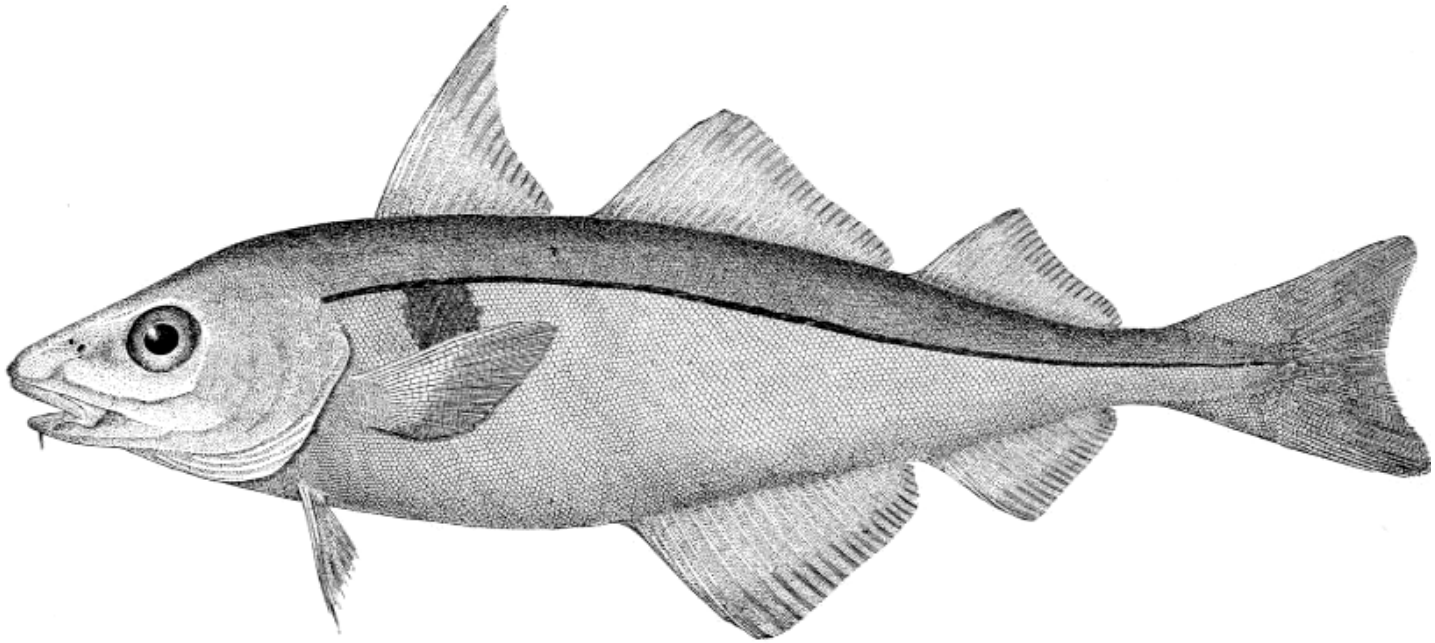
R. Gulf of Maine haddock (*Melanogrammus aeglefinus*)

Presenter: Michael Palmer



THE HADDOCK.

Melanogrammus æglefinus (L.), Gill. (p. 223.)

Drawing by H. L. Todd, from No. 10440, U. S. National Museum, collected at Eastport, Me., 1872, by U. S. Fish Commission.

Draft Presentation
For Peer Review Only.
Does not represent
final NOAA Decision/Policy.
4/28/08

R. GARM Models Meeting Summary

- AIM model presented
  - GARM II, 2005 – F_{MSY} – proxy = 0.23, B_{MSY} –proxy = 11.09 kg/tow
    - Terminal year exploitation rate = 0.18, survey biomass = 5.79 kg/tow
    - Overfished, but overfishing was not occurring
  - GARM III, 2008 – Updated with revised landings and included recreational landings and discard estimates
    - F_{MSY} – proxy = 0.23, B_{MSY} –proxy = 10.98 kg/tow
  - Terminal year exploitation rate = 0.29, survey biomass = 4.09 kg/tow
  - Overfished and overfishing is currently occurring

- Panel accepted AIM model for BRP determination, suggested age-structured assessment be performed if time permits.

R. Why age based assessments have never been attempted

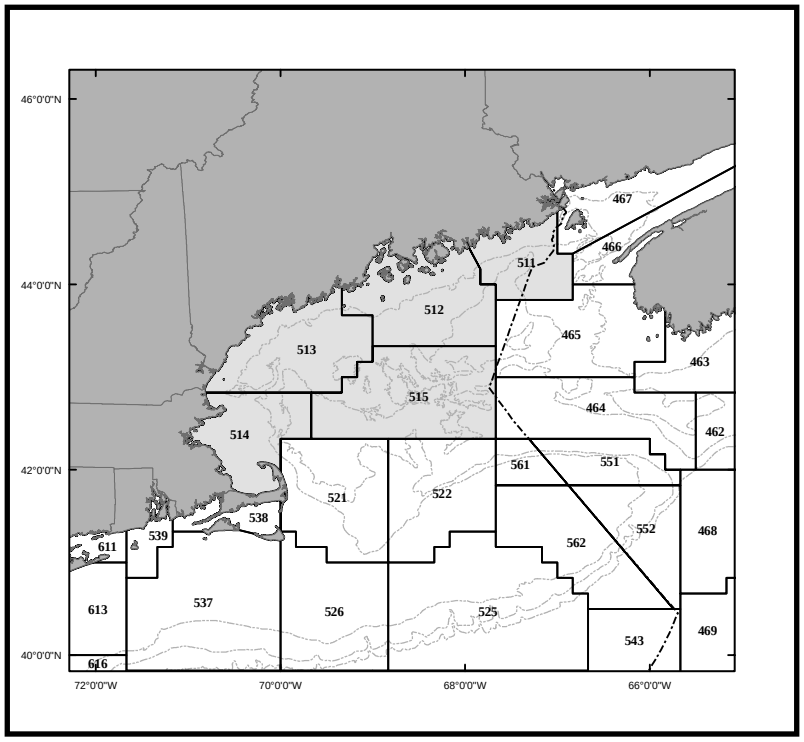
- Limited biological data during late 1980s through mid-1990s
  - Pervasive problem across commercial, recreational and survey data collections

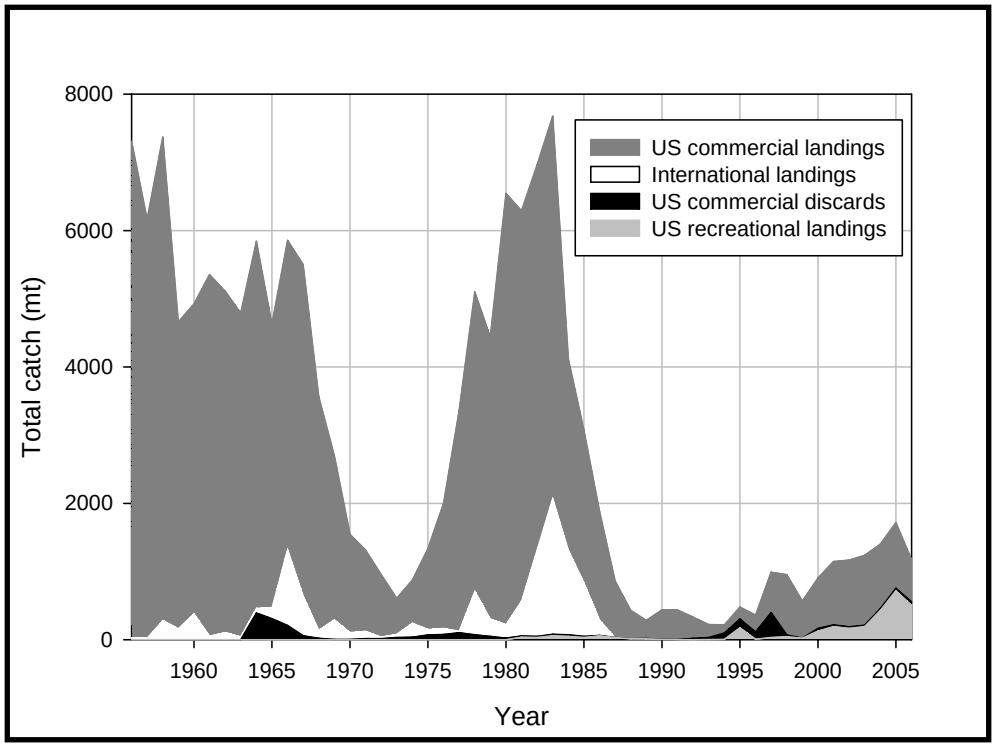
	Large				Scrod				
Year	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Total
1969		93	59				282	92	526
1970									0
1971	86			101				82	269
1972			74	115					189
1973	99		627					205	931
1974					207	47			254
1975					64	100			164
1976	30						74	108	212
1977		197	358		382	511	481	569	2498
1978	149	35	200		223	322	179	203	1311
1979	195		124	100	114			66	599
1980		319	102		51	175	257	201	1105
1981		52	257	638	53	358	514	381	2253
1982	103		1361	104	473	53	273	154	2608
1983	249	868	1317	496	312	308	340	203	4195
1984		79	828	391	187	94	139	113	1831
1985	347	597	573	536	353	202	298	84	2990
1986	283	234	789	271	181	242	207	204	2411
1987	214	102	515	405	162	79	75	136	1688
1988	91		100	202	261	50	42		746
1989			65	118	99			129	411
1990	34			100	41	50		50	275
1991		146	216	213	57		179	212	1023
1992	121			19	107		53	111	411
1993					103	56	125		338
1994		100	52	297				219	668
1995	62				194				256
1996	77			427		92		100	696
1997	120	255	497	355		124	358	147	1856
1998	309	111	78	313	689	49	156	35	1740
1999	117		300	211			214	102	944
2000	488	313	339	107	414	259	105	287	2312
2001	528	93	207	579	353	108	66	847	2781
2002	729	210		262	348	143	247	161	2100
2003	792	348	1282	1043	485	216	716	513	5395
2004	1898	942	101	601	1021	1085	262	451	6361
2005	1313	325	573	752	661	449	733	769	5575
2006	1193	687	453	617	928	535	569	514	5496
Average	351	271	423	337	281	216	255	231	1620

R. Progress Since Models Meeting

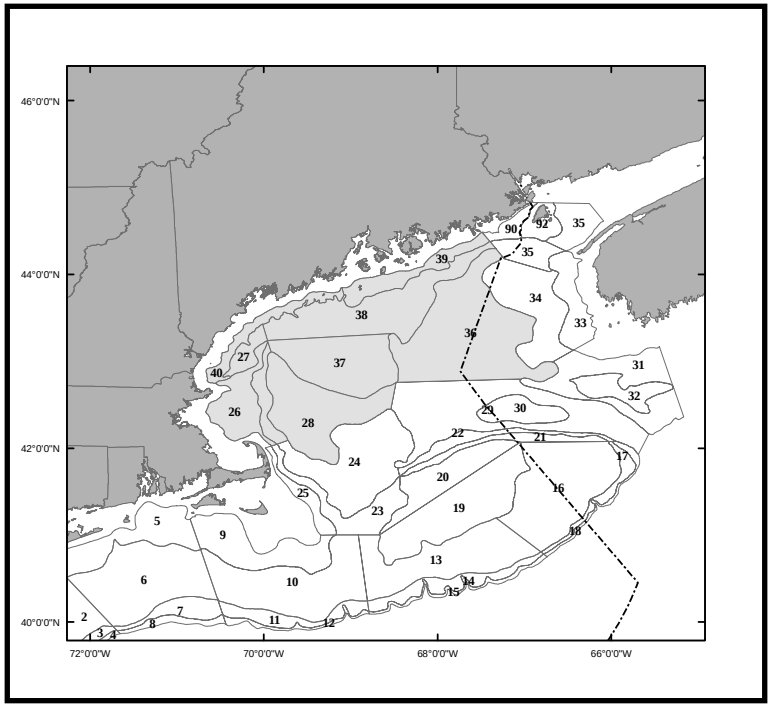
- Catch at age, catch weights at age and maturity ogives were assembled
- VPA assessment has been performed
  - Start in 1977
  - Plus group at 9^+
  - Natural mortality (M) assumed 0.2
  - Include commercial landings, discards and recreational landings
  - Tune to both NEFSC spring and autumn survey indices
- Parametric and non-parametric estimates of BRPs have been calculated

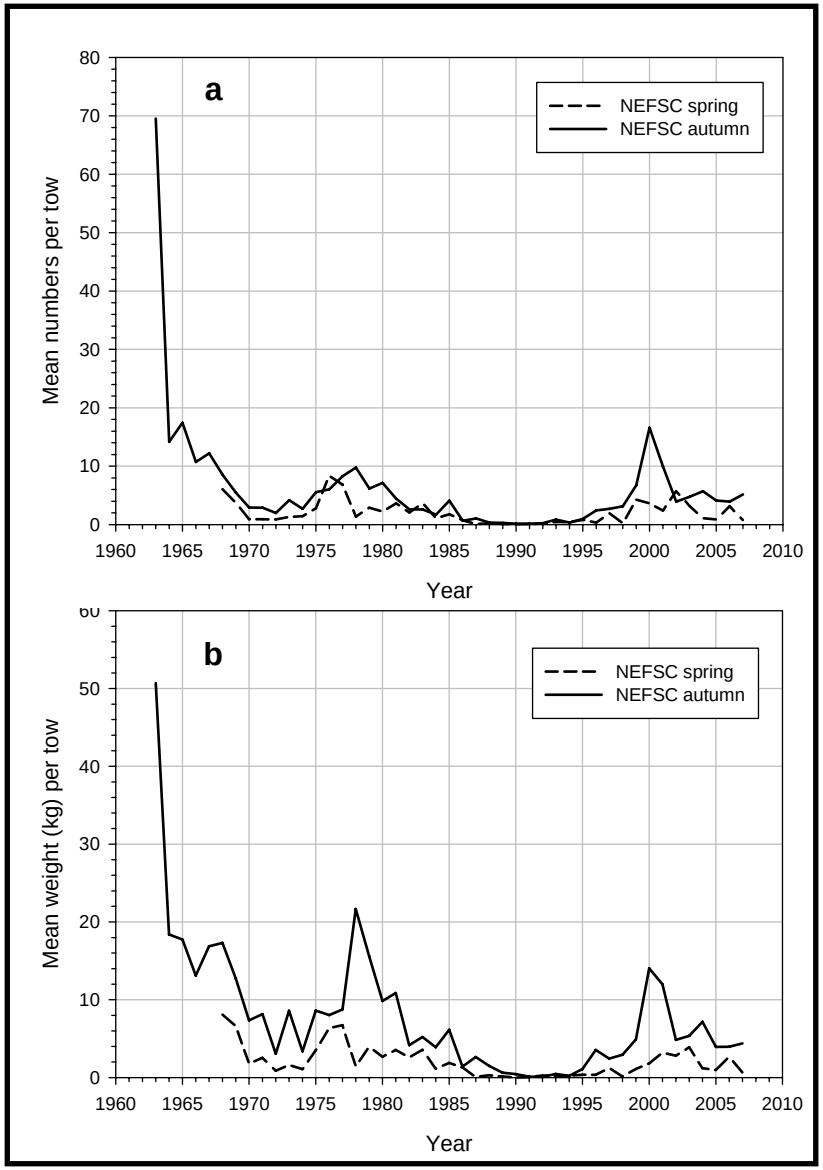
R. Stock overview - fishery removals





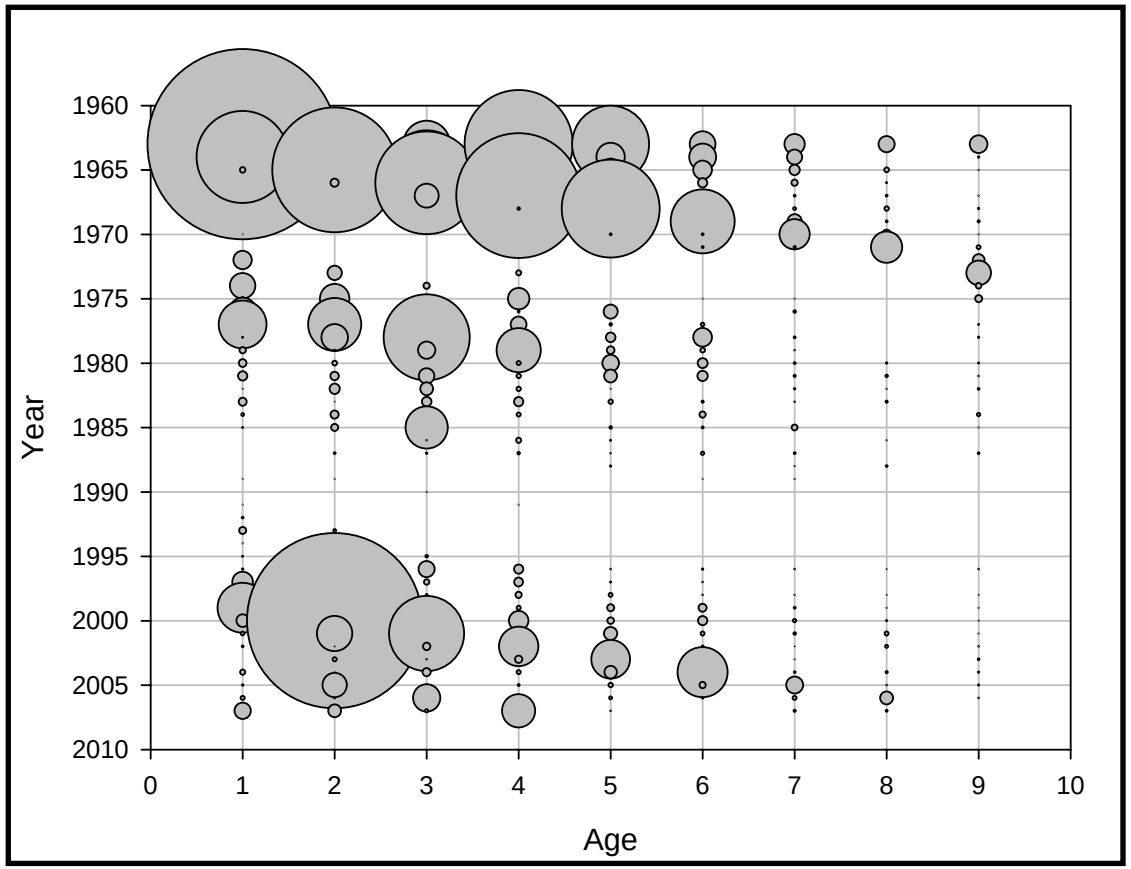
R. Stock overview - survey indices

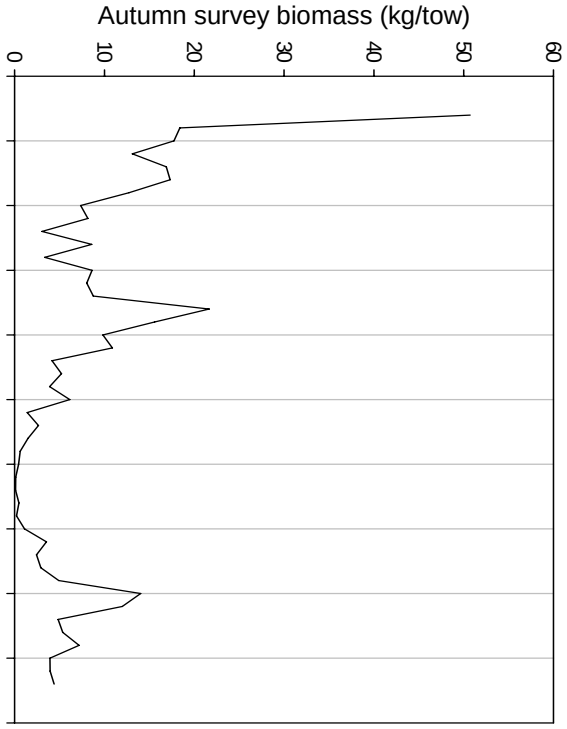




R. Stock overview – relative year class strength

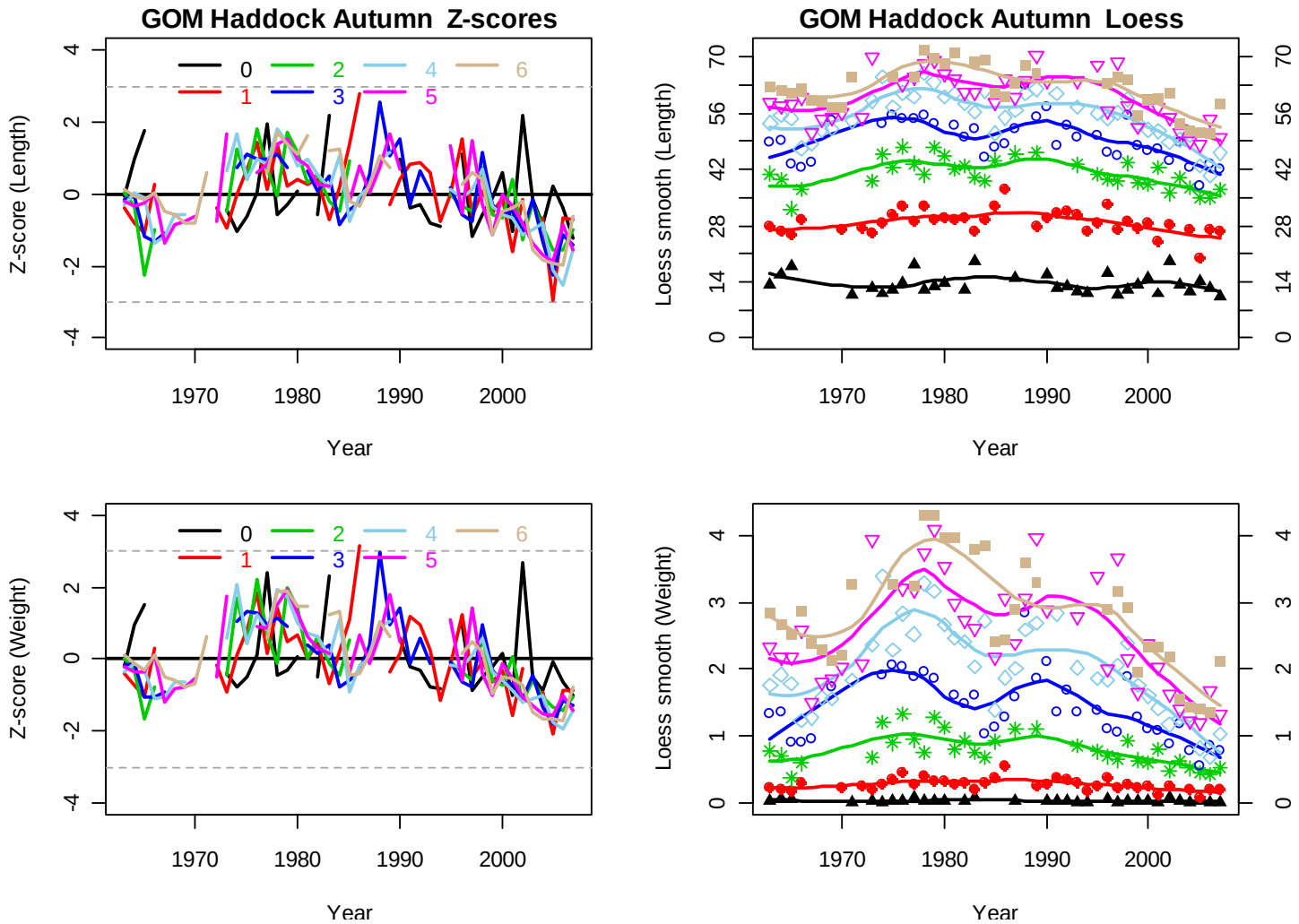
- Abundance has been driven primarily by 3 periods of strong recruitment.
  - 1962/63, 1975/76, 1998
  - Truncation of population age structure during periods of low abundance.





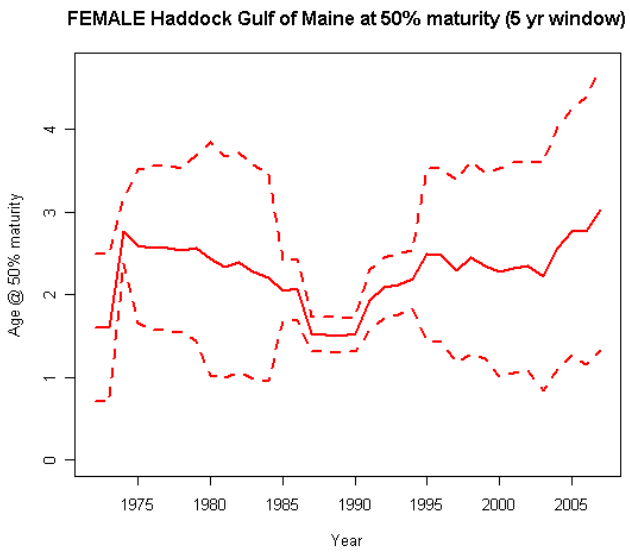
R. Stock overview - size at age

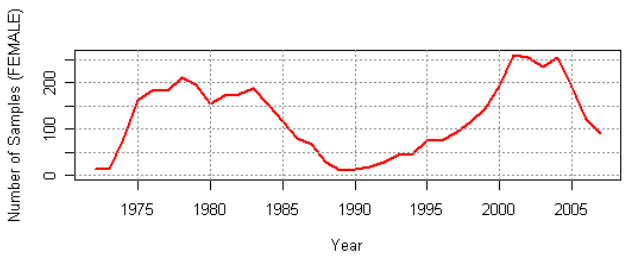
- Evidence of declining size at age (length and weight; O'Brien et al 2008)

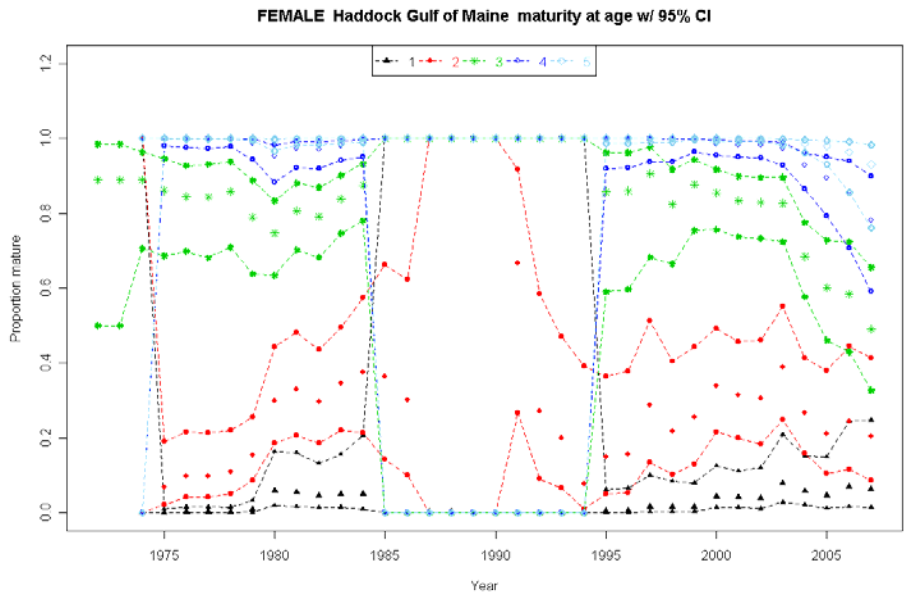


R. Stock overview - maturity ogive

- Used time series average







Age	Proportion mature (%)
0	0.00
1	0.03
2	0.25
3	0.80
4	1.00
5	1.00
6	1.00
7	1.00
8	1.00
9	1.00

R. VPA Results- diagnostics

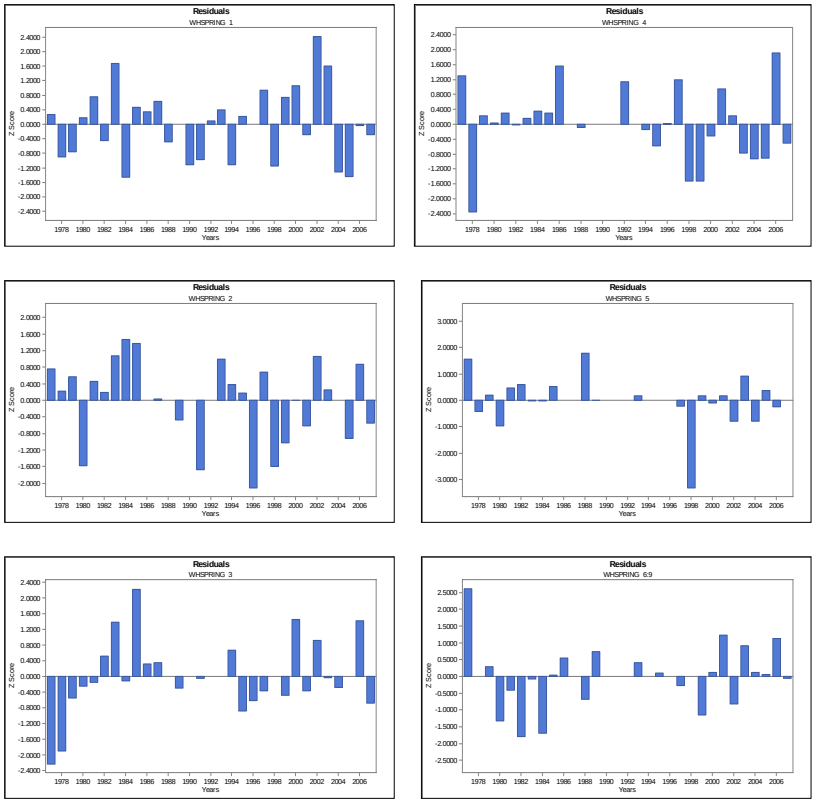
- Diagnostics were similar to previously accepted Georges Bank haddock assessments

VPA run description	1	12	2	5	9	10	11
Survey indices							
NEFSC Spring ages	1-9	1-6+	3-8		2-8	1-6	1,2,4,5,6
NEFSC Autumn ages (projected +1)	1-9	1-8+	1-8	1-9	2-8	1-8	1-8
Discards							
1977 - 1988 hindcast	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1989 - 2006 estimates	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Recreational catch							
1981 - 2006 MRFSS	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Estimated ages in t+1	1-8	1-8	1-8	1-8	2-8	1-8	1-8
Diagnostics							
Sum of squares	355.5	311.8	256.0	204.5	258.1	306.8	288.8
Mean squared residuals	0.909	0.899	0.826	0.969	0.822	0.897	0.911
CV t+1, n1	0.69	0.69	0.93	1.01		0.69	0.69
CV t+1, n2	0.49	0.49	0.66	0.71	0.65	0.49	0.49
CV t+1, n3	0.40	0.40	0.47	0.58	0.46	0.40	0.44
CV t+1, n4	0.35	0.35	0.39	0.51	0.39	0.35	0.38
CV t+1, n5	0.41	0.41	0.43	0.53	0.47	0.41	0.41
CV t+1, n6	0.32	0.33	0.35	0.48	0.34	0.32	0.33
CV t+1, n7	0.49	0.57	0.48	0.72	0.48	0.56	0.58
CV t+1, n8	0.33	0.35	0.32	0.46	0.33	0.35	0.37
Min/max CV q NEFSC Spring	0.17 - 0.22	0.17 - 0.21	0.17 - 0.22		0.17 - 0.22	0.18 - 0.22	0.18 - 0.21
Min/max CV q NEFSC Autumn	0.13 - 0.33	0.13 - 0.28	0.13 - 0.29	0.13 - 0.33	0.12 - 0.29	0.13 - 0.29	0.13 - 0.29
2006 F4-8	0.23	0.22	0.22	0.27	0.25	0.23	0.23
Biomass							
2006 mean biomass	6136	7021	7677	7025	6509	6812	6336
2006 SSB	5291	6345	6560	5848	5798	6149	5777

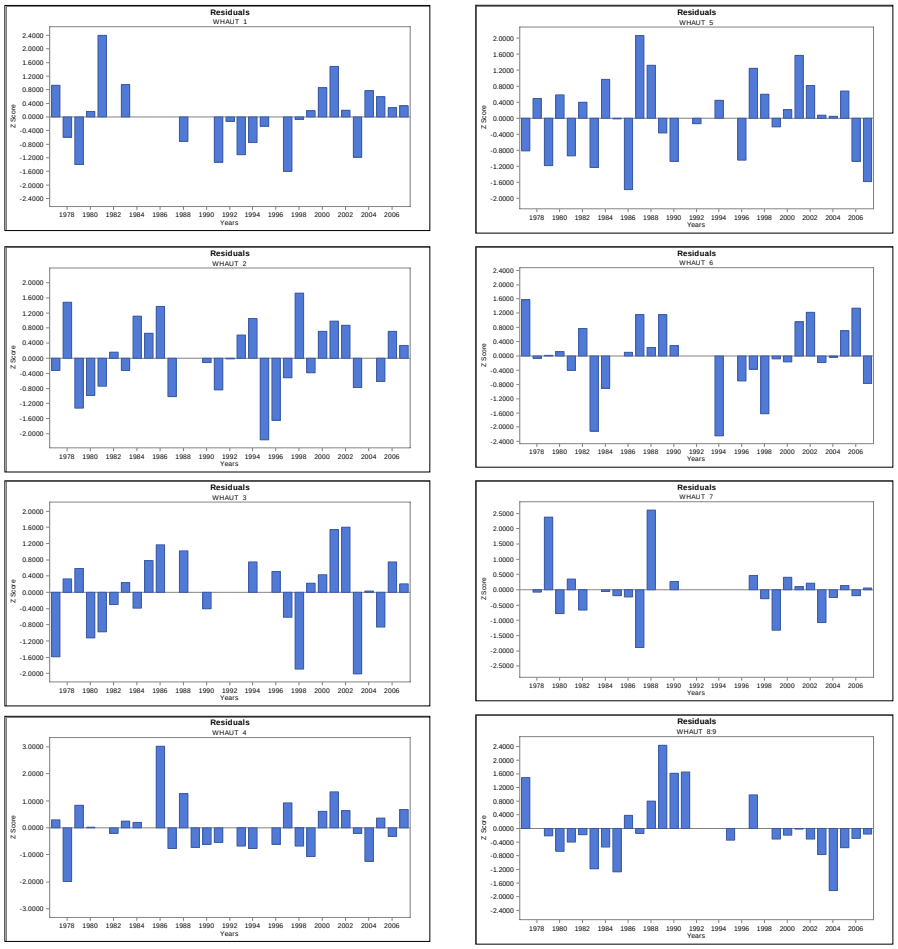
R. VPA Results (cont.) - residuals

- No strong residual patterns in the survey fits.

NEFSC Spring Ages 1 – 6:8^{+}

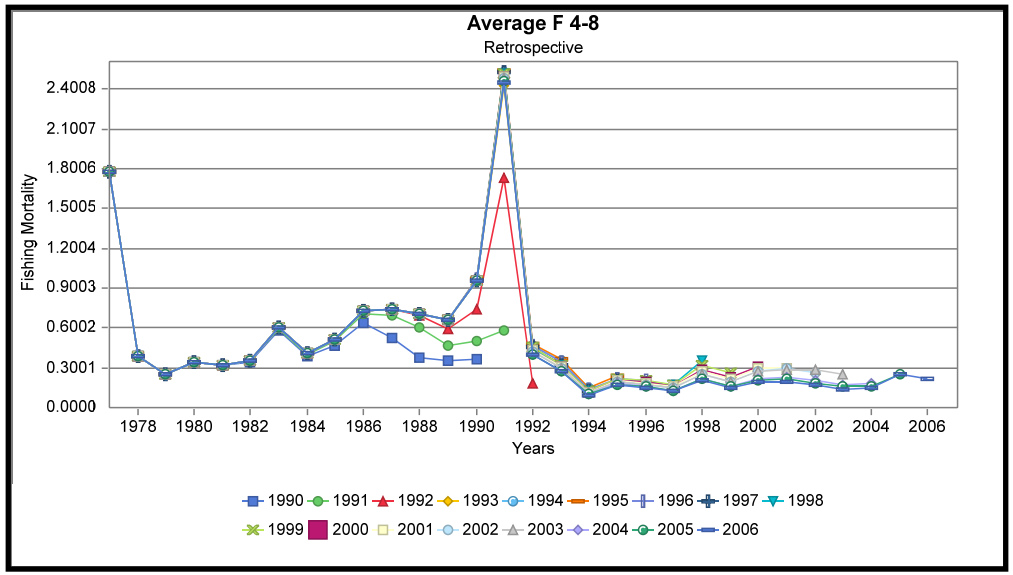


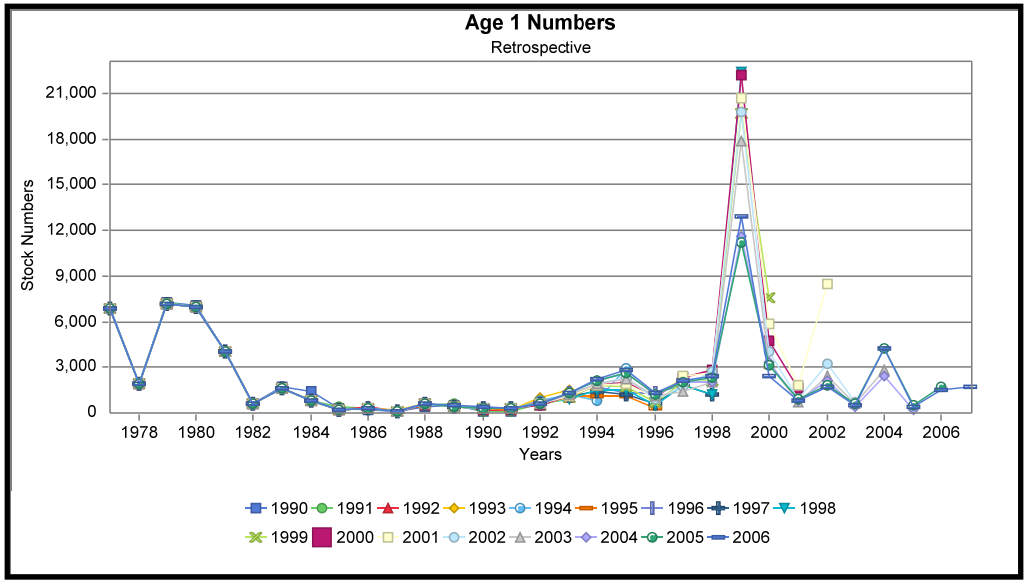
NEFSC Autumn Ages 1 – 8^{+}



R. VPA Results (cont.) – retrospective patterns

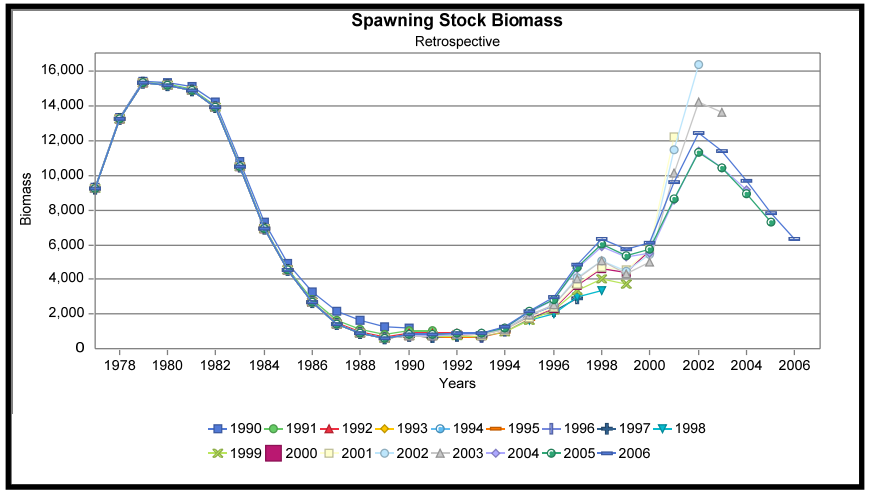
- No retrospective patterns evident in F or recruitment terminal estimates

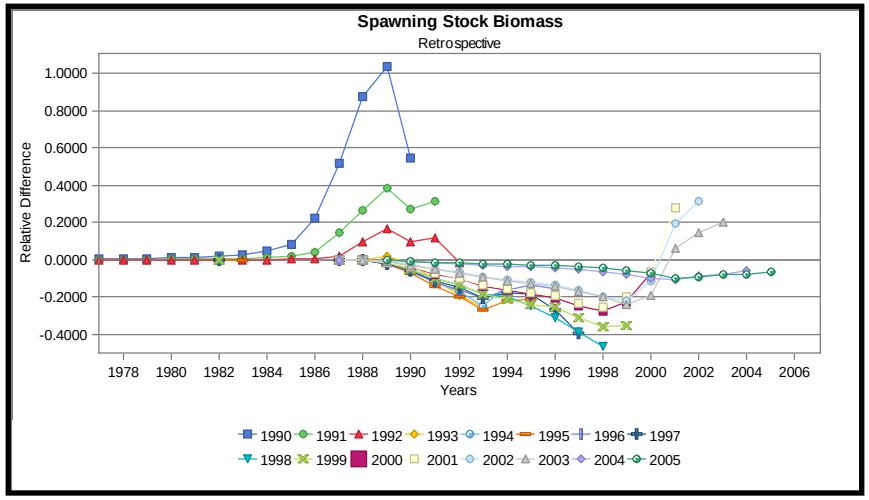


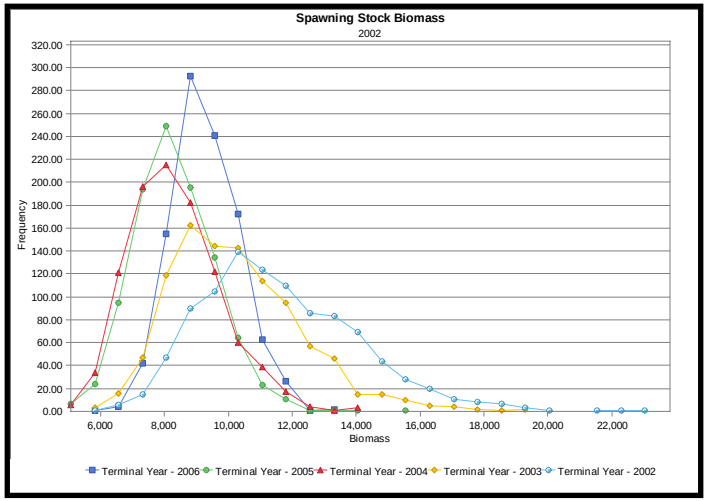


R. VPA Results (cont.) – retrospective patterns

- Weak retrospective pattern in spawning stock biomass terminal estimates
  - No separation of bootstrap distributions

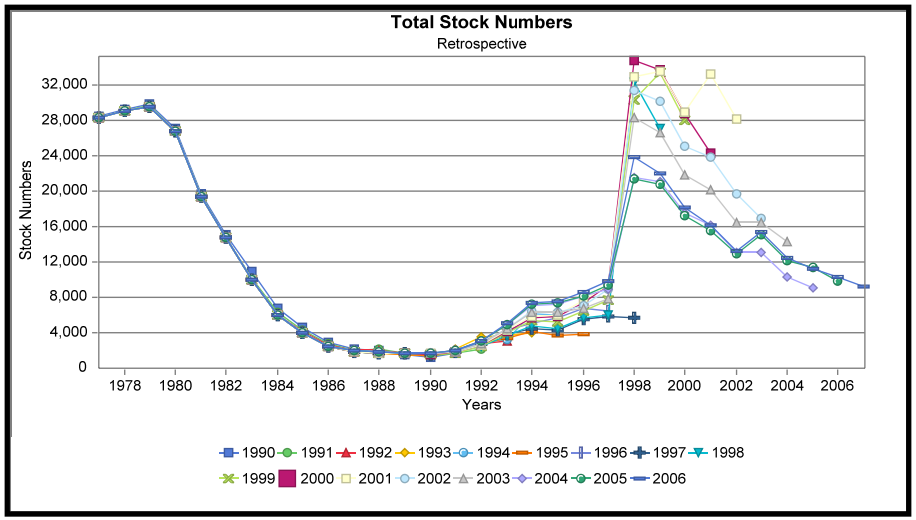


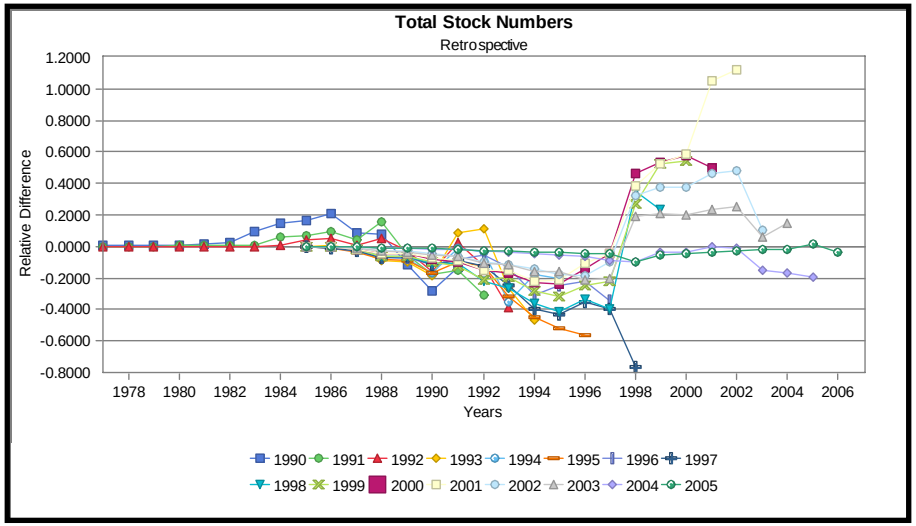


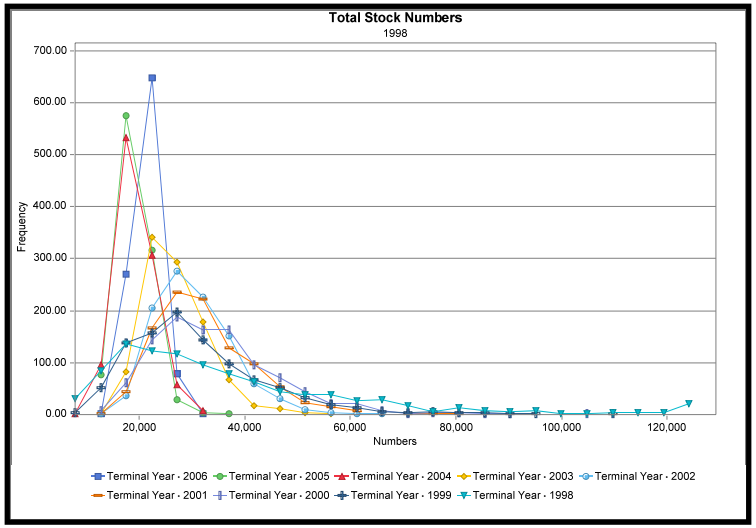


R. VPA Results (cont.) – retrospective patterns

- Weak retrospective pattern in stock number terminal estimates
  - No separation of bootstrap distributions

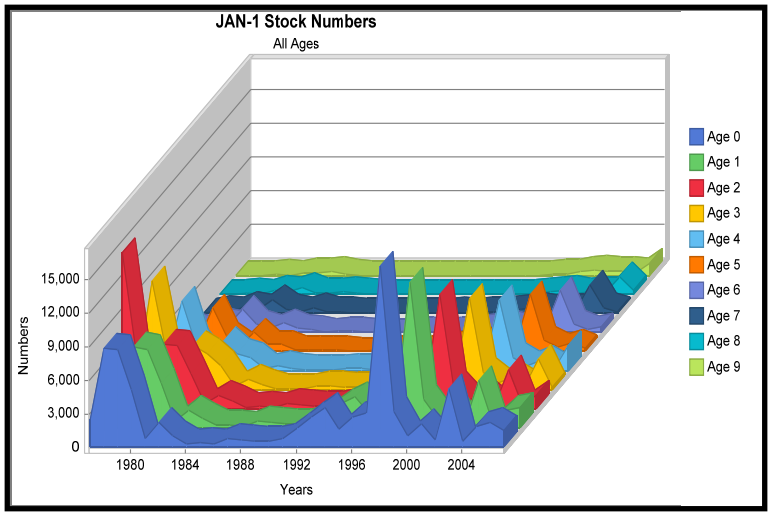


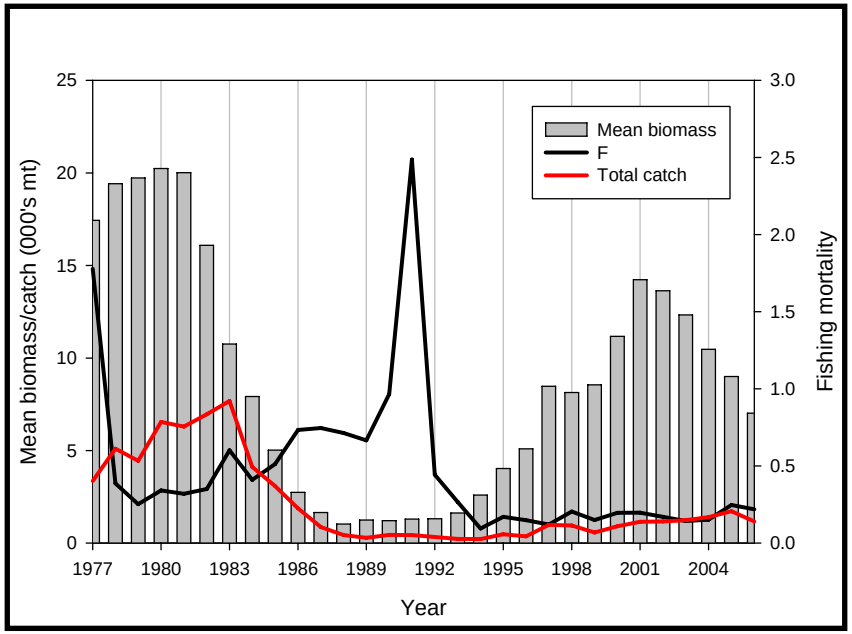


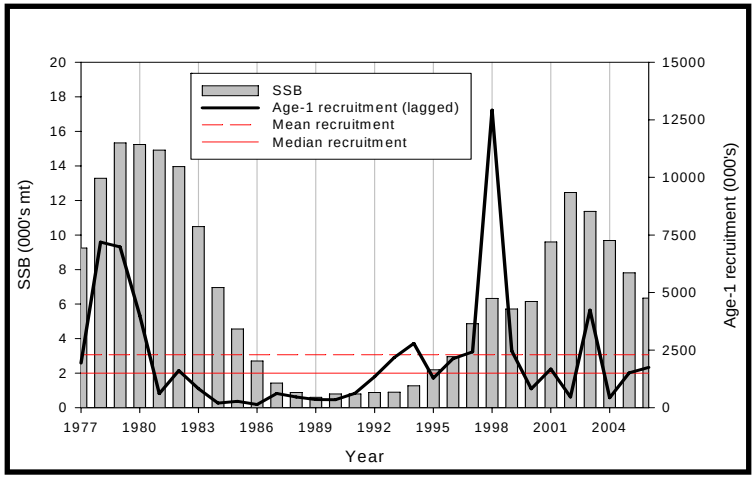


R. VPA Results (cont.) – general trends

- Several strong/moderate cohorts have progressed through the population between 1977 and 2006
- Maturation of these cohorts has driven spawning stock biomass
- Landings and fishing mortality (F) have remained relatively constant since 2001

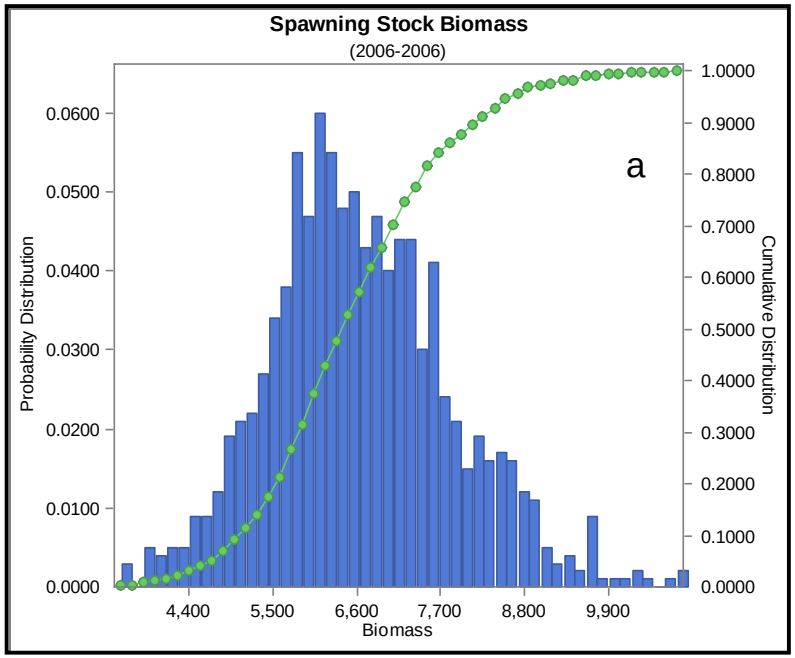


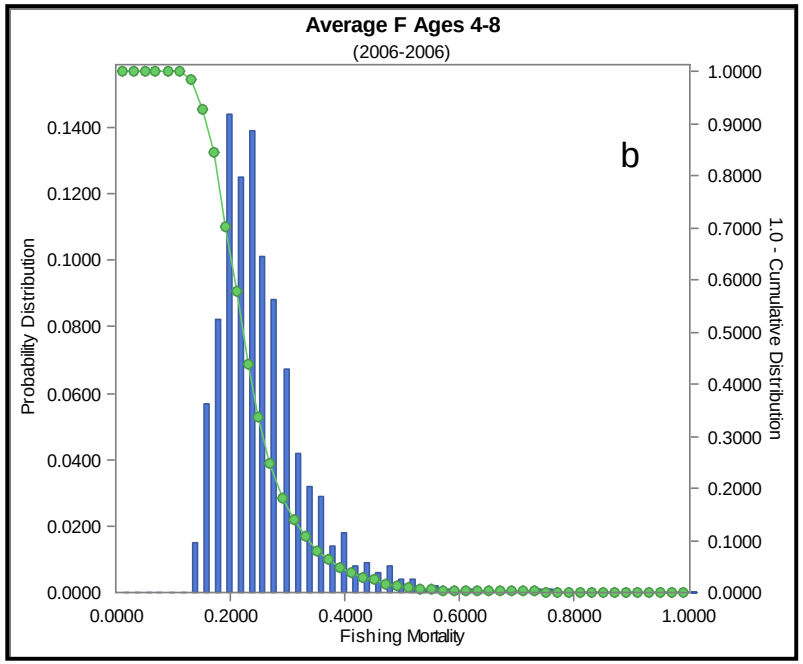




R. VPA Results (cont.) – SSB and F terminal estimates

- 2006 SSB = 6,345 mt
  - 80% CI = 5,102 mt – 8,193 mt
- 2006 $F_{4\text{-}8}$ = 0.219
  - 80% CI = 0.168 – 0.344





R. BRPs – Biological parameters

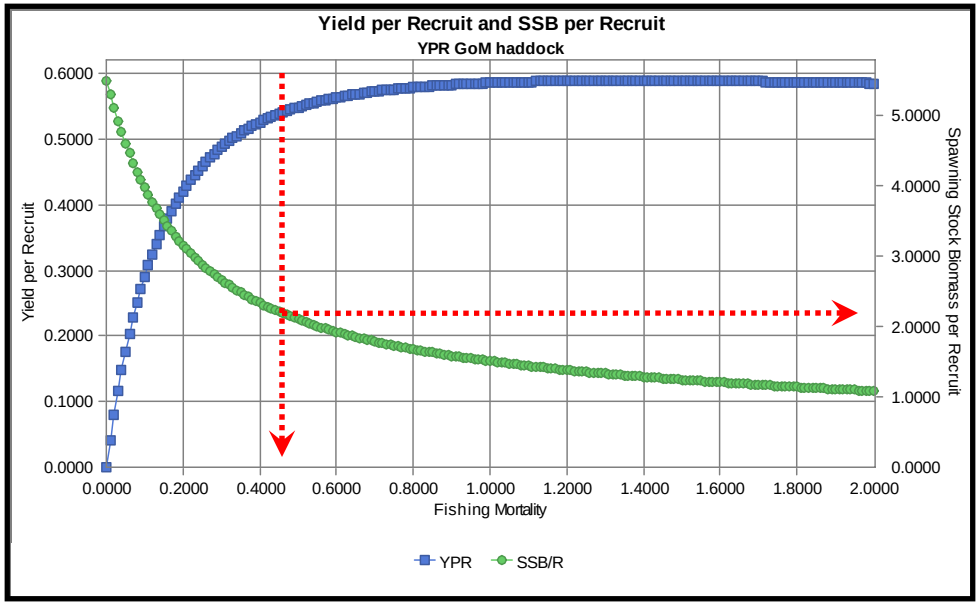
- Estimate input vectors needed for calculation of BRPs
  - Partial recruitment, catch weight at age, spawning weight at age, maturity at age, etc.
- Evidence of a decreasing trend in fish size, no clear evidence of trend in maturity
- Used average from 2002 to 2006 for all vector inputs with exception of maturity at age (time series average)
- Natural mortality assumed constant across ages (0.2)

Age	Fishery selectivity	Selectivity on natural mortality	Stock weights (kg)	Catch weights (kg)	Spawning stock weights (kg)	Proportion mature (%)
1	0.011	1.0	0.080	0.142	0.080	0.030
2	0.016	1.0	0.280	0.486	0.280	0.250
3	0.062	1.0	0.682	0.890	0.682	0.800
4	0.208	1.0	1.033	1.174	1.033	1.000
5	0.647	1.0	1.402	1.510	1.402	1.000
6	1.000	1.0	1.670	1.808	1.670	1.000
7	1.000	1.0	1.943	2.070	1.943	1.000
8	1.000	1.0	2.159	2.186	2.159	1.000
9	1.000	1.0	2.385	2.413	2.385	1.000

R. BRPs – non-parametric determination (YPR/SSPR)

- $F_{40\%}$ = 0.454 ($F_{.1}$ = 0.319, F_{max} = 1.373), YPR = 0.540 kg, SSB/R = 2.120 kg
  - Median age 1 recruitment (1977 – 2006) = 1.5 million fish
    - SSB_{MSY} = 3,180 mt, MSY = 810 mt
  - Mean age 1 recruitment (1977 – 2006) = 2.3 million fish
    - SSB_{MSY} = 4,880 mt, MSY = 1,240 mt
- Median values from AgePro Projection w/ $F_{40\%}$ harvest (cdf of 1977 – 2006 age 1 recruitment):
  - SSB_{MSY} = 4,000 mt, MSY = 900 mt

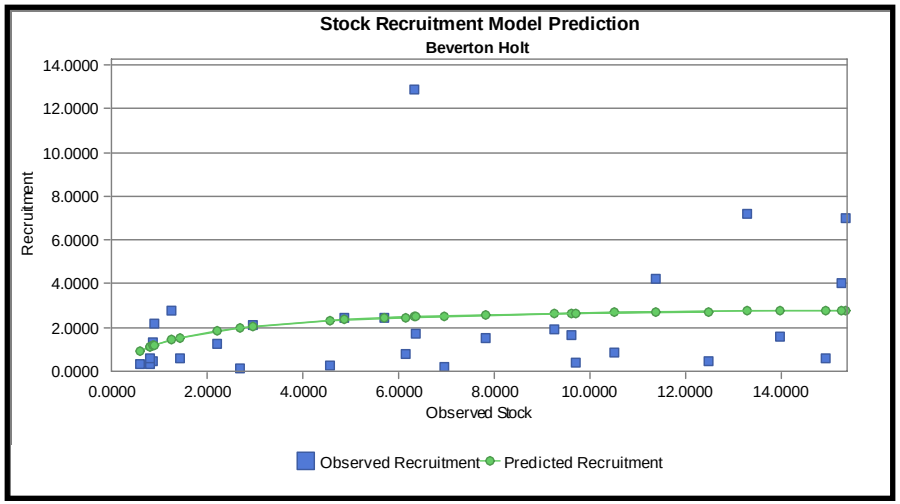
YPR = 0.540

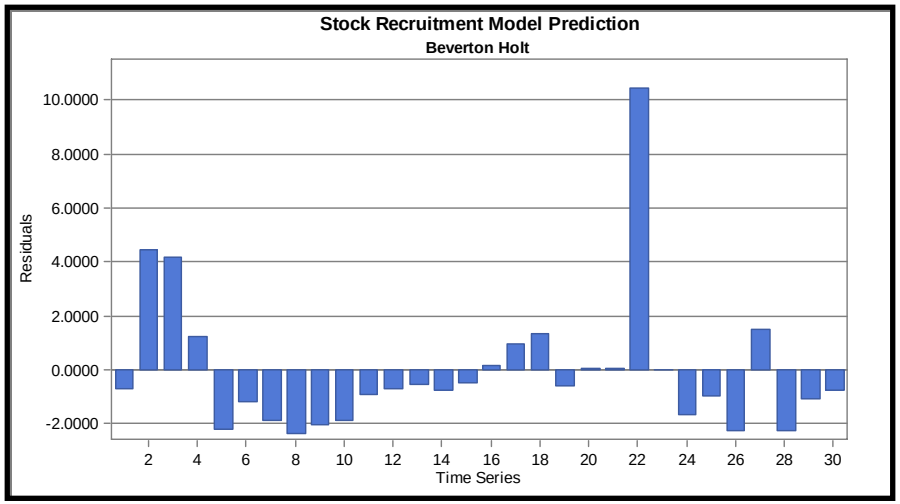


SSB/R = 2.120

R. BRPs – Parametric determination (stock recruit)

- Beverton-Holt fit (alpha = 3.047, beta = 1.415, steepness = 0.754, sigma = 1.031)
  - Poor fit to observed data, strong residual pattern, large sigma
- F_{MSY} = 0.545, SSB_{MSY} = 4,720 mt, MSY = 1,300 mt
- Median values from AgePro Projection w/ F_{MSY} harvest:
  - SSB_{MSY} = 7,500 mt, MSY = 2,040 mt





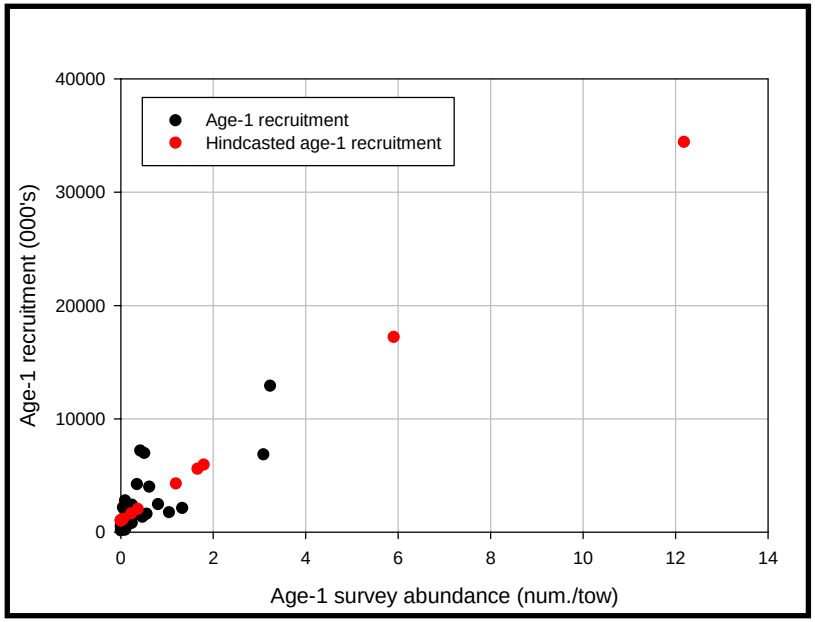
R. Projection recommendations

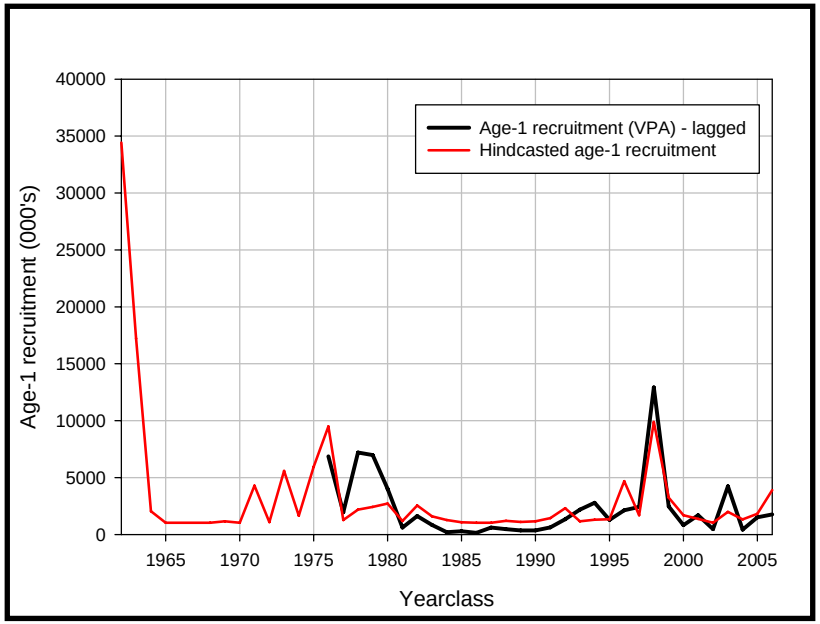
- Mean weights at age (catch and stock): 2002 – 2006
- Fishery selectivity (PR): 2002 – 2006
- Natural mortality: constant across ages (0.2)
- Maturity at age: single time series of female MAA from NEFSC spring survey
- AGEPRO projection using non-parametric YPR $F_{40\%}$, CDF of recruitment series
    - What recruitment to use?

	AIM		VPA			
BRP	**GARM 2002**	**GARM 2008**	**Non-parametric (YPR) (mean recruitment)**	**Non-parametric (YPR) w/ stochastic projection (AgePro)**	**Parametric (SR)**	**Parametric (SR) w/ stochastic projection (AgePro)**
SSBMSY	11.09 kg/tow	10.98 kg/tow	4,880 mt	4,000 mt	4,720 mt	7,500 mt
FMSY	0.23	0.23	0.454	0.454	0.545	0.545
MSY	5,100 mt	5,100 mt	1,240 mt	900 mt	1,300 mt	2,040 mt

R. Recruitment series

- If hindcast age 1 recruitment using NEFSC autumn survey numbers at age index there would be two YCs of larger magnitude than observed in the 1977 – 2006 time series





BRP	Empirical stochastic (AgePro)	Empirical stochastic (AgePro)	Empirical stochastic (AgePro)	Empirical stochastic (AgePro)
Recruitment	**1977 - 2006**	**1977 - 1985, 1997 - 2006 (exclude recruitment where SSB < 3000 mt)**	**1963 - 2006**	**1963 - 2006 (exclude 1962, 1963, 1998 YC)**
SSBMSY	4,000 mt (2,280 - 7,260)	5,260 mt (2,940 - 8,850)	5,520 mt (2,840 - 12,450)	4,180 mt (2,450 - 6,690)
FMSY	0.454	0.454	0.454	0.454
MSY	900 mt (510 - 1680)	1,180 mt (660 - 2073)	1,250 mt (640 - 2,790)	930 mt (550 - 1,560)