SEDAR 41 – South Atlantic Red Snapper

Review Workshop

Day one

March 15th, 2016

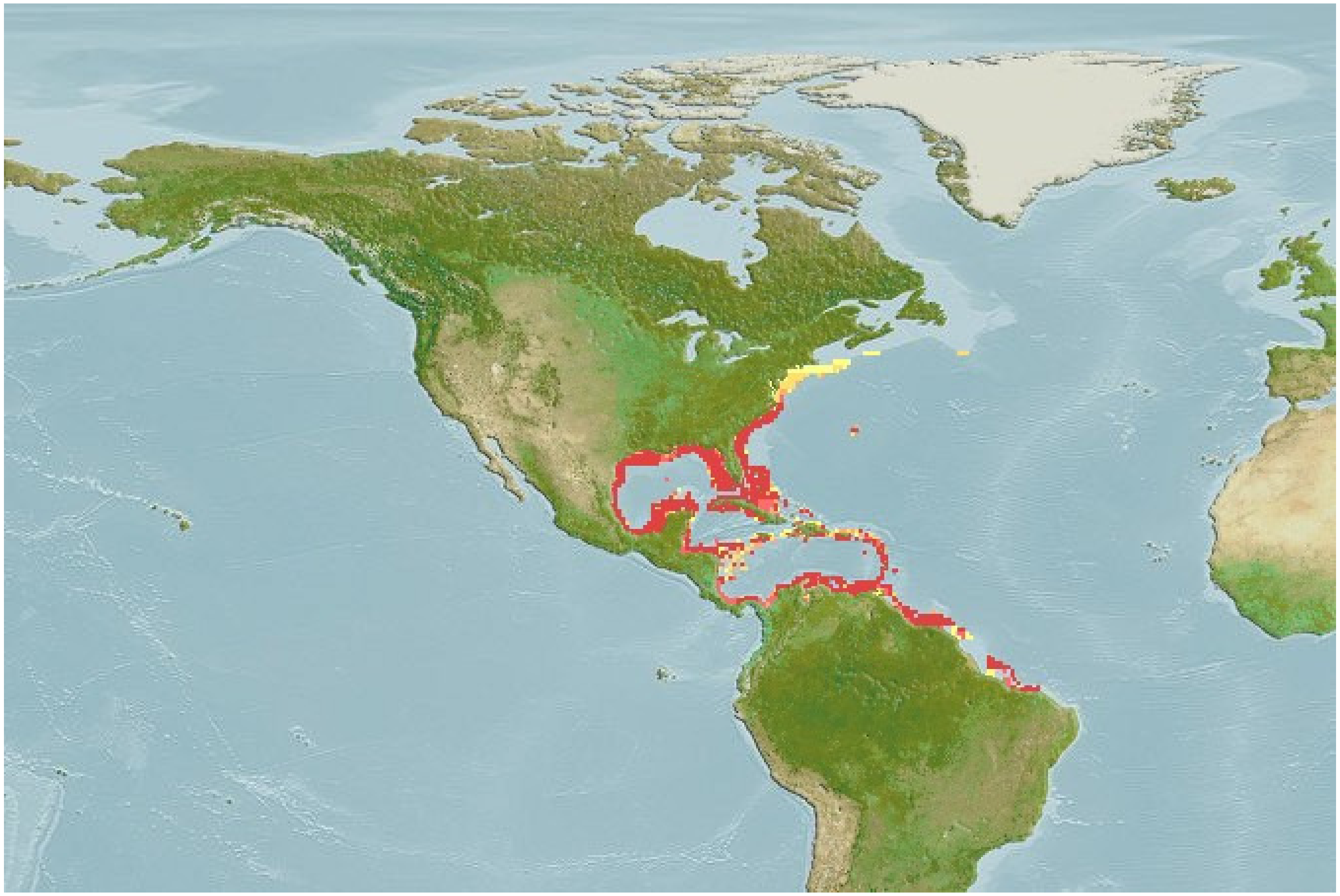
NOAA FISHERIES

Sustainable Fisheries Branch, Beaufort, NC

Outline

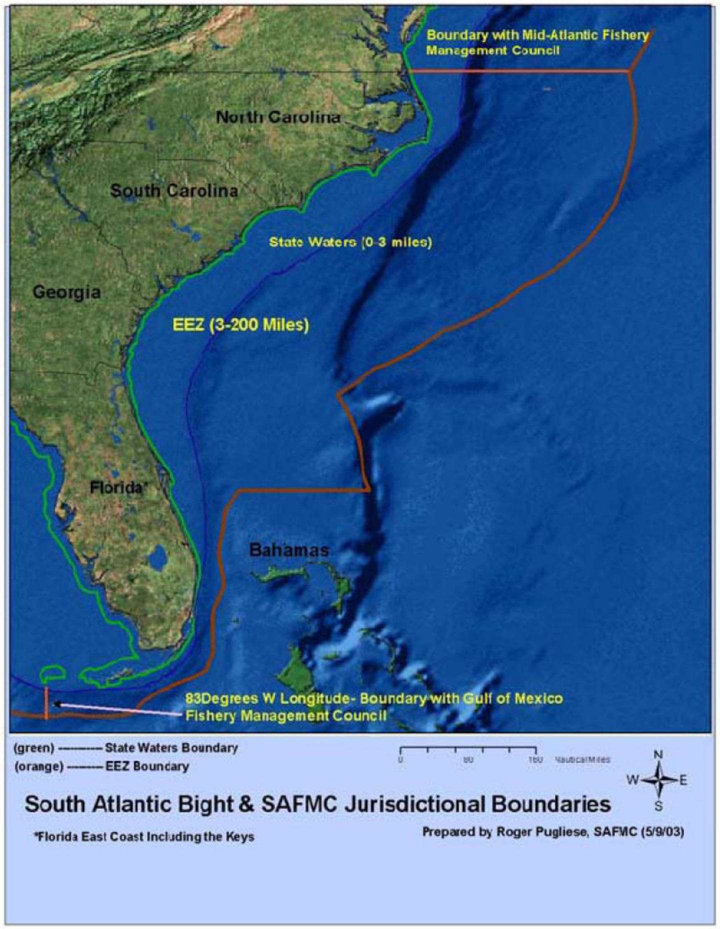
- Data Review
  - Stock definition
  - Life history
  - Removals
  - Compositions
  - Indices of abundance
  - Supplementary analyses
    - Catch curves
    - ASPIC
- Catch-age model
  - Base run
  - Sensitivities
  - Uncertainty analysis
- Projections

Stock definition



Regulations and Jurisdiction

- 1983 – 12" TL min size limit
- 1992 – 20" TL min size limit
- 2010 – moratorium with mini-seasons during which there was no minimum size limit.
  - 2012 – Two 3-day weekends
  - 2013 – One 3-day weekend
  - 2014 – Two 3-day weekends and One 2-day weekend.



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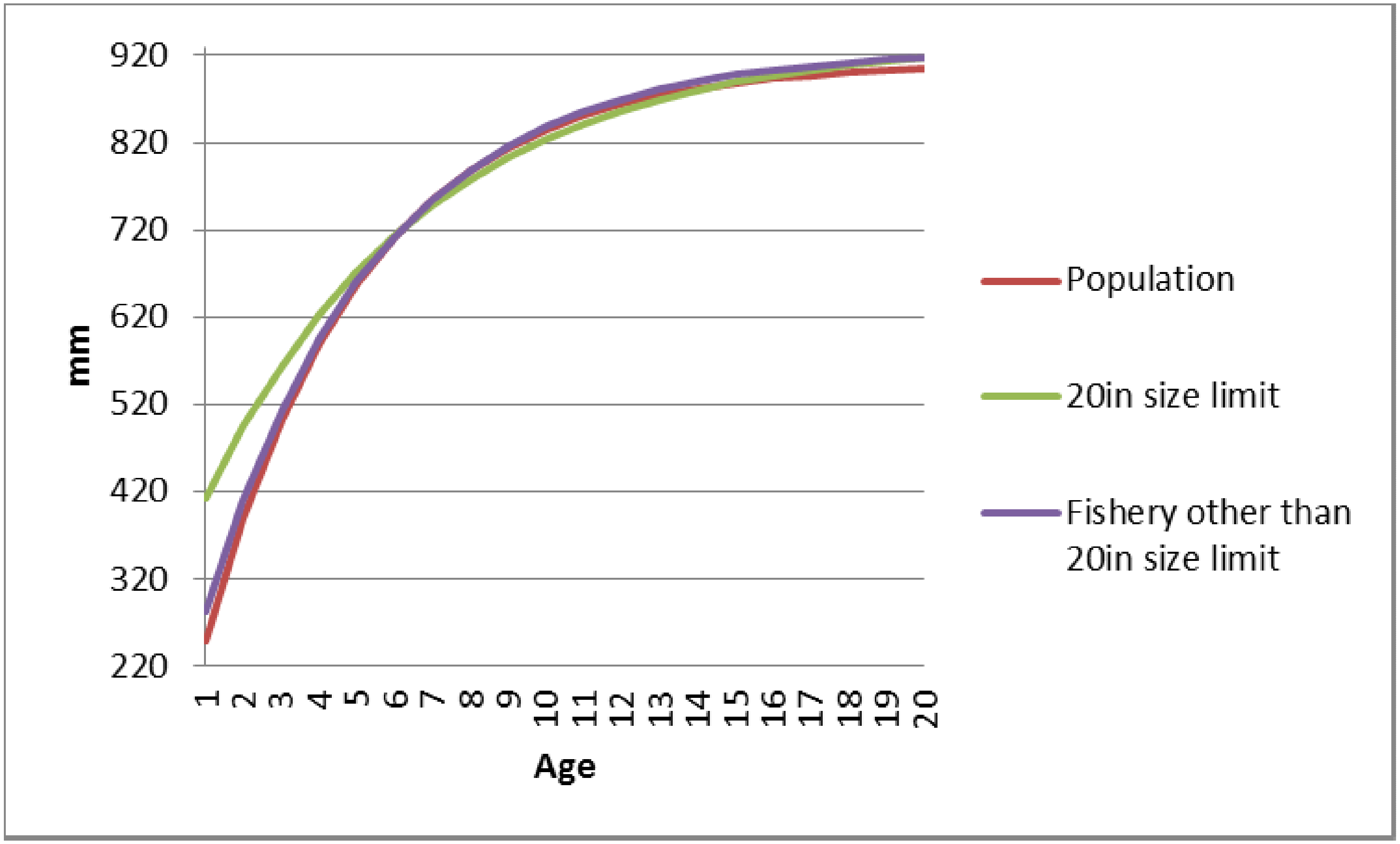
Life history

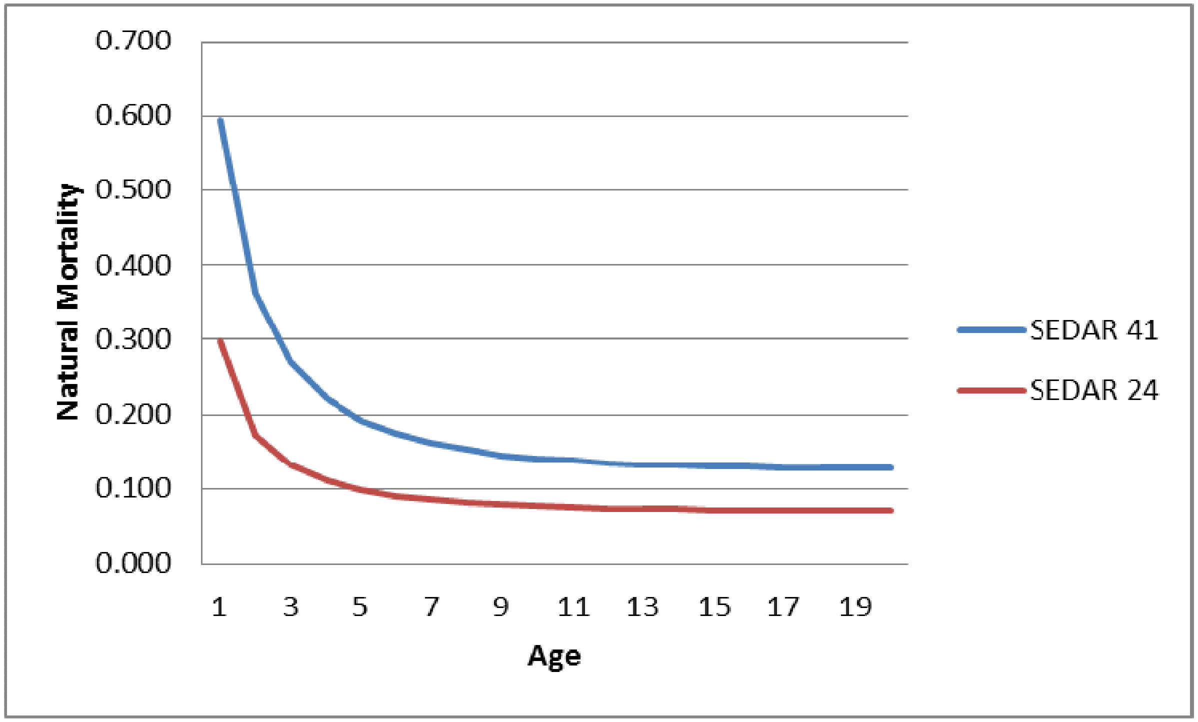
- Three growth curves were used:
  - Population growth curve – all data
  - 20” growth curve – fishery samples during 20” minimum size limit.
  - Fishery growth curve – fishery samples taken outside of the 20” minimum size limit.
- Growth curves were estimated external to the model and used as input.

Life History Data - growth curves



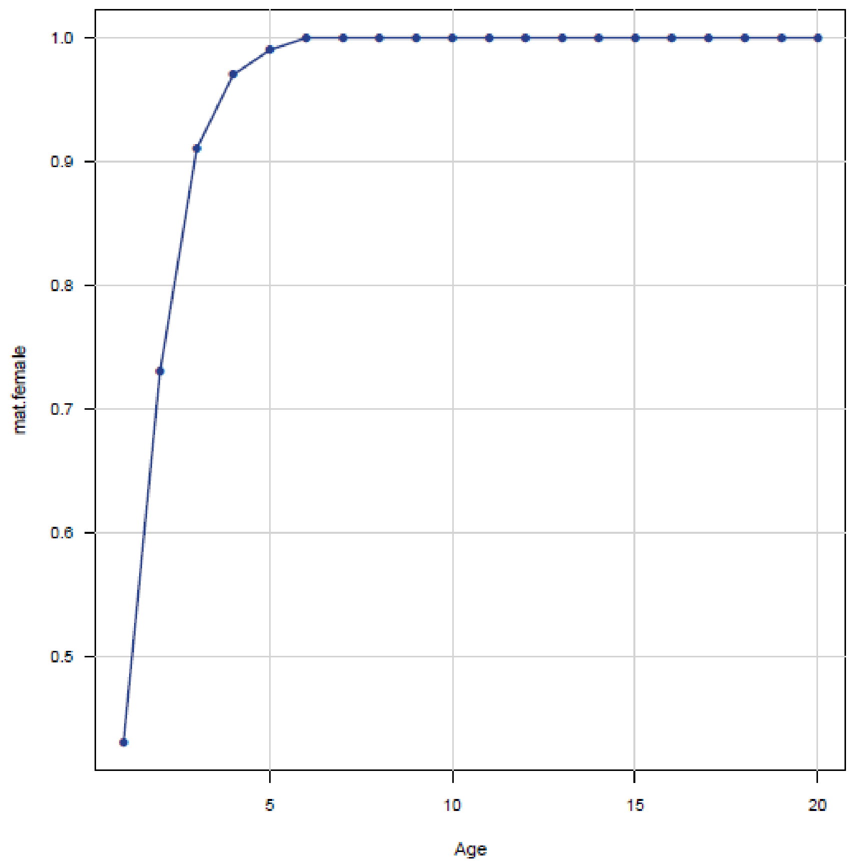
Life history – natural mortality

- Age-based method of Charnov et al. (2013) scaled to the Then et al. (2014) estimate using the maximum age of 51.



Life history - reproduction

- 50:50 sex ratio
- Logistic model for female maturity.
- Spawning season April-October, peak in mid-summer.
- Age-specific number of batches and batch fecundity.
- Spawning biomass is modeled as population fecundity.



Discard Mortality

Sector	Pre-Regulation	Range	Post-Regulation	Range
Recreational	37%	(27%-45%)	28.50%	(20%-36%)
Commercial	48%	(38%-58%)	38%	(28%-38%)

Set up 2 time blocks (for recreational: pre-2011 and 2011-2014, for commercial: pre-2007 and 2007-2014) when calculating dead discards.

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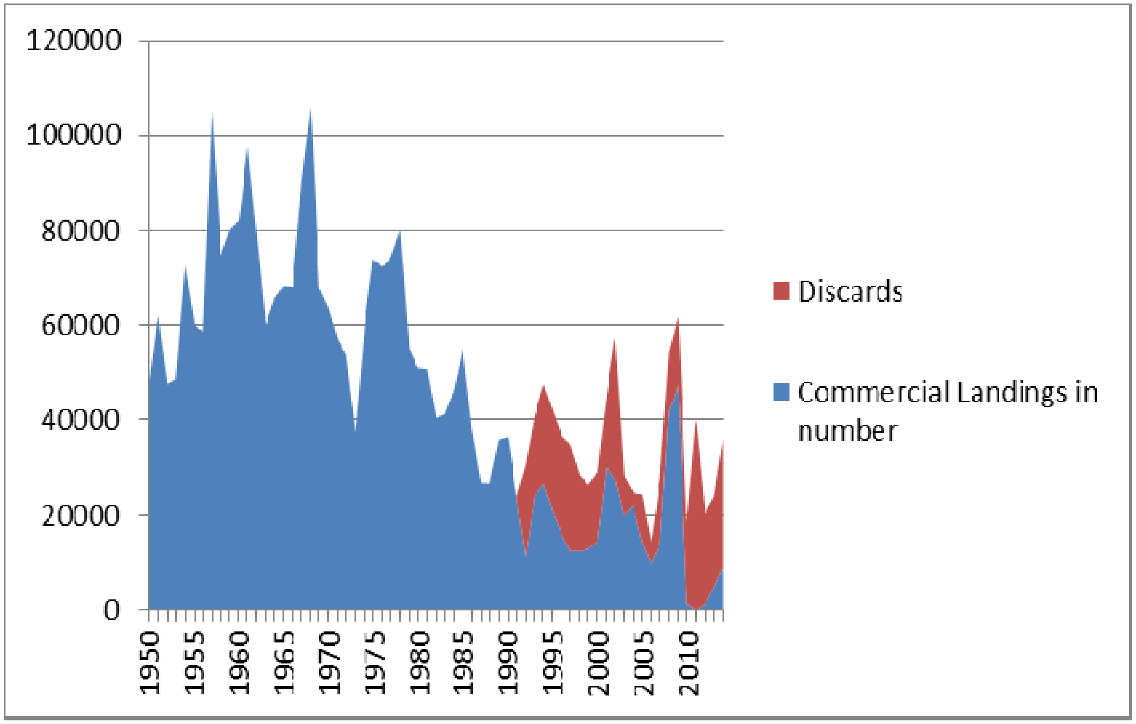
Removals

- At the DW, handline and diving landings were separated for comparison purposes.
- A plenary decision to lump them was made because diving was such a small proportion of the total commercial landings (~7%).
- The biological samples would not be lumped, only landings.

Commercial Landings and Discards

*2011 landings data omitted due to confidentiality

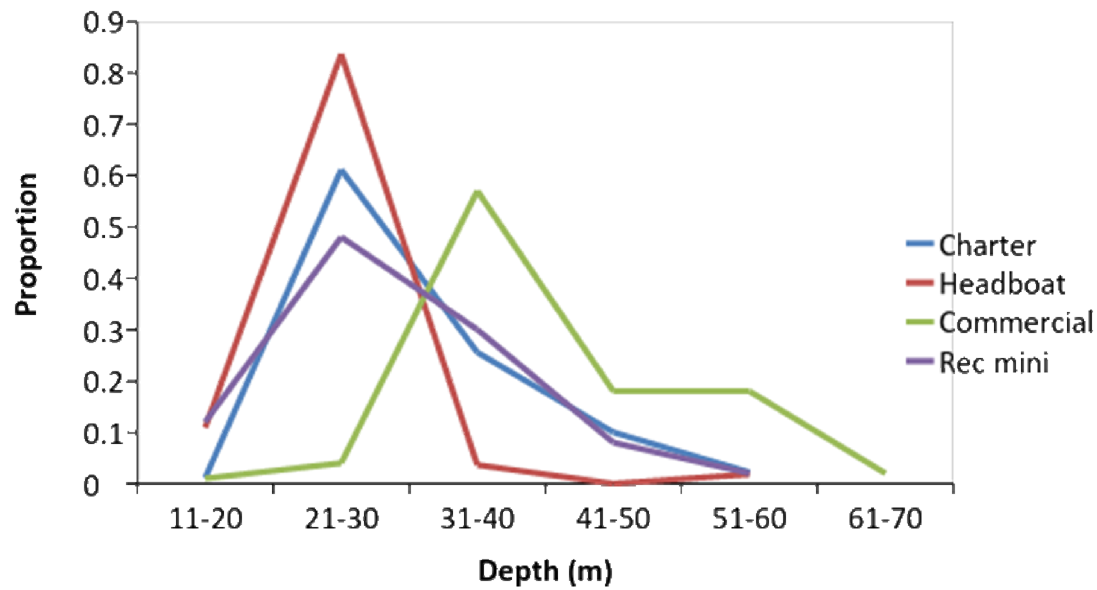
- Complete landings start in 1950. Before 1950, the majority of the data are imputed.
- Discards are available beginning in 1992.

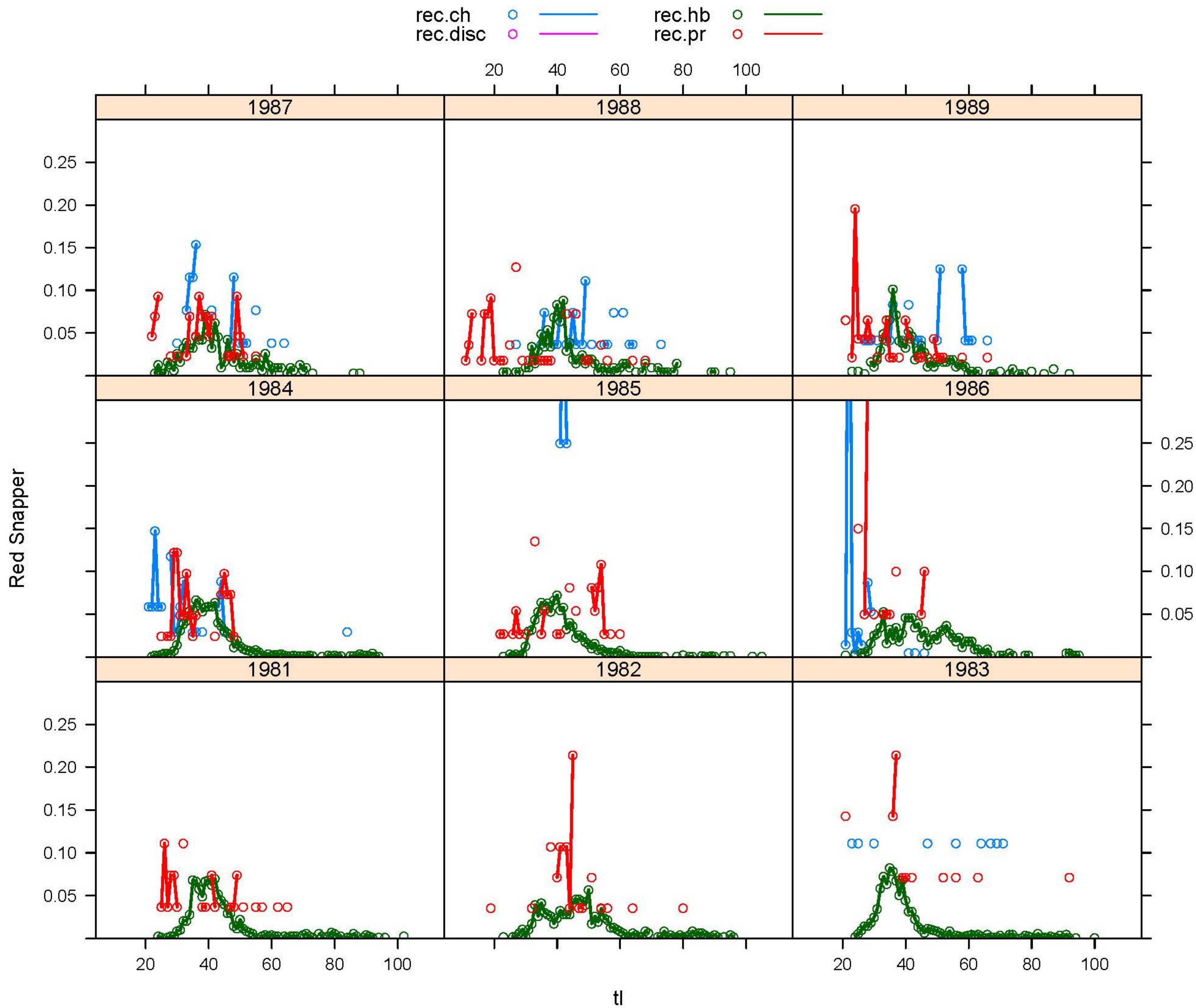


  - Estimates are generated using a discard rate from 2002-2009 to inform 1992-2001. Assumes negligible discarding due to 1983 minimum size regulation.

Recreational Fleets

- Landings and discards are provided by Headboat, Charter, and Private boat modes from 1981 to present.
- Historical landings are not split out by mode.
- Appear to be differences in the depth fished between HB and other MRIP Modes.




rec.ch
rec.disc
rec.hb
rec.pr
1987
1988
1989
1984
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Red Snapper
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0.10
0.05
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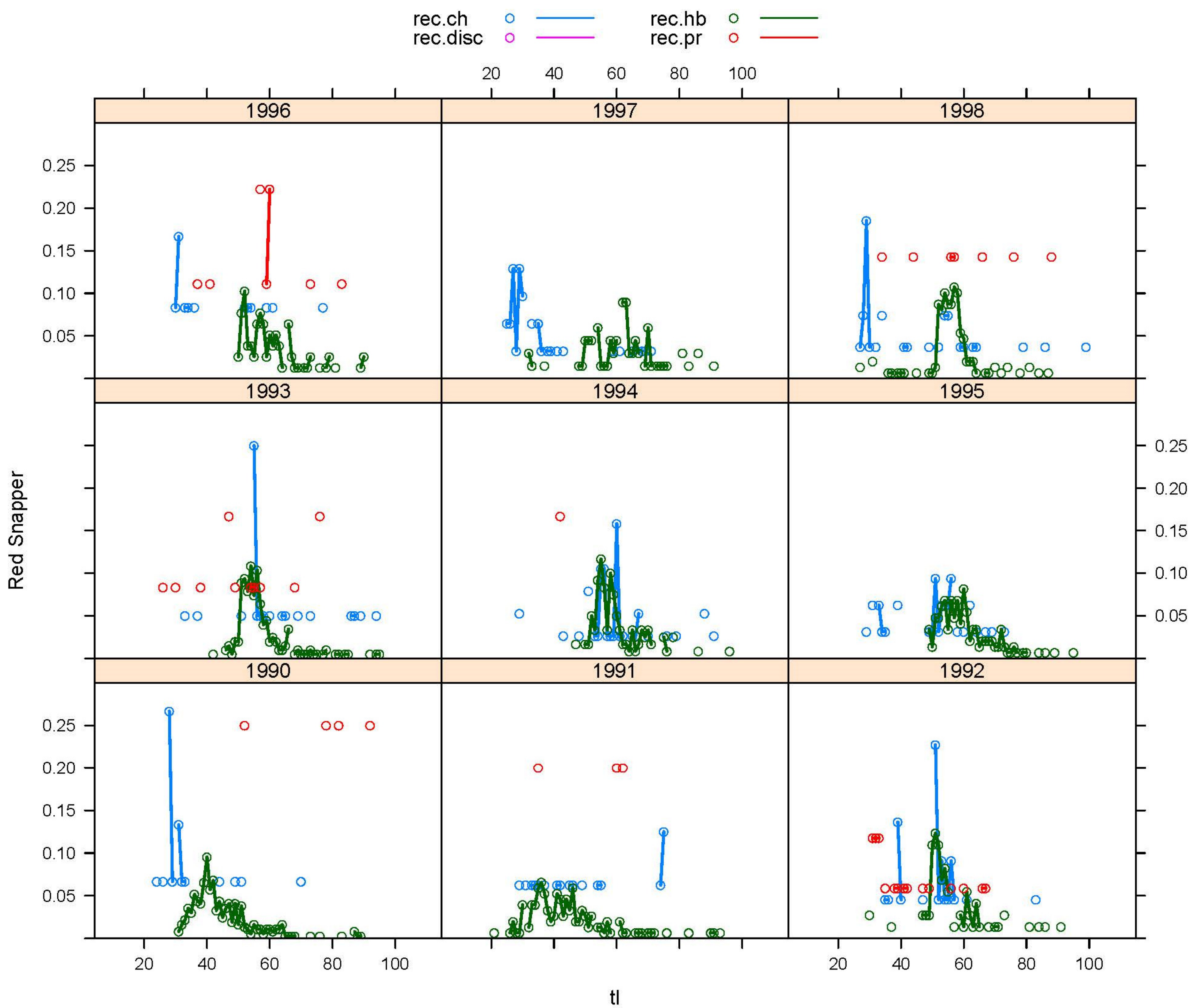
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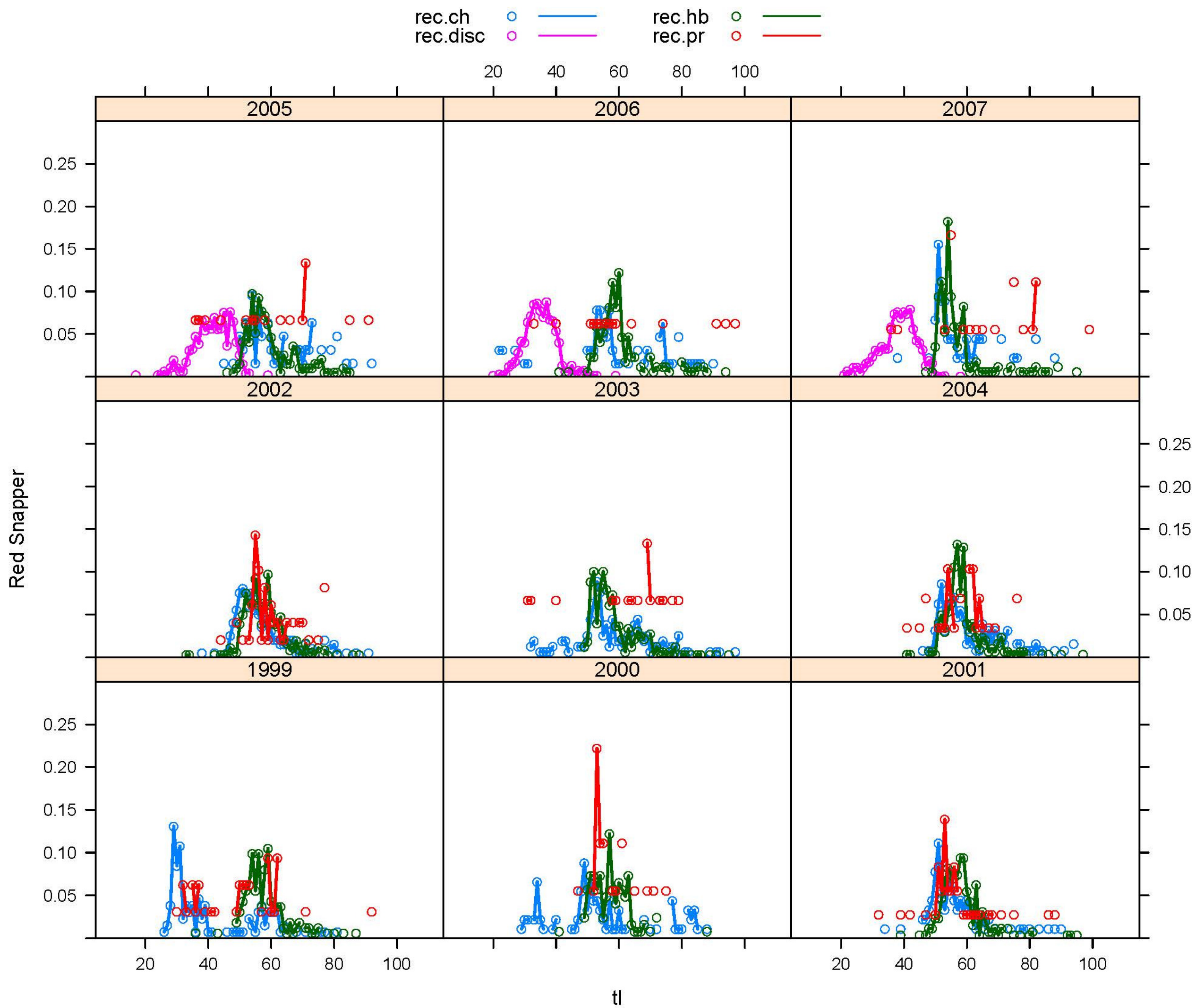
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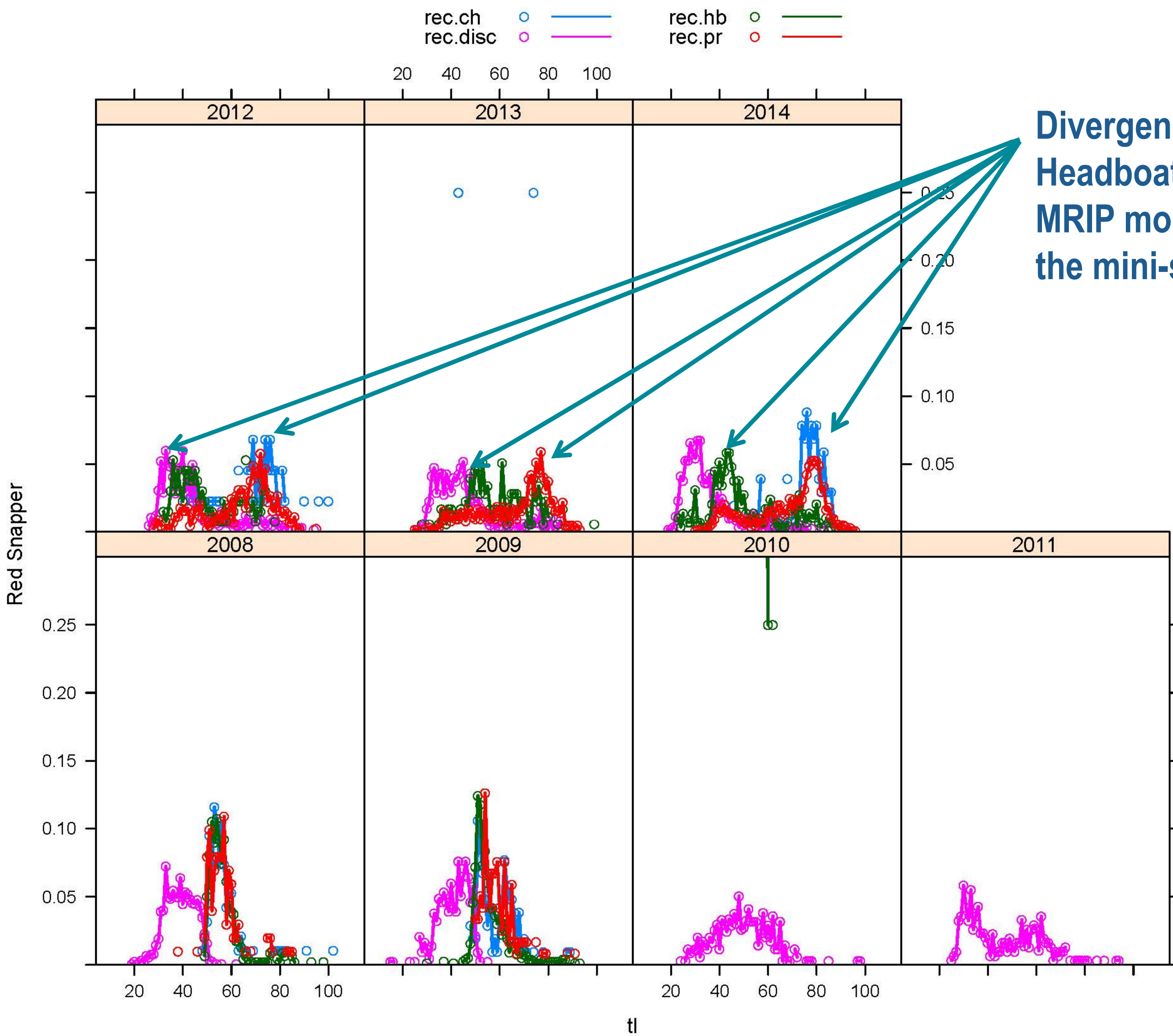
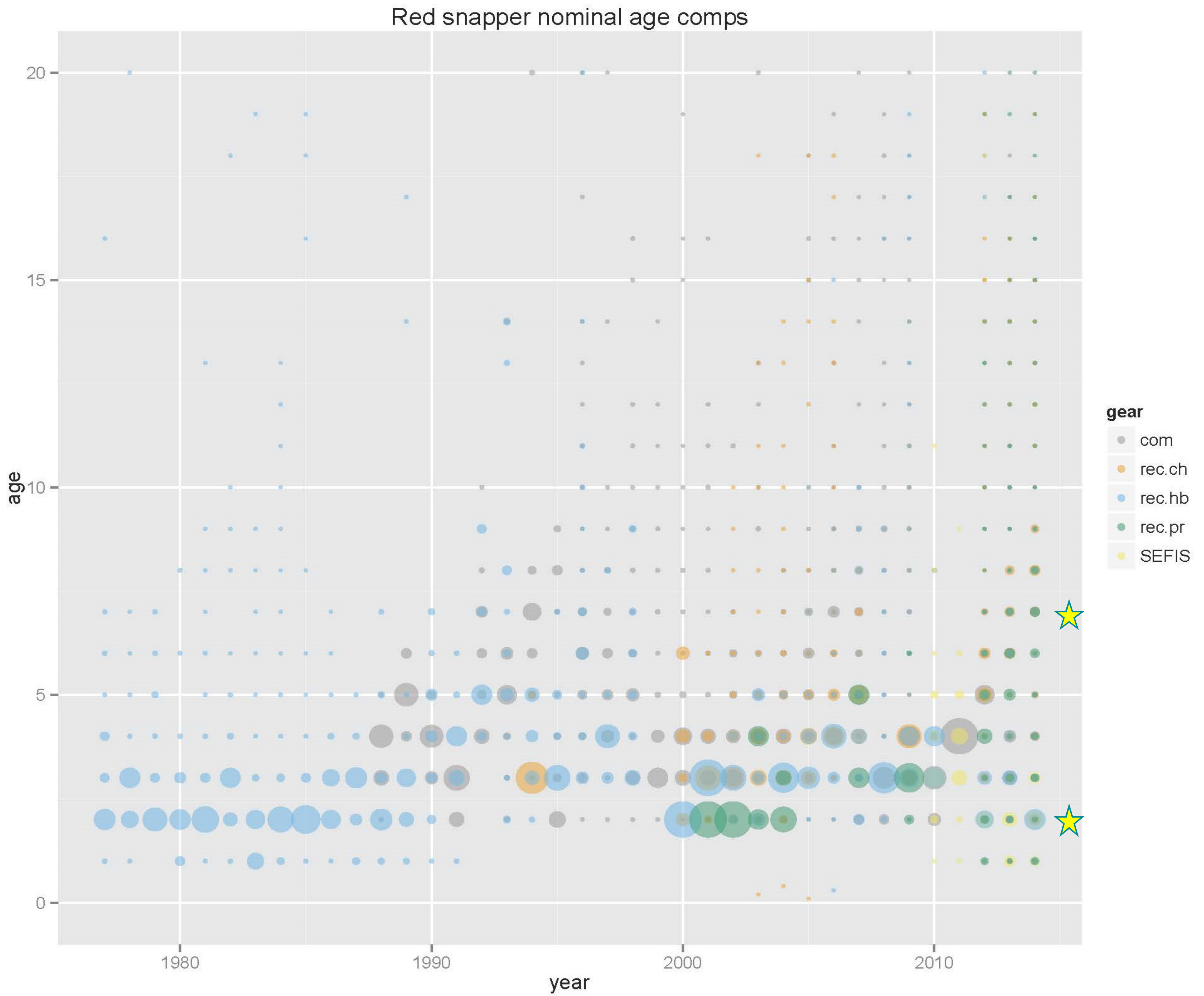


Divergence of the Headboat and other MRIP modes during the mini-seasons.

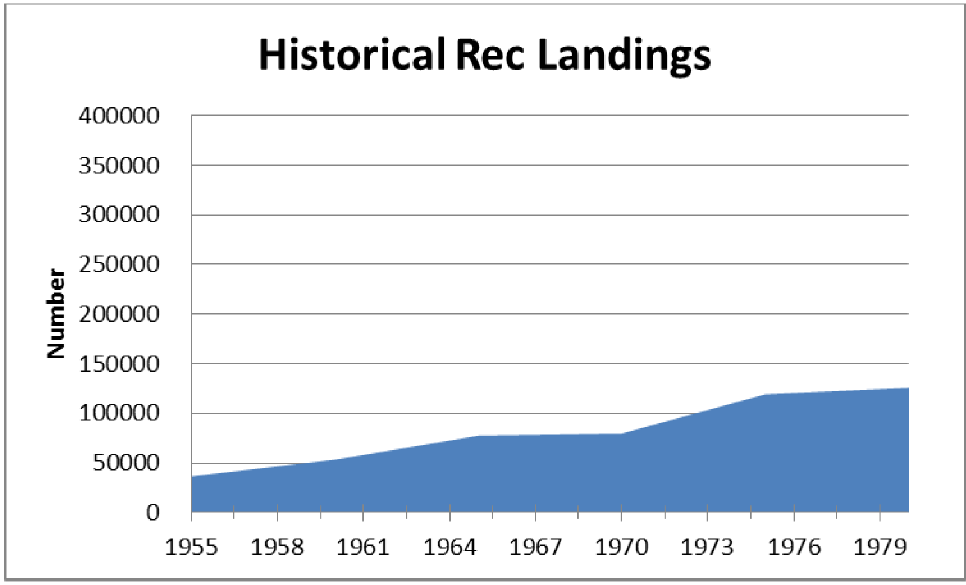


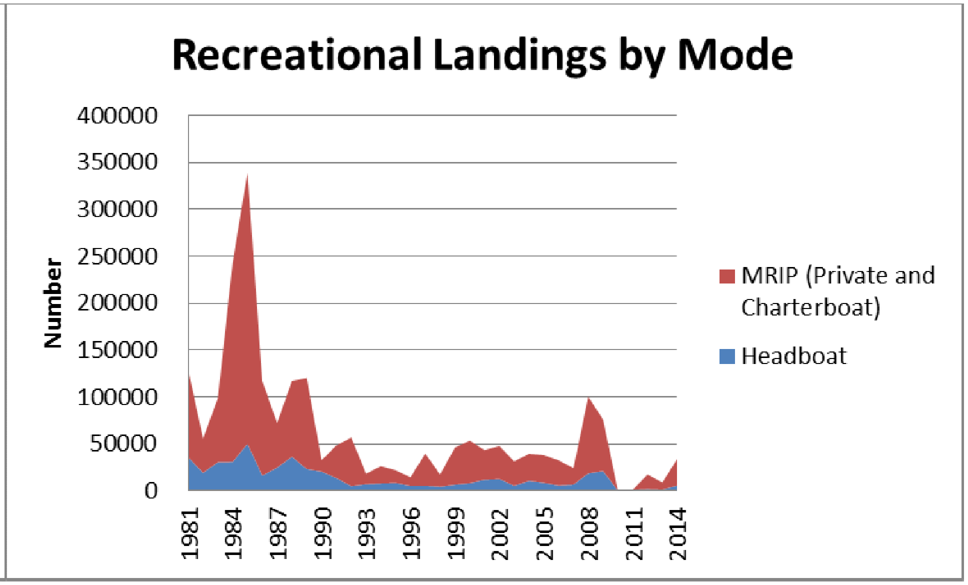
Red snapper nominal age comps
age
year
gear
com
rec.ch
rec.hb
rec.pr
SEFIS

Recreational data

- Recreational fleet groupings
  - The MRIP Charterboat and Private boat modes are grouped as one fleet.
  - Headboat stands alone as a fleet.
  - Different selectivities were applied during the moratorium time period.

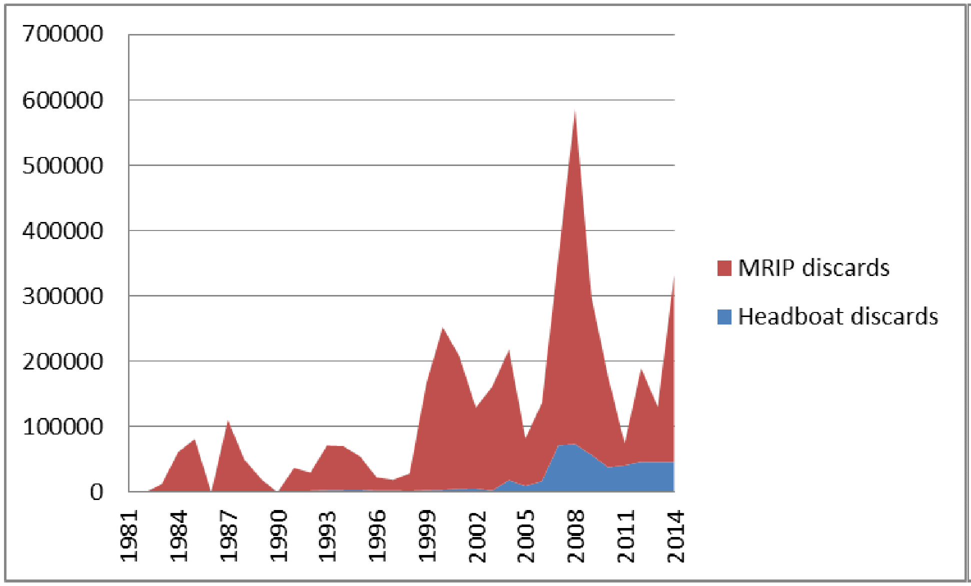
Recreational Landings

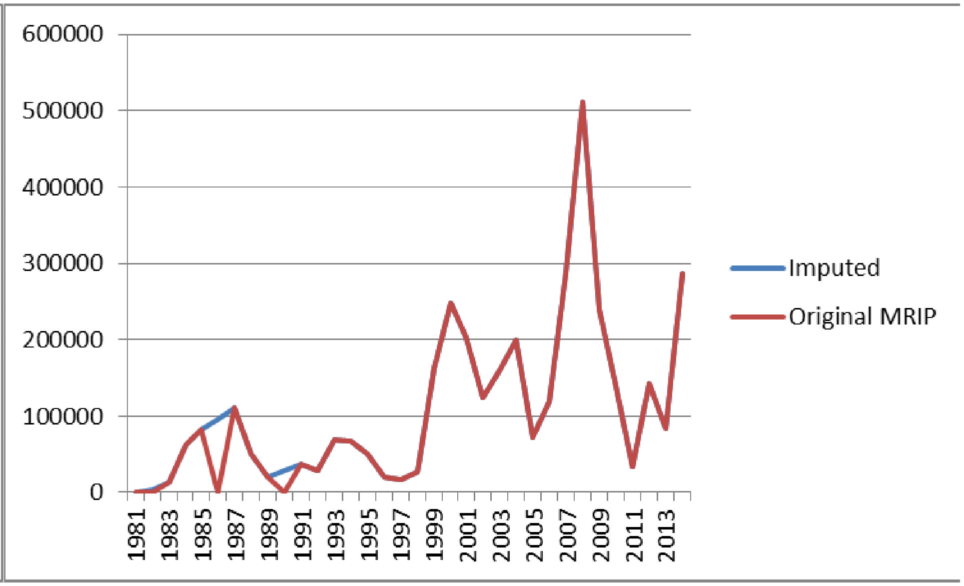




Historical recreational landings were not provided by mode.

Recreational Discards





- There are zeros in the time series (1982, 1986, and 1990) that are unlikely to be accurate given the surrounding years' values and that no regulation change occurred to cause a change.

Recreational discards

Years with zeros:

- Calculate the average of the year before and after zero and apply the average/3 for each of the three years. (loses year-to-year variation, but avoids creating data)

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Creating Weighted Compositions

- Use a 30 fish minimum per region (Carolinas, FL/GA) annually for length comps, and 10 fish per region annually for age comps.
  - These minimums prevent very small comp sample sizes to be scaled up by large landings.
  - Additional minimum trip numbers will be explored during model specification.
- Used comps from 1978 to present due to unrepresentative sampling before 1978.

Table 5. Sample sizes (number of trips) of length compositions (len) or age compositions (age) by survey or fleet. Data sources are commercial lines (cH), headboat (HB), headboat discard (HB.D), general recreational (GR),and MARMAP chevron trap (CVT).

Year	len.cH	len.cH.D	len.HB.D	age.cH	age.HB	age.GR	age.CVT
1978	.	.	.	.	80	.	.
1979	.	.	.	.	31	.	.
1980	.	.	.	.	30	.	.
1981	.	.	.	.	141	.	.
1982	.	.	.	.	55	.	.
1983	.	.	.	.	167	.	.
1984	125	.	.	.	166	.	.
1985	139	.	.	.	160	.	.
1986	94	.	.	.	97	.	.
1987	89	.	.	.	60	.	.
1988	84	.	.	.	.	.	.
1989	88	.	.	.	.	.	.
1990	63	.	.	11	23	.	.
1991	106	.	.	.	13	.	.
1992	82	.	.	11	.	.	.
1993	.	.	.	.	.	.	.
1994	.	.	.	14	.	.	.
1995	.	.	.	.	.	.	.
1996	.	.	.	48	.	.	.
1997	.	.	.	45	.	.	.
1998	.	.	.	14	.	.	.
1999	.	.	.	15	.	.	.
2000	.	.	.	28	.	.	.
2001	.	.	.	23	.	15	.
2002	.	.	.	.	.	84	.
2003	.	.	.	10	.	91	.
2004	.	.	.	25	.	83	.
2005	.	.	37	53	22	78	.
2006	.	.	29	84	49	26	.
2007	.	.	64	132	34	.	.
2008	.	.	61	158	47	.	.
2009	.	13	56	263	241	58	.
2010	.	.	50	.	.	.	73
2011	.	.	48	.	.	.	70
2012	.	.	56	39	40	121	148
2013	.	13	60	109	35	139	139
2014	.	.	56	64	49	315	150

Headboat logbook v. headboat observer data

Table 1. Number of red snapper positive trips reported in the SRHS and number of At-Sea Observer trips positive for red snapper by year and state, 2004-2013. No red snapper positive trips were sampled in the At-Sea Observer program in 2004.

	FL		GA		NC		SC		South Atlantic	
Year	SRHS reported trips (n)	At-Sea Observer trips sampled (n)	SRHS reported trips (n)	At-Sea Observer trips sampled (n)	SRHS reported trips (n)	At-Sea Observer trips sampled (n)	SRHS reported trips (n)	At-Sea Observer trips sampled (n)	SRHS reported trips (n)	At-Sea Observer trips sampled (n)
2004	1,326		146		69		256		1,797	
2005	1,191	40	129	1	24	1	152	6	1,496	48
2006	1,202	28	99	3	70	1	115	3	1,486	35
2007	1,353	58	80	2	37	7	160	3	1,630	70
2008	1,824	55	104	3	85	9	127	2	2,140	69
2009	2,177	49	153	7	81	2	160		2,571	58
2010	1,707	42	99	2	123	11	171		2,100	55
2011	1,399	41	99	1	56	8	204		1,758	50
2012	1,472	46	54	4	87	14	95	1	1,708	65
2013	1,440	45	70	10	92	19	60		1,662	74
Total	15,091	404	1,033	33	724	72	1,500	15	18,348	524

Assessment workshop modification

- There were perceived inconsistencies between age and length comps.
- Length comps may only be adding noise to the model.
- We are using an age-structured model, and we have high confidence in the ages determined for this species.

AW Panel recommended removing all length comps after 1992, except for the discard length comps.

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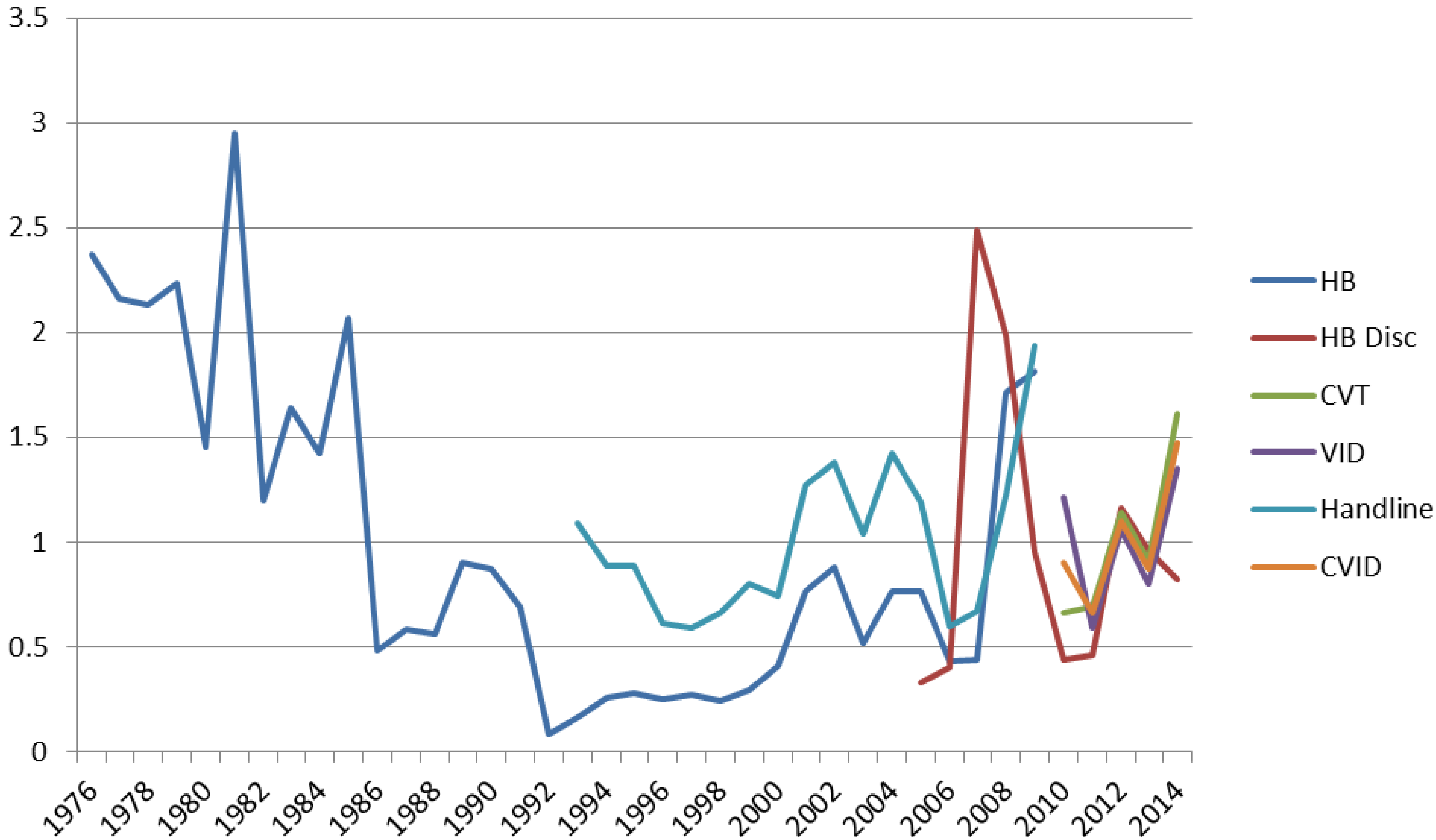
Indices of Abundance

- Three fishery dependent indices of relative abundance
  - Headboat logbooks (1976–2009)
  - Headboat discards (2005–2014)
  - Commercial handline logbooks (1993–2009)
- Logbook indices were truncated at 2009.
  - Fishing behavior changed due to the Red Snapper moratorium.
- One fishery independent index of abundance (SERFS combined chevron trap and video, CVID, 2010-2014).

Assessment panel recommendation:

- The chevron trap and video indices may be repetitive for Red Snapper due to the fact that the video cameras are mounted on the chevron traps.
- Combined the indices using the Conn method. (Conn, 2009. Hierarchical analysis of multiple noisy abundance indices. Can. J. Fish. Aquat. Sci. 67: 108–120)

All Indices



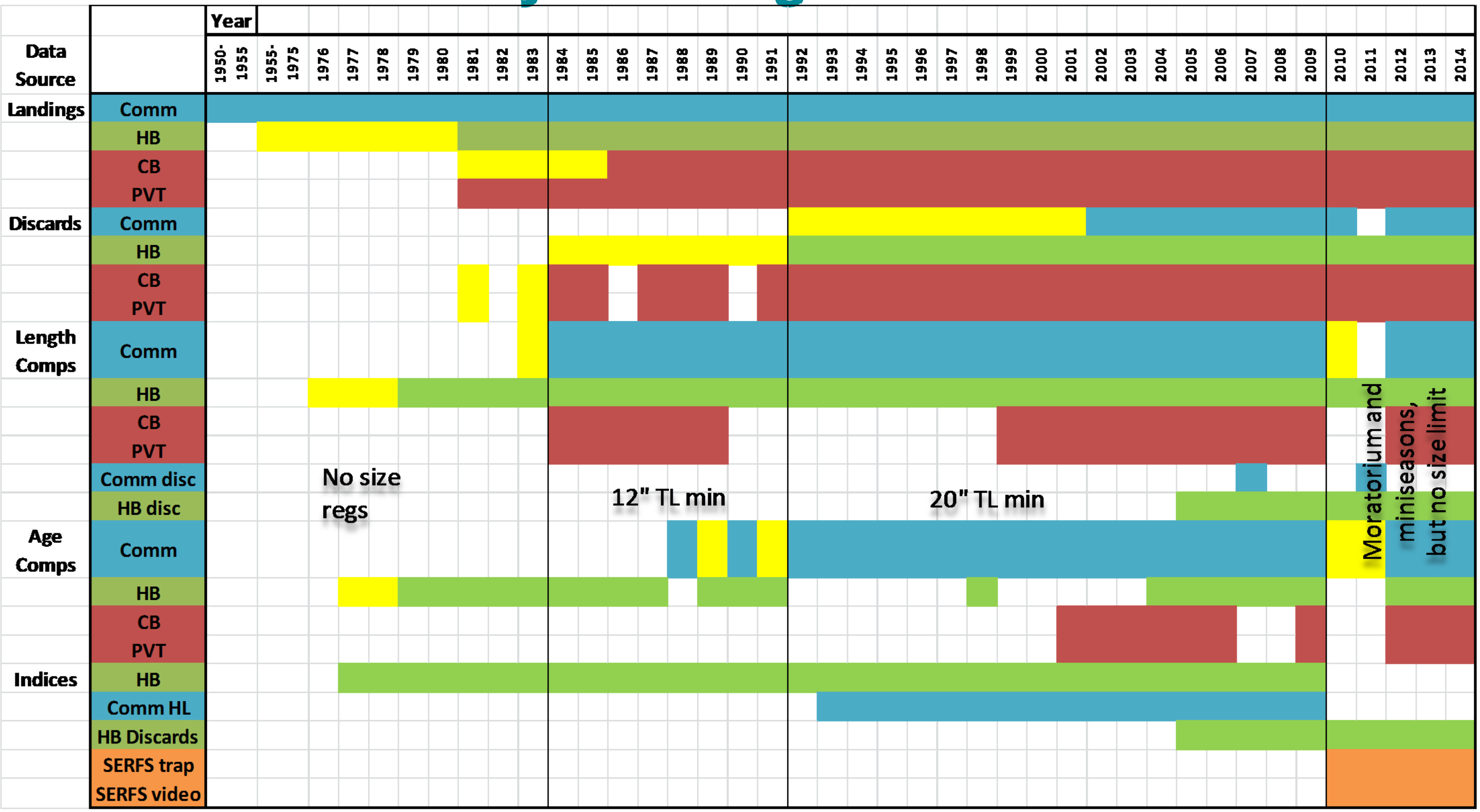
3.5
3
2.5
2
1.5
1
0.5
0
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
HB
HB Disc
CVT
VID
Handline
CVID

Additional recommendation

- The CVs of the fishery dependent indices do not reflect true variation in abundance. Fix the CVs to literature values of 0.2.

Francis et al. 2003. Quantifying annual variation in catchability for commercial and research fishing. Fish. Bull. 101: 293-304.

Data Availability and Regulations



Yellow highlighting indicates reconstructed data, very low sample sizes, and/or uneven sampling design.

Modeling Approach

- Catch Curves as a diagnostic for the mortalities used (M) and calculated (F).
- Surplus production model (A Stock Production model Incorporating Covariates (ASPIC)) for comparison purposes.
- Catch-age model (Beaufort Assessment Model, BAM) to provide stock status.

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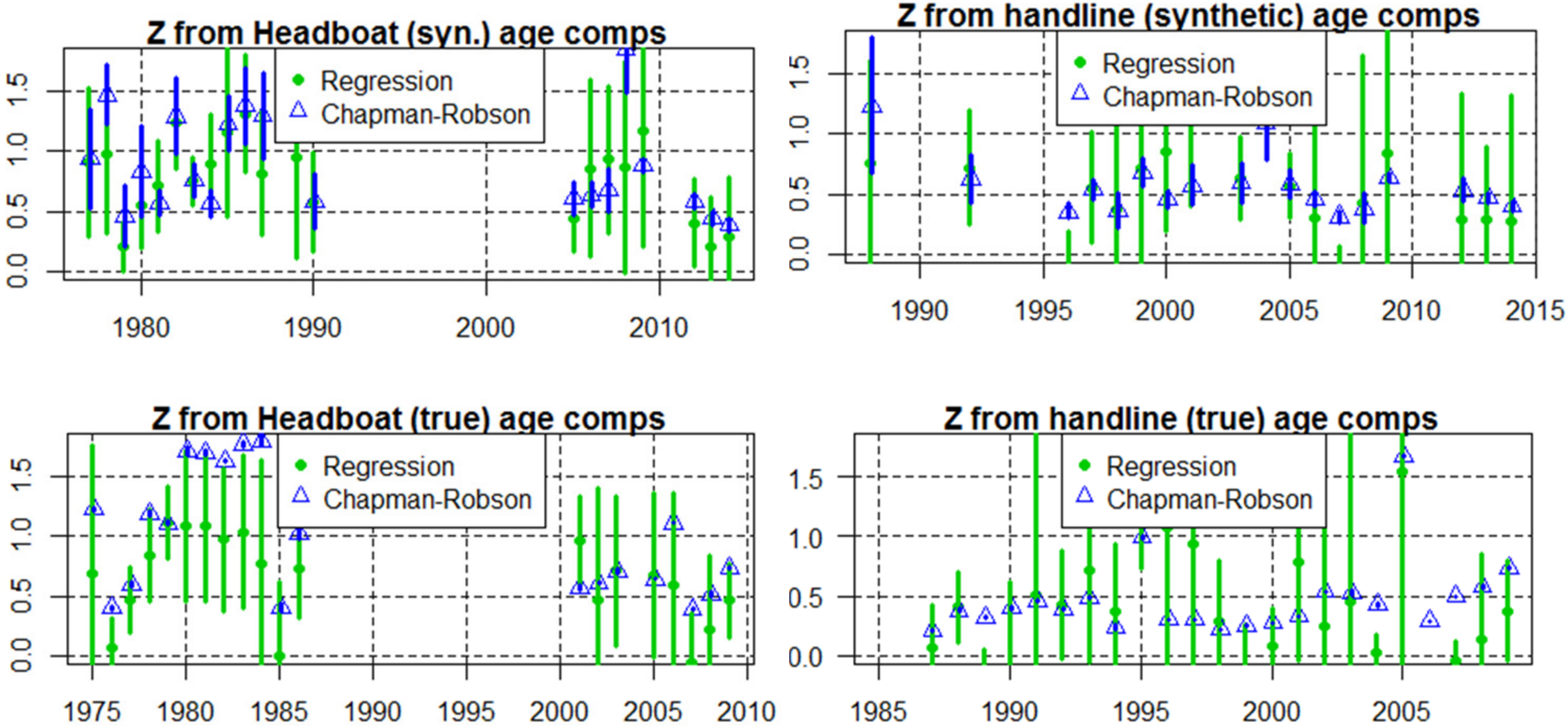
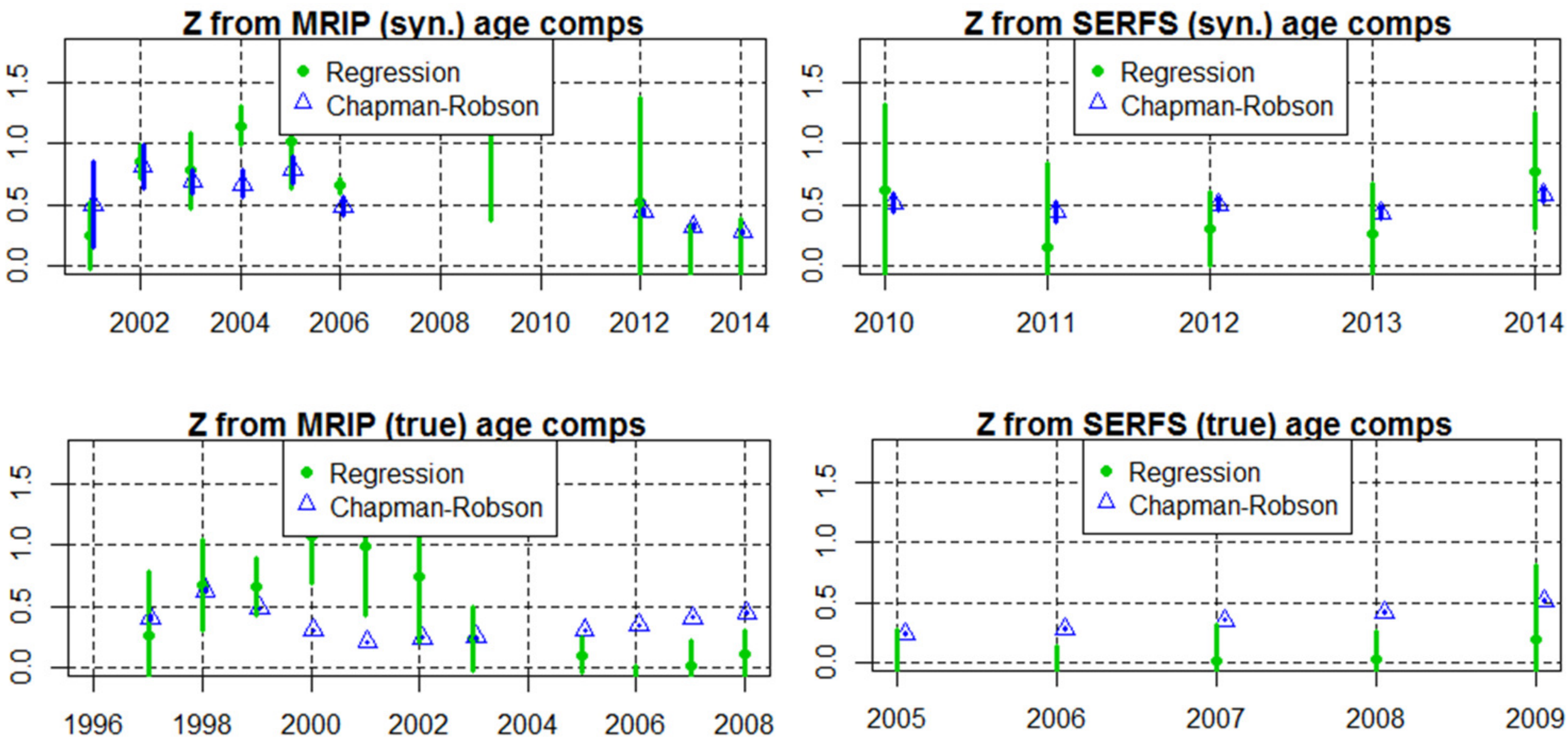
Catch curve analysis

- Two estimators
  - regression estimator
  - Chapman-Robson (C-R)
- Data
  - Commercial handline, headboat, general recreational (MRIP), & SERFS.
- Mostly synthetic cohorts (within year), some limited data on true cohorts (regression estimators only)

Catch Curves



Catch Curves cont'd.



Catch Curve Summary

	Aggregated estimate including all ages				Mean of linear regression							
					synthetic				true			
Time period	**hb**	hl	mrip	serfs	hb	hl	mrip	serfs	hb	hl	mrip	serfs
1-(75'-83')	**1.14**				**0.76**				**0.82**			
2-(84'-91')	**1.52**				**0.95**	0.76			**0.50**	0.08		
3-(92'-09')	**1.47**	0.74	0.88		**0.86**	0.56	0.85		**0.50**	0.42	0.42	-0.01
4-(10'-14')	0.71	0.54	0.26	0.61	0.30	0.28	0.09	0.42				
Mean	1.21	0.64	0.57	0.61	0.77	0.53	0.62	0.42	0.64	0.35	0.42	-0.01

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Production model

- ASPIC software of Prager (Version 7.03, 2005).
- Conditioned on yield.
- Non-equilibrium logistic formulation.
- Uncertainty from bootstrap.
- No age structure, recruitment variability, time-varying selectivity, age-specific M, or age-specific contributions to population fecundity.

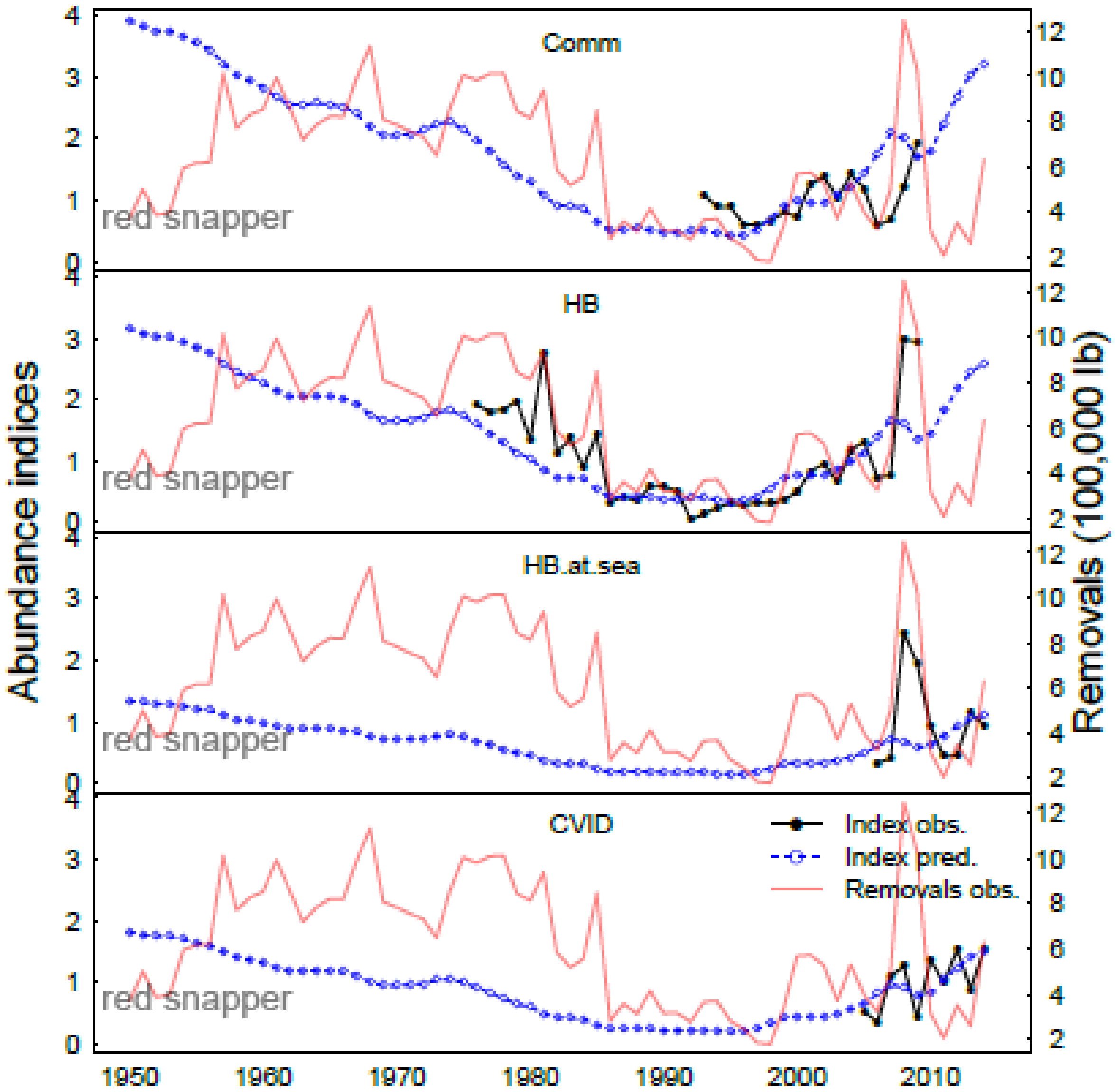
Production model – set up

- Commercial handline, Headboat, Headboat discards, and CVID indices.
- Landings 1950-2014
- Indices 1976-2014
- Upweighted CVID by 3
- HB_disc lagged forward 1yr.
- Extended CVID

Table 30. Parameter estimates from selected ASPIC surplus production model runs 318 (continuity), 319 (updated continuity), 320 (best configuration), and 323 (best configuration with B_1/K fixed) All parameter values are rounded to 3 significant digits. MSY, B_1, and K are in units of 1000 pounds. Catchability parameters correspond to the commercial (q_1), headboat (q_2), headboat-at-sea (q_3), and CVID (q_4) indices.

Run	F/F_{MSY}	B/B_{MSY}	B_1/K	MSY	F_{MSY}	q_1	q_2	q_3	q_4	B_1	K
318	2.15	0.53	0.467	805	0.313	9.35e-07	7.14e-07			2400	5140
319	0.614	1.3	1.94	802	0.314	9.42e-07	7.14e-07			9930	5110
320	0.531	1.48	0.91	805	0.322	8.69e-07	6.98e-07	2.98e-07	4.04e-07	4560	5010
323	0.53	1.47	0.467	807	0.321	8.74e-07	7e-07	2.99e-07	4.02e-07	2350	5030

Production model - fits to indices



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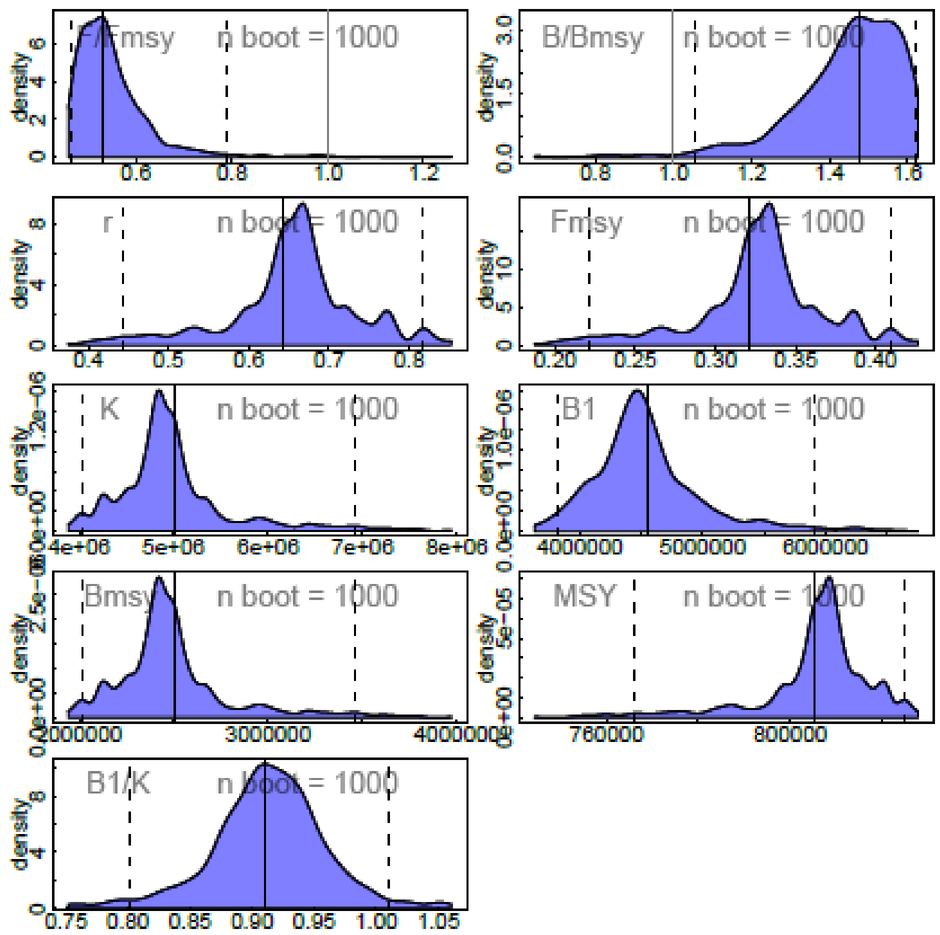
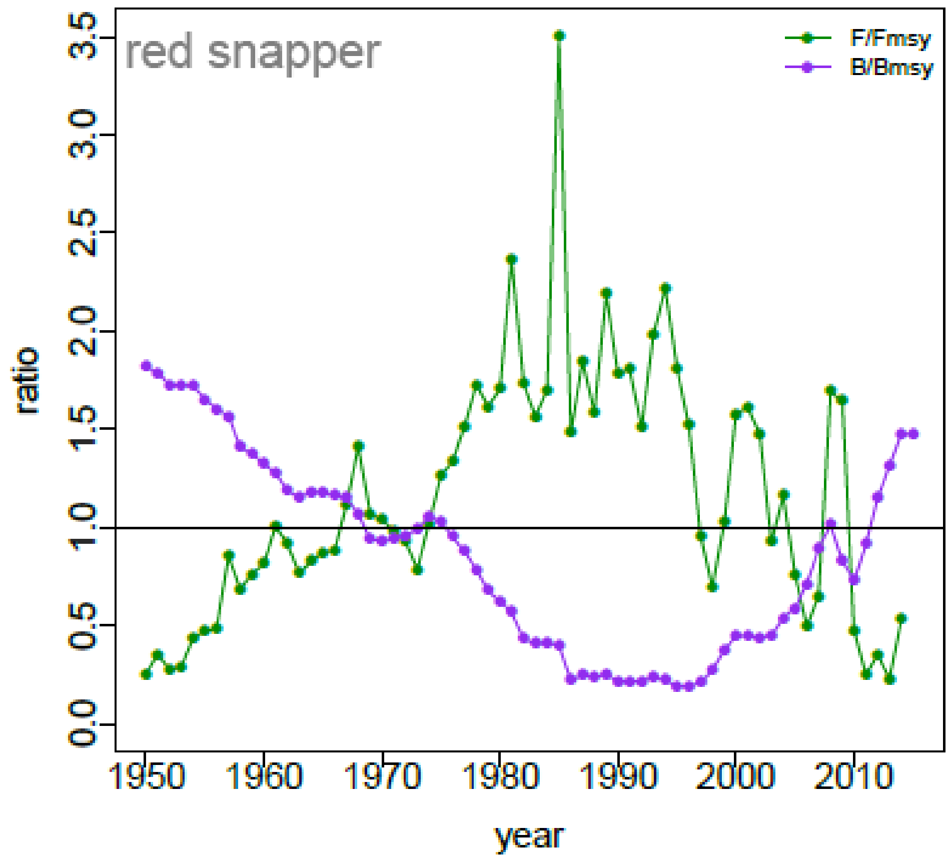
Production model – parameter estimates

- Blue shaded areas represent distributions of parameter estimates from 1000 bootstrap runs
- Thick black vertical lines represent fitted parameter values (solid) and 95% bootstrap percentile confidence intervals (dashed)
- Thin solid black vertical lines are plotted at one in the top two panels for reference



Production model - status



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Catch-age model configuration

- Start year: 1950. First year of reliable commercial landings, followed by historical recreational landings starting in 1955.
- Use a prior (with mean of 0.03) and estimate an initial F.
- Three time blocks for selectivities/growth:
  - Block 1: 1950 to 1992 (first size reg is put in place at the end of August 1983, but seemed to have minimal effect.)
  - Block 2: 1992 through 2009 (second size reg starts 1992).
  - Block 3: 2010 through the terminal year (no size regulations during mini-season, but all other fish are discarded due to the moratorium.)

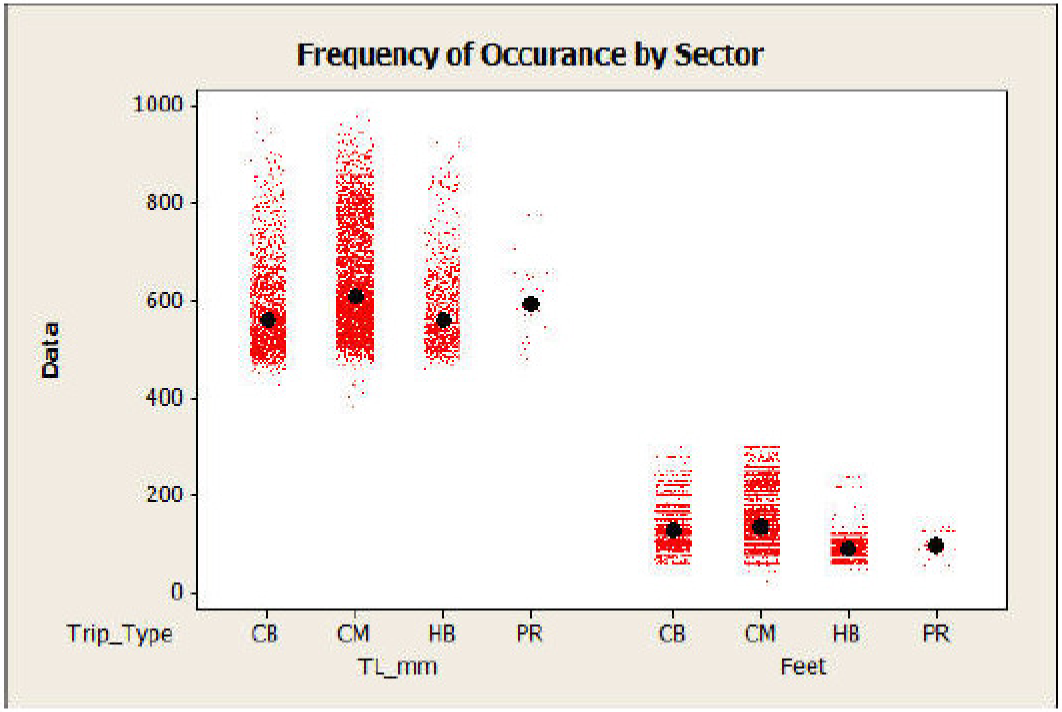
Catch-age model configuration cont'd

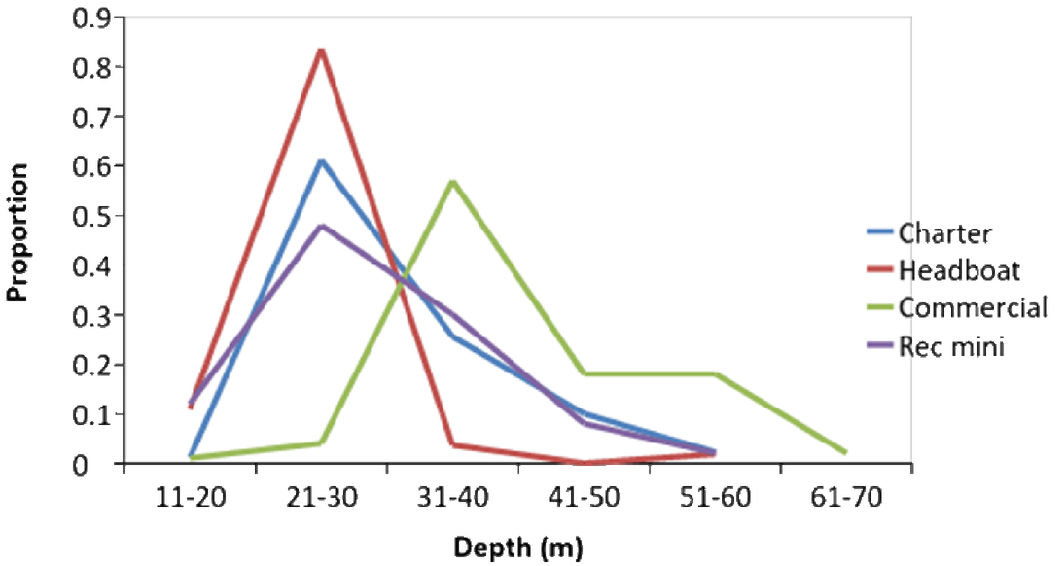
- Iteratively reweight the likelihood components in order to achieve standard deviations of the normalized residuals (SDNRs) of 1. (Francis 2011)
- Constant catchability.
- Plus group for compositions set to 13.
  - Based on <5% of data over age 13.
- Ages 1-20+ modeled, with 20+ as a plus group.
  - Based on the saturation of the life history parameters.

Considerations for functions to describe selectivities

- Depth fished
- Gear
- Age compositions
- Availability of each size class
- Catch curves

Depth fished





Gear – overall conclusions of literature review

- Hook type seems to have no effect, so there is no need for an additional time block to account for the regulation requiring circle hooks in 2011.
- Hook size matters, but we don't have hook size reported in the logbooks.
- In general, it's likely that the hook sizes are smaller for the headboat than for the commercial fleet.

Availability of size classes

- *Mitchell et al. 2014. Depth-Related Distribution of Post juvenile Red Snapper in Southeastern U.S. Atlantic Ocean Waters: Ontogenic Patterns and Implications for Management, Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, 6:1, 142-155*
  - Older, larger Red Snapper were generally distributed throughout all depths, whereas the younger and smaller Red Snapper occurred disproportionately in relatively shallow waters.
  - For Red Snapper equal to or larger than 50 cm FL, they found no evidence of a positive relationship between depth and age or length.
  - Age and length distributions of Red Snapper ≥ 50 cm FL did not differ between fishery-independent surveys and the commercial hook-and-line fishery.

Catch-age model configuration cont'd

Selectivities:

- Commercial handline, SERFS trap/video, commercial handline discards (blocks 1 and 3), and MRIP (block 3) – Logistic
- Headboat, headboat discards, MRIP (block 2), MRIP discards, commercial handline discards (block 2) – Dome-shaped

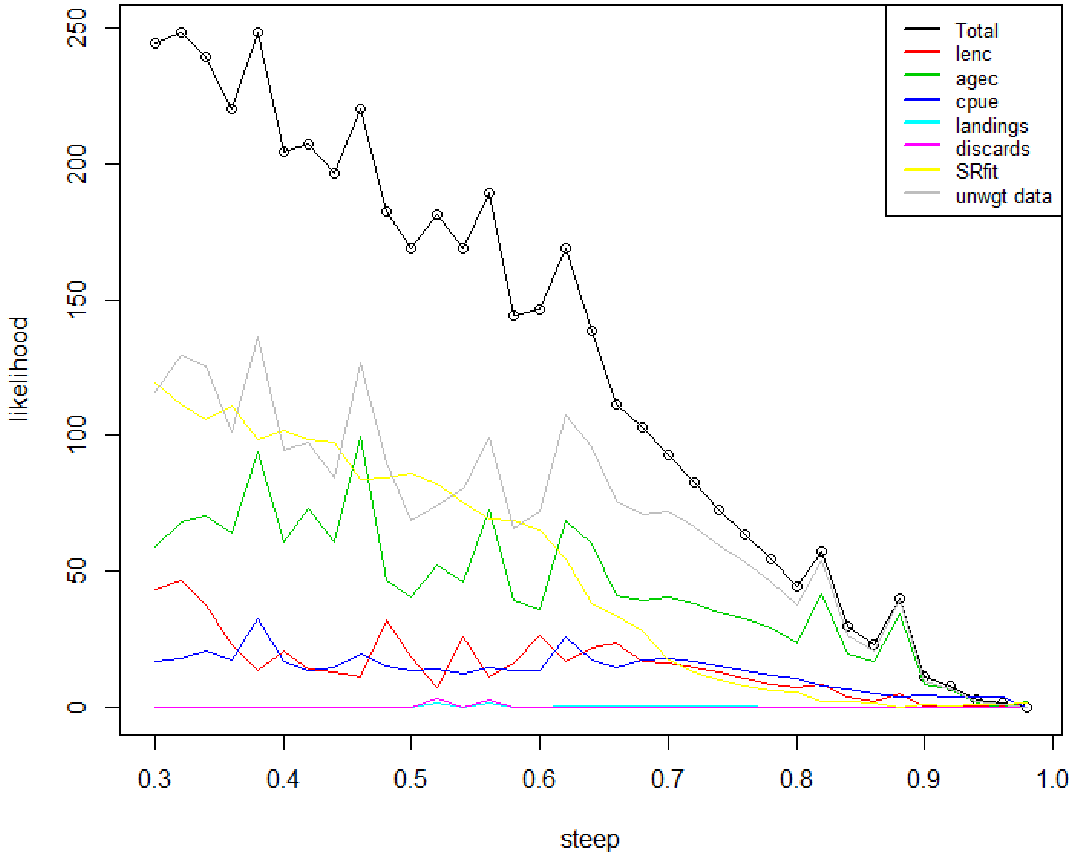
Dome-shaped selectivities modeled with a double logistic function.

Assumptions:

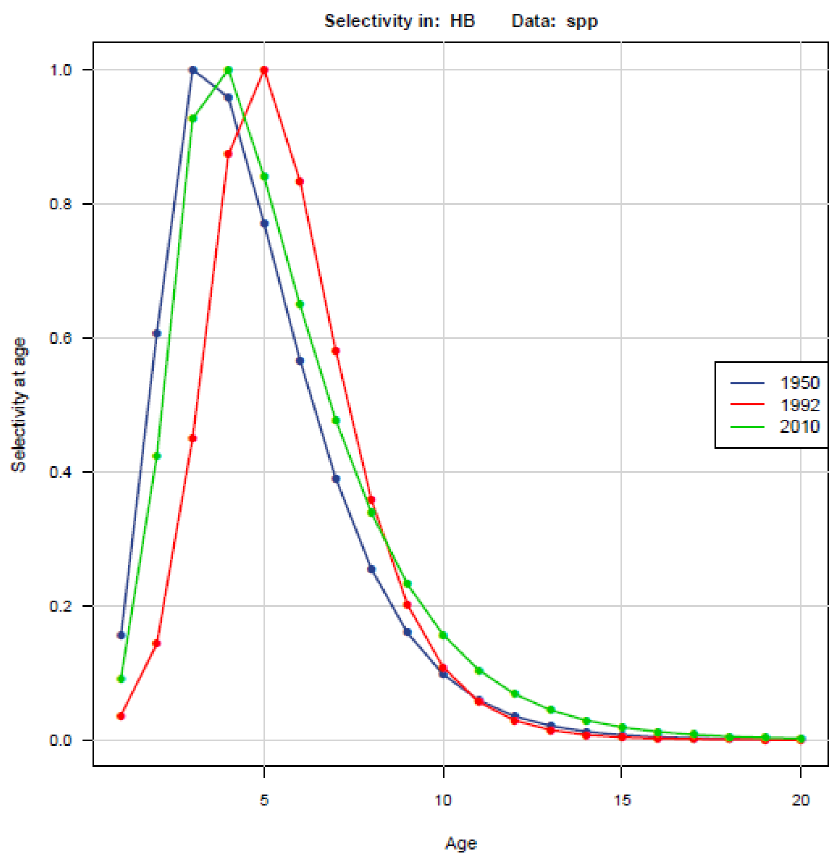
- MRIP mirrors Headboat in block 1.
- MRIP discards mirror Headboat discards

Steepness profile

- Estimation does not seem stable.
- Profile shows no defined minimum, only that steepness is not low.



Selectivity going to zero



- Composition data show that there is some selectivity on the oldest age classes, but the initial model estimates went to zero.
- Assessment panel recommended a plus group age of 10 for headboat.

Leading to a base run…

- Fix steepness at 0.99
  - No defined minimum in the likelihood profile.
  - The model estimates of steepness are all high, when they converge, and the estimation seems unstable.
  - Models average recruitment with deviations.
- Fix HB discards at age 10+.
- No upweighting: Leave the weightings as they are when SDNRs are near 1.

Issues discovered

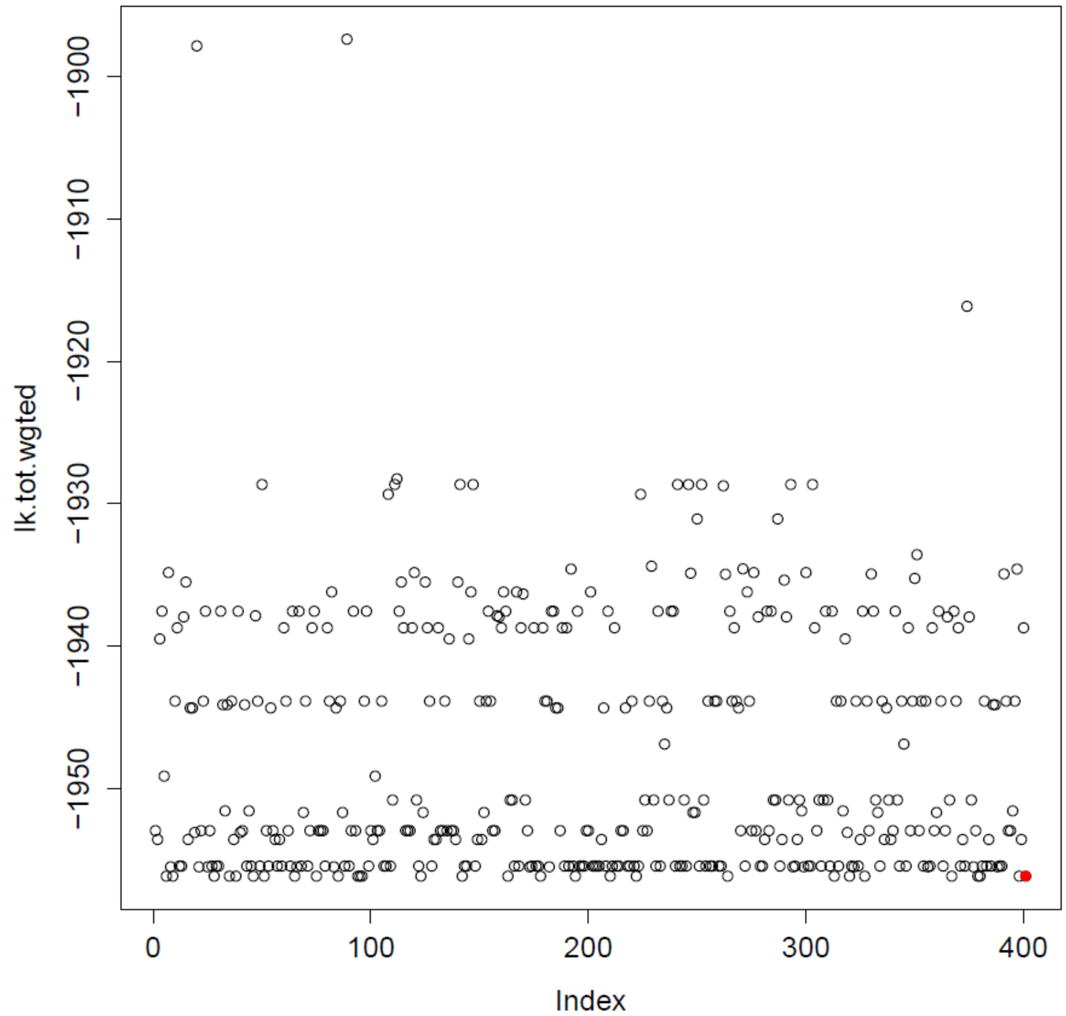
- Potential instability in the selectivity parameters
  - Changing the starting values changed some of the parameter estimates – model not finding minimum in the likelihood surface.
  - Ran a starting value analysis to determine the extent of the problem.
  - Used a new configuration of the estimation phases to come to a better solution.

Starting value analysis

- For each estimated parameter:
  - Draw a random uniform value from a distribution +/- 25% from the current starting value.
  - Run 400 bootstraps and keep track of the estimates and the total likelihood.

Starting value analysis

- Ran the analysis multiple times, and adjusted the phases to avoid estimating correlated parameters in the same phase.
- Adjusted the starting values and achieved the global minimum.
- Use those starting values in the base run.



Outline

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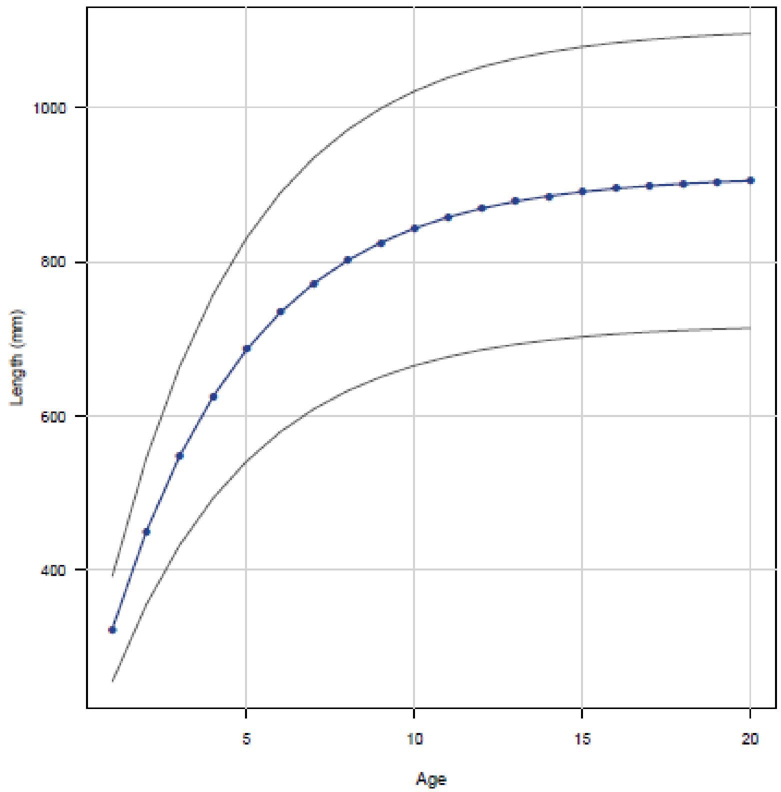
Estimated parameters

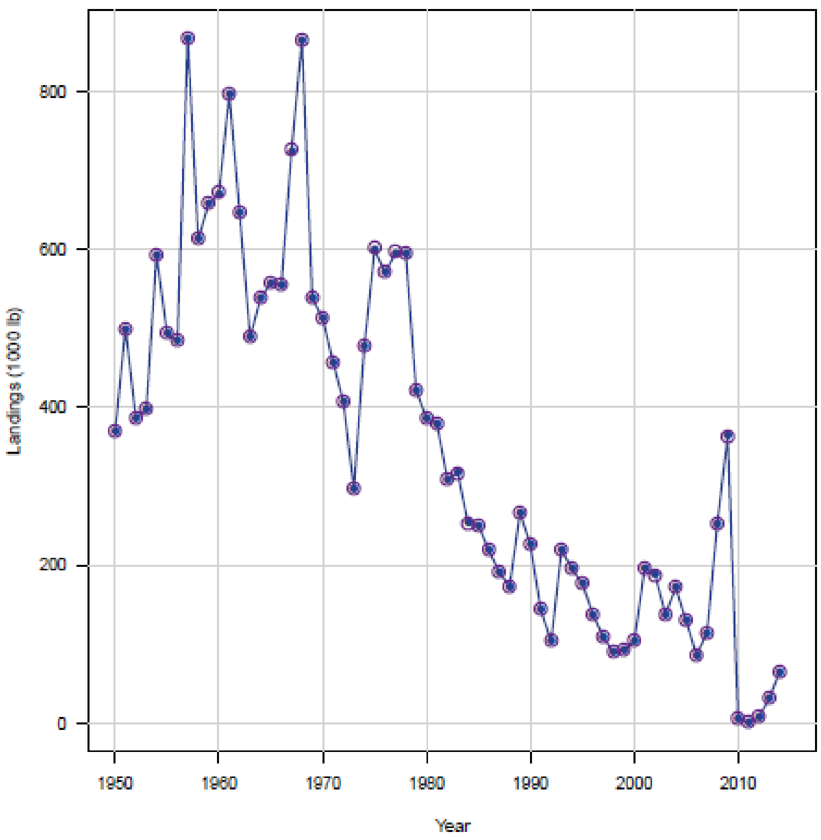
- Fishery growth curves CV (3): Population CV, Landings CV, Landings under 20” reg CV
- Deviations around initial age structure (19)
- S-R parameters (2): R_0 and sigma-R (steepness fixed)
- Annual R devs (37)
- Selectivity (40)
- Catchability (4): commercial handline, headboat, headboat discards, and CVID indices
- Fishing mortality (259): average F + annual deviations for each fleet (landings and discards)
- Initial F (1)

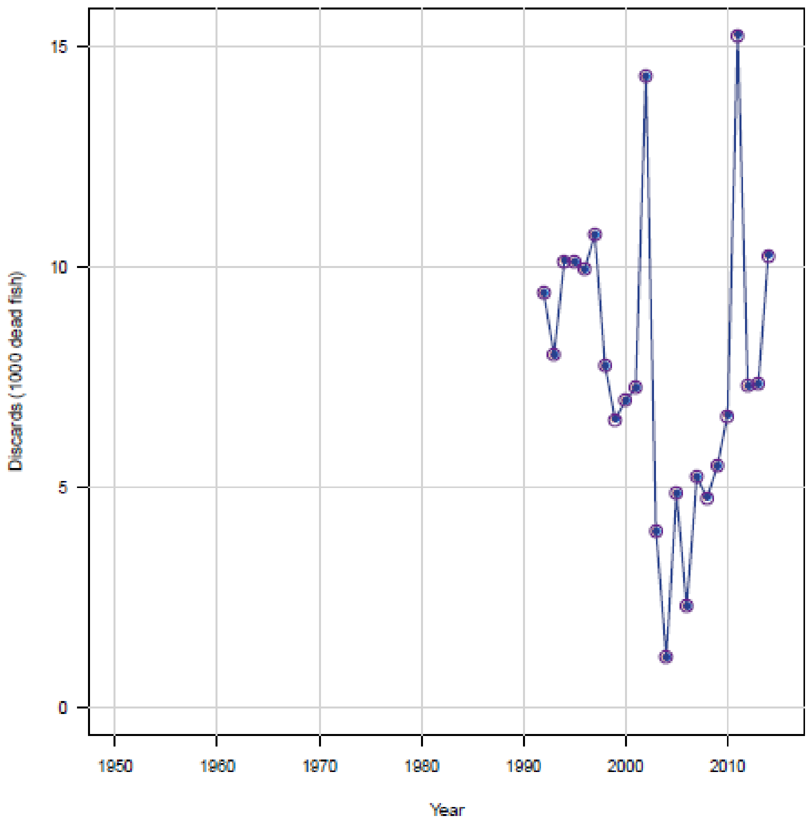
Growth variability



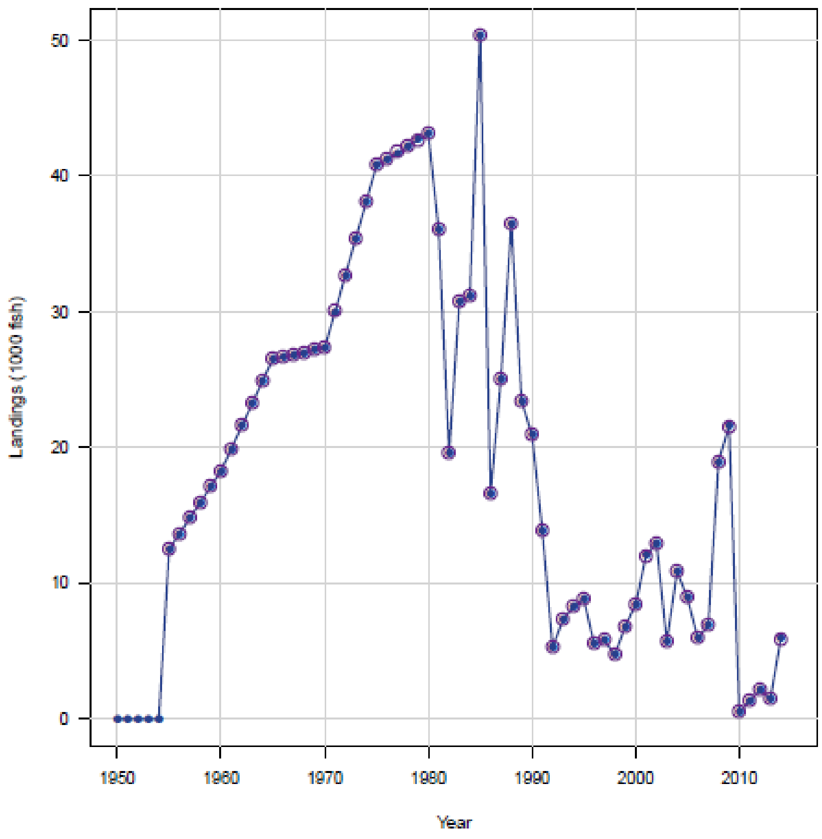
- Assumed constant CVs.
- Estimated one CV for each growth curve (3).

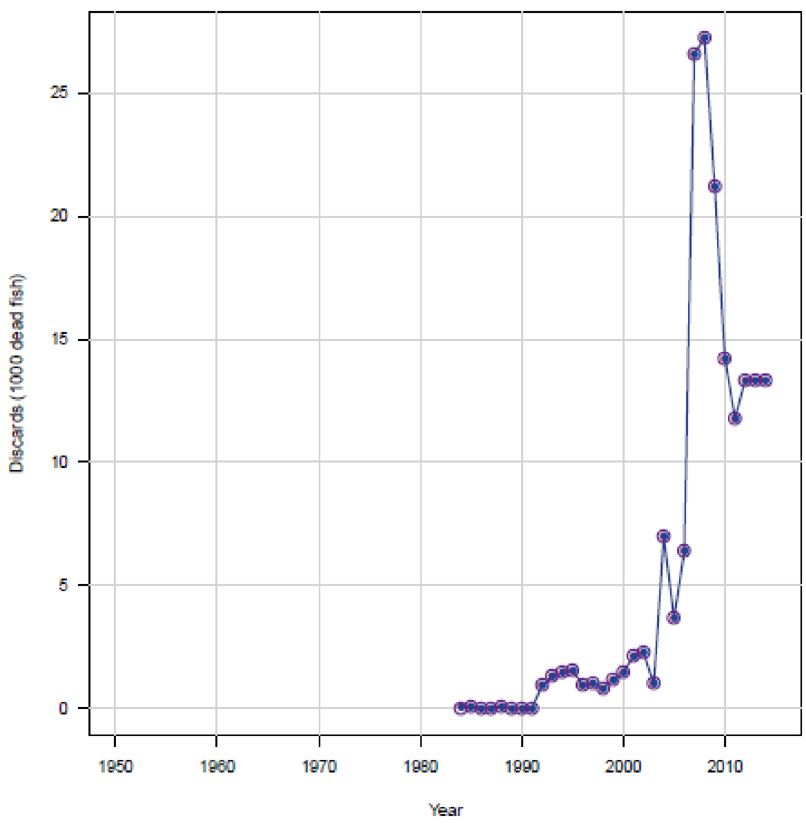
Commercial handline landings and discards



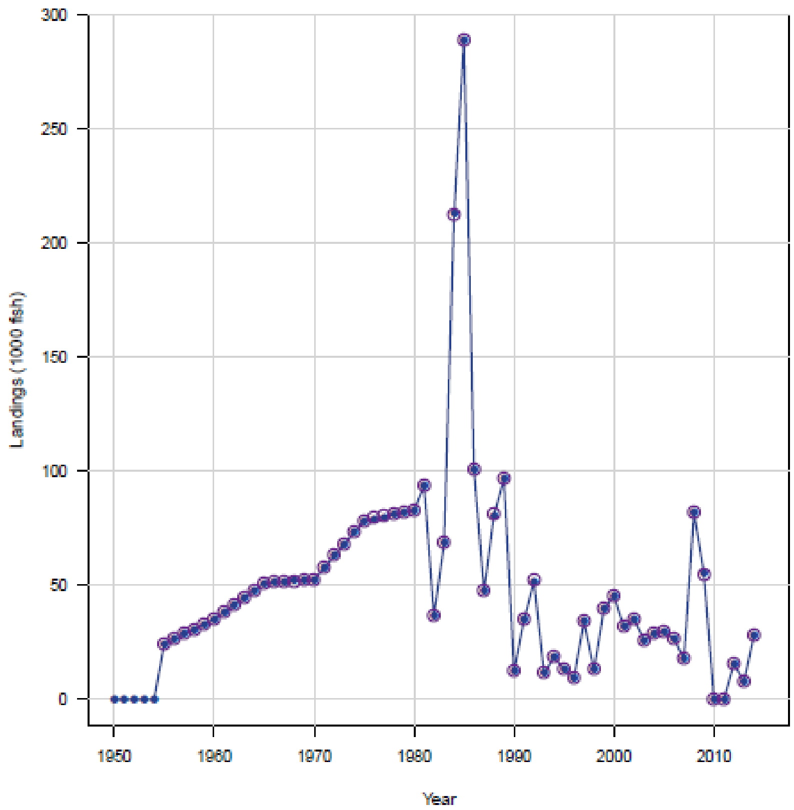


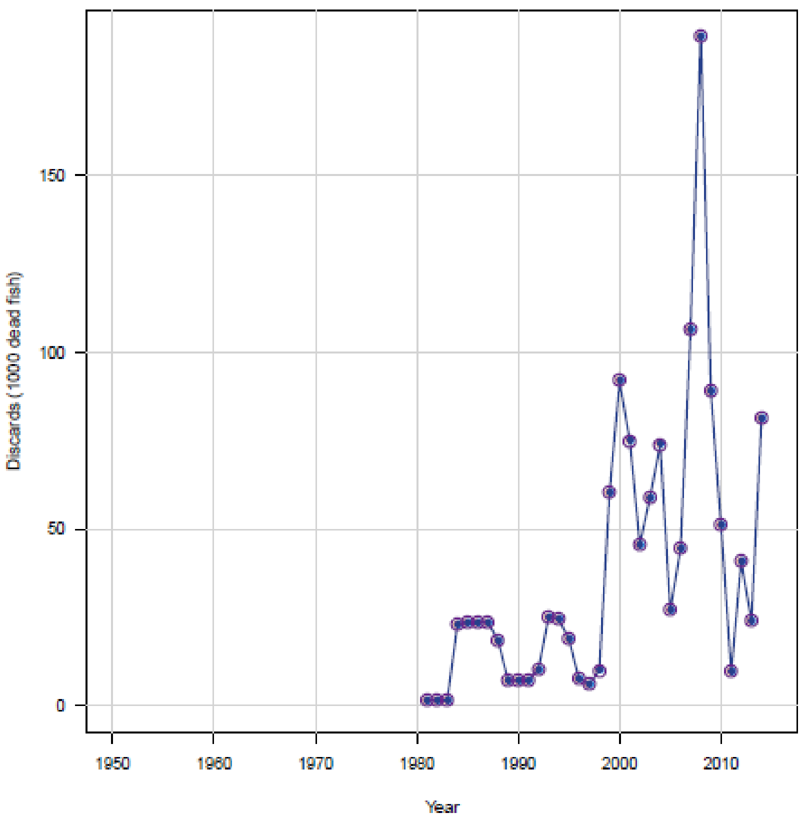
Headboat landings and discards



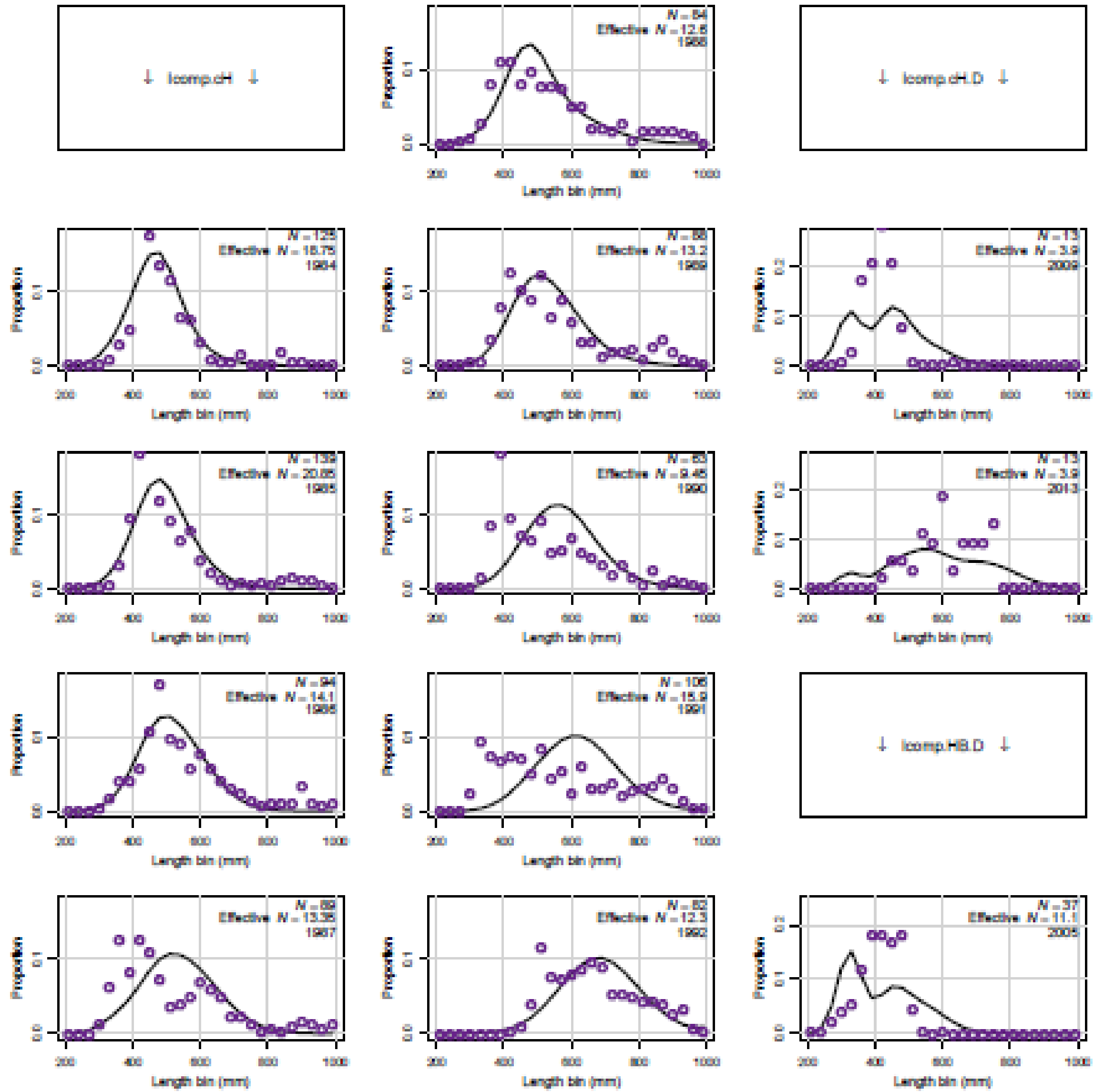


General recreational landings and discards

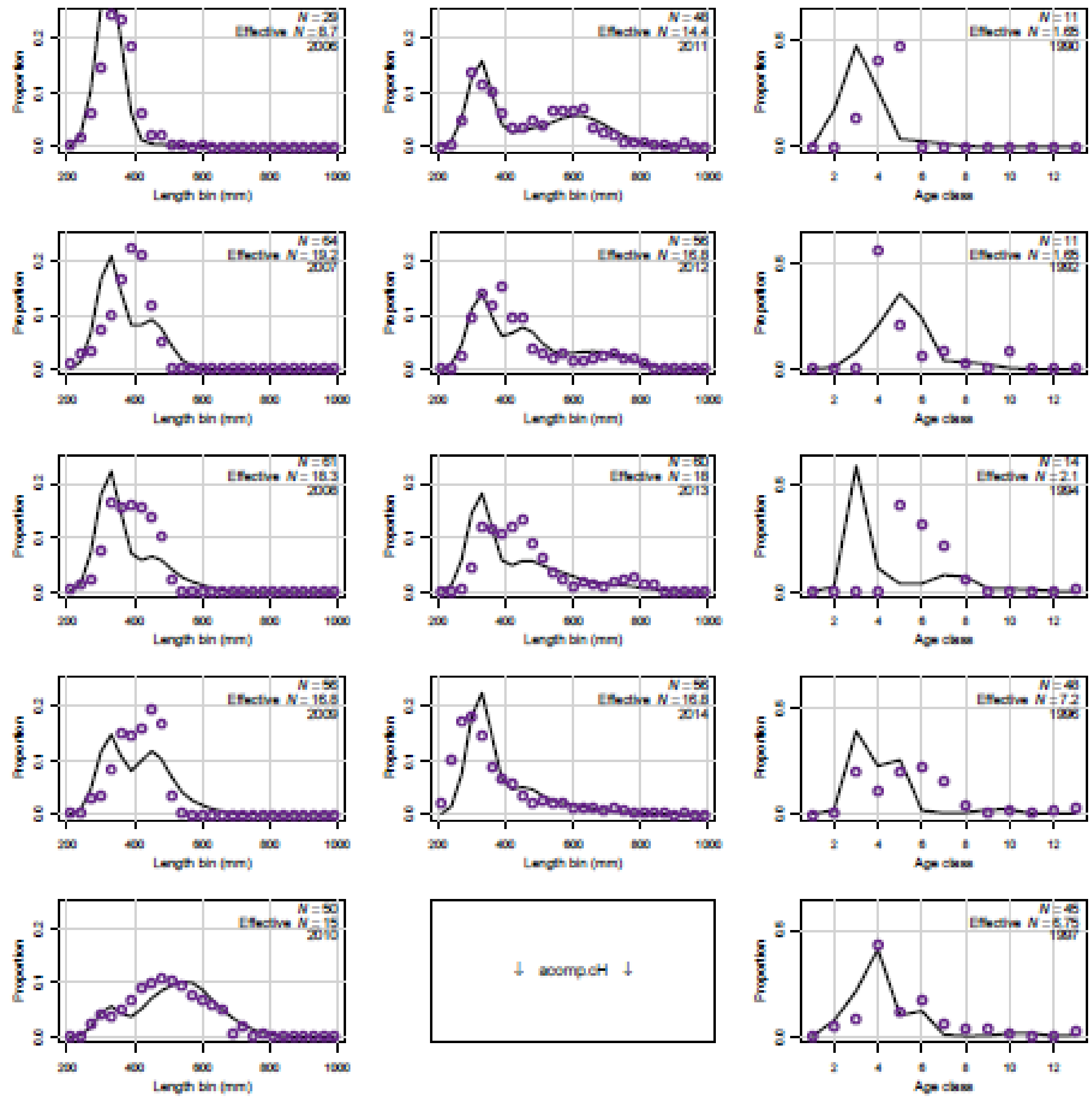




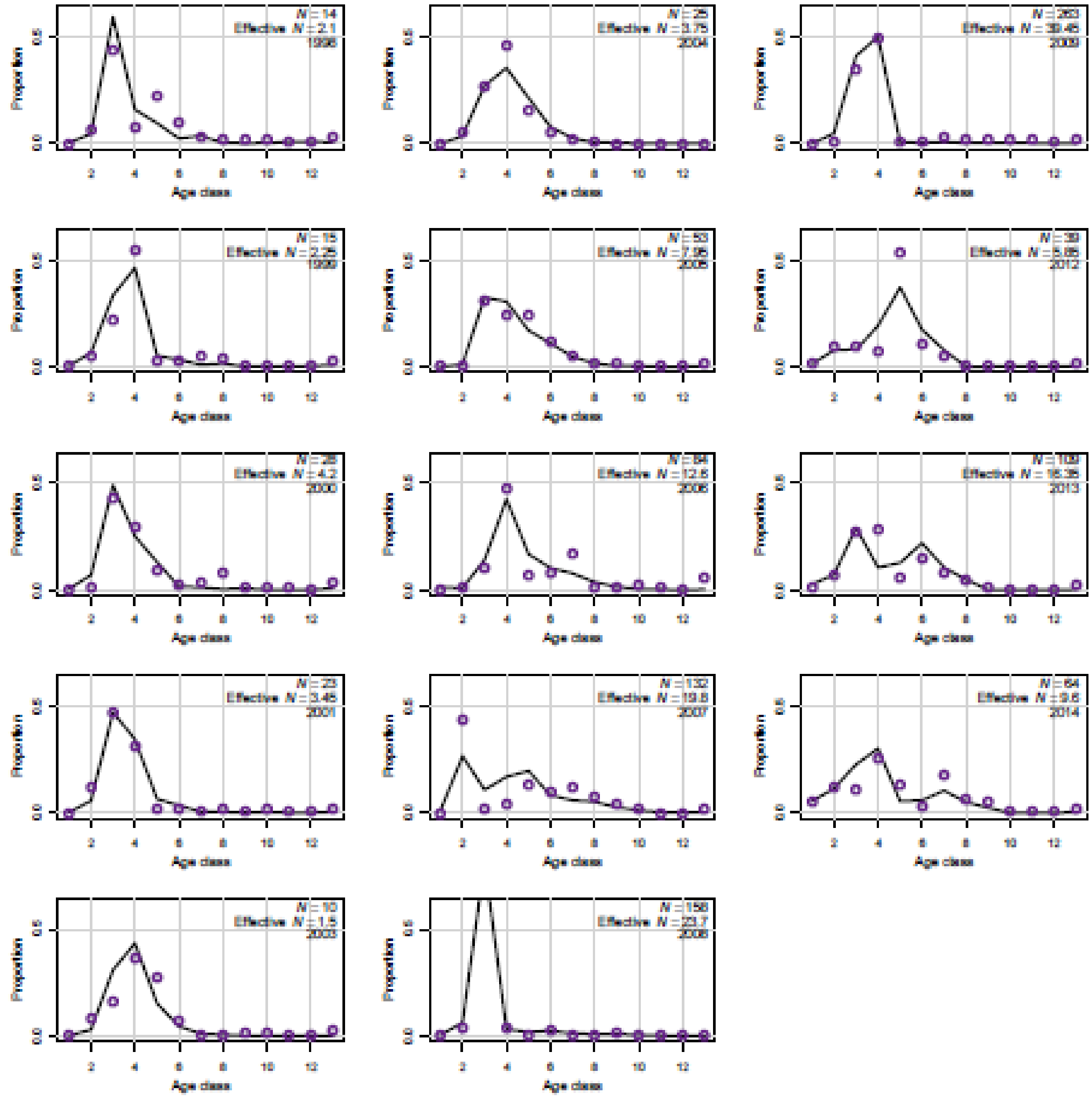
Composition fits



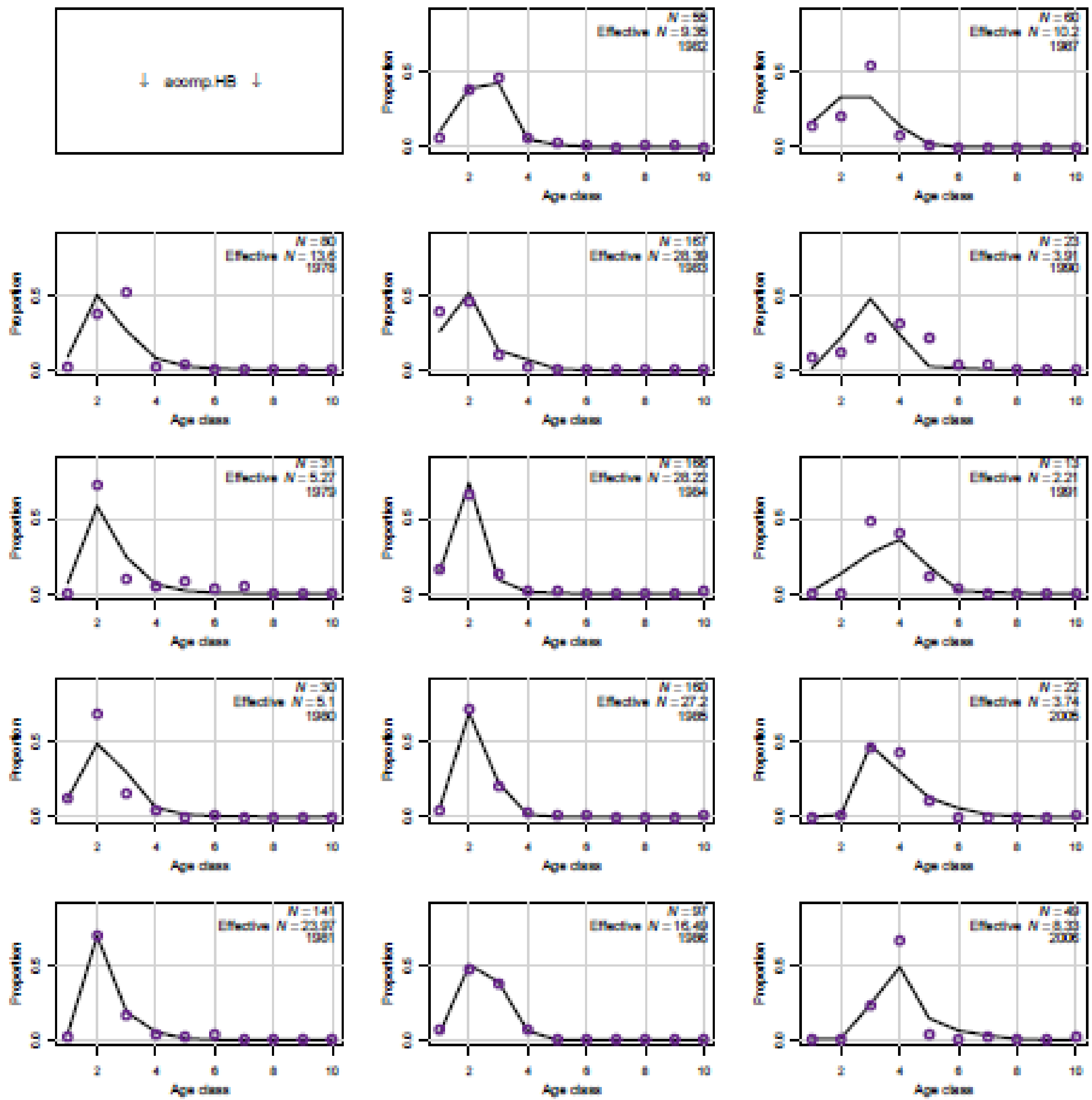
Comps cont'd



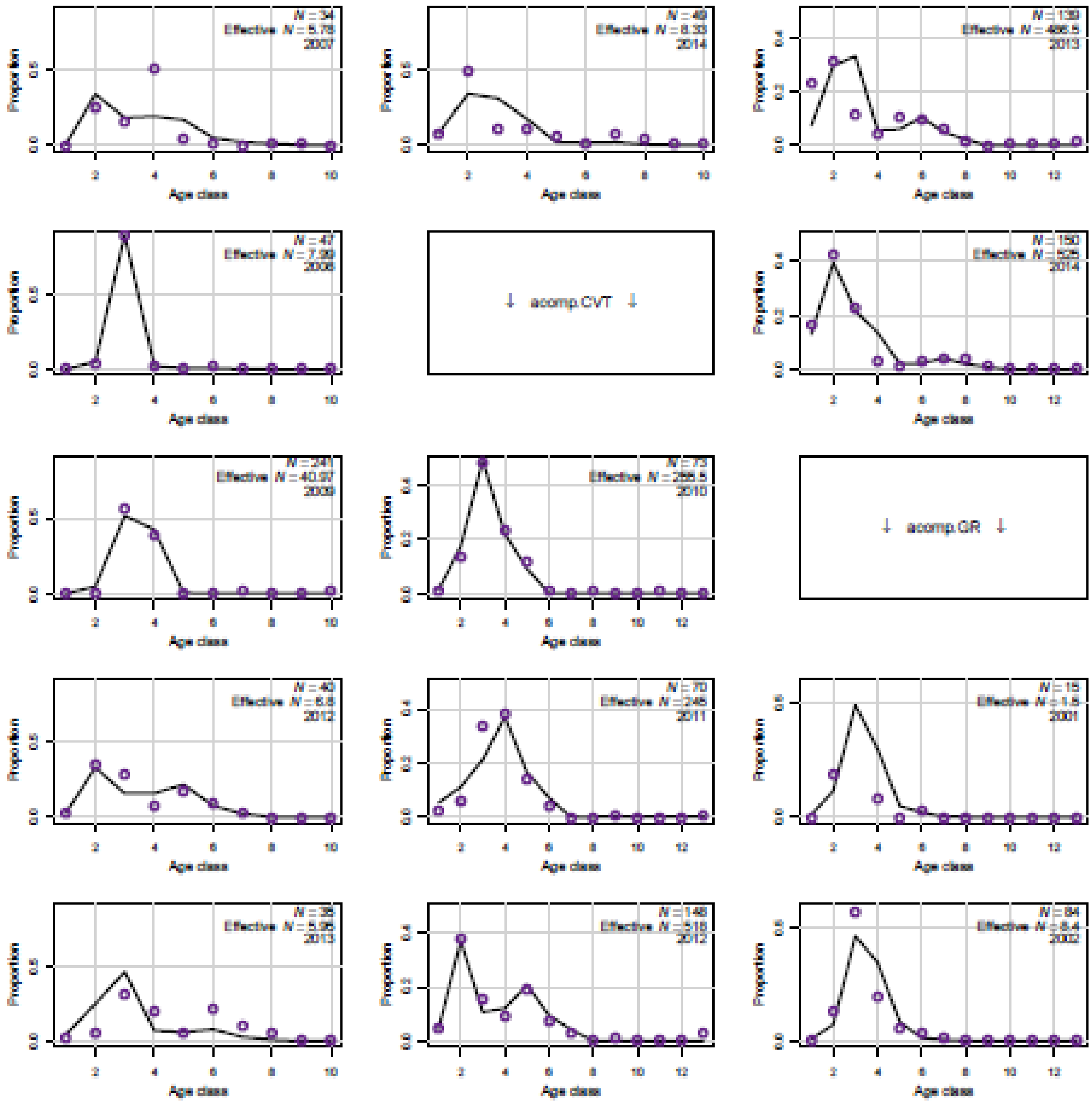
Comps cont’d



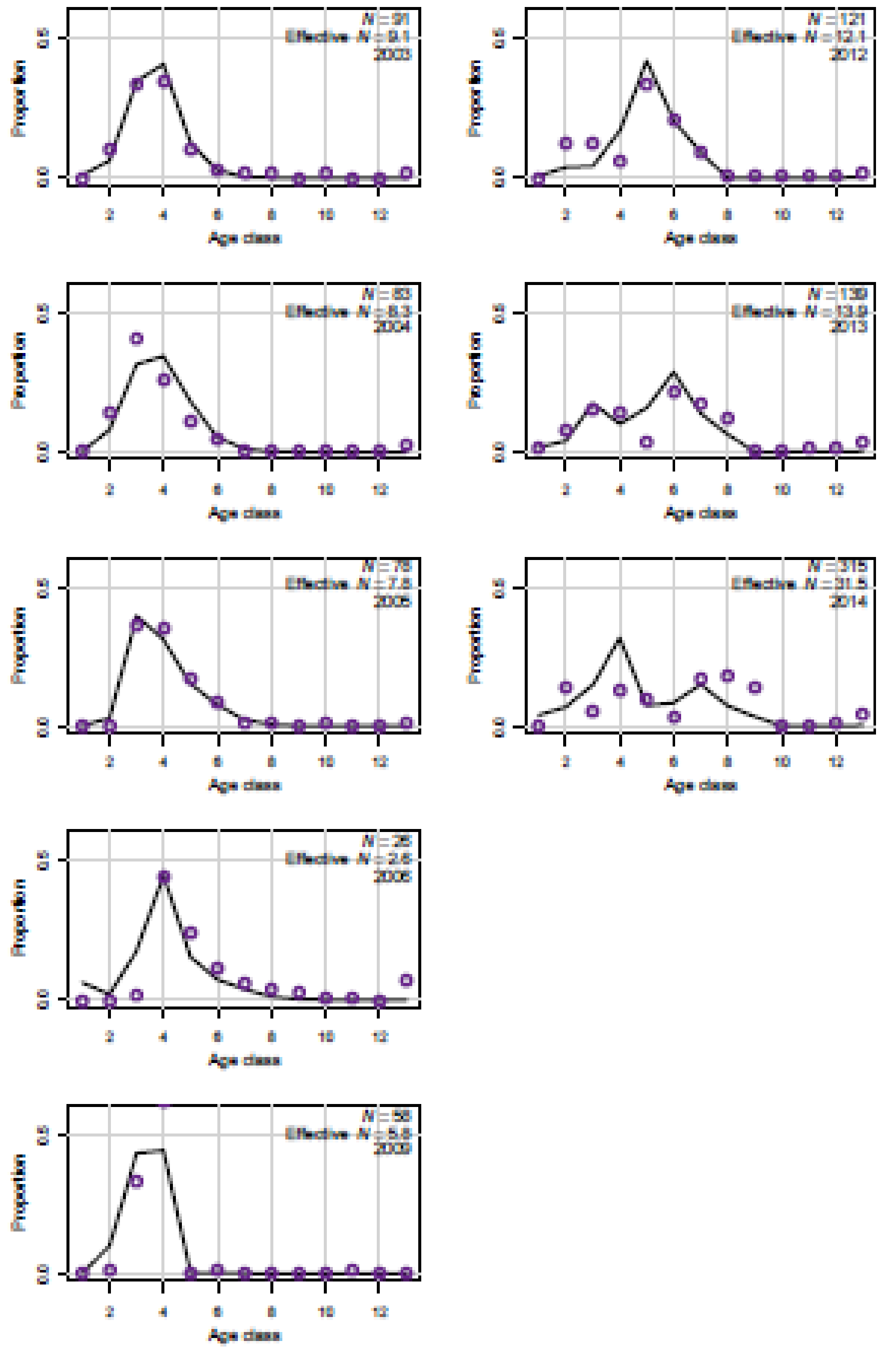
Comps cont’d



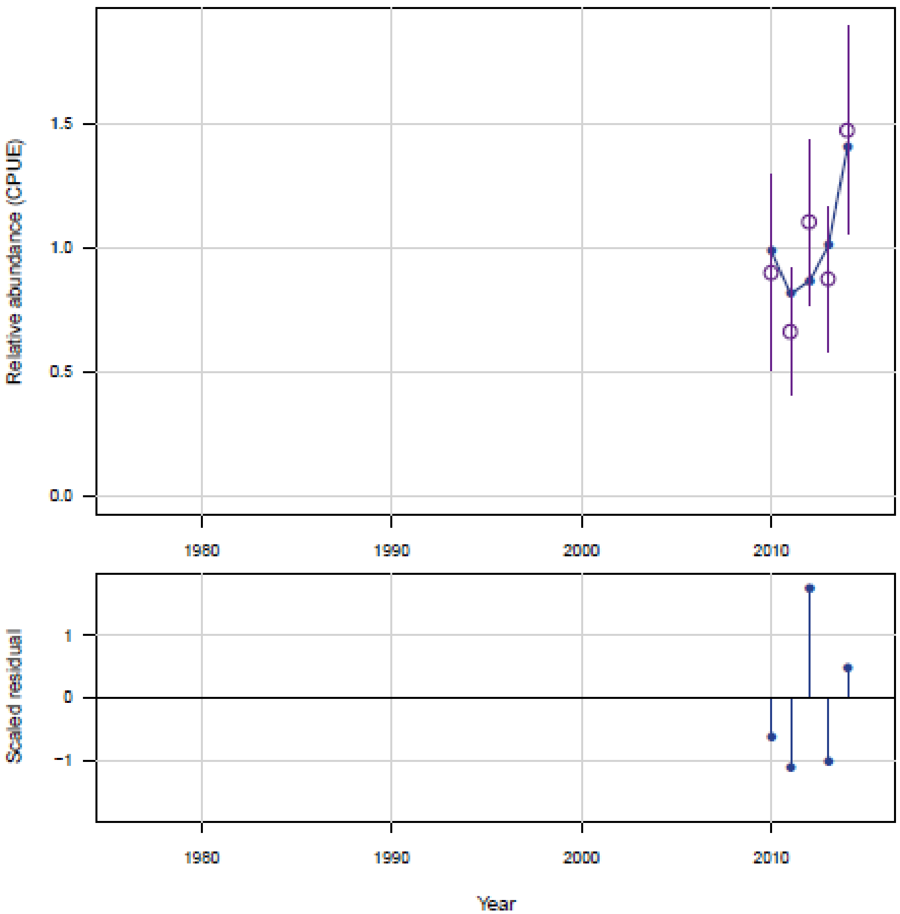
Comps cont'd

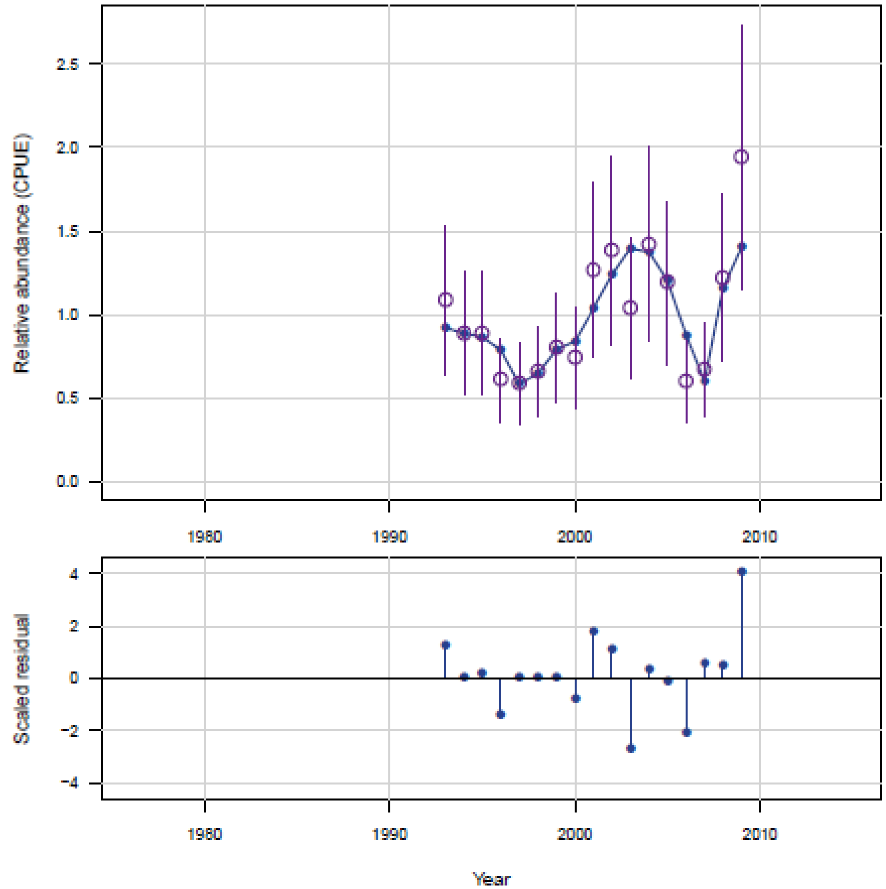


Comps cont'd

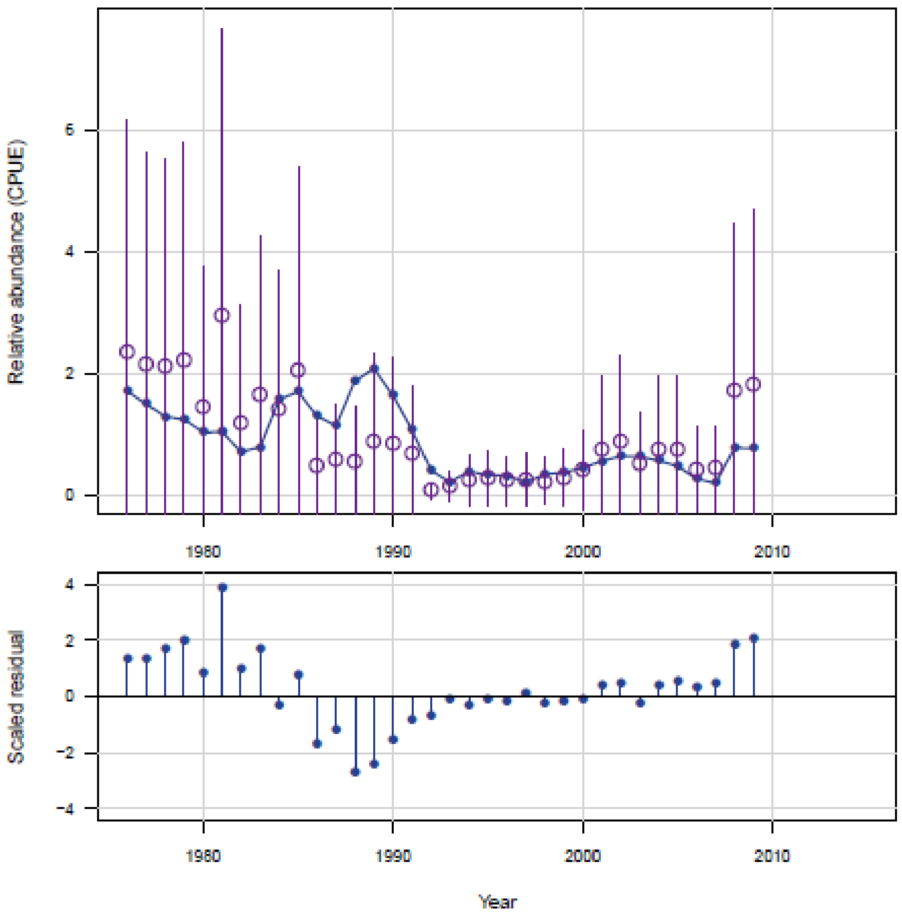

N = 91
Effective N = 9.1
2003
N = 121
Effective N = 12.1
2012
N = 83
Effective N = 8.3
2004
N = 139
Effective N = 13.9
2013
N = 78
Effective N = 7.8
2005
N = 315
Effective N = 31.5
2014
N = 26
Effective N = 2.6
2006
N = 58
Effective N = 5.8
2009
Proportion
Age class

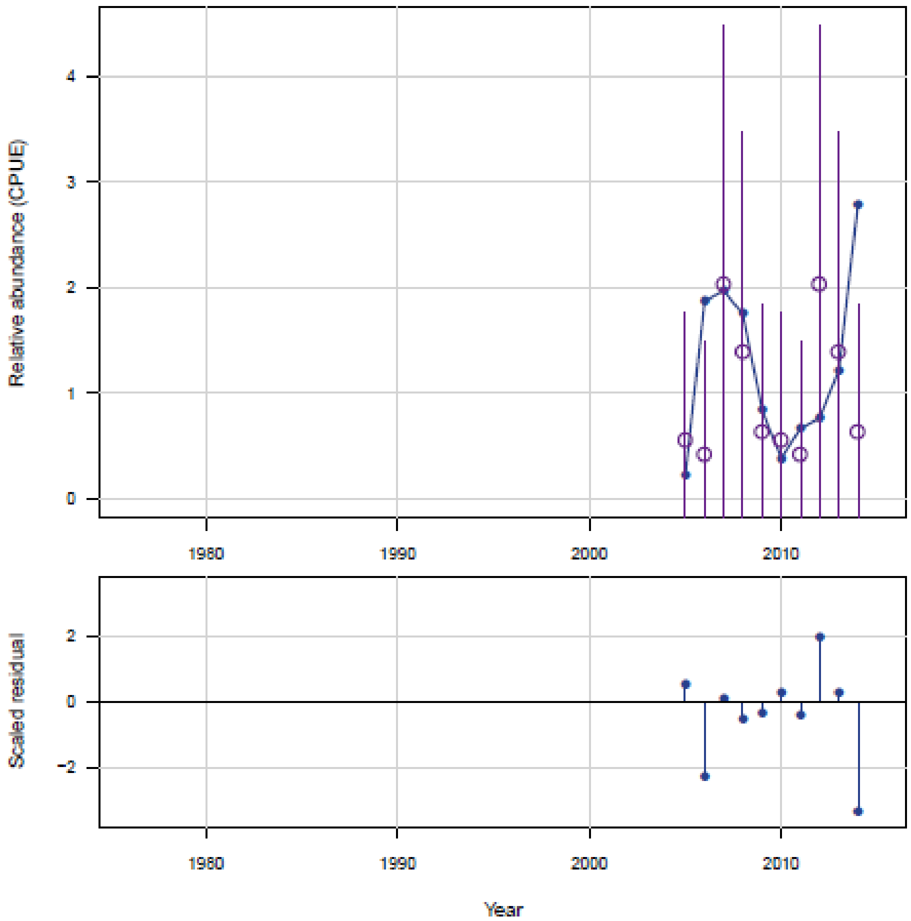
Indices – CVID and commercial handline



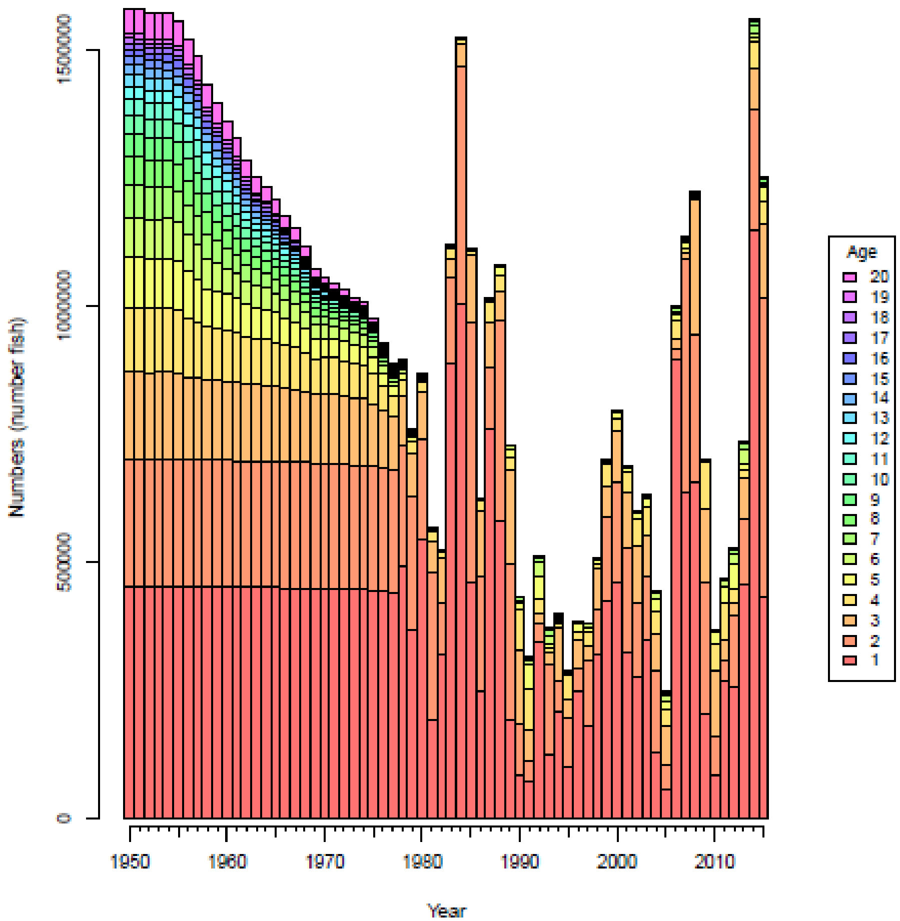


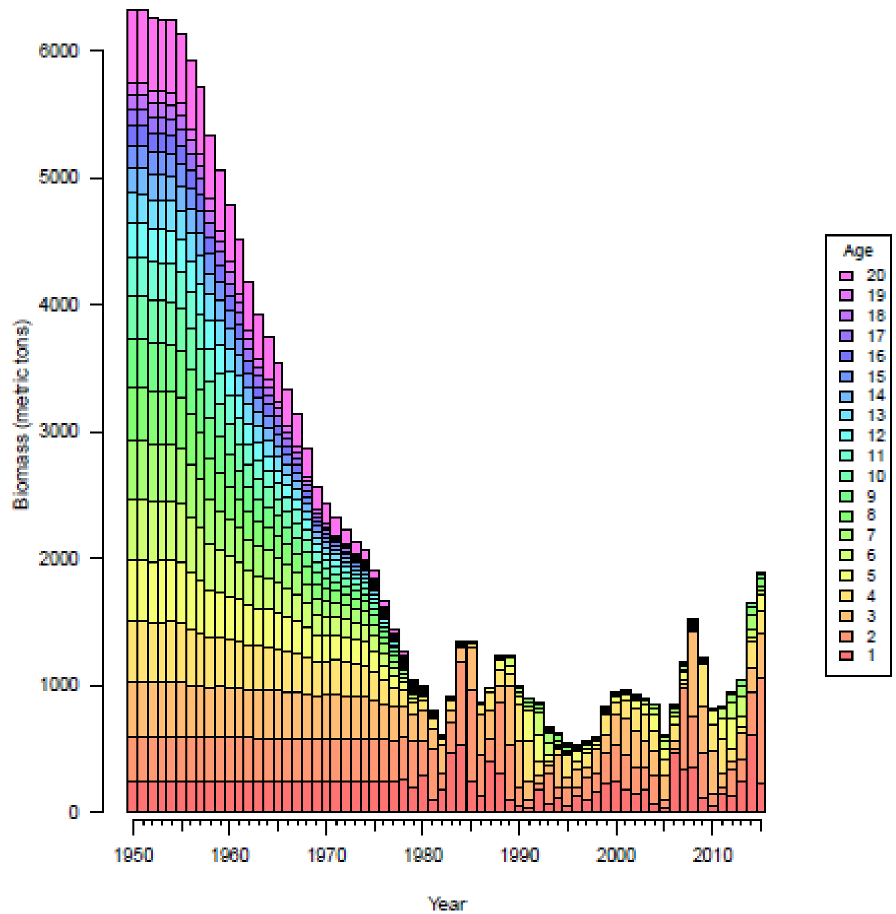
Indices – Headboat and headboat discard

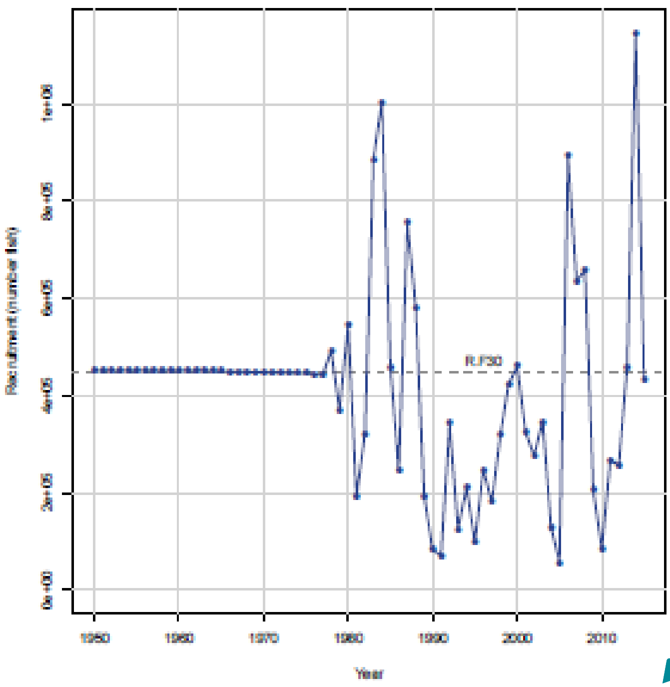




Numbers and Biomass at age

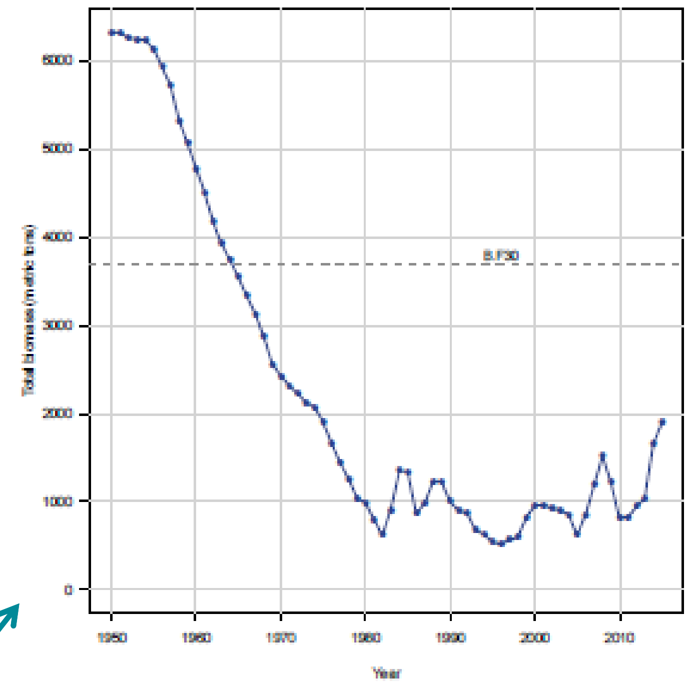


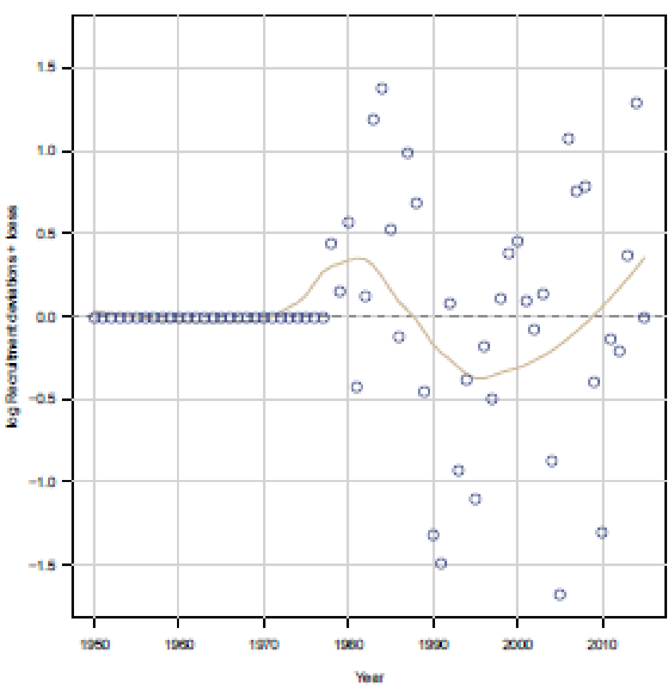




Recruitment

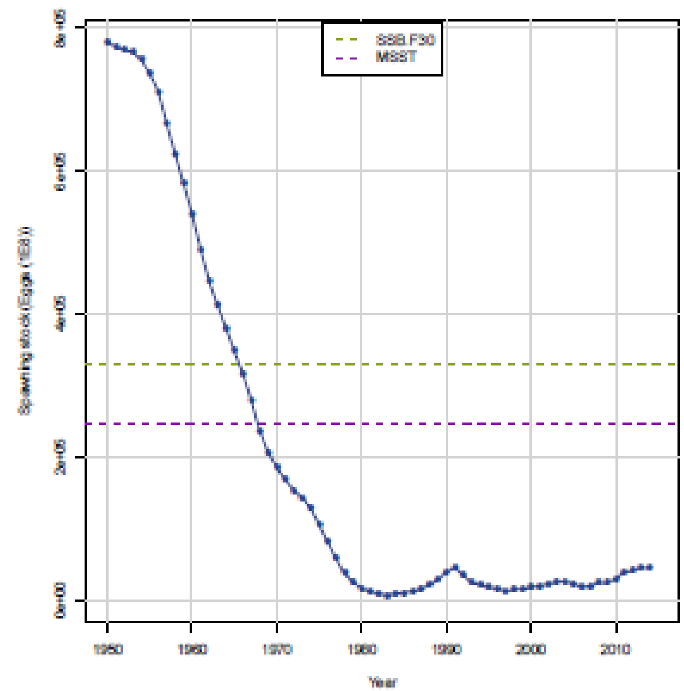
log recruitment residuals



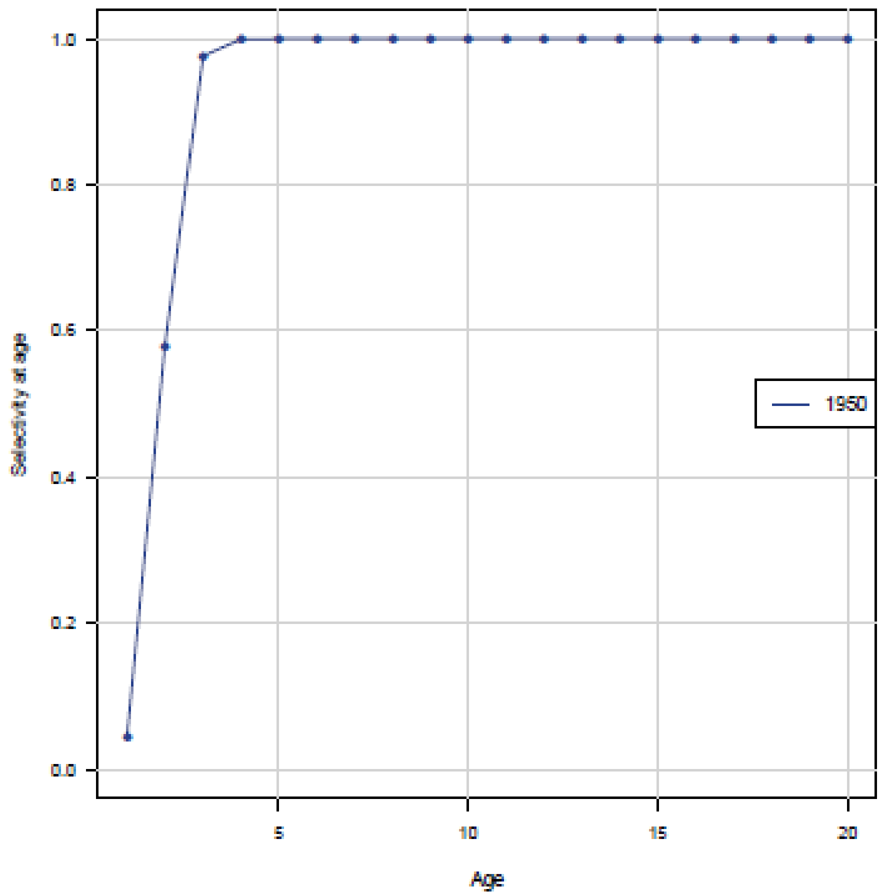


Biomass

SSB status

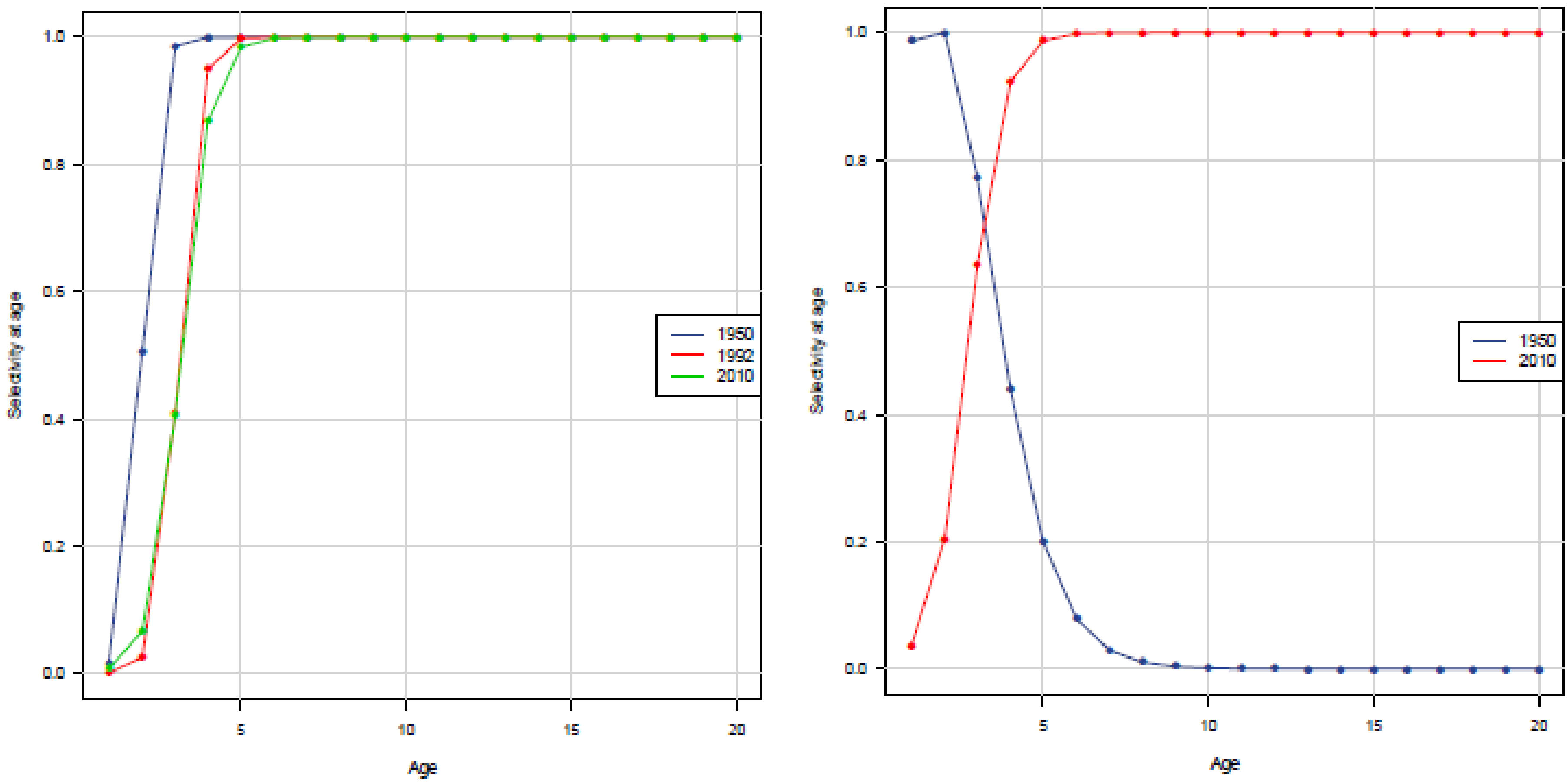


Selectivities

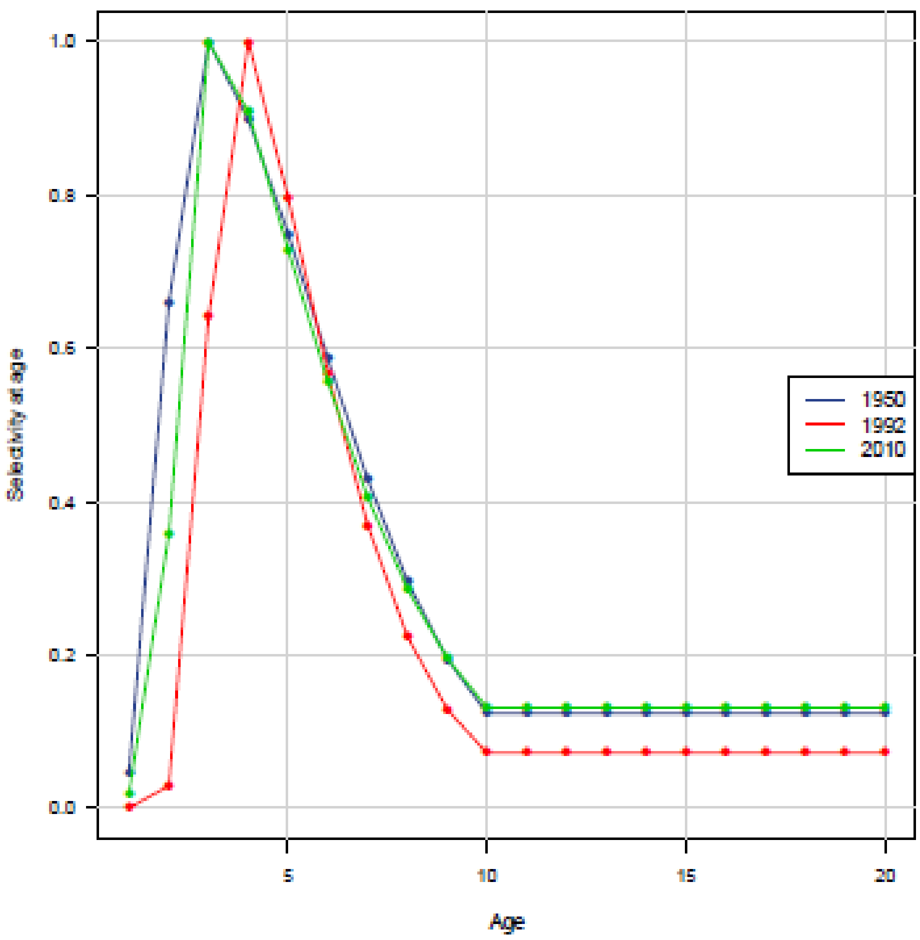


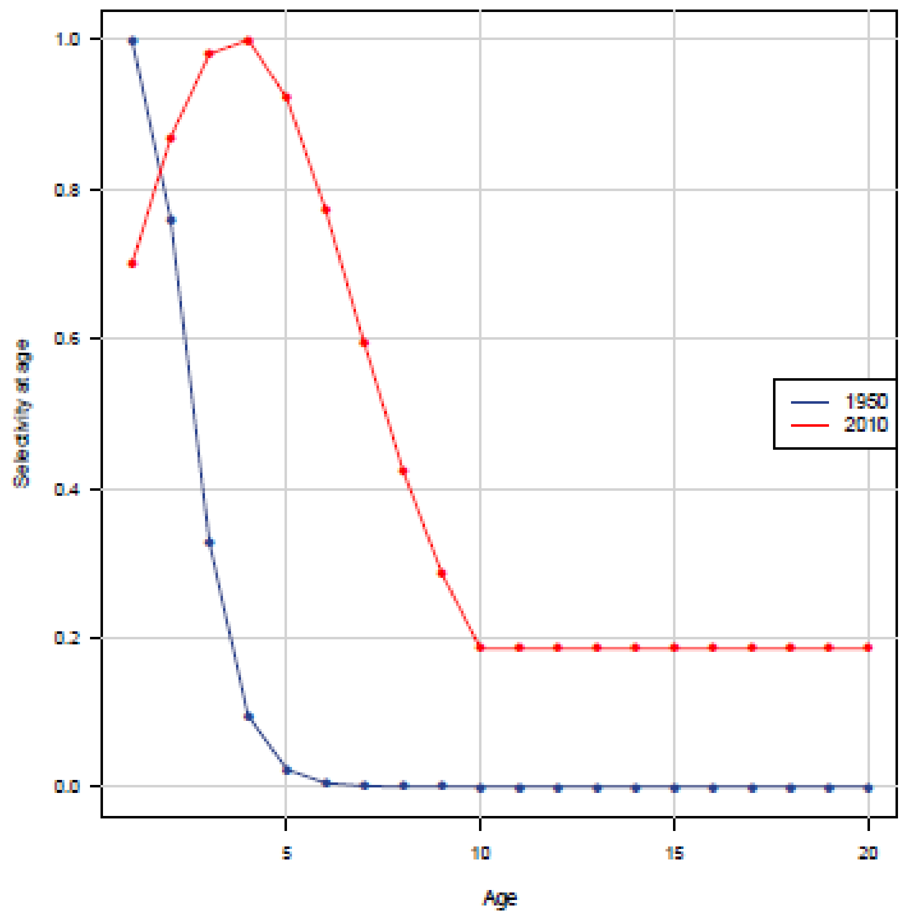
- SERFS

Commercial handline landings and discards

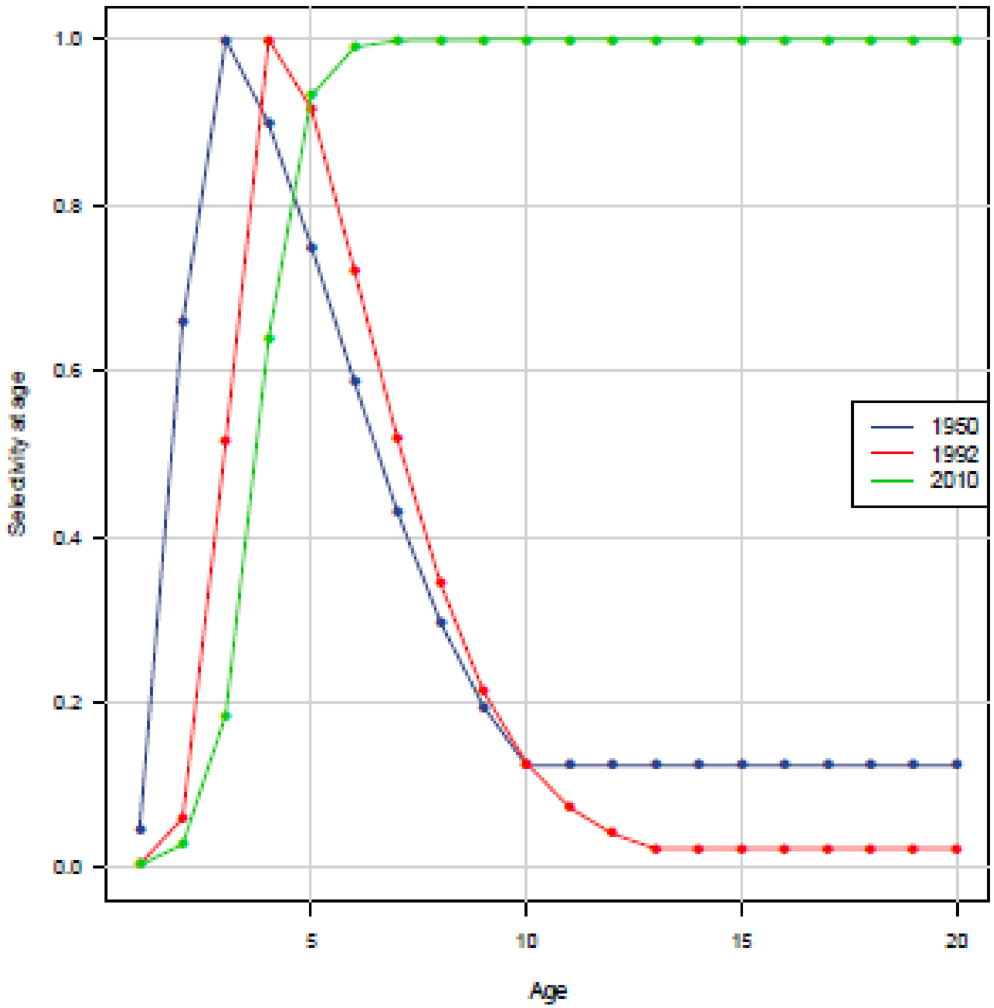


Headboat landings and discards



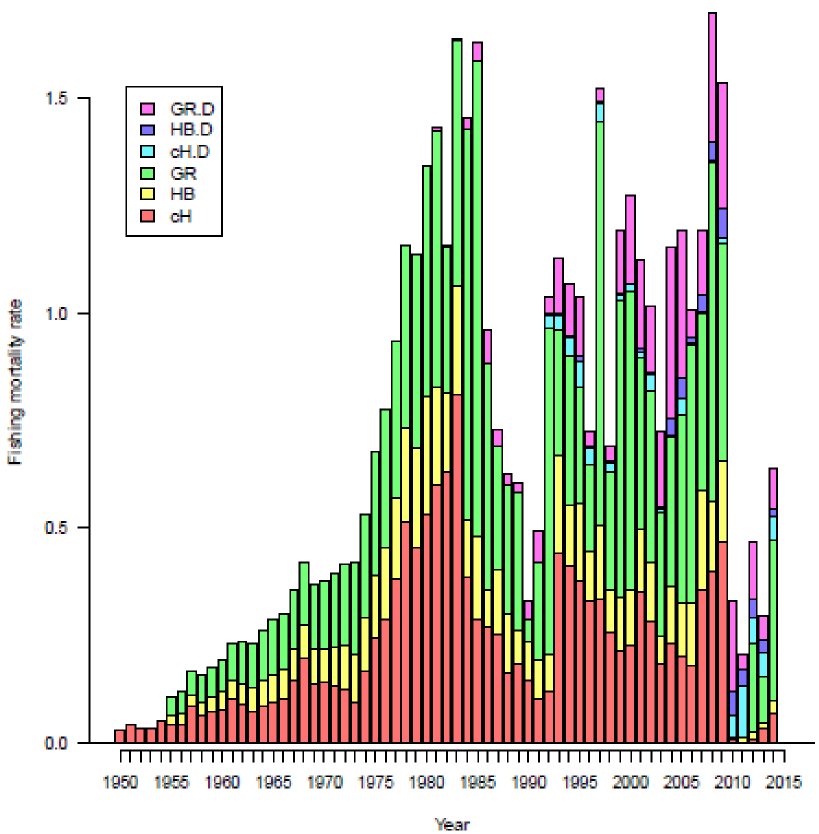


General recreational landings



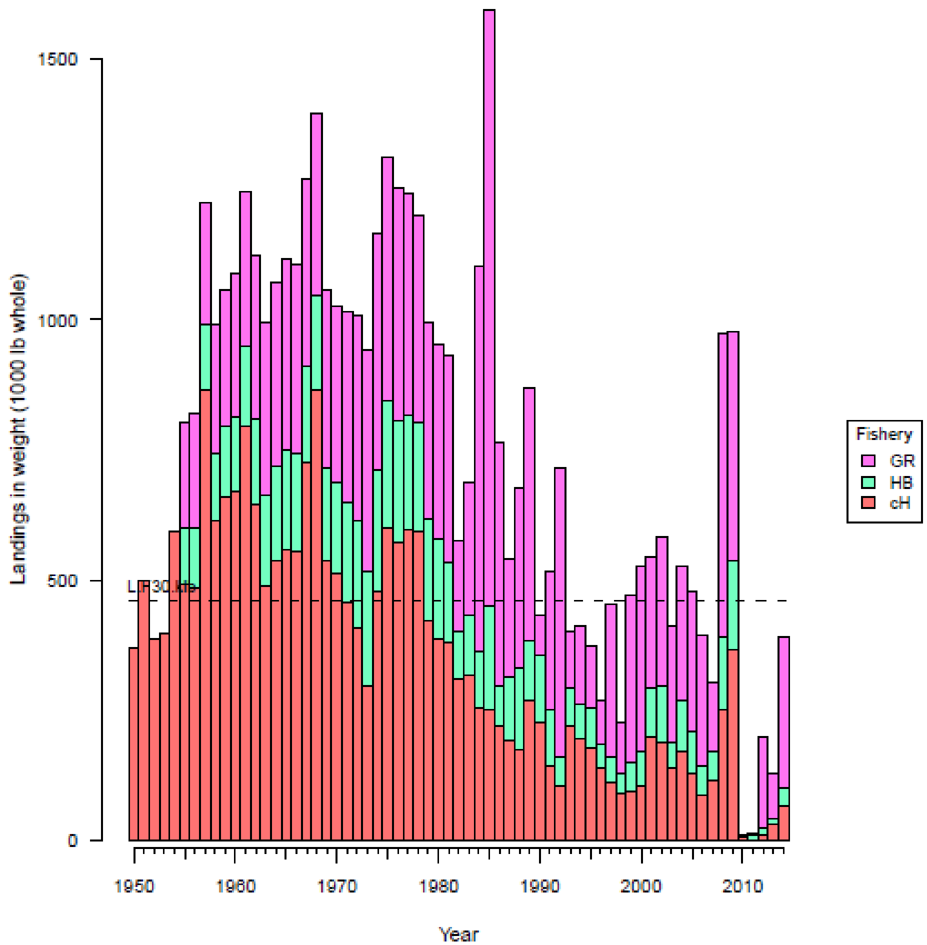
- Discards mirror headboat
- Initially attempted a dome-shaped curve for block 3, but the function kept going logistic.
- AW panel recommended using a logistic function.

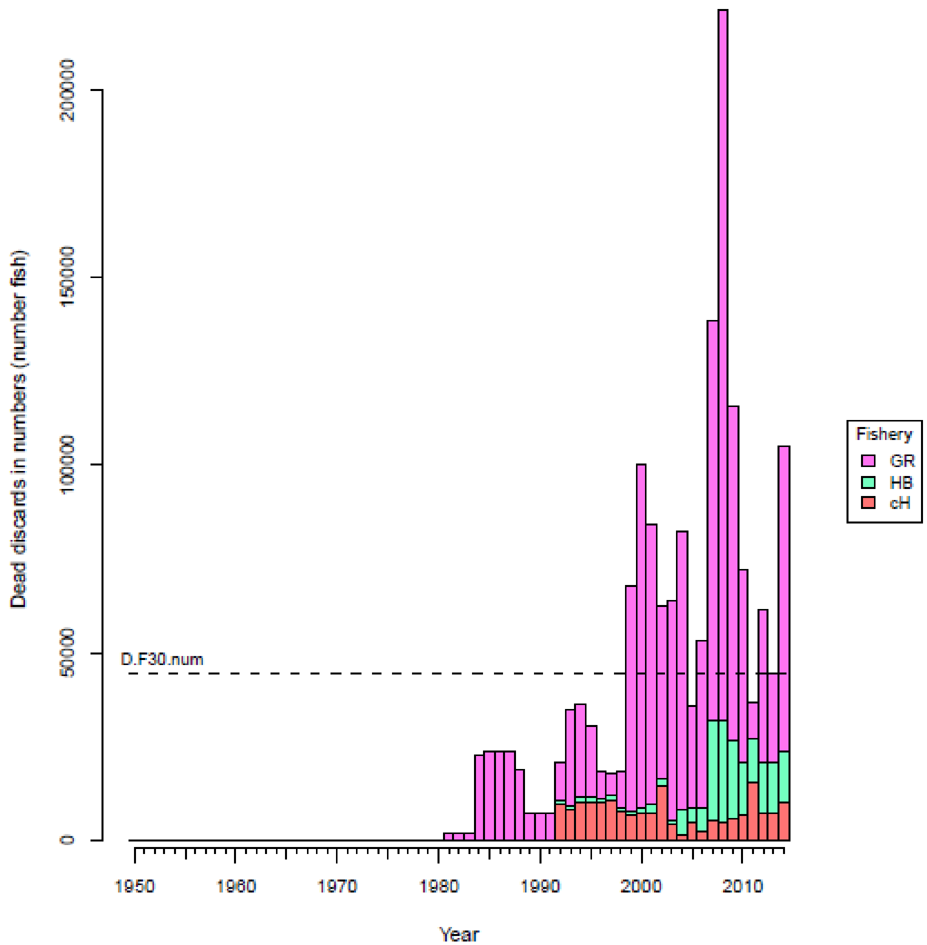
Fishing mortality by fleet



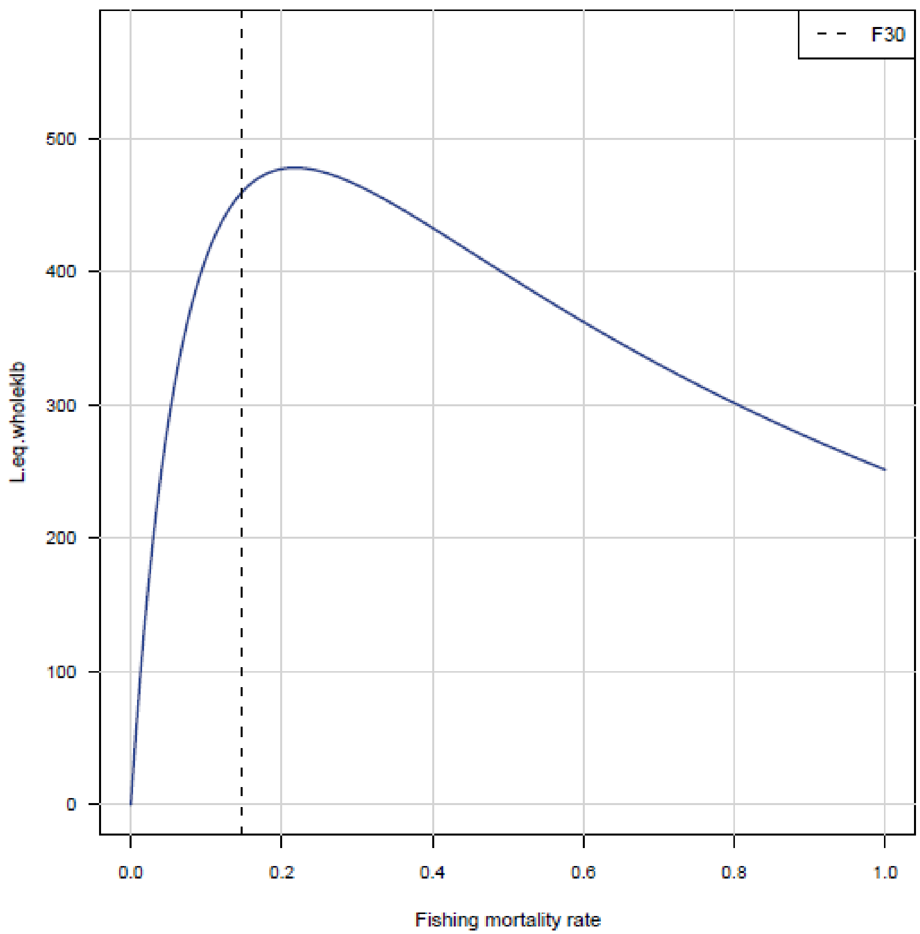
- Commercial fleet used to make up a half to a third, but has seen the biggest cut since the moratorium.
- General recreational fleet is the largest source of removals in recent years, but was always a substantial contributor to fishing mortality.

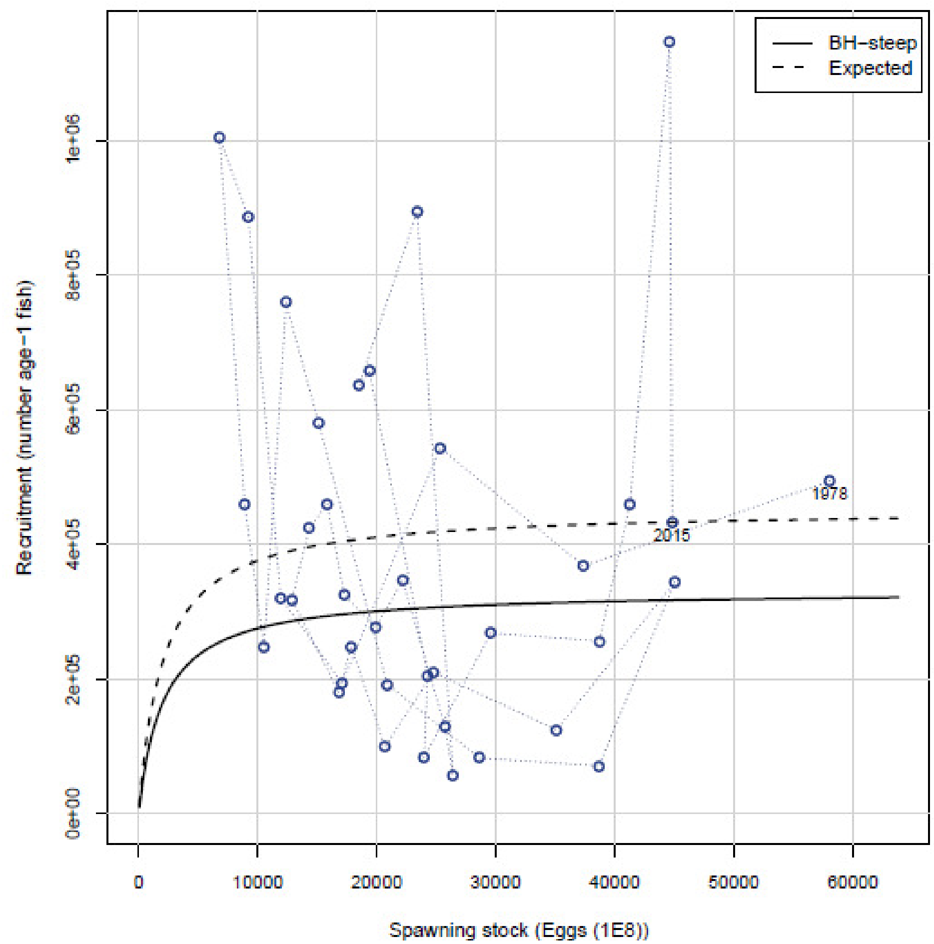
Landings (wgt) and discards (numbers)





Equilibrium yield at F and the result of h=0.99





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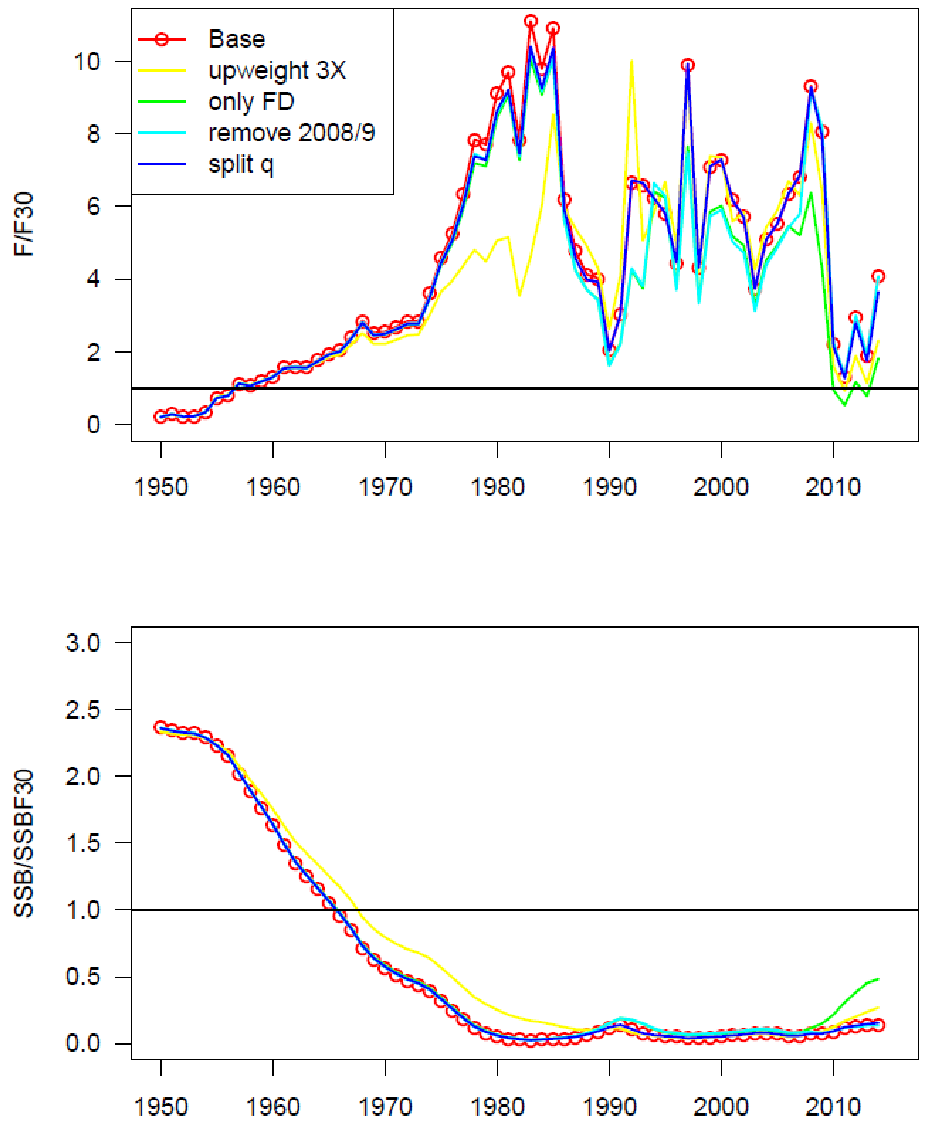
Sensitivities

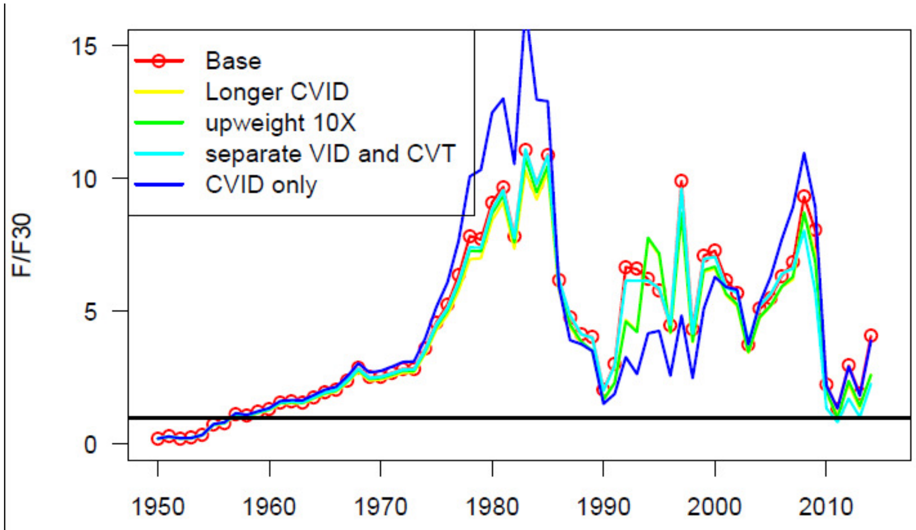
- S1: Remove the 2008 and 2009 years from the handline and headboat indices
- S2: Upweight fishery independent index further than was explored in the Assessment Workshop (10X likelihood weight after the iterative reweighting)
- S3: Upweight handline and headboat indices (3X likelihood weight after iterative reweighting)
- S4: Fishery dependent indices only
- S5: High value of M
- S6: Low value of M
- S7: Low discard mortality probabilities (commercial handlines rate set to 0.38 or 0.28, all recreational set to 0.27 or 0.20)
- S8: High discard mortality probabilities (commercial handlines rate set to 0.58 or 0.48, all recreational set 0.45 or 0.36)
- S9: Longer combined chevron trap and video (CVID) index (2005-2014)
- S10: Reduced general recreational landings in 1984 and 1985 by taking the geometric mean of surrounding years
- S11: Steepness $h = 0.84$
- S12: Headboat discard index excluded after 2009
- S13: Ageing error matrix included
- S14: Low value for age-specific number of batches
- S15: High value for age-specific number of batches
- S16: Headboat discard index dropped
- S17: High landings
- S18: Low landings
- S19: High discards
- S20: Low discards
- S21: Dome-shaped selectivity for commercial handline fleet
- S22: Separate video and trap index rather than a single CVID index
- S23: Fishery independent index only
- S24: Continuity run: changes include SEDAR24 values such as M, steepness, maturity, and SSB
- S25: Two time blocks for Headboat logbook index catchability (pre- and post-1992)

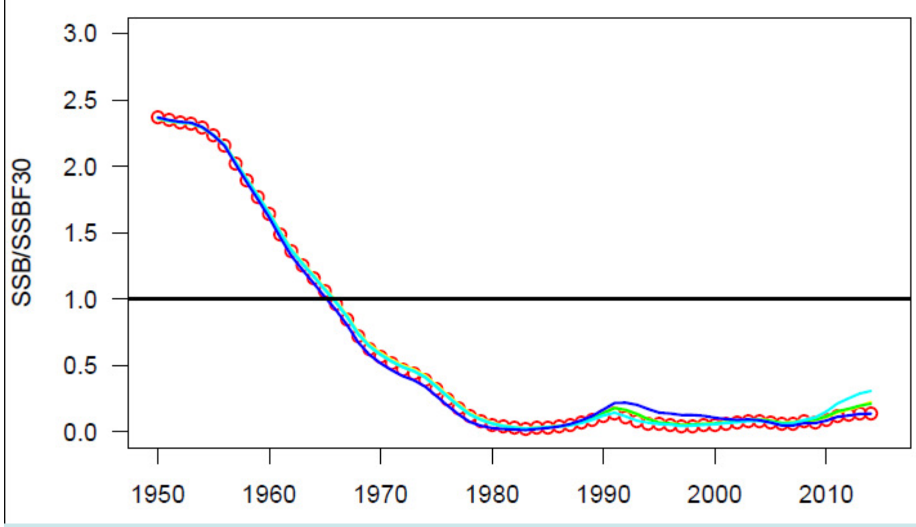
Sensitivity to changes to the FD indices

- Using only the fishery dependent indices, or upweighting them relative to the CVID index create a more optimistic status.
- Removing the last two years of the FD indices or using time-varying catchability for the HB index have little effect.



Sensitivities – to FI index changes

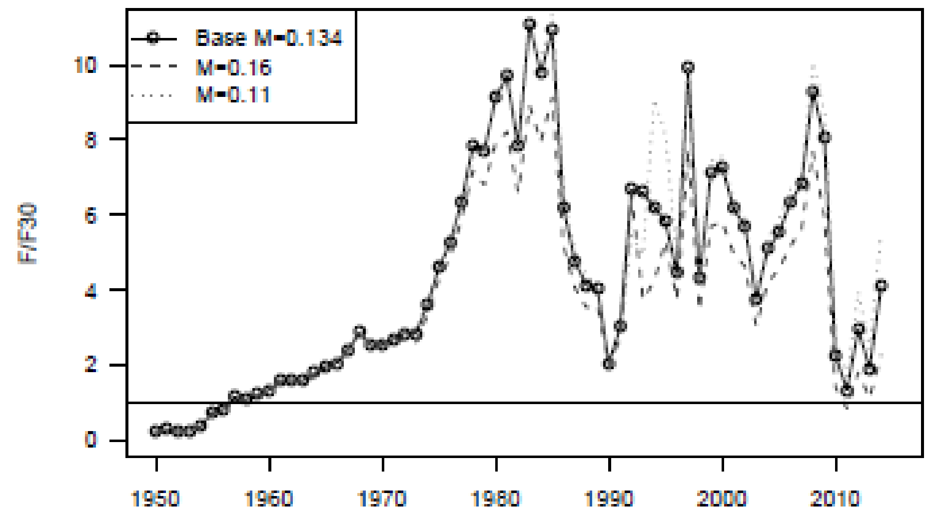


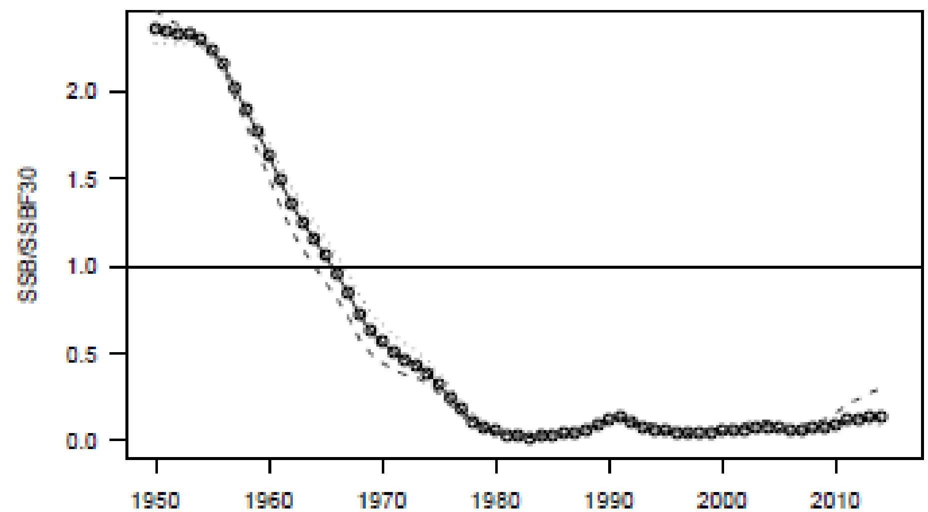


- Longer CVID time series.
- Upweight CVID 10X.
- Separate VID and CVT.
- Only CVID (no FD indices).

Sensitivity to natural mortality

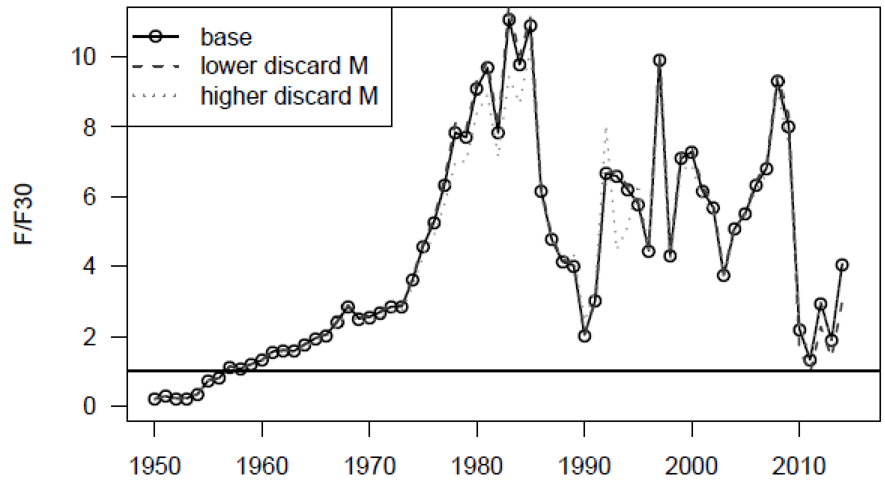
- Upper and lower asymptotic M are from the higher level of uncertainty decided at the last webinar.

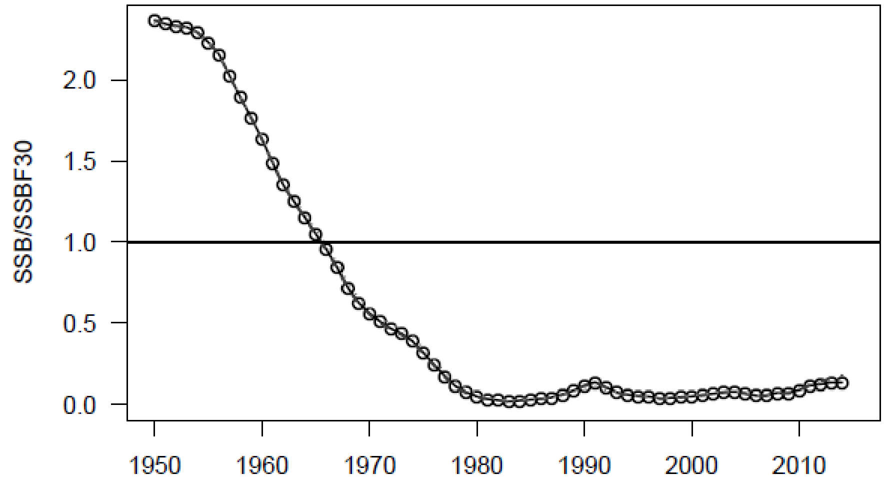




Sensitivity to discard mortality

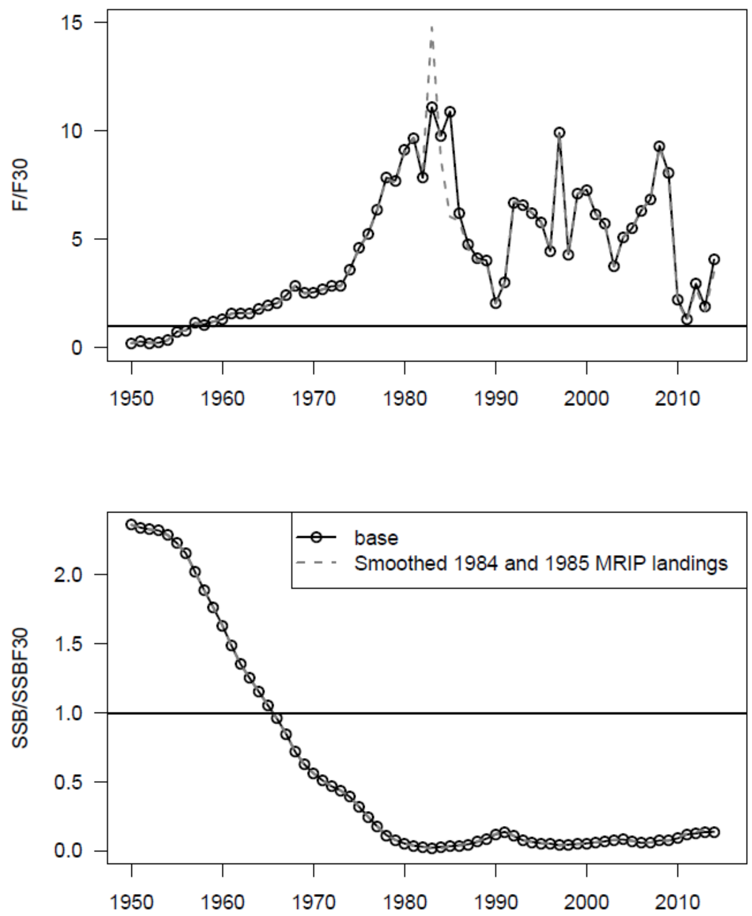
- Predictable effect on the model: higher discard M and lower discard M bracket the F status.
- Relatively little effect on the B status.





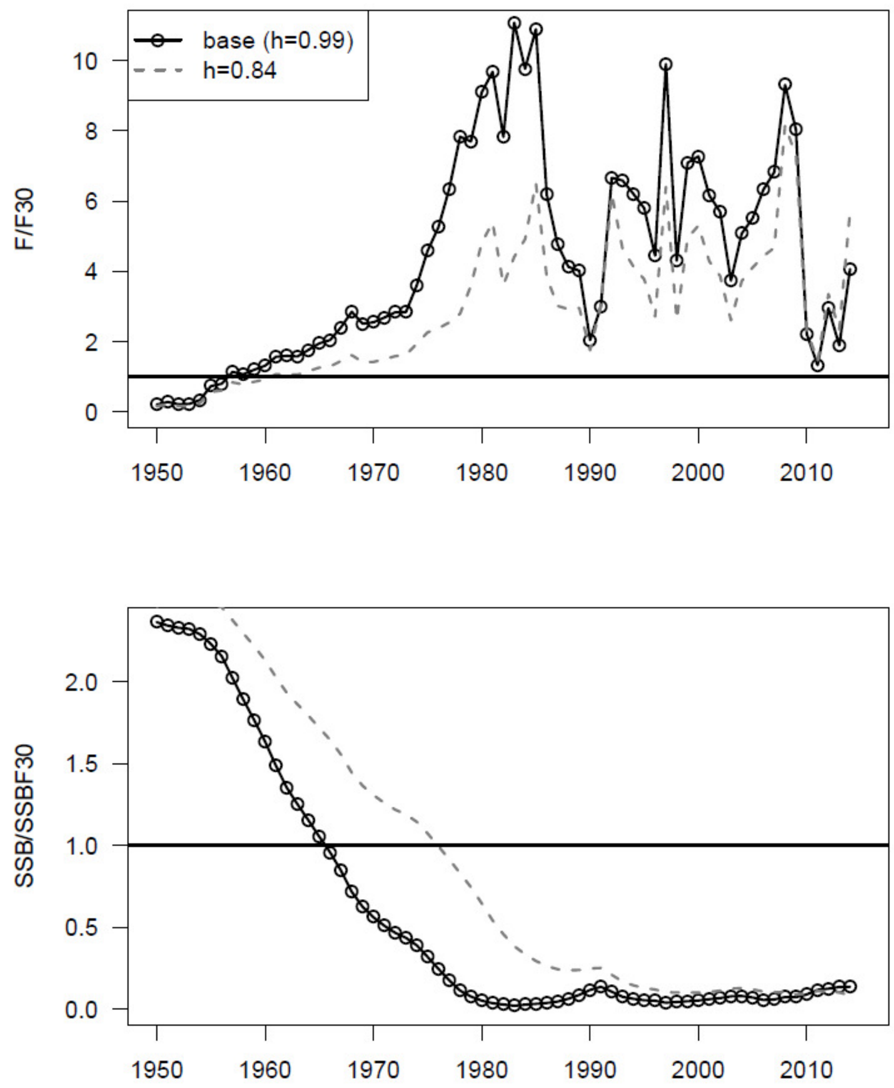
Sensitivity to peaks in MRIP landings

- Reduced the 1984 and 1985 peak using a geomean of surrounding years.
- Causes very little difference in either status except in the years where the change was made.



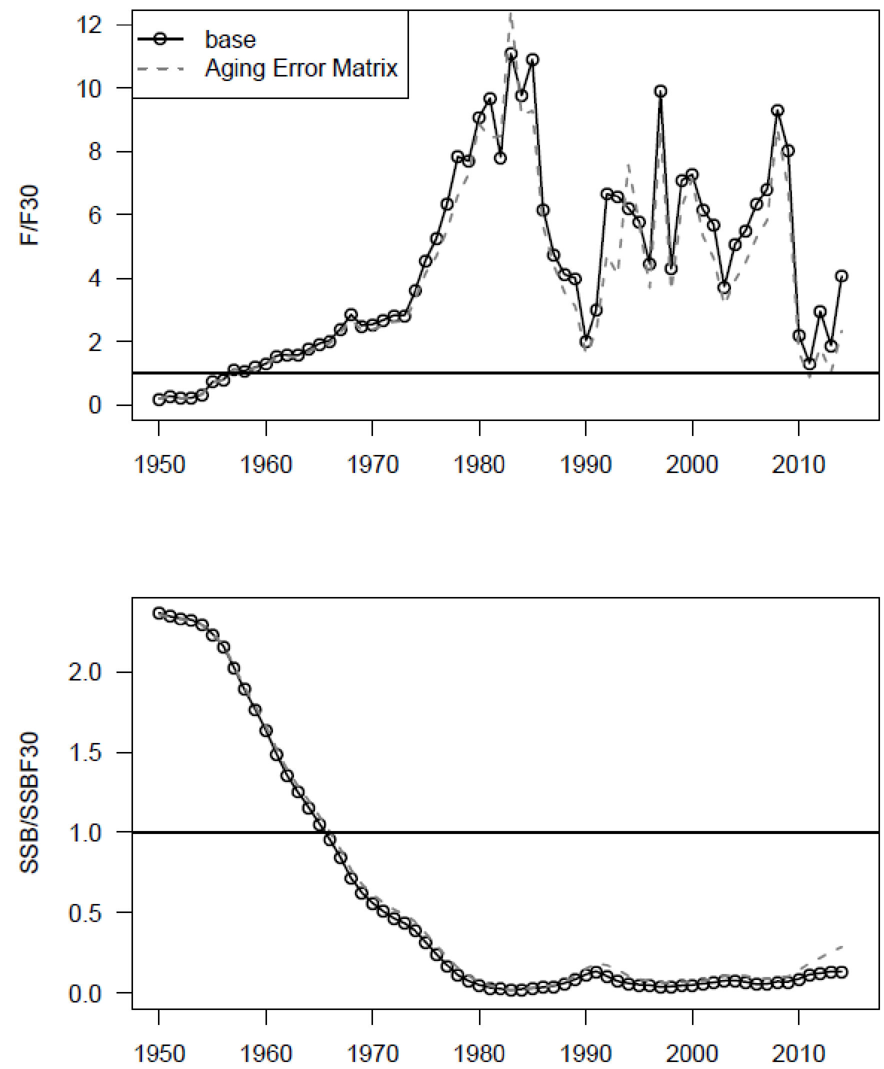
Sensitivity to steepness

- Lower steepness has large effect on terminal F status, but relatively little effect on terminal B status.



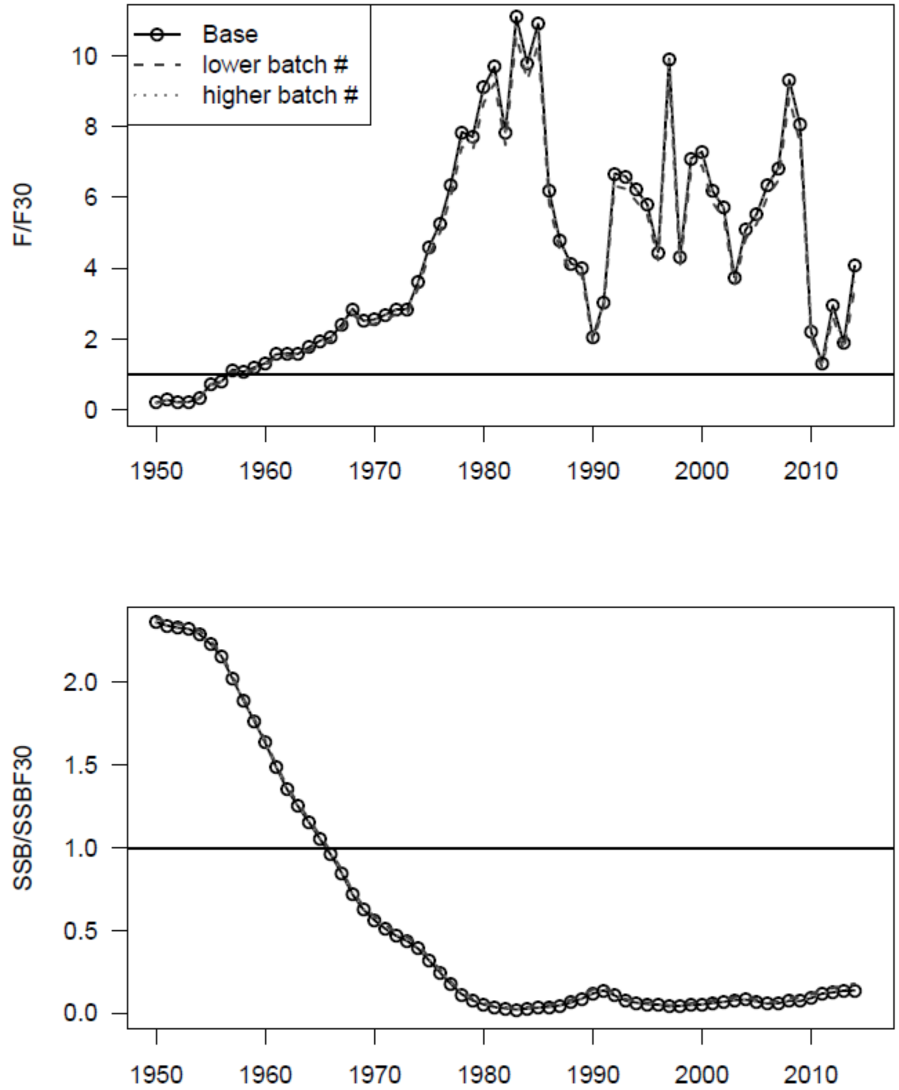
Sensitivity to the aging error matrix

- Aging error matrix increased the overall variability, without a set bias across the time series.



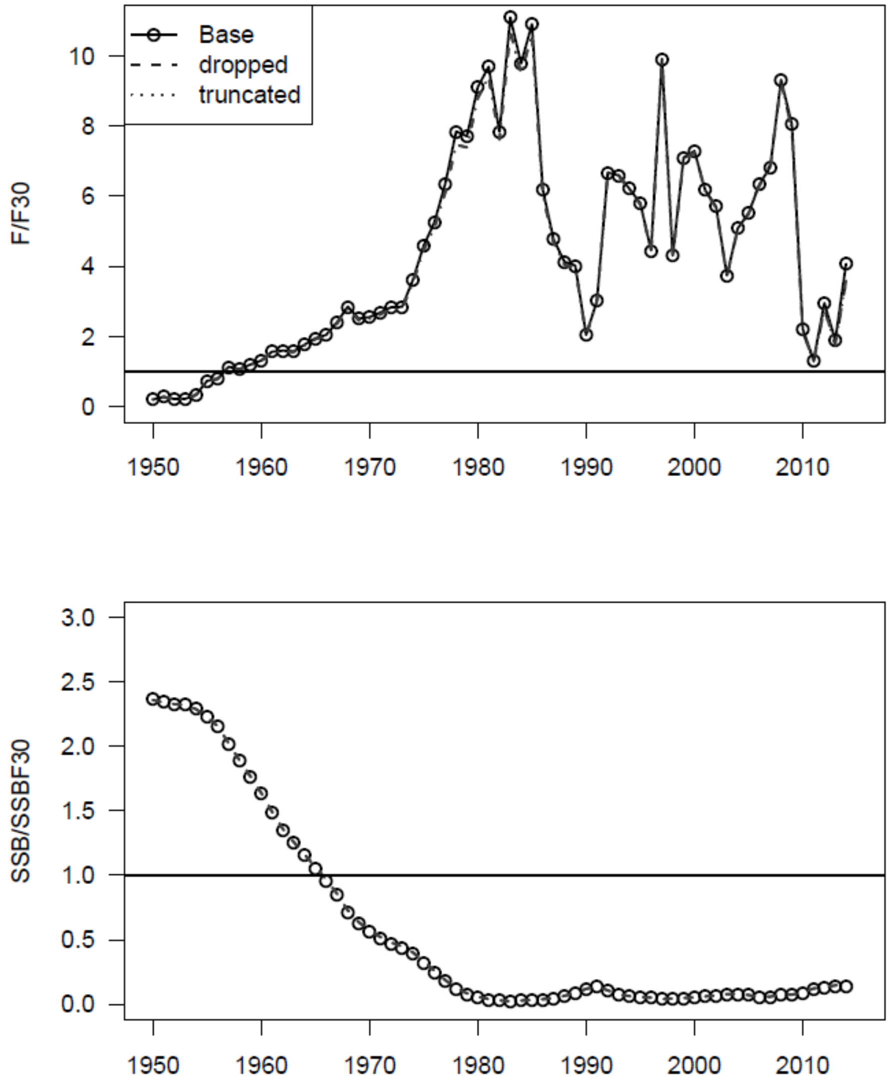
Sensitivity to batch number

- Almost no discernable difference.



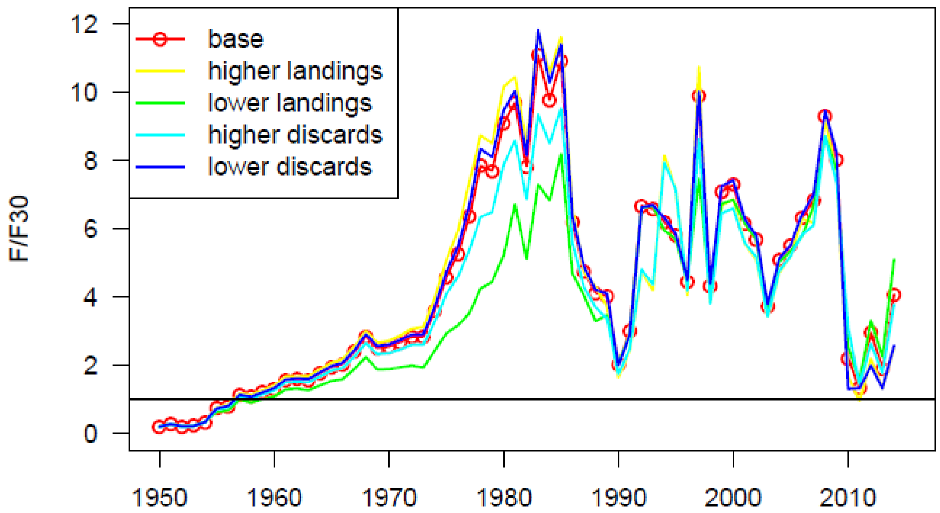
Sensitivity to HB discard index

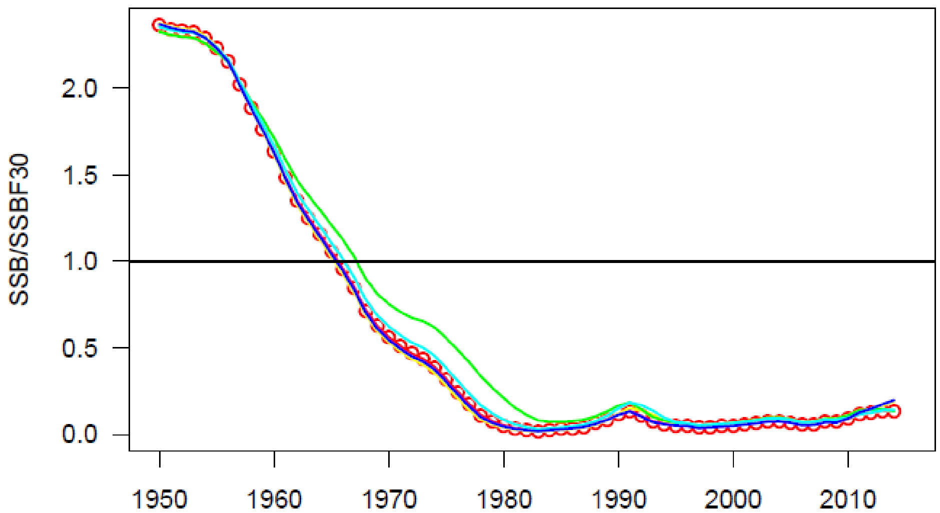
- Almost no discernable effect.



Sensitivity to landings and discard uncertainty

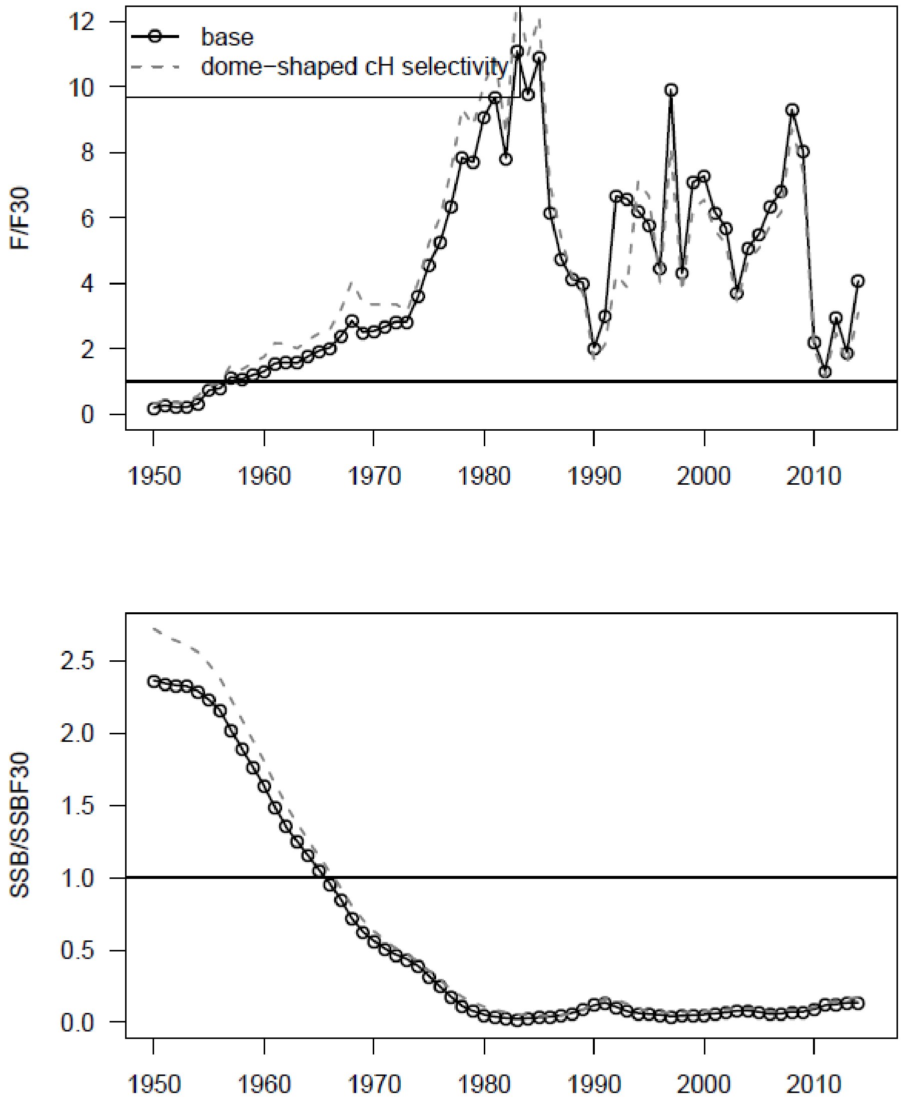
- Used the 10th and 90th quantiles from the MCB bootstrap step to create alternative landings and discards streams.
- Lower landings and lower discards bracket the base run.
- Very little effect on B status in the modern period.





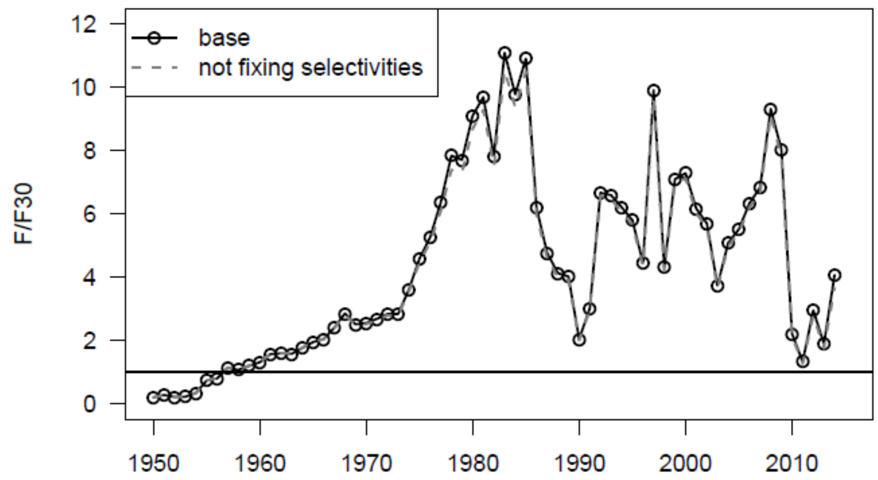
Sensitivity to dome-shaped selectivity for Commercial handlines

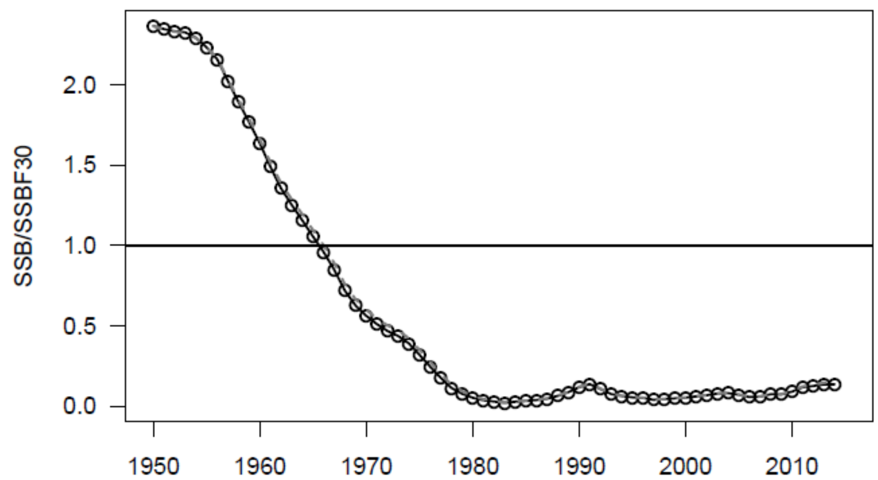
- Estimates a higher F pre-1992, and a lower F post-1992. Fstatus is not qualitatively different.
- Little effect on B status in the modern period.



Sensitivity to selectivity plus group

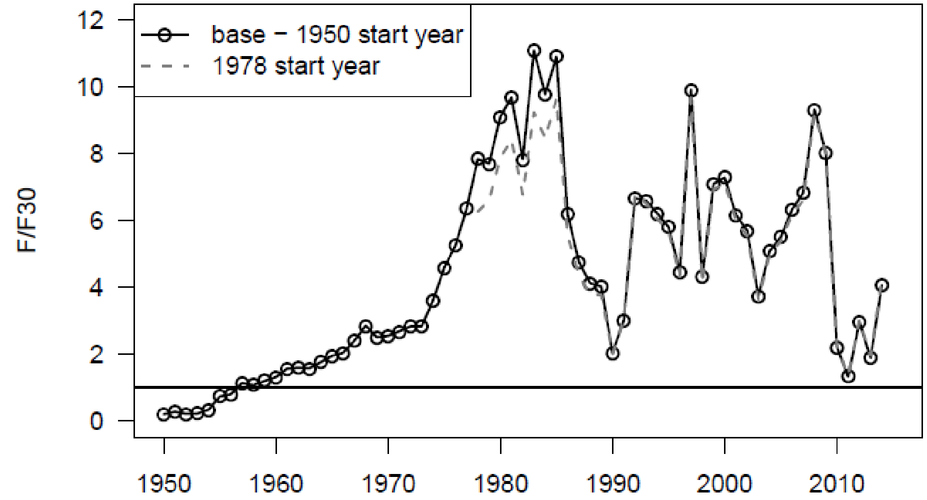
- Almost no discernable effect.

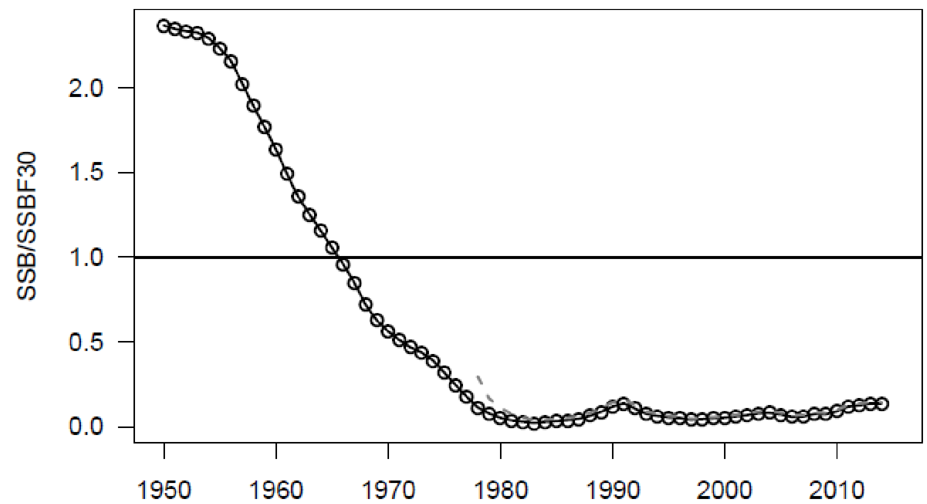




Sensitivity to the later start year - 1978

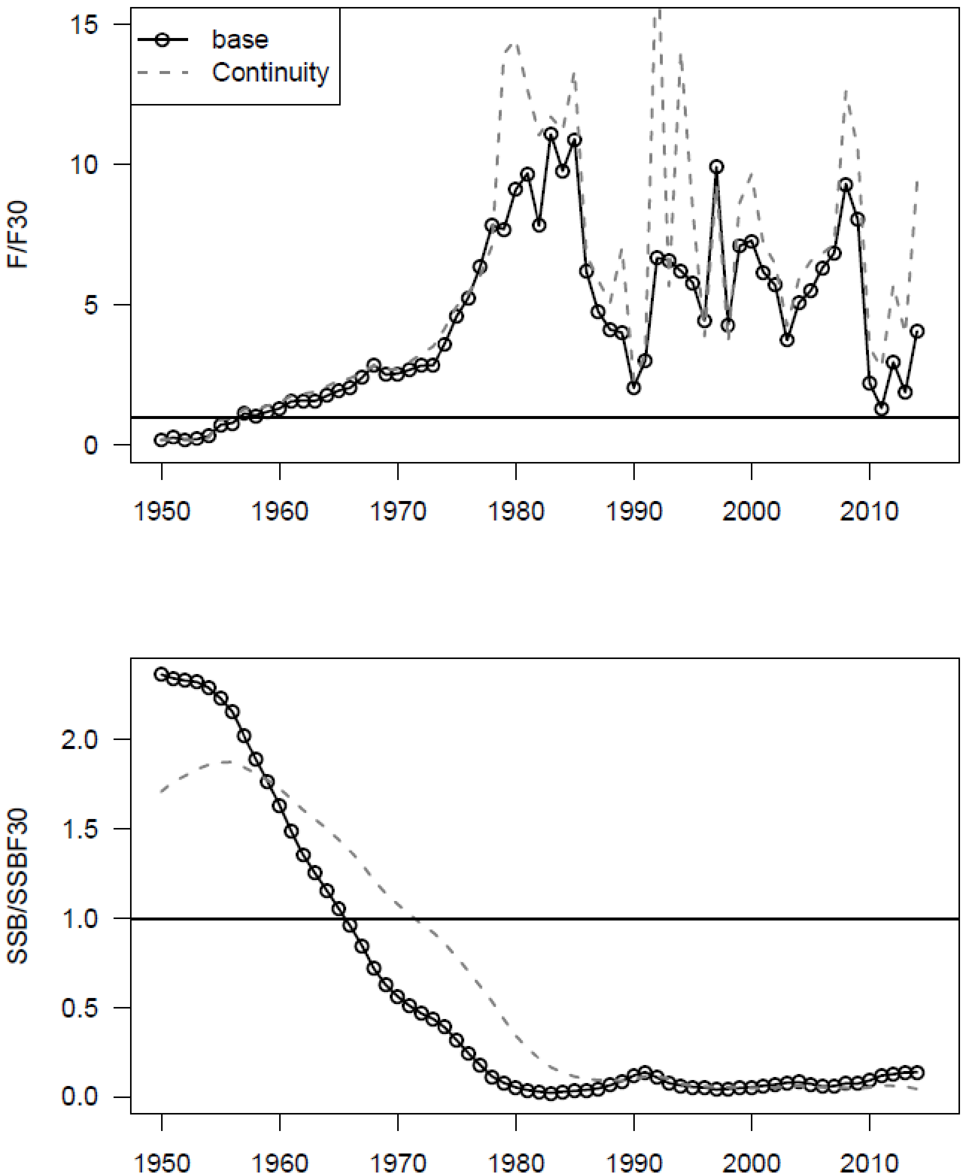
- F_{init} estimated at 0.2 (base run F_{init} estimate at 0.03 in 1950).
- Relatively little difference from base except for in first 10 years of the sensitivity.





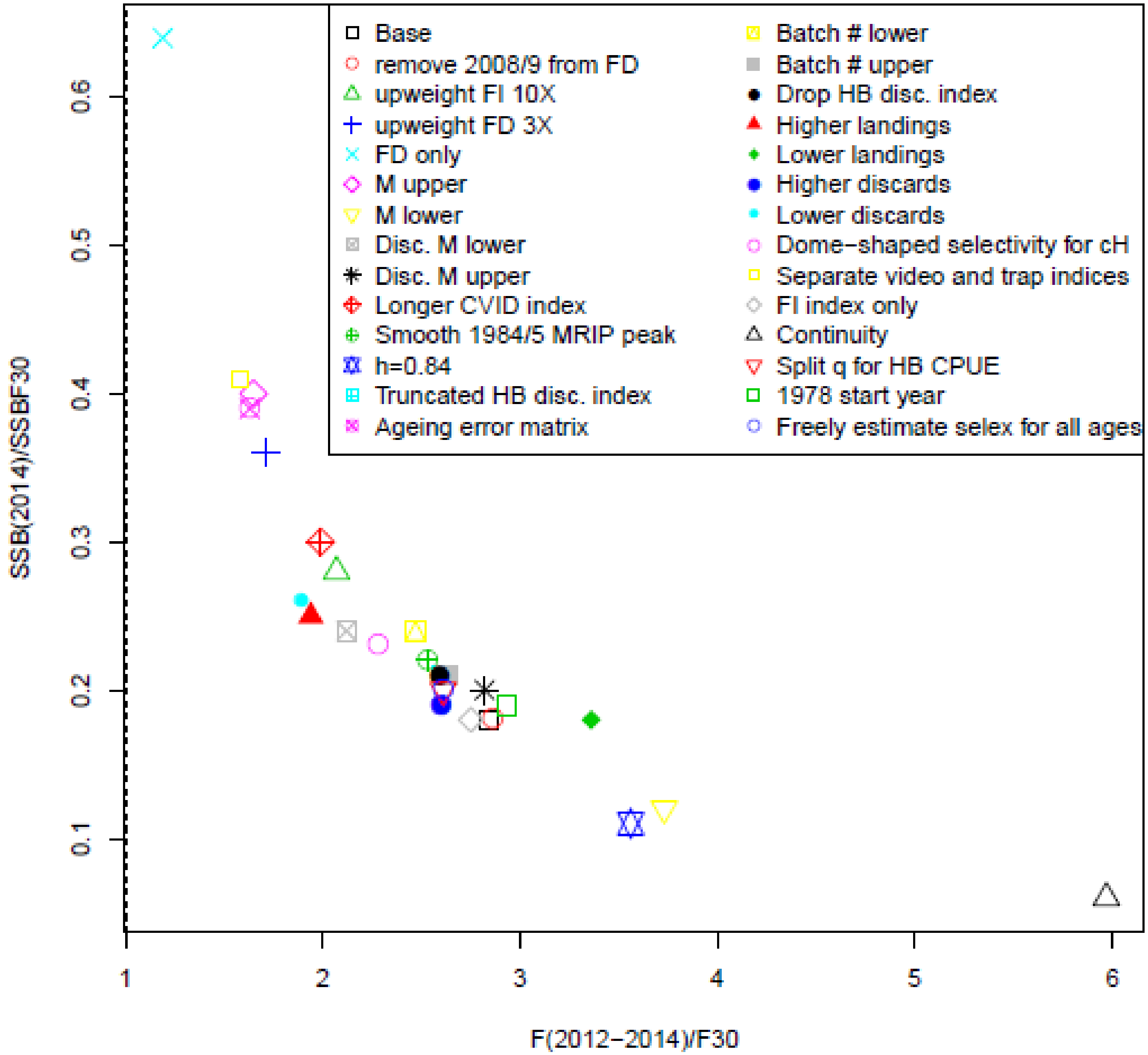
Continuity

- Changes include SEDAR 24 values for:
  - Natural mortality
  - Steepness
  - Recruitment SD
  - SSB = gonad weight
  - Spawning time of year
  - Max age
  - Discard mortalities
- Not exactly the inputs from the previous assessment, so should not be used as a literal comparison.

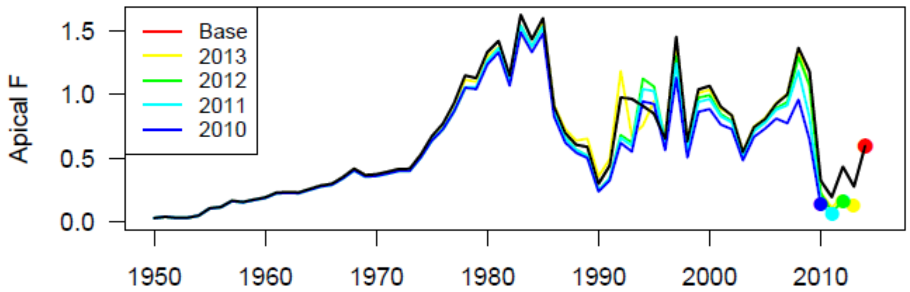


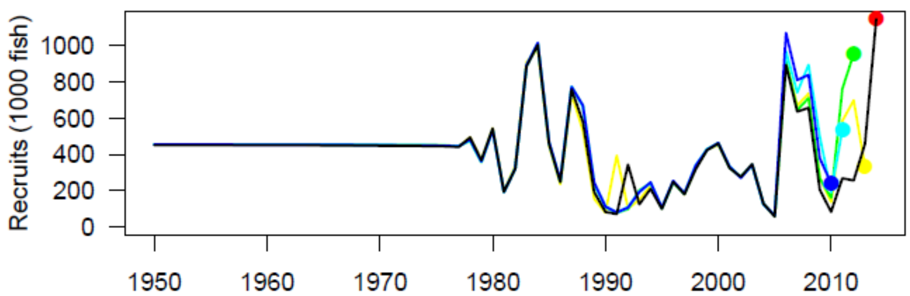
Phase plot:

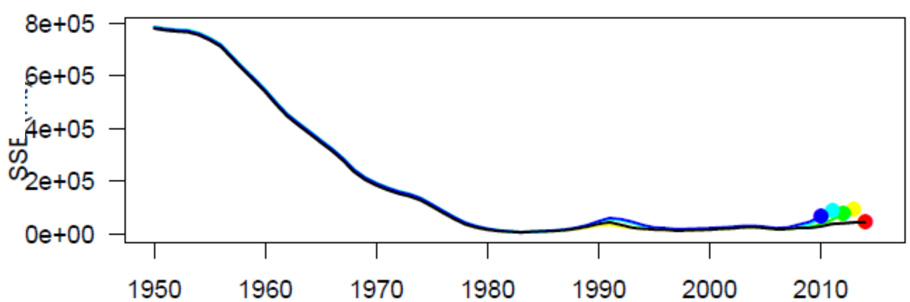
- All runs qualitatively agree with the base run.



Retrospectives



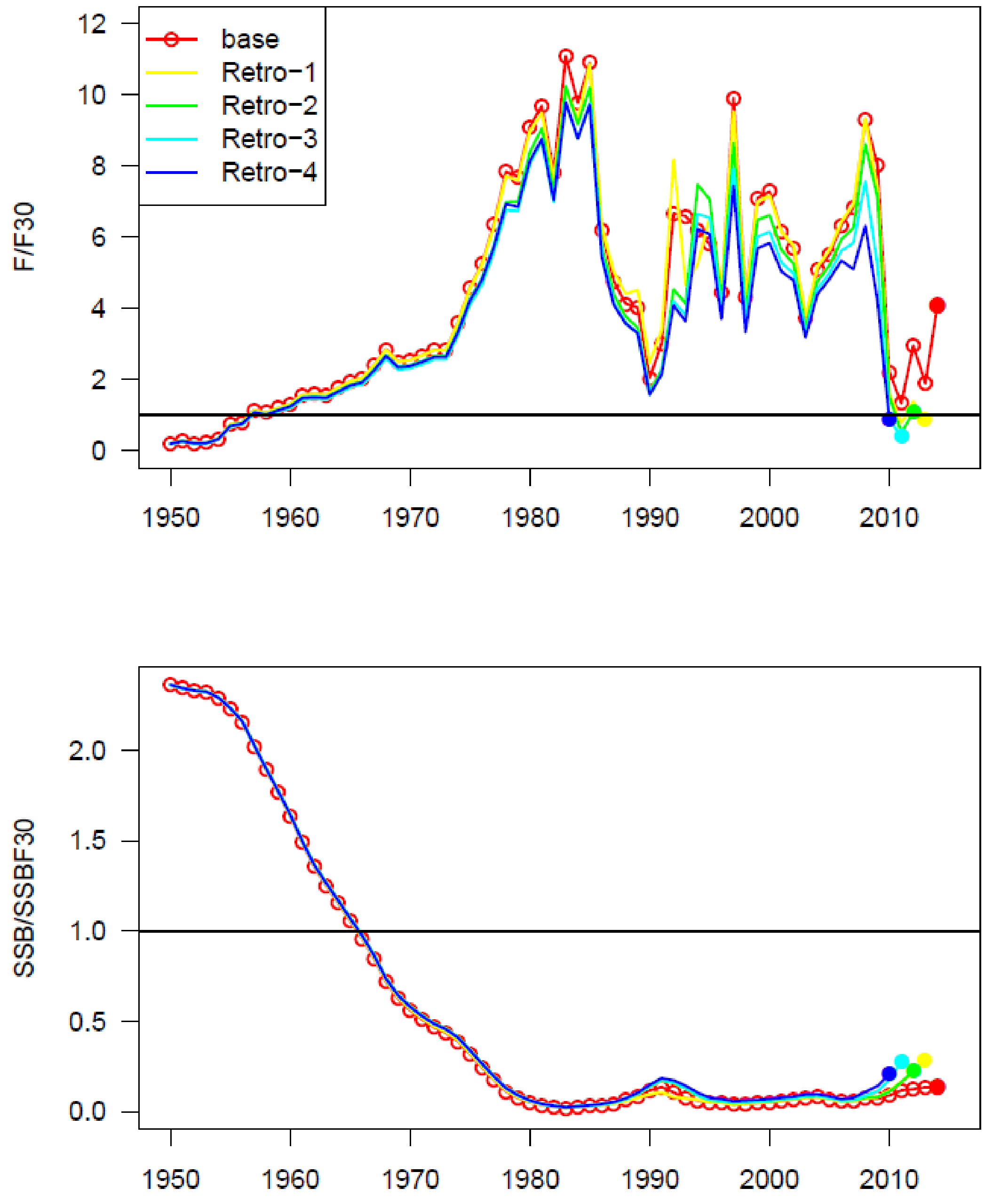




- There is a large change in F status when the terminal year's data are removed.
- Minimal pattern in recruits or SSB.

Retro status

- Removal of the terminal year has a large effect on the F status. (Refer to MCBs for uncertainty)



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  - Sensitivities
  - **Uncertainty analysis**
- Projections

MCB – Bootstrapping the data

- New time series of landings, discards, CPUE created by assuming lognormal error with mean equal to the point estimates and CV from model input (0.05 for landings in most recent time period (2008-2014), GLM estimates for CPUE)
- New length comps, age comps created each year by drawing N_{fish}, with each fish placed in a bin with probability equal to those in the original data.

Uncertainty in historic landings

- Commercial group provided estimates:
  - 1950 - 1961 – 0.25 CV
  - 1961 - 1977 – 0.20 CV
  - 1978 - 1985 – 0.10 CV
- Where state-specific, we used Florida values.
- Recreational group provided a CV on historical recreational catch (1955-1980) of 0.59. We applied a random scalar +/- 1 SD to the whole time period rather than annually vary the historic catch.

Uncertainty in recreational landings

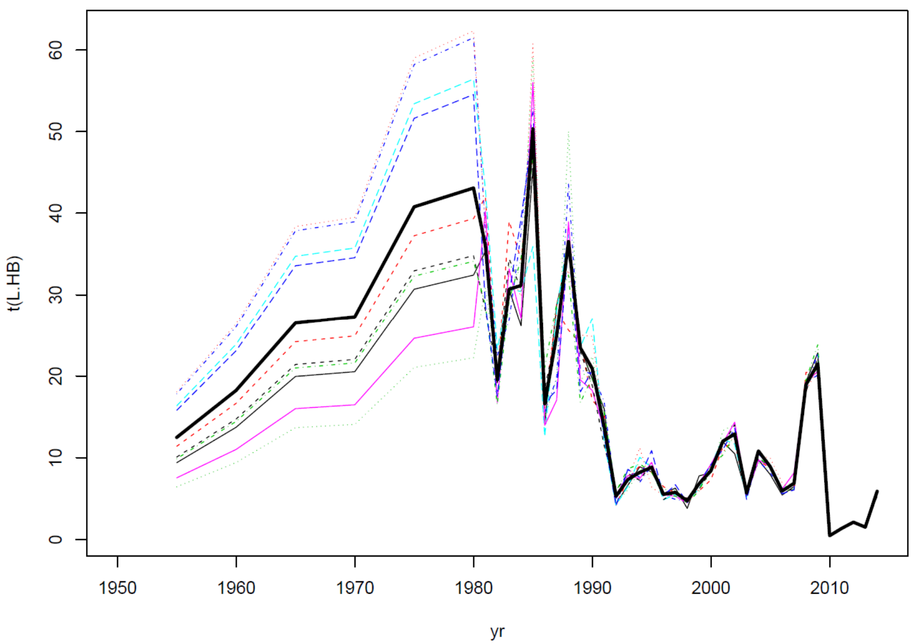
- For MRIP landings, apply a lognormal error with mean from base point estimates and CVs provided by the Recreational Working Group.
- For Headboat landings:
  - 1981-1995 – CV of 0.15 to indicate better certainty than in the historic time period, and than MRIP, but before the mandatory reporting and full compliance.
  - 1996-2007 – CV of 0.10, improvement from mandatory reporting.
  - 2008-current – CV of 0.05, improvement from full compliance.

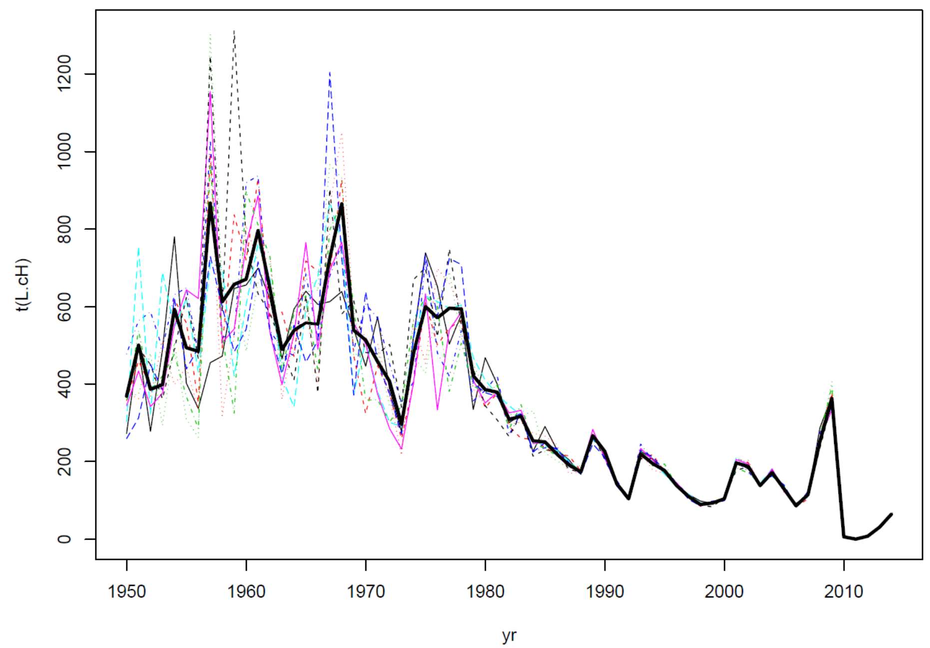
Uncertainty in Discards

- Recreational group and Commercial group provided no CVs for Headboat or Commercial handline discards.
  - We used a CV of 0.2, which is larger than landings, but smaller than the MRIP discard uncertainty.
- Recreational group provided CVs for MRIP discards, and we assume a CV of 1 where they are missing.
- Applied similarly to the CVs described for landings.

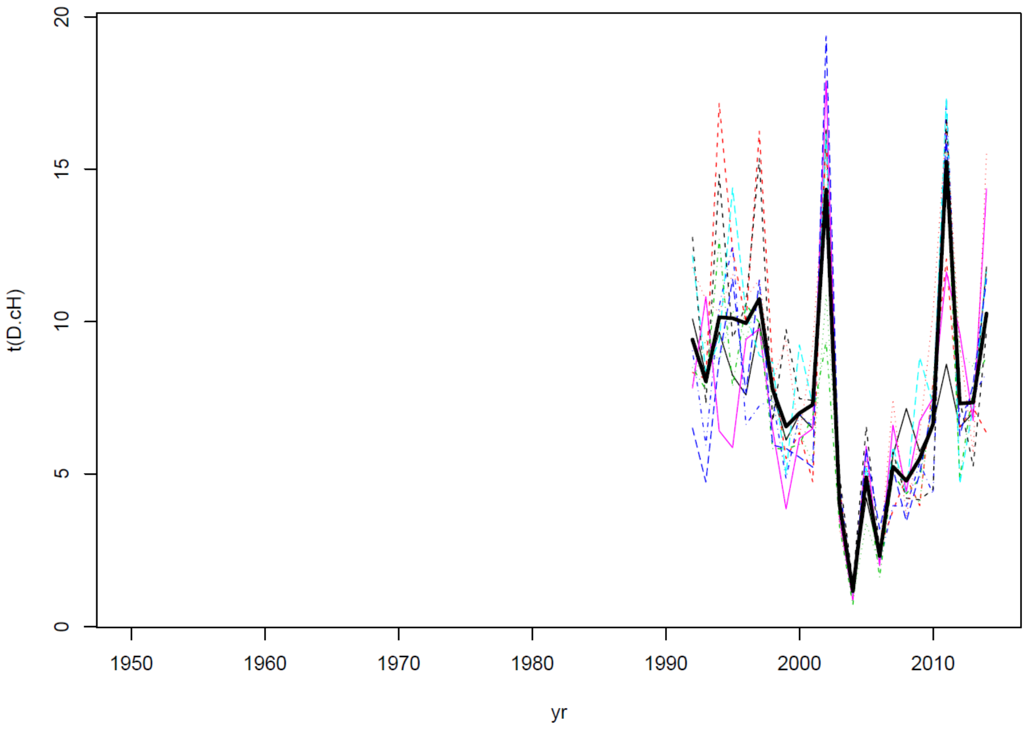
yr	cv.L.cH	cv.L.HB	cv.L.GR	cv.D.cH	cv.D.HB	cv.D.GR
1981	0.1	0.15	0.269	NA	NA	1.00
1982	0.1	0.15	0.345	NA	NA	1.00
1983	0.1	0.15	0.177	NA	NA	1.00
1984	0.1	0.15	0.217	NA	0.2	0.558
1985	0.1	0.15	0.201	NA	0.2	1.340
1986	0.05	0.15	0.289	NA	0.2	1.000
1987	0.05	0.15	0.202	NA	0.2	1.624
1988	0.05	0.15	0.283	NA	0.2	1.327
1989	0.05	0.15	0.210	NA	0.2	1.178
1990	0.05	0.15	0.287	NA	0.2	1.000
1991	0.05	0.15	0.309	NA	0.2	1.447
1992	0.05	0.15	0.192	0.2	0.2	0.789
1993	0.05	0.15	0.218	0.2	0.2	0.684
1994	0.05	0.15	0.267	0.2	0.2	0.810
1995	0.05	0.15	0.288	0.2	0.2	0.534
1996	0.05	0.1	0.424	0.2	0.2	1.072
1997	0.05	0.1	0.518	0.2	0.2	0.543
1998	0.05	0.1	0.236	0.2	0.2	0.957
1999	0.05	0.1	0.234	0.2	0.2	0.468
2000	0.05	0.1	0.229	0.2	0.2	0.446
2001	0.05	0.1	0.185	0.2	0.2	0.416
2002	0.05	0.1	0.169	0.2	0.2	0.562
2003	0.05	0.1	0.200	0.2	0.2	0.469
2004	0.05	0.1	0.212	0.2	0.2	0.294
2005	0.05	0.1	0.245	0.2	0.2	0.232
2006	0.05	0.1	0.264	0.2	0.2	0.313
2007	0.05	0.1	0.242	0.2	0.2	0.259
2008	0.05	0.05	0.274	0.2	0.2	0.360
2009	0.05	0.05	0.254	0.2	0.2	0.383
2010	0.05	0.05	1.000	0.2	0.2	0.387
2011	0.05	0.05	1.000	0.2	0.2	0.340
2012	0.05	0.05	0.166	0.2	0.2	0.387
2013	0.05	0.05	0.182	0.2	0.2	0.309
2014	0.05	0.05	0.108	0.2	0.2	0.212

Examples of bootstrapped data – headboat and handline landings





Handline discards



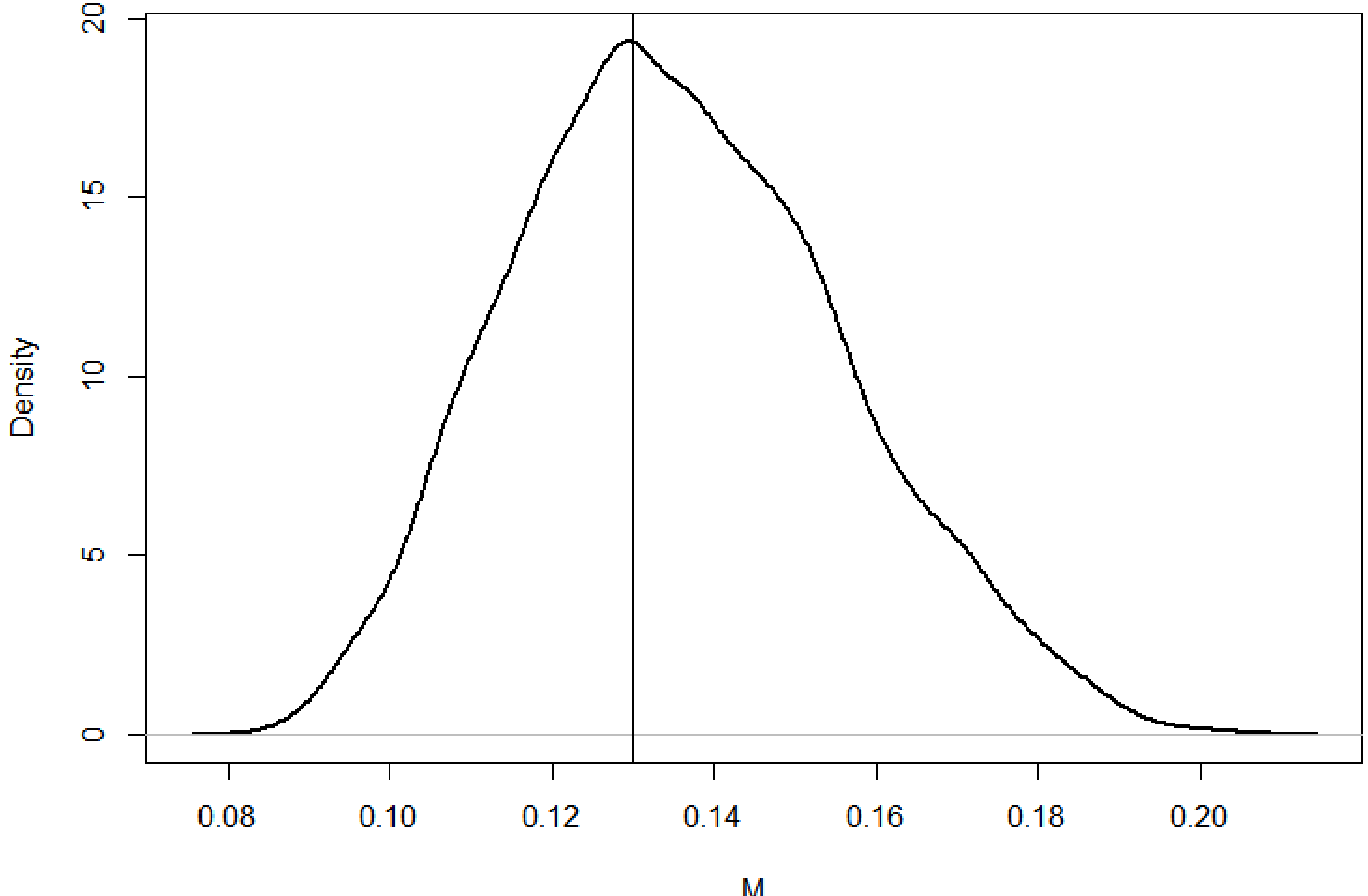
Monte Carlo Sampling

- Natural mortality
- Discard mortality
- Fecundity

Natural mortality

- Range provided by the life history group was very small (constant M = 0.12-0.14), and the AW Panel recommended an approach that would incorporate more uncertainty
- M is calculated using the Charnov age-dependent curve which is then scaled to the Then et al. estimator: $M=a*T_{max}^{b}$
  - The Then et al. (2014) data to estimate a and b were acquired, and drawn from with replacement.
  - Tmax was drawn from a uniform distribution

Natural mortality scalar ($M=aT_{max}^{b}$)

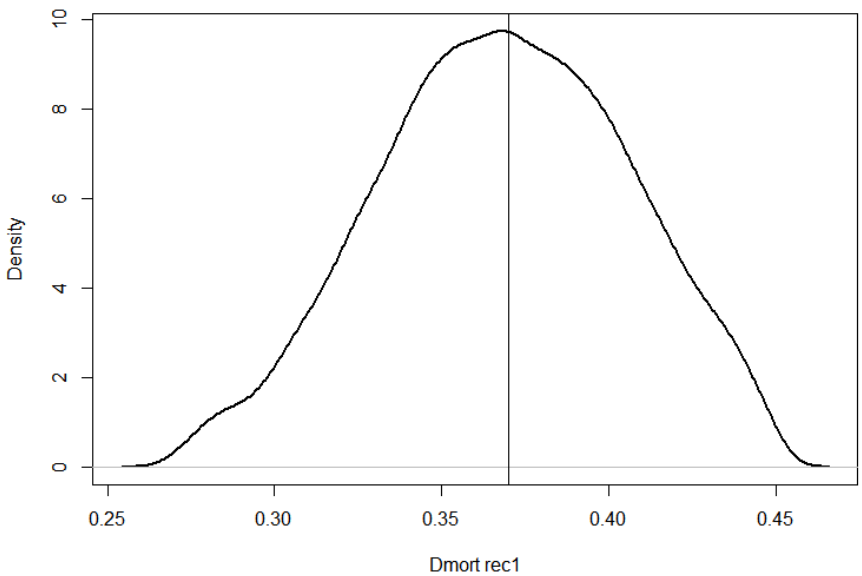


Discard mortality

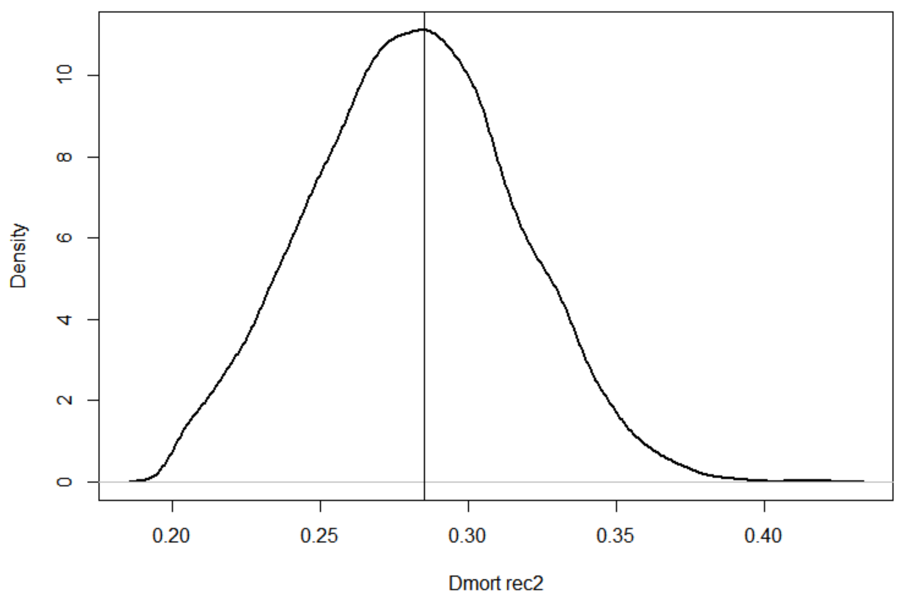
- Two periods for discard mortality: before and after circle hooks (different values for Commercial and Recreational)
- Draw period one mortality from a truncated normal distribution, with mean equal to the point estimate, and SD devised to give CIs
- Draw period two mortality from a truncated normal distribution, with mean equal to the point estimate, and SD devised to give CIs provided by the DW. Upper bound fixed at the period one value (i.e., discard mortality cannot increase with the implementation of circle hooks)

Discard mortality, Recreational

Period one

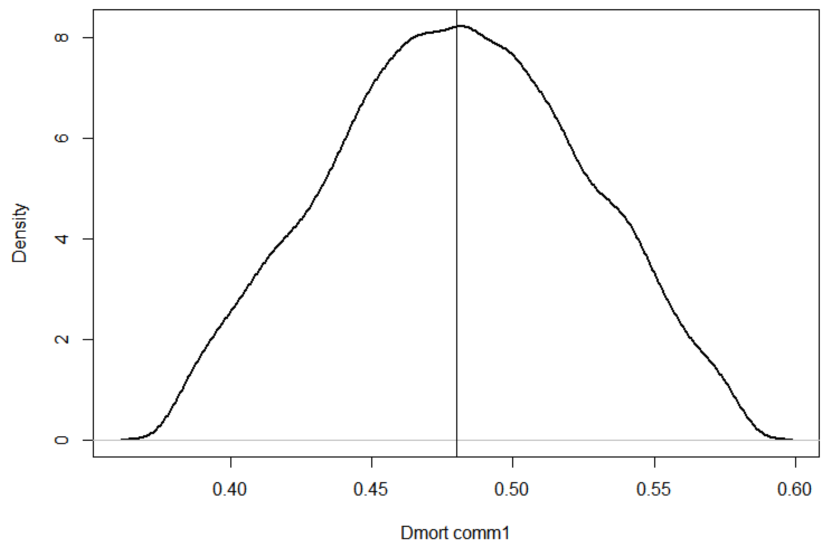


Period two (circle hooks)

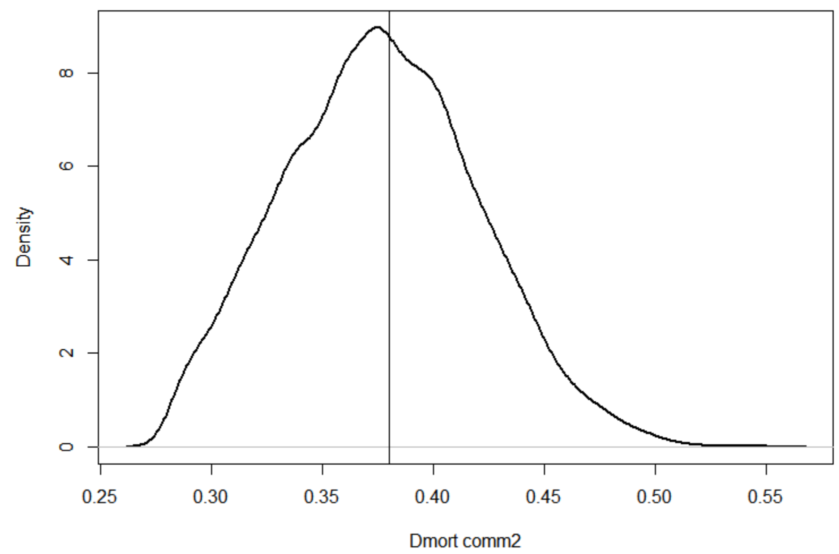


Discard mortality, Commercial

Period one



Period two (circle hooks)

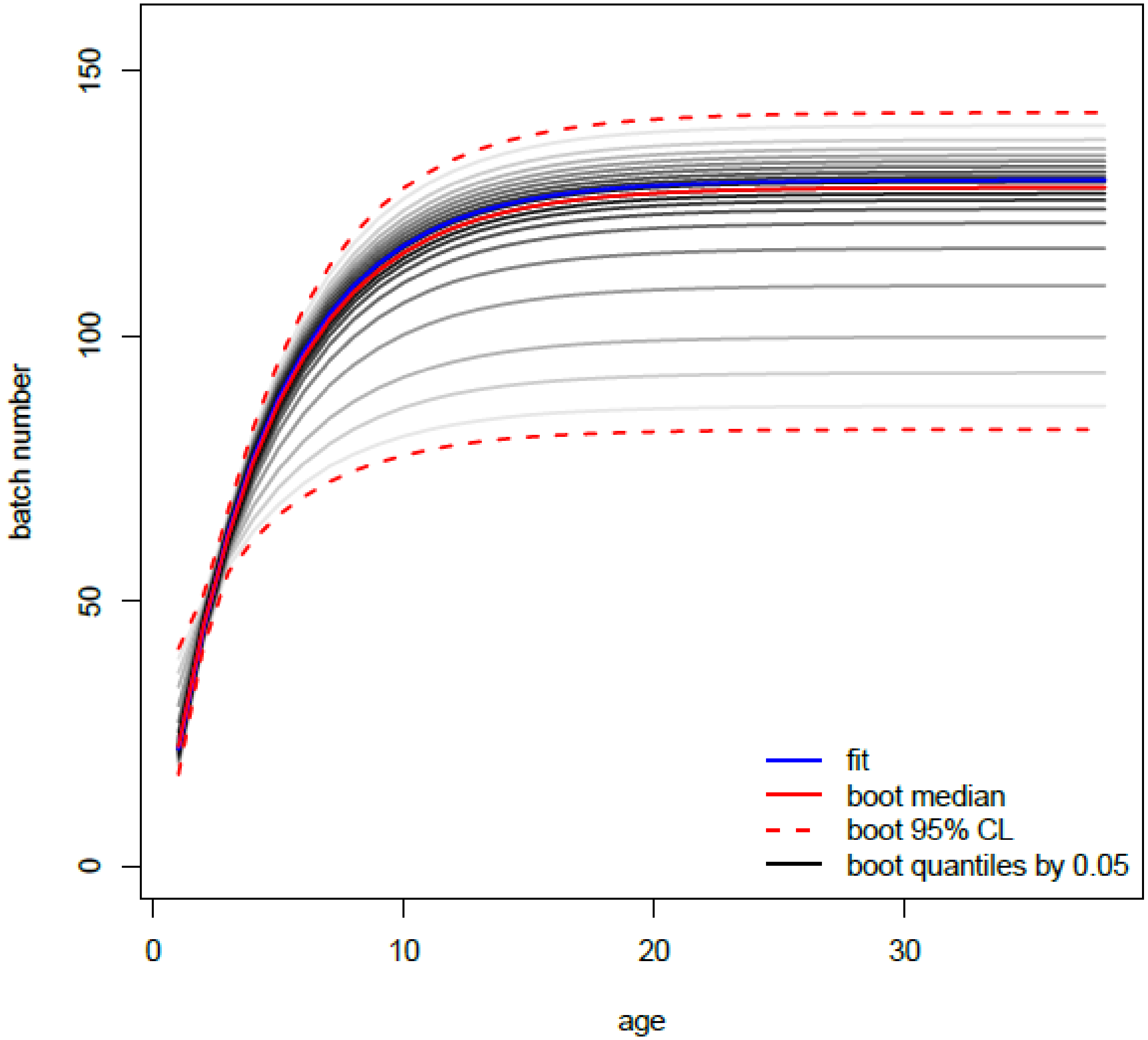


Fecundity

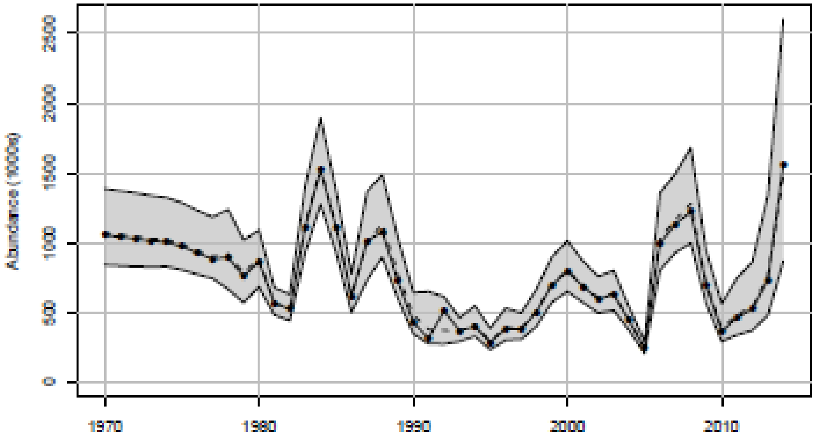
- Batch fecundity: a*len^{b}
  - Bootstrap fits to data provided 10000 estimates of a and b.
  - Parameters correlated, so they were drawn together with replacement and the regression model refit.
  - Fits outside of the 95% CI were trimmed.

- Number of batches at age
  - Used the same approach as above, but applied to fish length, day of year and spawning indicator presence.
  - A vector of batches at age was drawn from the trimmed data set for each MCB trial.

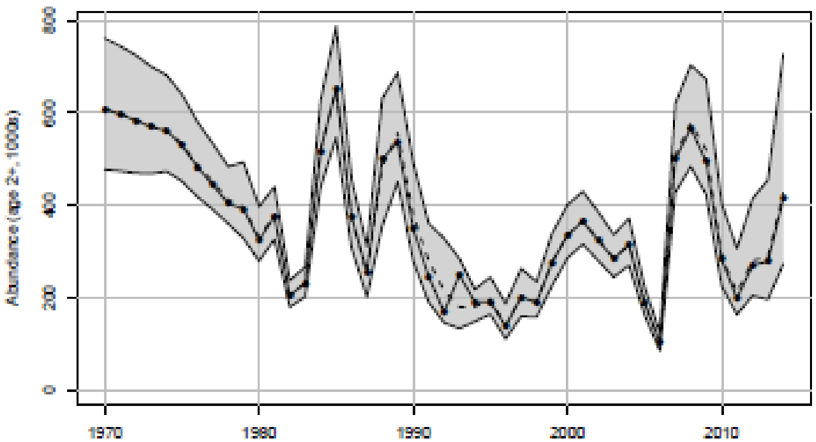
Batch number



Results – Abundance in Numbers

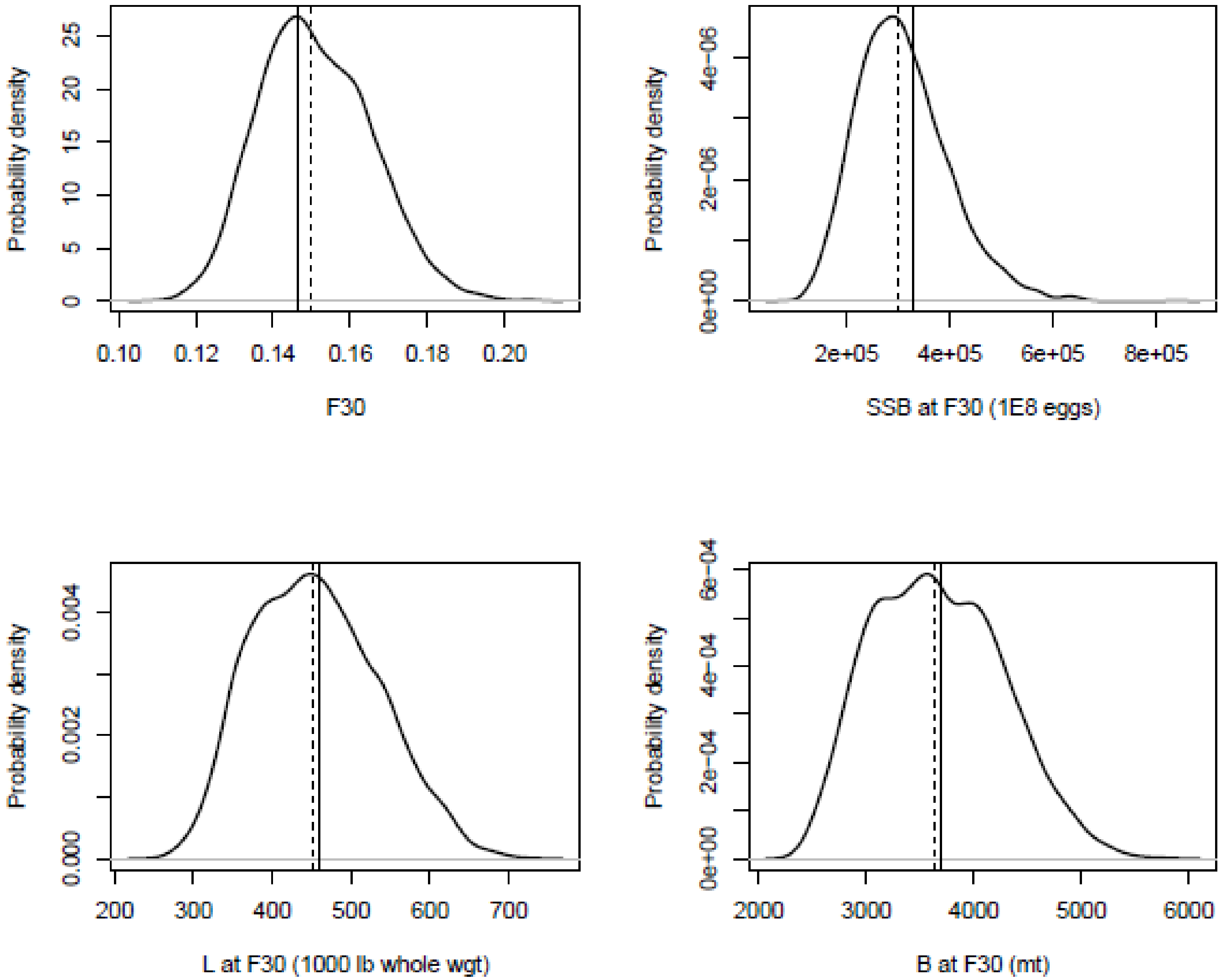


All ages

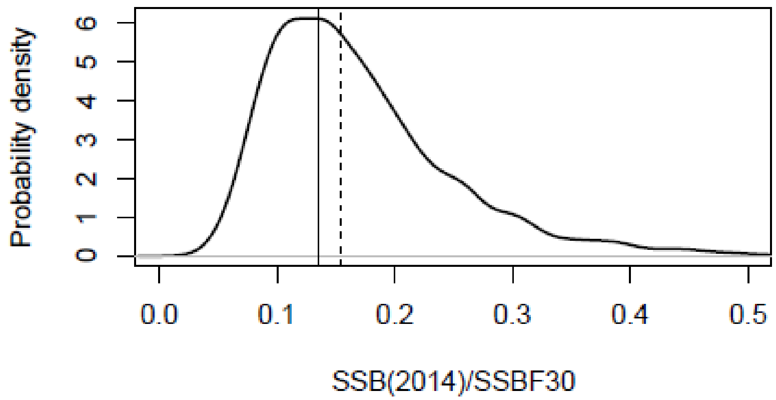


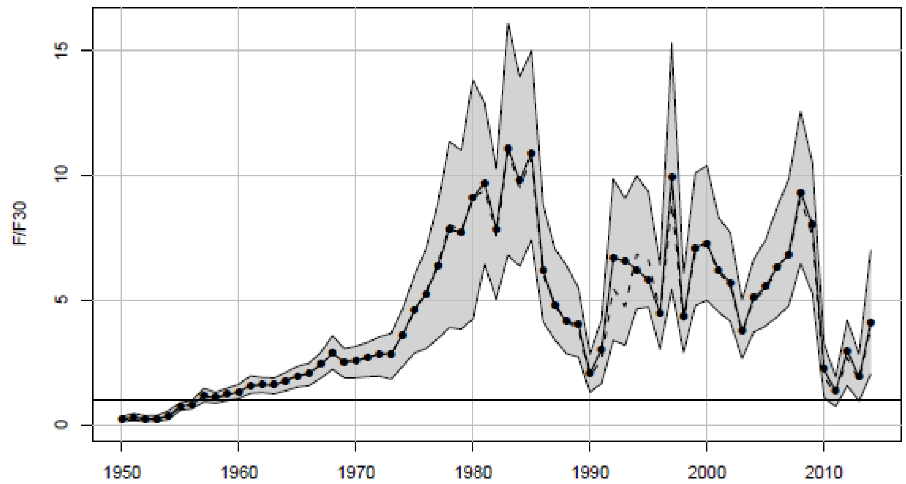
Ages 2+

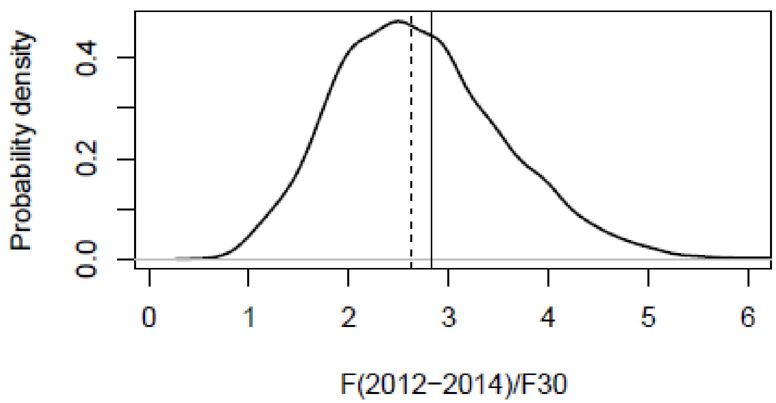
Benchmarks (solid line is from the base, dashed is MCB median)

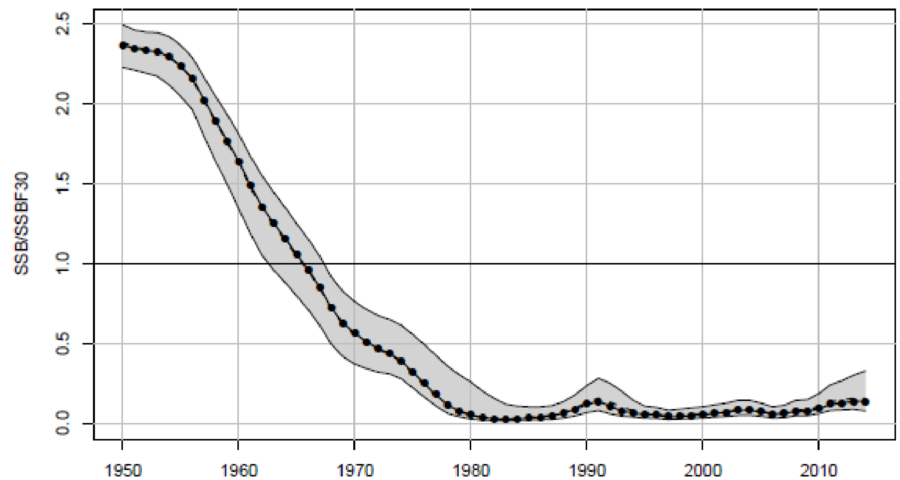


Status and uncertainty

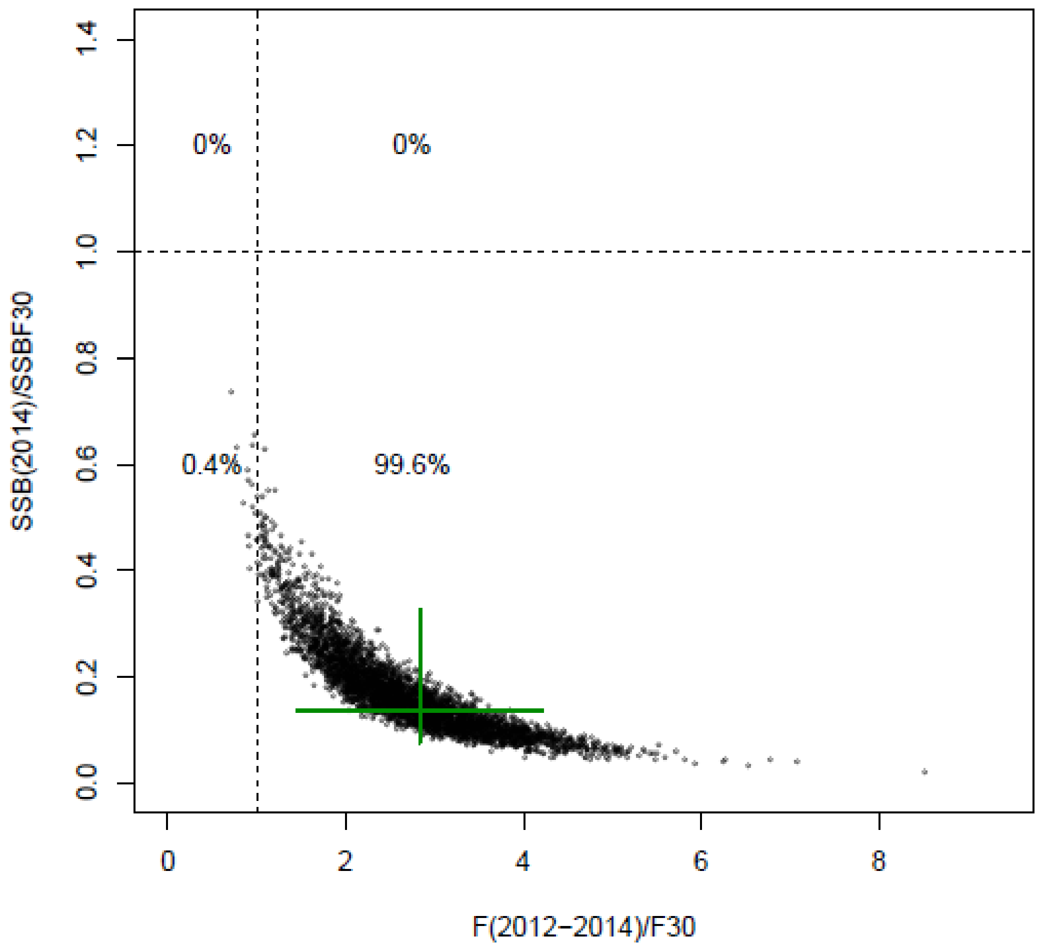








MCB – Phase plot



- 99.6% of the runs indicate the same status

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Projections

- Projection scenarios in the Terms of Reference:
  1. F=0
  2. $F=F_{current}$ (geometric mean of the last 3 years)
  3. $F=F_{30\%}$
  4. $F=F_{target}$
  5. $F=F_{rebuild}$ (max exploitation that rebuilds in greatest allowed time (2044))

  We added:

  6. F from discards only

Projection methodology

- Projections were run to predict stock status in years after the assessment, 2015–2044. The year 2044 is the last year
- of the current rebuilding plan.
- The structure of the projection model was the same as that of the assessment model, and parameter estimates were those from the assessment.
- Any time-varying quantities, such as recreational selectivity, were fixed to the most recent values of the assessment period.
- A single selectivity curve was applied to calculate removals, averaged across fleets using geometric mean *F*s from the last three years of the assessment period.
- Initial age structure at the start of 2015 was computed by the assessment model.
- Fishing rates that define the projections were assumed to start in 2017.

Projection initialization

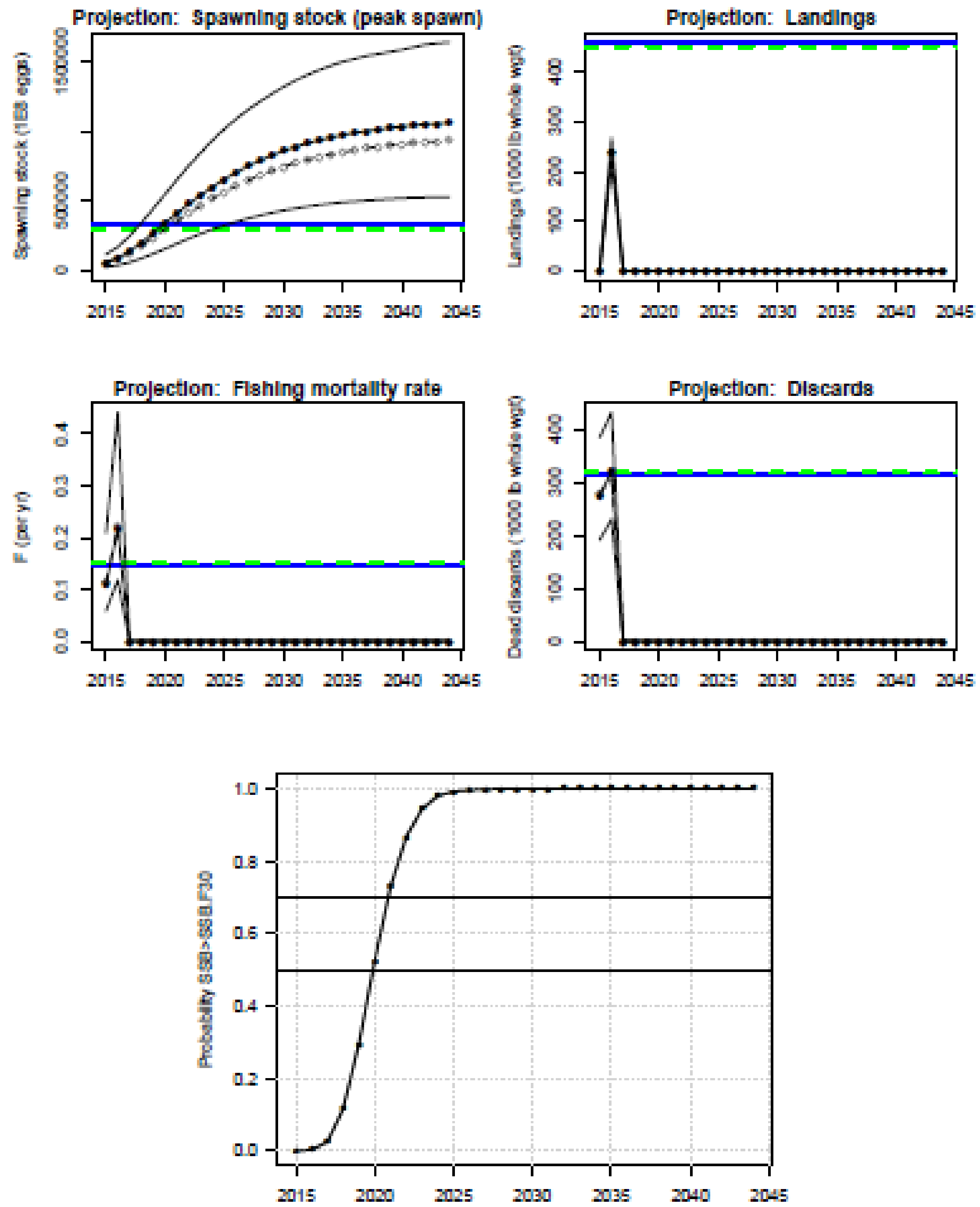
- For 2015, a moratorium year, the landings selectivity was set to 0 and the discard selectivity was rescaled to peak at 1.
  - We solved for the F that matched the current dead discards (mean of 2012-2014) in numbers.
- In 2016, a similar routine solved for the F that matched current landings (mean of 2012-2014), assuming a mini-season would occur.
- The discards only scenario treated the initialization year 2016 the same as 2015 (discards only), and then applied the mean F (from 2015-2016) forward starting in 2017.

Projection plot layout

- Expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5th and 95th percentiles of replicate projections.
- Solid horizontal lines mark $F_{30\%}$-related quantities, while dashed horizontal lines represent corresponding medians.

F=0

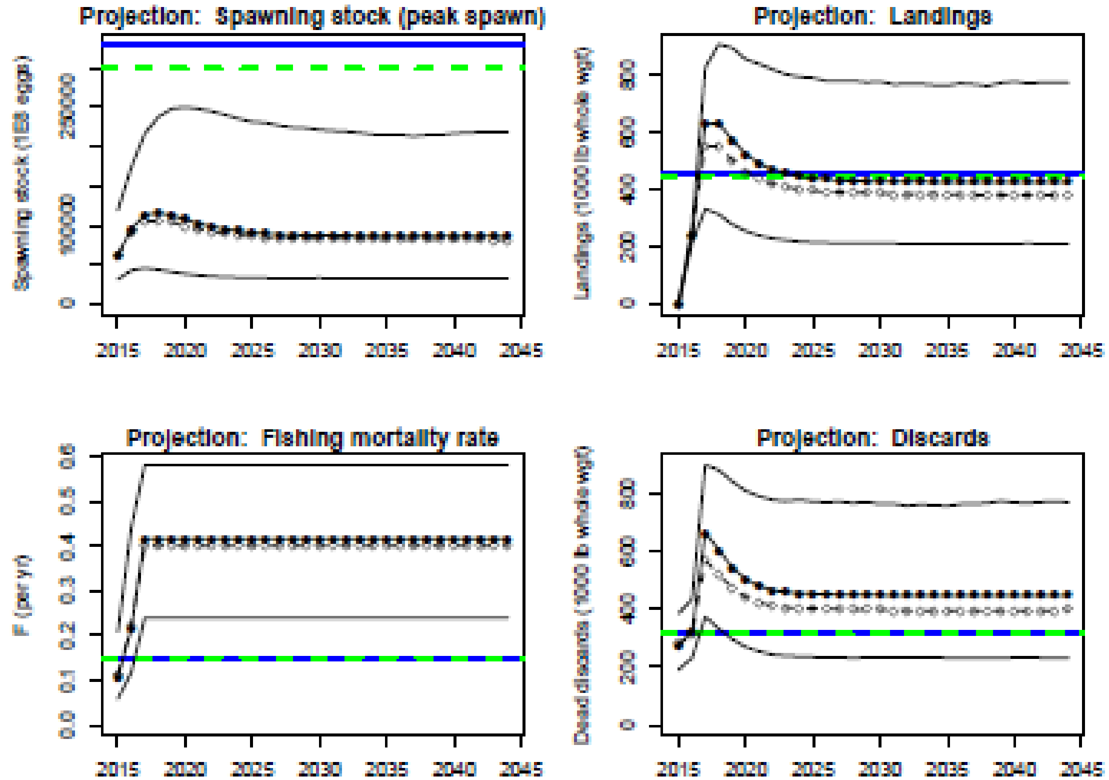
Stock rebuilt with 50% probability by 2021

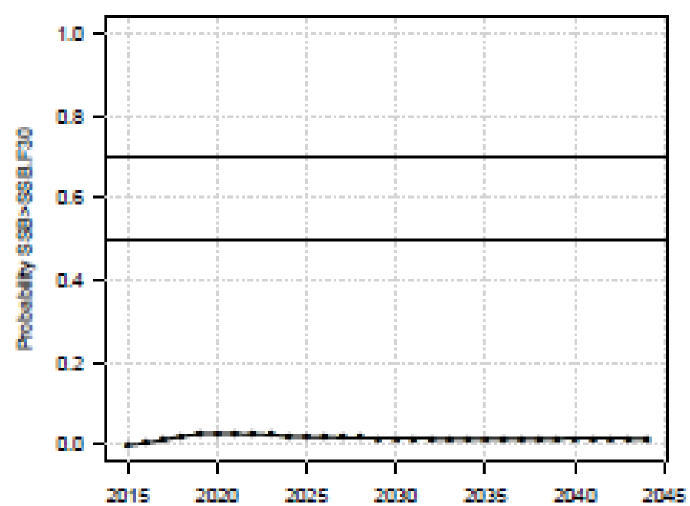


NOAA FISHERIES

$F=F_{current}$

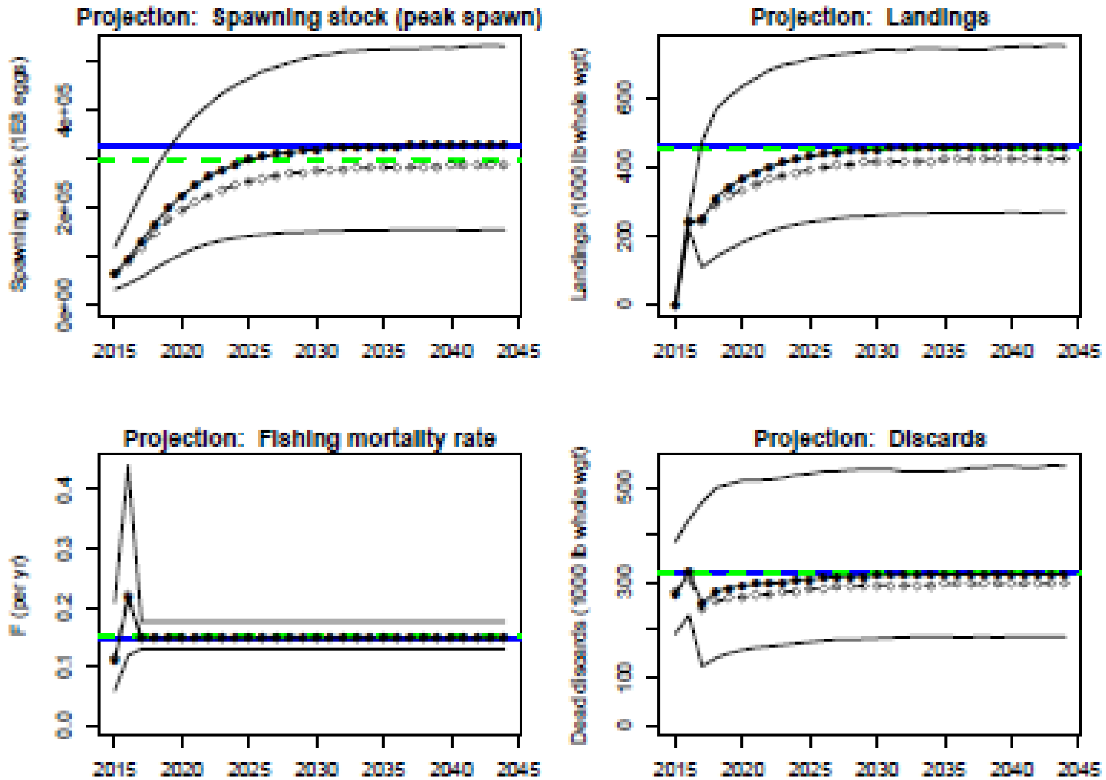
Stock remains overfished throughout the projection

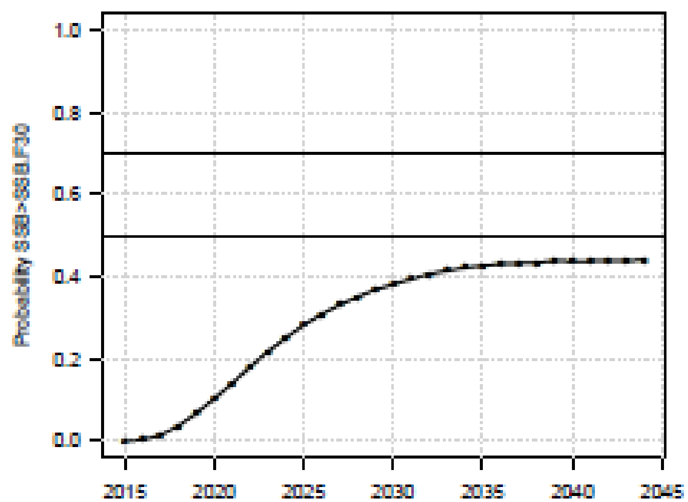




$F=F_{30\%}$

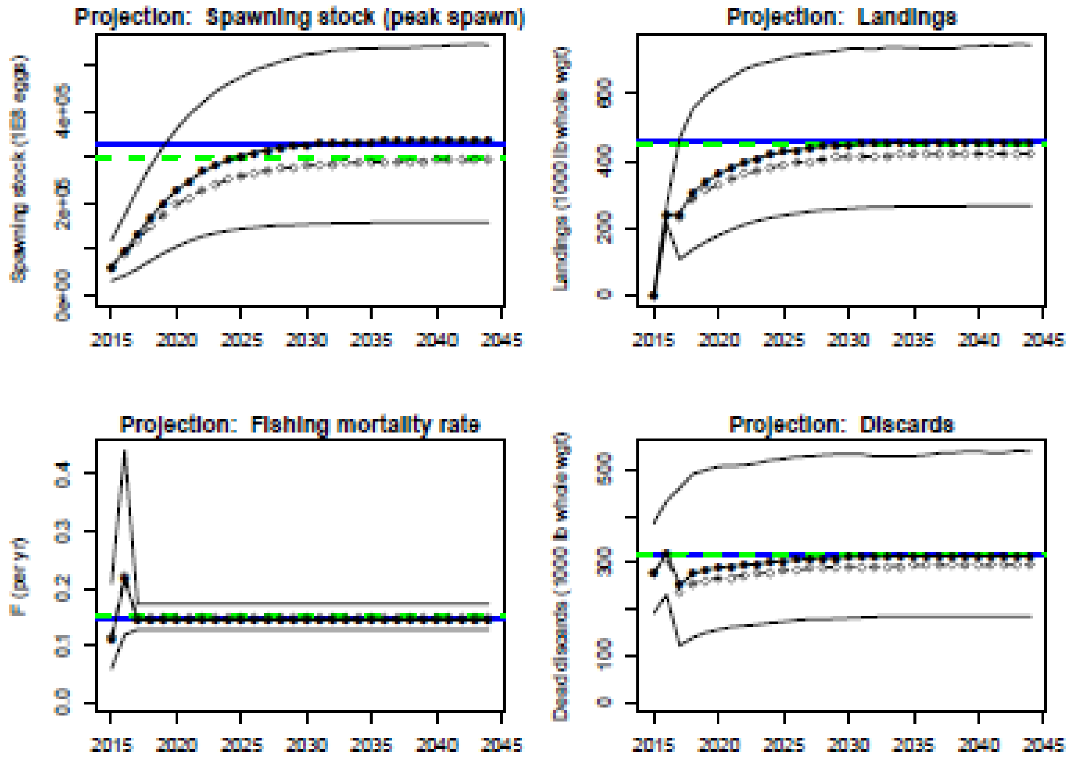
Stock remains overfished throughout projection.

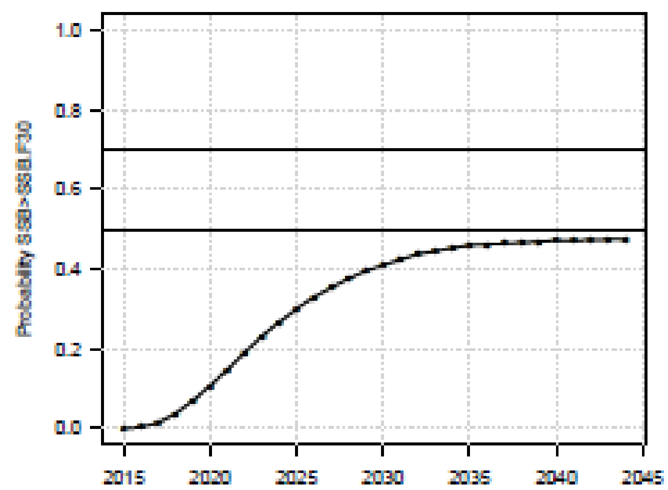




F_{target}=98%$F_{30\%}$

Stock remains overfished throughout projection.

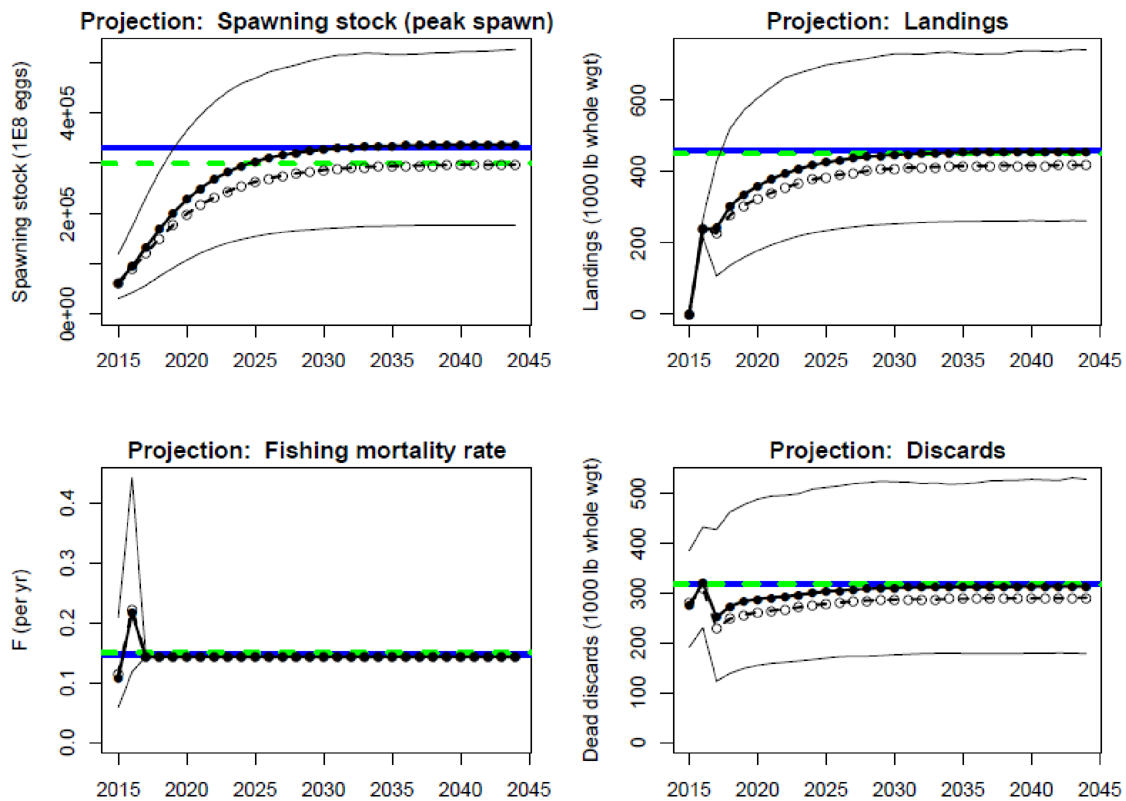


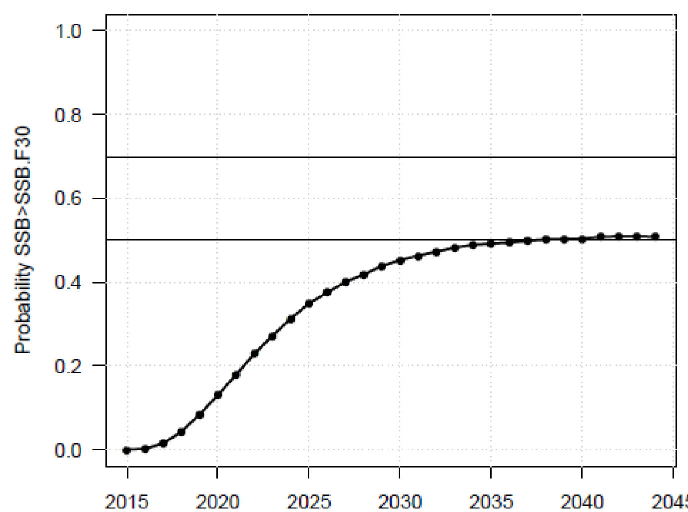


NOAA FISHERIES

$F_{rebuild}$

Stock recovers by the terminal year of the projection with 50% probability.

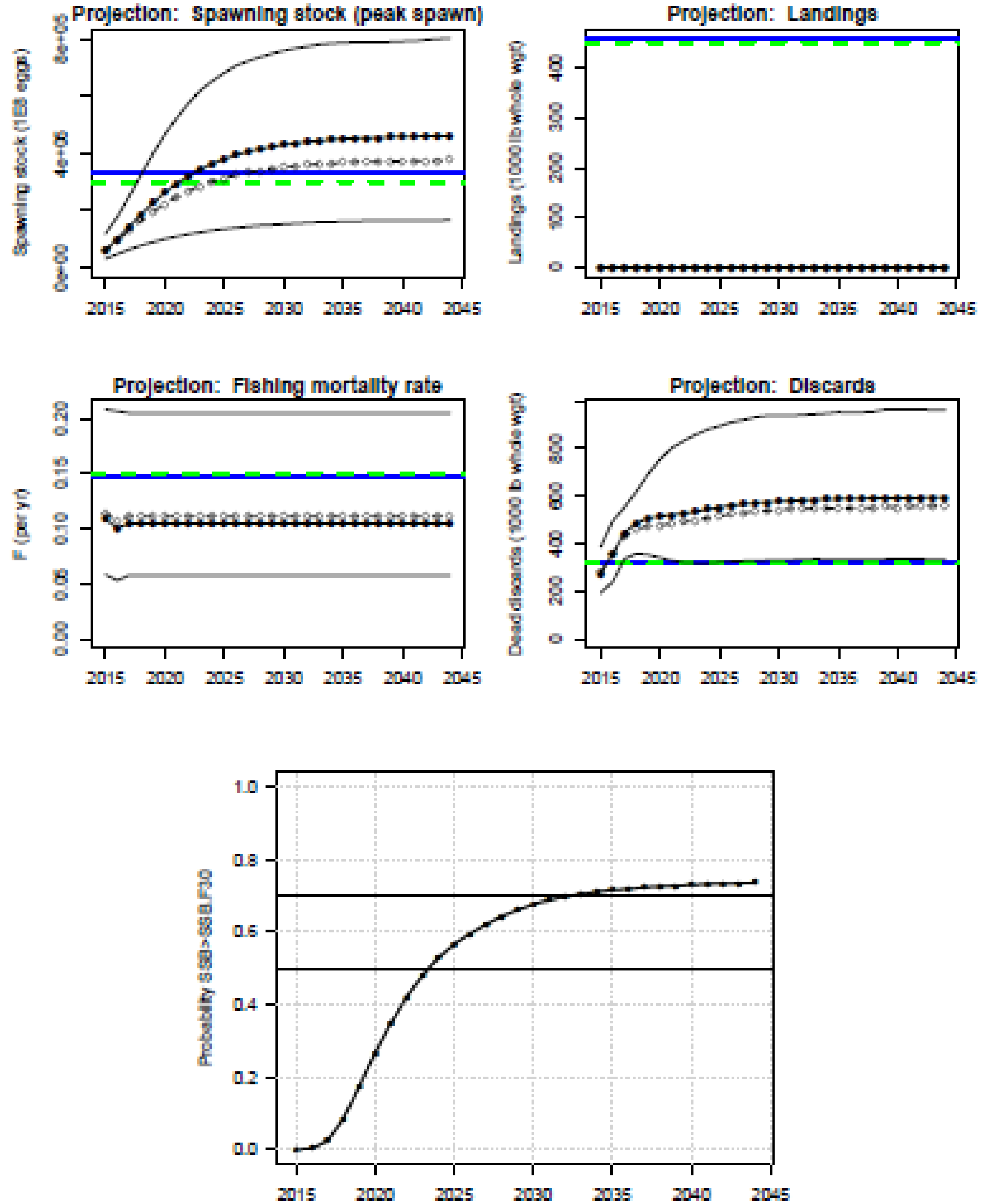




NOAA FISHERIES

Discards only

- Stock is rebuilt with 50% probability by 2024.
- Stock is rebuilt with 70% probability by 2034.



Questions?