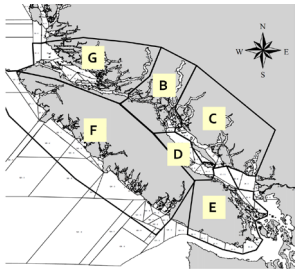
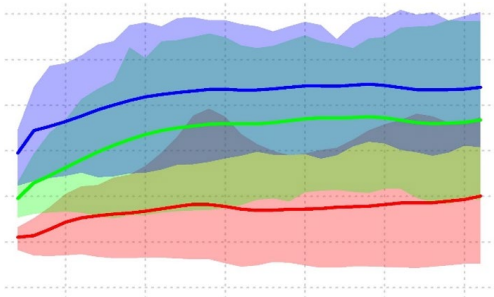
B.C. Manilla Clam Reference Case Operating Model Development

Updated data, models and example results

19 November 2023





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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. Data updates

Spatial definitions

Age- length observations

Length-weight observations

Length composition data

Catch curve analysis of Z (total mortality rate)

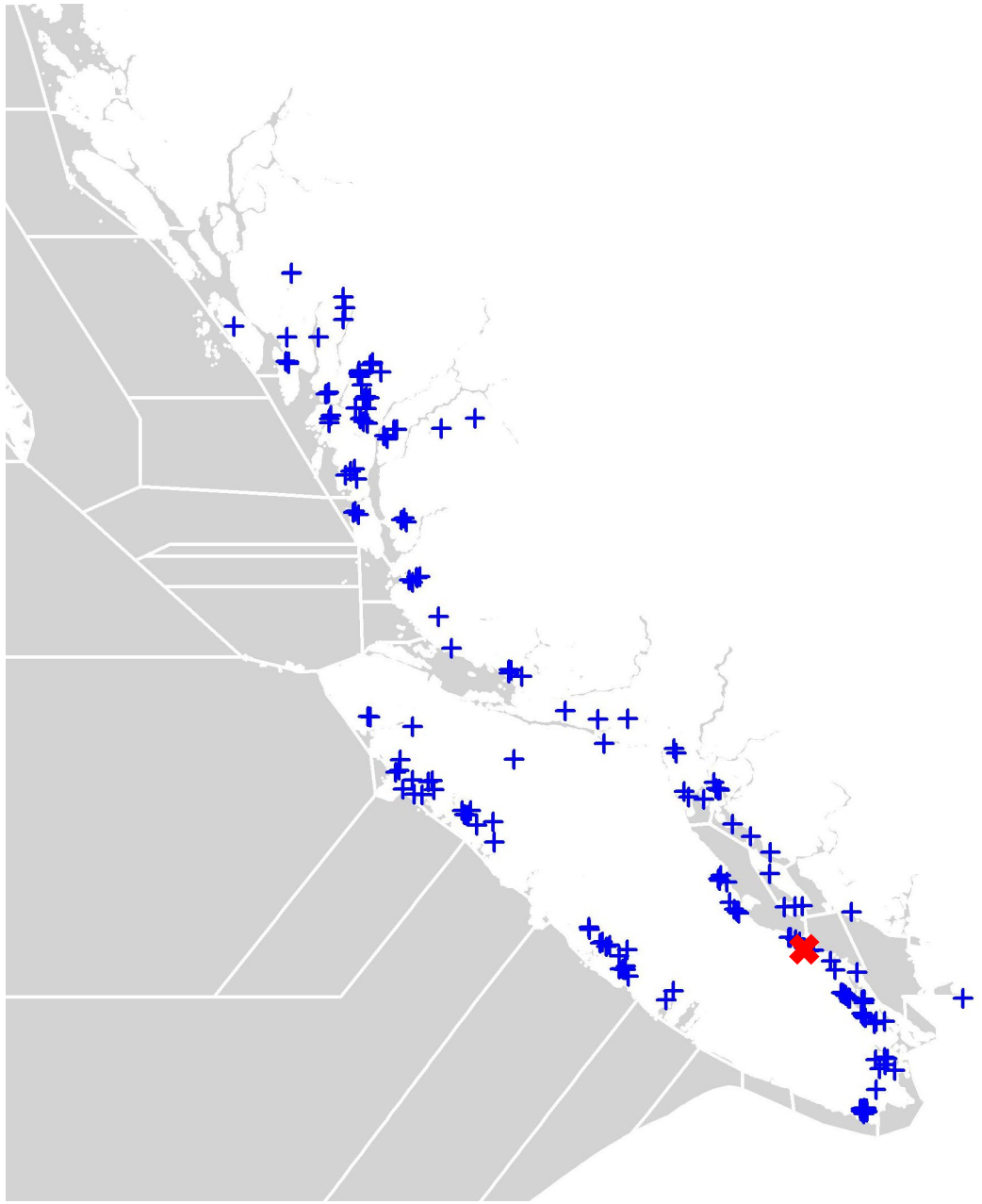
Annual catch data

Historical survey data

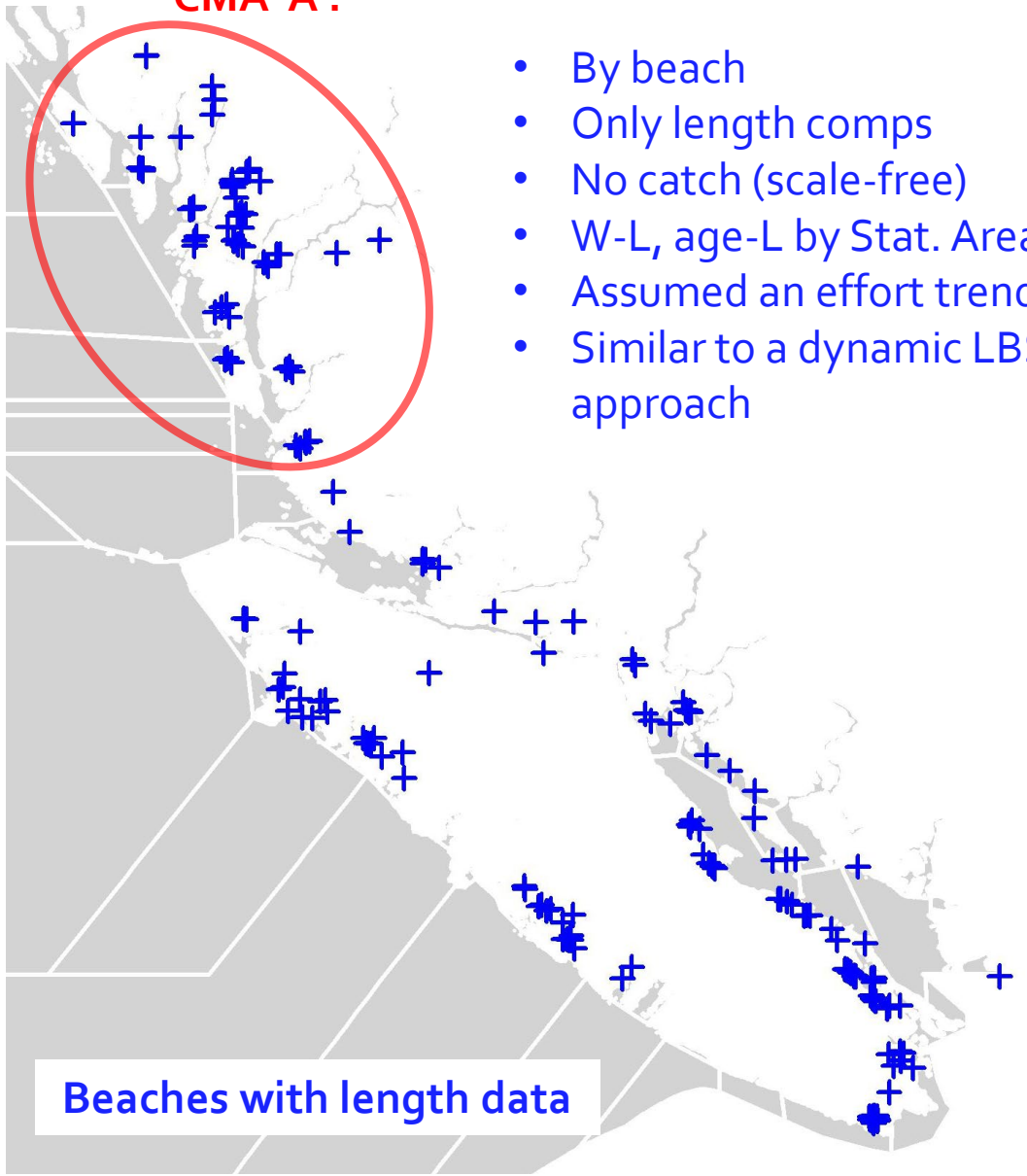
Intertidal Clam Monitoring Program

Previous models were by beach

- Beach was 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). Length data from biological data forms and annulus data are available for **85 beaches** (of more than 195)
- Model initializes at start of ramp up in landings (as documented in reports) in 1961.
- Growth and length-weight were characterized at the Stat. Area (PFMA) resolution.
- In the absence of harvest data, linearly ramped effort (1961 - 1990), then constant effort (1990 – 2022), similarly to an equilibrium approach like LBSPR)
- Recent catch = 1E5 (scale-free model was fitted).



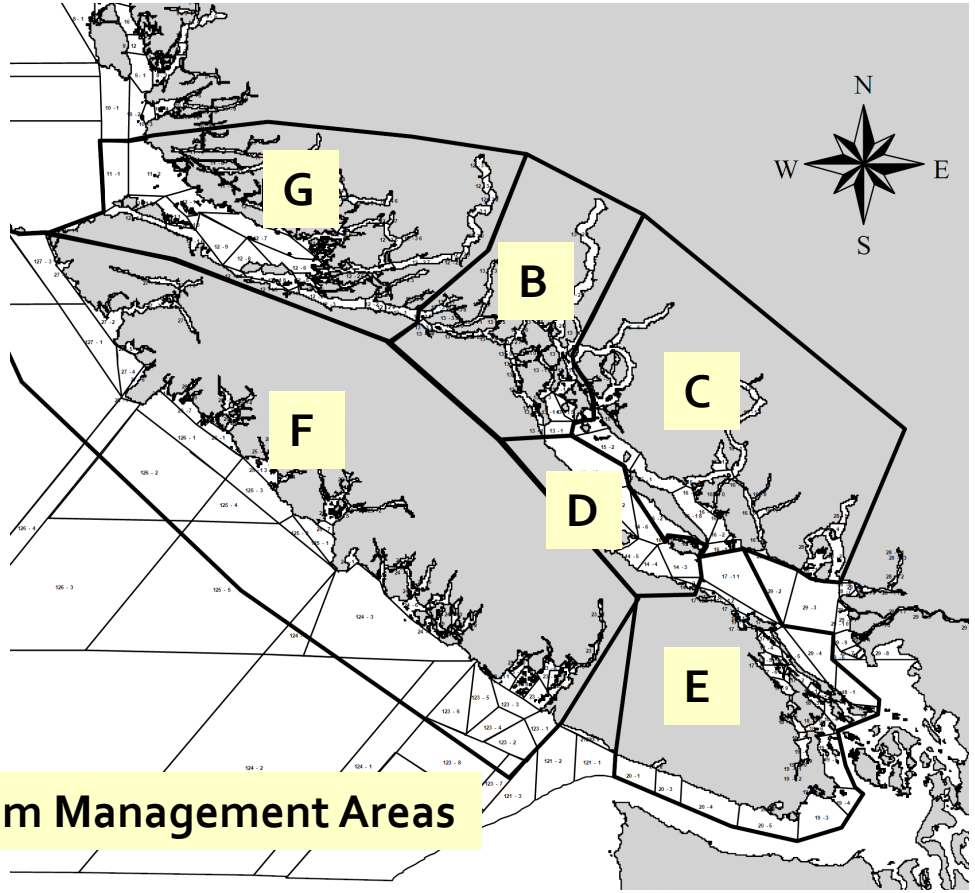
Previous Approach to Modelling



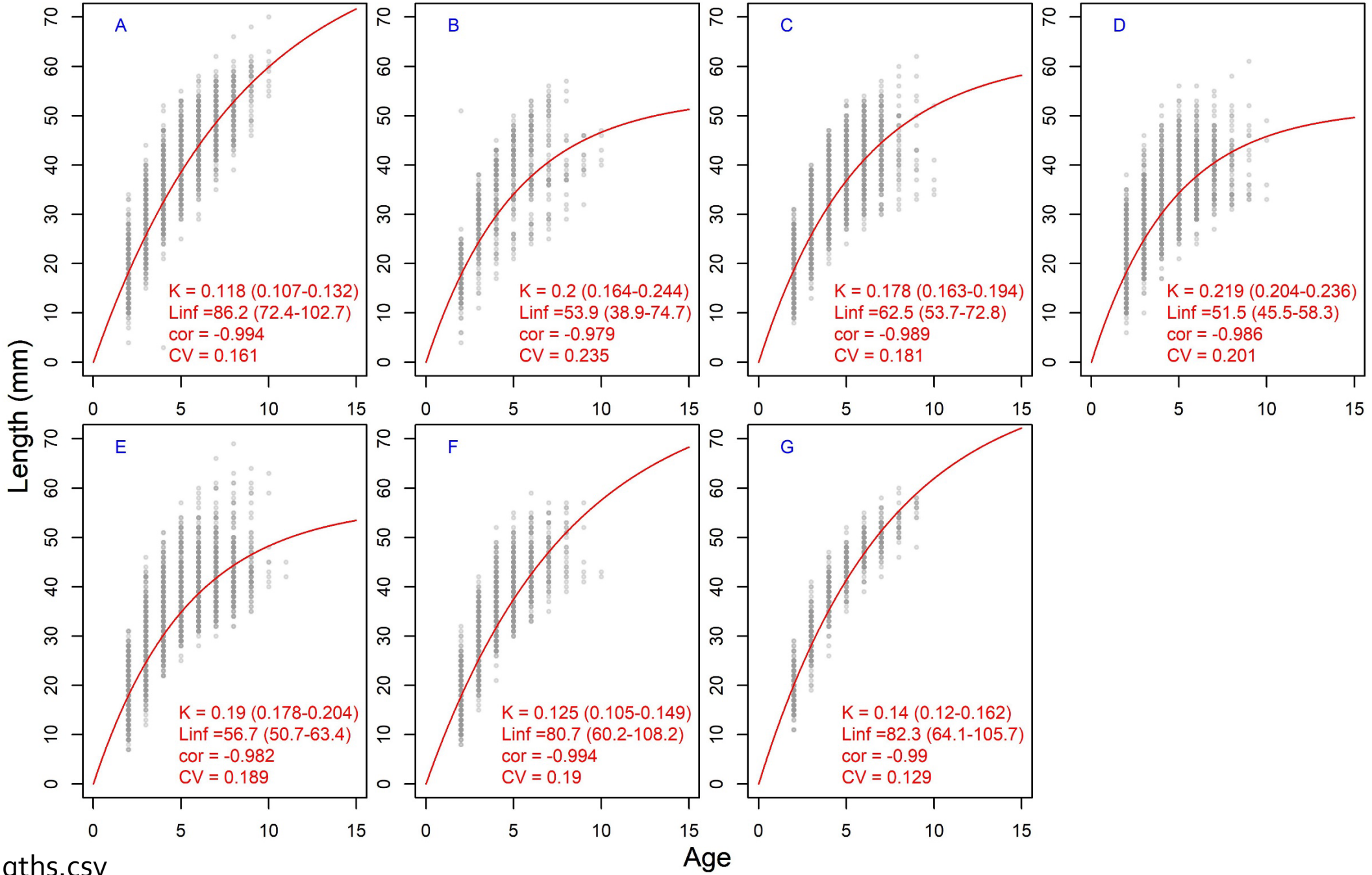
- By beach
- Only length comps
- No catch (scale-free)
- W-L, age-L by Stat. Area.
- Assumed an effort trend
- Similar to a dynamic LBSPR approach

New Approach

- By Clam Management Area (CMA) (W-L, age-L)
- Catch data from 2000 (equilibrium catch before this)
- Length composition
- No effort assumption this time
- Possible reconstructed index from beach surveys
- Intertidal Clam Monitoring Plan Info to be included



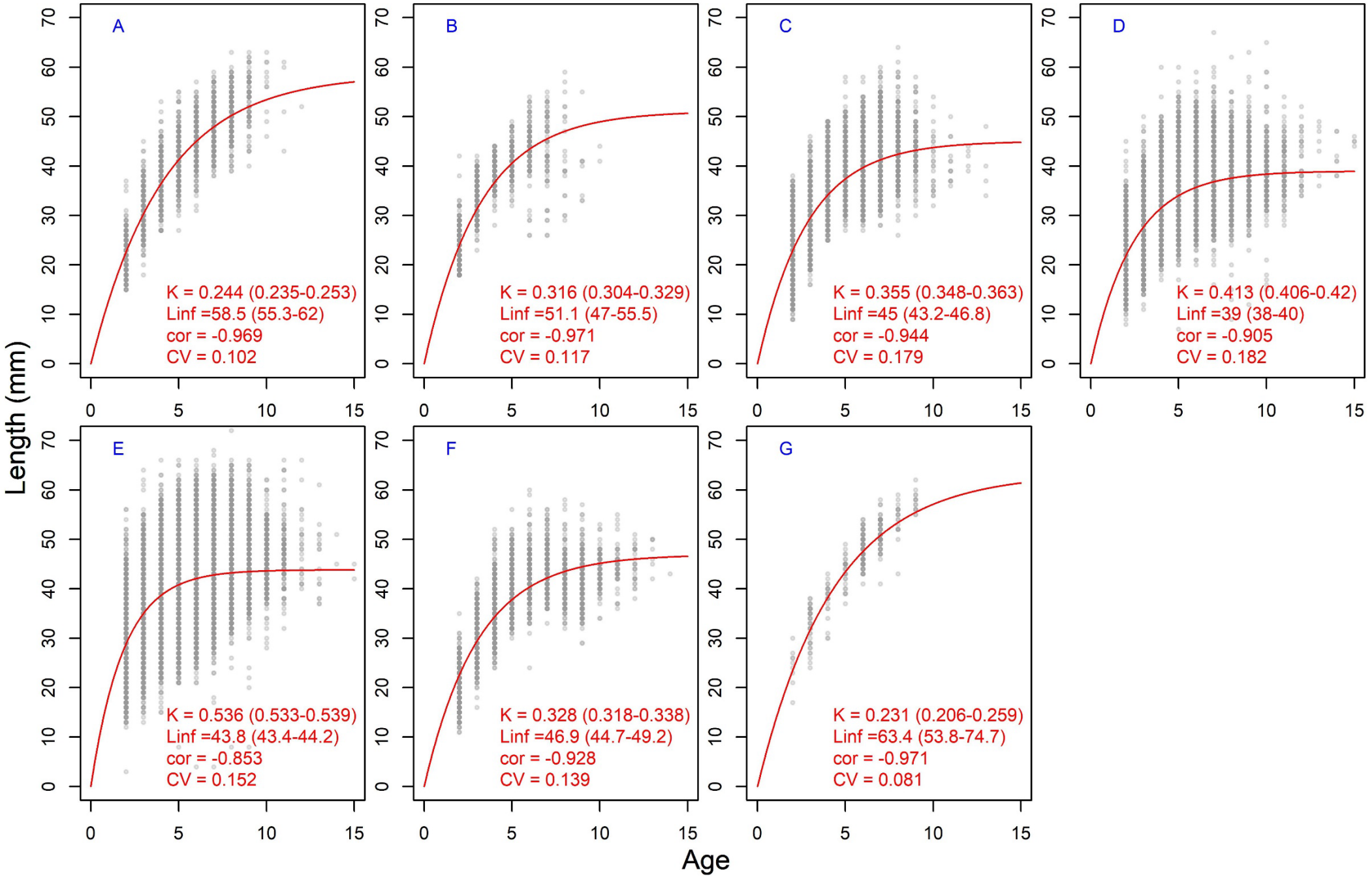
Somatic Growth, Annulus data



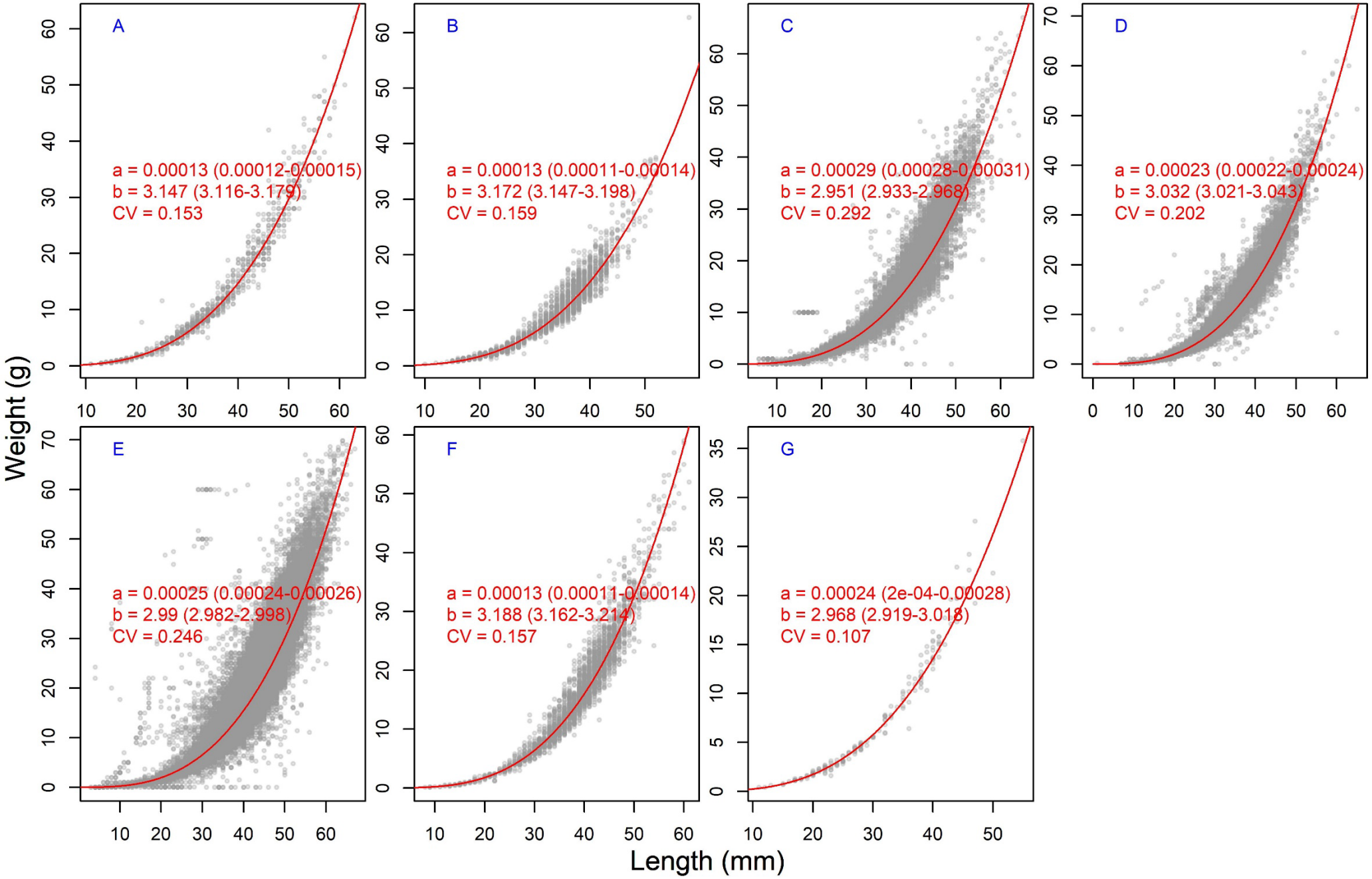
ClamAnnulusLengths.csv

Somatic growth, biological data

ClamBioData.csv



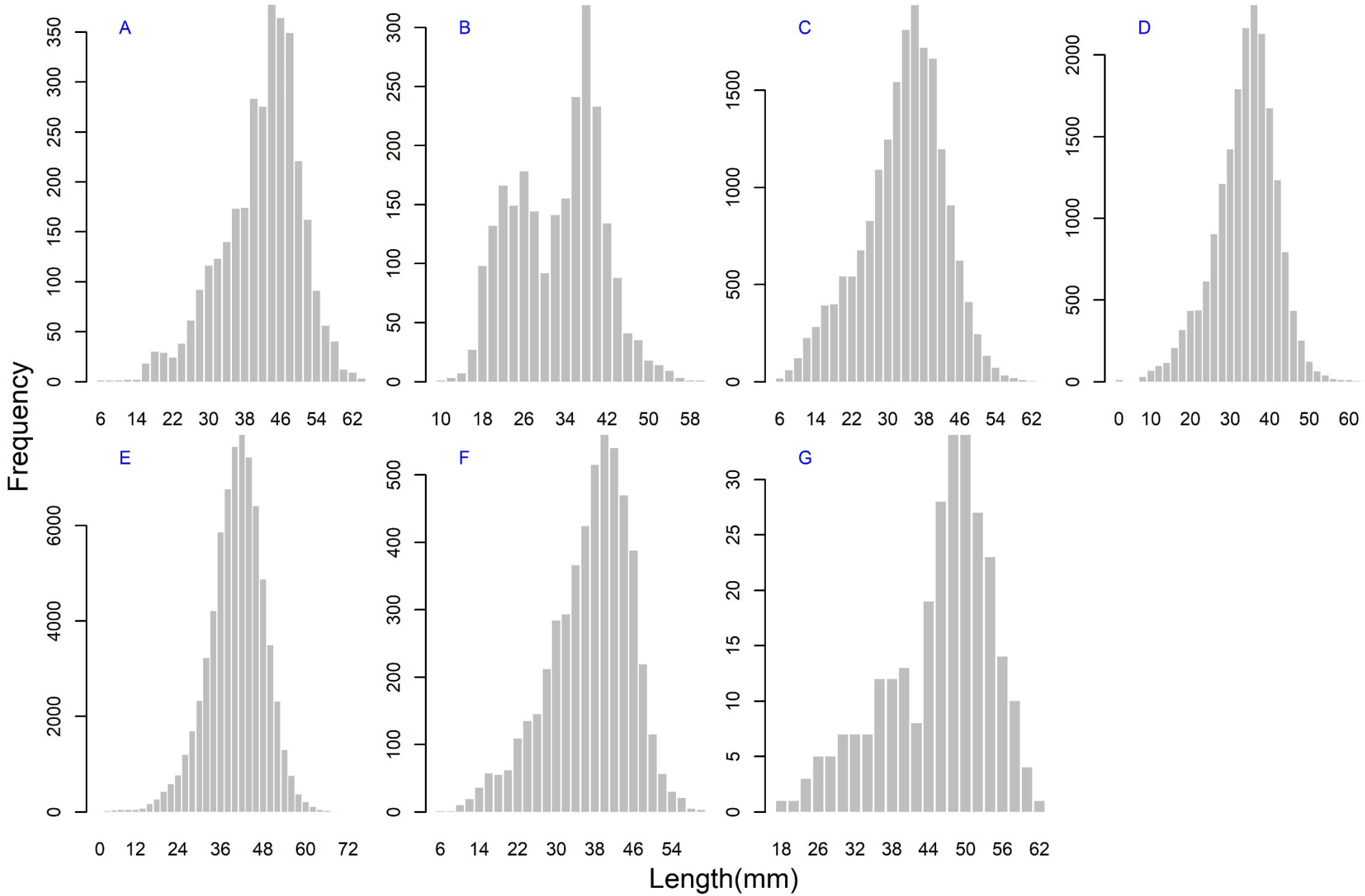
Biological data L-W



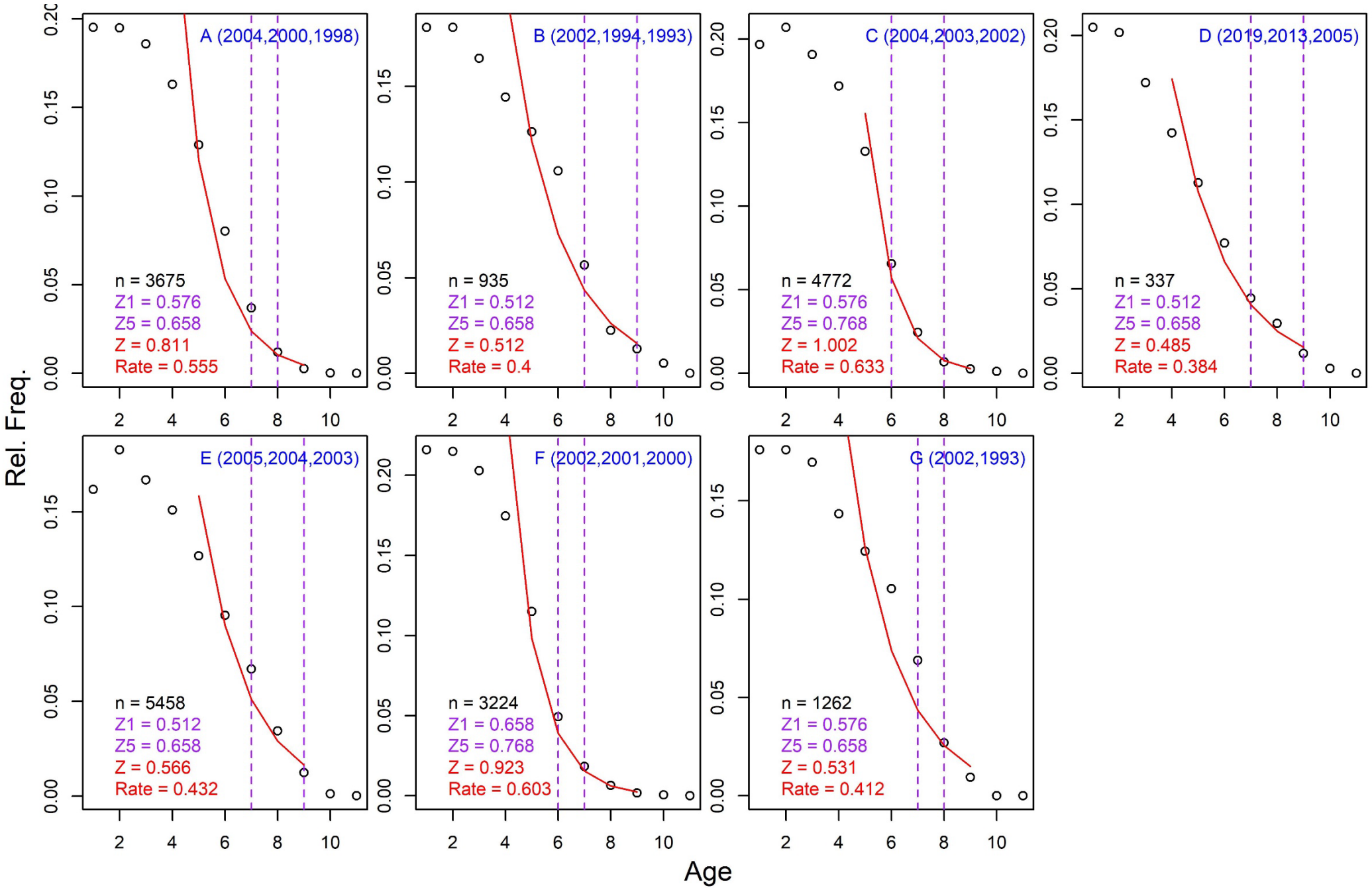
ClamBioData.csv

Length composition by CMA (all years)

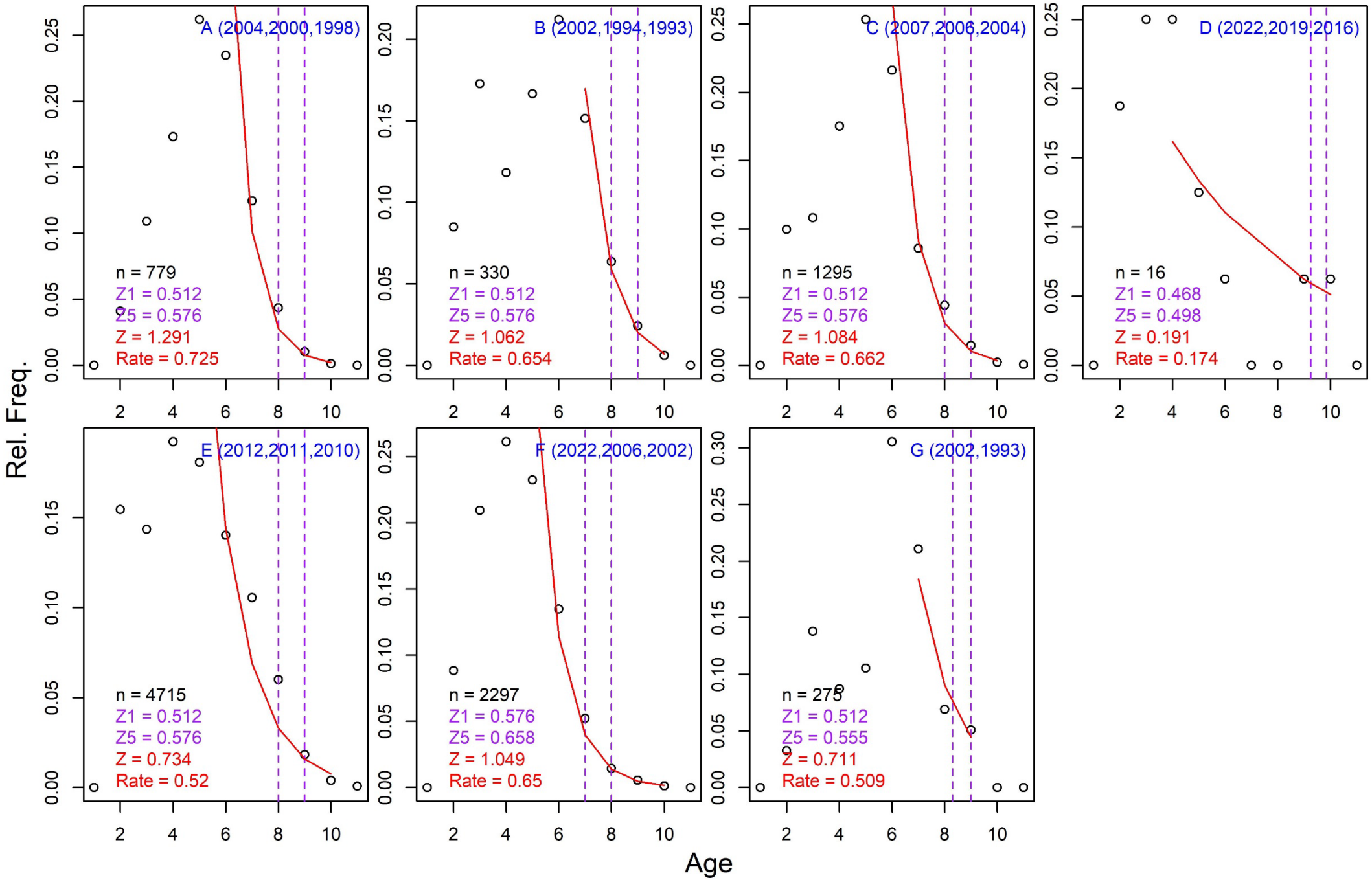
ClamBioData.csv



Catch curve by CMA - Annulus



Catch curve by CMA – bio data



Catches

Spool-up catches?

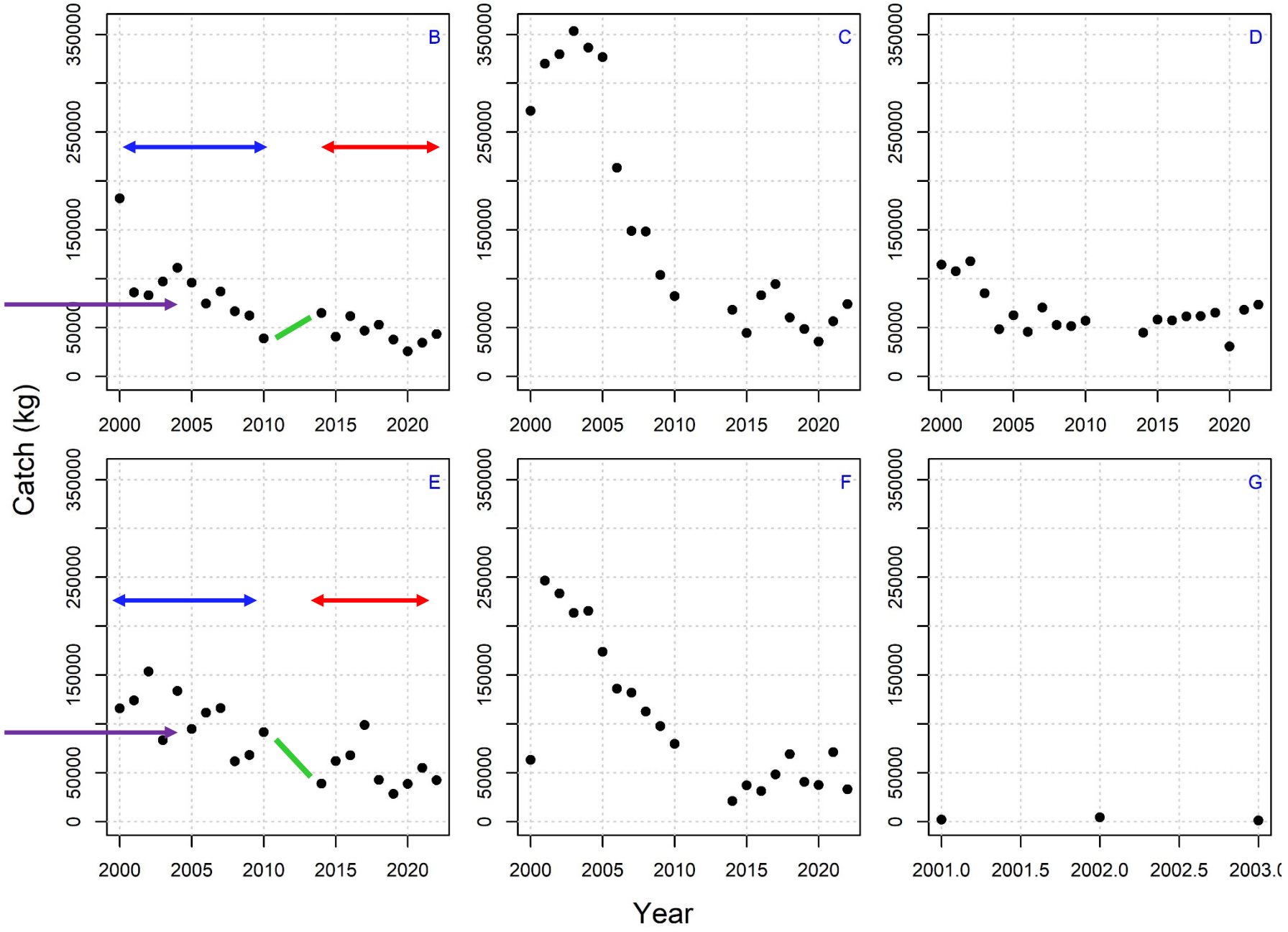
75% first five years

Missing catches?

Linearly interpolated

Manila_Buyer_Data_Sept_2023.csv

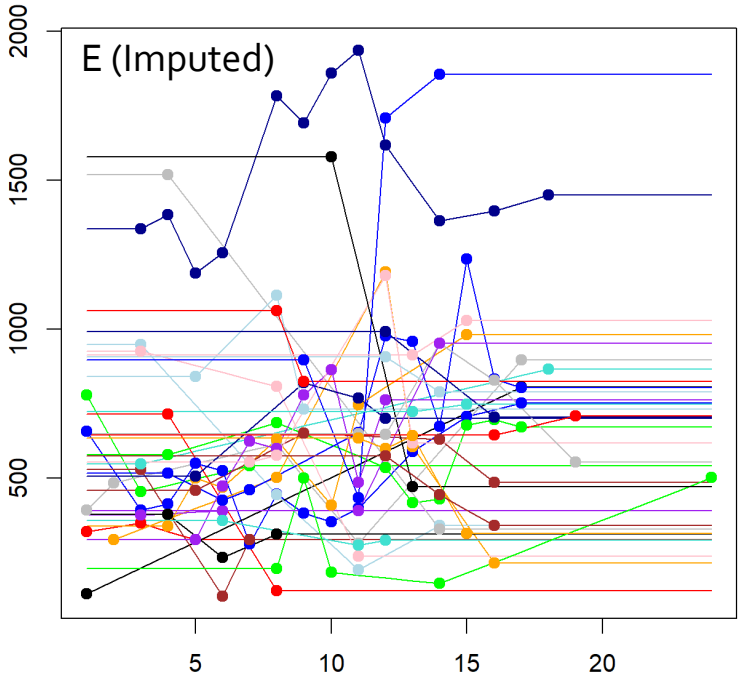
Manila_Fisher_Data_Sept_2023.csv

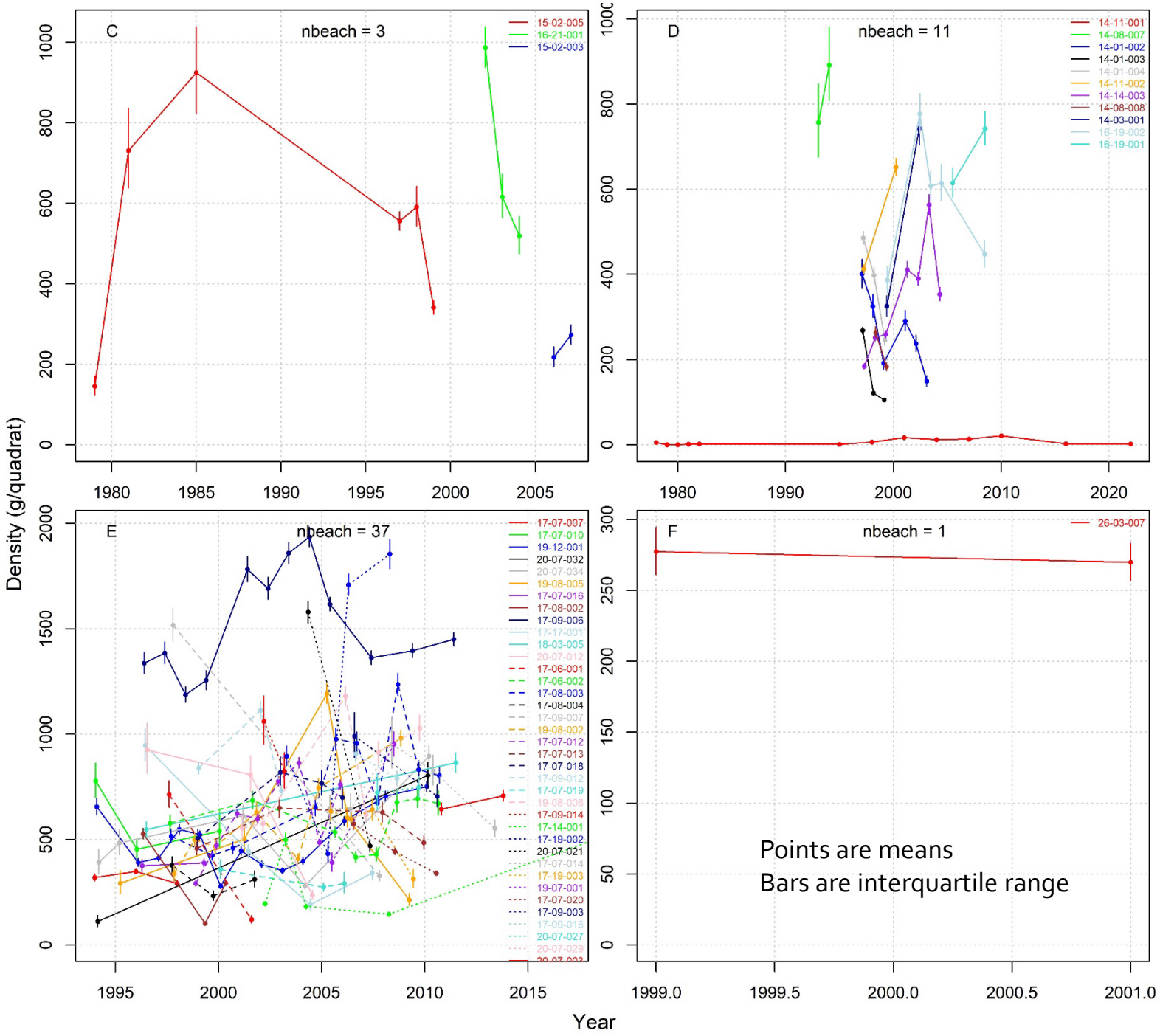


Historical Survey

ClamNumWgts.csv

- Inconsistent survey effort among CMAs
- Lots of beaches in CMA E between 1994 and 2015



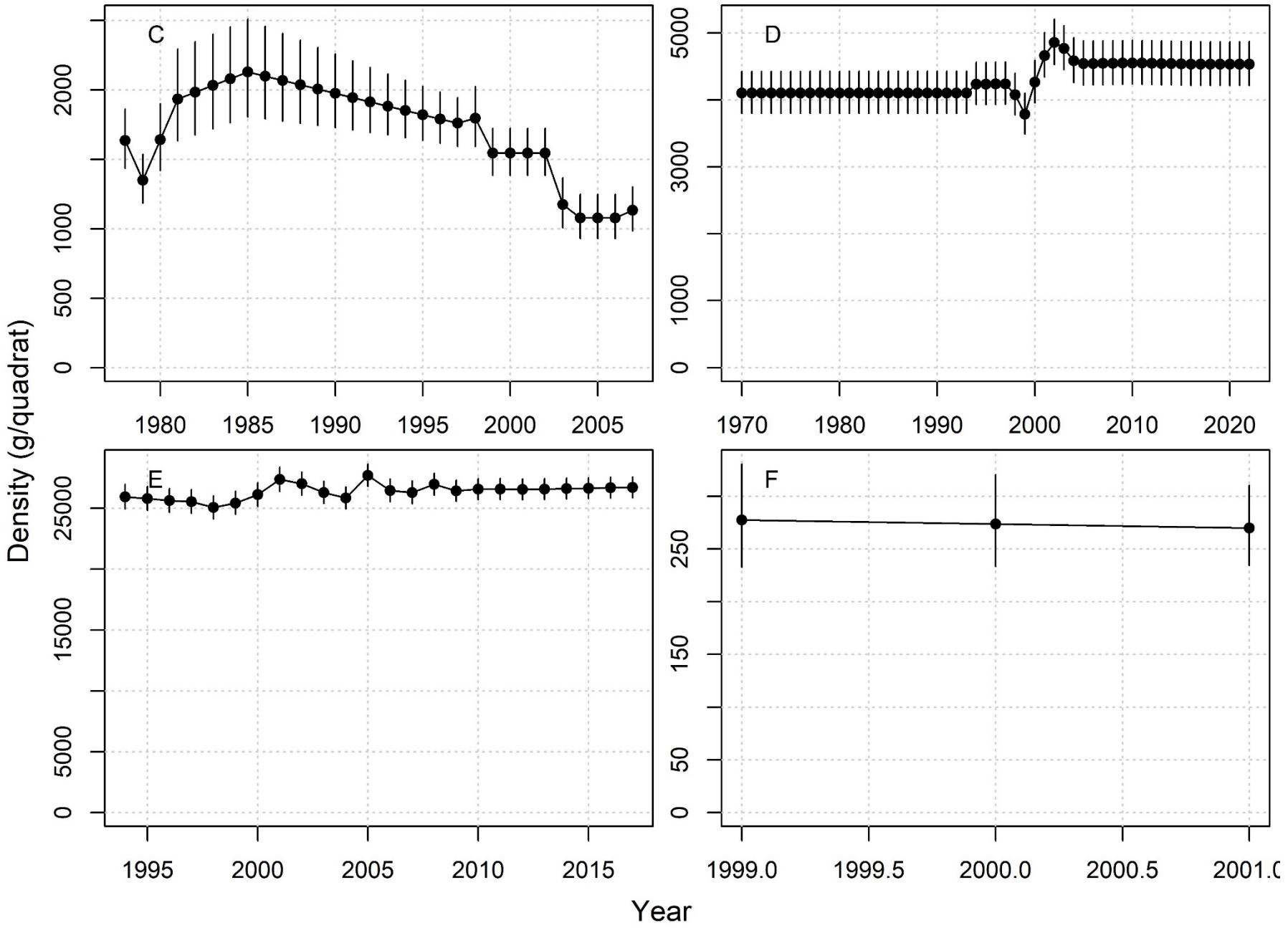


Combined (imputed) index.

Means are summed over beaches

St. Devs are calculated by:

$$\sigma_{CMA} = \sqrt{\sum \sigma^2_{beach}}$$

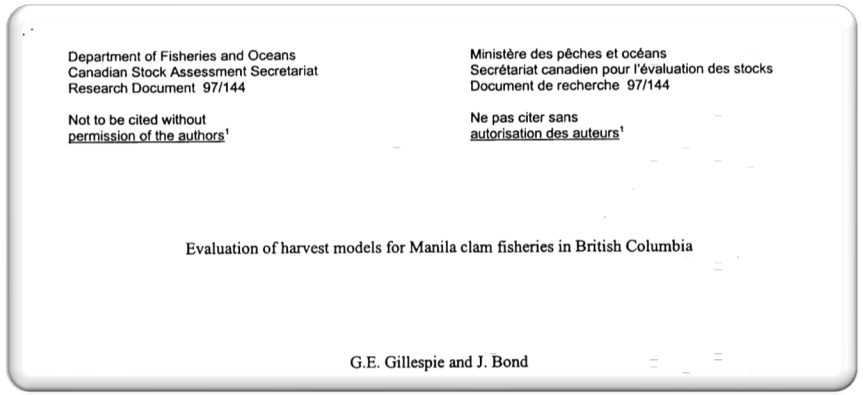


ICMP

- 2021-2022 available but not yet on GitHub
- Age data?
- Length data?
- Relative density?
- Can be extrapolated to total biomass??

Updates since Feb

- All modelling by CMA
- Added survey (ClamNumWgts.csv)
- Added historical catches
- ICMP ("Data from the new Intertidal Clam Monitoring Program for the 2021 and 2022 field seasons has been QAQC'd and entered into the 'Shellfish_Bio_Other' database")
- M = 0.381 (CV 15%)



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Canadian Stock Assessment Secretariat
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Evaluation of harvest models for Manila clam fisheries in British Columbia

G.E. Gillespie and J. Bond

More on data inputs?

Length comps
Somatic growth
Maturity
Selectivity
M critical

- Burton's approach to hierarchical modelling of Linf (possibility –
  but need to adjust priors possibly)
- What about an effort time series (slip-days, days fishing) (if a slip is a day of fishing then slips yr-1 could be an approximate index of fishing effort) maybe 2000+ (or 1996+)
- Can I use any of the biomass survey data?
- Drag equilibrium catches back to use earlier survey data (fishery ramp up from 1961 – 1990)?
- Definitely fit models to age-data now that the analyses are CMA level!
- Turn on/off the catch/slip metric of commercial CPUE (slips / yr may be decreasing – due to expiry. Were 800 commercial in 90s now 500 (less than 200 are fished) + 100. These are individual-based.)

2. Revised Models

Conditioning approach

Model fit

Model estimates

Operating model conditioning approach

- Statistical catch-at-length using the rapid conditioning model (RCM, of openMSE)
- Somatic growth and weight-length parameters taken from empirical data by CMA
- Age- and time-invariant *M* specified and sampled from a lognormal distribution mean = 0.381, cv = 0.15, 95% CI = [0.283, 0.511]
- Commercial selectivity was assumed to be fixed: 5% at 35 mm and fully selected and asymptotic from 39mm.

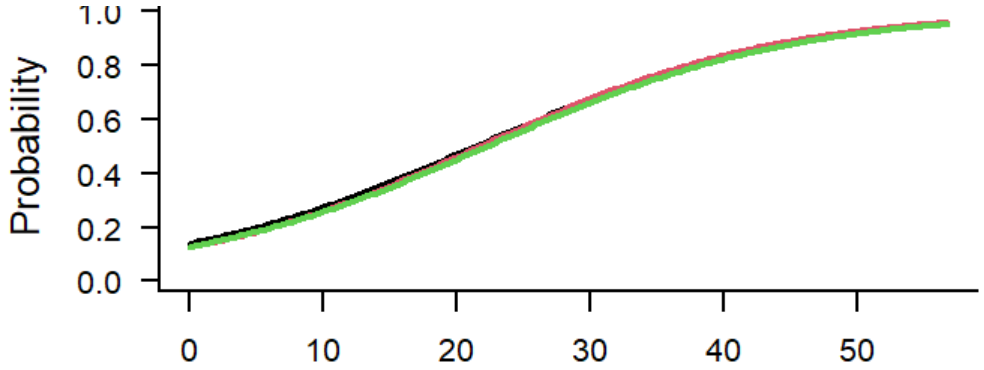
New for this round:

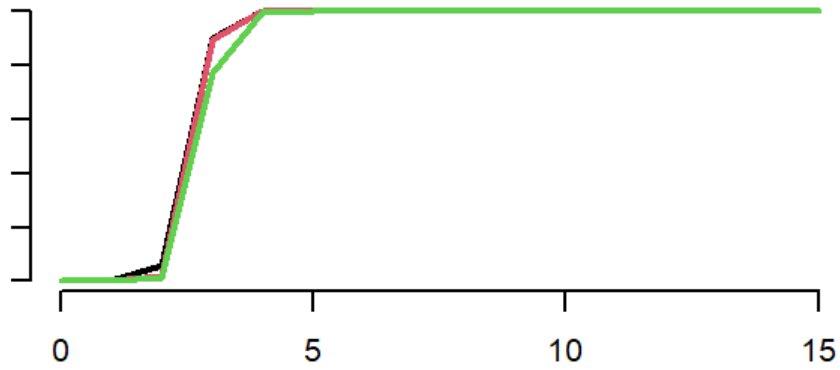
- Catch series
- Optional survey biomass index
- Depletion prior (reveals how informative the data are)

Model assumptions / specified parameters

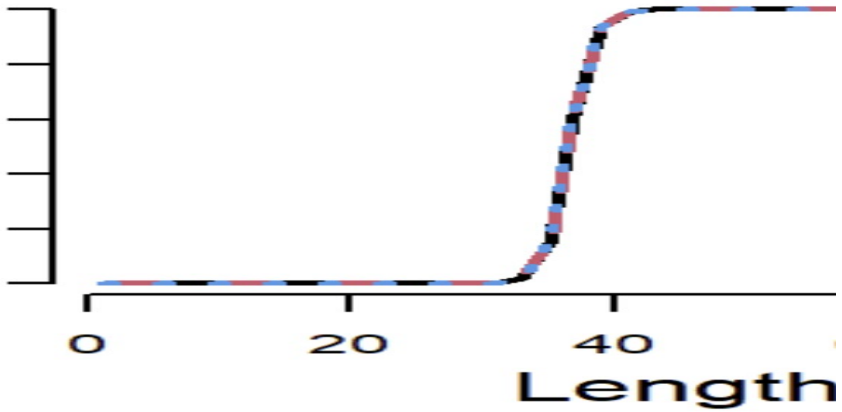
50% mature (spawning fraction) long before they are fully selected

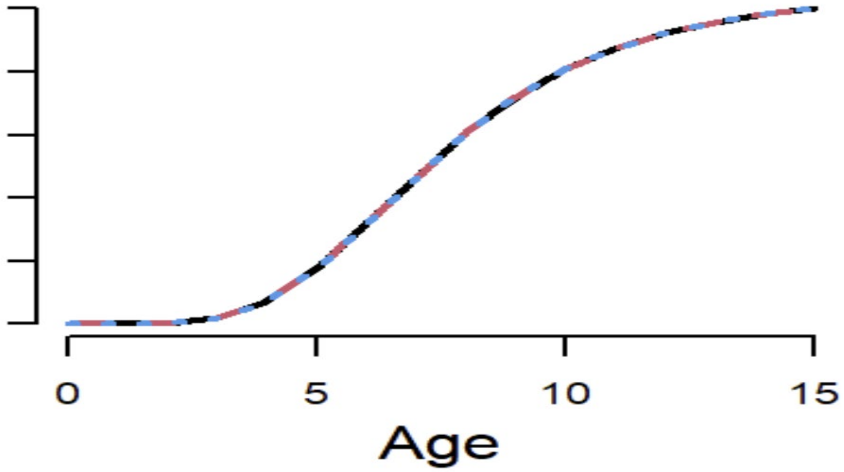
Maturity





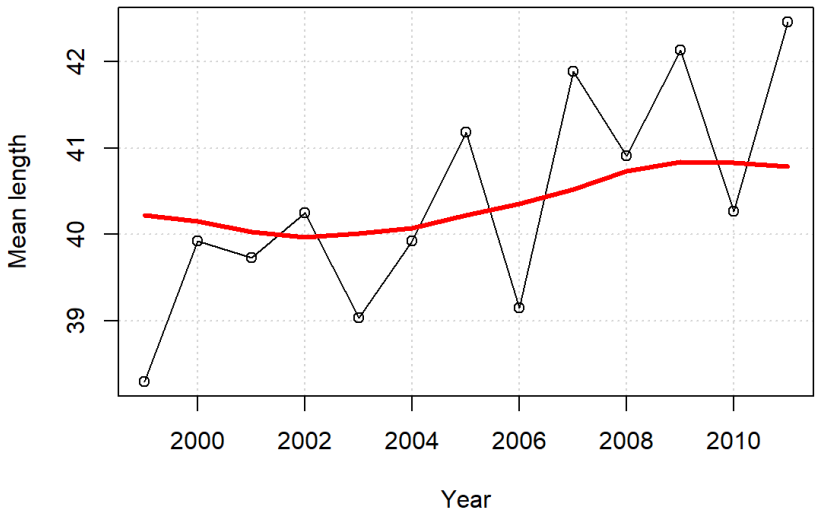
Selectivity

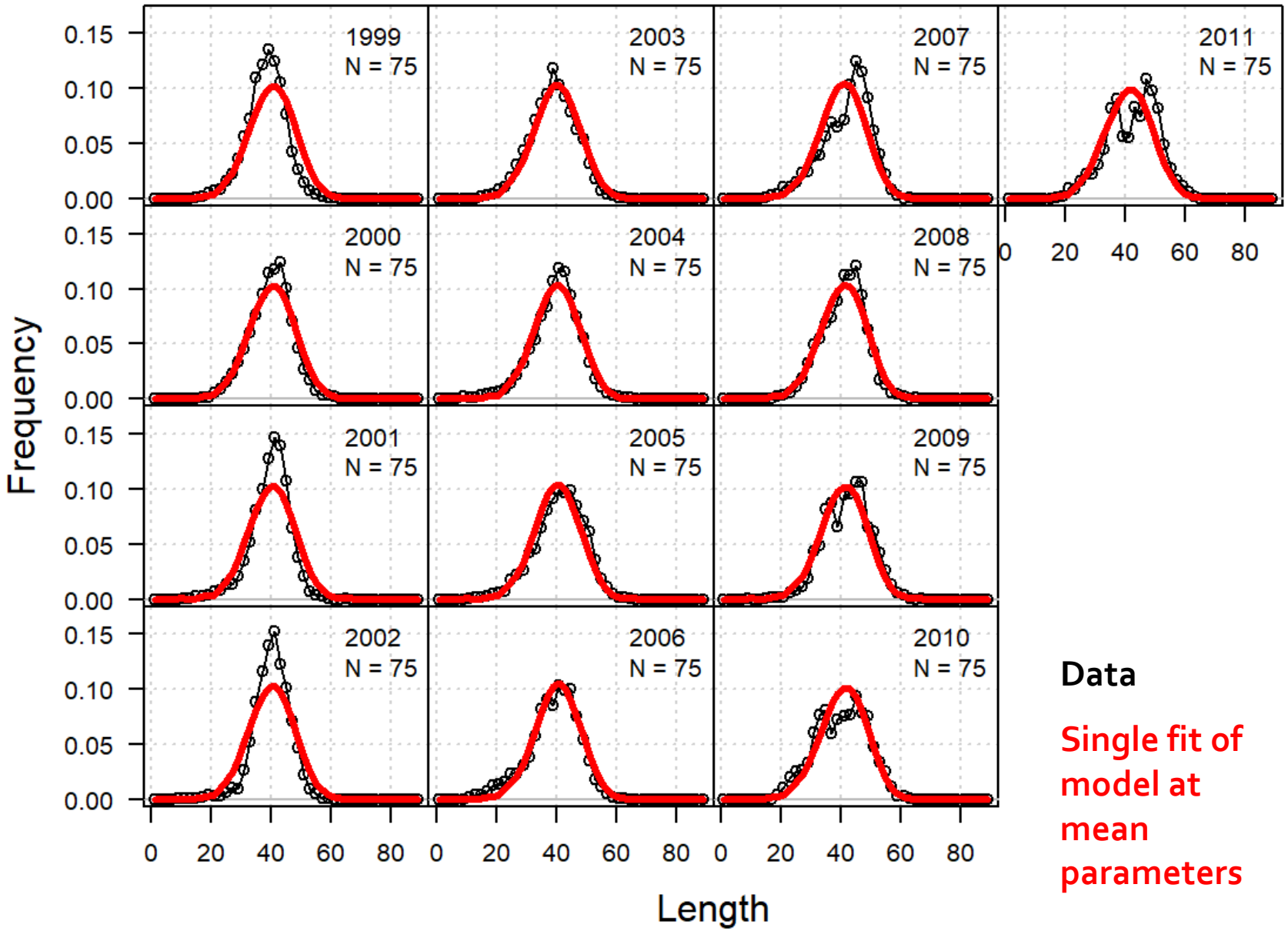




Model fit for CMA E: length composition

Assuming logistic selectivity





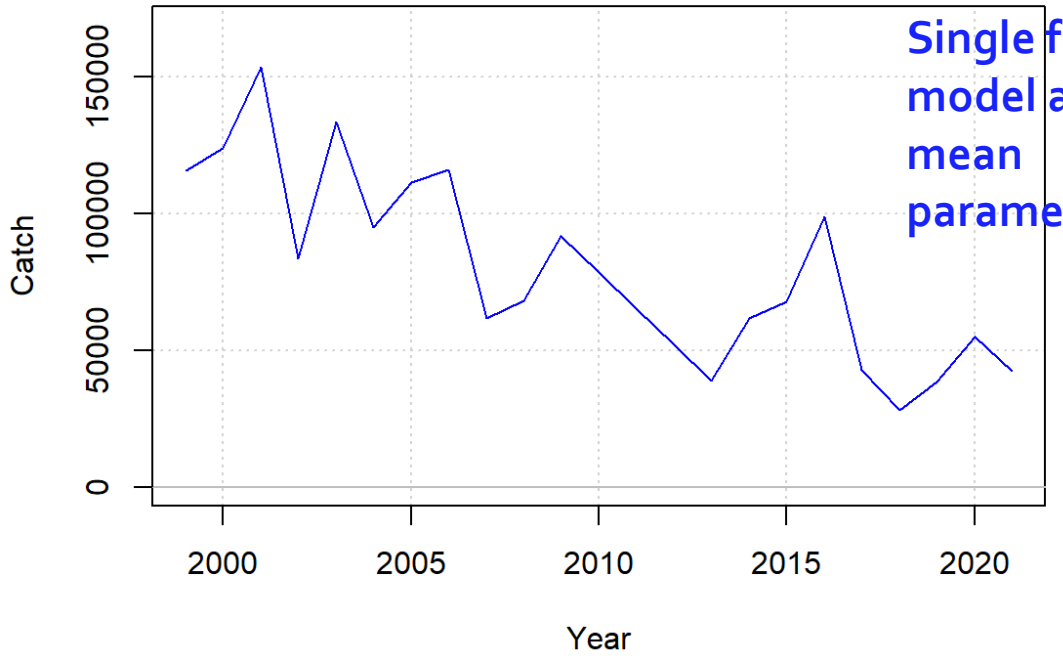
Data

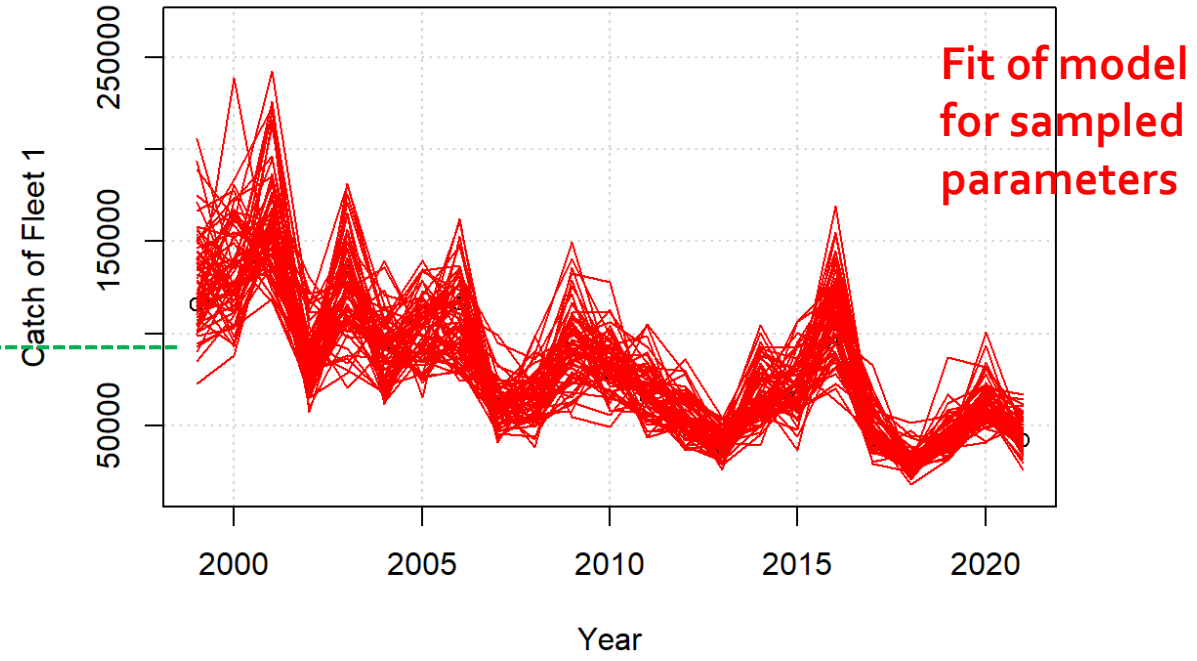
Single fit of model at mean parameters

Model fit for CMA E annual catches

Catch data were assigned a CV of 20% which is very high compared with your typical statistical catch at length or –age model (i.e. 2.5% for most stock synthesis assessments)

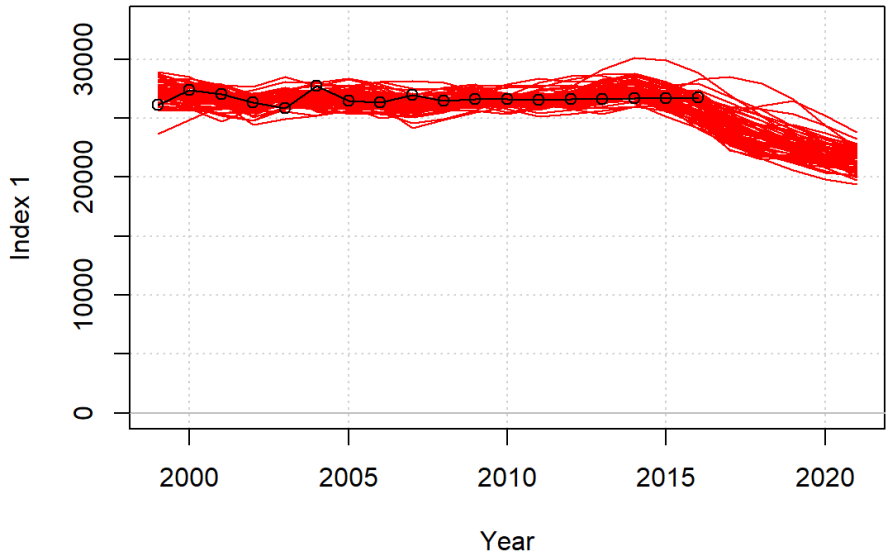
Equilibrium (average pre-2000) catches were 91 559kg and also assigned a CV of 20%, which is a 95% CI of [61 867, 160 515]

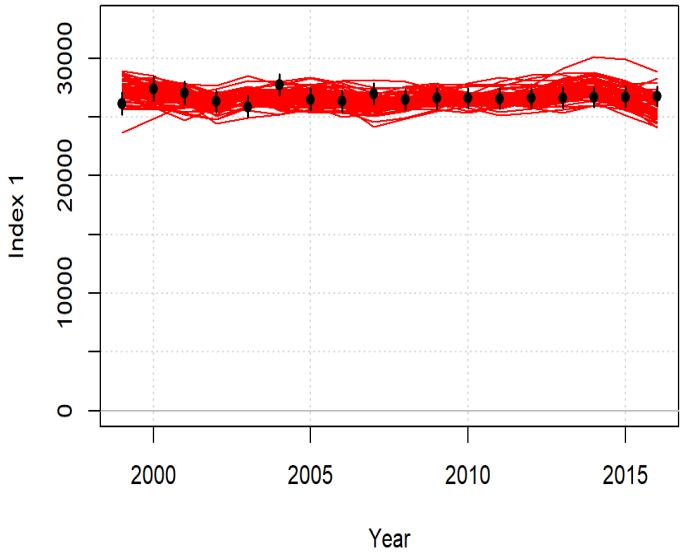




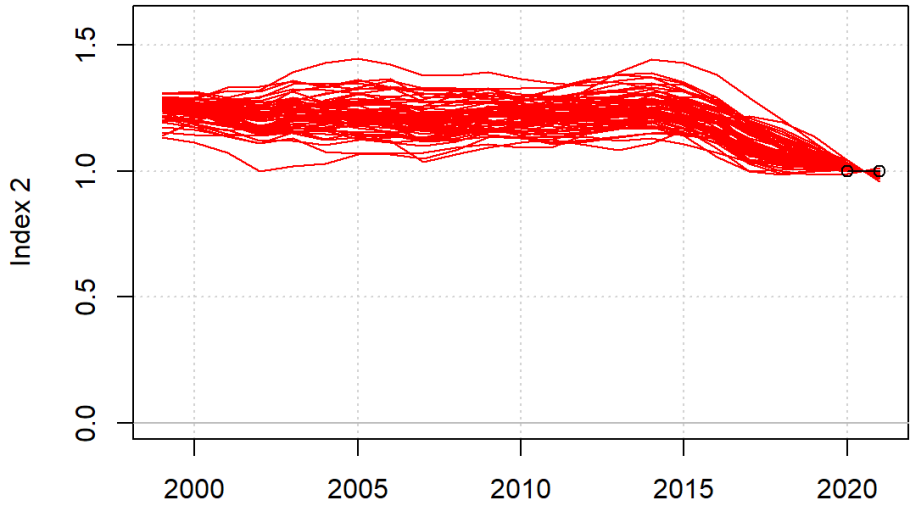
Model fit for CMA E

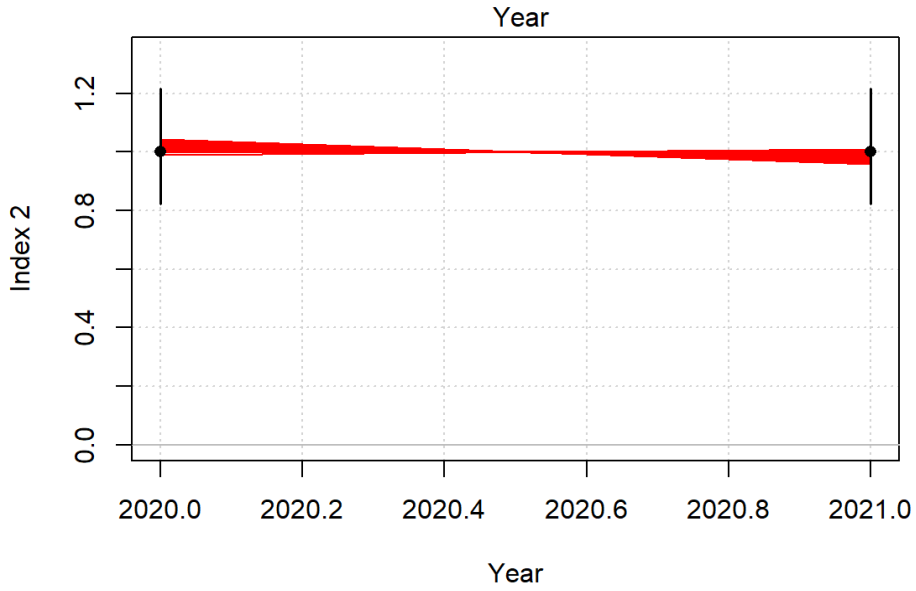
Imputed density survey (CV x 3, precision 1/8)





ICMP (made up)

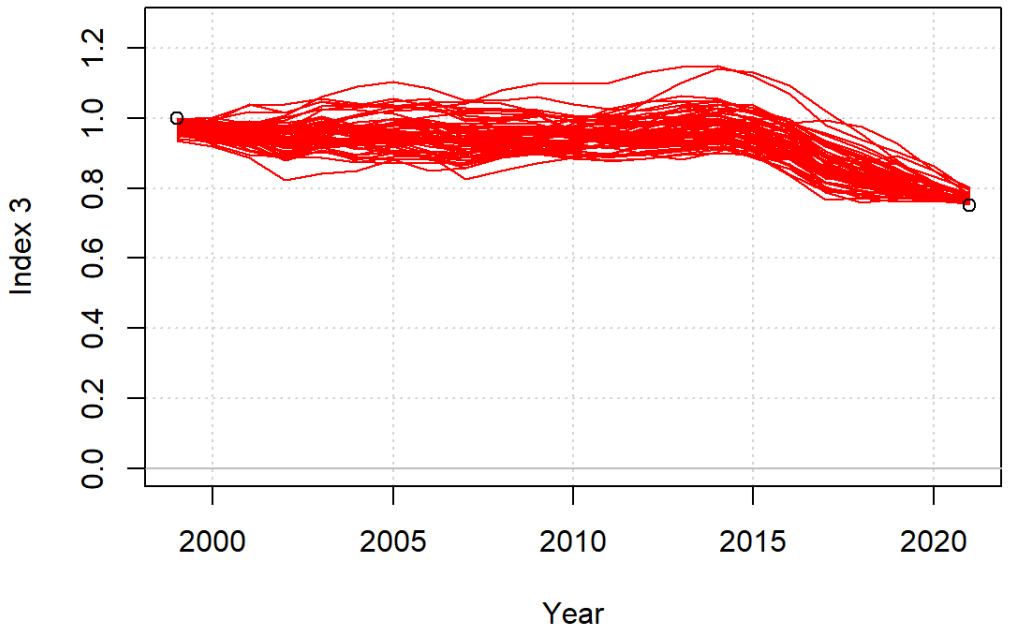


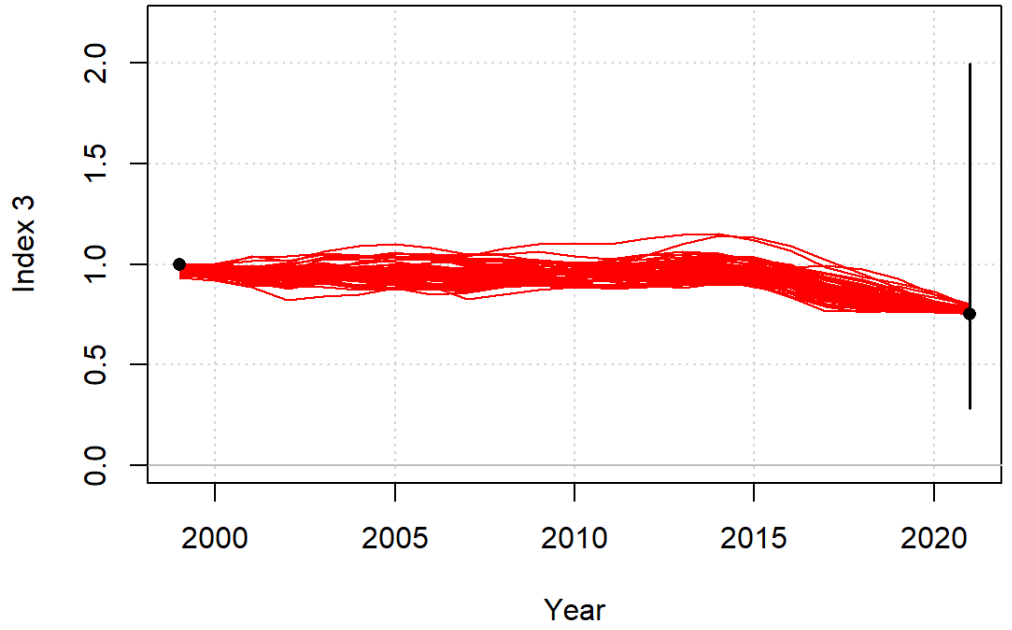


Biomass Depletion Prior (0.75, CV 0.4), CMA E

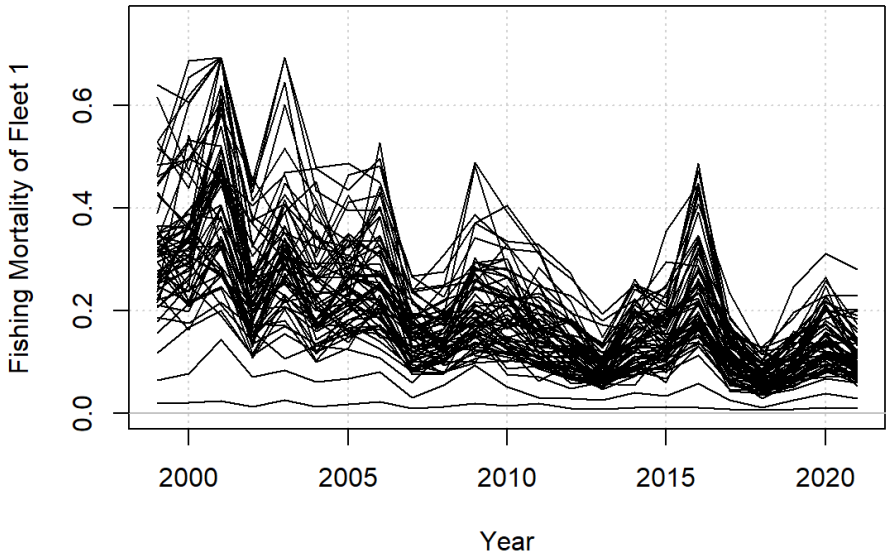
Despite down-weighting the imputed index by 1/8 and including a very vague prior on the biomass depletion, the model reliably estimates depletion values that closely match the prior mean (albeit flatter through the specified points).

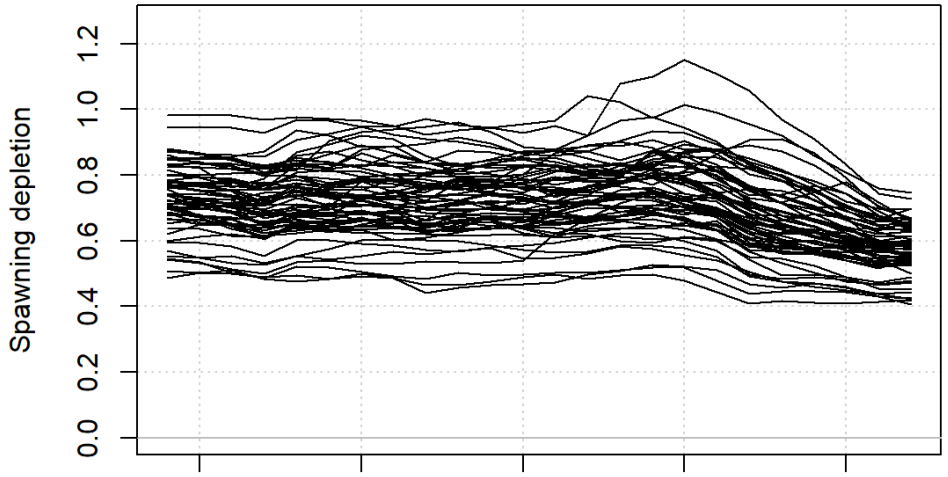
There is very little information about stock depletion in the composition data for the most data rich of the CMAs (E) (the x-axis of the DFO default harvest control rule)

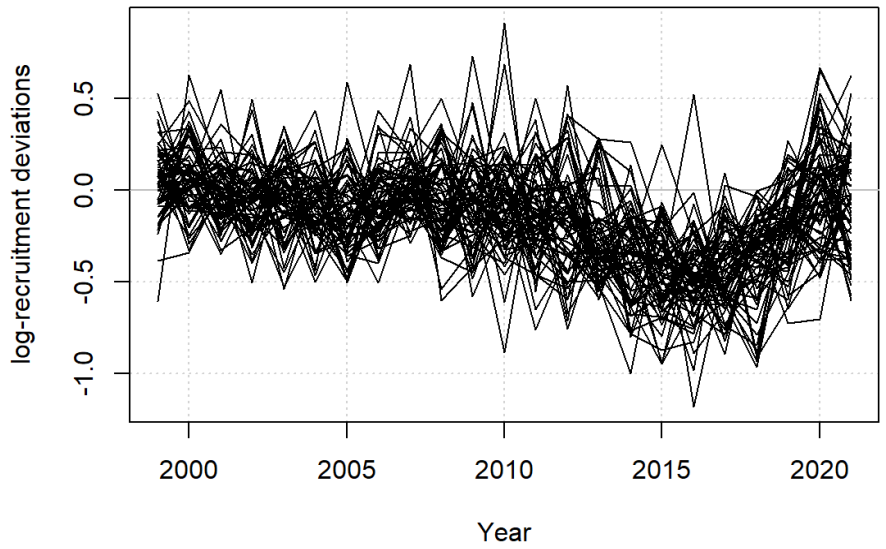


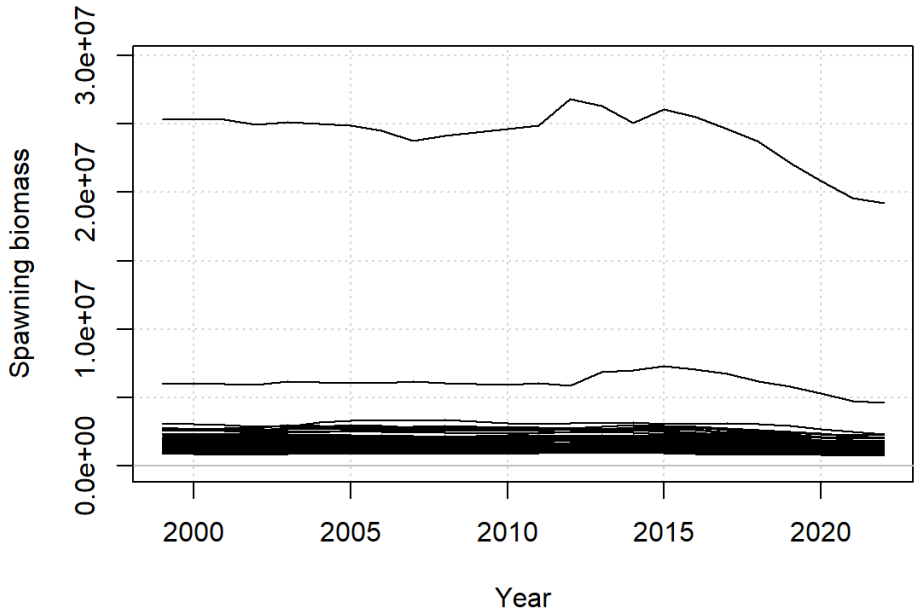


CMA E estimates / assumptions









Model estimates

M = natural mortality rate

HR = U = harvest rate (catch / vulnerably biomass)

F = -log(1-U)

D = depletion = SSB2022 / SSBo

B = biomass (all ages)

Bo = unfished biomass

SSBo = unfished spawning biomass

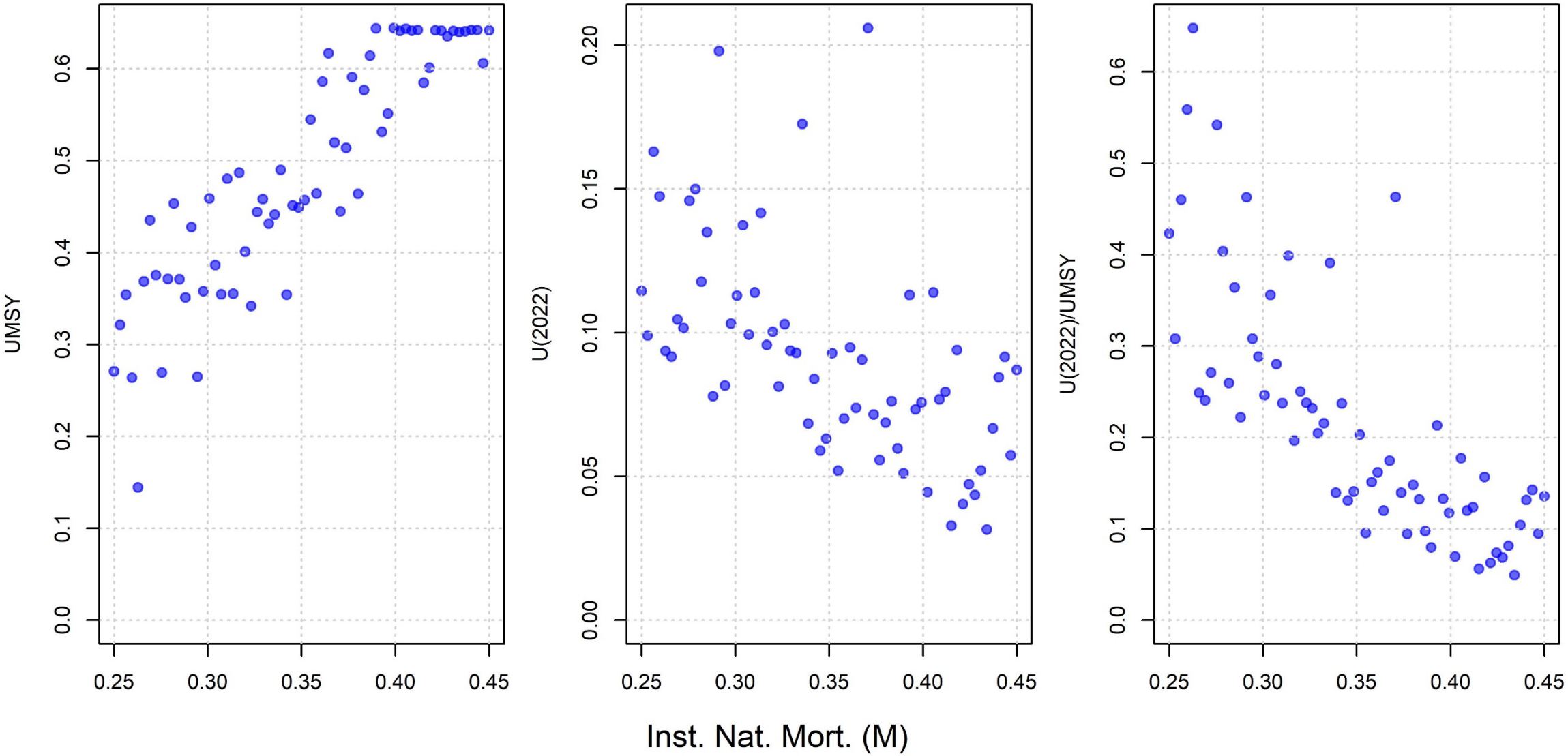
CMA	HR_2022	F_2022	D_2022	B_2022	B0	SSB0
C	0.0991	0.1421	0.5053	1679.588	3324.151	3021.23
E	0.0882	0.1157	0.5743	1323.16	2303.78	2208.943
F	0.0925	0.1278	0.4082	591.017	1448.003	1375.926

Reference Points

Br = SSBMSY / SSBo UMSY = MSY / VBMSY Us = U(2022) / UMSY Bs = SSB(2022) / SSBMSY

CMA	Br	Br_025	Br_975	UMSY	UMSY_025	UMSY_975	Us	Us_025	Us_975	Bs	Bs_025	Bs_975
C	**0.368**	0.343	0.385	**0.391**	0.302	0.534	**0.242**	0.168	0.329	**2.161**	1.235	2.757
E	**0.394**	0.352	0.484	**0.526**	0.332	0.643	**0.17**	0.053	0.395	**3.404**	2.182	5.108
F	**0.366**	0.35	0.384	**0.263**	0.201	0.389	**0.154**	0.001	0.438	**6.256**	3.464	9.871

M a key determinant of UMSY and U status (Us)



Results

- Highly variable and dependent on M input and stock depletion prior

- Very hard to evaluate stock status and stock size

- Model requires longer trend information (indices or effort)

- Age data would further inform current Z (combined mortality: fishing + M)

More on model fit and configuration?

- Maturity schedule?

- Early Catches available BC wide (Gillespie?) can these be broken down into CMA

- Additional rec catch (changing? – rec increasing, com effort decreasing)

- Value of information on maturity / more current age survey

- changes in maturity 12deg, 15deg spawning

- see info WRT fecundity with length

- Slot limits (what about a 'very large' class)

- Age error analysis (what is the impact on Z estimation and somatic growth estimation)?

- Aging for 'underexploited' beds for M calculation

- Winter kill as a robustness test?

- irec survey to get at recreational magnitude.

Possible analysis would be to (acknowledging that obtaining absolute biomass limit reference points – in kg – are not practical):

1) use CMA level models to demonstrate the theoretical sustainability subject to robustness tests (catches, M, growth)

2) Use specific well informed, high exploitation rate beaches to validate

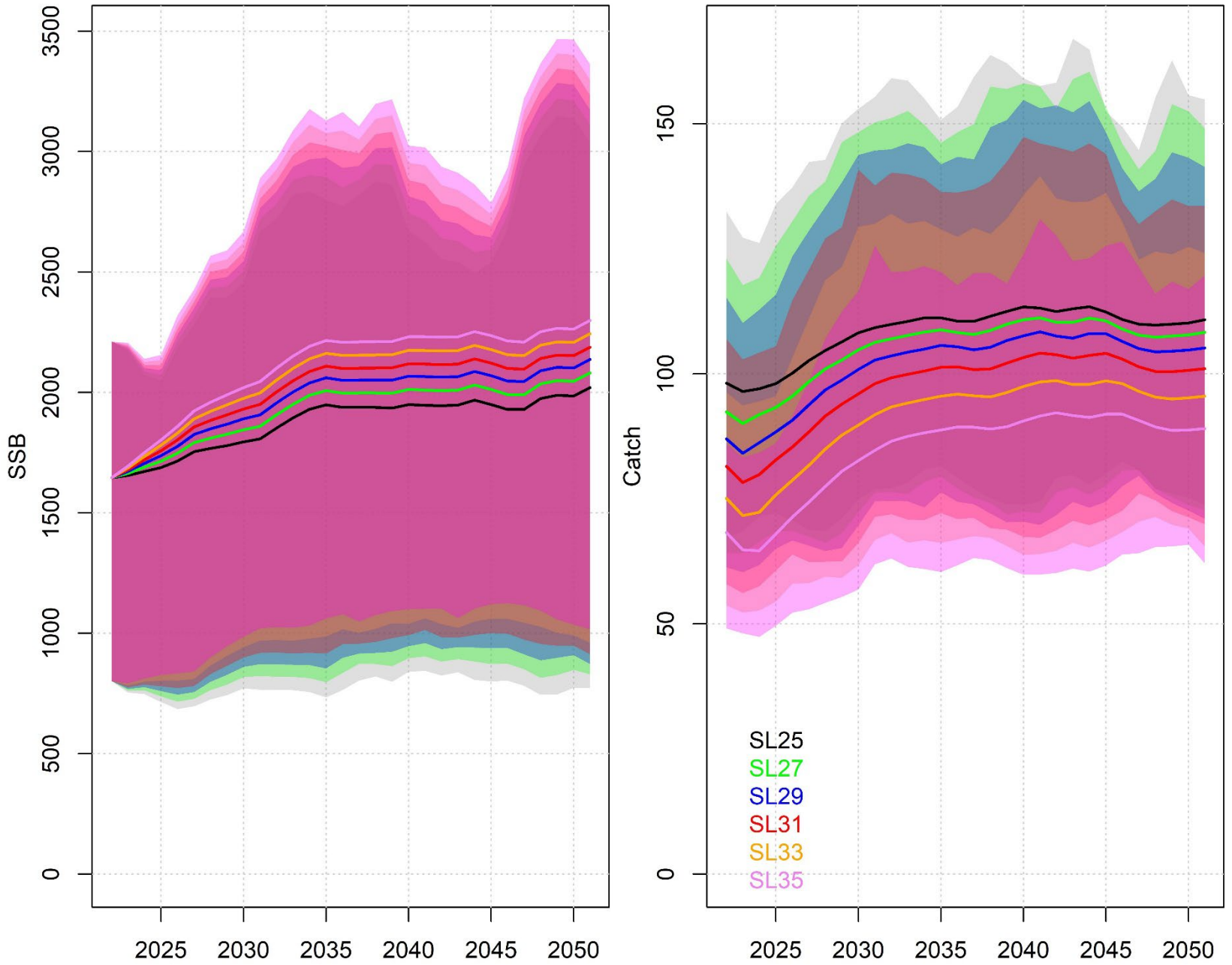
3) Conclude coast-wide status and management performance

3. Example uses

Size limits

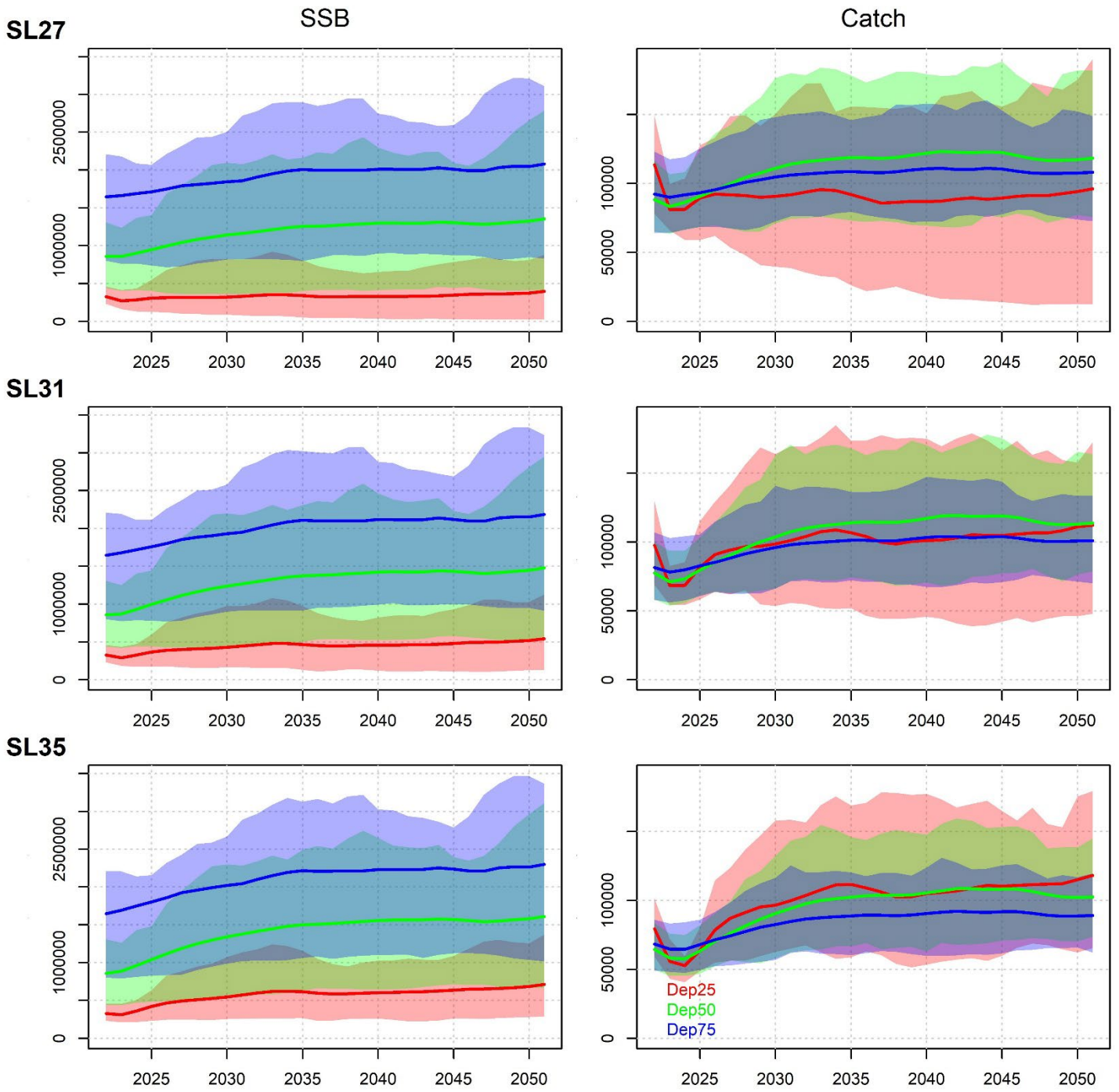
Survey exploitation control

Projecting size limits from 25 – 35 mm



Size limits by stock depletion in 2022

Dep25: B2022 / B2000 = 0.25
Dep50: B2022 / B2000 = 0.5
Dep75: B2022 / B2000 = 0.75



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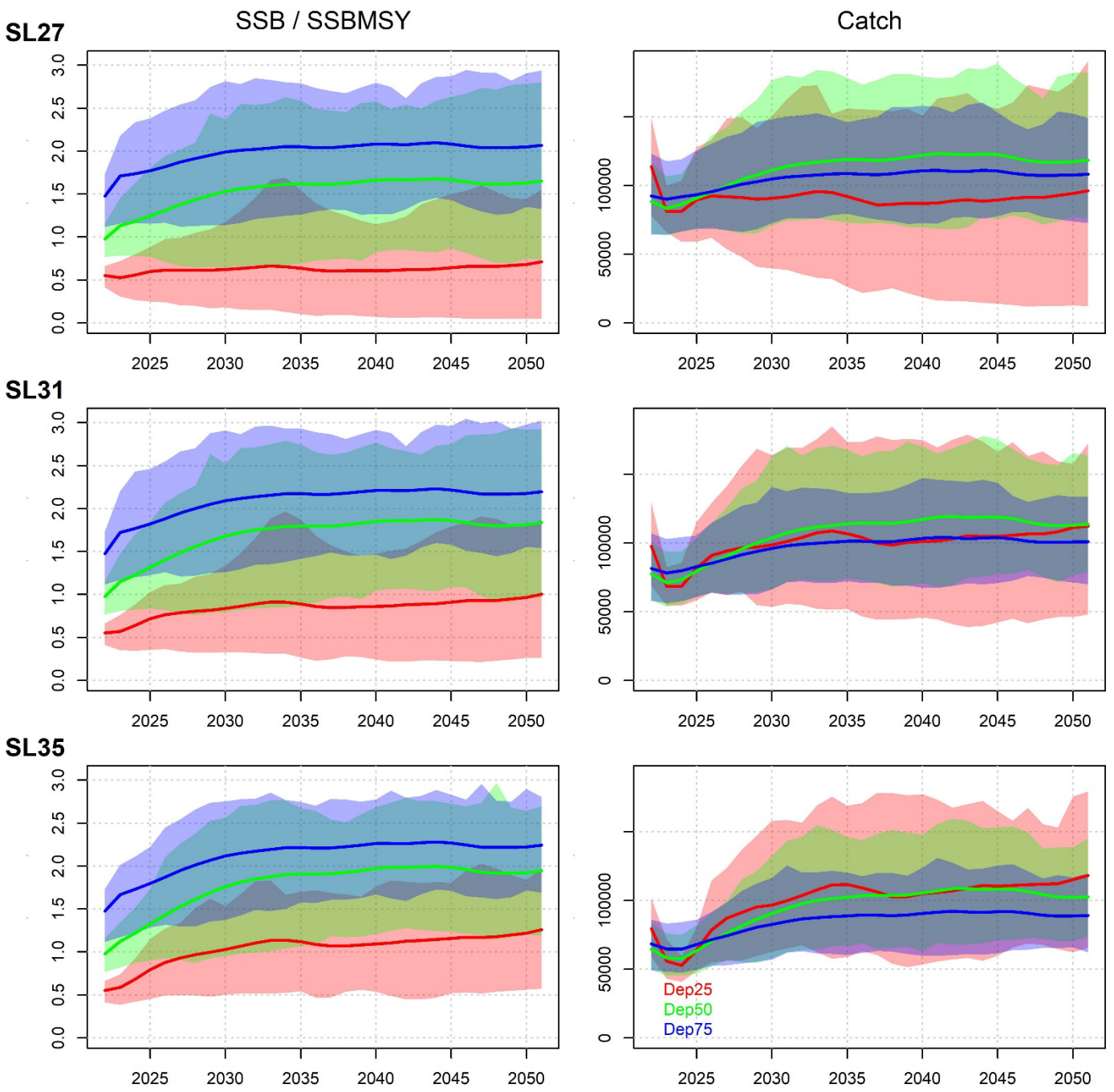

Could disaggregate CMA into beaches

- For example, CMA E has multiple surveys by beach
- Testing of bioeconomic closure (no fishing below x catch rate for example)
- Beach-level closure rules (shut below x kg / m^2)

- Use of buyer data to test opening / closing rules (opening by week) at resolution of subarea
- Opening 'green' (biotoxin & water quality monitoring) – in theory beach level
- Harvesters want quota, beaches removed from openings
- Landings trend / size.
- Tactical advice based on CPUE, ratio of legals / sublegals.
- Evaluation by yield, consistency in yield, ratio of legals / sublegals.

Next steps

- Age data fit
- Effort (slips / year / CMA)
- E biomass survey overlapping years only
- ICMP data (biomass density, lengths)
- Hierarchical estimates of asymptotic length (Linf) (Meghan Burton)
- More tactical beach-level, management options to test (e.g. open closure rules, index rate MPs etc.)
- Developing operating models at varying spatial scales
- Develop robustness tests (Catches, M, Selectivity, depletion – ie performance from LRP, predators?, climate – maturity?)

Performance metrics

- Yield
- Stability in yield
- Legal / sublegal ratio
- Conservation (LRP)
- Accessibility (ie in relation to the location of open / closed areas)
- Economic viability (density-deporation paper has reference points, price of fuel)
- Harvest rate (efficiency)

Other analyses

- ICMP goals?
- ICMP as an input to an exceptional circumstances protocol??
- ECP vs precision / power
- ICMP precision as an input to an HCR.
- ICMP as basis for informing the LRP

Thanks!

Dominique Bureau

Meghan Burton

Shannon Obradovich

Mackenzie Mazur