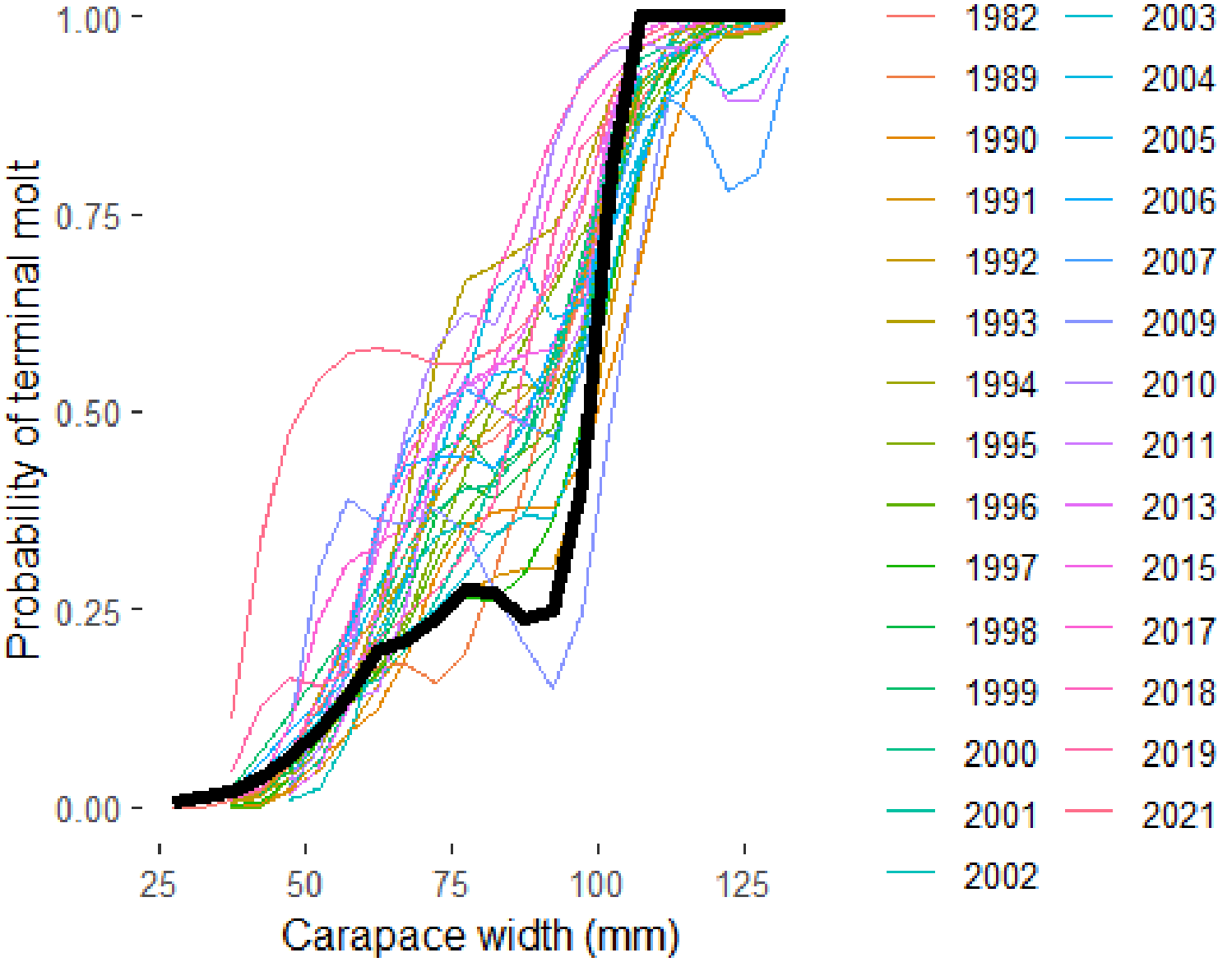
Currency of management: definitions of maturity

January 2024

Crab Plan Team

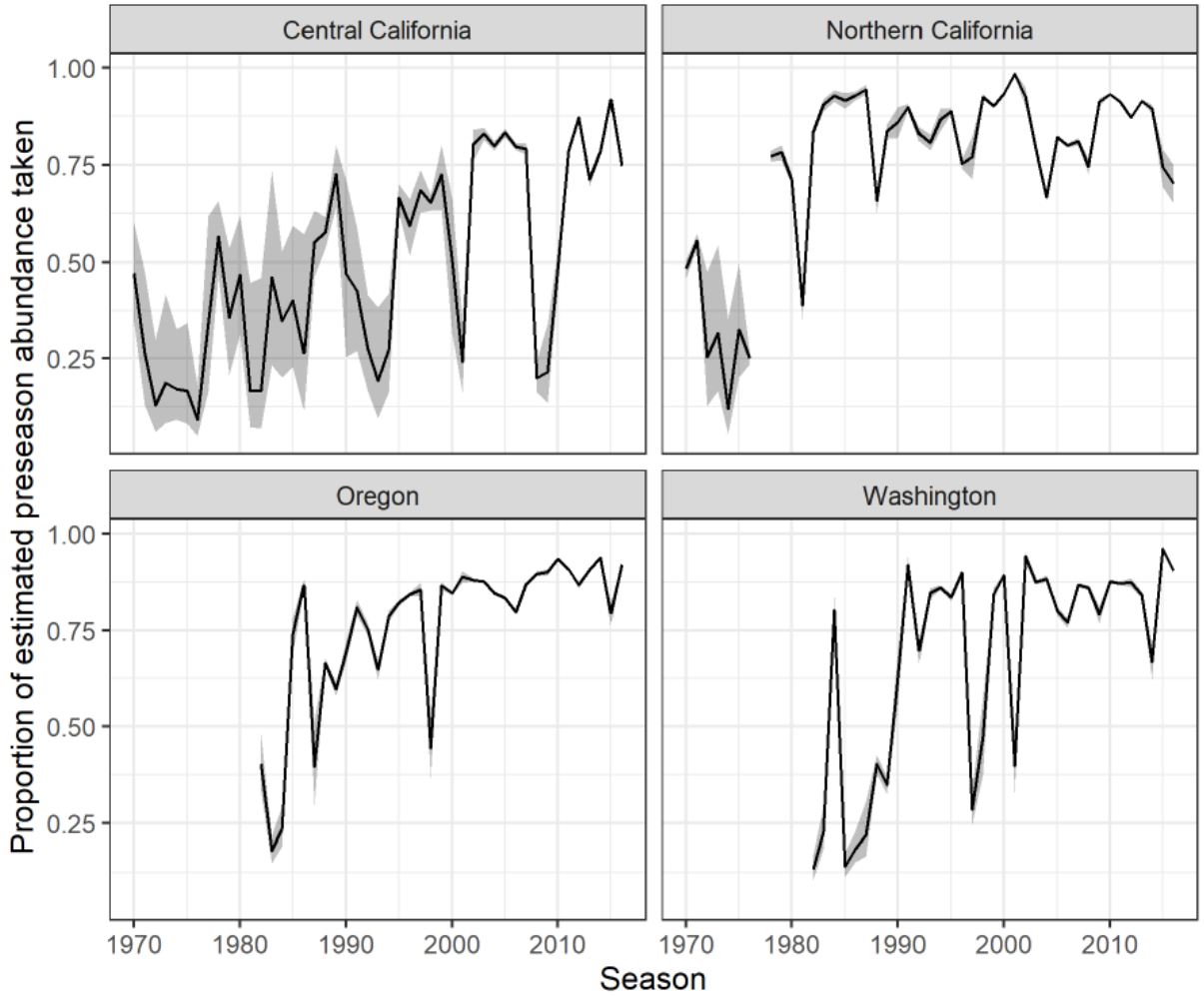
Problem

- Using the observed probability of having undergone terminal molt resulted in very high F35%
- Many more small mature males in the population
- all large males to be harvested as a result of many more small males being included in MMB and reference points, but also protected from the fishery by selectivity



Maybe a high F35% is acceptable?

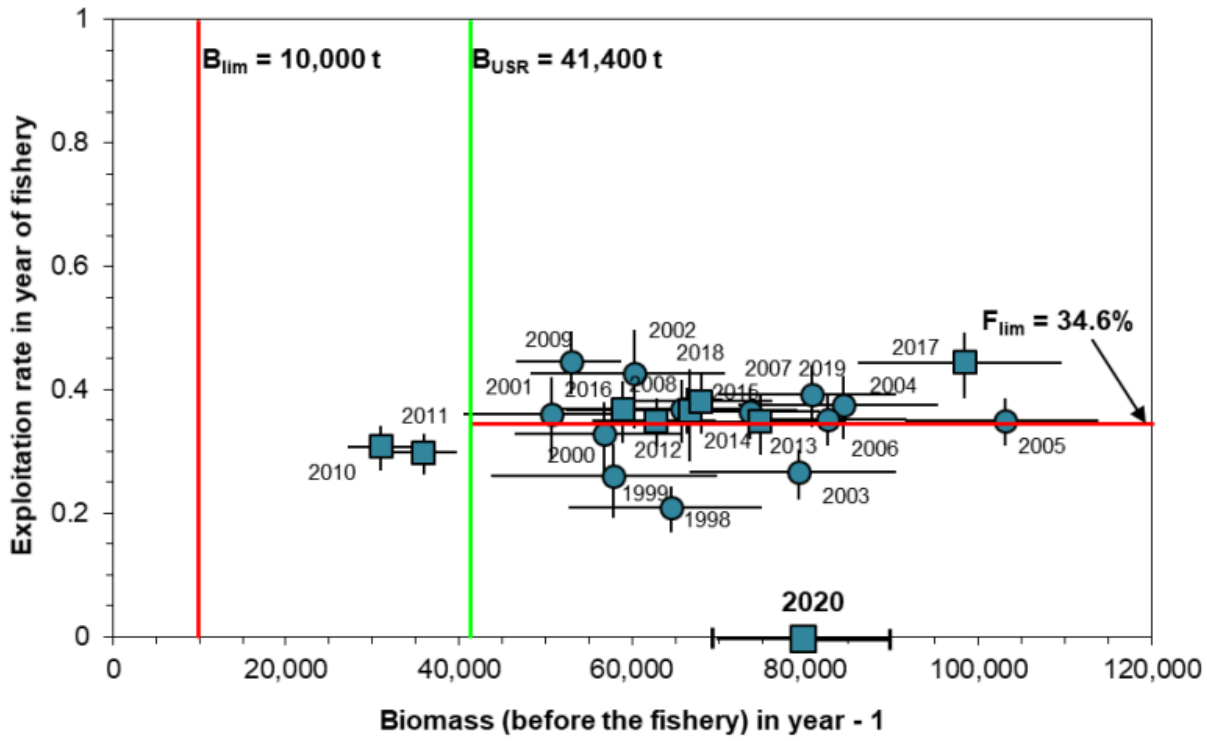
- Laboratory studies show small males can fertilize females (e.g. Watson, 1972 in which a 61 mm male successfully mated with a female that molted from 64 mm to 74 mm).
- Dungeness crab seem to do ok with high Fs, given size limits and seasons are appropriate (Richardson, 2020)
- No clear SR relationship.



Richerson, K. et al. 2020. Nearly half a century of high but sustainable exploitation in the Dungeness crab fishery.

Maybe F35% isn't acceptable?

- Functional maturity in situ appears to be >95mm carapace width (Conan and Comeau, 1986; Ennis et al., 1988)
- Other productive snow crab fisheries have lower Fs (see Gulf of St Lawrence →)



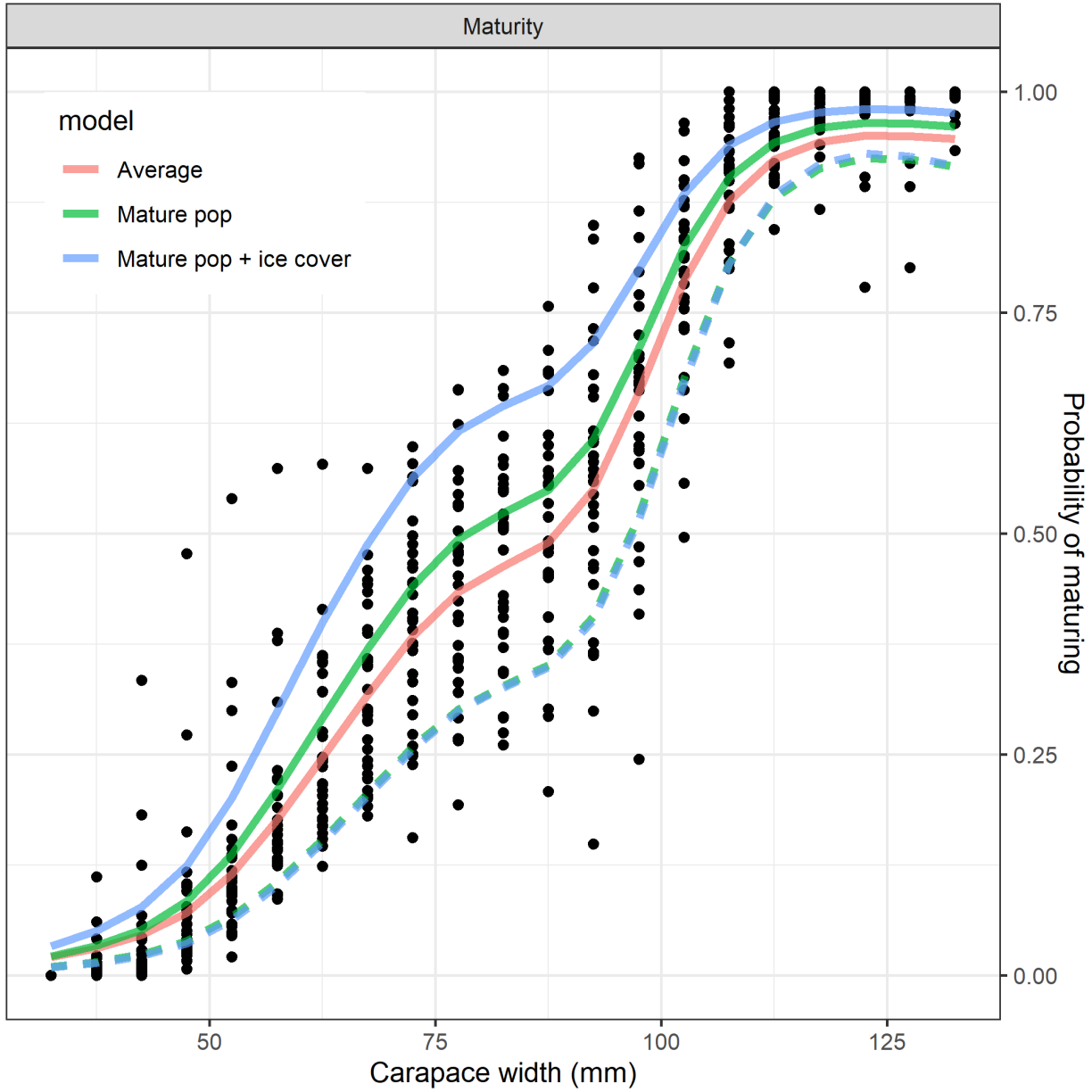
Variation in maturity

- GAM describing variability in probability of size at terminal molt using mature male density and ice cover:

  gam(p(molt)~s(size)+s(dens)+s(ice),family = betar(link='logit')

- Models with density and ice in them explain the data better.
- Higher densities of large mature males are associated with lower probabilities of terminally molting at size.

process	covariate	AIC
Maturity	Mature pop	-1028.3724
Maturity	Ice	-998.7248
Maturity	Mature pop, Ice	-1072.7937



Functional maturity

Specifying a subset of morphometrically mature crab as ‘functionally’ mature and using this definition in the calculation of reference points and OFLs

Larger males are potentially more important in reproduction

Larger males are definitely more important in the fishery

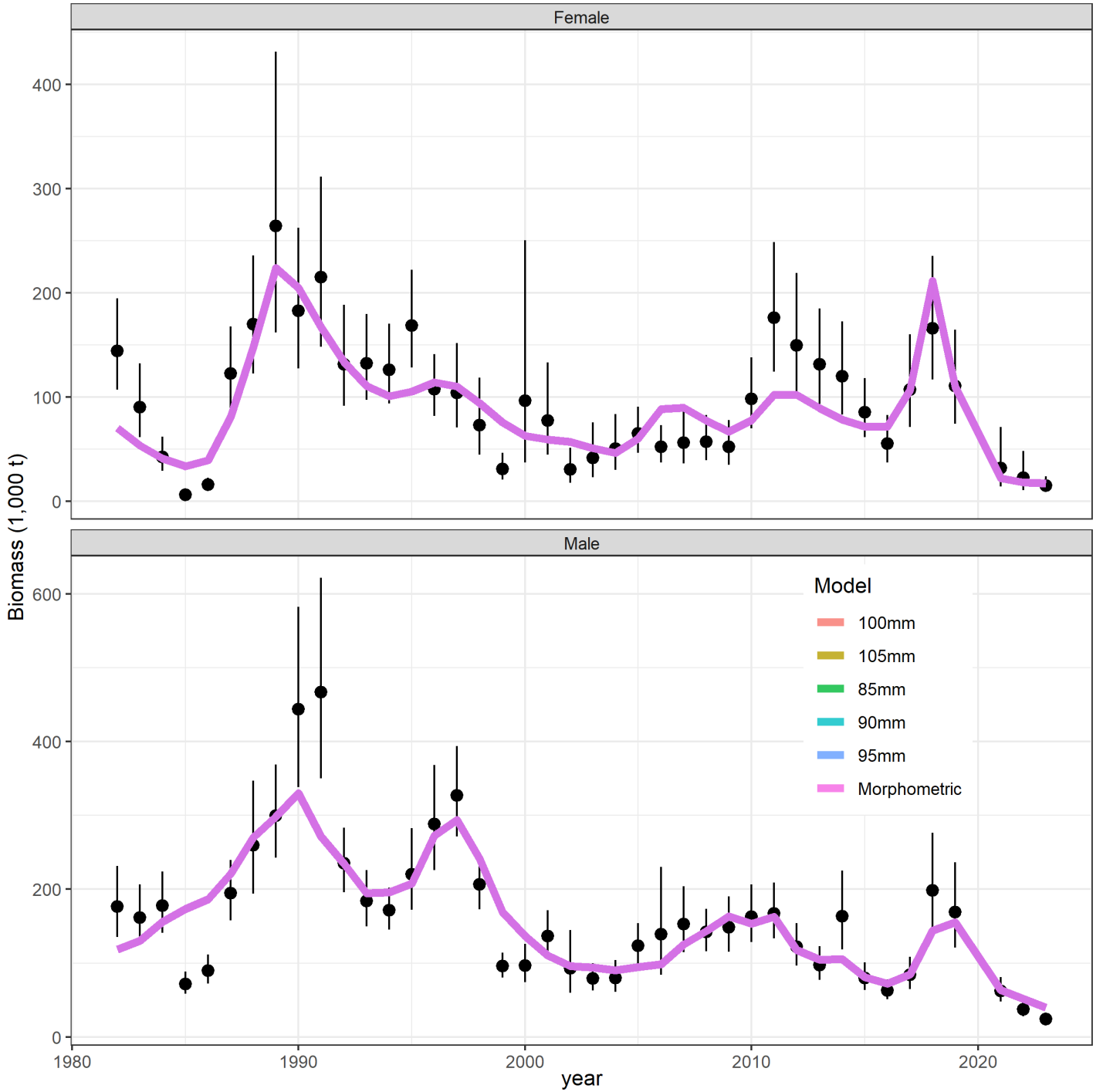
Larger males appear to impact maturity dynamics

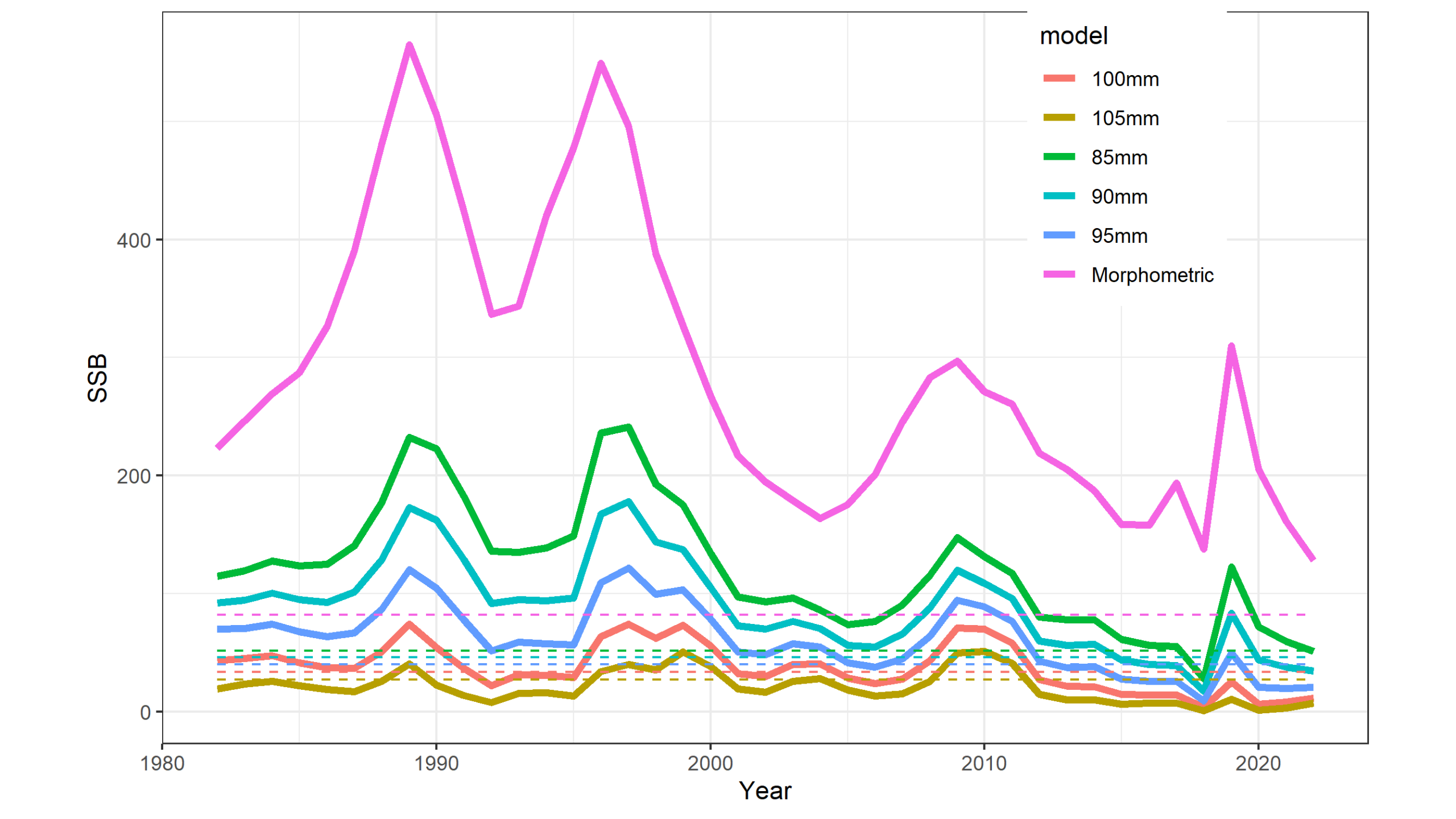
BBRKC functional maturity example

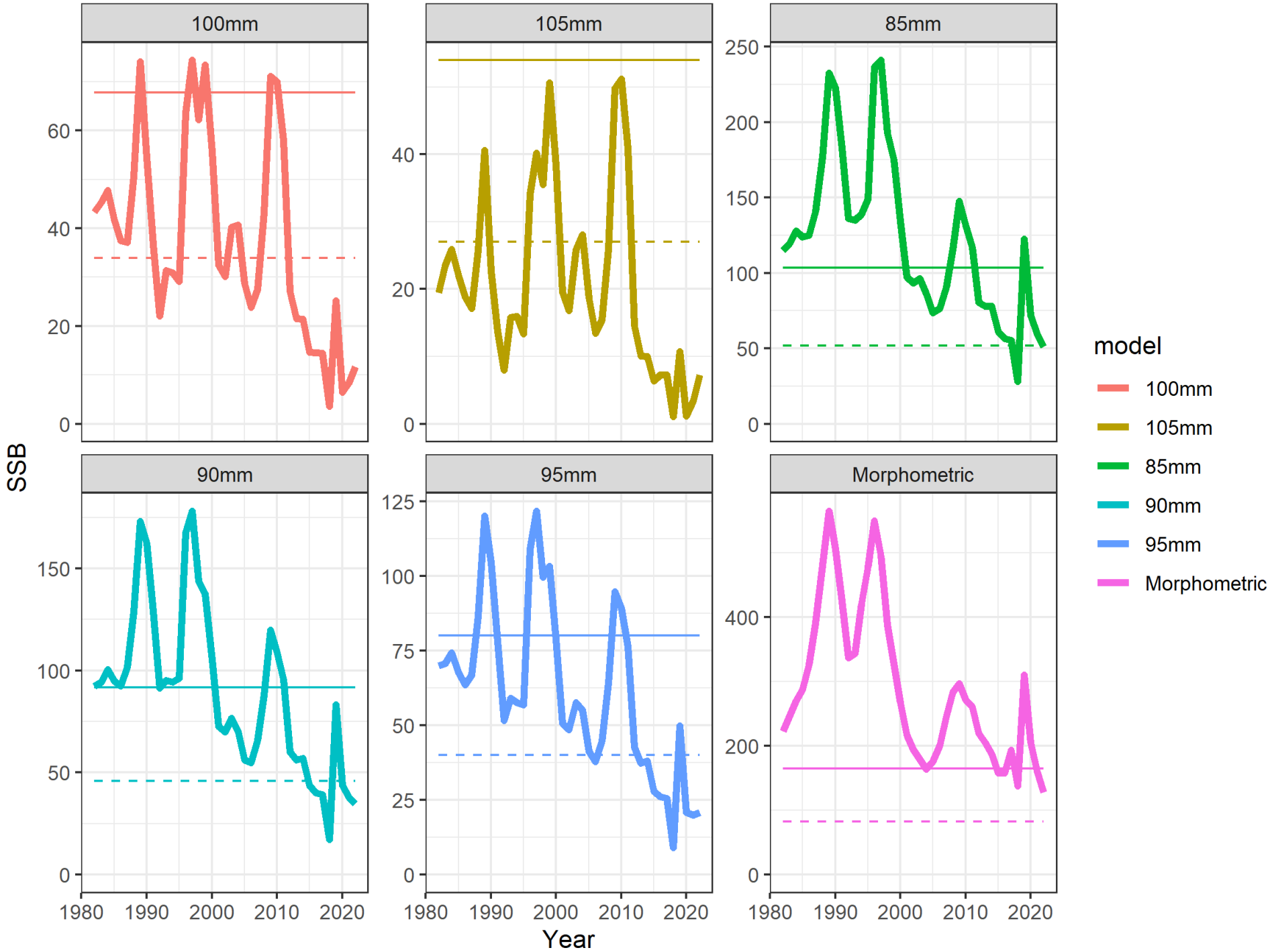
- Management currency = males > 119 mm carapace length
- Male and female RKC mature at 5–12 years old, depending on stock and temperature (Stevens 1990; Loher et al. 2001)
- Male maturity can be defined by multiple criteria including spermataphore production and size, chelae vs. carapace allometry, and participation in mating in situ (reviewed by Webb 2014).
- In Bristol Bay, 50% maturity is attained by males at 120 mm CL (Palof)
- Male legal size was set approximately one growth increment above size-at-maturity to allow males to mate at least once before becoming vulnerable to fishing (Donaldson and Donaldson, 1992). (quoted from Kruse et al., 2010)
- All of this implies that there are ‘mature’ BBRKC in the water that are not counted against MMB and BBRKC is essentially using a ‘functional’ maturity metric.

GMACS modifications

- Including a flag that indicates the inclusion or exclusion of morphometrically mature males as also ‘functionally’ mature
- Does not affect the model fitting, but changes the reference points and OFL calculations




model
100mm
105mm
85mm
90mm
95mm
Morphometric
SSB
400
200
0
1980
1990
2000
2010
2020
Year


100mm
105mm
85mm
90mm
95mm
Morphometric
SSB
Year
model
100mm
105mm
85mm
90mm
95mm
Morphometric

Model	MMB	B35	F35	FOFL	OFL	M	avg_rec	Status
Morphometric	128.09	164.55	63.54	24.78	23.37	0.29	155.67	0.78
85mm	51.08	103.61	2.05	0.57	3.12	0.29	155.67	0.49
90mm	34.70	91.85	1.32	0.26	1.59	0.29	155.67	0.38
95mm	20.87	80.21	0.91	0.00	0.06	0.29	155.67	0.26
100mm	11.71	67.77	0.65	0.00	0.06	0.29	155.67	0.17
105mm	7.28	53.98	0.49	0.00	0.06	0.29	155.67	0.13

Summary

- Morphometric maturity seems like an inappropriate currency of management because it can allow for all large animals to be removed from the population using current reference points.

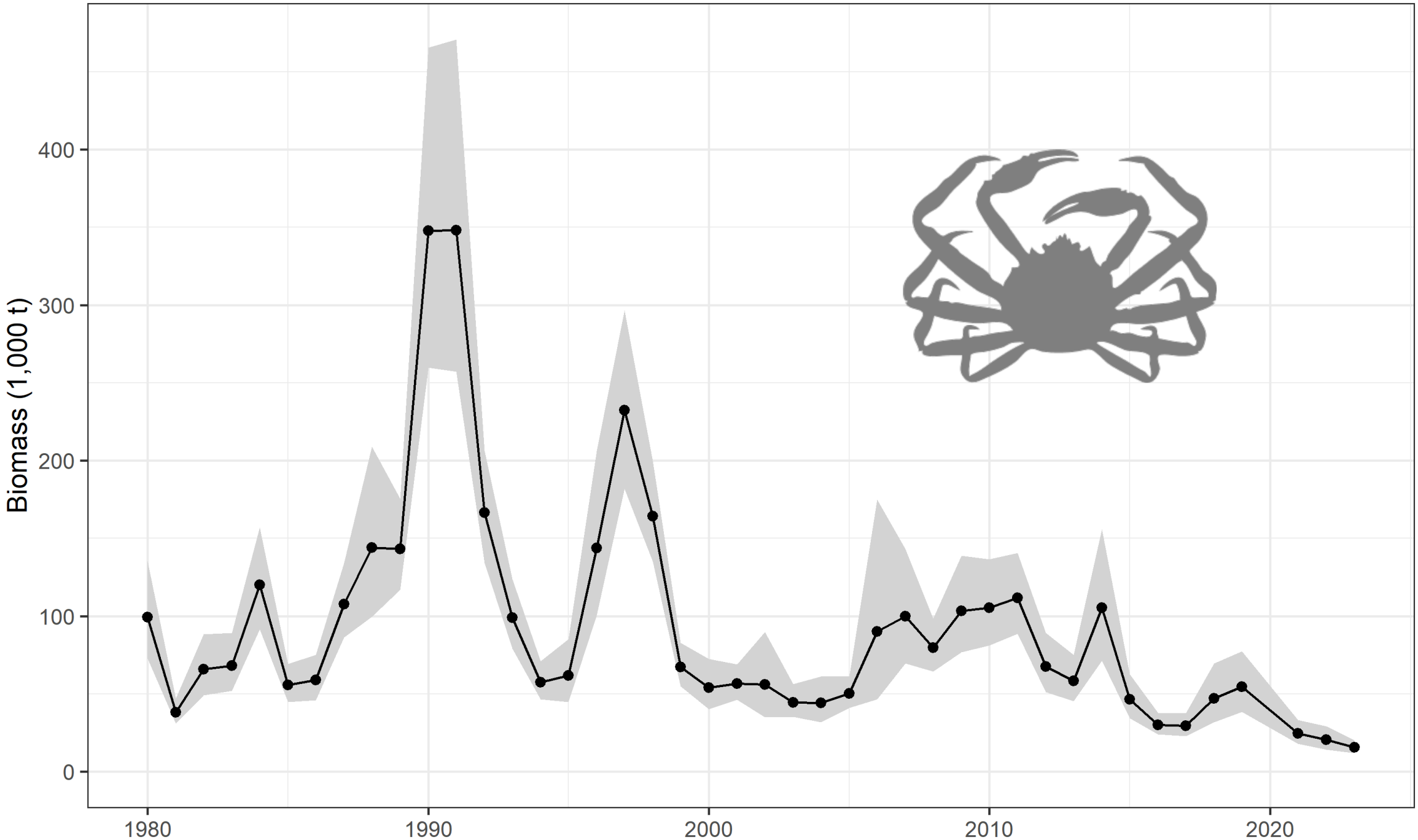
- Other stocks already use something like functional maturity to set reference points.

- GMACS can now do this for terminally molting stocks.

- Changing from morphometric maturity to functional maturity has a large impact on management quantities like OFL and FOFL.

Questions

- What would acceptable evidence be to specify functional mortality as different from morphometric maturity?
- What would be a convincing argument to select one size over another to represent functional maturity?
- If there is a change to some ‘functional’ maturity, should this impact the indices to which the model is fit?


Biomass (1,000 t)
400
300
200
100
0
1980
1990
2000
2010
2020