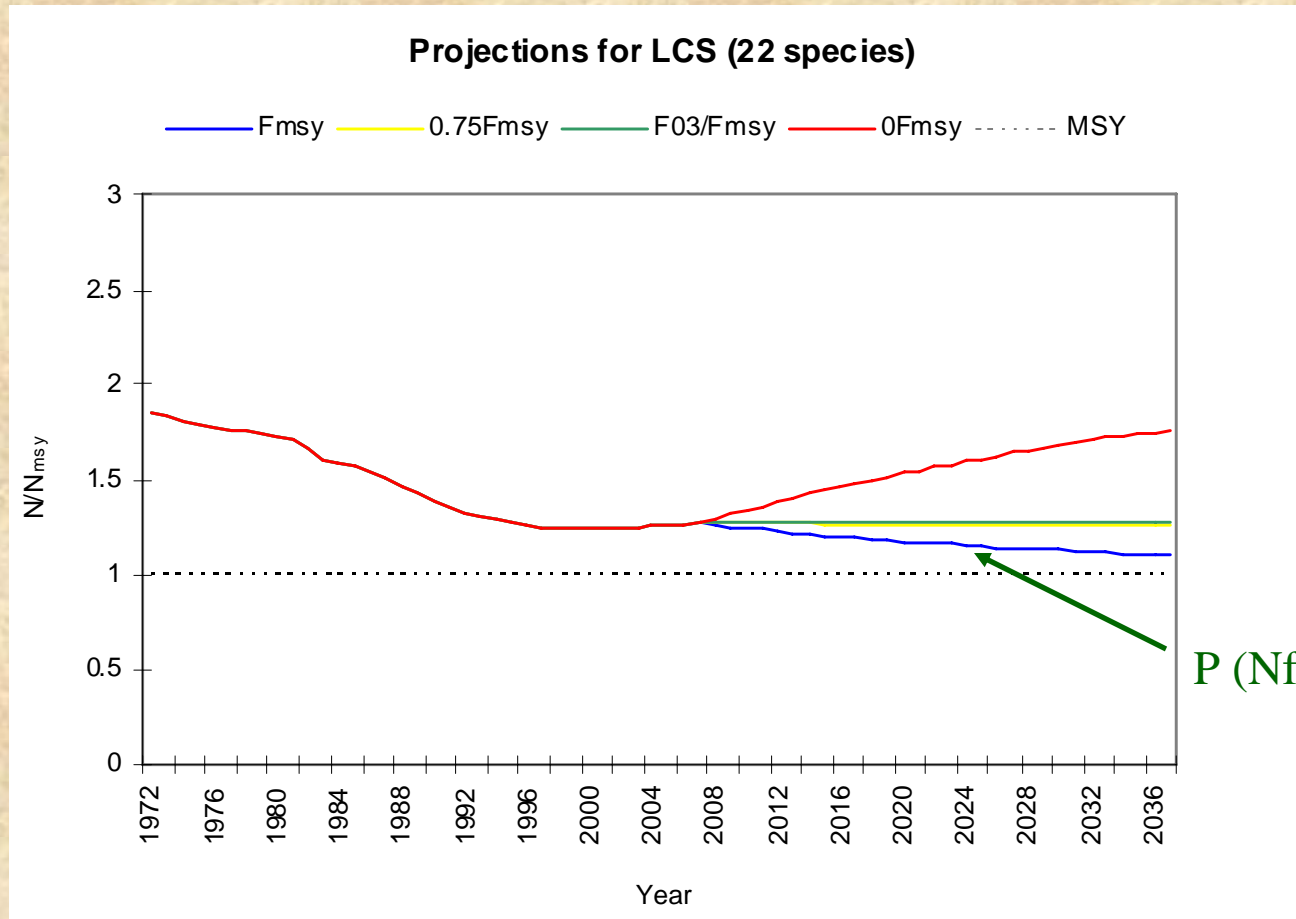
Model fits to CPUE series: LCS (22 species)



SPM results for LCS-Baseline: Prior and posterior pdfs for K, r, and Co

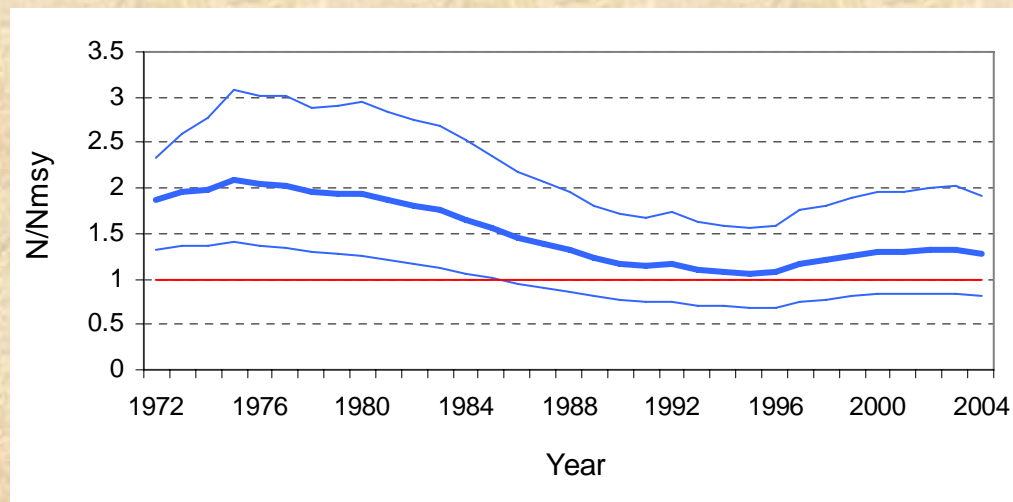
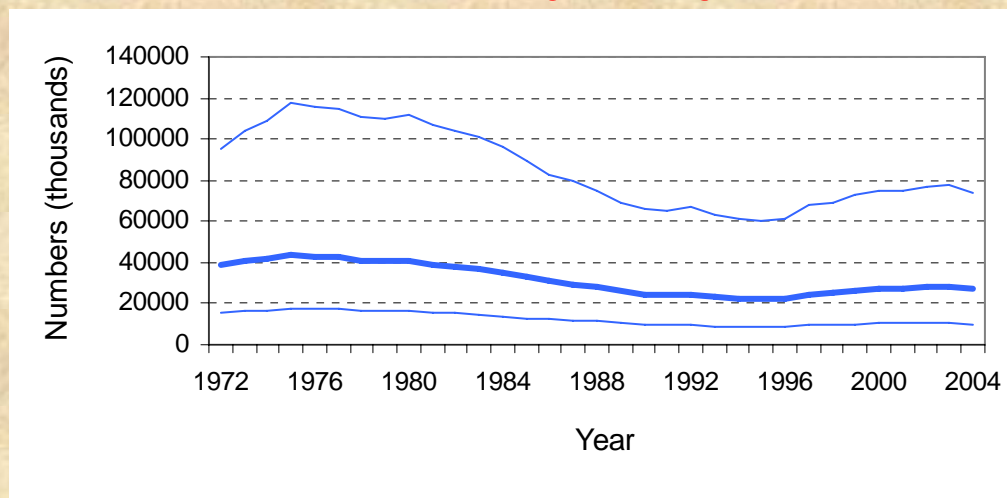


SPM results for LCS-Baseline: Projections

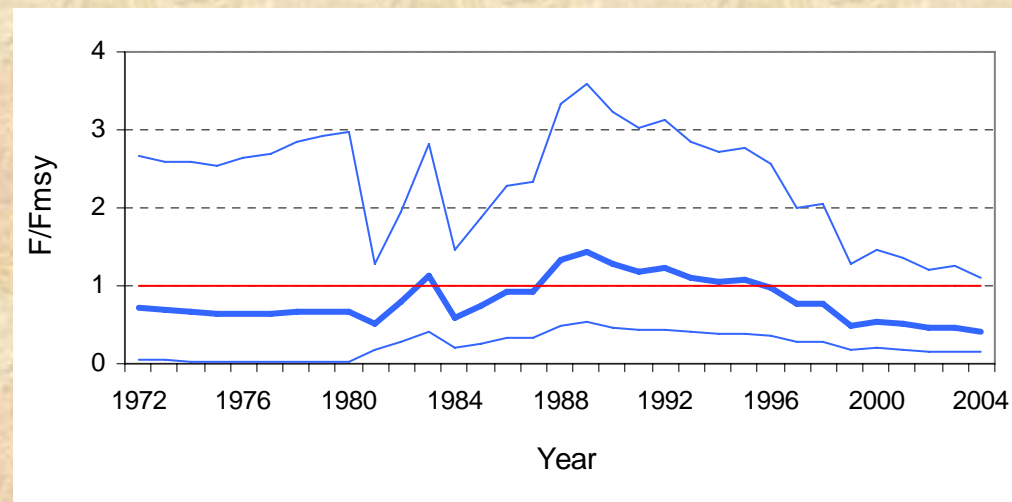


SPM results for LCS: Estimated biomass and relative biomass and fishing mortality rate trajectories of the WinBUGS SPM.

N trajectory

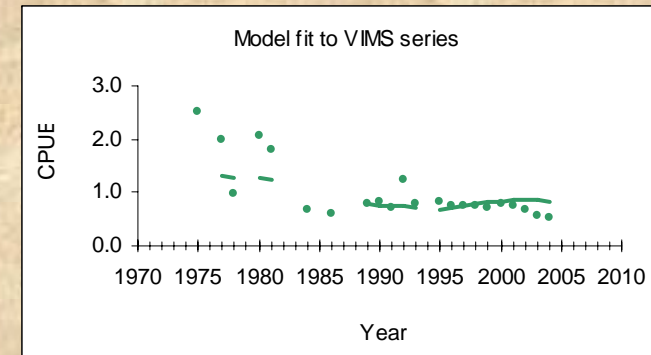
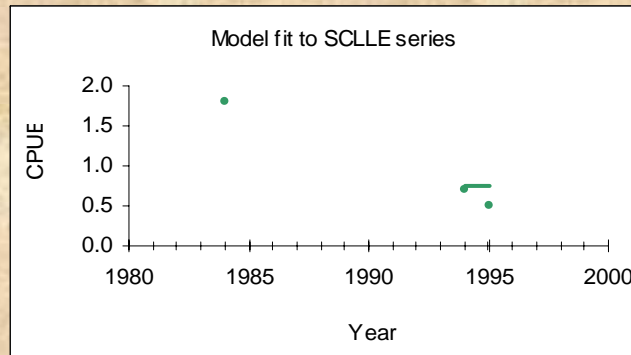
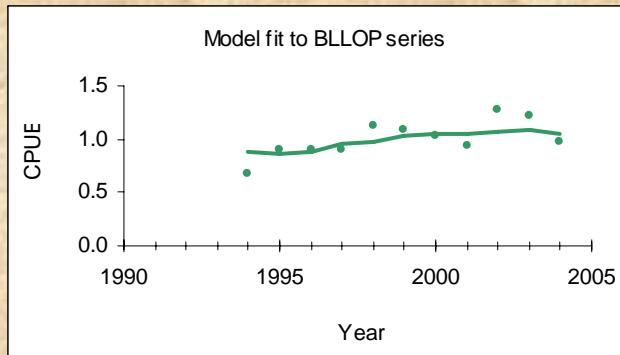
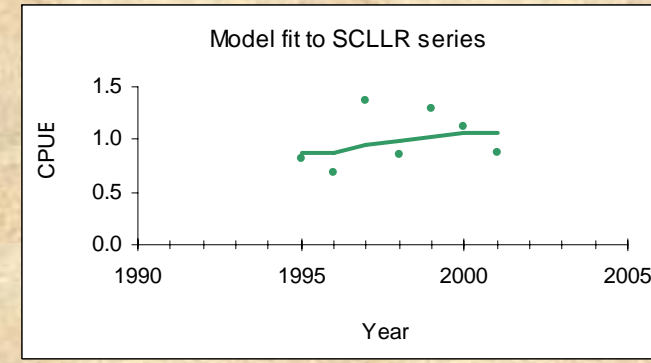
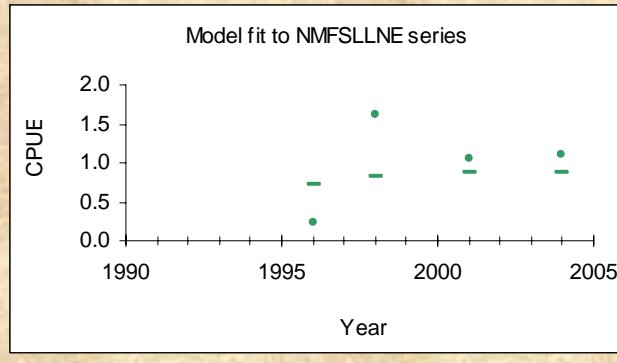
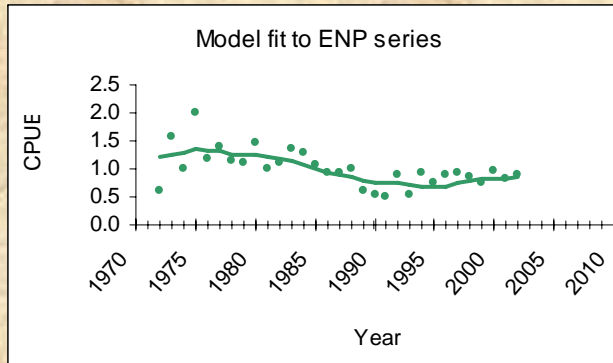
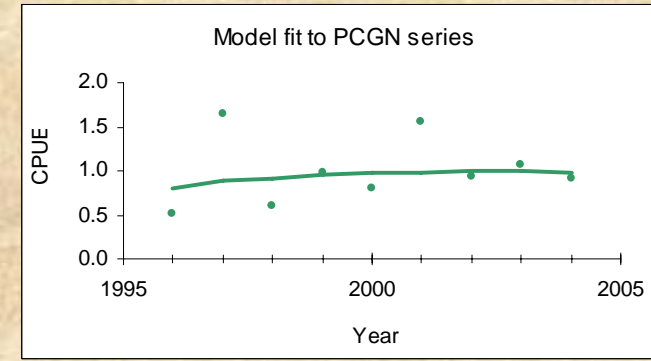
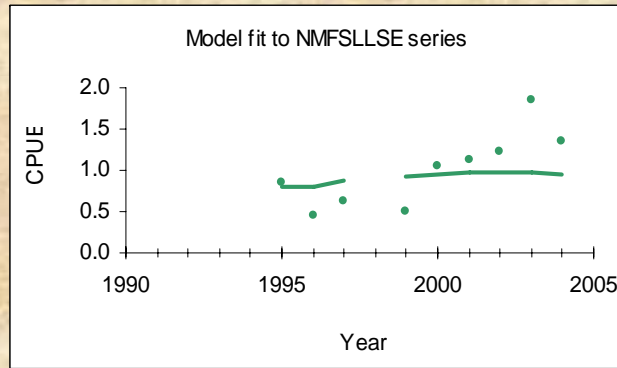
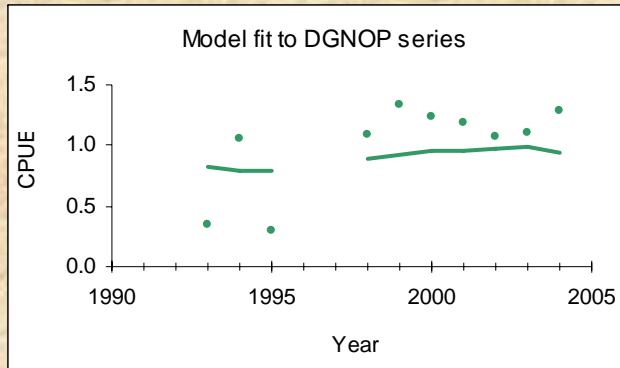


N/N_{MSY}

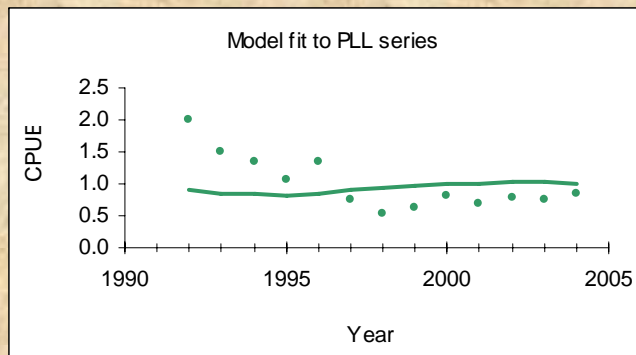
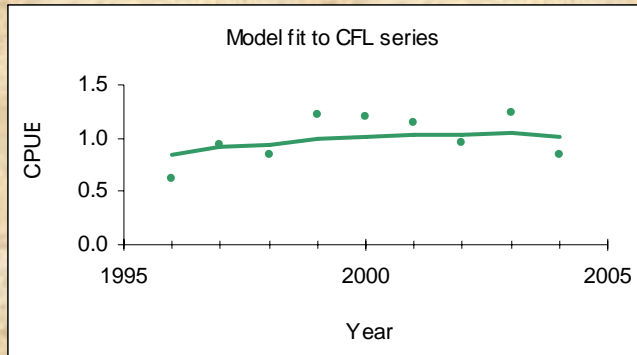


F/F_{MSY}

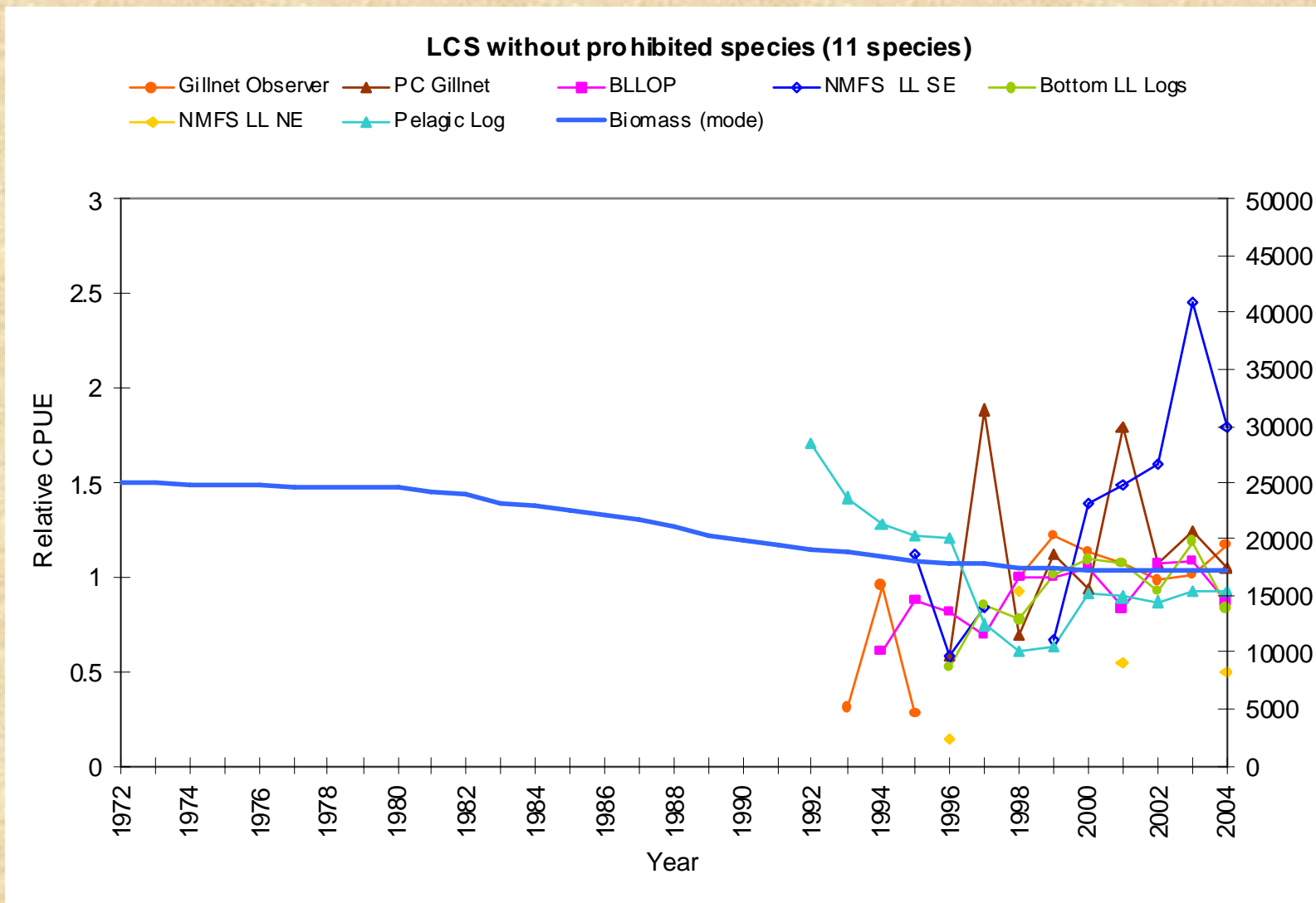
SPM results for LCS: WinBUGS SPM model fits to the CPUE series



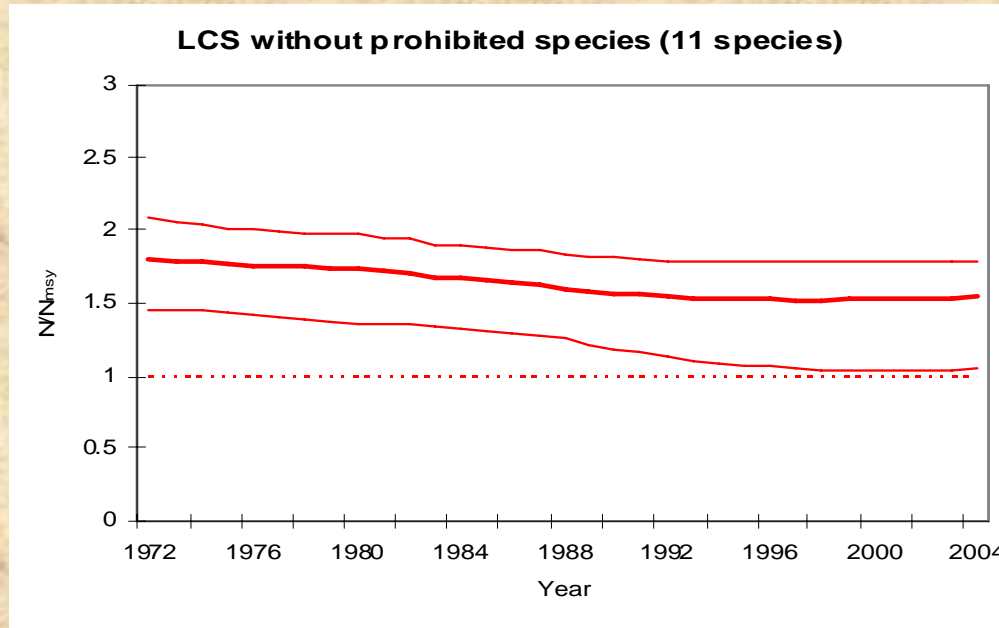
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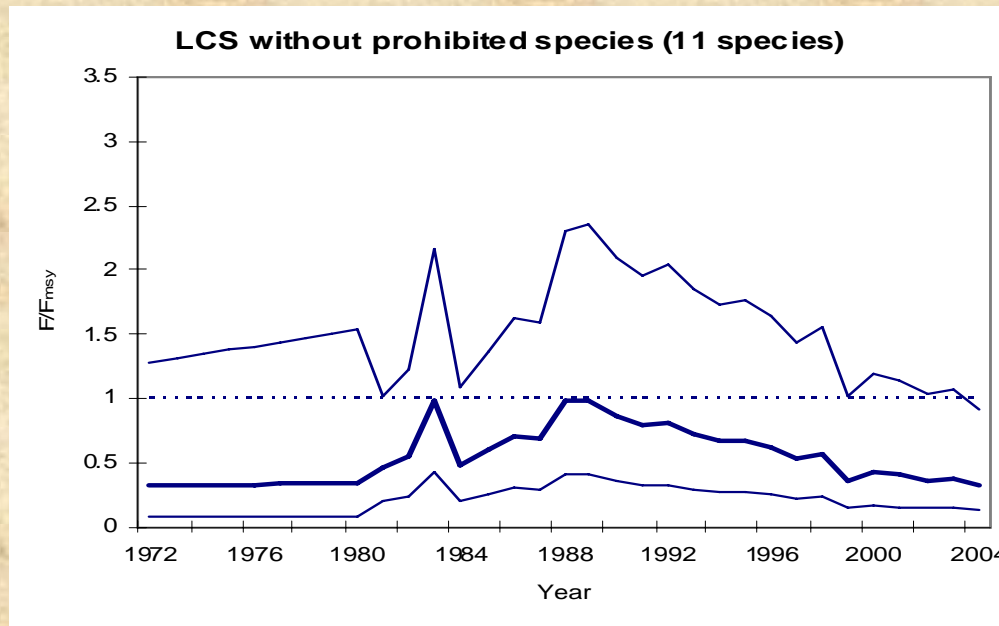
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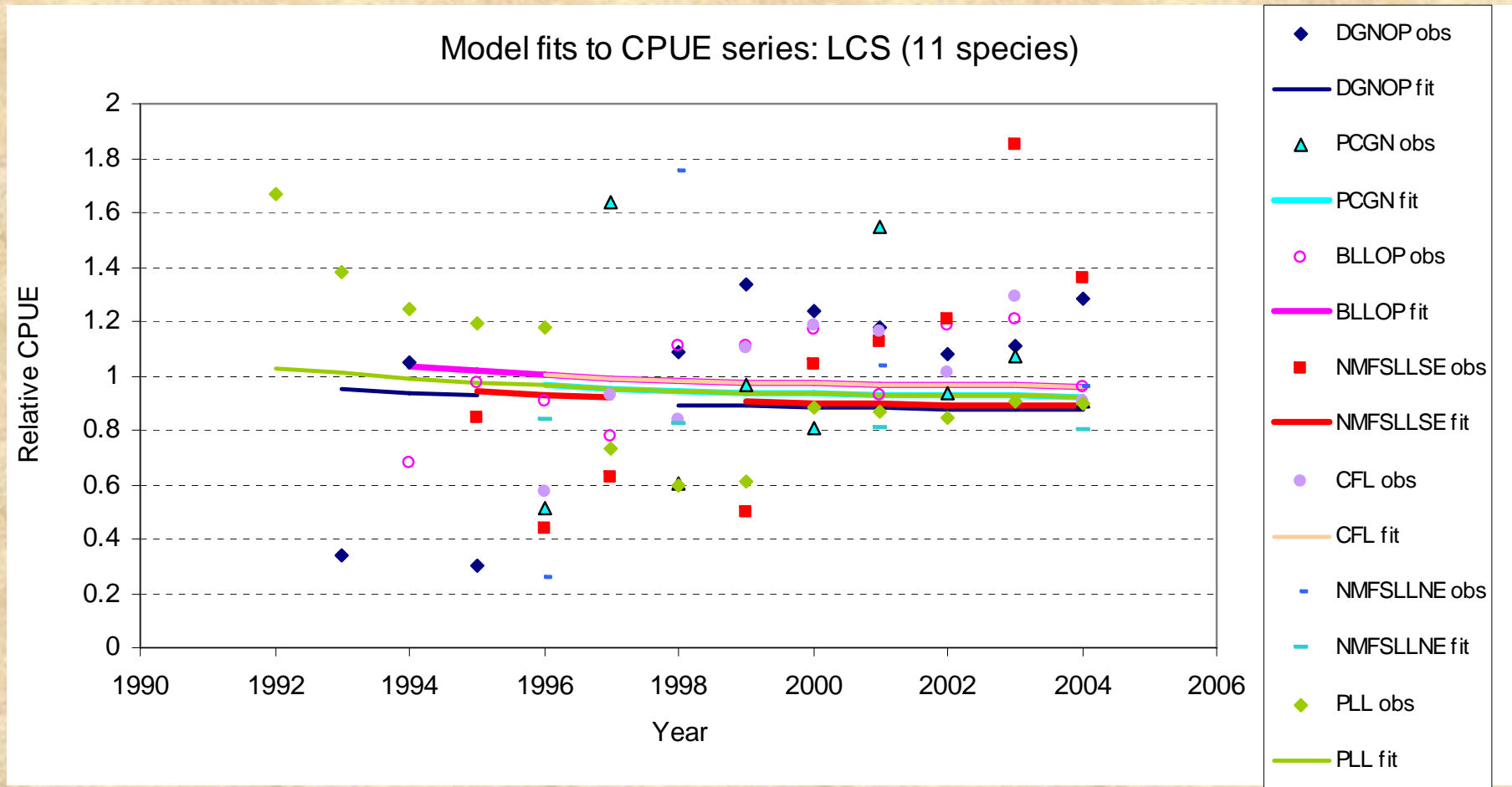


N/N_{MSY}

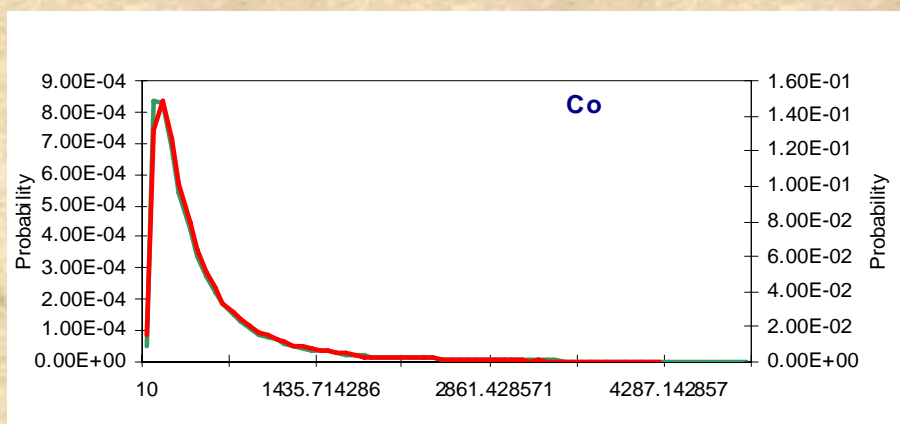
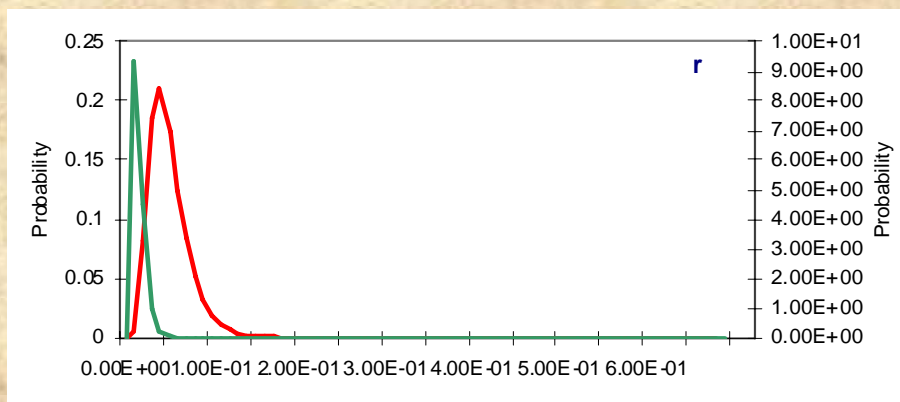
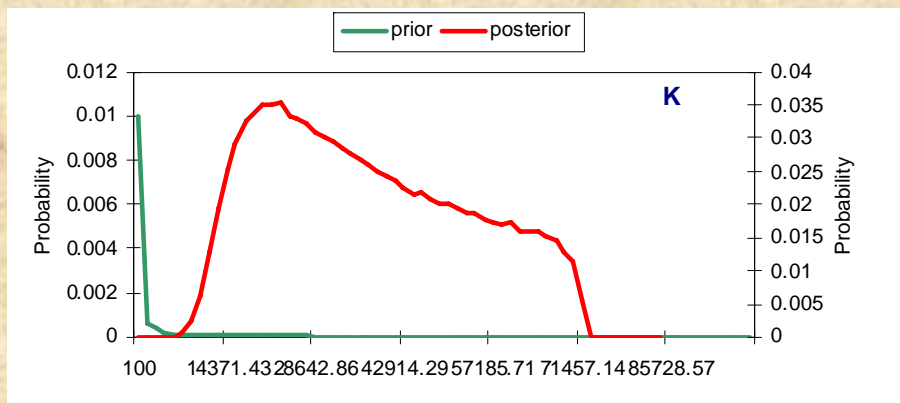


F/F_{MSY}

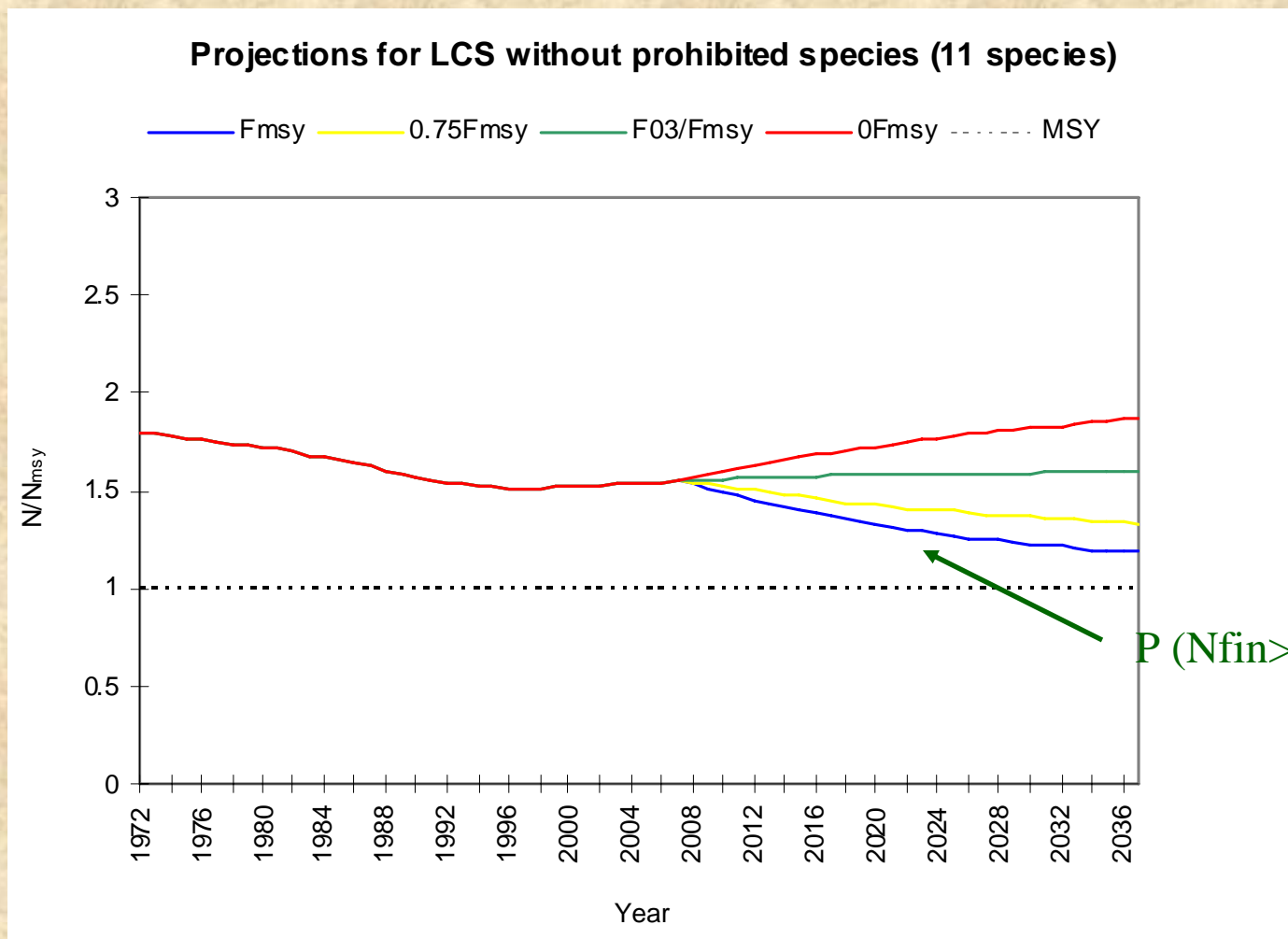
SPM results for LCS-Prohibited spp-Baseline: Model fits to the individual CPUE series



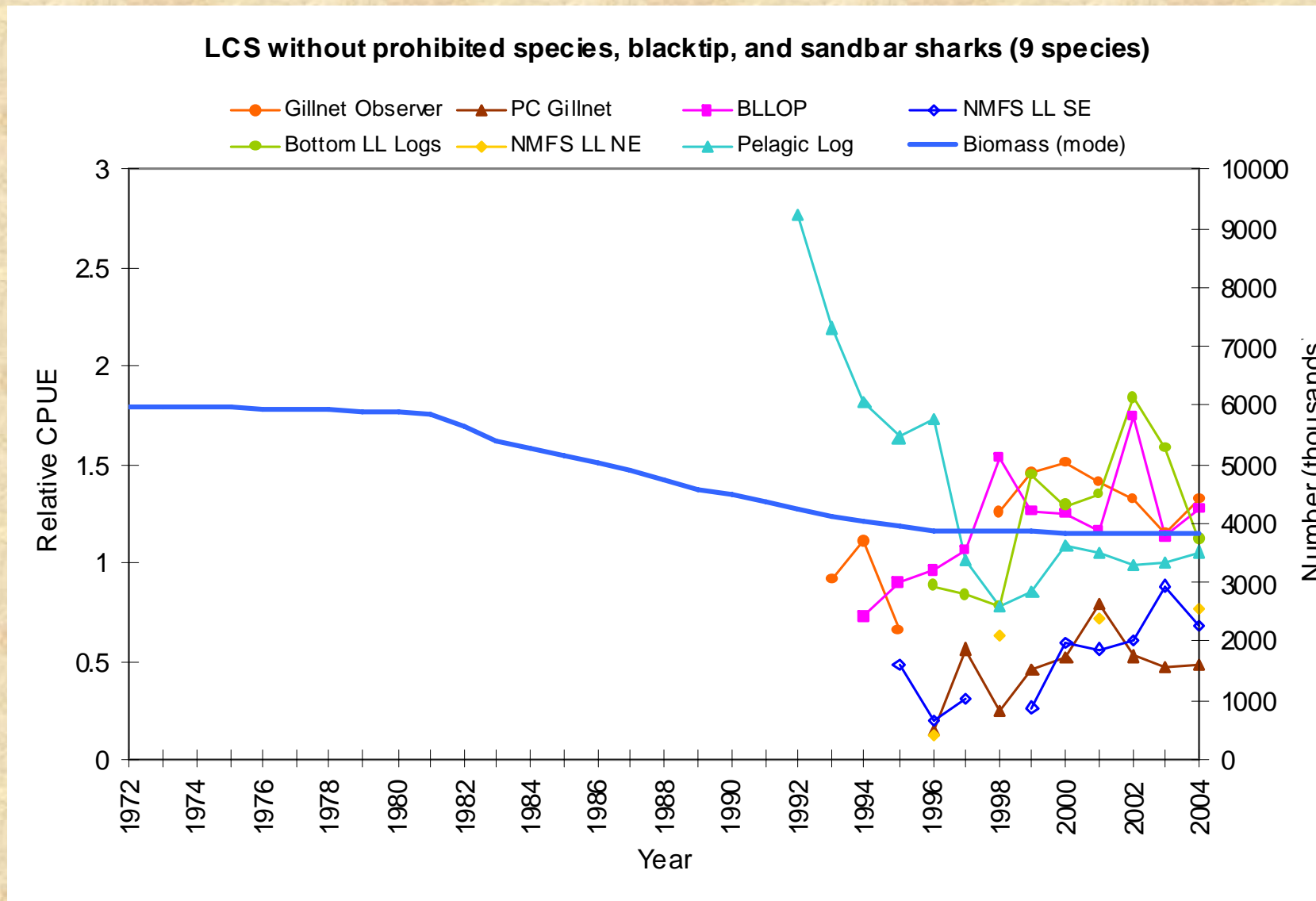
SPM results for LCS-Prohibited spp-Baseline: Prior and posterior pdfs for K, r, and Co



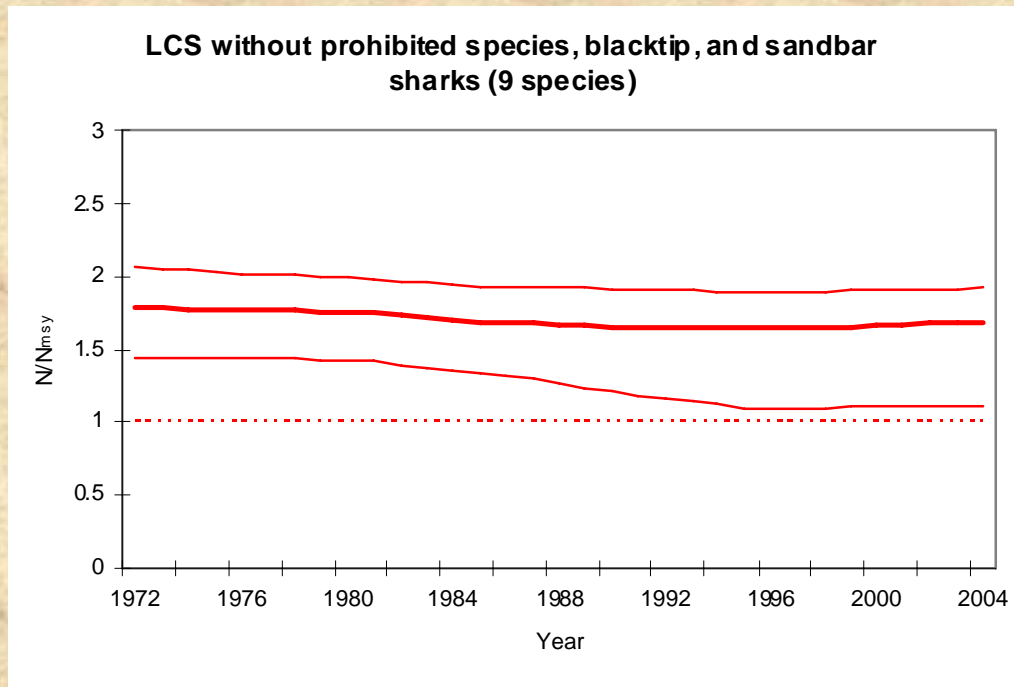
SPM results for LCS-Prohibited spp-Baseline: Projections



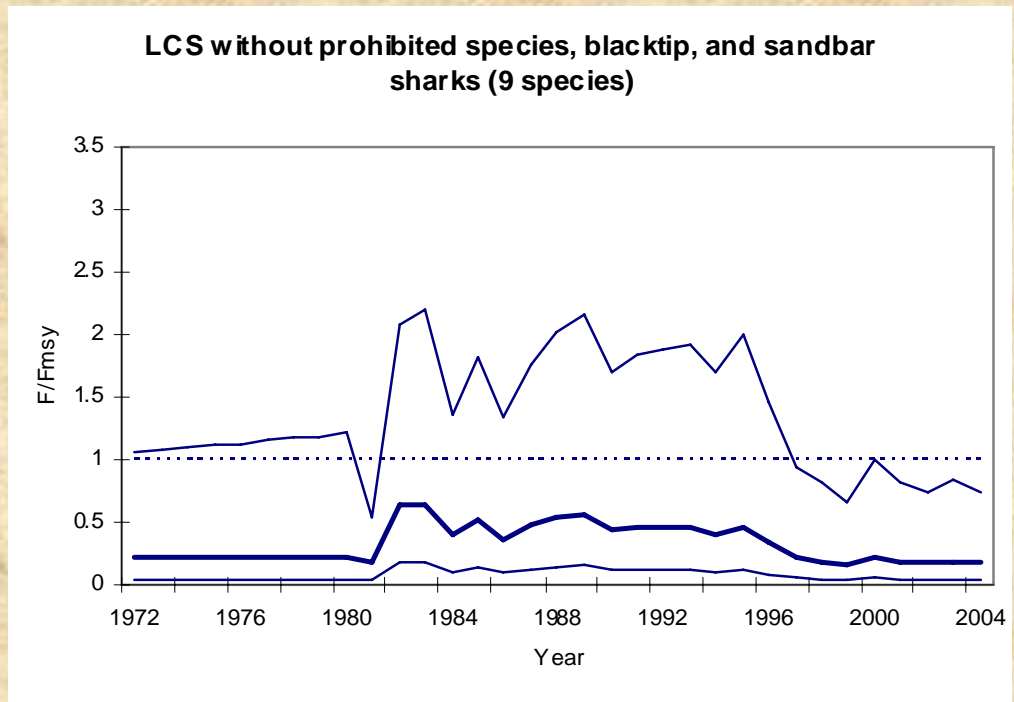
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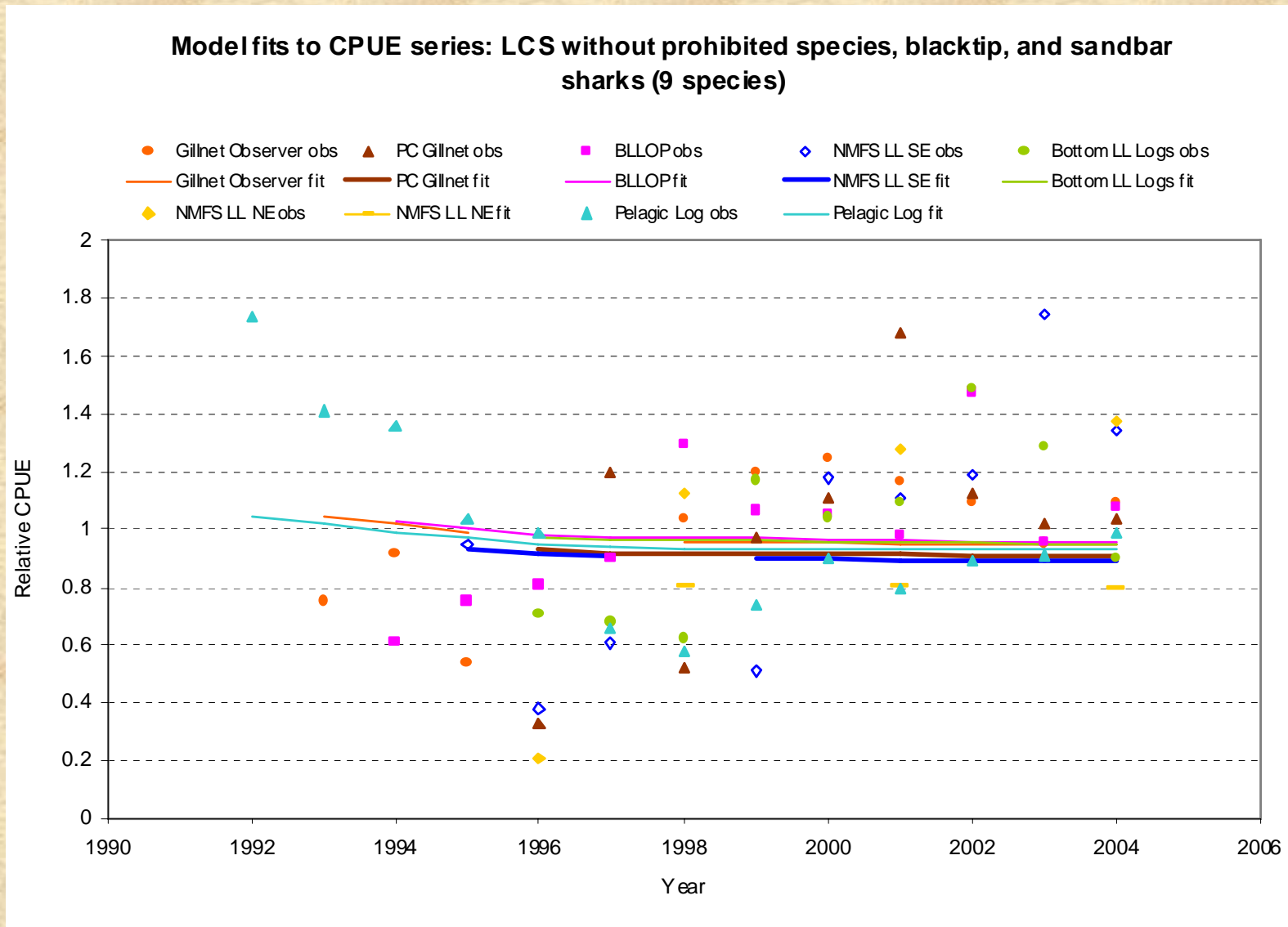


N/N_{MSY}

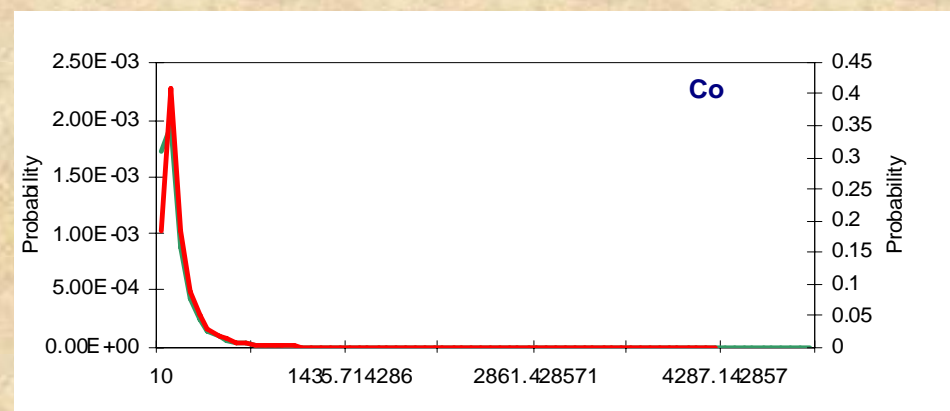
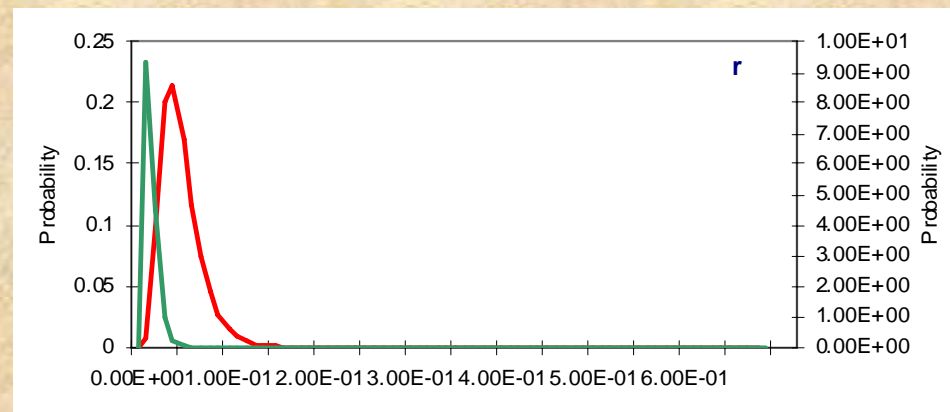
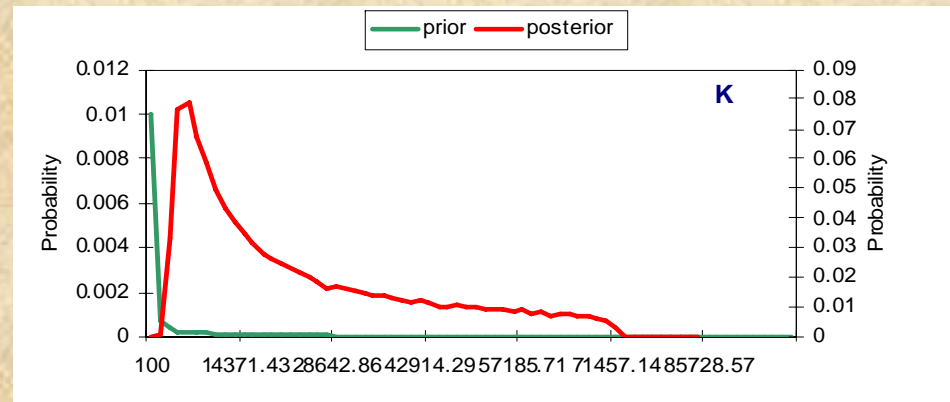


F/F_{MSY}

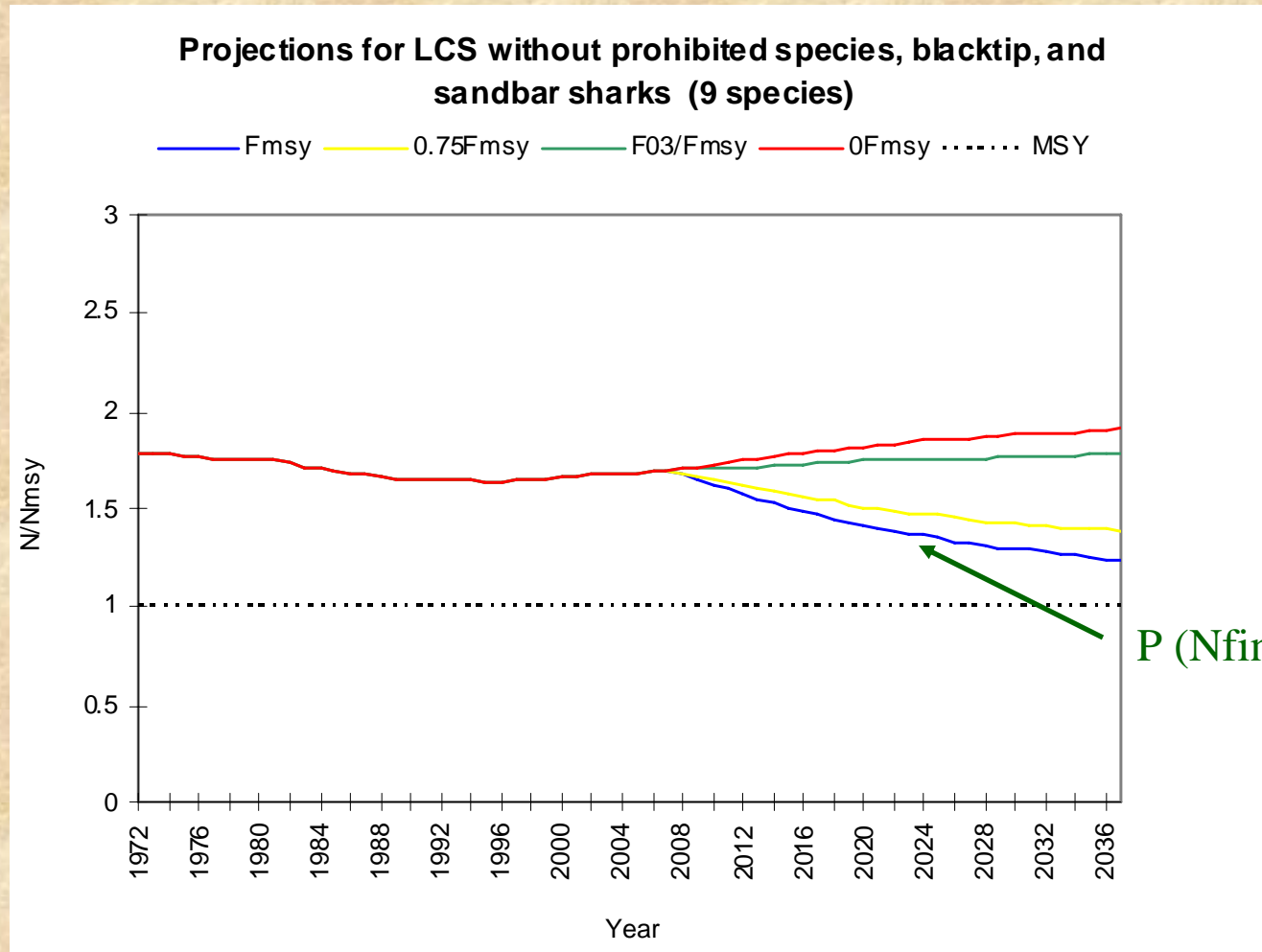
SPM results for LCS-Prohibited spp-BT-SB-Baseline: Model fits to the individual CPUE series



SPM results for LCS-Prohibited spp-BT-SB-Baseline: Prior and posterior pdfs for K, r, and Co



SPM results for LCS-Prohibited spp-BT-SB-Baseline: Projections

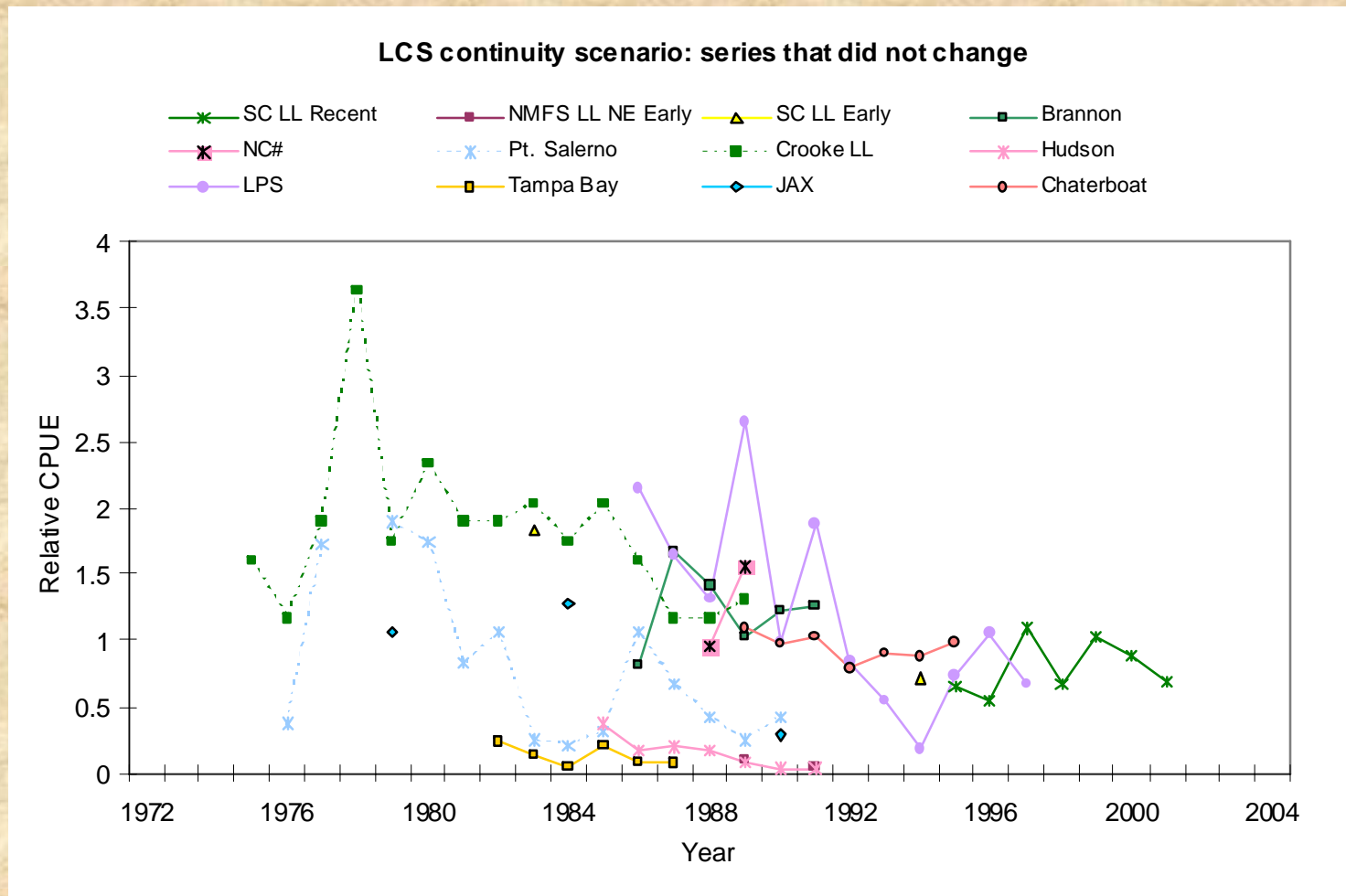


$P(N_{fin} > N_{msy}) = 0.94$

Continuity scenario for LCS: CPUE series

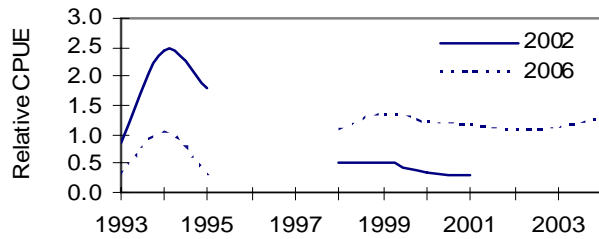
- **FISHERY-DEPENDENT:** Gillnet Observer, Pt. Salerno, Hudson, JAX, Crooke LL, Brannon, LPS, Charterboat, BLLOP, Bottom LL Logs, Pelagic Log, MRFSS (with requiem), NC#, Tampa Bay
- **FISHERY-INDEPENDENT:** VA LL, NMFS LL NE Late, NMFS LL NE Early, SC LL Early, SC LL Recent, NMFS LL SE

LCS Continuity scenario: CPUE series that did not change

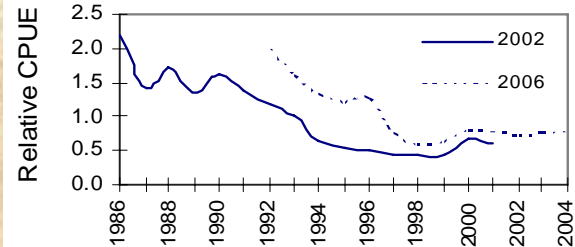


LCS Continuity scenario: CPUE series that changed

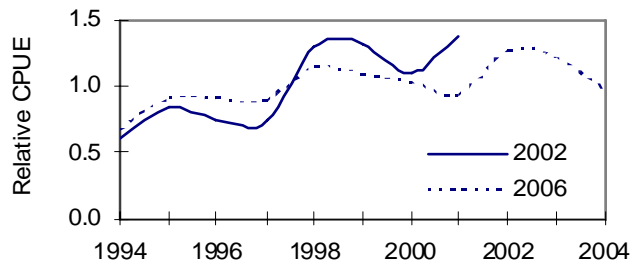
LCS continuity scenario series that changed:
Gillnet Observer



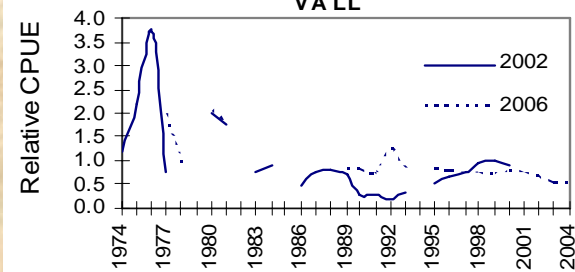
LCS continuity scenario series that changed:
Pelagic Log



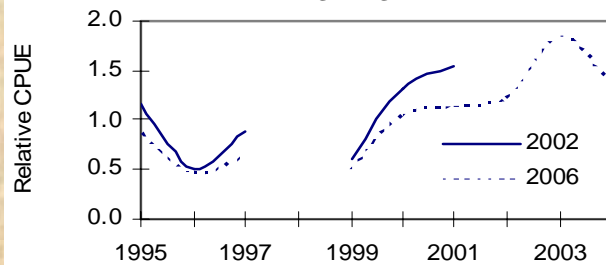
BLLOP



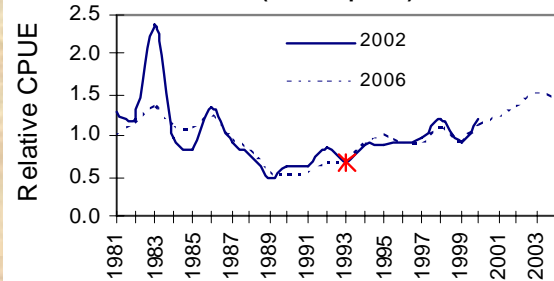
VALL



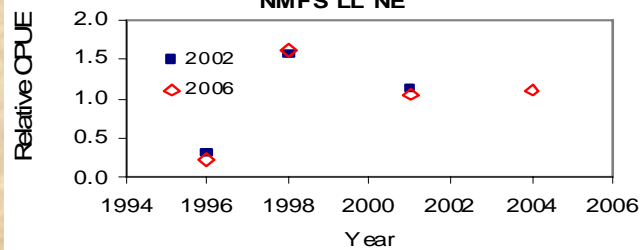
NMFS LL SE



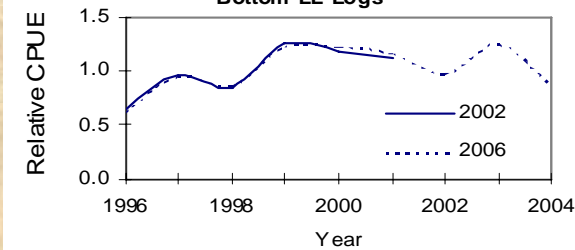
MRFSS (with requiem)




NMFS LL NE



Bottom LL Logs

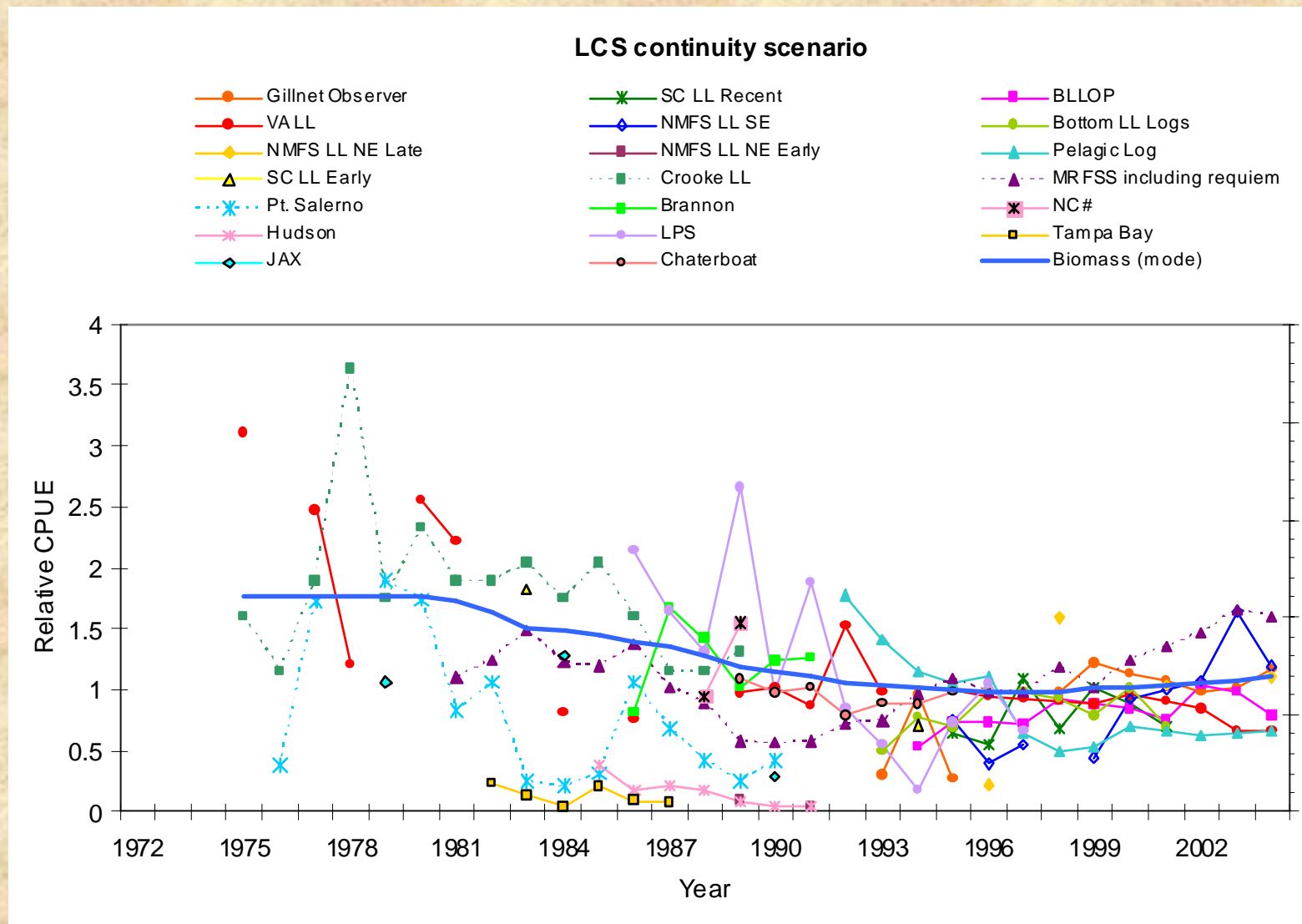


Inputs-Priors for LCS-Continuity scenario

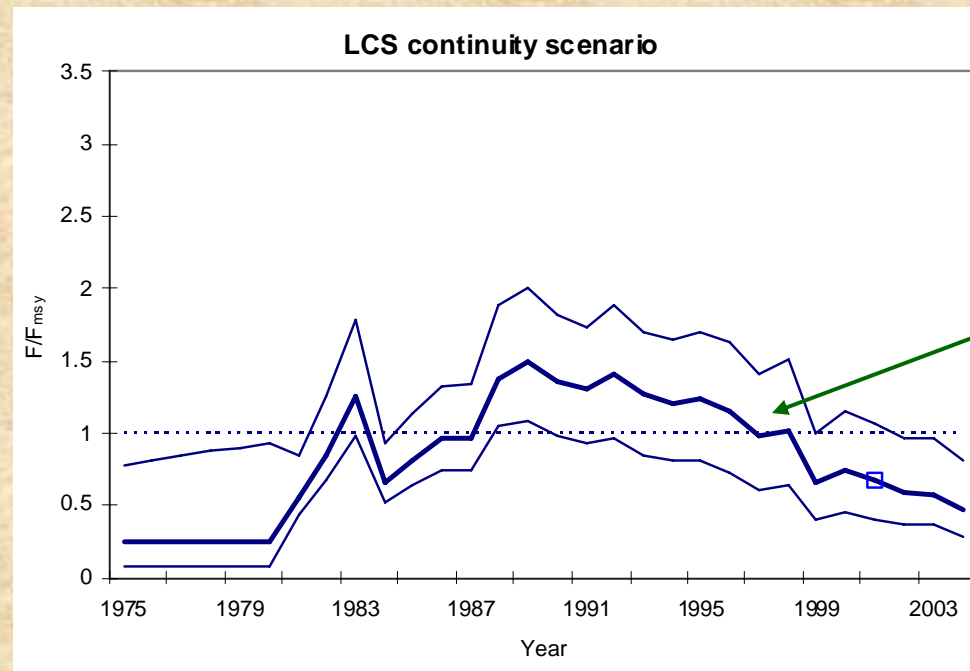
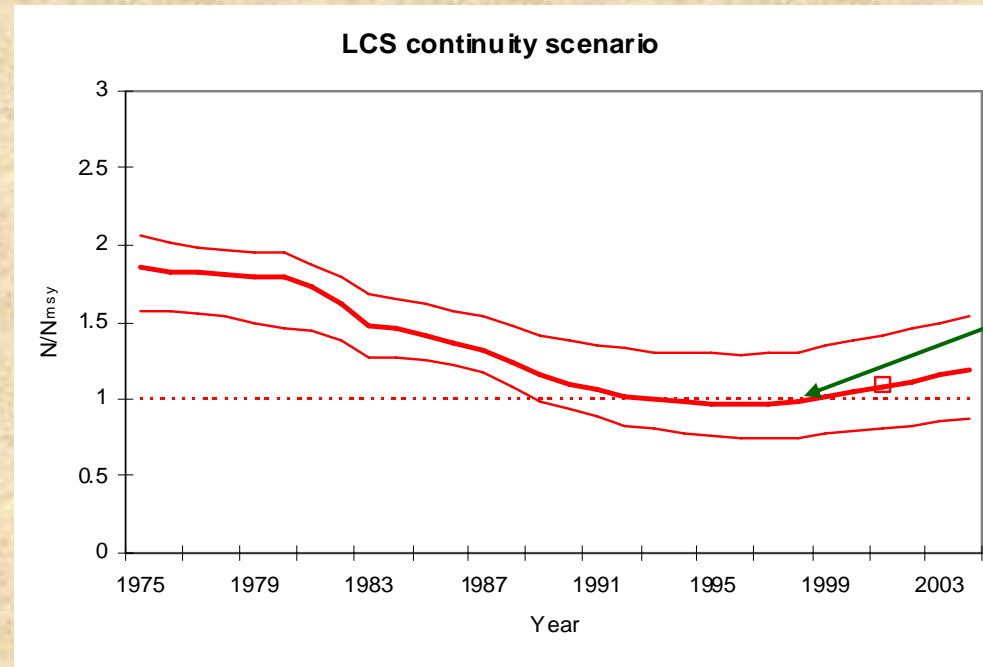
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- $K \sim \text{U}$ on $\log K$ (10^5 - 10^9)

	LCS-Continuity, Eq. W		LCS-Continuity, Inv. W		LCS-Retrospective	
	EV	CV	EV	CV	EV	CV
Importance function	priors		priors		priors	
K	12298	0.65	8109	0.11	35750	0.49
r	0.203	0.55	0.21	0.17	0.047	0.47
MSY	481.3	0.37	417	0.07	397.9	0.62
N ₂₀₀₄	7492	0.86	3333	0.13	25426	0.7
N₂₀₀₄/K	0.6	0.21	0.41	0.12	0.66	0.25
N _{init}	11292	0.67	8051	0.13	36151	0.52
N ₂₀₀₄ /N _{init}	0.66	0.22	0.42	0.12	0.66	0.23
C ₂₀₀₄ /MSY	0.56	0.31	0.6	0.08	0.94	0.52
F₂₀₀₄/F_{MSY}	0.51	0.52	0.74	0.17	0.83	0.75
N₂₀₀₄/N_{MSY}	1.2	0.21	0.83	0.12	1.32	0.25
C ₂₀₀₄ /repy	0.617	0.27	0.638	0.1	1.711	55.4
N _{MSY}	6149	0.65	4054	0.11	17875	0.49
F _{MSY}	0.101		0.105		0.024	0.47
repy	422.7	0.17	395.6	0.1	279.7	0.38
C ₀	291.9	0.94	138.6	0.65	415.3	1
Diagnostics						
CV (Wt) / CV (L*p)	1.43		1.09		0.5	
%maxpWt	0.096		2.5		0.015	

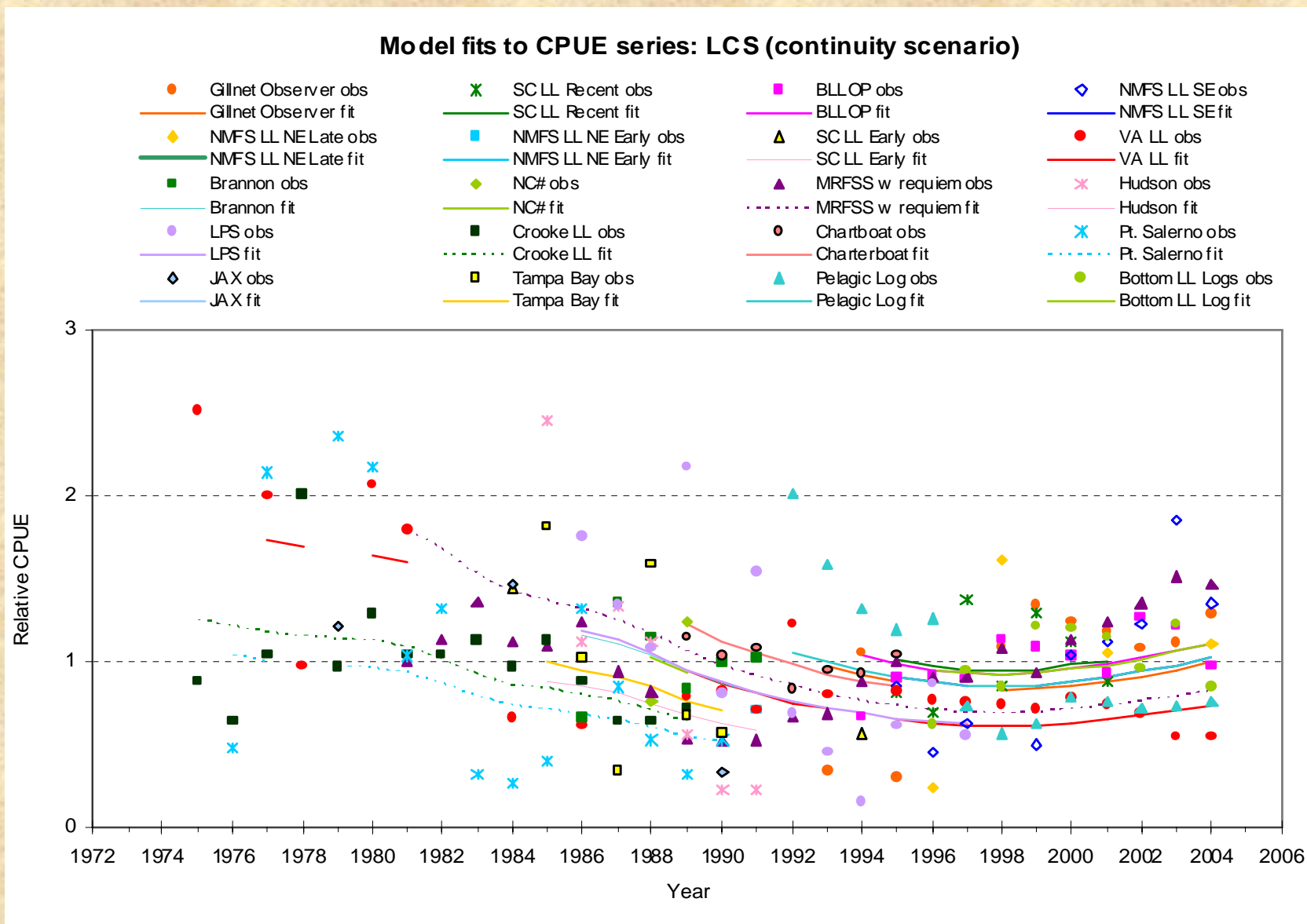
SPM results for LCS-Continuity scenario: Predicted biomass trend at posterior mode of the BSP model fitted to catch and CPUE data



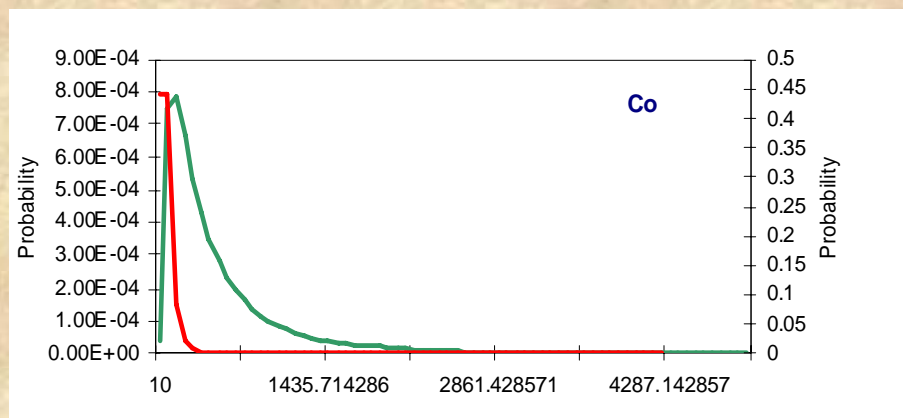
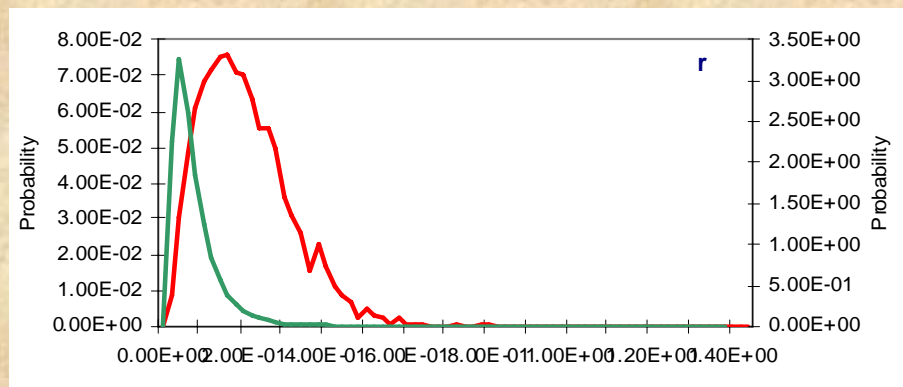
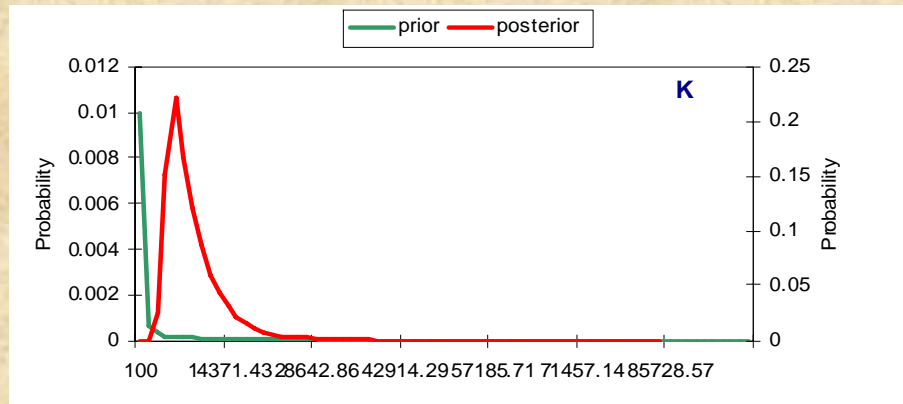
SPM
results for
LCS-
Continuity
scenario:
BSP
estimated
relative
biomass and
fishing
mortality
rate
trajectories



SPM results for LCS-Continuity scenario: Model fits to the individual CPUE series

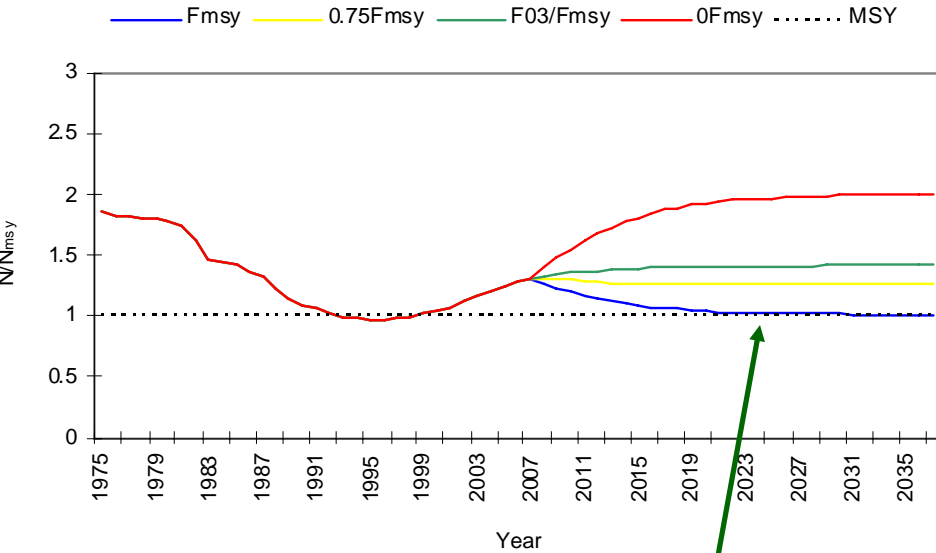


SPM results for LCS-Continuity scenario: Prior and posterior pdfs for K, r, and Co



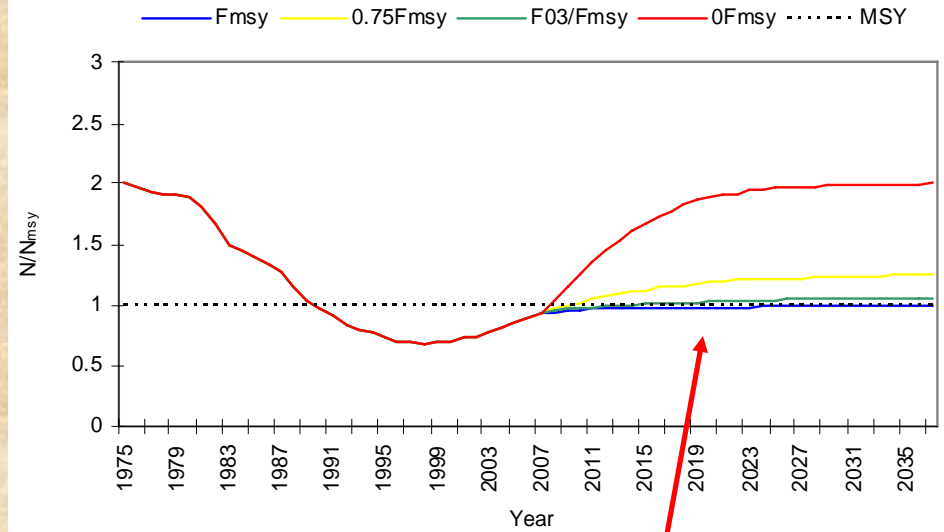
SPM results for LCS-Continuity scenario: Projections

Projections for LCS continuity scenario with equal weighting



$P(N_{fin} > N_{msy}) = 0.86$

Projections for LCS continuity scenario with inverse CV weighting

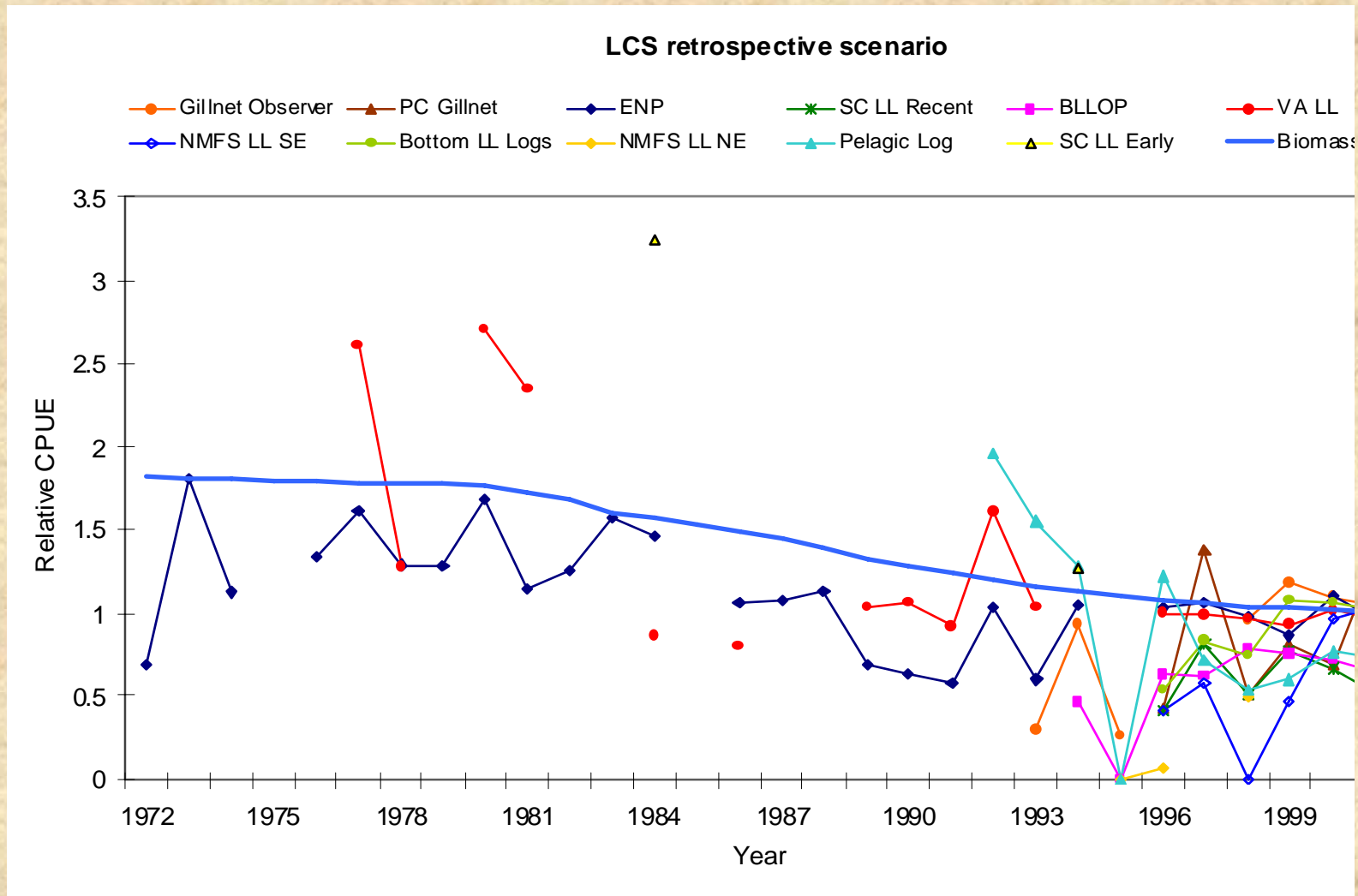


$P(N_{fin} > N_{msy}) = 0.29$

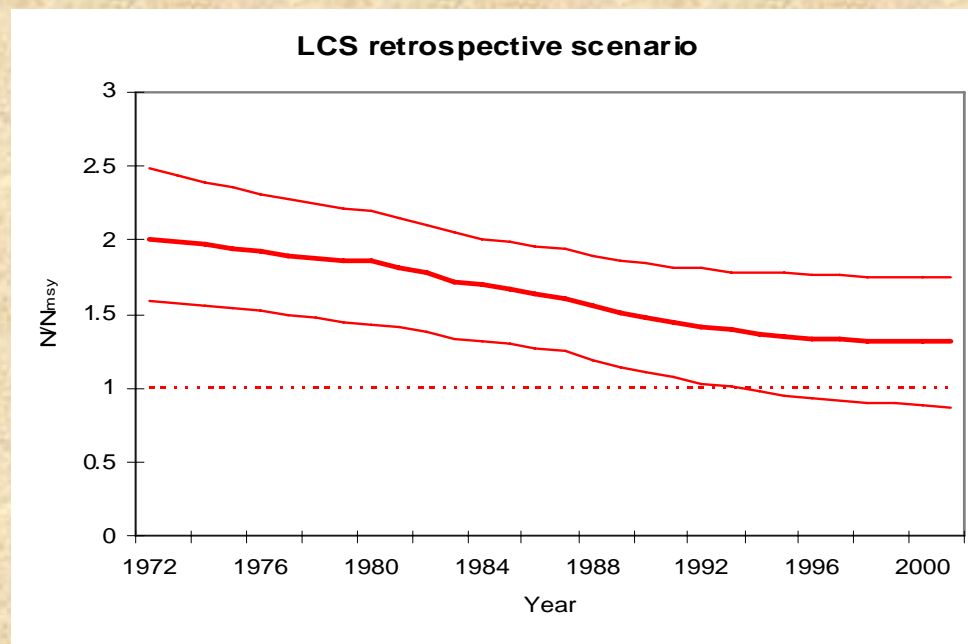
Inputs-Priors for LCS-retrospective analysis

- Model **ended in 2001**
 - Catches for 1972-1980 = $C_0 \sim \text{LN} (571.8, 1)$
 - $r \sim \text{LN} (0.045, 0.44, 0.001, 2.0)$
 - $N_{72/K} \sim \text{LN} (1, 0.2, 0.2, 1.1)$
 - $K \sim \text{U on log } K (10^5-10^9)$
- ↑
Mean (1981-2001)

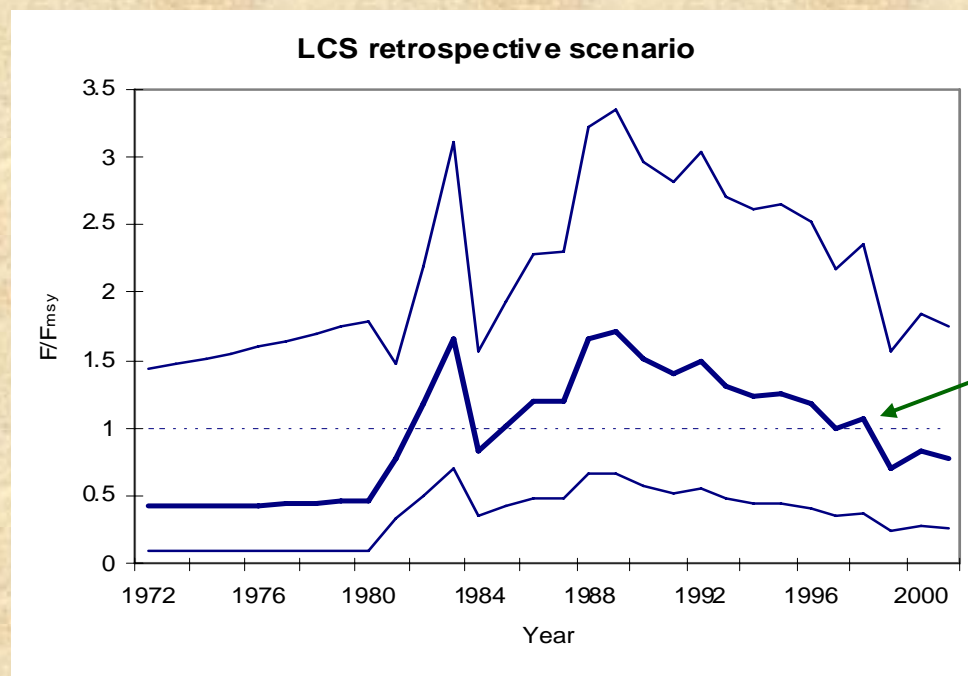
SPM results for LCS-retrospective analysis: Predicted biomass trend at posterior mode of the BSP model fitted to catch and CPUE data



**SPM results
for LCS-
Retrospective
analysis: BSP
estimated
relative
biomass and
fishing
mortality rate
trajectories**



N/N_{MSY}

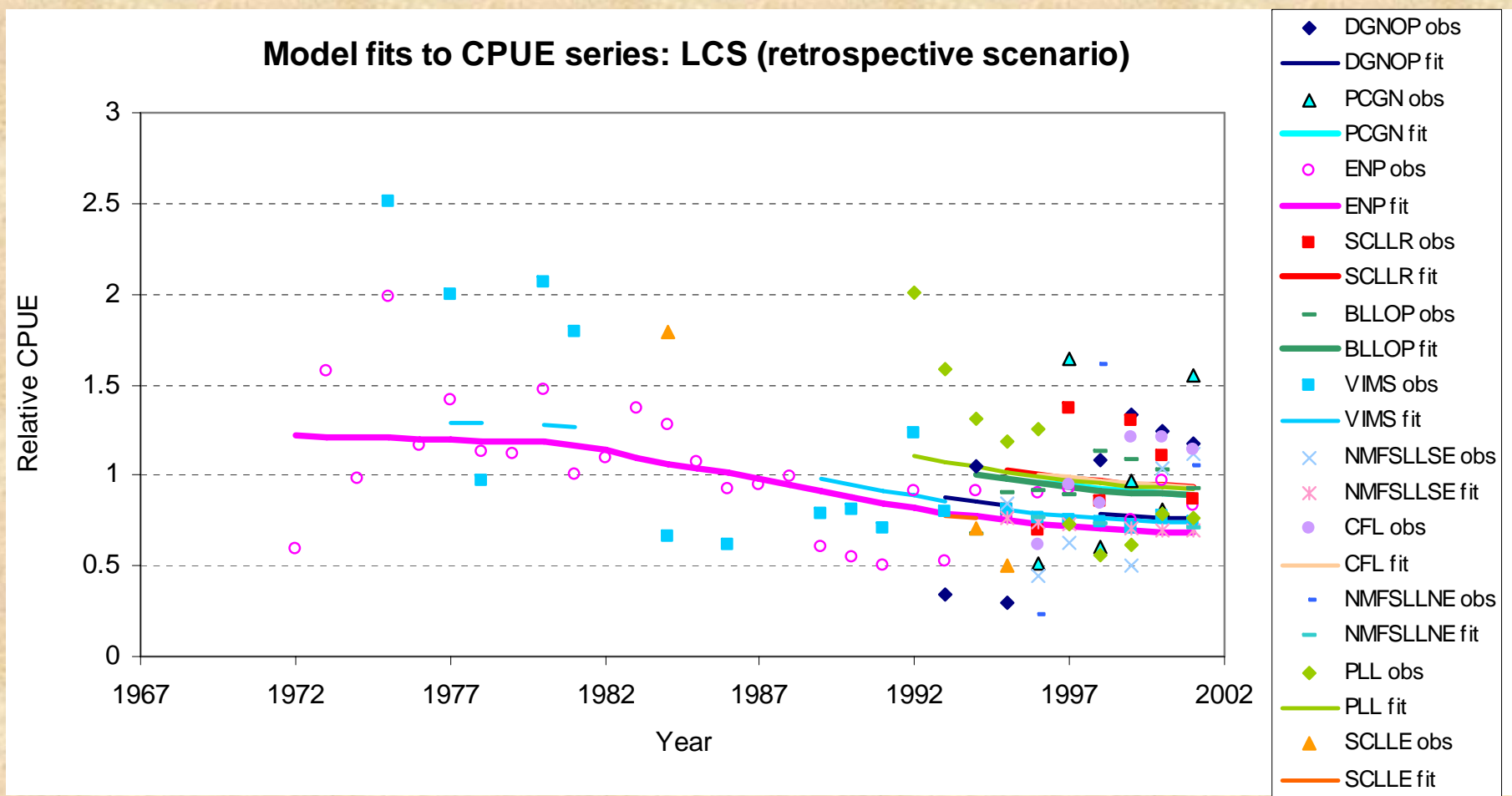


F/F_{MSY}

No overfishing
after 1998



SPM results for LCS-Retrospective analysis: Model fits to the individual CPUE series



Sensitivity Analyses

- Inverse CV weighting
- Including all CPUE series
- Removing one CPUE series at a time
- Using 1981 catch as a fixed catch for the years 1972-1980

INVERSE CV WEIGHTING

	LCS		LCS-PROH		LCS-PROH-SB-BT	
	EV	CV	EV	CV	EV	CV
Importance function	multivariate t		priors		priors	
K	12624	0.18	54958	0.41	28497	0.86
r	0.1	0.33	0.058	0.46	0.057	0.51
MSY	298.8	0.19	744	0.53	341.8	0.9
N ₂₀₀₄	4604	0.14	44108	0.49	24665	0.94
N₂₀₀₄/K	0.37	0.17	0.78	0.15	0.79	0.18
N _{init}	12411	0.18	47027	0.43	24074	0.88
N ₂₀₀₄ /N _{init}	0.38	0.16	0.92	0.18	0.95	0.21
C ₂₀₀₄ /MSY	0.88	0.25	0.42	0.51	0.31	0.7
F₂₀₀₄/F_{MSY}	1.24	0.41	0.3	0.7	0.23	0.93
N₂₀₀₄/N_{MSY}	0.74	0.17	1.56	0.15	1.59	0.18
C ₂₀₀₄ /repy	0.968	0.31	0.659	0.33	0.541	29.45
N _{MSY}	6312	0.18	27479	0.41	14249	0.86
F _{MSY}	0.05		0.029		0.029	
repy	276.3	0.23	412.3	0.31	138.6	0.55
C ₀	211	0.79	607	1.13	201.5	1.46
Diagnostics						
CV (Wt) / CV (L*p)	3.3		1.14		2.09	
%maxpWt	4.265		0.013		0.146	

ALL CPUE SERIES

	LCS				LCS-prohibited			
	MRFSS with requiem		MRFSS without requiem		MRFSS with requiem		MRFSS without requiem	
	EV	CV	EV	CV	EV	CV	EV	CV
Importance function	priors		priors		priors		priors	
K	35484	0.47	26781	0.44	55699	0.4	25945	0.57
r	0.05	0.49	0.05	0.48	0.05	0.47	0.05	0.48
MSY	430	0.53	313	0.49	704.57	0.56	289.37	0.65
N ₂₀₀₄	25804	0.64	16803	0.7	44461	0.48	14866	0.97
N₂₀₀₄/K	0.69	0.21	0.59	0.25	0.77	0.15	0.5	0.35
N _{init}	36247	0.5	27462	0.49	48720	0.42	23466	0.59
N ₂₀₀₄ /N _{init}	0.68	0.19	0.58	0.22	0.89	0.17	0.56	0.33
C ₂₀₀₄ /MSY	0.72	0.46	0.95	0.42	0.46	0.55	1.09	0.46
F₂₀₀₄/F_{MSY}	0.58	0.62	0.9	0.59	0.33	0.74	1.32	0.7
N₂₀₀₄/N_{MSY}	1.37	0.21	1.18	0.25	1.54	0.15	1.01	0.35
C ₂₀₀₄ /repy	0.94	3.82	1.09	3.1	0.7	0.37	1.23	0.44
N _{MSY}	17742	0.47	13390	0.44	27850	0.4	12972	0.57
F _{MSY}	0.03	0.49	0.03	0.48	0.03	0.47	0.02	0.48
repy	303	0.32	260	0.32	398	0.33	236	0.38
C ₀	426	0.99	352	0.93	514	1.12	347	1.05
Diagnostics								
CV (Wt) / CV (L*p)	0.73		0.72		0.78		0.66	
%maxpWt	0.036		0.051		0.025		0.071	

REMOVING 1 CPUE SERIES AT A TIME: LCS

Series removed	Gillnet	PC	SC LL		NMFS LL Bottom	NMFS LL Pelagic	SC LL				
	Observer	Gillnet	ENP	Recent	BLLOP	SE	LL Logs	NE	Log	Early	VA LL
	EV	EV	EV	EV	EV	EV	EV	EV	EV	EV	EV
Importance function	priors	priors	priors	priors	priors	priors	priors	priors	priors	priors	priors
K	33401	35128	36517	35184	34807	34626	35113	34851	37259	37233	44171
r	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
MSY	367	396	415	397	390	382	395	390	433	422	514
N ₂₀₀₄	23054	24907	25825	24960	24556	24332	24889	24604	27133	27027	33867
N₂₀₀₄/K	0.64	0.66	0.65	0.66	0.65	0.65	0.66	0.66	0.68	0.68	0.72
N _{init}	33903	35599	36520	35622	35274	35163	35576	35345	37555	37627	43283
N ₂₀₀₄ /N _{init}	0.63	0.66	0.65	0.66	0.65	0.65	0.66	0.65	0.68	0.68	0.74
C ₂₀₀₄ /MSY	0.87	0.81	0.8	0.81	0.82	0.84	0.81	0.82	0.74	0.76	0.65
F₂₀₀₄/F_{MSY}	0.8	0.71	0.74	0.7	0.72	0.75	0.71	0.72	0.62	0.64	0.51
N₂₀₀₄/N_{MSY}	1.27	1.32	1.29	1.32	1.31	1.3	1.32	1.31	1.36	1.35	1.45
C ₂₀₀₄ /repy	1.08	1.04	1.03	1.04	1.05	1.07	1.04	1.05	0.98	1.01	0.92
N _{MSY}	16700	17564	18258	17592	17403	17313	17557	17425	18629	18616	22085
F _{MSY}	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02
repy	269	281	287	283	279	274	282	278	298	290	319
C ₀	401	417	476	418	414	408	417	413	440	432	432
Diagnostics											
CV (Wt) / CV (L*p)	0.53	0.54	0.51	0.55	0.54	0.52	0.54	0.54	0.57	0.53	0.45
%maxpWt	0.014	0.017	0.019	0.017	0.016	0.012	0.017	0.015	0.032	0.016	0.009

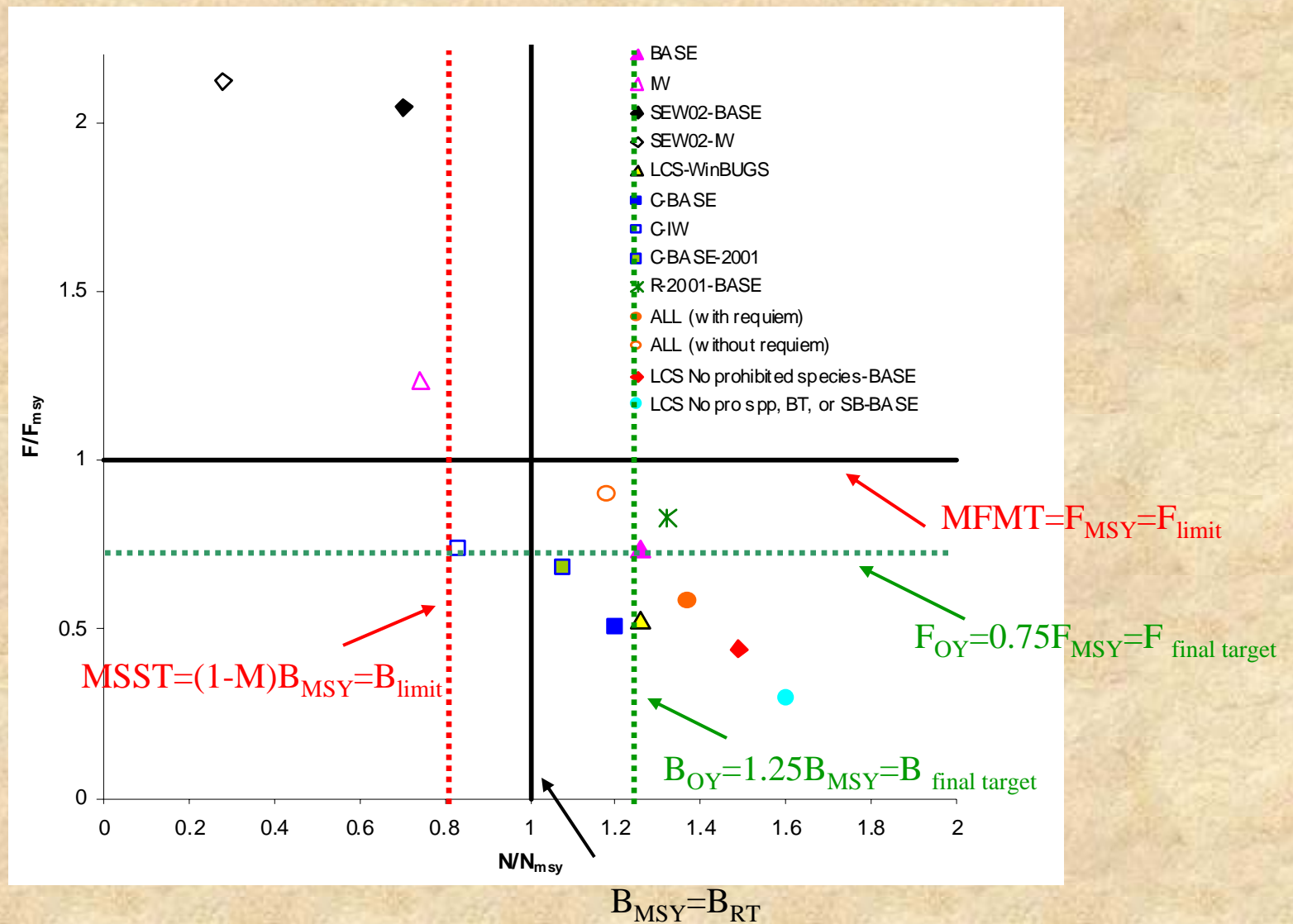
REMOVING 1 CPUE SERIES AT A TIME: LCS-PRO

Series removed	Gillnet	PC	NMFS LL	Bottom	NMFS LL	Pelagic	
	Observer	Gillnet	BLLOP	SE	LL Logs	NE	Log
	EV	EV	EV	EV	EV	EV	EV
Importance function	priors	priors	priors	priors	priors	priors	priors
K	48796	51093	50693	50383	50925	50770	52207
r	0.05	0.05	0.05	0.05	0.05	0.05	0.05
MSY	575	615	609	599	612	610	650
N ₂₀₀₄	37572	39888	39488	39168	39725	39572	40955
N₂₀₀₄/K	0.72	0.74	0.73	0.73	0.74	0.74	0.75
N _{init}	43426	45271	44921	44764	45122	45003	45809
N ₂₀₀₄ /N _{init}	0.81	0.84	0.83	0.83	0.84	0.84	0.86
C ₂₀₀₄ /MSY	0.62	0.56	0.57	0.59	0.57	0.57	0.52
F₂₀₀₄/F_{MSY}	0.53	0.45	0.46	0.49	0.46	0.46	0.4
N₂₀₀₄/N_{MSY}	1.44	1.48	1.47	1.46	1.47	1.47	1.49
C ₂₀₀₄ /repy	0.84	0.79	0.79	0.81	0.79	0.79	0.74
N _{MSY}	24398	25547	25346	25192	25463	25385	26104
F _{MSY}	0.02	0.03	0.03	0.02	0.03	0.03	0.03
repy	343	360	358	351	359	358	378
C ₀	439	460	457	447	458	457	496
Diagnostics							
CV (Wt) / CV (L*p)	0.41	0.53	0.51	0.47	0.52	0.52	1
%maxpWt	0.006	0.004	0.009	0.006	0.008	0.008	0.062

REMOVING 1 CPUE SERIES AT A TIME: LCS-PRO-BT-SB

Series removed	Gillnet	PC	NMFS LL		Bottom	NMFS LL	Pelagic
	Observer	Gillnet	BLLOP	SE	LL Logs	NE	Log
	EV	EV	EV	EV	EV	EV	EV
Importance function	priors	priors	priors	priors	priors	priors	priors
K	30695	31190	30874	31255	31381	31270	32600
r	0.05	0.05	0.05	0.05	0.05	0.05	0.05
MSY	353	357	355	360	361	359	378
N_{2004}	27070	27548	27243	27611	27734	27636	28894
N_{2004}/K	0.79	0.8	0.79	0.8	0.8	0.8	0.81
N_{init}	27346	27804	27509	27819	27946	27887	28901
N_{2004}/N_{init}	0.9	0.9	0.9	0.91	0.91	0.9	0.93
C_{2004}/MSY	0.39	0.38	0.39	0.37	0.37	0.38	0.34
F_{2004}/F_{MSY}	0.33	0.31	0.32	0.31	0.31	0.32	0.26
N_{2004}/N_{MSY}	1.59	1.6	1.59	1.6	1.6	1.6	1.63
$C_{2004}/repy$	0.72	0.68	0.72	0.71	0.71	0.71	0.61
N_{MSY}	15347	15595	15437	15627	15690	15635	16300
F_{MSY}	0.02	0.02	0.02	0.02	0.02	0.02	0.02
repy	119	119	119	120	120	119	126
C_0	132	132	132	133	132	131	142
Diagnostics							
CV (Wt) / CV (L*p)	0.24	0.25	0.25	0.26	0.26	0.24	0.78
%maxpWt	0.008	0.002	0.008	0.008	0.008	0.006	0.074

Results combined: Biological reference points (phase plot of relative biomass vs. relative fishing mortality)



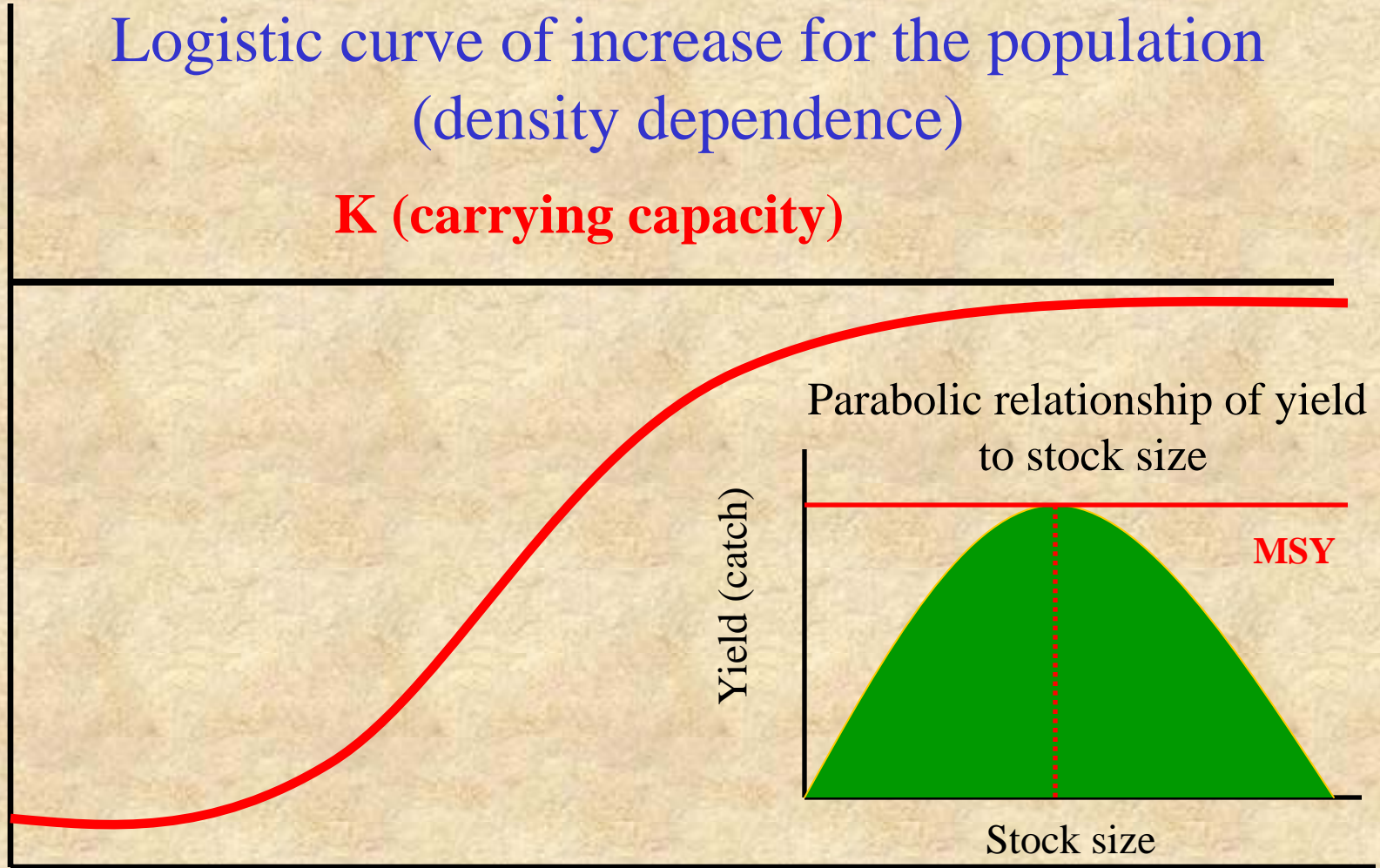
Additional slides

- Stock-recruitment curve; position of inflection point

Logistic curve of increase for the population
(density dependence)

K (carrying capacity)

Population size

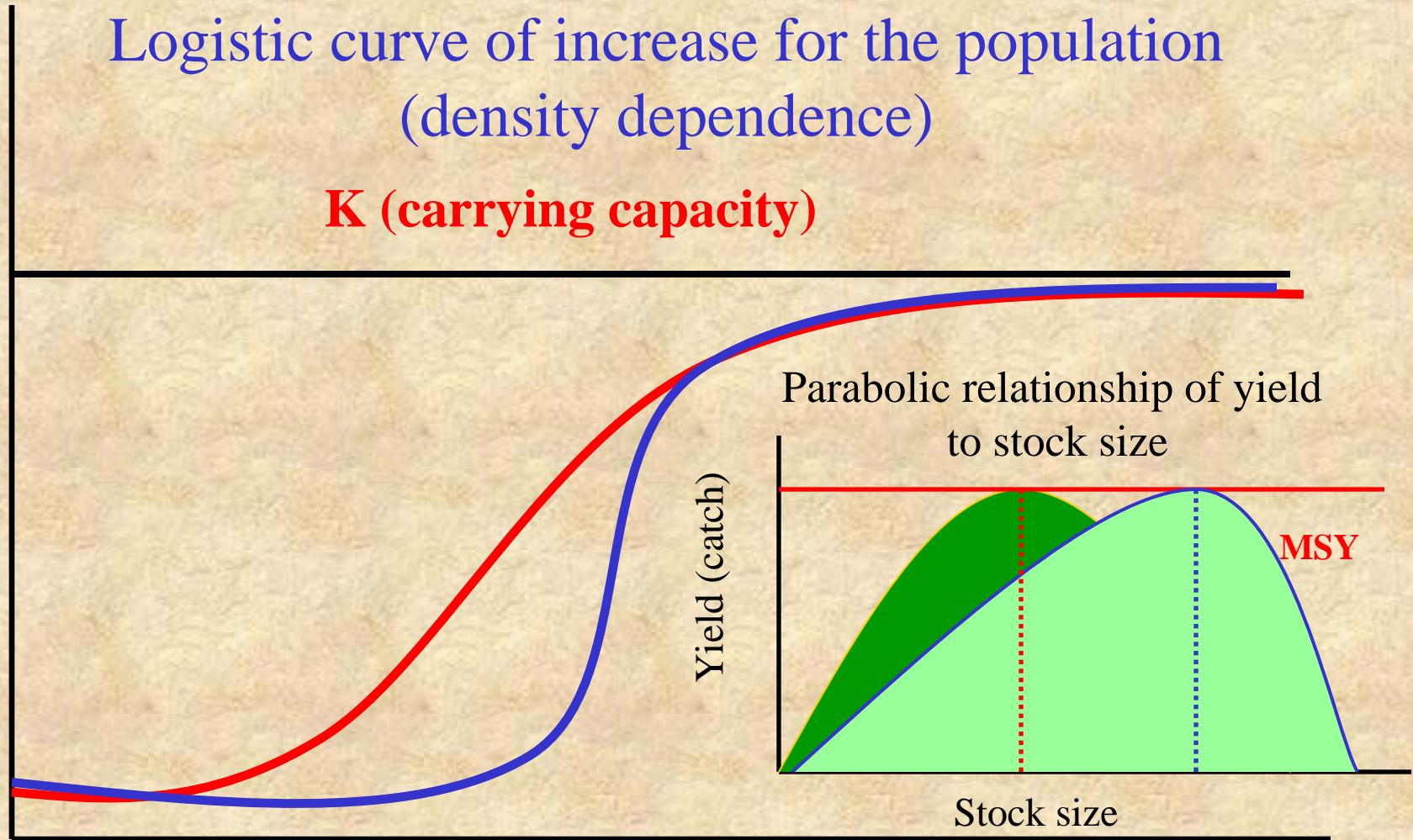


Time

Logistic curve of increase for the population
(density dependence)

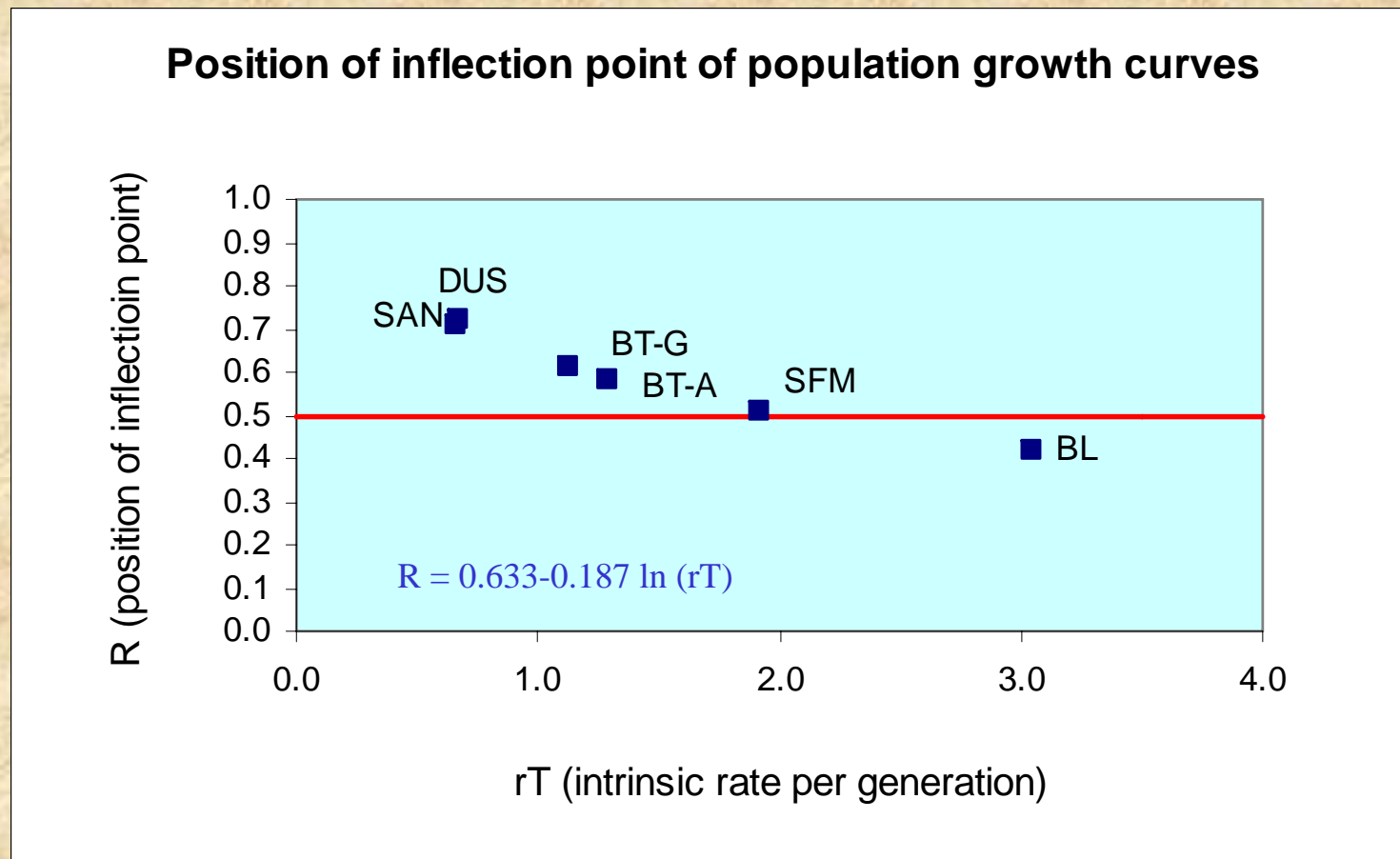
K (carrying capacity)

Population size

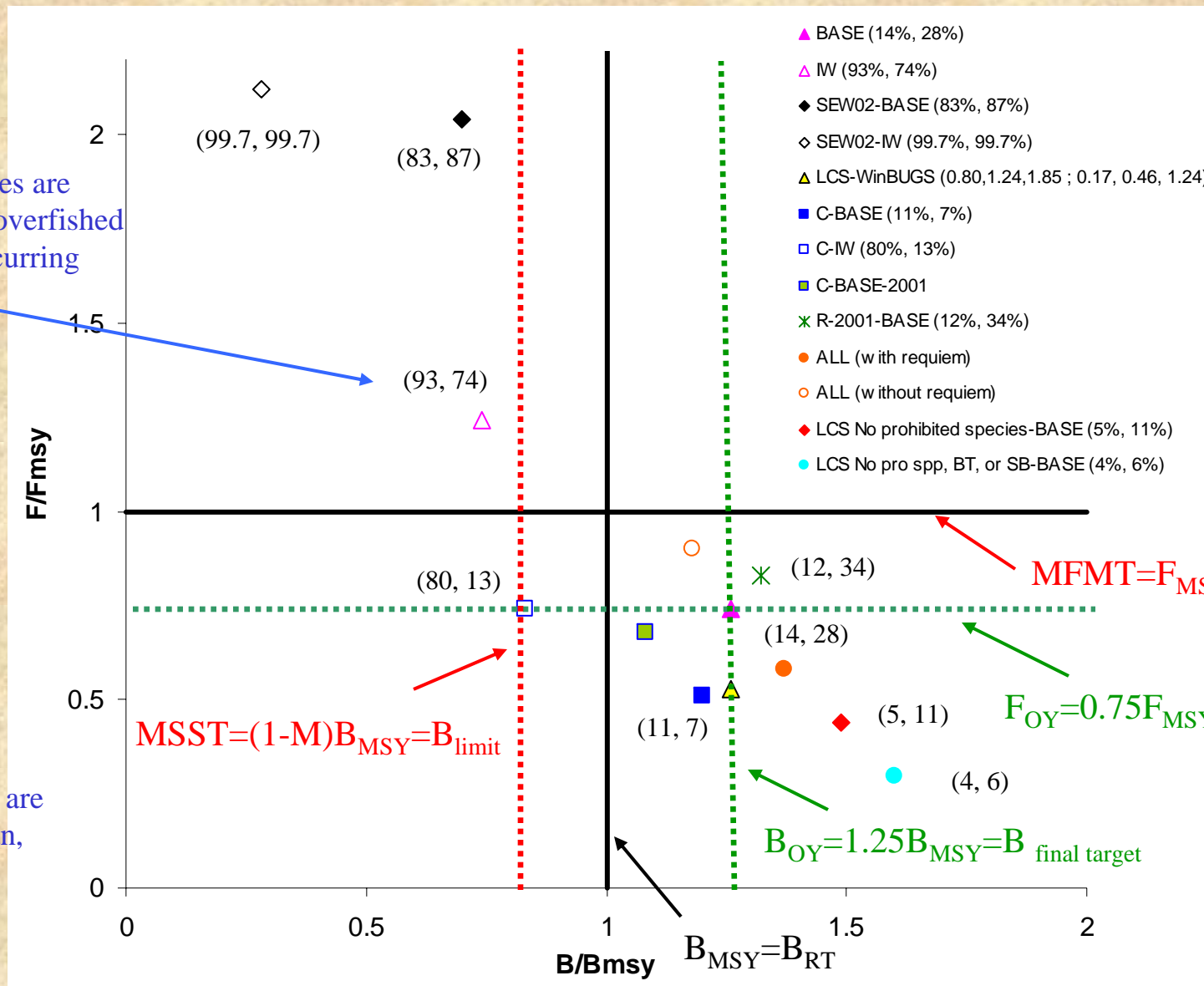


Time

Relationship between R (position of inflection point of population growth curves) and the rate of increase per generation for 6 species of sharks



Results combined: Biological reference points (phase plot of relative biomass vs. relative fishing mortality)



Numbers in parentheses are probabilities of being overfished and of overfishing occurring

WinBUGS

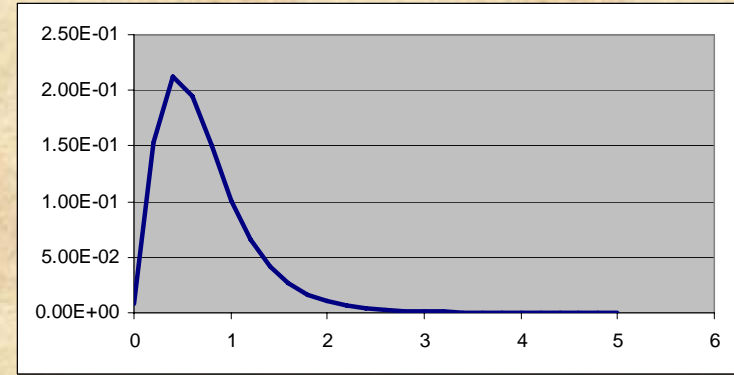
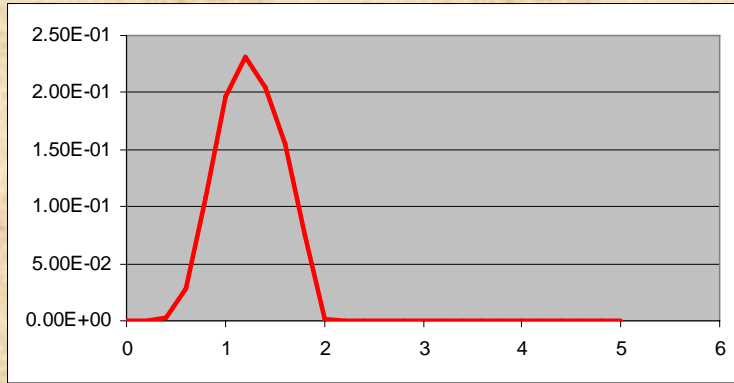
(0.80, 1.24, 1.85)

(0.17, 0.46, 1.24)

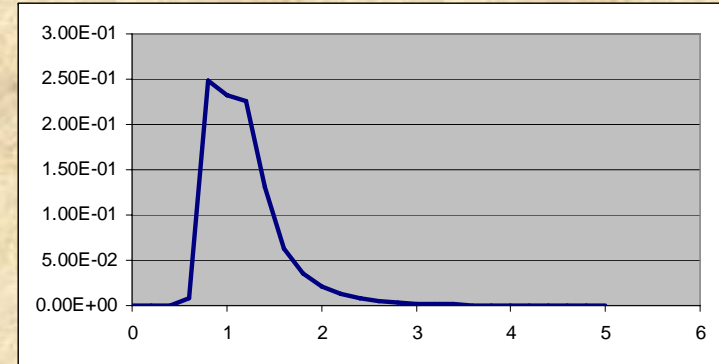
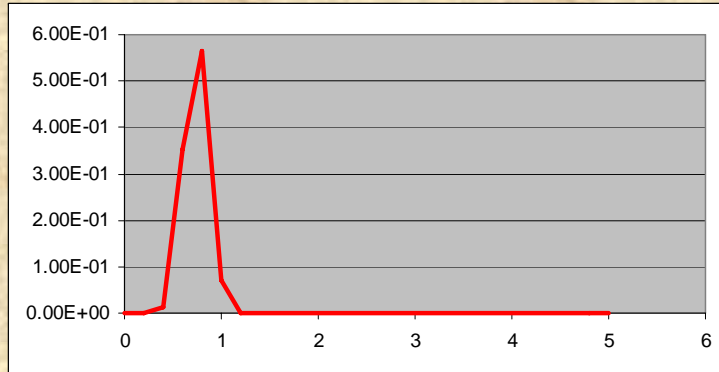
Numbers for WinBUGS are 2.5th percentile, median, and 97.5th percentile

N_{04}/N_{MSY} Posterior pdfs of points in phase plot F_{04}/F_{MSY}

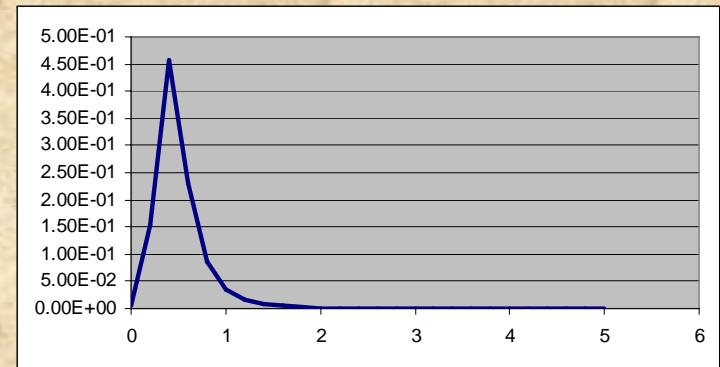
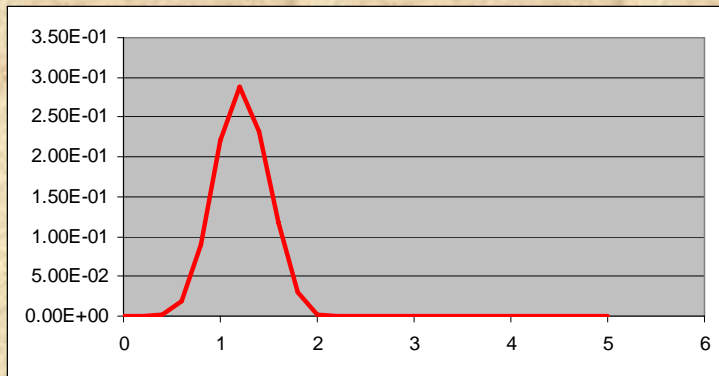
BASE



IW

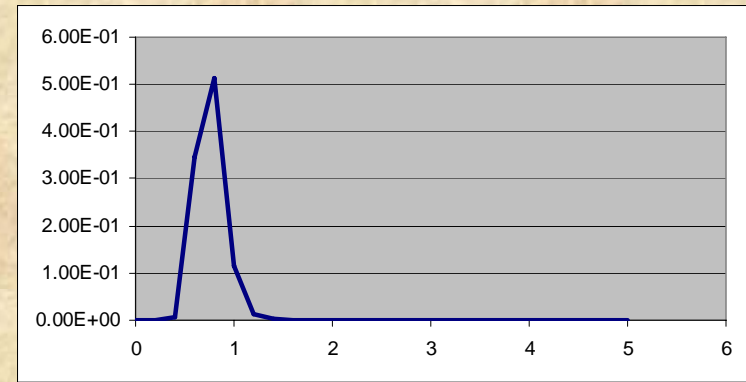
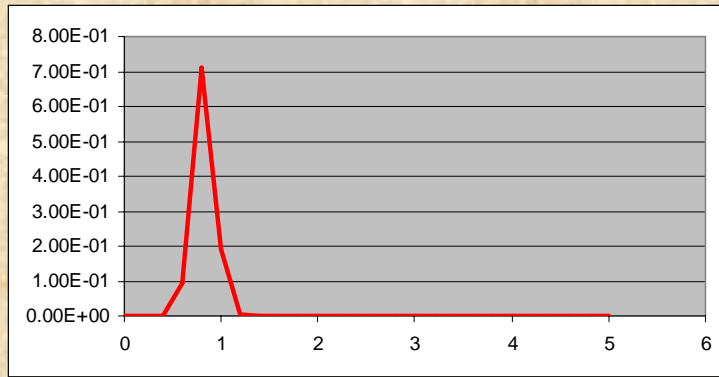


C-BASE

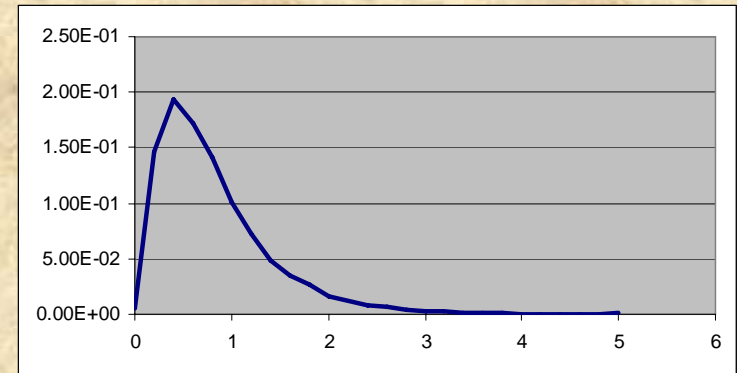
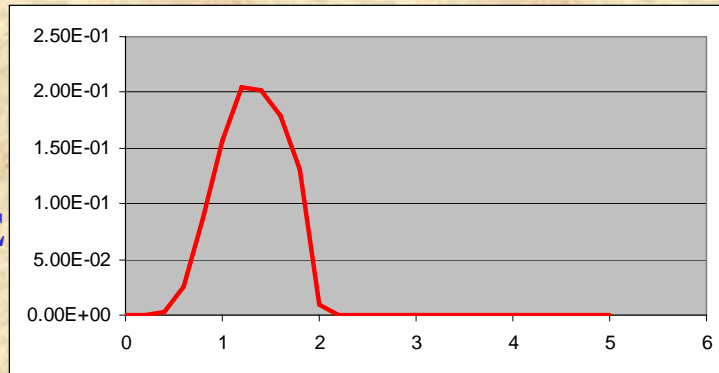


N_{04}/N_{MSY} Posterior pdfs of points in phase plot F_{04}/F_{MSY}

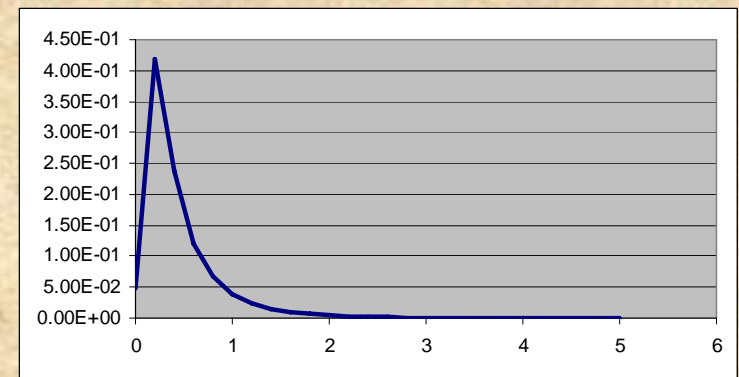
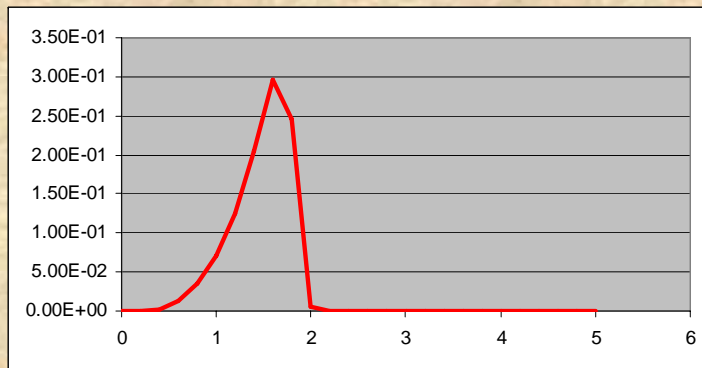
C-IW



R-2001-BASE

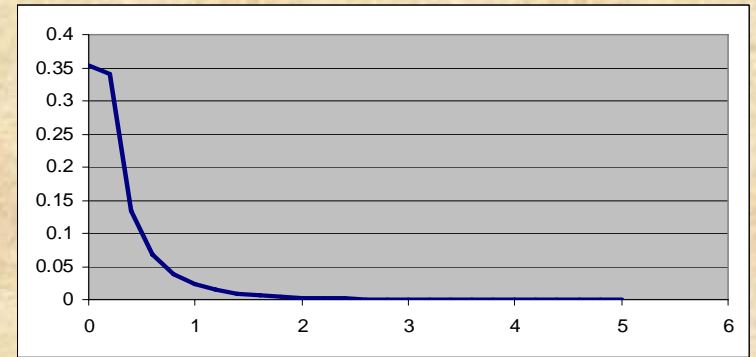
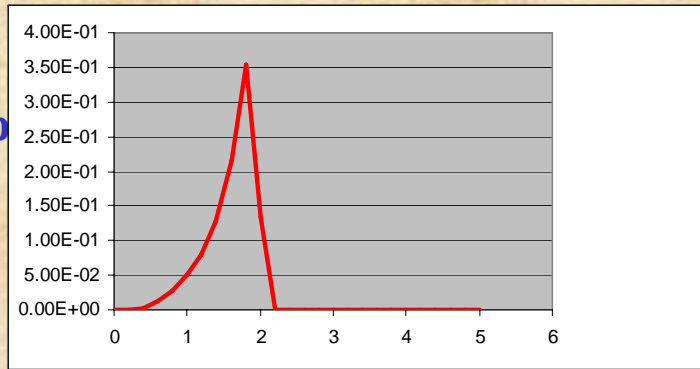


LCS-No proh
spp-BASE

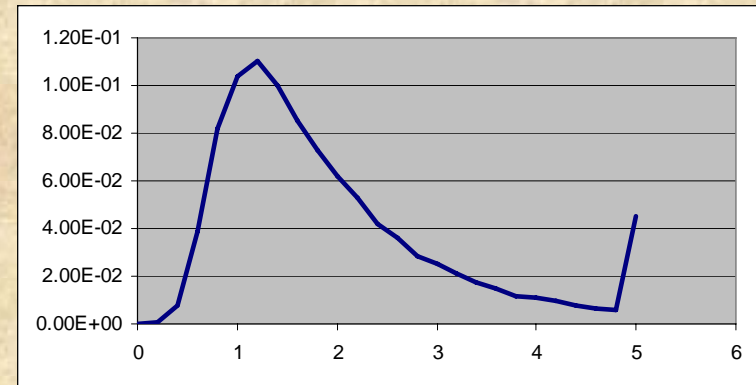
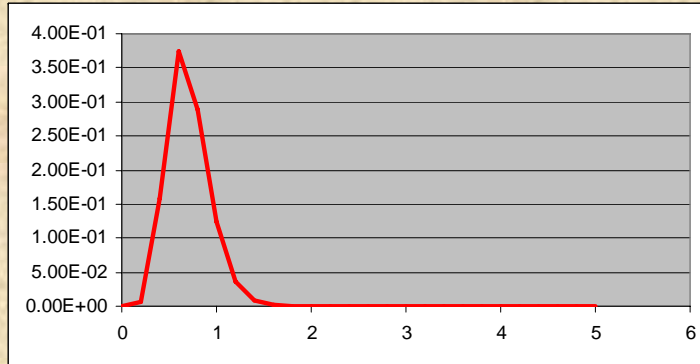


N_{04}/N_{MSY} Posterior pdfs of points in phase plot F_{04}/F_{MSY}

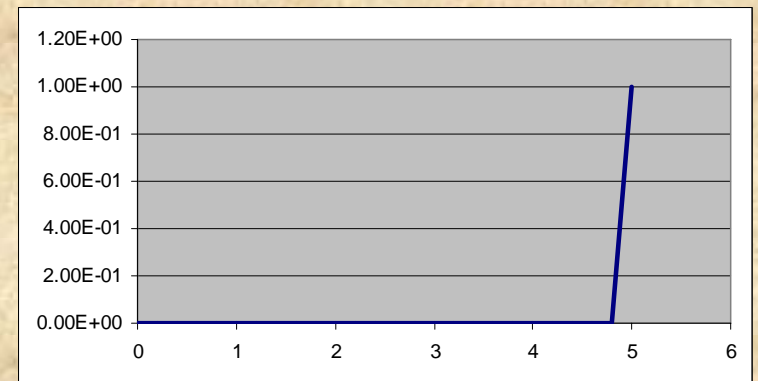
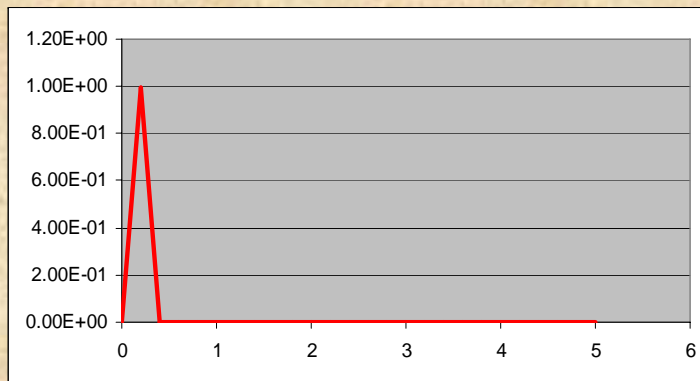
CS-No proh spp
SB-BT-BASE



SEW02-BASE



SEW02-IW

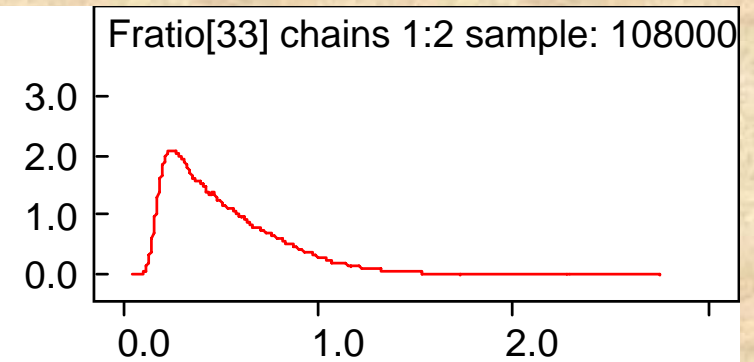
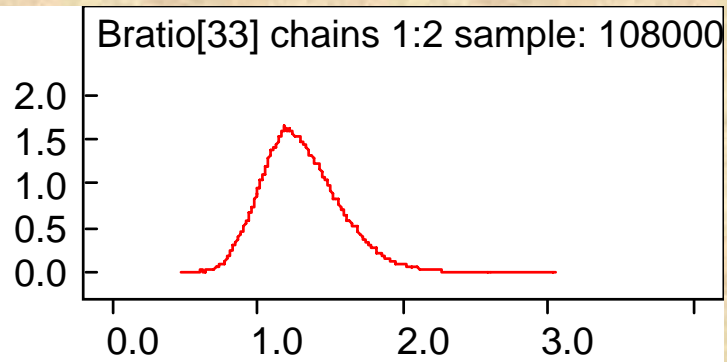


Posterior pdfs of points in phase plot

WinBUGS

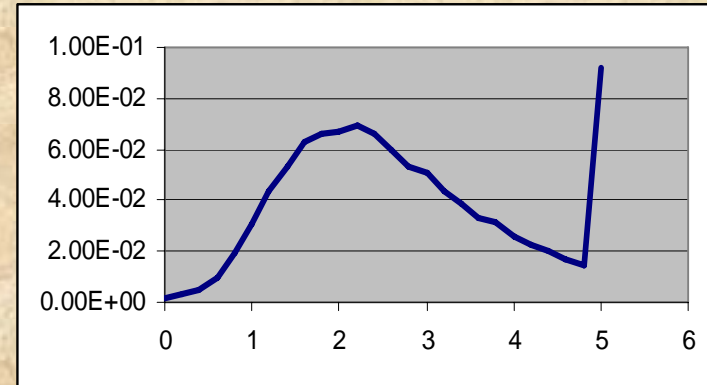
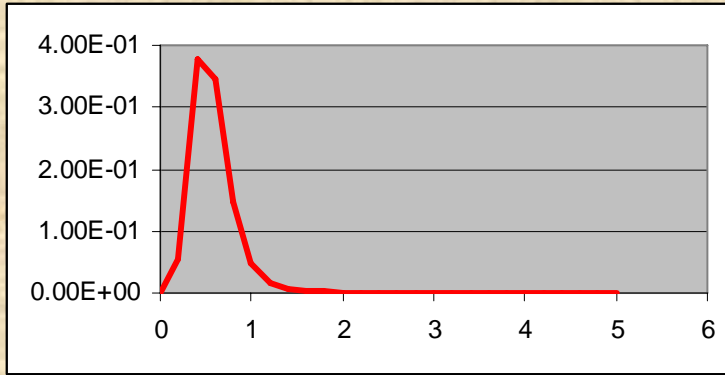
N_{04}/N_{MSY}

F_{04}/F_{MSY}



N_{04}/N_{MSY} Posterior pdfs of points in SANDBAR phase plot F_{04}/F_{MSY}

BSP

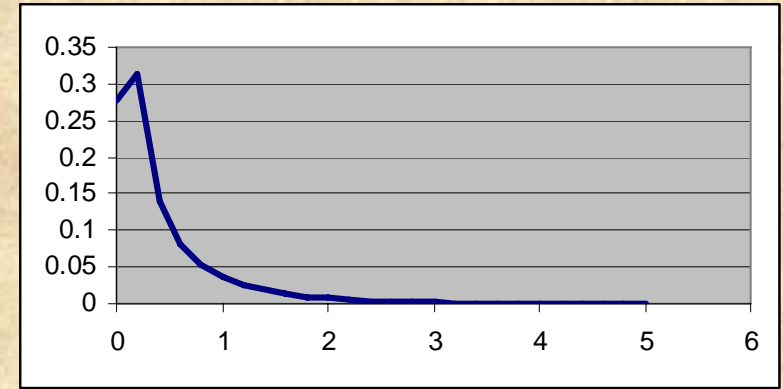
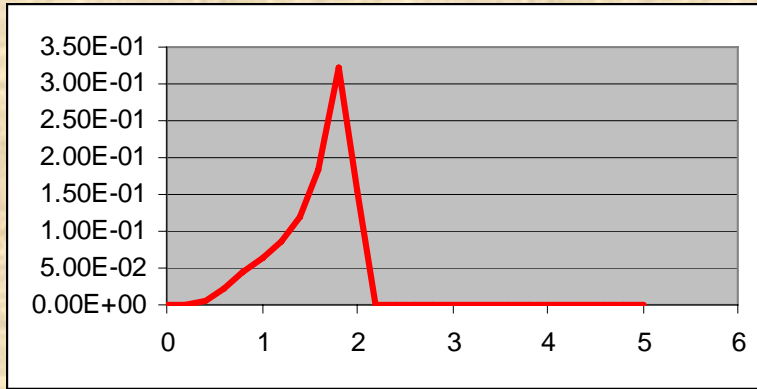


N_{04}/N_{MSY}

Posterior pdfs of points in BLACKTIP-G phase plot

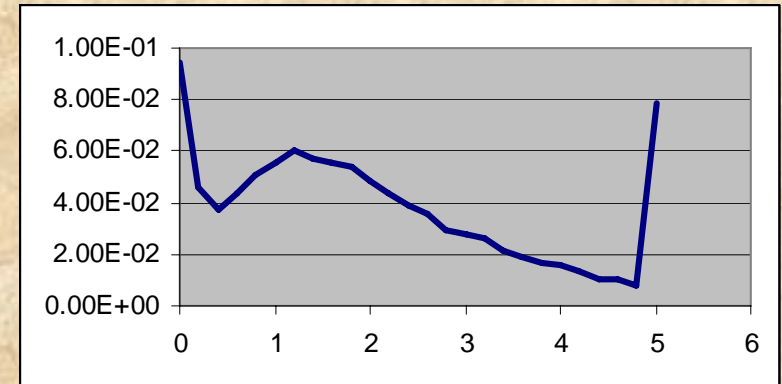
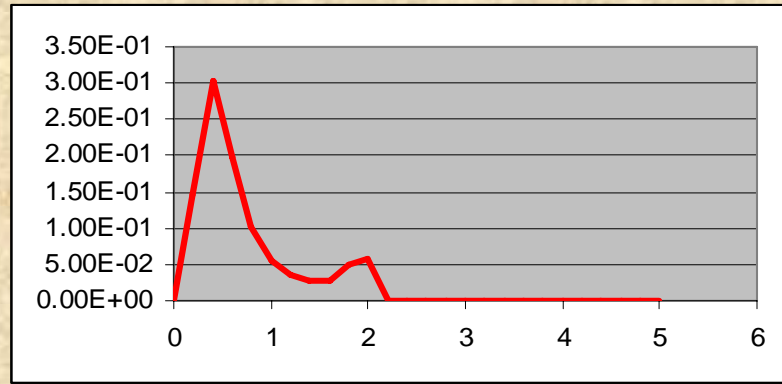
F_{04}/F_{MSY}

BSP

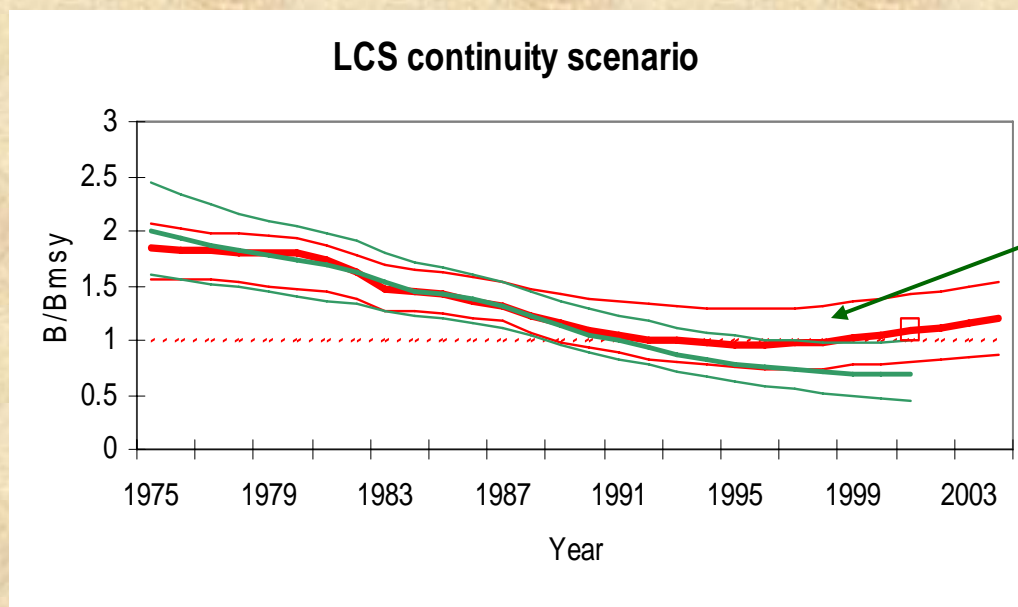


N_{04}/N_{MSY} Posterior pdfs of points in BLACKTIP-A phase plot F_{04}/F_{MSY}

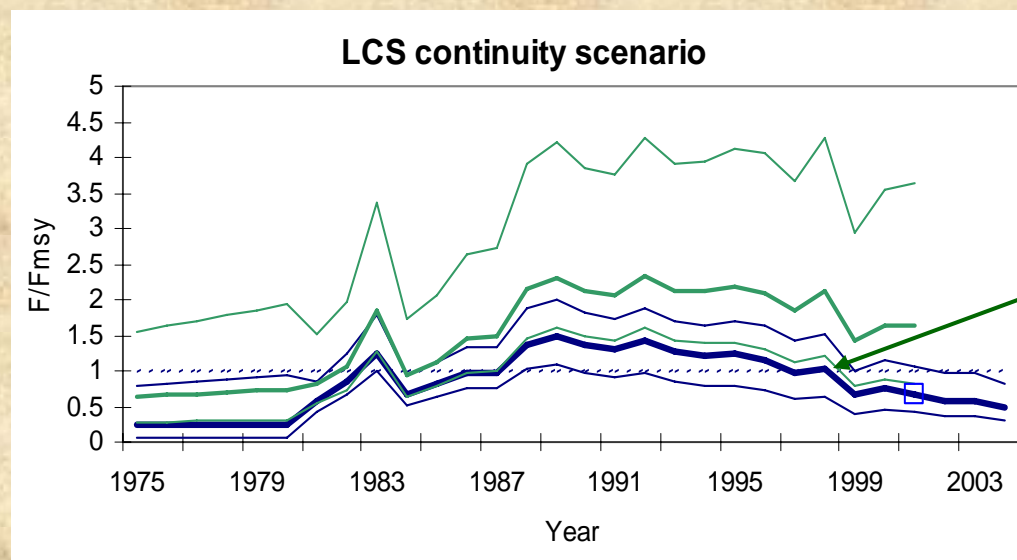
BSP



SPM
results for
LCS-
Continuity
scenario:
BSP
estimated
relative
biomass and
fishing
mortality
rate
trajectories



N/N_{MSY}



F/F_{MSY}