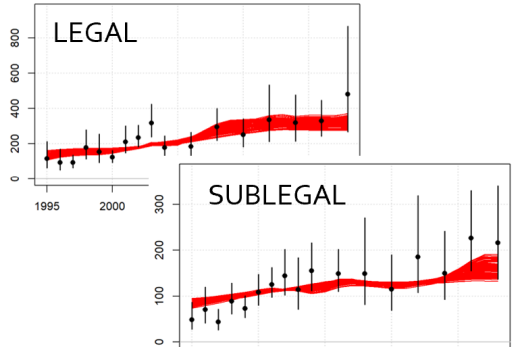
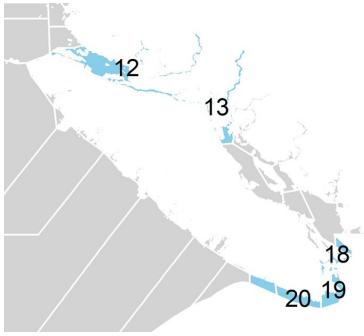
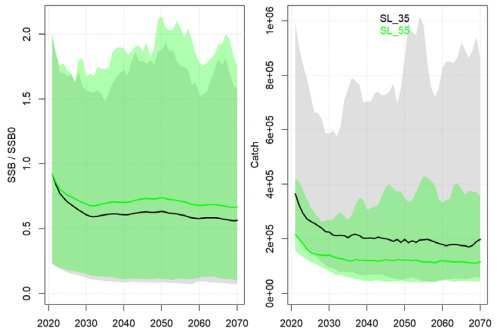
B.C. Green Sea Urchin Reference Case Operating Model Development

Updated data, models and example results

13 February 2024







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openMSE

www.openmse.com

PROJECT PAGE:
https://mis-assess.github.io/csrf_hh_io/

CODE:
https://github.com/mis-assess/csrf_hh_data/tree/main/OMs

Contents

1. Requests / feedback from last meeting
2. Data updates
3. Revised Models
4. Example uses of the framework
5. Next steps

1. Requests / feedback from previous meeting

Notes from last meeting (April 2023)

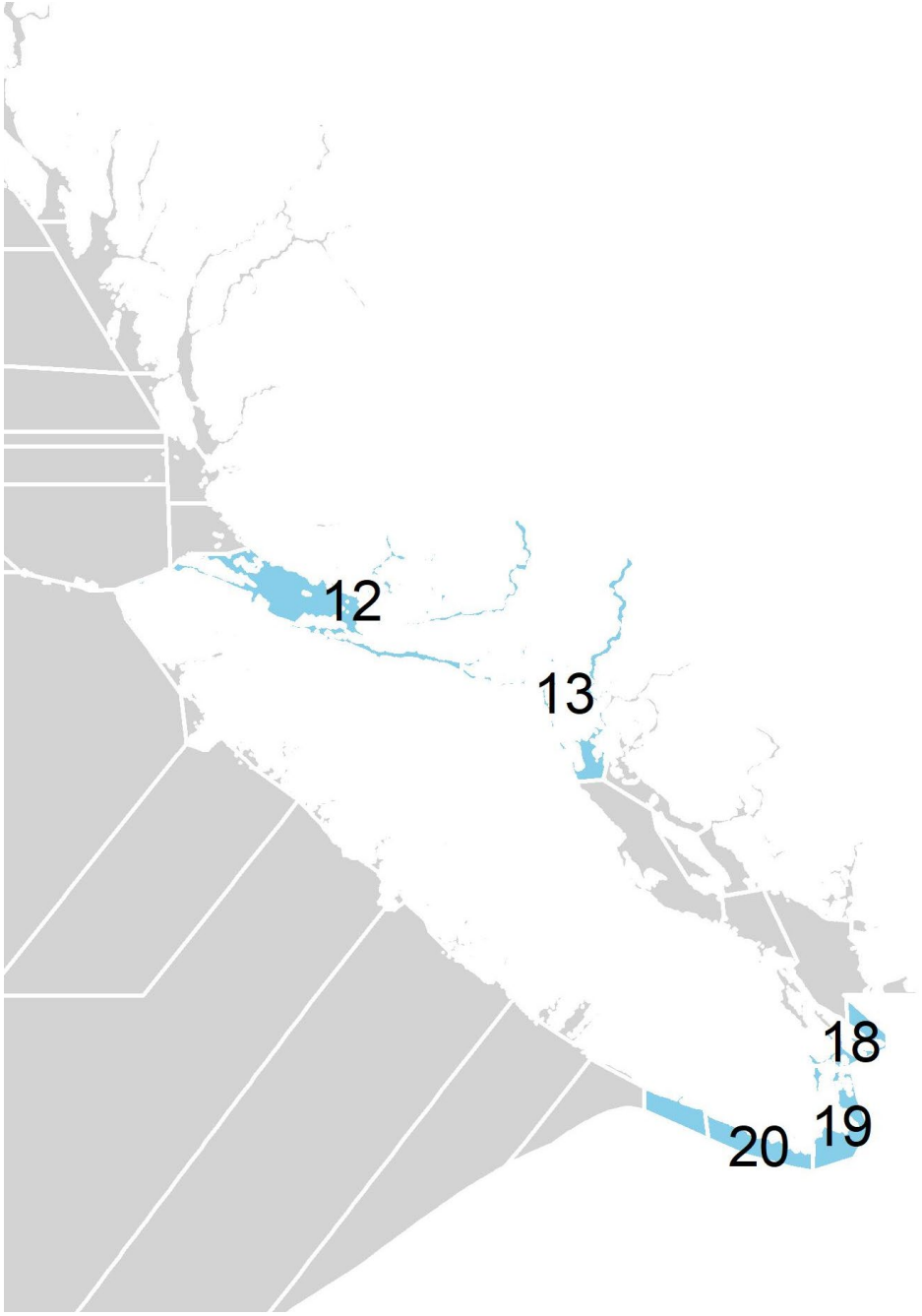
- Data prior to ~1995 are potentially less reliable Consider removal / disconnection (sensitivity analysis)
- CPUE seems hyperstable compared with aggregate biomass trends (spatial standardization)
- Should CPUE be included and if so should it be standardized?
- Somatic growth parameter ranges? Currently K comes from red urchin in California and Linf from eye-balling the W-L data (possible ratio approach using Washington state, GOM examples)
- Use life-history meta analysis to get to approximate M
- Sea otter M in projections? If so how?
- Absolute biomass available in 12 and 19 and used to infer quota in other areas (current management?)
- 1997 el Nino rec pulse (maybe see in fishery 2002)
- Possible selectivity reduced for very large 140mm + individuals (but may N.A. - GSU rarely go over 160)
- Consider a 3-resolution sensitivity analysis: 12,13,18,19,20 & south (18-20), north (12&13) & all
- Multispecies benthic survey starting (but not yet known how effective the survey might be)
- Concern about scaling to coast-wide reference points given selection bias toward fishing in high density areas and lack of (currently) information about density / magnitude in currently unfished areas.
- Data are partitioned into fished and unfished areas – check trends / comps
- GOM GSU linked https://aquadocs.org/bitstream/handle/1834/31017/03chenfi.pdf?sequence=1
- Resource availability ontogenetics

Areas for development in the use of OMs

- Density data per Stat. Area that are in the units used by managers to control fishery exploitation (e.g. urchins / sq m).
- Management performance metrics.
- Outputs (tables / figures for describing performance of alternative management options / policies).
- Informing management– what options are available to provide scientific advice to managers including, data types, data frequency, interval between surveys, data analysis, selection of reference points etc.
- Management levers – what approaches to management are possible?
- Important system uncertainties that management options should be robust to.

Assumptions

- Statistical Area (PFMA) are assumed to be the appropriate 'biological unit': a spatial resolution which, over the time-scale of tactical management decision making, biological and fishery processes are contained (e.g., no exchange with other areas). Only five PFMAs (12, 13, 18, 19, 20) had recent catches. These areas constitute greater than 95% of historical catches (according to harvest logs to 2020).
- Model initializes in 1987 following start of the dive fishery and runs to 2020 (last year of catch data).
- Did not appear to have age-length observations but could estimate length-weight relationships for some Stat Areas.
- Logistic (flat-topped) length selectivity was assumed for the fleet and the legal-size survey (>55mm).



2. Data updates

Data files 2022 – 2023 (not updated for this round)

Landings to 2020:

data_harvestlogs/Shellfish Dive Harvest Logs EXTERNAL.xlsx

Survey size data:

data_urchin/viewUrchSF_GRN.csv

Fishery size data:

data_urchin/viewUrchTestWidths_GRN.csv

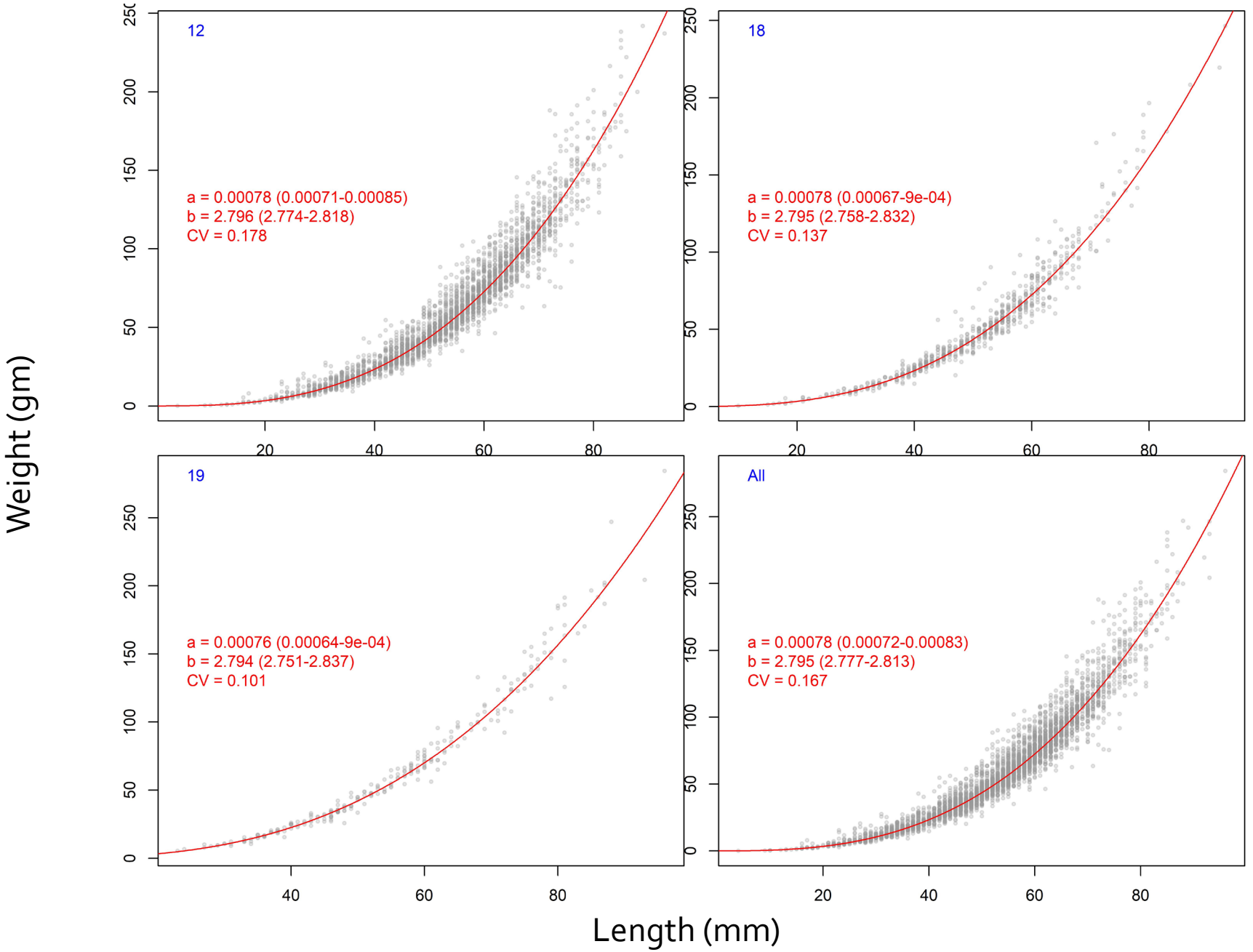
Survey weight at length:

data_urchin/viewUrchDissection_GRN.csv

Model inputs

Length-weight for some Stat. Areas (PFMAs)

Assuming the same length-weight relationship across all areas. Essentially that urchin are the same shape everywhere and not somehow mysteriously 'flatter' in other areas!



Chen et al. 2003 GOM green urchin

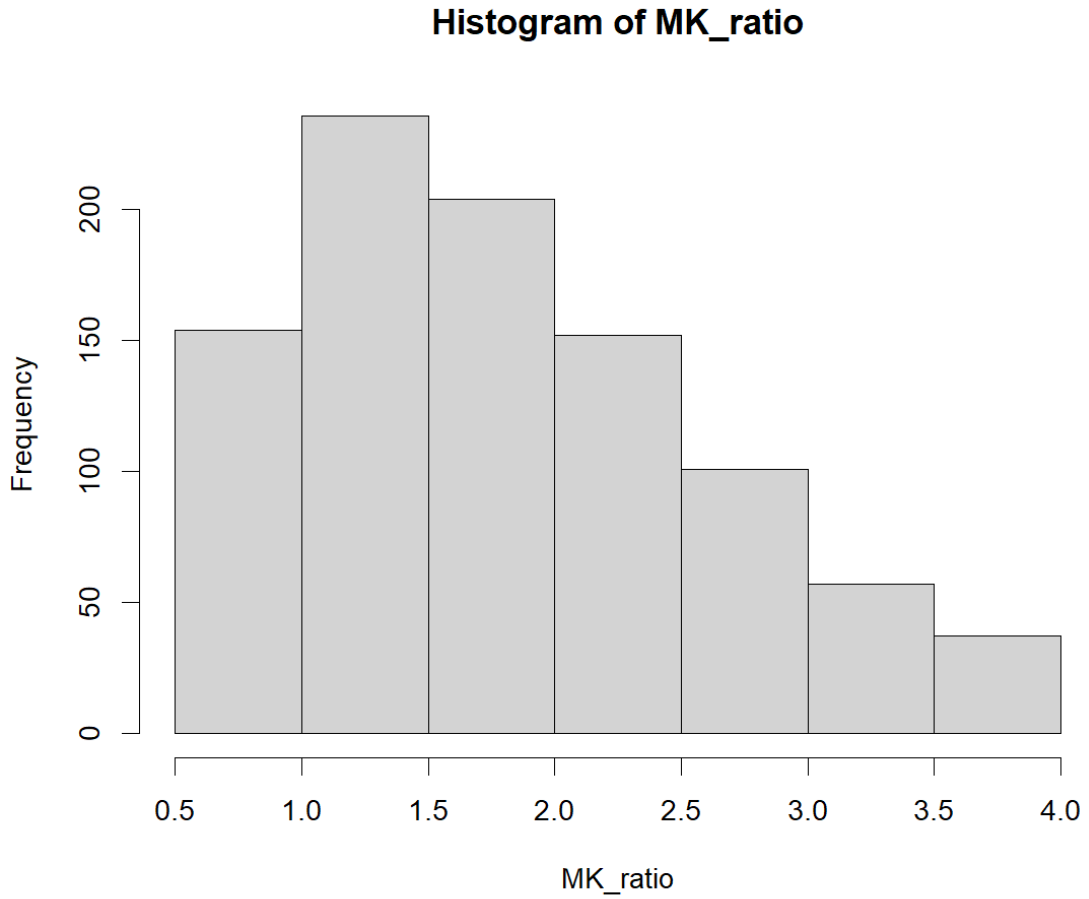
Estimates of 1cm yr-1 in Strait of Georgia (Foreman and Lindstrom 1974). Given asymptotic diameter of approximately 8cm is equivalent to a min K value around 0.125

Table 1

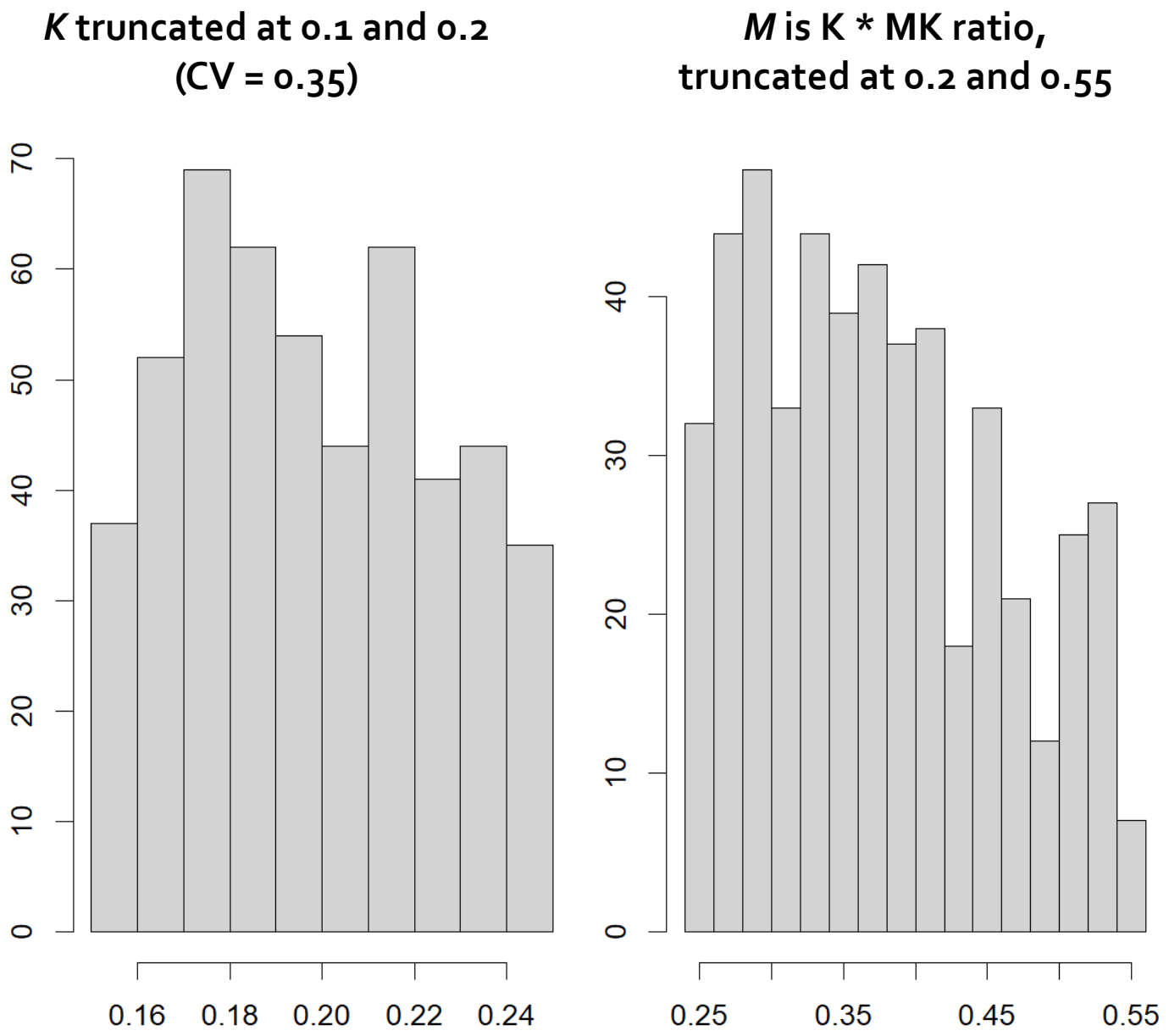
The average asymptotic size (L_∞) and Broady growth coefficient (K) estimated for different areas and habitats along the coast of Maine in the study done by Vadas et al. (1997, 2002). Coefficient of variation (CV) was calculated by using Equation 2.

		Parameter		Coefficient of variation (CV)	
Area	Habitat	L_∞	K	CV(L_∞)	CV(K)
Northeast	Barren	63.1	0.1404	0.242	1.209
Northeast	Kelp	88.5	0.1263	0.224	0.543
Center	Barren	67.0	0.2315	0.084	0.354
Center	Kelp	63.4	0.3268	0.065	0.248
Southeast	Barren	80.1	0.1776	0.099	0.397
Southeast	Kelp	95.2	0.1181	0.128	0.338

Life – history analysis (openMSE, FishLife, FishBase):

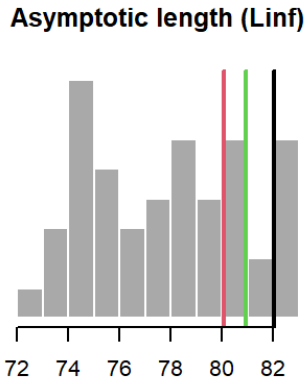


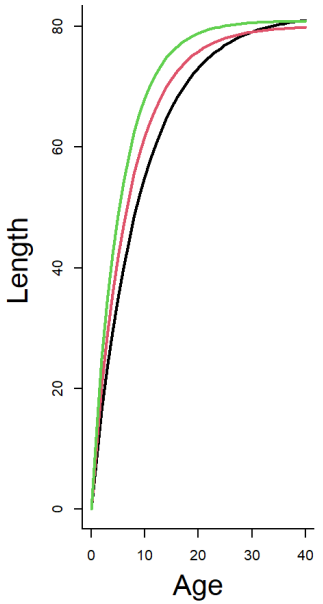
Example of sampled parameters (n=300) for *K* (Linf yr^{-1}) and *M* (yr^{-1}) based on life-history ratio of M/K

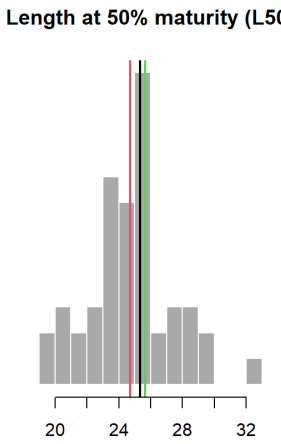


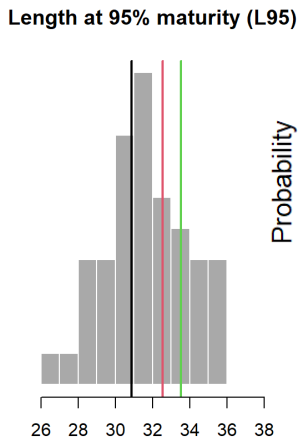
Assumptions

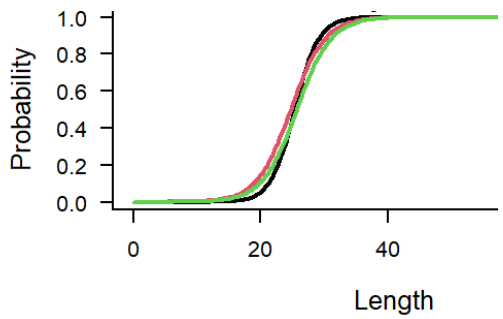
- Natural mortality considered relatively uncertain and sampled from 0.05 – 0.15 (60 – 20 years to 5% survival, respectively)
- Asymptotic length between 72-84mm
- vB growth K between 0.1-0.2
- Steepness (resilience) was fixed to 0.8 (but presumably should be vague!)
- 50% sexually mature at 25mm (Waddell et al. 2002) (log normal CV of 20%)











1. Data updates for this round

Biomass estimates up to the last stock status report (2021). Included are the density estimates in that report, used the dynamic biomass model:

CalculateTotalBiomass _Area 12 and 19 surveys - 2021.xls

Results from code to get green sea urchin densities (no. per m2) from multispecies invertebrate dive survey dataset:

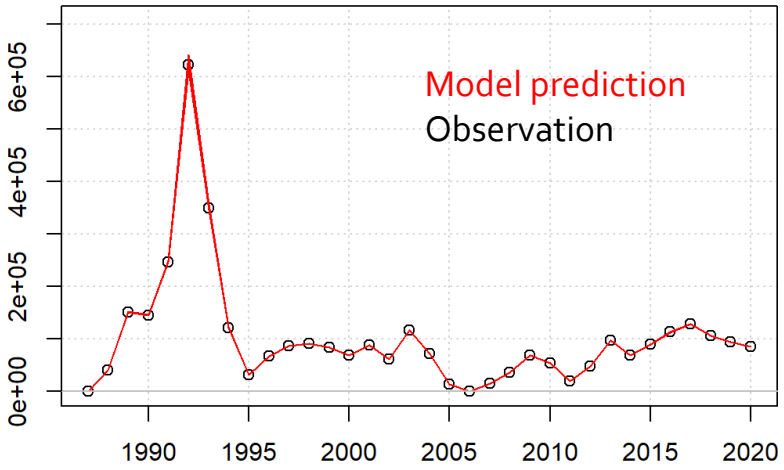
Multispecies_noab_export_to2021_(2022-05-17)_wNewSO.xlsx

Data summary

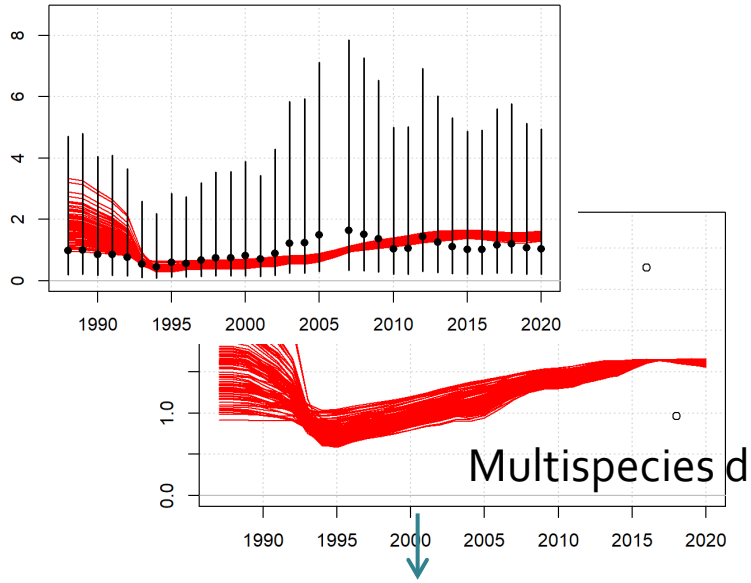
Stat. Area	Fishery landings / effort	Survey length composition	Relative (abs?) biomass index	Fishery length composition	Std. CPUE	Length-Weight	MSS density
12	1988 – 2020 (32 yrs)	1995 – 2018 (17 yrs)	Legal / sublegal 1995 -2018	1996 – 2006 (11 yrs)	-	1996-2010 (n = 2763)	2016-2018 (nq = 3287)
19	1987 – 2020 (28 yrs)	2000 – 2020 (8 yrs)	Legal / sublegal 2008 - 2020	1996 – 2006 (11 yrs)	-	2000-2010 (n = 254)	2017 (nq = 40)

Data Sources (Stat Areas 12 & 19, 'Data Rich')

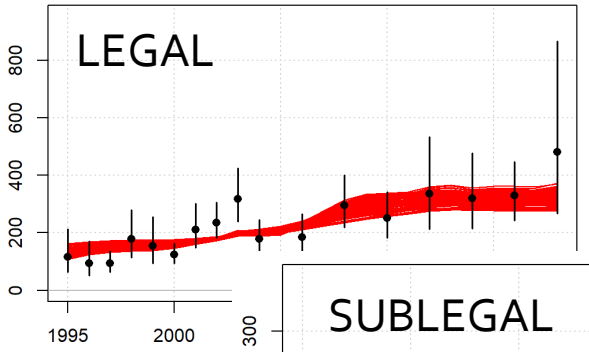
Fleet Catches

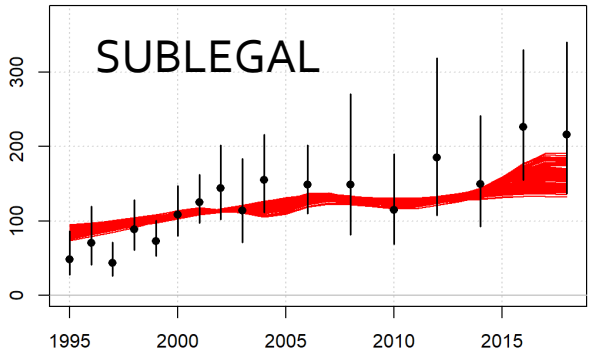


Nominal Fleet CPUE



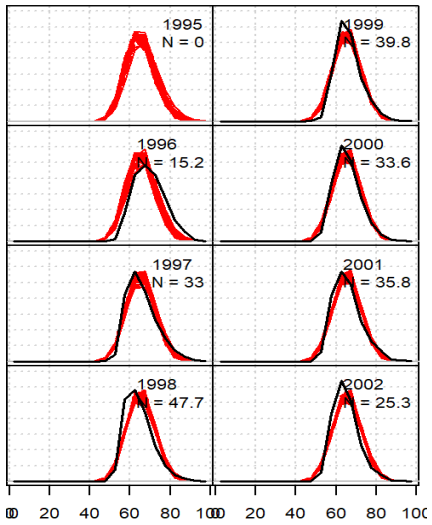
Survey relative biomass





Multispecies density

Fleet length composition data



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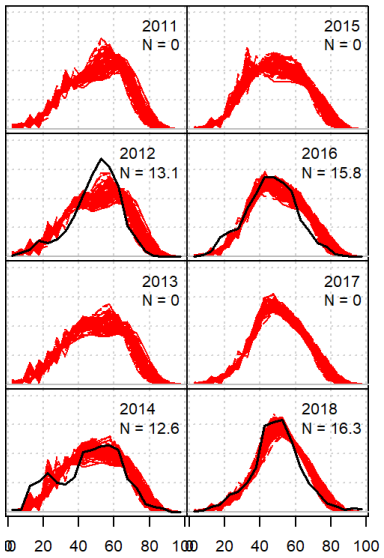
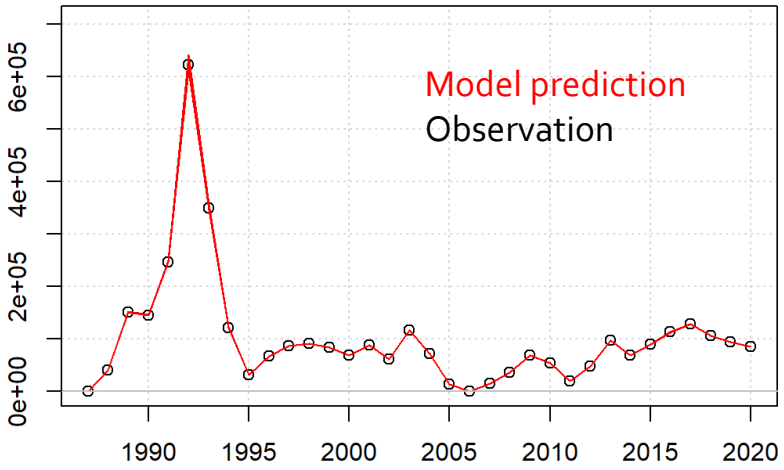


RCM (Rapid Conditioning Model of openMSE)

- Peer-reviewed statistical catch at age / length model
- Fits individual models (multiple red lines in figures above) given sampled parameter values for population and fishery dynamics such as M, steepness etc.)
- Creates an openMSE operating model for calculating reference points, evaluating harvest control rules, harvest strategies, data collection protocols etc.

Data Sources (Stat Areas 13, 18 & 20, 'Data Moderate')

Fleet Catches



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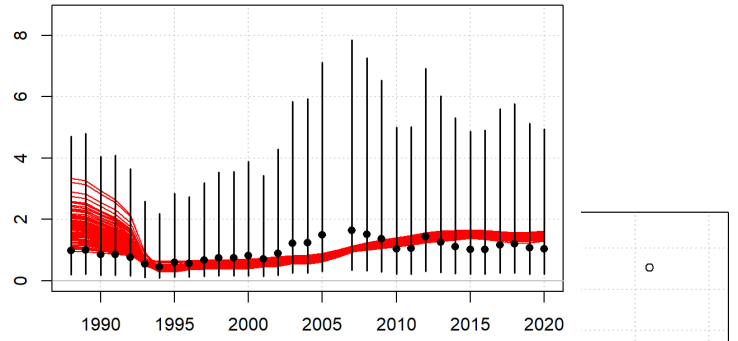

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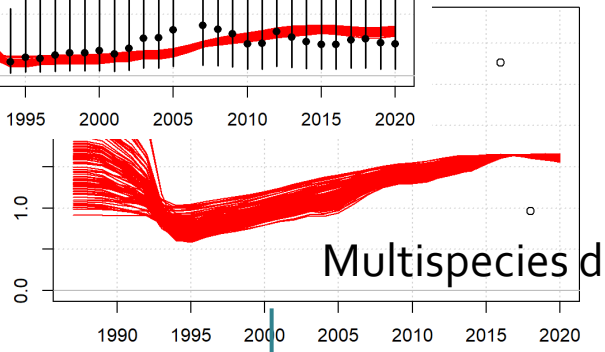
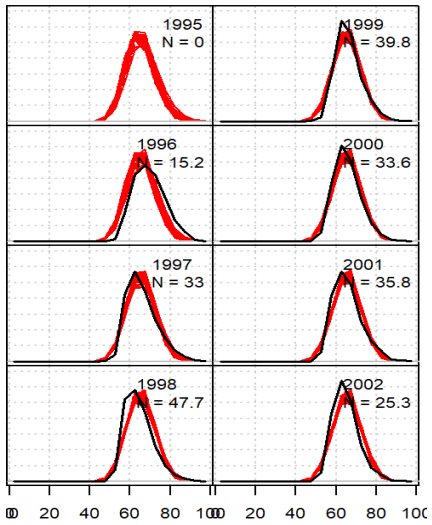


Other than a suspect nominal CPUE trend, there are no relative abundance time-series data for 15, 18 and 20.

Fleet length composition data



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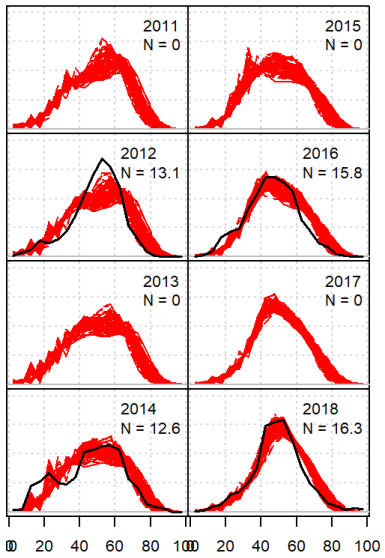
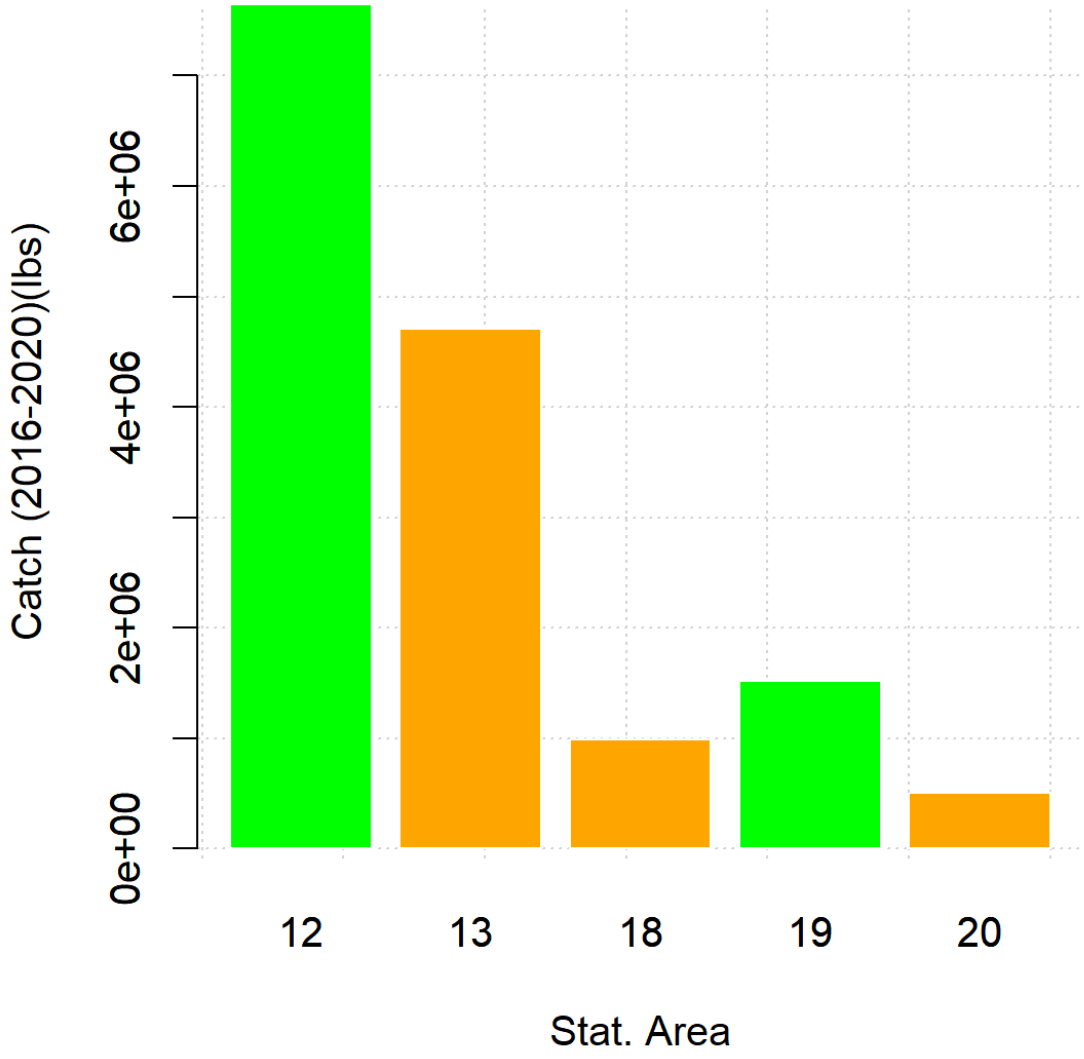
Survey length composition data



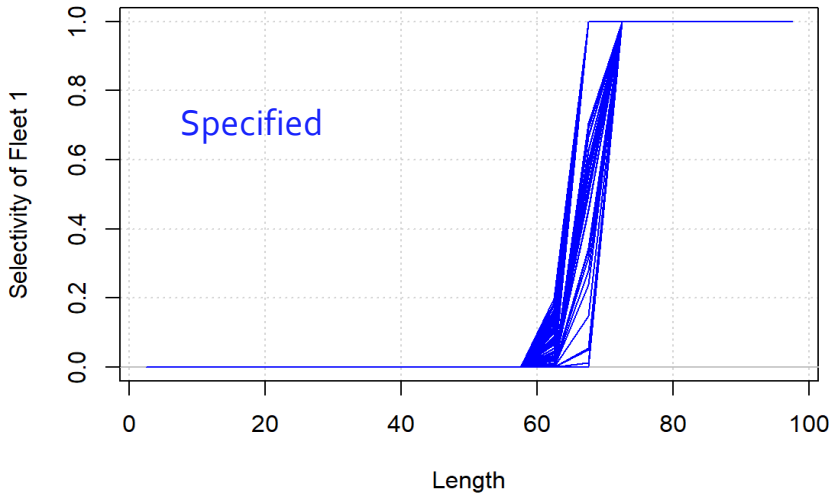
Recent catches & data

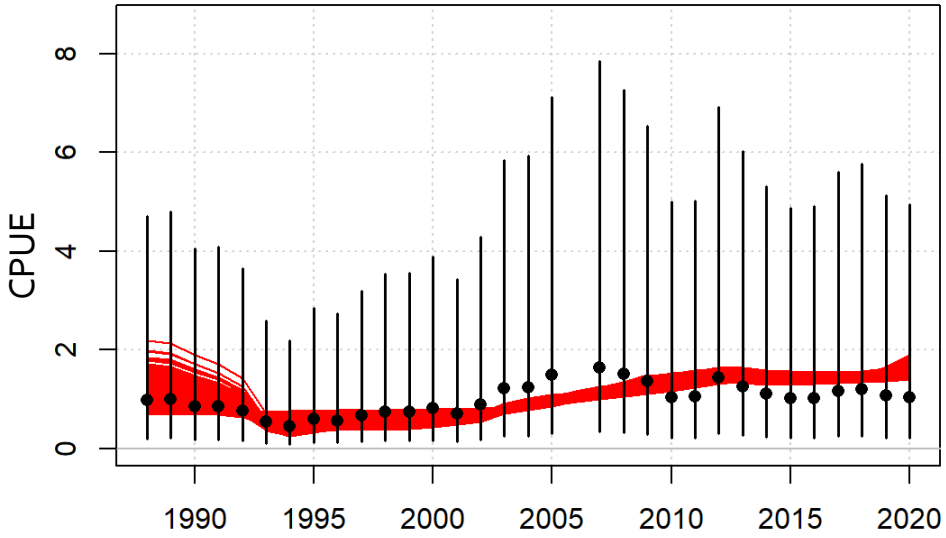


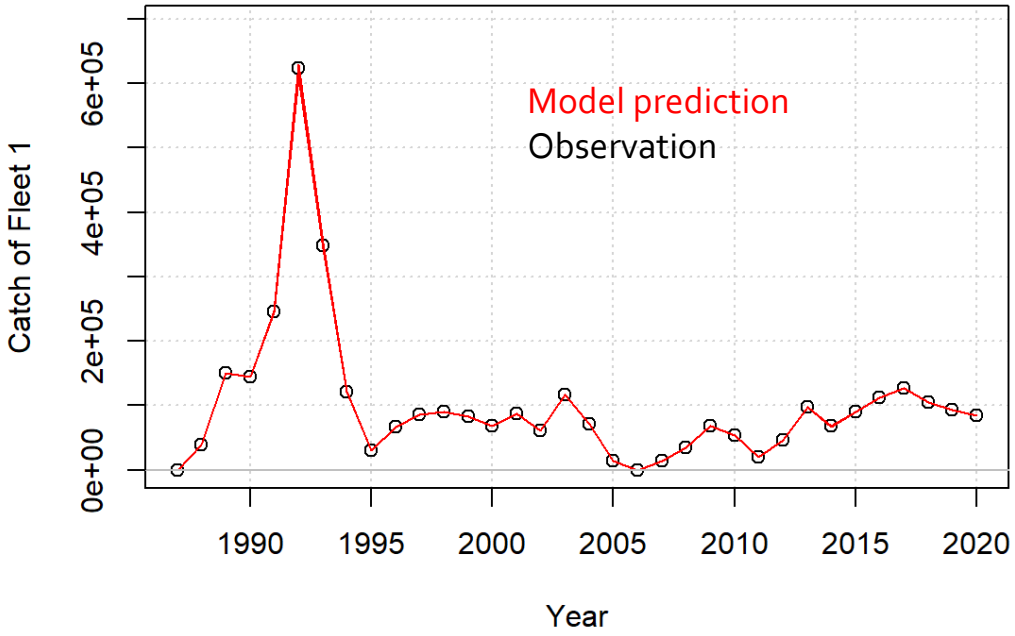
3. Revised Models

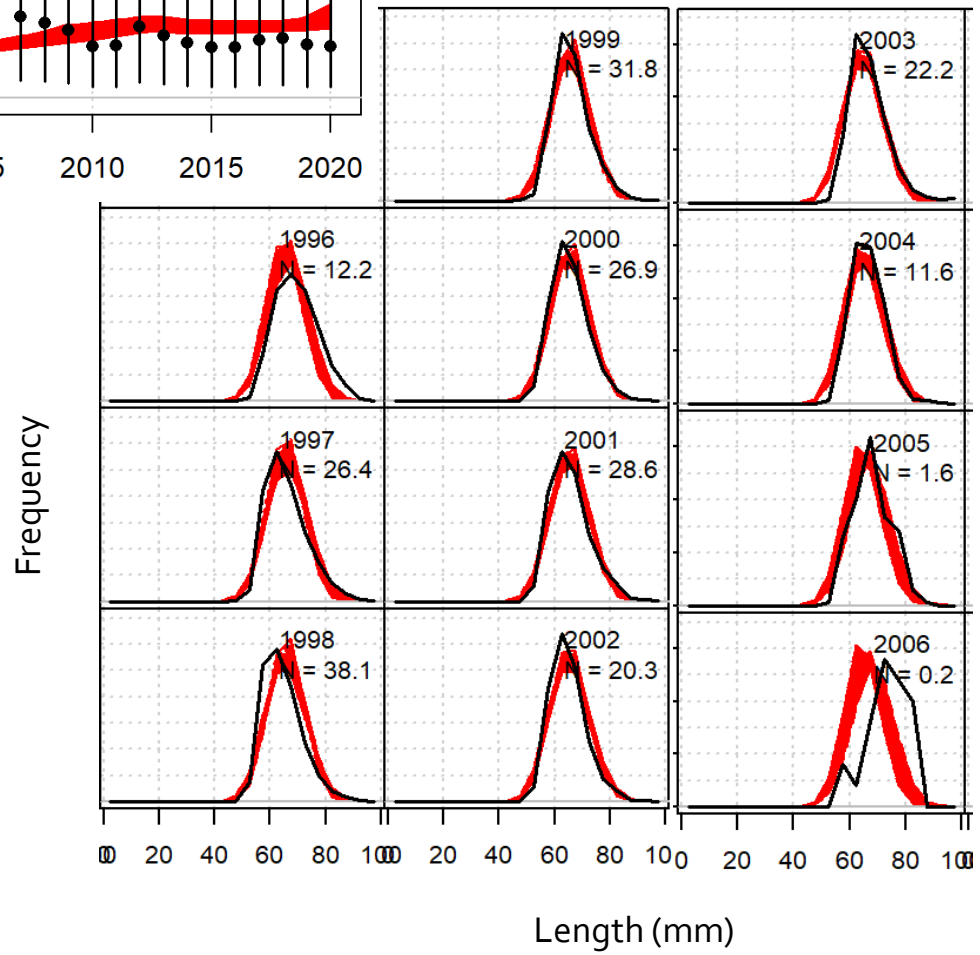
(Data Rich, Stat. Areas. 12 and 19)

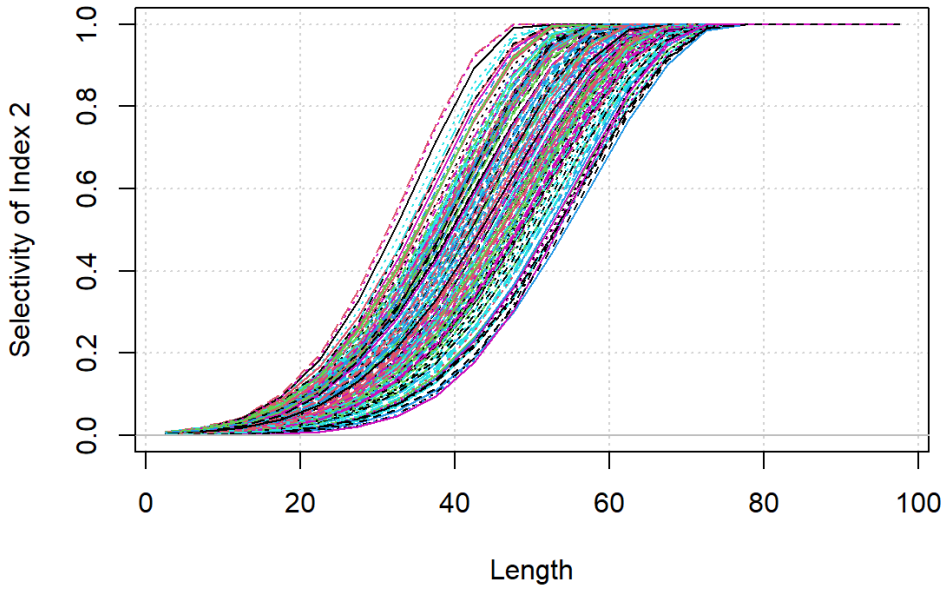
Stat Area 12 – model fit to fishery data

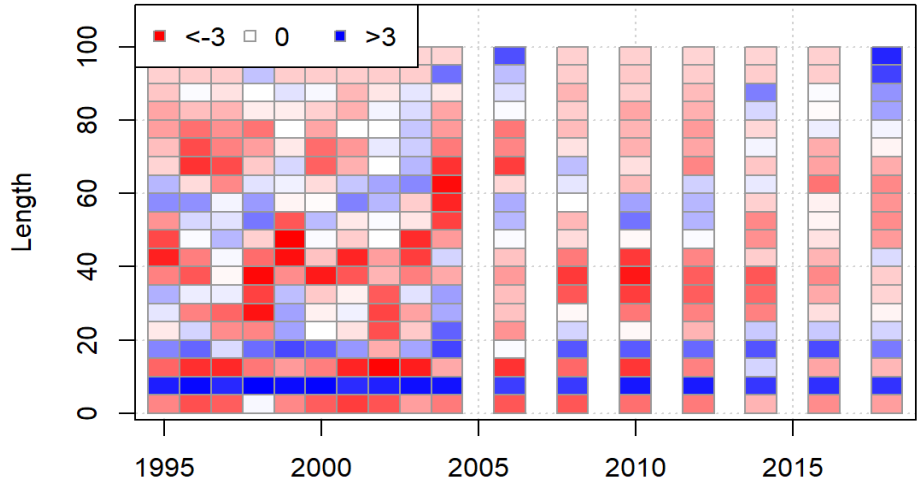




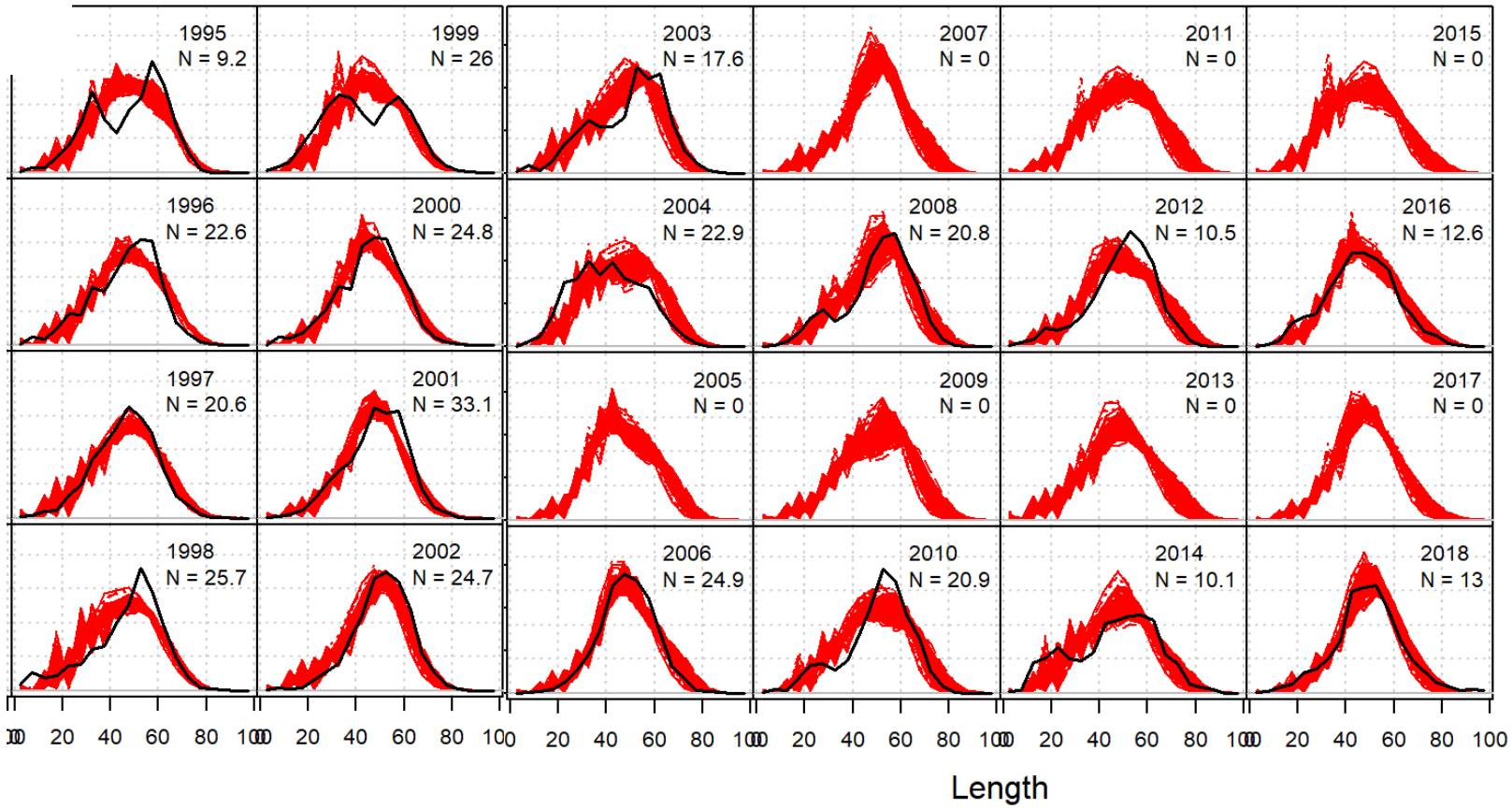




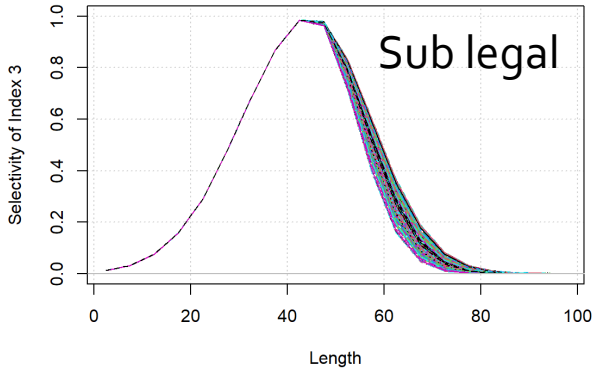


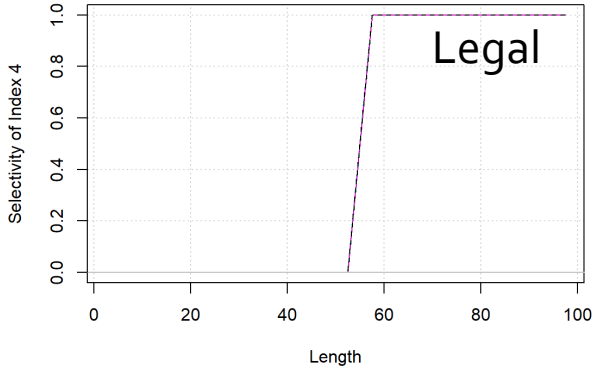


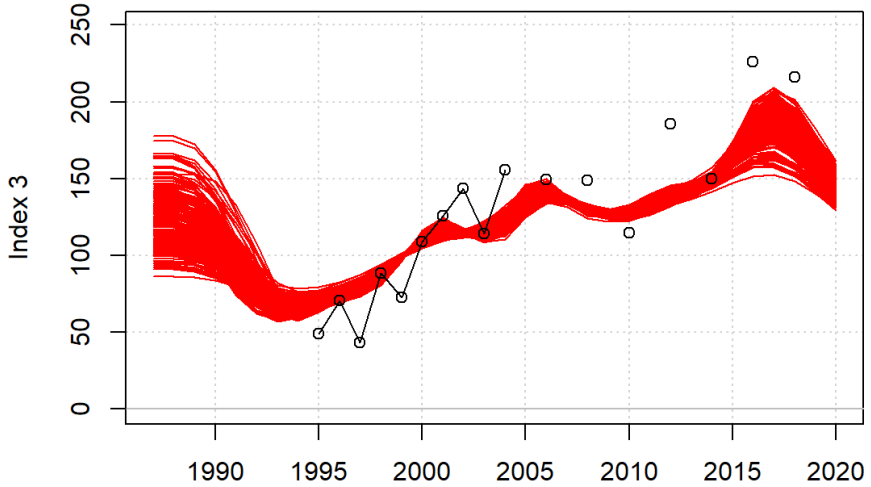
Stat Area 12 – model fit to survey length composition

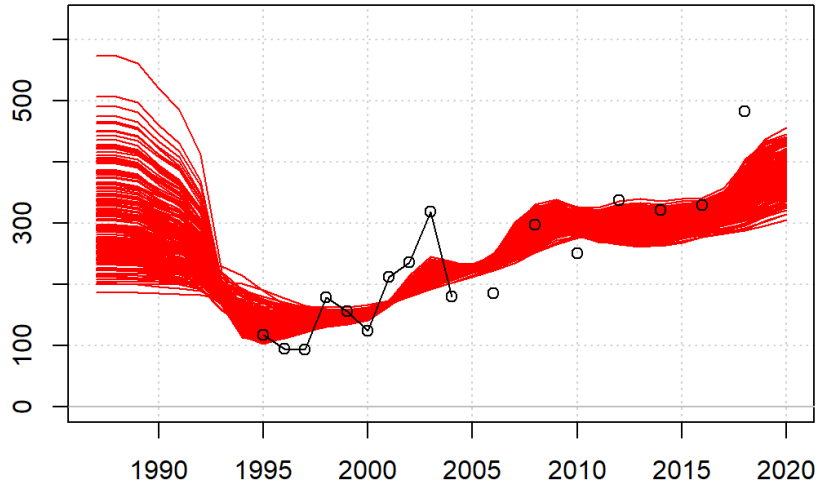


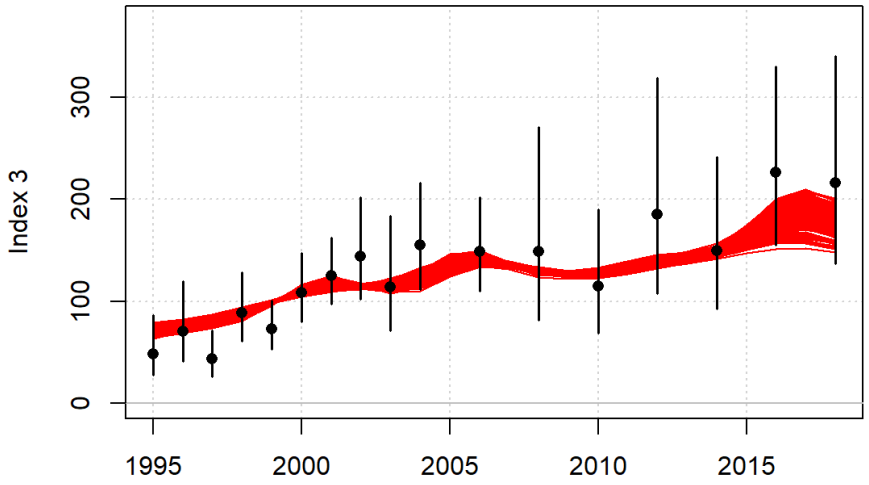
Stat Area 12 – model fit to survey indices

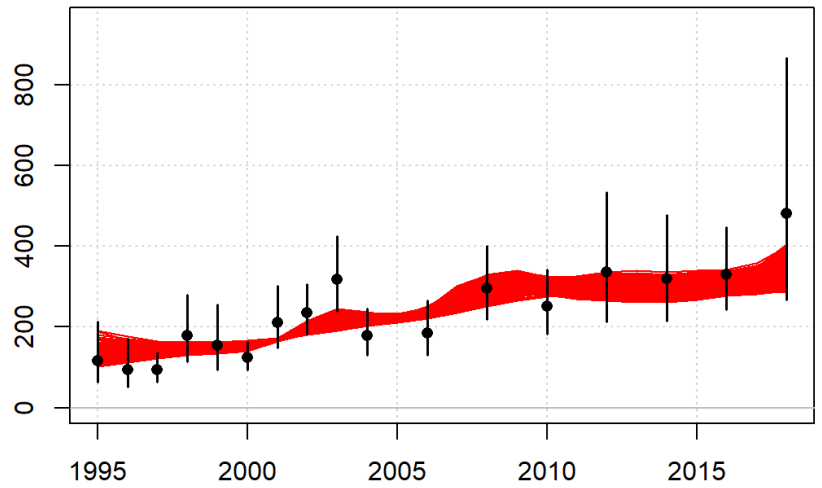




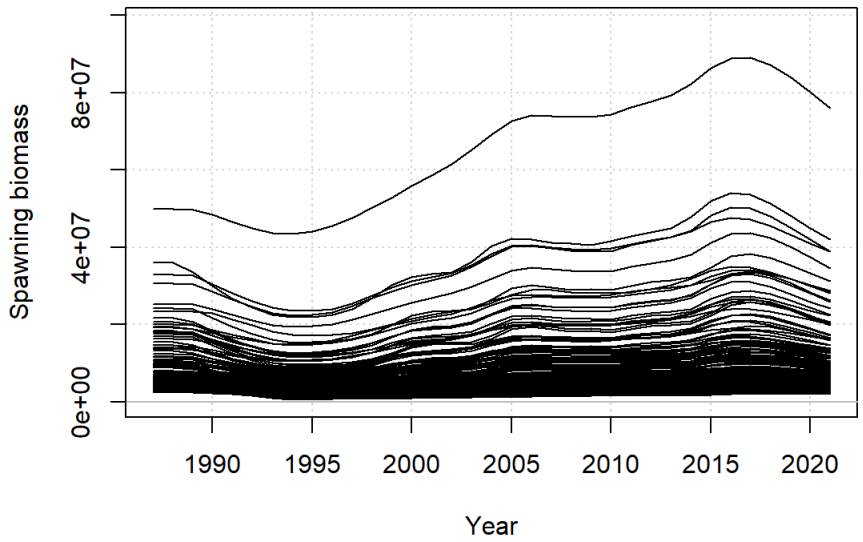


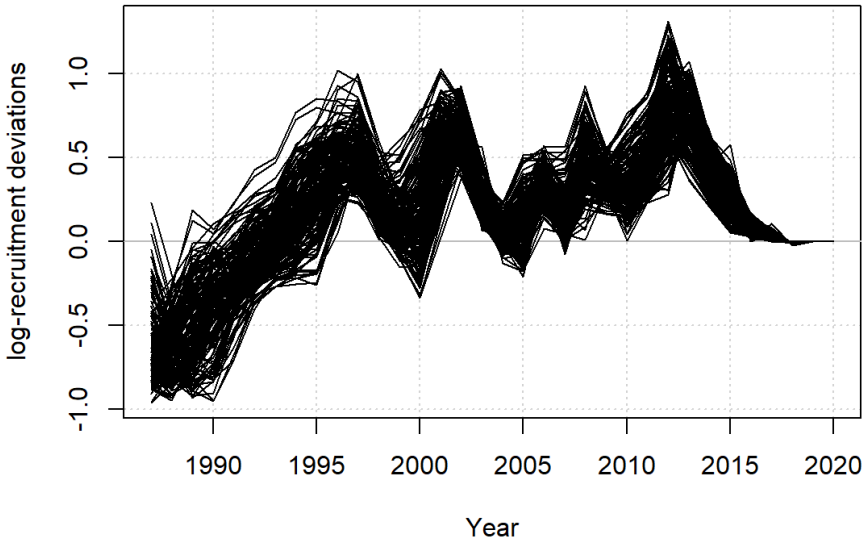


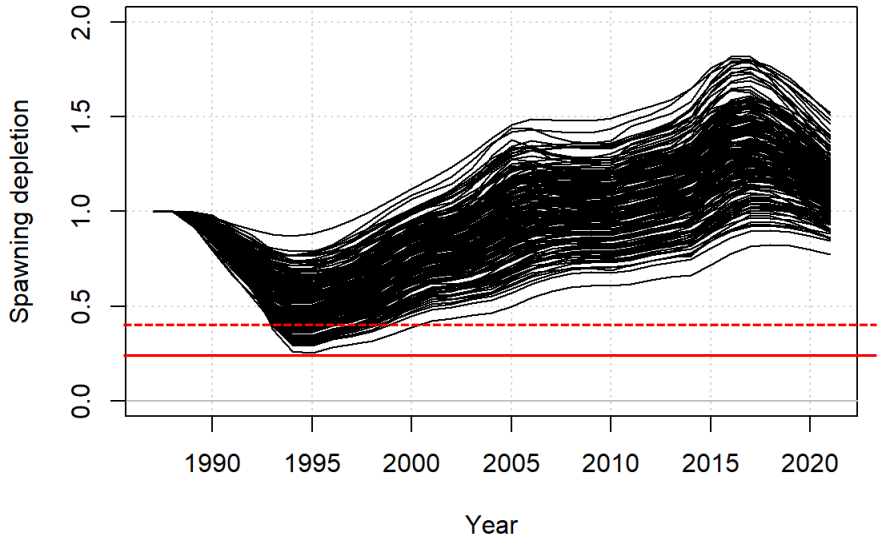


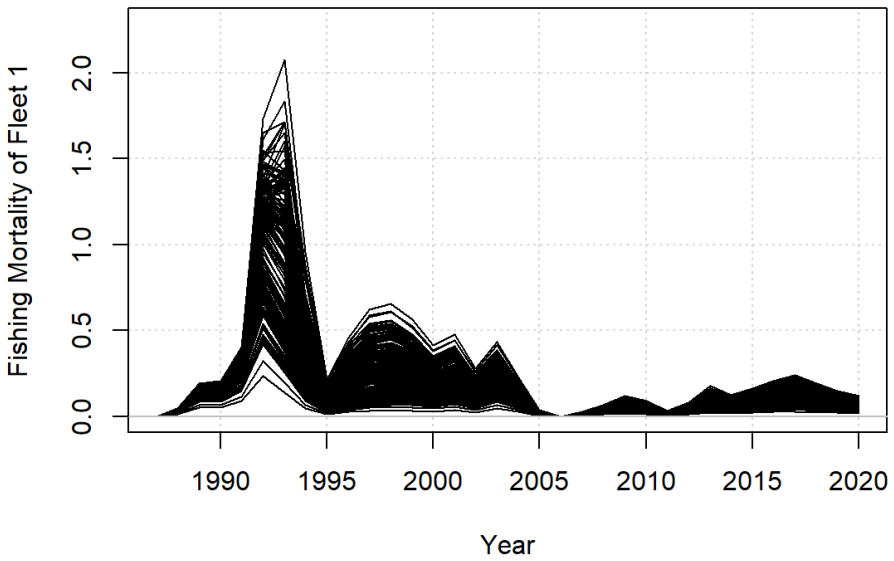


Stat Area 12 – model estimates

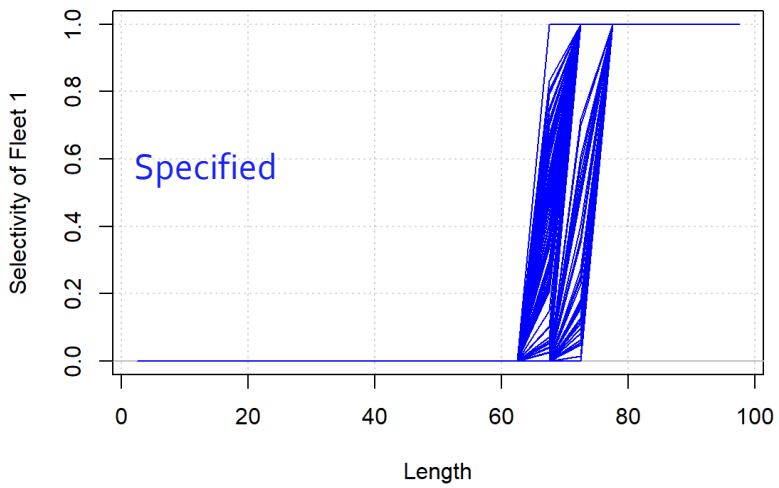


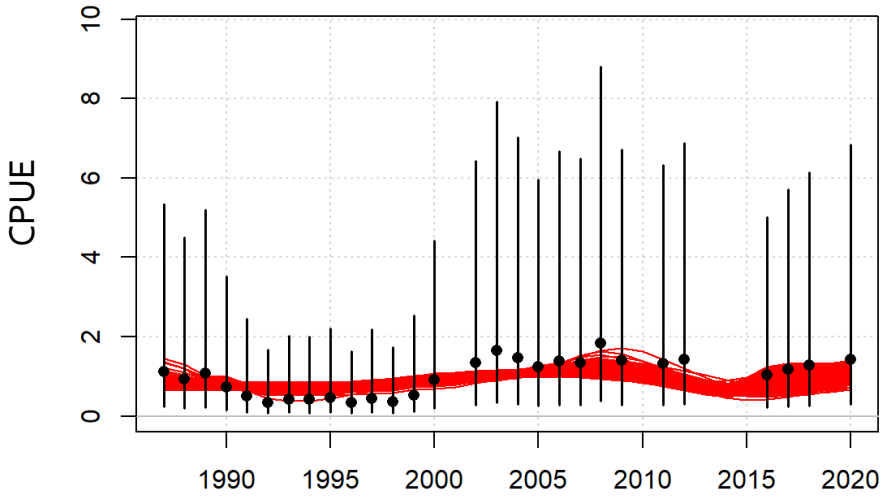


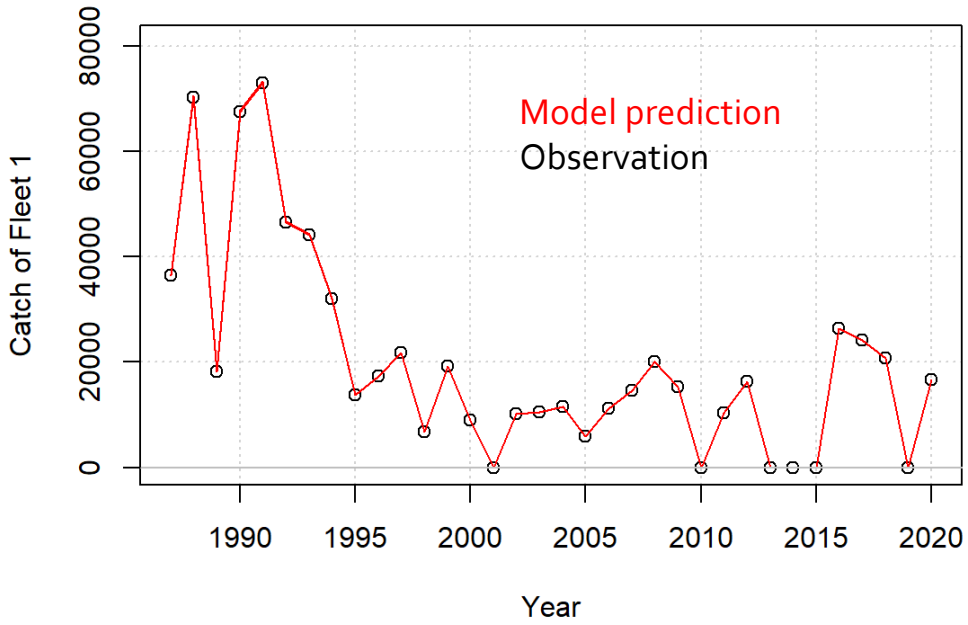


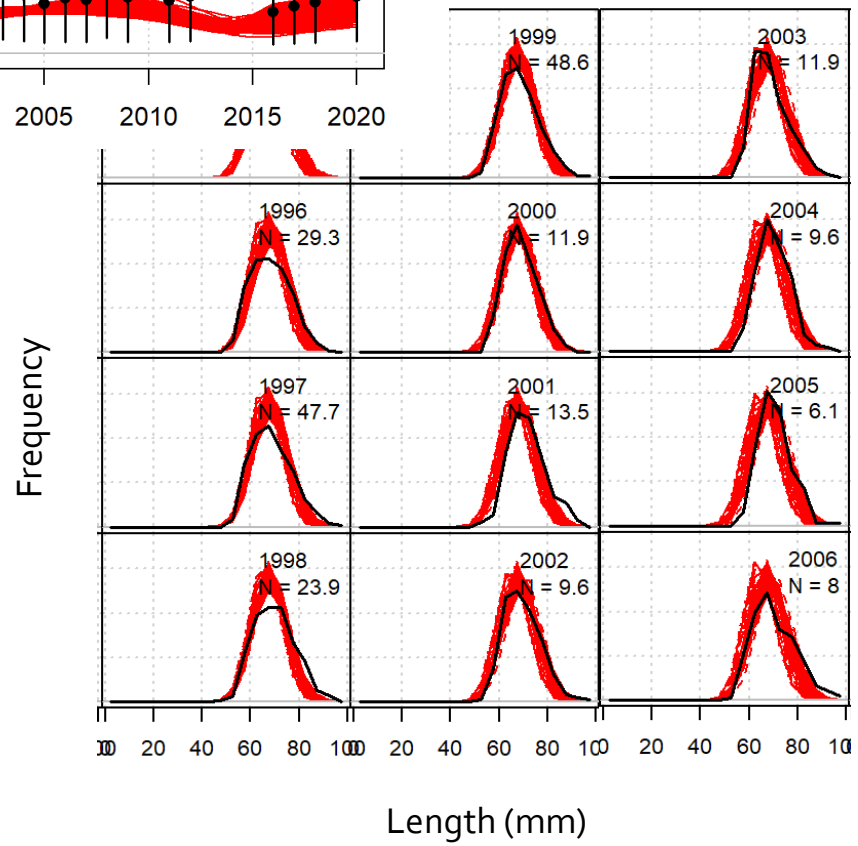


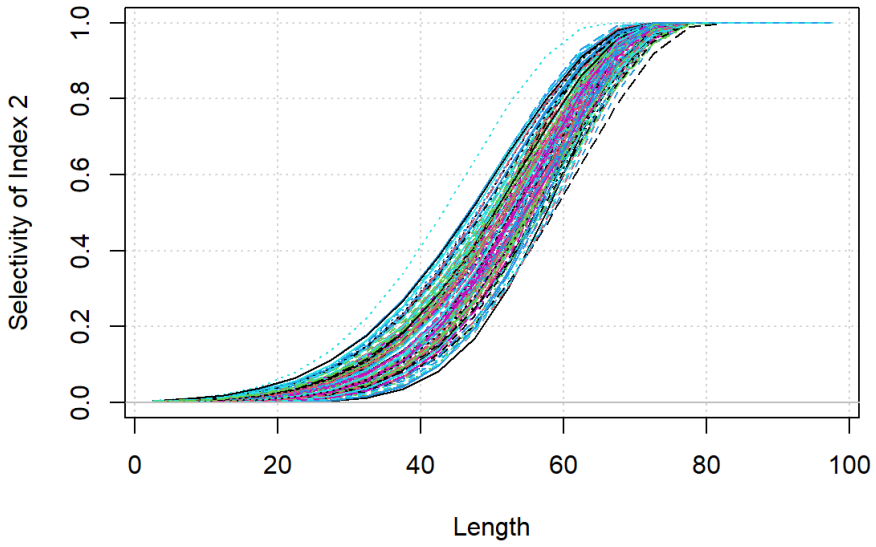
Stat Area 19 – model fit to fishery data

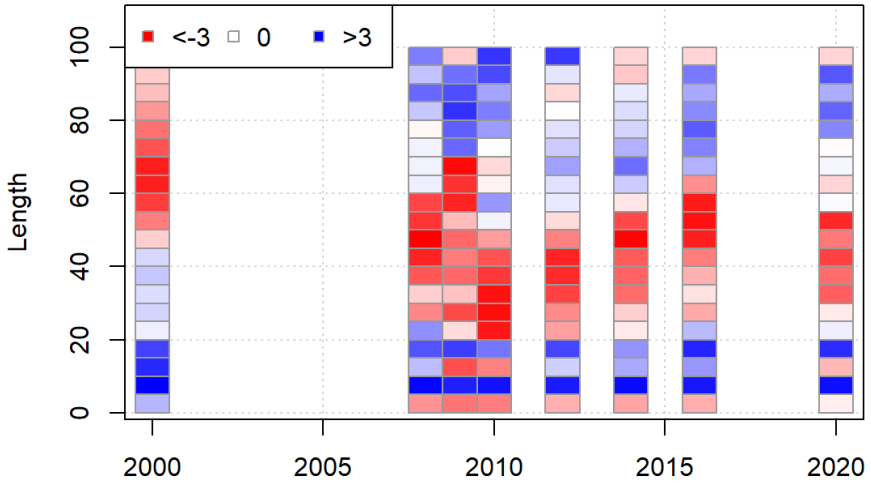




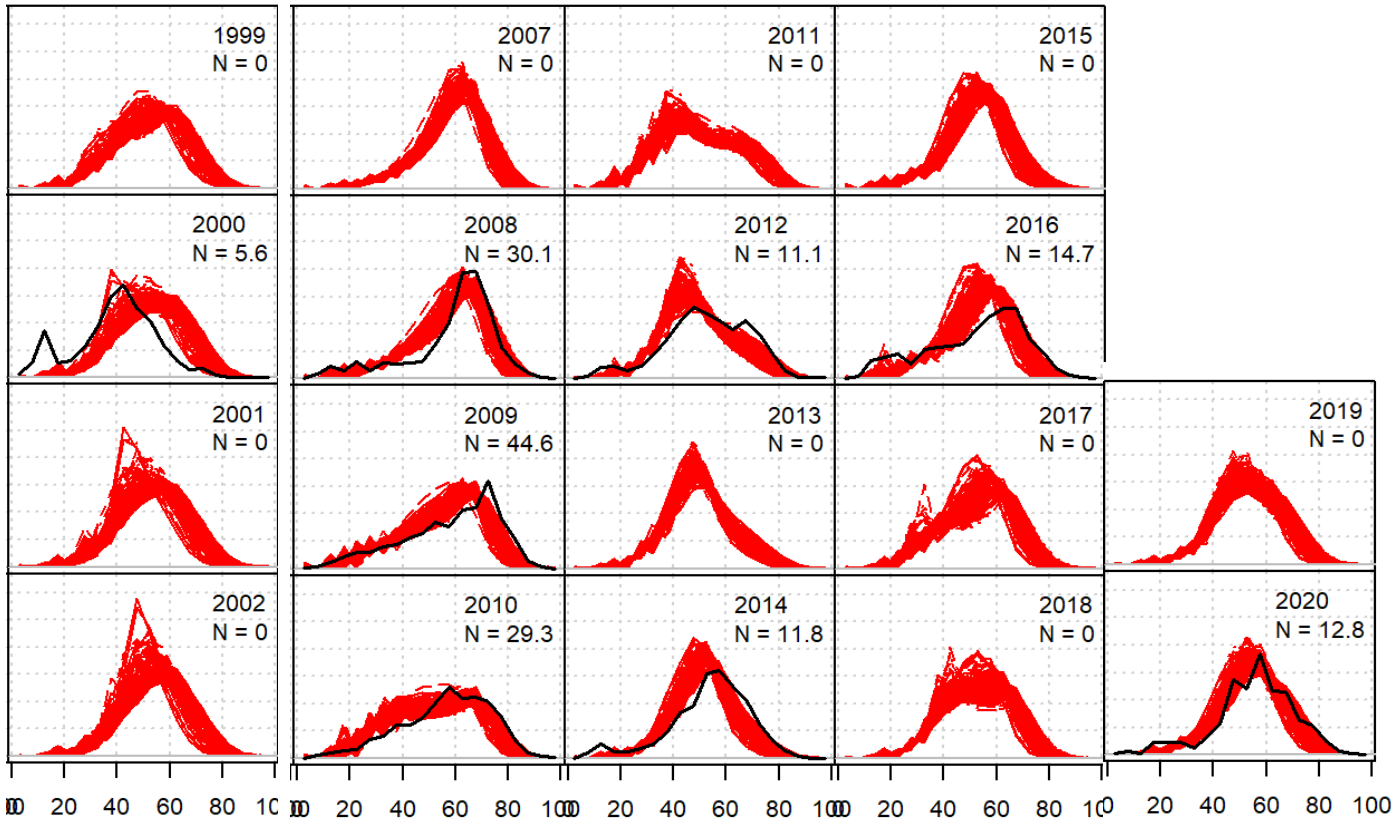




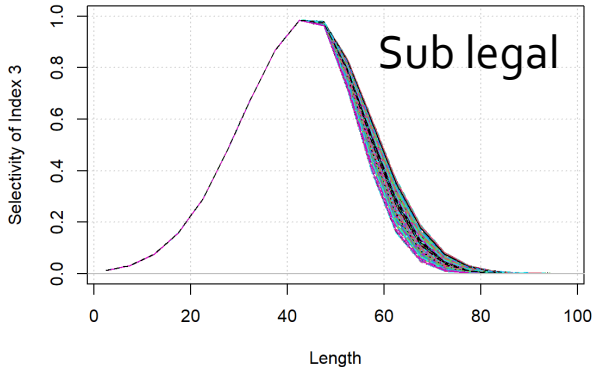


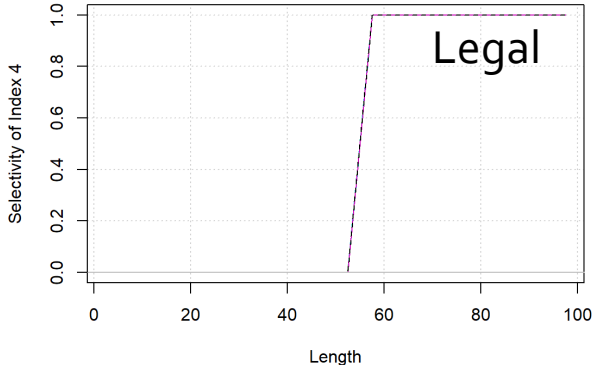


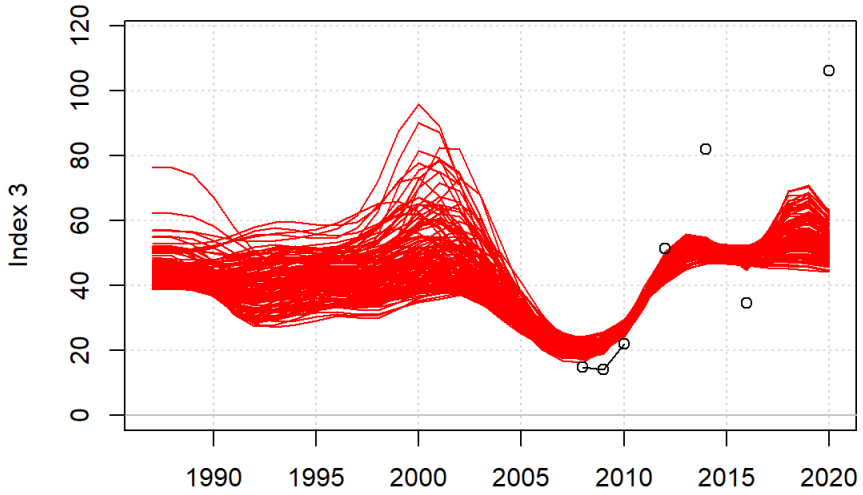
Stat Area 19 – model fit to survey length composition

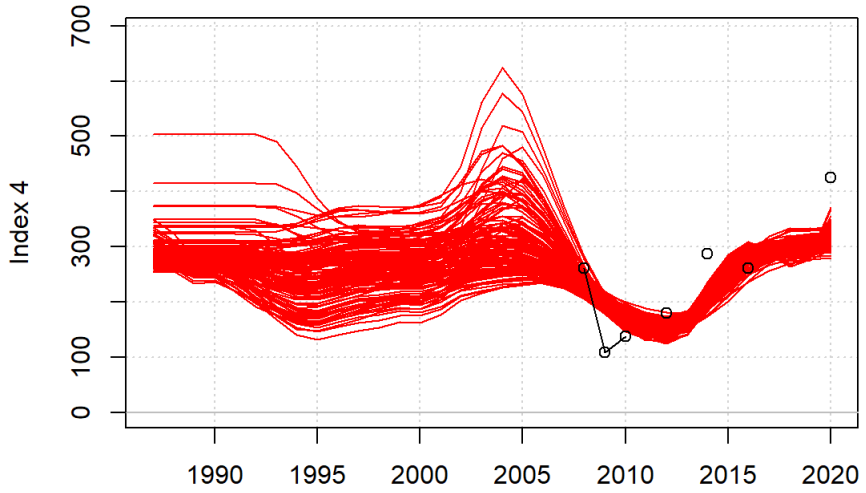


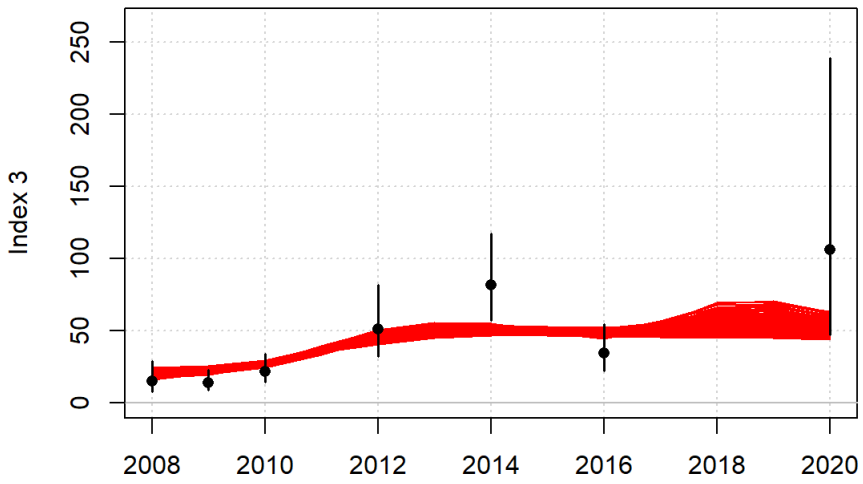
Stat Area 19 – model fit to survey indices

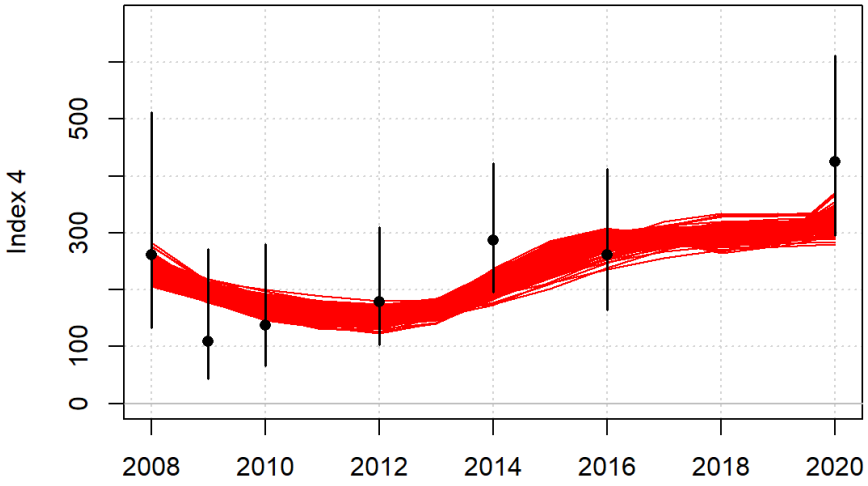




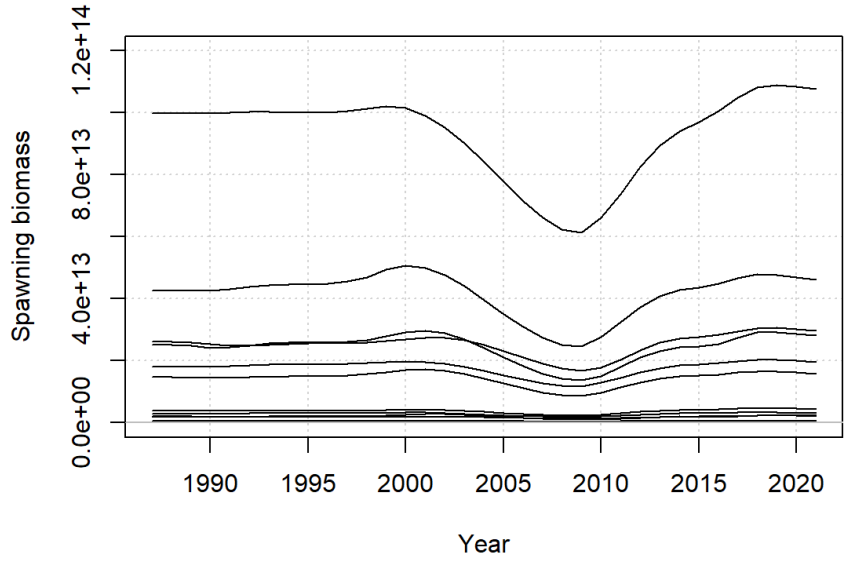


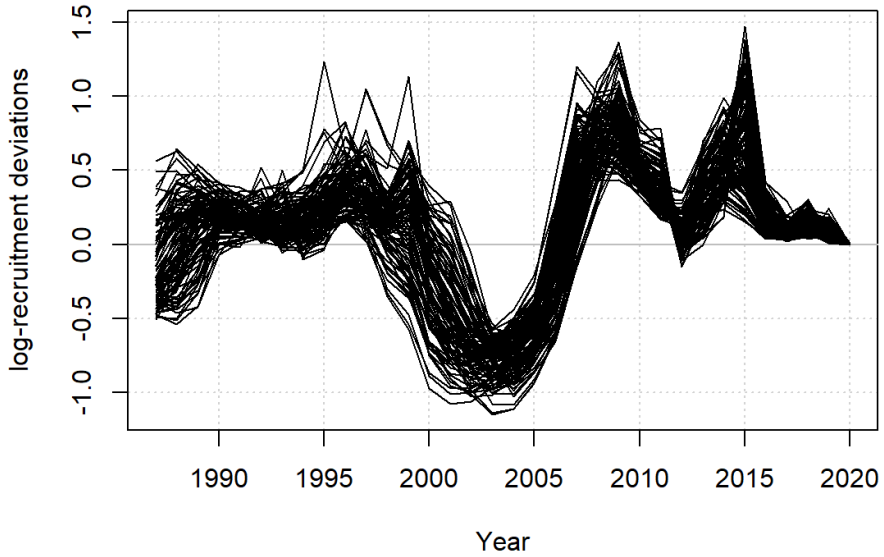


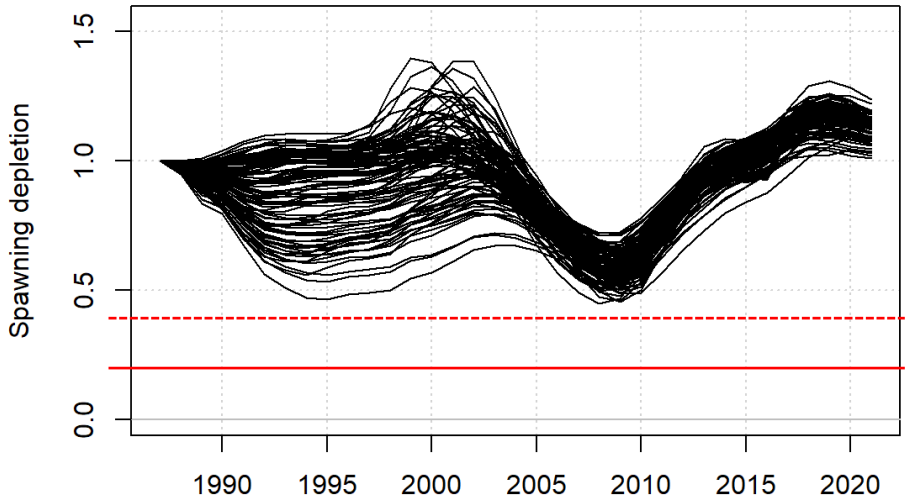


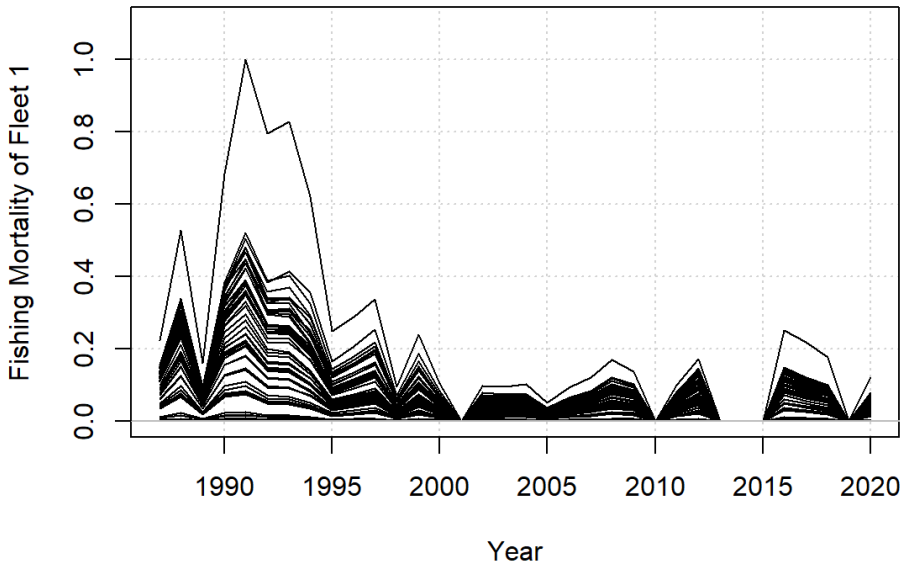


Stat Area 19 – model estimates









Stat area comparison

Stat	Depletion	SSBMSY / SSB0			UMSY			Current U relative to UMSY		
Area	Mean	Median	2.50%	97.50%	Median	2.50%	97.50%	Median	2.50%	97.50%
12	**1.41**	**0.63**	0.42	0.91	**0.61**	0.31	0.66	**0.10**	0.00	0.28
13	**0.67**	**0.67**	0.43	0.93	**0.64**	0.62	0.66	**0.65**	0.48	0.89
18	**0.68**	**0.61**	0.41	0.87	**0.59**	0.22	0.66	**0.00**	0.00	0.00
19	**0.98**	**0.71**	0.43	0.96	**0.63**	0.36	0.68	**0.02**	0.00	0.15
20	**0.59**	**0.63**	0.35	0.93	**0.58**	0.18	0.67	**0.00**	0.00	0.00

Precautionary input controls and reference points can mix poorly!

The higher the fishery selectivity the higher the BMSY reference level relative to unfished!

Stat. area 12 and 19 fitting results

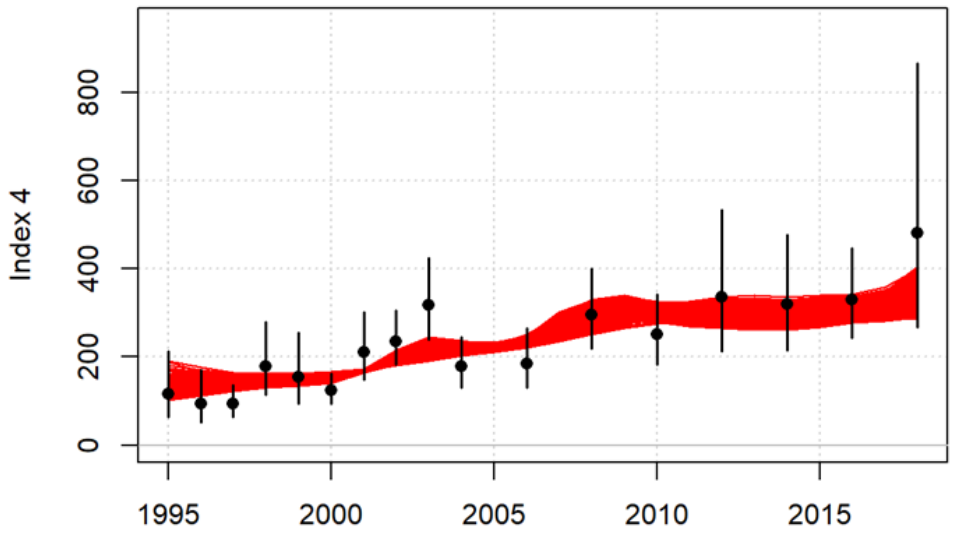
- Indices suggest increases in both sub legal and legal biomass following high exploitation rates
- Exploitation rates are estimated to be extremely high (biomass low) in some simulations (implausibly so?)
- Absolute biomass is very uncertain – the increasing biomass trends are explained by catches but, in some simulations, by recruitment deviations (which does not inform scale)
- Stock status is much more certain, and likely to be healthy in both areas.

Improvements

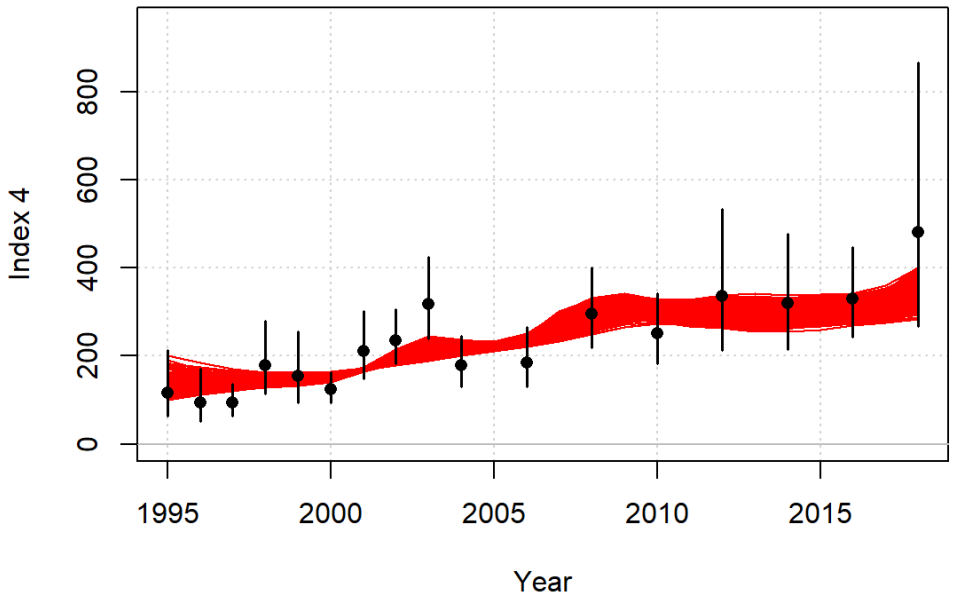
- Latest harvest log data
- Currently we are missing a longer time series of relative abundance and size data are weakly informative about stock status – are standardized CPUE an option?
- Prior on biomass (scale) or current exploitation rate, to very approximately constrain model. We have density in 12 and 19 - is there no prior info on habitat area (very approximately)?
- Limits on annual exploitation rate (what is the maximum fraction of urchin that have been caught in each area)?
- Length class 1 – 2 (5 – 10 mm): remove from estimation?
- Investigate fitting diagnostics for higher steepness values
- More representative M/K ratio (I think it used Fishbase phylum *Echinodermata* rather than family *Echinidae*)

Area 12, steepness impact on fit (negligible).

Steepness (0.4 – 0.7)

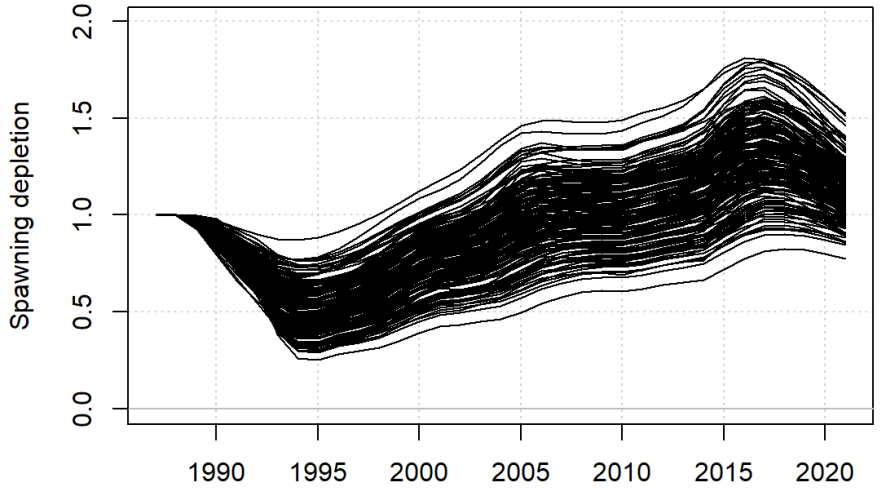


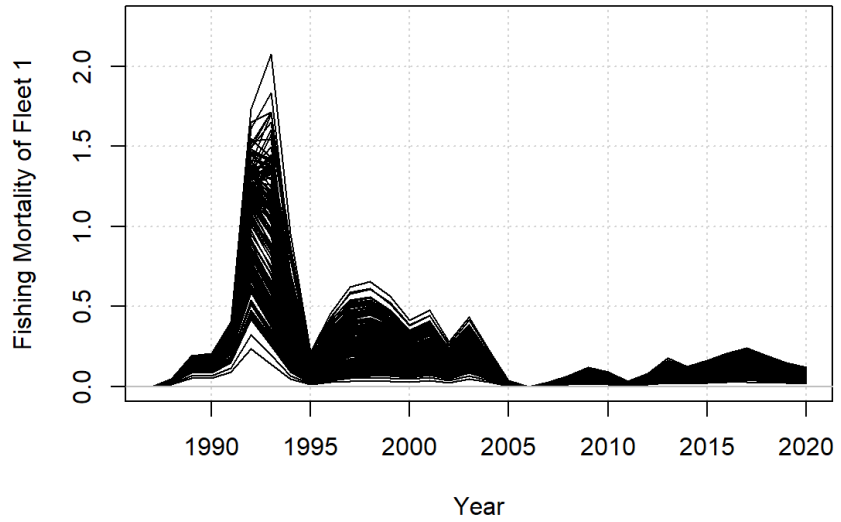
Steepness (0.8 – 0.95)



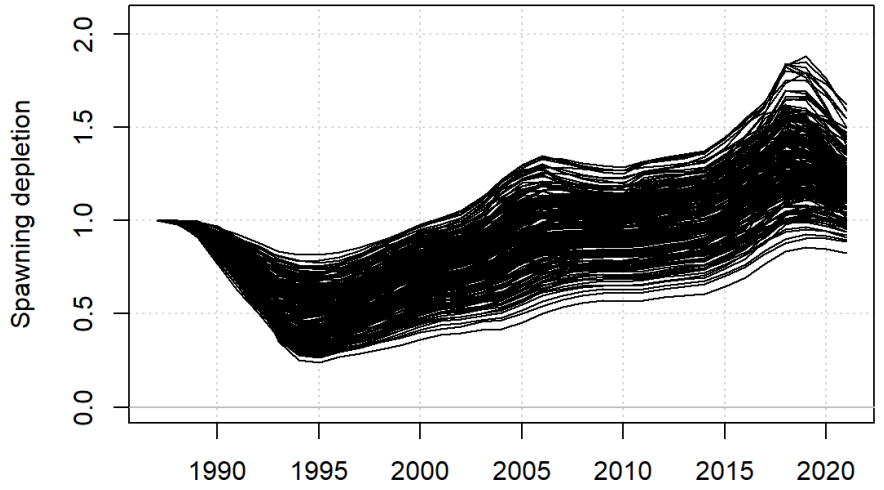
Aggregating stat areas

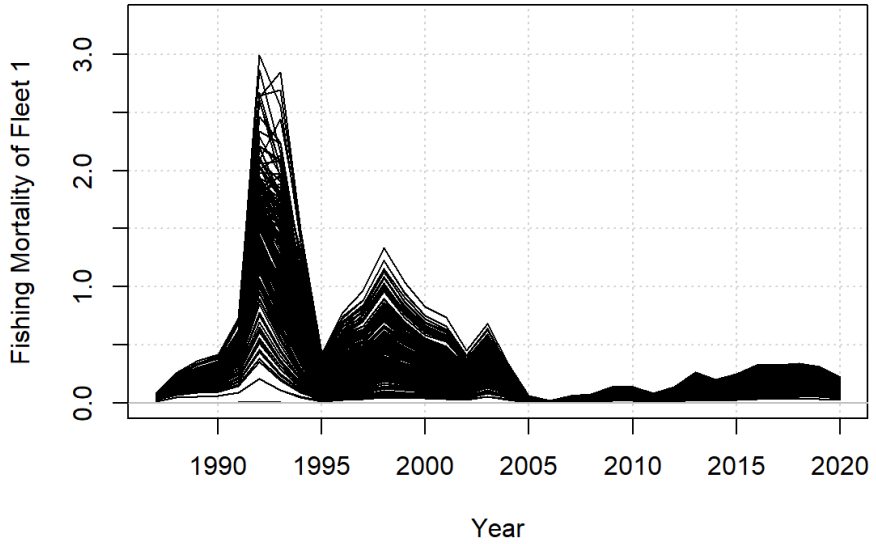
Area 12 only



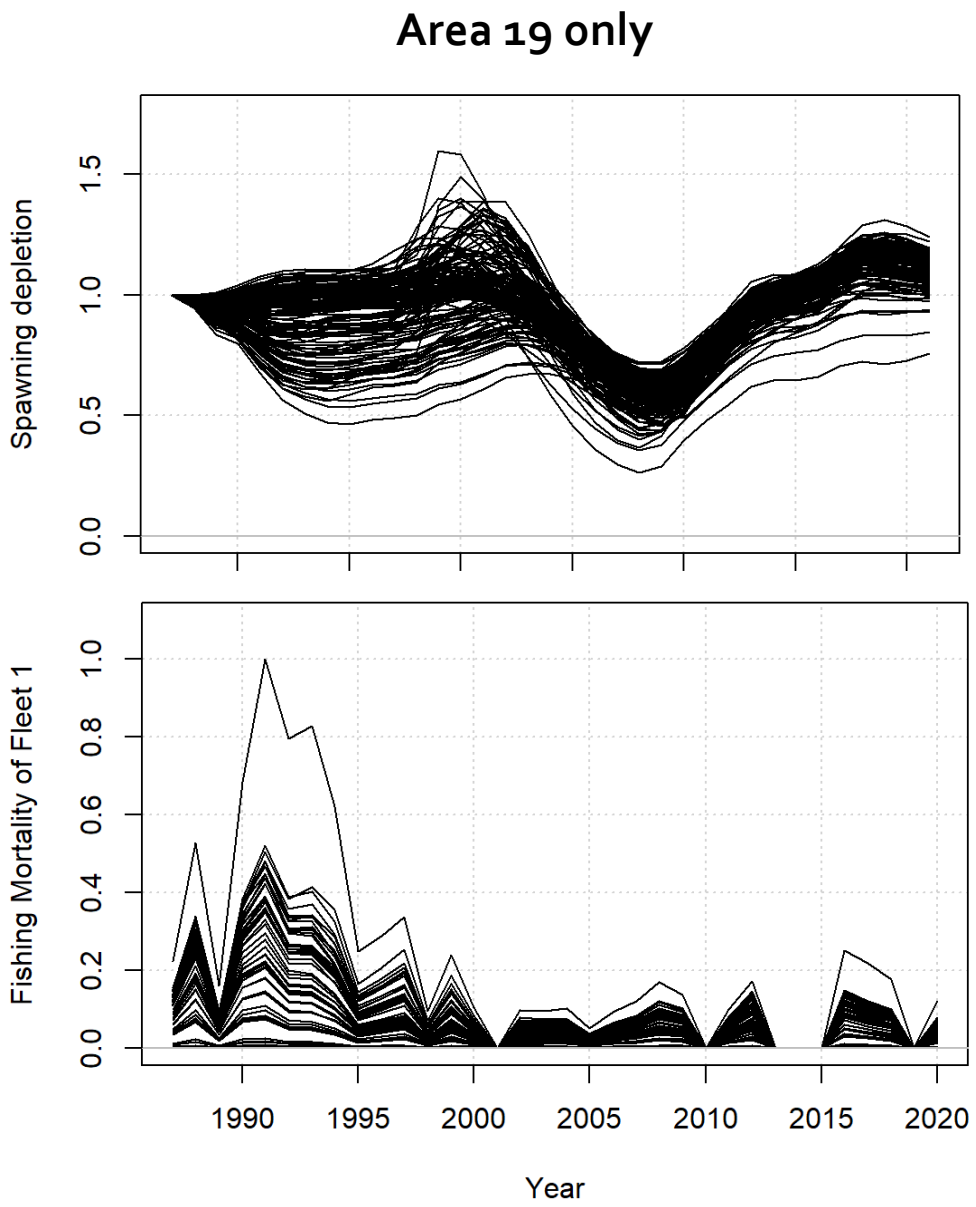


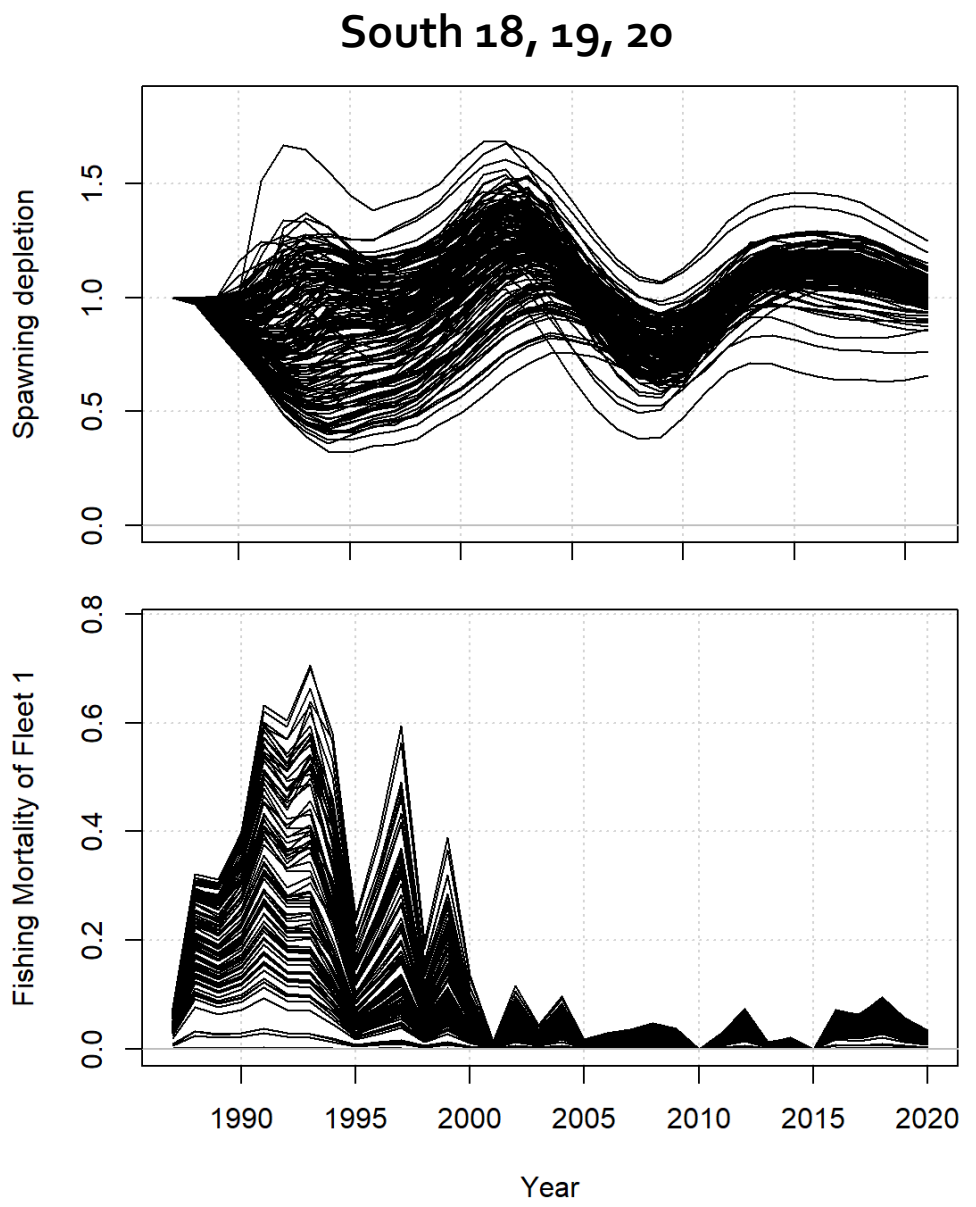
North 12 & 13





Aggregating stat areas





4. Example uses

Density based Harvest Control Rules

Size limits

Sketching natural survival scenarios

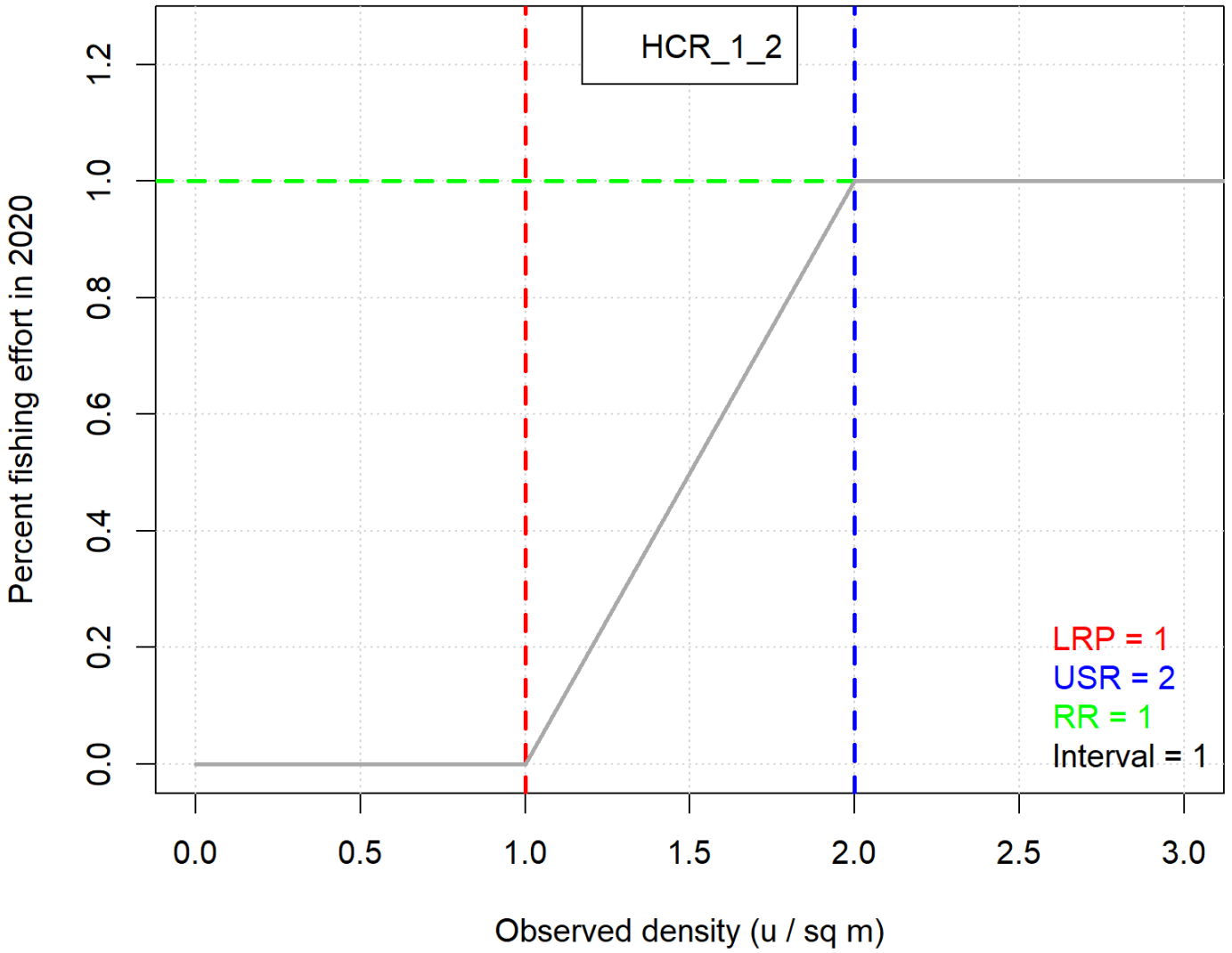
Density based harvest control rules

Year	Historical density observation
2016	2.767
2018	0.961

Simulated density observations are generated in the future by scaling to 'true' simulated historical stock numbers.

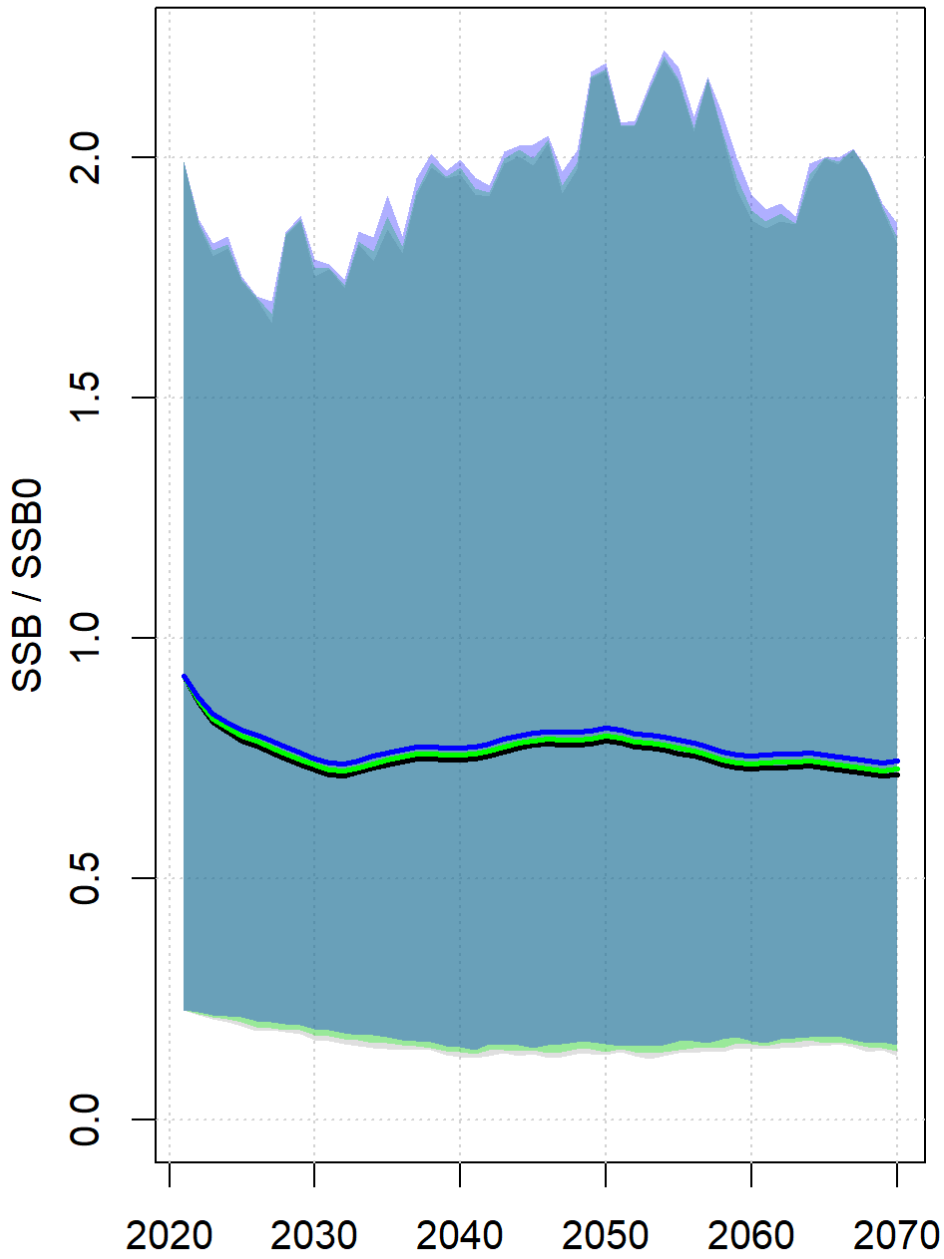
Four MPs were defined with varying density control points:

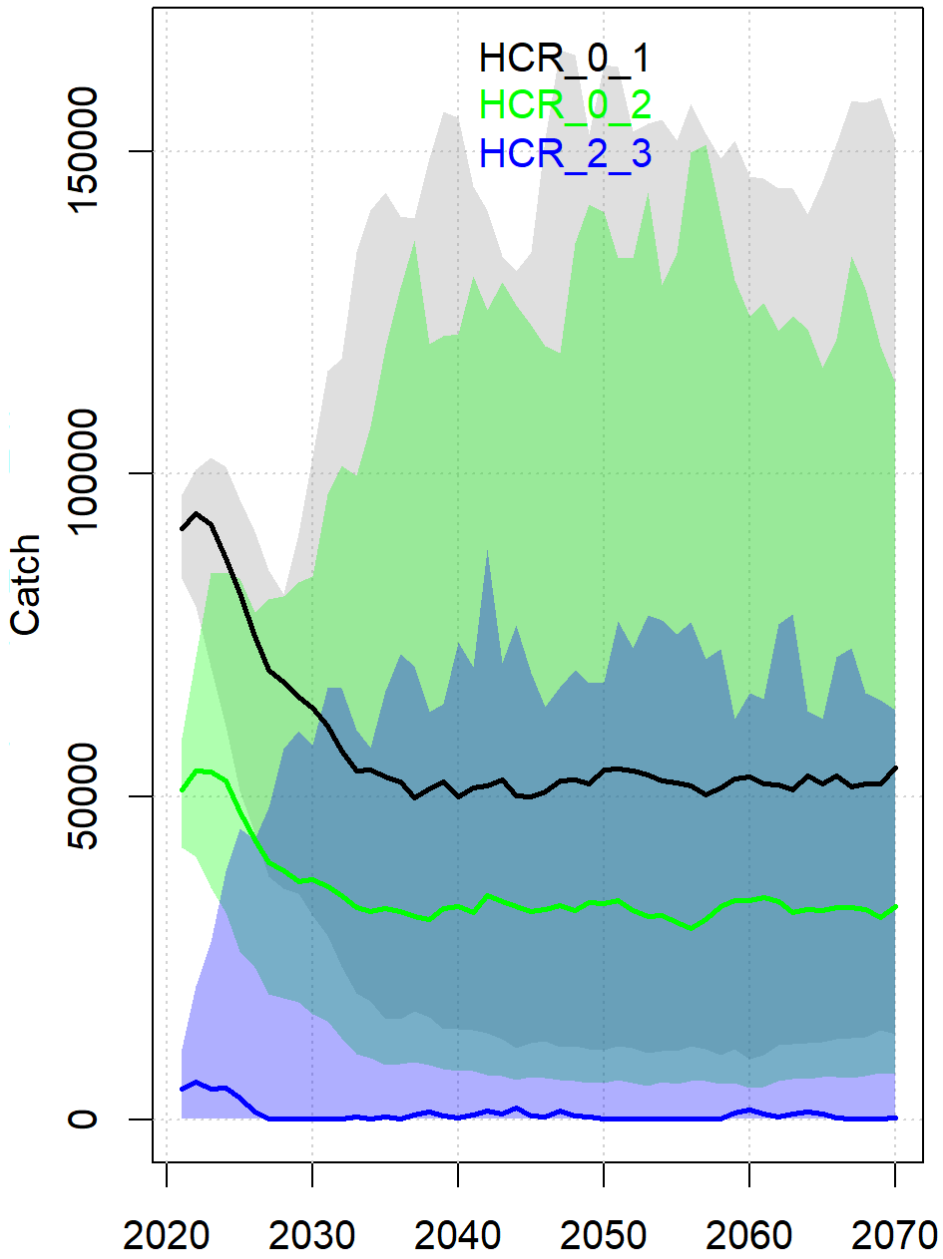
HCR_0_1
HCR_0_2
HCR_1_2
HCR_2_3



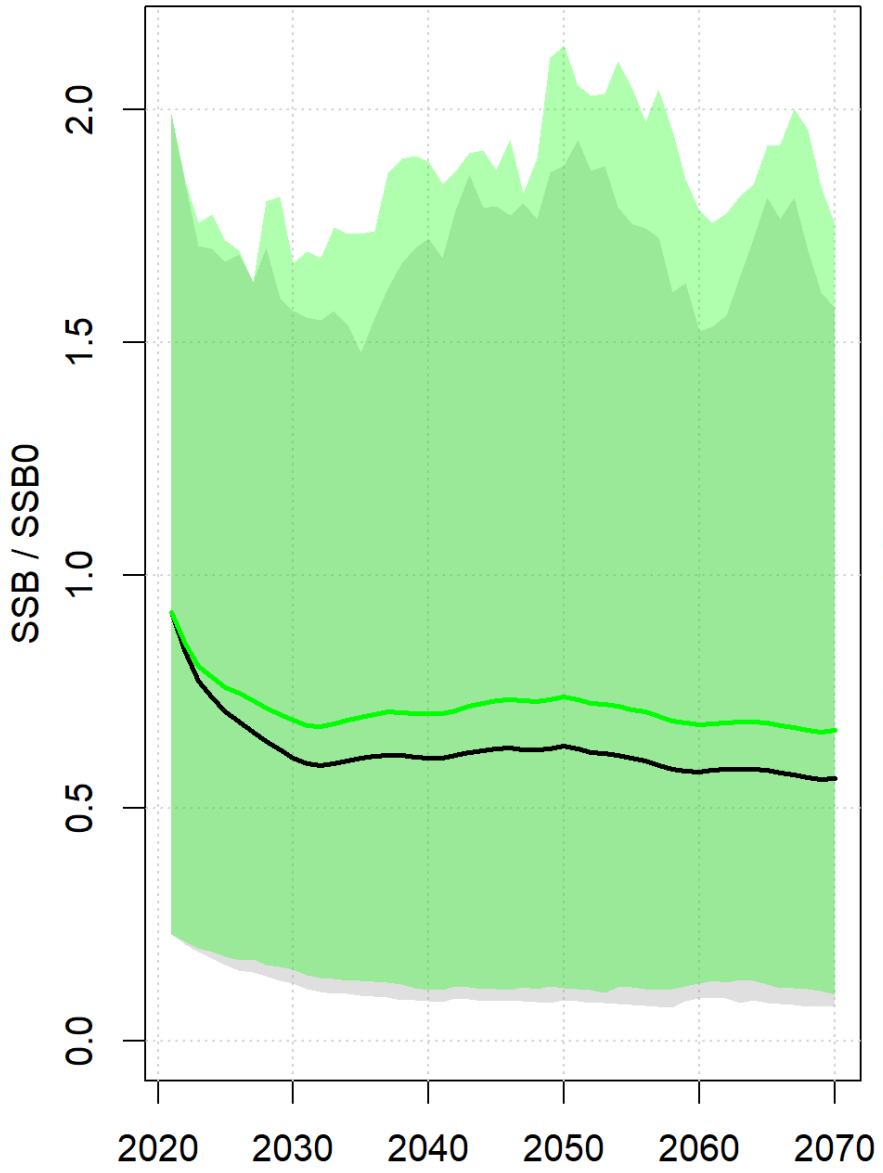
50-year projection for area 12

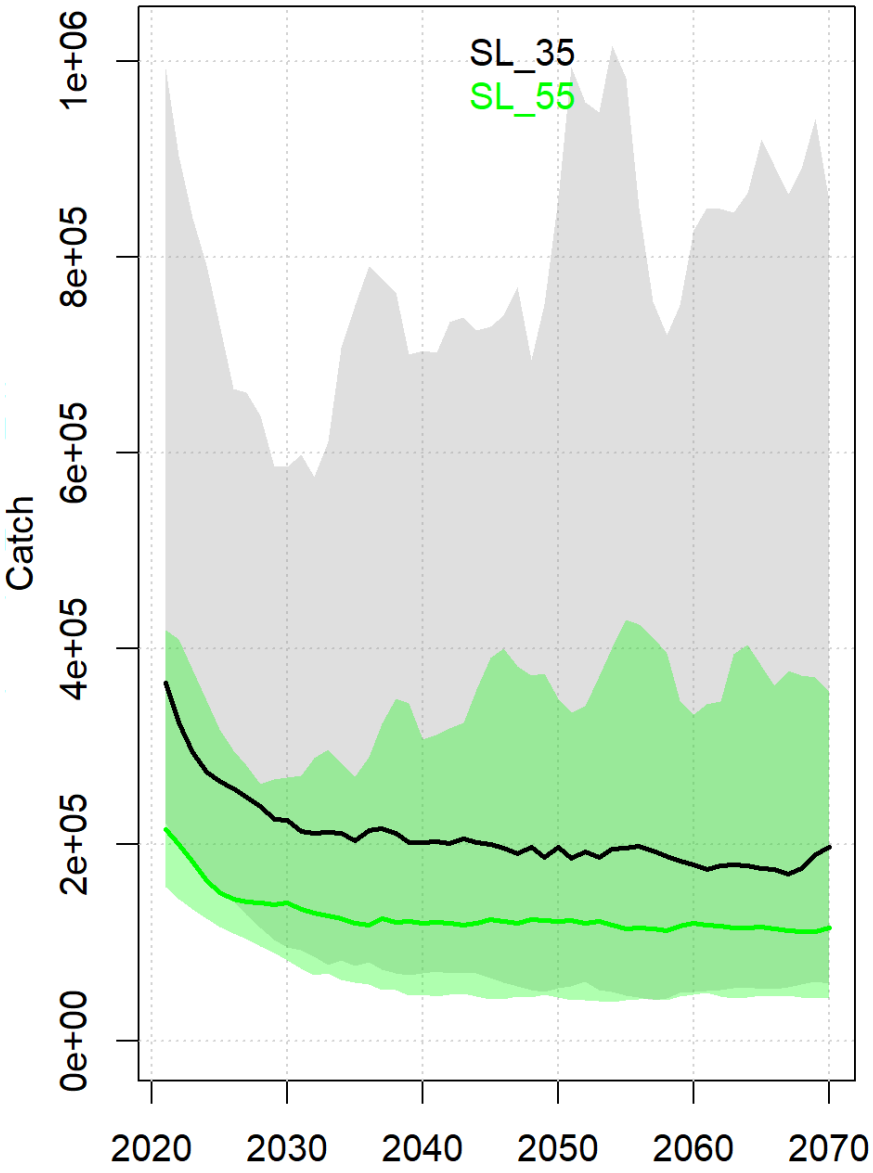
Strong implications for catch, very little implication for stock status.





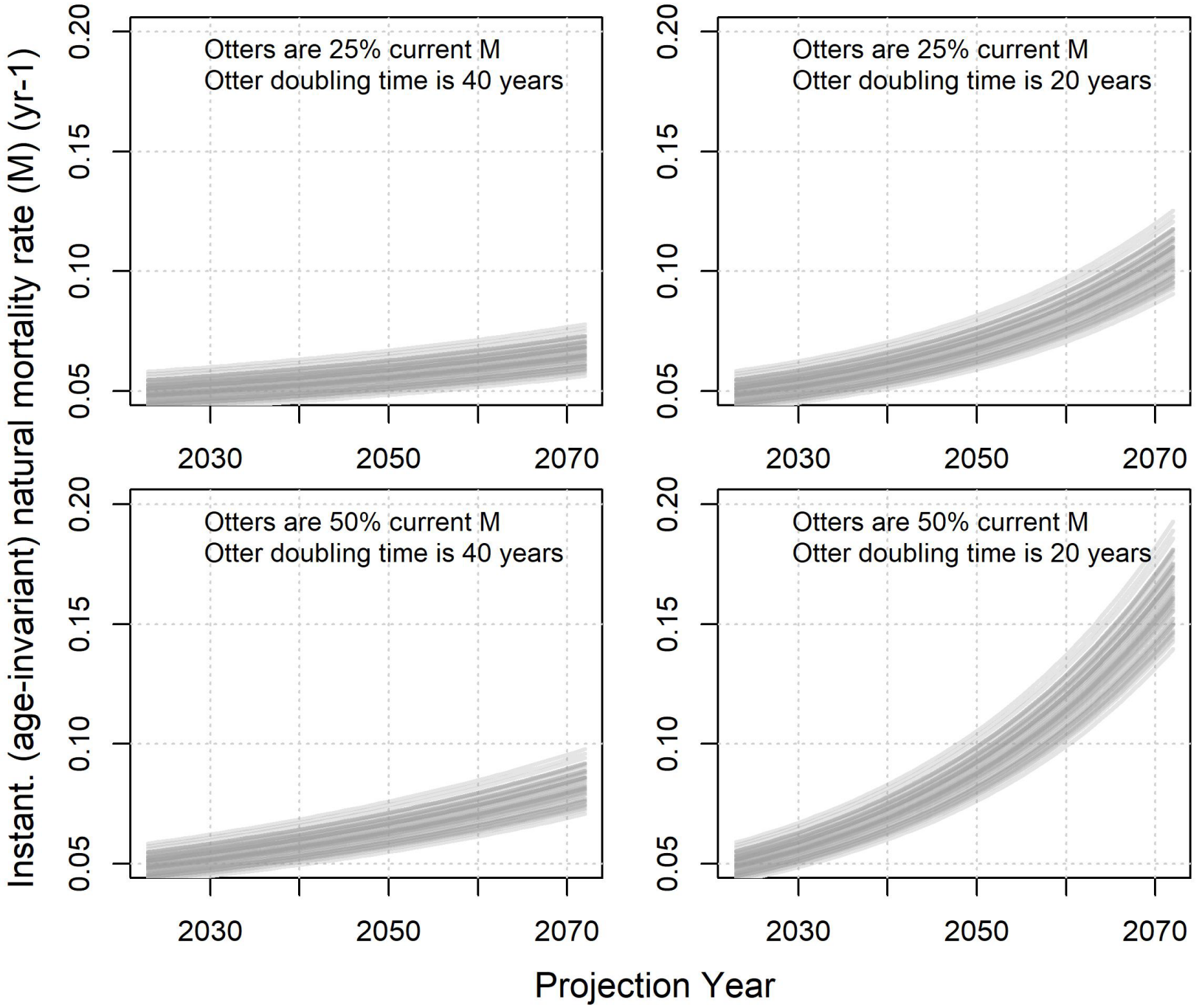
Size Limits area 12 (current effort levels)





Otters and M, the Geoduck thought experiment:

- Simplistic projection approach based on modifying 'natural mortality rate'
- Assign a fraction of current M (that varies among simulations) to sea otters
- Assign a doubling time of the sea otter population
- Obviously could do much more complex M response to biomass density, abundance of other species, predator – prey functional response etc.



5. Next steps

Data finalization

Areas for operating model refinement

Management questions

Robustness

Performance metrics

More on analyses, management questions?

One or more problem statements or questions:

- What is coast wide status / status by Stat. area, N/S area, on aggregate?
- We need a limit reference point coastwide and by Stat area
- What is a suitable density based limit reference point?
- We want to know the potential biological risk from increasing numbers of predators

Robustness tests

- Natural mortality rate (climate, predators)
- Changes in somatic growth
- Changes in recruitment strength
- Changes in habitat / carrying capacity
- Disease

…

Performance metrics

- Yield
- Conservation (LRP)
- Stability in yield
- Economic viability
- Accessibility (ie in relation to the location of open / closed areas)
- Harvest rate (efficiency)

More on next steps

Notes on next steps

Thanks!

Erin Wylie

Lyanne Curtis

Chris Rooper

Dominique Bureau

Shannon Obradovich

Mackenzie Mazur