Sea Scallop Assessment Update and Proposed ACL/OFLs

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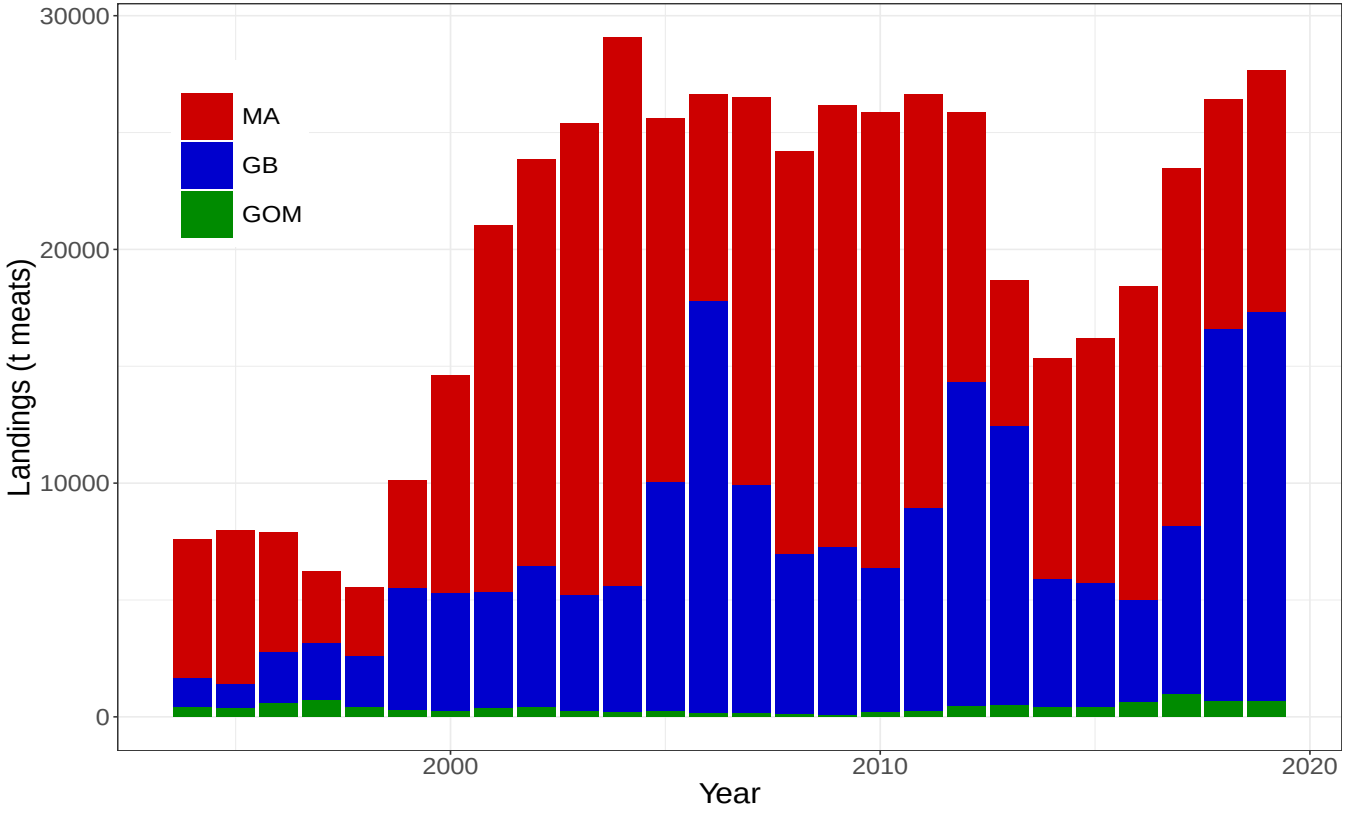
Sea Scallop Assessment Update

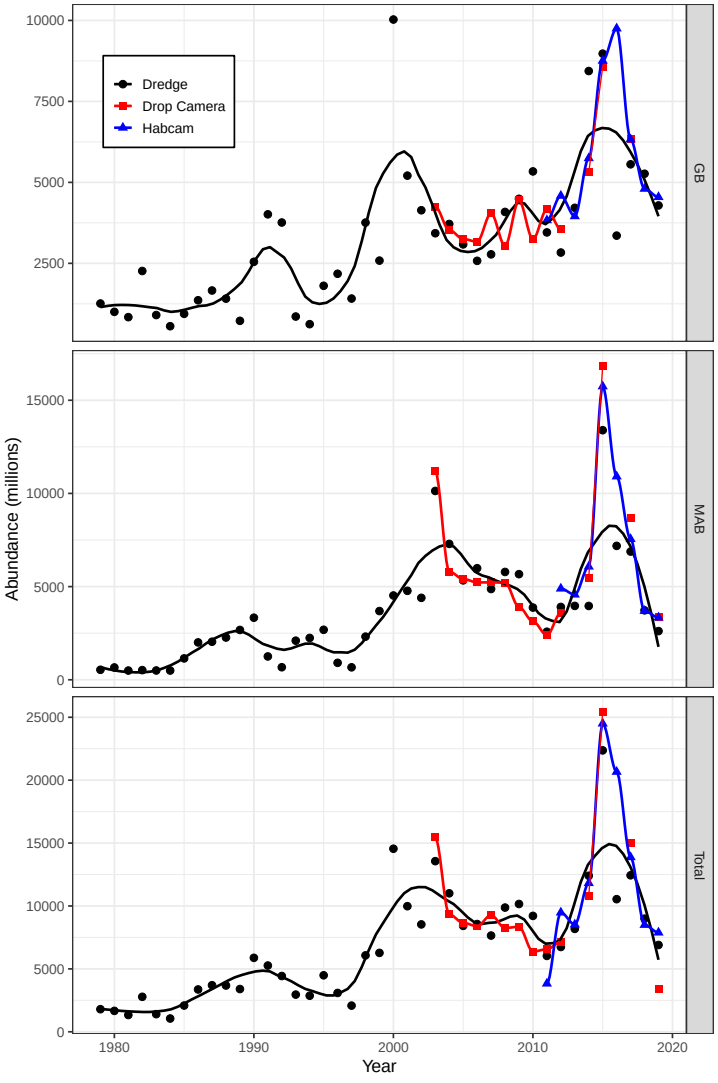
- Last benchmark in 2018 (SARC-65). Not overfished, no overfishing.
- TOR: Update catch and survey data, CASA assessment and SYM reference point models
- No projections (SAMS model) done for the update assessment. These needed to wait for the 2020 survey data
- Level 3 review to consider new variable selectivity SYM reference point model

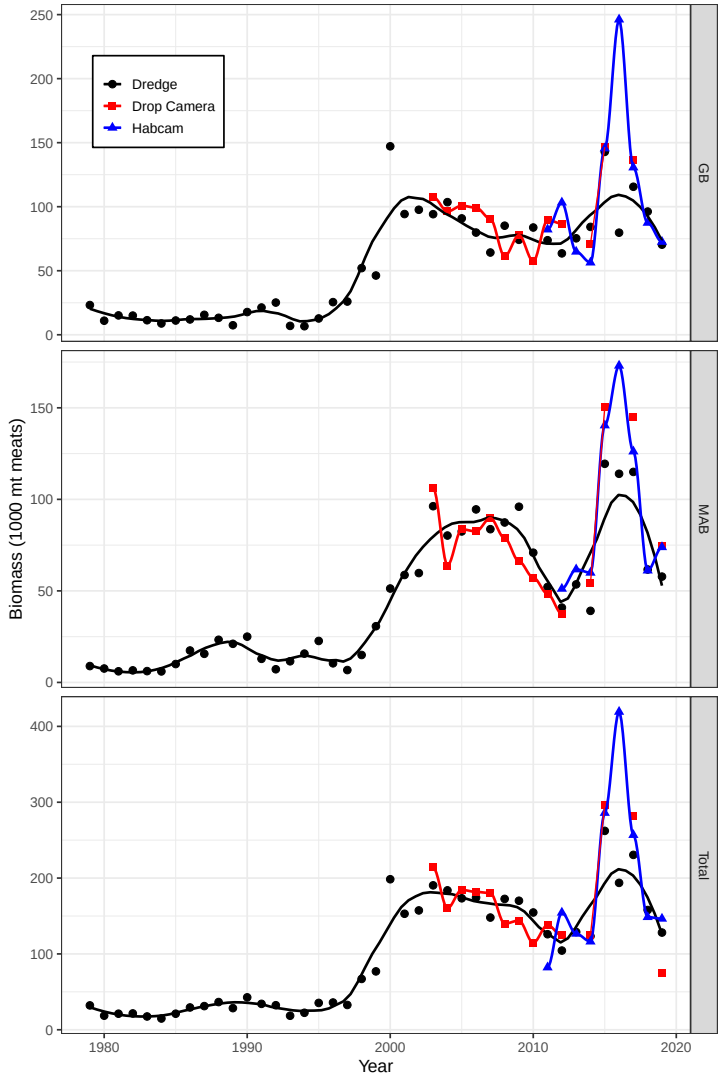
Landings

Landings increased in 2018-2019, in large part due to harvesting of the 2012 year class in the Nantucket Lightship area and the 2013 year class in the Elephant Trunk and Hudson Canyon South rotational areas. Landings in 2019 were the second highest on record.



Sea Scallop Surveys - Plots





CASA Models

CASA is a size-based forward projecting stock assessment model that has been used to assess sea scallop populations since 2007. It provides historical estimates of abundance, biomass, and fishing mortality based on commercial data (landings and commercial shell heights from observers), surveys and biological information such as growth data.

Due to differences in life history parameters and fishing history, CASA models are developed for three regions, Mid-Atlantic, Georges Bank open and Georges Bank closed, and then combined.

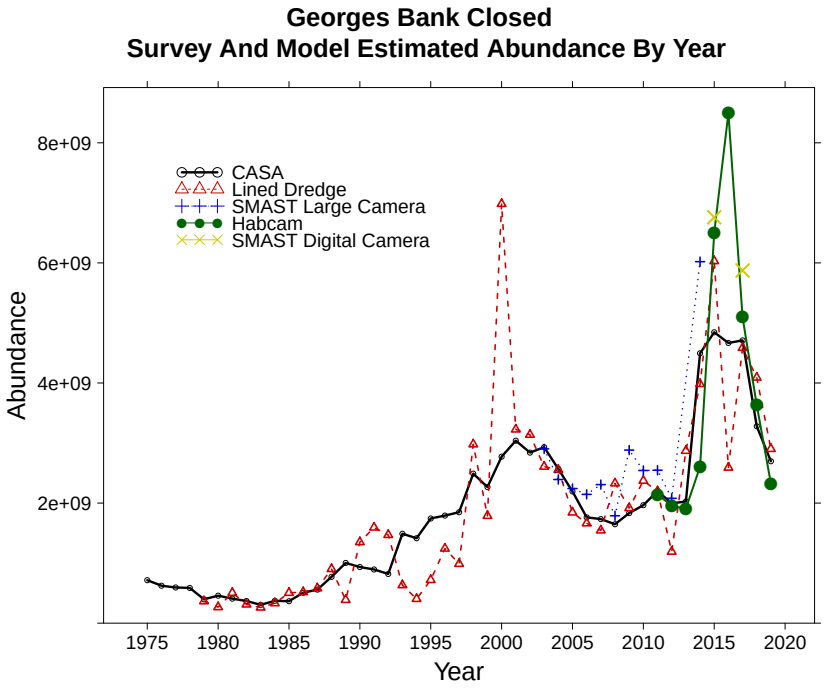
The 2018 benchmark CASA models included for the first time temporal estimation of natural mortality. This was modeled for juveniles only in Mid-Atlantic and Georges Bank open, based on empirical evidence of high juvenile mortality of strong year classes. Natural mortality in the Georges Bank closed areas was modeled for all sizes, based on observations of anomalous declines in certain years.

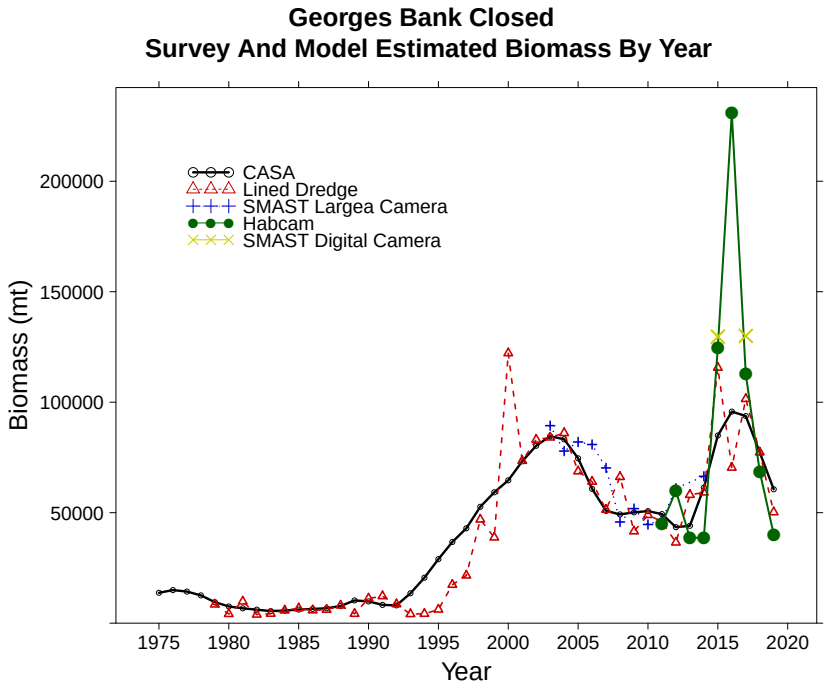
Growth modeling

Growth is modeled by growth transition matrices that are estimated using shell growth increment and a mixed-effects model to estimate von Bertalanffy parameters and their variance among individuals (Hart and Chute 2009). Evidence from the 2018 benchmark indicated that there has been substantial temporal changes in growth, with growth rates tending to increase from about 1994 to 2012. This is modeled in CASA by employing different growth transition matrices for different periods of time.

In recent years, growth appears to have slowed, so we modeled growth in the most recent period using the transition matrices for the mid-1990s slow growth era, except in GB Open, where we used new data to estimate a new growth transition matrix. Growth matrices were the same as in the benchmark for all other periods.

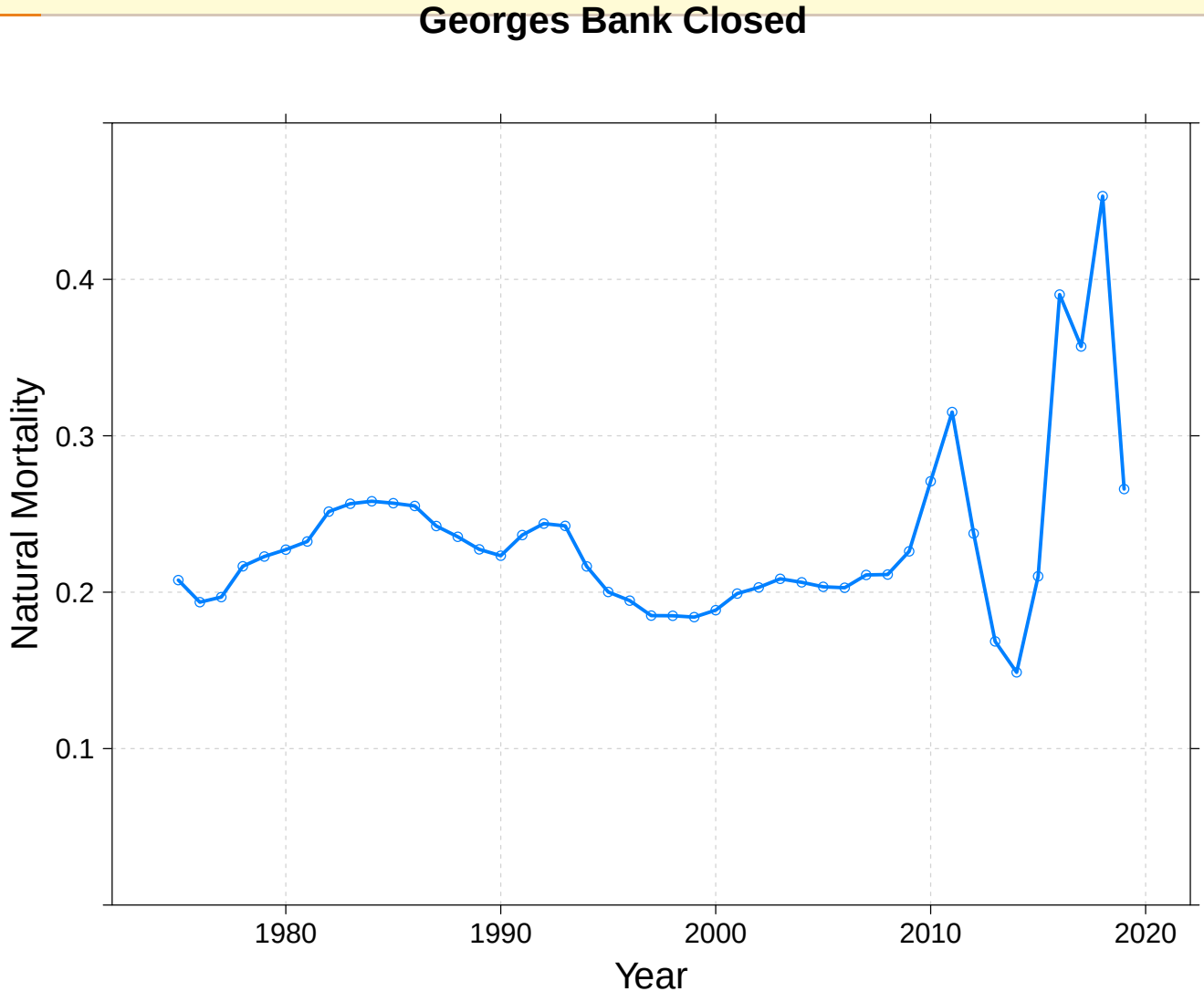
Georges Bank Closed Area
Observed and estimated abundance and biomass





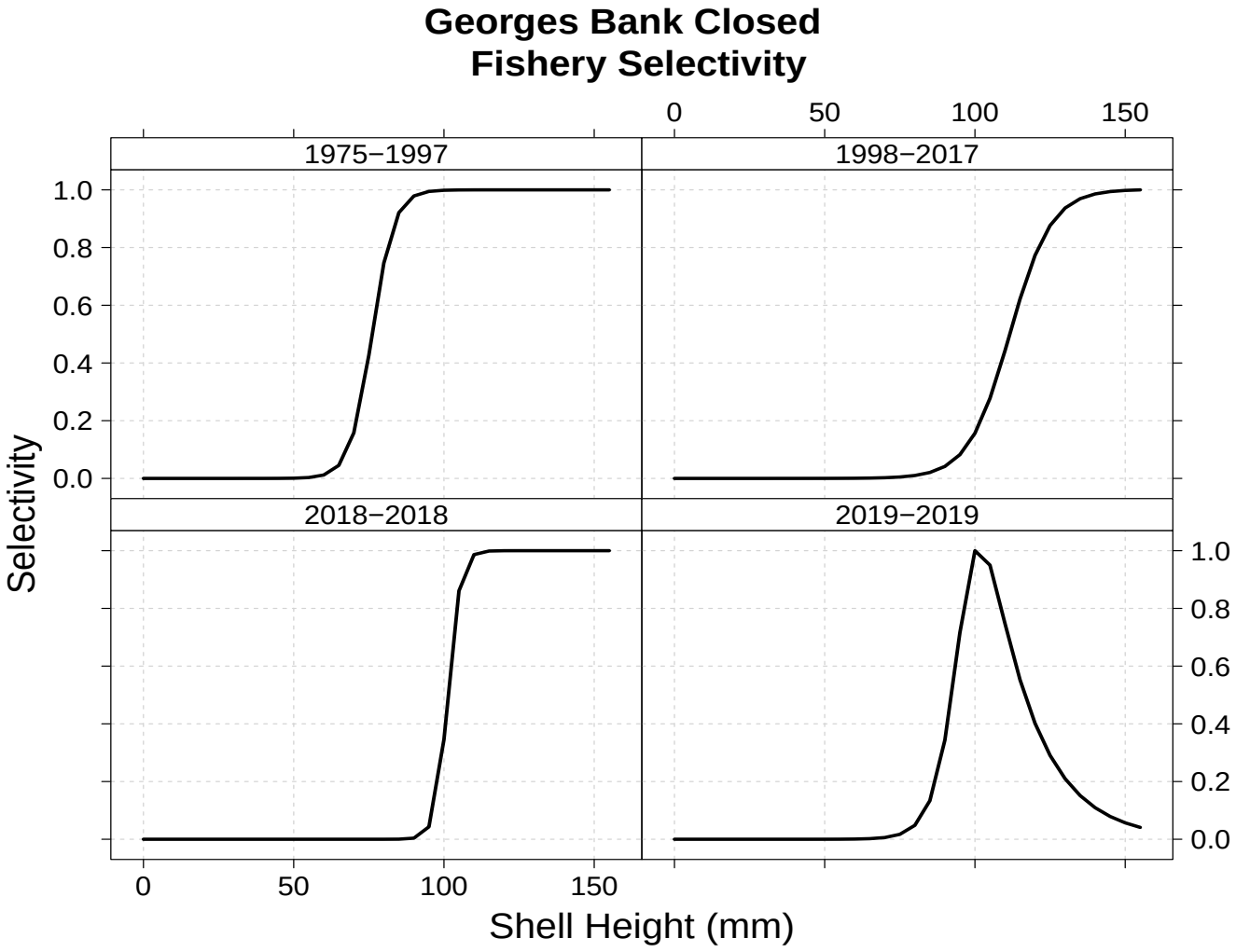
Estimated abundance (left) and biomass (right) with expanded estimates from the lined dredge (red), SMAST large camera (blue), Habcam (green), and SMAST digital camera (light green) surveys.

Georges Bank Closed Area
Natural mortality for all sizes by year

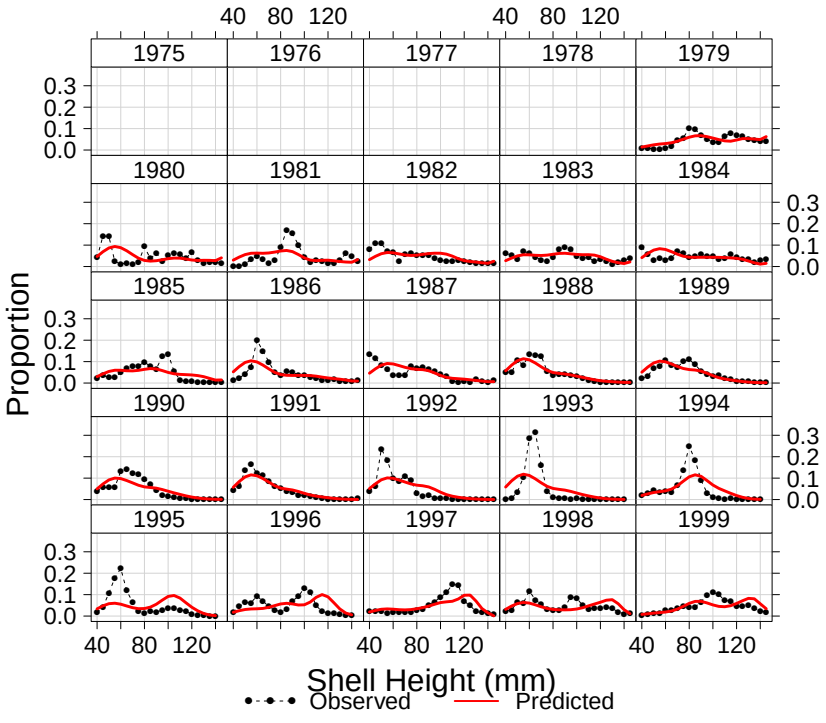


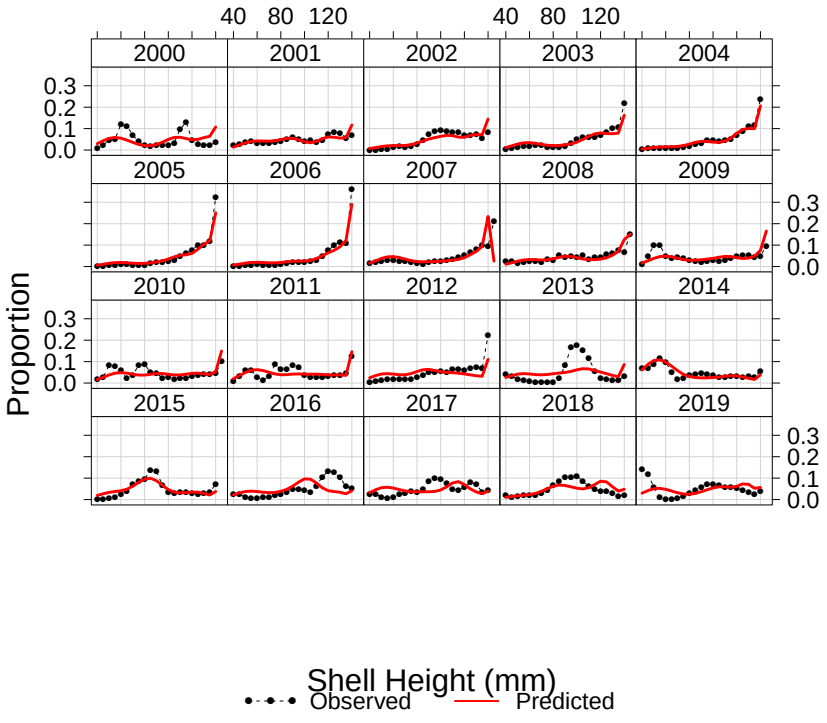
Georges Bank Closed Area Estimated fishery selectivity curves

Note changes in selectivity in 2018 and 2019

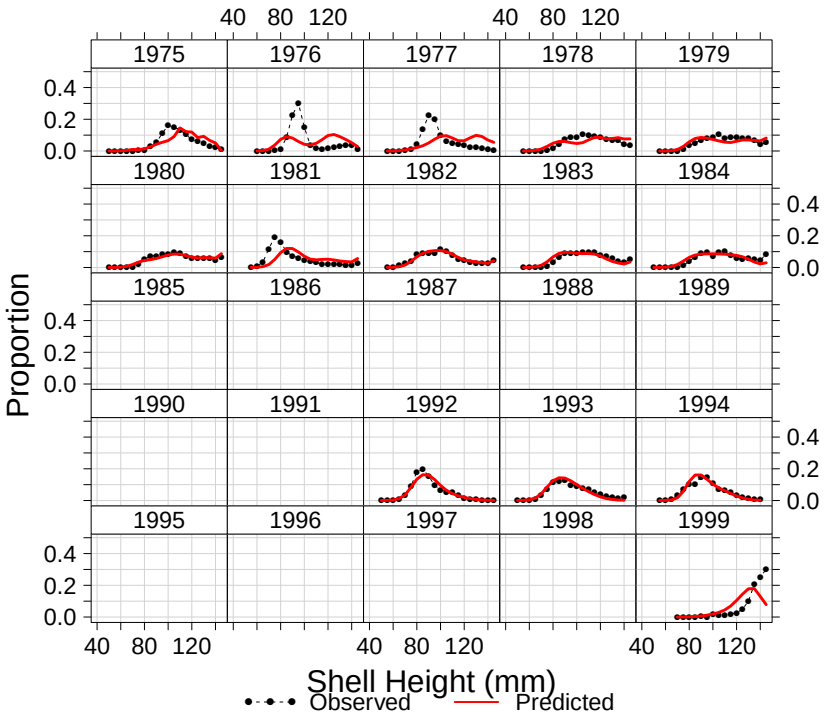


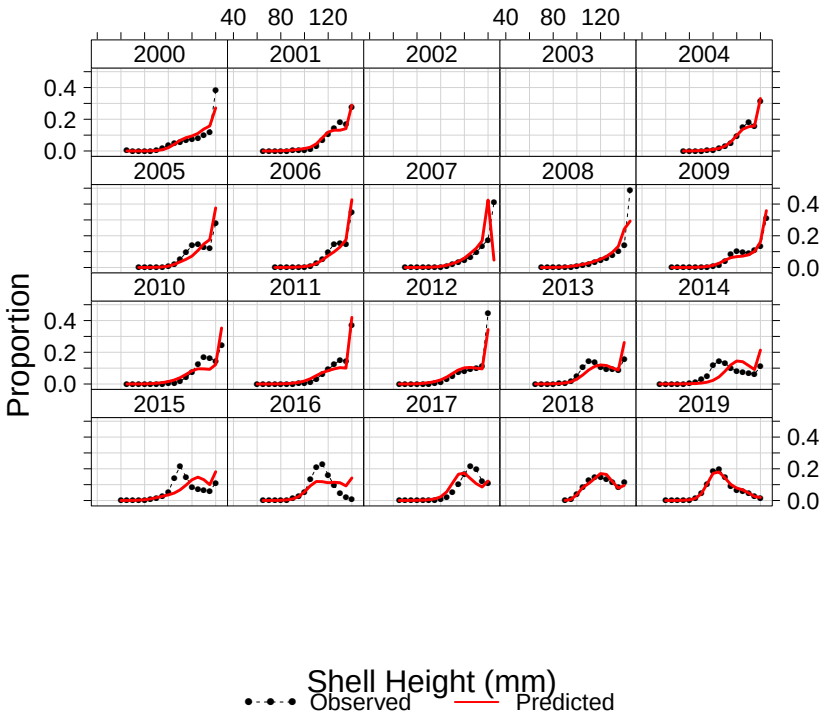
Georges Bank Closed Area
Dredge survey shell height proportions



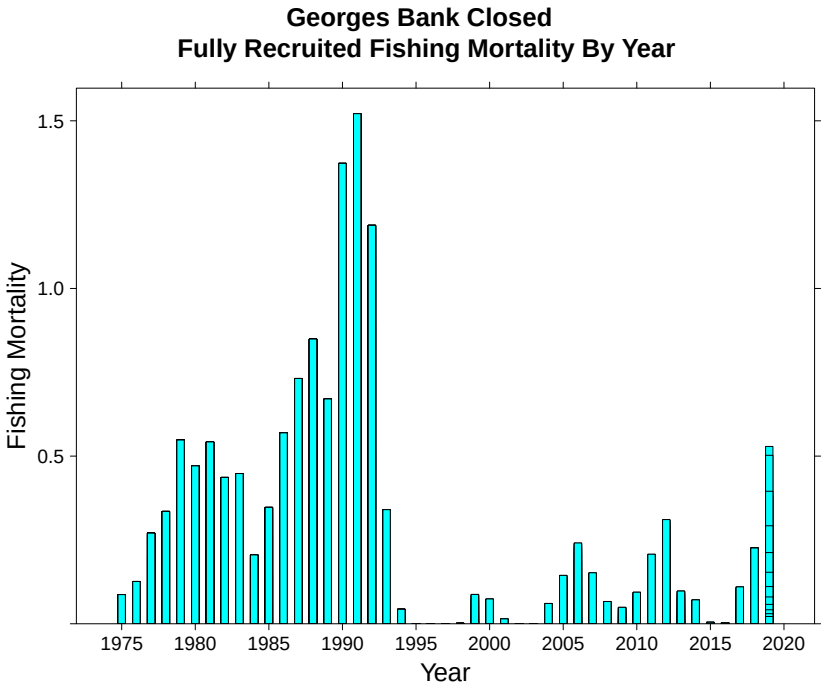


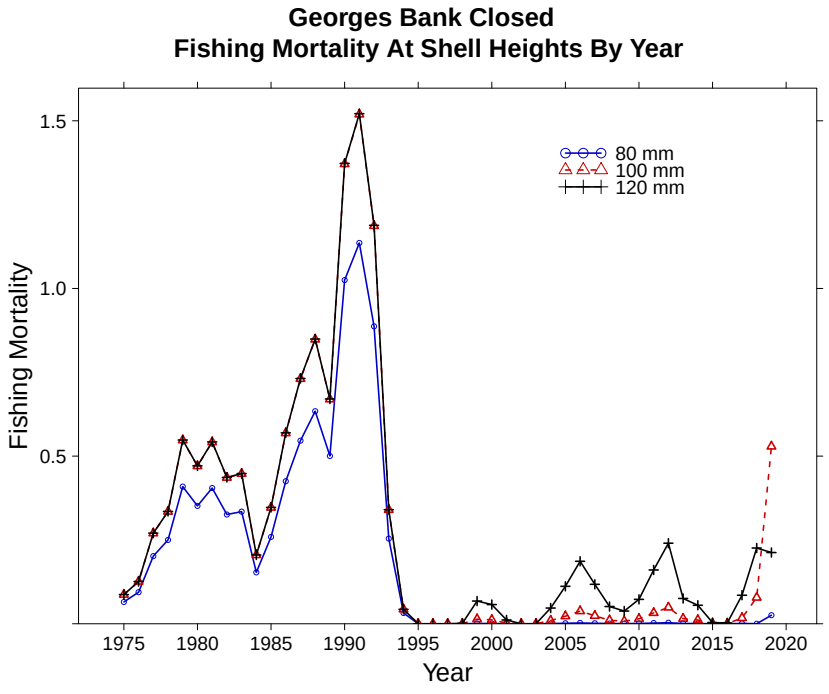
Georges Bank Closed Area
Fishery shell height proportions





Georges Bank Closed Area
Fishing mortality

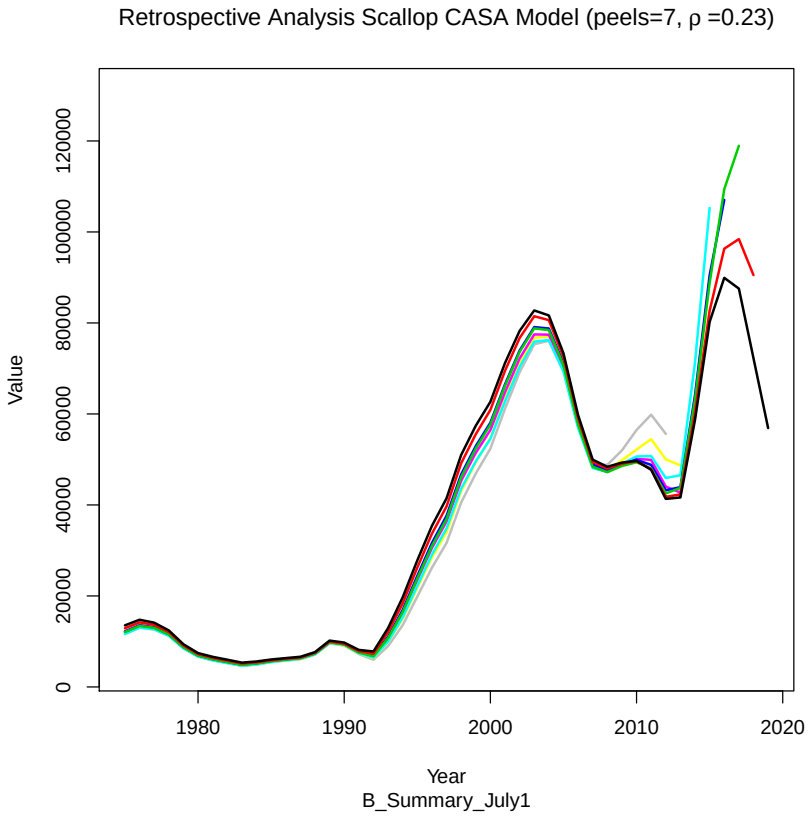


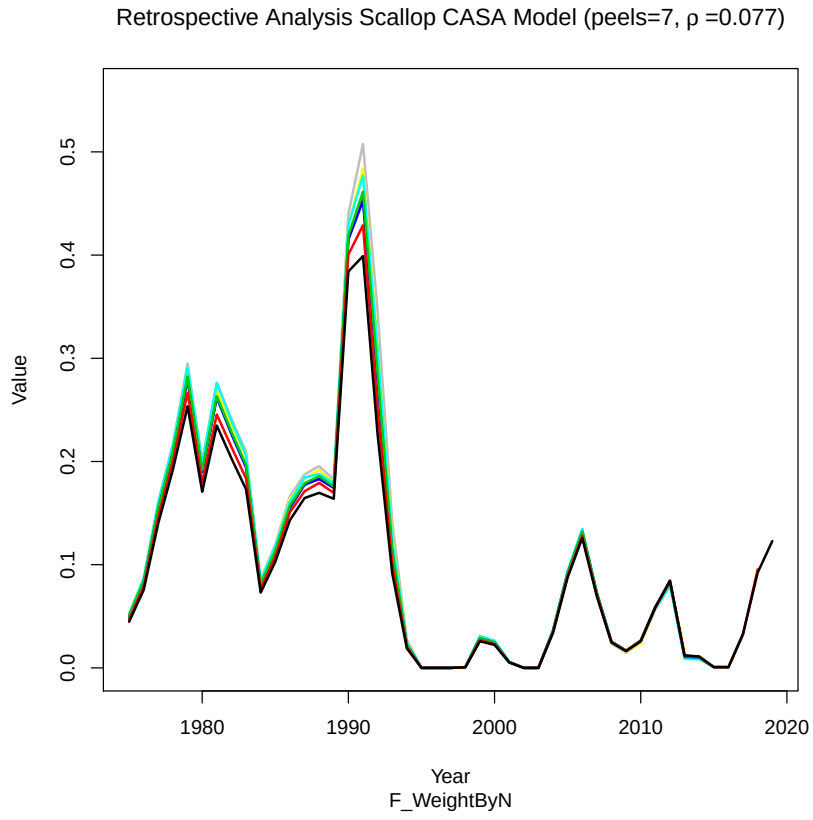


All sizes (left) and at 80, 100, and 120 mm shell height (right).

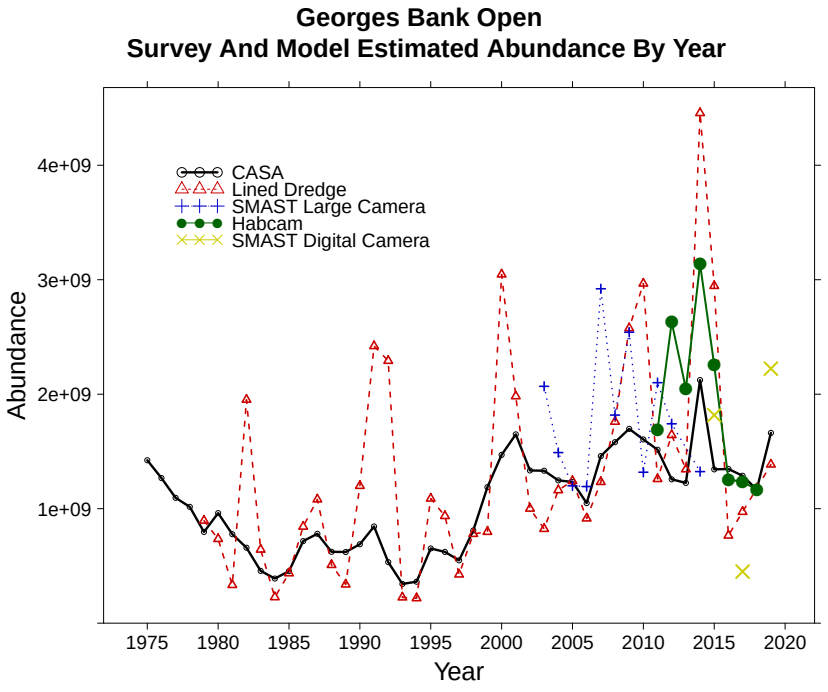
Georges Bank Closed Area

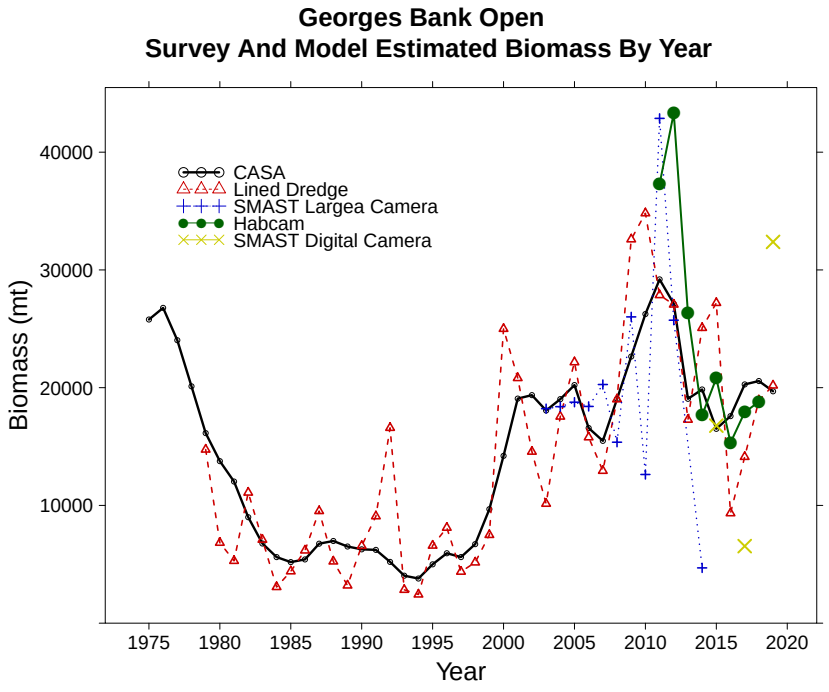
Seven peels retrospective analysis for biomass and fishing mortality





Georges Bank Open Area
Observed and estimated abundance and biomass

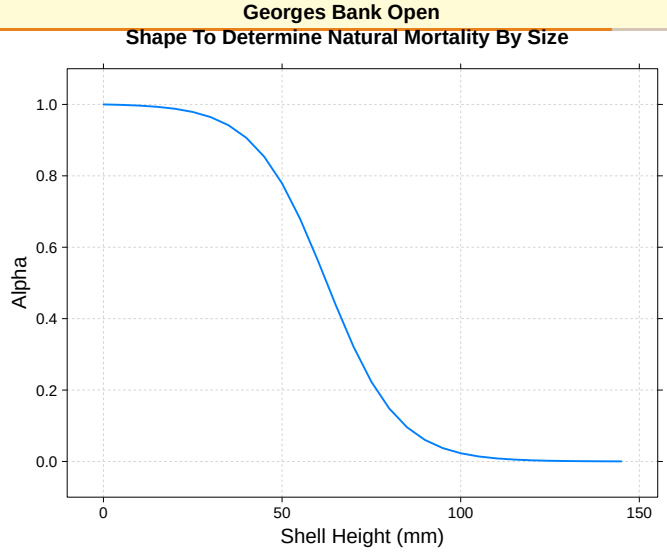


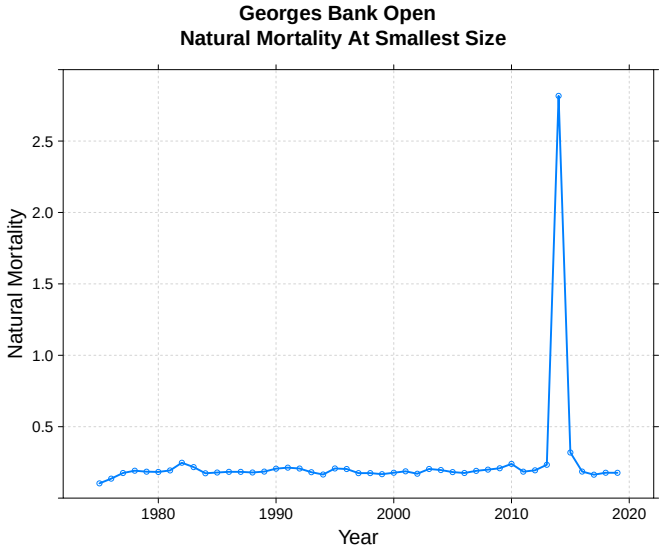


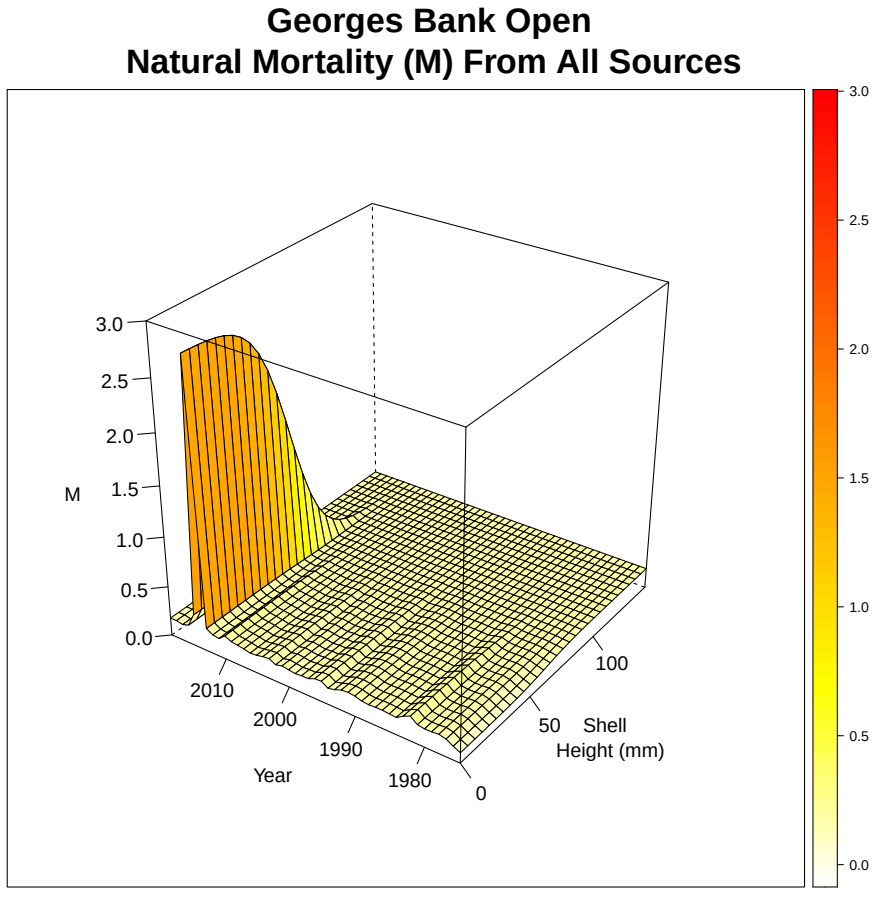
Estimated abundance (left) and biomass (right) with expanded estimates from the lined dredge (red), SMAST large camera (blue), Habcam (green), and SMAST digital camera (light green) surveys.

Georges Bank Open Area

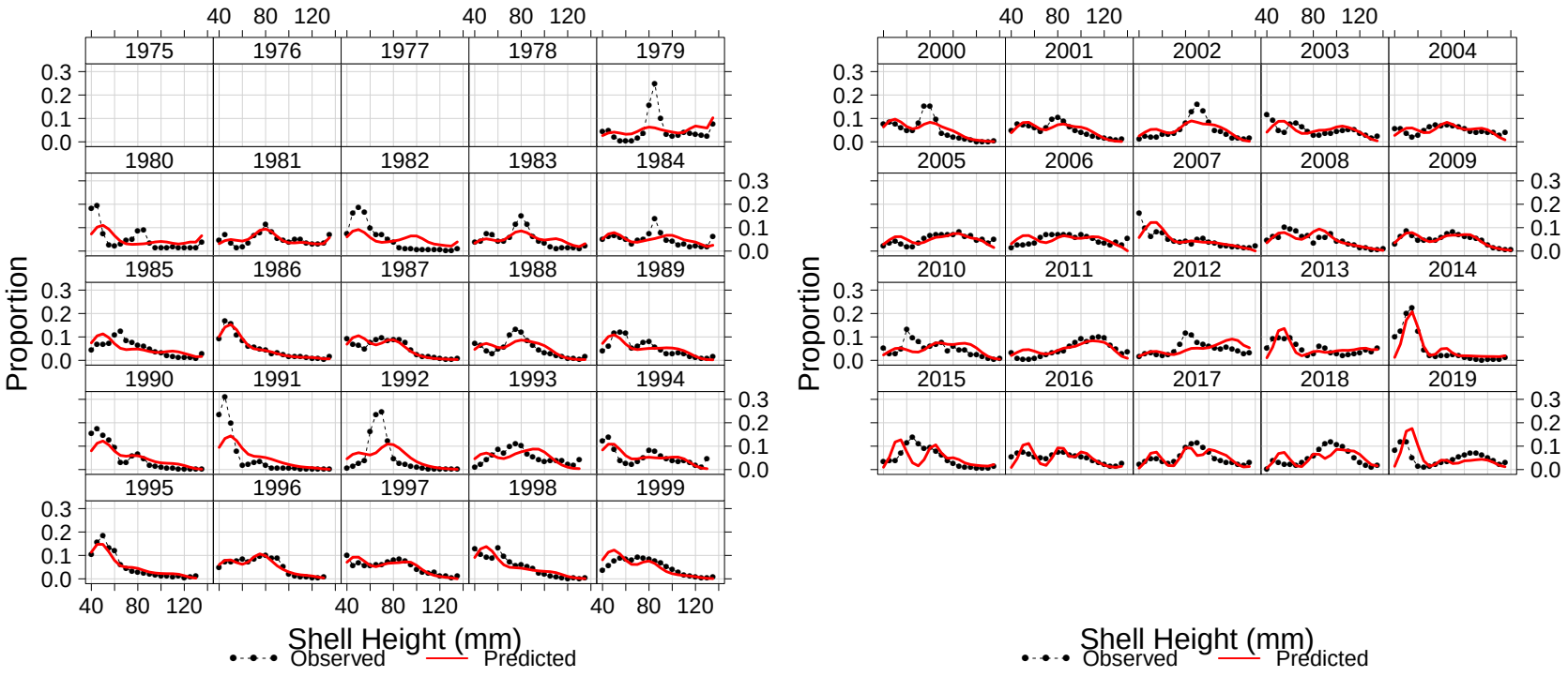
Logistic curve and natural mortality by size and year



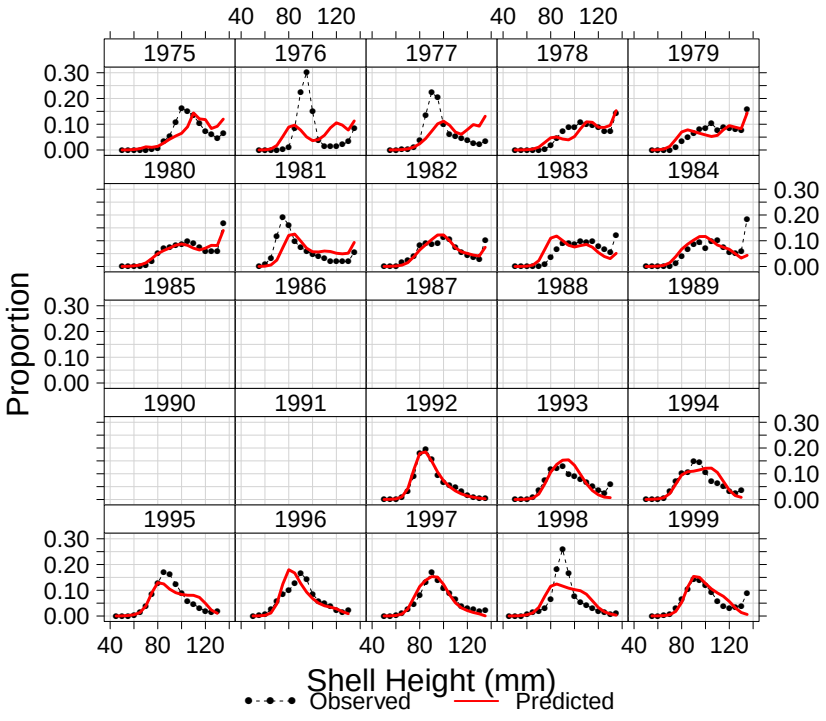


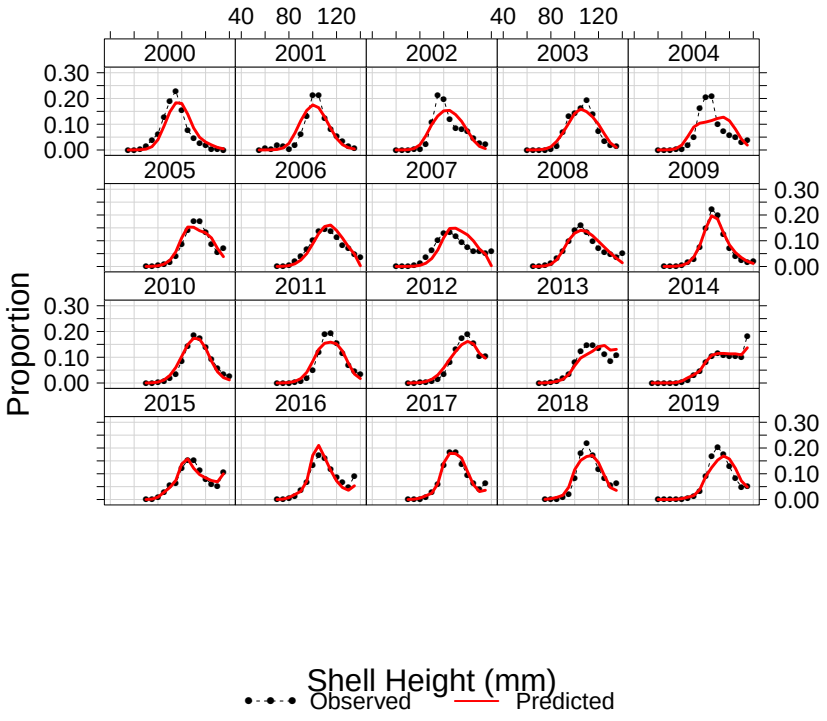


Georges Bank Open Area
Dredge survey shell height proportions

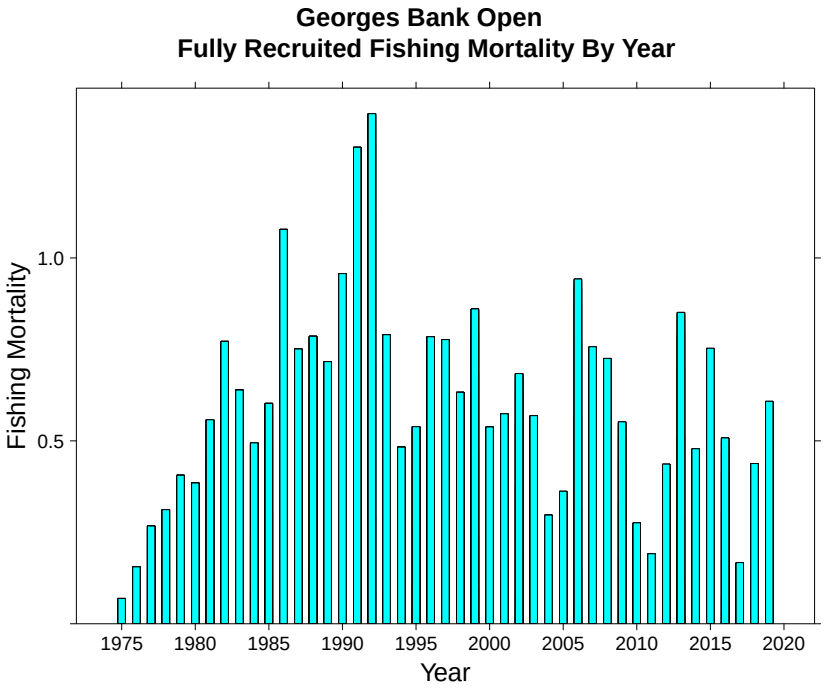


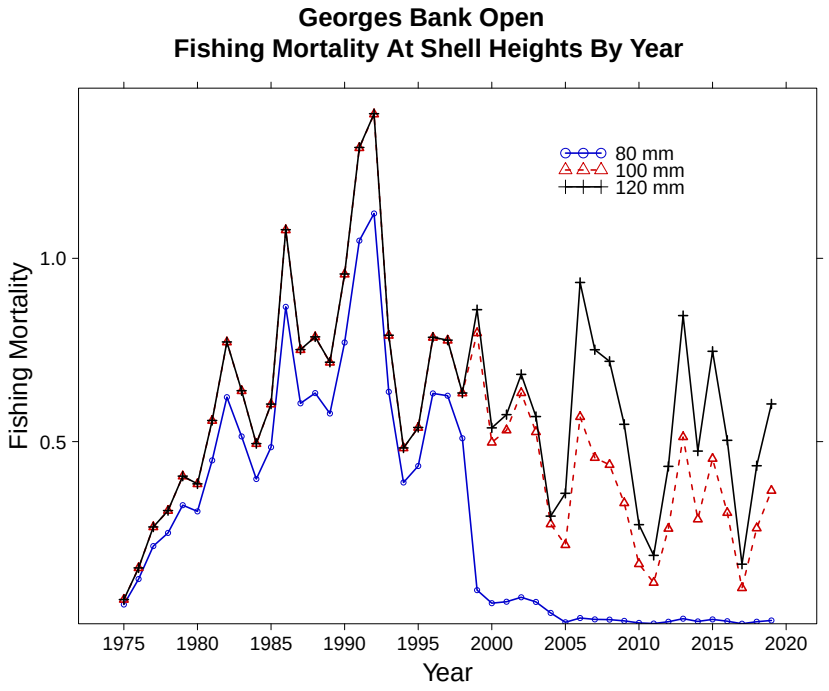
Georges Bank Open Area
Fishery shell height proportions





Georges Bank Open Area
Fishing mortality

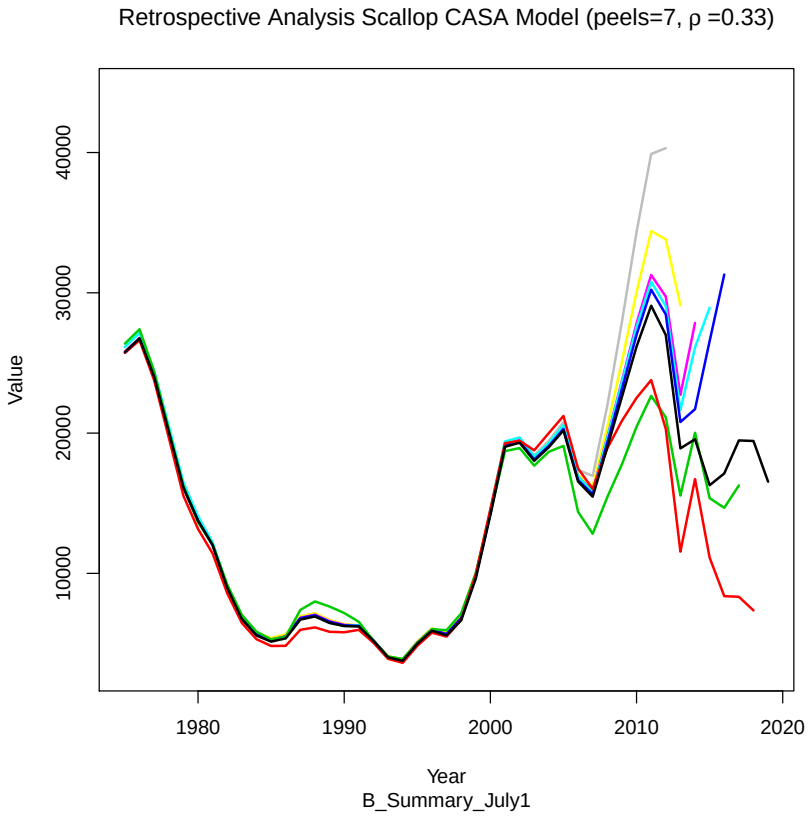


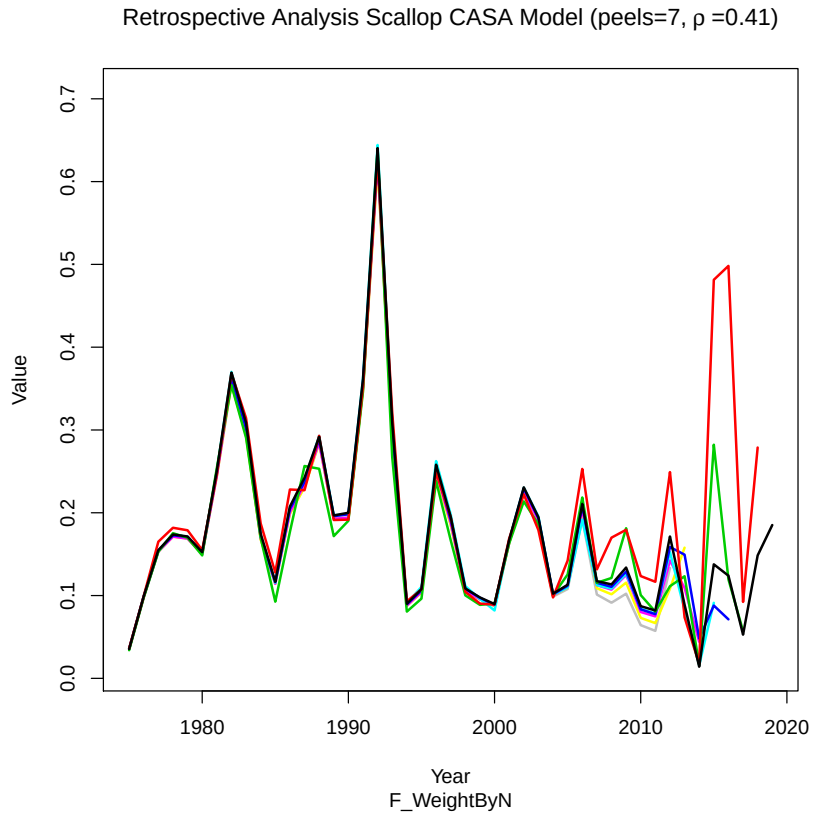


All sizes (left) and at 80, 100, and 120 mm shell height (right).

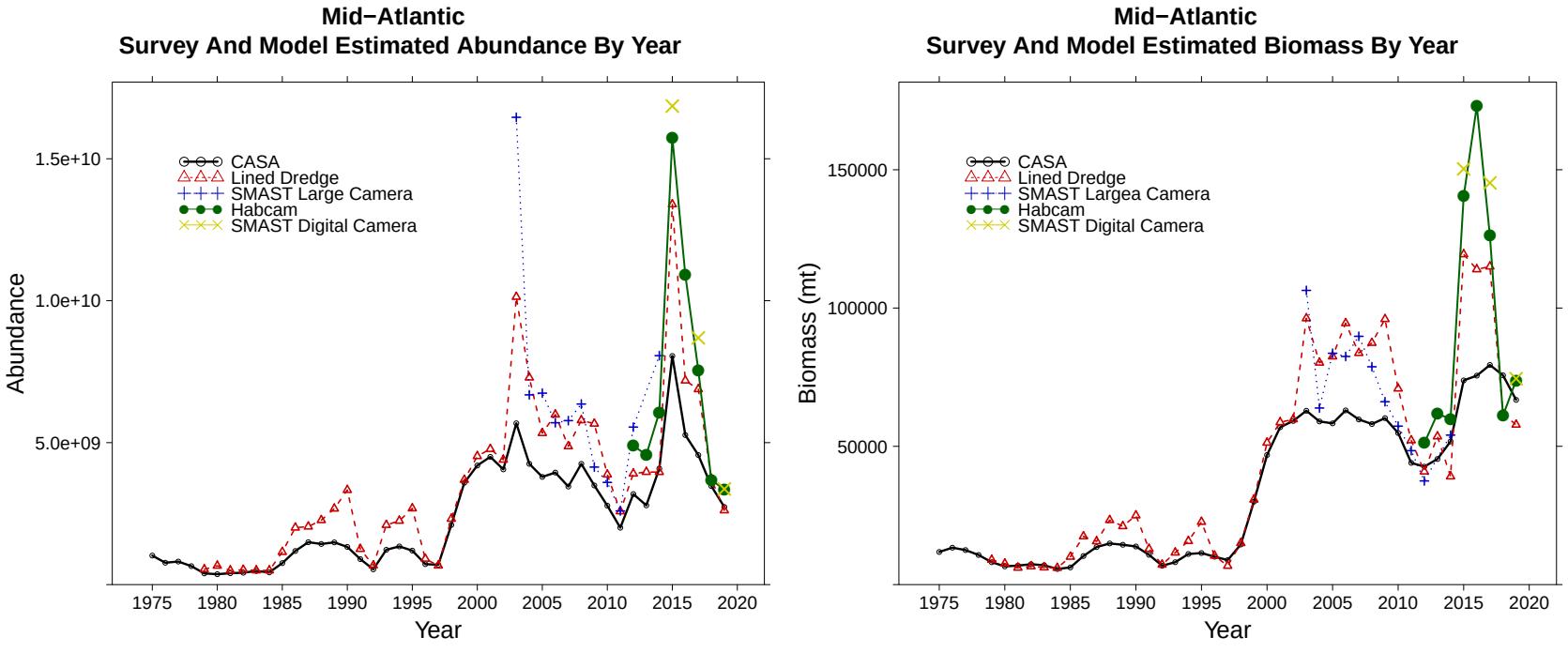
Georges Bank Open Area

Seven peels retrospective analysis for biomass and fishing mortality





Mid-Atlantic Area
Observed and estimated abundance and biomass



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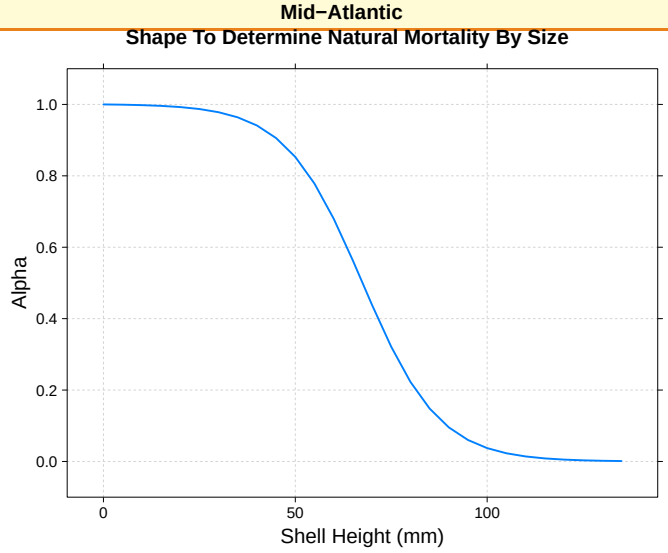
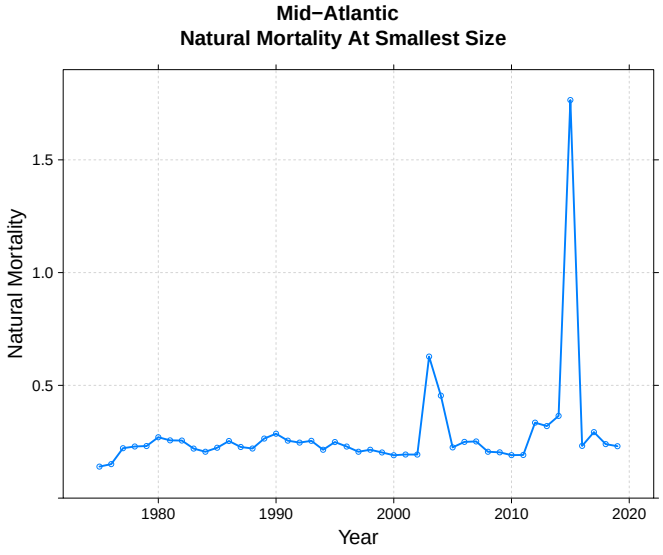
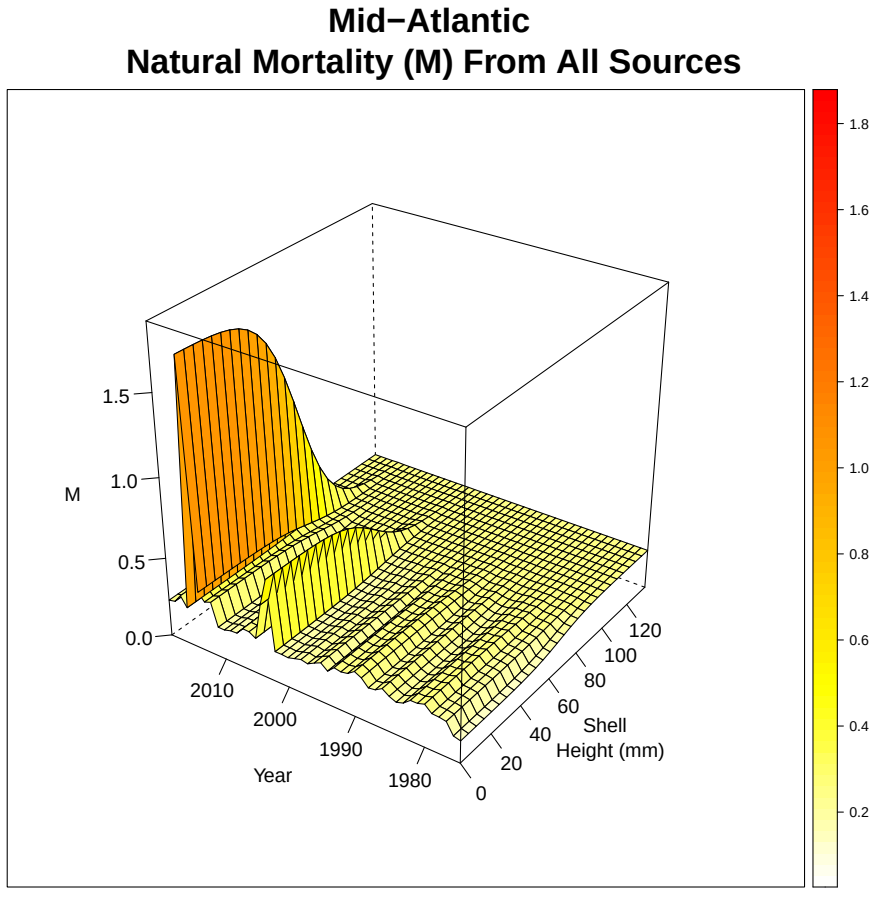
Mid-Atlantic Area

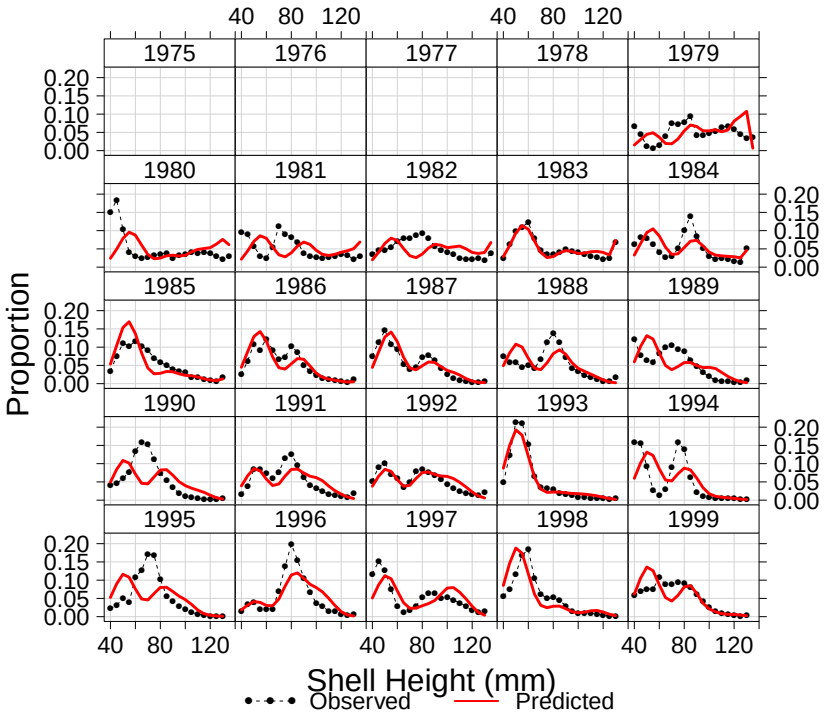
Logistic curve and natural mortality by size and year

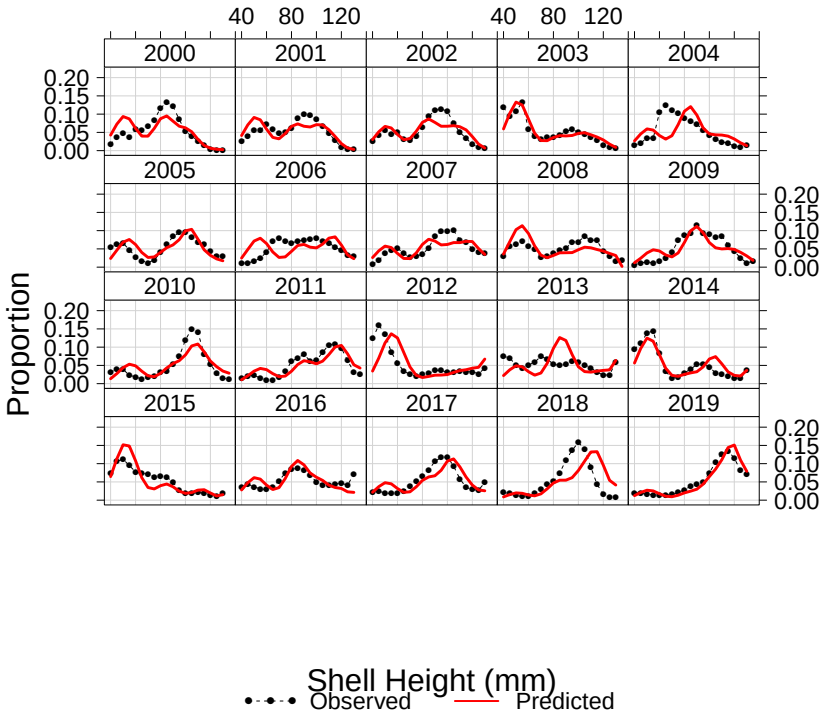




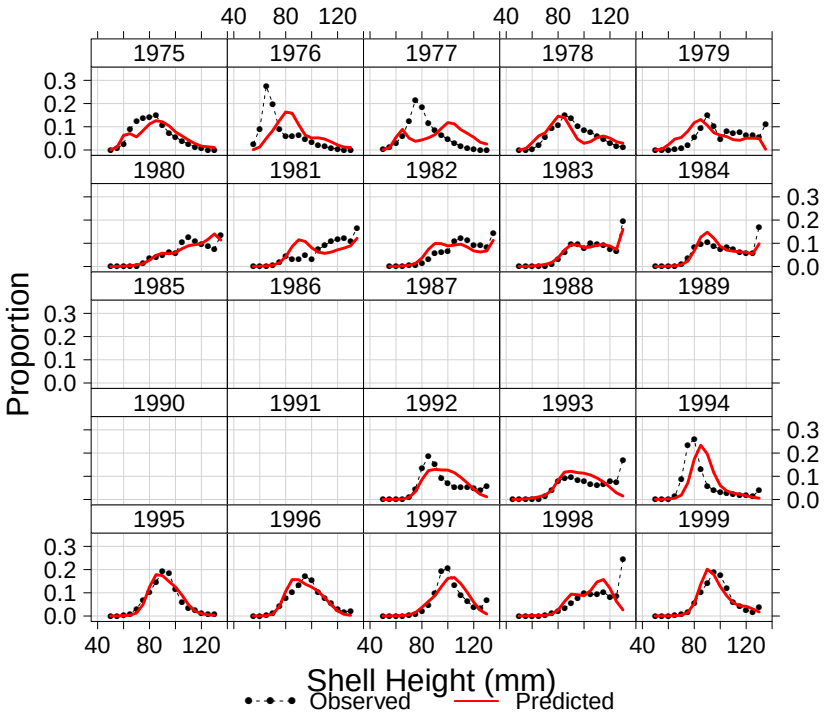


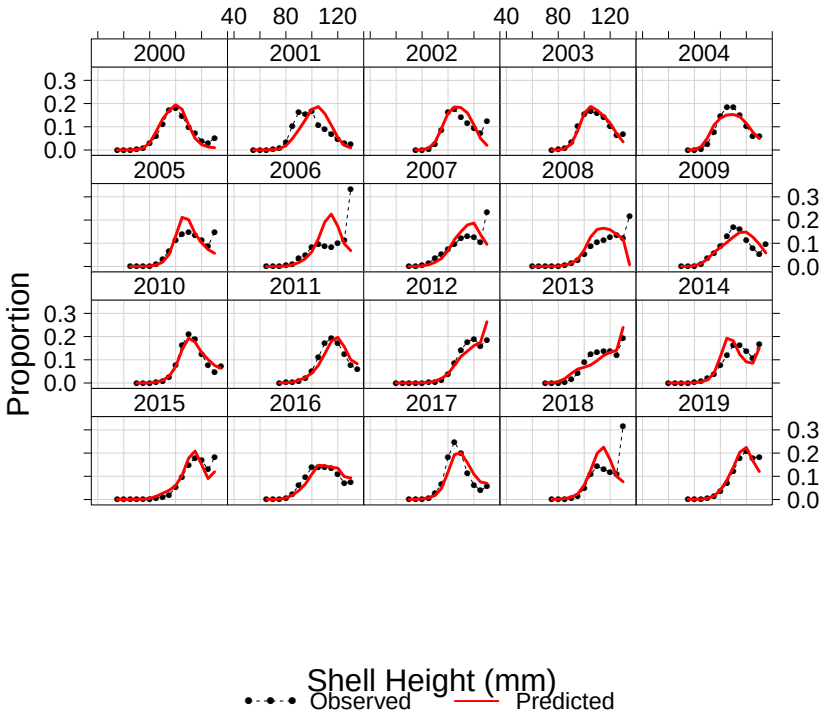
Mid-Atlantic Area
Dredge survey shell height proportions



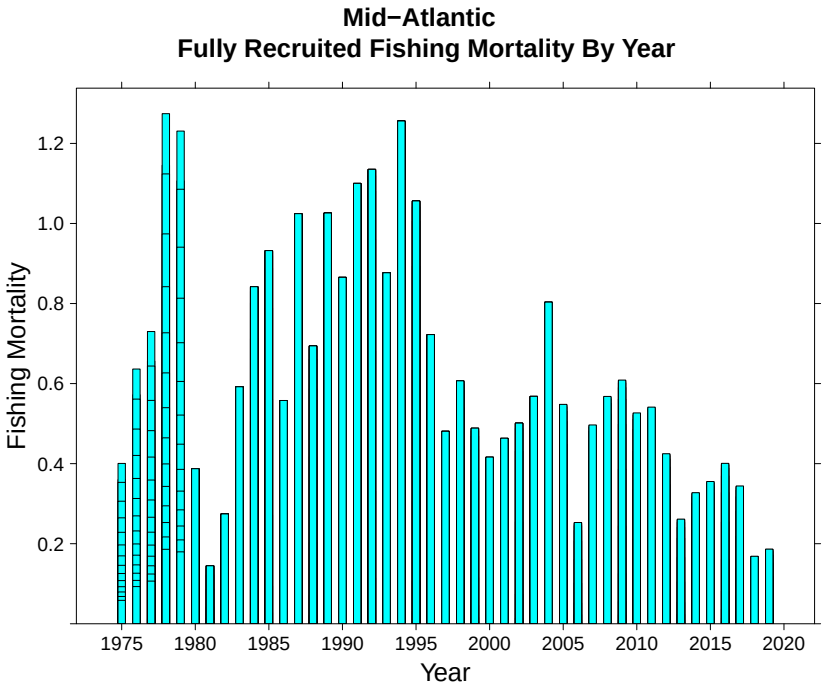


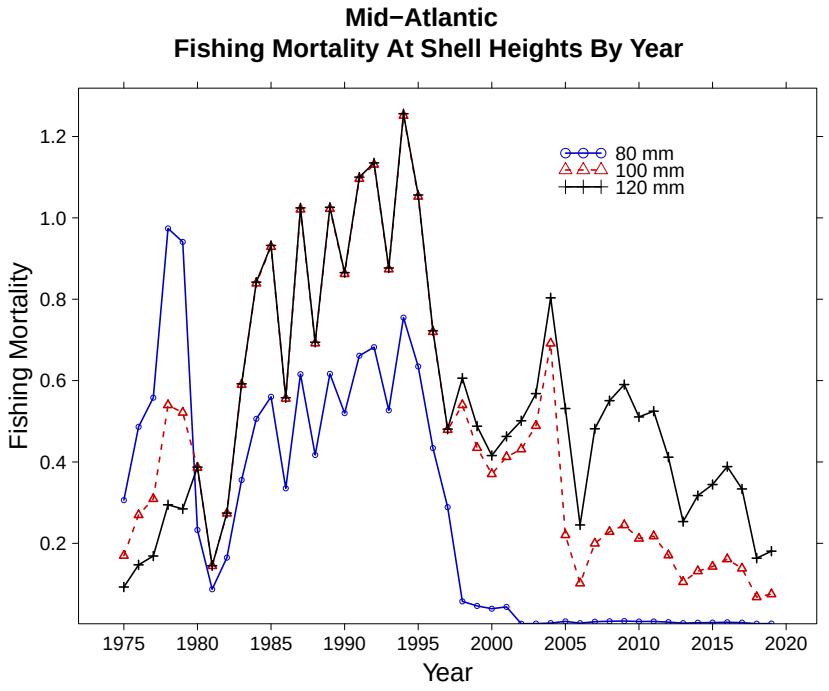
Mid-Atlantic Area
Fishery shell height proportions





Mid-Atlantic Area
Fishing mortality

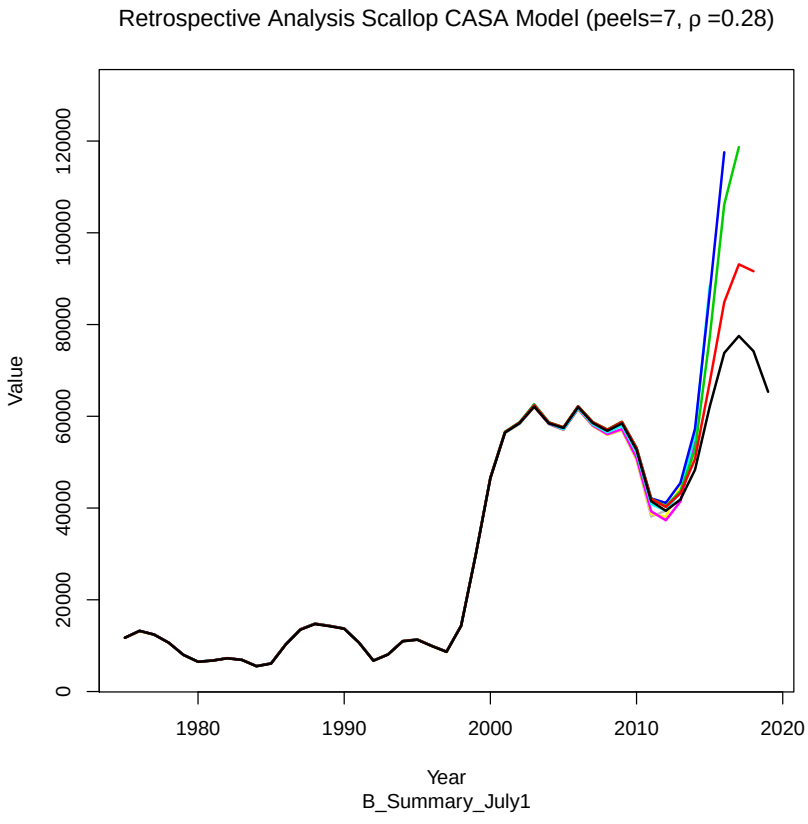


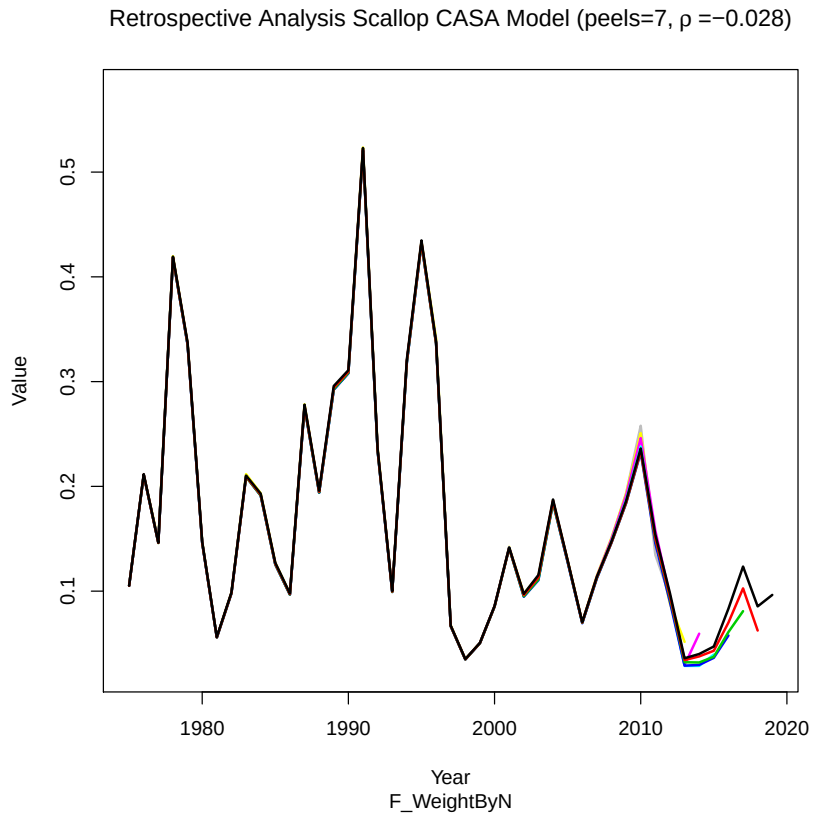


All sizes (left) and at 80, 100, and 120 mm shell height (right).

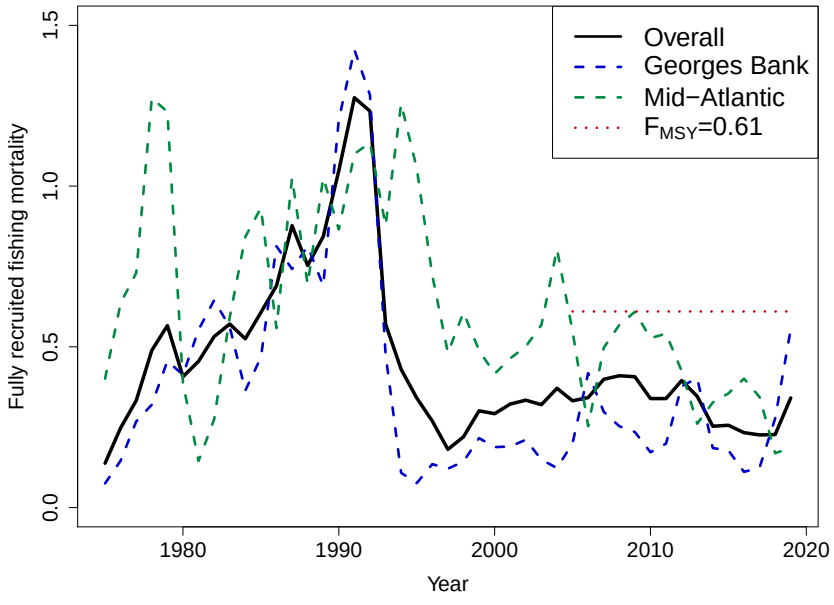
Mid-Atlantic Area

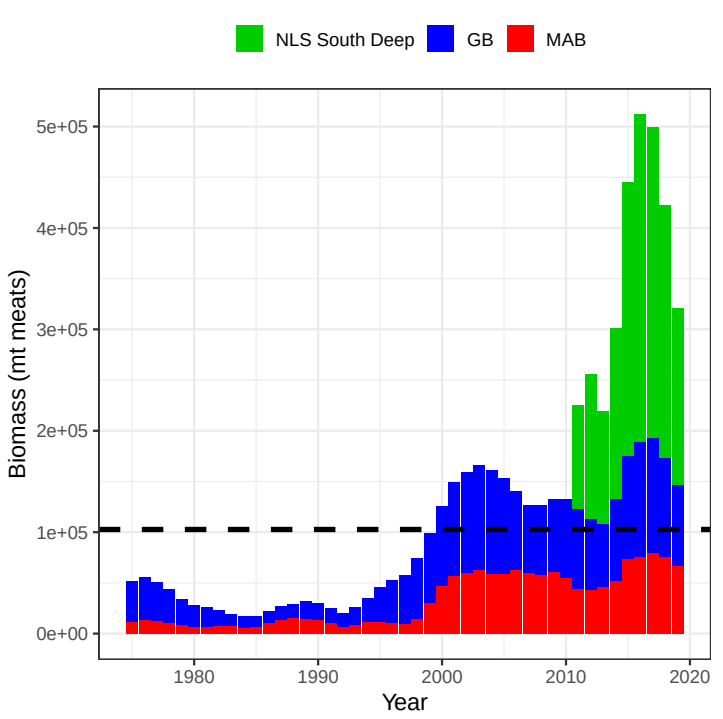
Seven peels retrospective analysis for biomass and fishing mortality





All Three Regions Combined
Fully recruited fishing mortality and biomass





Estimated fully recruited fishing mortality (left) and biomass (right) for Georges Bank (open and closed combined) and Mid-Atlantic sea scallops, including Habcam biomass estimates of scallops located in the deep water southeast portion of Nantucket Lightship Area.

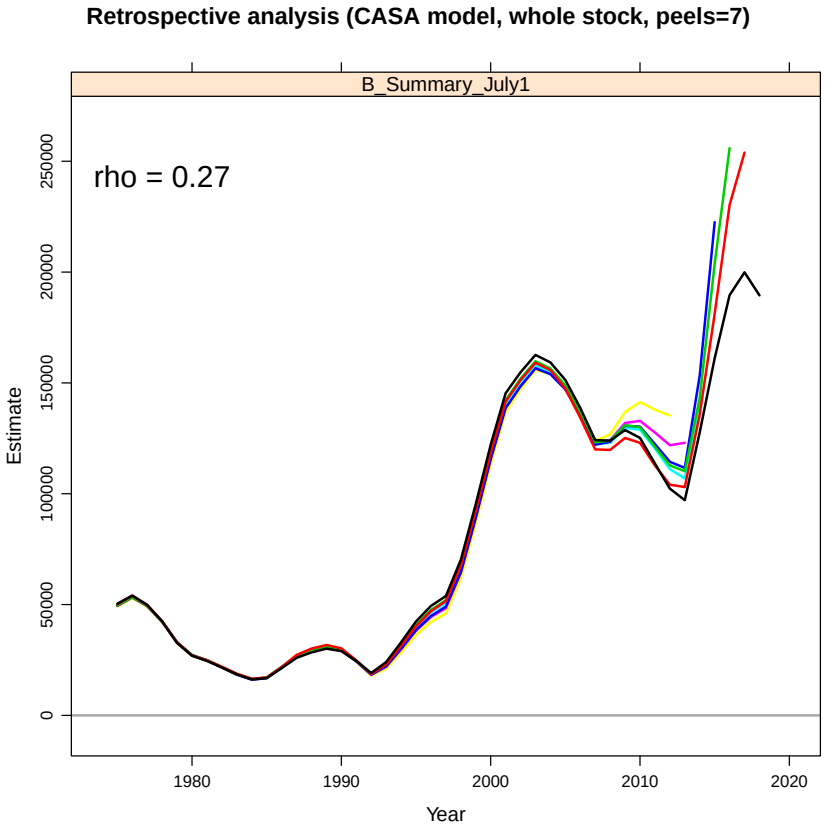
All Three Regions Combined
2019 biomass and fishing mortality estimates

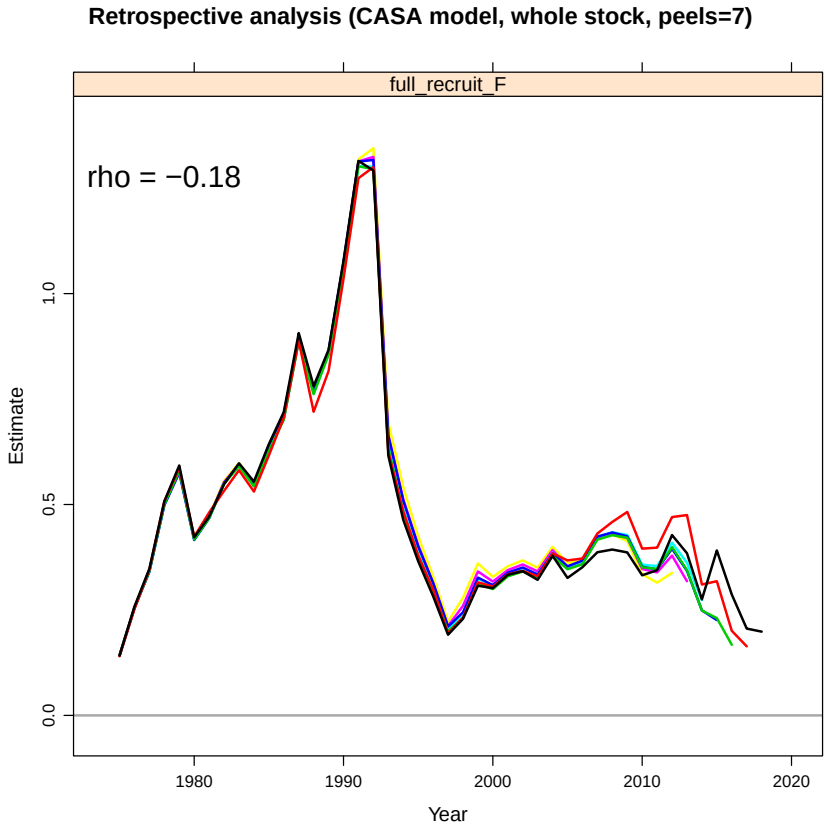
Stock	Biomass (mt meats)	CV	F	CV
Georges Bank Closed	60,587	0.09	0.53	0.35
Georges Bank Open	19,692	0.06	0.61	0.14
Mid-Atlantic	66,795	0.04	0.19	0.34
Total	147,073	0.04	0.34	0.06

Scallops located in the deep water southeast portion of Nantucket Lightship Area are excluded.

All Three Regions Combined

Seven peels retrospective analysis for biomass and fishing mortality





SYM Reference Point Model

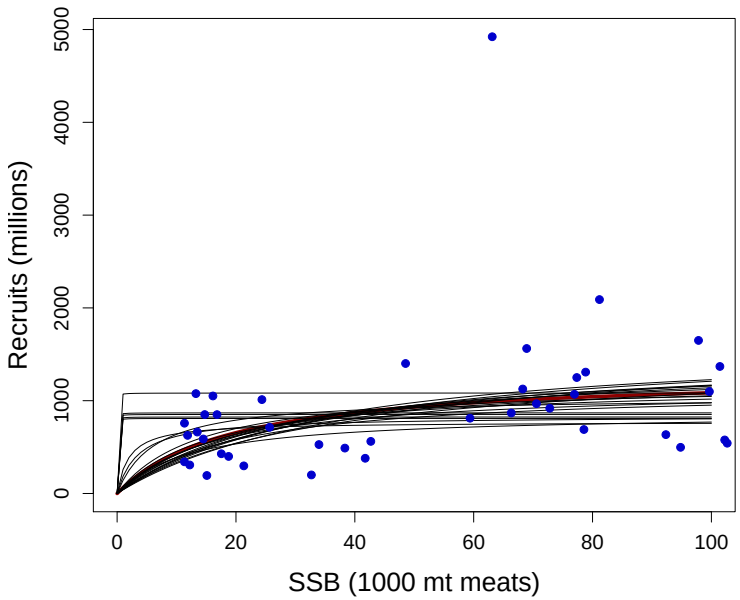
SYM combines per-recruit calculations with a stock-recruit relationship to obtain MSY-based reference point estimates (Hart 2013). It treats per-recruit and stock-recruit parameters as uncertain, and propagates this uncertainty to give probabilistic reference point estimates. Although this model is separate from CASA, it models population dynamics in a similar way, with growth transition matrices based on growth in the latest period from the CASA model, and parameter means are the same as the CASA point estimates for these parameters (e.g., natural mortality and shell height/meat weight relationships).

There are two SYM models, one for Georges Bank and the other for the Mid-Atlantic.

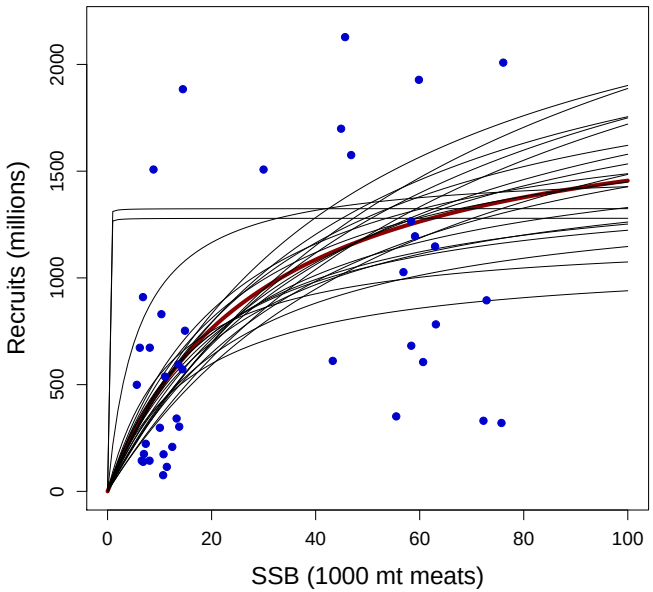
Stock-Recruit Relationships

We used three year old "recruits" in order to avoid high density-dependent natural mortality in some years. Beverton-Holt functions fairly well estimated with lowest recruitment during the lower biomass period and highest recruitment when biomass was higher. The Georges Bank relationship is fairly certain to be near saturation greater than 50000 t, but the saturation point is less clear for the Mid-Atlantic.

Georges Bank



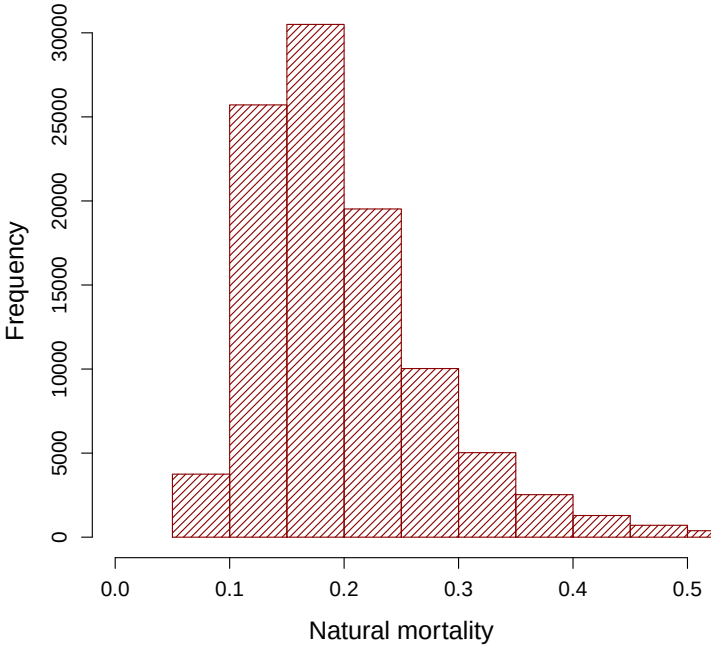
Mid-Atlantic



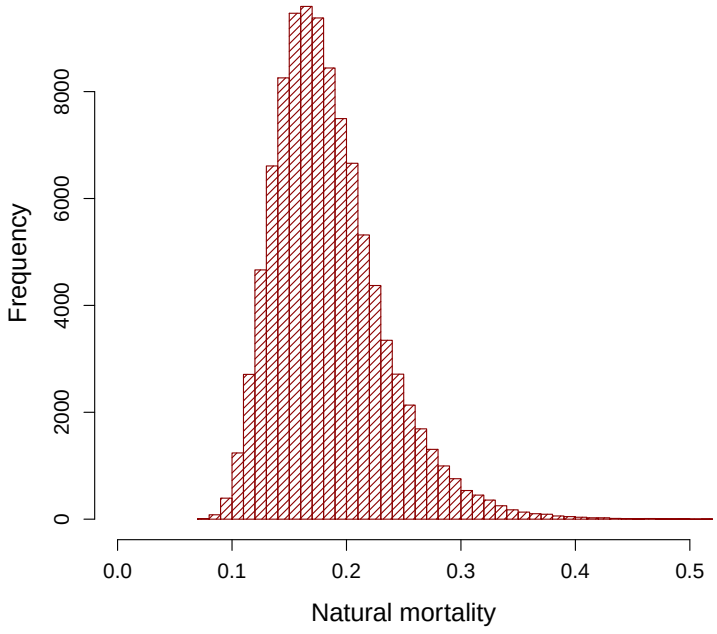
Natural Mortality

Simulated as $1/\gamma$ distribution with $\mu = 0.2$ (GB), $\mu = 0.25$ (MA), standard deviation reduced by 33% from SARC-65.

$\sigma = 0.082$ (GB, SARC-65)



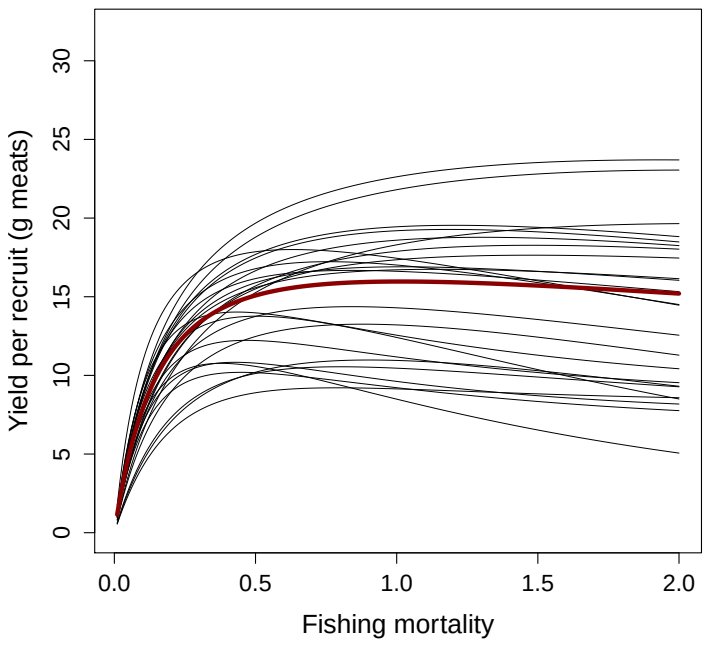
$\sigma = 0.055$ (GB, this assessment)



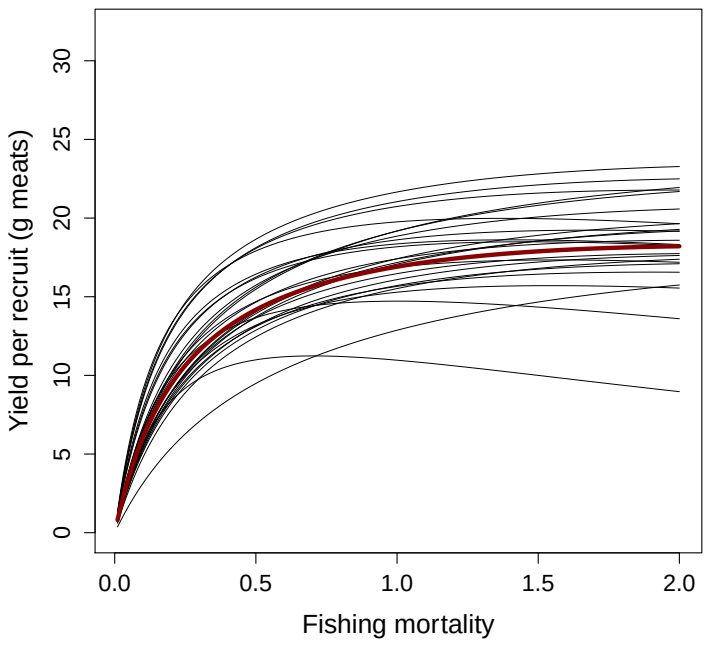
Example Yield Per Recruit Curves

Substantial variation, mainly from propagation of the uncertainty in natural mortality. The mean YPR curve is almost flat.

Georges Bank



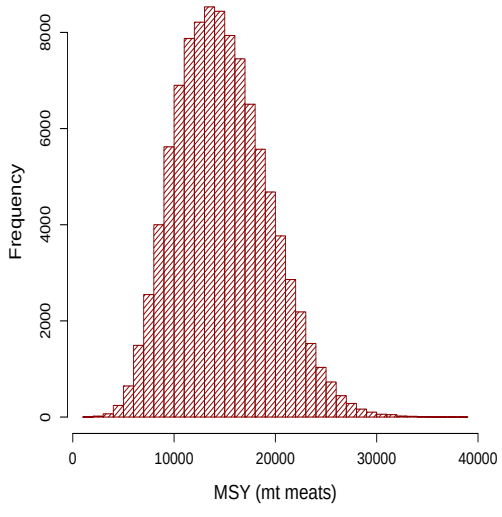
Mid-Atlantic



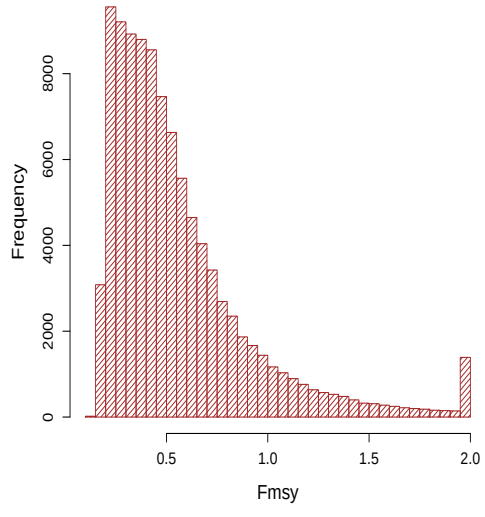
Georges Bank MSY, FMSY and BMSY

Uncertainty in MSY, F_{MSY}, and B_{MSY} on Georges Bank

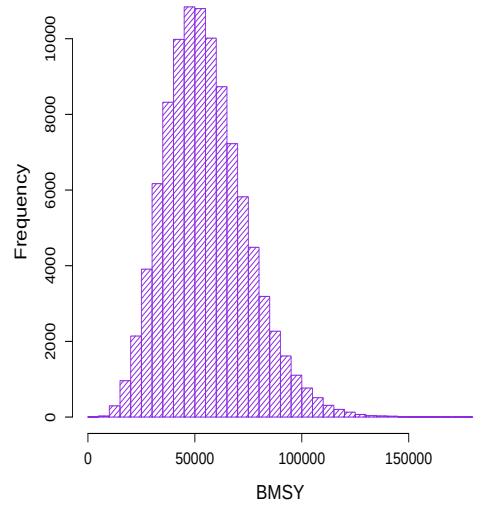
MSY



F_{MSY}



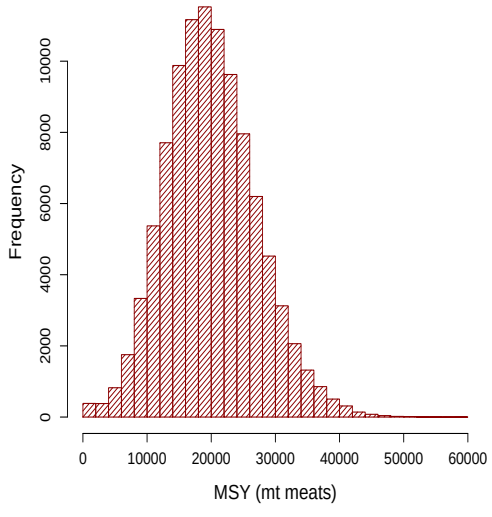
B_{MSY}



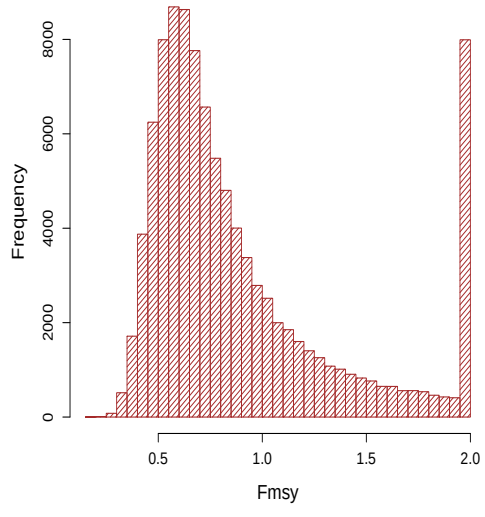
MSY, FMSY and BMSY - Mid-Atlantic

Uncertainty in MSY, F_{MSY}, and B_{MSY} in Mid-Atlantic

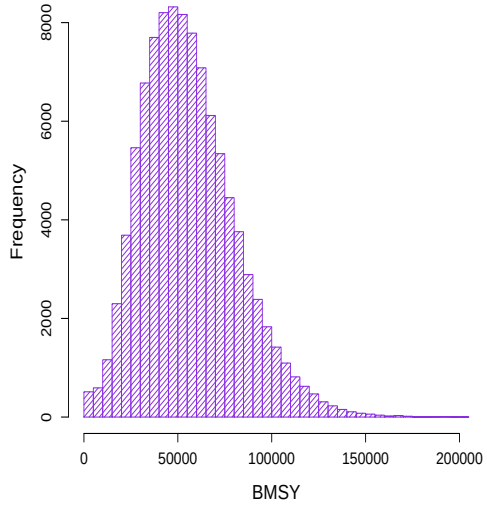
MSY



F_{MSY}



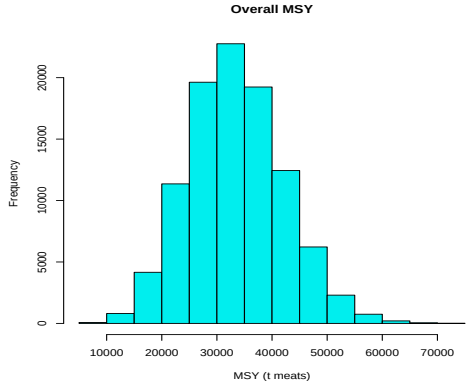
B_{MSY}



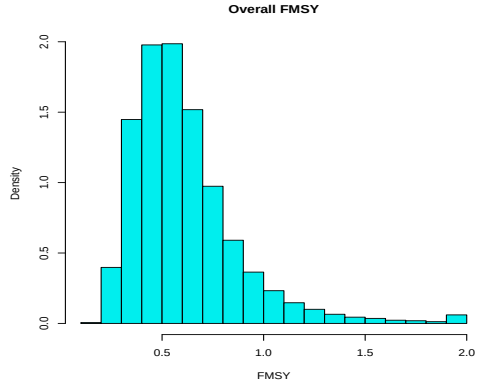
MSY, F_{MSY} and B_{MSY} - Combined

Uncertainty in MSY, F_{MSY}, and B_{MSY} for Georges Bank and Mid-Atlantic combined

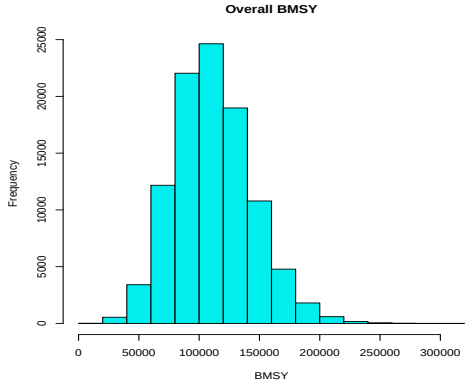
MSY



F_{MSY}



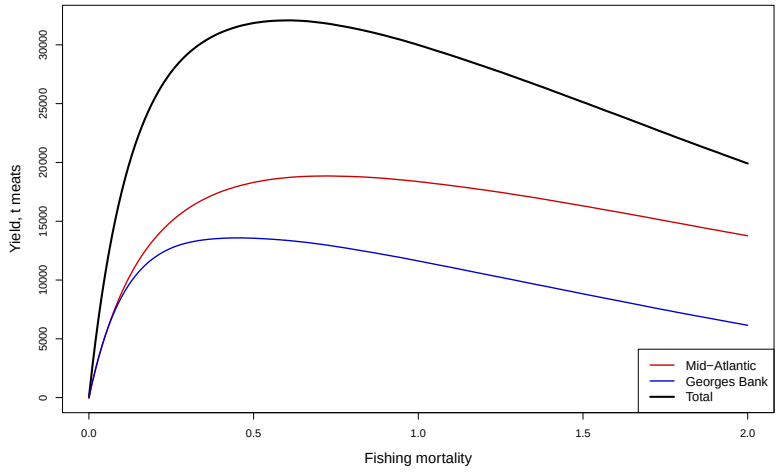
B_{MSY}

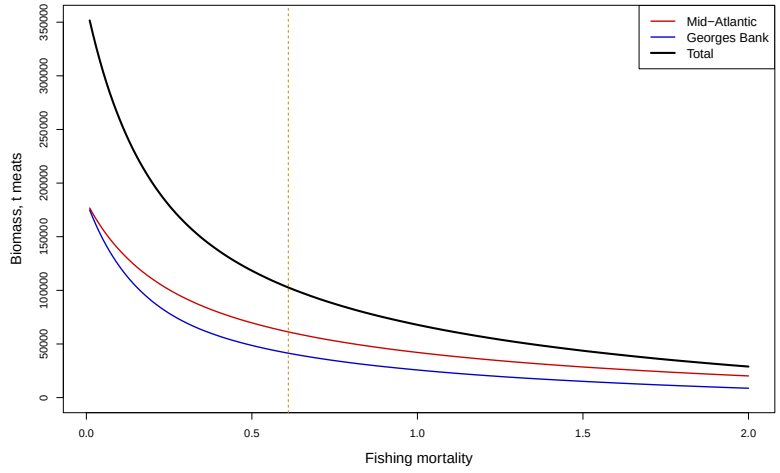


Combined Yield and Biomass Curves

2020 $F_{MSY} = 0.61$ $B_{MSY} = 102,657$ t

2018 $F_{MSY} = 0.64$ $B_{MSY} = 116,766$ t





Changes to the SAMS forecasting model for 2020

- Growth in the SAMS model differs by area, based on shell ring analysis.
- Biomass forecasts for 2020 were in most areas overestimated
- The CASA model reduced growth in the most recent period, based on empirical observations
- Growth in the SAMS model was reduced commensurate with the CASA reductions, except in two areas: Nantucket Lightship South (already slow growth), and Closed Area II Southwest (surveys indicate the dominant year class is growing well)
- Special shell height to meat weight conversions were used in the Nantucket Lightship Area, based on recent dredge surveys.

ACL/OFL methods

- The SAMS model was initialized to 2020 survey data (or in a few cases, 2020 forecasts from 2019) and projected to 2021 based on 2020 management measures.
- ACL landings were calculated by assuming $F = 0.45$ in all areas in 2021 and 2022. Discards/incidental mortality were estimated as 5% of biomass in the Mid-Atlantic, and 10% on Georges Bank, based on estimates from the 2018 benchmark assessment.
- OFL landings in 2021 were calculated by assuming $F = 0.61$ in all areas. OFL landings in 2022 were calculated by assuming $F = 0.45$ in 2021, and then $F = 0.61$ in 2022. Discards were calculated similarly to the ACL.

ACL and OFL estimates (in t meats)

Limit	Year	Biomass	Landings	Discards	Total
ACL	2021	147,298	30,517	5110	35,627
ACL	2022	137,316	28,074	4798	32,872
OFL	2021	147,298	38,714	6678	45,392
OFL	2022	137,668	35,636	6290	41,926