Sandbar Shark Assessment
State-space, Age-structured Production Model

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Miami

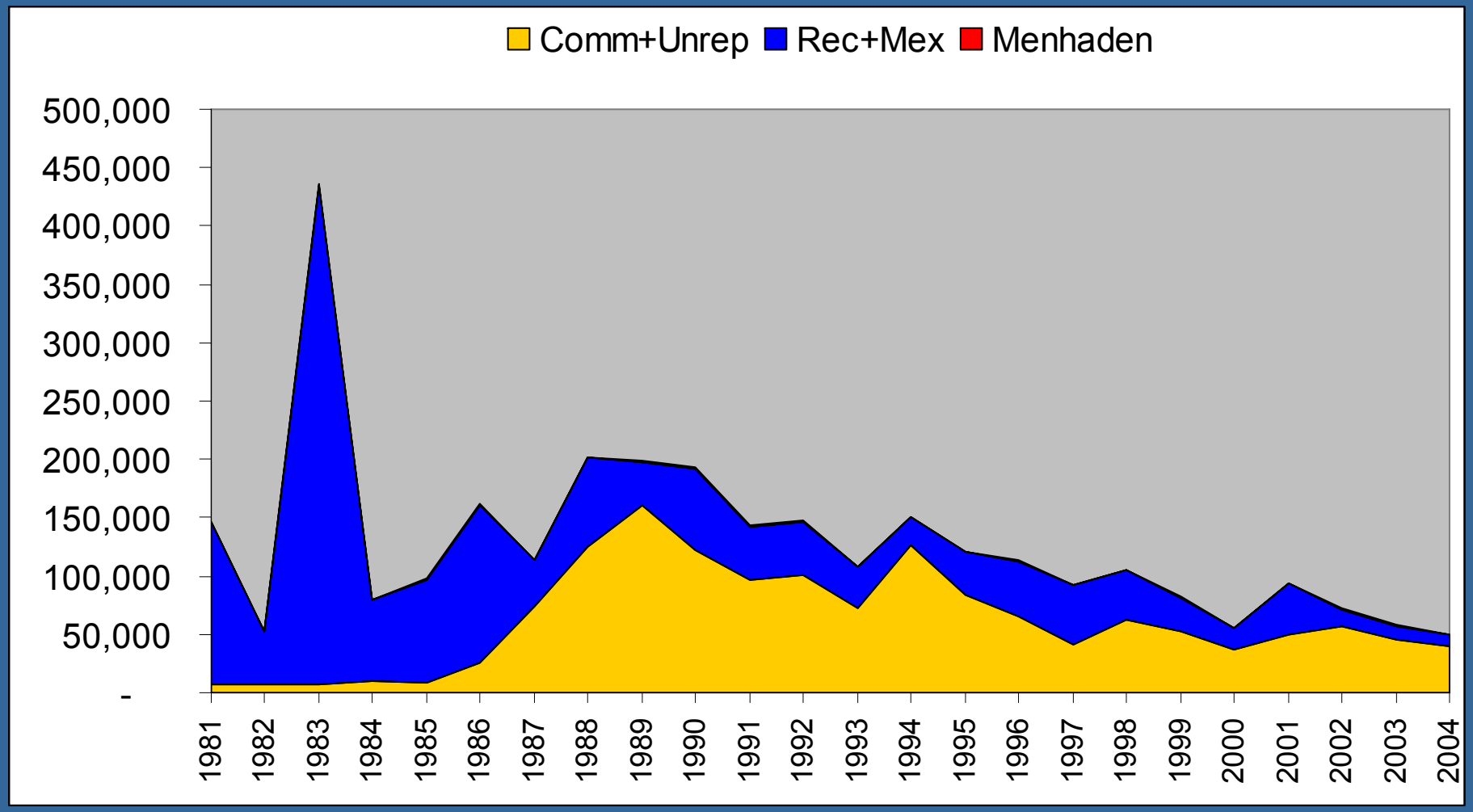
OUTLINE

1. Data Inputs
   a. Fishery
   b. Biology
2. Model Description
3. Base Model and Results
4. Sensitivity Cases
5. Summary of all Results
6. Continuity case
7. Retrospective Analyses

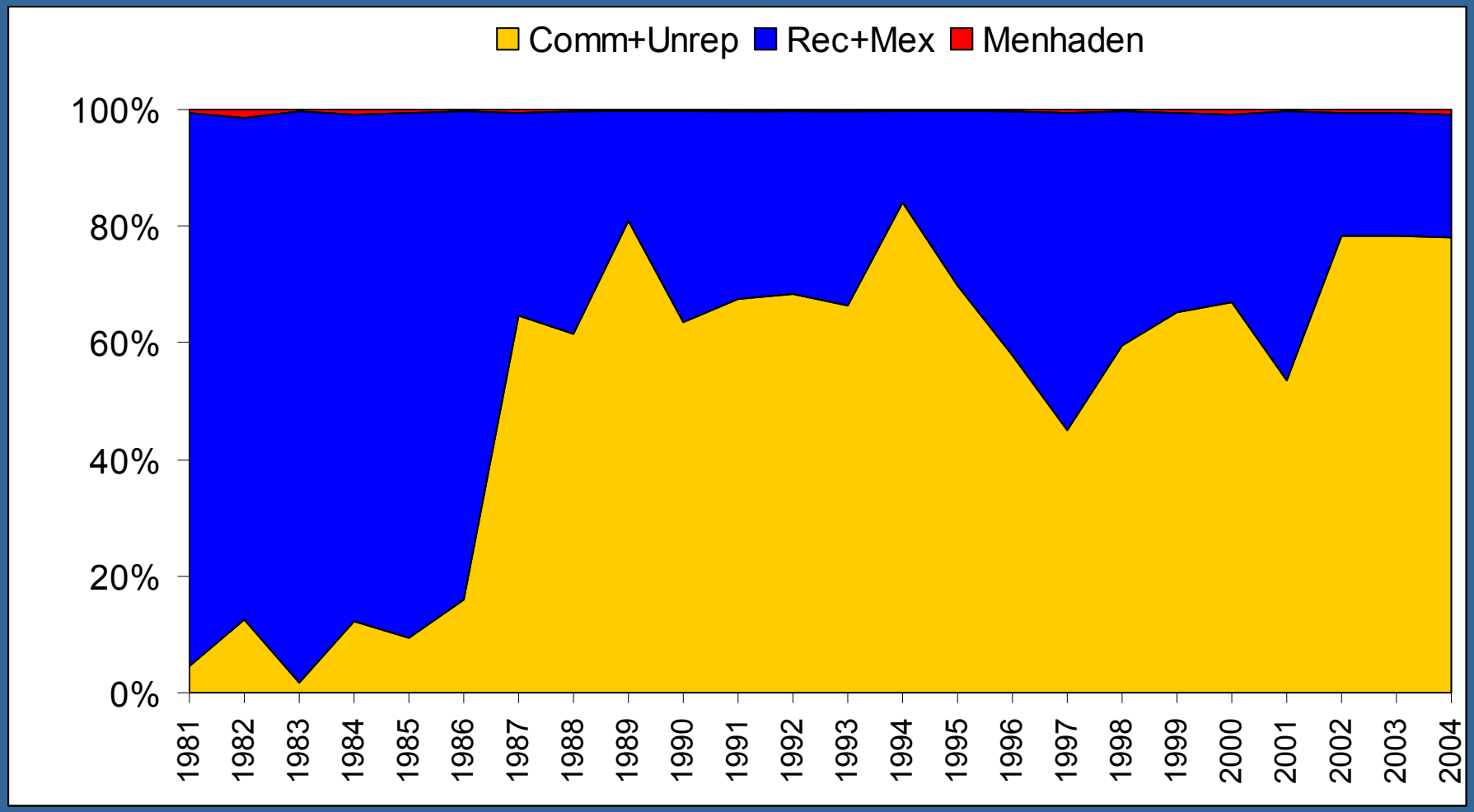
1a. Fishery Inputs

- Catch Series:
  - Commercial + Unreported Commercial
  - Recreational + Mexican + Unreported Mexican
  - Menhaden discard

Catches


Comm+Unrep
Rec+Mex
Menhaden
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
-
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004

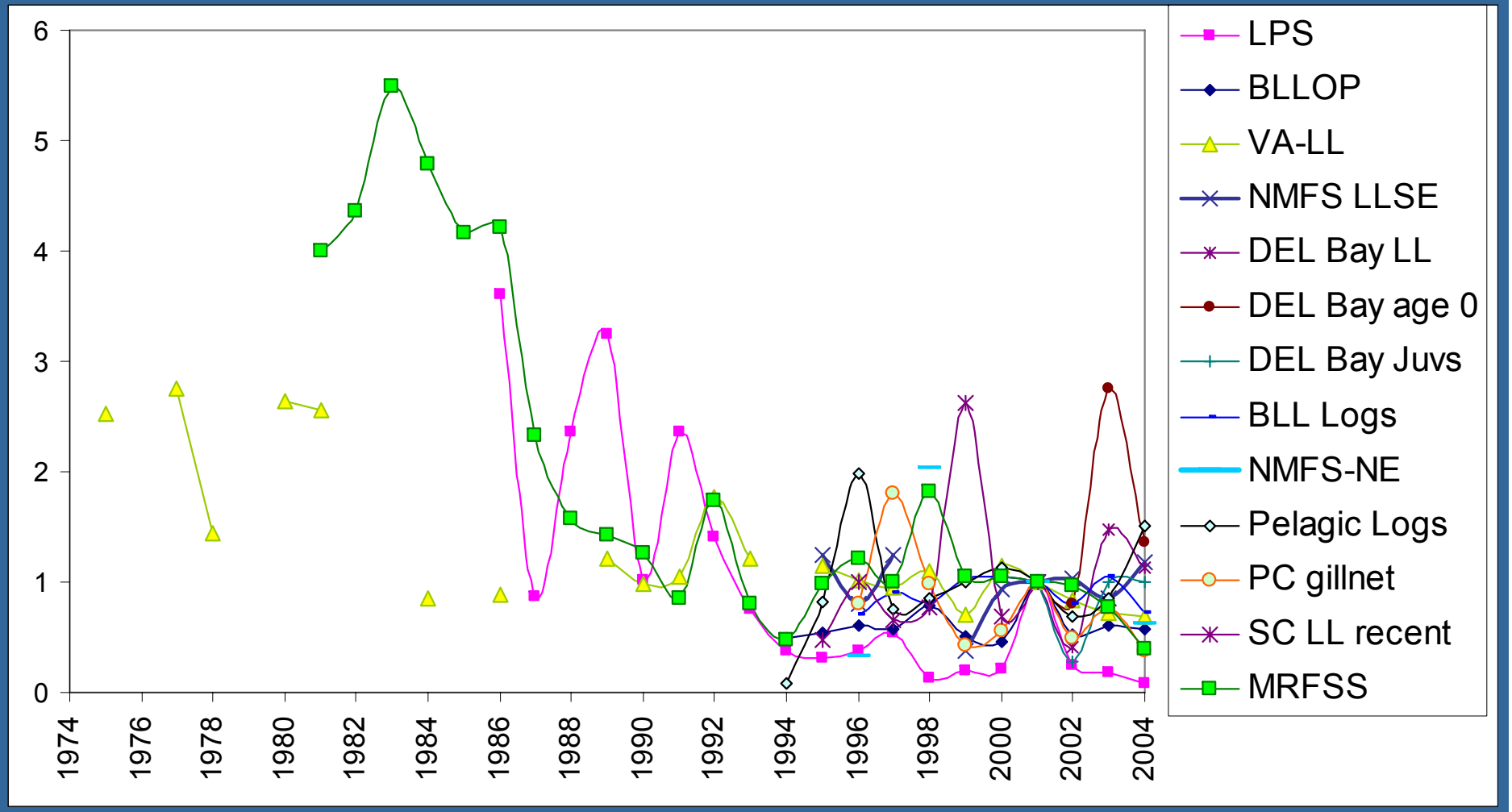
Catches


Comm+Unrep
Rec+Mex
Menhaden
100%
80%
60%
40%
20%
0%
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004

1a. Fishery Inputs

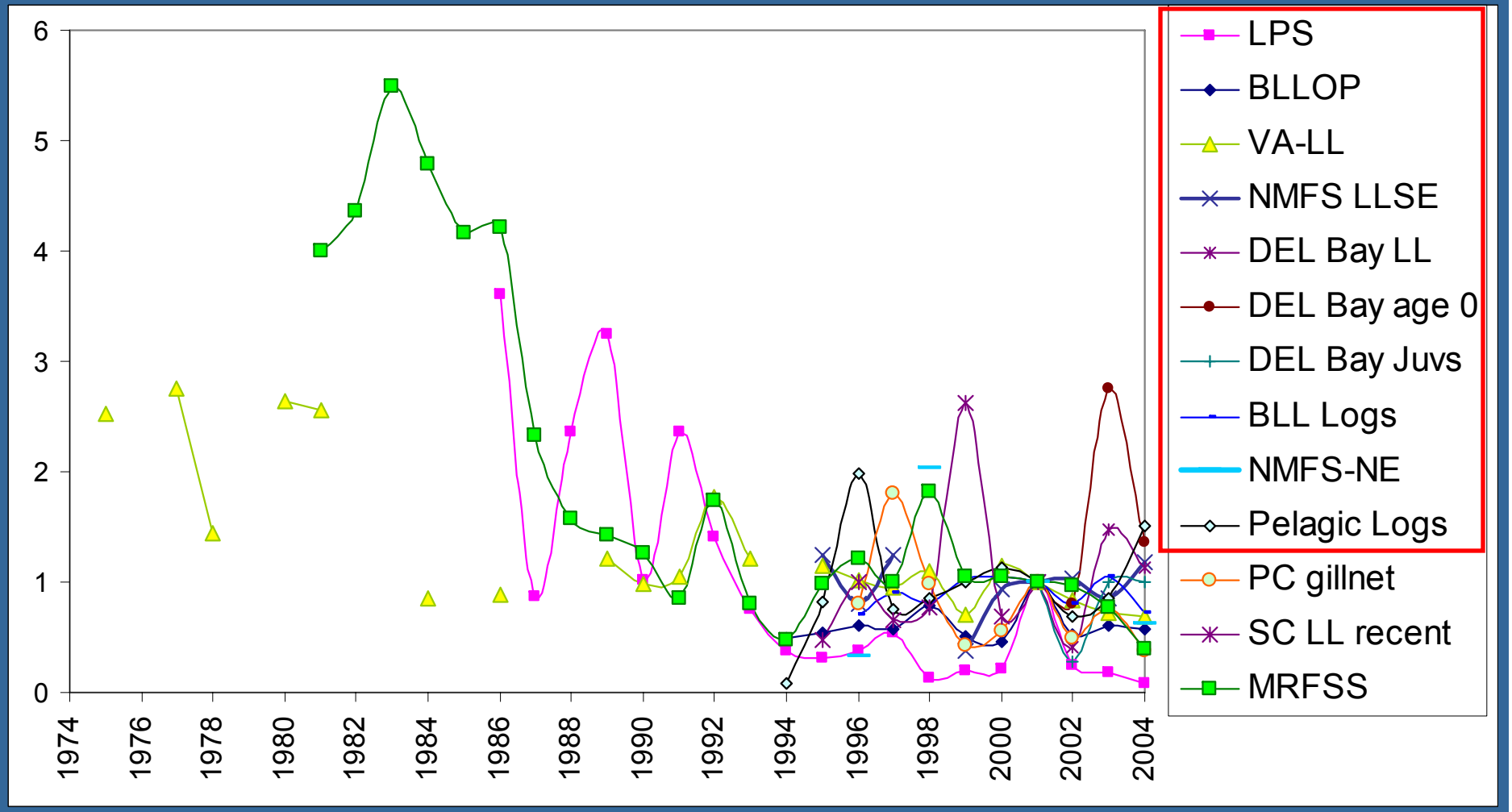
- Indices of Abundance:
  - LPS, VA-LL, BLLOP, NMFS LL SE, BLL Logs, NMFS LL NE, Pelagic Log, SC LL Recent
  - MRFSS
  - DE Bay Juveniles, SC LL Recent

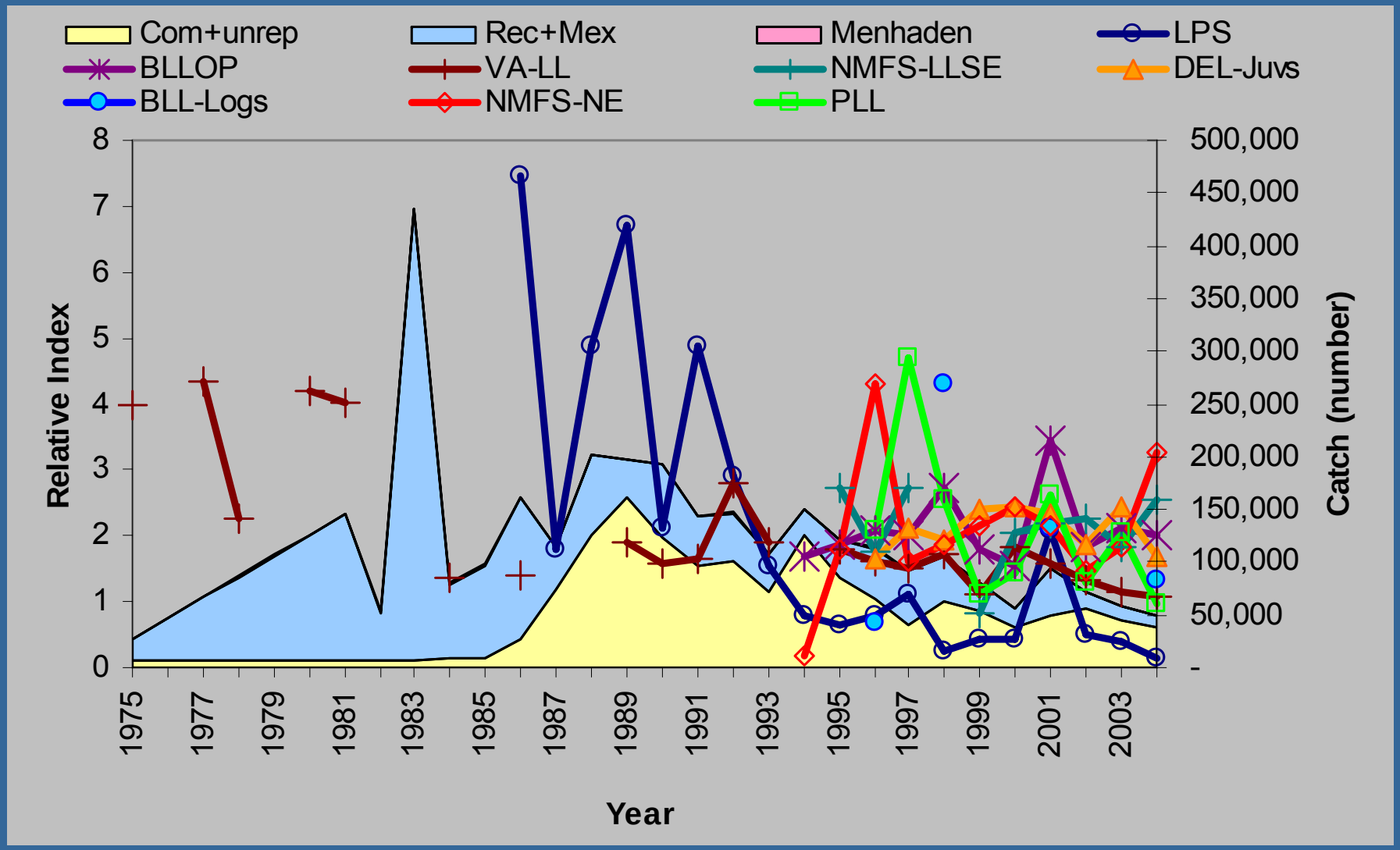
INDICES


6
5
4
3
2
1
0
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
LPS
BLLOP
VA-LL
NMFS LLSE
DEL Bay LL
DEL Bay age 0
DEL Bay Juvs
BLL Logs
NMFS-NE
Pelagic Logs
PC gillnet
SC LL recent
MRFSS

INDICES

Base Indices




Com+unrep
Rec+Mex
Menhaden
LPS
BLLOP
VA-LL
NMFS-LLSE
DEL-Juvs
BLL-Logs
NMFS-NE
PLL
Relative Index
Catch (number)
Year
0
1
2
3
4
5
6
7
8
-
50,000
100,000
150,000
200,000
250,000
300,000
350,000
400,000
450,000
500,000
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003

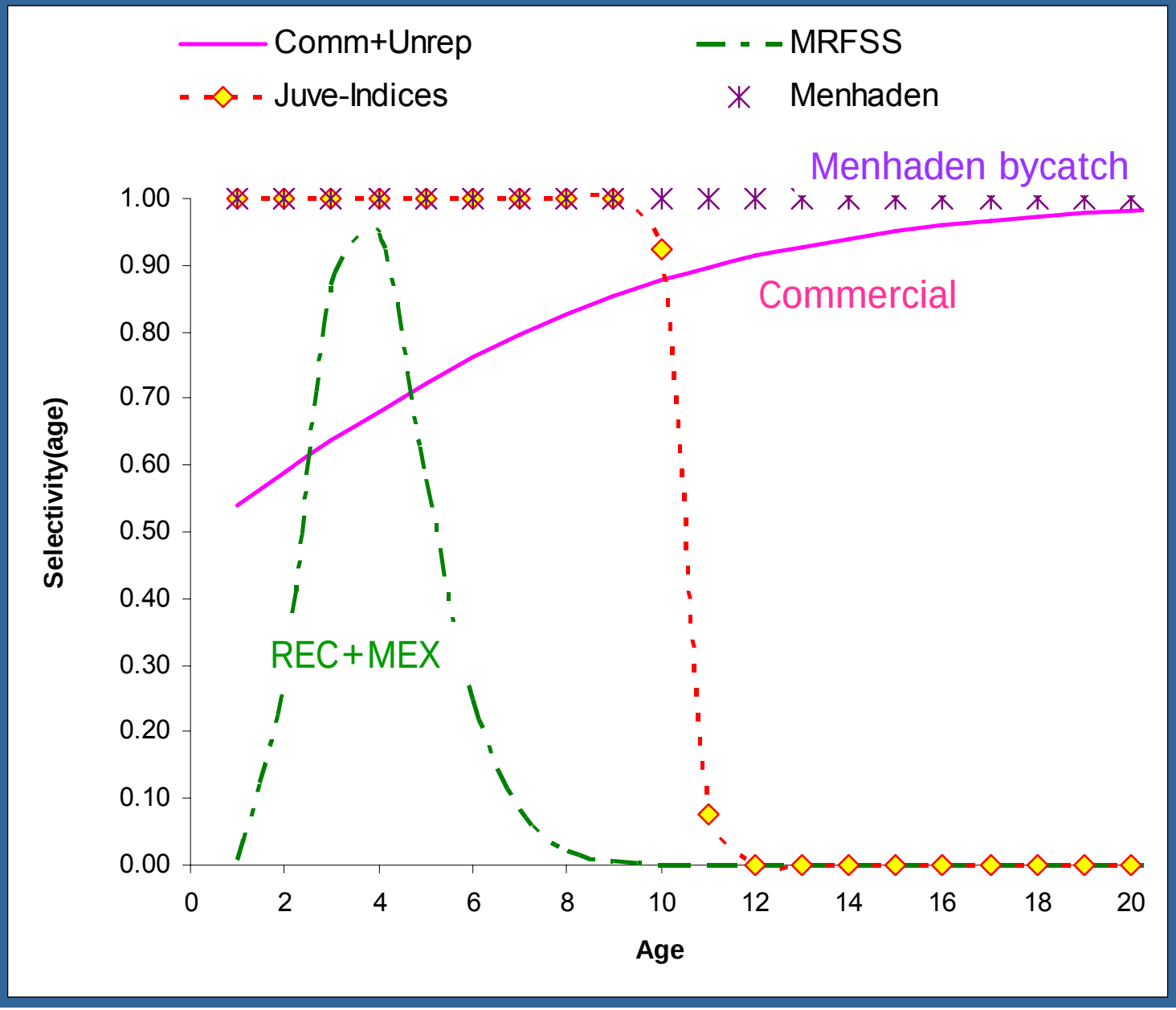
1a. Fishery Inputs

- Selectivity for catches:
  - Commercial + Unreported Commercial
  - Recreational + Mexican + Unreported Mexican
  - Menhaden discard

Selectivity Derivations

- Selectivity reflects both vulnerability to gear as well as availability to fishery
- P89 of AW report and pp38-39 of DW report
- some length frequency data, info from 2002 assessment, collective knowledge of fisheries and participants at DW

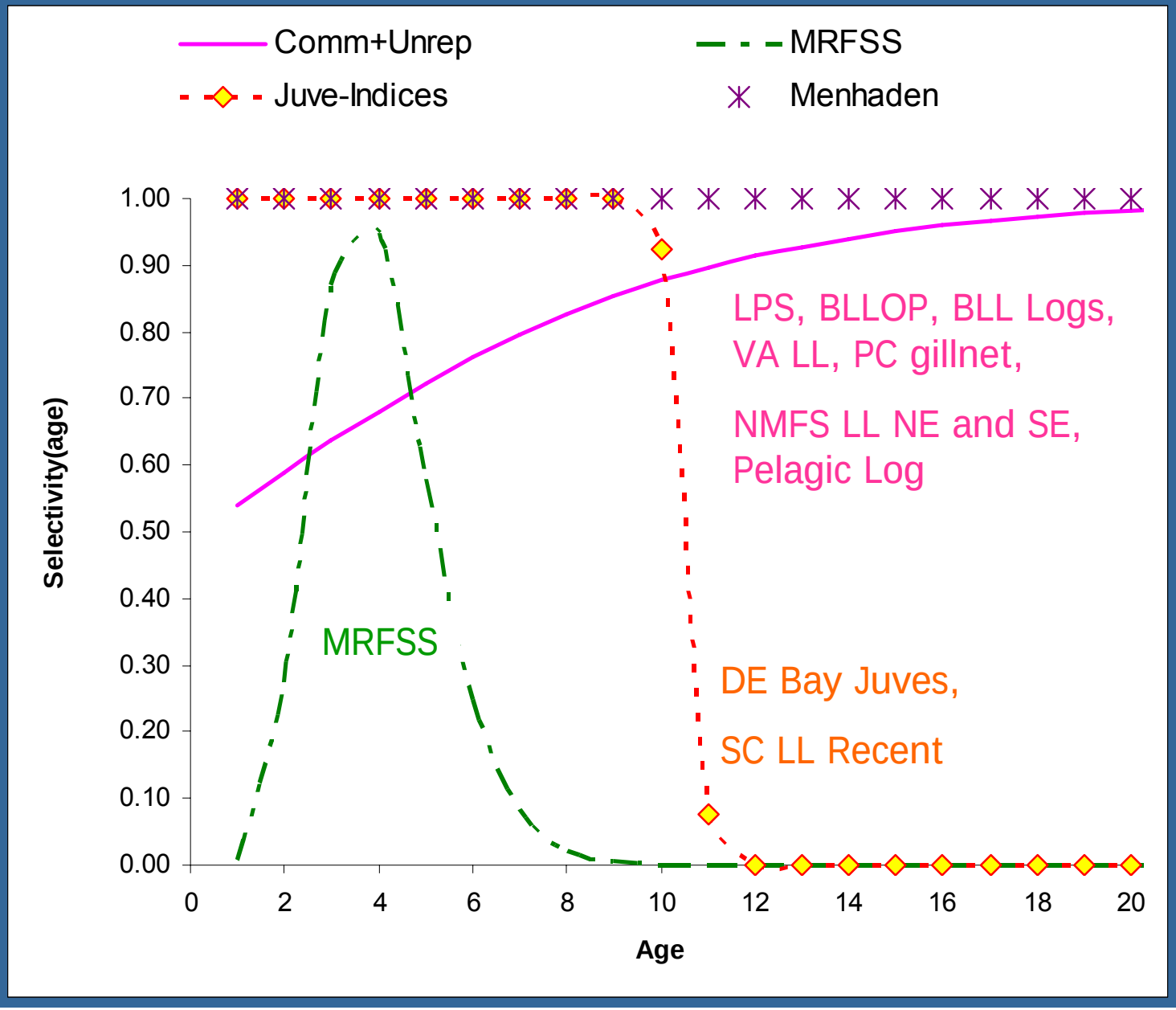
Selectivity - Catch



1a. Fishery Inputs

- Selectivity for Indices:
  - LPS, VA-LL, BLLOP, NMFS LL SE, BLL Logs, NMFS LL NE, Pelagic Log, SC LL Recent
  - MRFSS
  - DE Bay Juveniles, SC LL Recent

Selectivity - Indices



1b. Biological Inputs – DW values

- Pup-production: 8.4
- Natural Mortality: 0.26 → 0.1
- Pup-Survival: mode 0.60
- Maturity: ~ 50% age 19.5;
  ~100% age 30
- Steepness: 0.2-0.4

Steepness – Max. Repro Rate (α)

- α = pup.survival X virgin.spawners.per.recruit

  α = pup.survival X $$\varphi_0 = \sum_{age} fec_{age} \cdot mat_{age} \prod_{j=1}^{age-1} \mathrm{e}^{-M_j}$$

- Steepness = α / (α+4)

1b. Biological Inputs – DW values

- Pup-production: 8.4
- Natural Mortality: 0.26 → 0.1
- Pup-Survival: mode 0.60
- Maturity: ~ 50% age 19.5;
  ~100% age 30
- ~~Steepness: 0.2-0.4~~ 0.18

steepness only defined on [0.2 , 1.0]

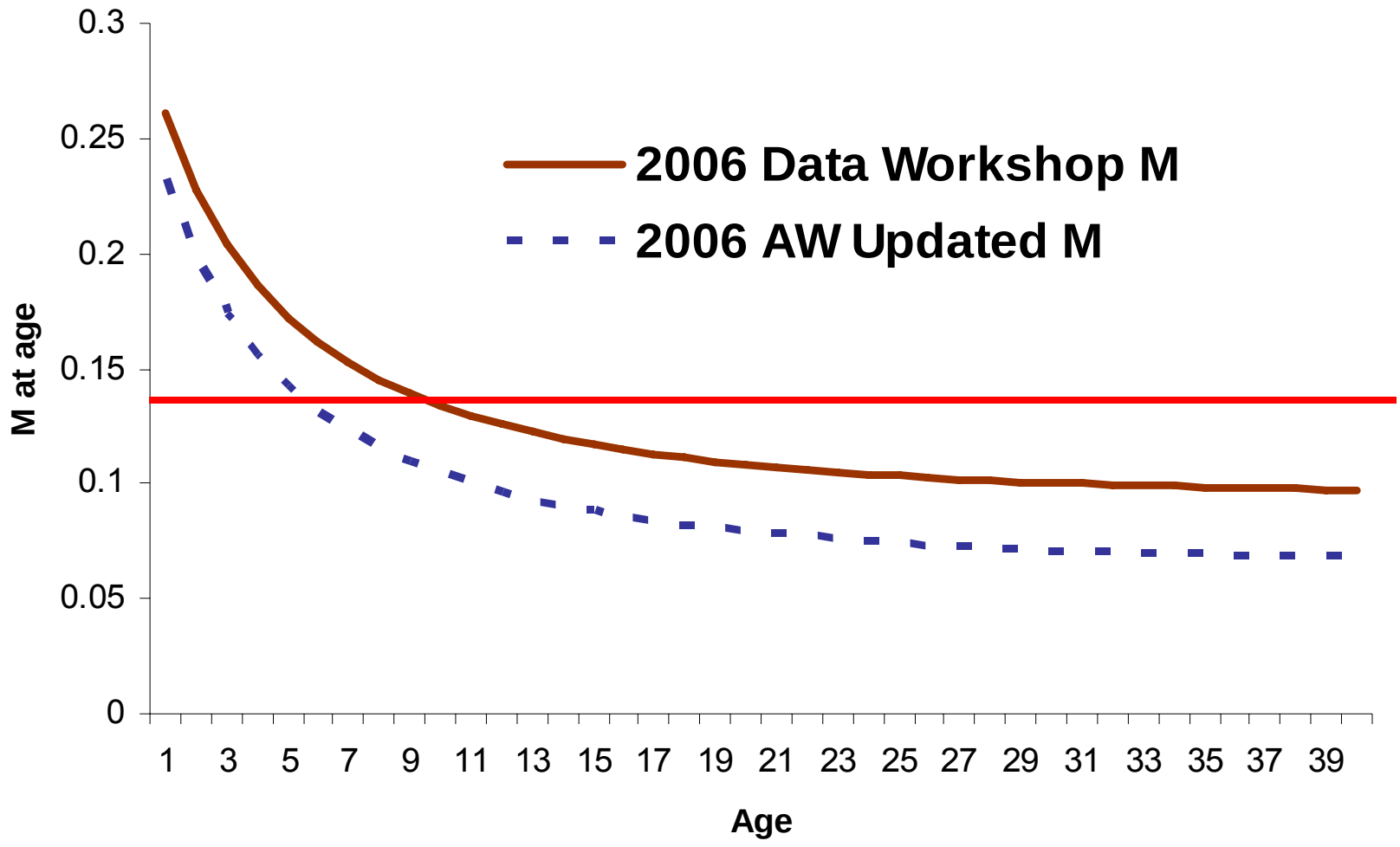
1b. Biological Inputs – AW updates

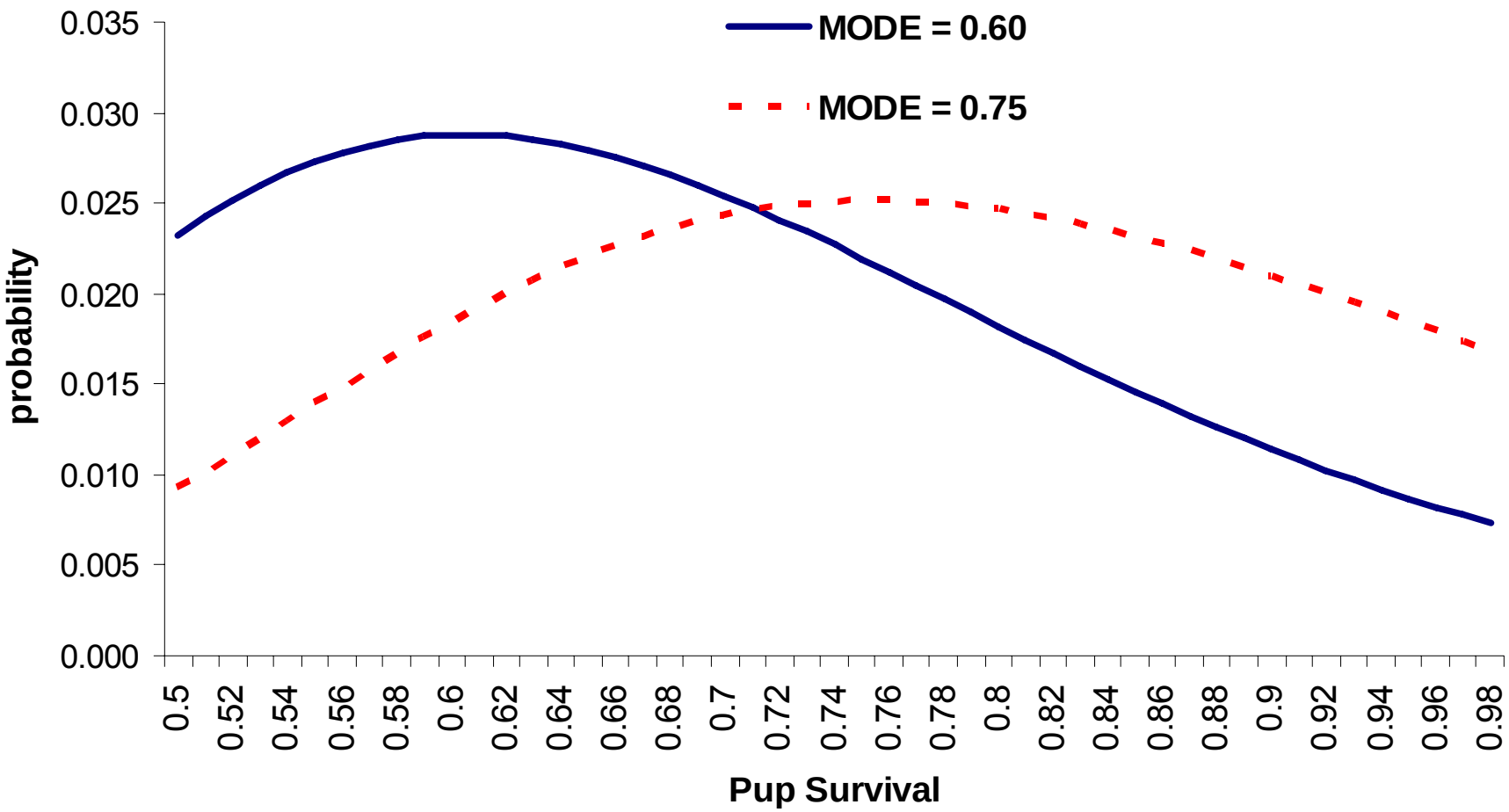
- Pup-production: 8.4
- Natural Mortality: 0.26 → 0.1 0.23 → 0.07
- Pup-Survival: mode 0.60 0.75
- Maturity: ~ 50% age 19.5;
  ~100% age 30
- Steepness: 0.2-0.4 0.38

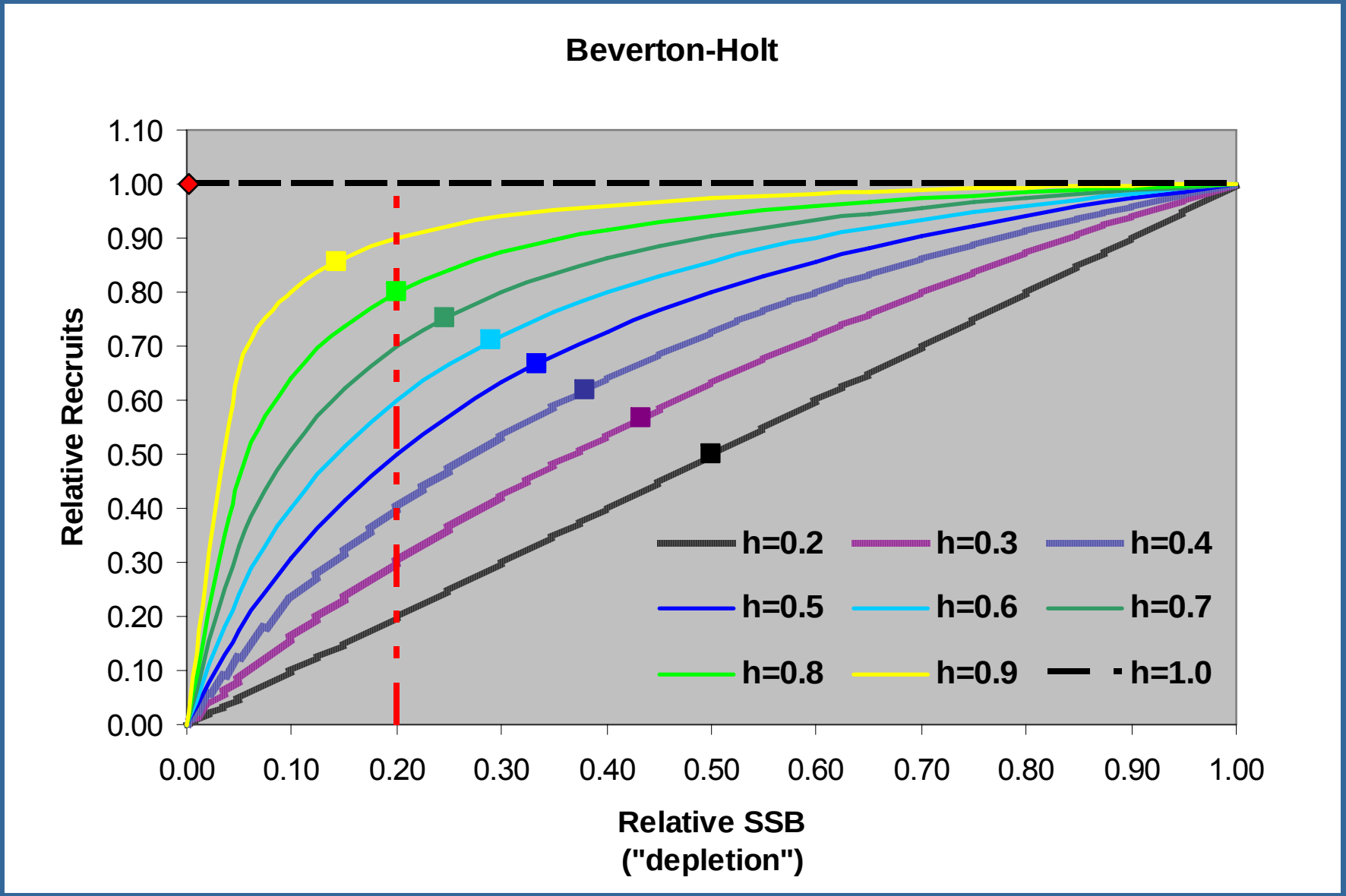
1b. Biological Inputs – AW updates

- Pup-production: 8.4
- Natural Mortality: 0.26 → 0.1 0.23 → 0.07
- Pup-Survival: mode 0.60 0.75
- Maturity: ~ 50% age 19.5;
  ~100% age 30
- Steepness: 0.2-0.4 0.38

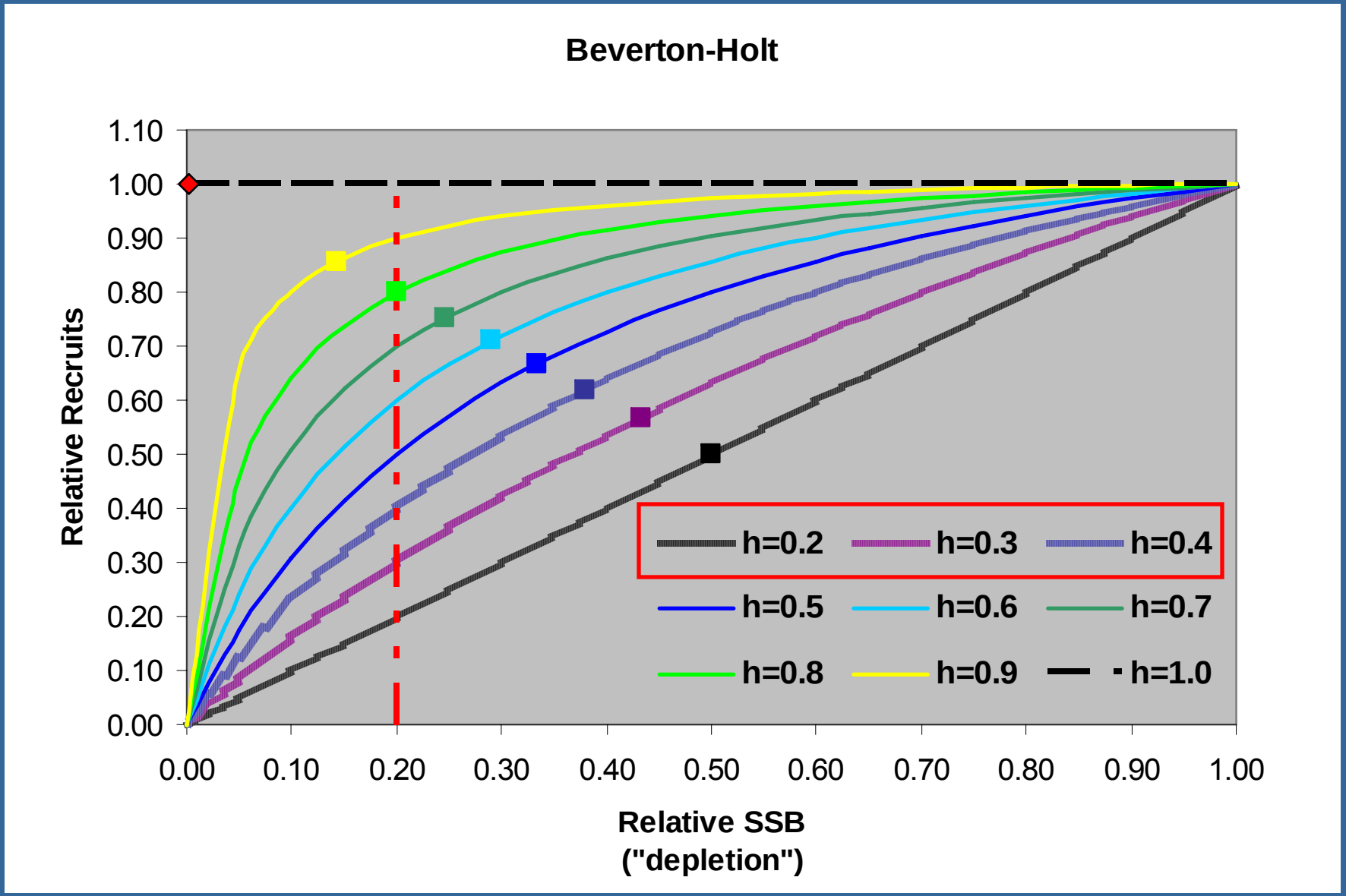
NOTE: Same problem with steepness in 2002, but pup-production was increased


0.3
0.25
0.2
0.15
0.1
0.05
0
M at age
2006 Data Workshop M
2006 AW Updated M
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
Age

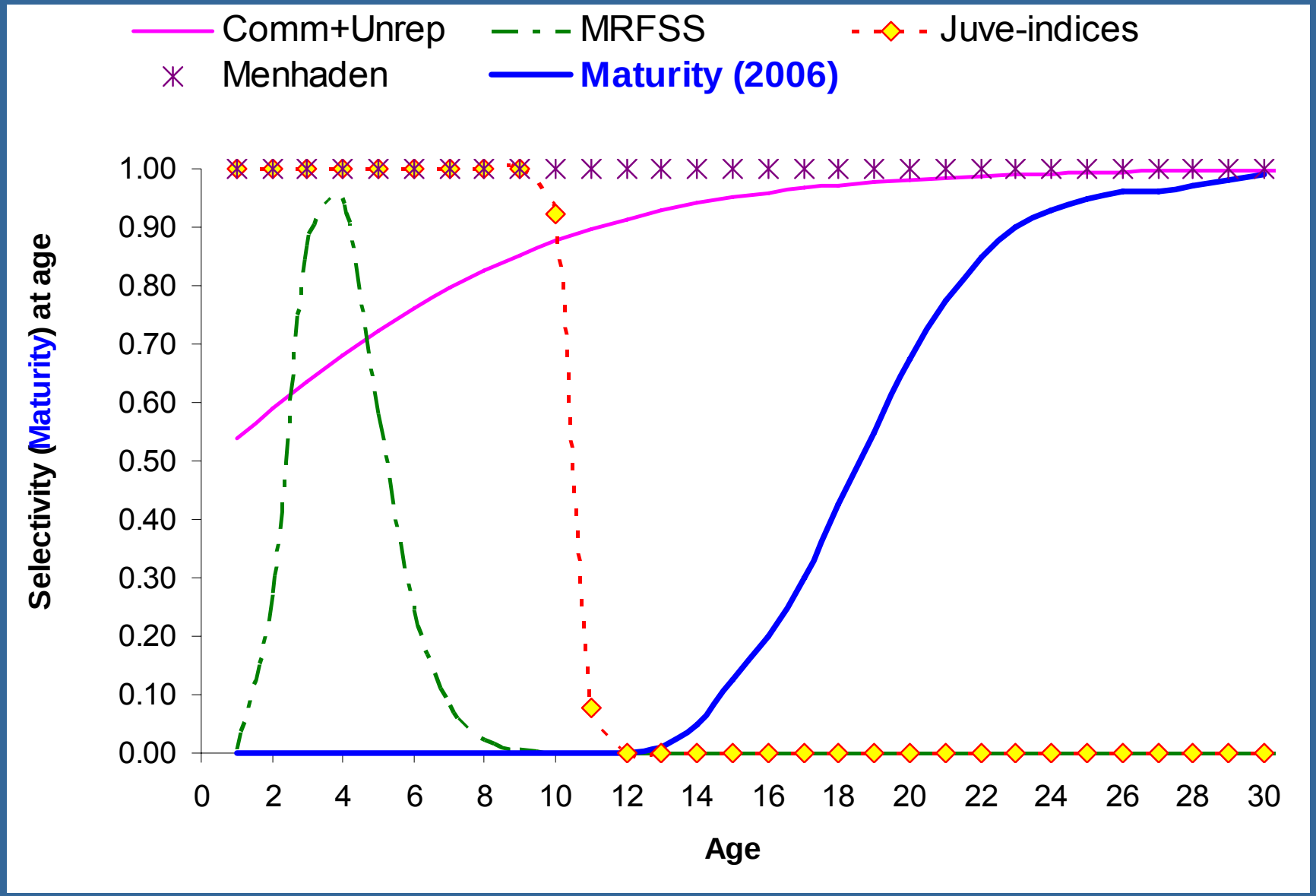

MODE = 0.60
MODE = 0.75
probability
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.5
0.52
0.54
0.56
0.58
0.6
0.62
0.64
0.66
0.68
0.7
0.72
0.74
0.76
0.78
0.8
0.82
0.84
0.86
0.88
0.9
0.92
0.94
0.96
0.98
Pup Survival

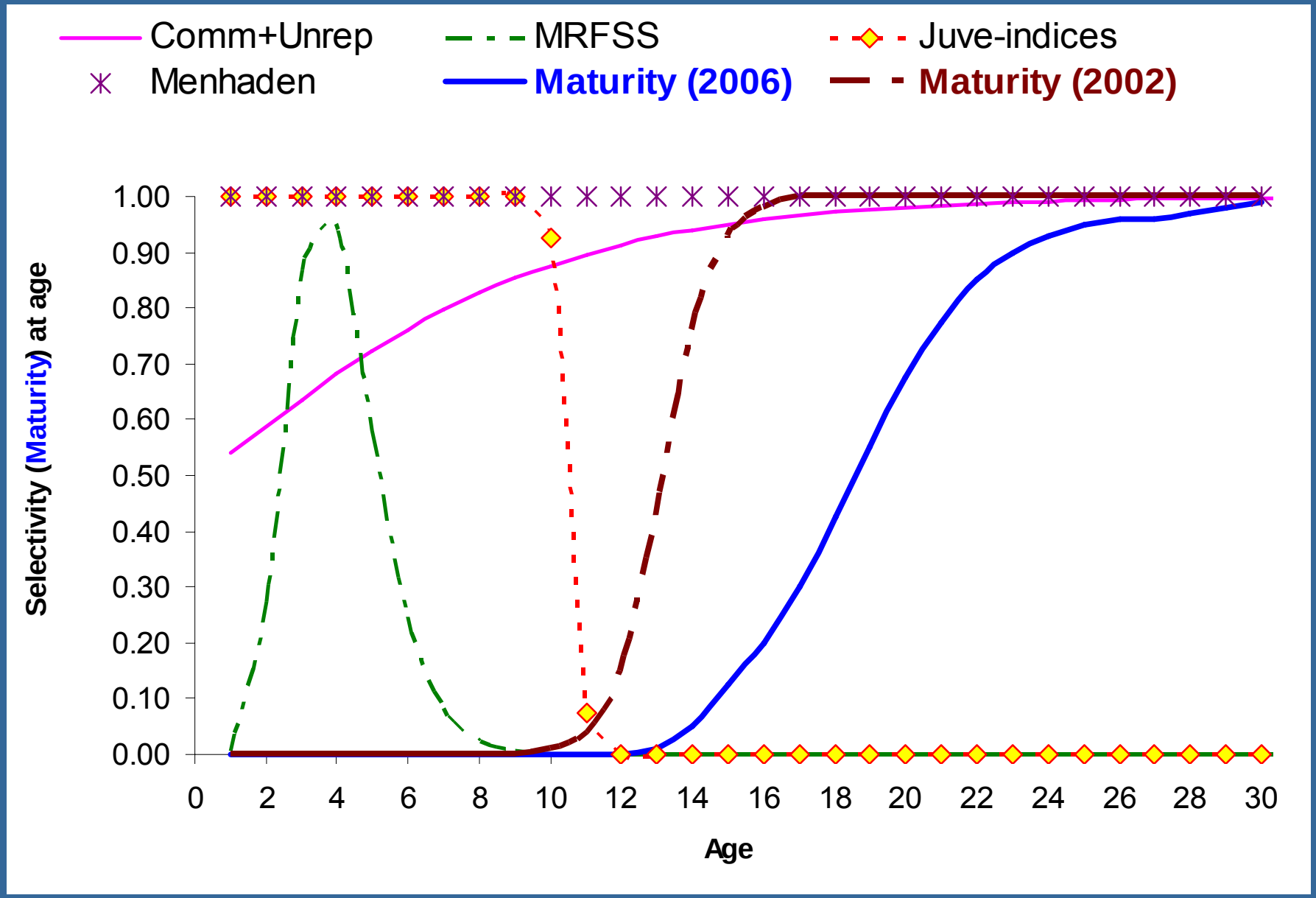


Steepness of 0.2-0.4 ➔ factor of about 2.6 between survival at origin vs virgin



Steepness of 0.2-0.4 ➔ factor of about 2.6 between survival at origin vs virgin


Comm+Unrep
MRFSS
Juve-indices
Menhaden
Maturity (2006)
Selectivity (Maturity) at age
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Age


Comm+Unrep
MRFSS
Juve-indices
Menhaden
Maturity (2006)
Maturity (2002)
Selectivity (Maturity) at age
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
Age

Maturity Studies

- 2002: Age and growth study by Sminkey and Musick (1995) also mentioned size ranges at maturity
- 2006: Merson (1998) reproductive study; used Sminkey and Musick growth model to convert size to age
- Merson revisited prior to AW, compared with NMFS repro. database → same conclusion

2. Model Description

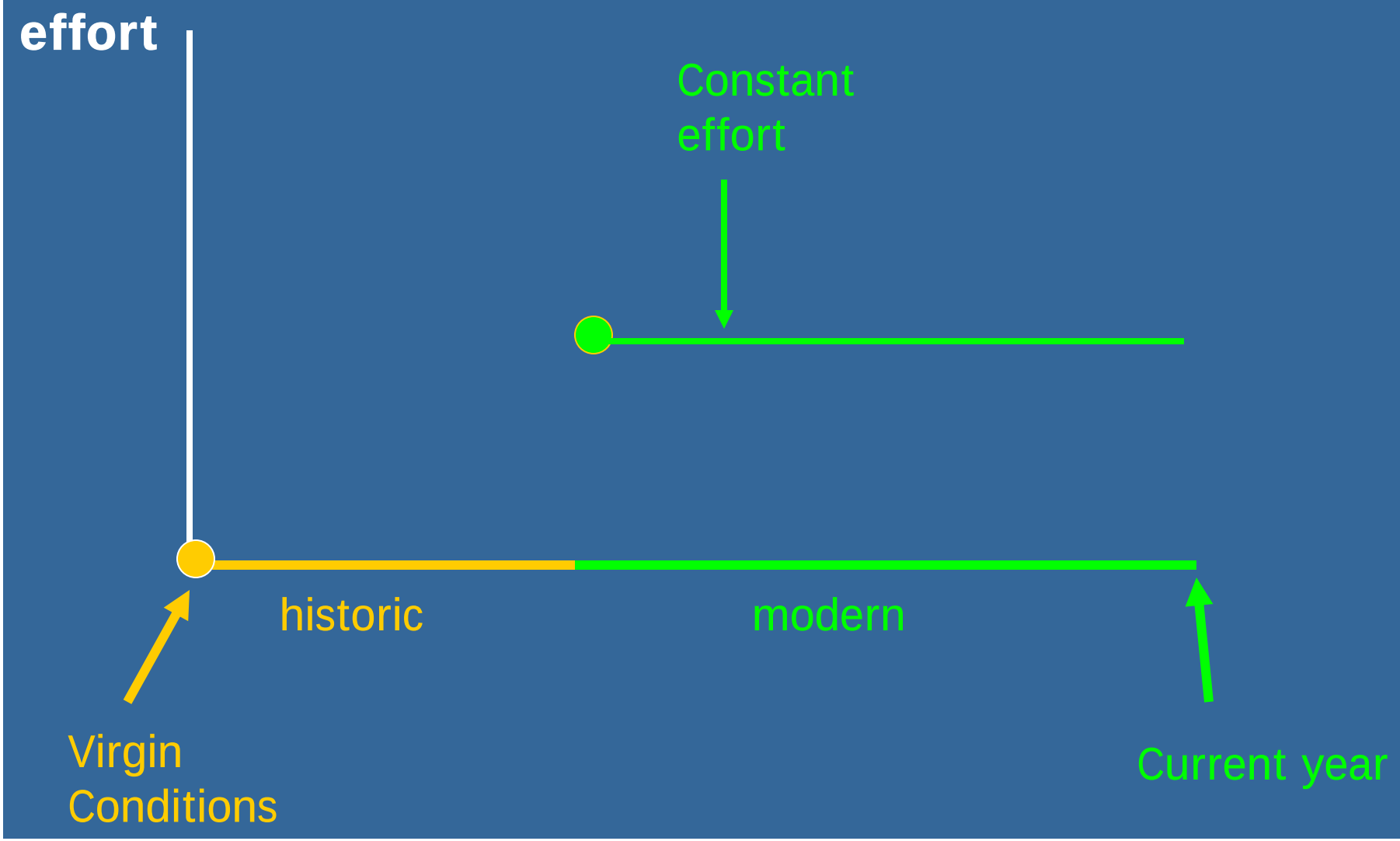
- State-space Age-structured Production model
- Process error in reproduction (pup-survival and virgin number pups), fishing effort
- Observation error in catches and indices
- Recruitment at age 1; ages 1-40 modeled, age 40 is a plus group

2. Model Description*

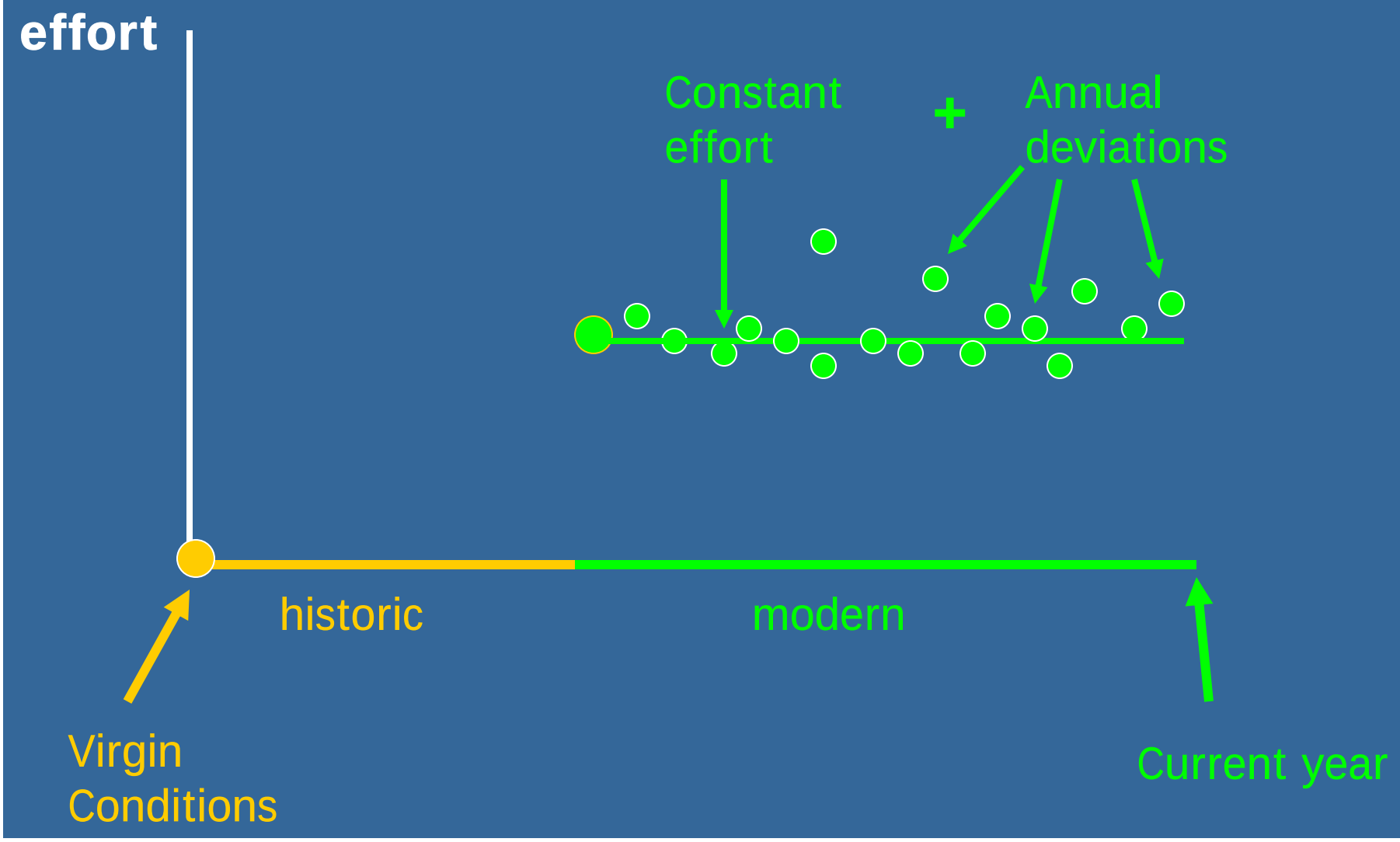
- Time series split into historic and modern period
- Historic period begins in year when virgin conditions can be assumed; spans years where data are very sparse
- Modern period spans recent years, when data are presumed to be more abundant

*See pp85-88 for model equations

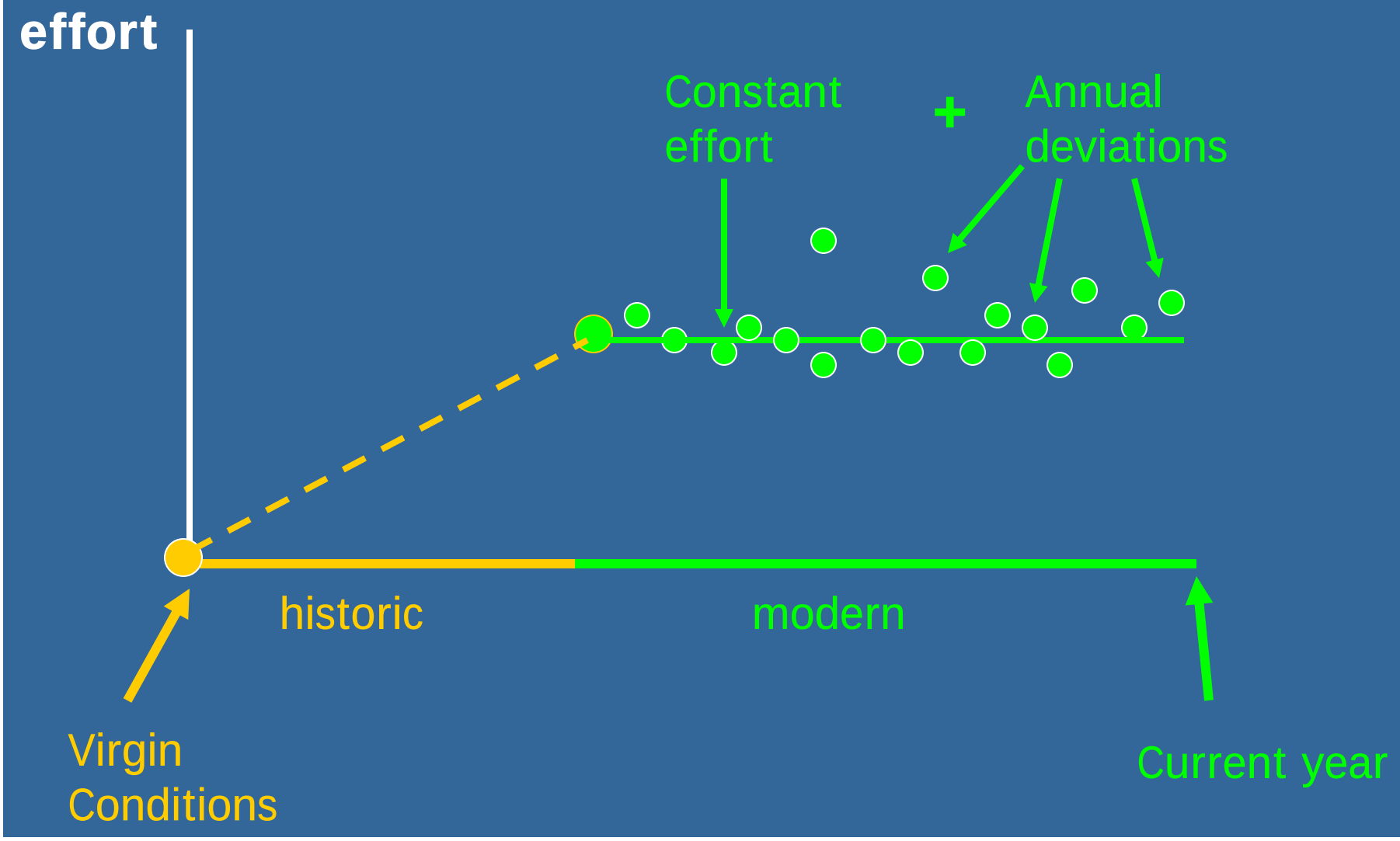
2. Model Description

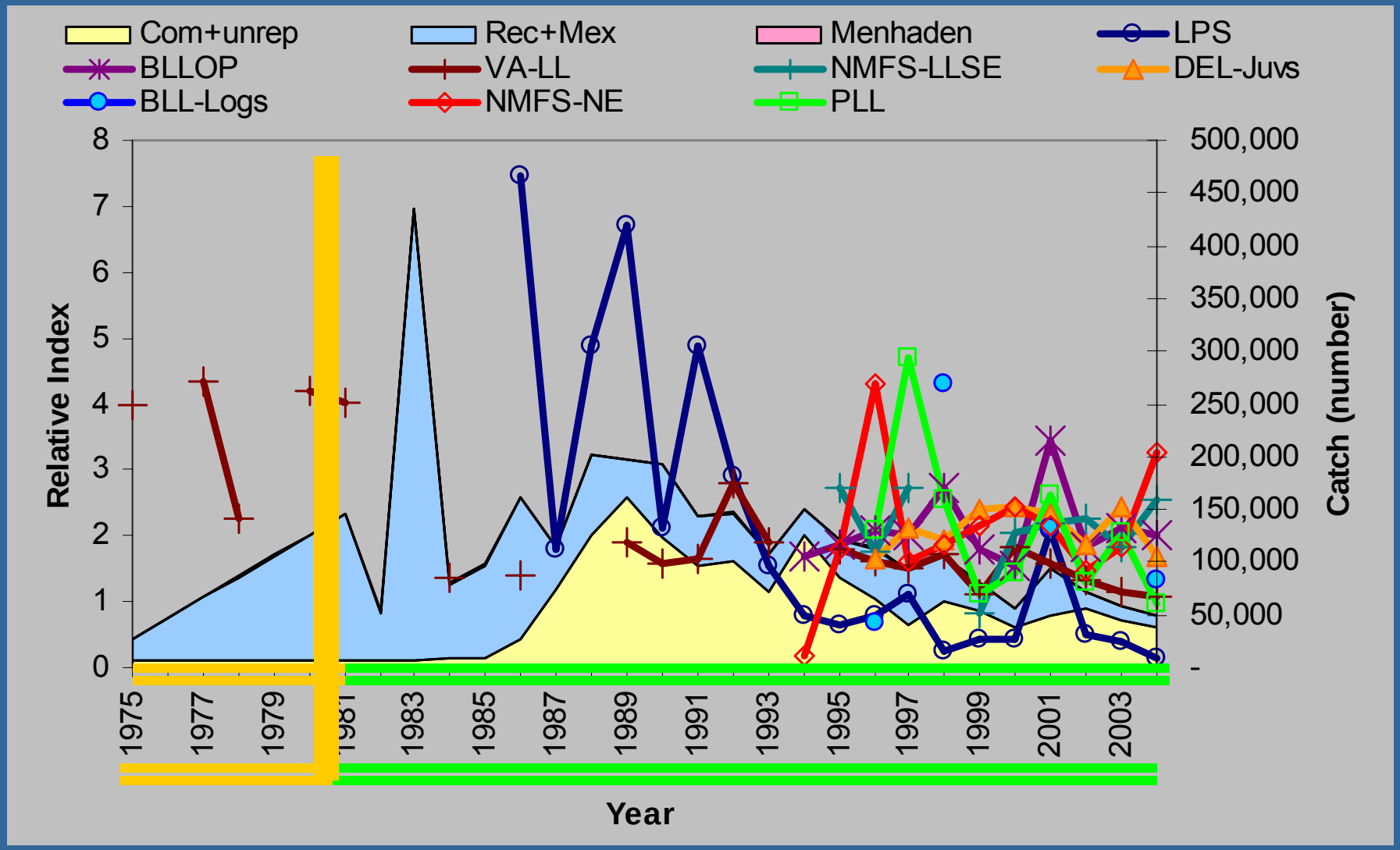


2. Model Description



2. Model Description





historic

1975-1980

modern

1981-2004

2. Model Description

- Estimated catch series begin in 1981; earliest index (VA LL) begins in 1975
- Catches from 1975-1980 were estimated
  - Commercial: fixed to 1981 value
  - Rec+Mex: linear increase from 0 to 1981 value
  - Menhaden: fixed at series average

3. Base Model and Results

- Virgin conditions: 1975
- ‘estimated’ historical catches
- Updated biological parameters
- Base case indices (updated Pelagic LL)
- Historic catches downweighted by ½
- Rec 1983 catch downweighted by 1/10
- Catches “fit” 5 times “better” than indices

3. Base Model and Results

- SSF_{2004}/SSF_{MSY} = 0.72 ➔ overfished
- F_{2004}/F_{MSY} = 3.72 ➔ overfishing
- Steepness = 0.32
- SPR_{MSY} = 0.73
- F_{MSY} = 0.015

CATCHES

Fig 4.6

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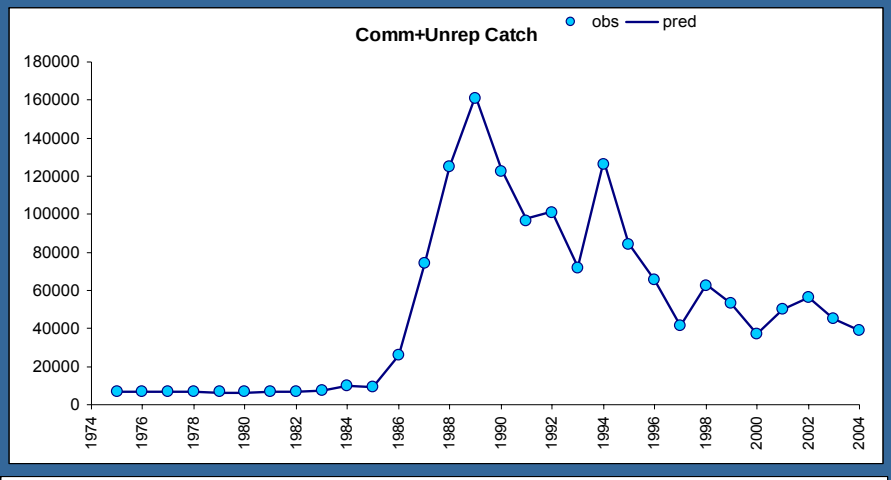
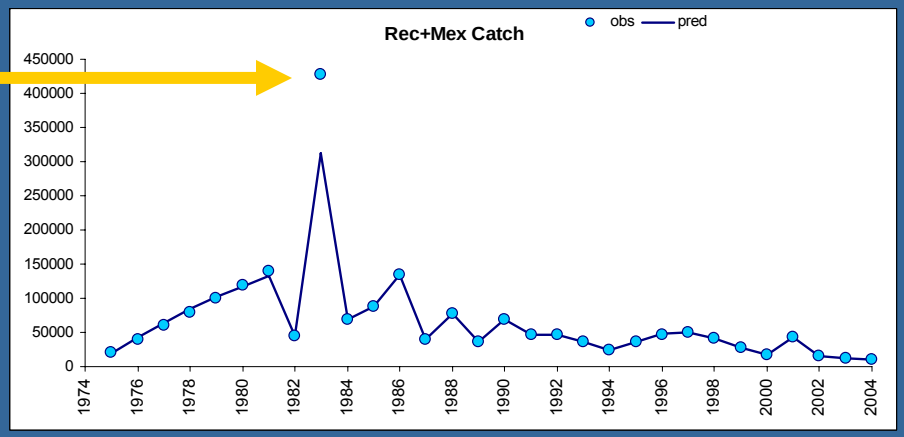
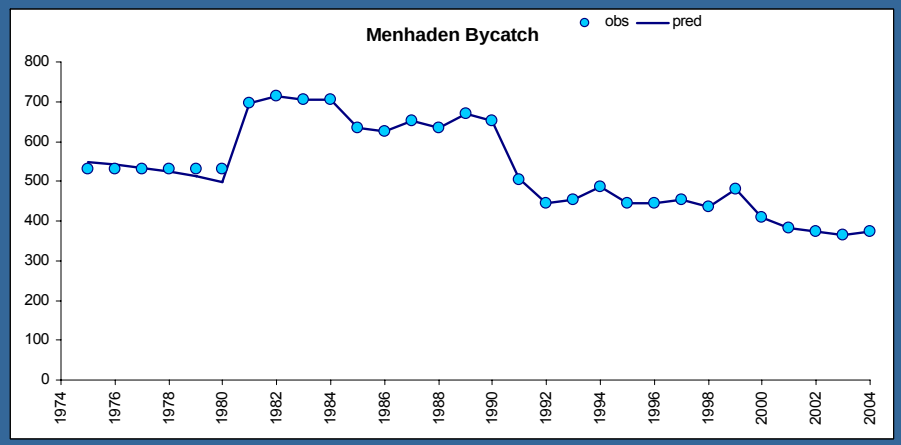
downweighted



Commercial + Unreported



Recreational + Mexican



Menhaden discard

INDICES

Fig 4.7

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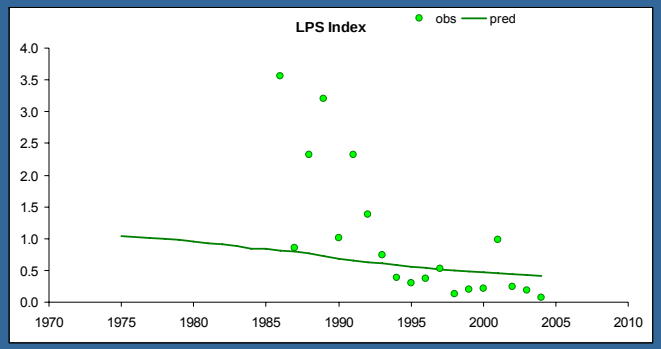
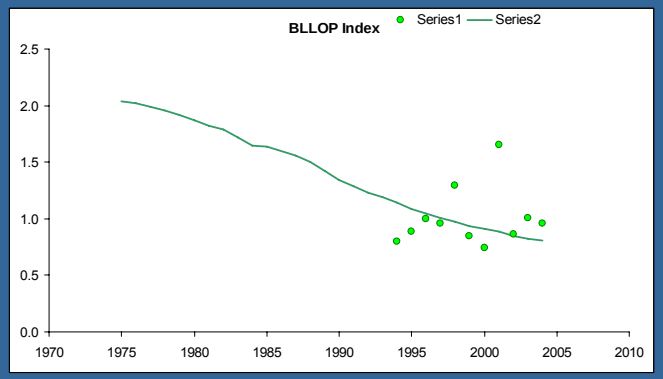
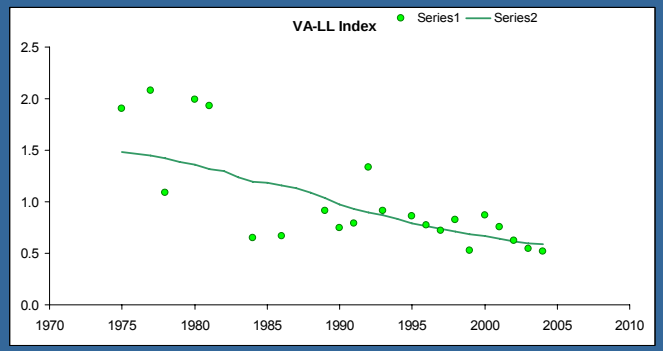


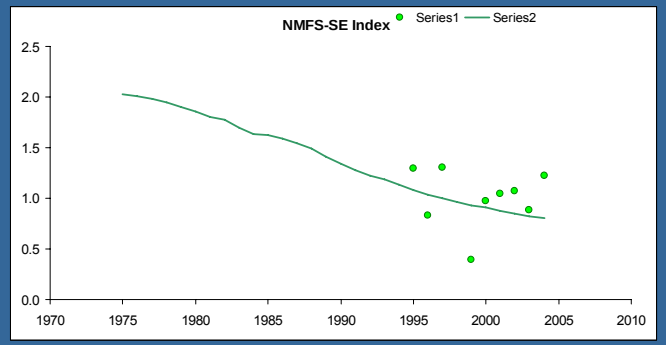
LPS



BLLOP



VA LL



NMFS-LL-SE

INDICES

Fig 4.7

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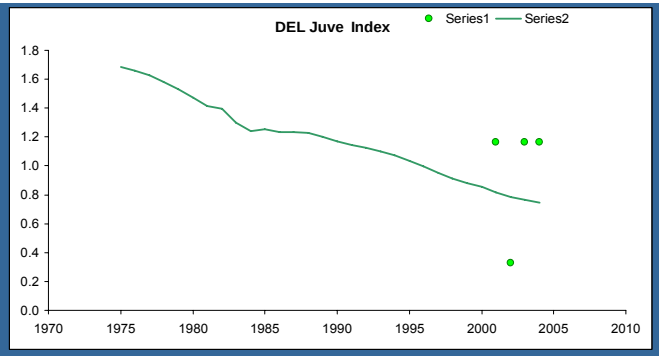
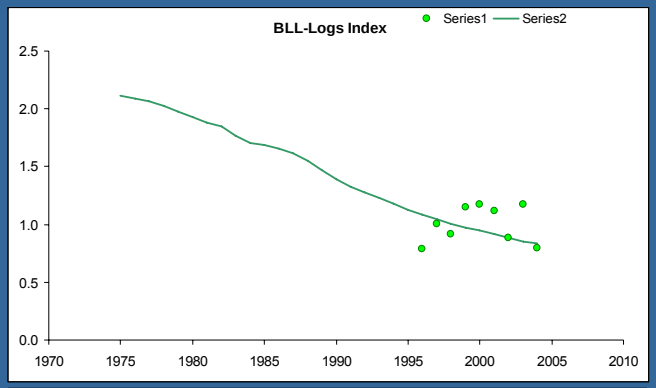
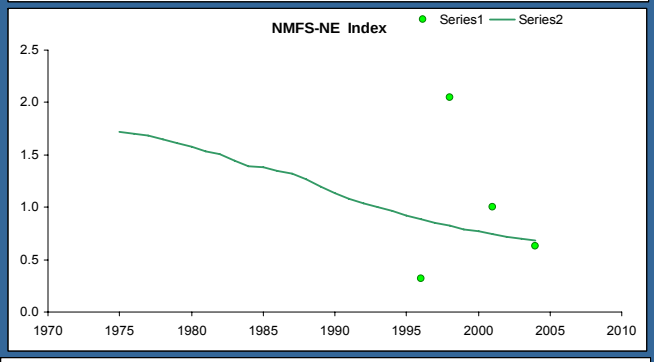


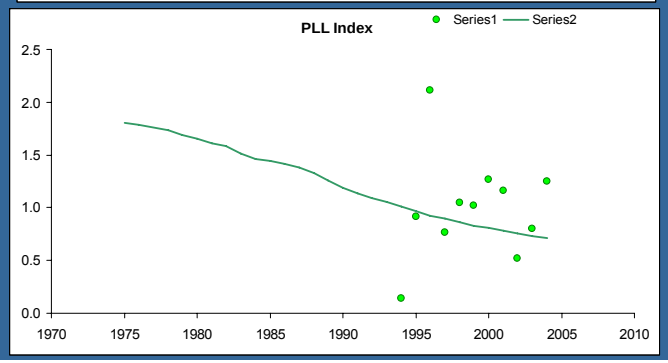
DEL Juves



BLL Logs



NMFS-LL-NE



PLL

Fig 4.5

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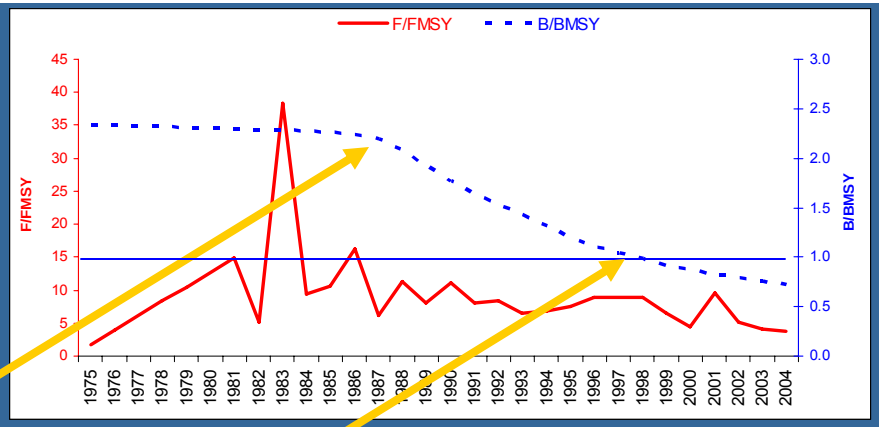
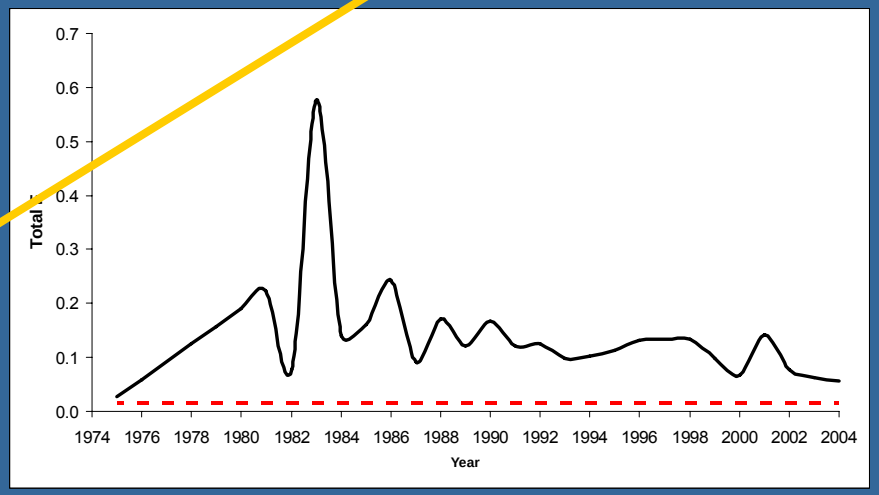
Steep decline from 1987

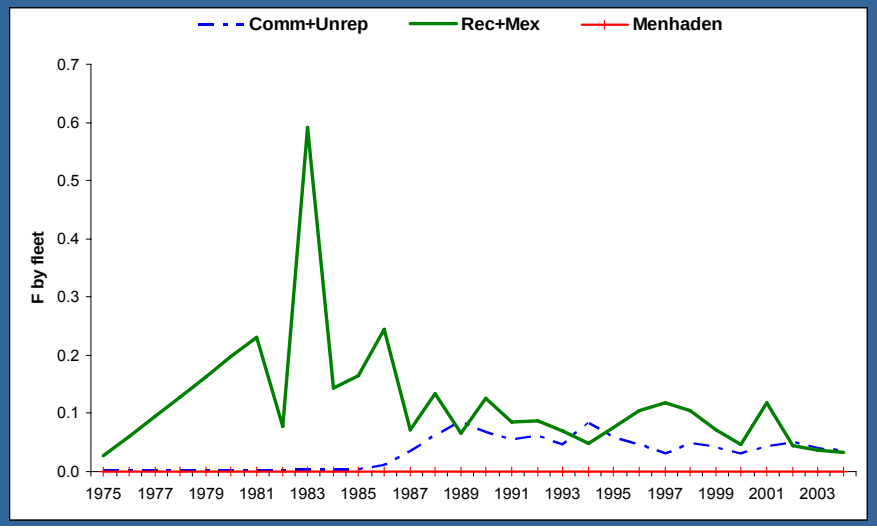
Overfished from 1999



F/F_{MSY} and B/B_{MSY}



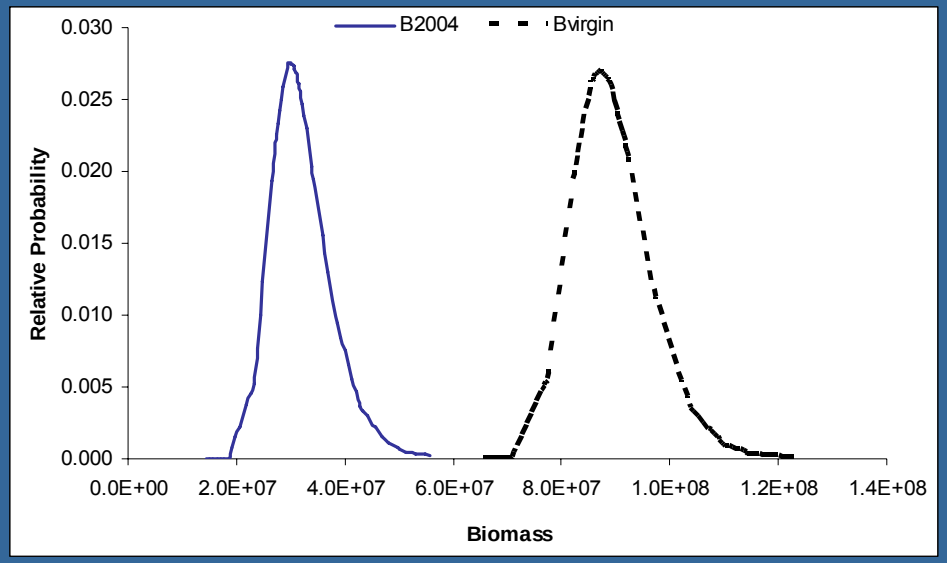
Total F and F_{MSY}

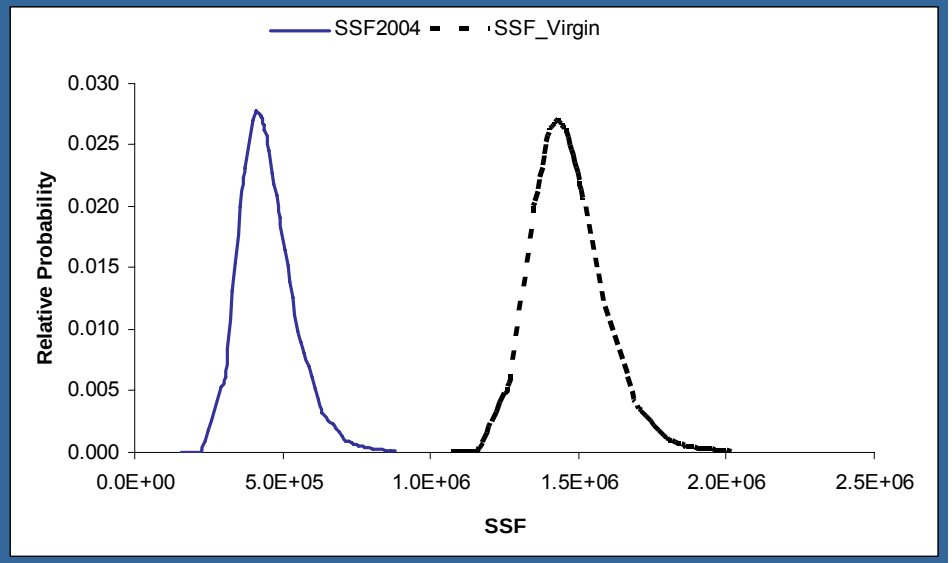


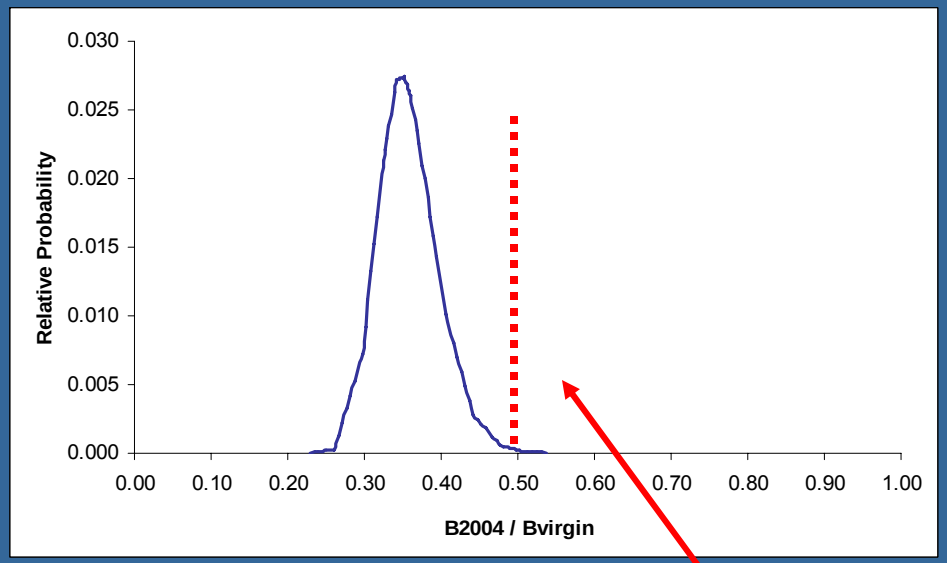
F by fleet

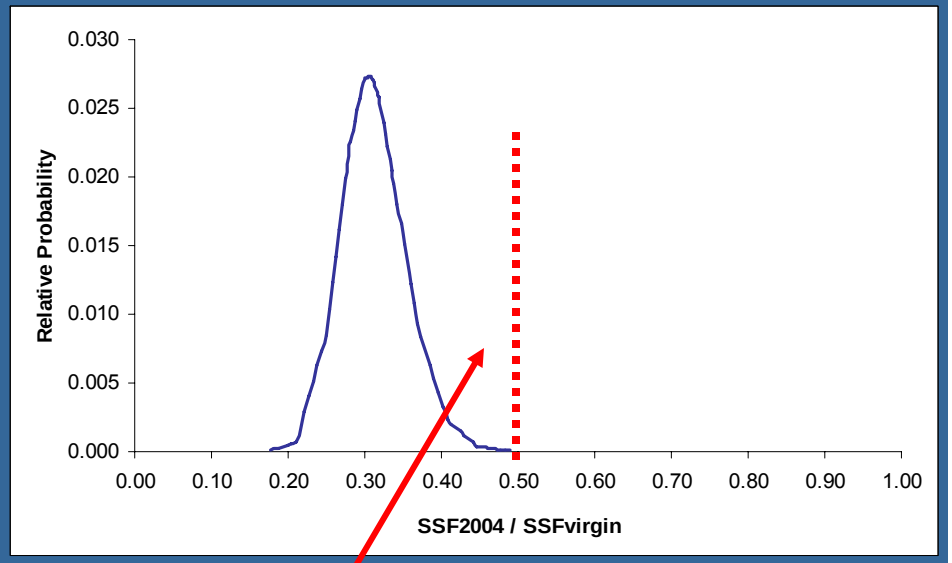
Uncertainty

- Likelihood profiling option in ADMB to estimate posterior distributions for parameters

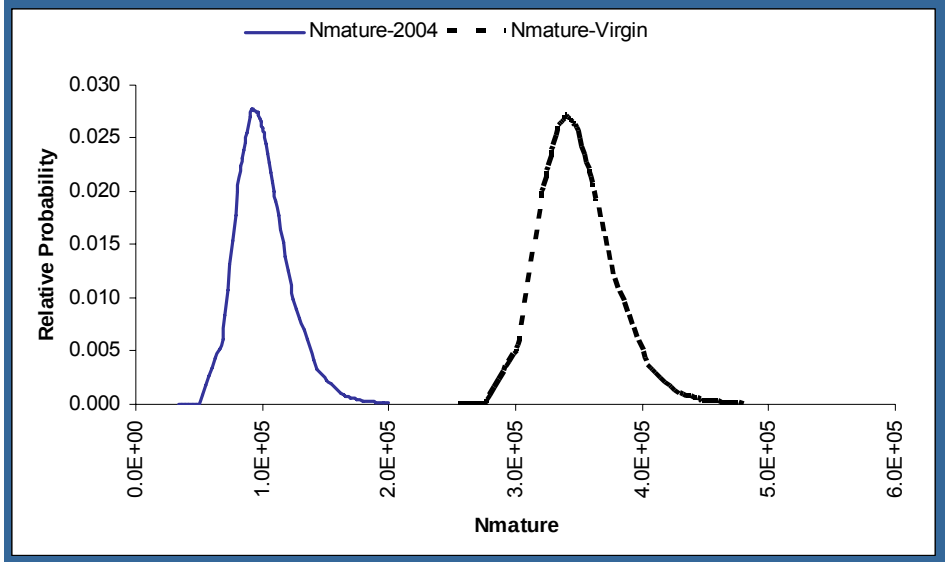


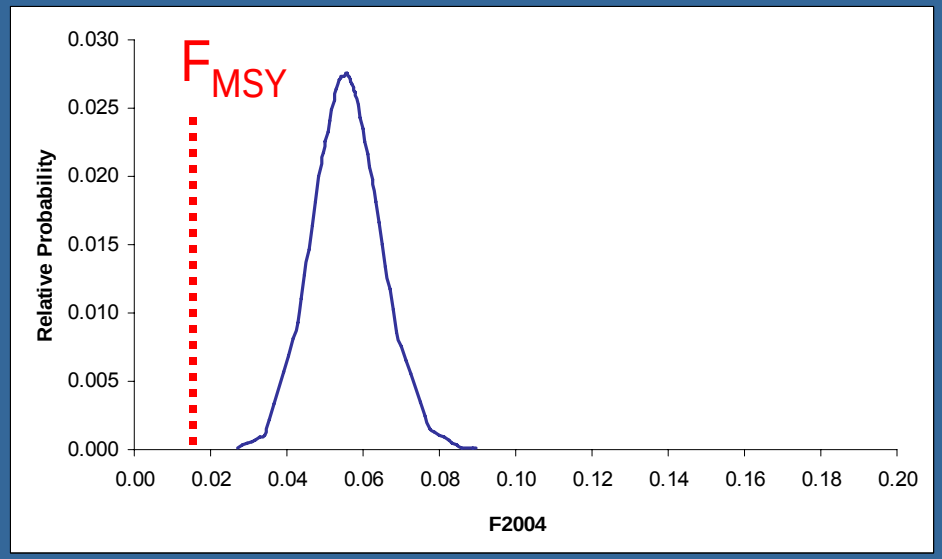


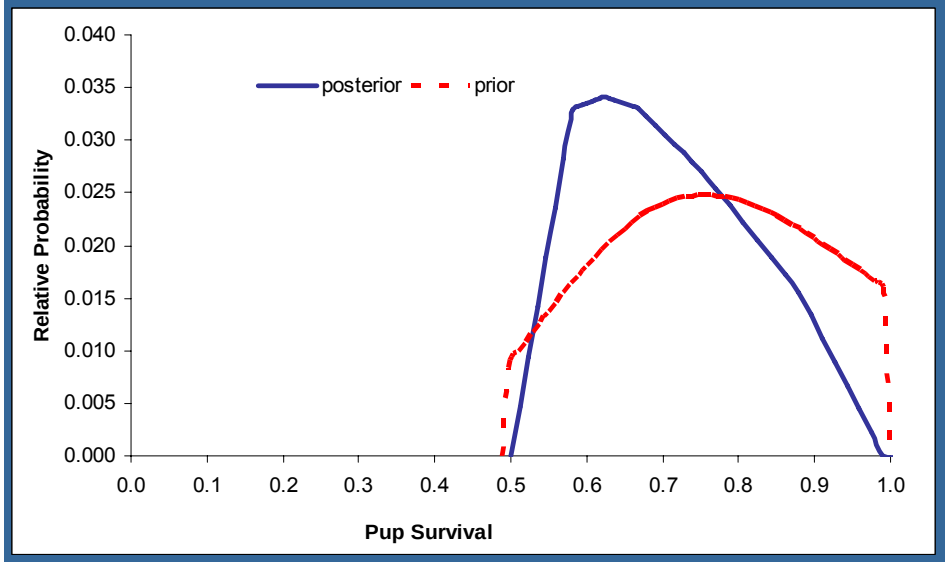


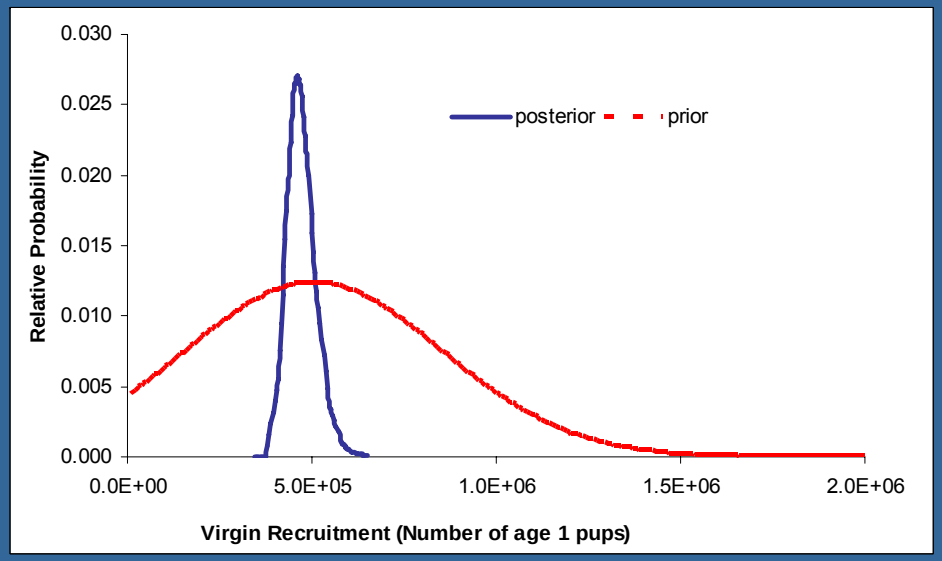


Schaeffer production – MSY at K/2


Nmature-2004
Nmature-Virgin
Relative Probability
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.0E+00
1.0E+05
2.0E+05
3.0E+05
4.0E+05
5.0E+05
6.0E+05
Nmature

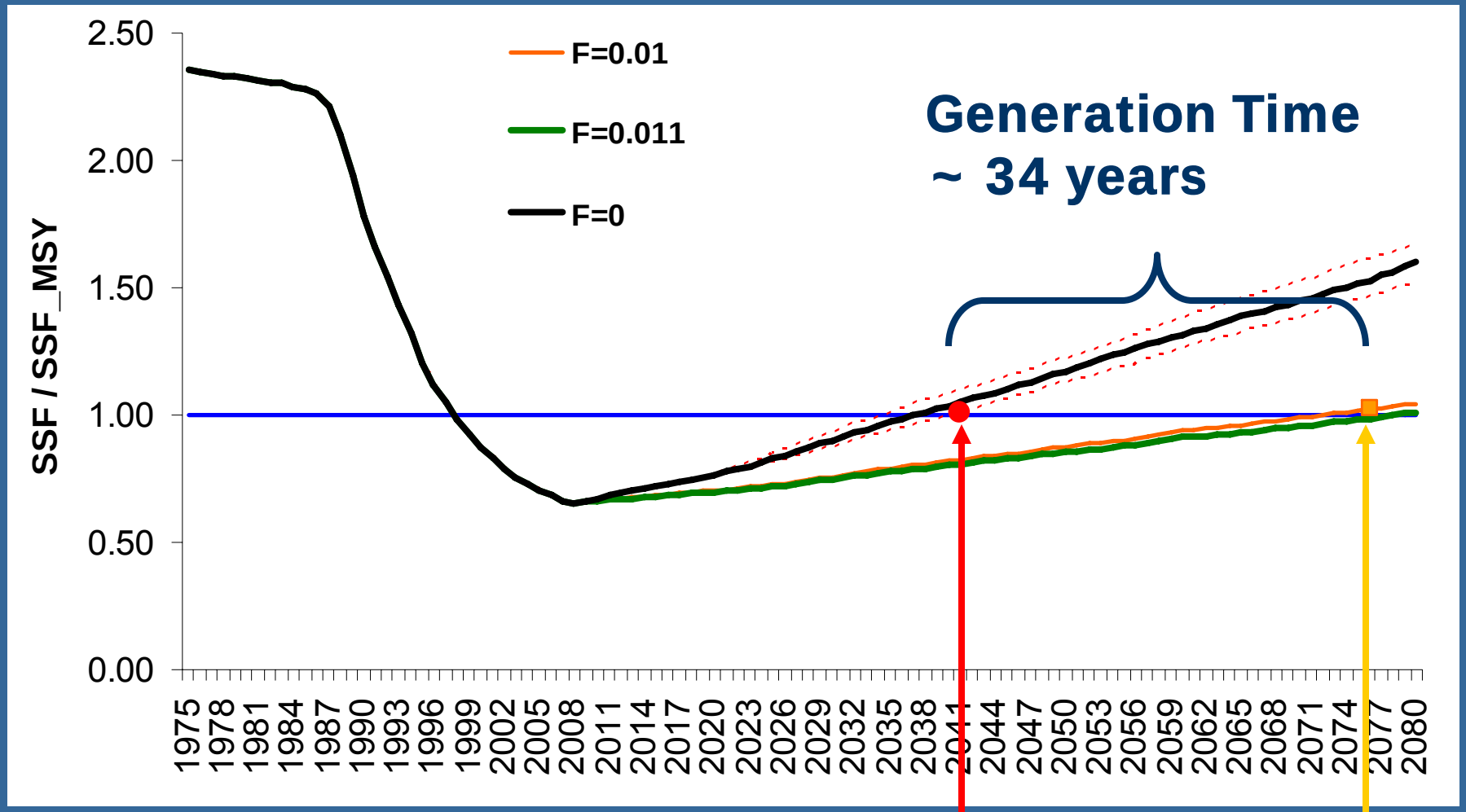

F MSY
Relative Probability
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
F2004


posterior
prior
Relative Probability
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Pup Survival


posterior
prior
Relative Probability
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0.0E+00
5.0E+05
1.0E+06
1.5E+06
2.0E+06
Virgin Recruitment (Number of age 1 pups)

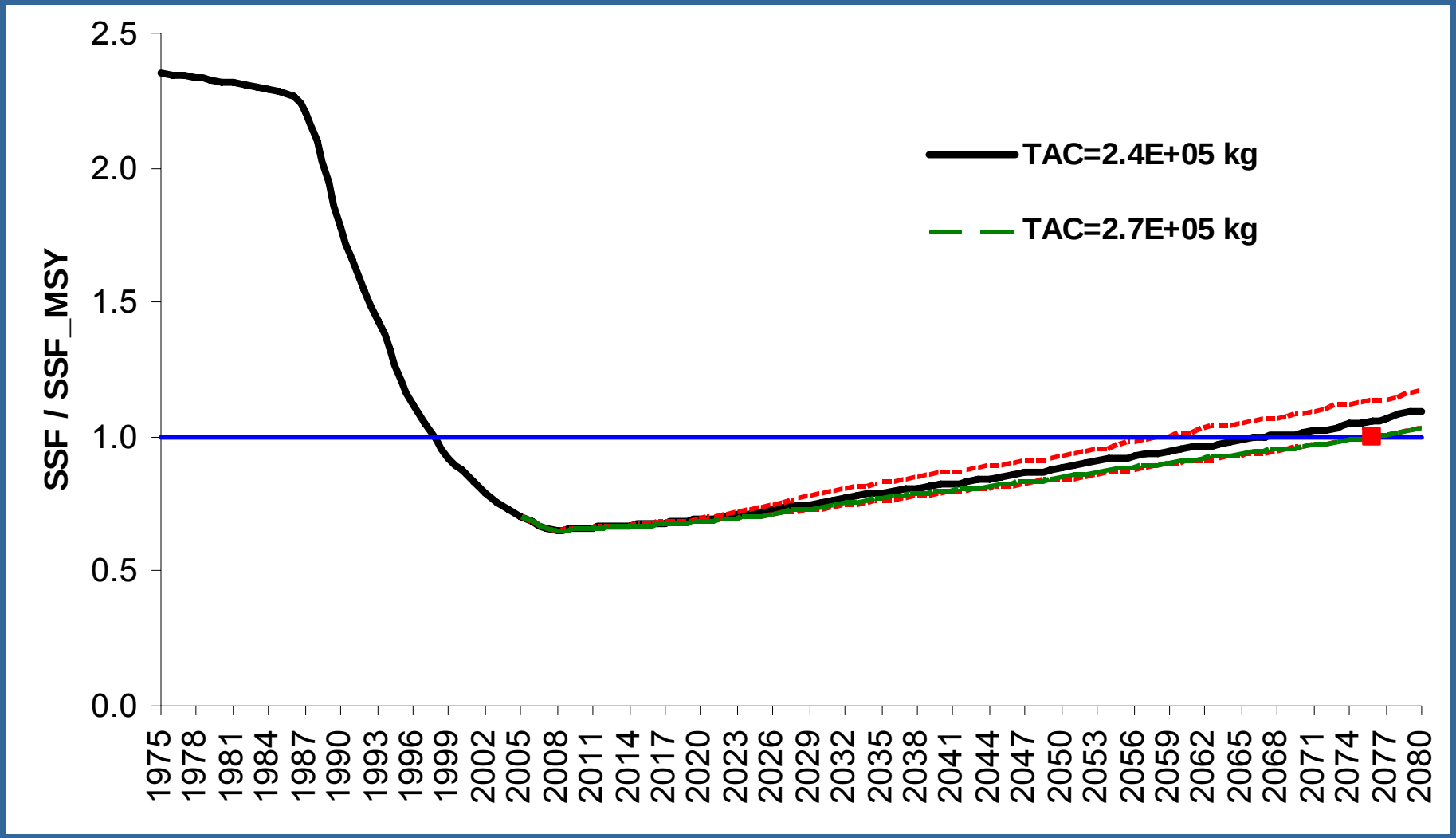
3. Base Model and Results

- Projection Scenarios
  - Constant F=0
  - Constant F=0.01
  - Constant TAC=240,000 kg
  - Constant TAC=270,000 kg



70th percentile to rebuild with F=0 (year 2041)

rebuild target (year 2076)



MSY 4.03E+5 kg

C_{2004} ~ 50,000 sharks

Model Est. Y_{2004} ~ 1.12E+6 kg

4. Sensitivity Analyses

- SB-1: inverse CV weighting of indices
- SB-2: all indices used
- SB-SPR_{50}: pup survival and M fixed to force SPR_{MSY}=0.50

5. Summary of all Results

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	BASE		Inv. CV BS-1		all indices BS-2		BS-SPR$_{50}$	
Parameter	**Est**	**CV**	**Est**	**CV**	**Est**	**CV**	**Est**	**CV**
AICc	145.129		247.833		120.087		141.61	
Objective Function	-118.92		-67.57		-109.1		-116.42	
MSY (kg)	4.03E+05	---	4.94E+05	---	7.96E+04	---	8.10E+05	---
Pups-virgin	4.61E+05	0.07	5.06E+05	0.07	6.13E+05	0.08	3.52E+05	0.06
SSF_{2004}	4.28E+05	0.19	5.38E+05	0.14	8.59E+05	0.15	4.95E+05	0.18
$Nmature_{2004}$	9.66E+04	0.19	1.22E+05	0.14	1.95E+05	0.15	1.13E+05	0.18
B_{2004}	3.06E+07	0.16	3.87E+07	0.12	5.42E+07	0.13	3.28E+07	0.16
B_{2004}/B_{virgin}	**0.35**	**0.1**	**0.4**	**0.08**	**0.47**	**0.07**	**0.35**	**0.11**
SSF_{2004}/SSF_{virgin}	0.31	0.13	0.35	0.1	0.47	0.07	0.28	0.13
$Nmature_{2004}/Nmature_{virgin}$	0.28	0.13	0.33	0.1	0.43	0.08	0.26	0.13
SSF_{2004}/SSF_{MSY}	**0.72**	**0.46**	**0.85**	**0.37**	**0.83**	**2.28**	**0.82**	**0.14**
SPR_{MSY}	0.73	---	0.70	---	0.96	---	0.50	---
F_{2004}	0.06	0.15	0.04	0.16	0.04	0.15	0.05	0.14
F_{MSY}	0.015	---	0.017	---	0.002	---	0.031	---
F_{2004}/F_{MSY}	**3.72**	**0.15**	**2.62**	**0.16**	**18.3**	**0.15**	**1.73**	**0.14**
Pup-survival	0.62	0.27	0.67	0.24	0.37	0.28	0.82	(fixed)
alpha	1.88	---	2.02	---	1.1	---	4.09	---
steepness	0.32	---	0.34	---	0.22	---	0.51	---

6. Continuity

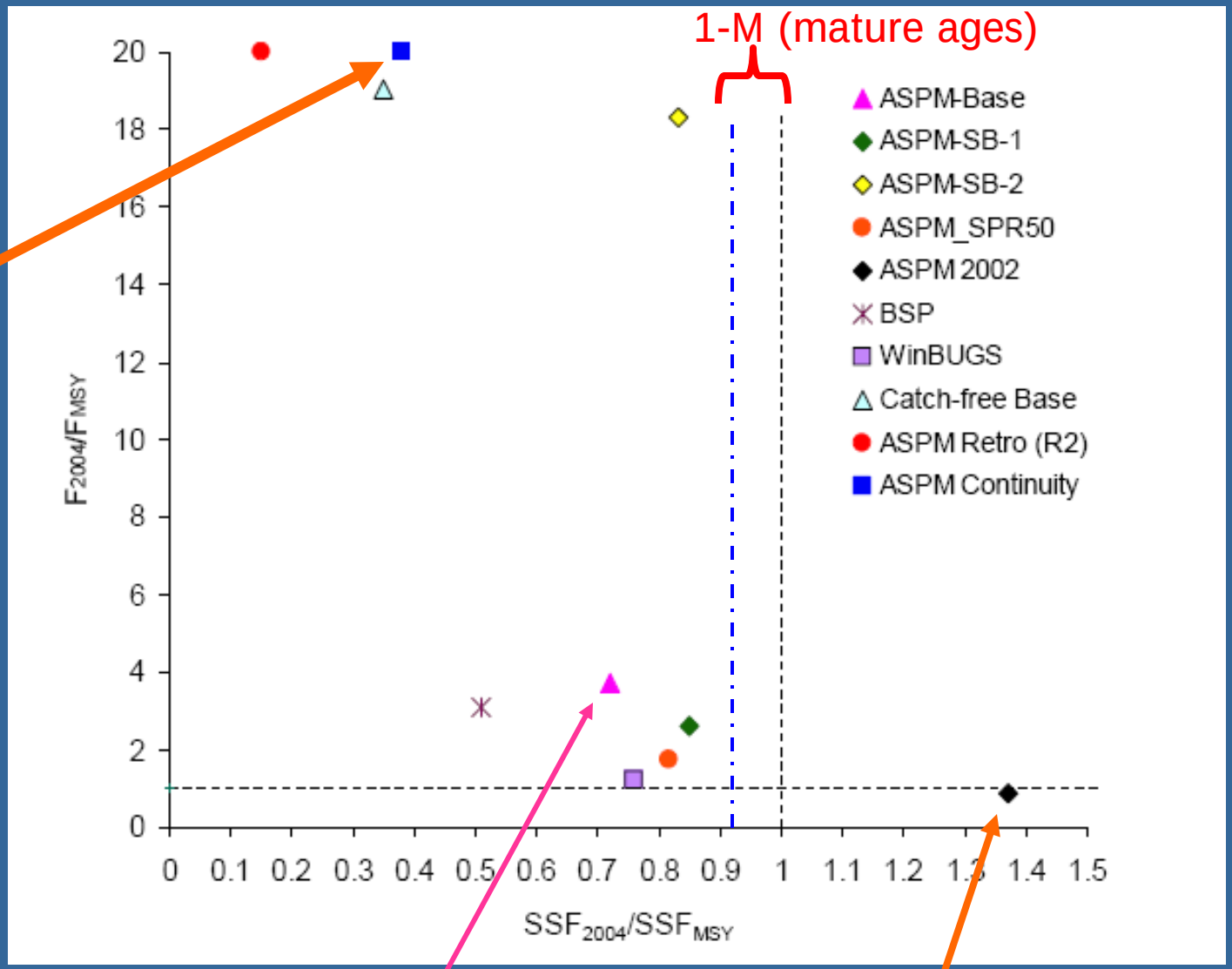
- Used model from 2002
- Used same catches, *similar* indices
- Used same selectivities
- Used 2002 biological parameters

6. Continuity

- 2002 vs 2006 indices:
  - Not all same indices available (VIMS by ages)
  - VIMS 2002 covered years 1981-2001;
    VIMS 2006 began in 1975
  - Nominal 2002 vs Standardized 2006
  - Split series 2002 vs Single Standardized 2006

6. Continuity Result

- SSF_{2004}/SSF_{MSY} = 0.38 ➔ overfished
- F_{2004}/F_{MSY} = 65.7 ➔ overfishing
- Steepness = 0.21
- SPR_{MSY} = 0.95
- F_{MSY} = 0.003



Contin. case

BASE 2006

BASE 2002

Fig. 4.10

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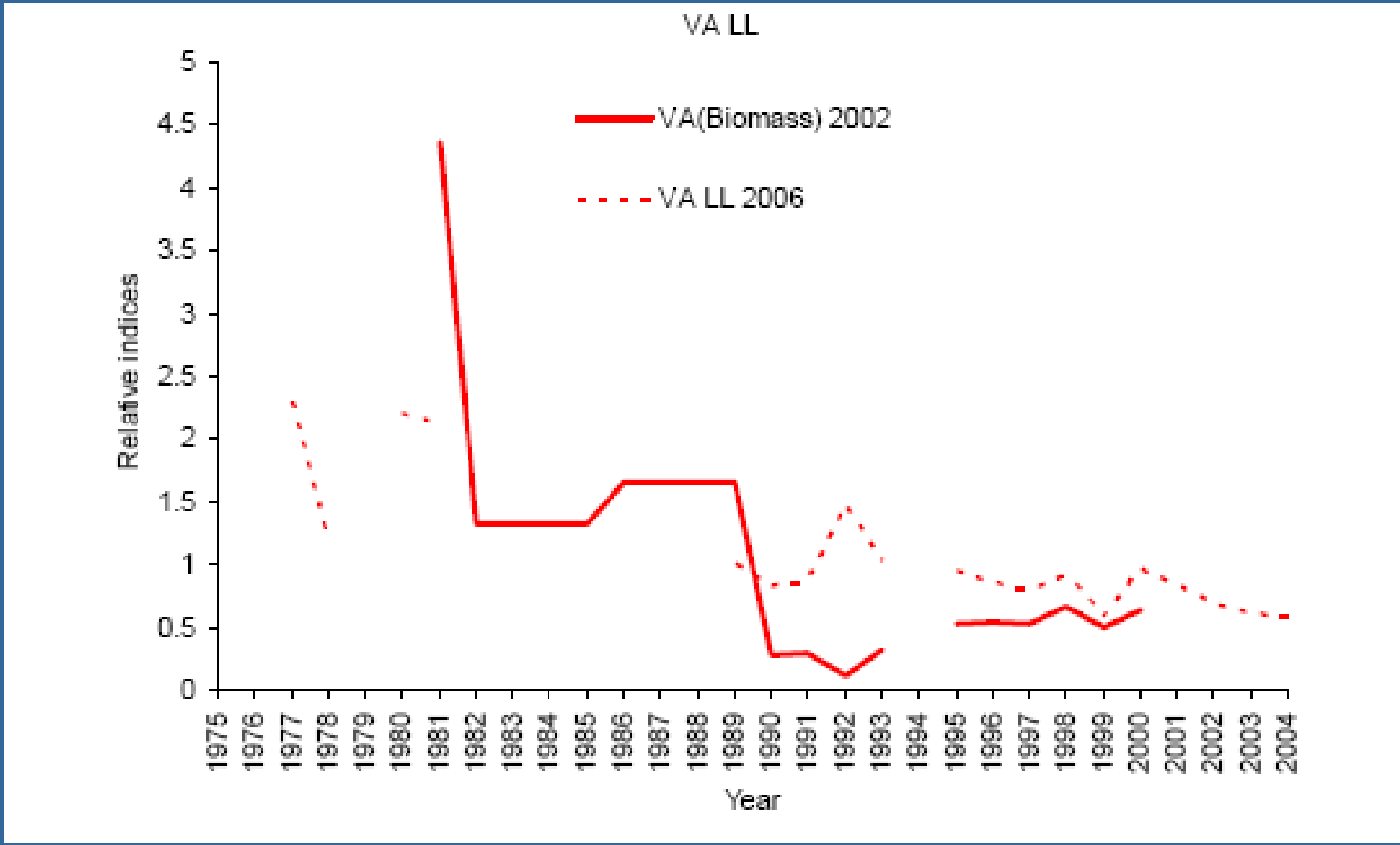
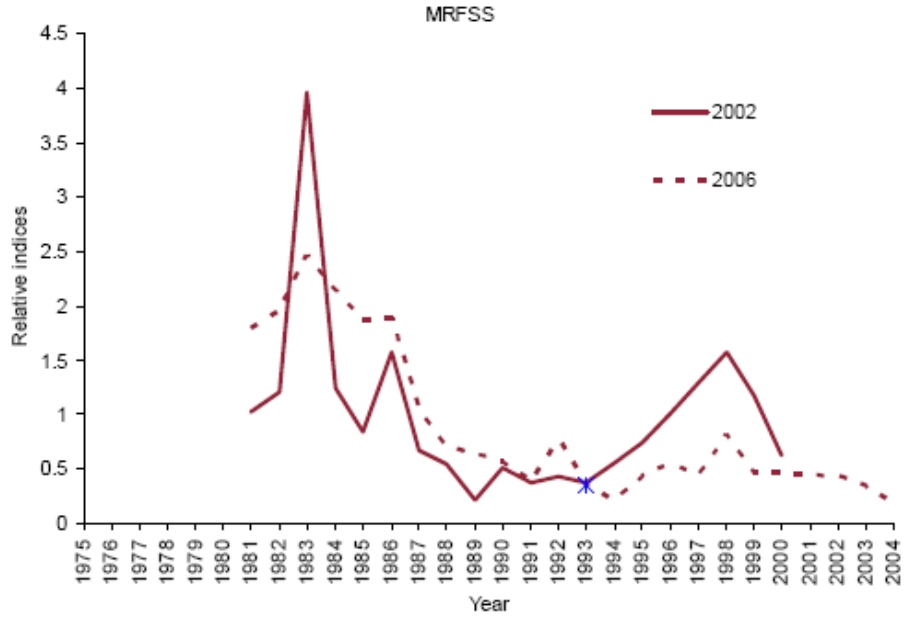
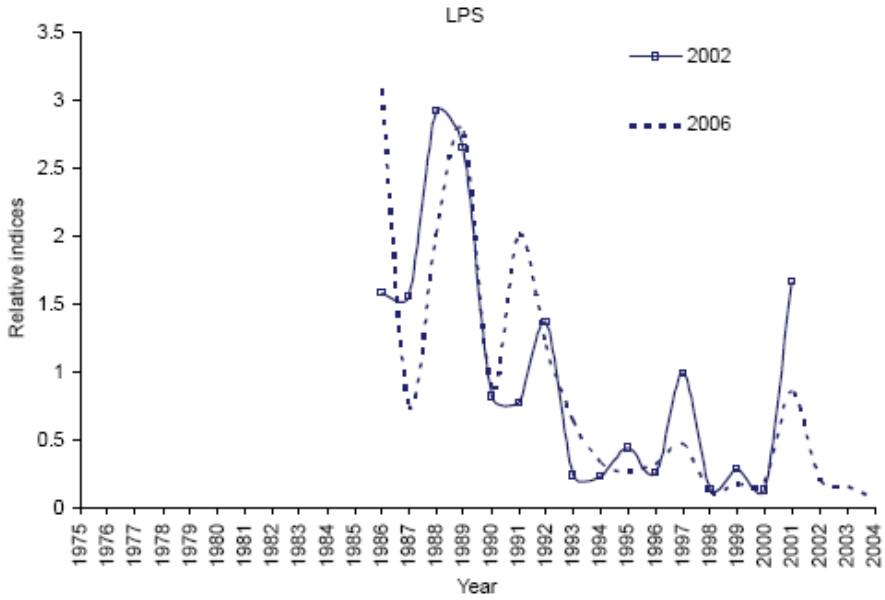
7. Retrospective analyses

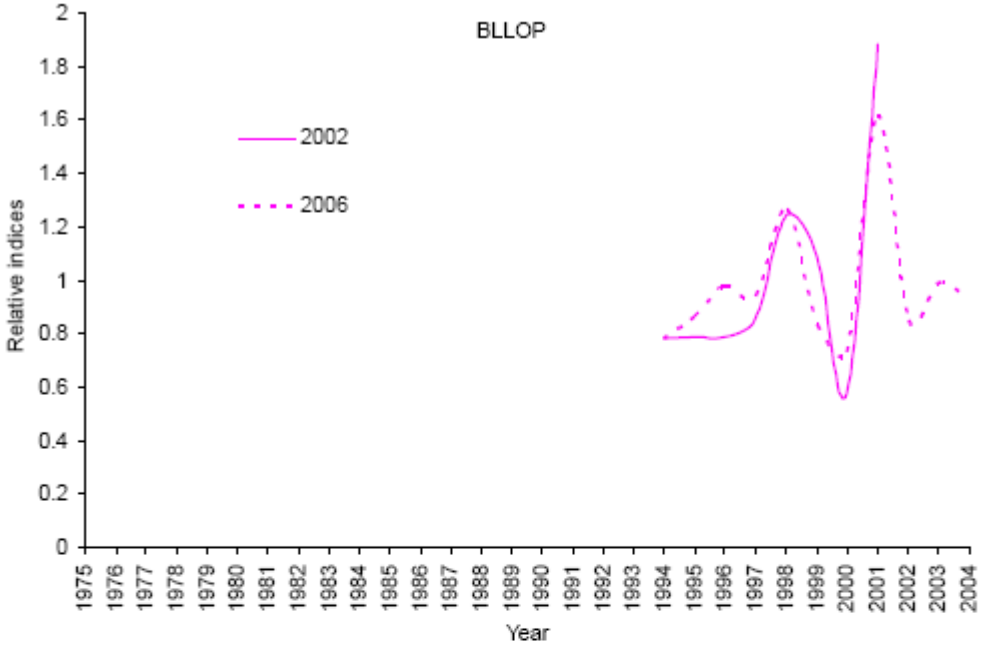
- Why the change in status from 2002 to 2006?
  - Used 2002 assessment model
  - 2002 biological parameters
  - Catches and indices updated through 2006...
    - As noted previously, indices are not the same

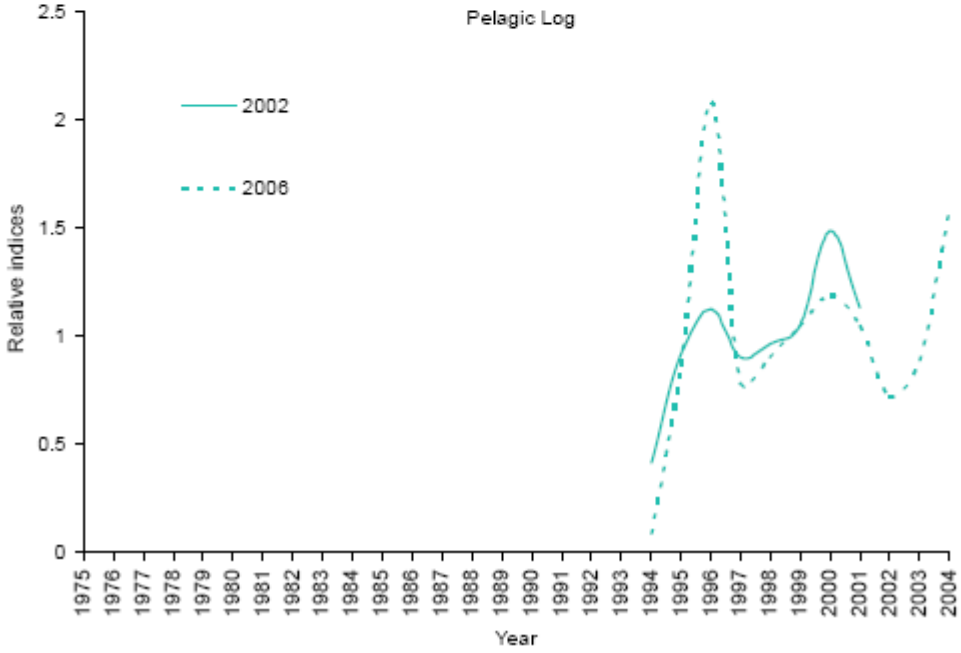
7. Retrospective – a promising hypothesis




MRFSS
2002
2006
Relative indices
Year


LPS
2002
2006
Relative indices
Year


BLLOP
2002
2006
Relative indices
Year
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004


Pelagic Log
2002
2006
Relative indices
Year
0
0.5
1
1.5
2
2.5
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004

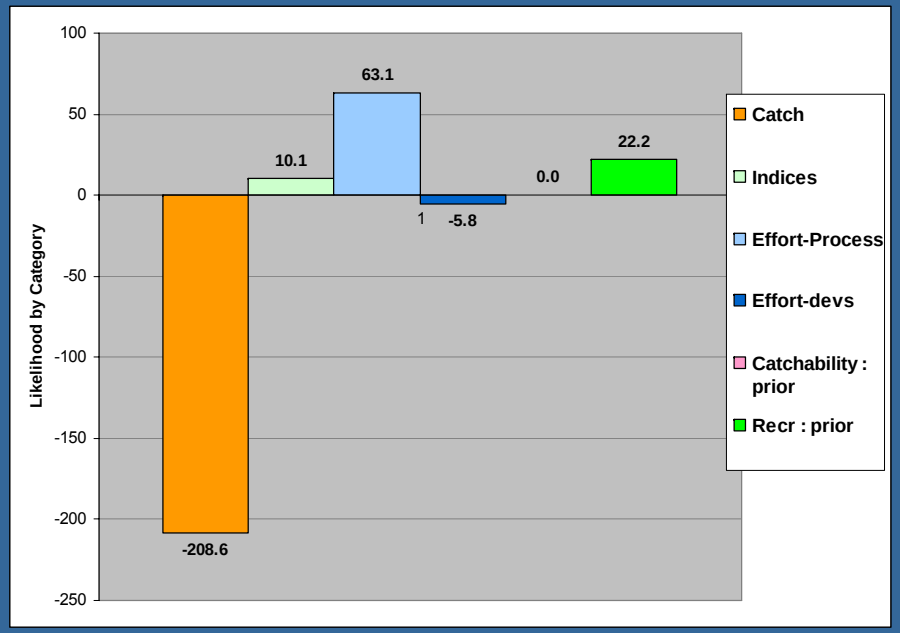
7. Retrospective analyses

- some indices from 2002 ended with an upswing, and those “same” indices showed a downturn for 2006 assessment
- Stepping back to 2002 with current data, not possible to achieve 2002 result
- Various configurations attempted, all results concluded overfished and overfishing

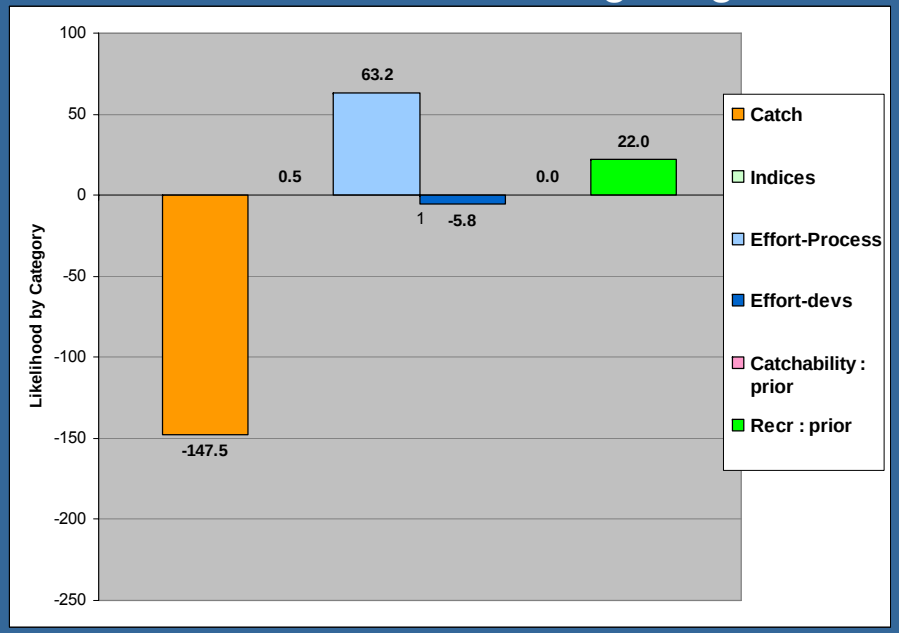
Model Run	SSF/SSF_{MSY}	F/F_{MSY}
BASE	0.72	3.72
SB-1	0.85	2.62
SB-2	0.83	18.3
SB-SPR50	0.82	1.73
R1	0.15	235
R2	0.15	82.3
R3	0.18	124
R4	--	--
R5	--	--
R6	0.48	3.45

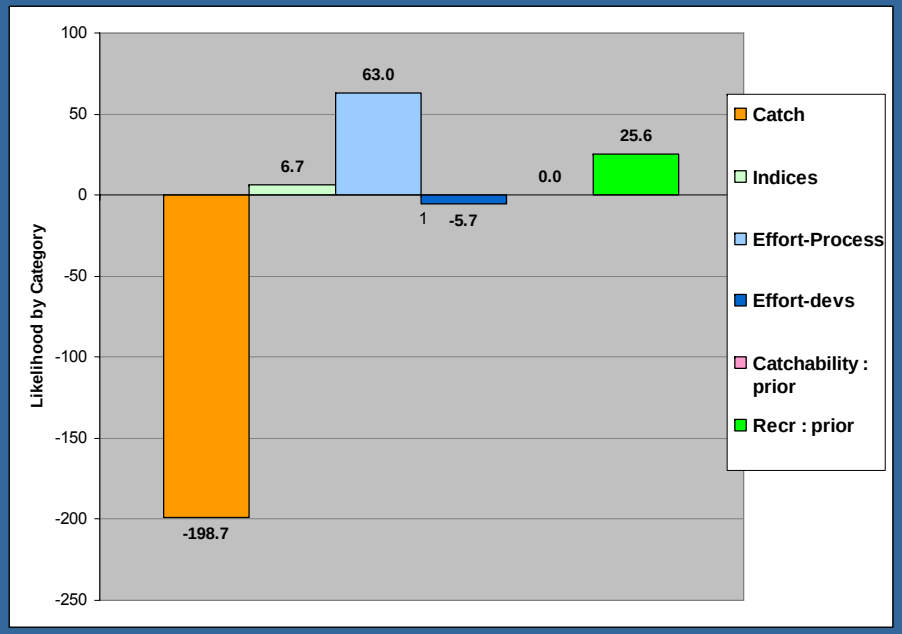
Retrospective analyses described on p.96 of AW report

BASE

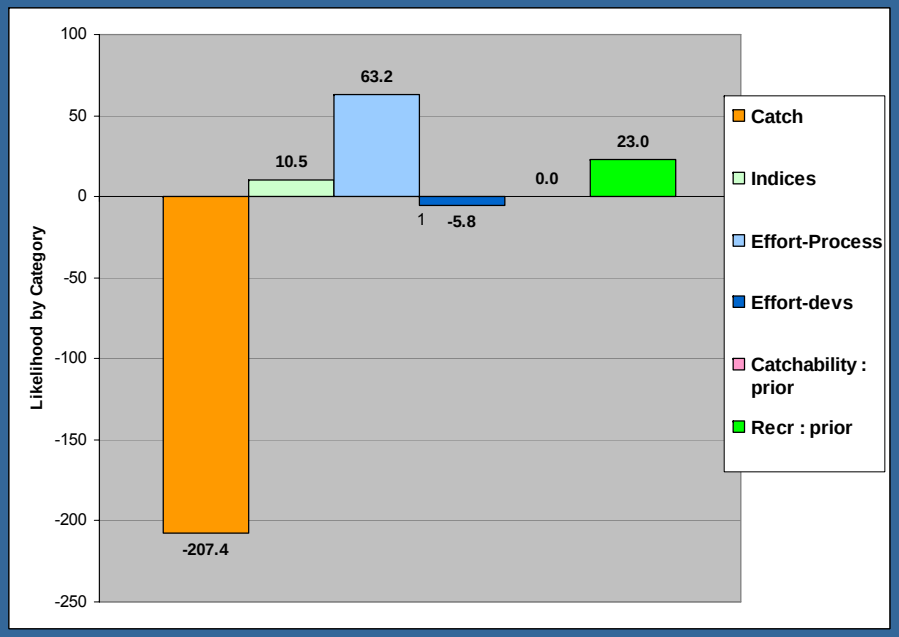


SB-1 inverse CV weighting





SB-2 all indices



SB-SPR50

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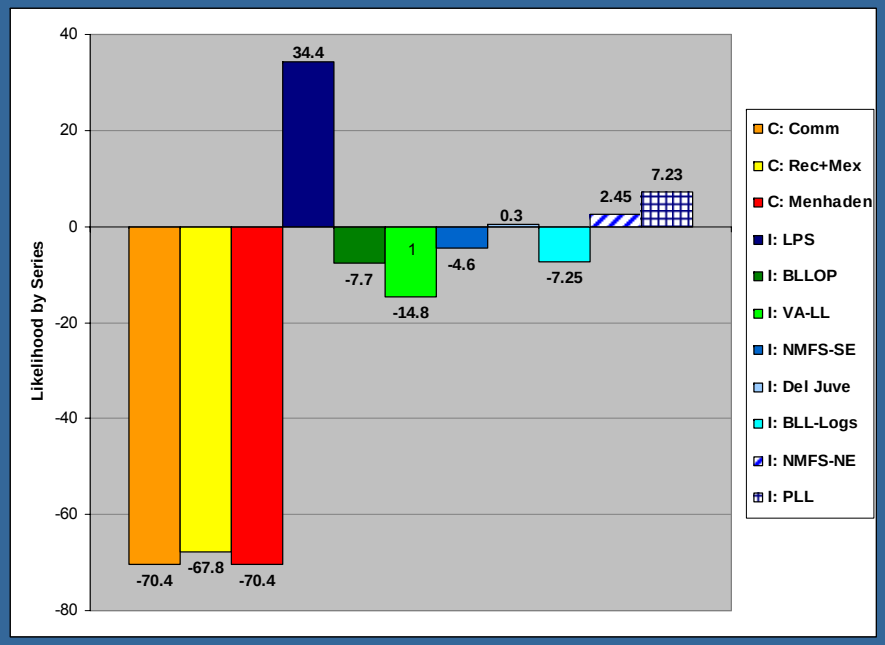
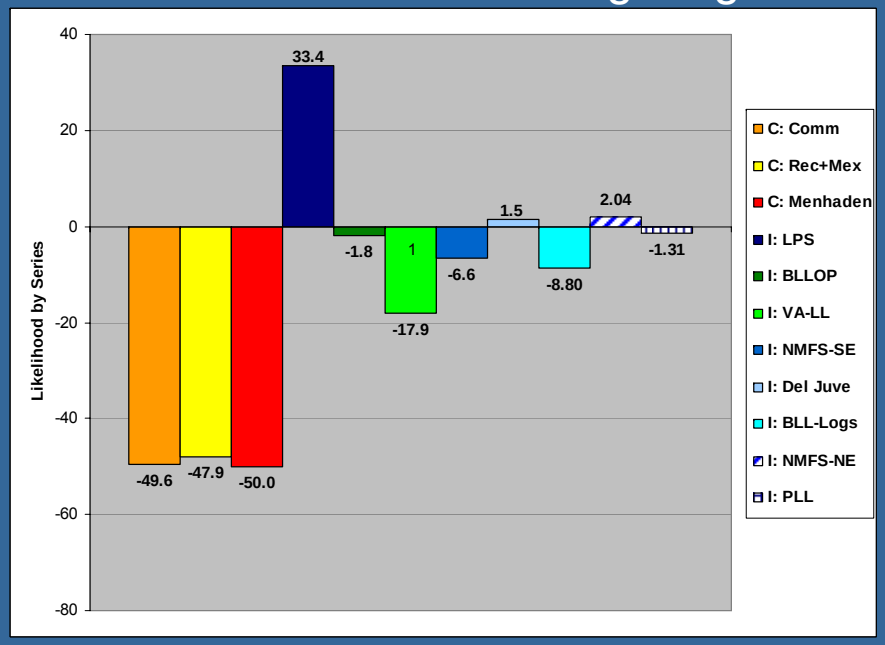
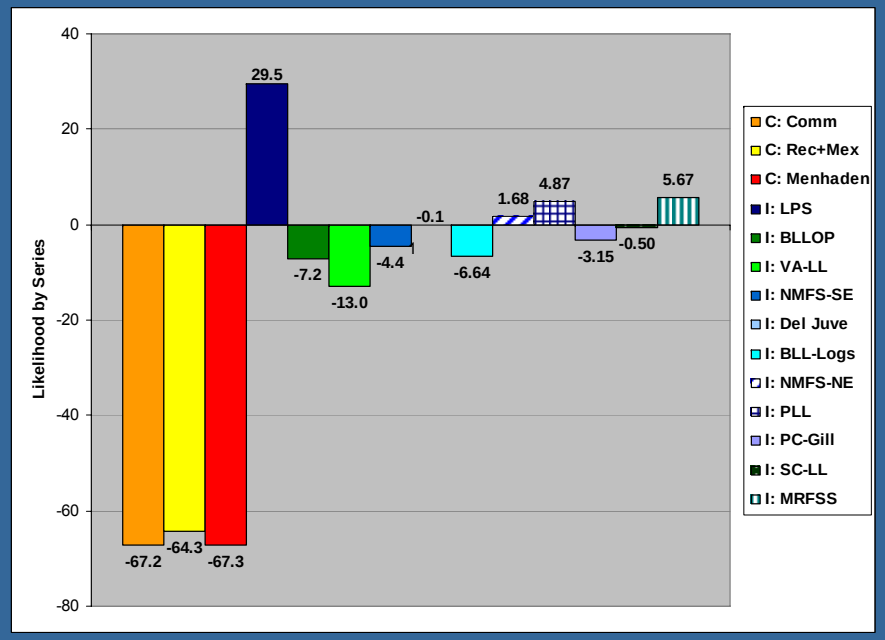
BASE

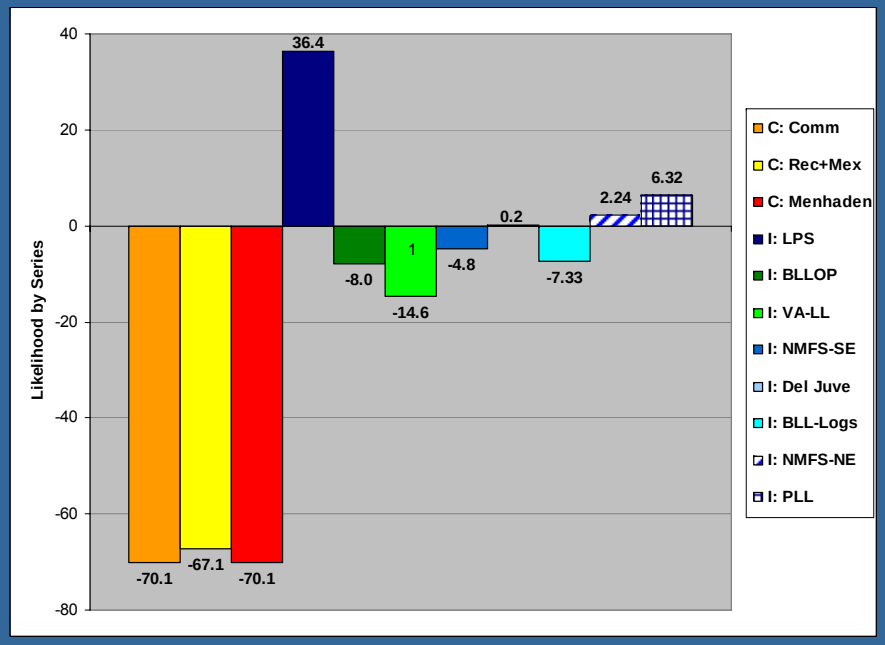


SB-1 inverse CV weighting





SB-2 all indices



SB-SPR50

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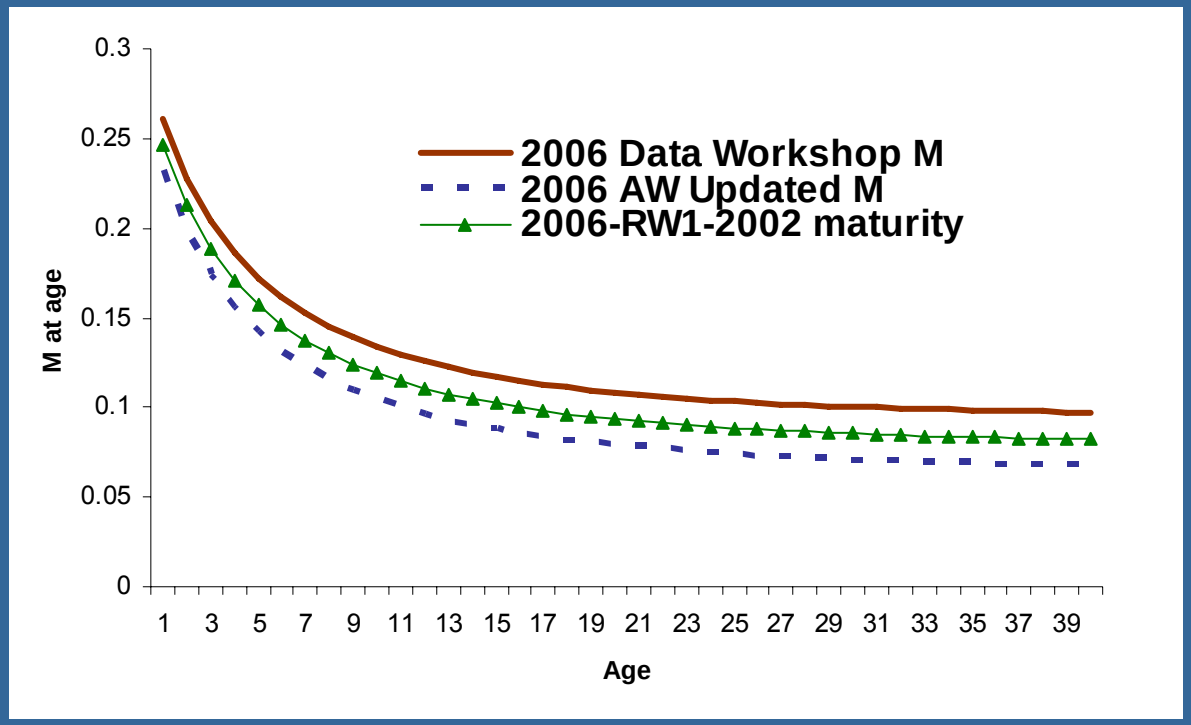
Review Workshop Requests

RW additional runs

- SB-RW1: using 2002 maturity ogive



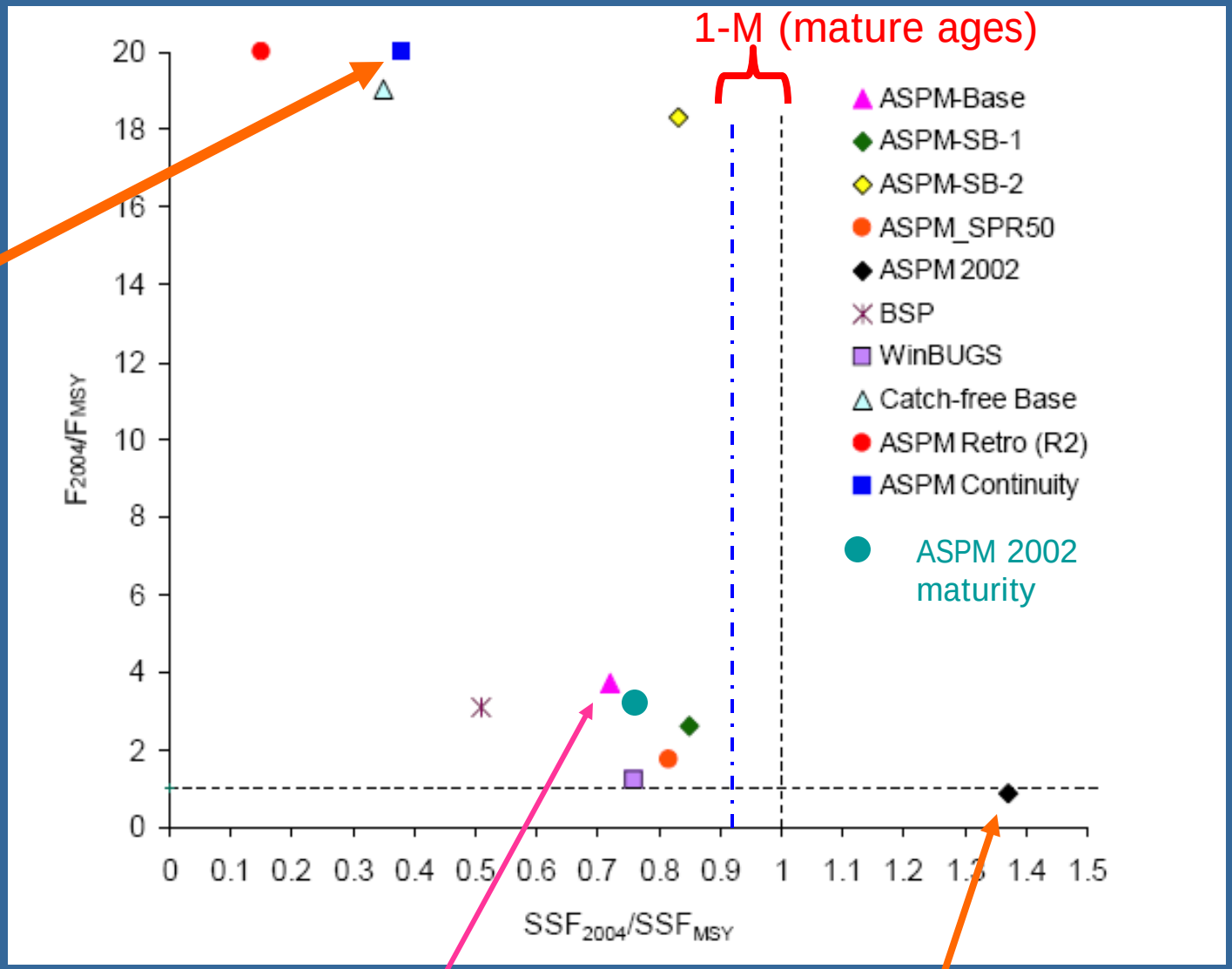
2002 maturity

Adj. pup survival

Incr. surv by 1.5%

➔ Steepness 0.37

Parameter	BASE Est	BASE CV	SB-RW1 Est	SB-RW1 CV
AICc	145.129		**143.66**	
Objective Function	-118.92		**-119.66**	
MSY (kg)	4.03E+05	---	**4.32E+05**	**---**
Pups-virgin	4.61E+05	0.07	**5.55E+05**	**0.08**
SSF_{2004}	4.28E+05	0.19	**5.59E+05**	**0.18**
$Nmature_{2004}$	9.66E+04	0.19	**1.25E+05**	**0.18**
B_{2004}	3.06E+07	0.16	**2.76E+07**	**0.16**
B_{2004}/B_{virgin}	0.35	0.1	**3.49E-01**	**0.16**
SSF_{2004}/SSF_{virgin}	0.31	0.13	**3.49E-01**	**0.10**
$Nmature_{2004}/Nmature_{virgin}$	0.28	0.13	**3.00E-01**	**0.11**
SSF_{2004}/SSF_{MSY}	0.72	0.46	**7.58E-01**	**0.48**
SPR_{MSY}	0.73	---	**0.76**	**---**
F_{2004}	0.06	0.15	**5.27E-02**	**0.15**
F_{MSY}	0.015	---	**0.017**	**---**
F_{2004}/F_{MSY}	3.72	0.15	**3.10**	**0.15**
Pup-survival	0.62	0.27	**0.58**	**0.27**
alpha	1.88	---	**1.77**	**---**
steepness	0.32	---	**0.31**	**---**



Contin. case

BASE 2006

BASE 2002

Fig. 4.10

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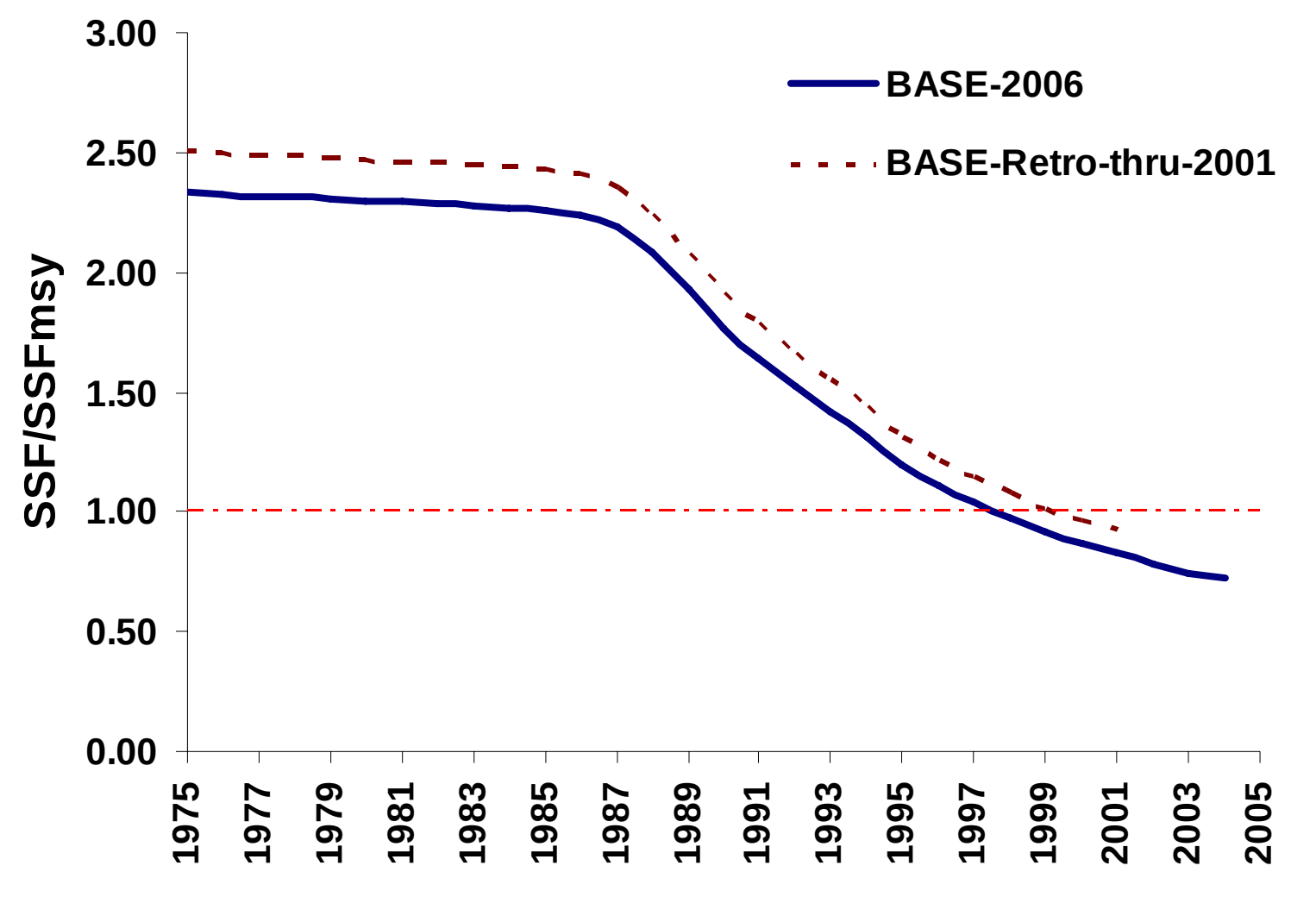
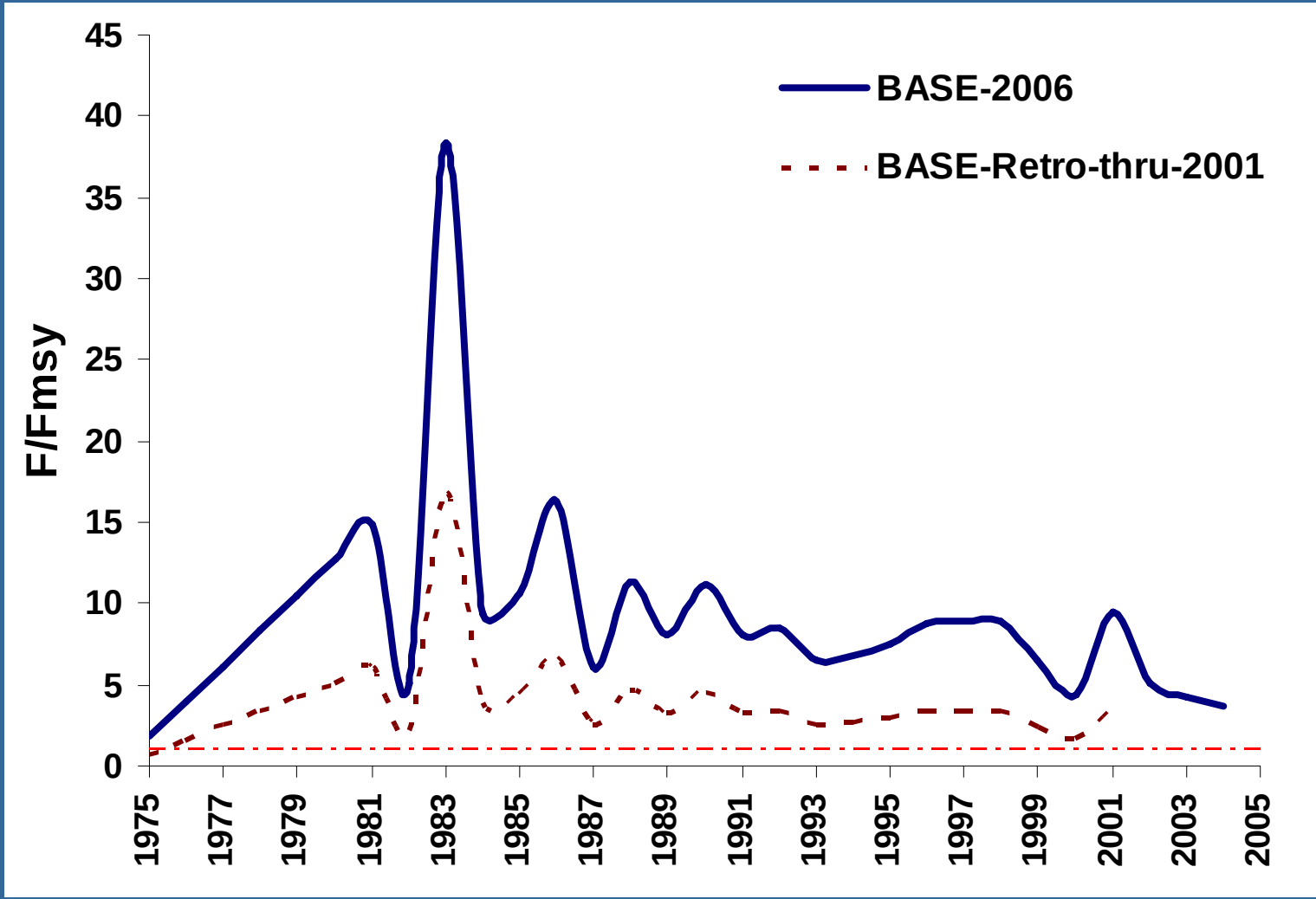
Sandbar RW-Retro-2001

- Use 2006 model, 2006 catches and indices and biological inputs
- Run model on data through year 2001

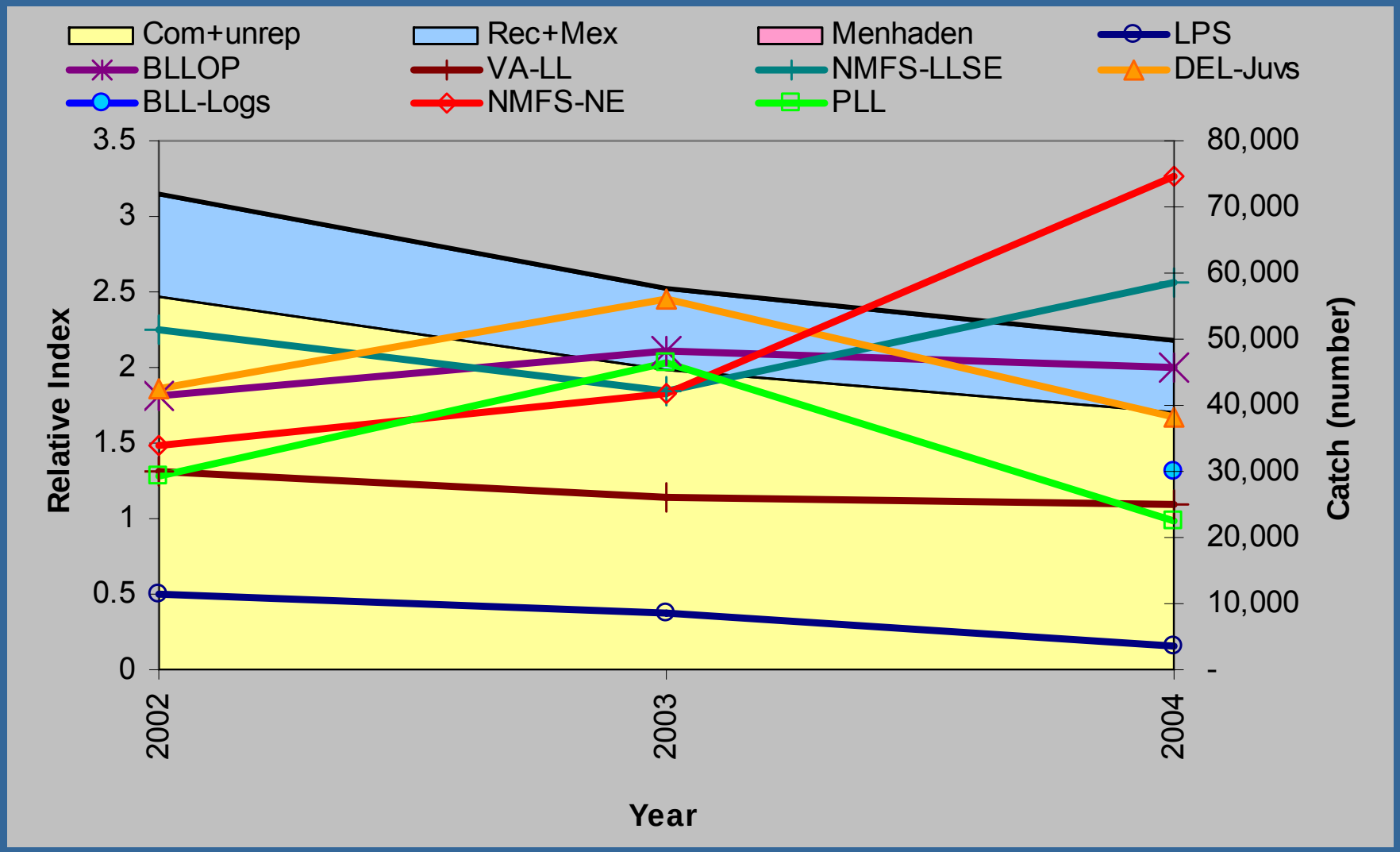
Sandbar RW-Retro-2001



Sandbar RW-Retro-2001



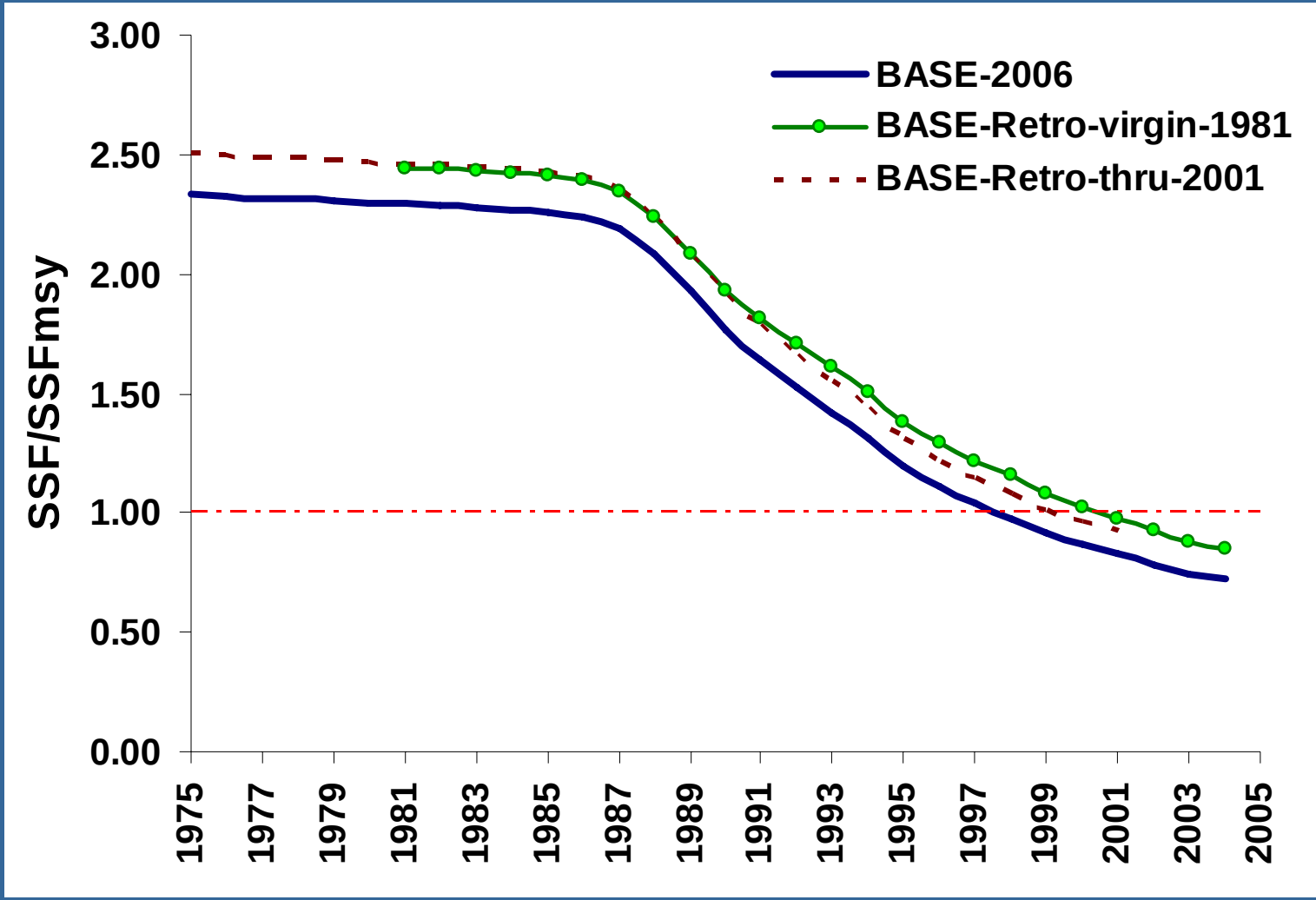
	BASE		SB-Retro-2001	
Parameter	Est	CV	Est	CV
AICc	145.13		173.96	
Objective Function	-118.92		-104.96	
MSY (kg)	4.03E+05	---	5.16E+05	---
Pups-virgin	4.61E+05	0.07	4.70E+05	0.09
SSF_{2004}	4.28E+05	0.19	5.22E+05	0.22
$Nmature_{2004}$	9.66E+04	0.19	1.18E+05	0.22
B_{2004}	3.06E+07	0.16	3.66E+07	0.20
B_{2004}/B_{virgin}	0.35	0.10	0.41	0.12
SSF_{2004}/SSF_{virgin}	0.31	0.13	0.37	0.14
$Nmature_{2004}/Nmature_{virgin}$	0.28	0.13	0.34	0.14
SSF_{2004}/SSF_{MSY}	0.72	0.46	0.92	0.38
SPR_{MSY}	0.73	---	0.67	---
F_{2004}	0.06	0.15	0.13	0.18
F_{MSY}	0.015	---	0.04	---
F_{2004}/F_{MSY}	3.72	0.15	3.50	0.18
Pup-survival	0.62	0.27	0.75	0.29
alpha	1.88	---	2.26	---
steepness	0.32	---	0.36	---


Com+unrep
Rec+Mex
Menhaden
LPS
BLLOP
VA-LL
NMFS-LLSE
DEL-Juvs
BLL-Logs
NMFS-NE
PLL
3.5
3
2.5
2
1.5
1
0.5
0
Relative Index
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
-
Catch (number)
2002
2003
2004
Year

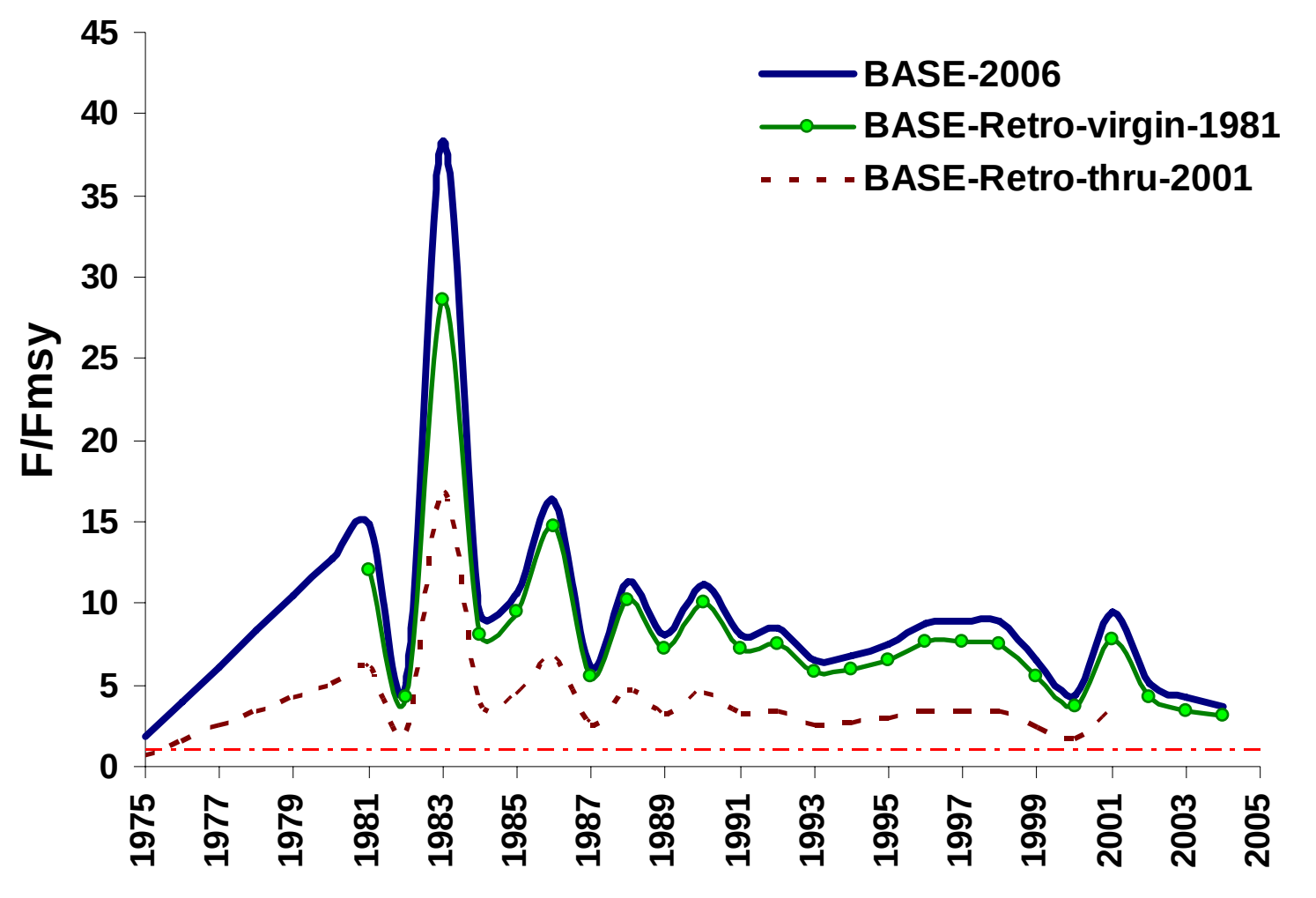
Sandbar RW-Virgin-1981

- Use 2006 model, 2006 catches and indices and biological inputs
- Run model beginning in 1981
- Drop “historic” catch estimates
- Drop years 1975-1980 in VA-LL

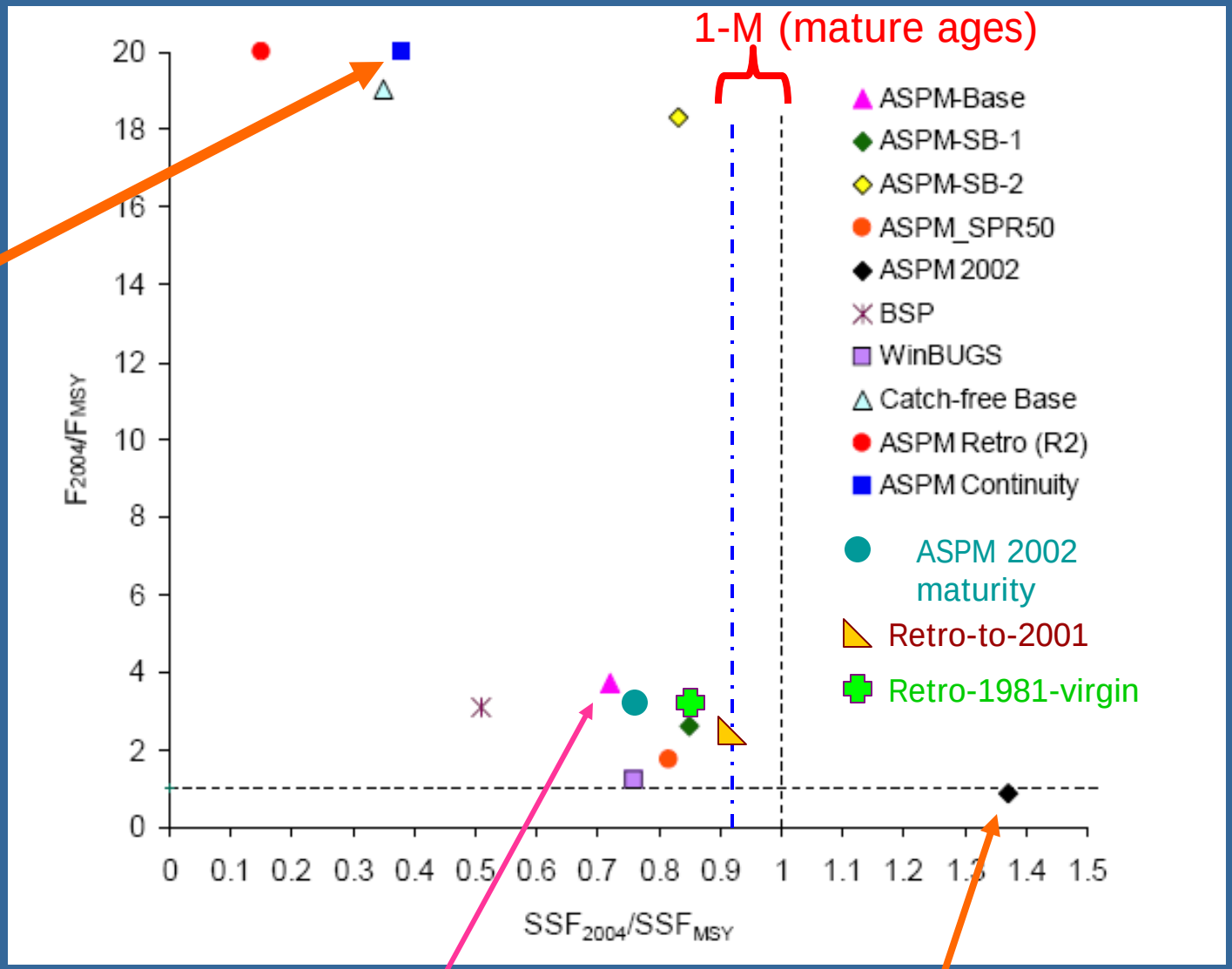
Sandbar RW-Virgin-1981



Sandbar RW-Virgin-1981



	BASE		SB-Retro-1981virgin	
Parameter	Est	CV	Est	CV
AICc	145.13		240.25	
Objective Function	-118.92		-88.43	
MSY (kg)	4.03E+05	---	4.28E+05	---
Pups-virgin	4.61E+05	0.07	4.41E+05	0.08
SSF_{2004}	4.28E+05	0.19	4.58E+05	0.21
$Nmature_{2004}$	9.66E+04	0.19	1.03E+05	0.21
B_{2004}	3.06E+07	0.16	3.24E+07	0.18
B_{2004}/B_{virgin}	0.35	0.10	0.39	0.11
SSF_{2004}/SSF_{virgin}	0.31	0.13	0.35	0.13
$Nmature_{2004}/Nmature_{virgin}$	0.28	0.13	0.32	0.13
SSF_{2004}/SSF_{MSY}	0.72	0.46	0.85	0.44
SPR_{MSY}	0.73	---	0.70	---
F_{2004}	0.06	0.15	0.05	0.17
F_{MSY}	0.015	---	0.02	---
F_{2004}/F_{MSY}	3.72	0.15	3.05	0.17
Pup-survival	0.62	0.27	0.67	0.28
alpha	1.88	---	2.01	---
steepness	0.32	---	0.33	---



Contin. case

BASE 2006

BASE 2002

Fig. 4.10

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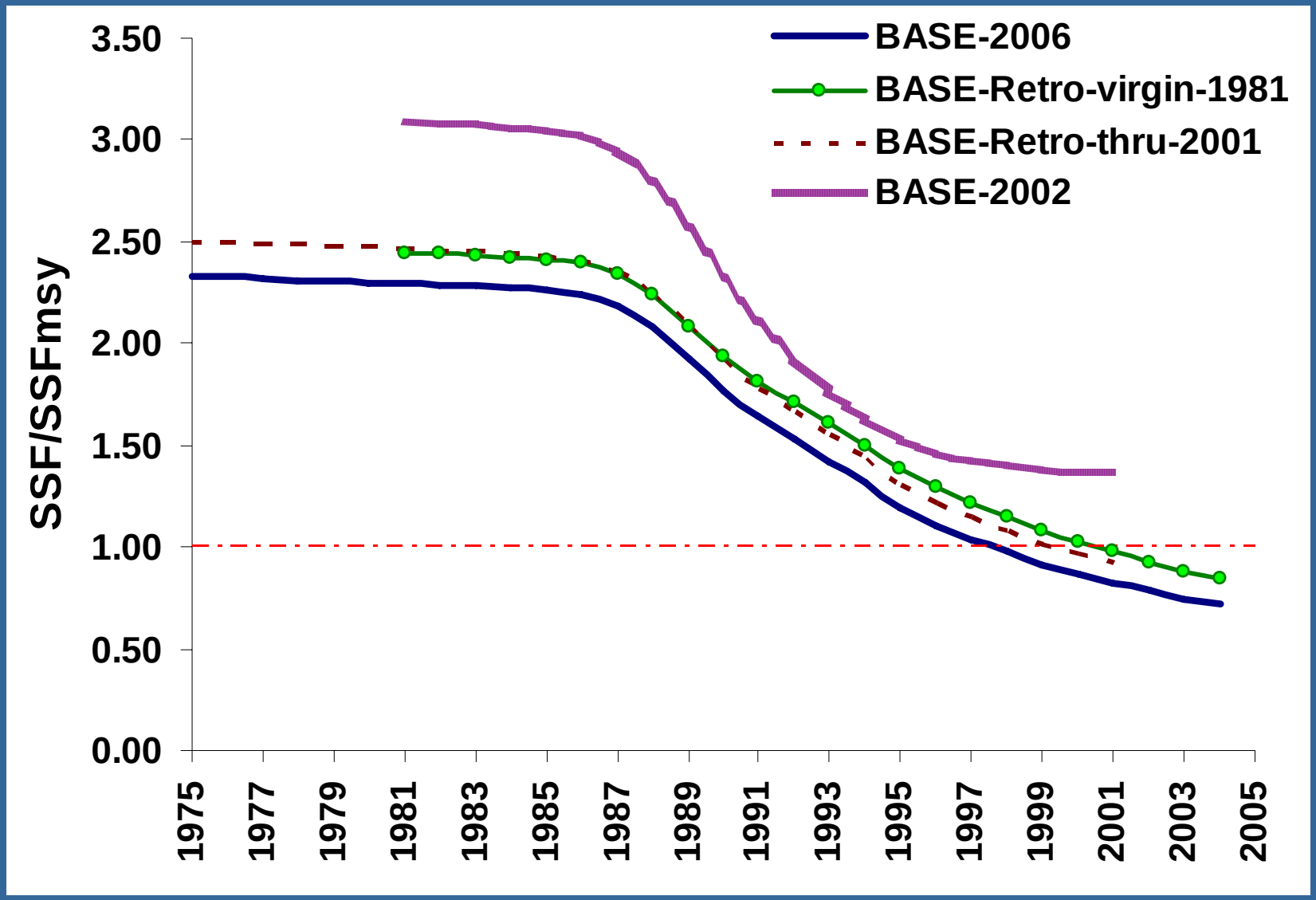
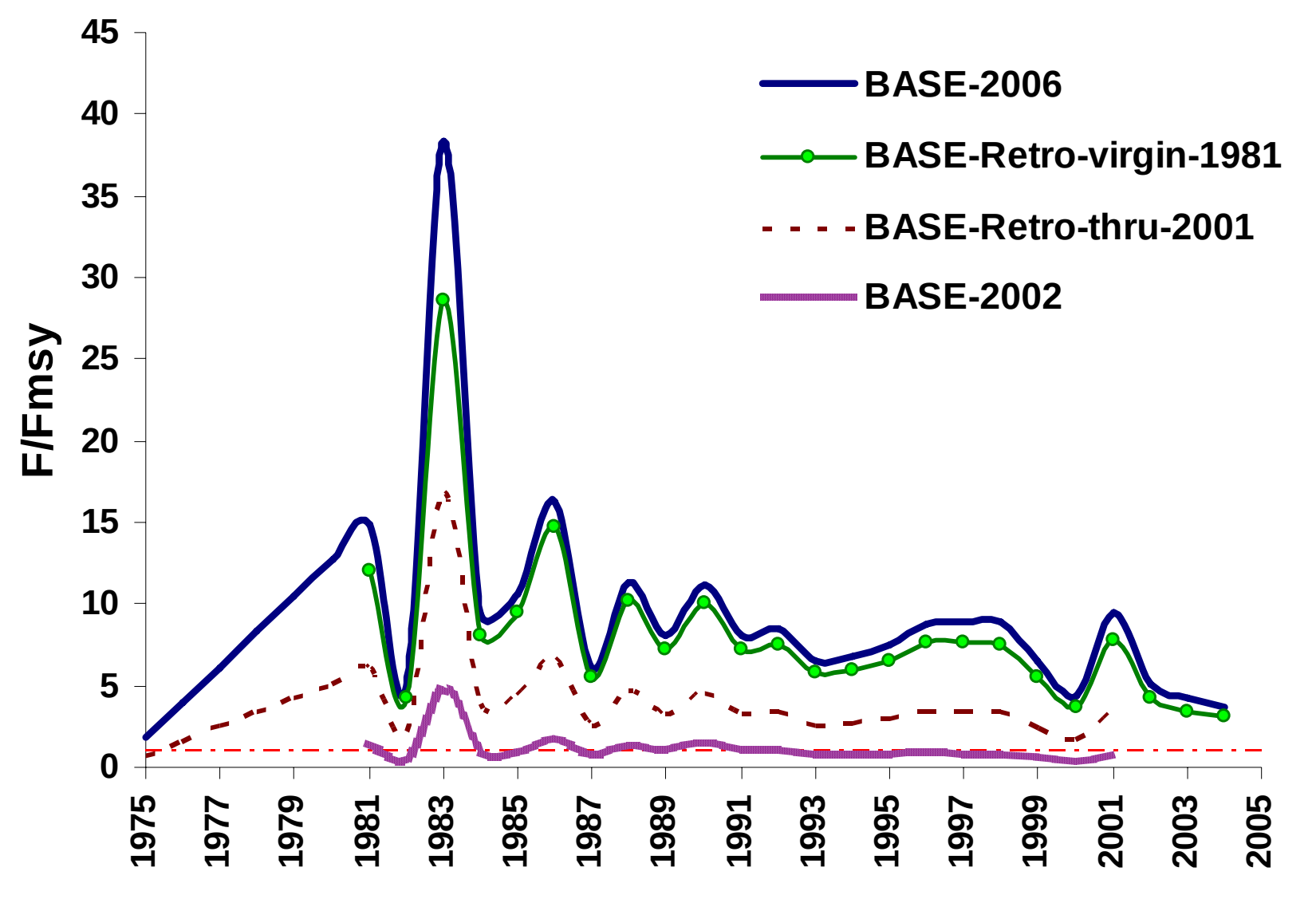
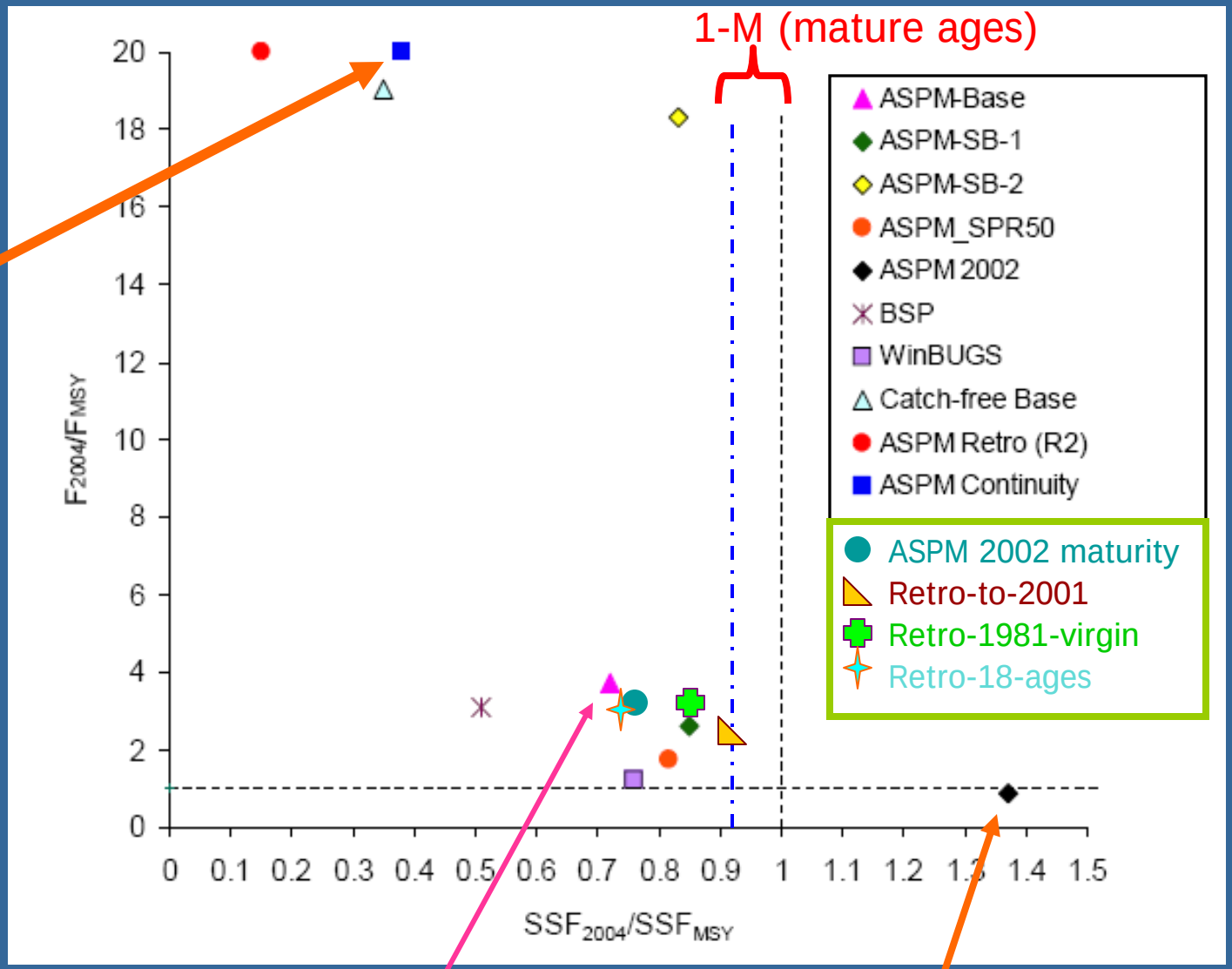

BASE-2006
BASE-Retro-virgin-1981
BASE-Retro-thru-2001
BASE-2002
SSF/SSFmsy
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005


F/Fmsy
45
40
35
30
25
20
15
10
5
0
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
BASE-2006
BASE-Retro-virgin-1981
BASE-Retro-thru-2001
BASE-2002

Parameter	BASE Est	CV	SB-Retro-2001 Est	CV	SB-Retro-1981virgin Est	CV	BASE-2002
AICc	145.13		173.96		240.25		862.47
Objective Function	-118.92		-104.96		-88.43		282.46
MSY (kg)	4.03E+05	---	5.16E+05	---	4.28E+05	---	1.16E+06
Pups-virgin	4.61E+05	0.07	4.70E+05	0.09	4.41E+05	0.08	4.90E+05
SSF2004	4.28E+05	0.19	5.22E+05	0.22	4.58E+05	0.21	1.70E+06
Nmature2004	9.66E+04	0.19	1.18E+05	0.22	1.03E+05	0.21	
B2004	3.06E+07	0.16	3.66E+07	0.20	3.24E+07	0.18	
B2004/Bvirgin	0.35	0.10	0.41	0.12	0.39	0.11	
SSF2004/SSFvirgin	0.31	0.13	0.37	0.14	0.35	0.13	
Nmature2004/Nmaturevirgin	0.28	0.13	0.34	0.14	0.32	0.13	
SSF2004/SSFMSY	0.72	0.46	0.92	0.38	0.85	0.44	1.38
SPRMSY	0.73	---	0.67	---	0.70	---	0.46
F2004	0.06	0.15	0.13	0.18	0.05	0.17	0.08
FMSY	0.02	---	0.04	---	0.02	---	0.09
F2004/FMSY	3.72	0.15	3.50	0.18	3.05	0.17	0.08
Pup-survival	0.62	0.27	0.75	0.29	0.67	0.28	0.61
alpha	1.88	---	2.26	---	2.01	---	4.78
steepness	0.32	---	0.36	---	0.33	---	0.54

18 age classes

Yellow values are values for year 2001 (BASE-2002 assessment)



Contin. case

RW runs

BASE 2006

BASE 2002

Fig. 4.10

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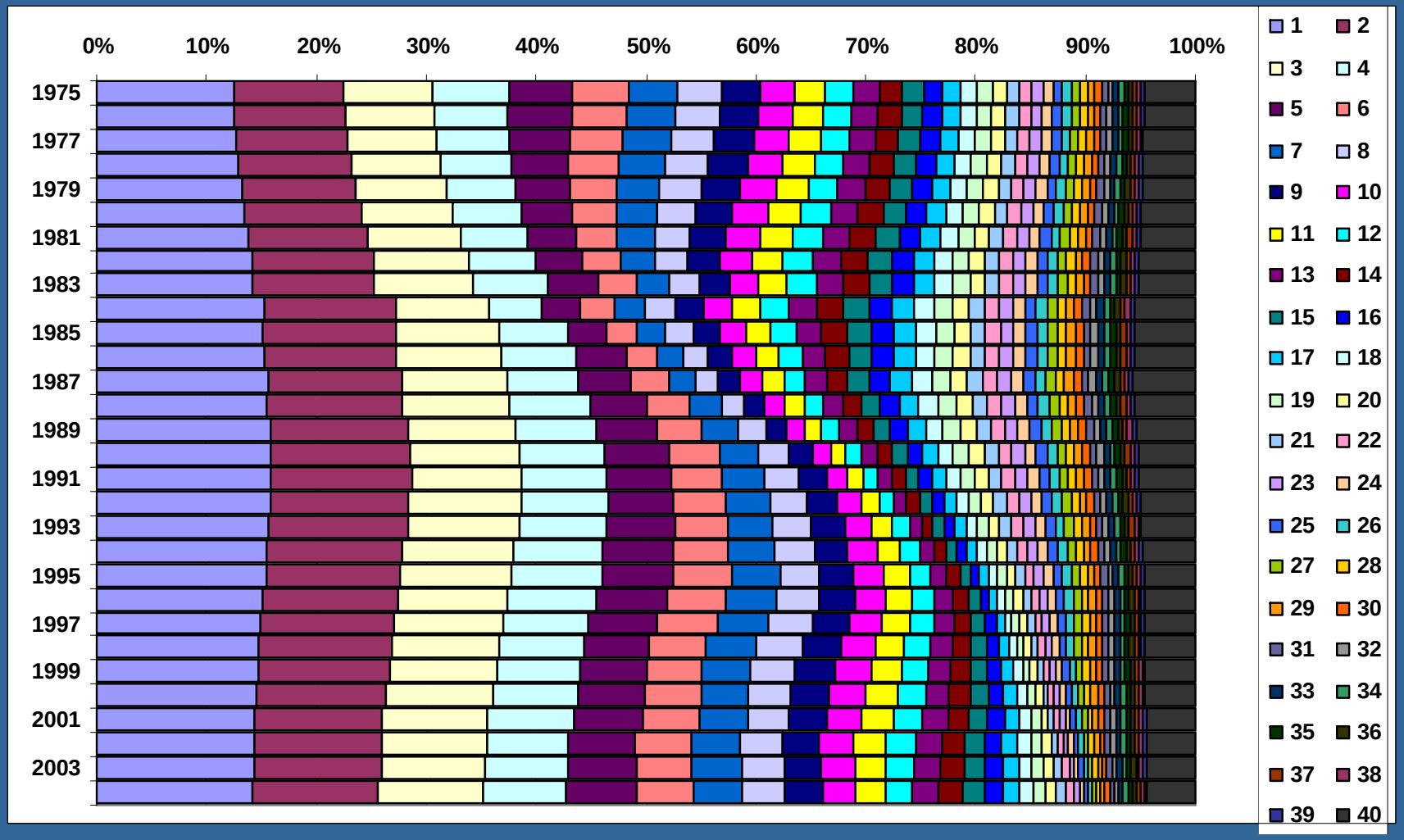
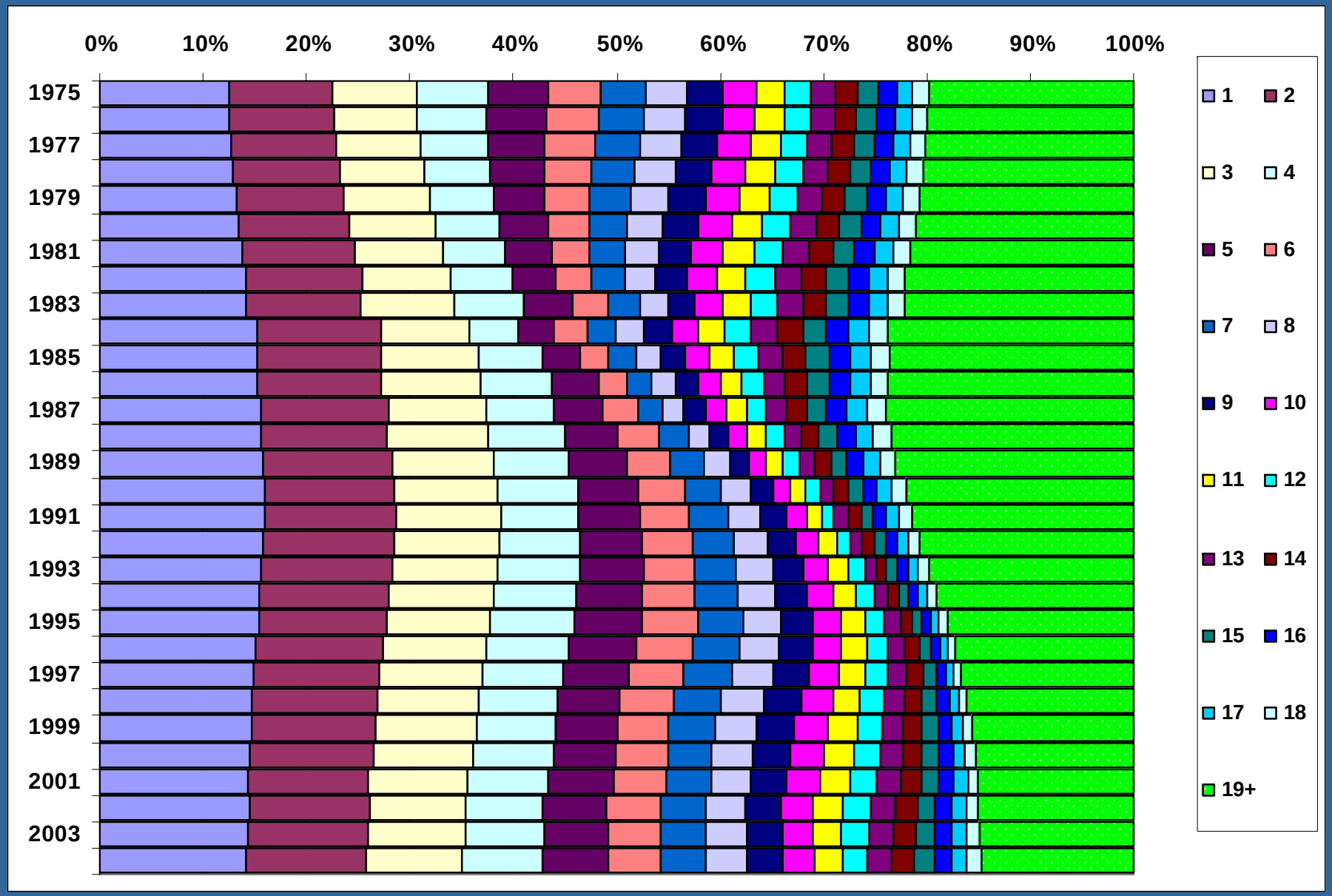
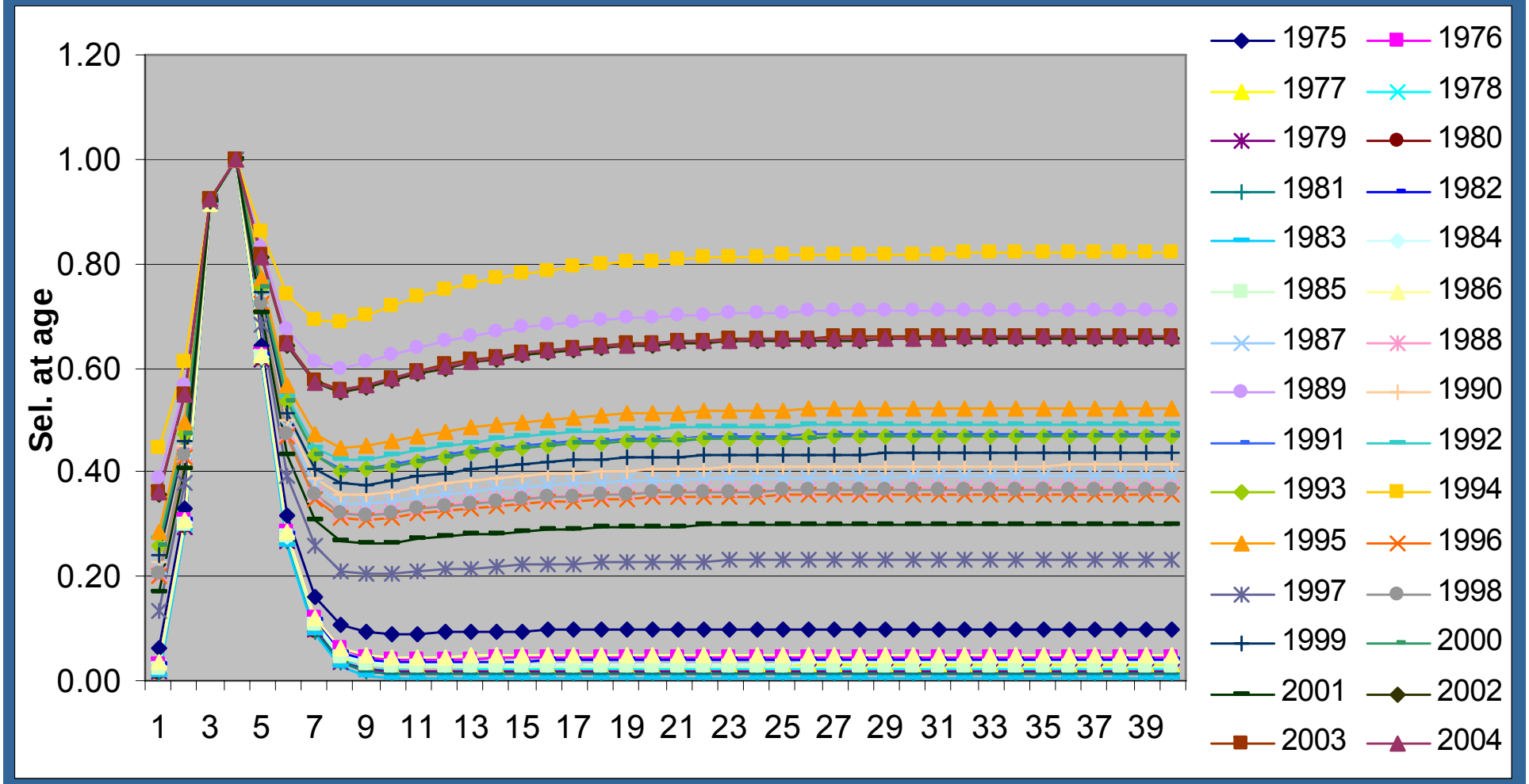
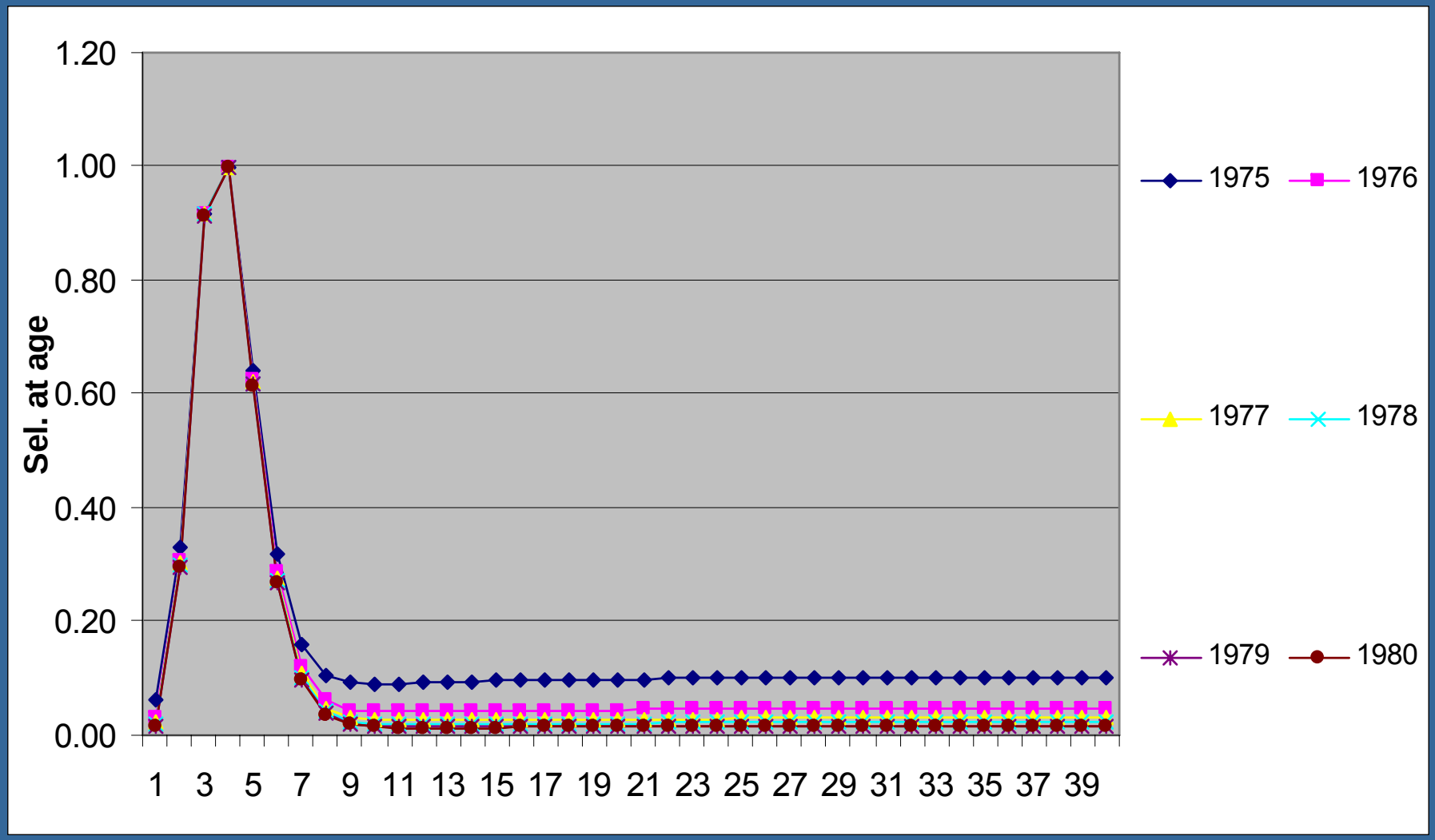
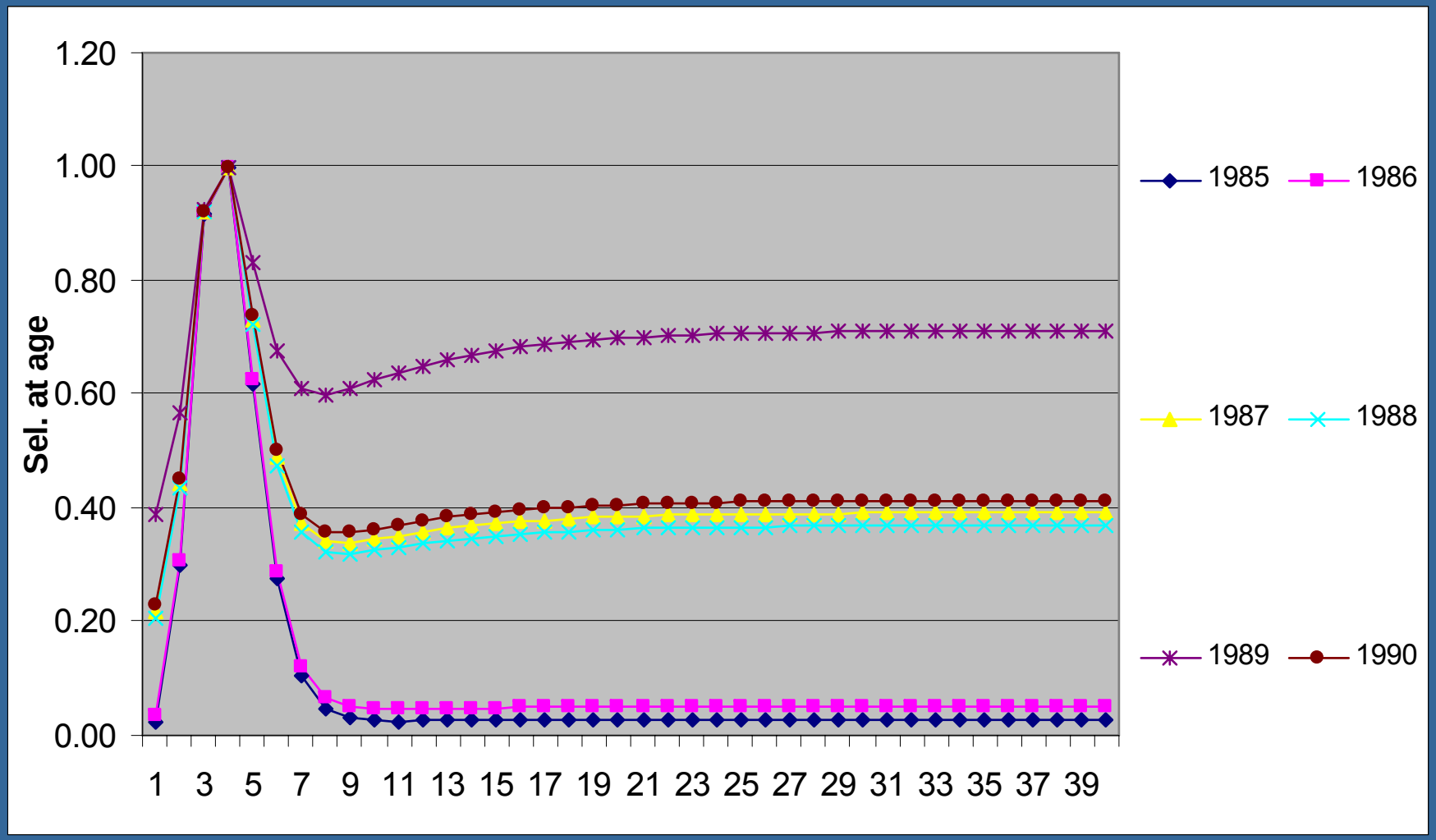
Age Structure for SB-BASE

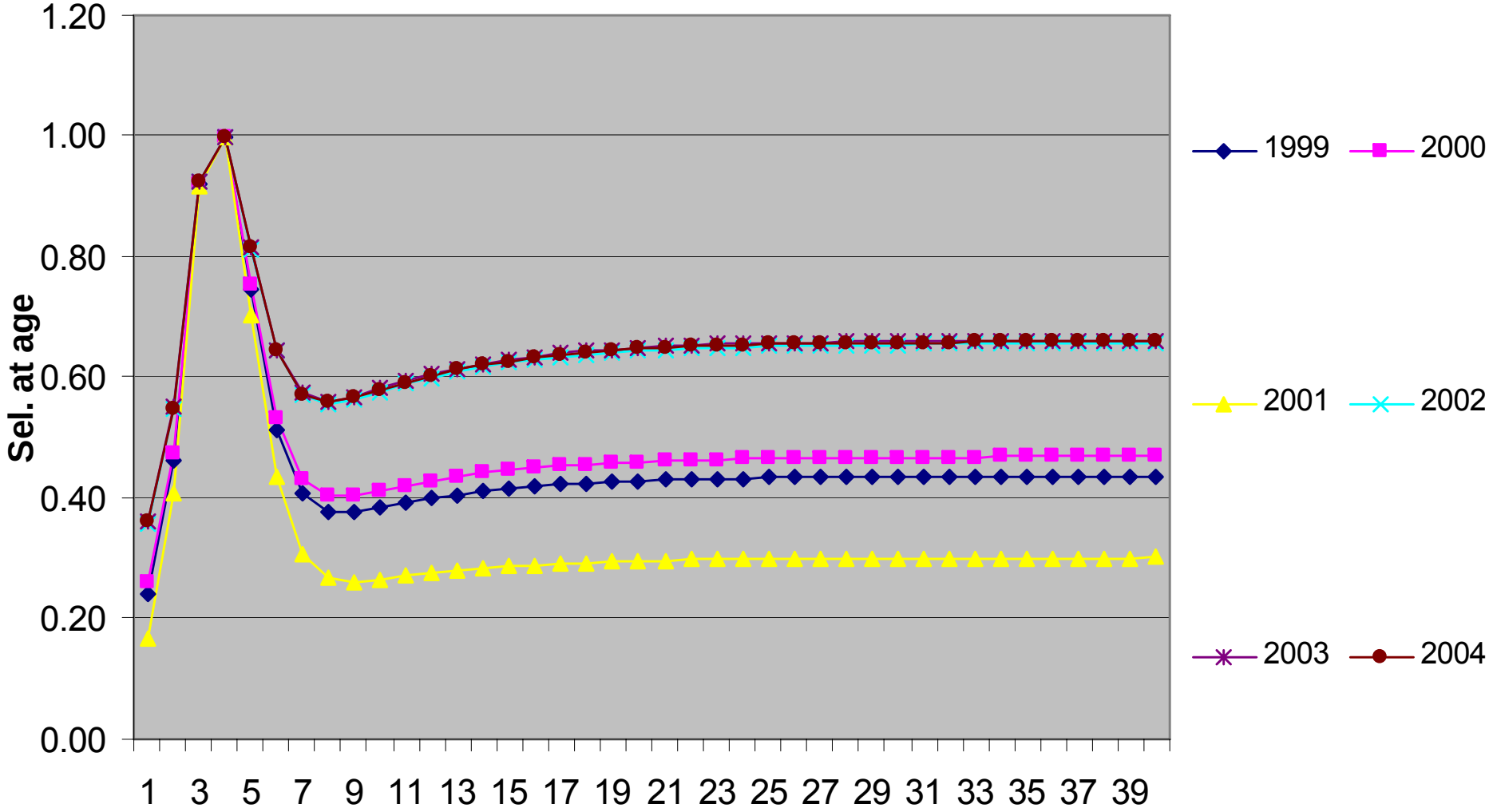



0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19+

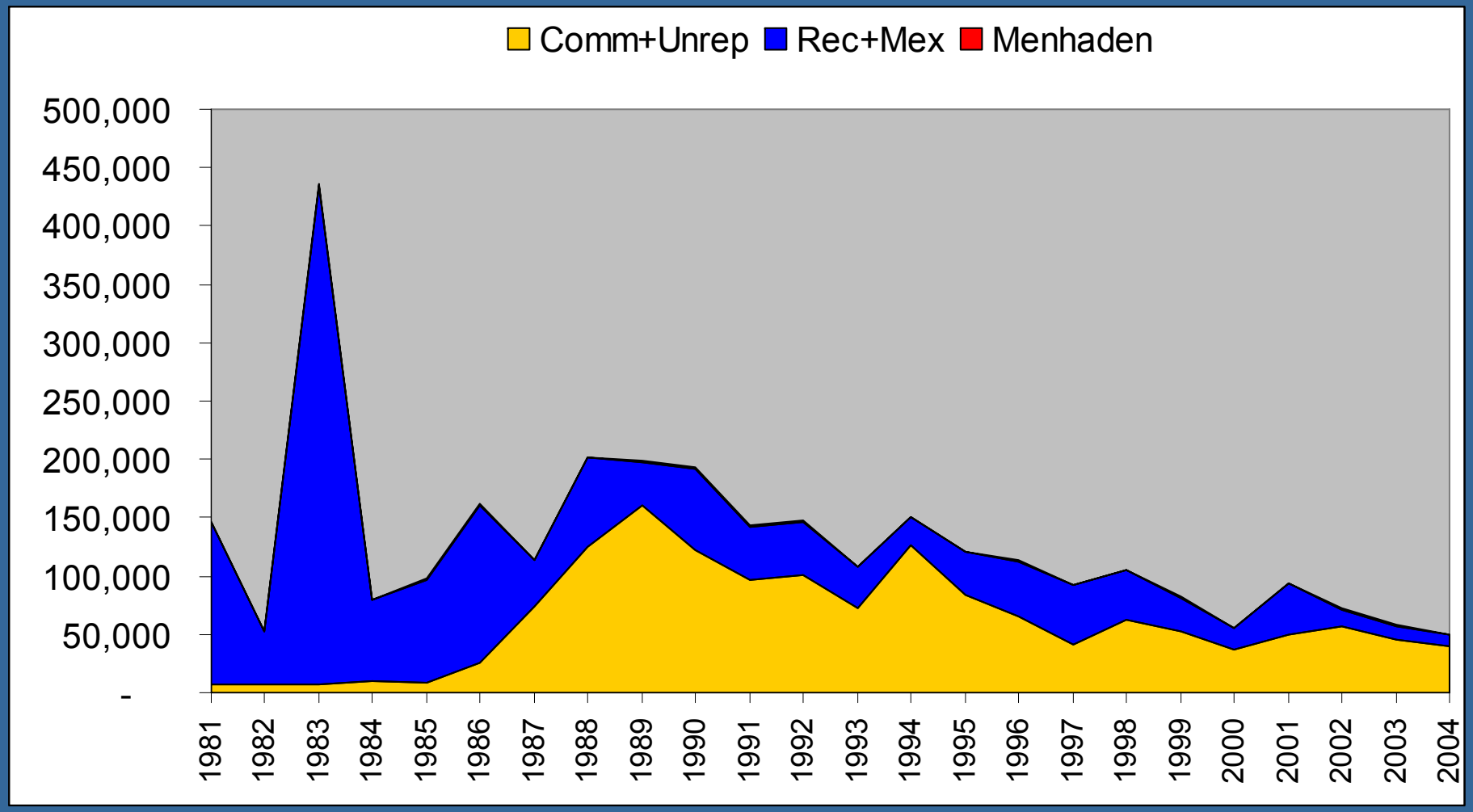

Sel. at age
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004


1.20
1.00
0.80
0.60
0.40
0.20
0.00
Sel. at age
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
1975
1976
1977
1978
1979
1980


1.20
1.00
0.80
0.60
0.40
0.20
0.00
Sel. at age
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
1985
1986
1987
1988
1989
1990

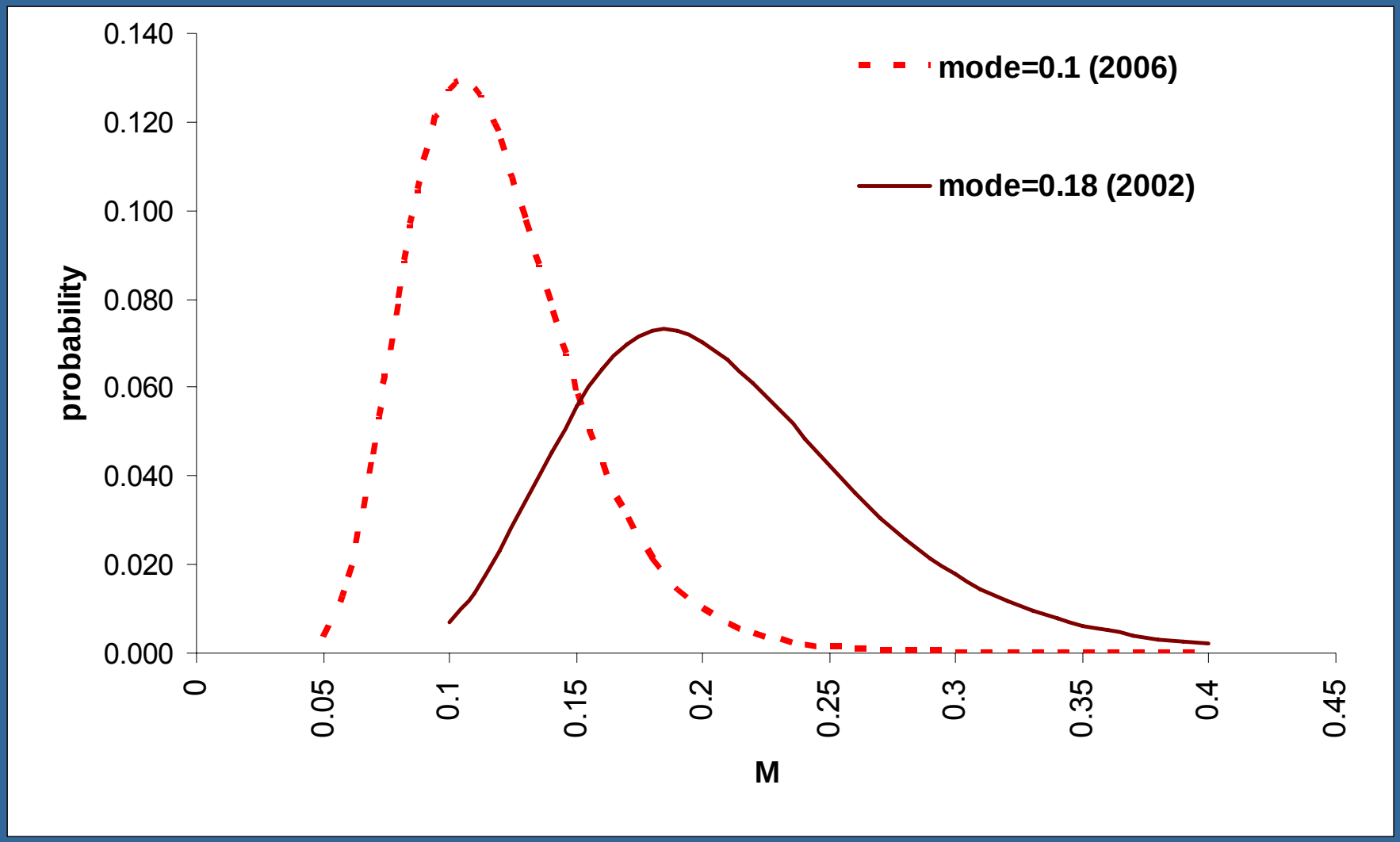

1.20
1.00
0.80
0.60
0.40
0.20
0.00
Sel. at age
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
1999
2000
2001
2002
2003
2004

Catches


Comm+Unrep
Rec+Mex
Menhaden
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
-
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004

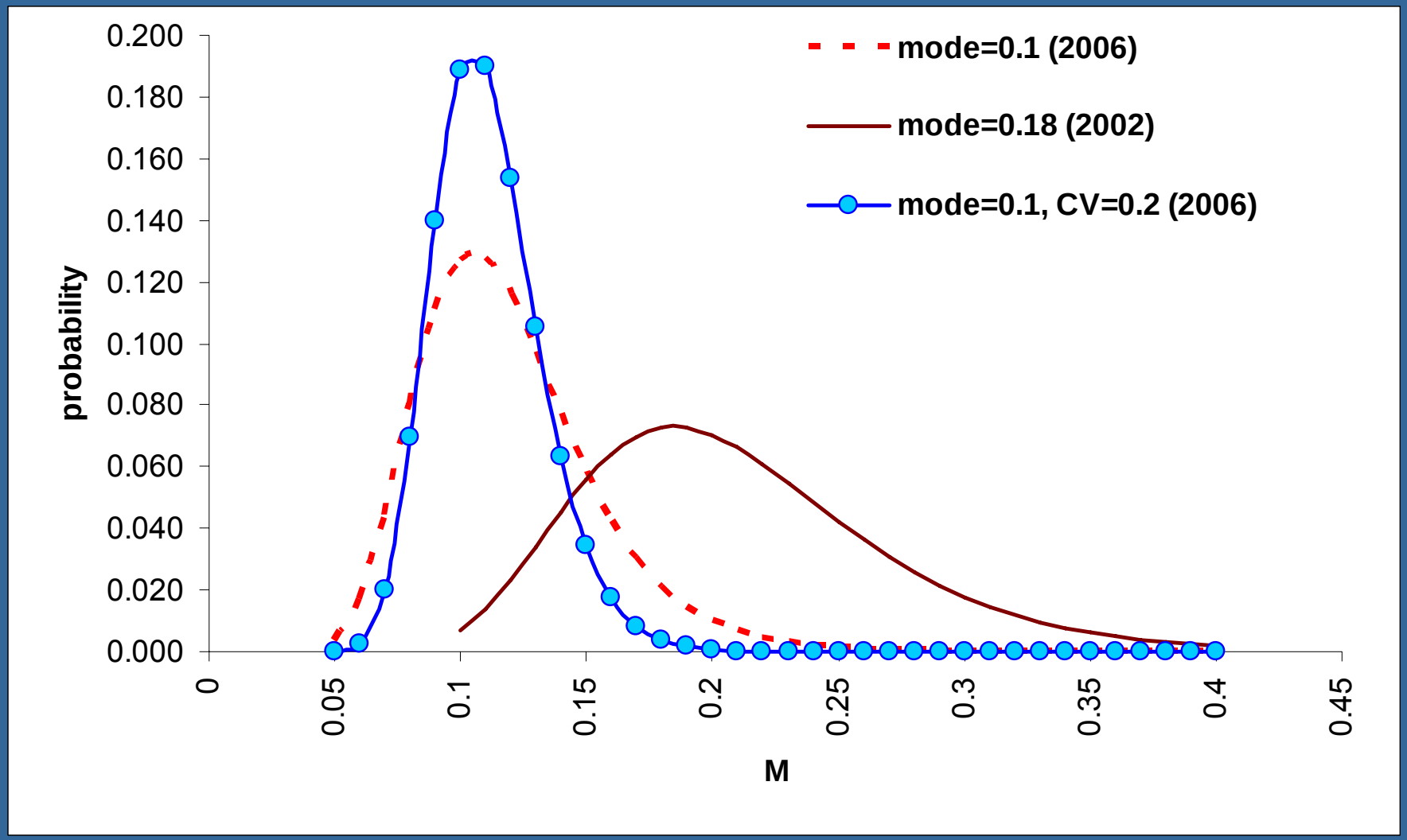
Sandbar – RW – constant M

- Use 2006 model, 2006 catches and indices, 2006 DW values*, estimate an age constant M
- 2002 prior for M ~ LN(mode=0.18, CV=0.25)
- Base steepness:
  - 0.06 (no adjustment to DW values)
  - 0.08 (adjust pup survival)
  - 0.18 (M=0.14)
  - 0.39 (M=0.10) ➔ 2006 prior: (0.1, CV=0.3)


mode=0.1 (2006)
mode=0.18 (2002)
probability
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
M

SB – RW - M constant

- First run ➔ M = 0.152 (CV=0.17)
  - ➔ steepness=0.13 (alpha=0.61)
- Next run: M in [0.05, 0.2, CV=0.2)
  - M=0.133 (CV=0.17)
  - ➔ steepness=0.18 (alpha=0.90)
- Another run?


mode=0.1 (2006)
mode=0.18 (2002)
mode=0.1, CV=0.2 (2006)
probability
0.200
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
M

SB – RW – incr Comm. Catch 10%

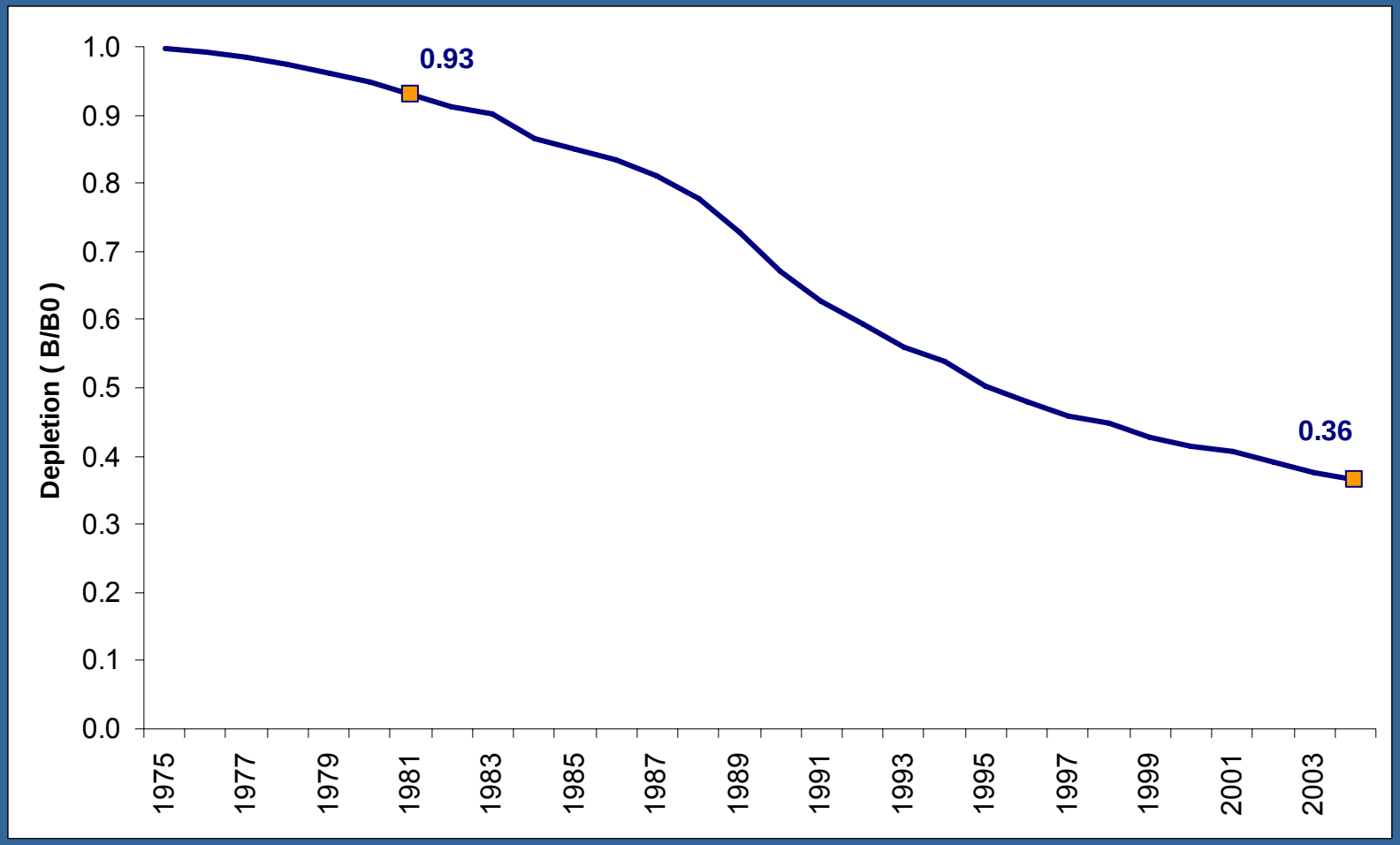
- Use 2006 everything
- Increase the commercial catch in year 2004 only by 10%

SB – RW – incr Comm. Catch 10%

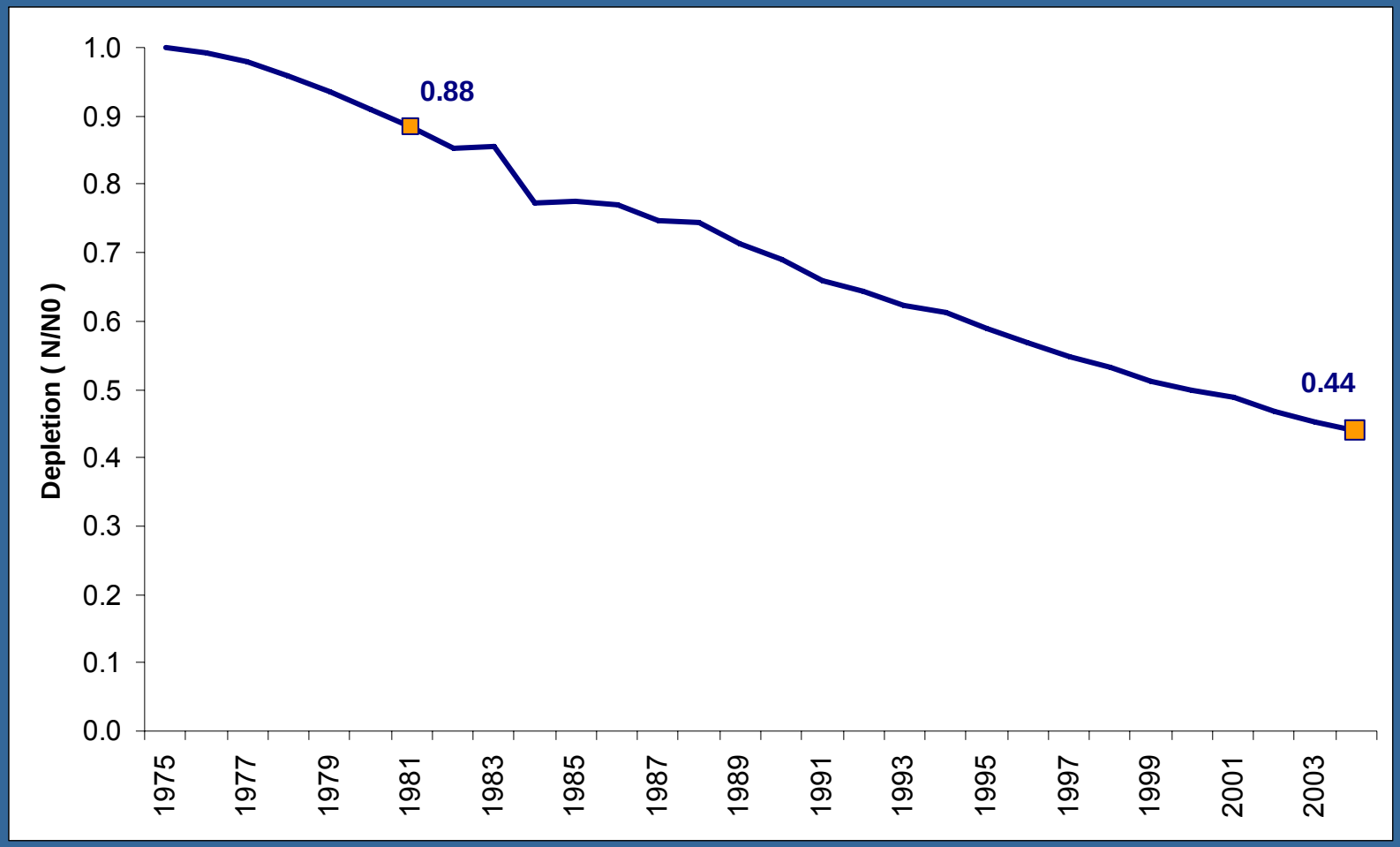
- SSB/SSB_{MSY}
  - BASE: 0.72 sens: 0.76
- F/F_{MSY}
  - BASE: 3.72 sens: 3.89

→ No need to do a run with 5% increase in catch

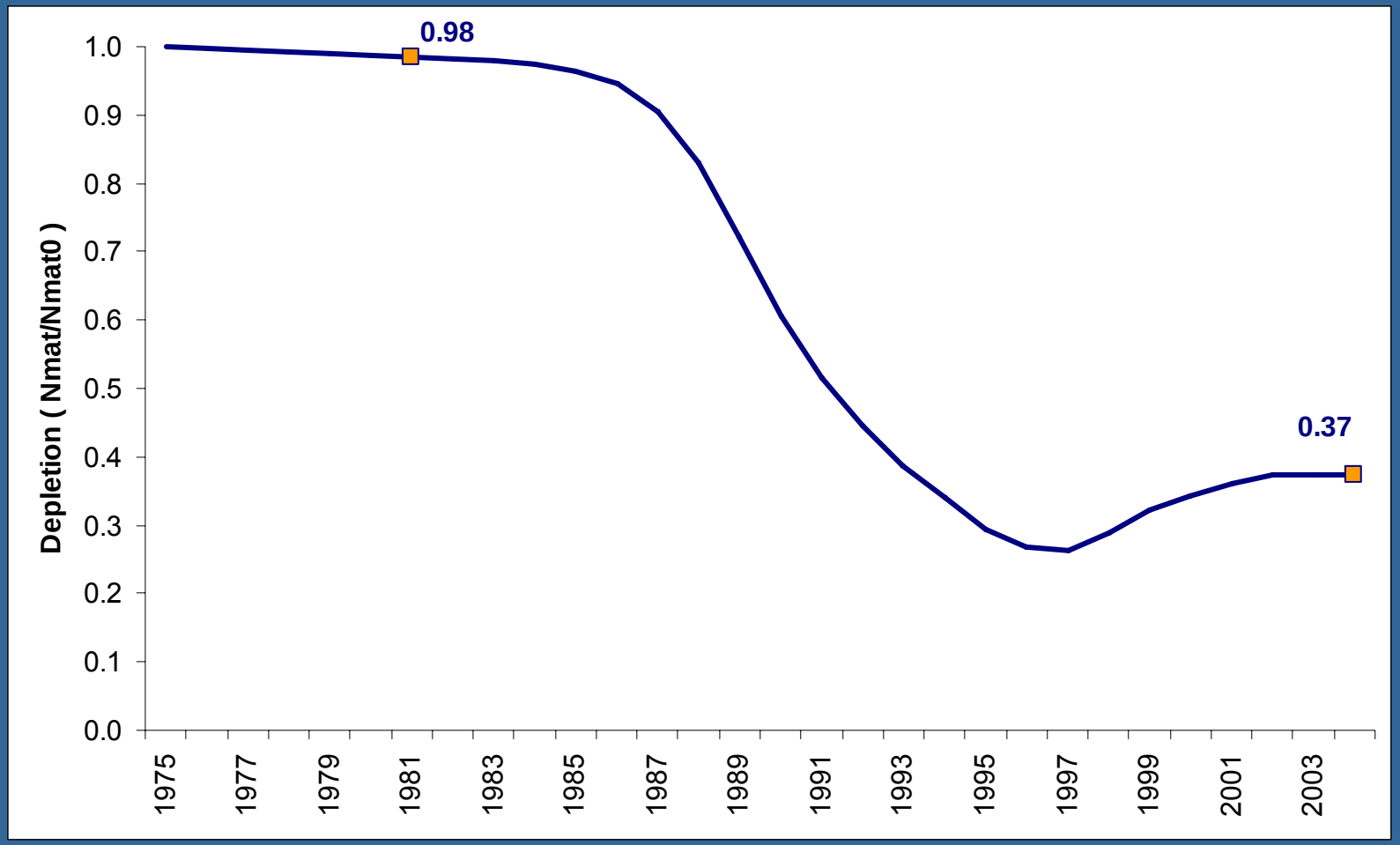
SB – RW – Depletion trends



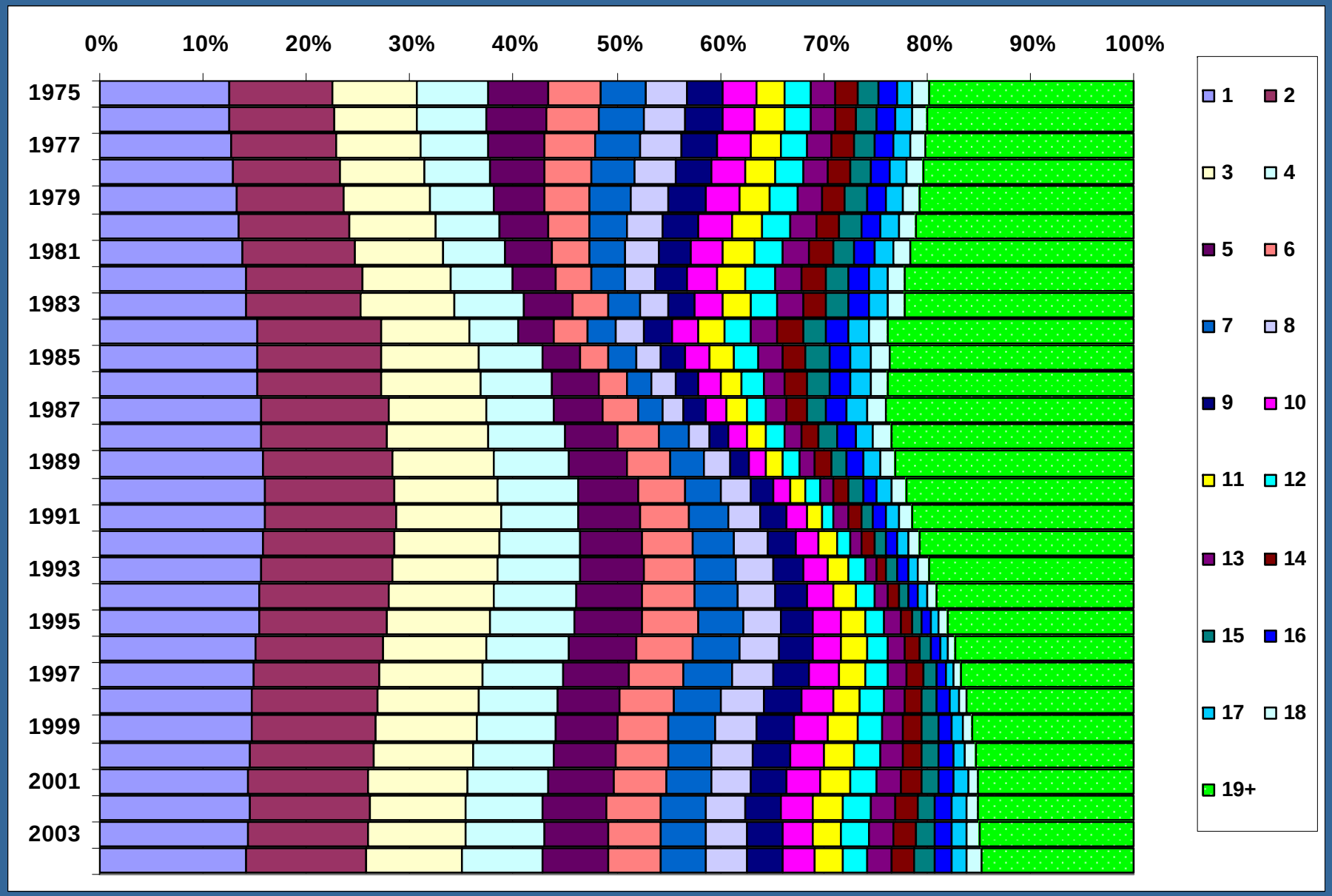
SB – RW – Depletion trends



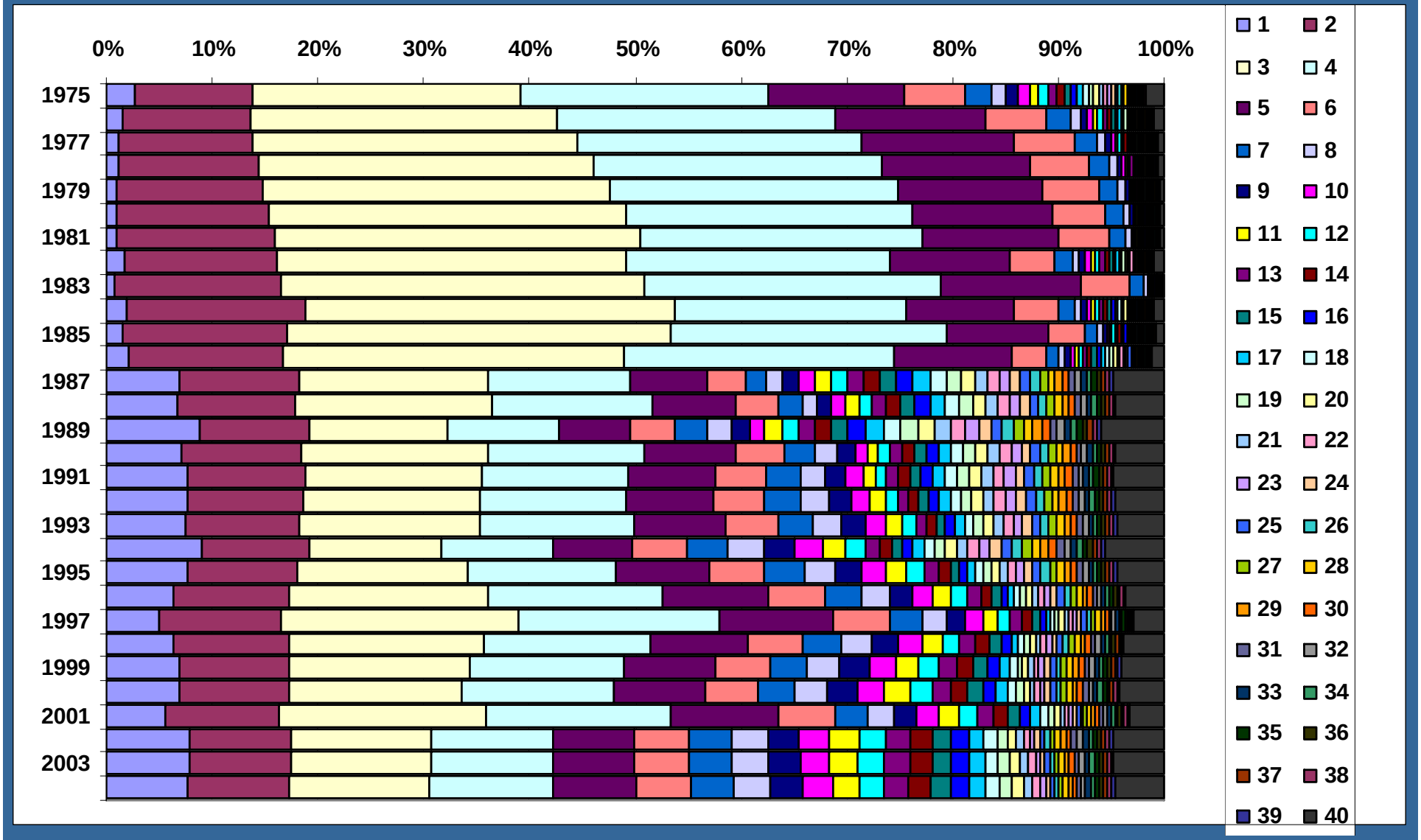
SB – RW – Depletion trends

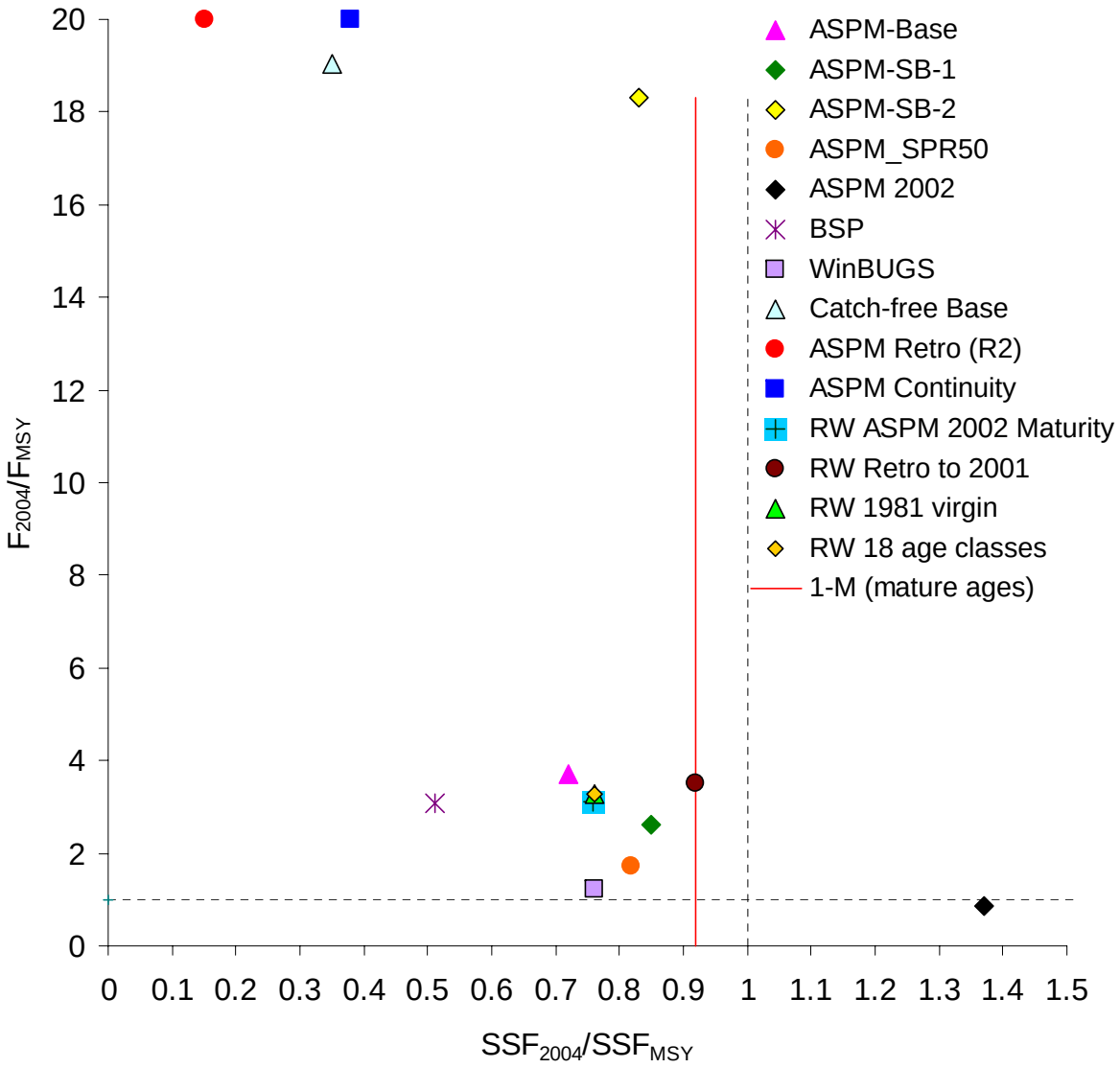


Age Structure



Model Est. CAA





Sandbar Shark Phase Plot with additional Reviewer Requested Sensitivities