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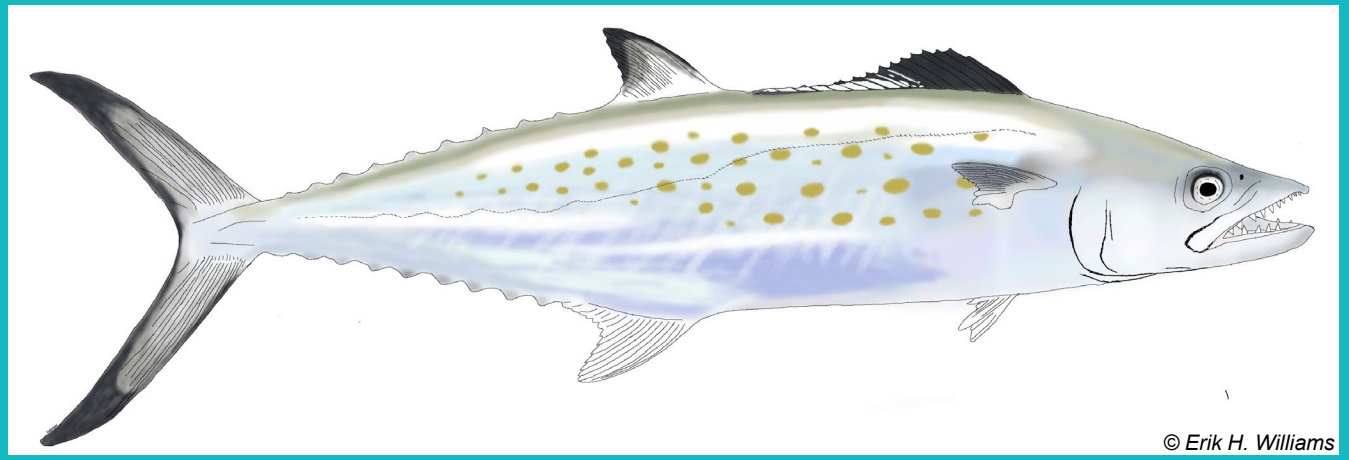
Southeast Fisheries Science Center

Sustainable Fisheries Division

Atlantic Fisheries Branch

SEDAR 78 – U.S. Atlantic Spanish Mackerel Stock Assessment



South Atlantic Fisheries Management Council

Scientific and Statistical Committee

August 4 , 2022

Credits

This stock assessment was constructed, coded, analyzed, diagnosed, fitted, summarized, and reported entirely by **Rob Cheshire**, with support from **Matt Vincent**.

Thanks to Rob and Matt for all their efforts!

Background

- SEDAR 28 (2012)
  - Not overfished (SSB_{2011}/MSST=2.29)
  - Not overfishing ($F_{2009\text{-}2011}/F_{MSY}$=0.526)
- SEDAR 78 Operational assessment
  - Terminal year 2020
  - Data provision delays altered original schedule
  - 1 data scoping call and 4 assessment webinars
  - Panel input and approval of all decisions

Topics

- **Data Review**
- Model update
- Base run
- Sensitivities and retrospective
- Uncertainty
- Projections

Life history

- Von Bertalanffy growth (*updated*)
  - Population growth curve – all data
  - Fishery growth curve – fishery samples taken during 12” minimum size limit
  - Female growth curve – female population growth
- Age-based natural mortality (*updated*)
  - Lorenzen curve scaled to Hoenig constant M as in SEDAR28 using updated population growth parameters

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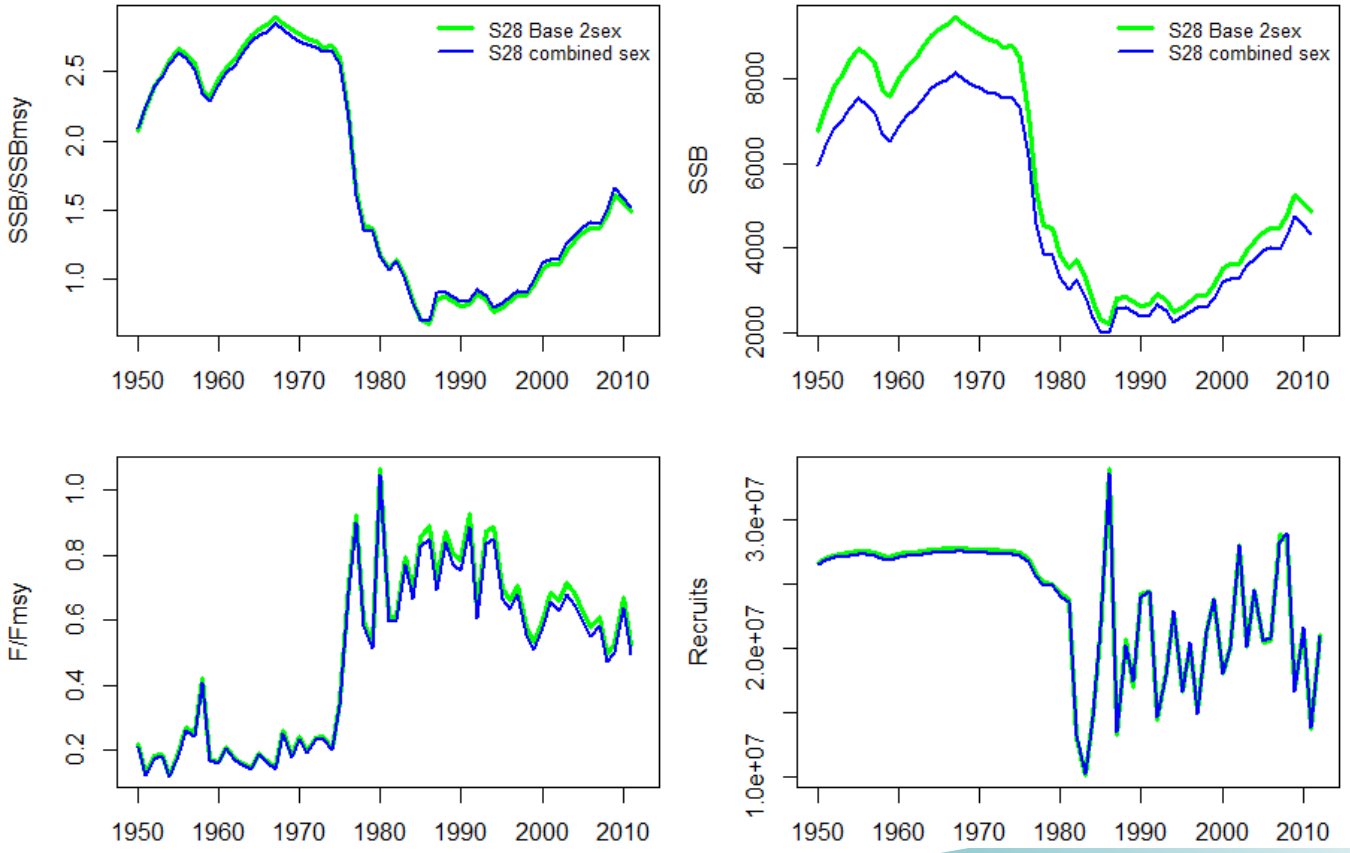
Growth models

- SEDAR 28 modeled sexually dimorphic growth
  - Few data inputs separable by sex
  - Increase in number of parameters
  - SEDAR 28 reviewers questioned utility of 2-sex model
  - Compared results of SEDAR 28 using single sex model



Growth models

- TOR#2: Update growth and reproductive models if additional samples are available for fish below 275 mm

- Developed growth models for population, females, ~~males~~, fishery
- Implemented Diaz correction for all except fishery model
- With and without inverse sample size weighting by calendar age
- Initial model runs estimated t0 ranging from -1.3 to -2.7 therefore t0 was fixed to -0.5 as in SEDAR 28 except for the fishery growth model

Growth models

Figure 1, pdf page 115

model	Diaz Correction	weighted	Linf (mm)	K	t0	cv
Population*	yes	yes	582.5	0.598	-0.5	0.18
population	yes	no	491.6	0.786	-0.5	0.17
model	Diaz Correction	weighted	Linf (mm)	K	t0	cv
fishery	no	yes	738.9	0.146	-3.57	0.13
Fishery*	no	no	680. 4	0.197	-2.77	0.12
model	Diaz Correction	weighted	Linf (mm)	K	t0	cv
Females*	yes	yes	610.1	0.62	-0.5	0.16
females	yes	no	518.3	0.779	-0.5	0.16

Growth model application

- **Population growth model (t_0 fixed)**
  - Used for calculation of Lorenzen age-dependent natural mortality
  - Used for size/weight estimation of discards (general recreational and shrimp bycatch)
- **Fishery-dependent growth model (t_0 estimated)**
  - Used for weight estimation of landings
- **Female growth model (t_0 fixed)**
  - Used for calculation of SSB (weight)

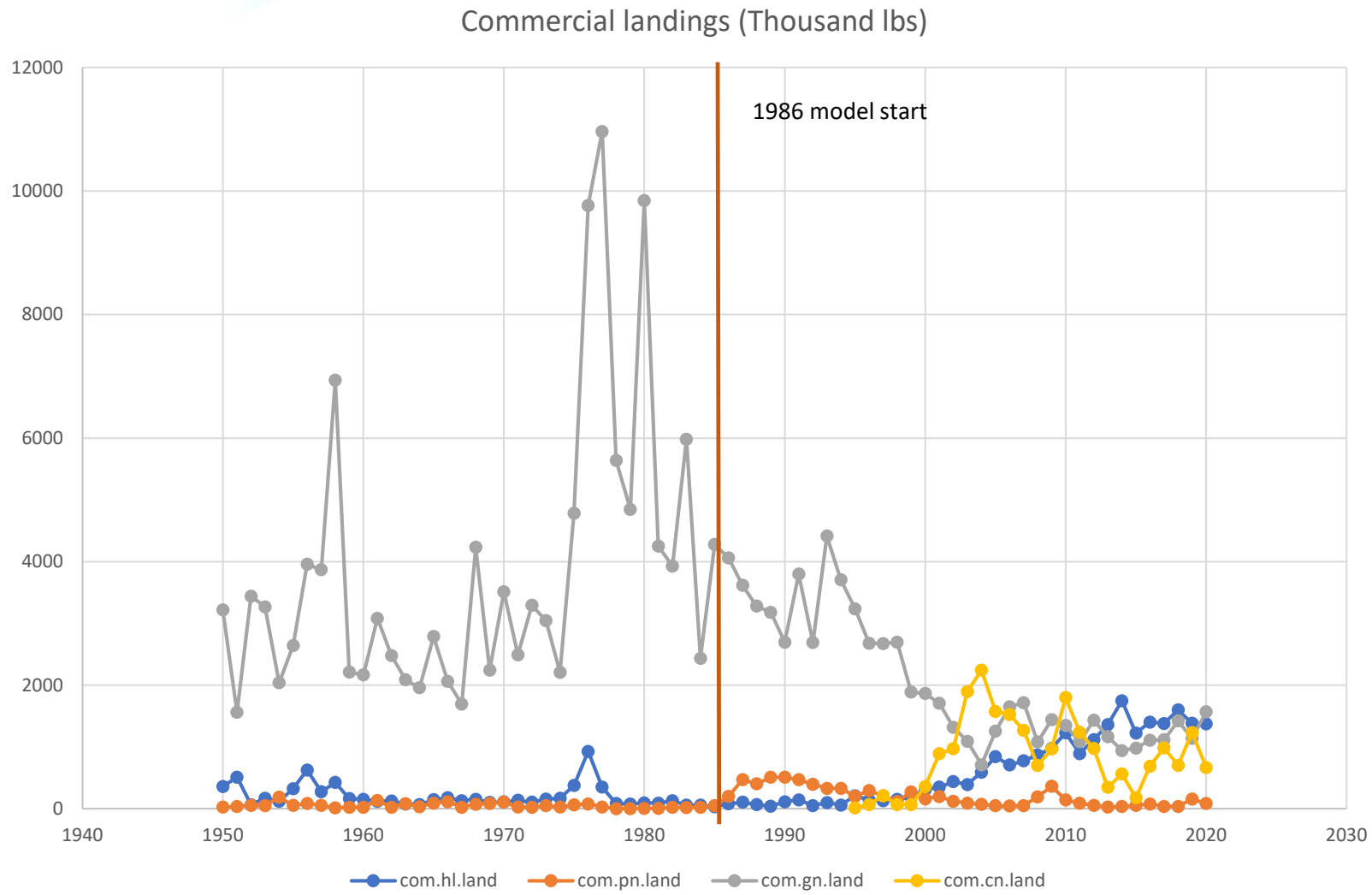
Landings and discards

- Six time series of removals
- Commercial handline, gill net, and pound net
- Shrimp bycatch
- General recreational (private, charter, shore, and headboat) landings and discards (SEDAR 78 WP-03)
  - Three domains identified as large/small relative to adjacent years (1981 landings, 2020 landings and discards)
  - All traced to FL shore mode, estimates accepted for base run with relatively high CV values
  - Impact of COVID on 2020 estimates evaluated, imputed data did not deviate from the 2015-2019 data

Commercial Landings

Table 2, pdf page 91

hl – handline, pn – pound net, gn – gillnet, cn – cast net



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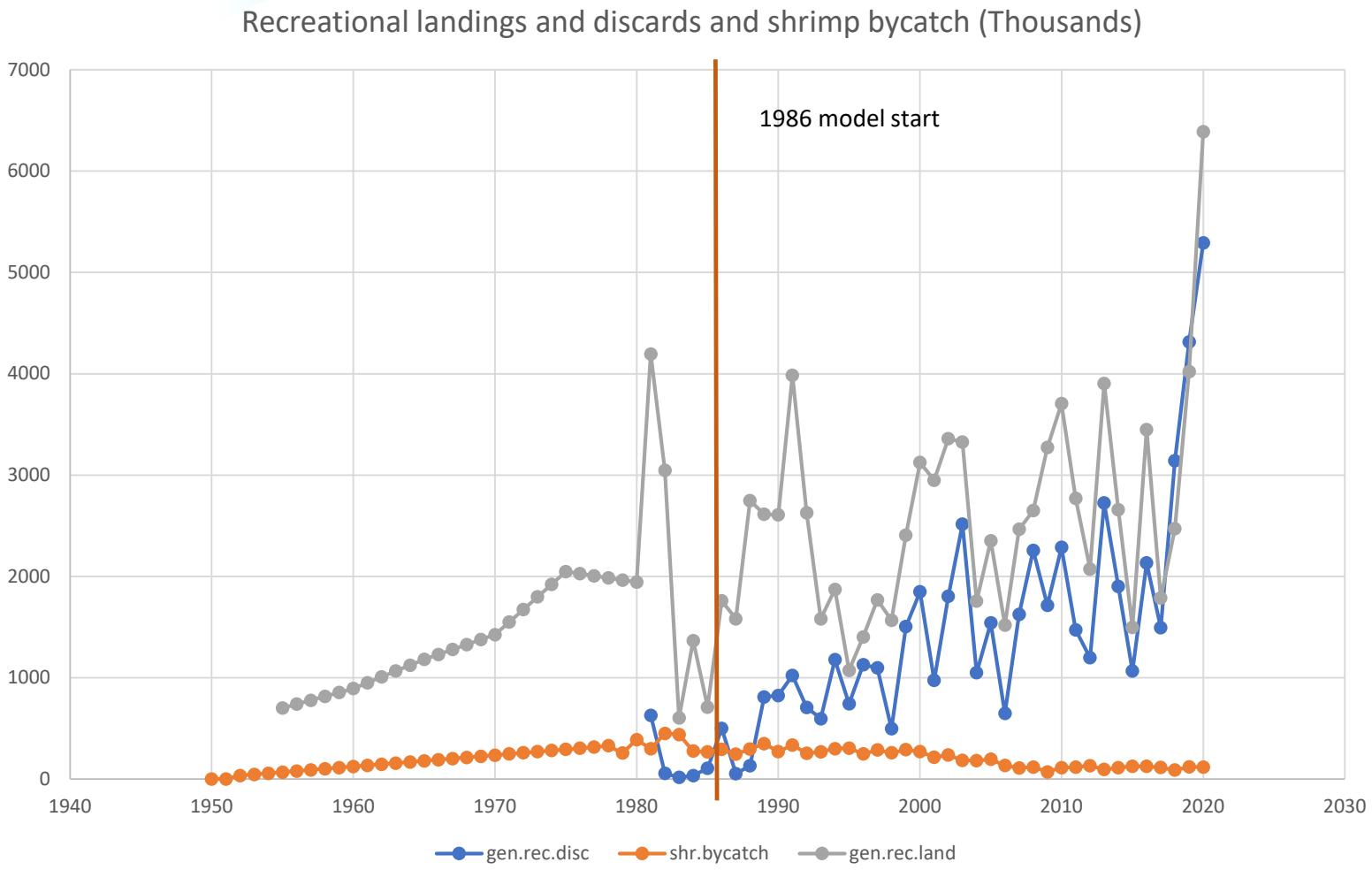
Recreational and Shrimp Bycatch

Table 2, pdf page 91

disc – discards (live and dead), shr – shrimp bycatch (dead)



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Indices of abundance

Table 3, pdf page 92
Fig 11-13, pdf pages 134-136

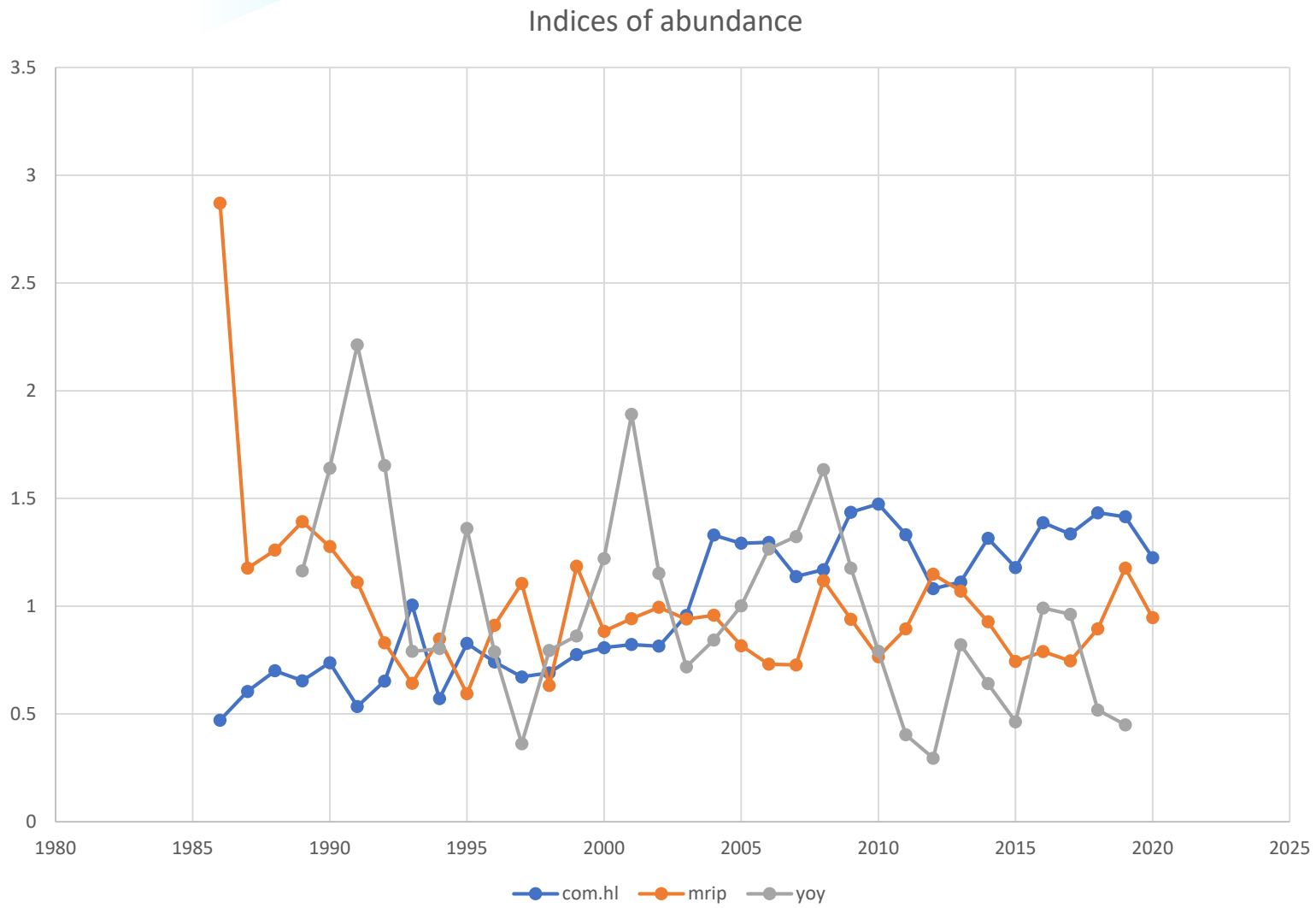
- SEAMAP-SA Coastal Trawl Survey- YOY (SEDAR78-WP01, WP02)
  - 1989-2019, ZINB model, age-0 only
- MRIP (SEDAR78-WP09)
  - 1982-2020, coverage ME to FL
  - Directed trips (guild approach problematic)
  - Harvested fish, CVs fixed at 0.2
- Florida commercial trip ticket (SEDAR78-WP12)
  - 1986-2020
  - Positive trips, gamma distribution model
  - Trips with greater than 500lb trip limit, CVs fixed at 0.2

Indices of abundance

Table 3, pdf page 92

Fig 11-13, pdf pages 134-136

com.hl – FL trip ticket, mrip – recreational, yoy – SEAMAP trawl



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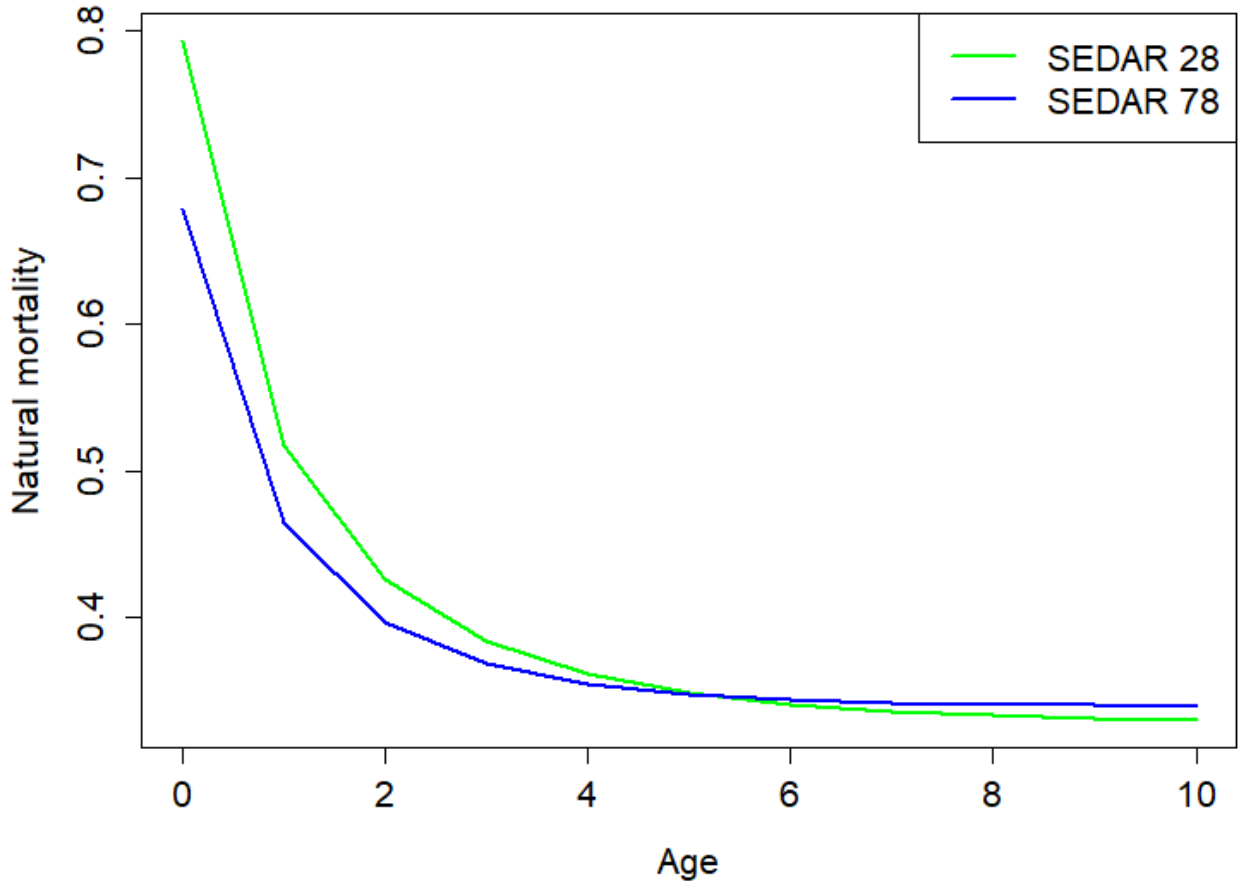
Length and age compositions

- Length compositions determined to be noisy and uninformative as in previous assessments
- Modified minimum sample size requirements for age compositions to match current best practices (30 fish, 10 trips)
  - Annual commercial handline and cast net fleet age compositions did not meet minimum sample size for most years
  - Selectivity differences precluded pooling with other gears
  - Pooled across years, annual samples sizes included for model fit

Natural Mortality

Table 1, pdf page 90

- Constant = 0.35 based on Hoenig (fish only) as in SEDAR 28
- Age-dependent based on Lorenzen method with updated population growth model, scaled to ages 2+ as in SEDAR 28



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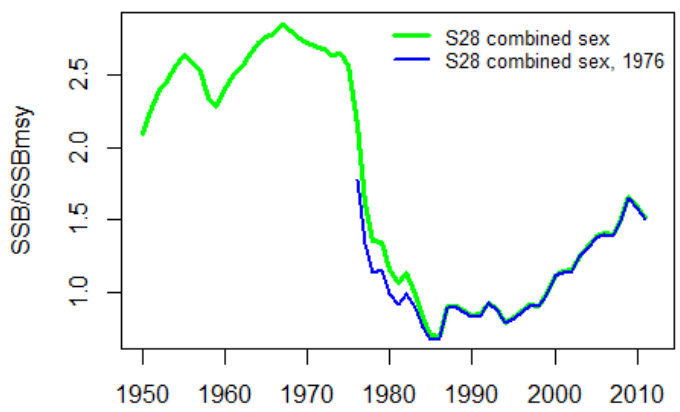
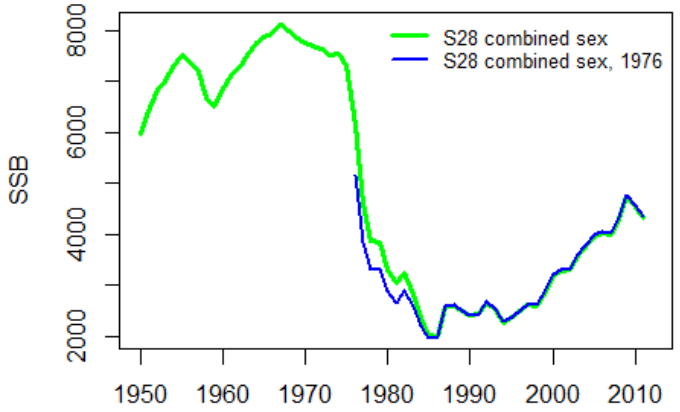
Topics

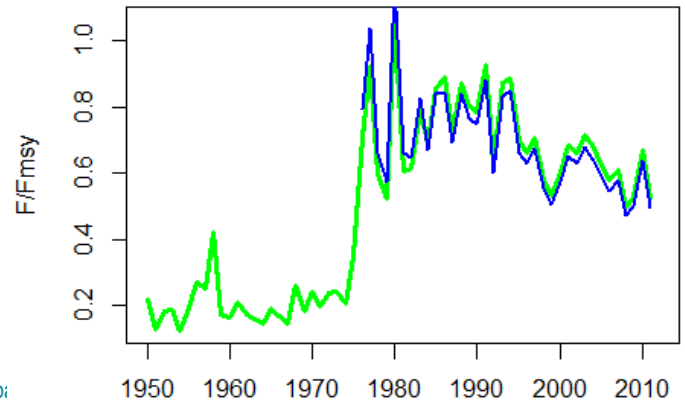
- Data Review
- **Model update**
- Base run
- Sensitivities and retrospective
- Uncertainty
- Projections

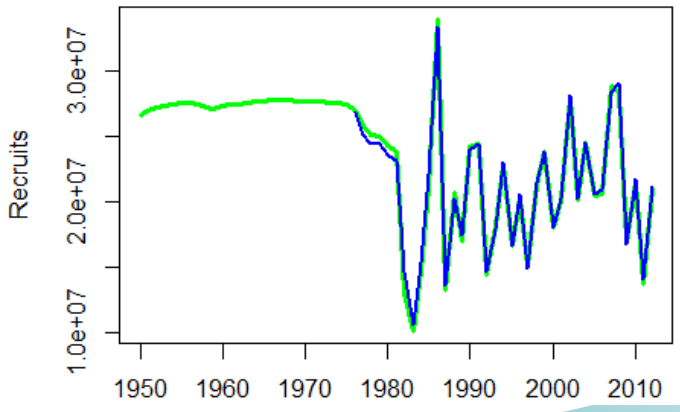
Assessment start year

- SEDAR 28 start year was 1950 with assumptions about initial F and initial age structure
- SEDAR 78 composition data start in 1990, index in 1982
- Compared SEDAR 28 model with 1976 start year









Assessment start year

- The start year for SEDAR 78 evaluations:
  - 1976 – SEDAR 28
  - 1982 - start year of the MRIP index
  - 1986 - start year of the FL trip ticket index

- The model had difficulty estimating initial F and initial numbers at age for 1976 and 1982 likely due to large fluctuations in MRIP landings and limited information from compositions to inform recruitment in early years.

- Starting the model in 1986 resulted in a stable initial F estimate and initial age structure. The MRIP index was truncated to start in 1986 and renormalized. (**Base Run**)

Selectivity – SEDAR 28

Fishery	Function	Pooled
Commercial Handline	Logistic (flat-topped)	no
Commercial Gillnet	Logistic (flat-topped)	no
Commercial Pound Net	Double-logistic (dome-shaped)	no
Commercial Cast Net	Double-logistic (dome-shaped)	no
General Recreational	Double-logistic (dome-shaped)	no
General Rec Discards	Dome-shaped	no
Shrimp Bycatch	Dome-shaped	no

Selectivity function evaluations

- Evaluated functional form and parameters for cast net selectivity
- Evaluated slope for logistic selectivities (commercial handline and gillnet)
- Evaluated functional form for domed selectivities (pound net and gen rec)
- Evaluated selectivity parameters for commercial pound net
- Evaluated selectivity parameters for general recreational

- General approach
  - Investigated the fit across components with likelihood profiling
  - Evaluated model results across range of values

Selectivity modifications based on parameter likelihood profiles.

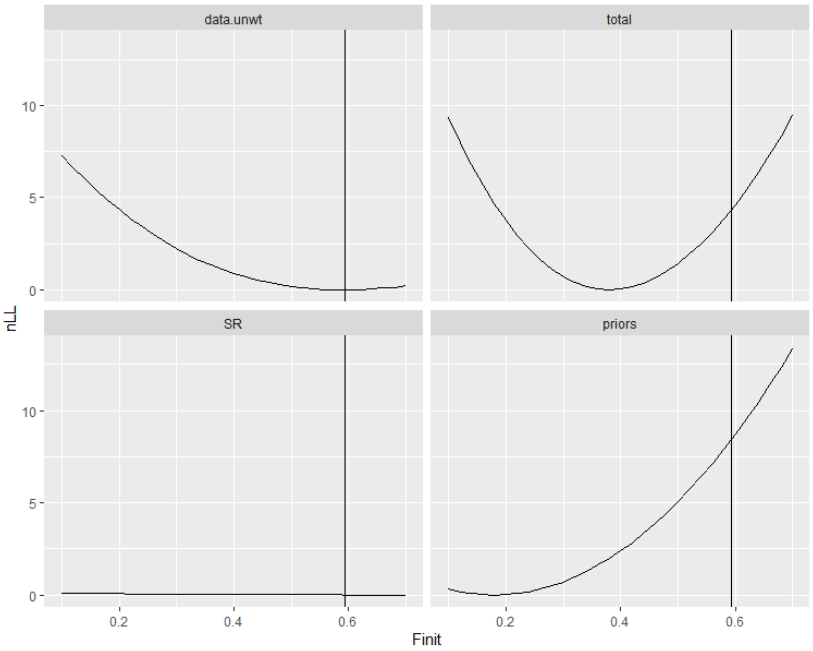
Table 12, pdf page 99

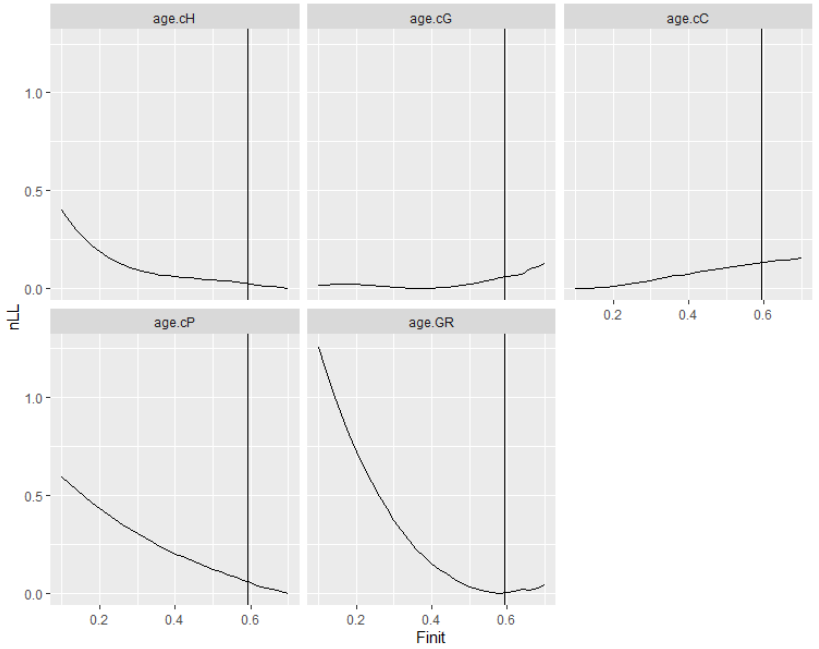
Fishery	Function	Pooled
Commercial Handline	Logistic	yes
Commercial Gillnet	Double-logistic	no
Commercial Pound Net	Estimated age-0, age-1 = 1.0, exponential model age-2+	no
Commercial Cast Net	Logistic	yes
General Recreational	Estimated age-0, age-1 = 1.0, exponential model age-2+	no
General Rec Discards	Age-0, Age-1 (fixed)	no
Shrimp Bycatch	Age-0, Age-1 (fixed)	no

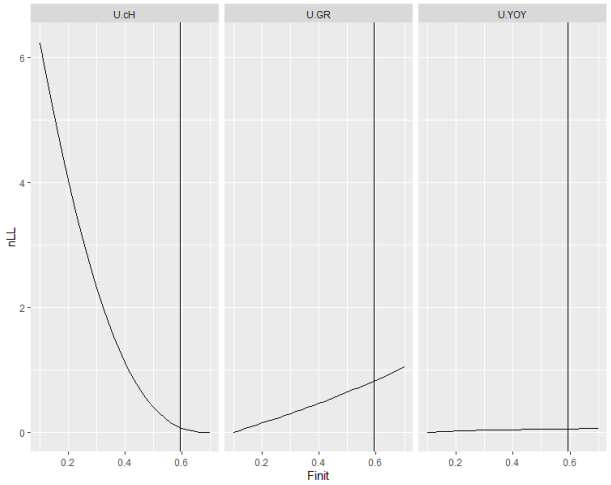
F_init (F for pre-1986 period) likelihood profiles

- Base model estimate = 0.59
- Estimate relies predominantly on the commercial handline index, and commercial handline, commercial pound net, and general recreational age compositions to inform the minimum approaching the estimate from 1.0.

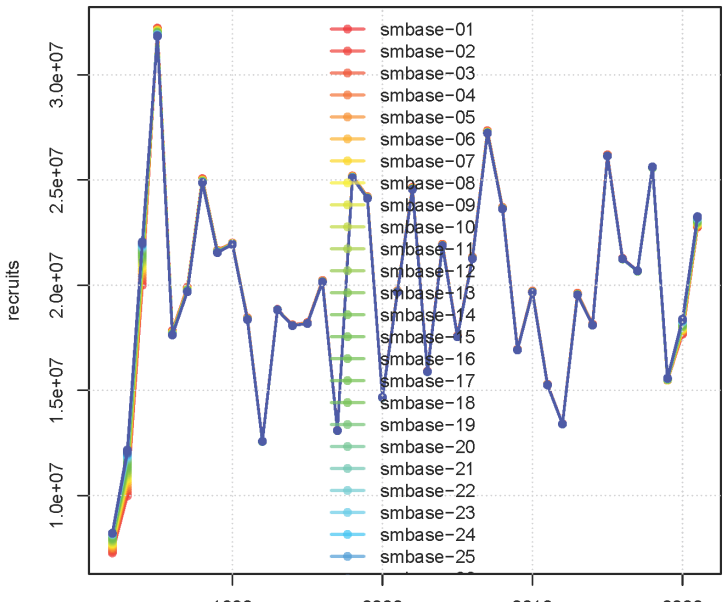
F_init: profile starting in 1986, 0.1 to 0.7, base est=0.59

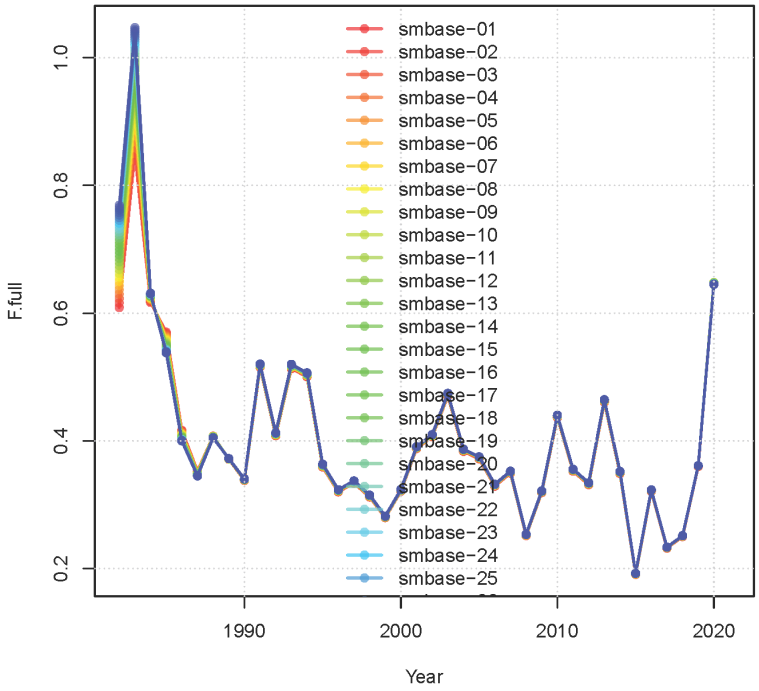


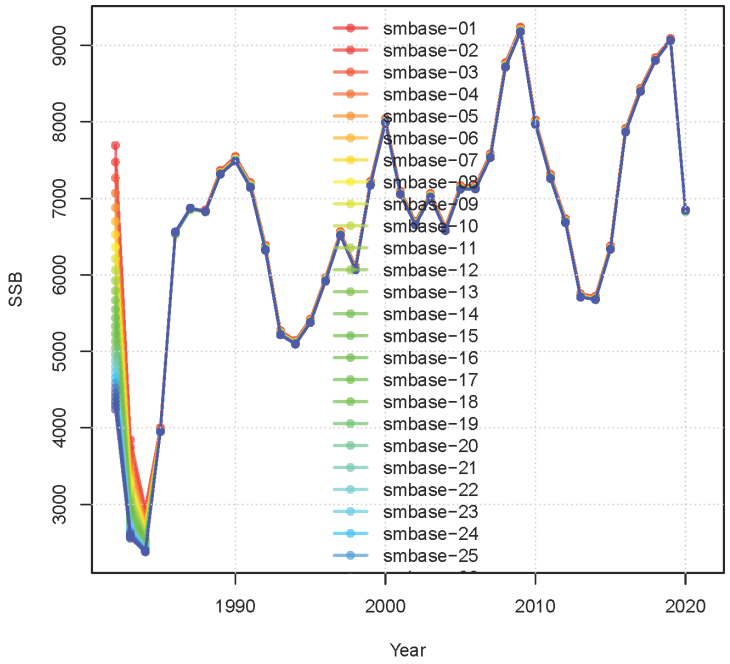




F_init: profile starting in 1986, 0.1 to 0.7, base est = 0.59.







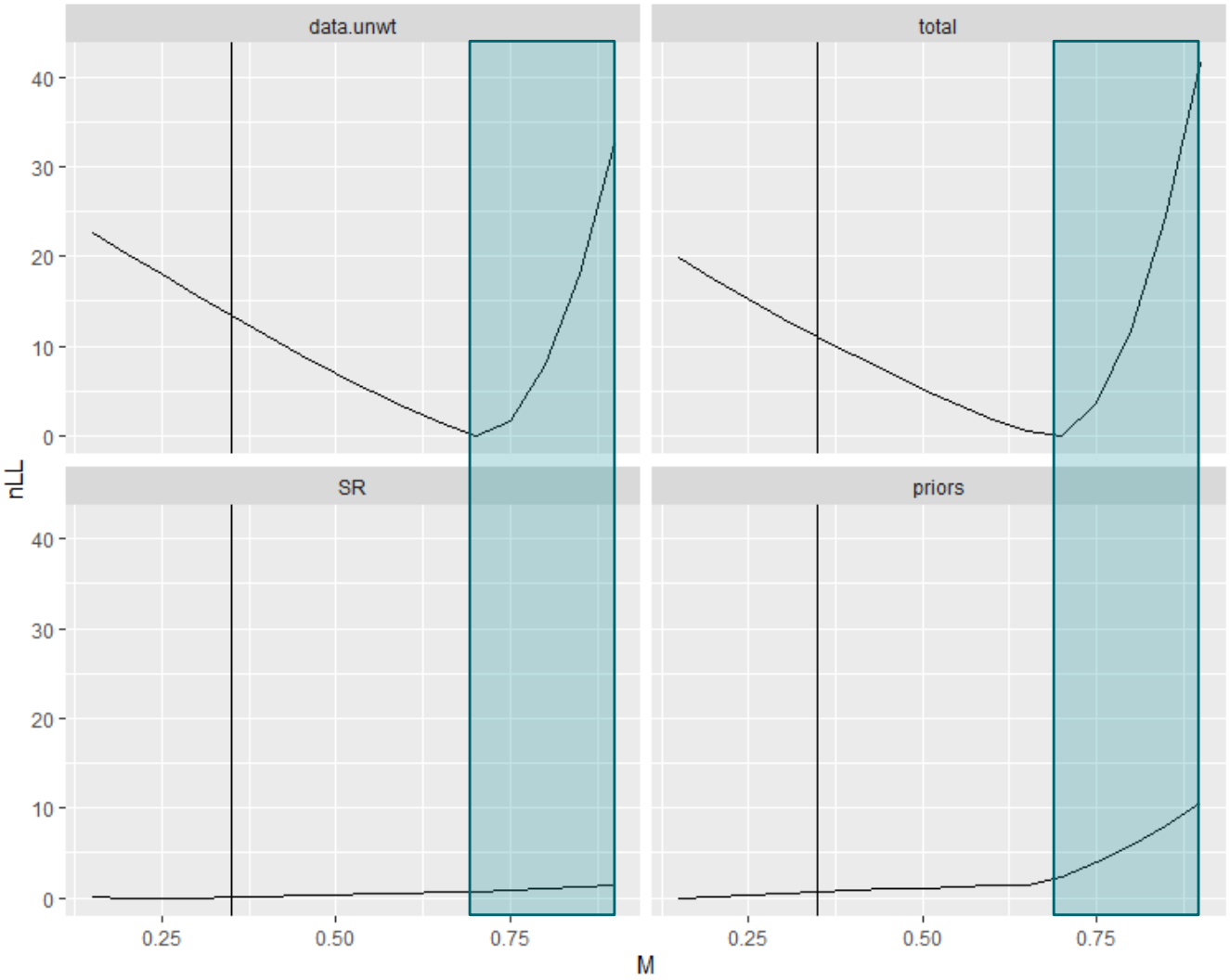
M profiles (base fixed at 0.35)

- Is M estimable and reasonable?
  - M wants to go higher and then hits bounds
  - A higher M would probably allow better fit to GR and cP comps that have big drop from age-1 to age-2
  - Possibly a symptom of conflicting information from indices and removals

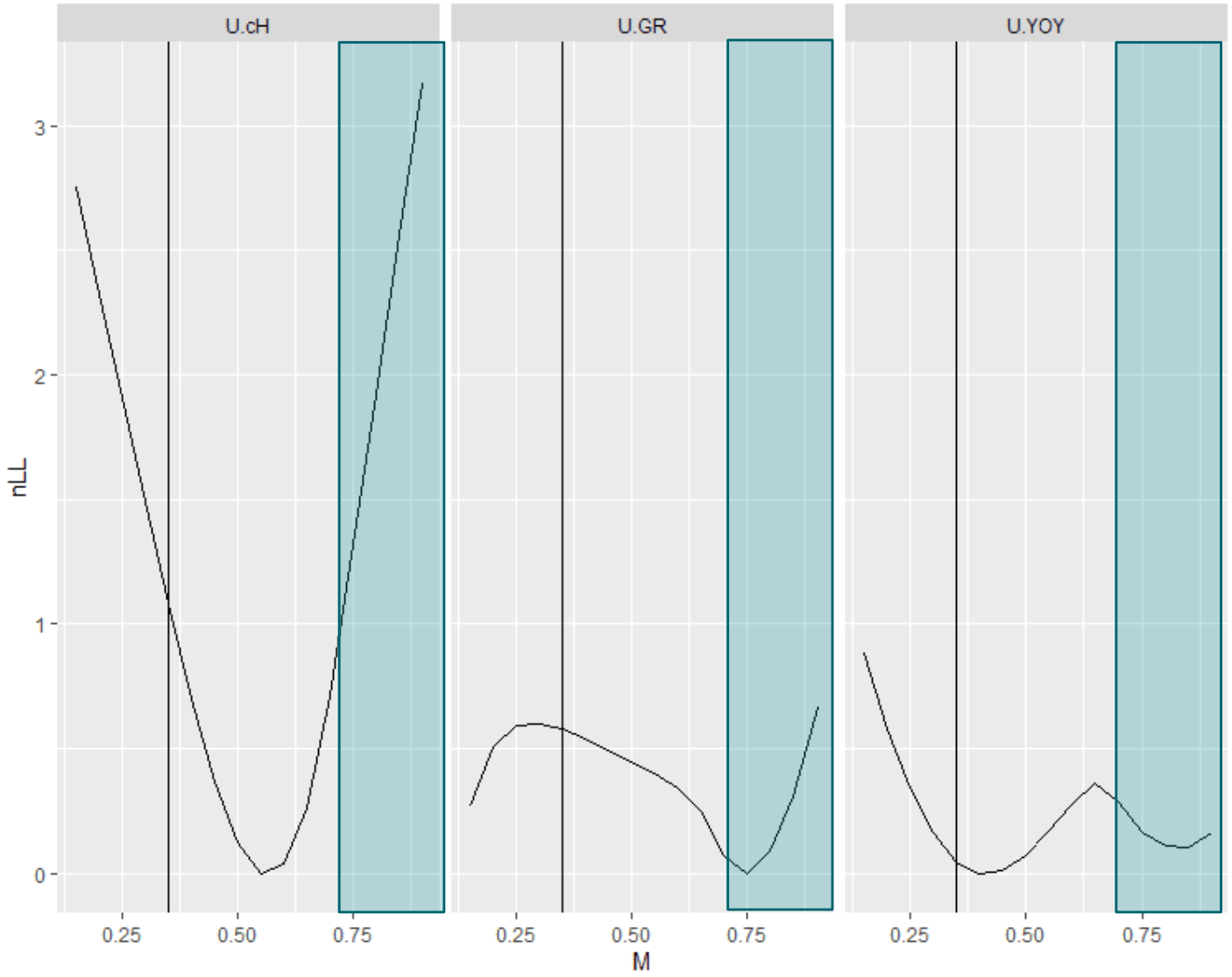
Bounding issues

- log(average F) for SB.D and cP at M=0.7
- cP sigma selectivity parameter at M=0.7
- F.init at M=0.7

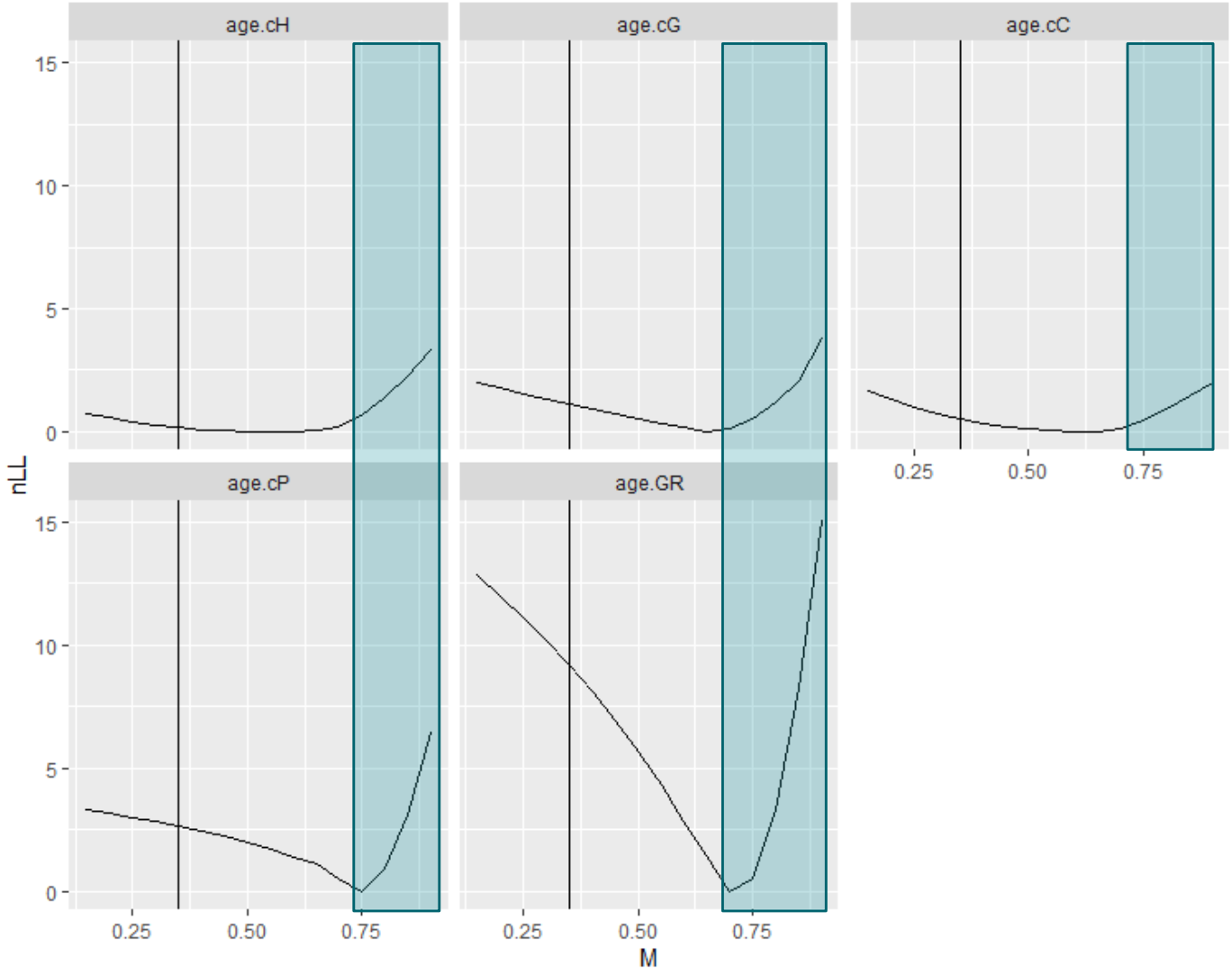
M profile - overall



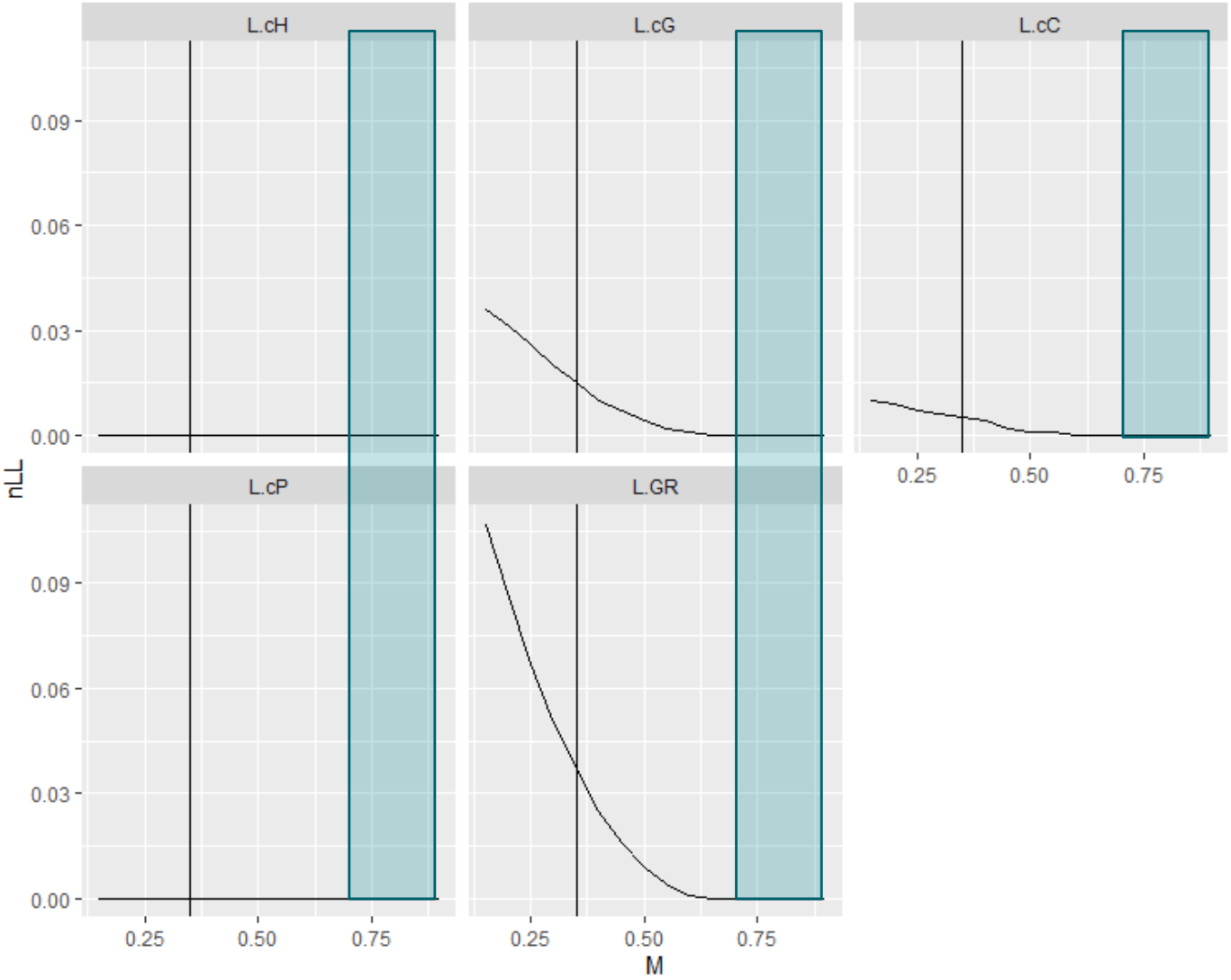
M profile - indices



M profile – age comps



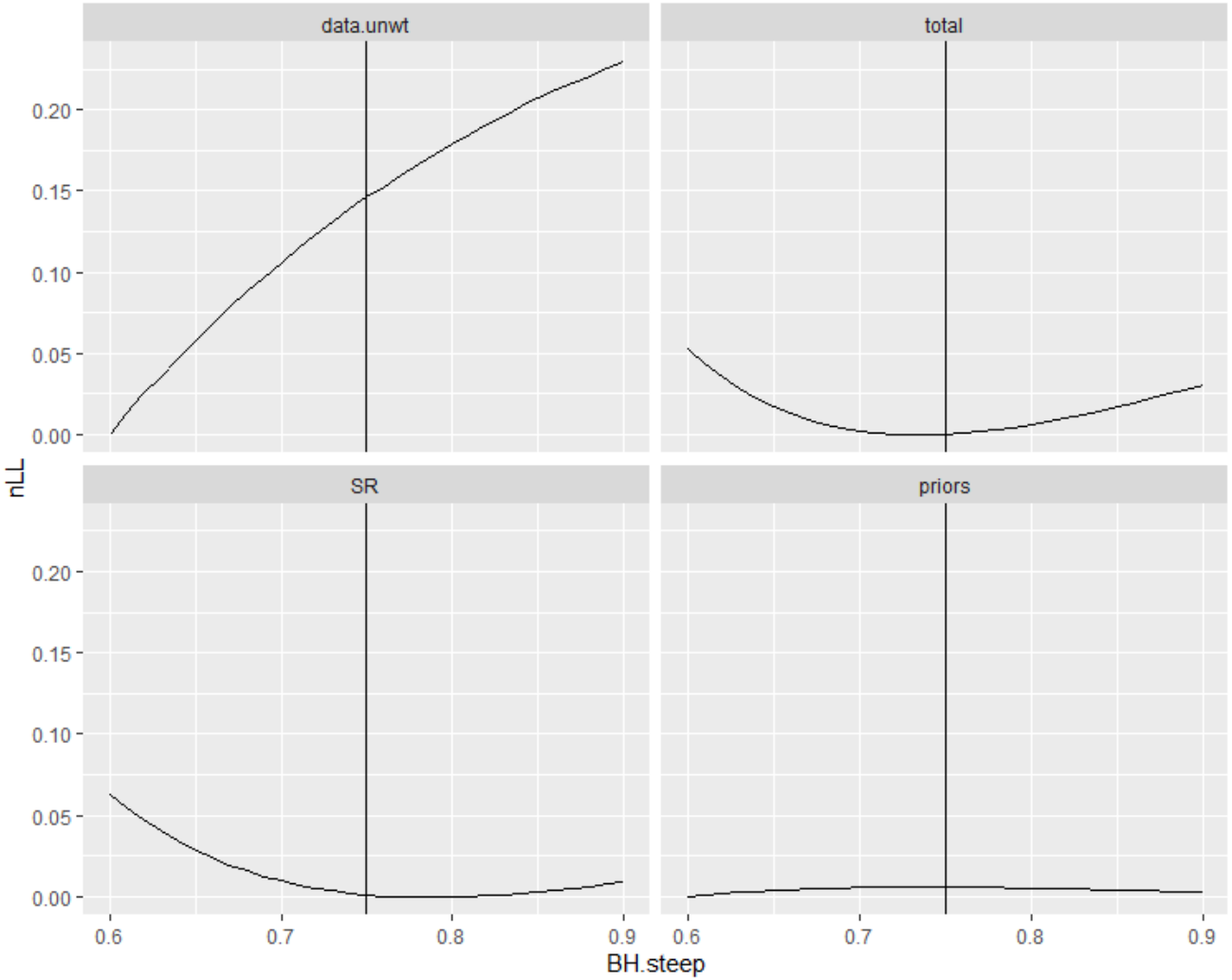
M profile - landings



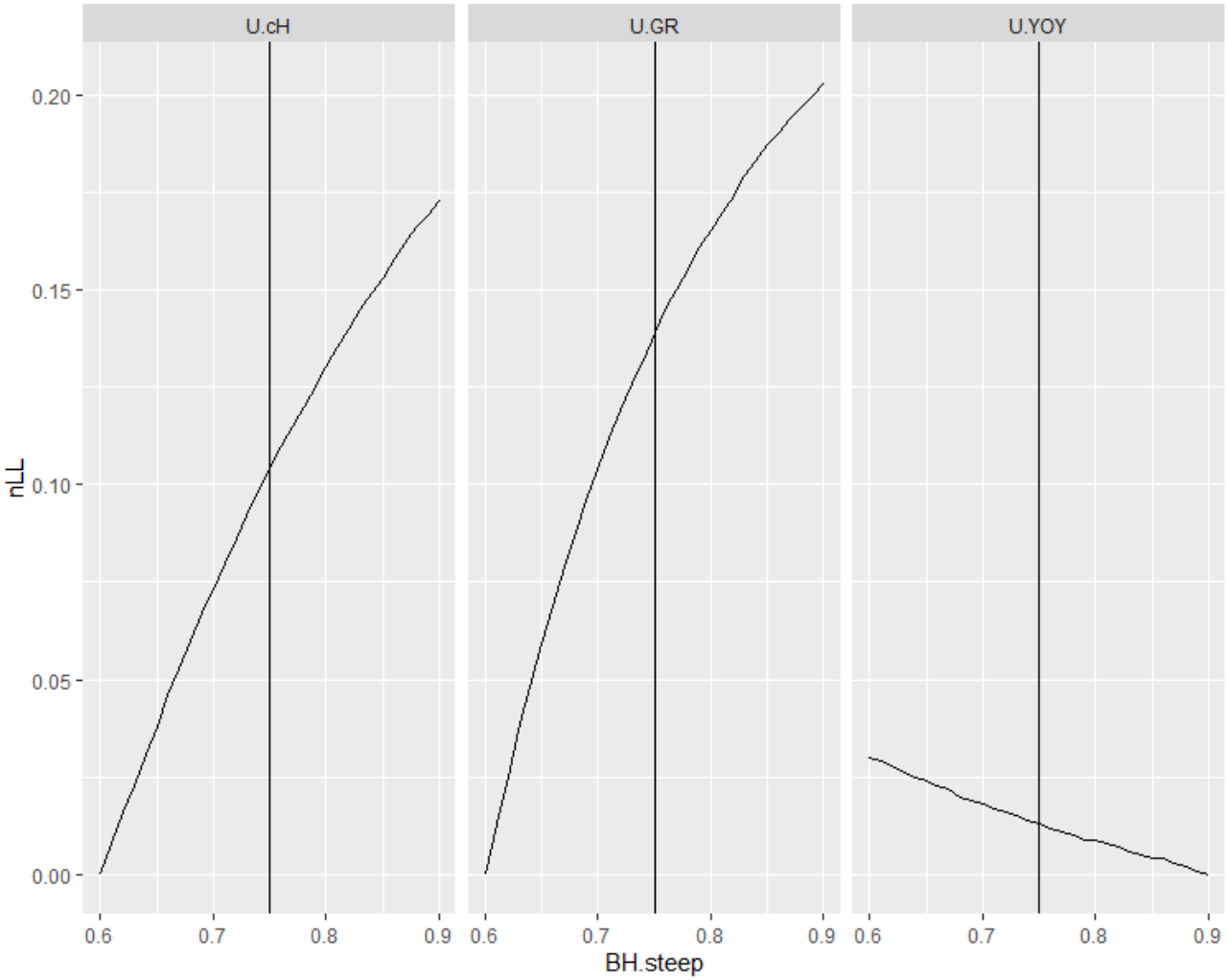
Steepness profiles

- Is steepness estimable and reasonable?
  - Almost no signal from the data to inform steepness
  - Model estimated steepness = 0.73
    - starting value of 0.75
  - SEDAR 28 value based on likelihood profile
  - No good information to modify previous decision

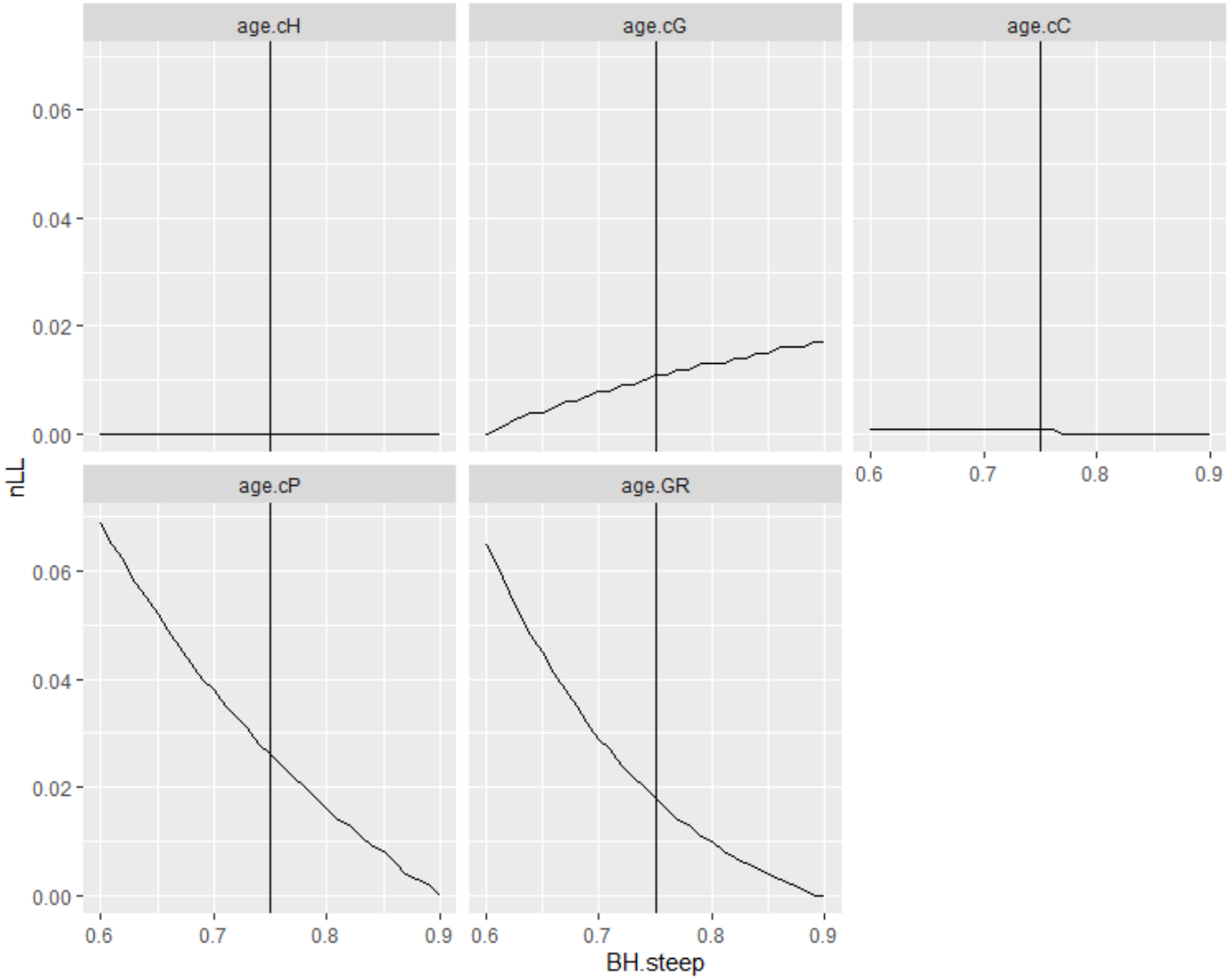
Steepness profile - overall



Steepness profile - indices



Steepness profile – age comps



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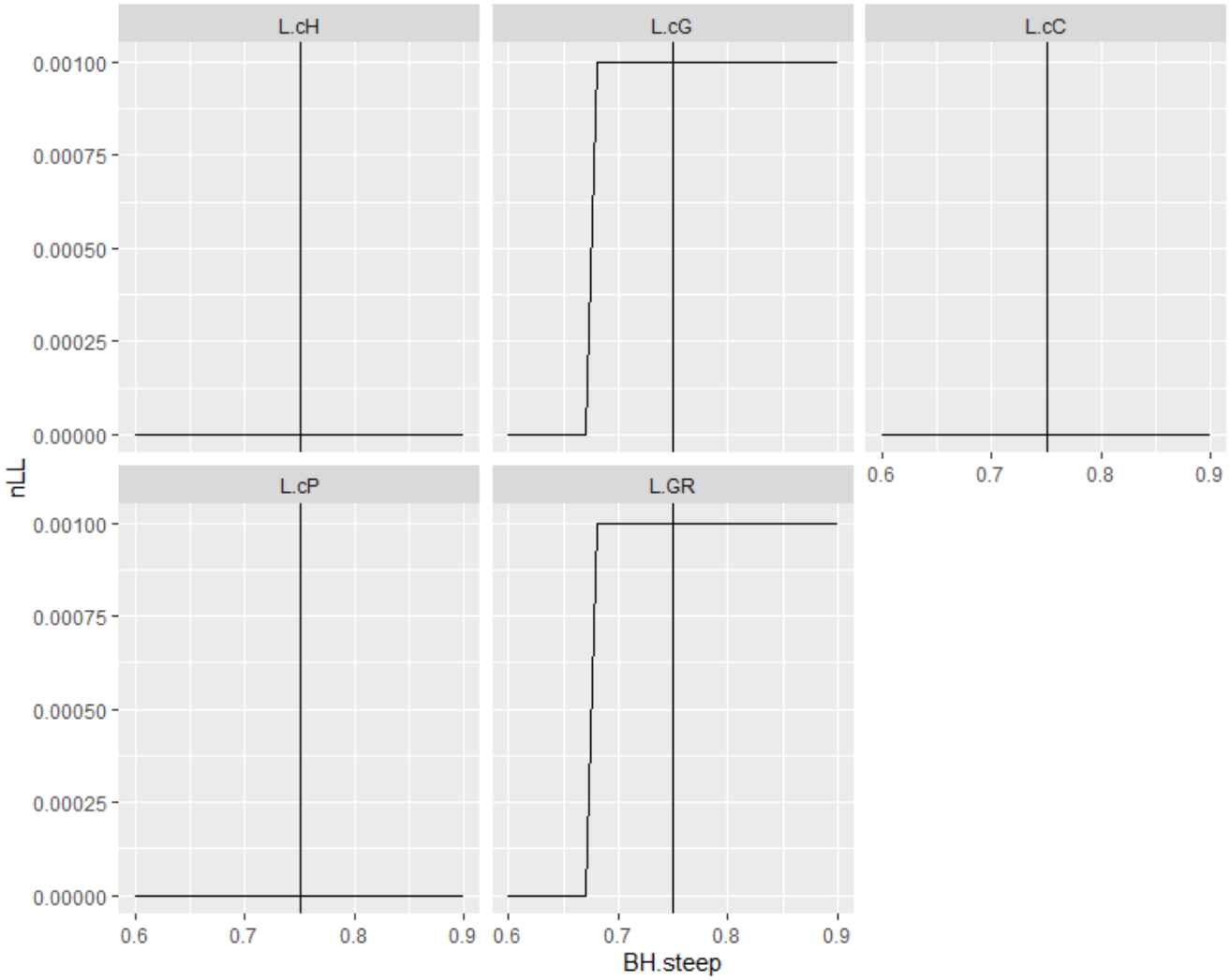
Steepness profile - landings



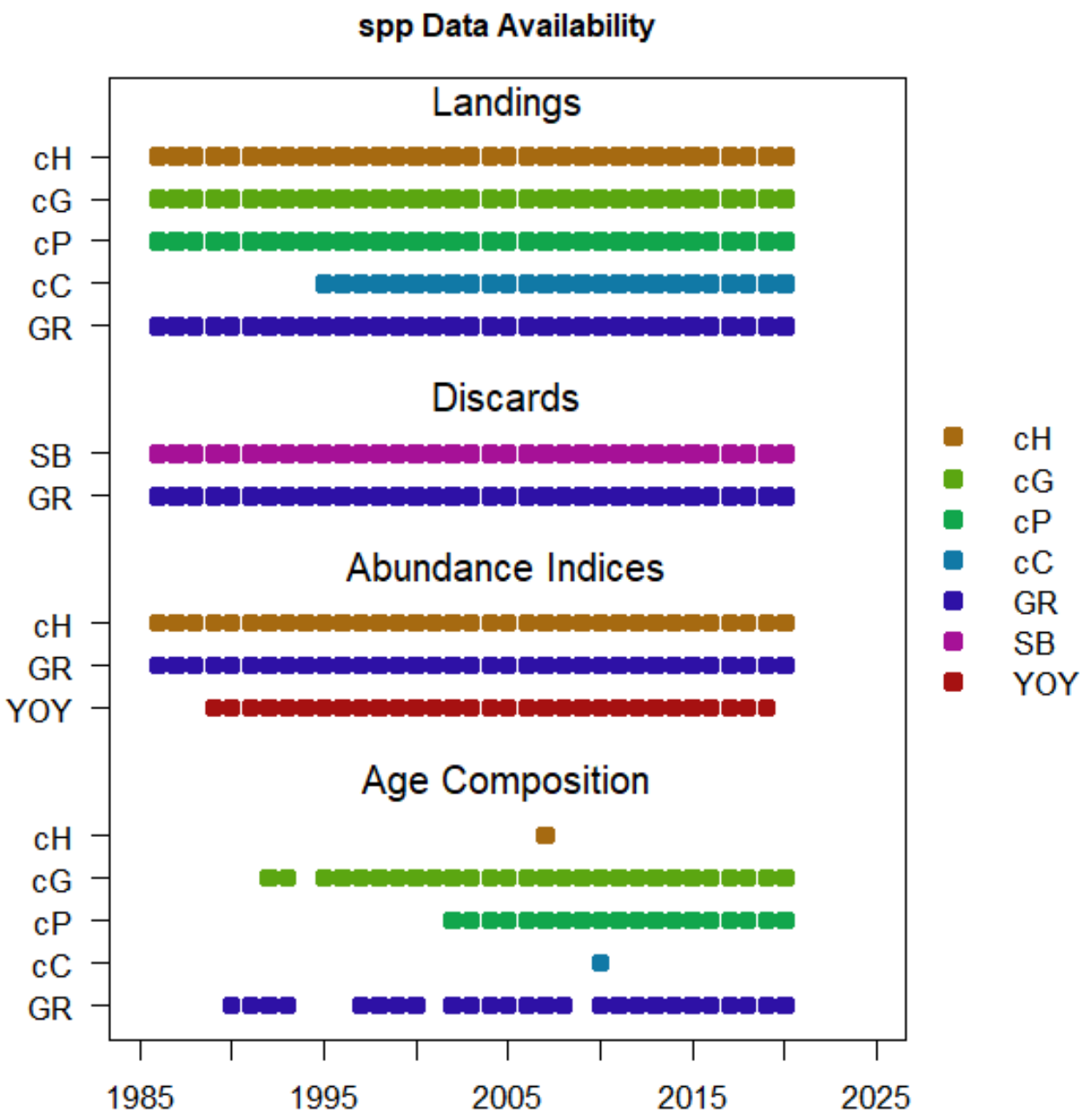
Topics

- Data Review
- Model update
- **Base run**
- Sensitivities and retrospective
- Uncertainty
- Projections

Base run recommendations

- Start model in 1986 (and truncate MRIP index)
- Allow model to estimate initial F
- No information in M or steepness profiles to deviate from fixed values from SEDAR 28 for base run

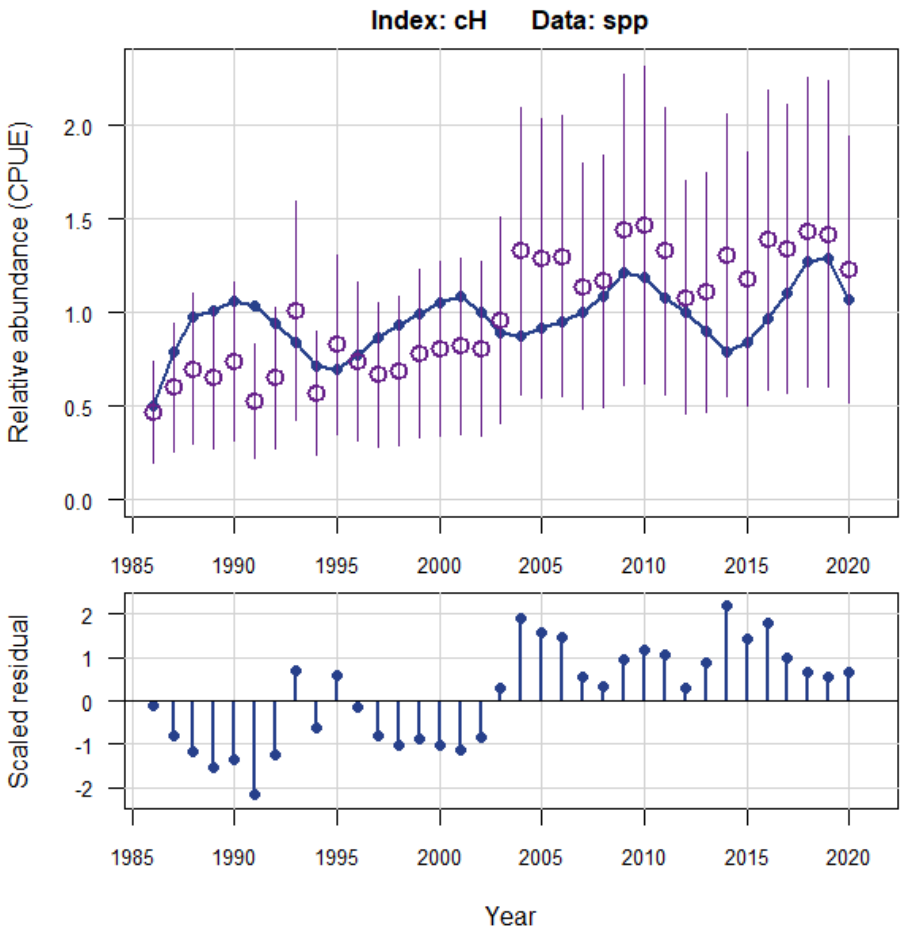
Base Run - Data

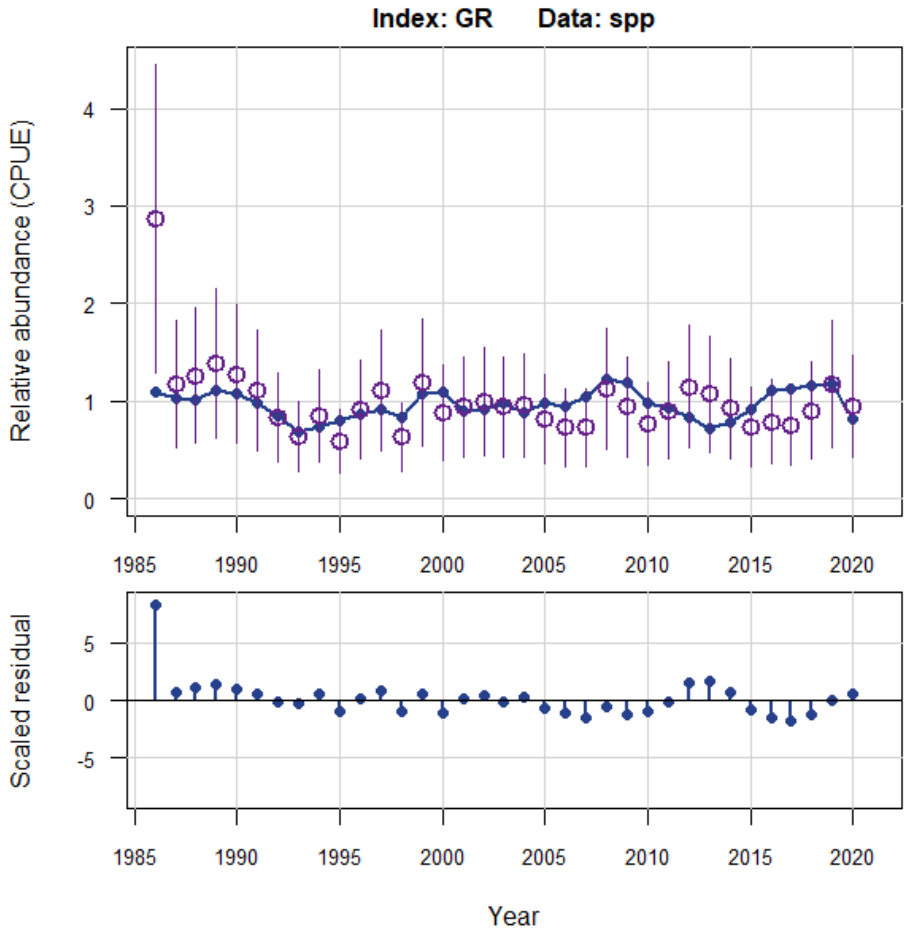


commercial handline (cH)
commercial gill net (cG)
commercial pound net (cP)
commercial cast net (cC)
general recreational (GR)
shrimp bycatch (SB)
young-of-the-year (YOY)

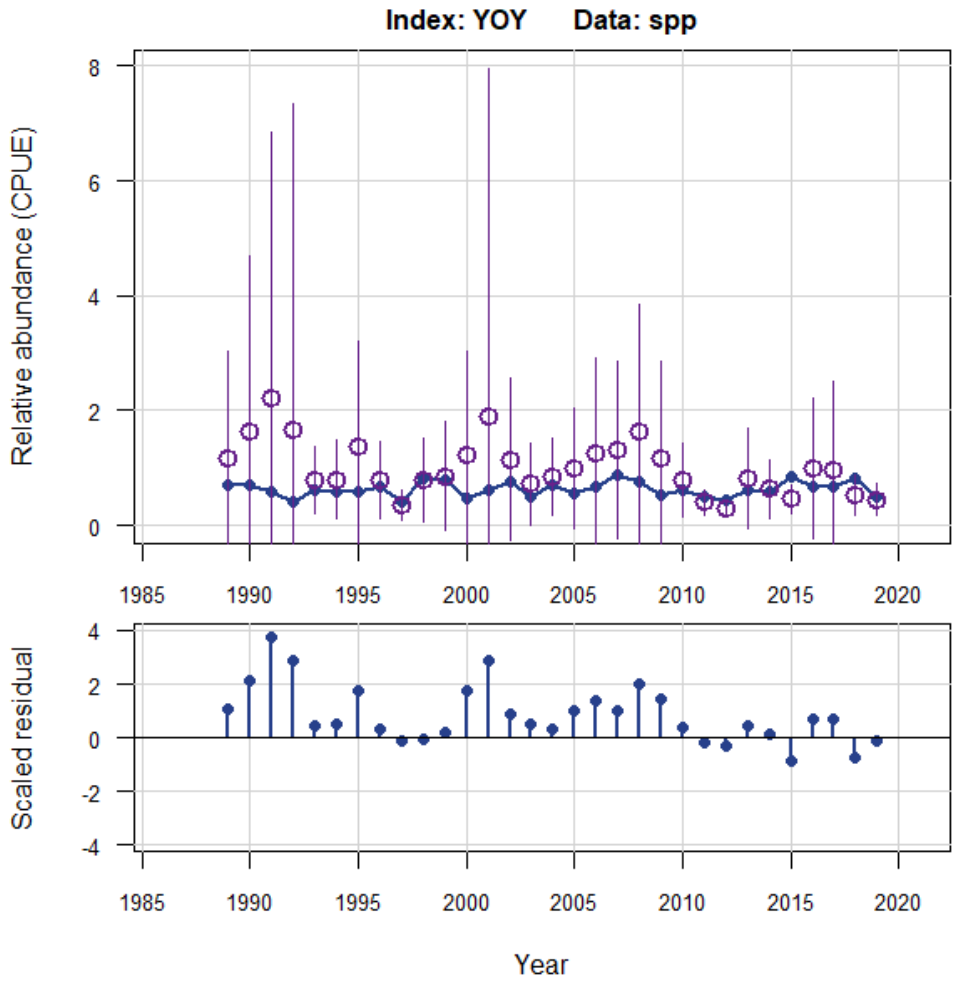
Fig 11-12, pdf page 134-135

Base Run – Indices (1)



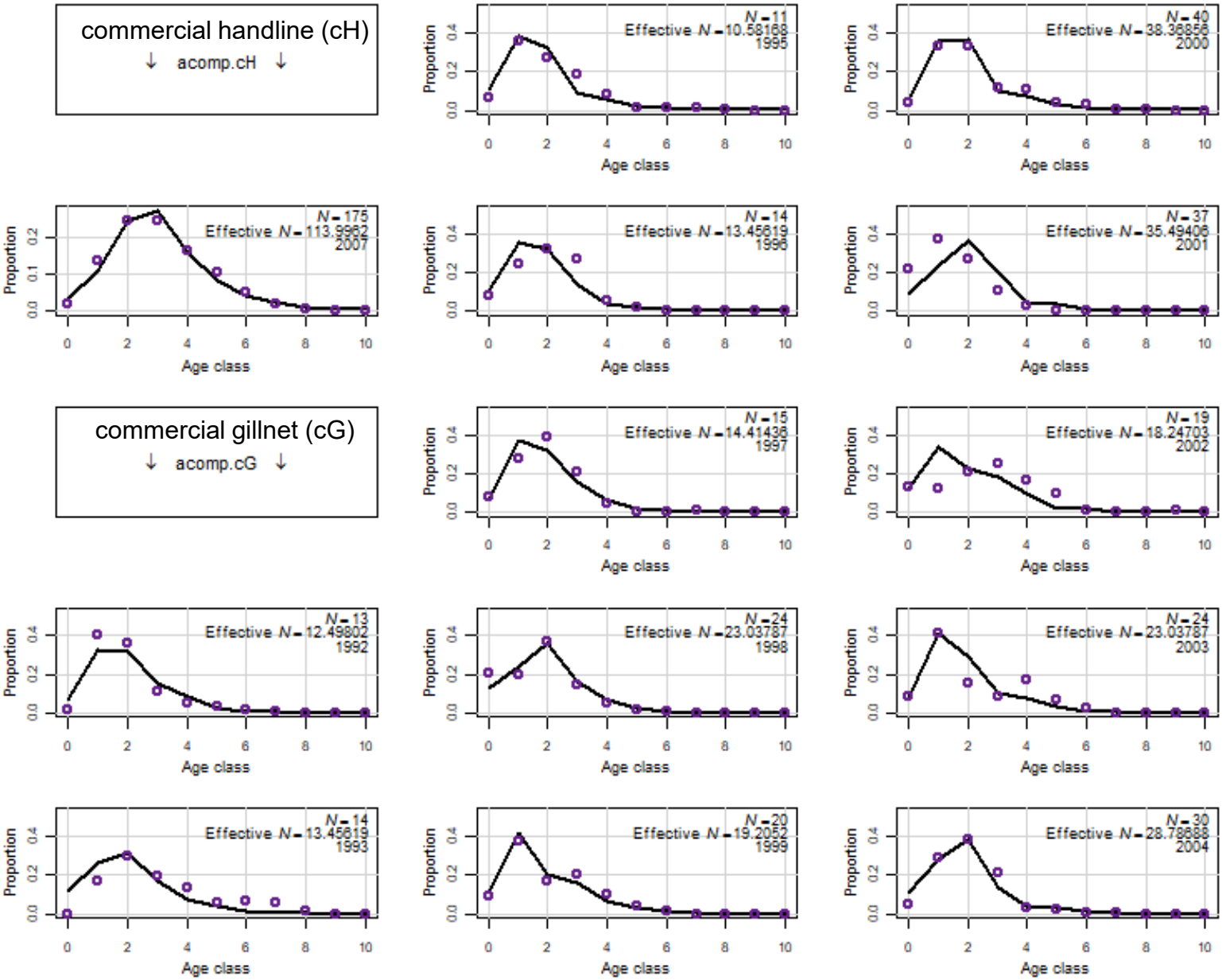


Base Run – Indices (2)



Base Run – Annual age compositions (1)

Fig 2, pdf page 116



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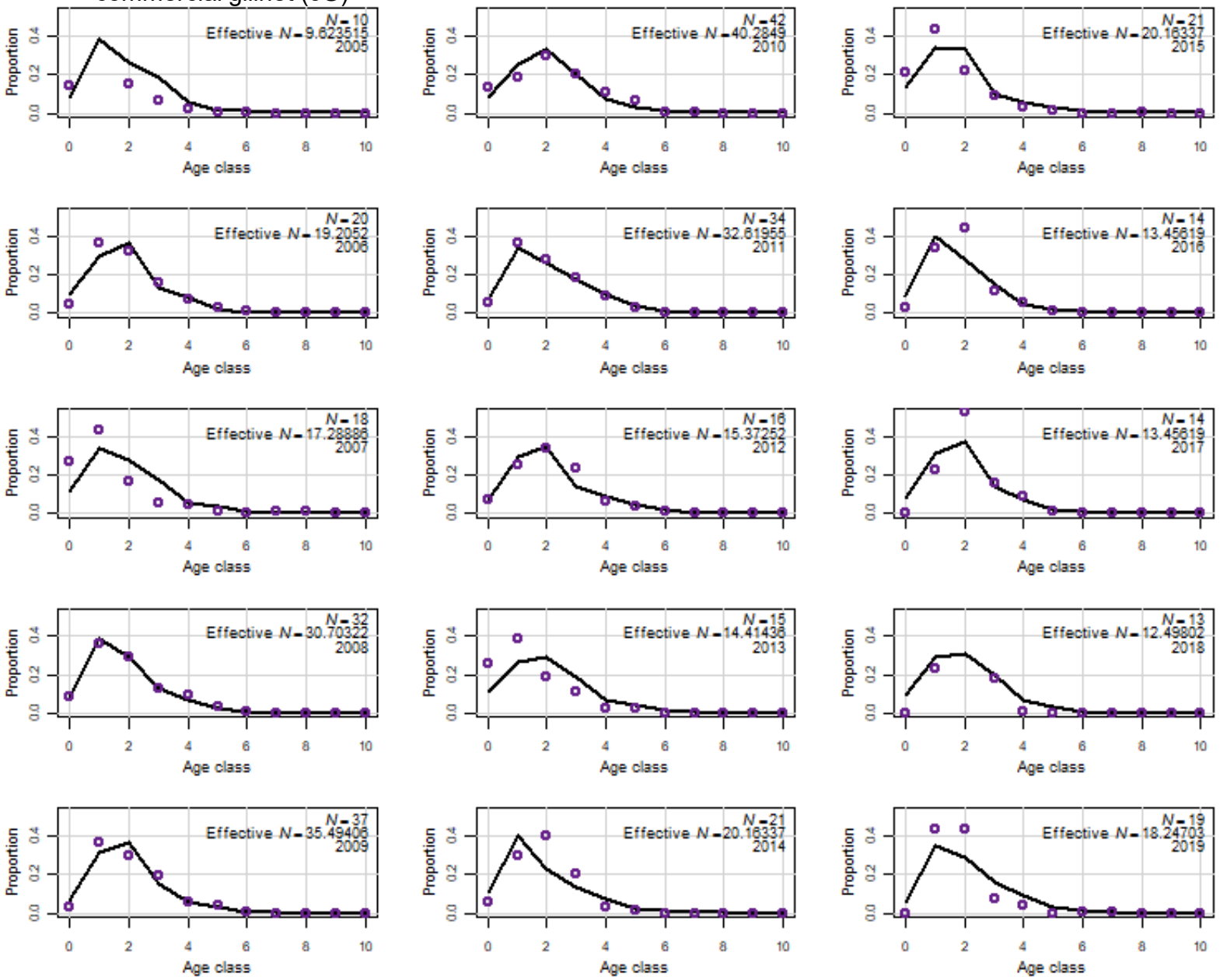
Base Run – Annual age compositions (2)

Fig 2, pdf page 117

commercial gillnet (cG)



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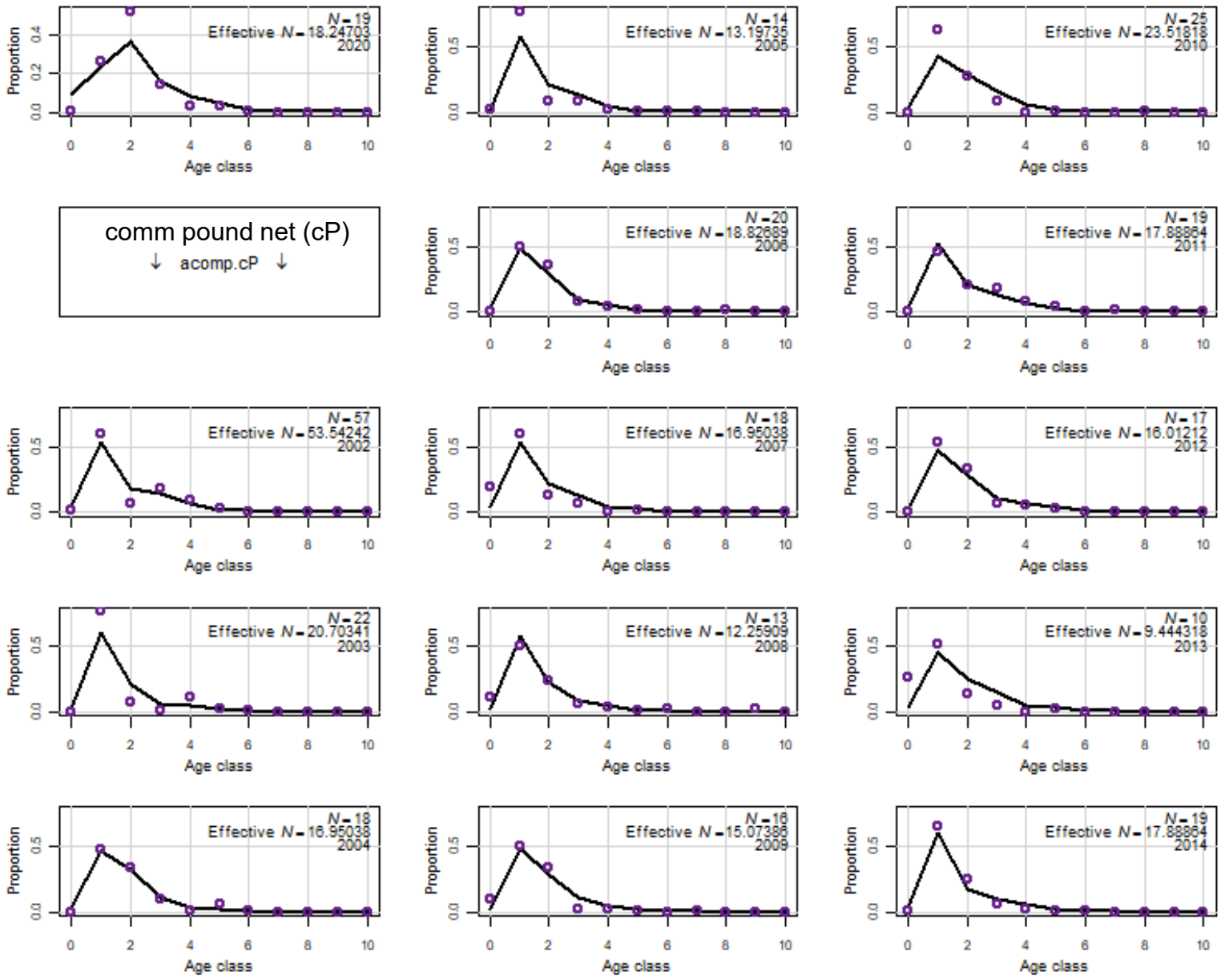
Base Run – Annual age compositions (3)

Fig 2, pdf page 118



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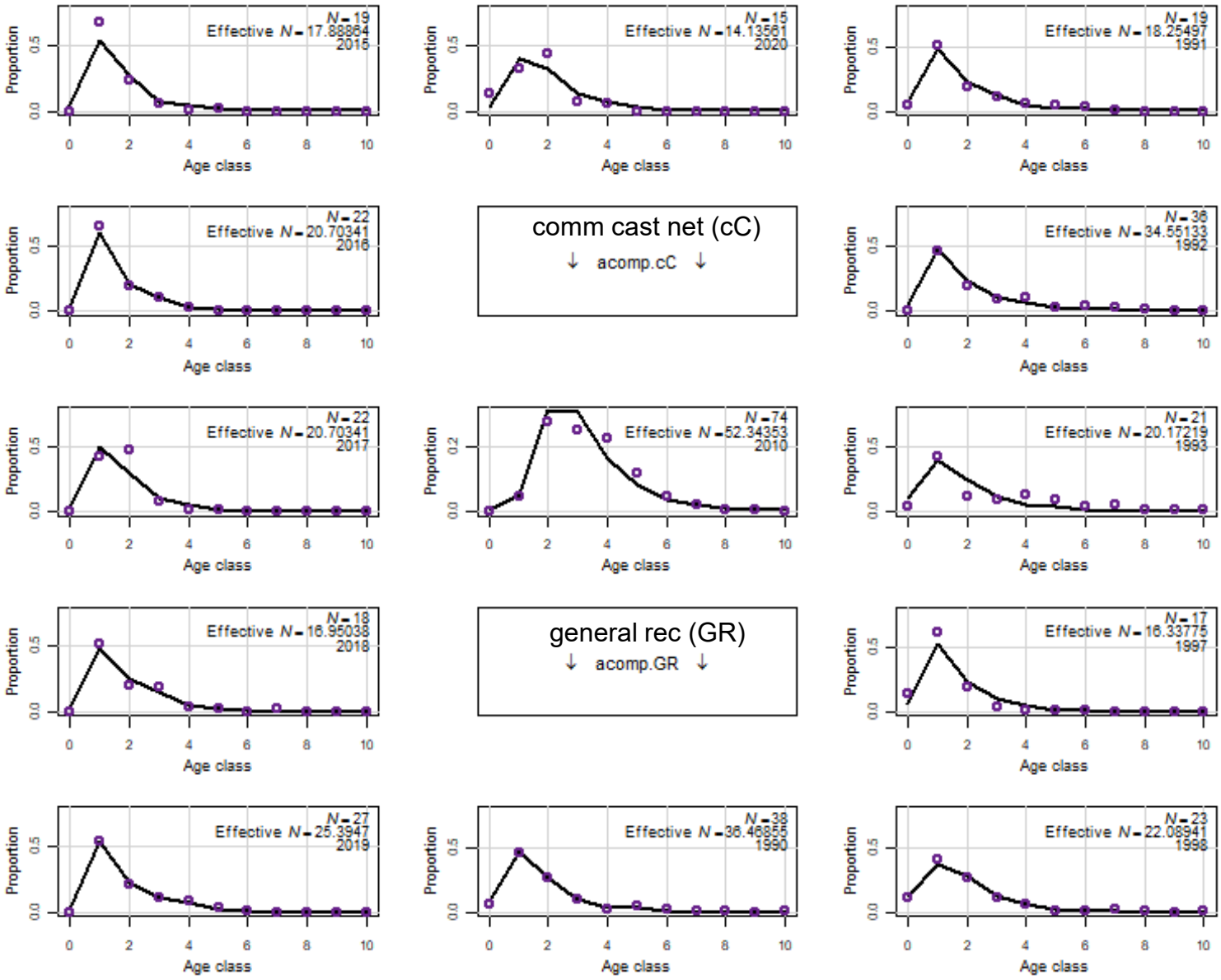
Base Run – Annual age compositions (4)

commercial gillnet (cG)



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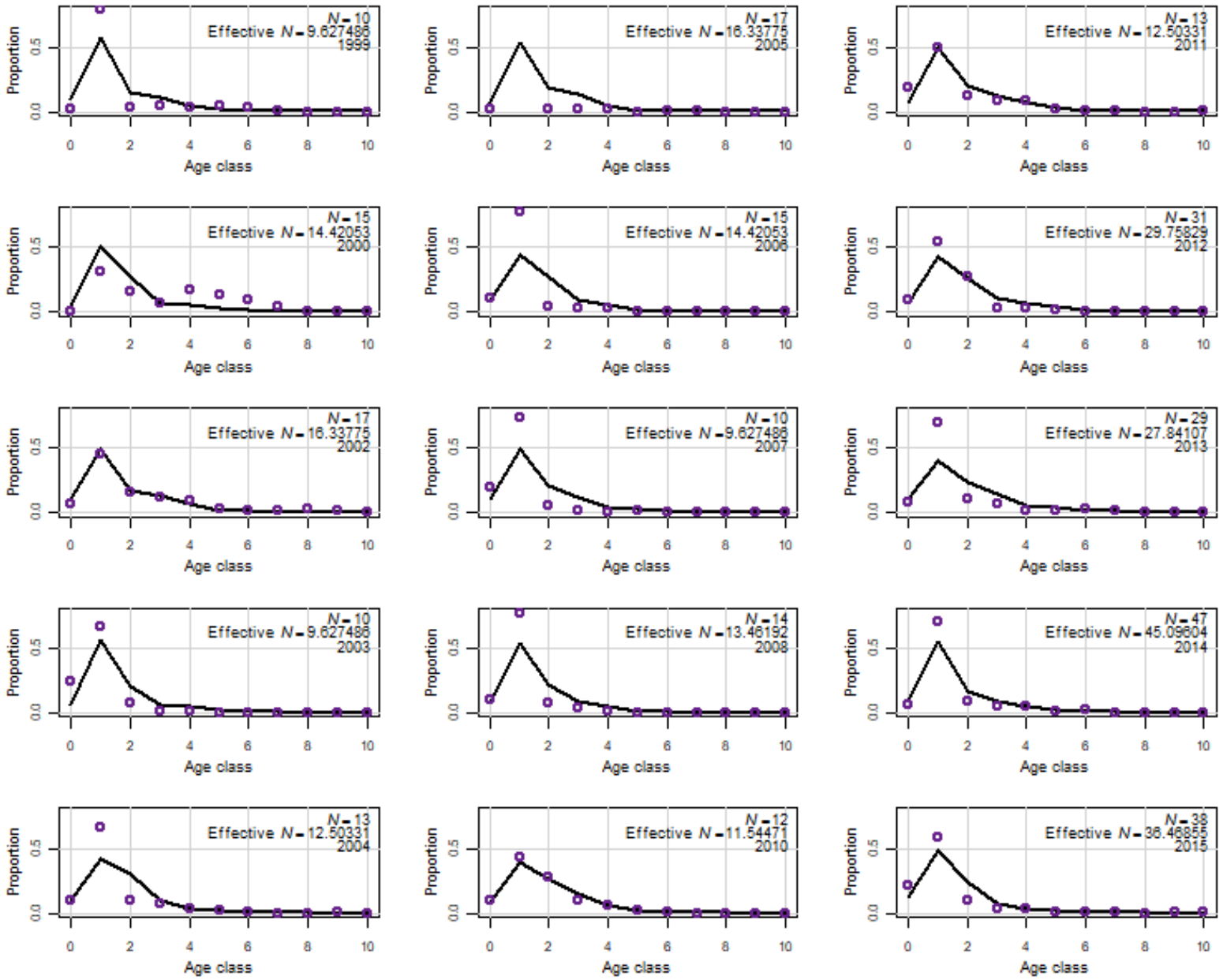
Base Run – Annual age compositions (5)

Fig 2, pdf page 120

general rec (GR)



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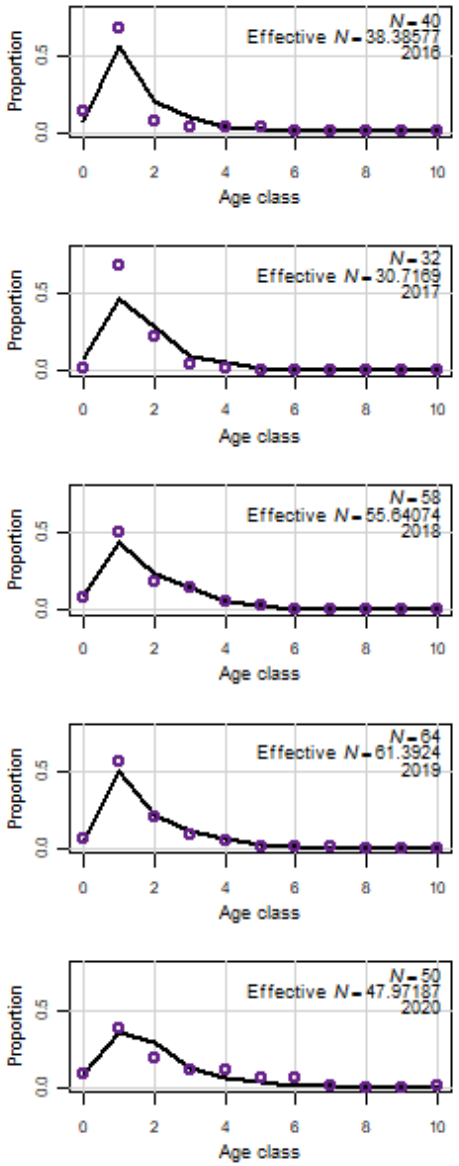
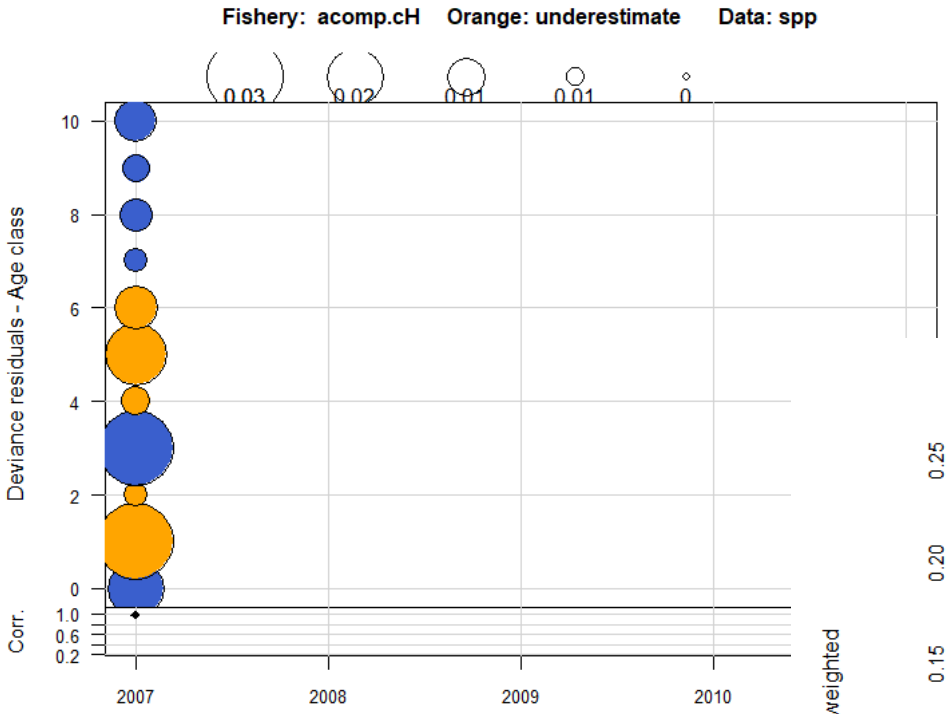
Base Run – Annual age compositions (6)

general rec (GR)



Base Run – Age compositions (acomp) comm handline (cH) (7)



commercial handline (cH)

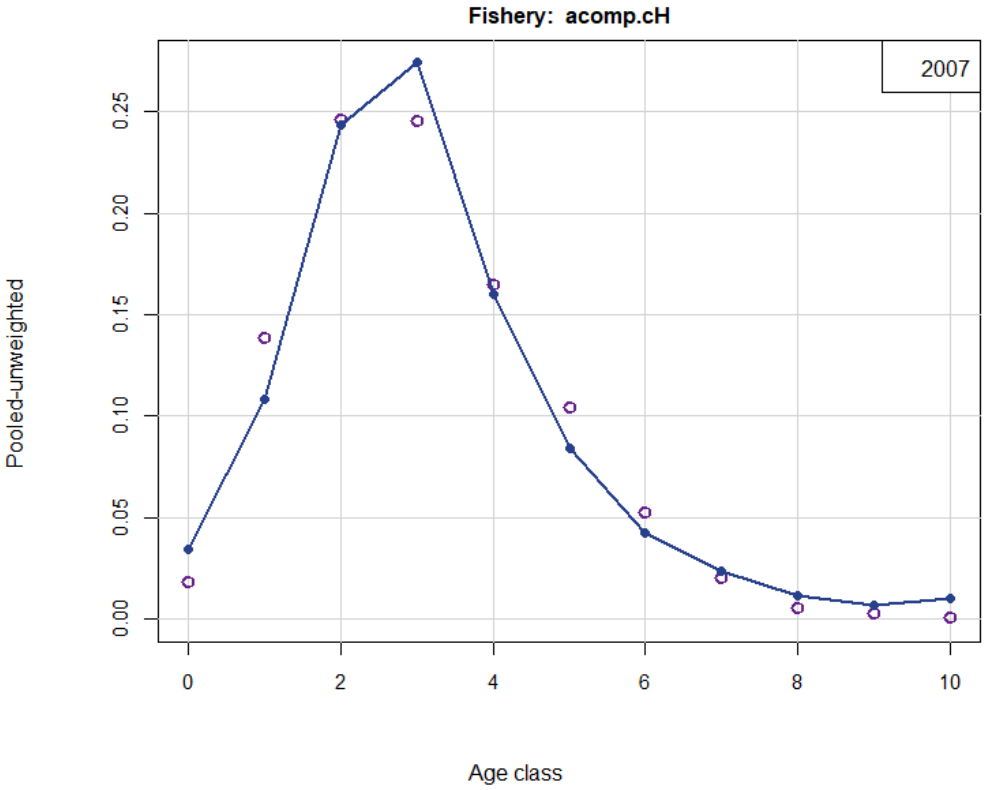


Fig 3, pdf page 122

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Base Run – Age compositions (acomp) comm gillnet (cG) (8)

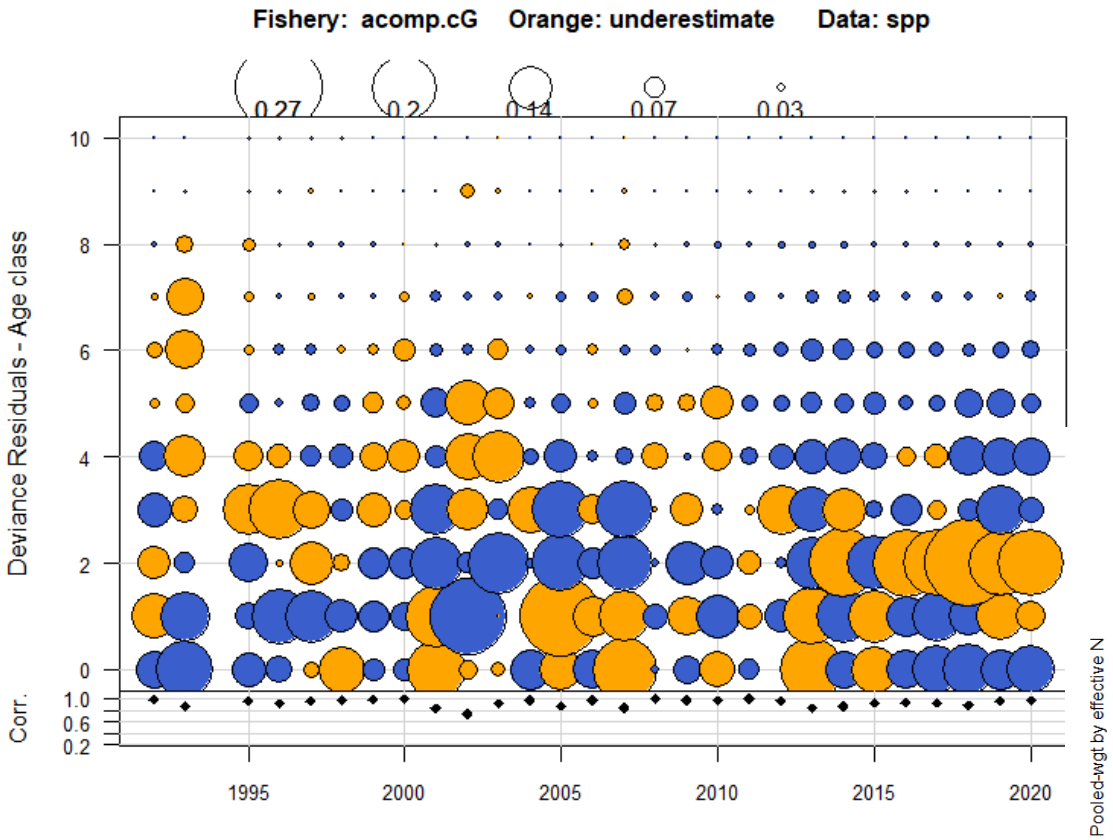
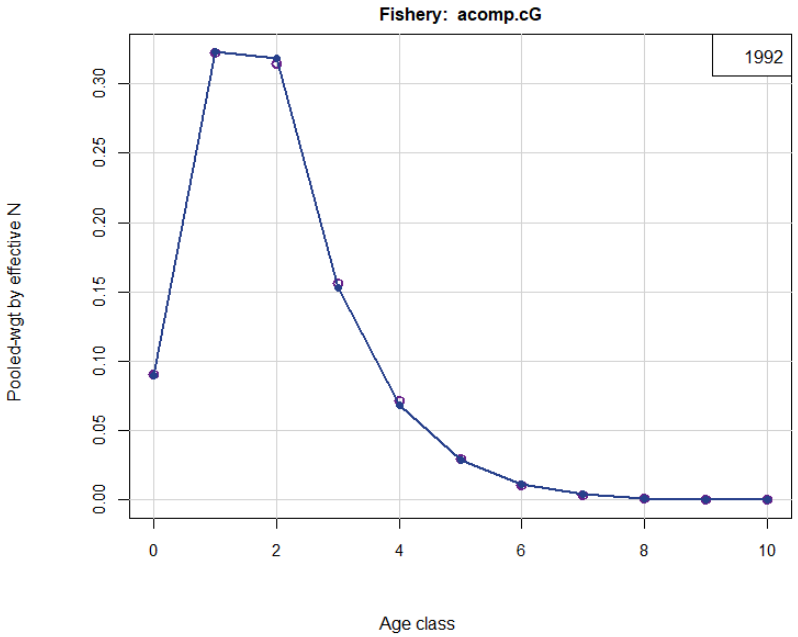


Fig 3, pdf page 124



Base Run – Age compositions comm pound net (cP) (9)

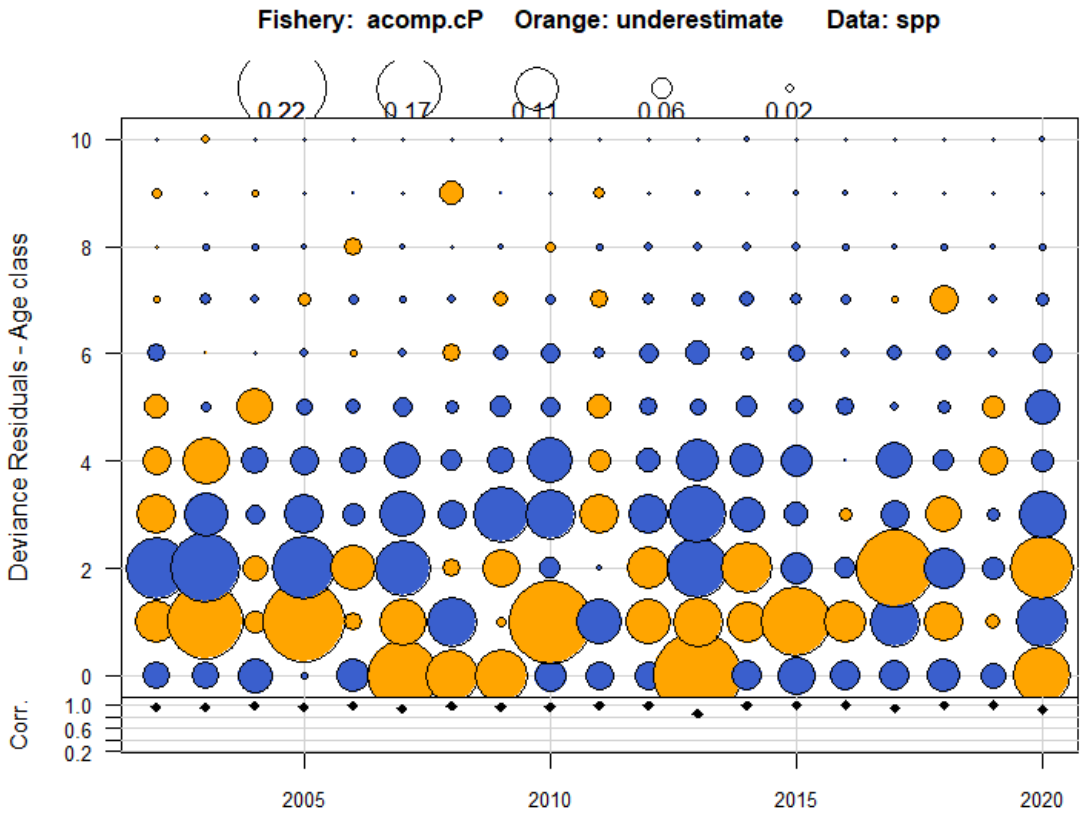
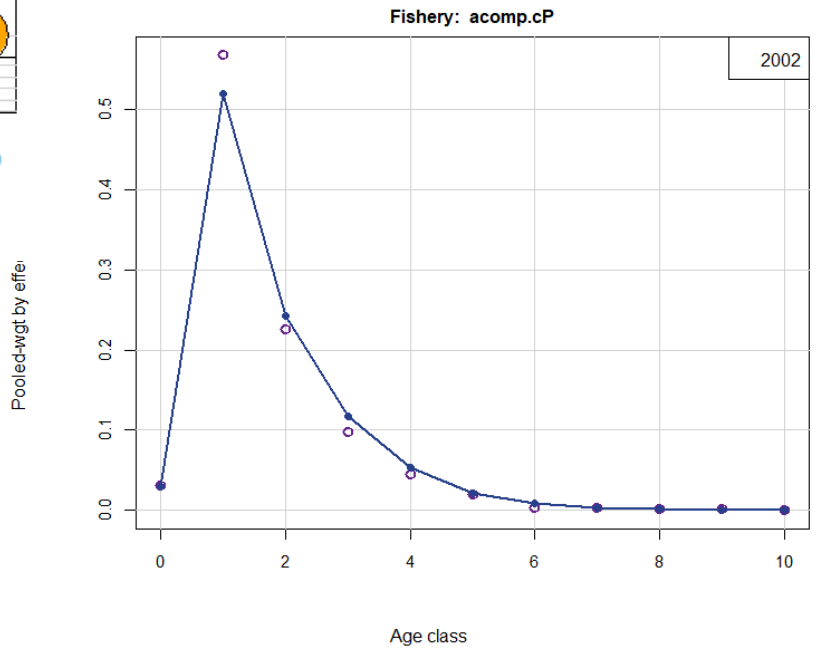
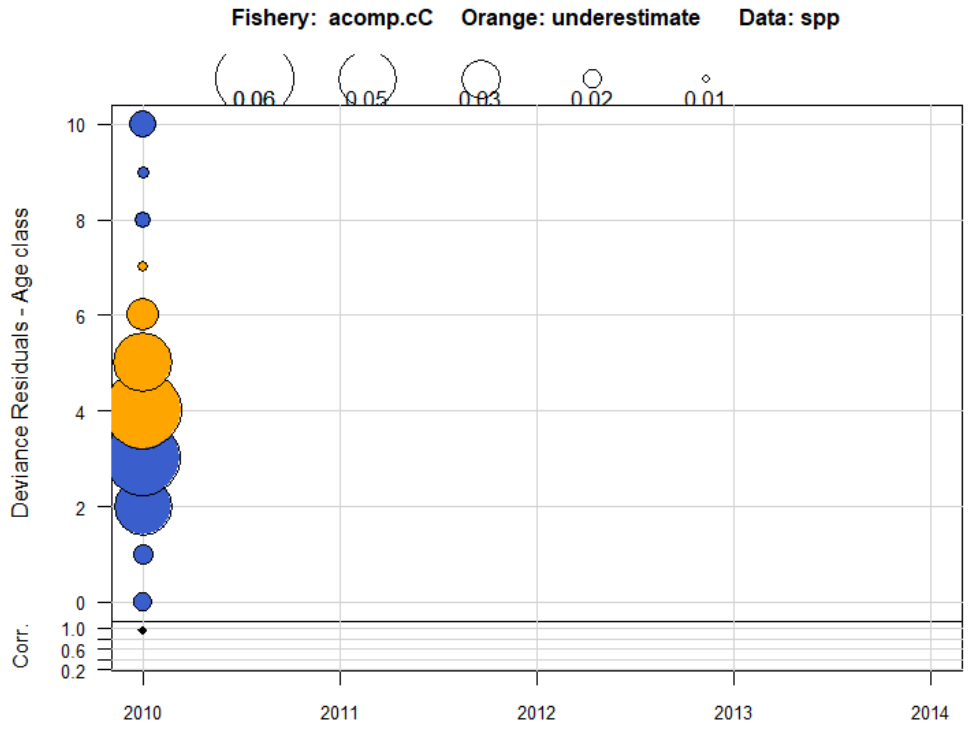


Fig 3, pdf page 123



Base Run – Age compositions comm cast net (cC) (10)



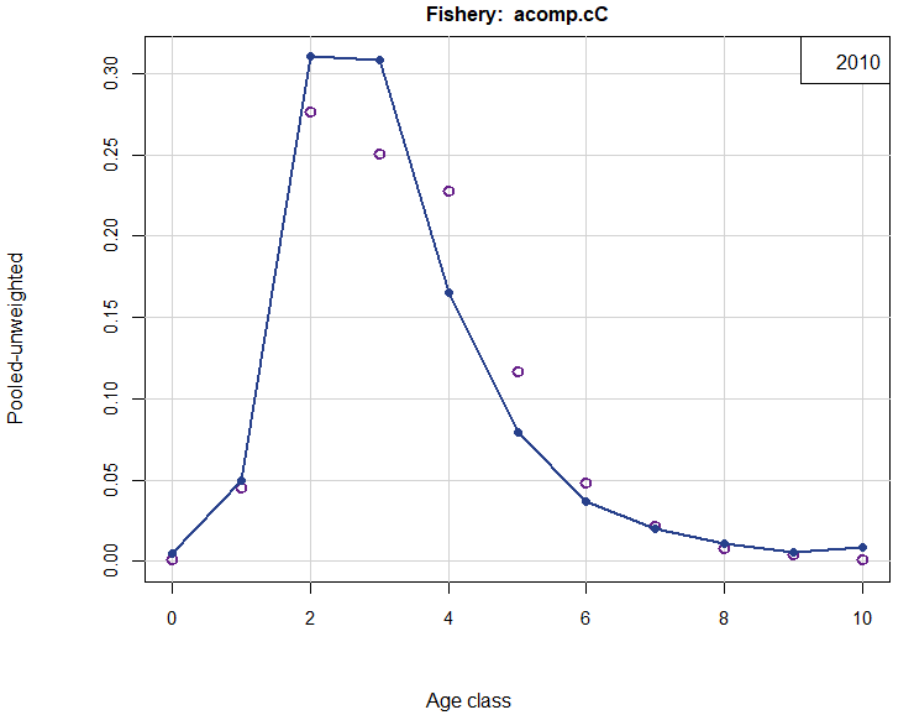


Fig 3, pdf page 125

Base Run – Age compositions general recreational (GR) (11)

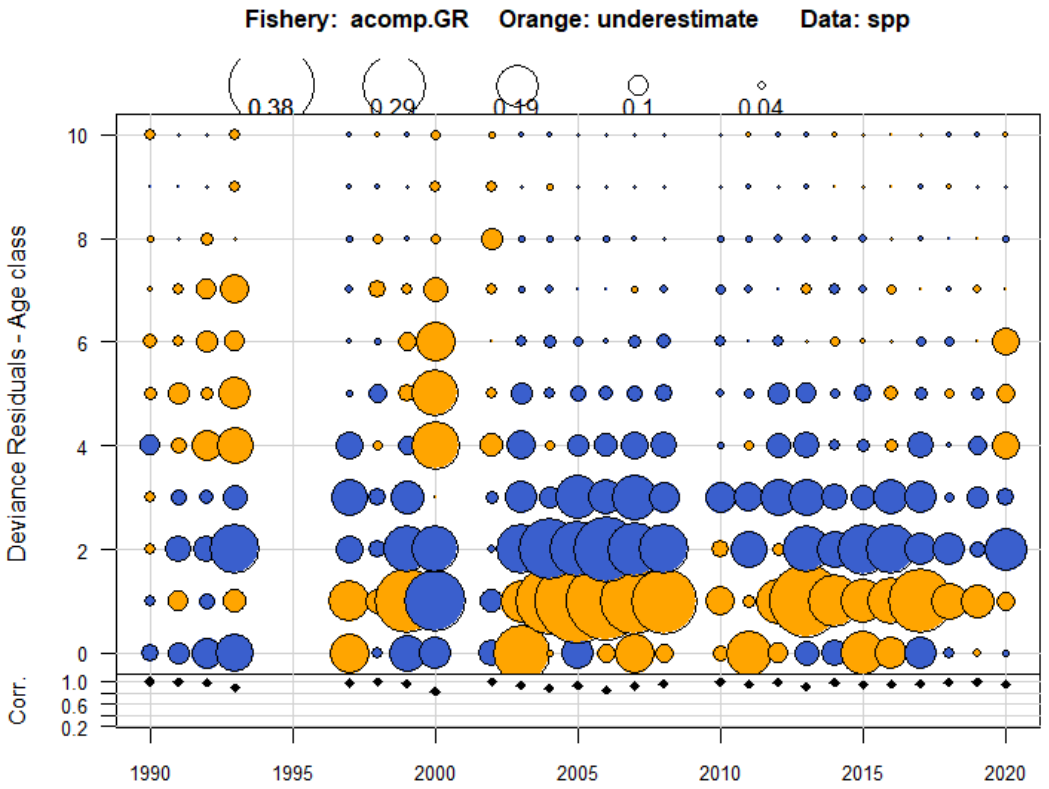
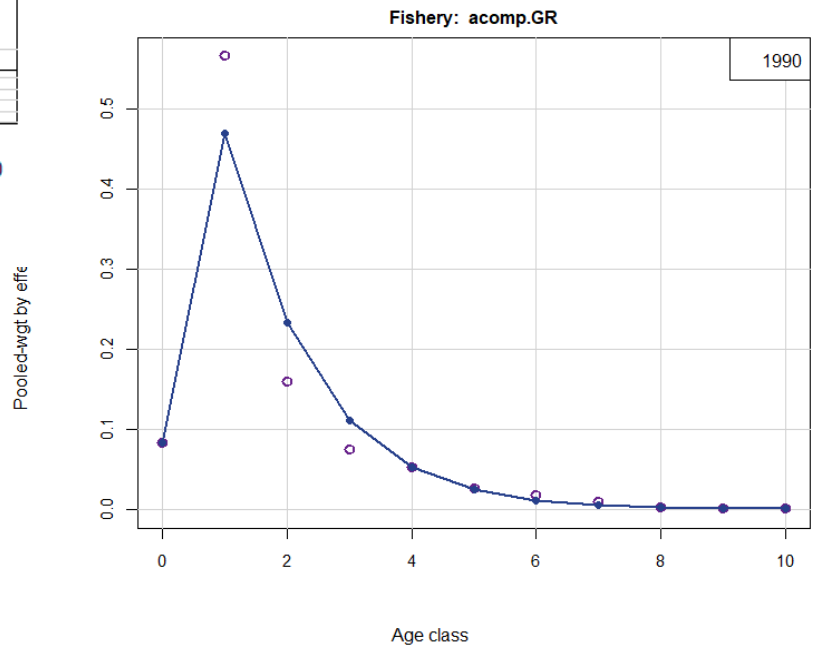
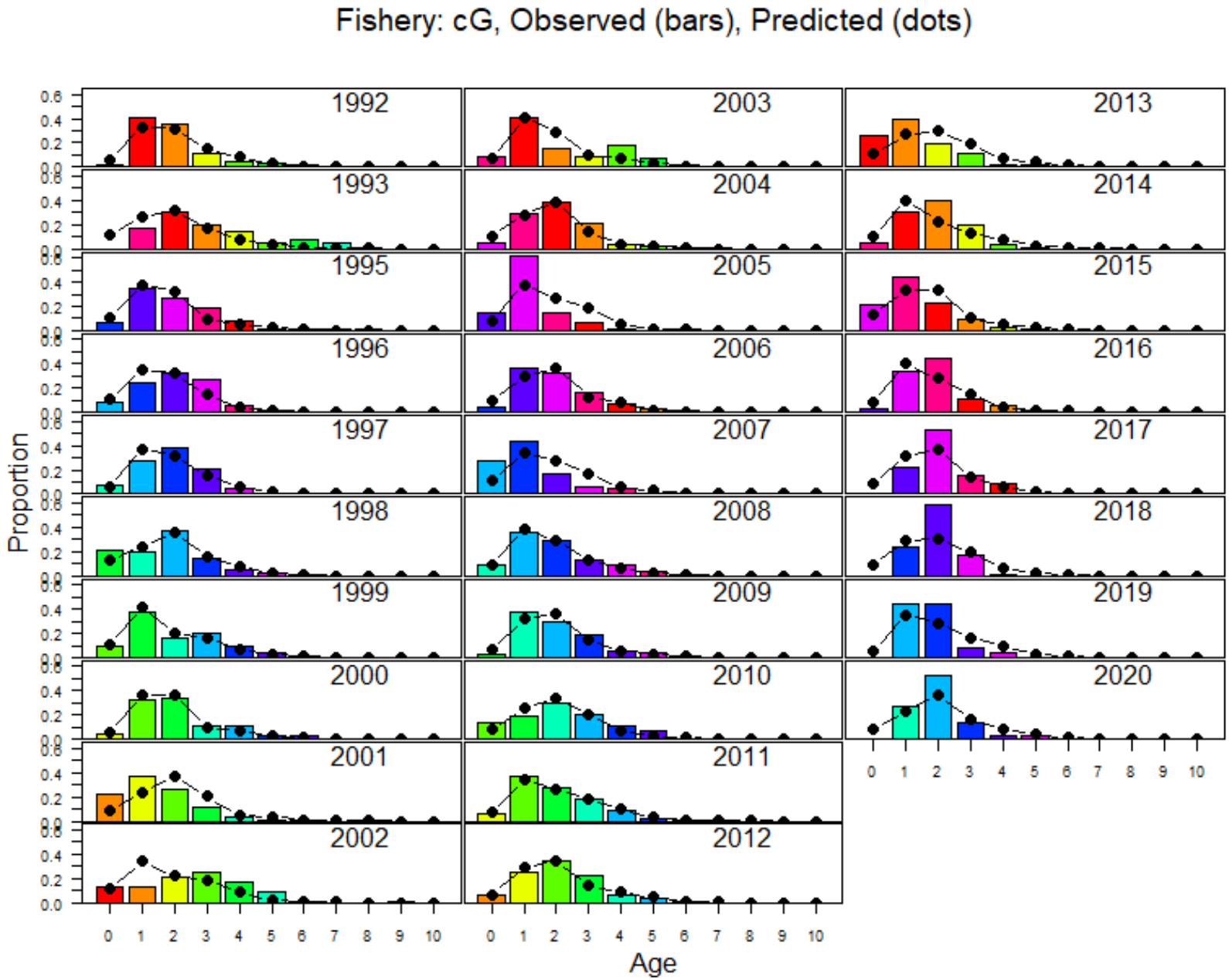


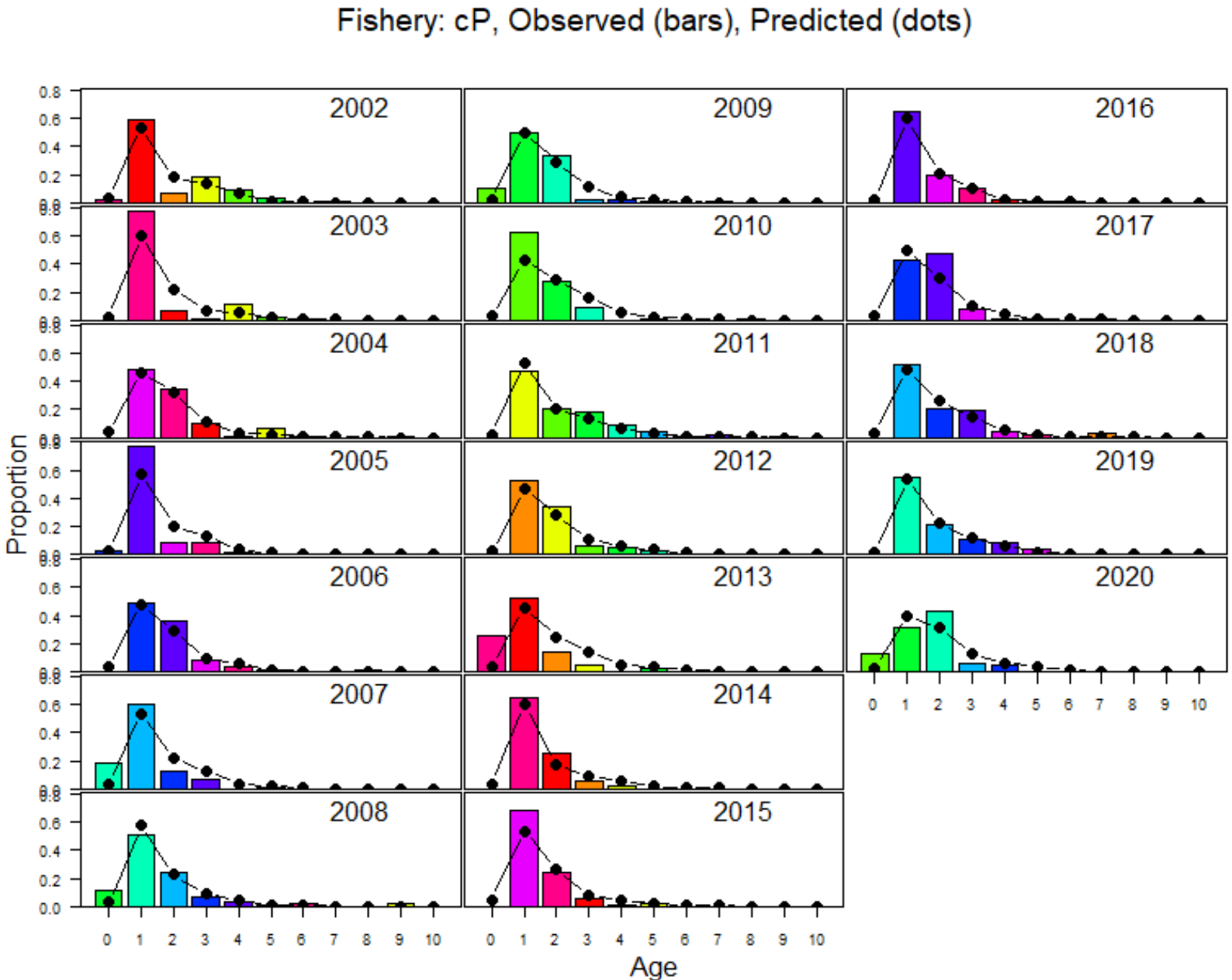
Fig 3, pdf page 126



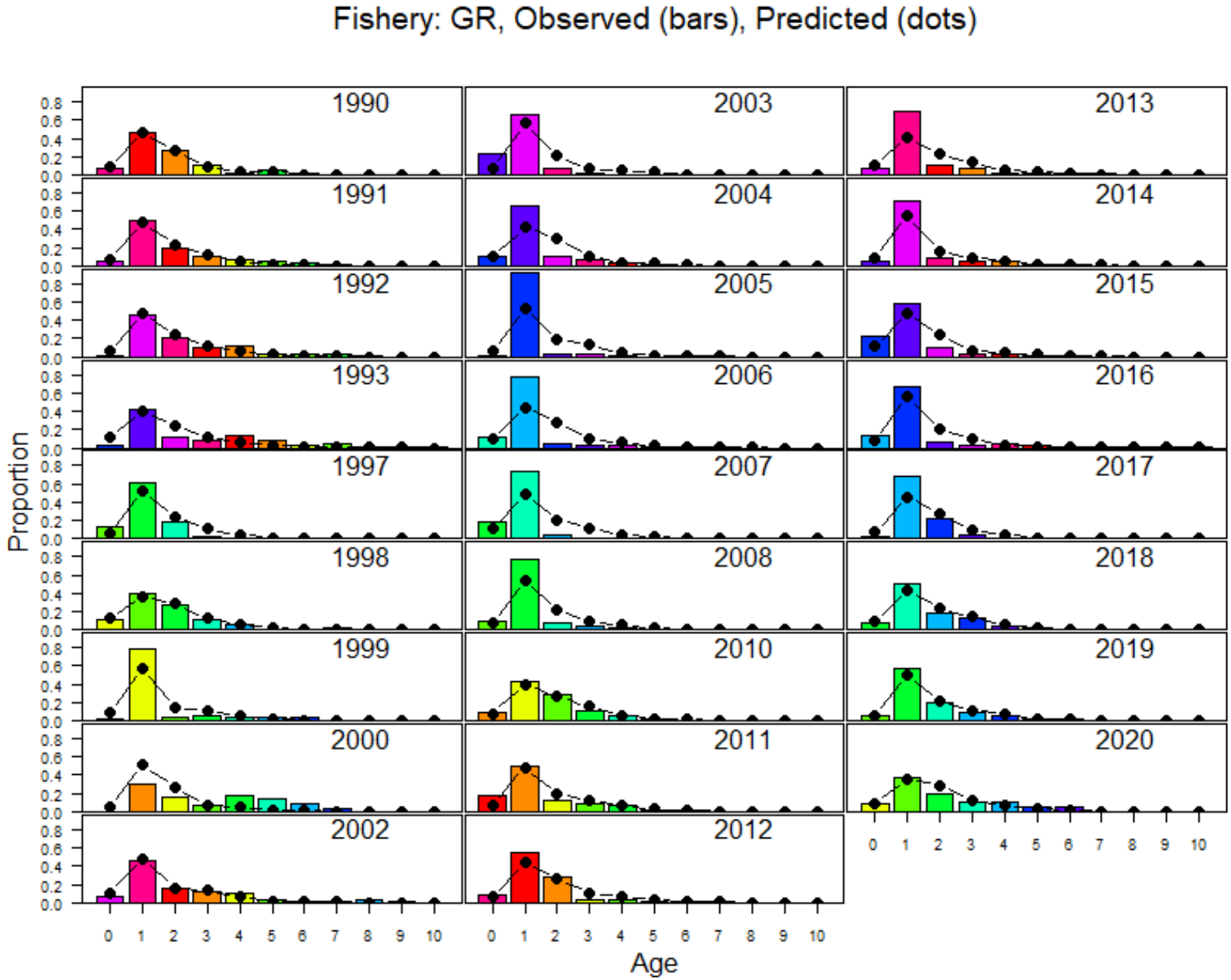
Base Run – commercial gillnet (cG) cohorts (by color)



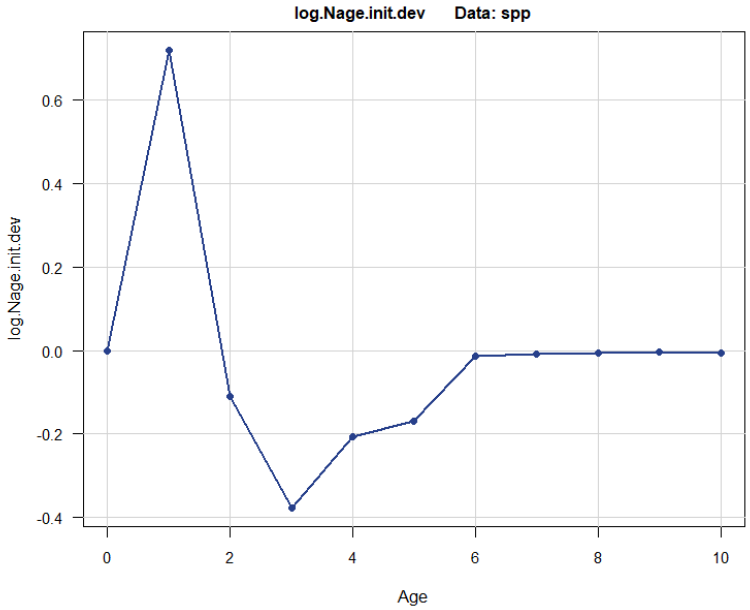
Base Run – commercial pound net (cP) cohorts (by color)

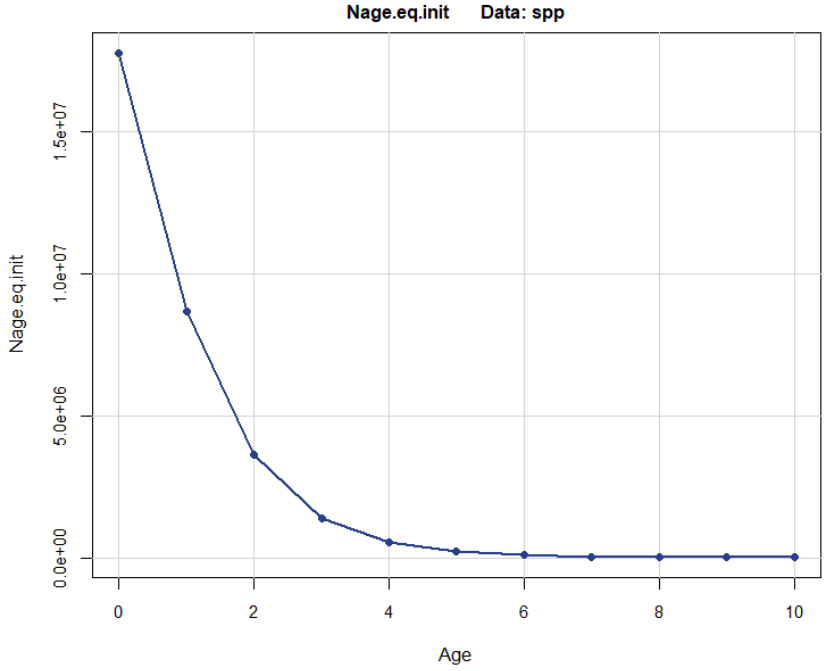


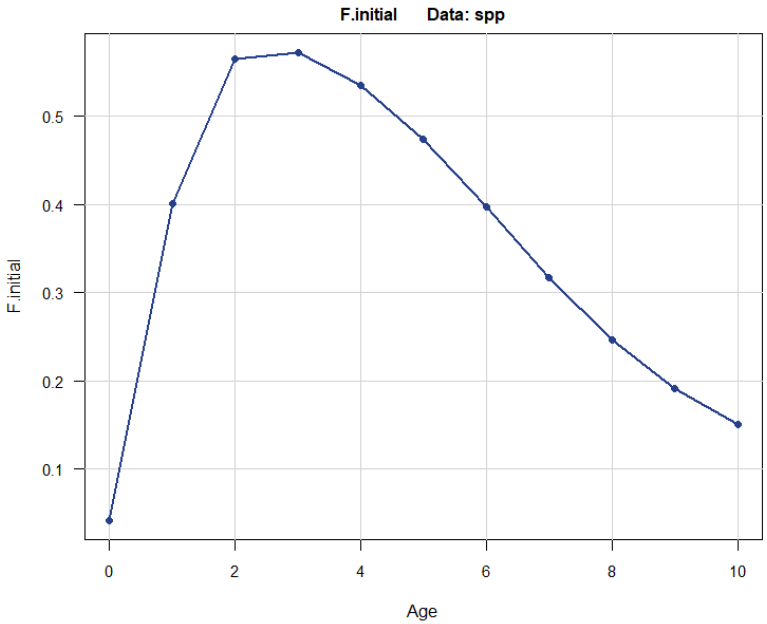
Base Run – general recreational (GR) cohorts (by color)

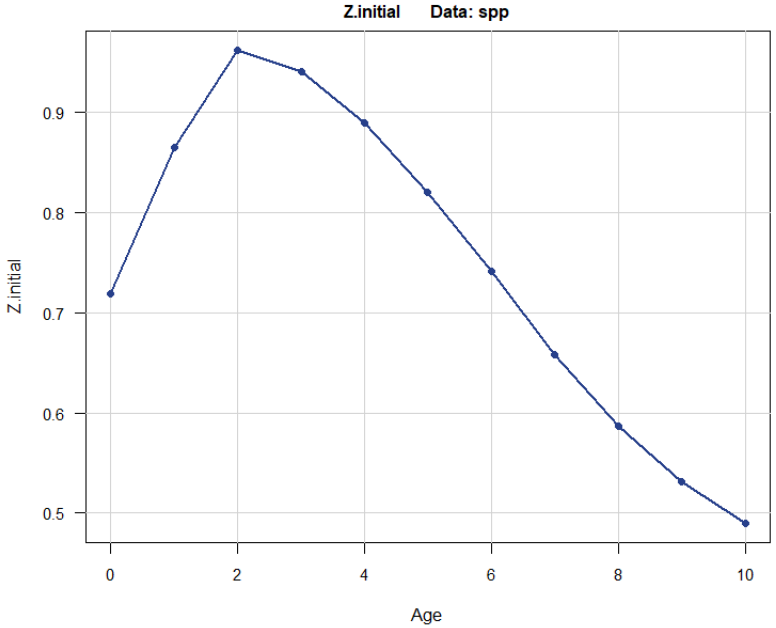


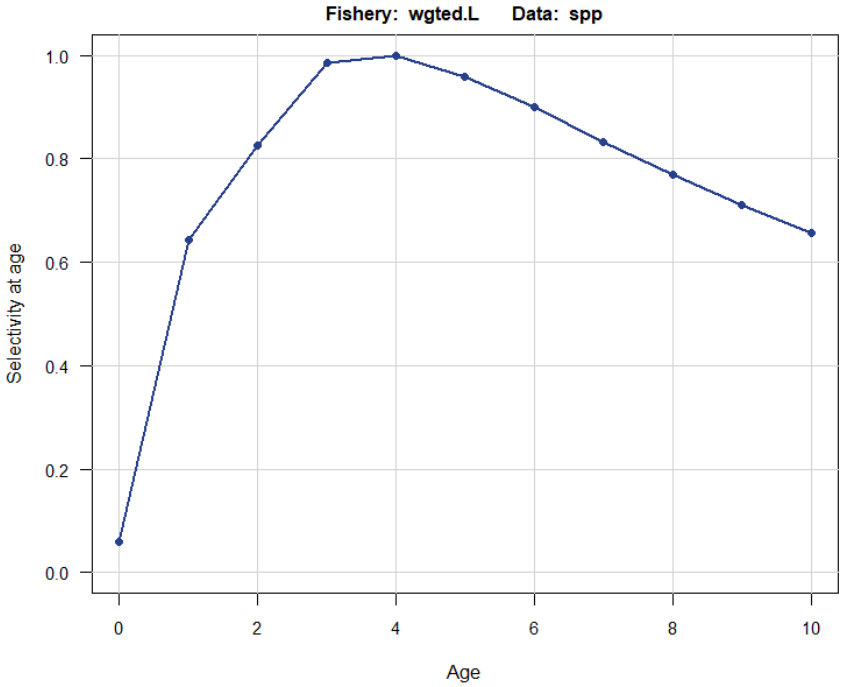
Base Run – Initial conditions

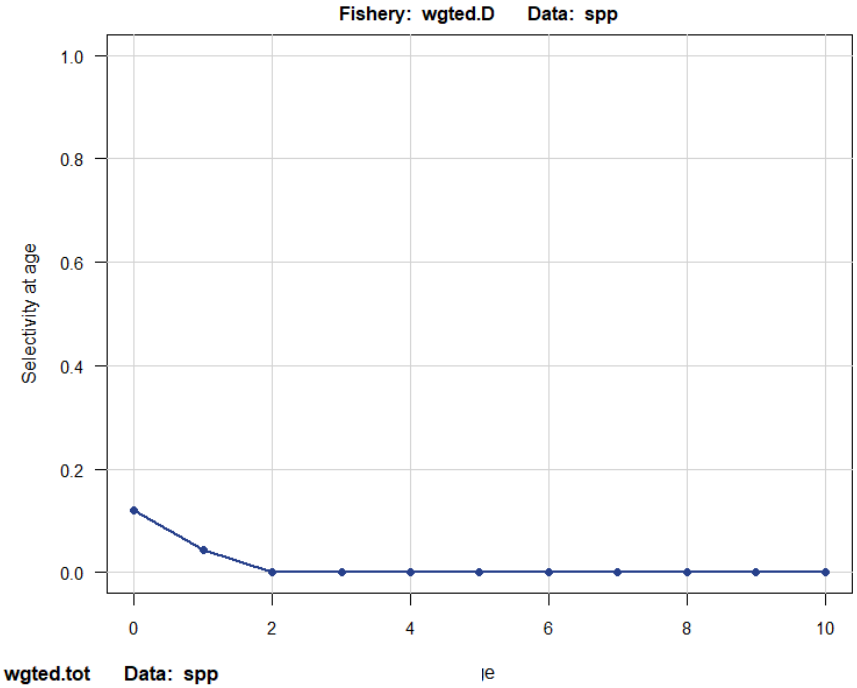




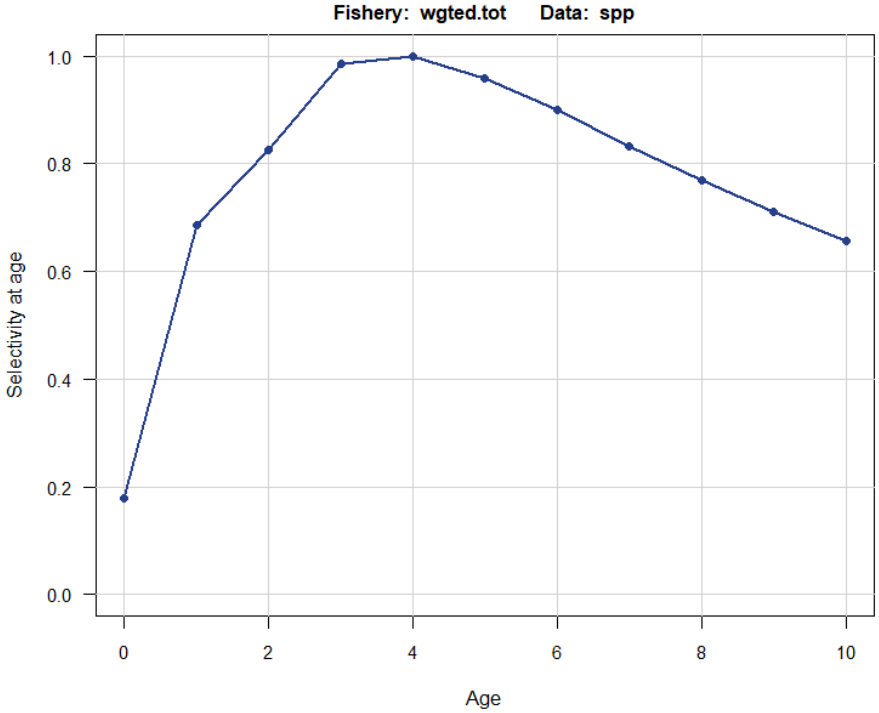








Base Run – Selectivity (weighted)



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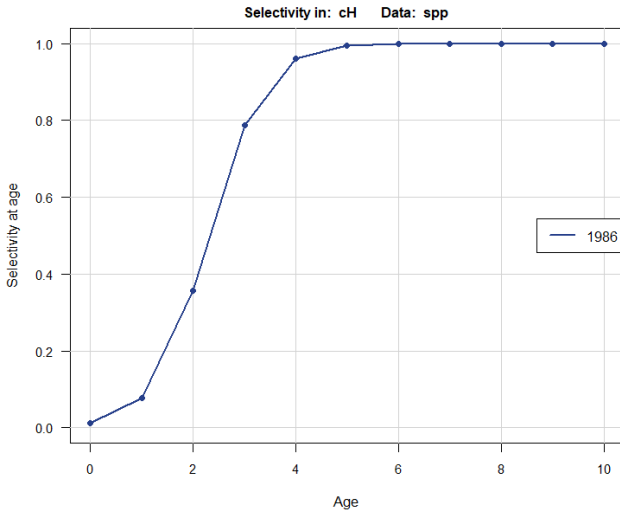
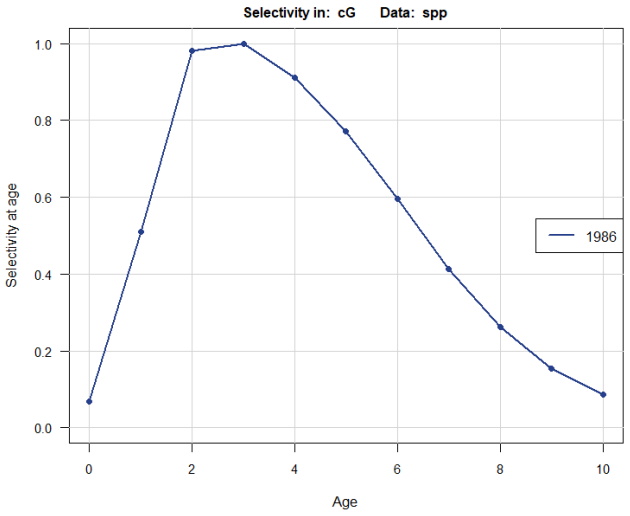
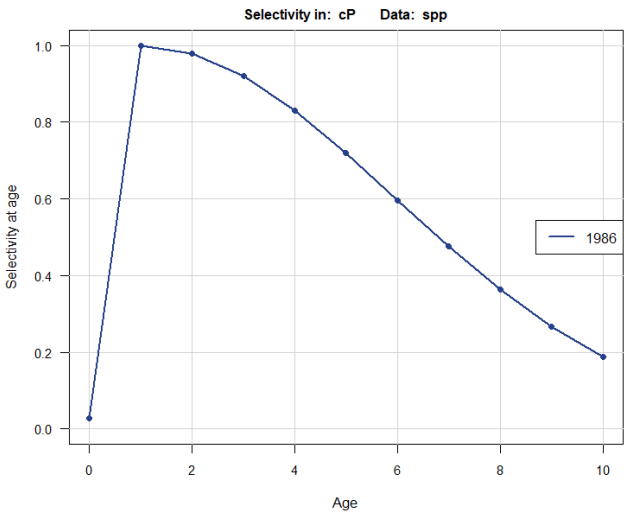
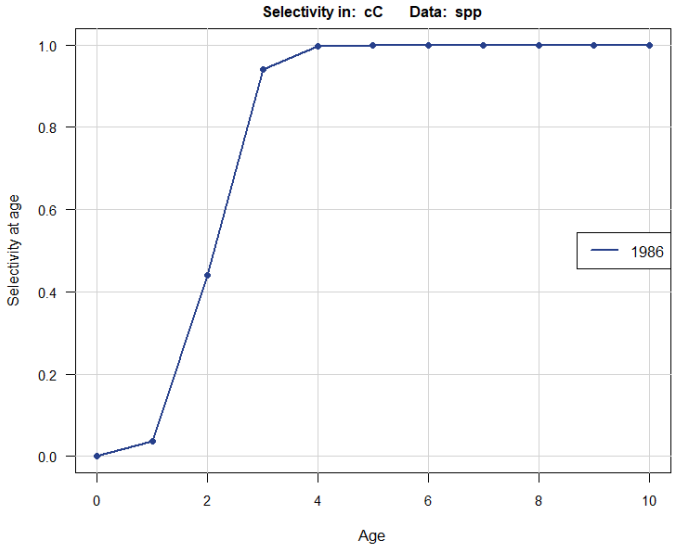
commercial handline (cH), commercial gill net (cG), commercial pound net (cP), commercial cast net (cC), general recreational (GR)

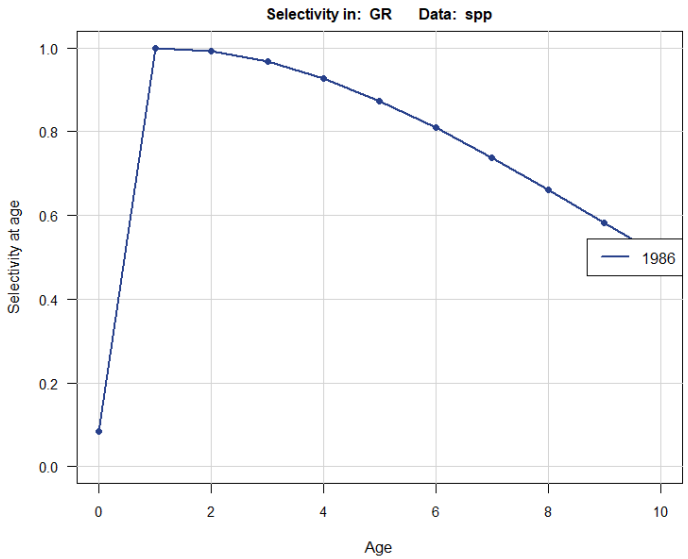






Base Run – Selectivity (fleet specific)

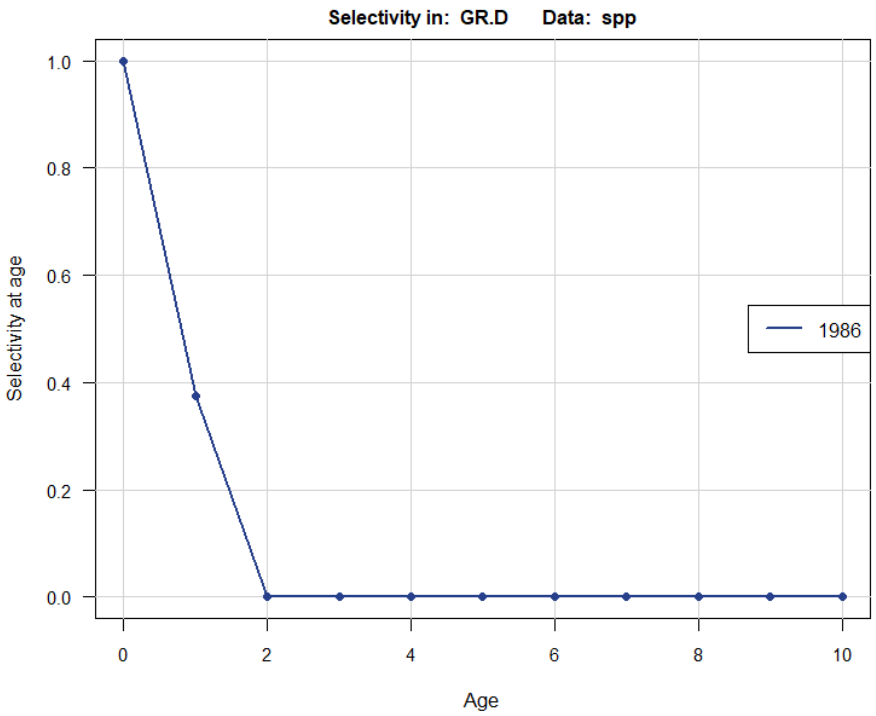


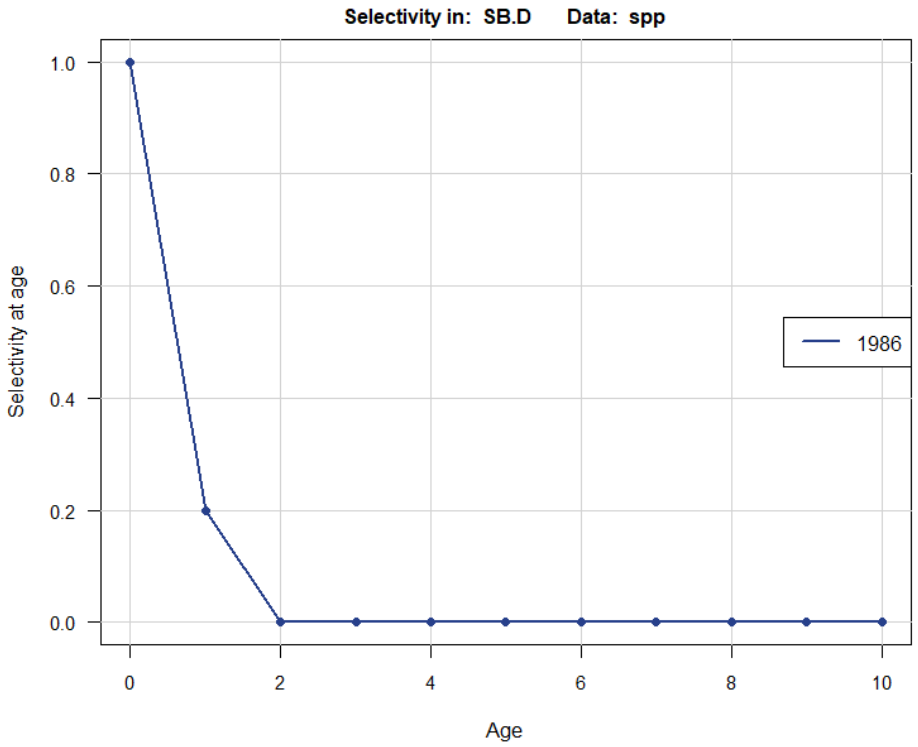


Figs 17-21, pdf pages 140-144

Base Run – Selectivity (fixed)

Figs 22-23, pdf pages 145-146

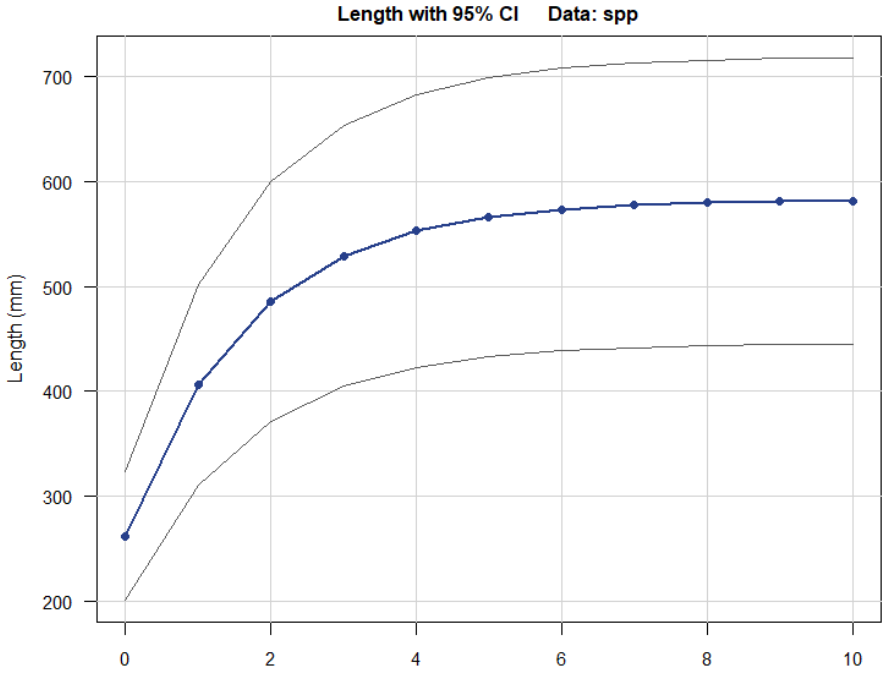


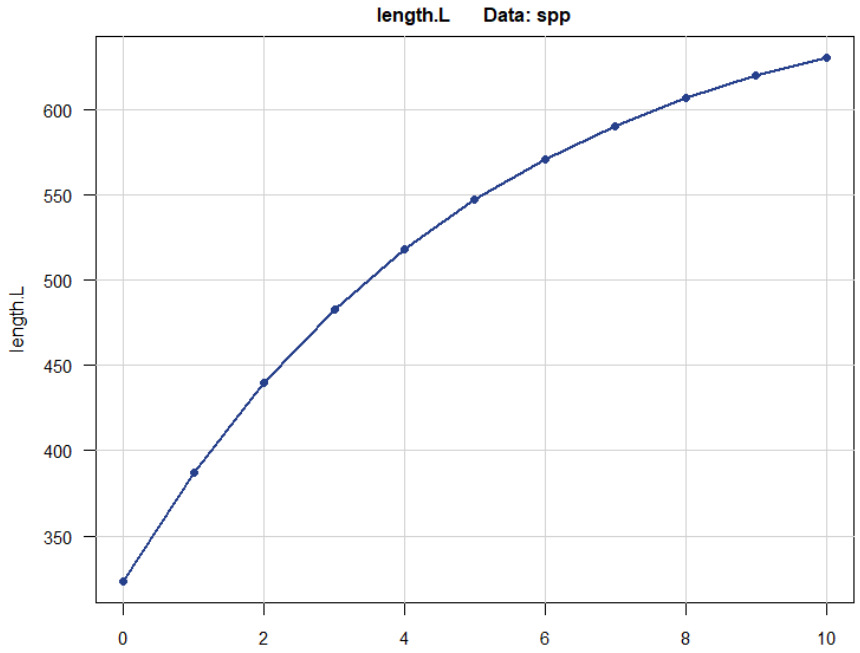


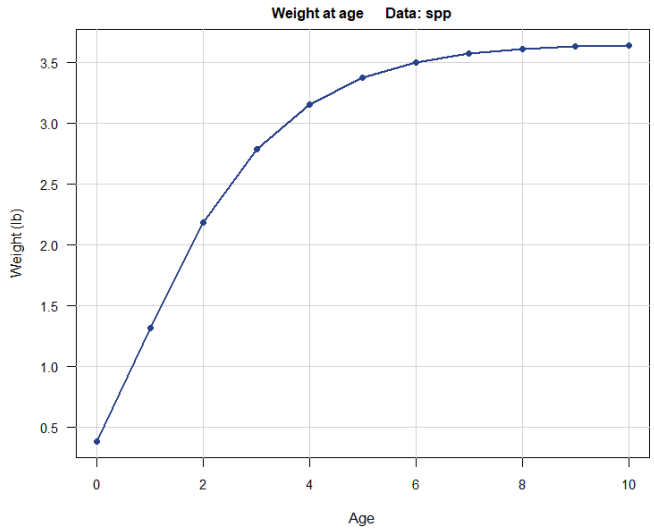
general recreational (GR)

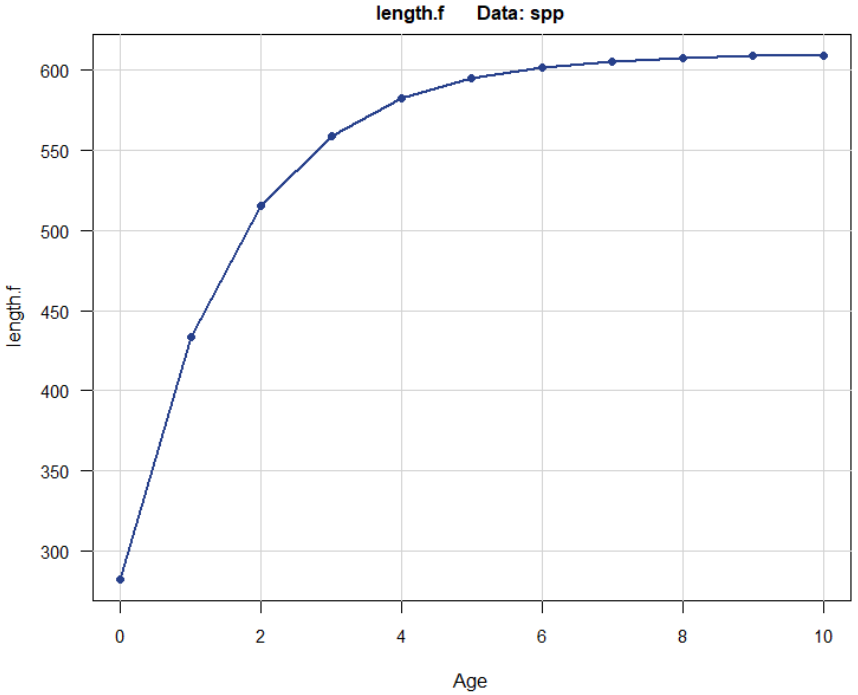
shrimp bycatch (SB)

Base Run - Growth

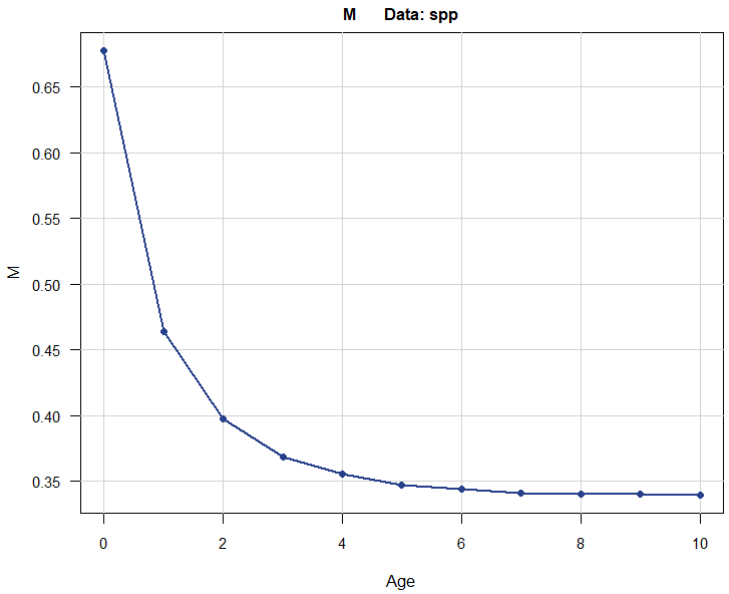


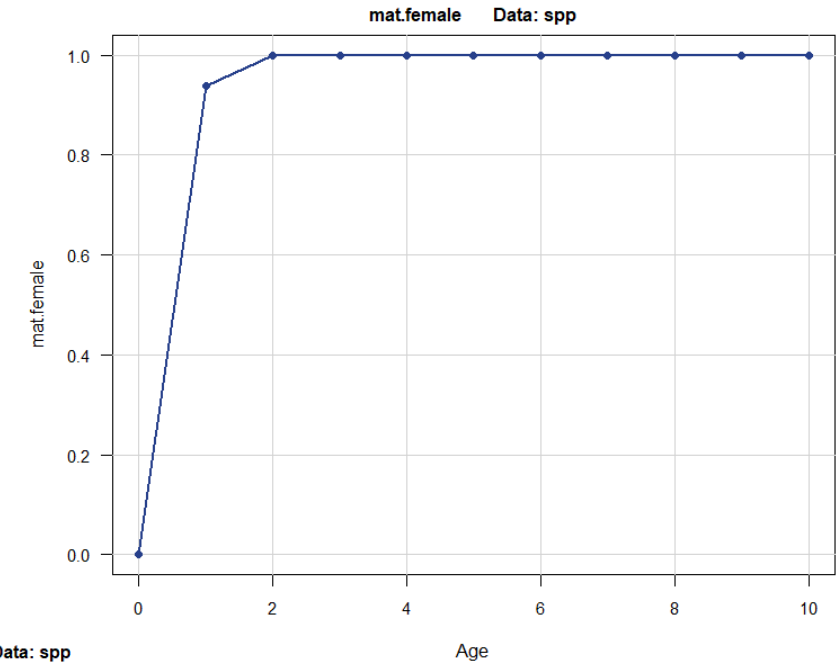


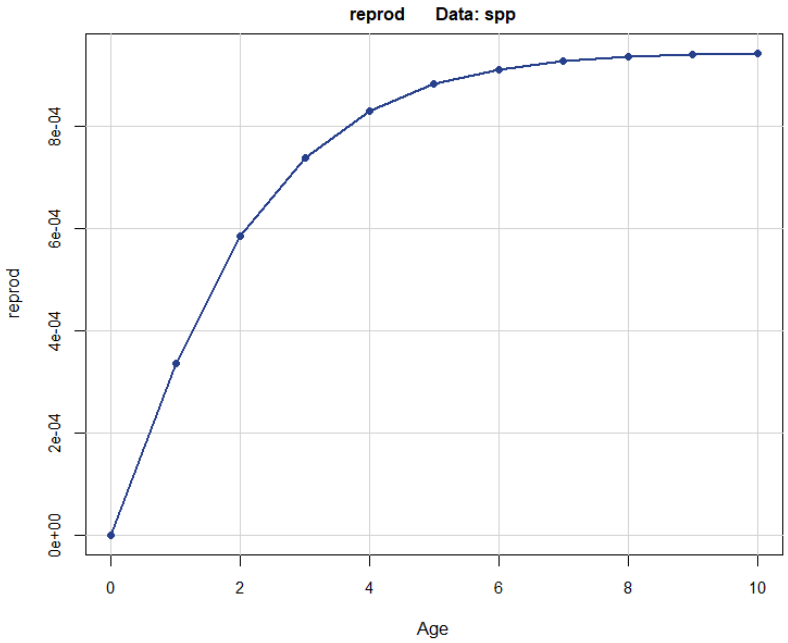




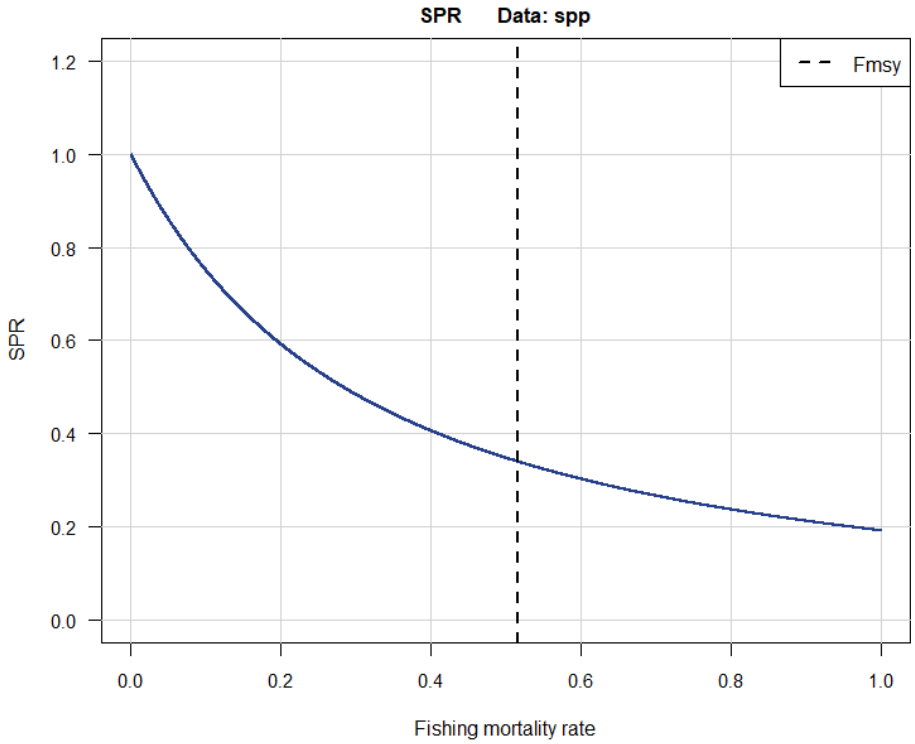
Base Run – Mortality and female maturity

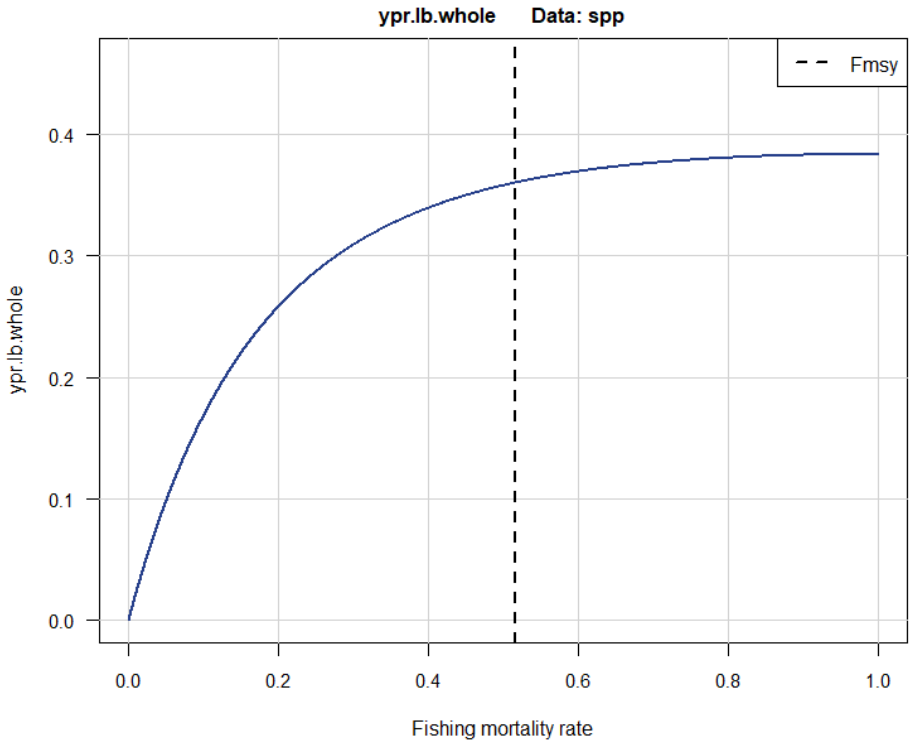






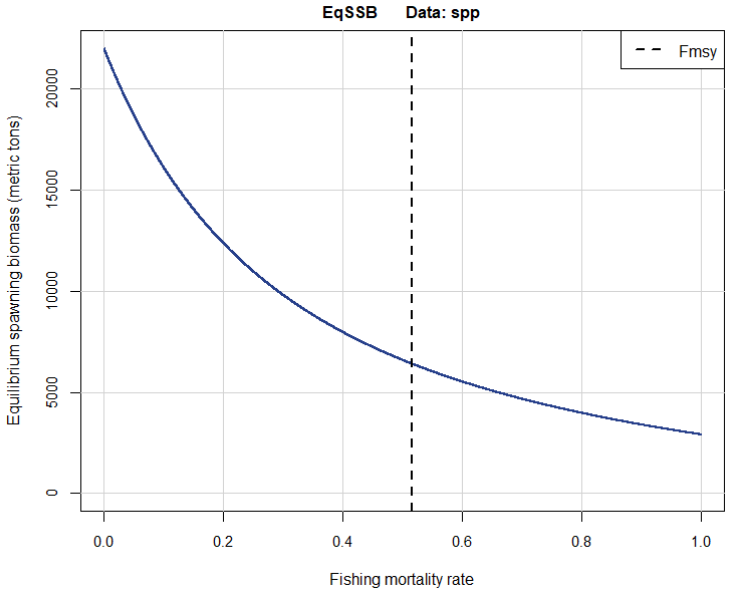
Base Run – per recruit

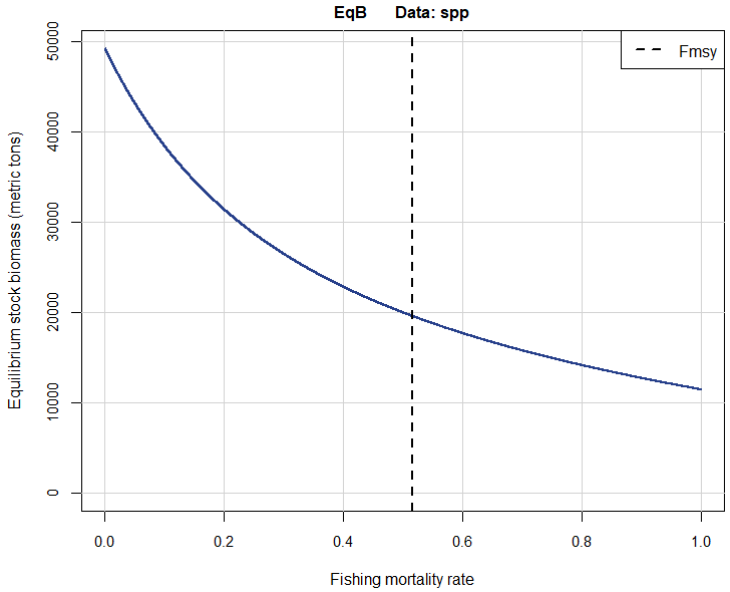


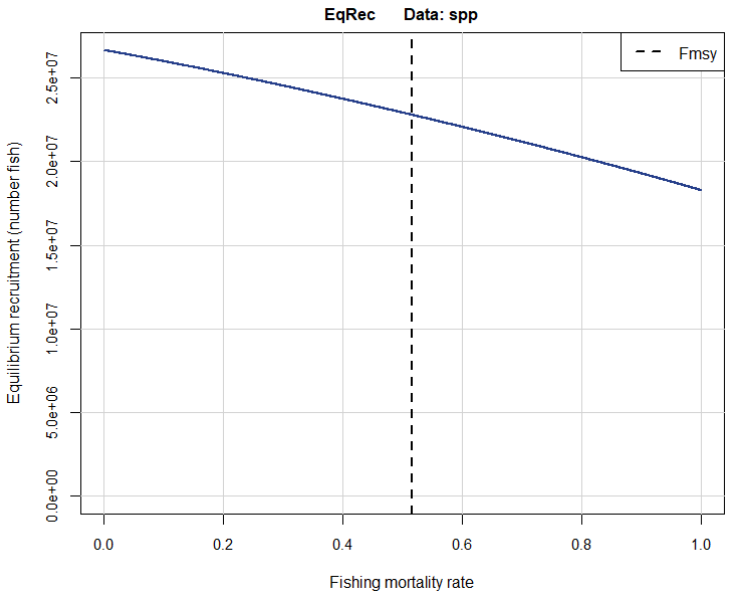


Base Run – equilibrium

Fig 34, pdf page 157







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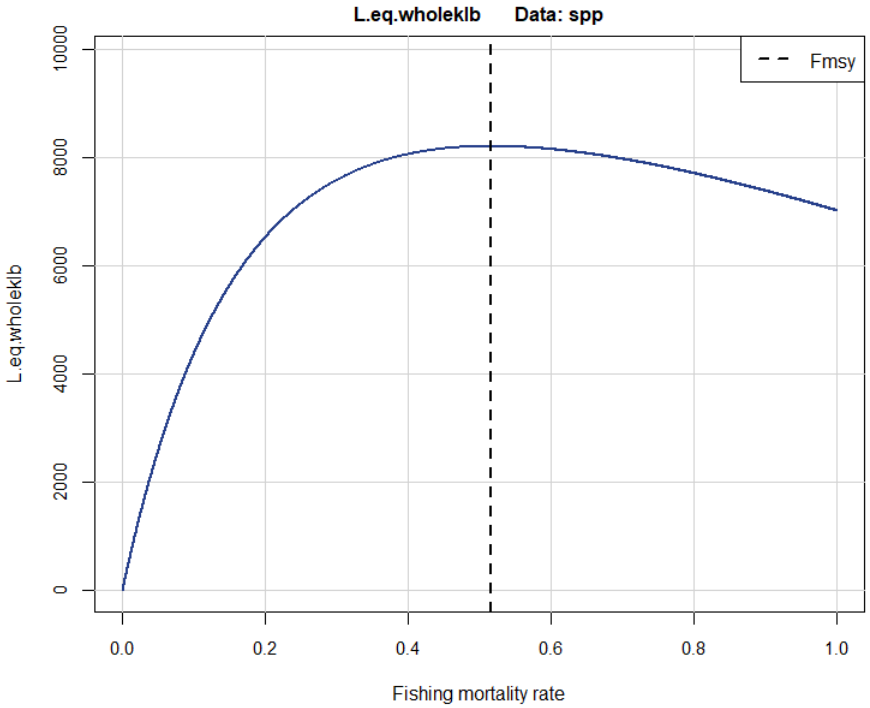
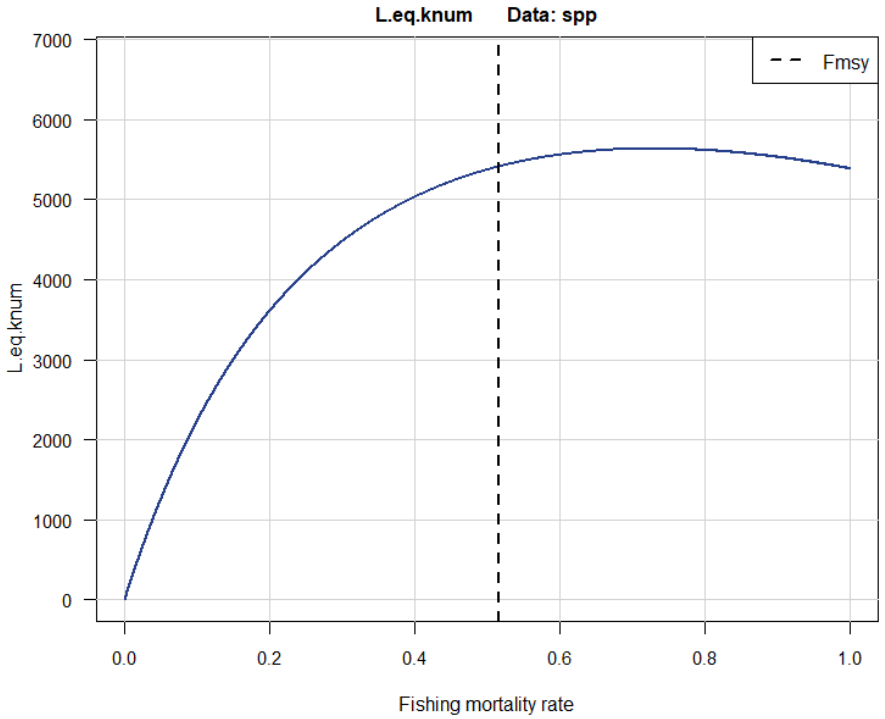
Base Run – equilibrium

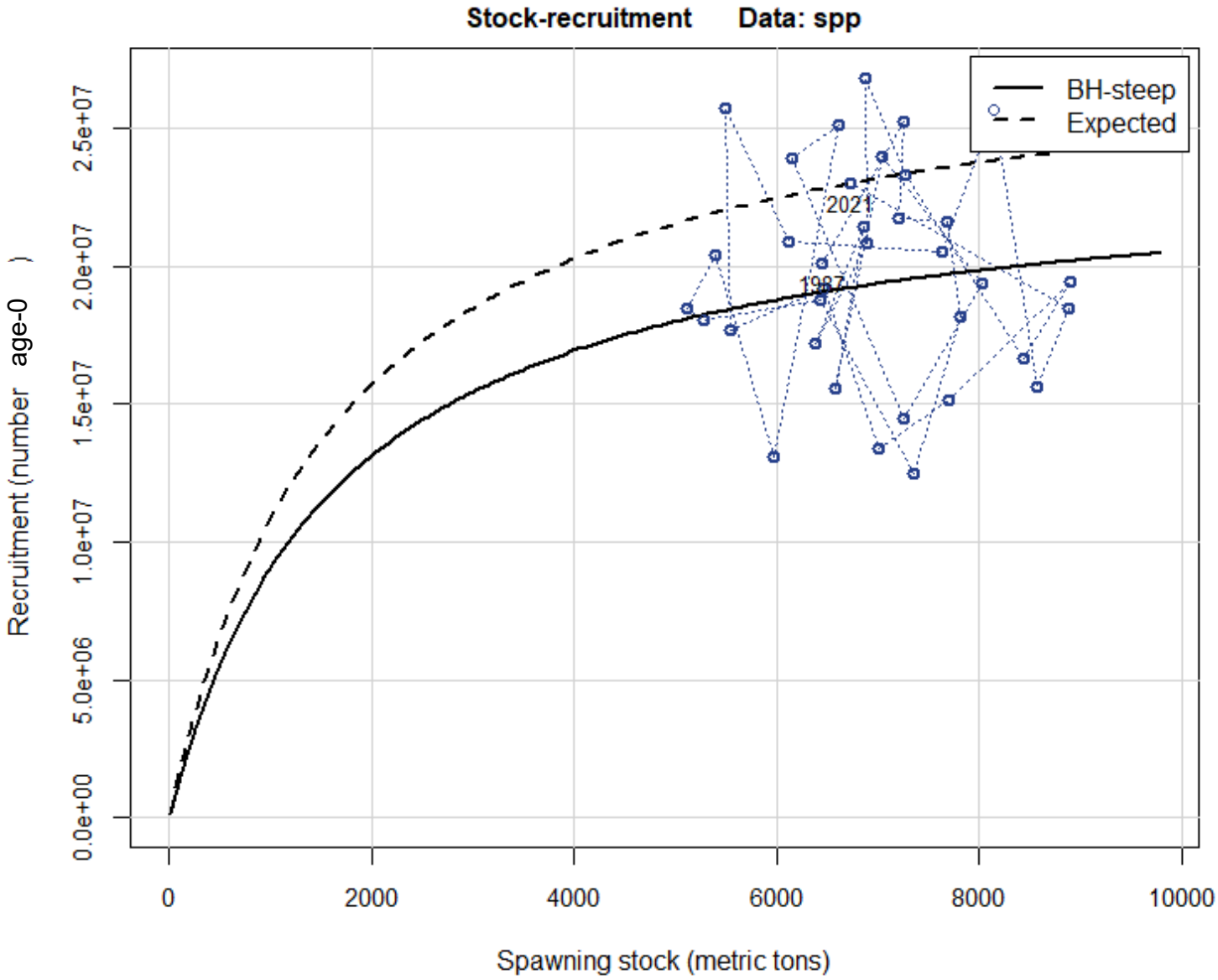
Fig 34, pdf page 157





Base Run – Stock-recruitment

Fig 31, pdf page 154



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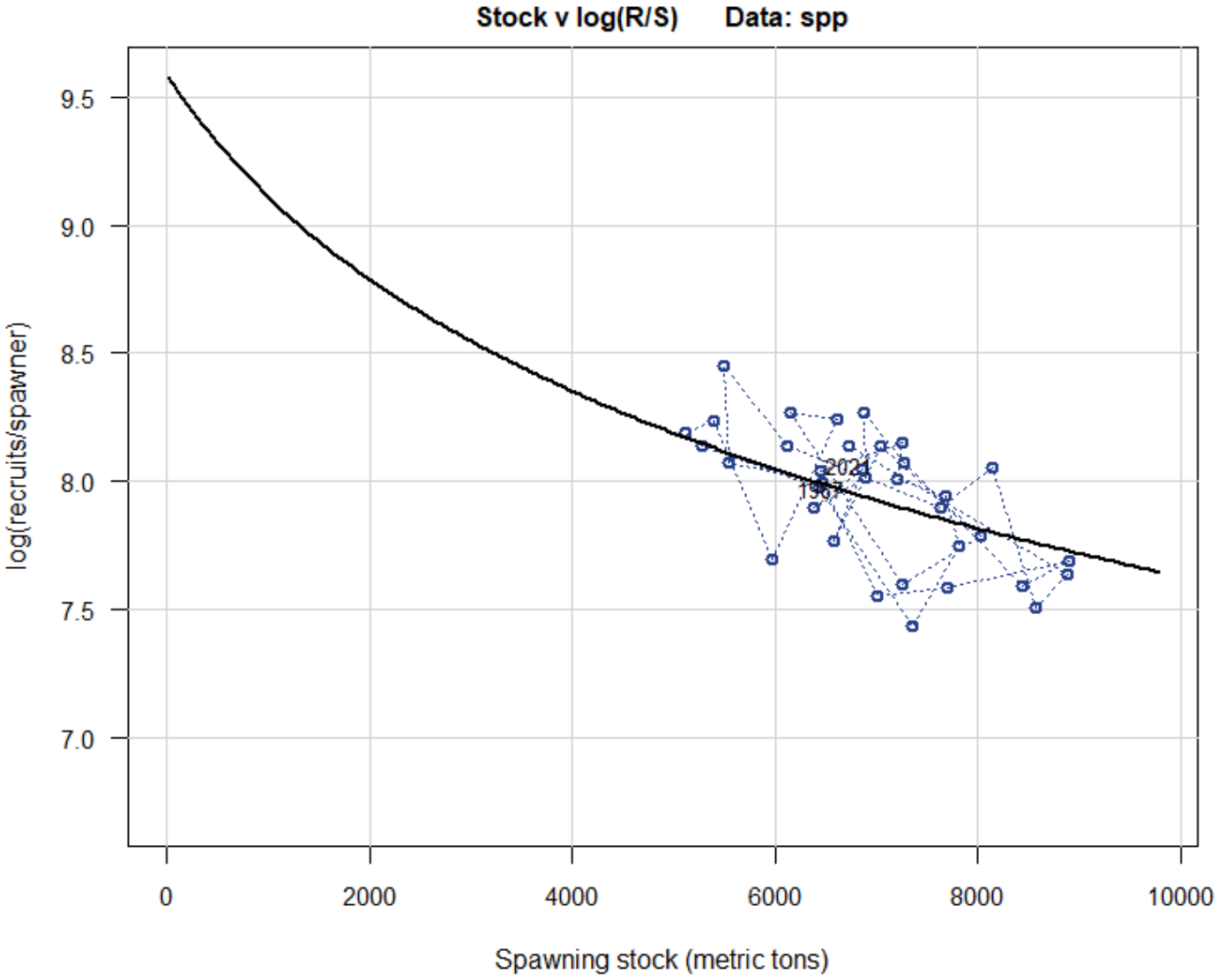
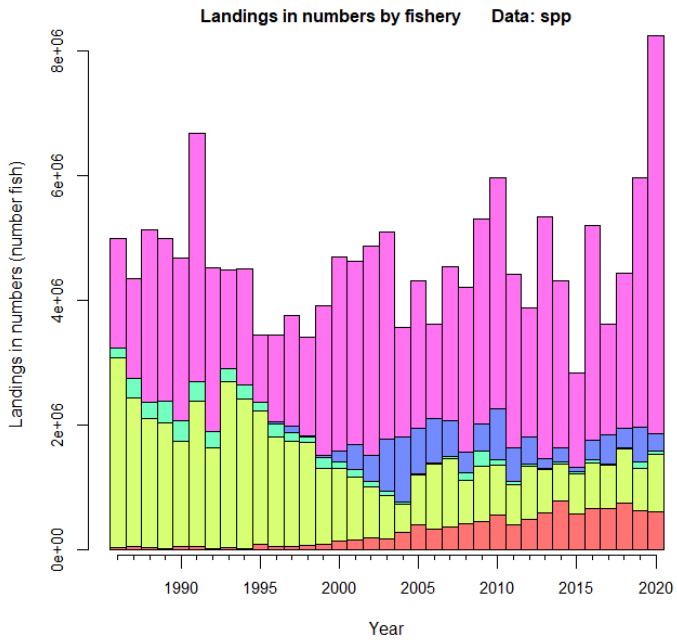
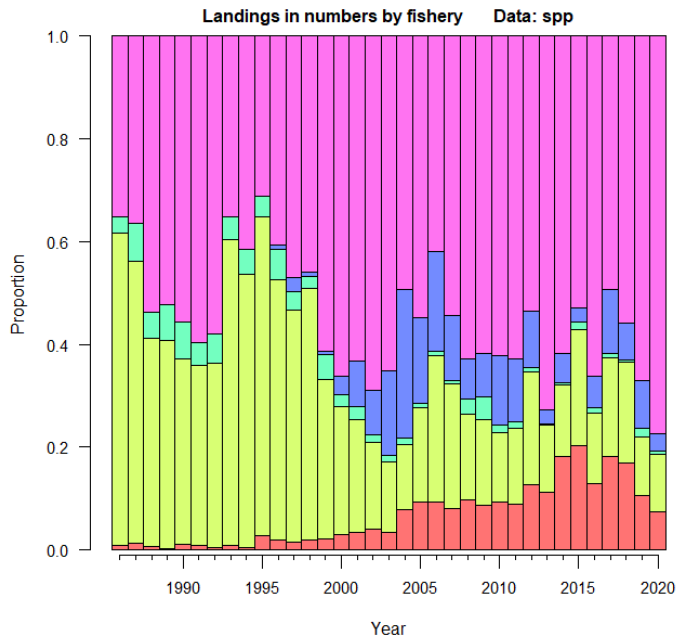
Base Run – Stock-recruitment

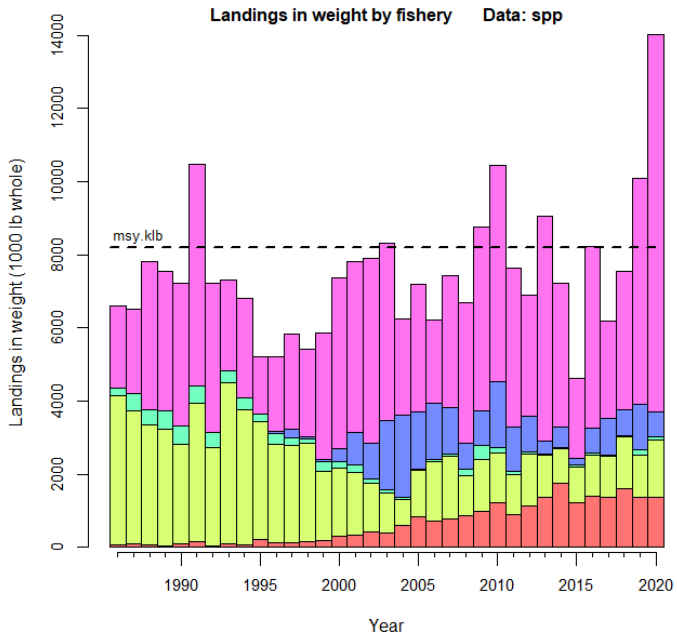
Fig 31, pdf page 154



Base Run – Estimated Landings







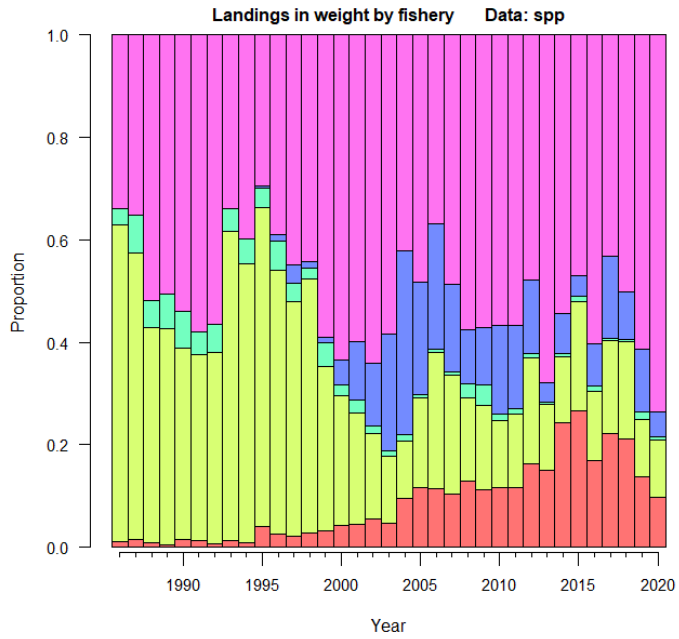


Fig 27-28, pdf pages 150-151

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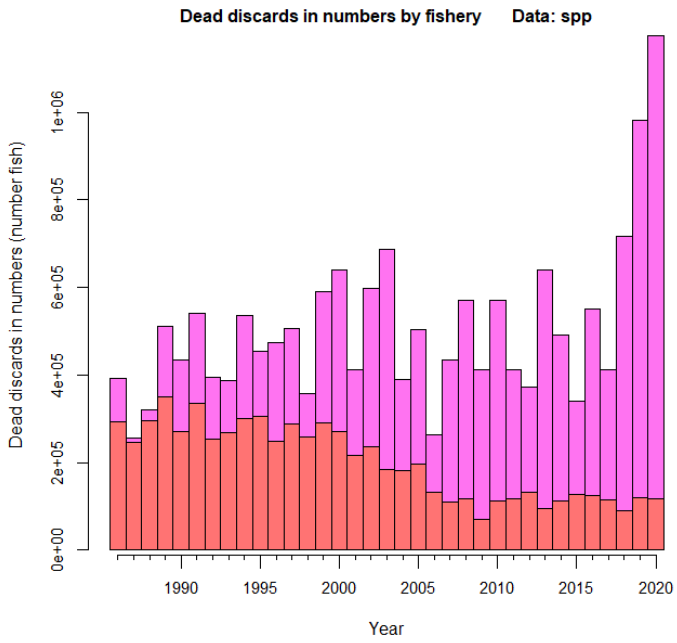
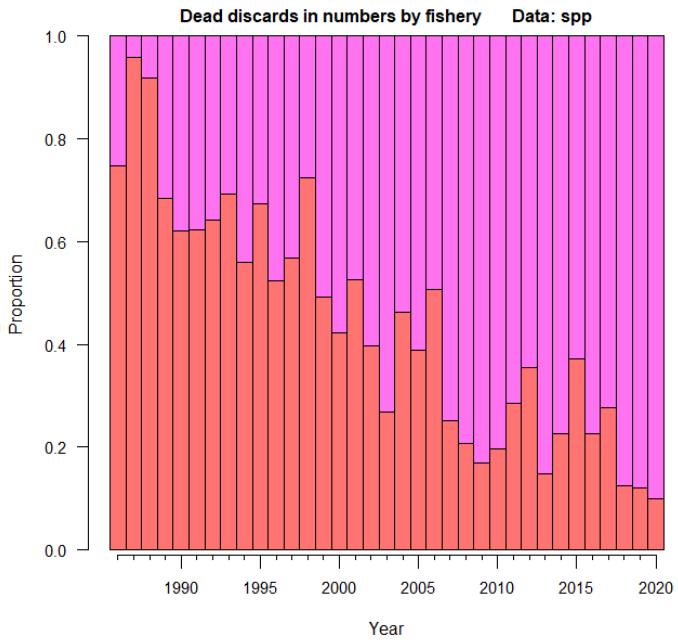
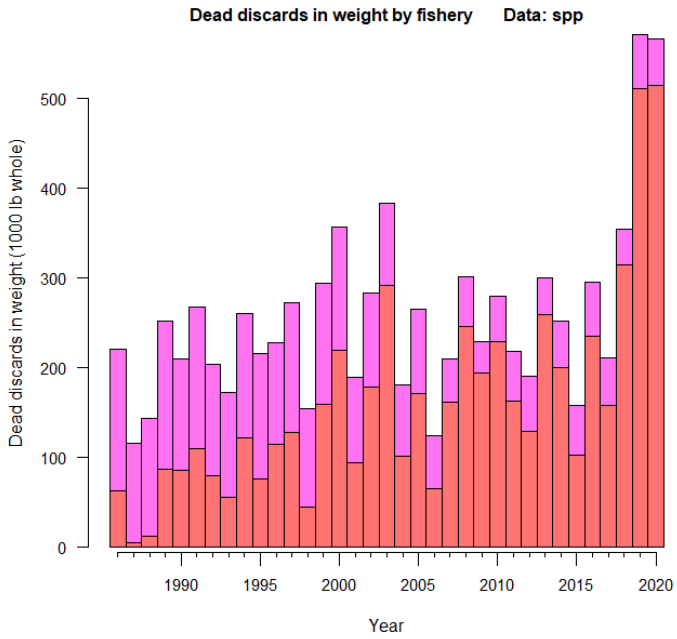
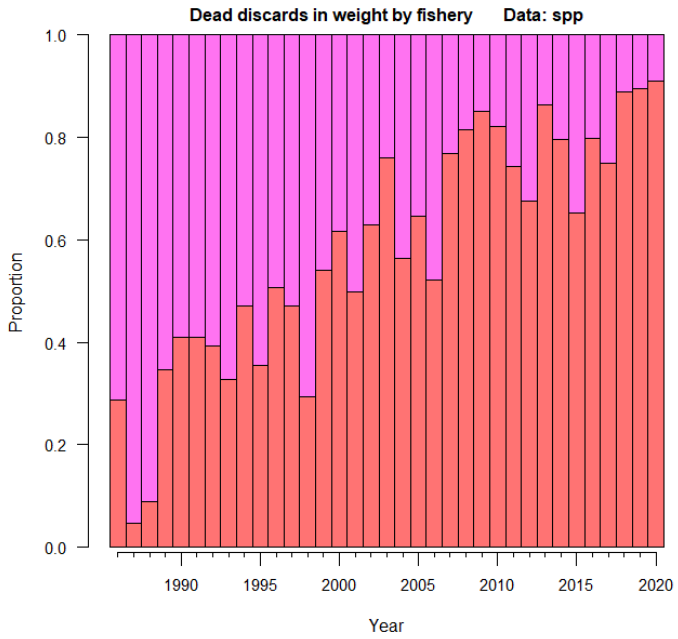
Base Run – Estimated Discards (note: legend changes between numbers and weight)



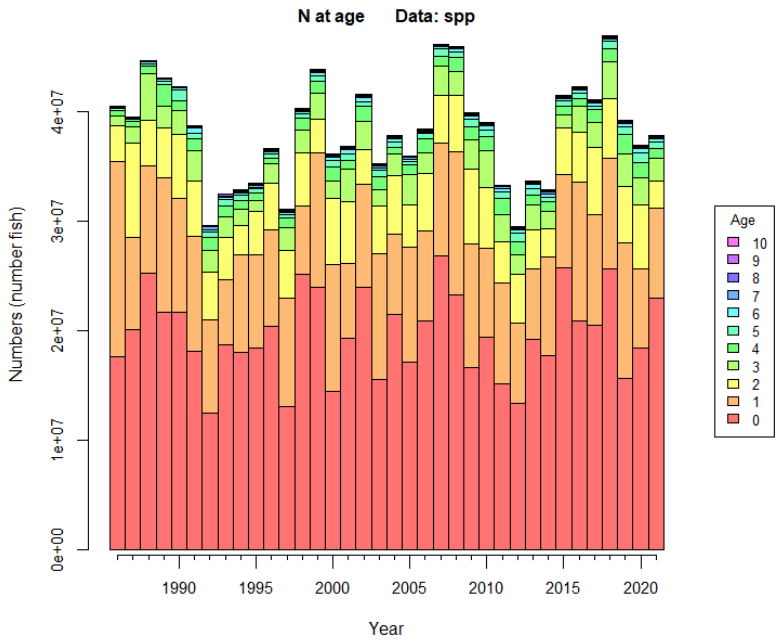


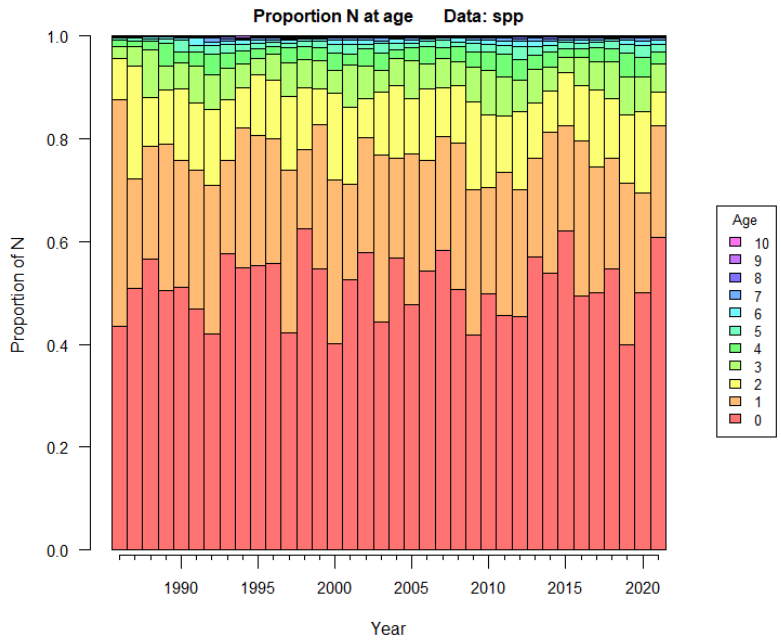


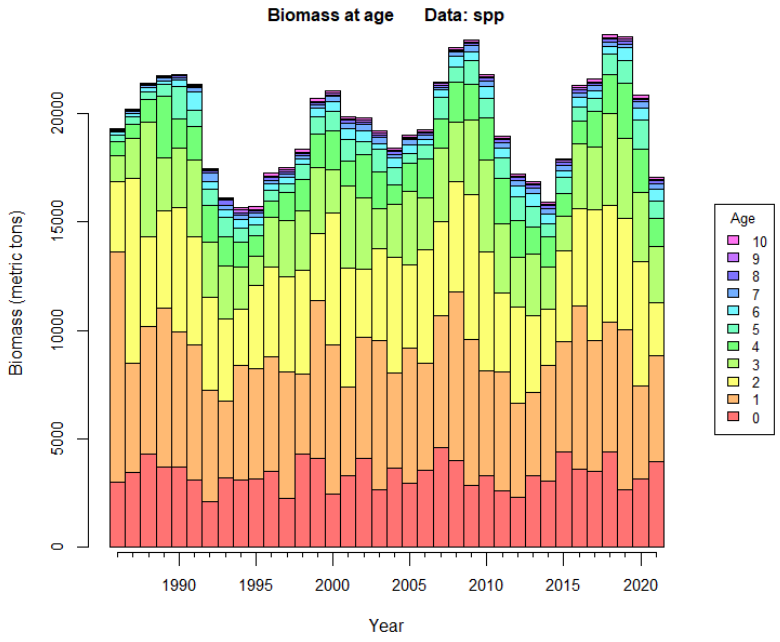


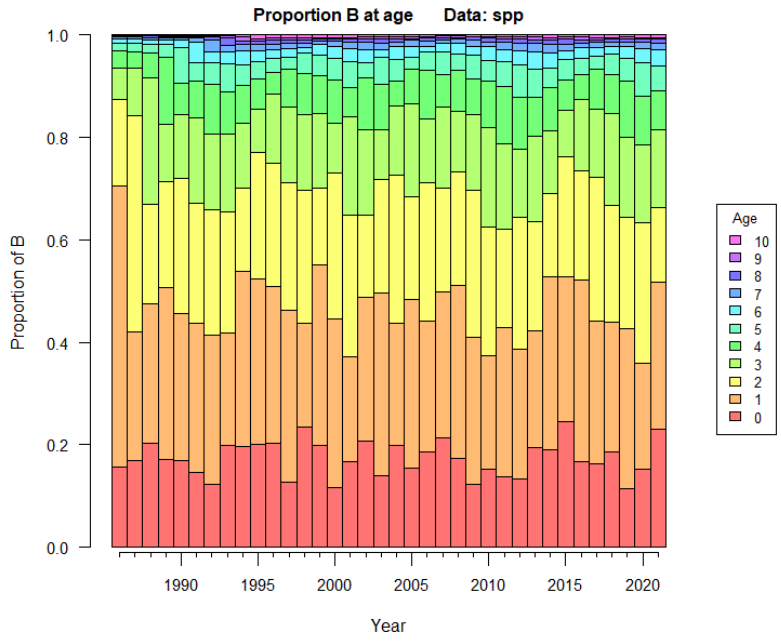
Figs 29-30, pdf pages 152-153

Base Run – Numbers and biomass at age

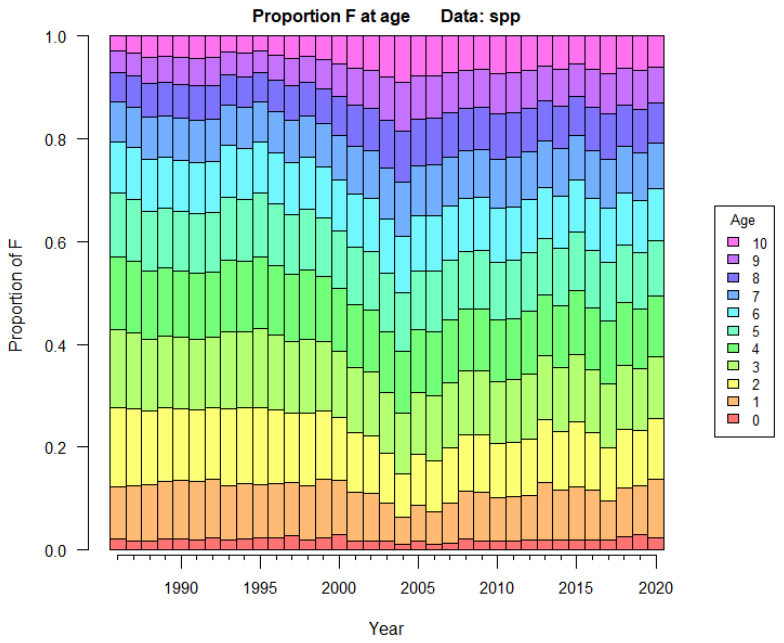


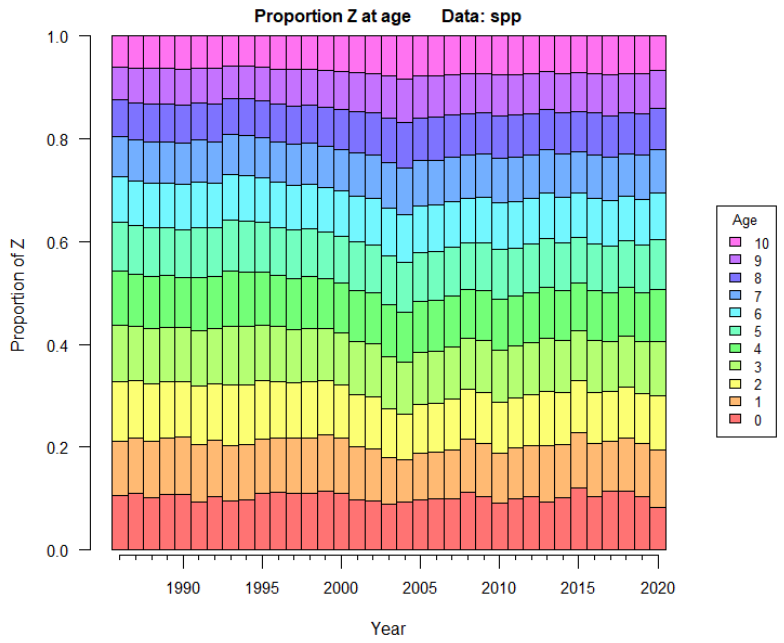


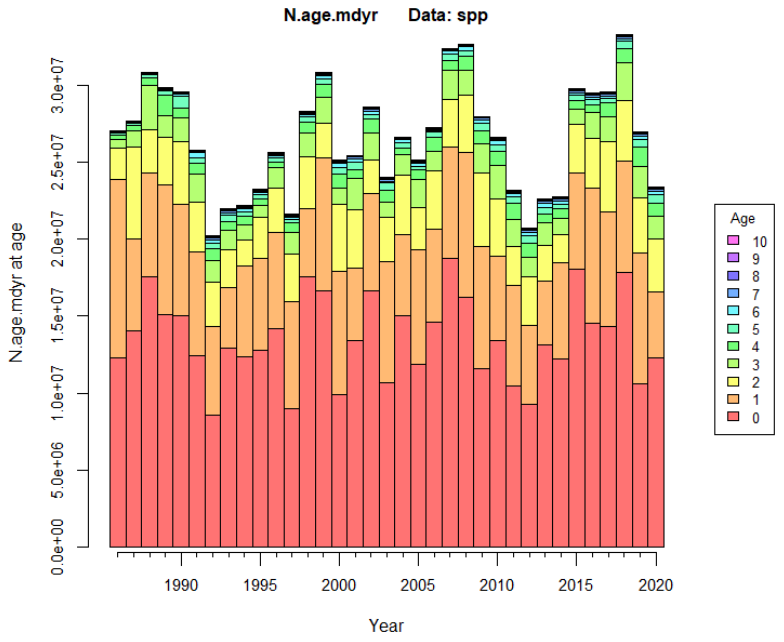


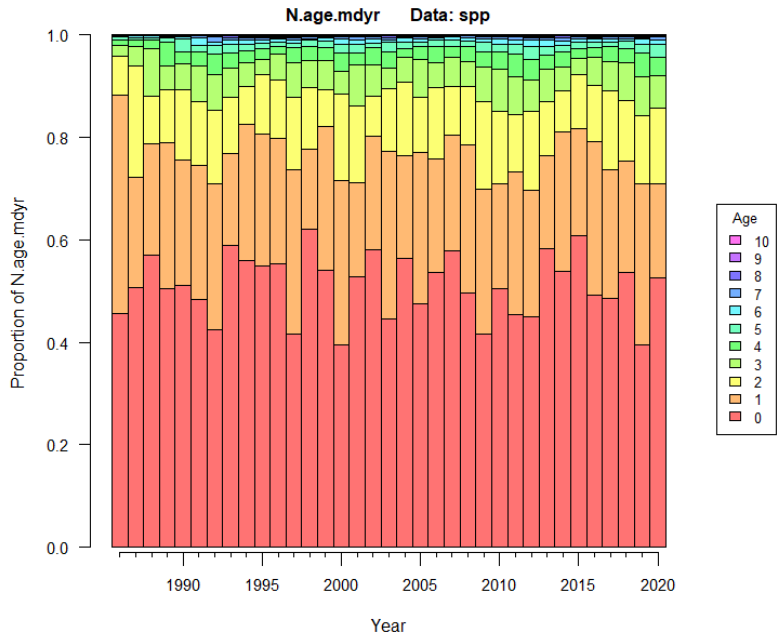


Base Run – F at age and Numbers (mdyr)

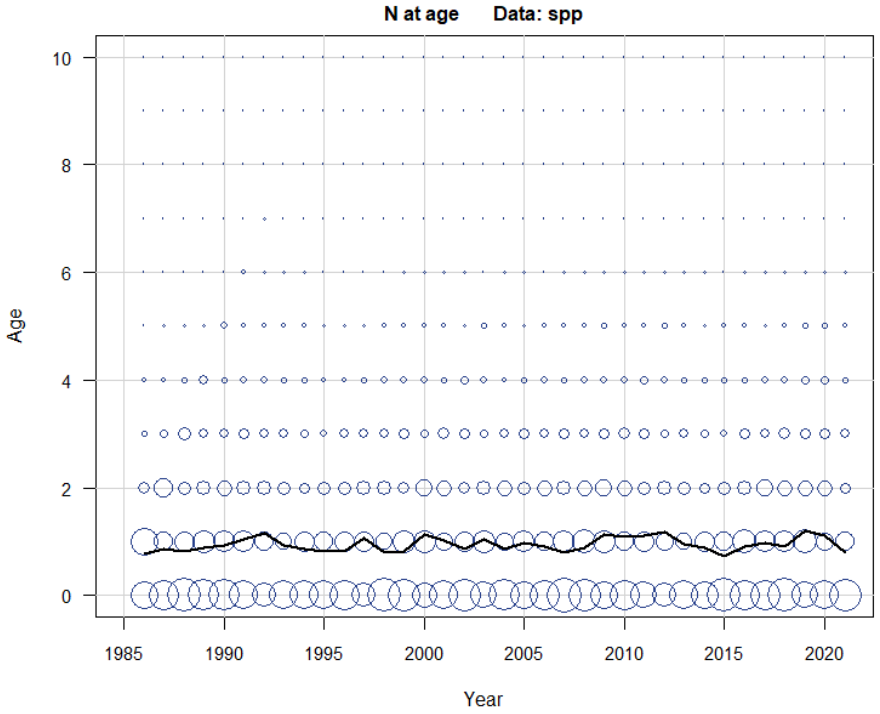


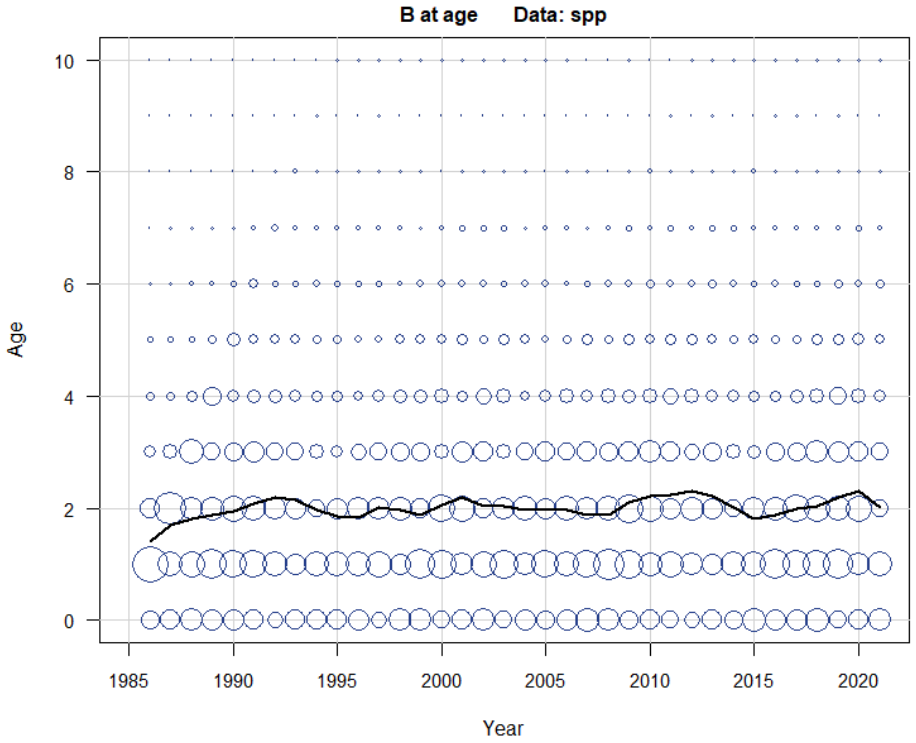




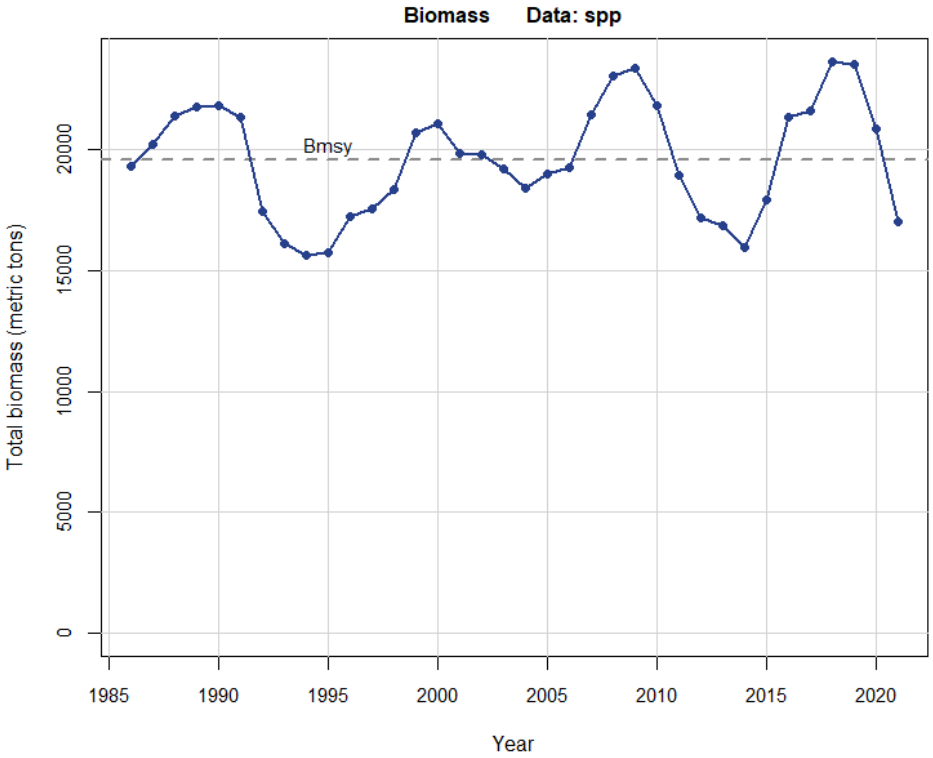


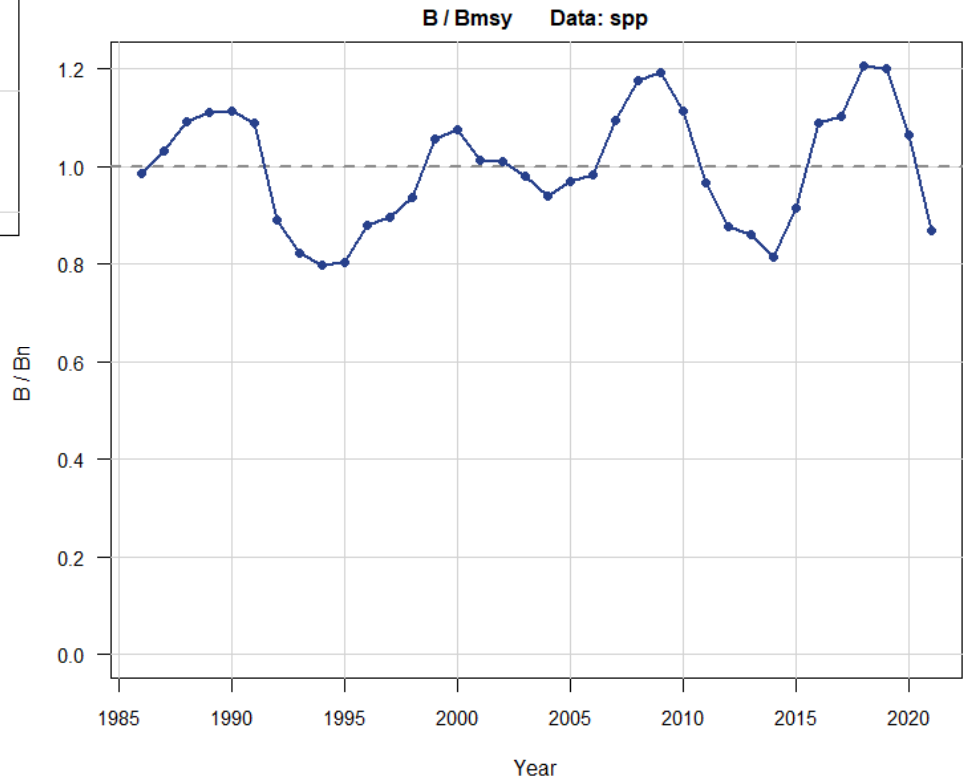
Base run – Annual average numbers and biomass at age.



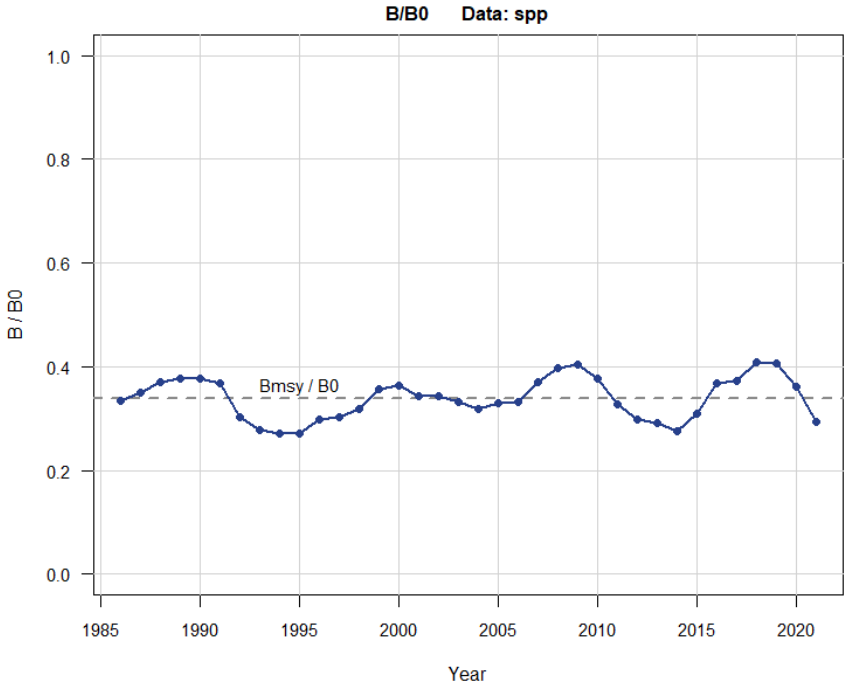


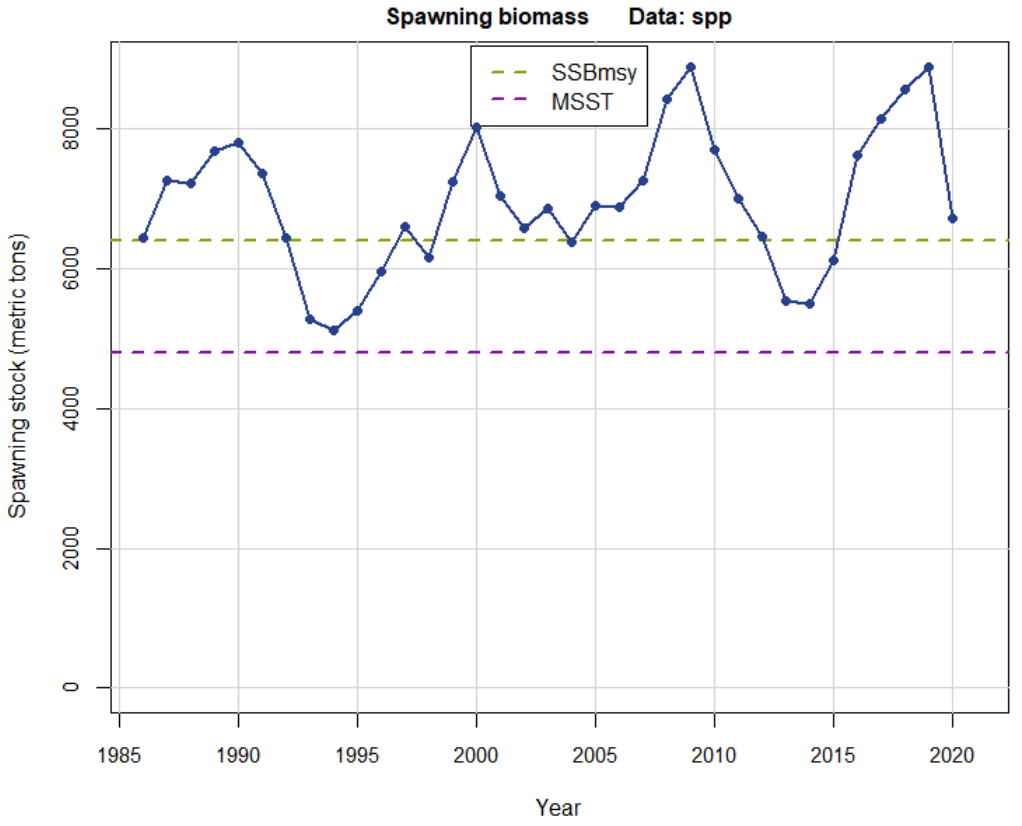
Base run – Total biomass and B/Bmsy



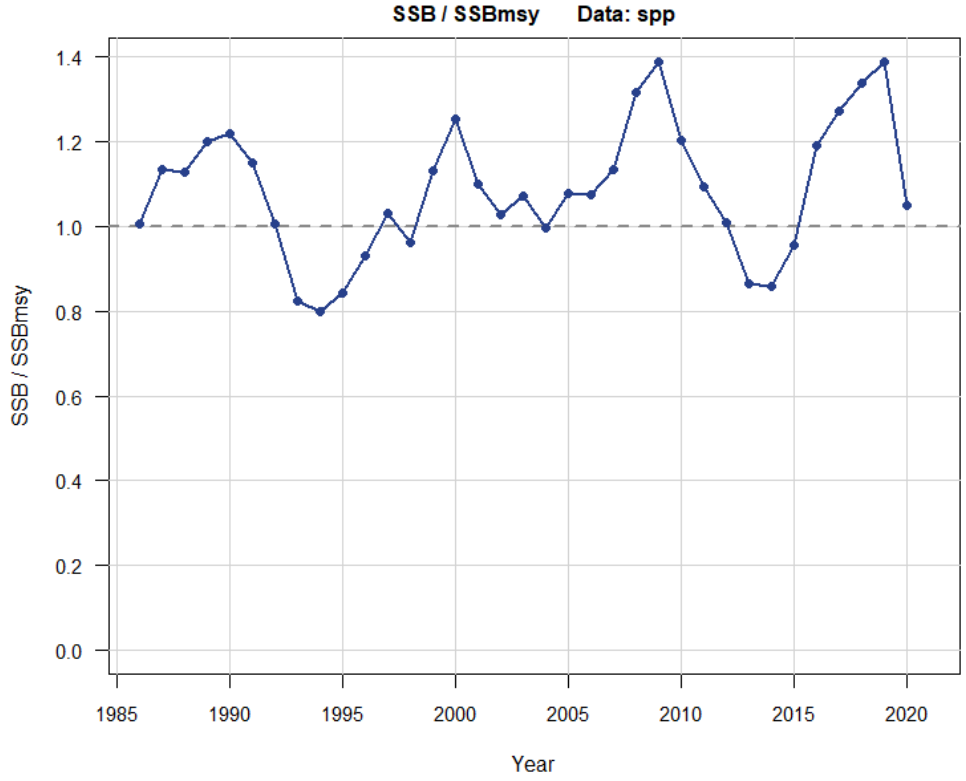


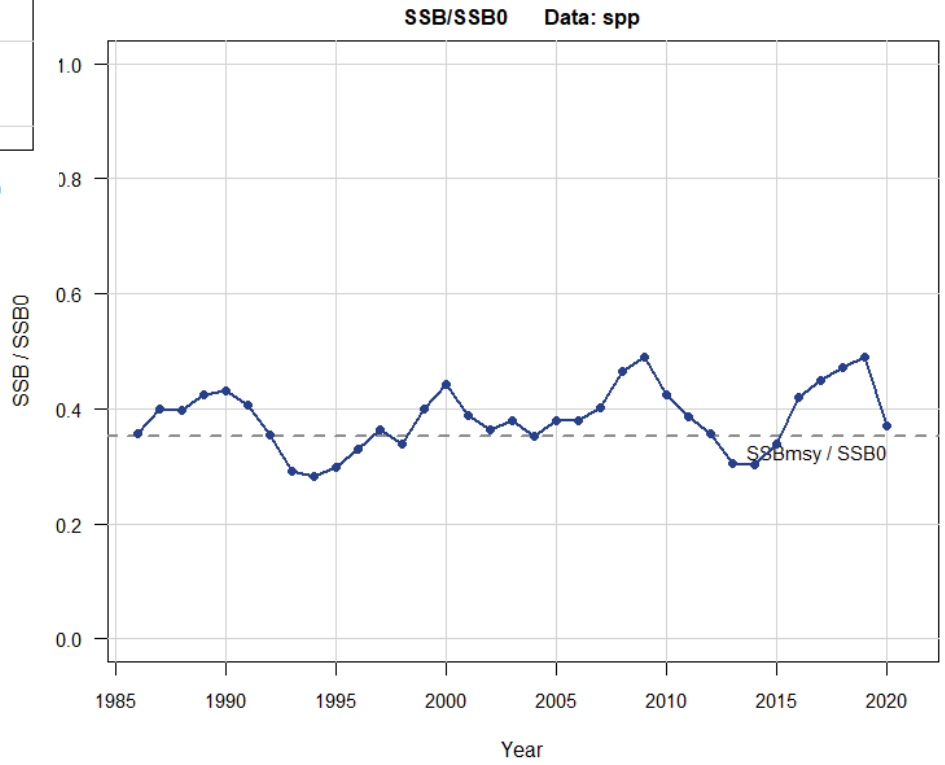
Base run – Biomass/B0 and SSB



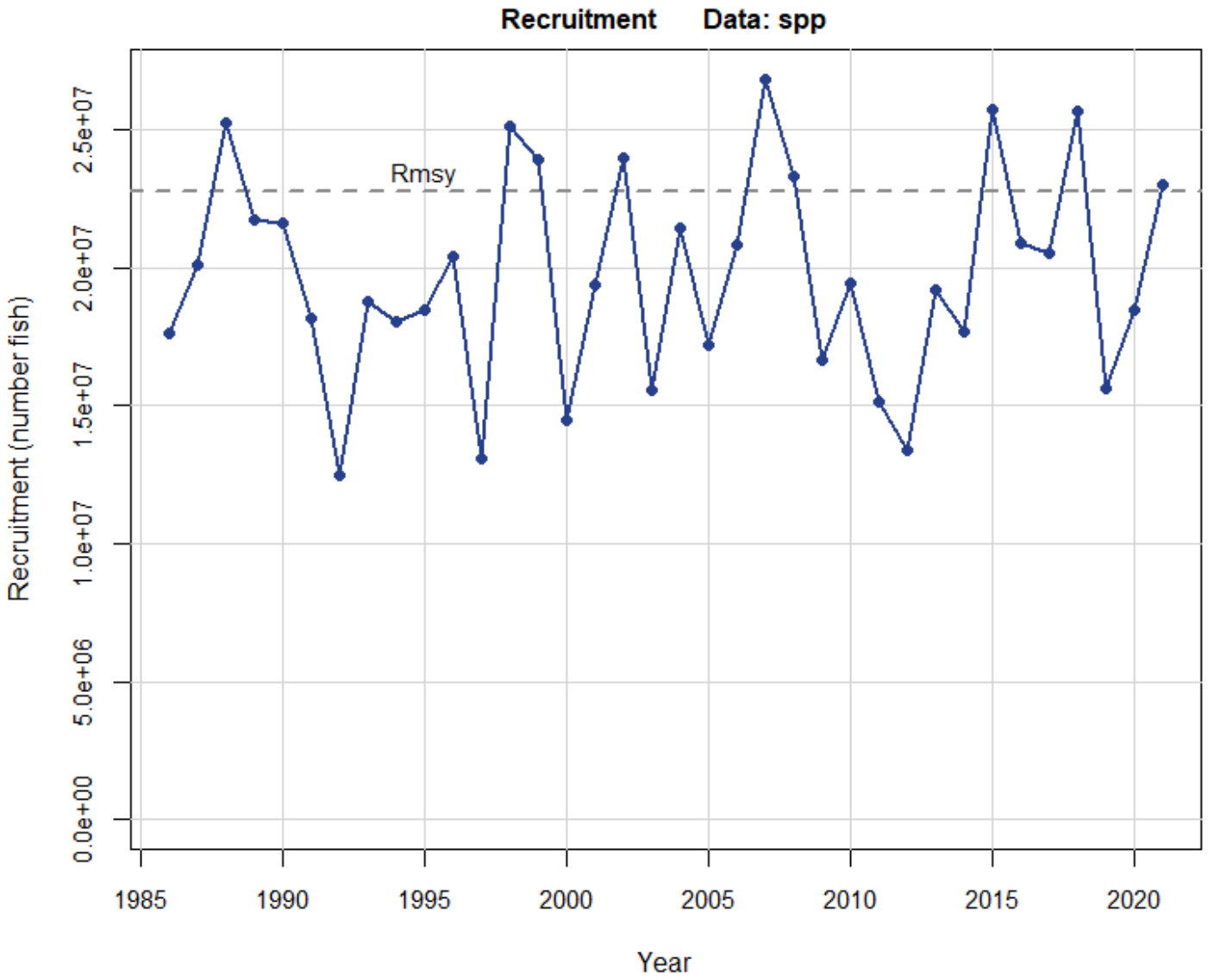


Base run – SSB/SSBmsy, SSB/SSB0





Base run – recruitment



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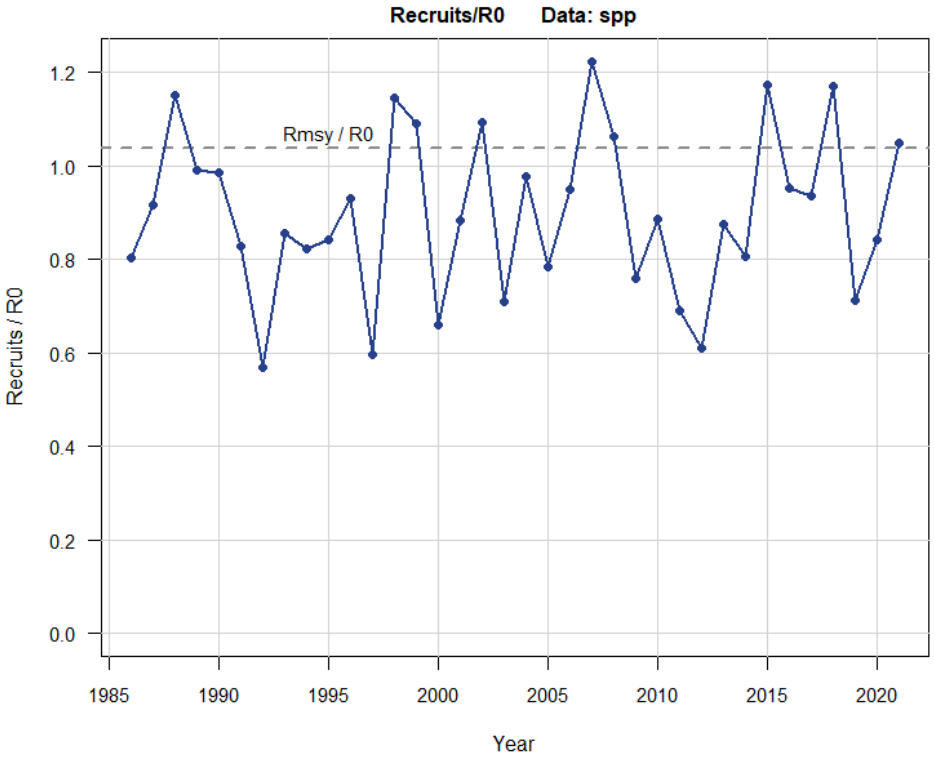
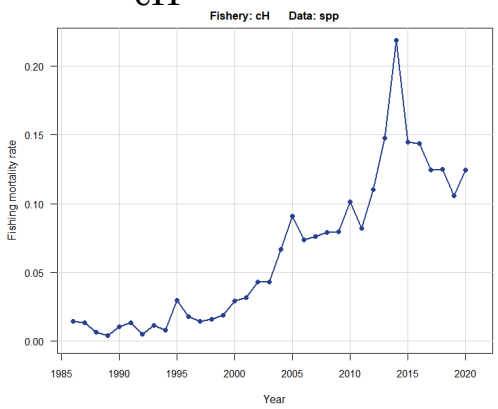
Base run – recruitment



Base Run – Fishing mortality

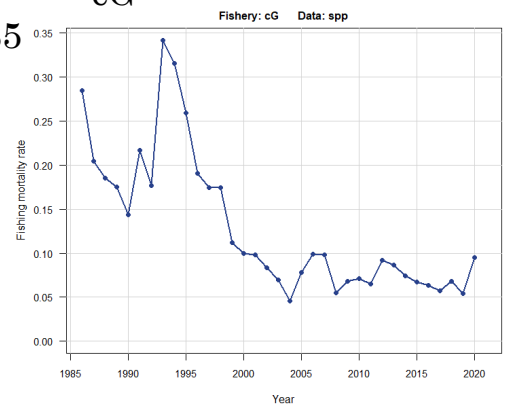
cH

0.2



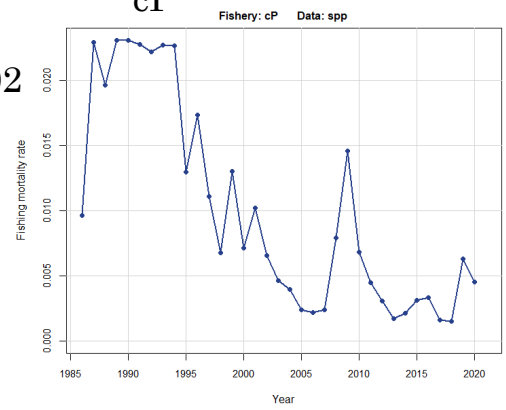
cG

0.35



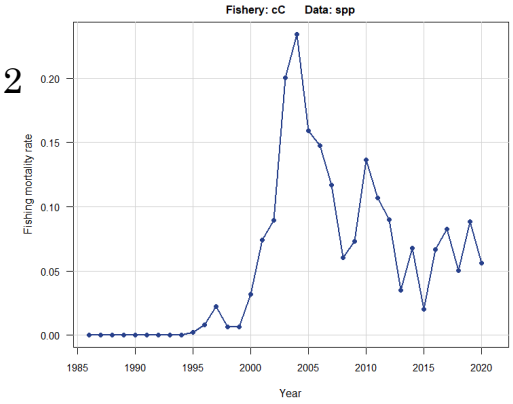
cP

0.02



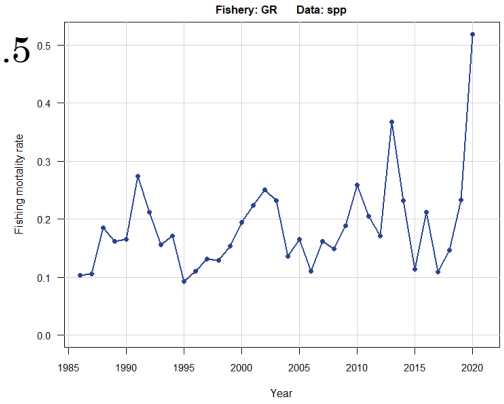
cC

0.2



GR

0.5



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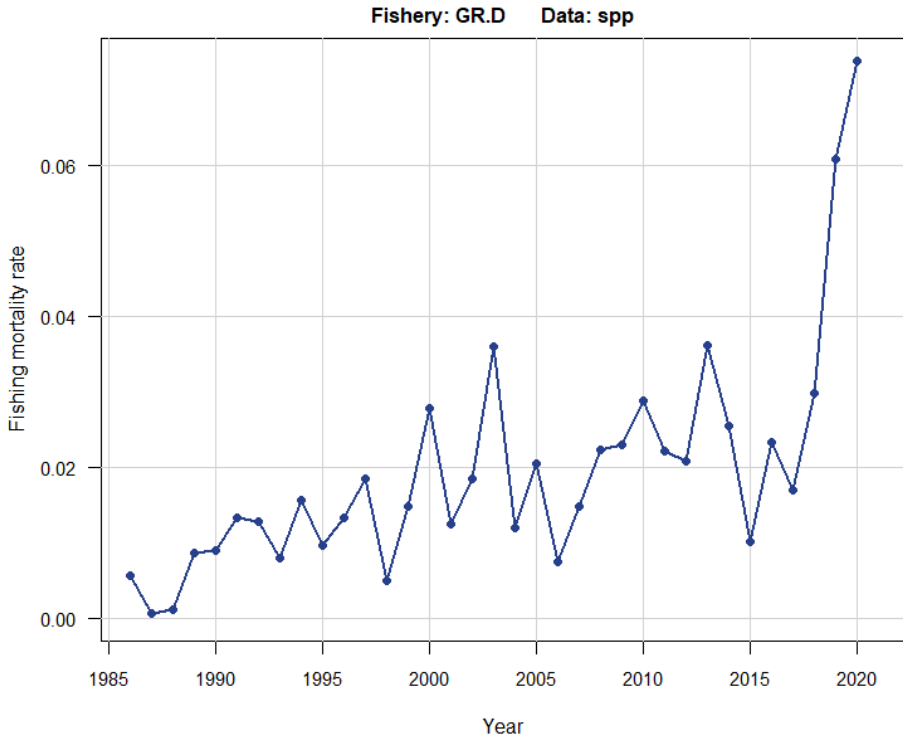
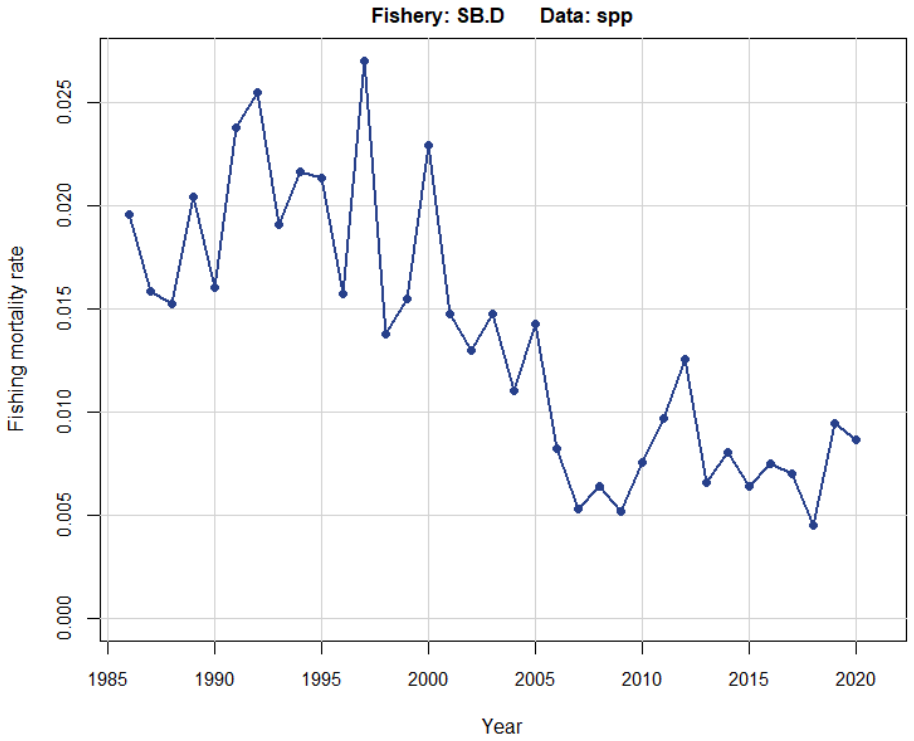
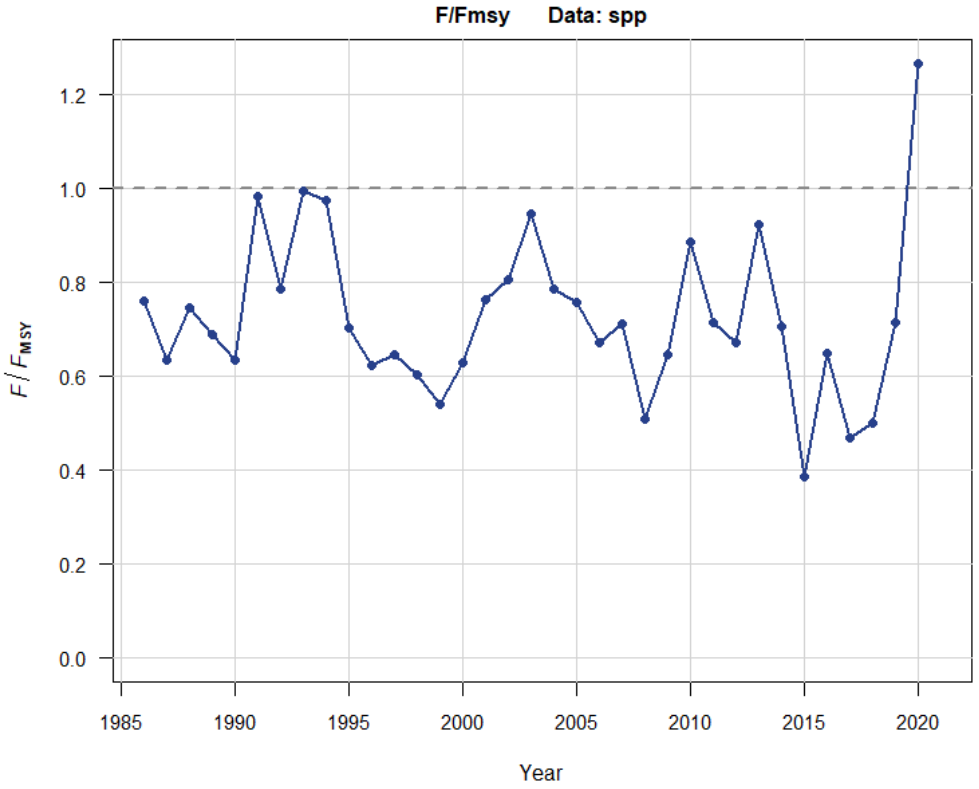
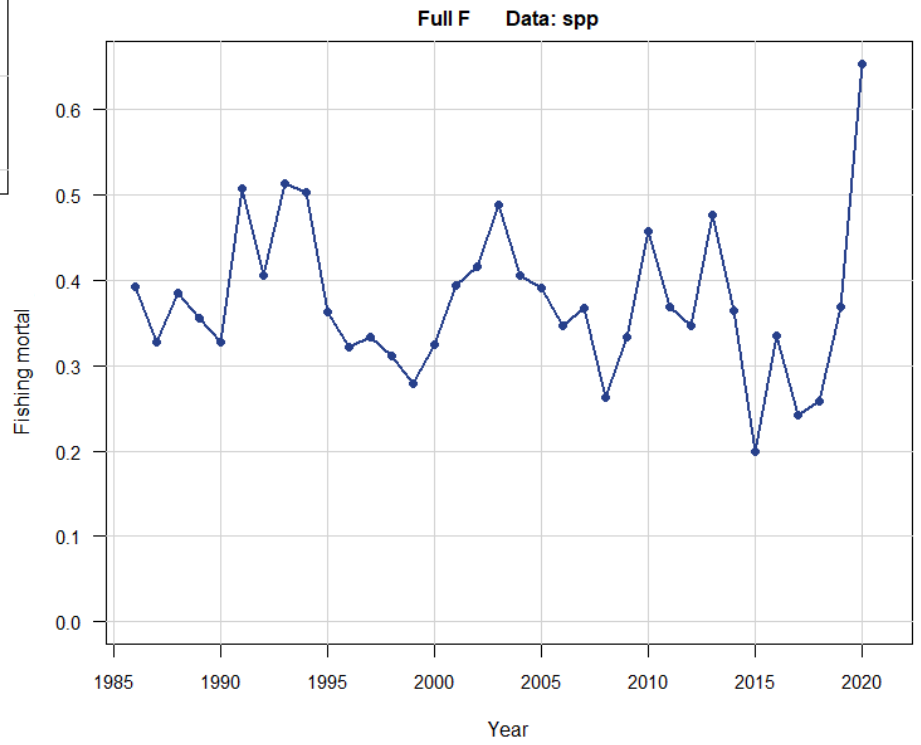
Base Run – Fishing mortality



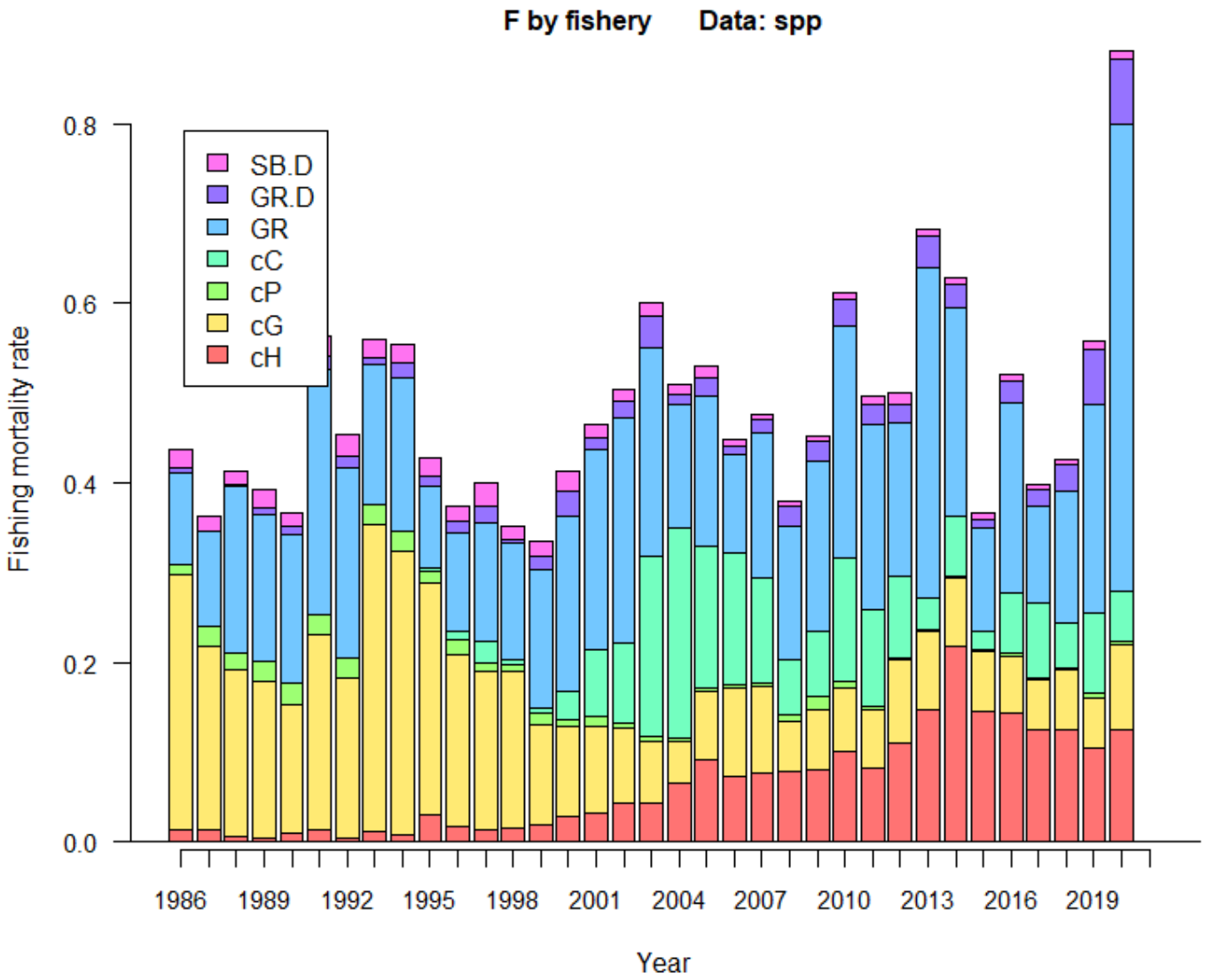


Base Run – Fishing mortality F/Fmsy, F-full





Base Run – Fishing mortality



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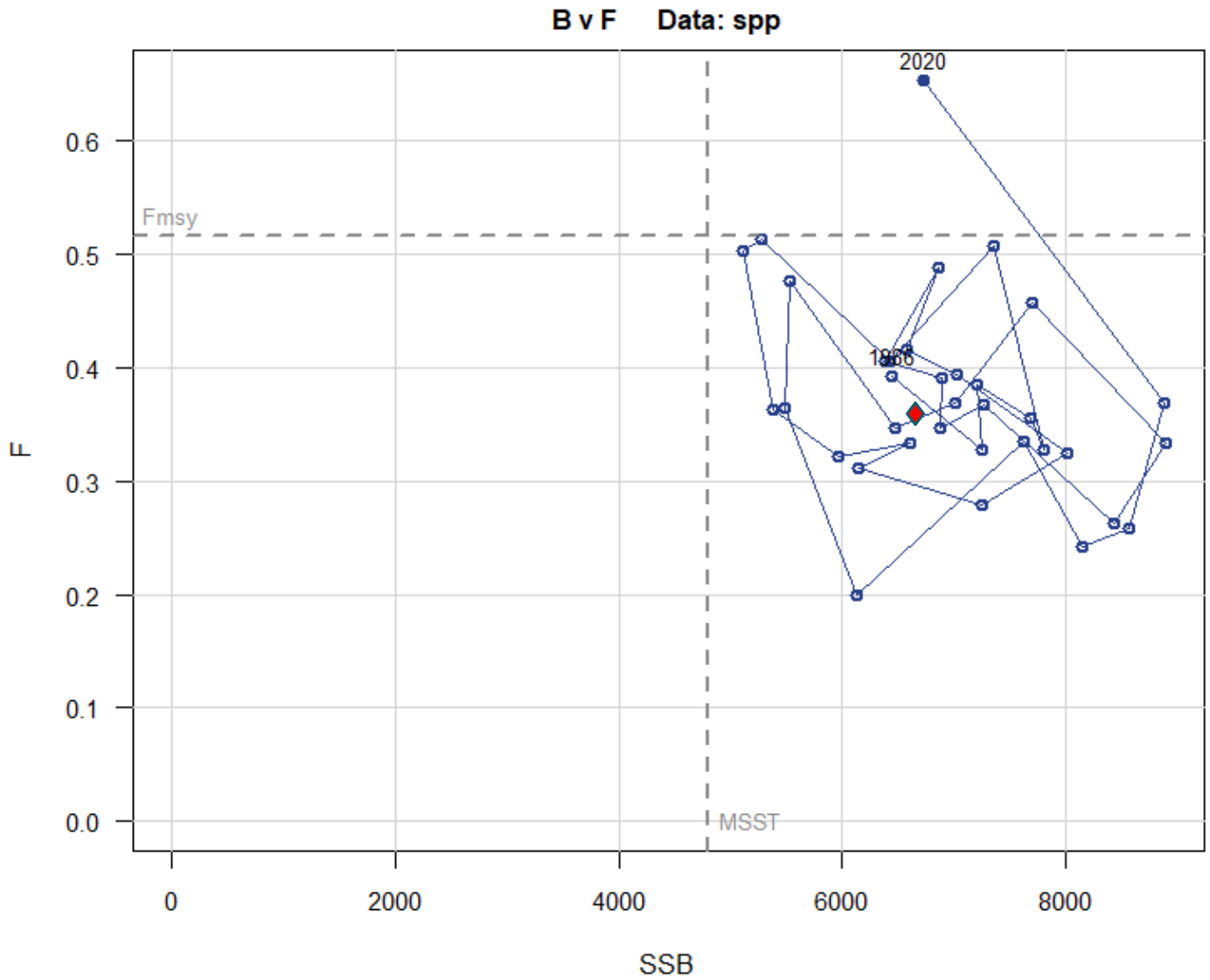
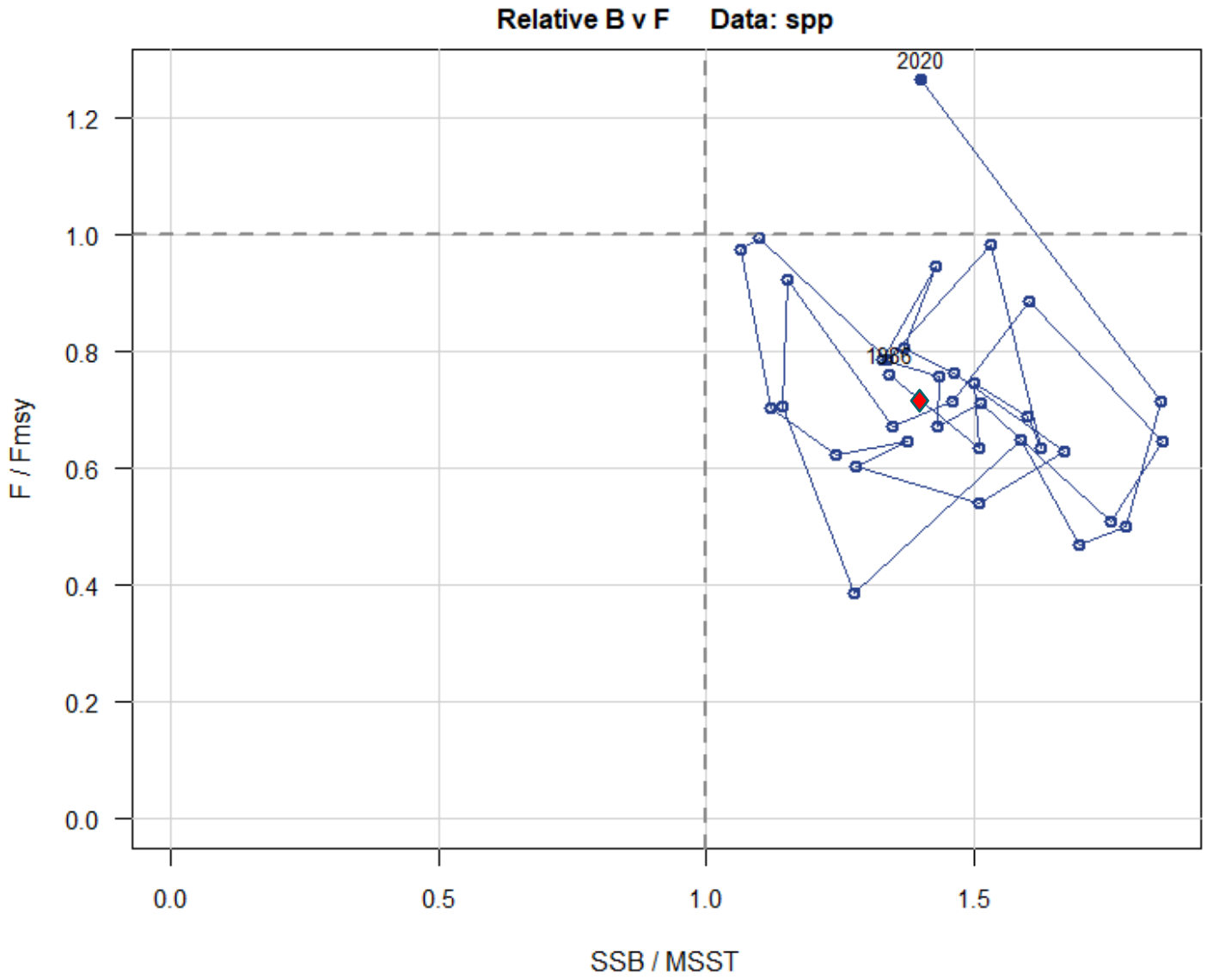
Base Run – Phase, geometric mean F(2018-2020)=0.40 ♦



Base Run – Phase , geometric mean F(2018-2020)=0.77 ♦



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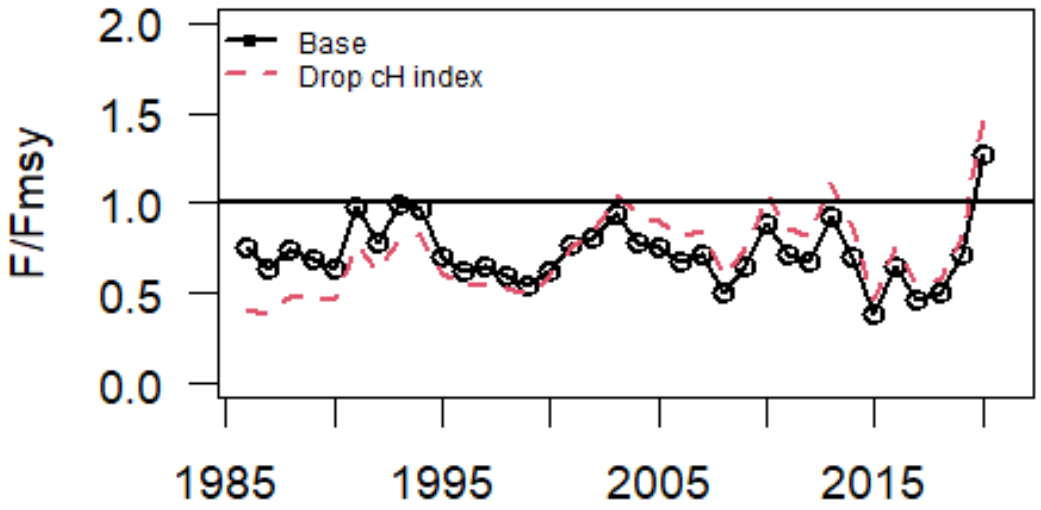
Topics

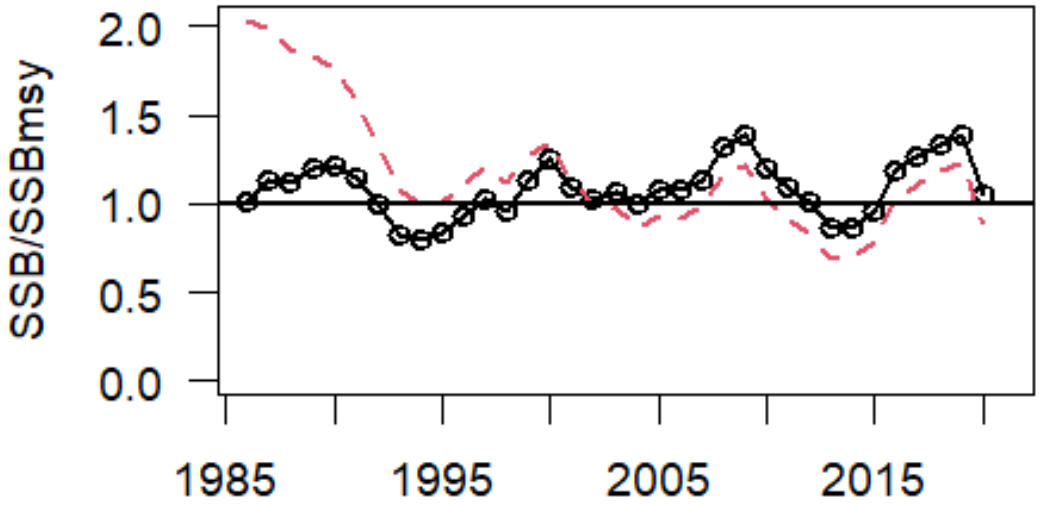
- Data Review
- Model update
- Base run
- **Sensitivities and retrospective**
- Uncertainty
- Projections

Sensitivity runs

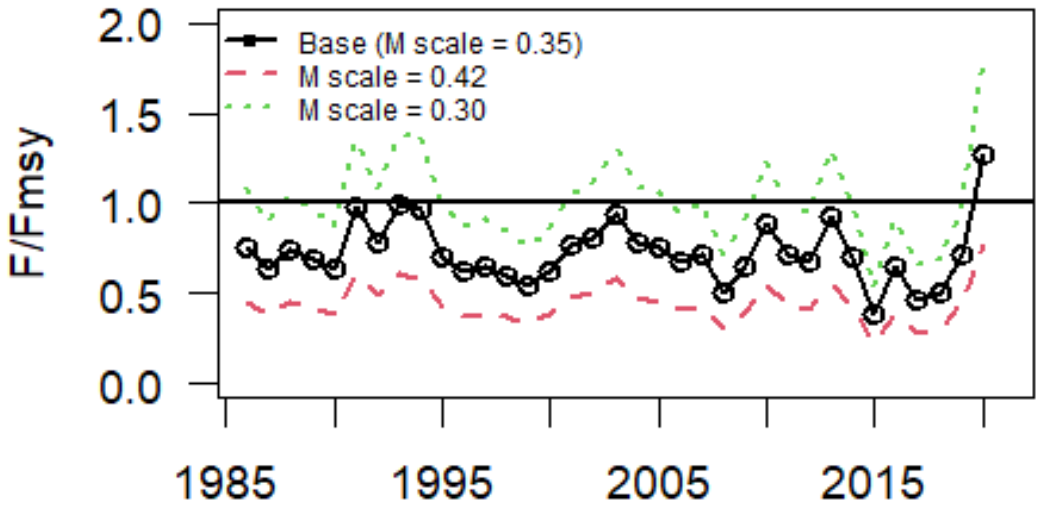
- High and low M (natural mortality) – 0.3, 0.42
- High and low steepness – 0.6-0.9
- High and low discard mortality - 0.1, 0.3
- Drop commercial handline index

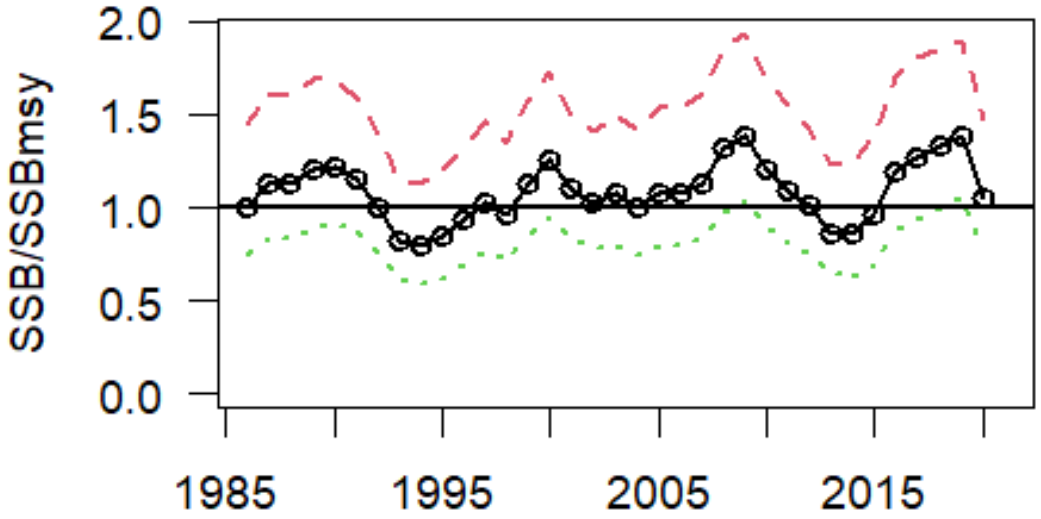
Drop commercial handline (cH) index



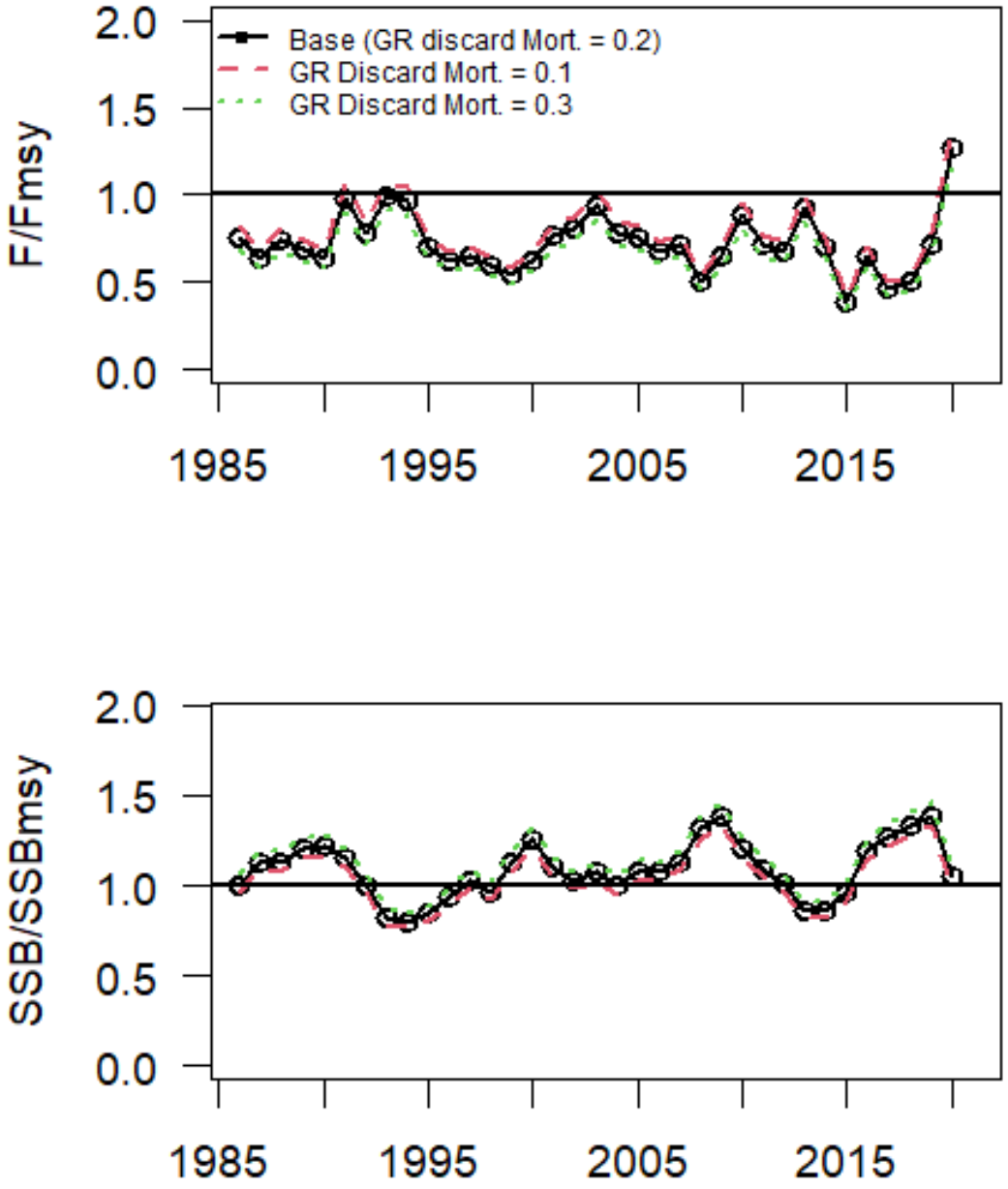


Natural Mortality (M)

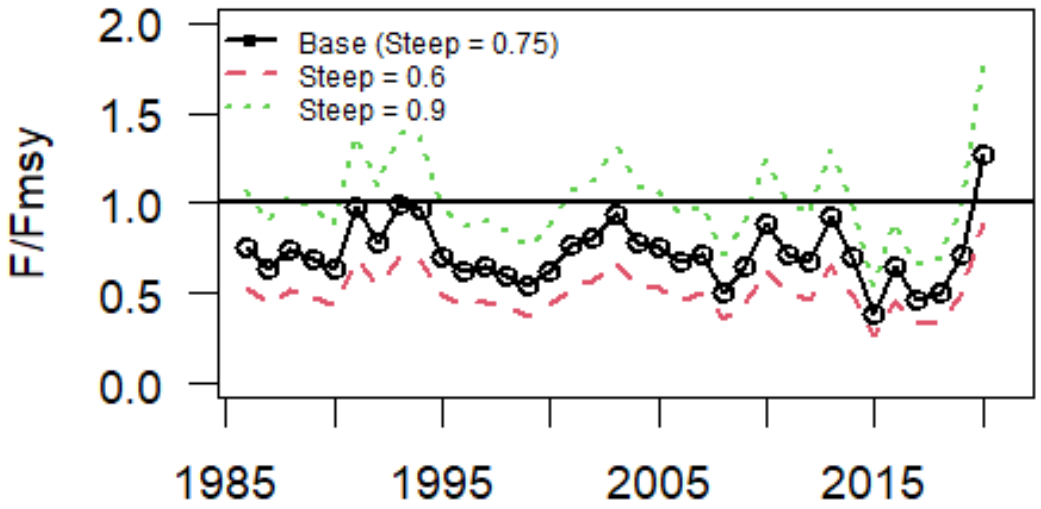


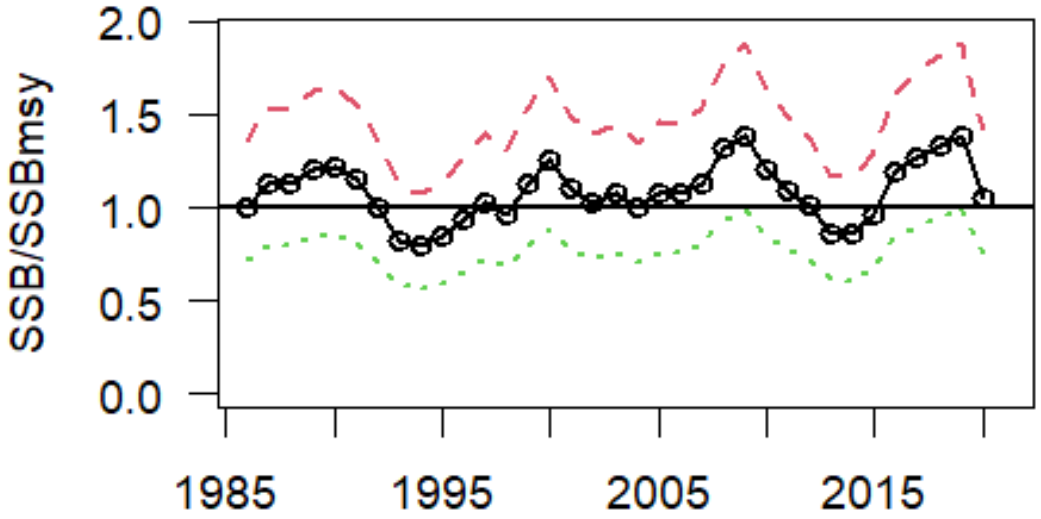


General recreational discard mortality



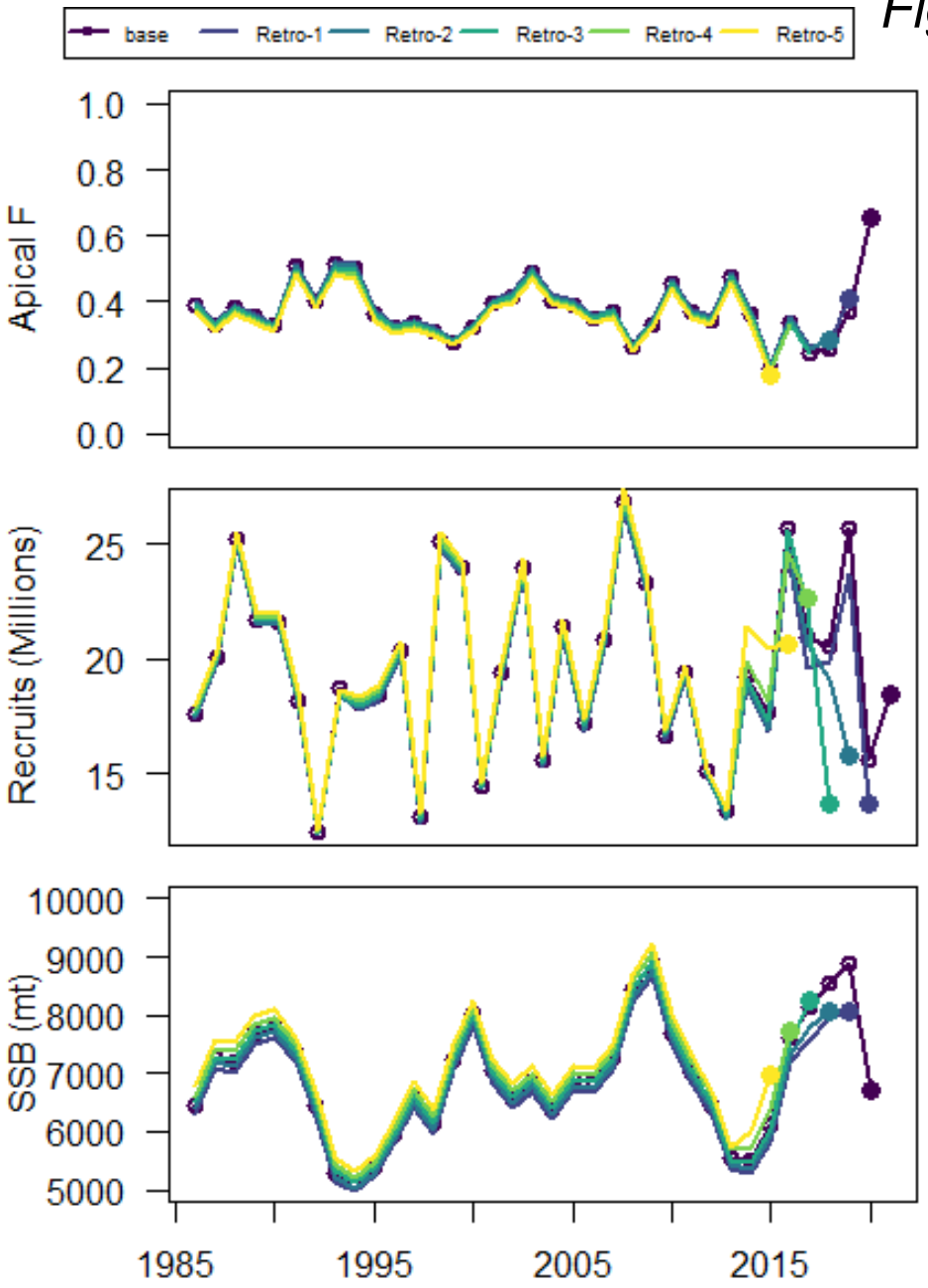
Steepness (steep)





Retrospective Analysis

Fig 46, pdf page 169



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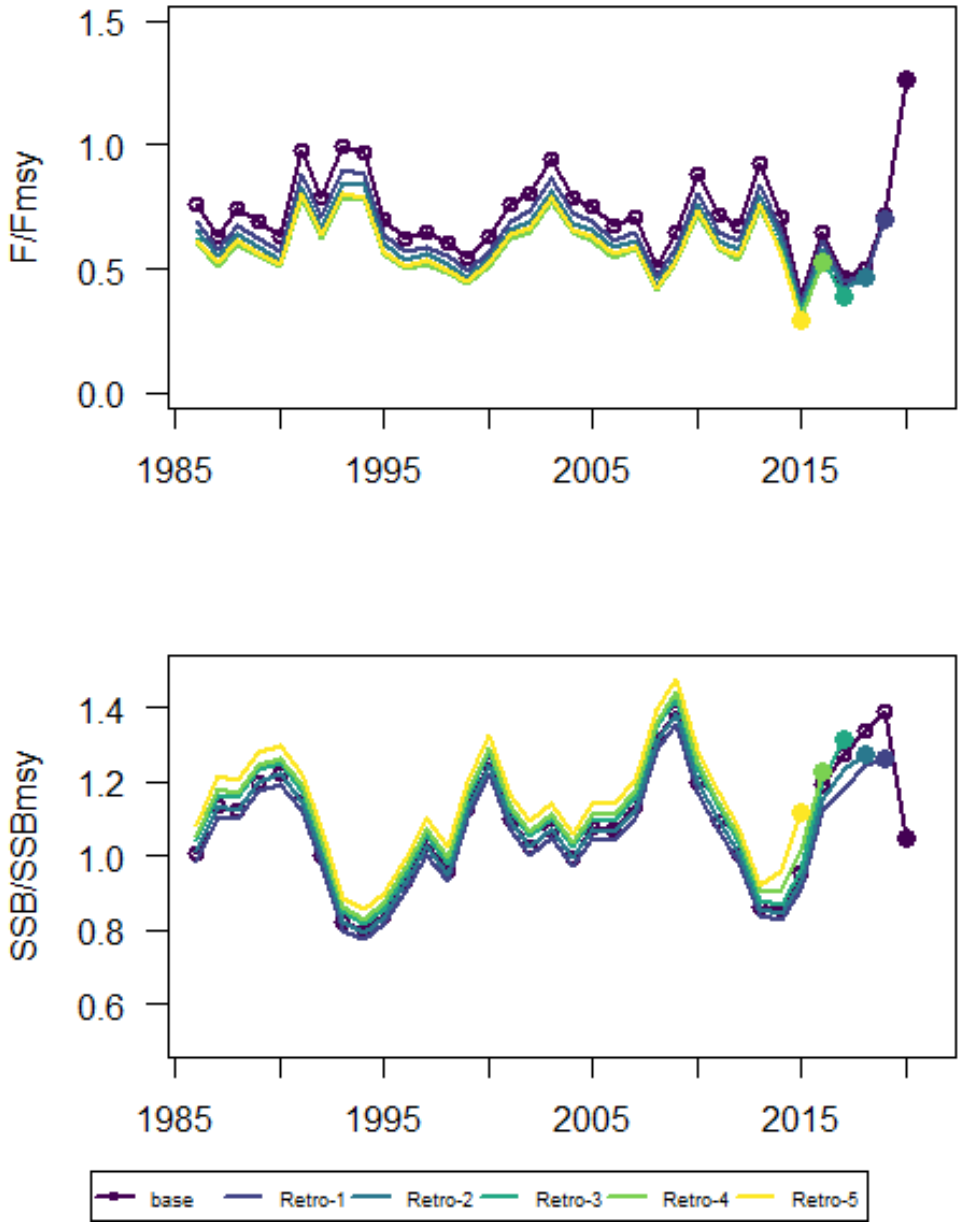
Retrospective Analysis



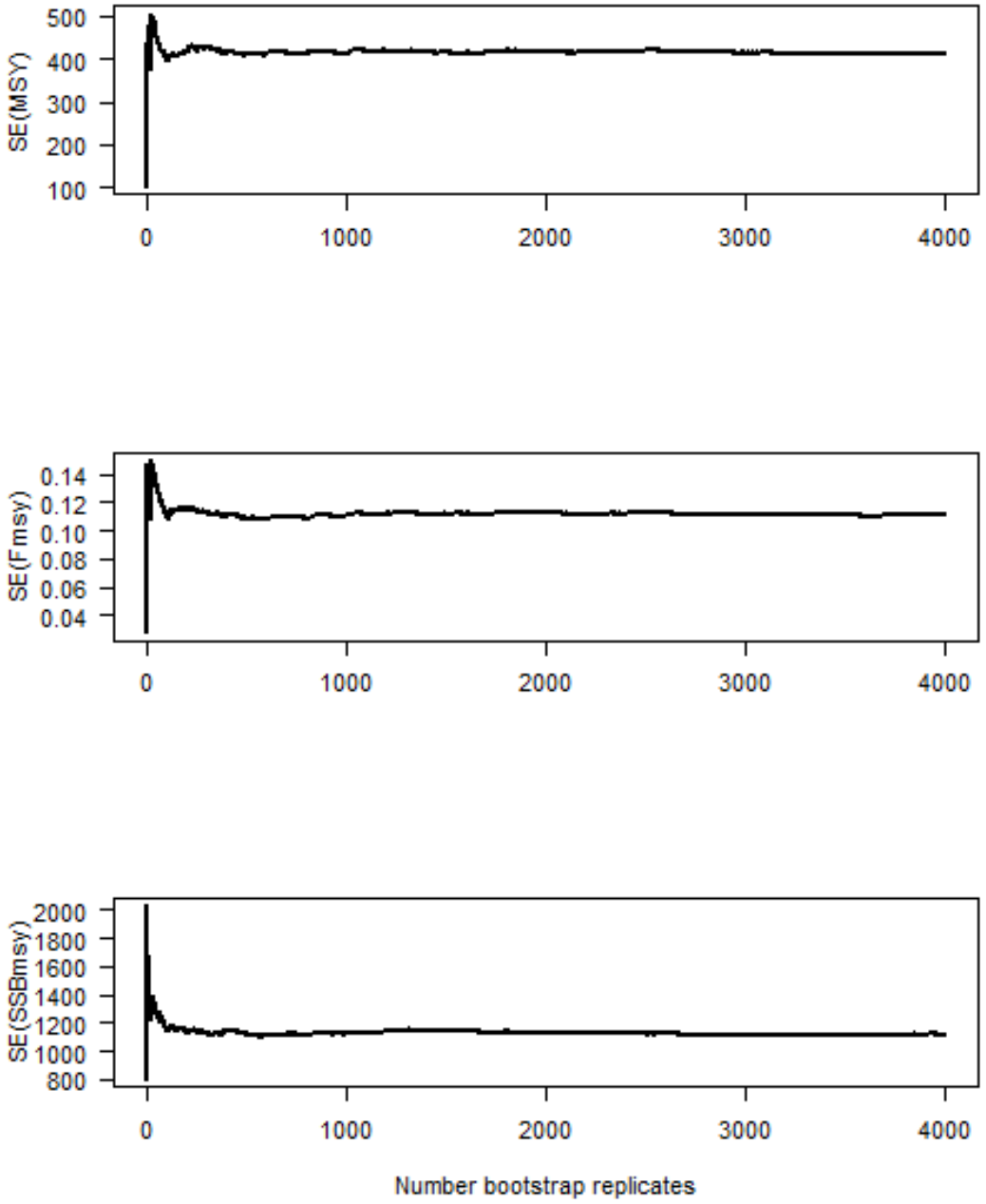
Topics

- Data Review
- Model update
- Base run
- Sensitivities and retrospective
- **Uncertainty**
- Projections

Uncertainty analysis (MCB Ensemble)

- Bootstrap the data
  - Multinomial resampling of age and length comps
  - Multiplicative lognormal error on indices, landings, and discards
- Monte Carlo draws
  - Natural mortality – Truncated Normal distribution
    - $M \sim N(0.35, 0.036)$ with bounds $(0.3, 0.42)$
    - Use +/- 2 ages for Hoenig(fish) M bounds (0.3,0.42)
  - Steepness – Truncated Normal distribution
    - $S \sim N(0.75, 0.097)$ with bounds $(0.6, 0.9)$
  - Discard mortality – Truncated Normal distribution
    - $D \sim N(0.2, 0.05)$ with bounds $(0.1, 0.3)$

Stabilization of standard error over the 4000 bootstrap replicates



- Filter for MCBE runs
  - Runs that did not converge=0
  - Runs with parameters at or near bounds (+/- 5% of the range)=23

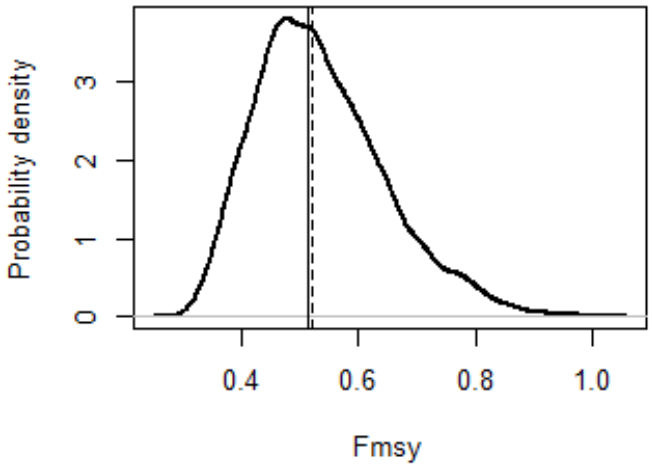
Benchmarks

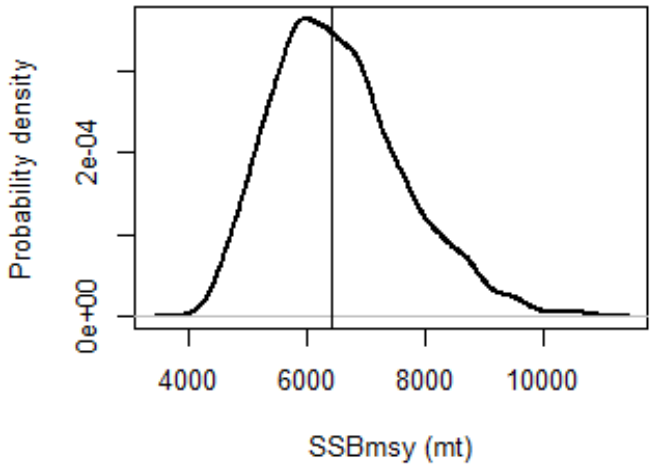
Solid vertical line=point estimate from base run

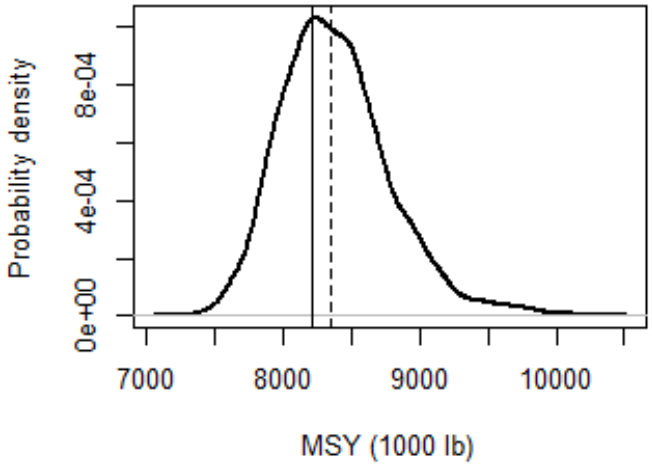
Dashed vertical line=median from MCBE

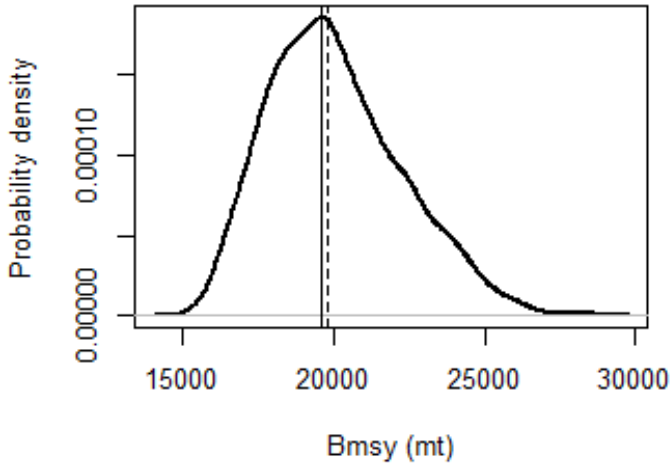
SSB=mature female biomass

F=apical F









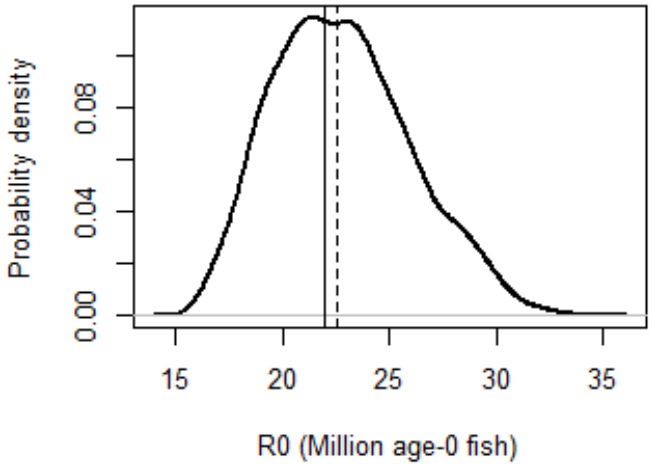
Spawner – recruit parameters

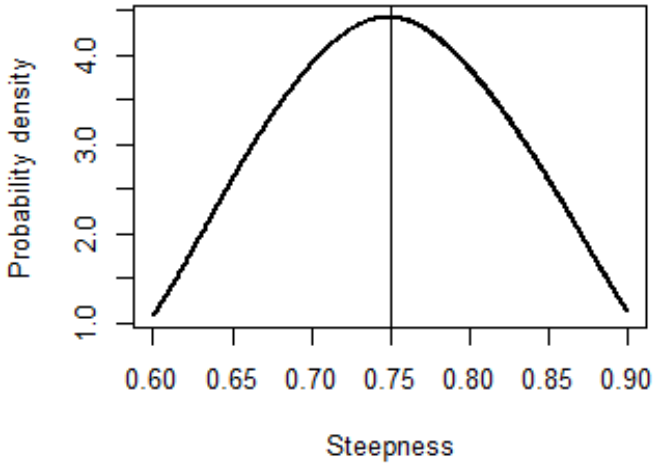
Solid vertical line=point estimate from base run

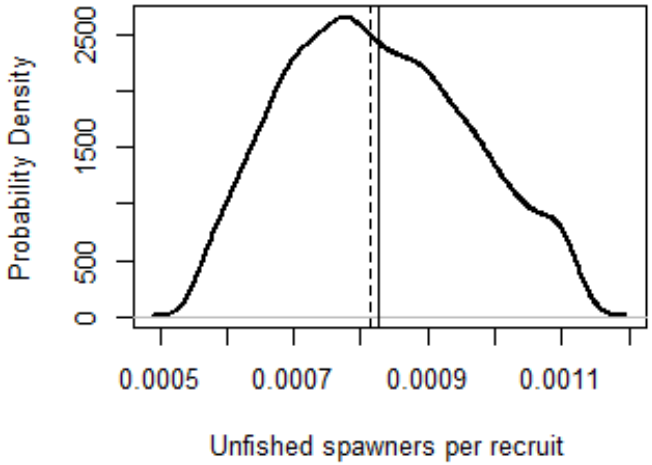
Dashed vertical line=median from MCBE

SSB=mature female biomass

F=apical F







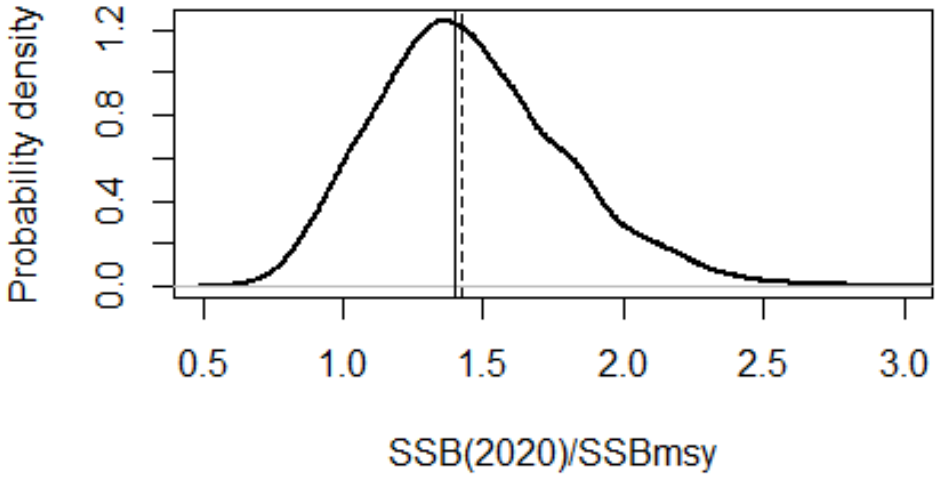
Status

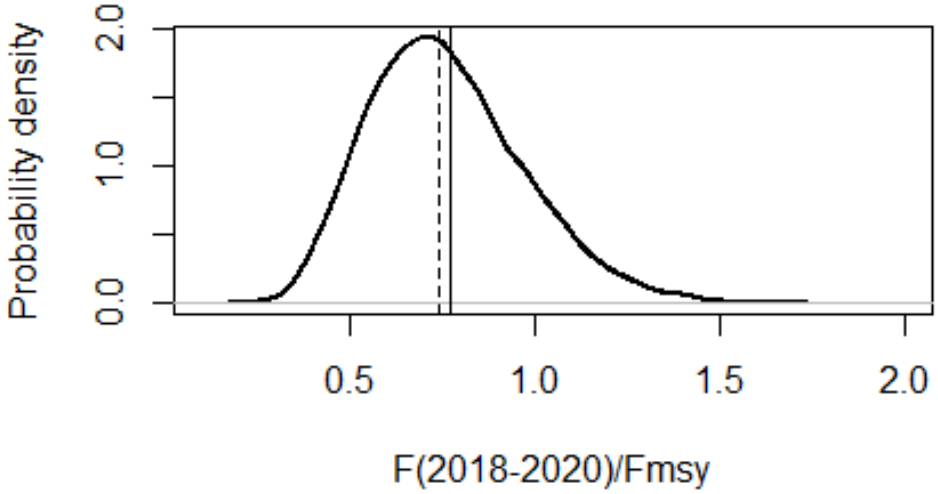
Solid vertical line=point estimate from base run

Dashed vertical line=median from MCBE

SSB=mature female biomass

F=apical F





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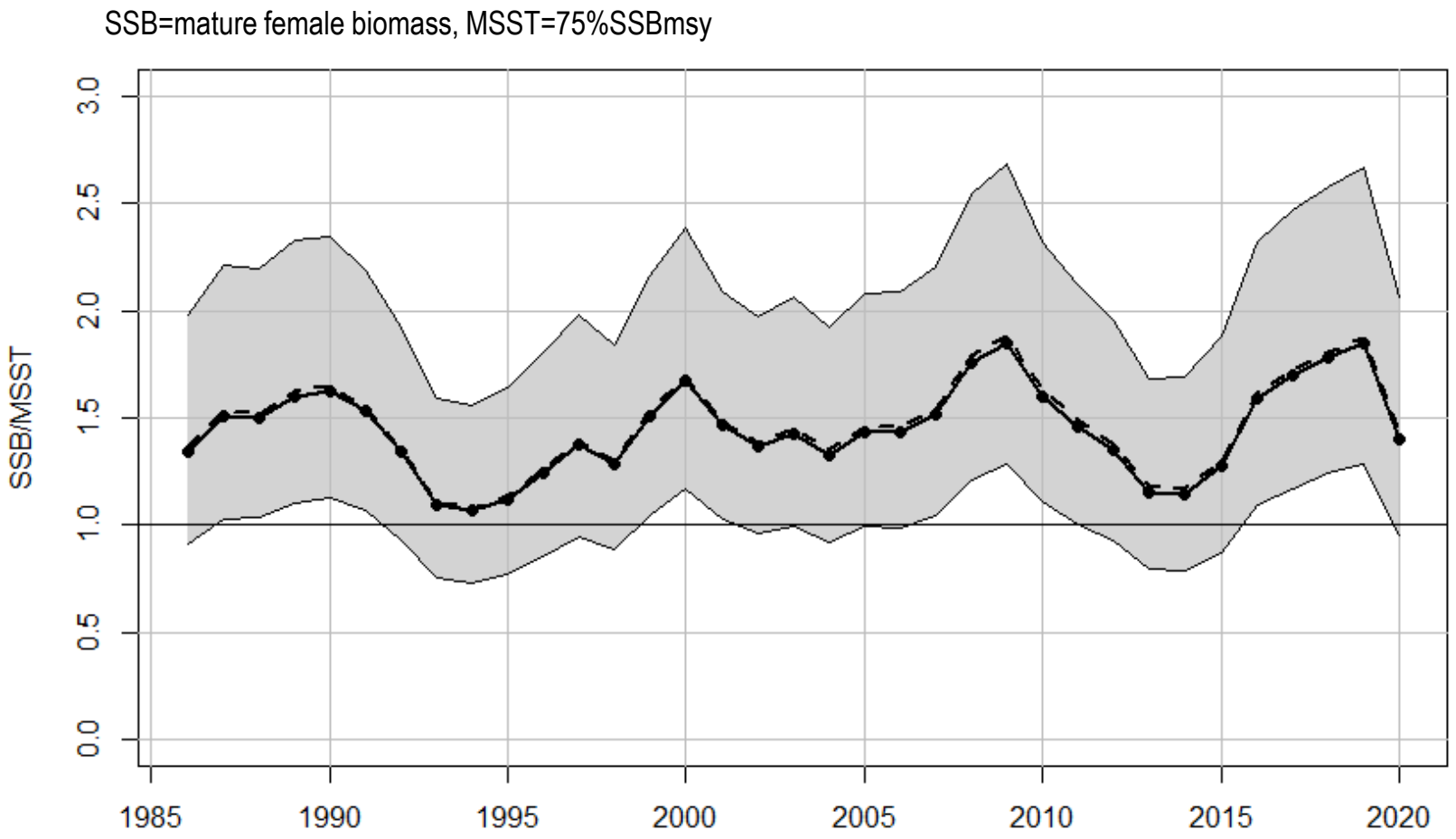
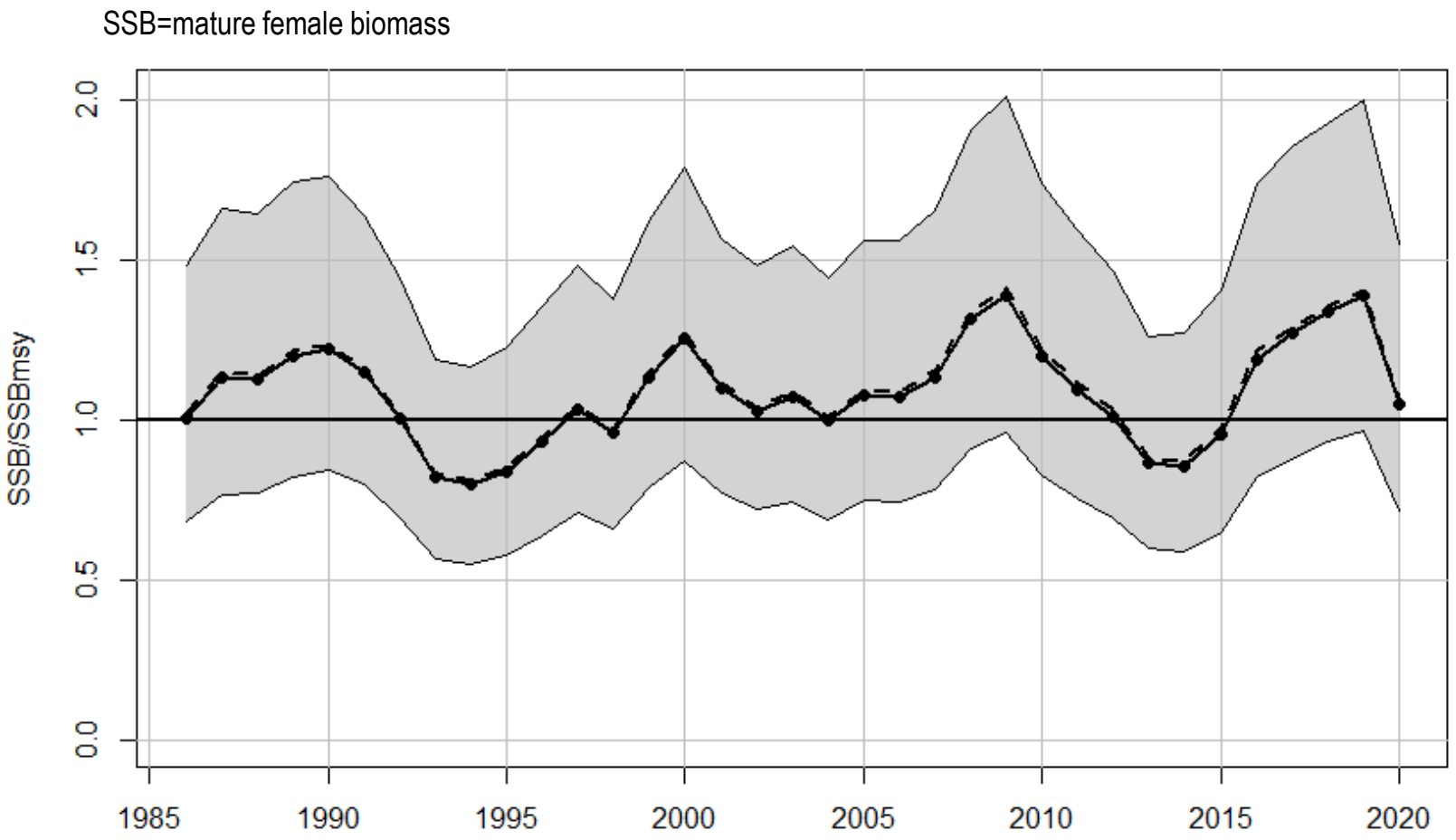
Status time series – SSB/MSST



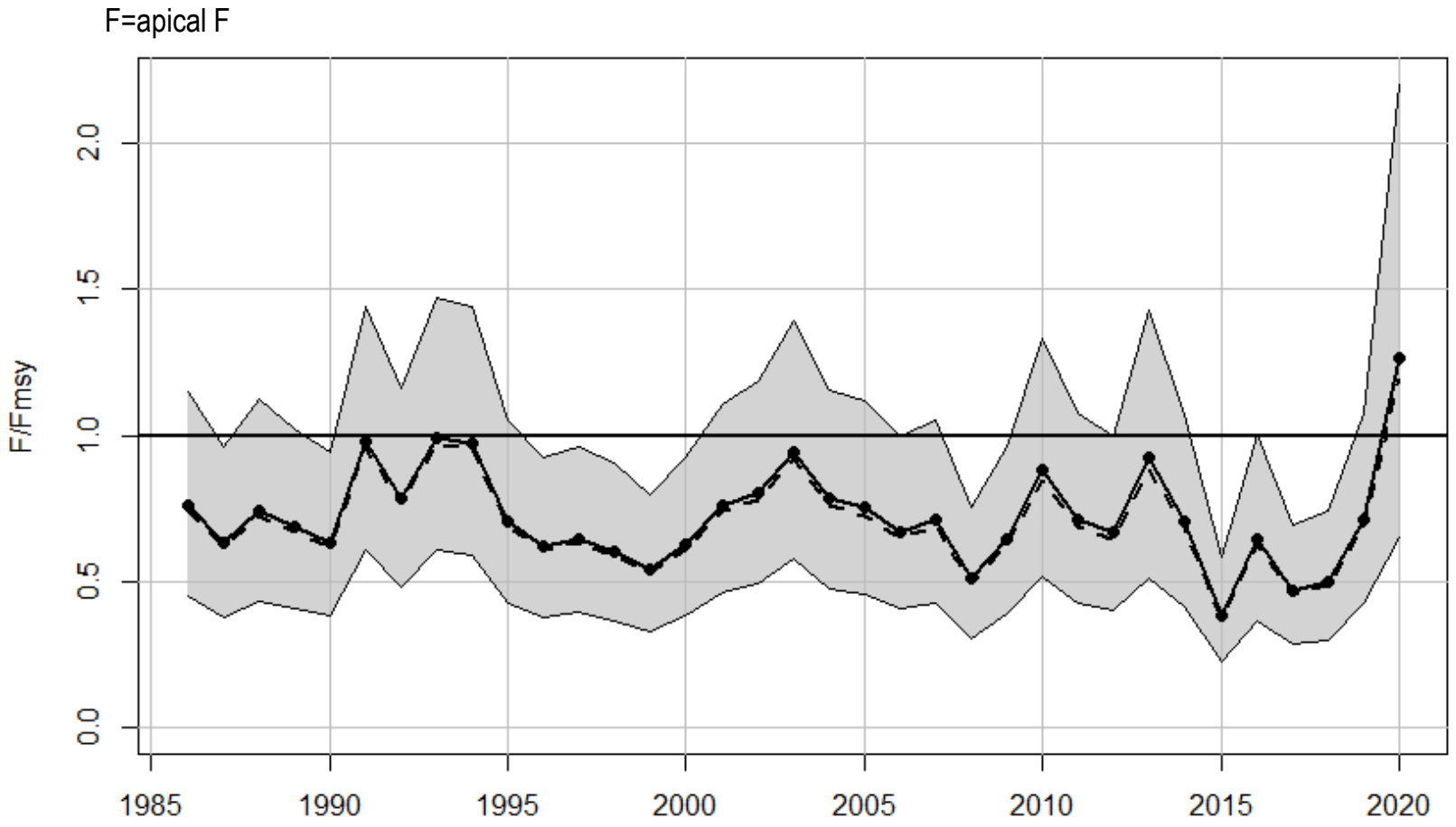
Solid line indicates estimates from base run; dashed lines indicate the median of the MCBE trials; gray error bands indicate 5th to 95th percentiles of the MCB trials.

Status time series – SSB/SSBmsy



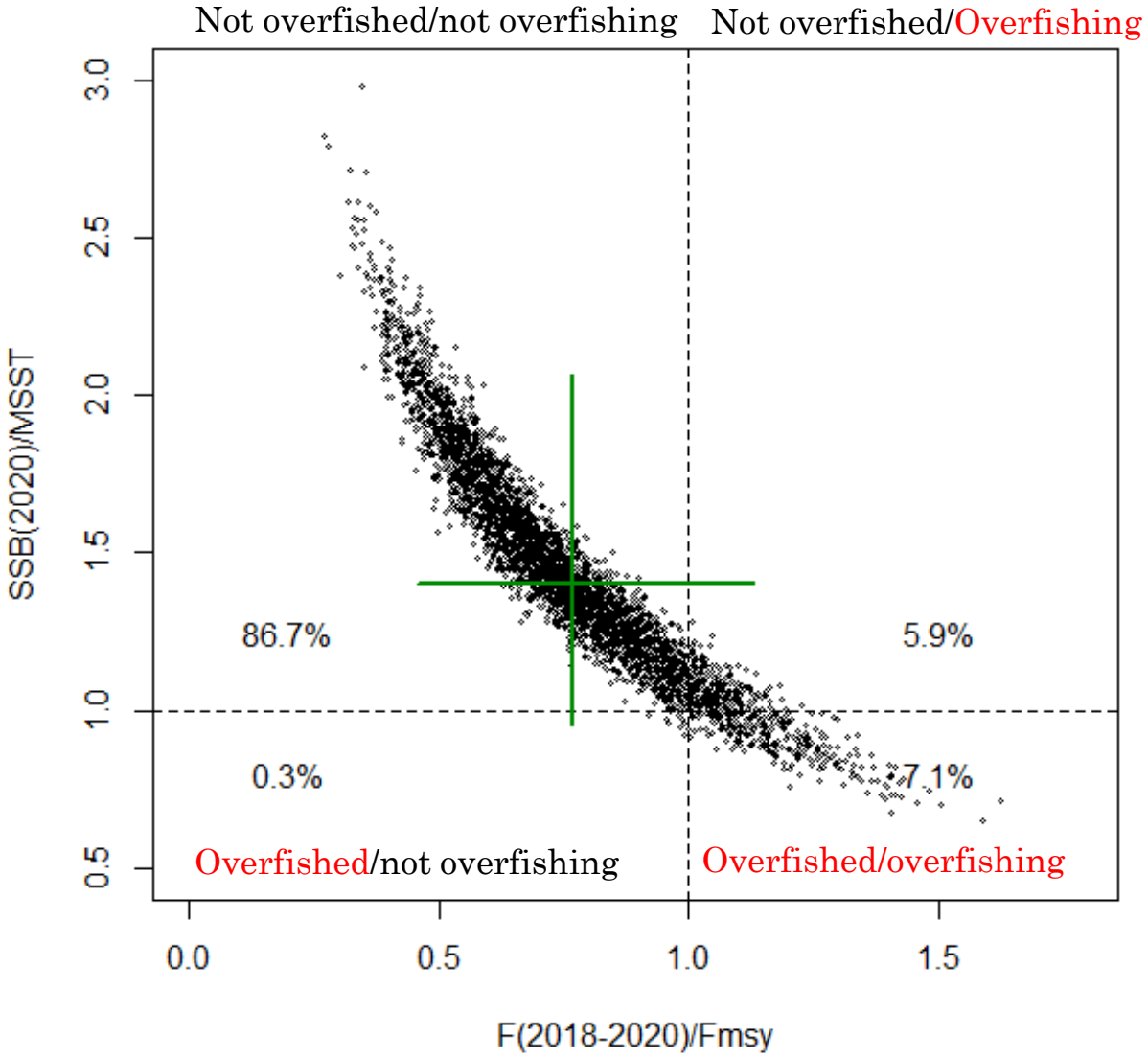
Solid line indicates estimates from base run; dashed lines indicate the median of the MCBE trials; gray error bands indicate 5th to 95th percentiles of the MCB trials.

Status time series – F/Fmsy

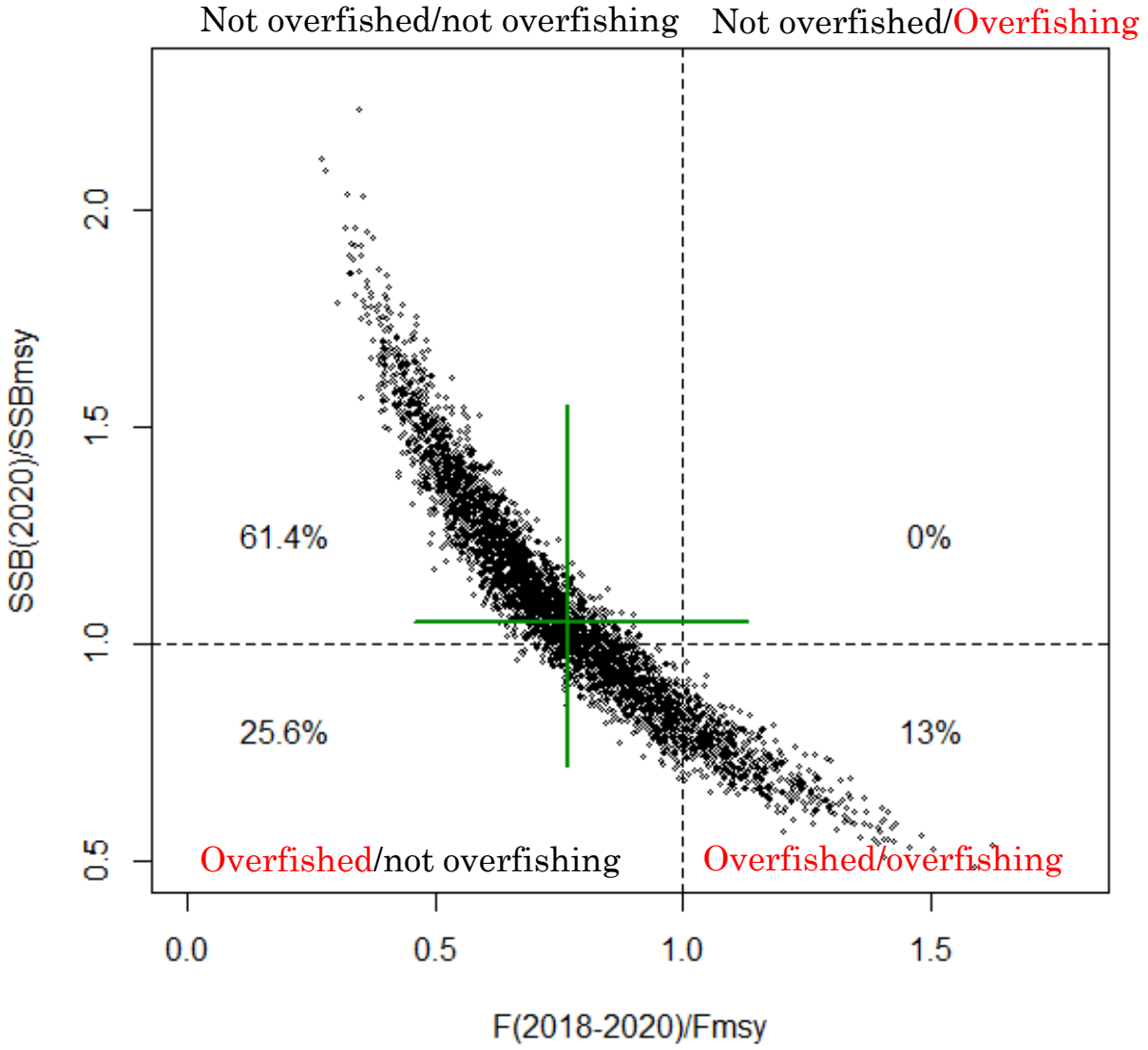


Solid line indicates estimates from base run; dashed lines indicate the median of the MCBE trials; gray error bands indicate 5th to 95th percentiles of the MCB trials.

Status – Phase SSB/MSST



Status – Phase SSB/SSBmsy



Topics

- Data Review
- Model update
- Base run
- Sensitivities and retrospective
- Uncertainty
- **Projections**

F-current

Shaded area = 5th and 95 percentile

Horizontal lines = MSY-related quantities (blue=base, green=MCBE median)

Solid estimate lines=base run or deterministic projection estimates

Dashed estimate lines=median values from MCBE or stochastic projection

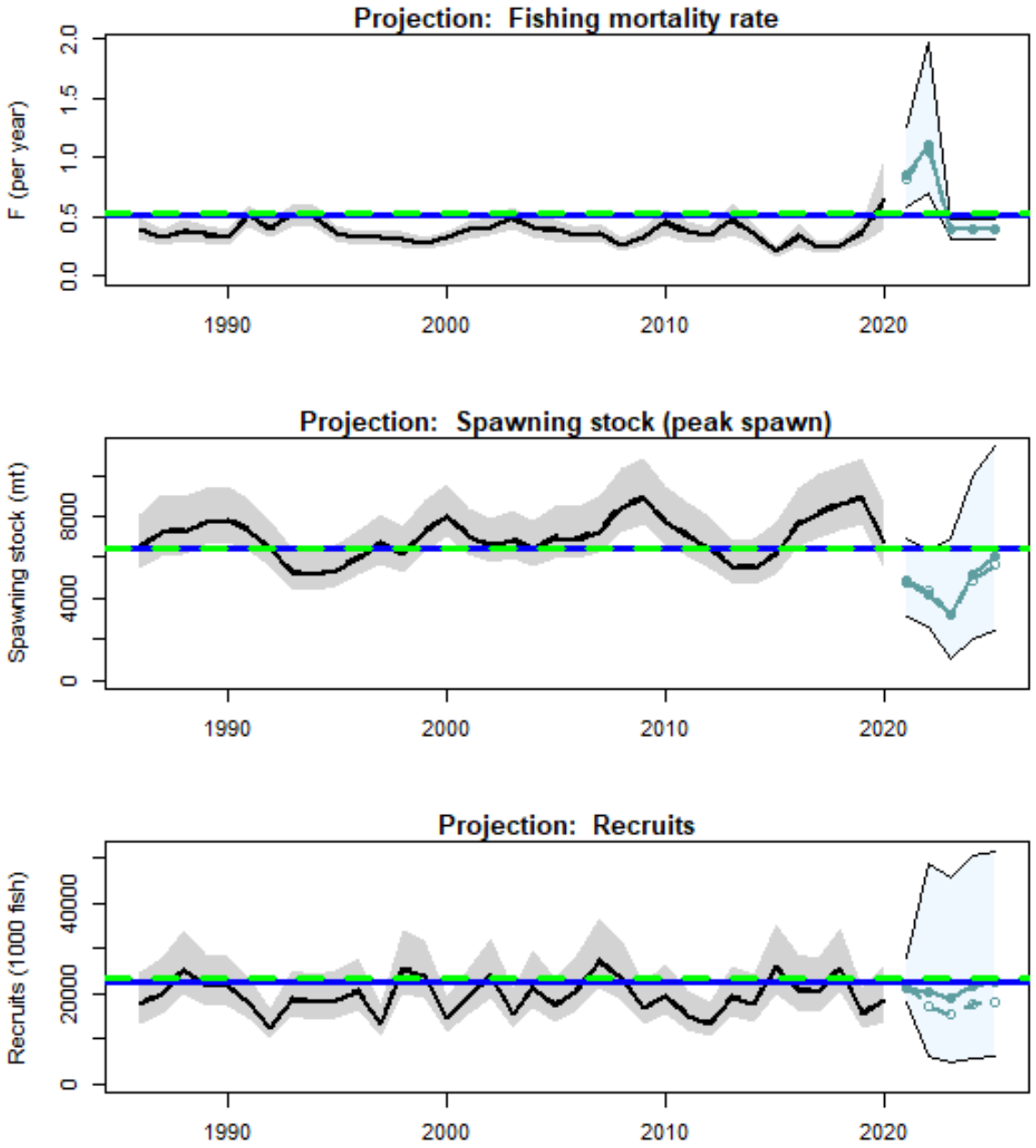


Fig 48, pdf page 171

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F-current

Shaded area = 5th and 95 percentile

Horizontal lines = MSY-related quantities (blue=base, green=MCBE median)

Solid estimate lines=base run or deterministic projection estimates

Dashed estimate lines=median values from MCBE or stochastic projection

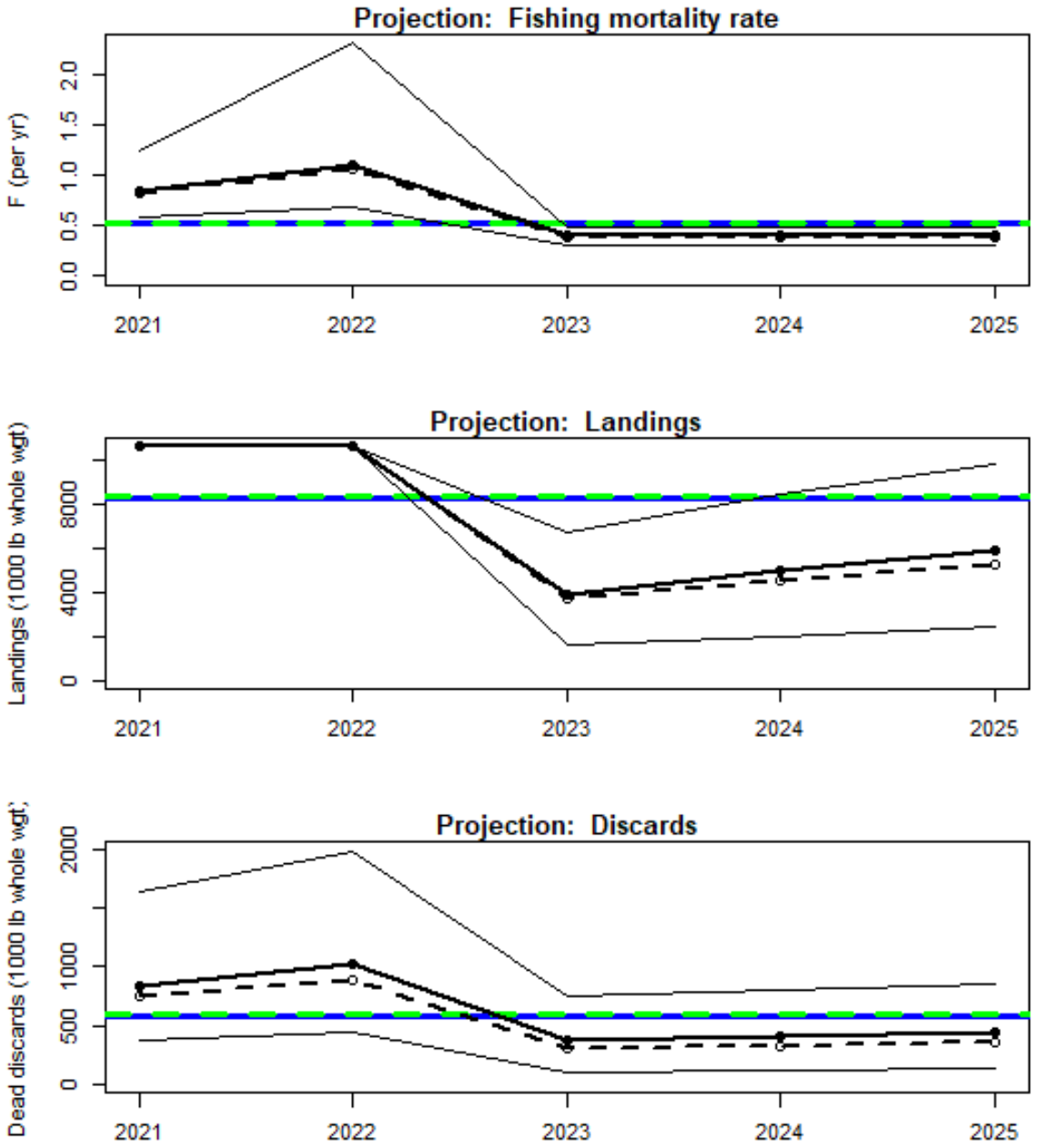

Fig 48, pdf page 171

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Fmsy

Shaded area = 5th and 95 percentile

Horizontal lines = MSY-related quantities (blue=base, green=MCBE median)

Solid estimate lines=base run or deterministic projection estimates

Dashed estimate lines=median values from MCBE or stochastic projection

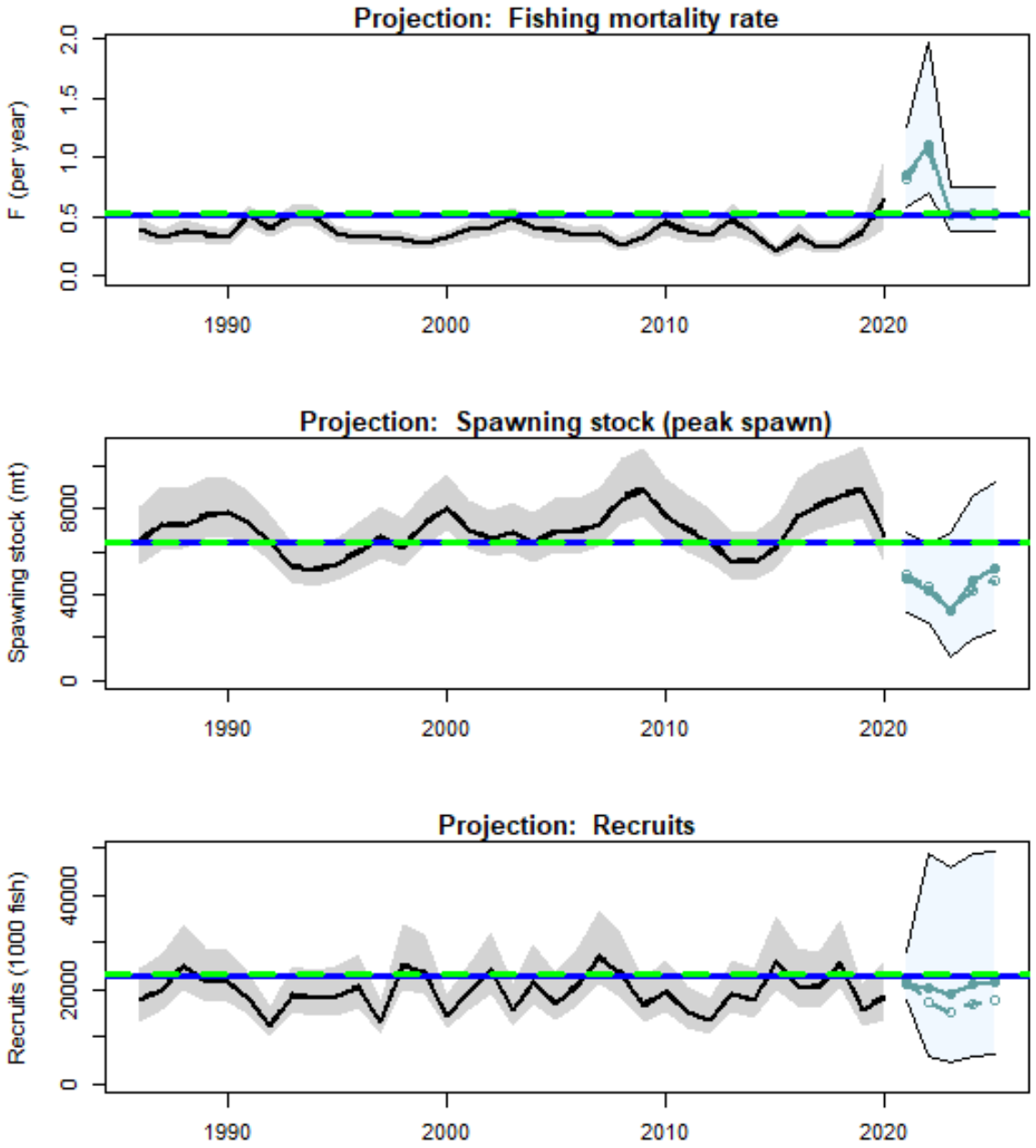

Fig 49, pdf page 172

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Fmsy

Shaded area = 5th and 95 percentile

Horizontal lines = MSY-related quantities (blue=base, green=MCBE median)

Solid estimate lines=base run or deterministic projection estimates

Dashed estimate lines=median values from MCBE or stochastic projection

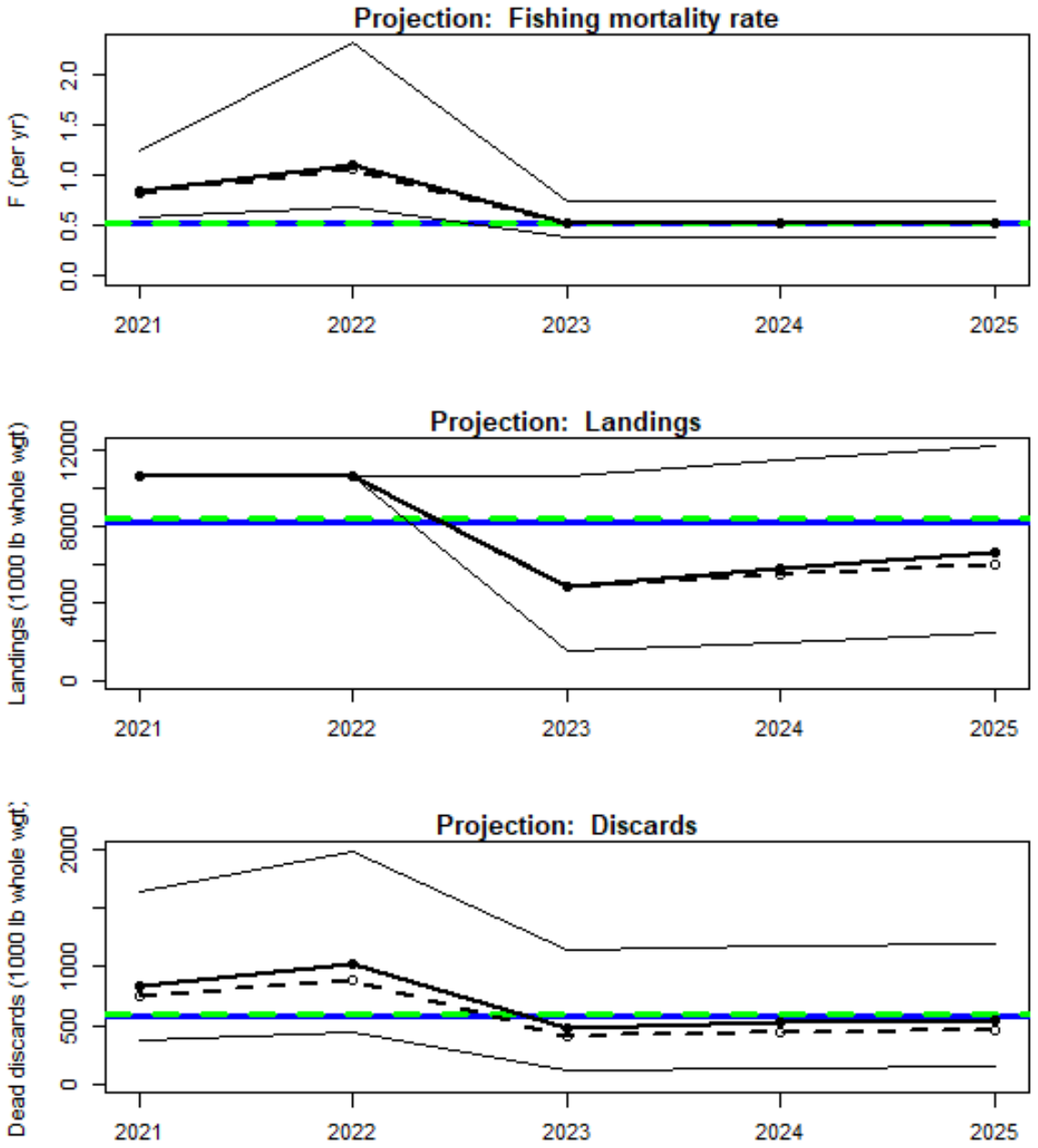

Fig 49, pdf page 172

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75%Fmsy

Shaded area = 5th and 95 percentile

Horizontal lines = MSY-related quantities (blue=base, green=MCBE median)

Solid estimate lines=base run or deterministic projection estimates

Dashed estimate lines=median values from MCBE or stochastic projection

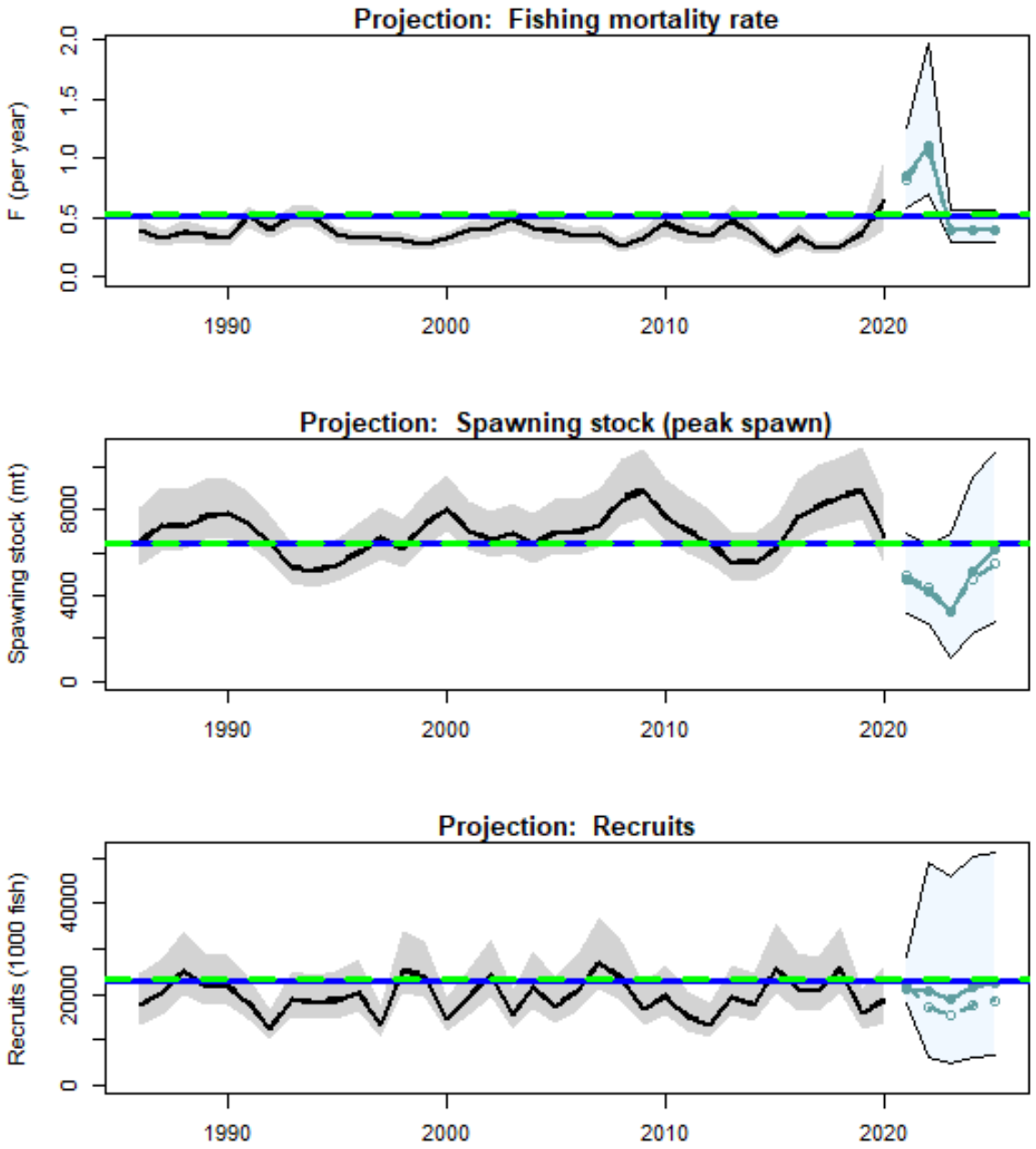

Fig 50, pdf page 173

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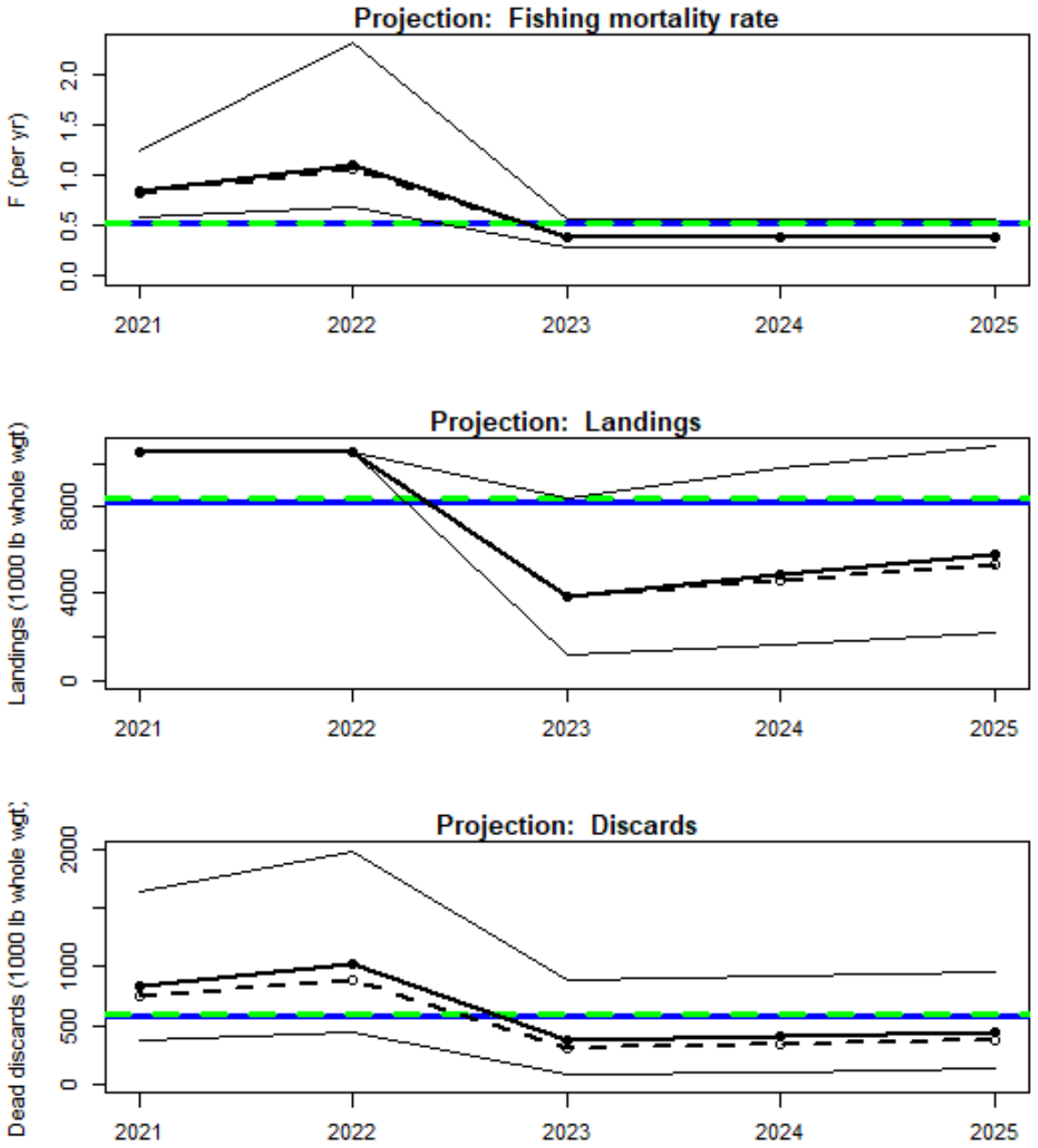
75%Fmsy

Shaded area = 5th and 95 percentile

Horizontal lines = MSY-related quantities (blue=base, green=MCBE median)

Solid estimate lines=base run or deterministic projection estimates

Dashed estimate lines=median values from MCBE or stochastic projection



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Sampling and research recommendations

- Improved knowledge of natural mortality and steepness
- A pelagic fishery survey with adequate spatio-temporal coverage and sample sizes
- A long-term recruitment index
- Adequate representative length and age samples from each fishery including discards*
- More robust shrimp bycatch estimates*

(*sampling improvement)

Research recommendations (1)

- Age-dependent natural mortality was estimated by indirect methods (Lorenzen) for this assessment. Telemetry- and conventional-tagging programs can provide alternative estimates of natural mortality. Investigate new methods for determining point estimates for natural mortality.

- Implement systematic age sampling for the general recreational and commercial sectors. Age samples were important for this assessment for determining key parameters but sample sizes were limited, particularly for the general recreational sector, commercial handline and commercial cast net sectors, which account for the majority of the recent landings.

- The recreational discards have increased dramatically in the last 2 years of this assessment. A better understanding of the size composition and mortality of discarded fish would improve the assessment, especially if discards continue to increase due to effort or future management changes.

Research recommendations (2)

- **Development of a fishery-independent survey for pelagic species** would decrease reliance on a fishery-dependent index of abundance that has unexplained trends in residual values in recent years.

- Limited information is available for shrimp bycatch in the Atlantic. Comprehensive observer coverage across space and time are need to adequately capture the scale and size distribution of bycatch for Spanish mackerel and other species.

Genus: *Scomberomorus* (the Spanish mackerels)

In the U.S. Atlantic:

Scomberomorus maculatus (up to 14 lbs.)

Scomberomorus regalis (up to 30 lbs.)

Scomberomorus cavalla (up to 90 lbs.)

Meet the Chinese seerfish:

Scomberomorus sinensis (up to 180 lbs.)

Found in Western Pacific, but known to enter the Mekong River. Let's see Jeremy Wade (River Monsters) wrestle one of these!

Questions?