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# SNOW CRAB REBUILDING PLAN CONSIDERATIONS



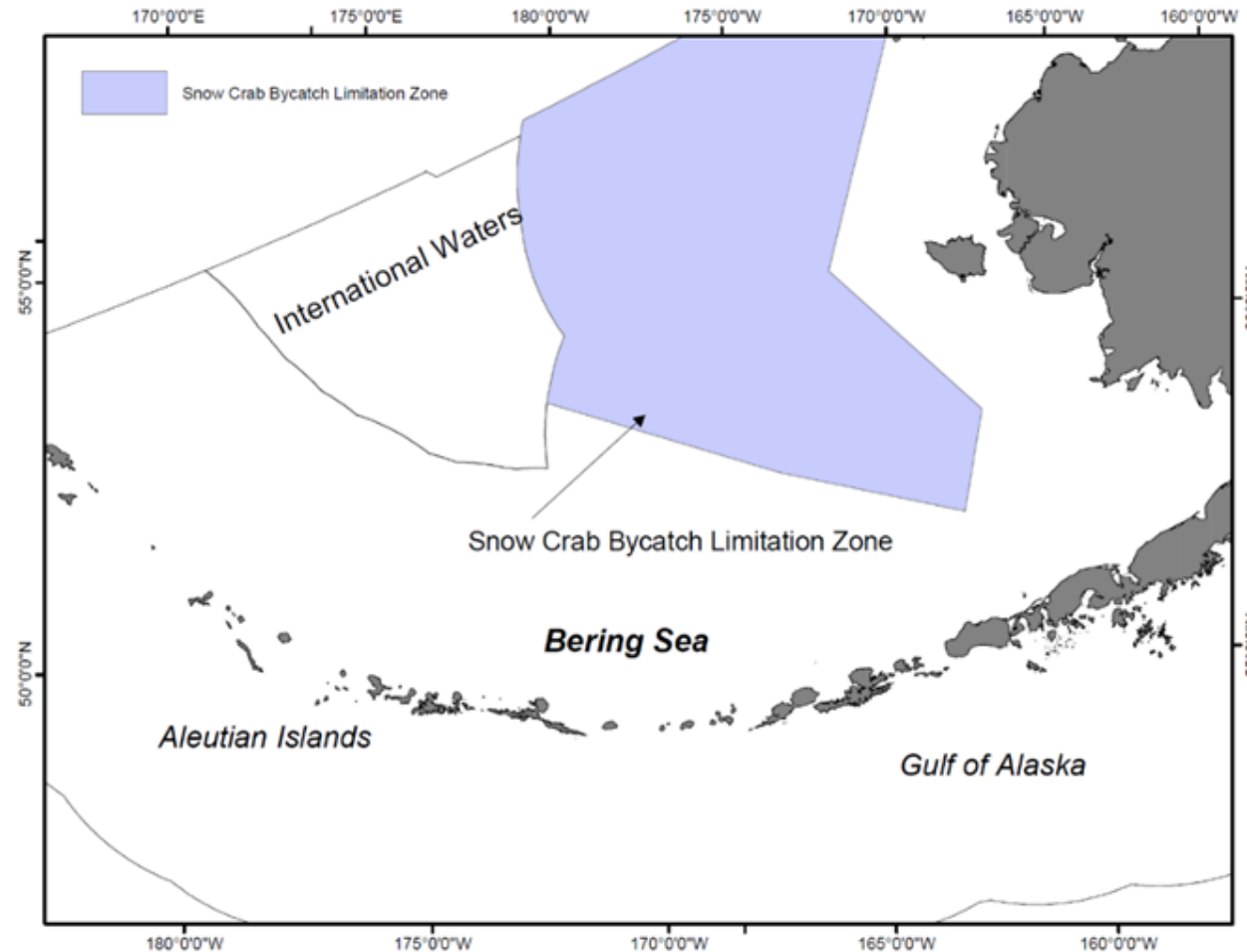
# DISCUSSION ITEMS FOR SNOW CRAB REBUILDING PLAN

Projections for  $T_{min}$  and  $T_{max}$  in May

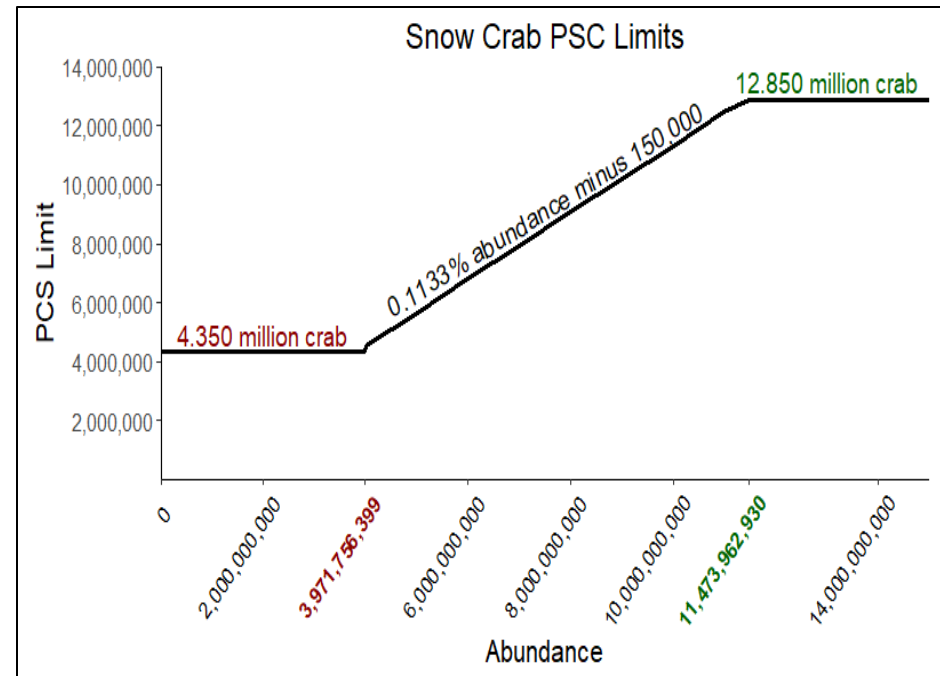
Additional considerations for rebuilding plan?

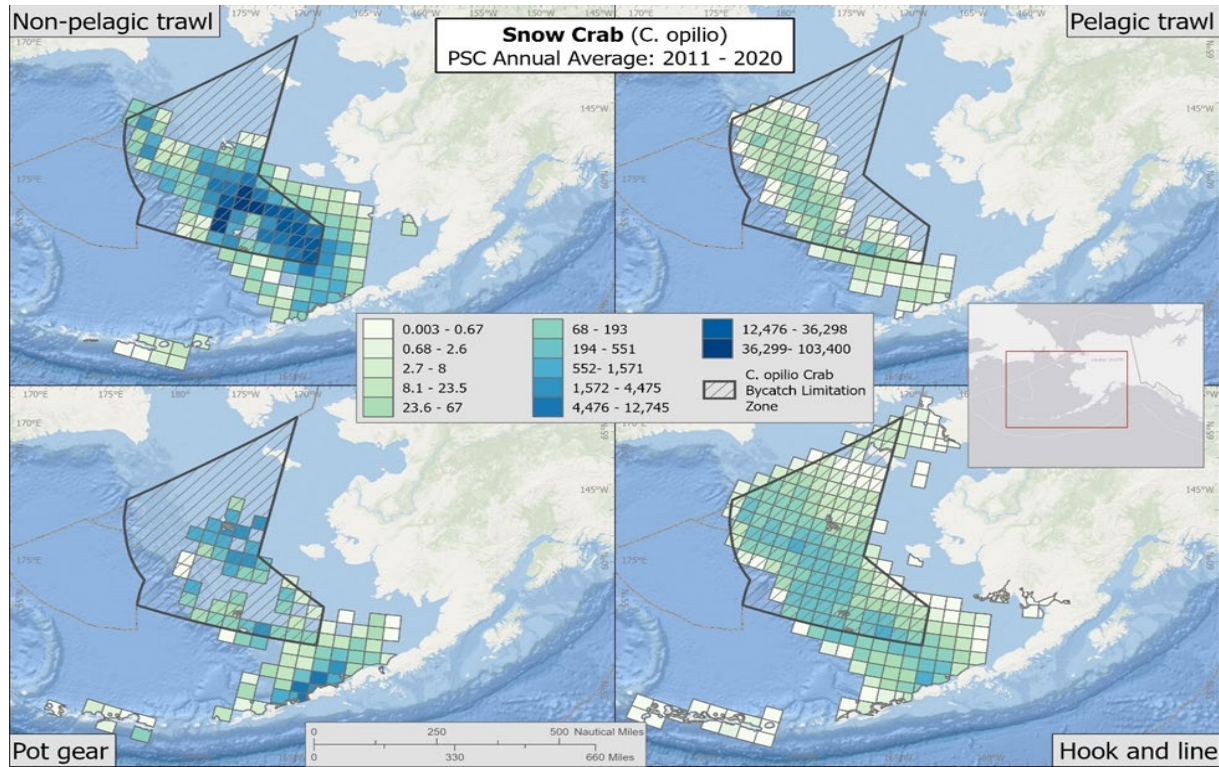
- Bycatch in groundfish fisheries?
  - Trawl limit under COBLZ
  - Fixed gear no limit
- Habitat considerations?

# EBS SNOW CRAB BYCATCH LIMITATION ZONE (COBLZ)



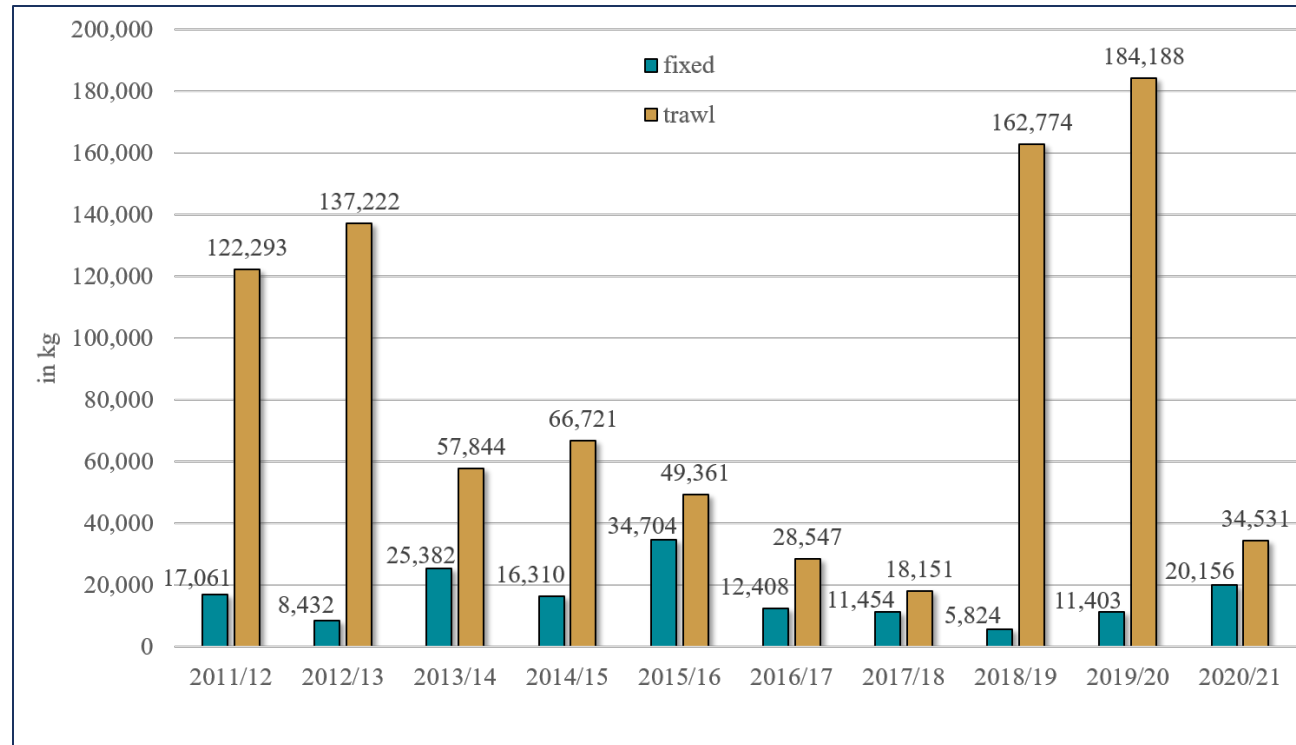
- Set annually at 0.1133% of the snow crab abundance estimates with a minimum and maximum abundance threshold minus an additional 150,000 crab
  - If 0.1133% multiplied by the total abundance is less than 4.5 million crab, then the minimum PSC limit will be 4.350 million crab
  - If 0.1133% multiplied by the total abundance is greater than 13 million crab, then the maximum PSC limit will be 12.850 million animals.
  - Table 4 (page 22 of discussion paper) provides snow crab abundance and the PSC limit from 2012-2021





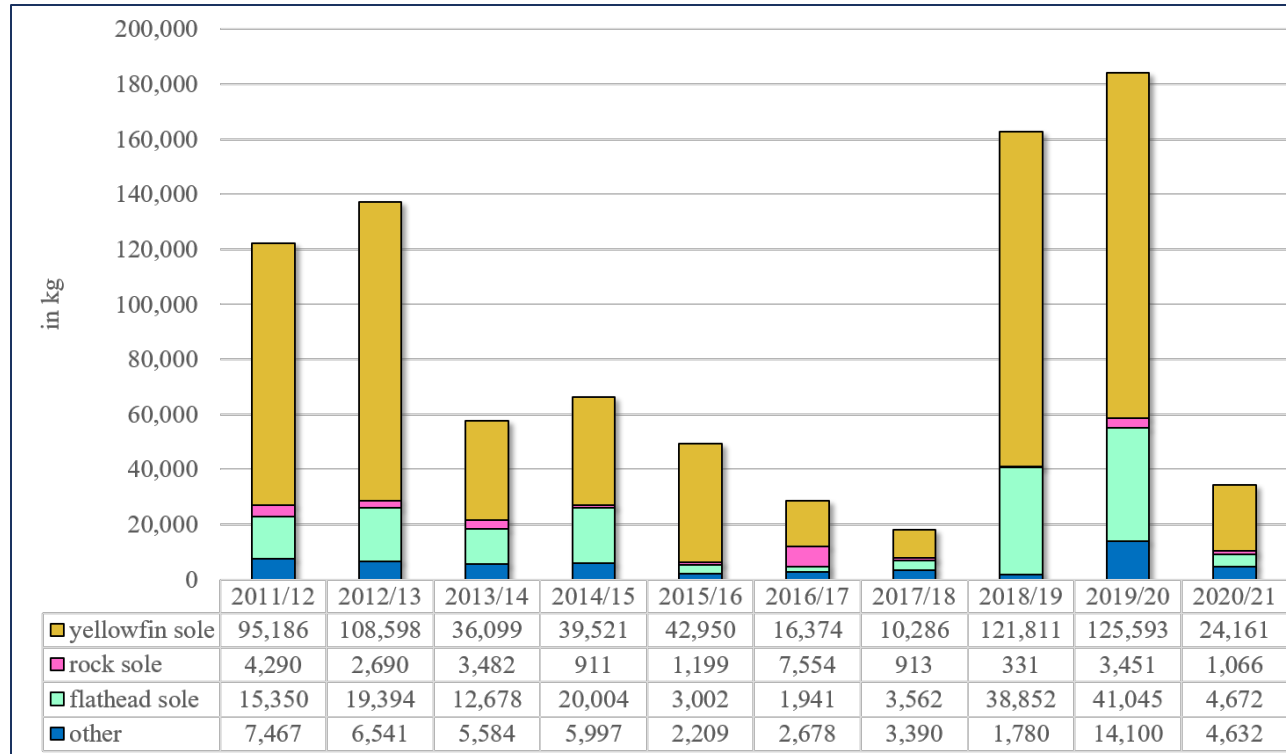
- NPT PSC occurred primarily in the southeast portion of the COBLZ, and extends northwest throughout the zone and primarily east and south of the COBLZ
- Pelagic trawl gear follows a similar spatial pattern but to small magnitude
- PSC in pot gear is distributed throughout the southern two-thirds of the COBLZ and southeast border of COBLZ along the AI
- HAL gear has the largest spatial distribution, which is likely due to the spatial distribution of effort in the HAL fisheries

# BERING SEA SNOW CRAB INCIDENTAL CATCH IN GROUND FISH FISHERIES



- Pot and hook-and-line Pacific cod fishing accounts for most BSS bycatch in the fixed gear category with about 75% coming from pot gear.
- Hook-and-line Pacific cod fishing is spread out throughout the stock area.
- Pot Pacific cod fishing is concentrated on the north side of Unimak Island to Port Moller.

# BERING SEA SNOW CRAB TRAWL INCIDENTAL CATCH BY TRIP TARGET



- 2018/19 and 2019/20 increased BSS bycatch in the yellowfin fishery was due mainly to increased yellowfin sole fishing in the area above the Pribilof Islands.
- “Other” species includes: Alaska plaice, arrowtooth flounder, Atka mackerel, Greenland turbot, Kamchatka flounder, other flatfish, Pacific cod, rockfish, and pollock.

# Snow crab updates

SSC meeting

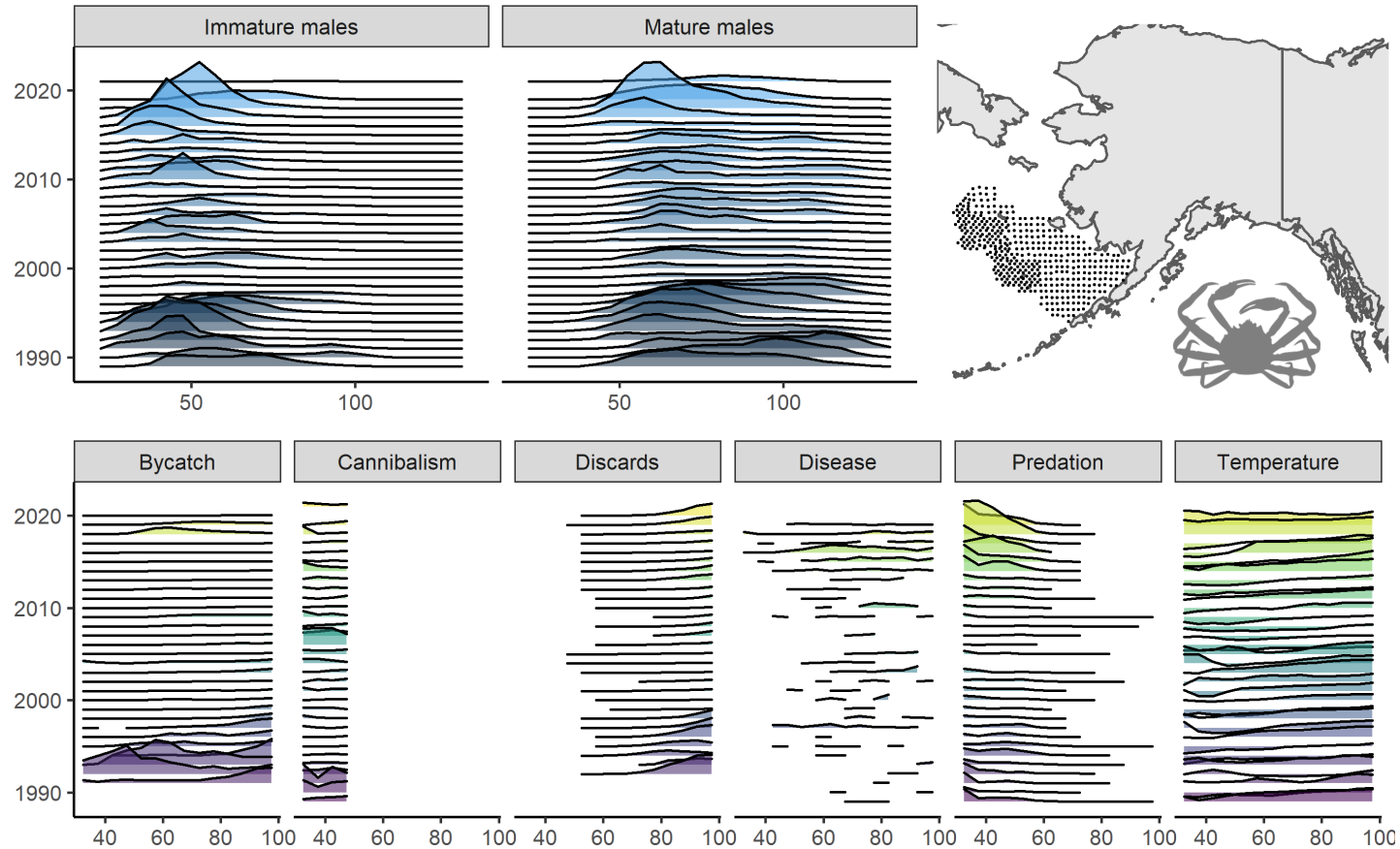
February 1, 2022

Cody Szuwalski



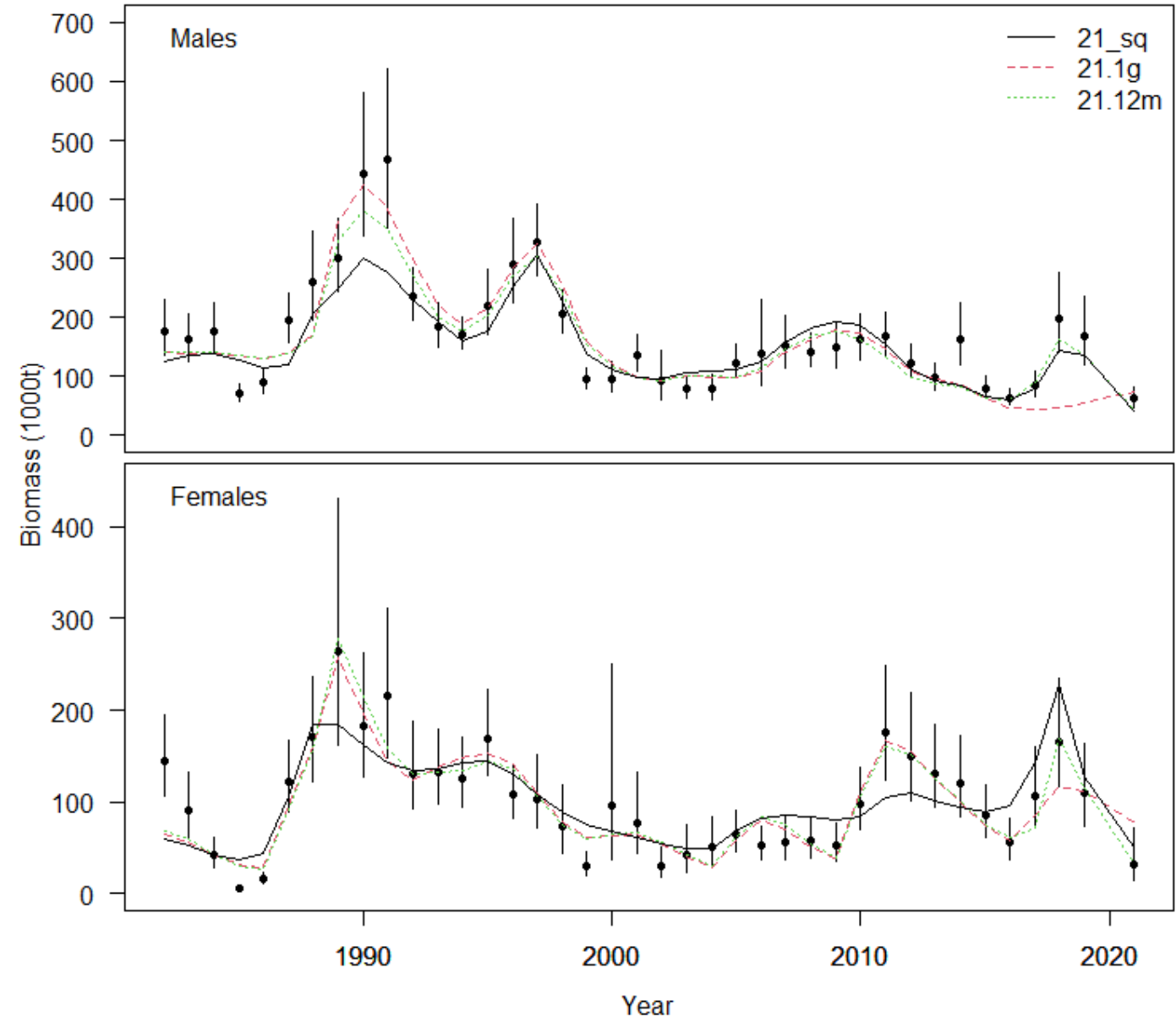
# Activities since October

- What happened?
  - Male only population dynamics model + GAM
  - Predation, temperature, disease, cannibalism, fishery effects
- GMACS
  - Time-varying natural mortality
  - Renewed adoption
- Rebuilding
  - Projections
  - Recruitment, natural mortality, other potential scenarios



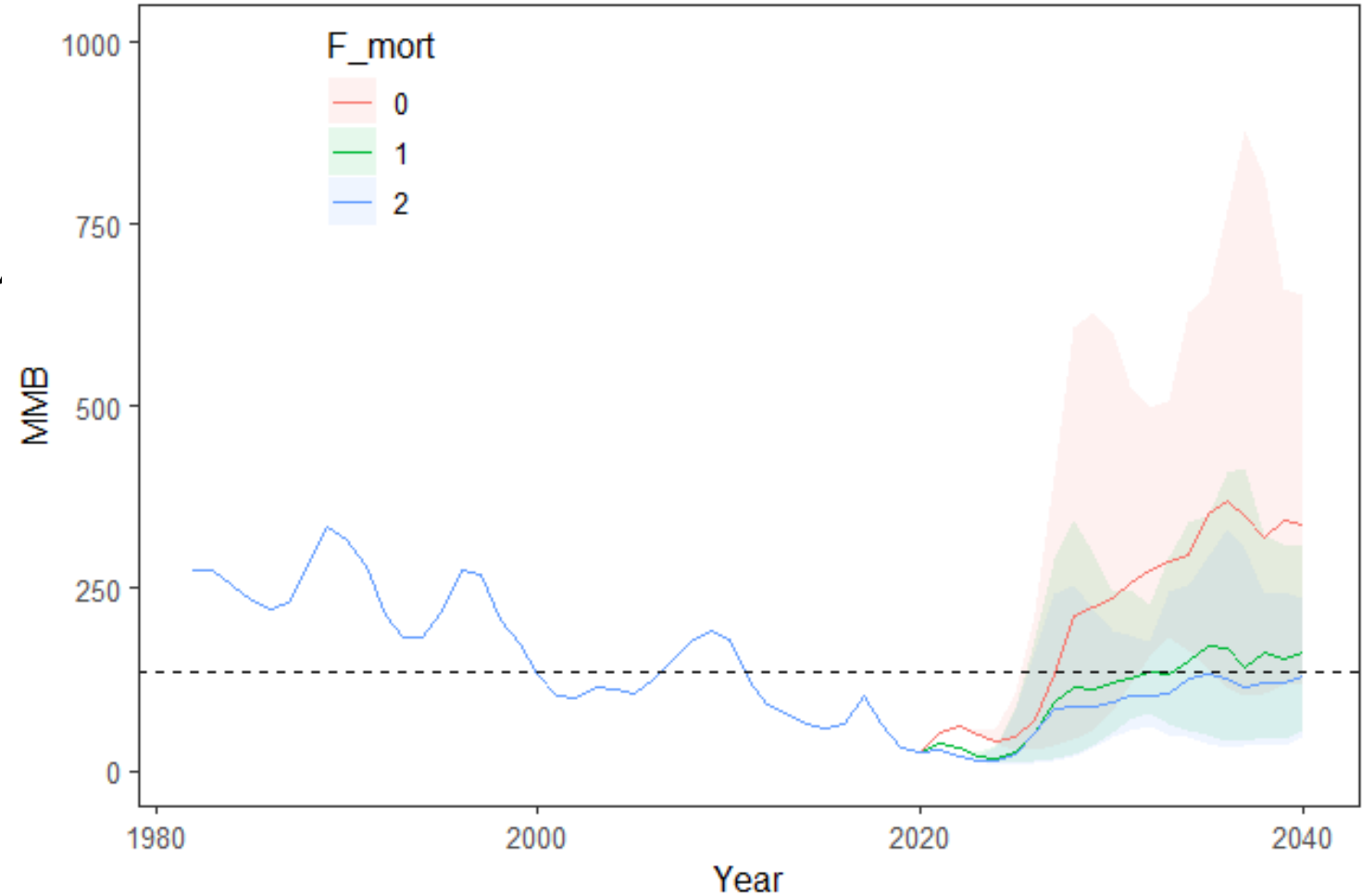
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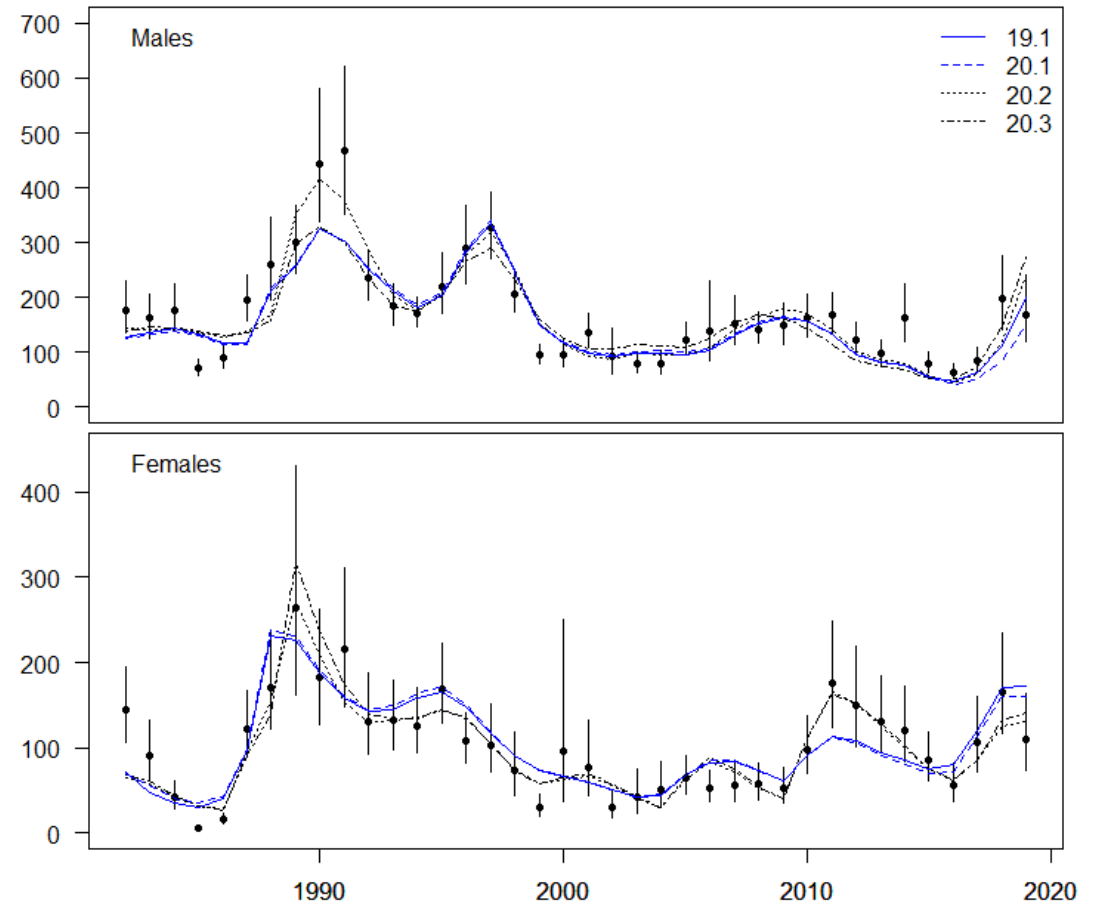
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How do we get to GMACS?

# Sept. 2020: CPT accepted GMACS for snow crab

- Better model fits
- Improved structure and assumptions
- Model stability
- Common code base



# Reproducing the numbers at size matrix

- Males reproduced well:  
Mean absolute relative difference in numbers at size bin over year = 0.00001%
- GMACS can reproduce the male dynamics nearly perfectly rounded to the whole number

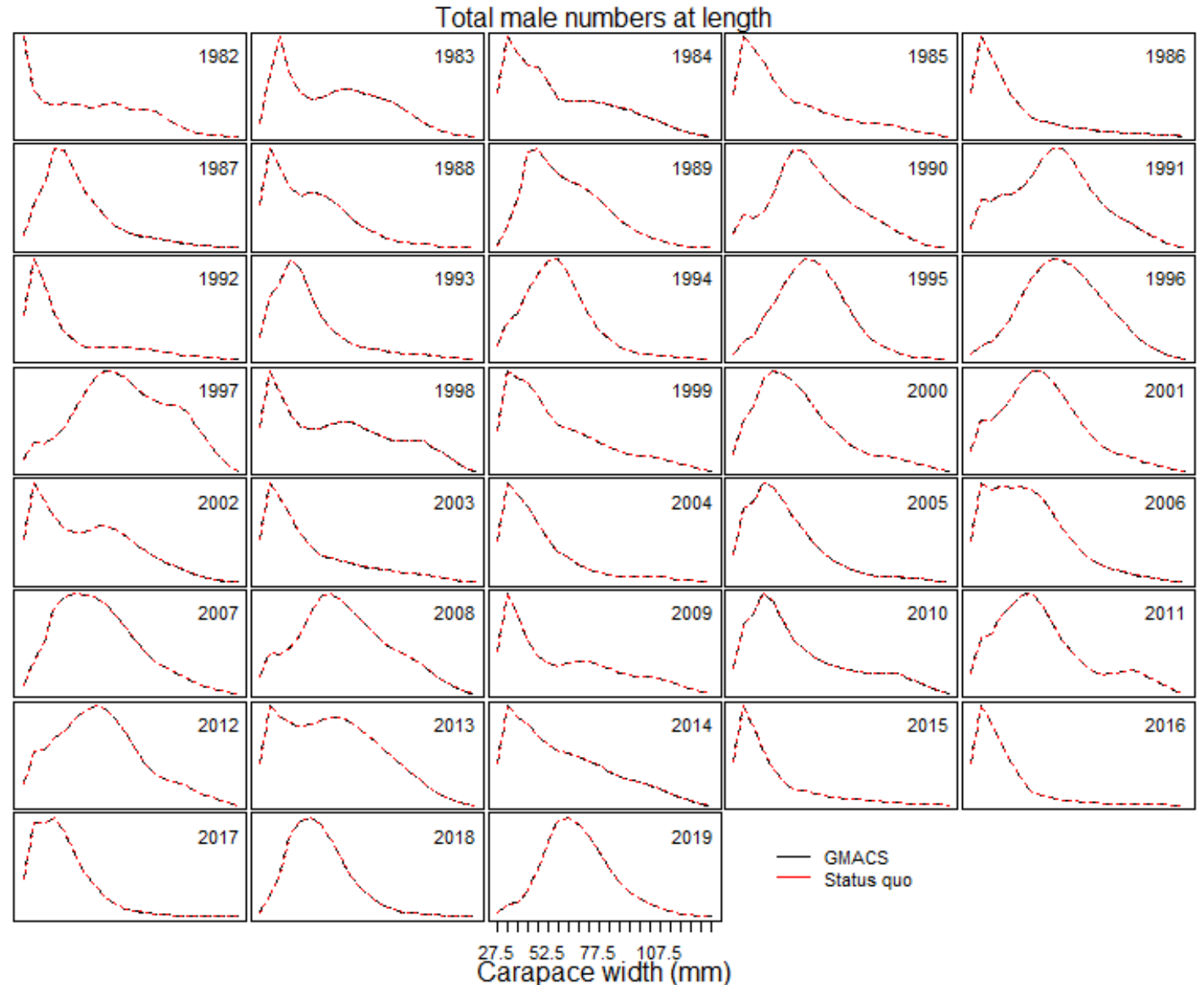


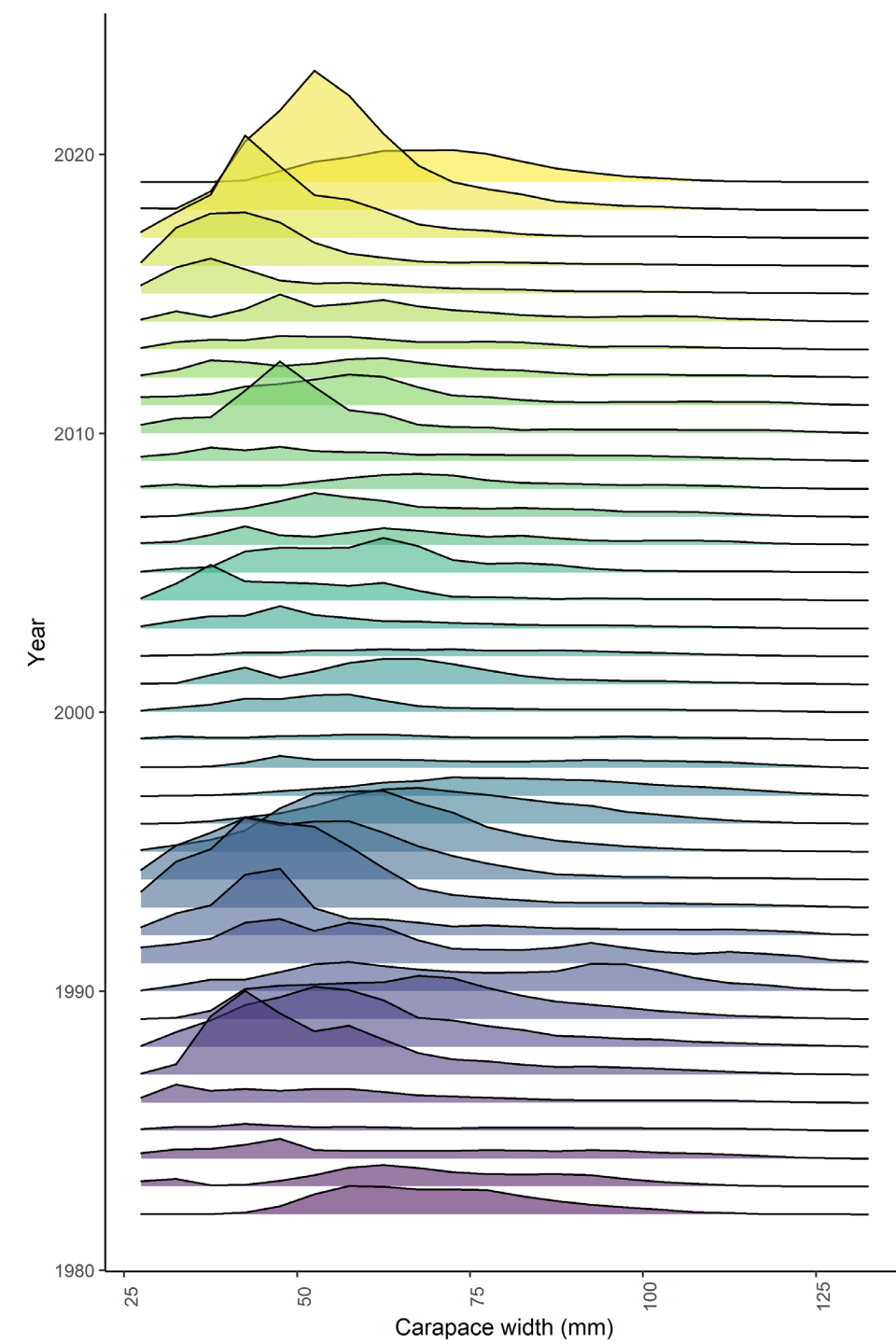
Table 12: Differences between GMACS and the status quo model.

Process	GMACS	Status quo
Recruitment	Yearly recruitment estimate + parameter to divide recruitment between sexes	Separate estimated recruitment deviations and average recruitment for both sexes
Fishing mortality	Total mortality and female discards treated consistently (see May CPT document)	Total mortality and female discards treated inconsistently (see May CPT document)
Growth	Linear growth for both males and females	Linear growth for males; kinked growth for females
BSFRF	Freely estimated availability curves for all sex/year combinations	Logistic availability curves for some sex/year combinations
Natural mortality	Estimated M for mature males, mature females, immature males, immature females (n=4)	Estimated M for mature males, mature females, immature males and females (n=3)

# Oct. 2020: SSC rejected GMACS

Reasons listed:

- Changes in stock size
- Retrospective patterns
- Large estimated recruitment
- High estimated fishing mortality
- Natural mortality priors should use Barefoot Ecologist

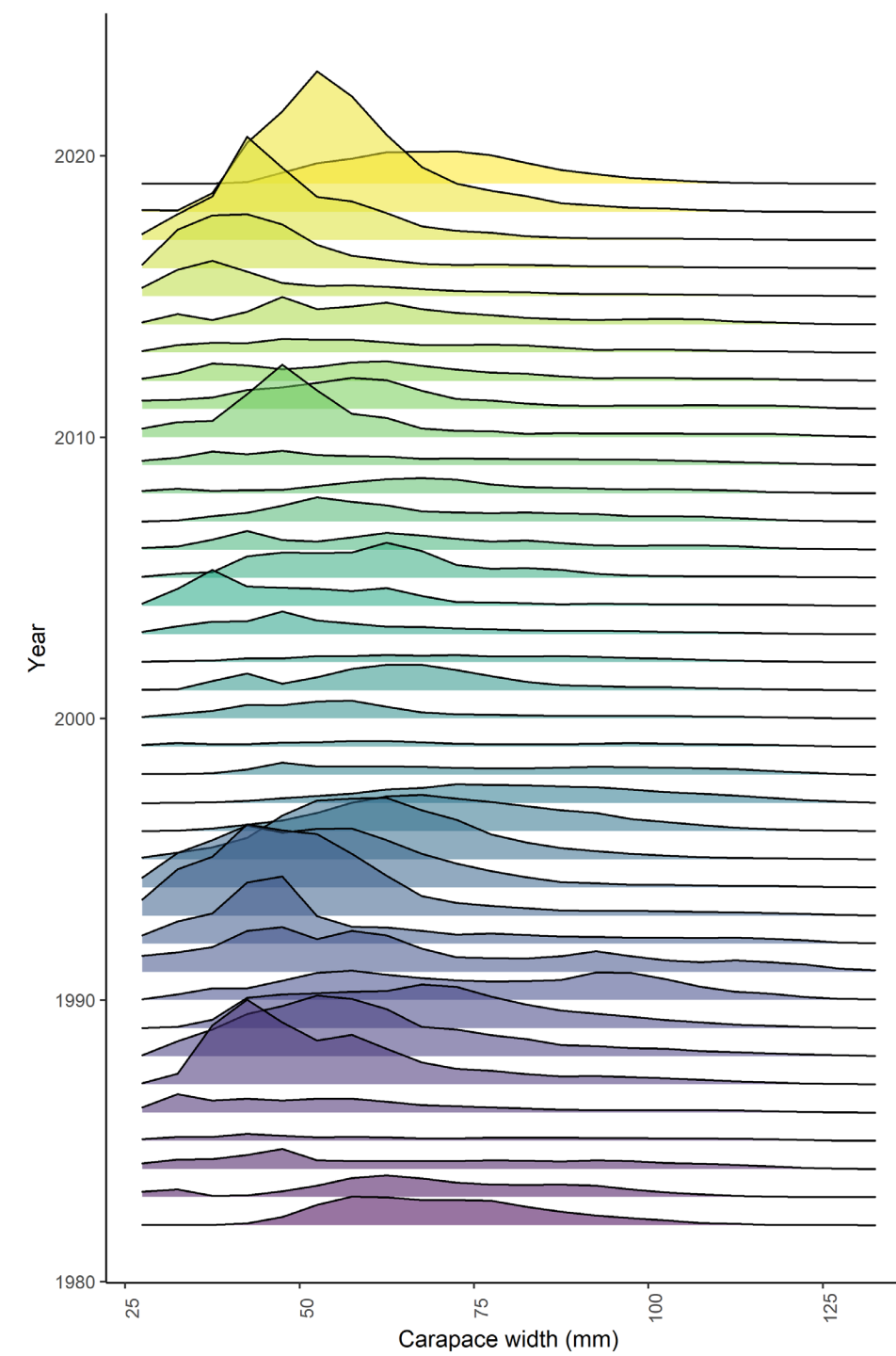




# Oct. 2020: SSC rejected GMACS

## Responses given

- Changes in stock size
  - Changes in stock size were commensurate with increases in the survey—the population was moving from the lowest MMB observed to the largest cohort ever observed...increases were expected.
- Retrospective patterns
  - Retrospective patterns existed in both the status quo model and GMACS
- Large estimated recruitment
  - The large estimated recruitment reflected a cohort we had observed in the survey for 4 years
- High estimated fishing mortality
  - This was actually a ‘feature’ of the status quo model
- Natural mortality priors should use Barefoot Ecologist
  - The assessment used the same methods as the Barefoot Ecologist

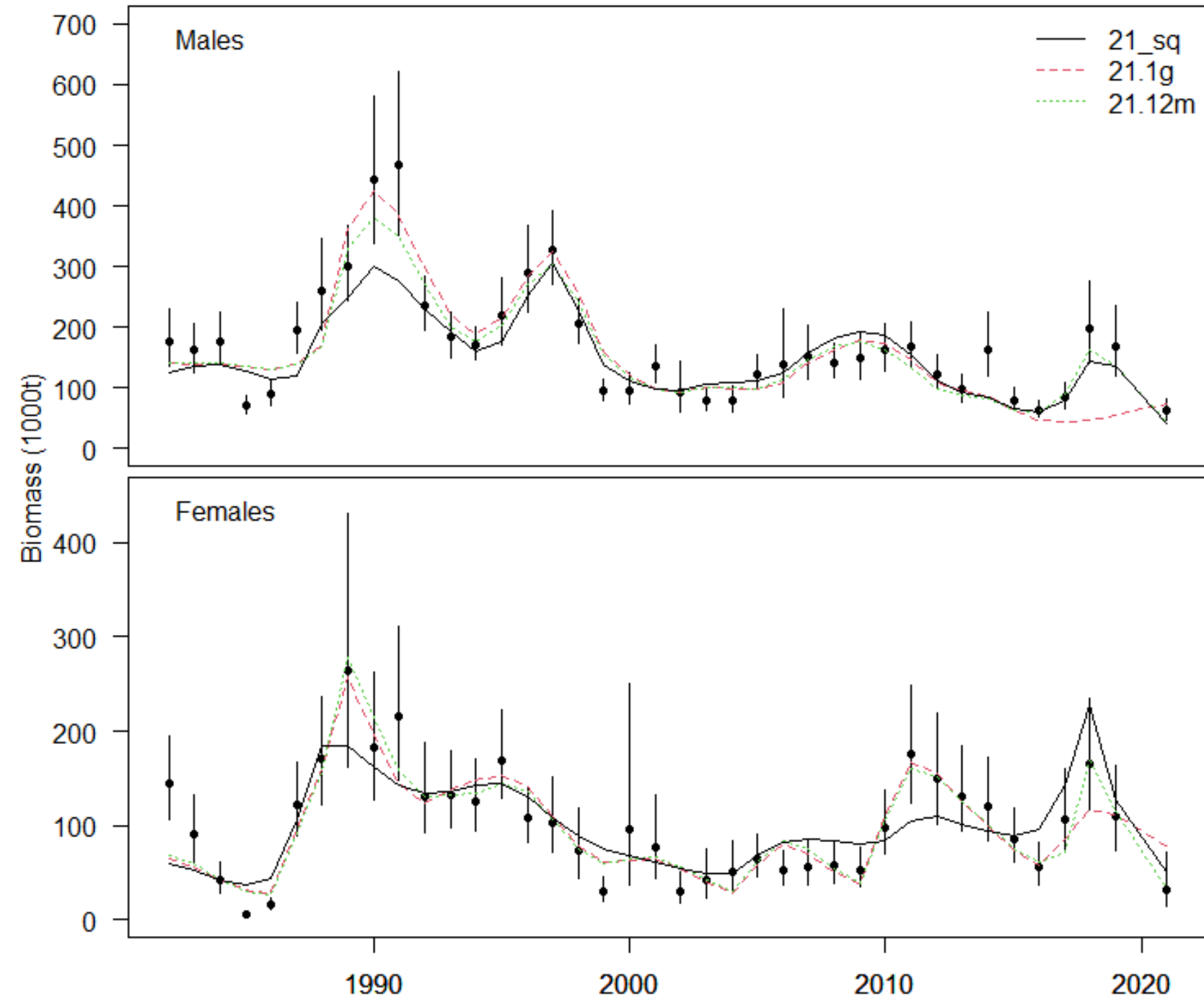


# August 2021

- Status quo model would not converge with new data
- Status quo model with extra mortality in 2018 and 2019 was accepted for use

Could not code time-varying natural mortality for terminally molting into GMACS in time for use in management

Snow crab in GMACS with time-varying M  
(January 2022)

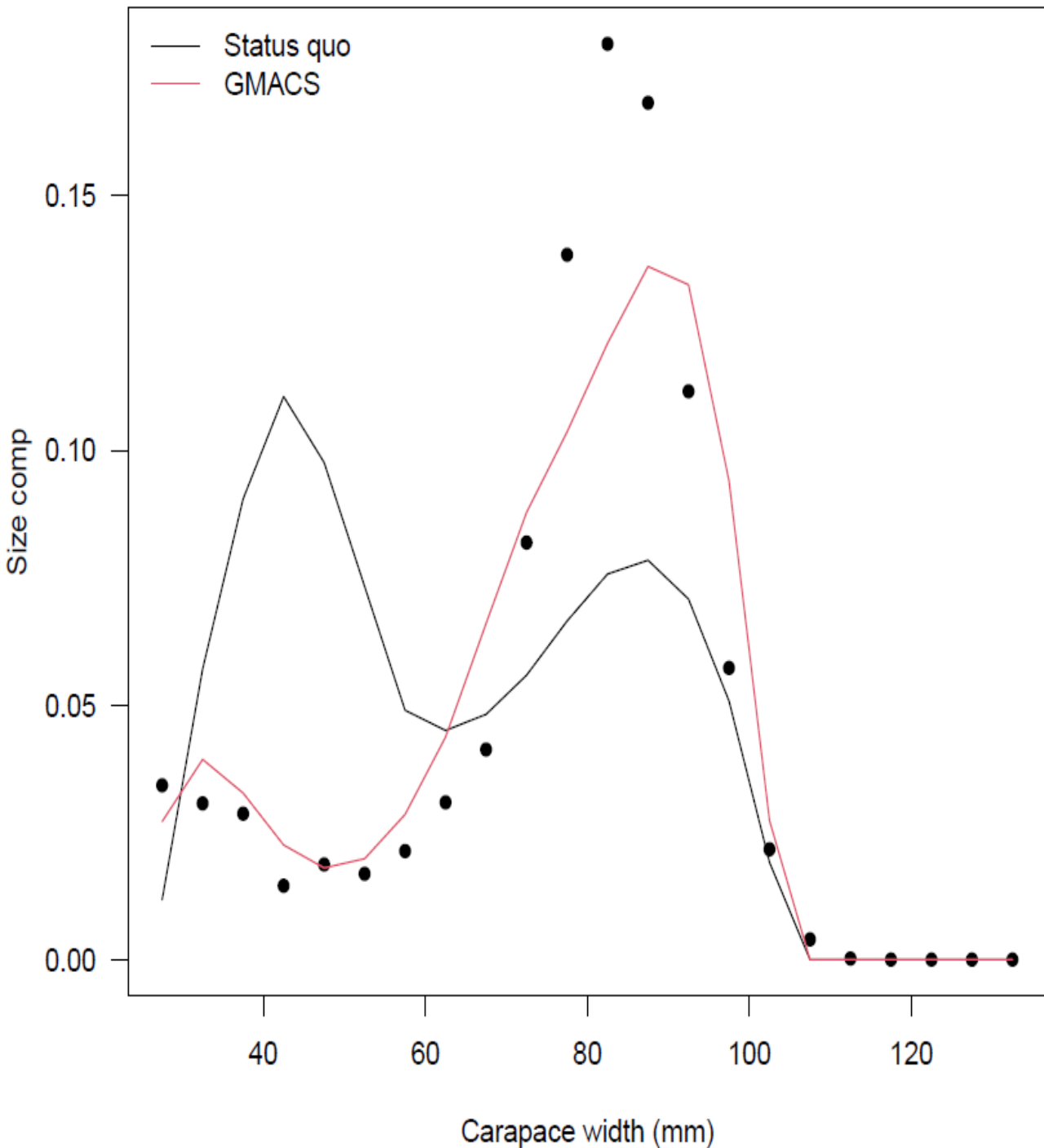


- Fits in recent years are very similar between status quo and the new GMACS for males
- Time-varying M 'works' for terminally molting life histories in GMACS now

Model	MMB	B35	F35	FOFL	OFL	M	avg_rec
Status quo	26.74	153.42	1.43	0.37	7.50	0.27	106.14
GMACS (no time-m)	43.51	84.20	2.60	1.40	23.69	0.35	125.20
GMACS (time-m)	25.53	135.32	2.31	0.00	0.10	0.36	189.52
GMACS (time-m + avg M fixed to status quo)	23.37	155.94	1.51	0.00	0.10	0.27	119.89

- Even though time-varying M ‘works’ in GMACS, management quantities are quite different
- Estimated M increased with GMACS, but even when fixing M in GMACS to that estimated by the status quo, the FOFL was still zero

Why?



- FOFL is calculated on projected biomass at the time of the fishery
- Estimates of 2021 size comps differed dramatically between GMACS and SQ
- The status quo model estimated *large numbers of small immature crab* that were not seen in the survey
- This resulted in more MMB in 2022 as the stock was projected forward and those small crab grew and matured.
- GMACS did not have this issue

# We need to use GMACS

But GMACS does not solve problems related to:

- Retrospective patterns
- Identifying appropriate time-variation in population processes (though these can be considered in GMACS...and also can 'treat' retrospective patterns)
- Uncertainty around appropriate currency of management (morphometric maturity vs. functional maturity)

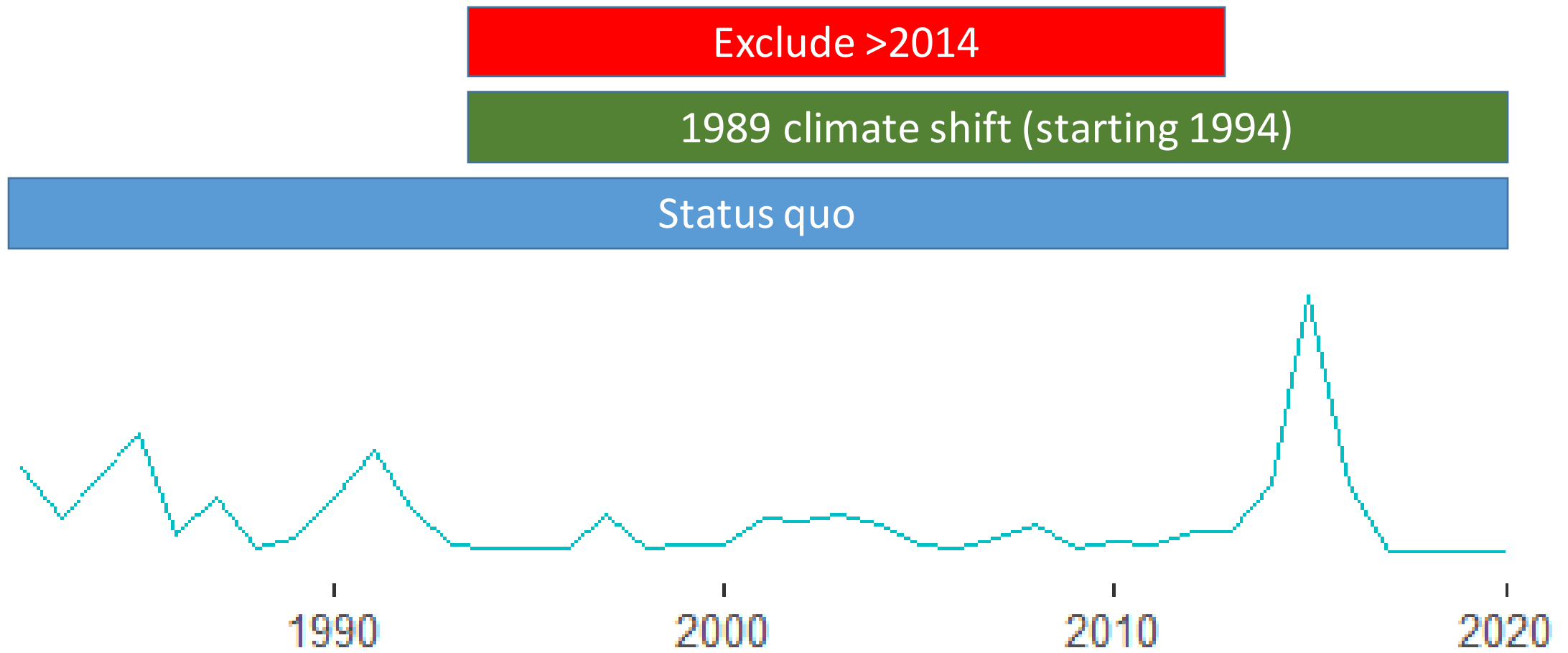
What needs to be done to get GMACS approved?

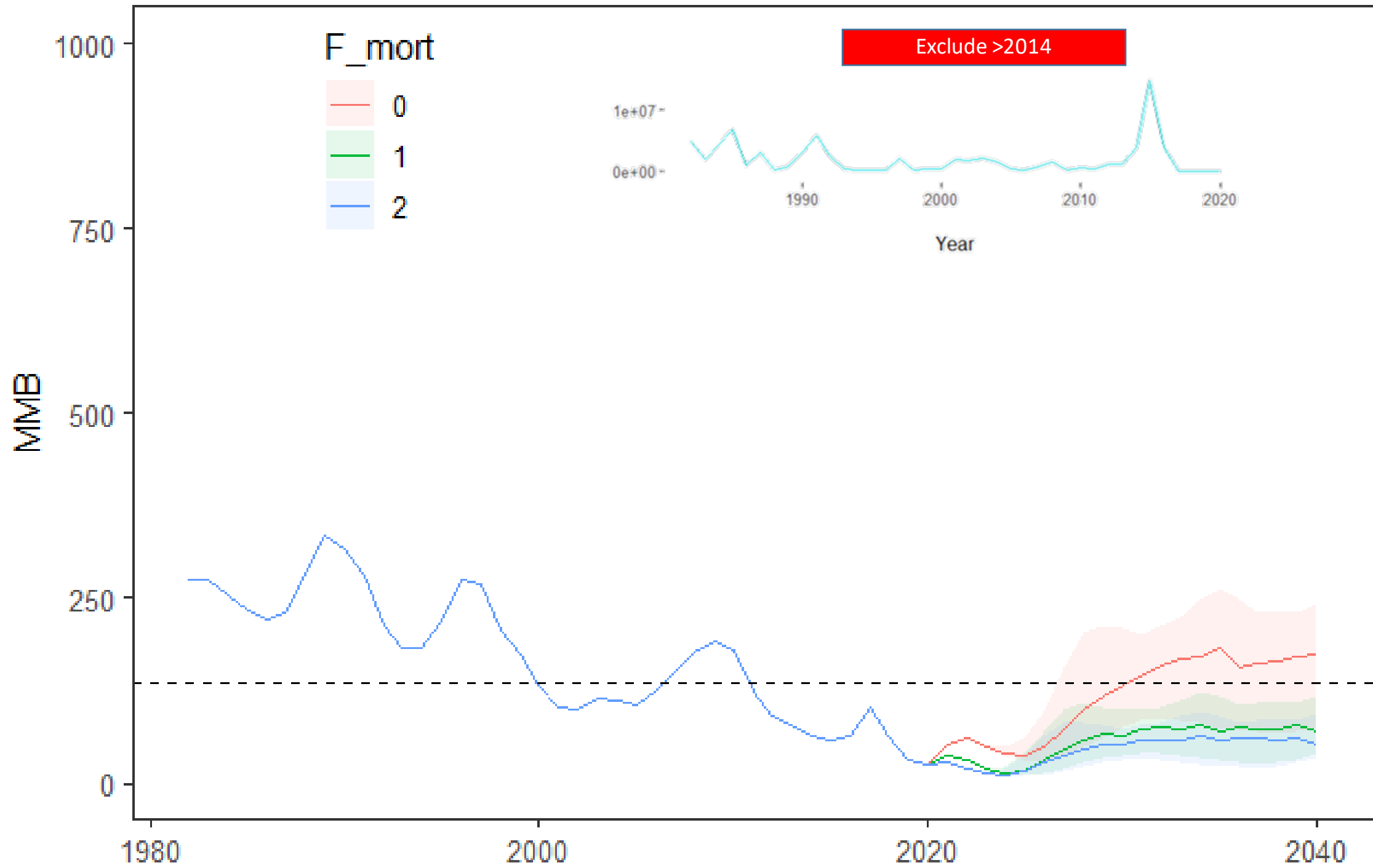


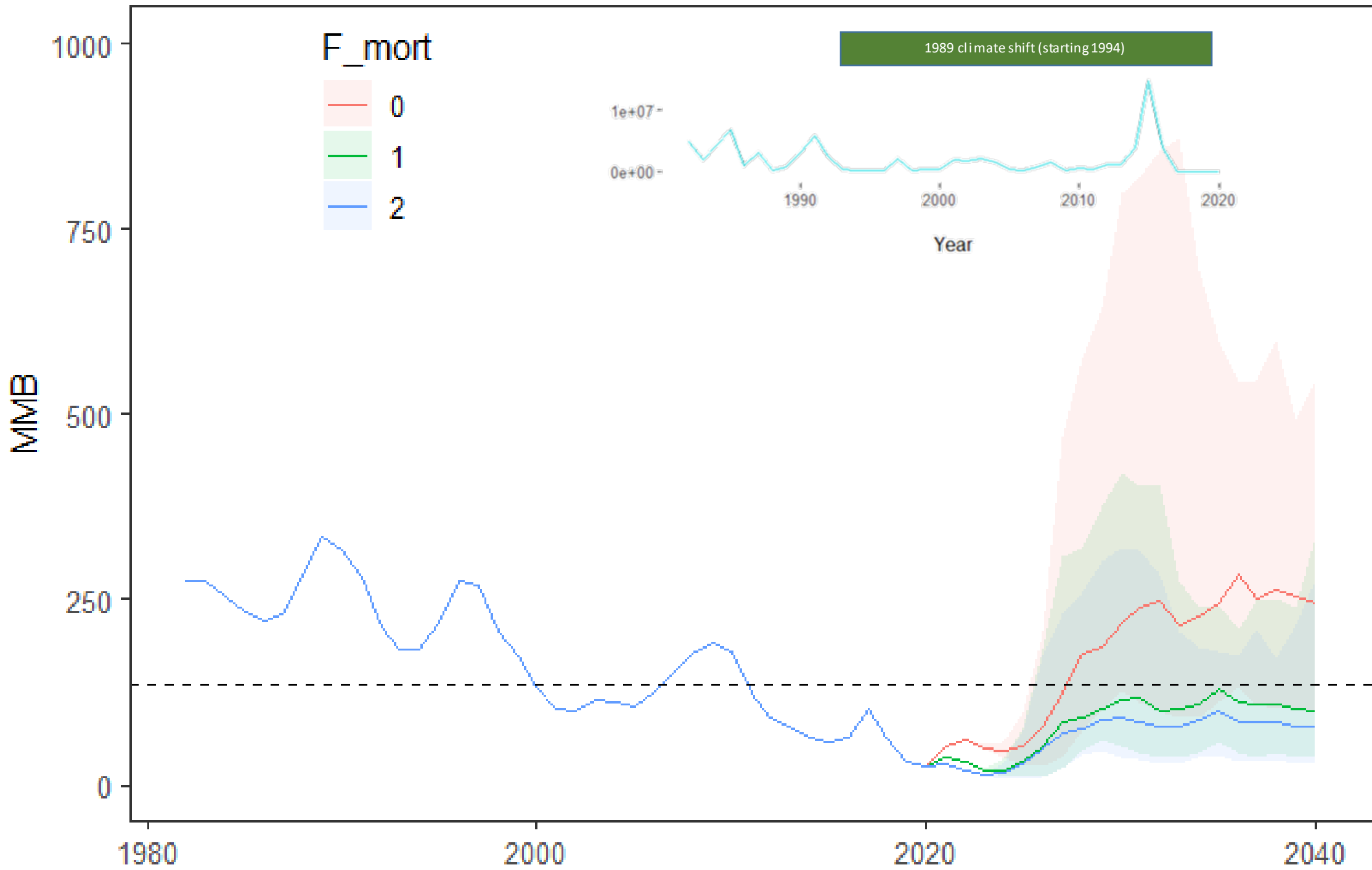
# Rebuilding projection assumptions

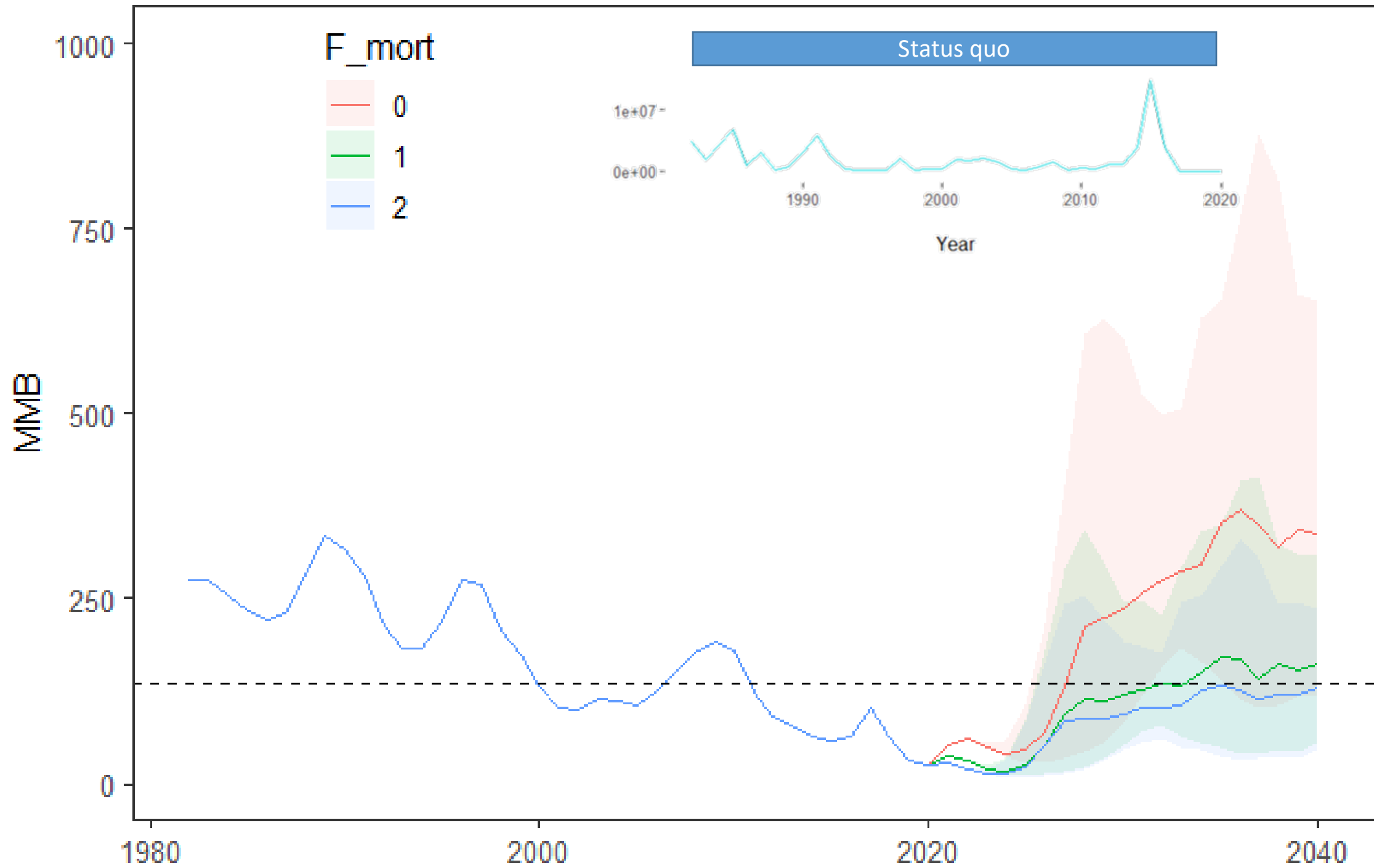
- Three axes for consideration:
  - Recruitment
  - Natural mortality
  - Fishing mortality
- Demonstration projections with GMACS
- BMSY is based on:
  - Recruitment 1982-2020
  - Average natural mortality NOT including the 2018 & 2019 deviations

# Projected recruitment









What rebuilding scenarios need to be considered?