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4/29/08

B. Georges Bank haddock

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Garm-III BRP Meeting

28 April – 2 May 2008

Woods Hole, MA

Outline

1. Orientation
2. Data
3. Models
4. Current Reference points (NEFSC 2002)
5. Proposed Reference points (GARM3-BRP, data through 2006)
6. Conclusions

1. Orientation

Georges Bank stock

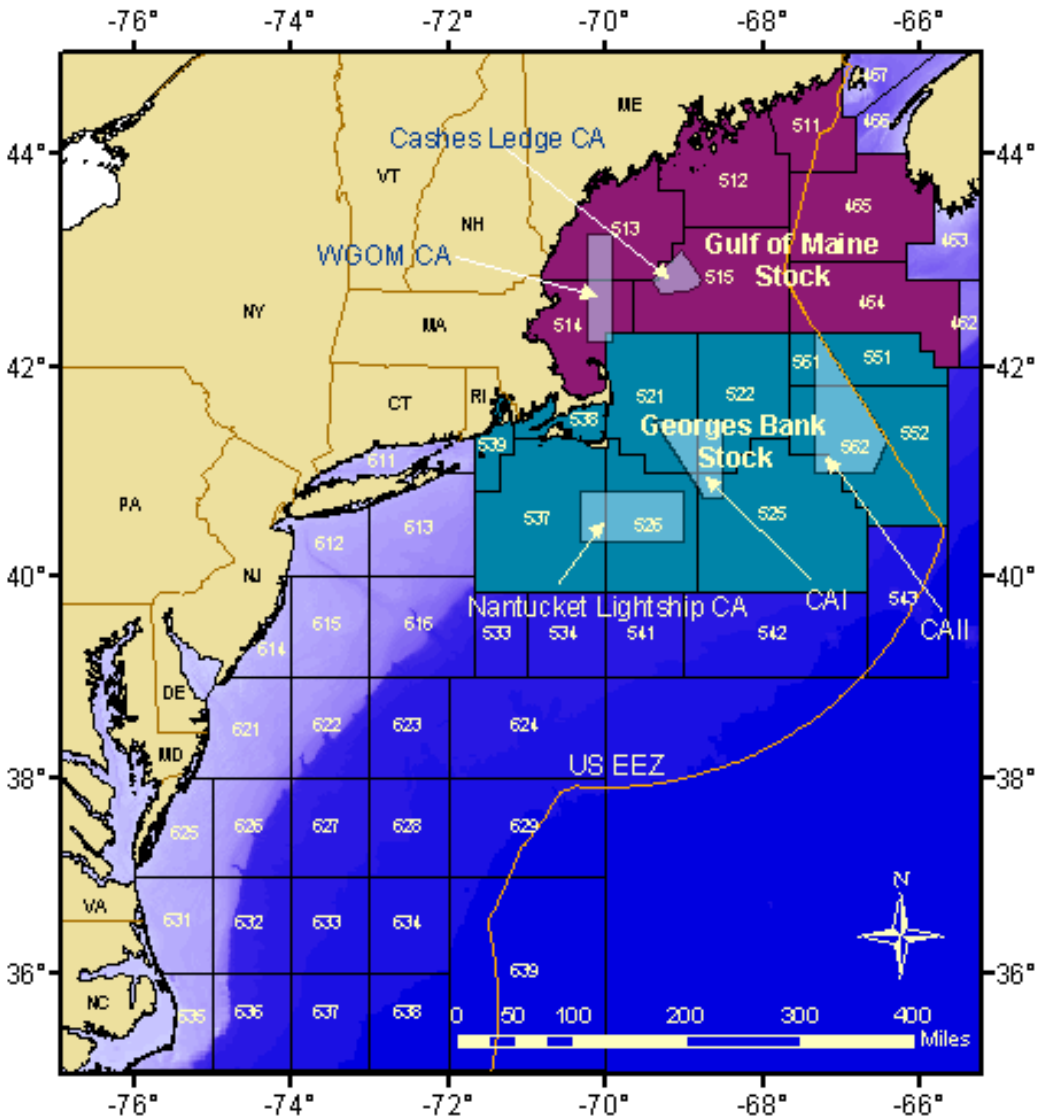

Figure 2.1. Statistical areas used to define the Gulf of Maine and Georges Bank haddock stocks.

Georges Bank stock

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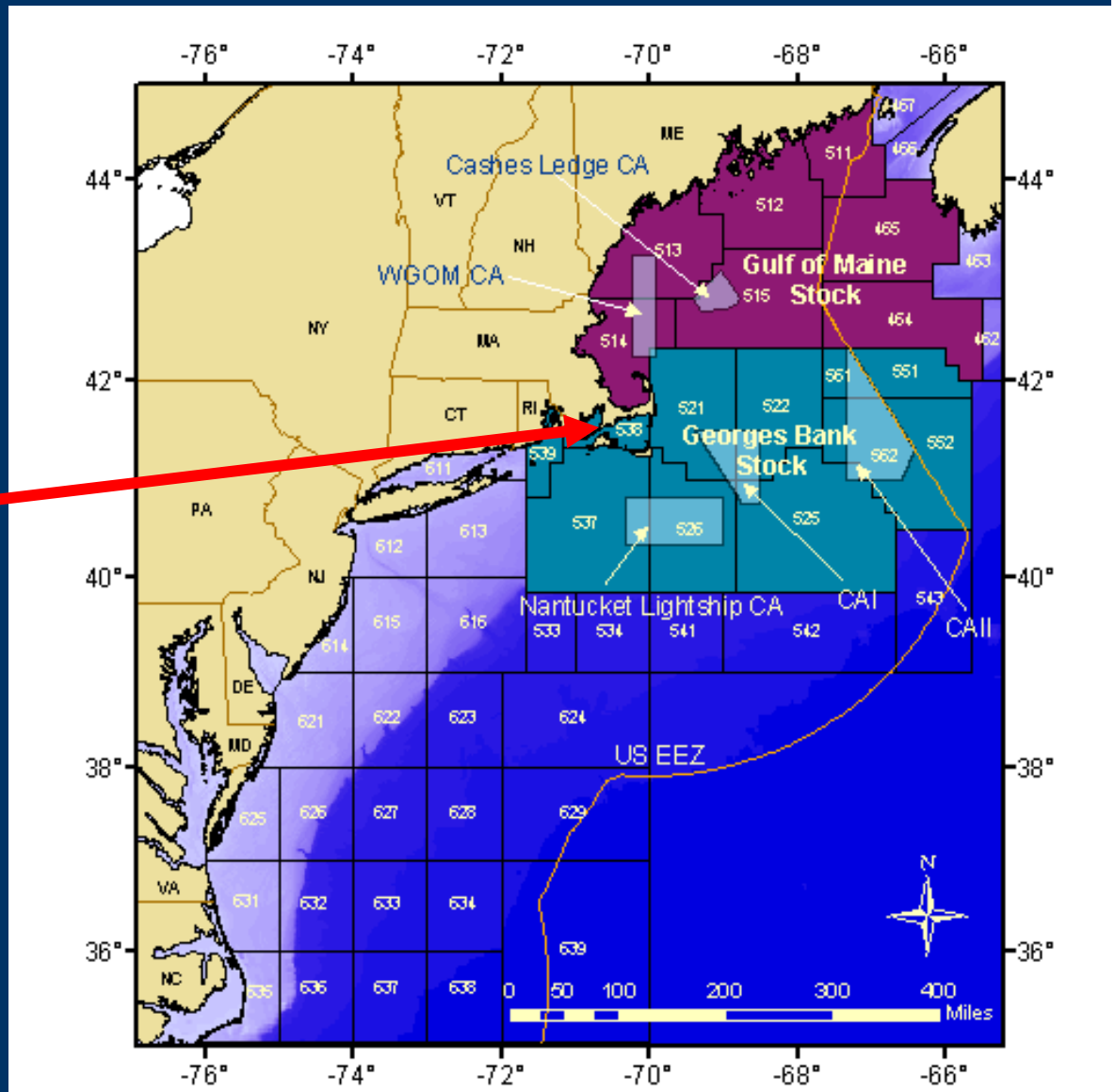
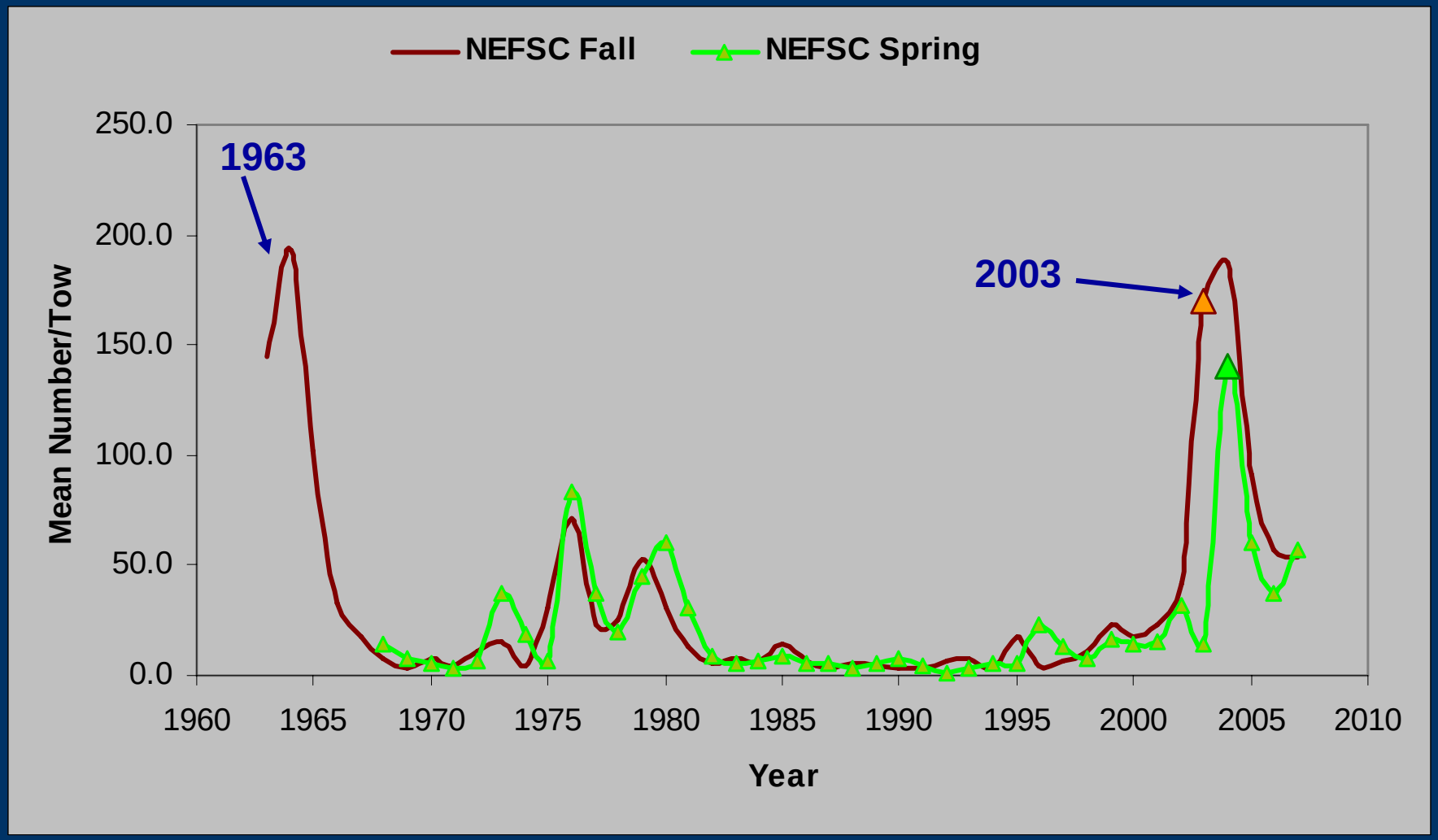


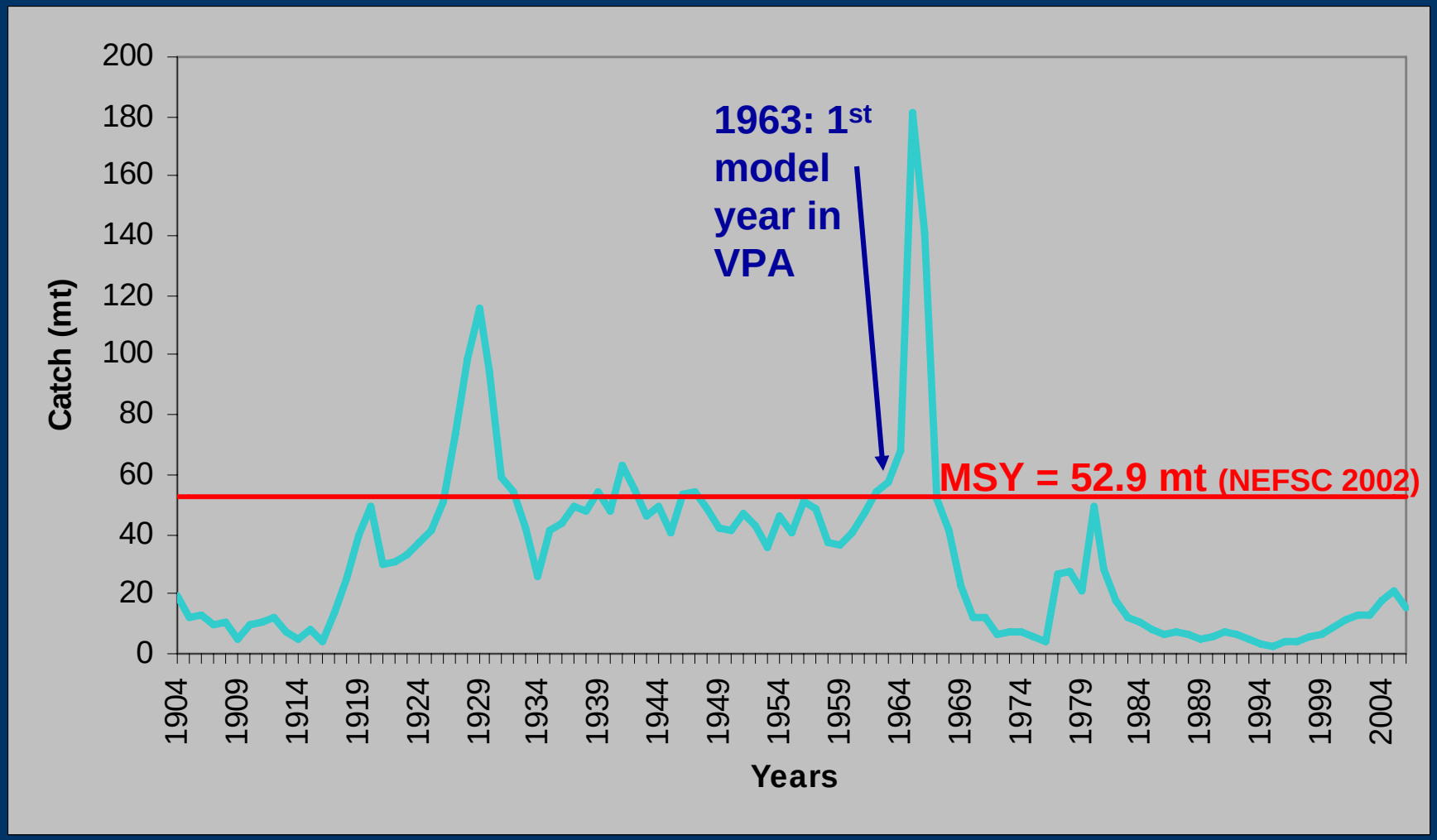
Figure 2.1. Statistical areas used to define the Gulf of Maine and Georges Bank haddock stocks.

2. Data

Survey Trends



Historical Landings



Landings and Discards

- Landings allocation procedure accepted at GARM3 data meeting (Oct-Nov 2007)
- Discard estimation accepted at GARM3 model meeting (Feb 2008)
  - Previous: discard to kept haddock
  - GARM3: discard to kept (all species)
- US Landings and discards re-estimated for years 1989-2006
- Discards not hindcasted

Year	GARM2 US Catches	GARM3 US Catches	GARM3/GARM2
1989	1430	1778	1.24
1990	2001	2110	1.05
1991	1395	1448	1.04
1992	2005	2084	1.04
1993	687	848	1.23
1994	**218**	**3054**	**14.01**
1995	218	365	1.67
1996	313	581	1.85
1997	888	1227	1.38
1998	1841	2347	1.27
1999	2775	2667	0.96
2000	3366	3324	0.99
2001	4754	5163	1.09
2002	6477	6887	1.06
2003	5703	6019	1.06
2004	7746	9654	1.25
2005		7725	
2006		4839	

Year	GARM2 US landings	GARM3 US landings	GARM 2 US discards*	GARM3 US discards
1989	1430	1430	0	348
1990	2001	2005	0	105
1991	1395	1395	0	53
1992	2005	2005	0	79
1993	687	687	0	161
1994	218	206	**0**	**2848**
1995	218	231	0	134
1996	313	320	0	261
1997	888	880	0	347
1998	1841	1914	0	433
1999	2775	2572	0	95
2000	3366	3203	0	121
2001	4631	4820	123	343
2002	6330	6532	147	355
2003	5564	5760	139	259
2004	7179	7375	**566**	**2279**
2005		6604		1121
2006		2643		2196

**inferred as:*

Catch-landings

**** update from Table B2 in WP4.B**

Year	Discards (mt)	Landings (mt)	Discards:Landings	CV for Discards
1989	348	1430	0.24	0.7
1990	105	2005	0.05	1.3
1991	53	1395	0.04	2.9
1992	79	2005	0.04	1.2
1993	161	687	0.23	0.9
1994	**2848**	**206**	**13.82**	**1.2**
1995	**134**	**231**	**0.58**	**1**
1996	**261**	**320**	**0.81**	**2.2**
1997	347	880	0.39	1.7
1998	433	1914	0.23	1.8
1999	95	2572	0.04	1.2
2000	121	3203	0.04	0.6
2001	343	4820	0.07	0.6
2002	355	6532	0.05	0.4
2003	259	5760	0.05	0.4
2004	2279	7375	0.31	**1.4**
2005	1121	6604	0.17	0.2
2006	**2196**	**2643**	**0.83**	**0.3**

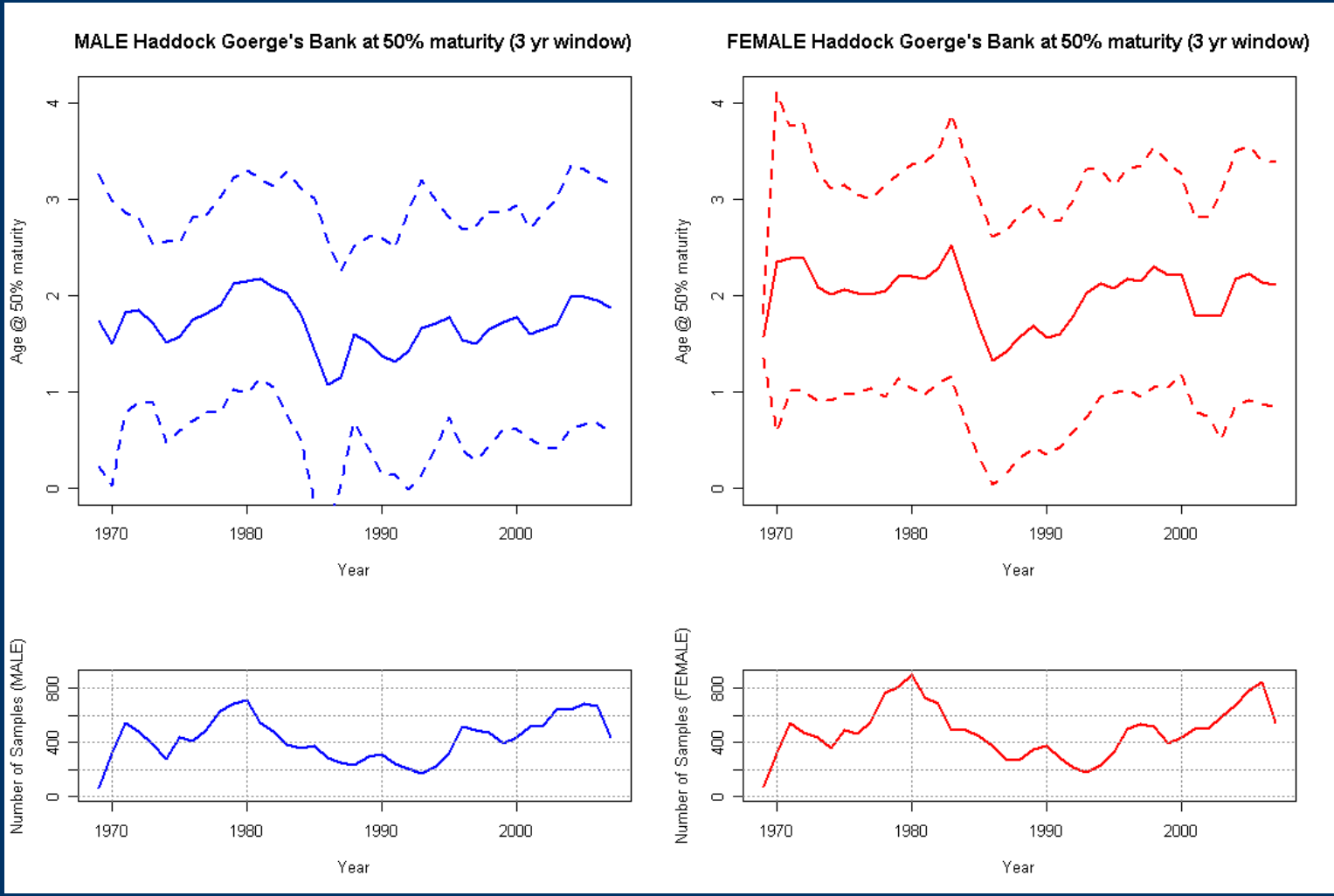
CV on landings at age

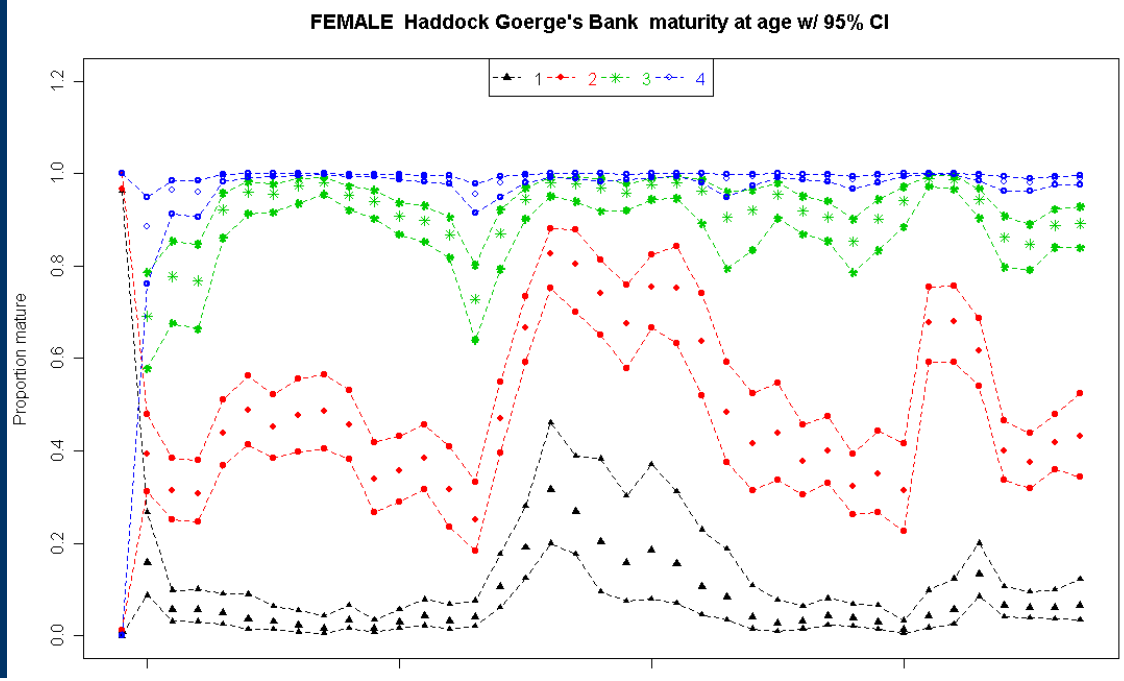
	Age								
Year	1	2	3	4	5	6	7	8	9
1989		0.12	0.40	0.20	0.19	0.19	0.26	0.36	0.58
1990		0.64	0.19	0.18	0.10	0.21	0.24	0.28	0.62
1991		0.39	0.43	0.08	0.31	0.29	0.36	0.46	0.79
1992		0.54	0.19	0.28	0.07	0.15	0.13	0.30	0.43
1993		0.04	0.26	0.22	0.26	0.15	0.23	0.28	0.50
1994		0.50	0.09	0.28	0.41	0.37	0.14	0.47	0.48
1995		0.46	0.11	0.13	0.51	0.48	0.37	0.26	-----
1996		0.32	0.17	0.35	0.43	0.86	0.69	0.65	0.86
1997		0.56	0.09	0.18	0.15	0.35	0.72	0.71	0.72
1998		0.40	0.19	0.11	0.14	0.23	0.32	0.51	0.75
1999		1.32	0.25	0.15	0.12	0.13	0.23	0.32	0.39
2000		0.26	0.13	0.13	0.10	0.11	0.15	0.22	0.38
2001		0.35	0.10	0.11	0.10	0.08	0.10	0.14	0.18
2002		1.31	0.29	0.09	0.10	0.12	0.13	0.15	0.19
2003		1.34	0.25	0.17	0.05	0.13	0.09	0.13	0.12
2004		-----	0.54	0.11	0.17	0.07	0.15	0.14	0.12
2005		0.76	0.60	0.21	0.07	0.15	0.09	0.16	0.13
2006		-----	0.14	0.38	0.14	0.04	0.12	0.11	0.14

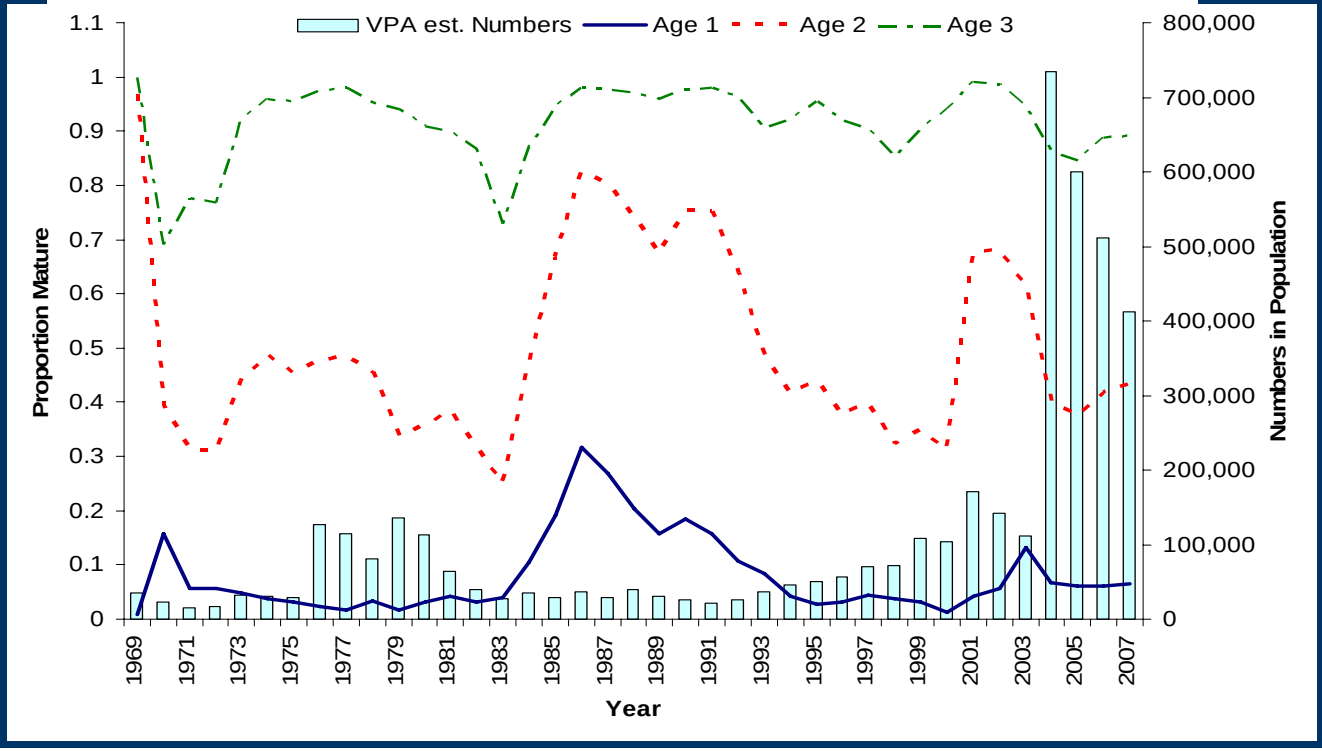
Proportion at age of annual landings

Year	Age 1	2	3	4	5	6	7	8	9+
1989	0.00	0.23	0.03	0.36	0.12	0.20	0.04	0.02	0.02
1990	0.00	0.00	0.36	0.13	0.35	0.08	0.05	0.01	0.01
1991	0.00	0.04	0.05	0.50	0.09	0.20	0.09	0.04	0.01
1992	0.00	0.02	0.10	0.08	0.55	0.10	0.12	0.02	0.01
1993	0.00	0.15	0.10	0.18	0.10	0.32	0.09	0.05	0.02
1994	0.00	0.05	0.52	0.13	0.07	0.07	0.14	0.02	0.01
1995	0.00	0.07	0.48	0.33	0.03	0.02	0.03	0.05	0.00
1996	0.00	0.07	0.47	0.26	0.11	0.03	0.03	0.03	0.01
1997	0.00	0.03	0.36	0.39	0.13	0.03	0.01	0.02	0.02
1998	0.00	0.03	0.20	0.32	0.24	0.13	0.06	0.01	0.01
1999	0.00	0.00	0.13	0.19	0.31	0.19	0.11	0.05	0.02
2000	0.00	0.05	0.11	0.21	0.22	0.22	0.11	0.05	0.02
2001	0.00	0.03	0.27	0.18	0.19	0.15	0.09	0.06	0.04
2002	0.00	0.00	0.03	0.41	0.17	0.14	0.09	0.06	0.09
2003	0.00	0.00	0.06	0.08	0.52	0.09	0.12	0.05	0.09
2004	0.00	0.00	0.01	0.36	0.06	0.40	0.07	0.05	0.05
2005	0.00	0.00	0.00	0.03	0.51	0.08	0.27	0.05	0.06
2006	0.00	0.00	0.07	0.00	0.04	0.61	0.05	0.18	0.04

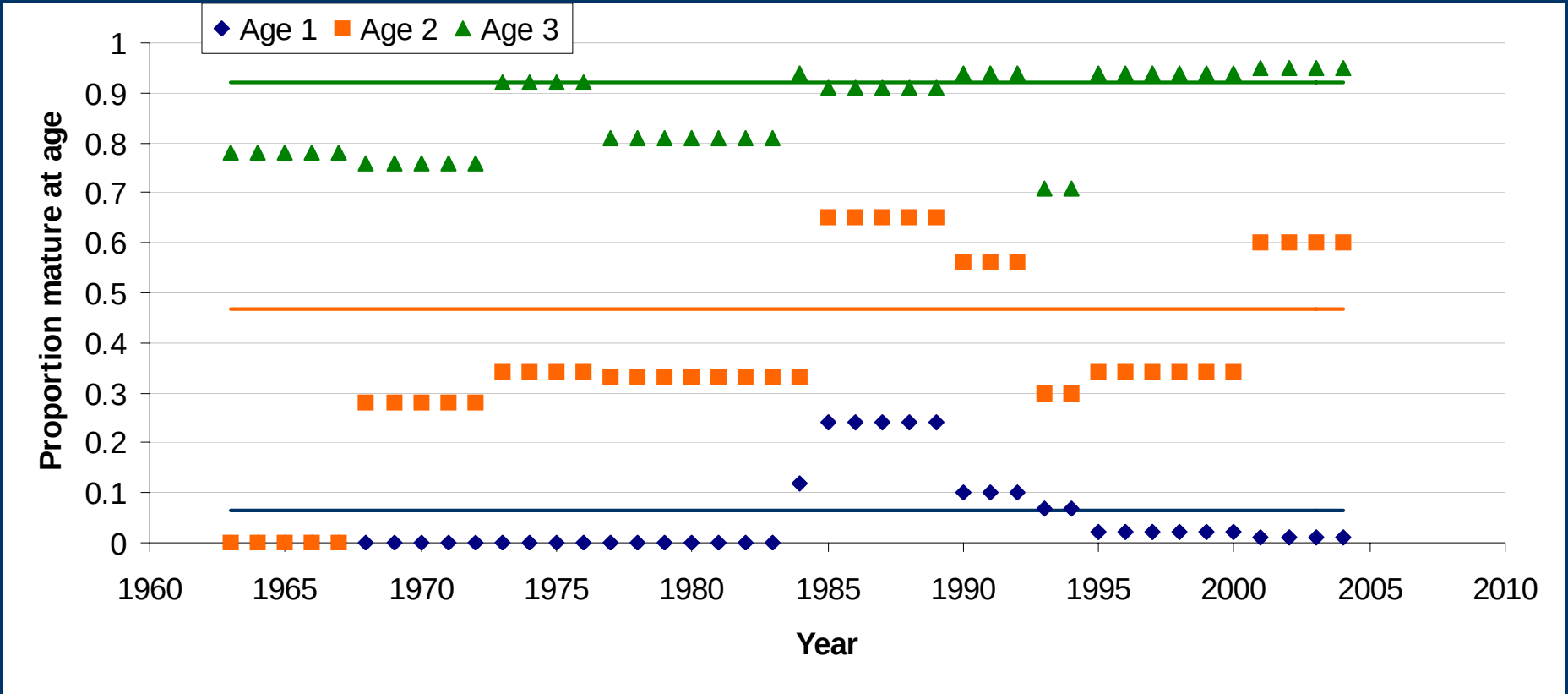
Maturity


MALE Haddock Goerge's Bank at 50% maturity (3 yr window)
FEMALE Haddock Goerge's Bank at 50% maturity (3 yr window)
Age @ 50% maturity
Number of Samples (MALE)
Number of Samples (FEMALE)
Year
0
1
2
3
4
400
800
1970
1980
1990
2000


FEMALE Haddock Goerge's Bank maturity at age w/ 95% CI
1
2
3
4
Proportion mature
0.0
0.2
0.4
0.6
0.8
1.0
1.2


VPA est. Numbers
Age 1
Age 2
Age 3
Proportion Mature
Numbers in Population
Year
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
0
100,000
200,000
300,000
400,000
500,000
600,000
700,000
800,000
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007

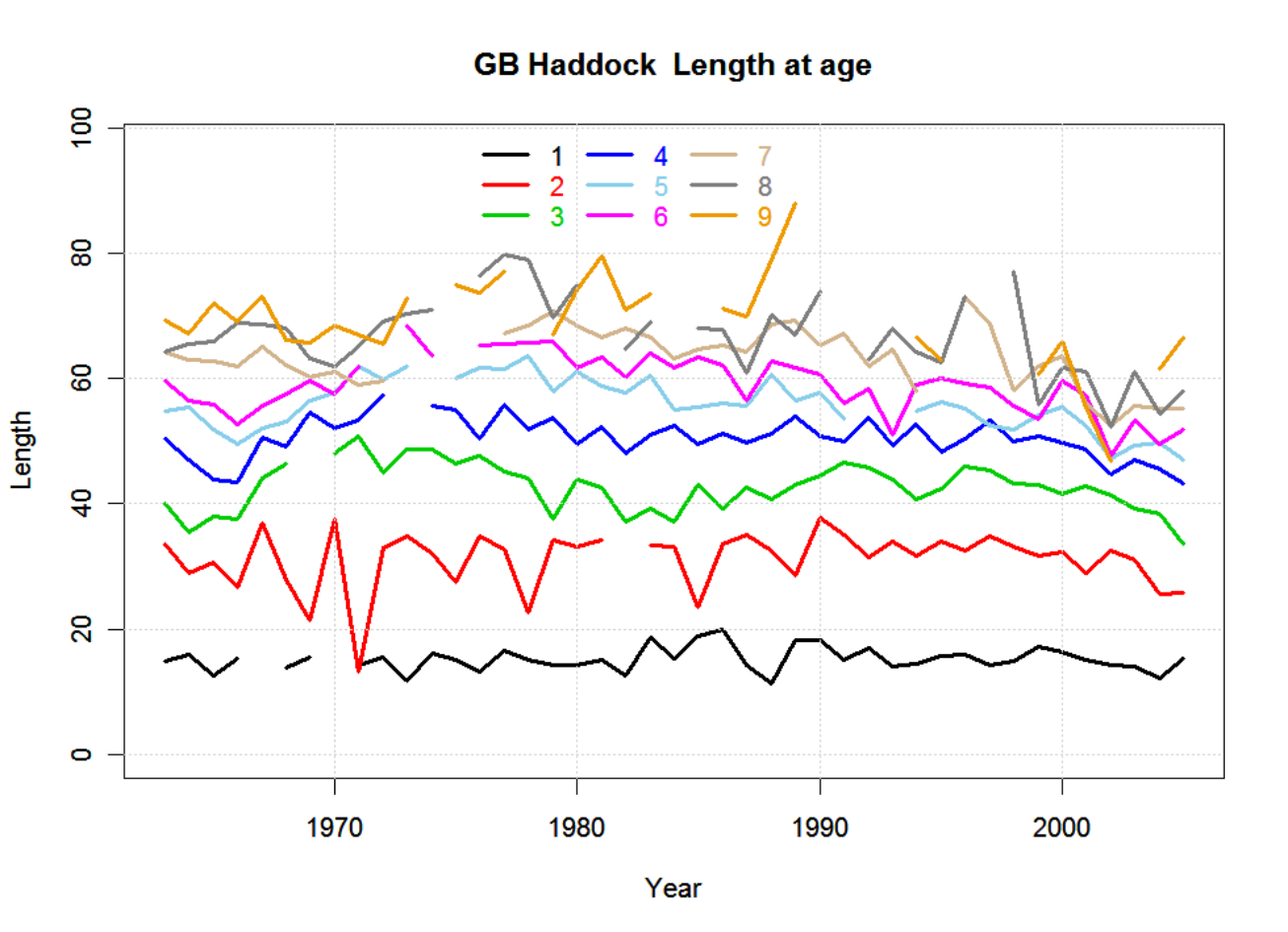
Decision: Use 1 maturity ogive



Natural Mortality

- M=0.2, all ages, all years

Length

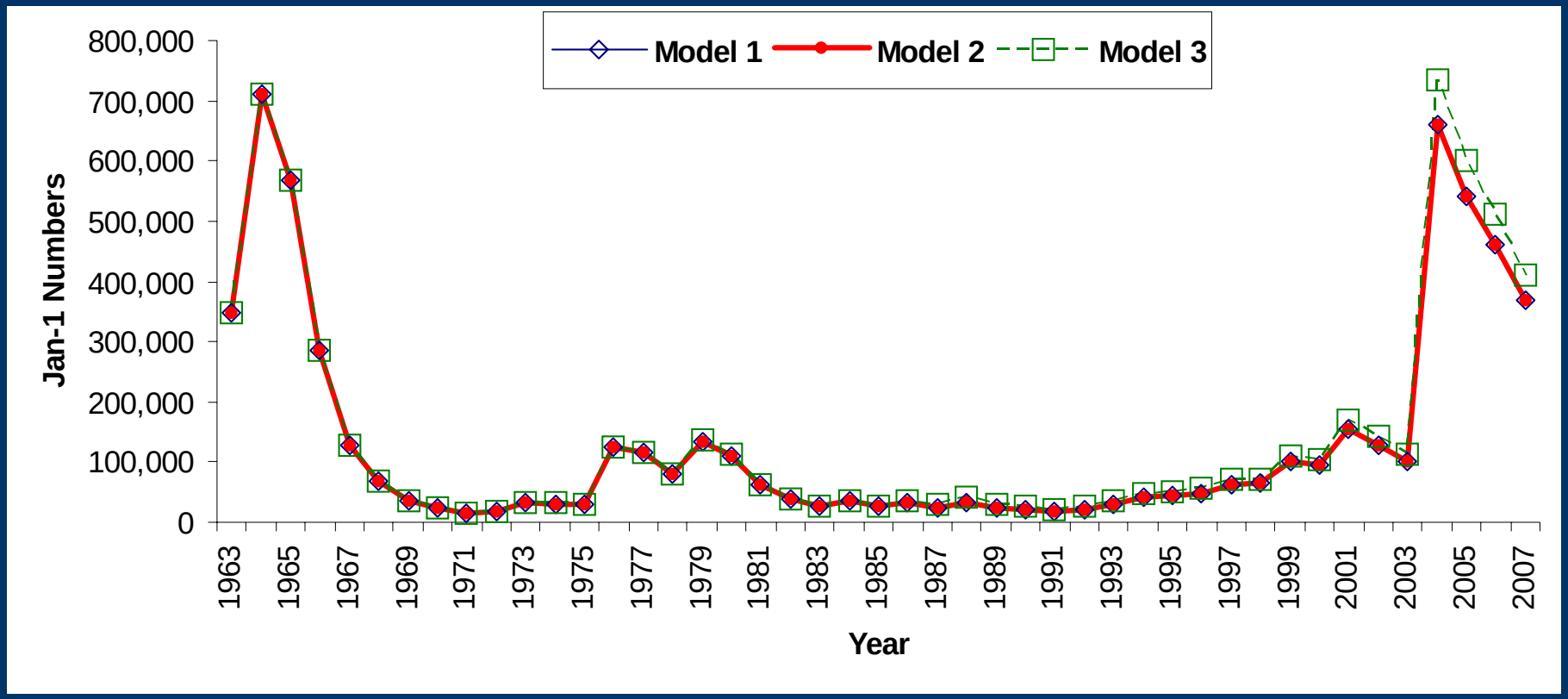

GB Haddock Length at age
1
2
3
4
5
6
7
8
9
Length
0
20
40
60
80
100
1970
1980
1990
2000
Year

3. Models

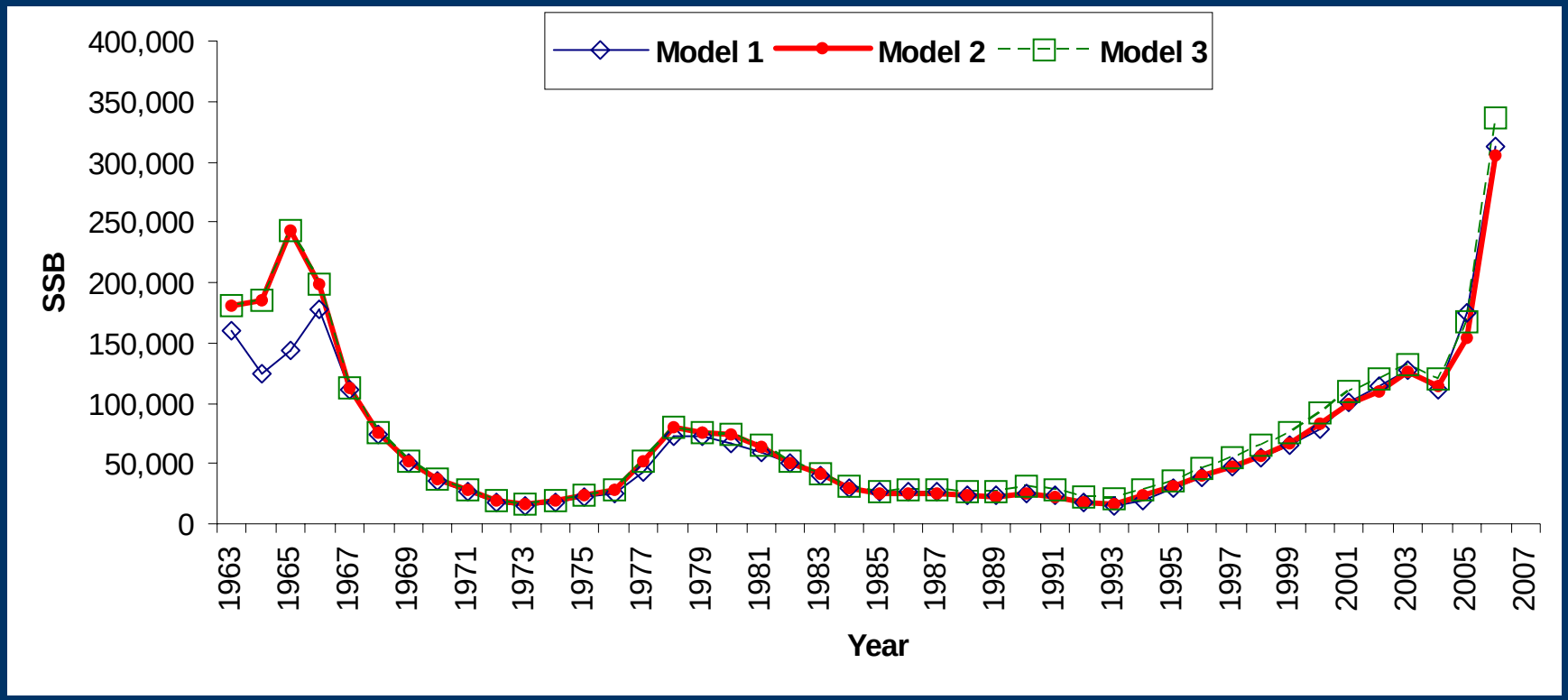
- **Base model: ADAPT VPA v.2.7.7**
- *Bridge building exercise*
  - Model 1: “Continuity” model, same maturity stanzas as GARM2, only added 2 years CAA
  - Model 2: same CAA as Model 1, single maturity ogive
  - Model 3: same CAA 1963-1988, re-estimated CAA 1989-2006, single maturity ogive

- Sensitivity Model: ASAP v.2

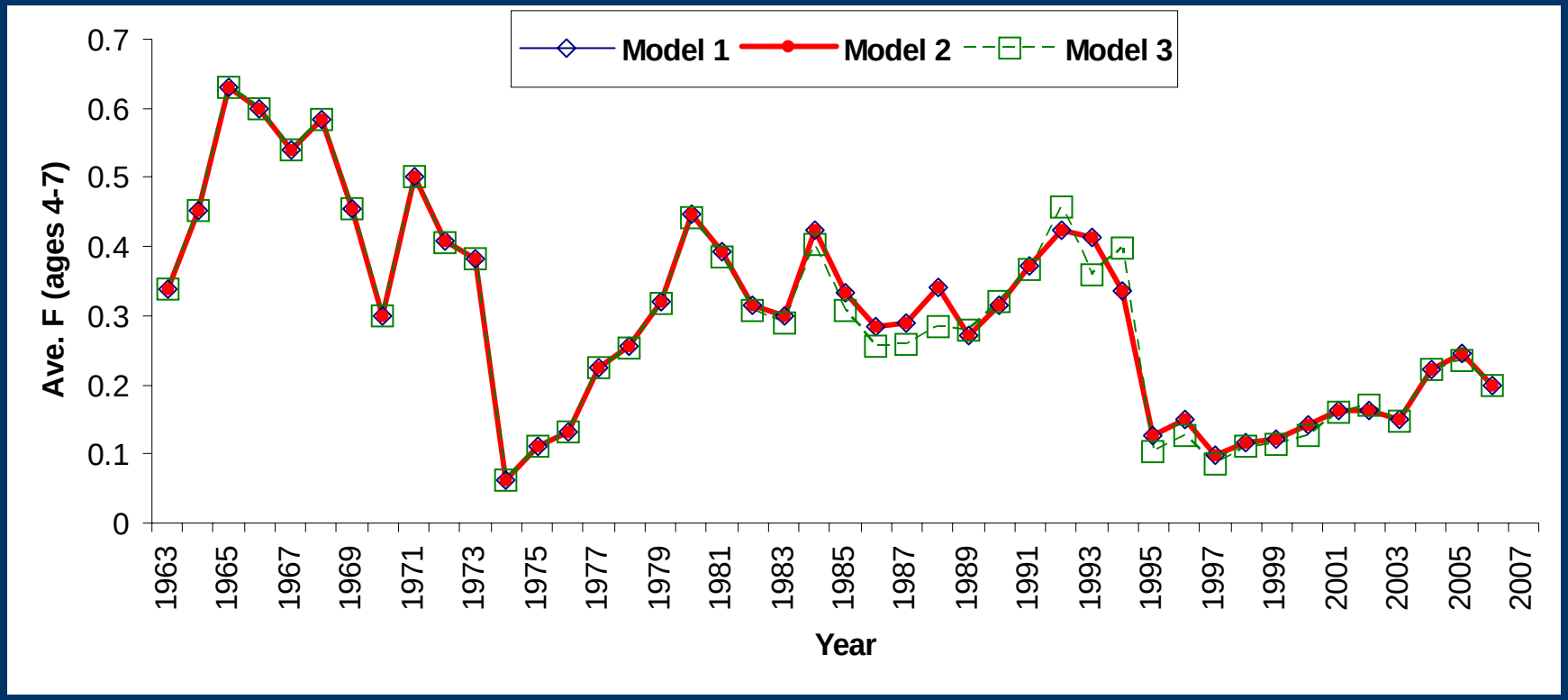
Jan-1 Numbers



SSB


Model 1
Model 2
Model 3
SSB
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
Year

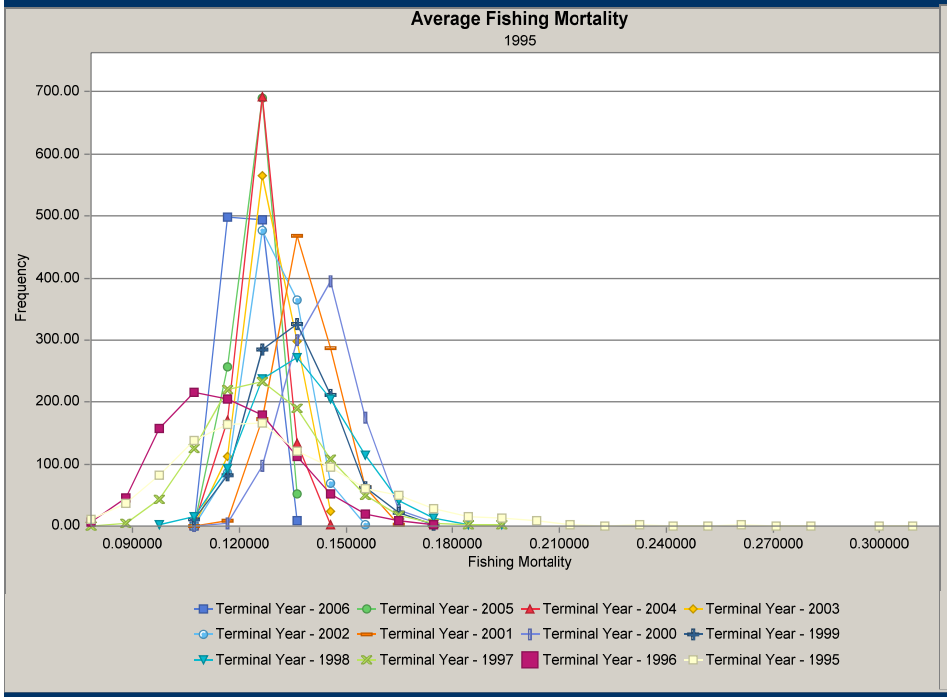
Average Unweighted $F_{ages\ 4\text{-}7}$

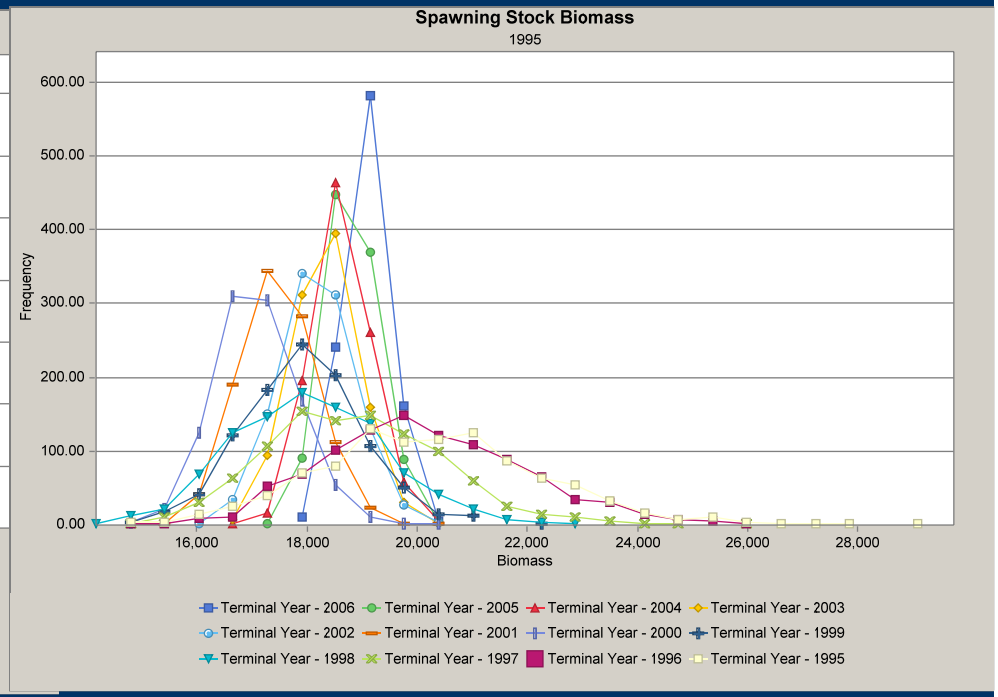


VPA bootstrapped estimates

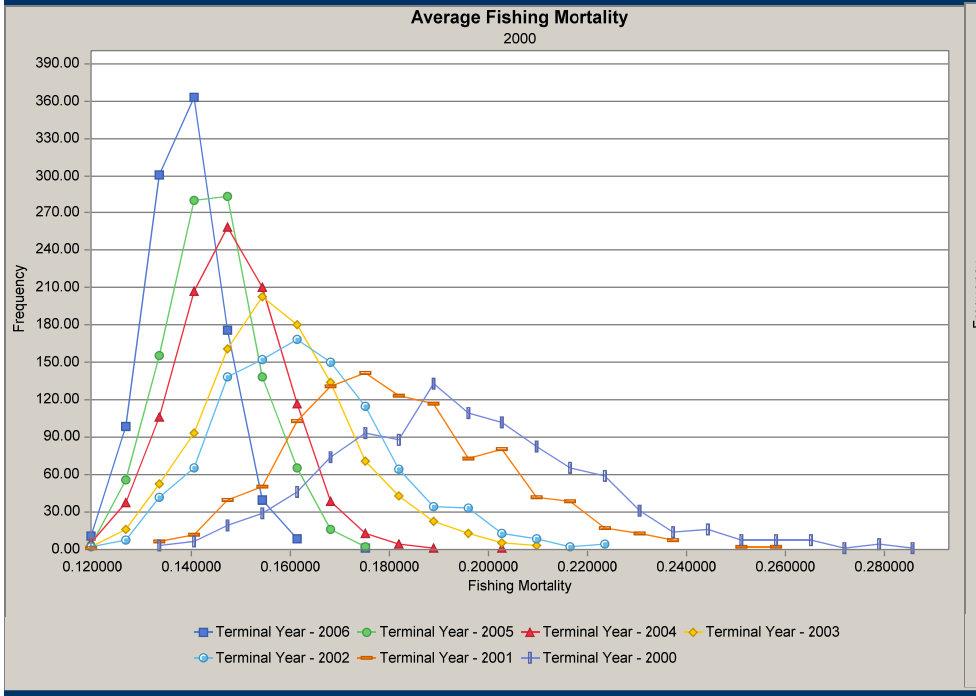
Model	$Catch_{2006}$	F_{2006}	SSB_{2006}	N_{2007}	B_{2007}
VPA-1	15,493	0.1979	313,299	369,960	431,745
10th-90th		*[0.1633--0.2578]*	*[234,951--420,638]*	*[278,456--508,297]*	*[315,581--593595]*
VPA-2	15,493	0.1979	305,066	369,960	431,745
10th-90th		*[0.1633--0.2578]*	*[229,512--409,284]*	*[278,456--508,297]*	*[315,581--593595]*
VPA-3	17,312	0.1995	336,989	411,743	481,419
10th-90th		*[0.1676--0.2558]*	*[251,931--457,234]*	*[305,158--575,448]*	*[345,990--669,872]*

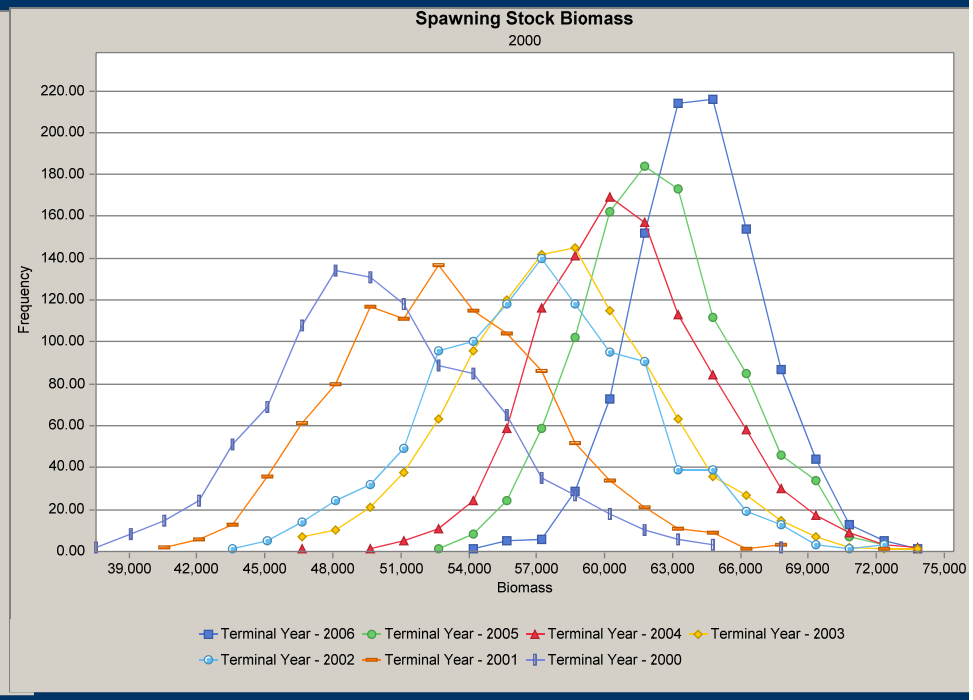
VPA Retrospective Bootstraps: Model 1 (1995)



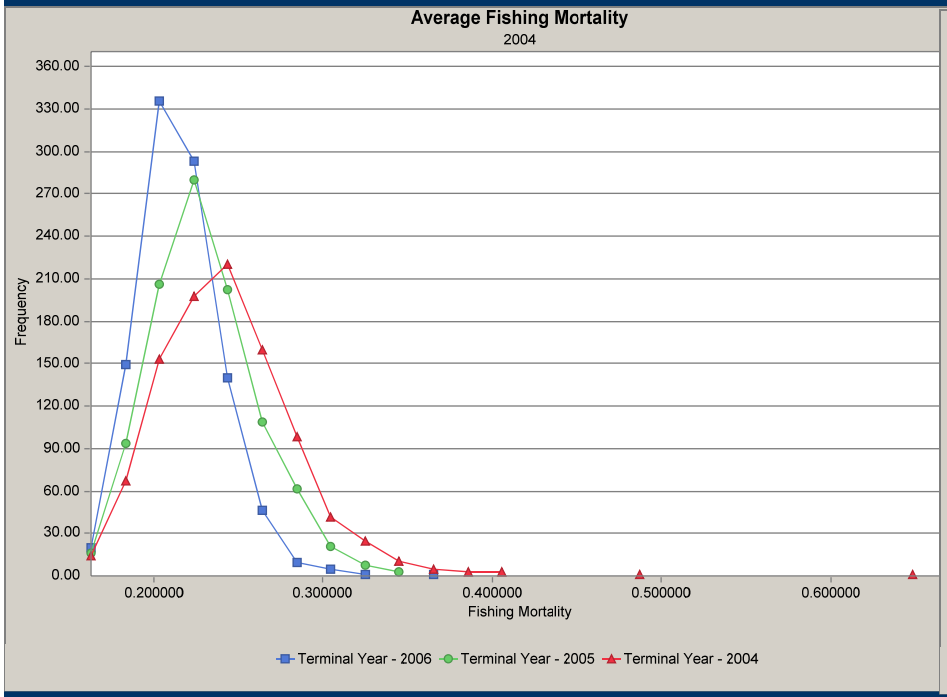


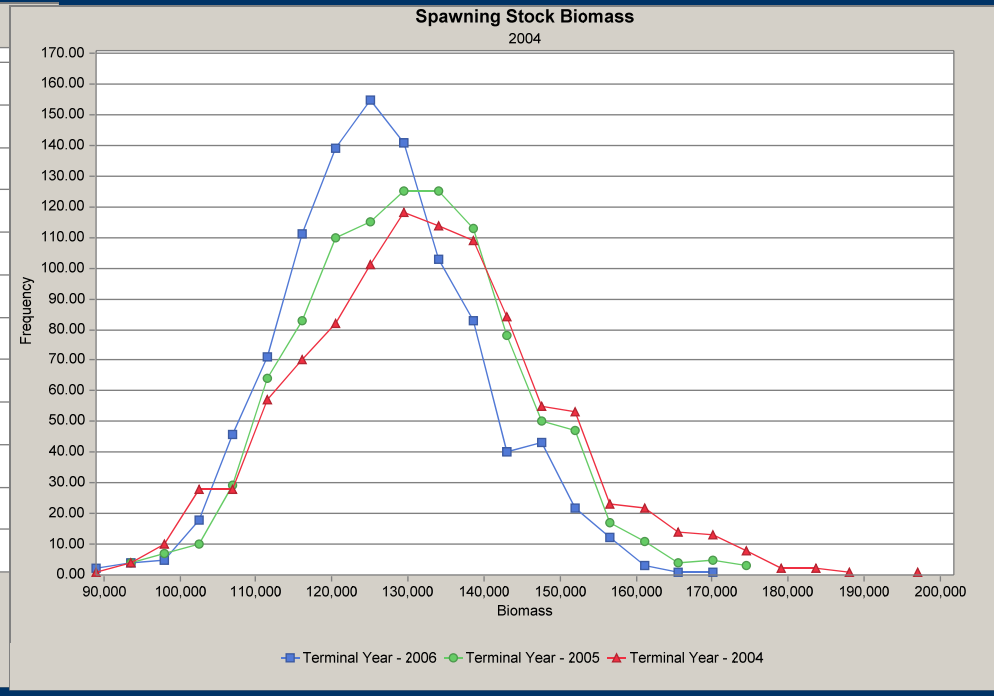
VPA Retrospective Bootstraps: Model 1 (2000)



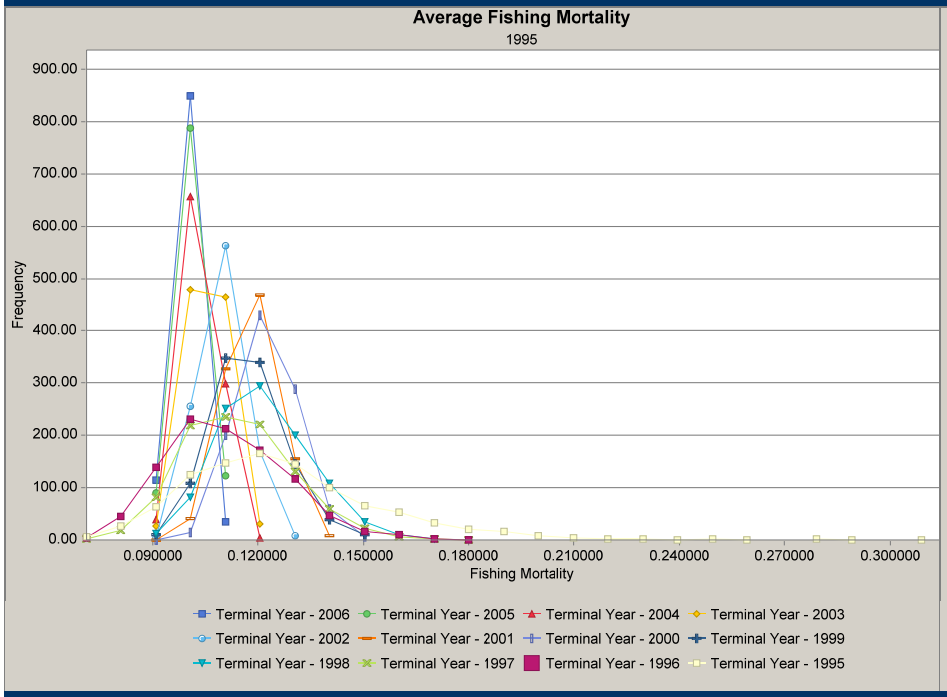


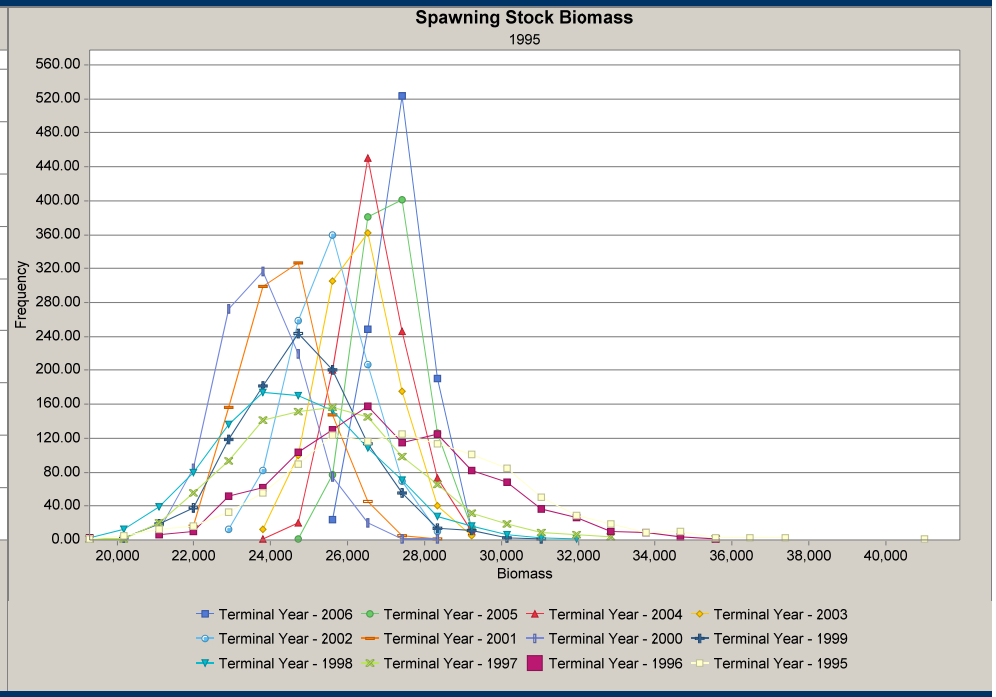
VPA Retrospective Bootstraps: Model 1 (2004)



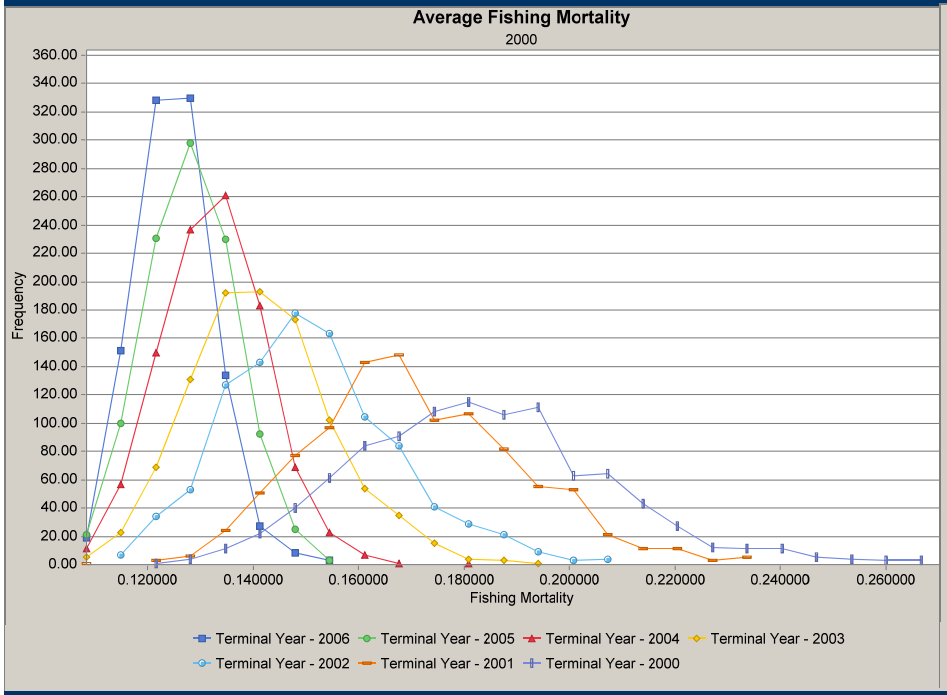


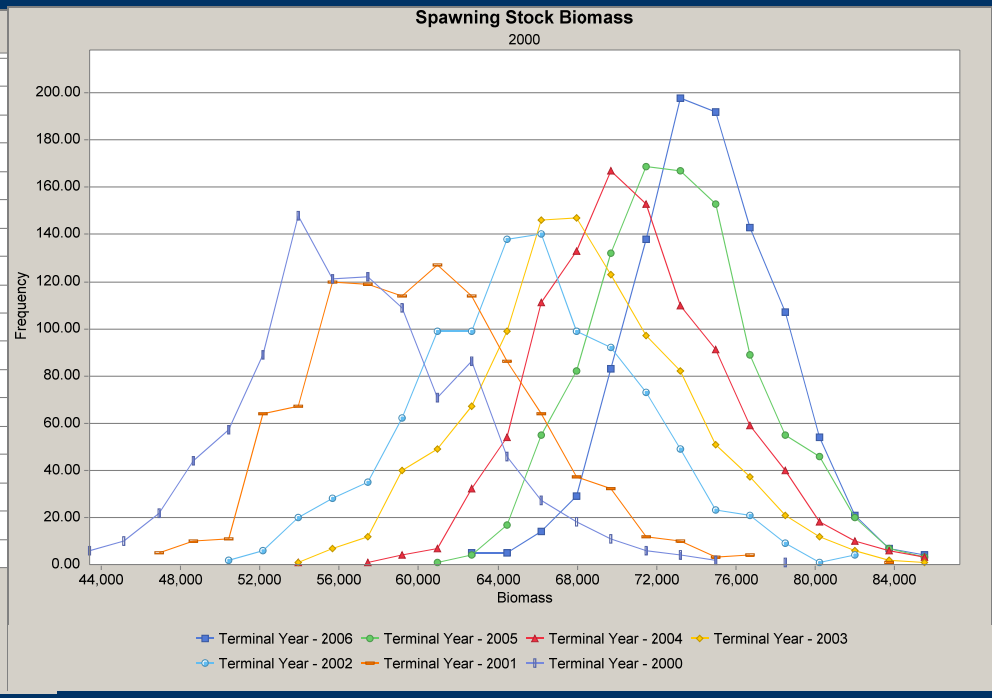
VPA Retrospective Bootstraps: Model 3 (1995)



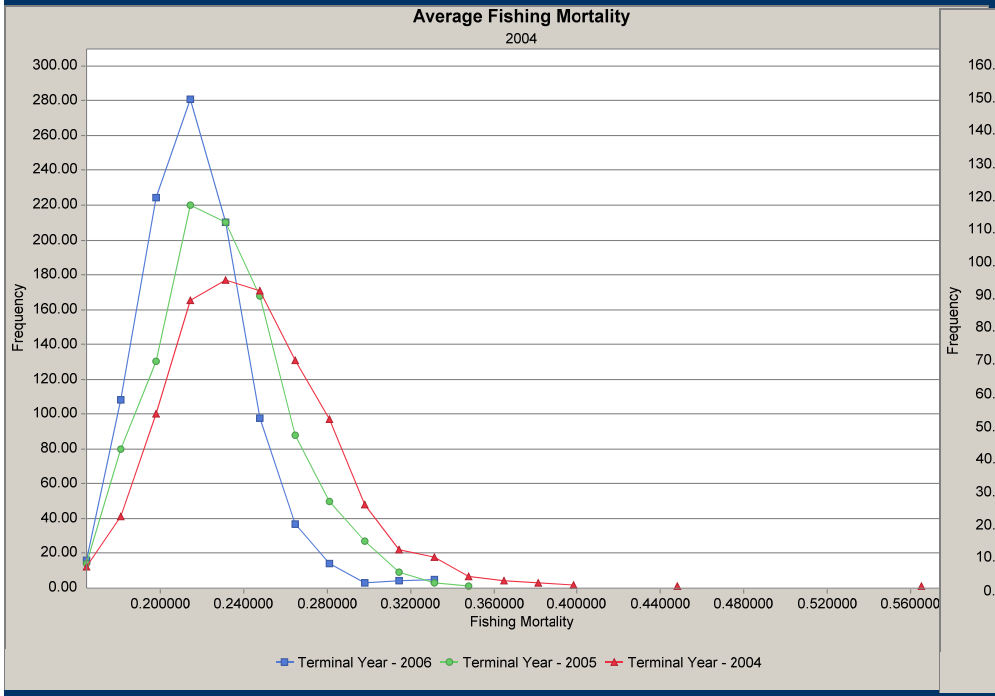


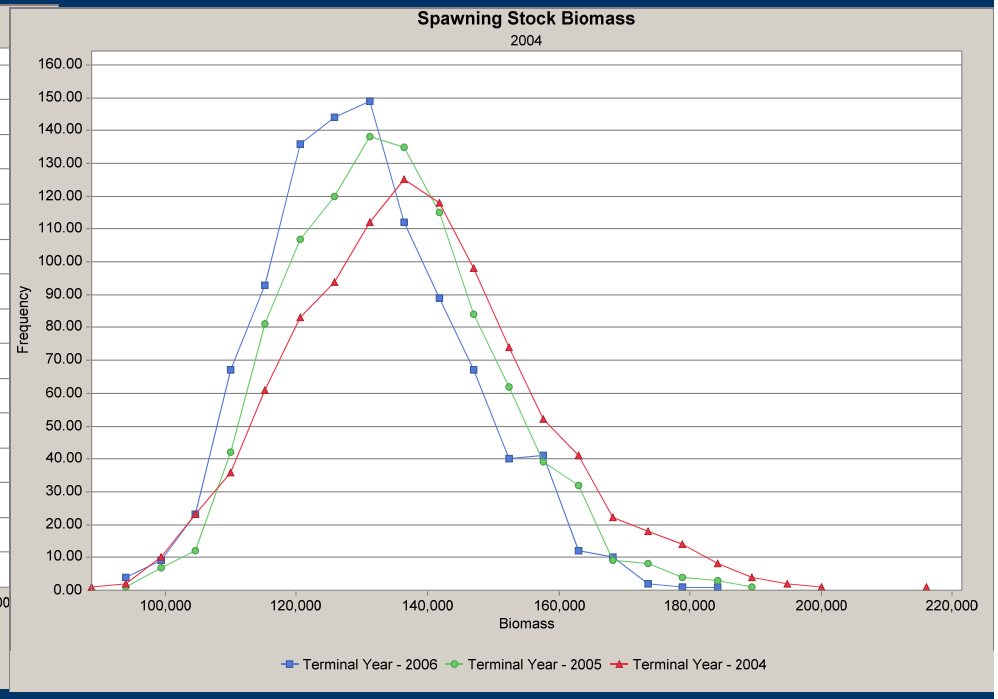
VPA Retrospective Bootstraps: Model 3 (2000)





VPA Retrospective Bootstraps: Model 3 (2004)





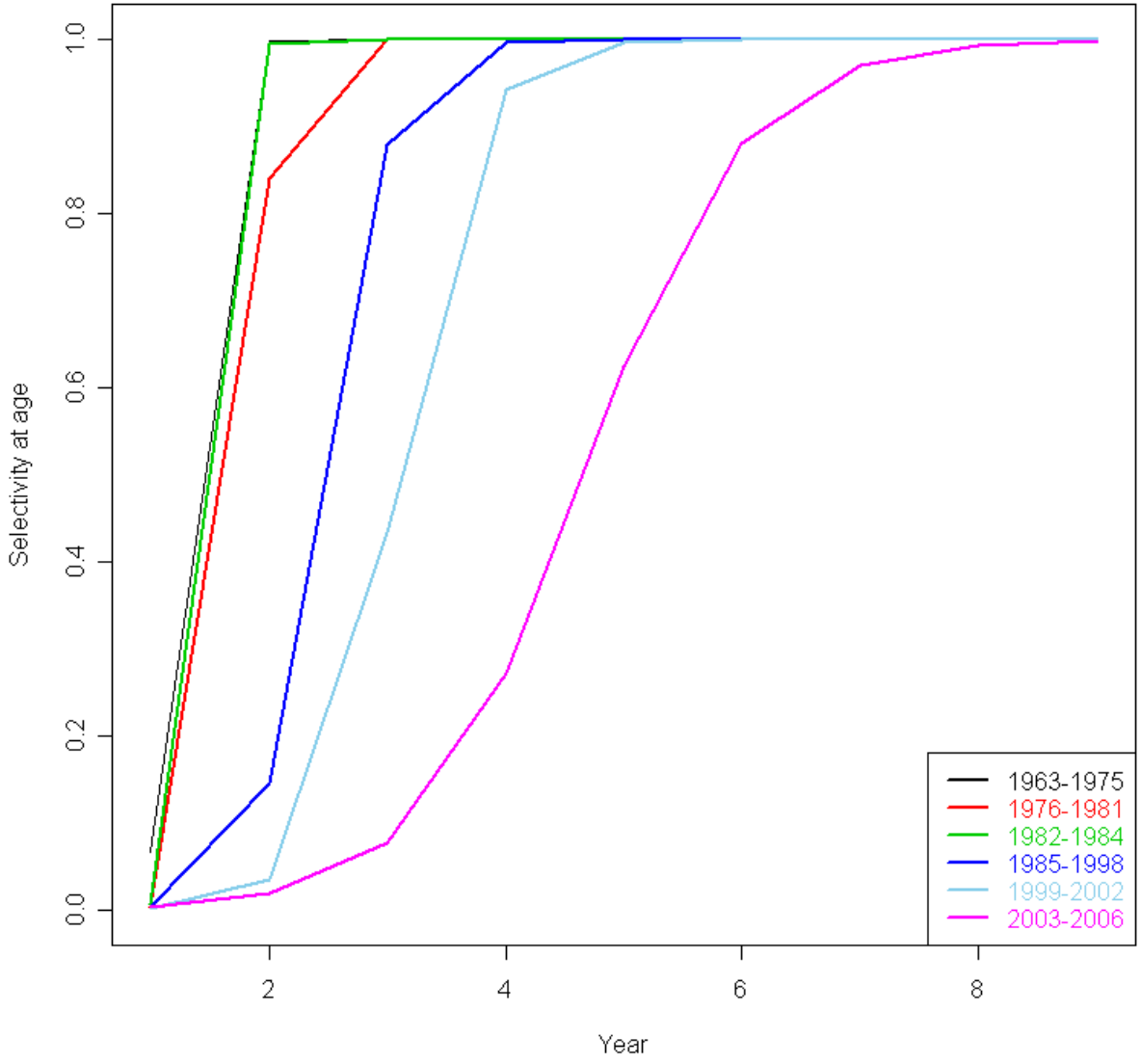
Conclusion

- VPA Model 3 (updated CAA, single maturity ogive) is preferred VPA
- No retrospective pattern, incorporates decisions made at GARM3 data and methods meetings for estimating landings and discards

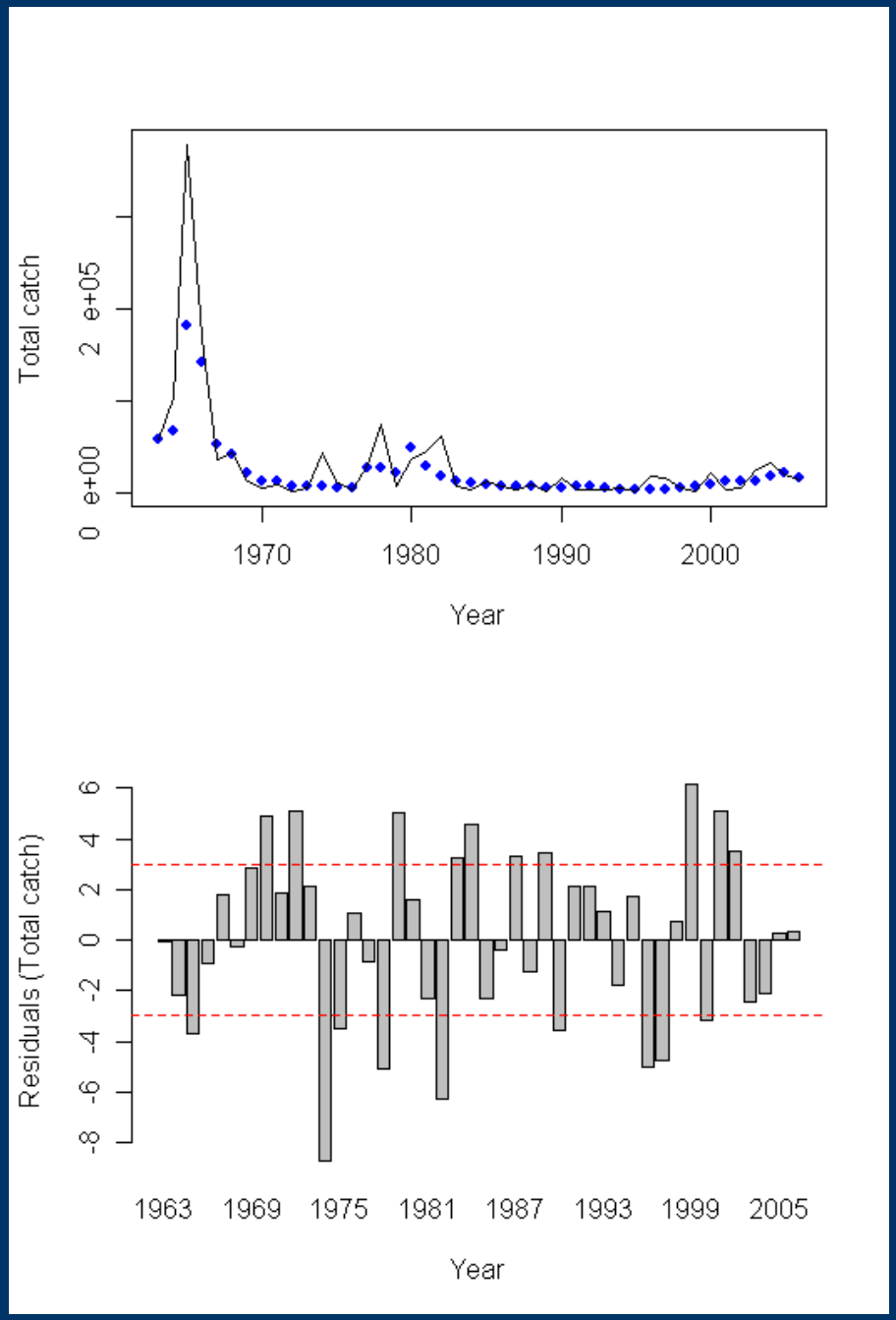
Sensitivity model: ASAP v.2

- Same years of data input as VPA (CAA and indices 1963-2006)
- Single maturity ogive
- Specified logistic selectivity, worked up incrementally from a single selectivity ogive (final model had 6 time blocks)
- Beverton-Holt S-R function, with CV inflated for 1963, 2003 year classes (1.0 versus 0.5 for all other years)

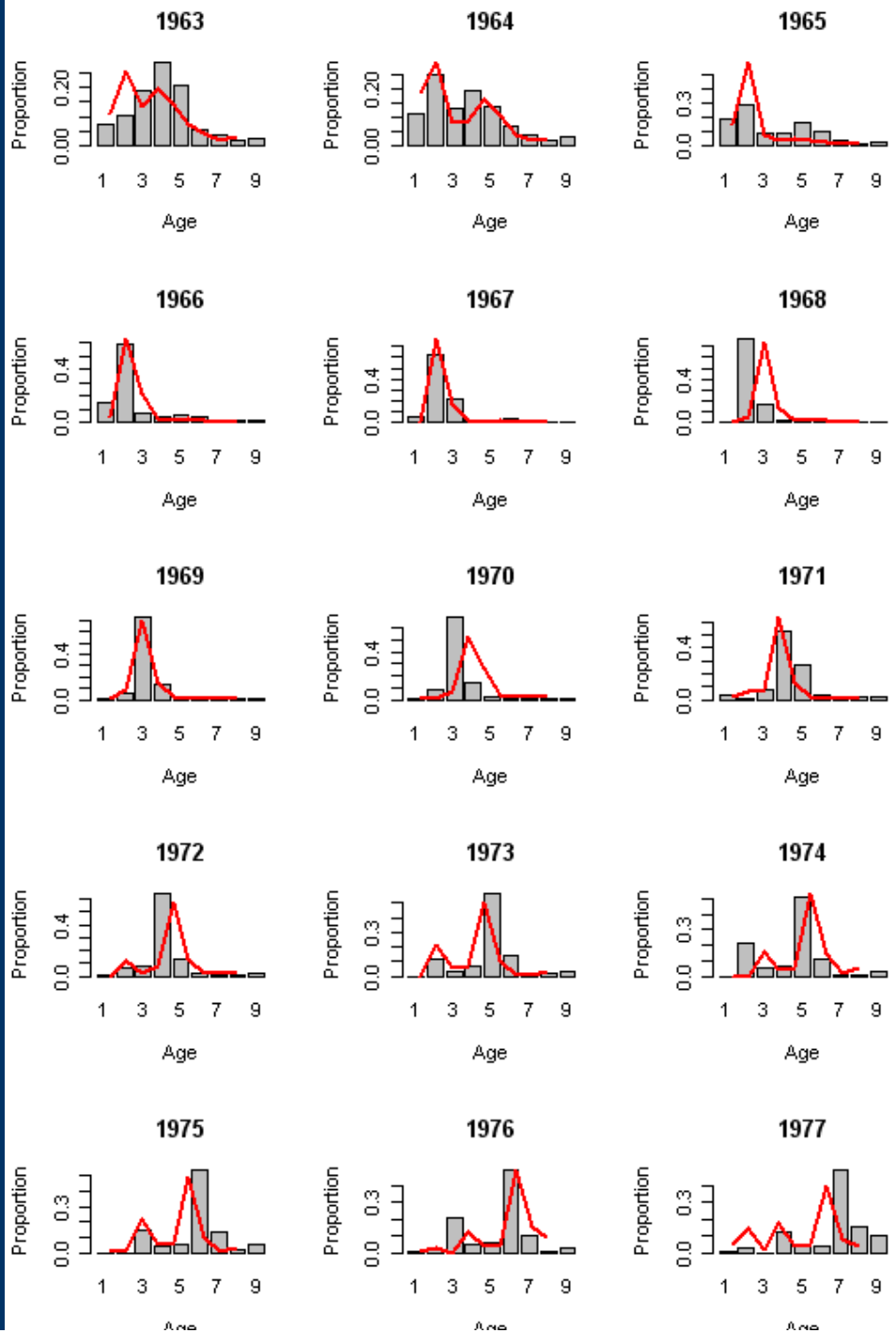
ASAP Results - Selectivity



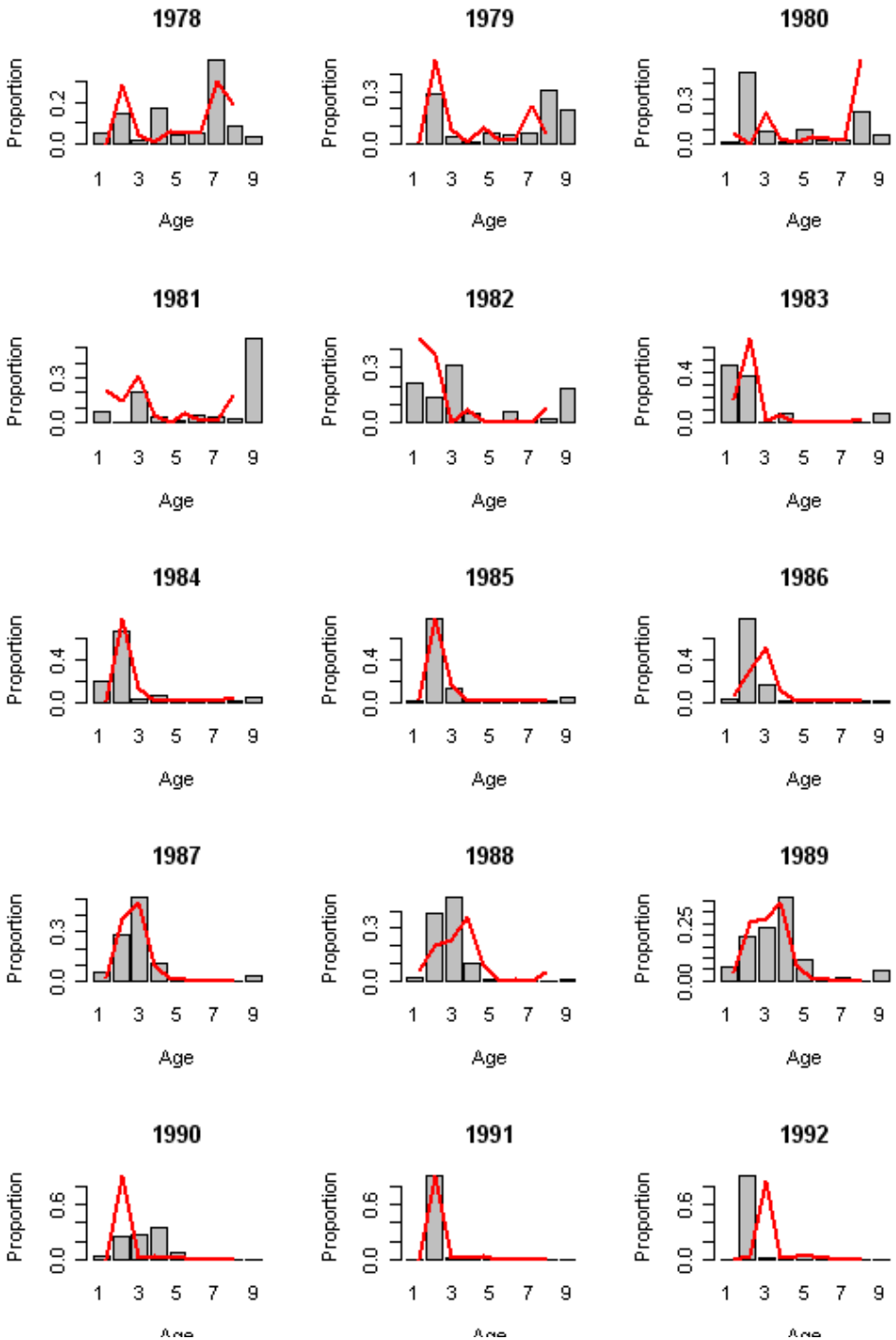
ASAP Results – Total Catch Fit



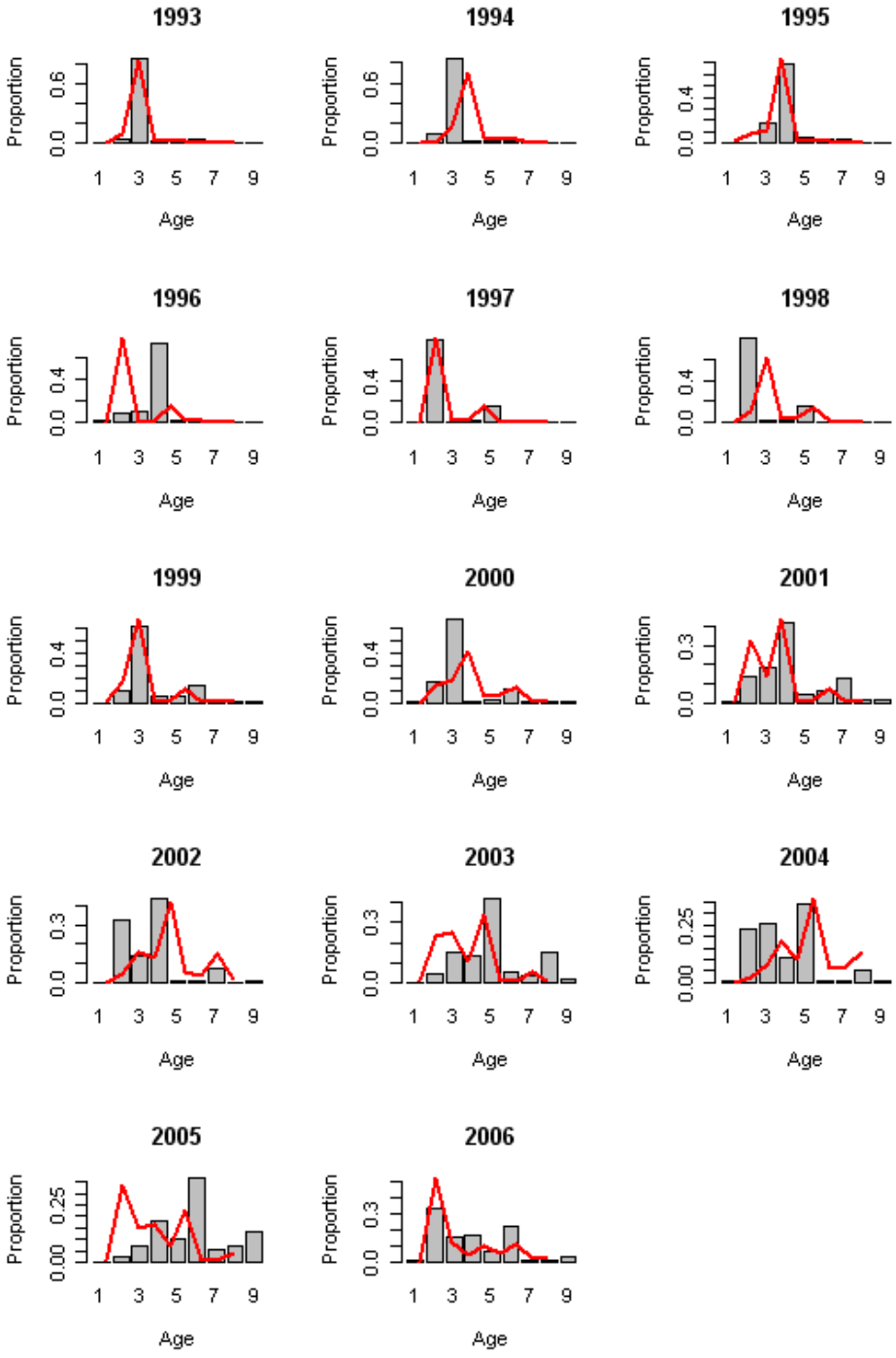
ASAP Results – Age Comp. Fit



ASAP Results – Age Comp. Fit



ASAP Results – Age Comp. Fit

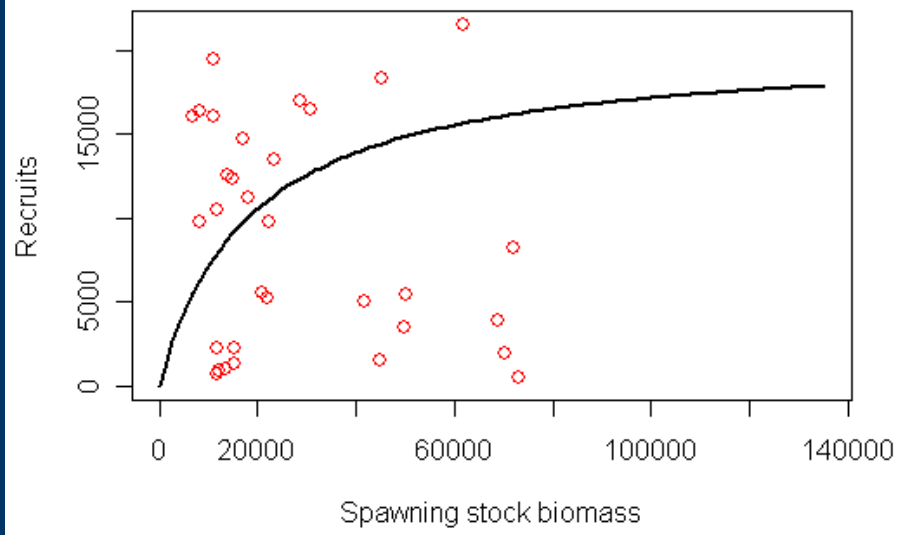


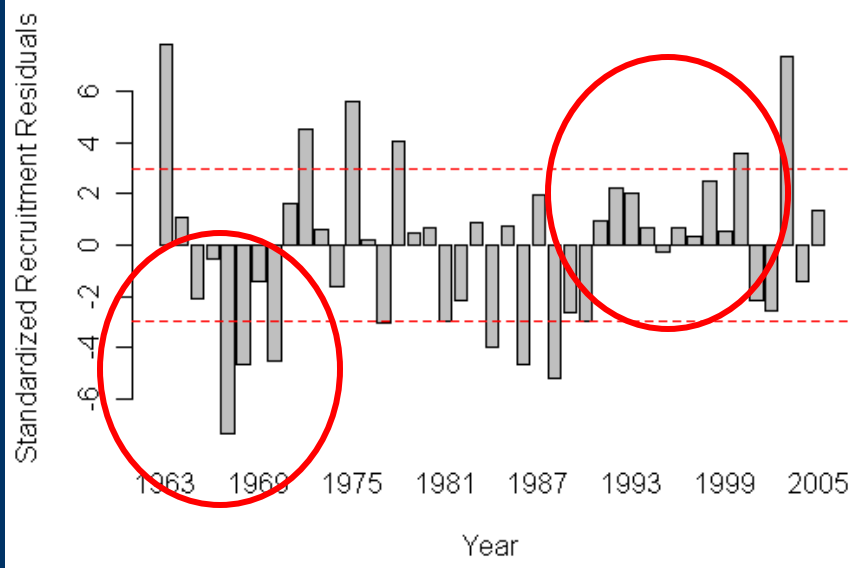
ASAP Results – Beverton-Holt Fit

h=0.68,

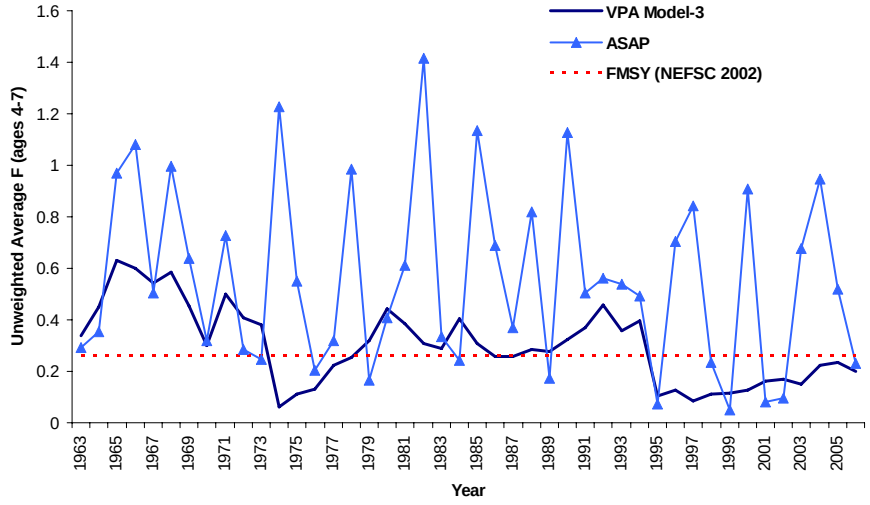
R_0=17.9 million,

SSB_0=135 million mt

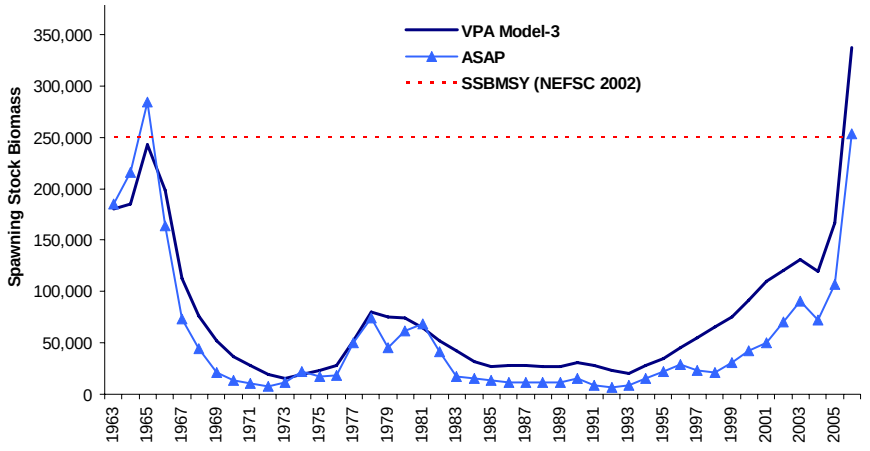




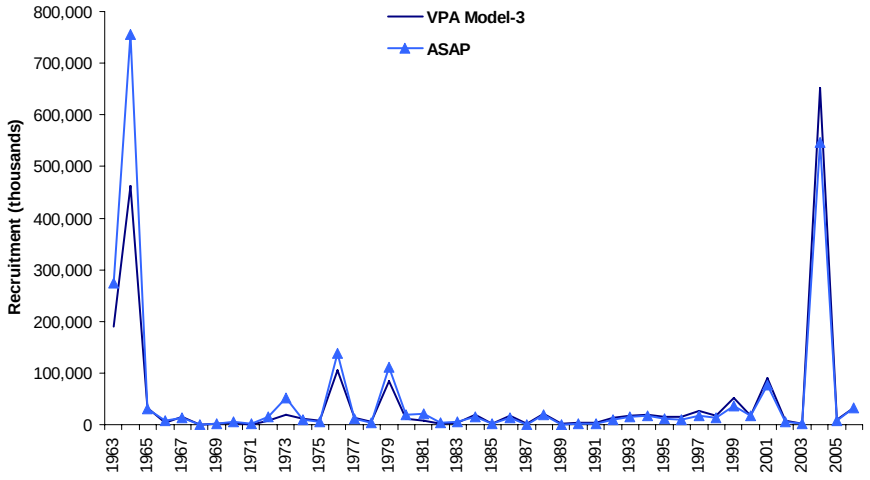
ASAP – VPA Model 3 comparison



Ave F

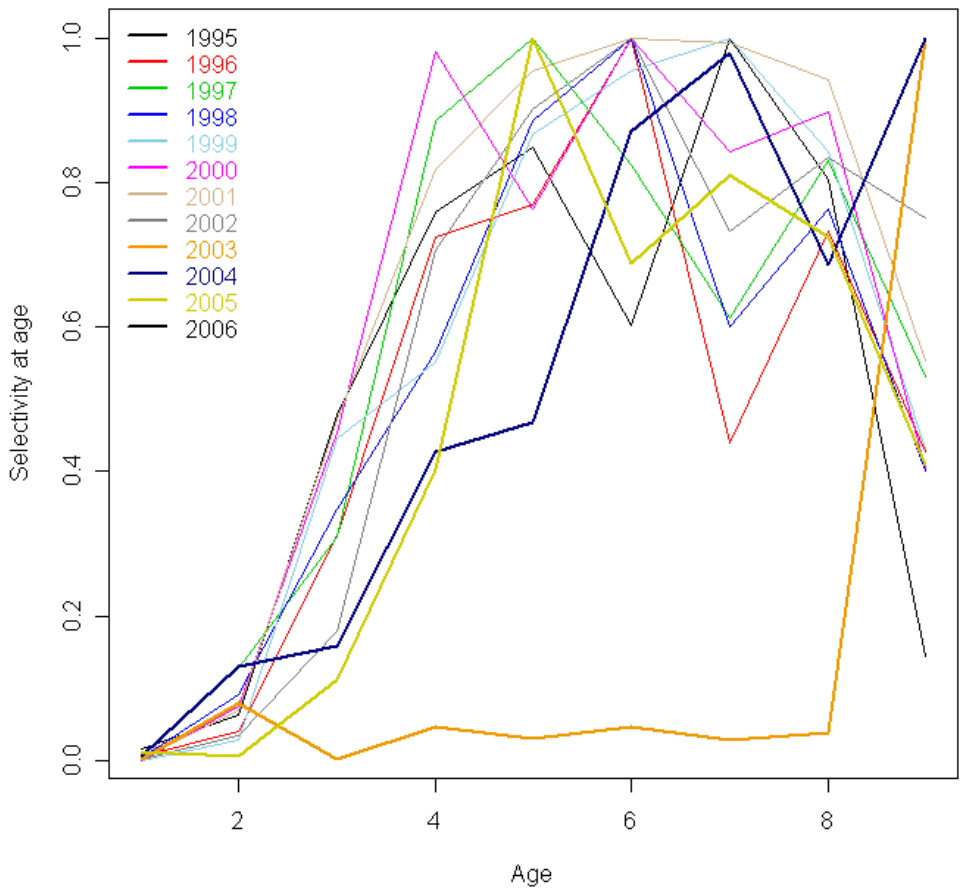


SSB

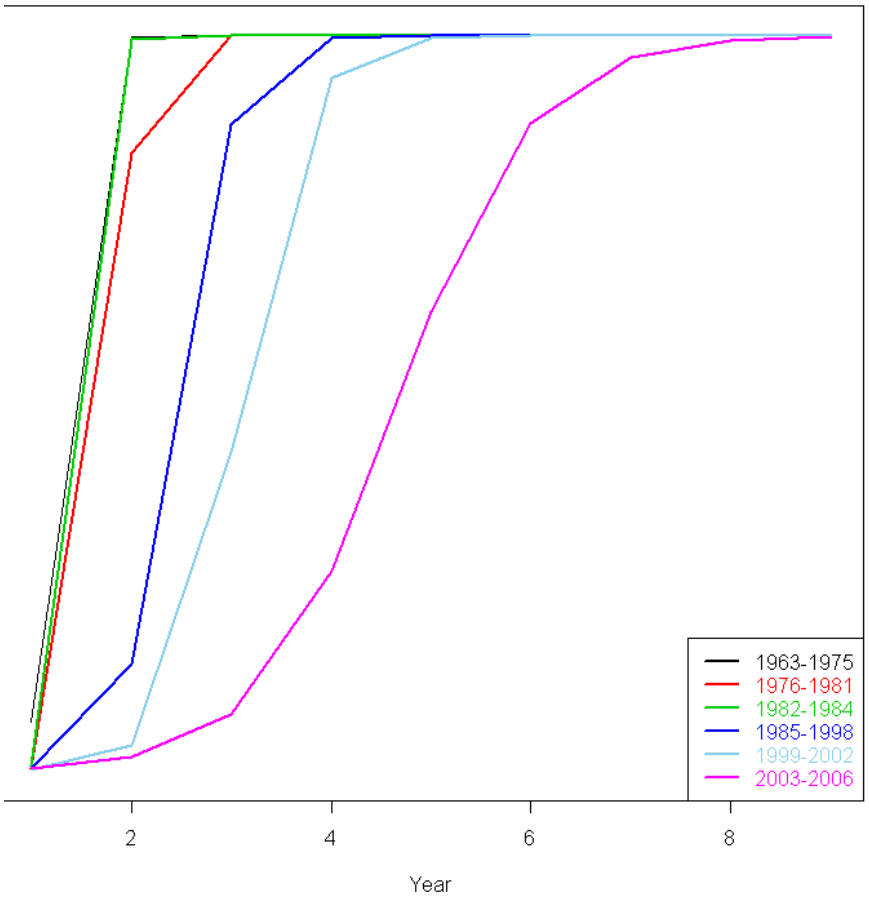


Age 1

VPA


1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Selectivity at age
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
Age

ASAP


1963-1975
1976-1981
1982-1984
1985-1998
1999-2002
2003-2006
2
4
6
8
Year

ASAP Conclusions

- Not ready for primetime, but a good start
- Given CV in discards vs catch, in future developments, goal would be to split out discards →requires hindcasting
- CAA exists back to 1931, total catch back to about 1904; *may* be some short indices *(need to put on archaeologist hat)*
- Other suggestions…?

4. Current Reference Points (NEFSC 2002)

- CAA available back to 1931 (Clark et al. 1982)
- Several parametric S-R functions were fit to SSB, Recr. Estimates from 1931-2000, but were rejected due to poor residual diagnostics
- Observed that recruitment was higher when SSB>75,000 mt (median of 1931-2000 VPA estimates)

4. Current Reference Points (cont.) (NEFSC 2002)

- Calculated mean recruitment in years where SSB>75,000 mt (but excluded 1963 from calculation): 68.87 million age-1 fish

- From YPR analysis, $F_{40\%}$=0.263,
  - YPR = 0.769 kg ➔ MSY = 52,900 mt
  - SSB/R = 3.63 kg ➔ SSB_{MSY} = 250,300 mt

  established $0.5*SSB_{MSY} = SSB_{threshold}$ = 125,150 mt

5. GARM3 Proposed Reference Points

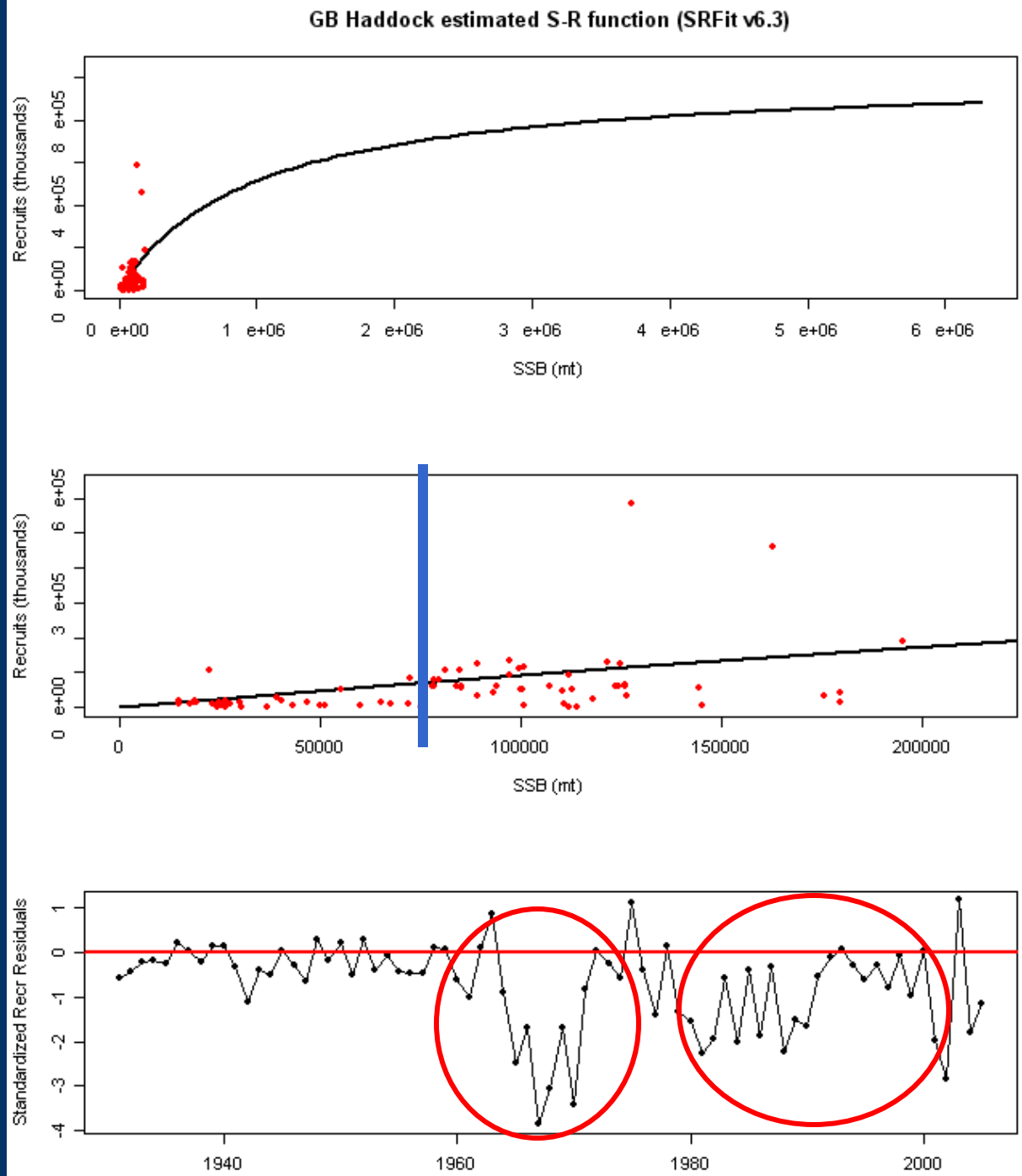
- Parametric: ran VPA Model 3, augmented with CAA for years 1931-2006 (Clark et al. 1982); attempted to fit B-H in SRFit

Fit to SSB, Recruitment estimates from VPA Model 3 with historical CAA

h=0.65,

R_0=881.6 million,

SSB_0=6.26 million mt



Non-parametric approach with AGEPRO

- Estimated $F_{40\%}$ in YPR analysis: 0.34
- Projected at $F_{40\%}$ for 100 years to determine $SSB_{40\%}$ and $Yield_{40\%}$ as proxies for SSB_{MSY} and MSY
- Projections sampled from cdf of VPA estimated recruitment (1931-2006)
- Stochastic projections from bootstrapped terminal year NAA for 1931-2006 VPA (Model 3 augmented with historical catch)

Non-parametric approach with AGEPRO (cont.)

	AGEPRO estimate	NEFSC 2002	AGEPRO/ (NEFSC 2002)
SSB_{MSY}	76,396	250,300	0.31
MSY	15,496	52,900	0.29
R_{MSY}	13,655,778	75,000,000	0.18

AGEPRO estimates really low, because stock was overfished for many years in the sampled recruitments

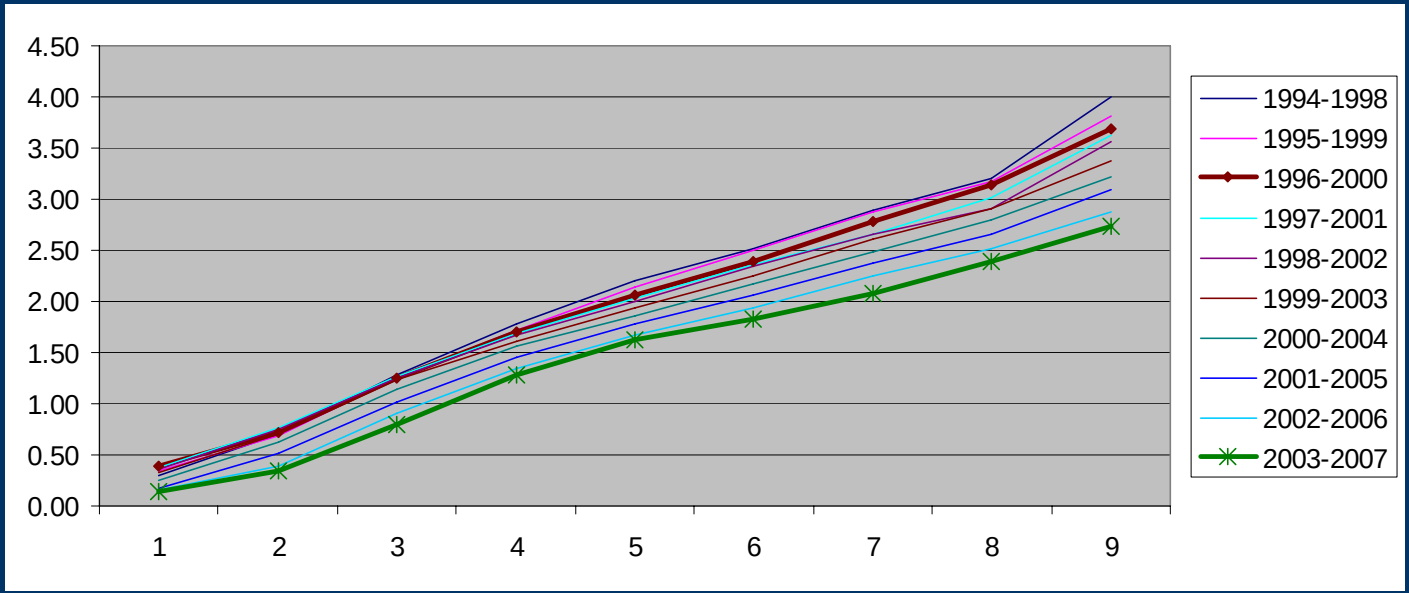
Non-parametric: YPR with average recruitment estimate

- As in NEFSC 2002, the median SSB was calculated, and then the average recruitment for years where SSB>median calculated w/o 1963, 2003 year classes
- NEFSC 2002 SSB_{median}: 75,000 mt
- GARM3-BRP SSB_{median}: 84,384 mt

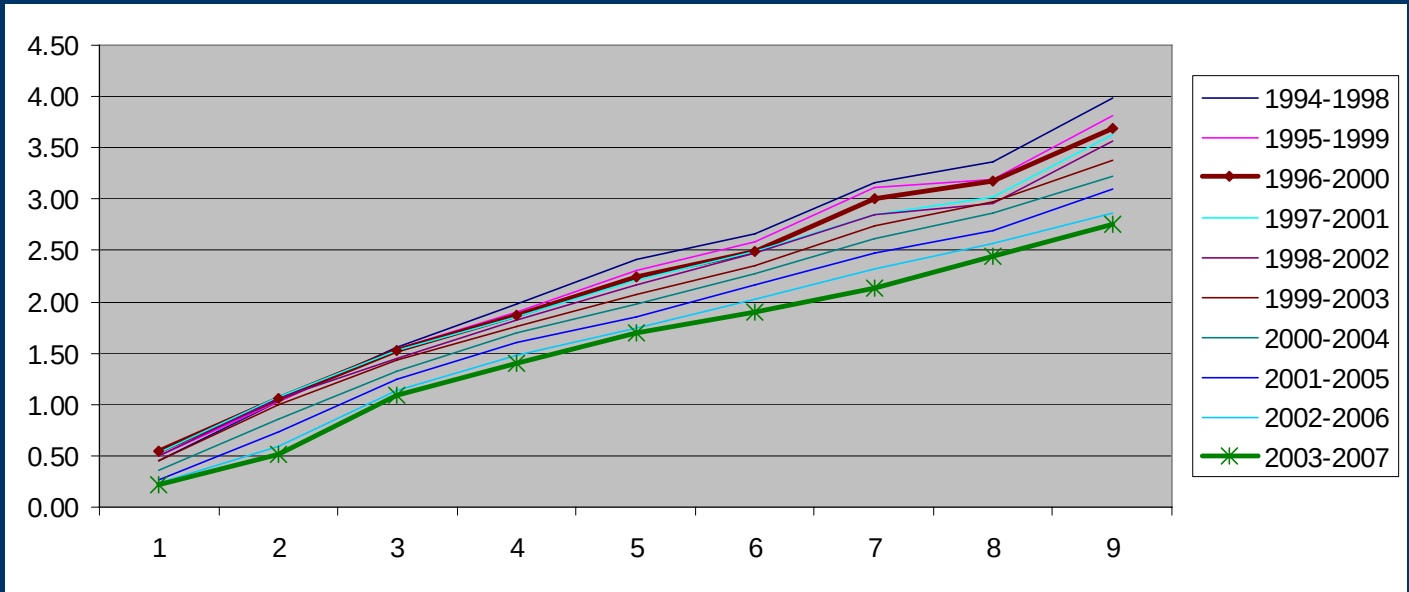
➔ Different because of new landings & discards, maturity ogive

Non-parametric: YPR with average recruitment estimate (cont.)

- NEFSC 2002 ave. recr: 68.87 million
- GARM3-BRP ave. recr: 61.15 million



Ave. stock weight (kg)



Ave. catch weight (kg)

GARM3 VPA Model-3						
Age	Selectivity	M Scalar	Stock wt	Catch wt	SSB wt	Maturity
1	0.013	1	0.157	0.230	0.157	**0.063**
2	0.073	1	0.395	0.599	0.395	**0.469**
3	0.133	1	0.909	1.140	0.909	0.920
4	**0.510**	1	1.350	1.473	1.350	0.993
5	**0.831**	1	1.678	1.750	1.678	0.999
6	**1.000**	1	1.936	2.017	1.936	1.000
7	1.000	1	2.243	2.327	2.243	1.000
8	1.000	1	2.518	2.565	2.518	1.000
9	1.000	1	2.871	2.871	2.871	1.000

NEFSC 2002 assmt						
Age	Selectivity	M Scalar	Stock wt	Catch wt	SSB wt	Maturity
1	0.003	1	0.257	0.359	0.257	**0.012**
2	0.088	1	0.619	0.851	0.619	**0.548**
3	0.471	1	1.145	1.324	1.145	0.948
4	**0.920**	1	1.558	1.699	1.558	0.992
5	**1.000**	1	1.867	1.976	1.867	1.000
6	**1.000**	1	2.167	2.274	2.167	1.000
7	1.000	1	2.478	2.615	2.478	1.000
8	1.000	1	2.802	2.869	2.802	1.000
9	1.000	1	3.225	3.225	3.225	1.000

6. Conclusions

- Parametric fits of S-R still not acceptable
- Non-parametric YPR with ave R(>SSB_{median}), dropping 1963 and 2003 from calculation
- Selectivity at age has shifted to older ages
- WAA is different (fish lighter at age, because they are smaller)
- BRPs from GARM3 < NEFSC 2002 for above reasons, but reflect shifts in biological parameters for stock at larger size (SSB_{2000}=64,100 mt, SSB_{2006}= 336,989 mt)
- "True" WAA, selectivity for pop at MSY *probably* somewhere between NEFSC 2002, GARM3

Table B12. * expanded from report WP 4.B**

	GARM3 VPA Model-3	GARM3-NEFSC 2002 weights	NEFSC 2002
F40%	0.340	0.360	0.260
YPR	0.608	0.700	0.769
SSB/R	2.823	3.220	3.634
ave (R>SSBmed)	***61,150,000***	***61,150,000***	***68,870,000***
MSY	**37, 180 mt**	**42.81 mt**	**52900 mt**
SSBmsy	**172,600 mt**	**196,900 mt**	**250300 mt**
1931-1960 ave (R)	*74,870,000*	*74,870,000*	*75,230,000*
MSY	45,519	52,409	45,000 mt*
SSBmsy	211,352	241,081	230,000 mt*

*1931-1960 growth, maturity

GARM3 (1931-1960) ave Recr

74.87 million 75.23 million for NEFSC 2002

GARM3 (SSB median)

84,384 mt 75,000 mt for NEFSC 2002

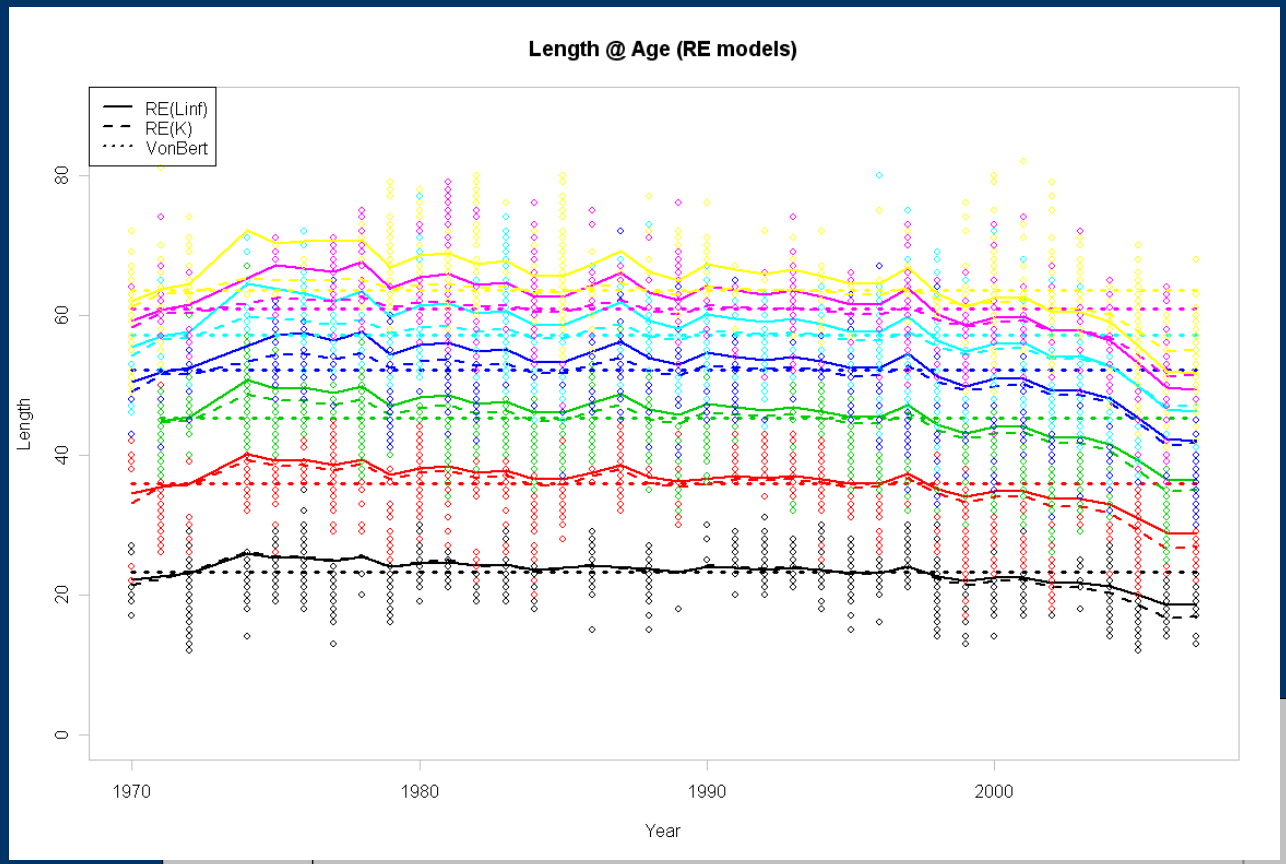
GARM3 (Recruitment in years where SSB>SSB median)

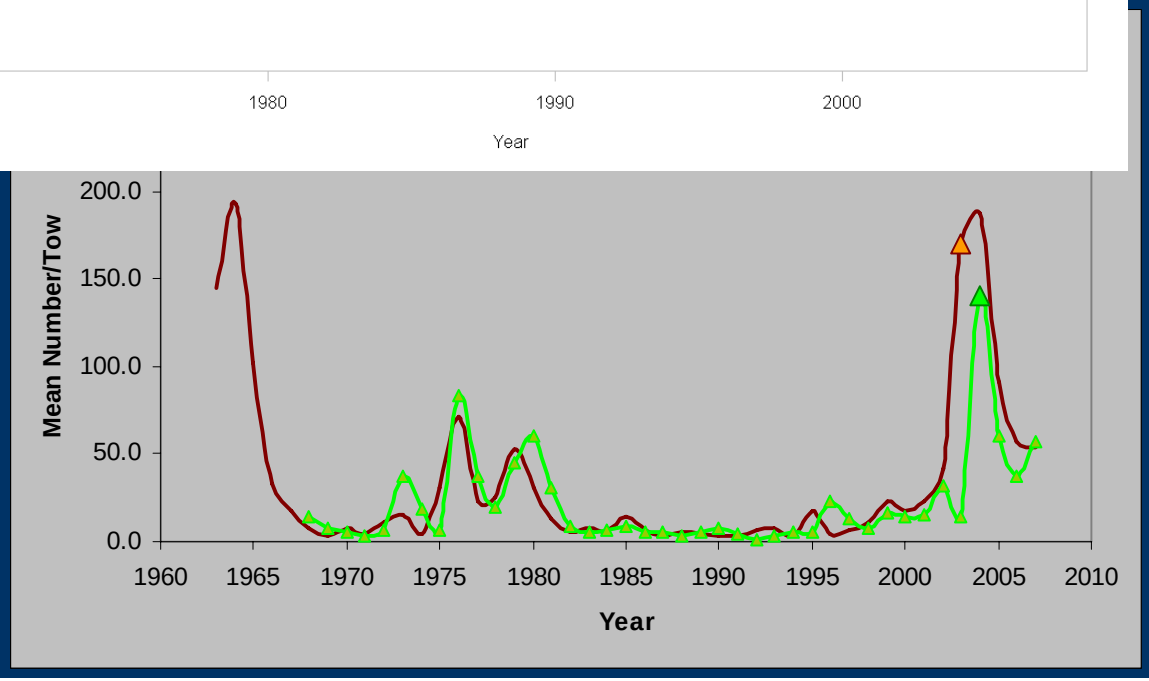
61.15 million 68.87 million for NEFSC 2002

NEFSC-AUTUMN

Year	Age-0	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-7	Age-8	Age-9+
1963	**83.93**	25.39	9.22	6.81	8.34	5.95	2.04	1.68	1.18	0.46
1964	2.37	**112.87**	63.74	5.83	1.79	3.81	1.56	0.69	0.25	0.33
1965	0.33	10.16	**77.39**	9.70	1.07	0.80	0.91	0.80	0.25	0.27
1966	6.14	0.95	2.89	**18.39**	3.35	0.52	0.49	0.33	0.12	0.07
1967	0.03	6.72	0.36	1.00	**6.76**	1.62	0.49	0.21	0.33	0.18
1968	0.09	0.06	0.95	0.13	0.33	**3.86**	1.27	0.27	0.16	0.39
1969	0.39	0.03	0.00	0.28	0.13	0.16	**1.52**	0.51	0.09	0.27
1970	0.04	4.13	0.21	0.01	0.28	0.27	0.51	**1.37**	0.48	0.40
1971	2.43	0.00	0.31	0.07	0.01	0.22	0.03	0.09	**0.75**	0.28
1972	6.75	2.52	0.00	0.52	0.09	0.00	0.09	0.06	0.03	**1.30**
1973	3.23	9.00	1.61	0.00	0.19	0.04	0.00	0.07	0.01	0.72
1974	0.75	1.77	0.98	0.31	0.00	0.01	0.00	0.00	0.00	0.22
1975	23.48	0.63	0.72	4.86	0.92	0.00	0.03	0.00	0.01	0.30
1976	4.32	64.17	0.52	0.54	0.82	0.30	0.00	0.04	0.10	0.25
1977	0.13	2.14	18.73	0.56	0.57	0.64	0.34	0.04	0.01	0.09
1978	13.22	0.84	1.04	9.27	0.18	0.26	0.45	0.01	0.00	0.01
1979	1.32	45.57	0.04	0.90	3.81	0.26	0.28	0.05	0.01	0.00
1980	11.68	2.71	12.72	0.45	0.18	1.70	0.48	0.46	0.09	0.06
1981	0.38	6.13	2.08	3.70	0.21	0.42	0.53	0.00	0.00	0.01
1982	1.36	0.00	1.33	0.34	1.40	0.13	0.07	0.21	0.01	0.10
1983	5.80	0.24	0.21	0.27	0.30	0.94	0.12	0.00	0.10	0.01
1984	0.03	3.32	0.88	0.24	0.28	0.06	0.45	0.00	0.00	0.12

1985	11.35	0.65	1.53	0.22	0.05	0.10	0.07	0.17	0.00	0.05
1986	0.00	5.11	0.09	1.21	0.06	0.13	0.13	0.02	0.03	0.03
1987	1.80	0.00	0.79	0.10	0.77	0.06	0.06	0.02	0.02	0.00
1988	0.07	3.02	0.18	1.30	0.12	0.40	0.12	0.11	0.00	0.03
1989	0.47	0.05	2.71	0.20	0.66	0.09	0.13	0.02	0.02	0.00
1990	0.77	0.67	0.02	1.19	0.05	0.17	0.04	0.00	0.00	0.00
1991	2.16	0.21	0.24	0.05	0.22	0.02	0.02	0.00	0.00	0.02
1992	2.85	2.08	0.23	0.24	0.00	0.47	0.02	0.08	0.03	0.06
1993	1.52	4.04	2.01	0.30	0.00	0.06	0.15	0.02	0.00	0.00
1994	0.91	0.77	0.81	0.67	0.12	0.05	0.02	0.17	0.06	0.00
1995	2.27	7.14	4.90	2.32	0.38	0.01	0.00	0.07	0.02	0.00
1996	1.31	0.54	0.93	1.04	0.49	0.14	0.01	0.01	0.00	0.01
1997	0.32	2.47	1.47	0.75	0.55	0.33	0.13	0.00	0.07	0.08
1998	4.32	2.79	2.47	0.72	0.41	0.18	0.16	0.02	0.00	0.01
1999	1.82	0.84	3.37	8.05	3.52	2.32	0.82	1.32	0.75	0.31
2000	4.14	2.82	5.48	3.10	1.10	0.66	0.13	0.27	0.09	0.19
2001	0.85	8.77	1.68	7.44	2.12	1.16	0.36	0.22	0.13	0.01
2002	0.12	1.91	22.27	5.45	8.54	1.87	0.62	0.53	0.68	0.10
2003	**154.54**	0.07	0.45	8.55	1.77	3.36	0.29	0.28	0.00	0.22
2004	1.63	**163.65**	0.22	0.84	13.62	1.18	4.54	0.50	0.67	0.15
2005	4.23	1.77	**77.24**	0.28	0.70	4.74	0.48	0.84	0.11	0.10
2006	0.94	4.54	0.73	**48.36**	0.40	0.43	1.28	0.10	0.21	0.02
2007	0.84	1.24	7.01	1.19	**42.31**	0.35	0.23	0.53	0.13	0.07


Length @ Age (RE models)
RE(Linf)
RE(K)
VonBert
Length
0
20
40
60
80
1970
1980
1990
2000
Year


Mean Number/Tow
200.0
150.0
100.0
50.0
0.0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year