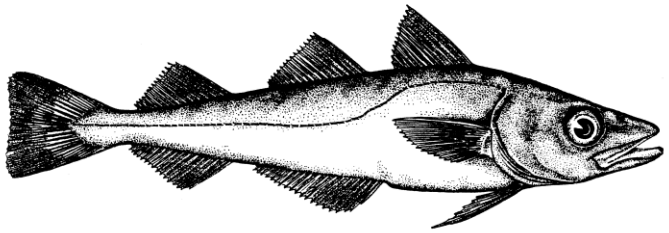
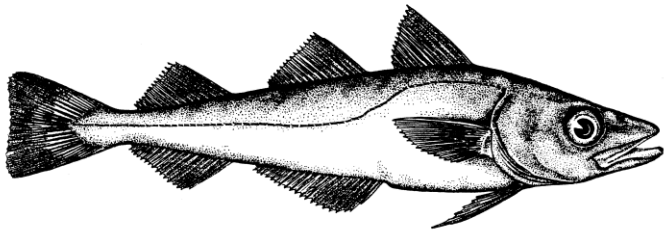


Gulf of Alaska pollock
Overview: Surveys

- The 2014 biomass estimate for Shelikof Strait is 840 kt, which is a 6% decrease from 2013, but is still larger than any other biomass estimate in Shelikof Strait since 1985.

- The ADFG crab/groundfish survey 2014 biomass estimate is close to the 2013 estimate (2% lower).

- The biomass estimate from the 2013 summer acoustic survey, 880 kt, is consistent with 2013 bottom trawl and 2014 acoustic surveys, but was not incorporated into the assessment model.



Gulf of Alaska pollock
Overview: Assessment

- There were important changes to the assessment model.
  - Start the model in 1970 rather than 1964
  - Remove summer bottom trawl surveys in 1984 and 1987 and Shelikof Strait acoustic surveys in 1981-1991,
  - Estimate summer bottom trawl catchability
  - Use a random walk for changing fishery selectivity parameters
  - Use an age-specific mortality schedule with higher juvenile mortality,
  - Model age-1 and age-2 pollock in the winter acoustic surveys as separate indices.

- The author's 2015 ABC recommendation is 191,309 t, which is an increase of 14% from 2014.

- GOA pollock was determined to be in Tier 3b (very slightly below $B_{40\%}$), but will increase in 2016.

- The estimated abundance of mature fish is projected to remain stable near $B_{40\%}$ or to increase over the next five years; projected ABCs are around 250 kt for the same period.

Plan Team and SSC comments on assessments in general

- *Consider whether it is possible to estimate M with at least two significant to increase validity of the estimated OFL.*

  We evaluated six methods to estimate the age-specific pattern of natural mortality external to the assessment model, and recommended an ensemble average for use in the model.

- *The SSC recommended that assessment authors give greater attention to how current year catch is determined.*

  We averaged the percent of ABC taken in the previous five years, and applied that percentage (95%) to the current year ABC/TAC.

- *Projections for two future years should be shown on the phase plot figure.*

  The phase plot figure was modified as recommended.

- *Recommended use of the random effects approach to determine area apportionments.*

  The random effects model was used the summer apportionment using the summer bottom trawl survey. It was not used for the winter apportionment calculations due to concerns about how the model performed with short, highly variable time series.

Plan Team and SSC comments specific to GOA Pollock

- *The GOA Plan Team suggested that inter-annual smoothing be used instead of blocks. The SSC concurred with the Plan Team recommendation.*

  We reintroduced random walks in the parameters governing the ascending portion of the selectivity curve with stiffer penalties on the amount that the parameter can change from one year to the next.

- *The GOA Plan Team questioned the assumption of the multinomial error assumption for all ages is questionable. The Team suggested that younger ages, age-1 and possibly age-2, might be better treated separately. The SSC concurred with the Plan Team recommendation.*

  We separated the age-1 and the age-2 pollock from the remaining age classes for the Shelikof Strait acoustic survey biomass and age composition.

- *The SSC in its December 2012 minutes recommended that the assessment authors explore if there are variations in female relative abundance that may explain variations in spatial distributions by management areas.*

  No progress on this one.

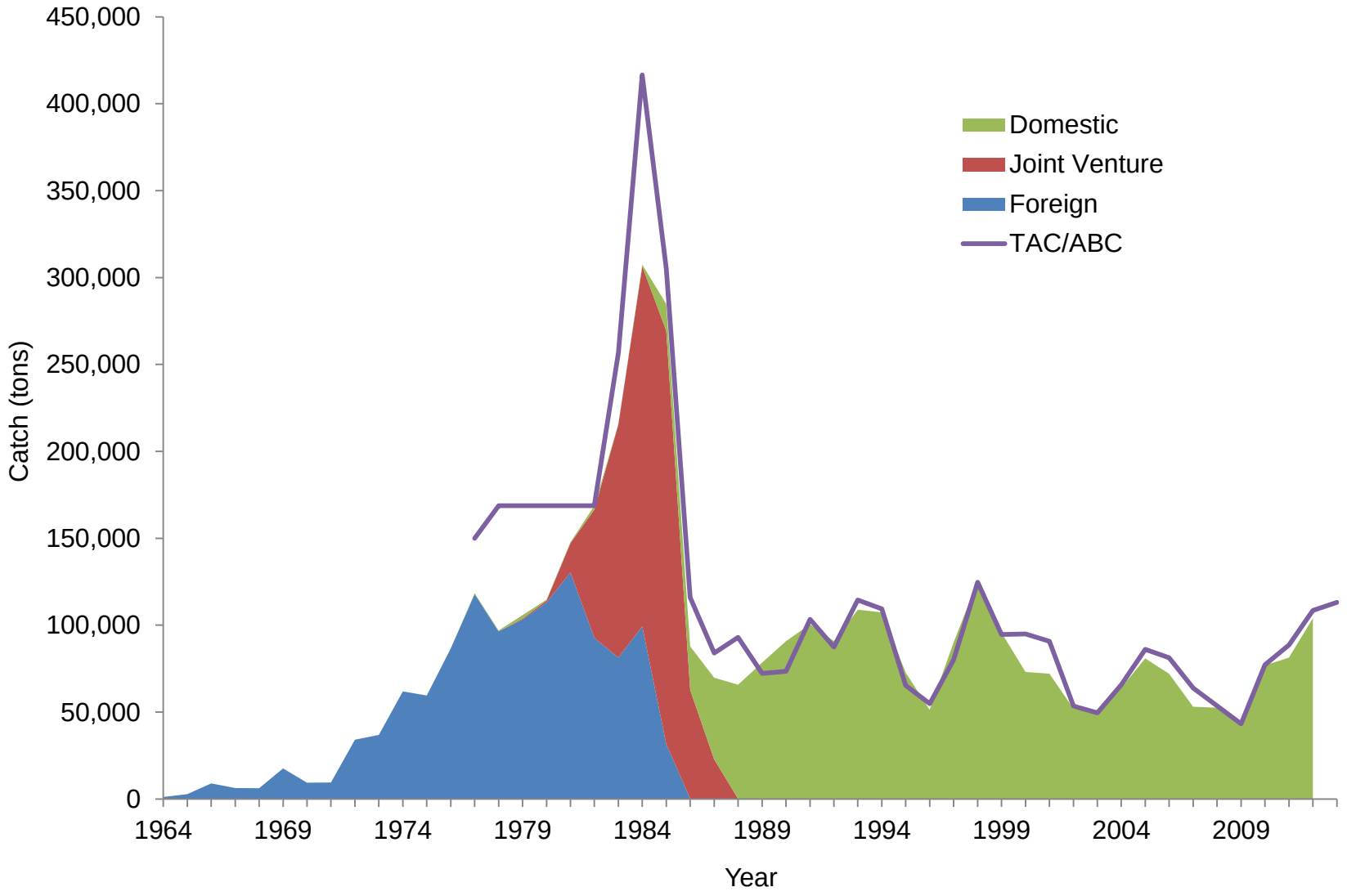
- *The SSC noted a discrepancy between including the 2012 recruitment in projections but not in calculating the B100% reference point.*

  We decided it was appropriate to maintain our practice of omitting the final year estimate of age-1 recruitment in calculation of average recruitment for status determination, but using that estimate for projecting ABCs and OFLs.

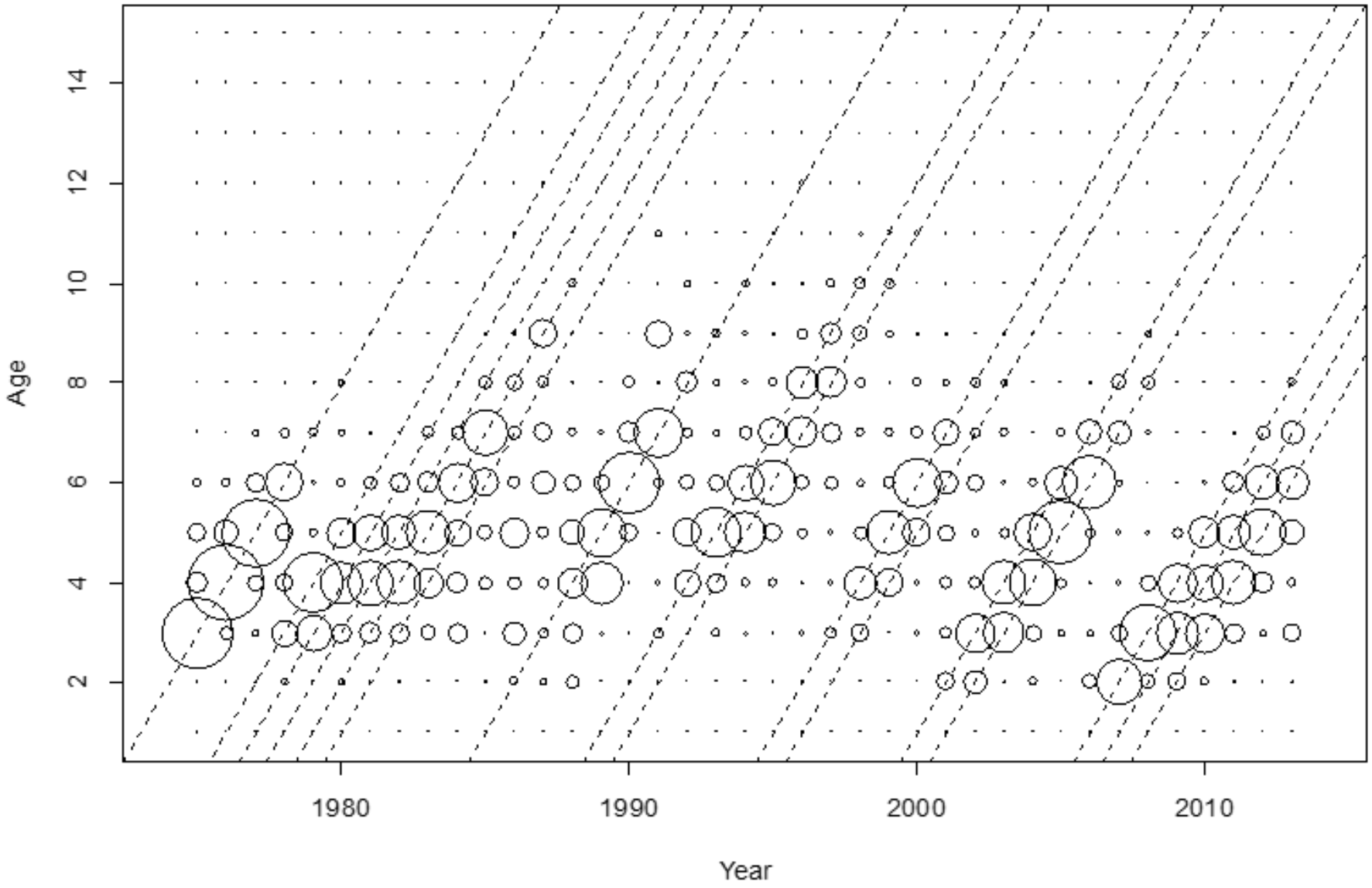
Data used in the assessment

Source	*Type*	*Years*
Fishery	Total catch biomass	1970-2013
Fishery	Age composition	1975-2013
Shelikof Strait acoustic survey	Biomass	1992-2014
Shelikof Strait acoustic survey	Age composition	1992-2014
NMFS bottom trawl survey	Area-swept biomass	1990-2013
NMFS bottom trawl survey	Age composition	1990-2013
ADFG trawl survey	Area-swept biomass	1989-2013
ADFG survey	Age composition	2000, 2002, 2004, 2006, 2008, 2010, 2012

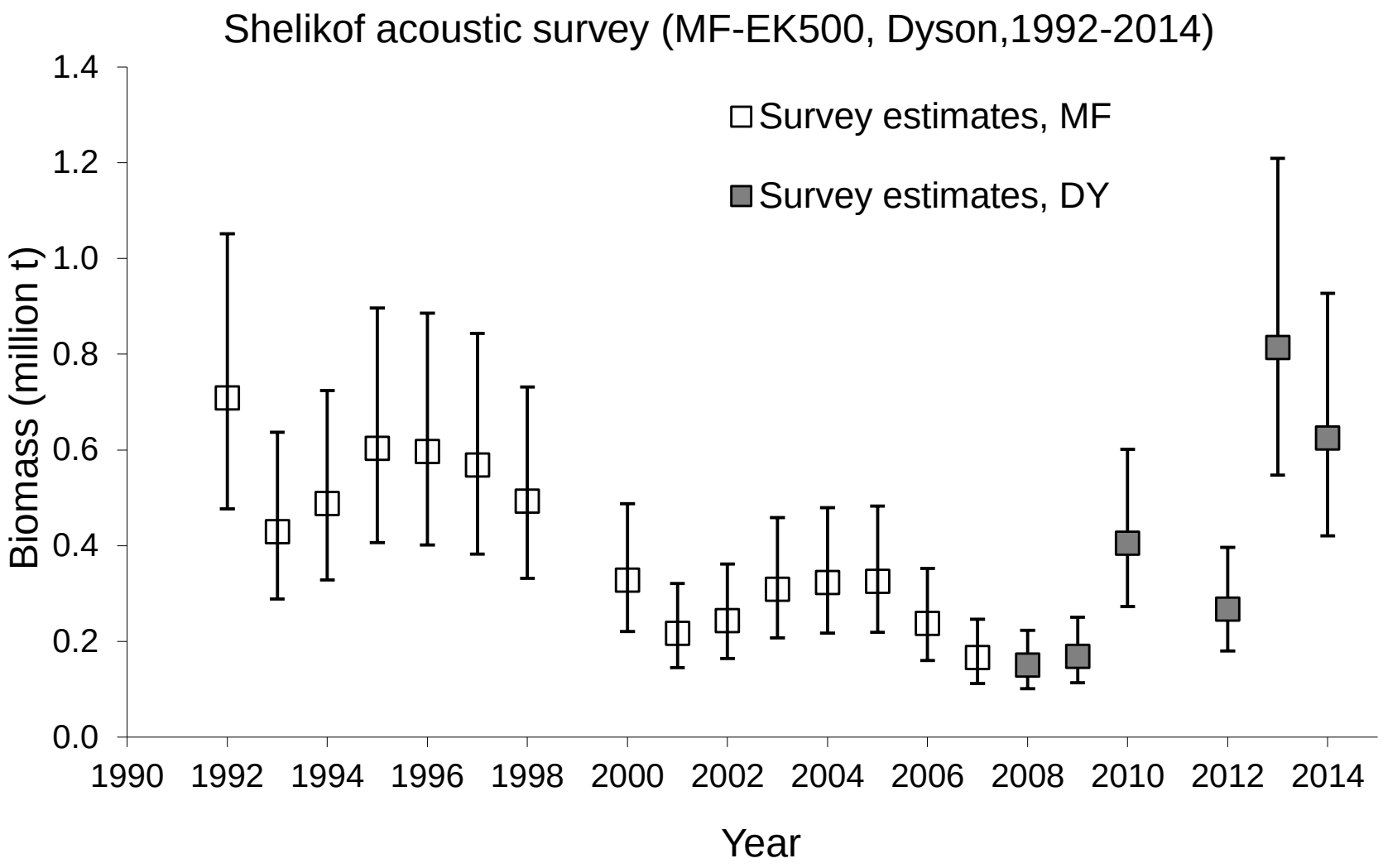
Total catch 1964-2013



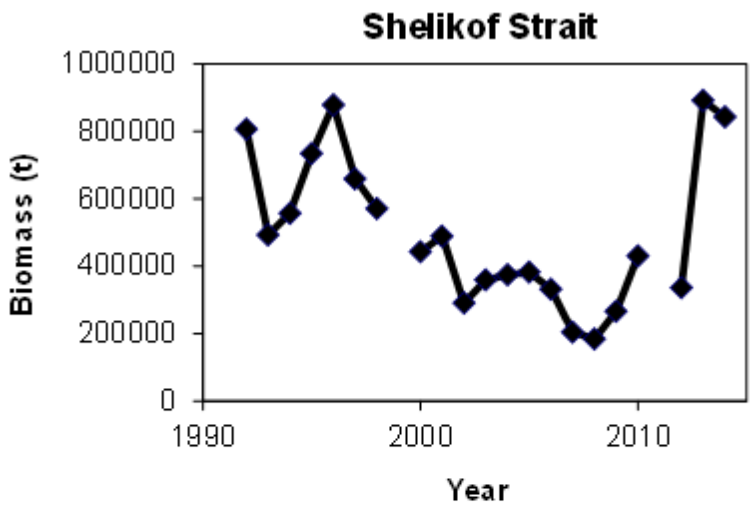
Catch at age, 1975-2013

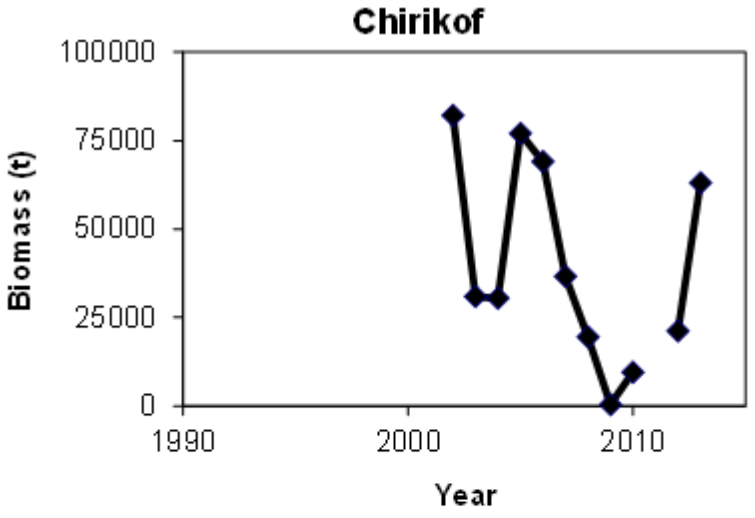


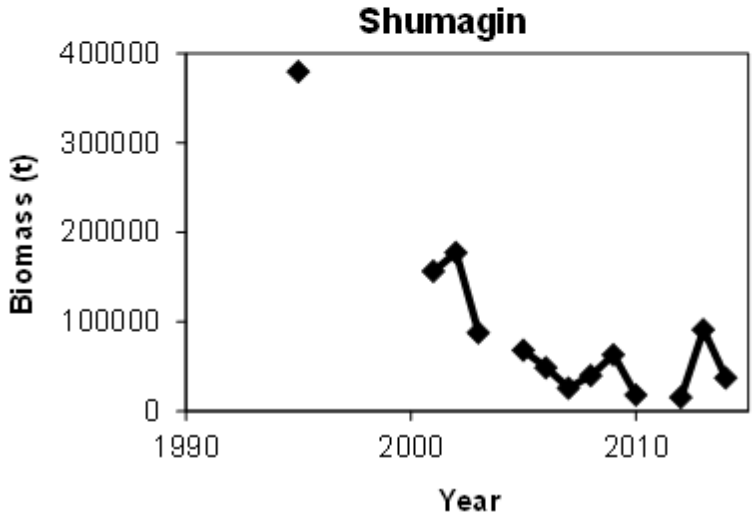
Shelikof Strait acoustic survey, 1992-2014

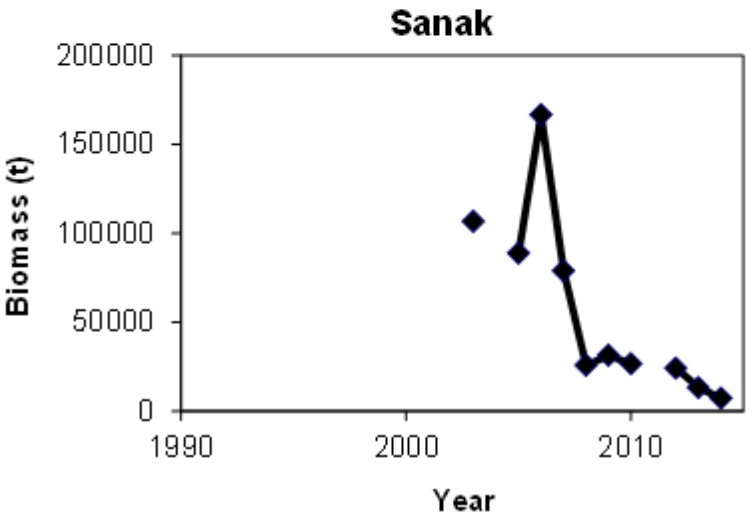


Acoustic surveys outside Shelikof Strait



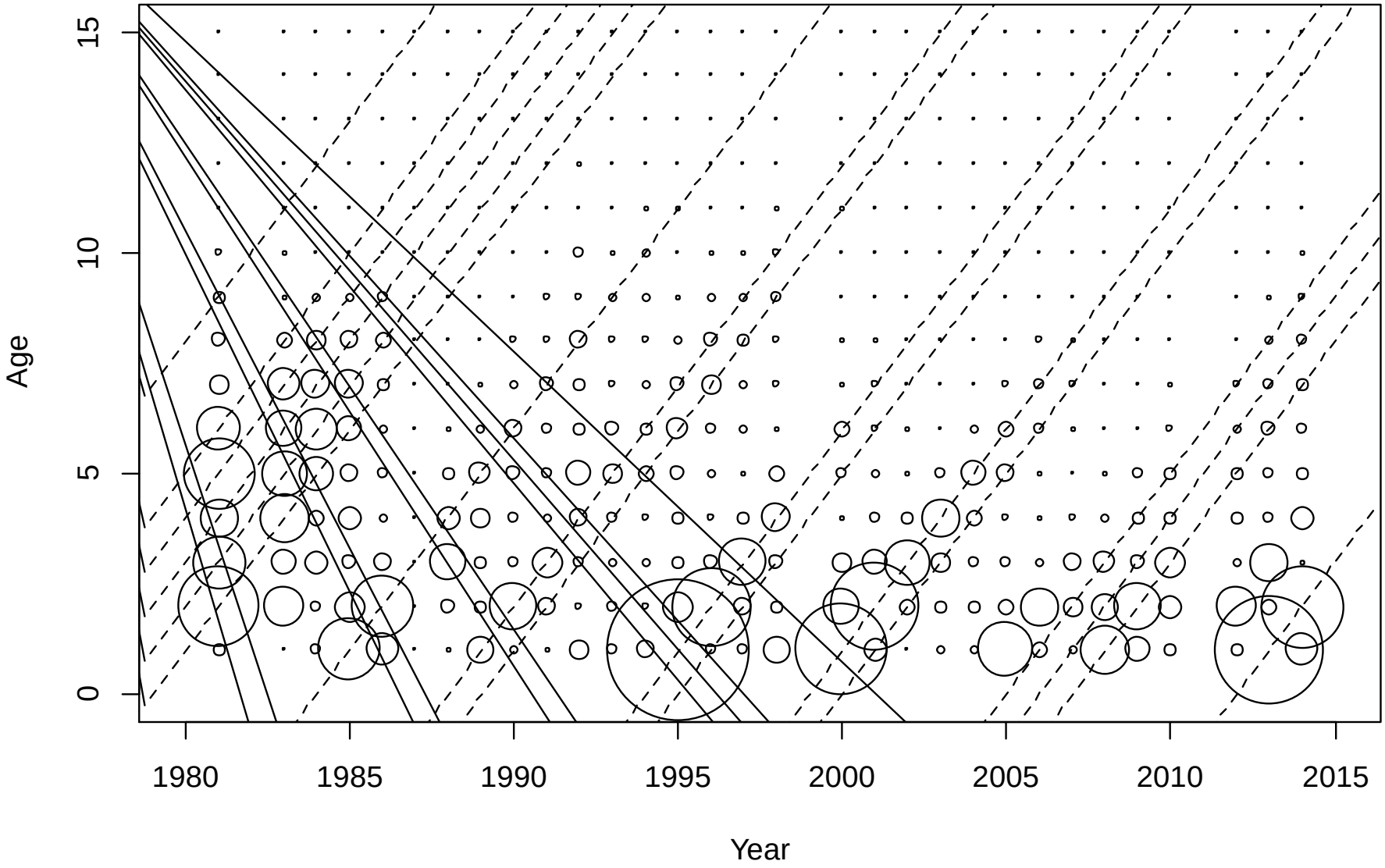




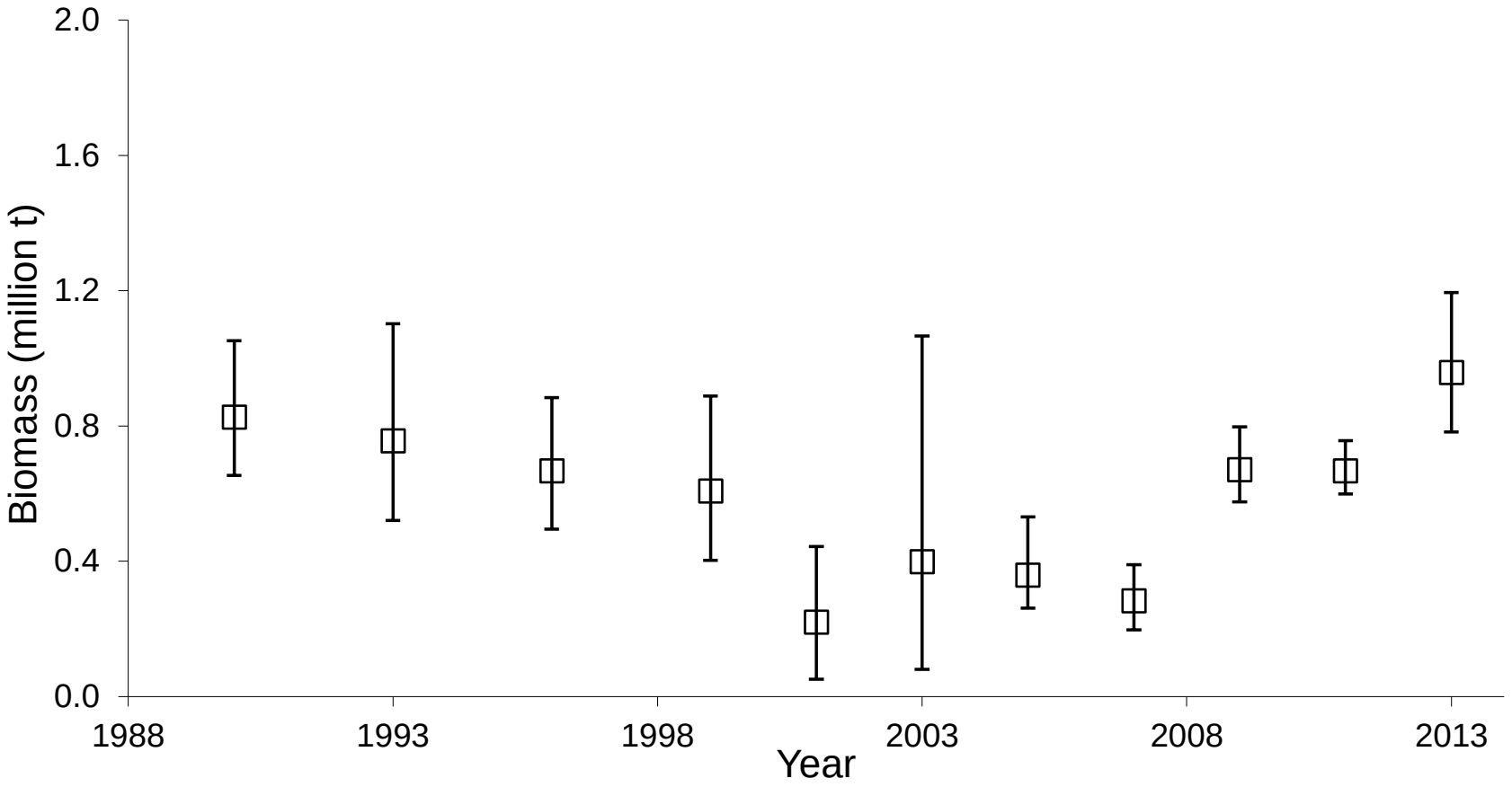


Total for all winter acoustic surveys = 902,249 t (93% in Shelikof Strait)

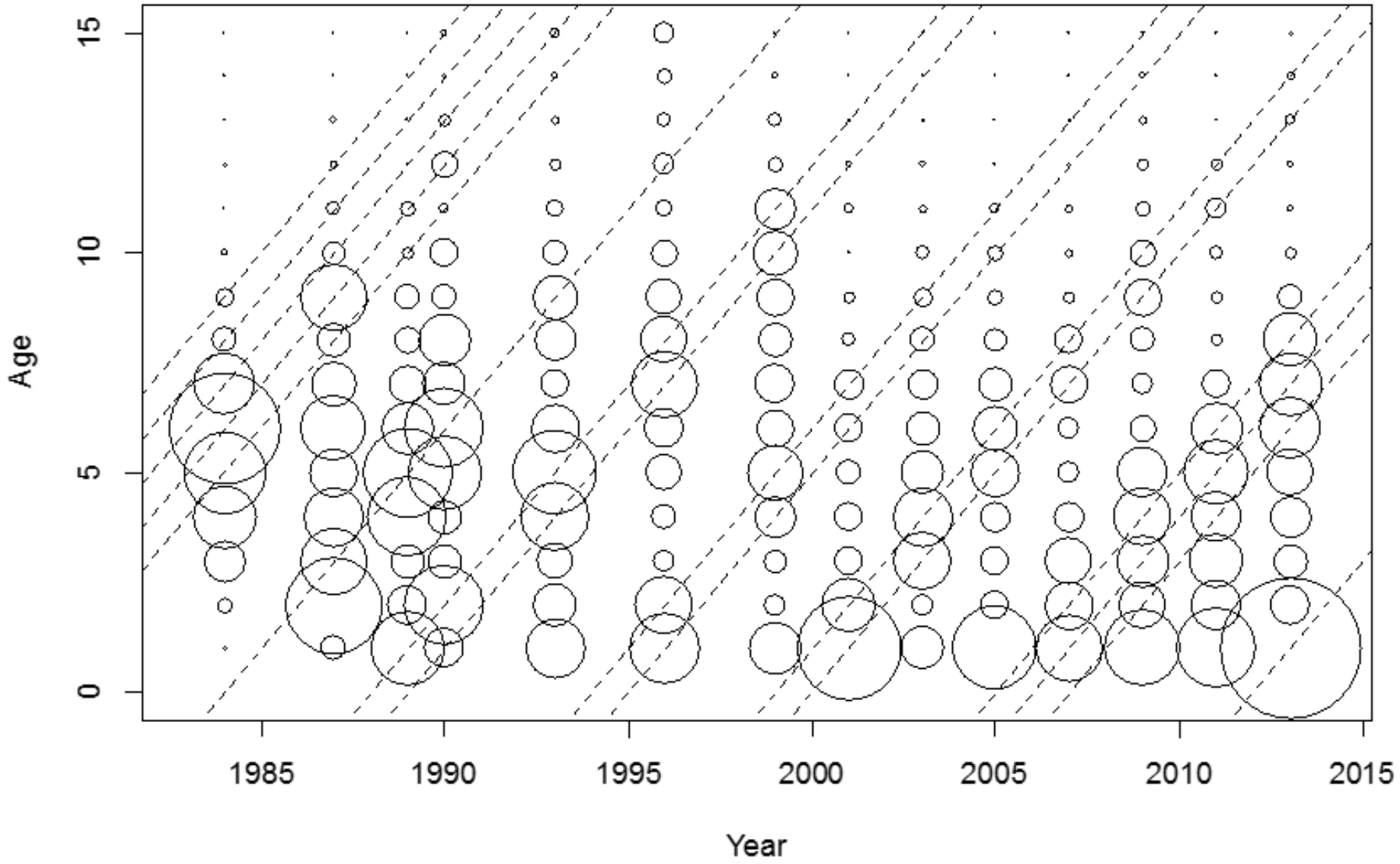
Shelikof Strait survey age comp, 1981-2014



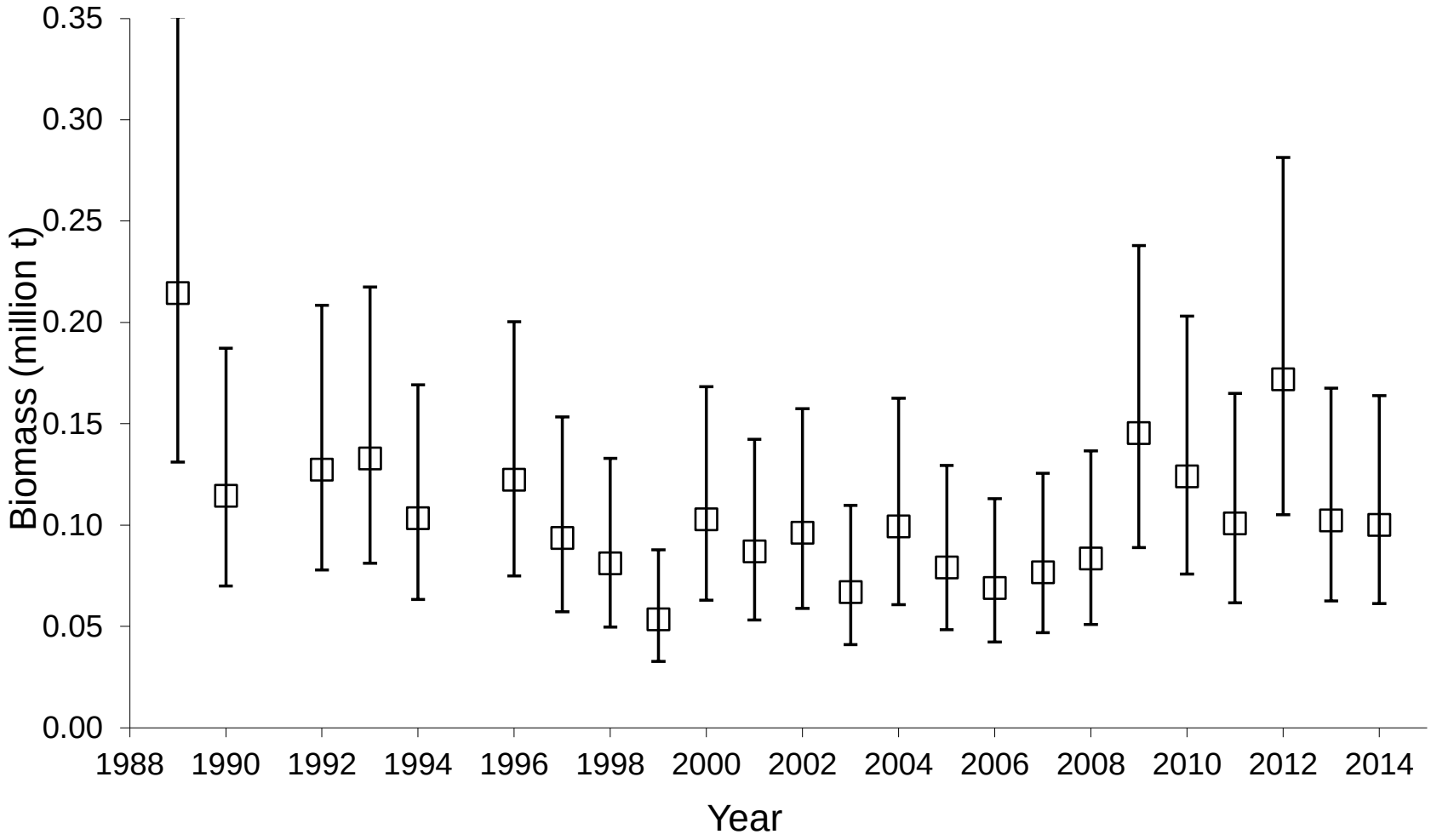
NMFS bottom trawl survey (1990-2013)



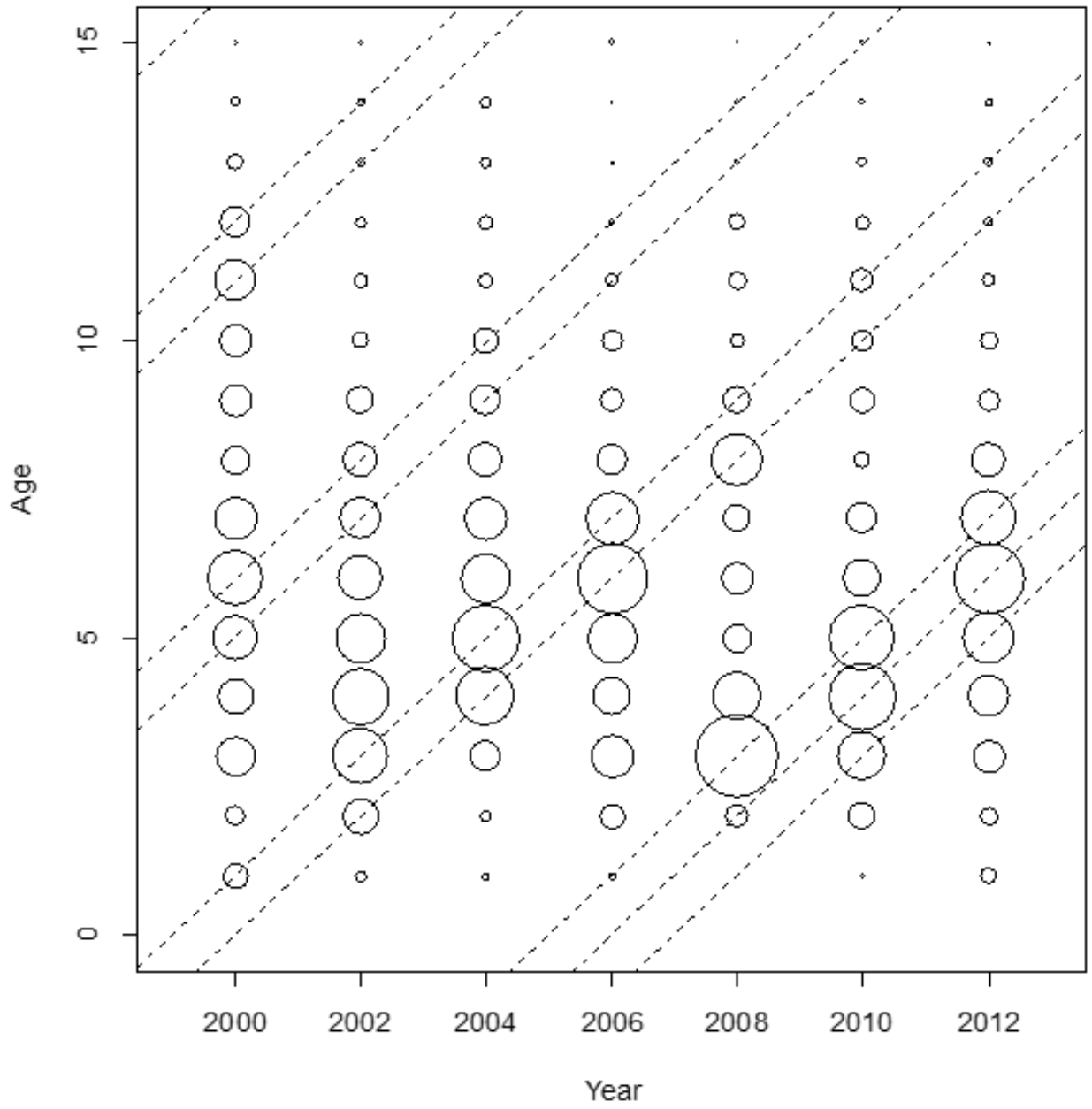
NMFS Bottom trawl survey age comp (1990-2013)



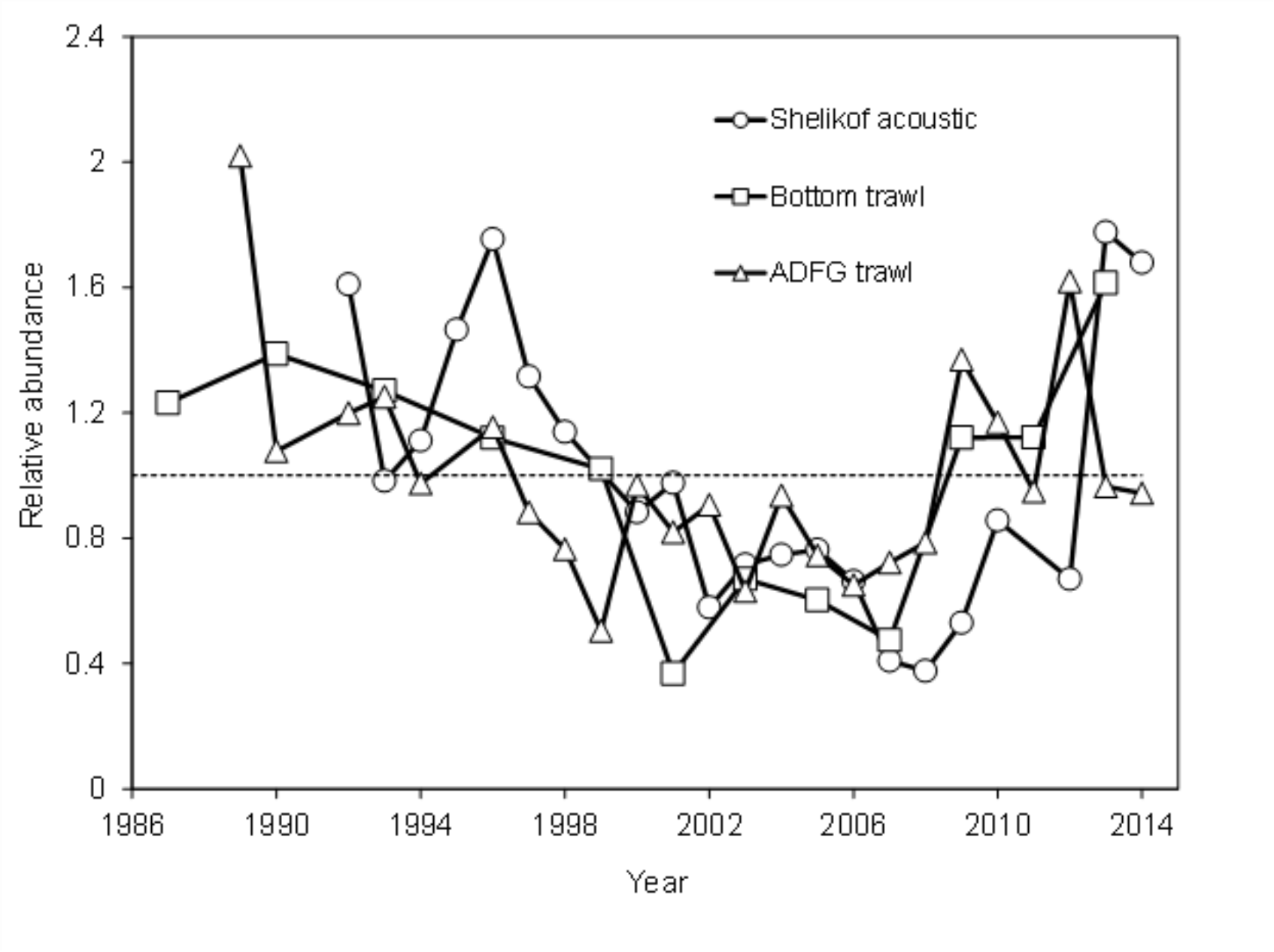
ADFG crab/groundfish trawl survey (1989-2014)



ADFG crab/groundfish trawl survey age comp (2000-2012)



Relative trends in abundance indices (1987-2014)



Parameters estimated independently

- Natural mortality: new age-specific pattern
- Weight at age by fishery and survey
- Proportion mature at age

Natural mortality estimation methods (statistical model-based)

- Multispecies models that include GOA pollock
  - Hollowed et al. 2000
  - Van Kirk et al. 2010
  - Van Kirk et al. 2012
- Averaged the last ten years of M estimates

Natural mortality estimation methods (theoretical/empirical)

Brodziak et al. 2011—Age-specific M is given by

$$M(a) = \begin{cases} M_c \dfrac{L_{mat}}{L(a)} & for\ a < a_{mat} \\ M_c & for\ a \geq a_{mat}\ , \end{cases}$$

where L_{mat} is the length at maturity, M_c = 0.30 is the natural mortality at L_{mat}, L(a) is mean length at age for the summer bottom trawl survey for 1984-2013.

Lorenzen 1996—Age-specific M for ocean ecosystems is given by

$$M(a) = 3.69\ \bar{W}_a^{-0.305},$$

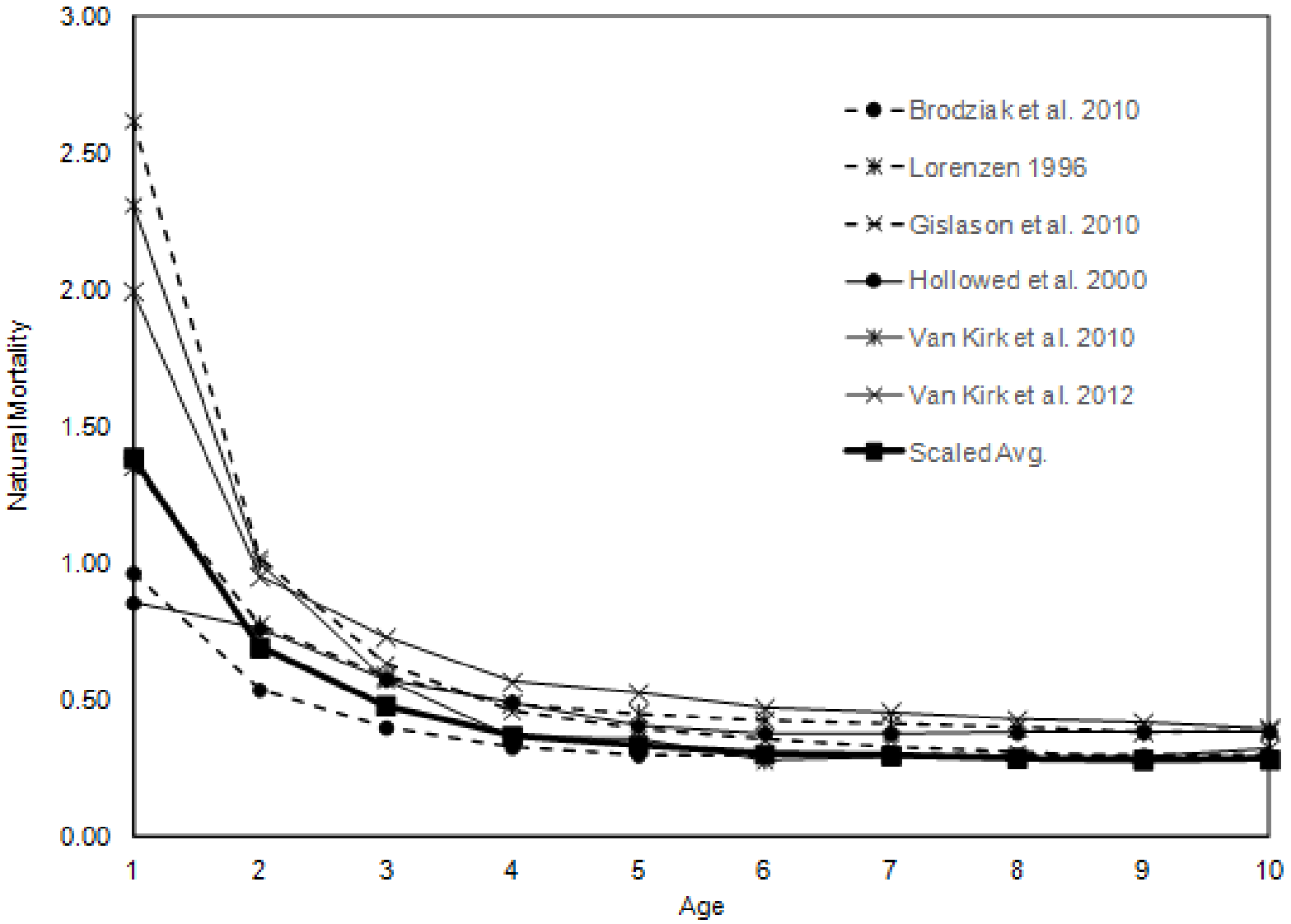
where *Wa* is the mean weight at age from the summer bottom trawl survey for 1984-2013.

Gislason et al. 2010—Age-specific M is given by

$$\ln(M) = 0.55 - 1.61 \ln(L) + 1.44 \ln(L_\infty) + \ln(K),$$

where L_∞ = 65.2 cm and K = 0.30 were estimated by fitting von Bertalanffy growth curves using the NLS routine in R using summer bottom trawl age data for 2005-2009 for sexes combined in the central and western Gulf of Alaska.

Natural mortality estimates



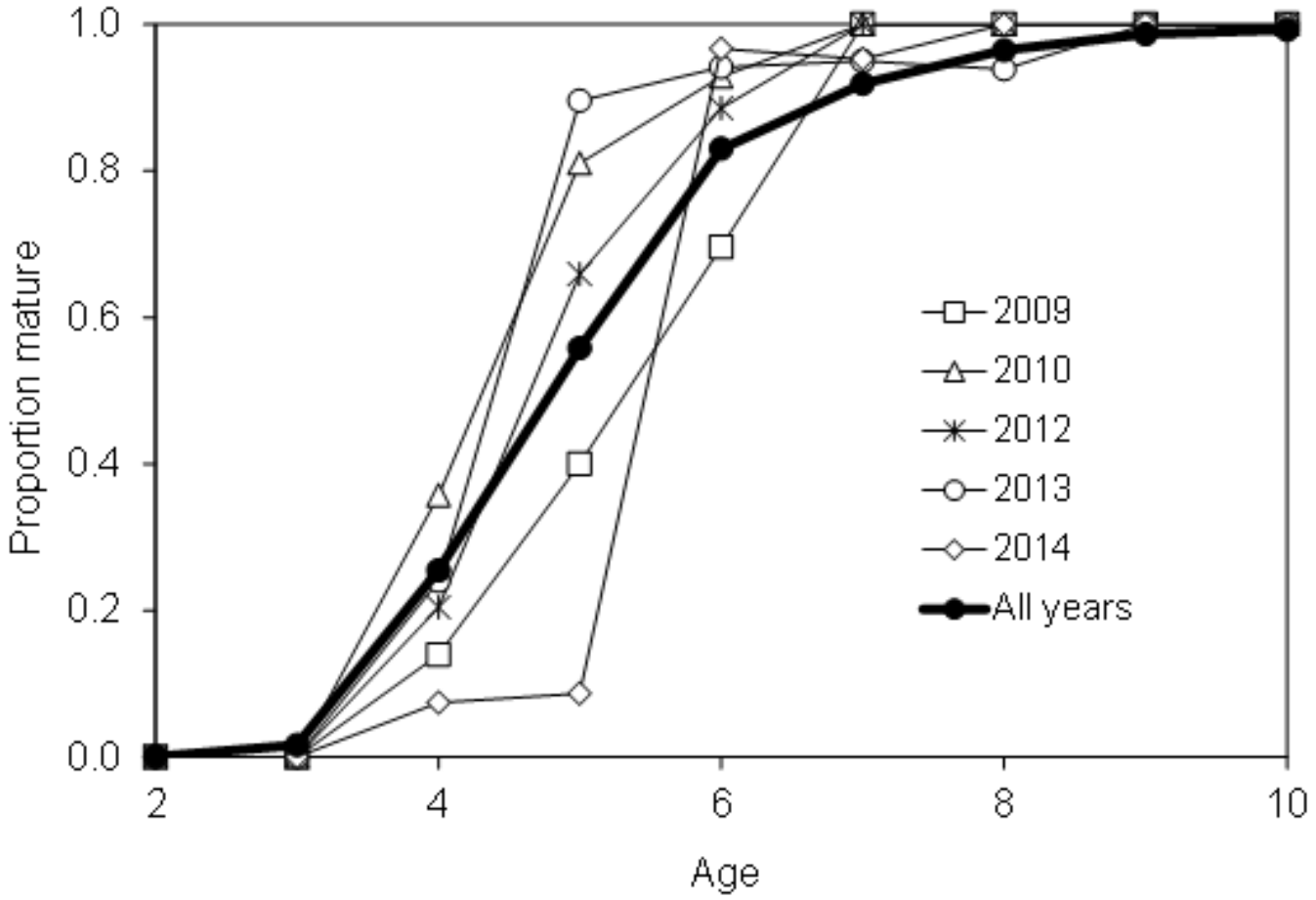
Natural mortality estimates

Age	*Length (cm)*	*Weight (g)*	*Brodziak et al. 2010*	*Lorenzen 1996*	*Gislason et al. 2010*	*Hollowed et al. 2000*	*Van Kirk et al. 2010*	*Van Kirk et al. 2012*	*Average*	*Rescaled Avg.*
1	15.3	26.5	0.97	1.36	2.62	0.86	2.31	2.00	1.69	1.39
2	27.4	166.7	0.54	0.78	1.02	0.76	1.01	0.95	0.84	0.69
3	36.8	406.4	0.40	0.59	0.64	0.58	0.58	0.73	0.59	0.48
4	44.9	752.4	0.33	0.49	0.46	0.49	0.37	0.57	0.45	0.37
5	49.2	966.0	0.30	0.45	0.40	0.41	0.36	0.53	0.41	0.34
6	52.5	1154.2	0.30	0.43	0.36	0.38	0.28	0.47	0.37	0.30
7	55.1	1273.5	0.30	0.42	0.33	0.38	0.30	0.46	0.36	0.30
8	57.4	1421.7	0.30	0.40	0.31	0.38	0.29	0.43	0.35	0.29
9	60.3	1624.8	0.30	0.39	0.29	0.39	0.29	0.42	0.35	0.28
10	61.1	1599.6	0.30	0.39	0.28	0.39	0.33	0.40	0.35	0.29

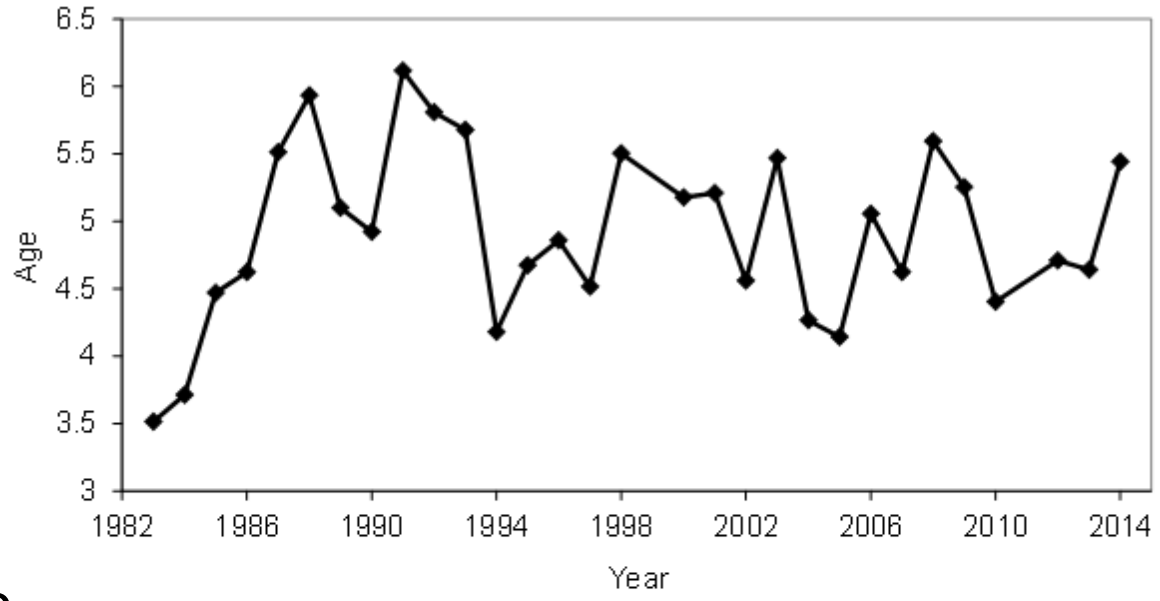
Clay Porch's nifty rescaling equation:

$$M(t) = M_{target} \frac{nL(t)}{\sum_{t_c}^{t_{max}} L(t)}$$

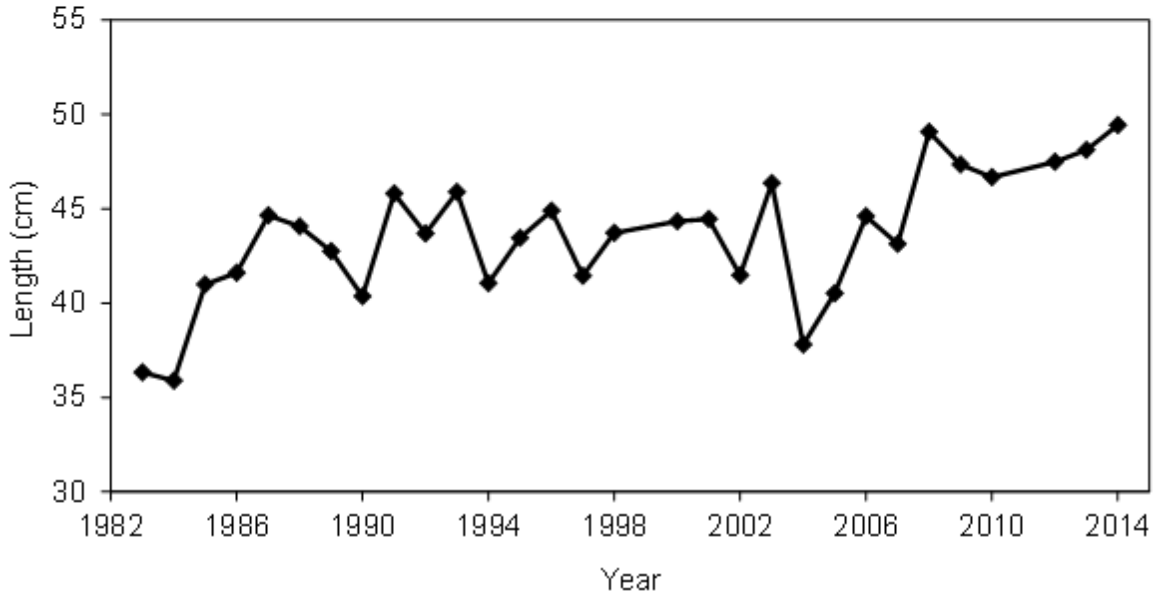
Recent maturity curves



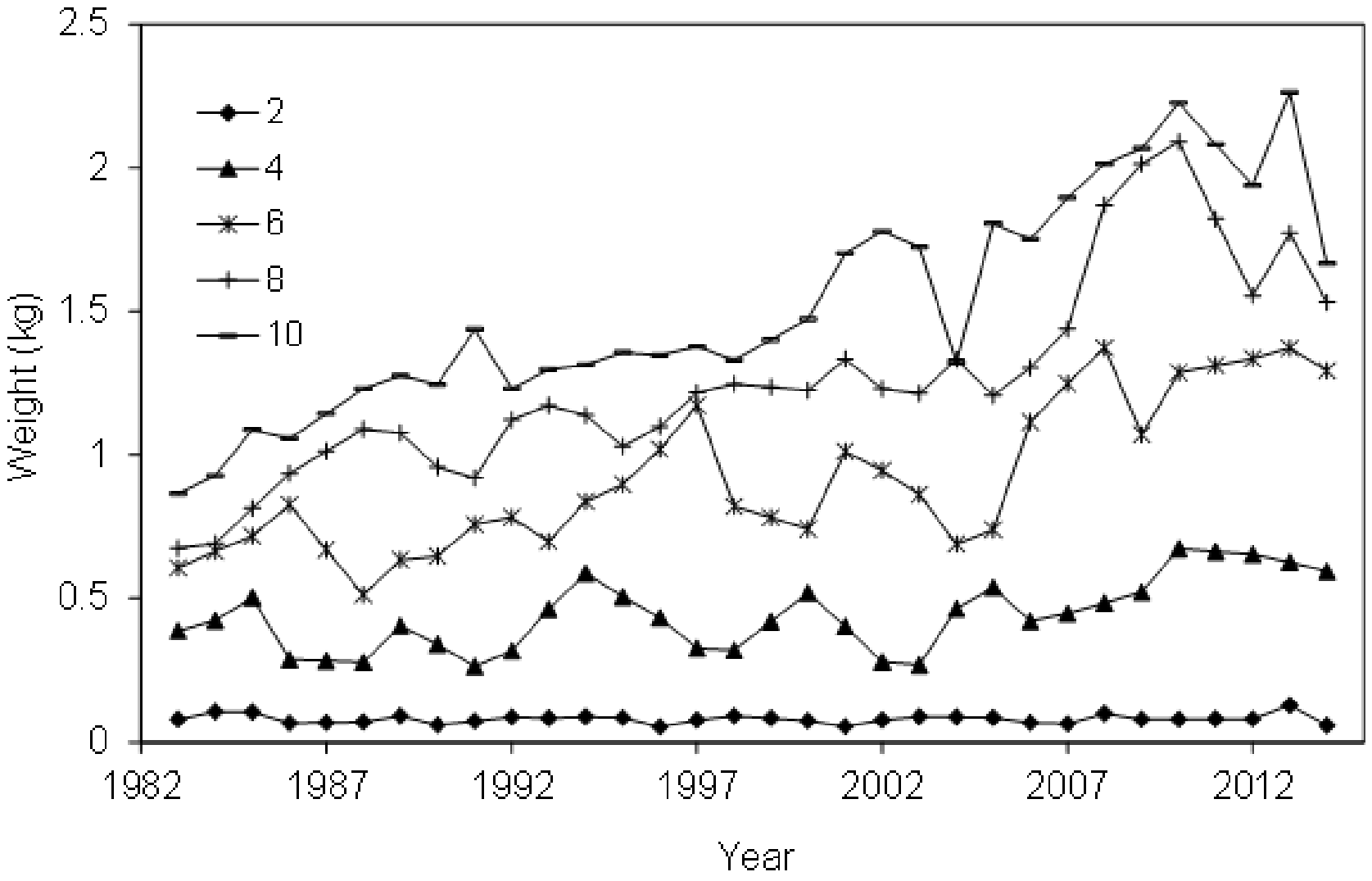
Age at 50% mature



Length at 50% mature



Shelikof survey changes in weight at age



Likelihood components

Likelihood component	Statistical model for error	Variance assumption
Fishery total catch (1970-2014)	Log-normal	CV = 0.05
Fishery age comp. (1975-2013)	Multinomial	Year-specific sample size = 20-200
Shelikof acoustic survey biomass (1992-2014)	Log-normal	CV = 0.20
Shelikof acoustic survey age comp. (1992-2014)	Multinomial	Sample size = 60
NMFS bottom trawl survey biom. (1990-2013)	Log-normal	Survey-specific CV = 0.12-0.38
NMFS bottom trawl survey age comp. (1990-2013)	Multinomial	Sample size = 60
ADFG trawl survey biomass (1989-2014)	Log-normal	CV = 0.25
ADFG survey age comp. (2000, 2002, 2004, 2006, 2008, 2010, 2012)	Multinomial	Sample size = 30
Recruit process error (1970-1977, 2013, 2014)	Log-normal	σ_R =1.0

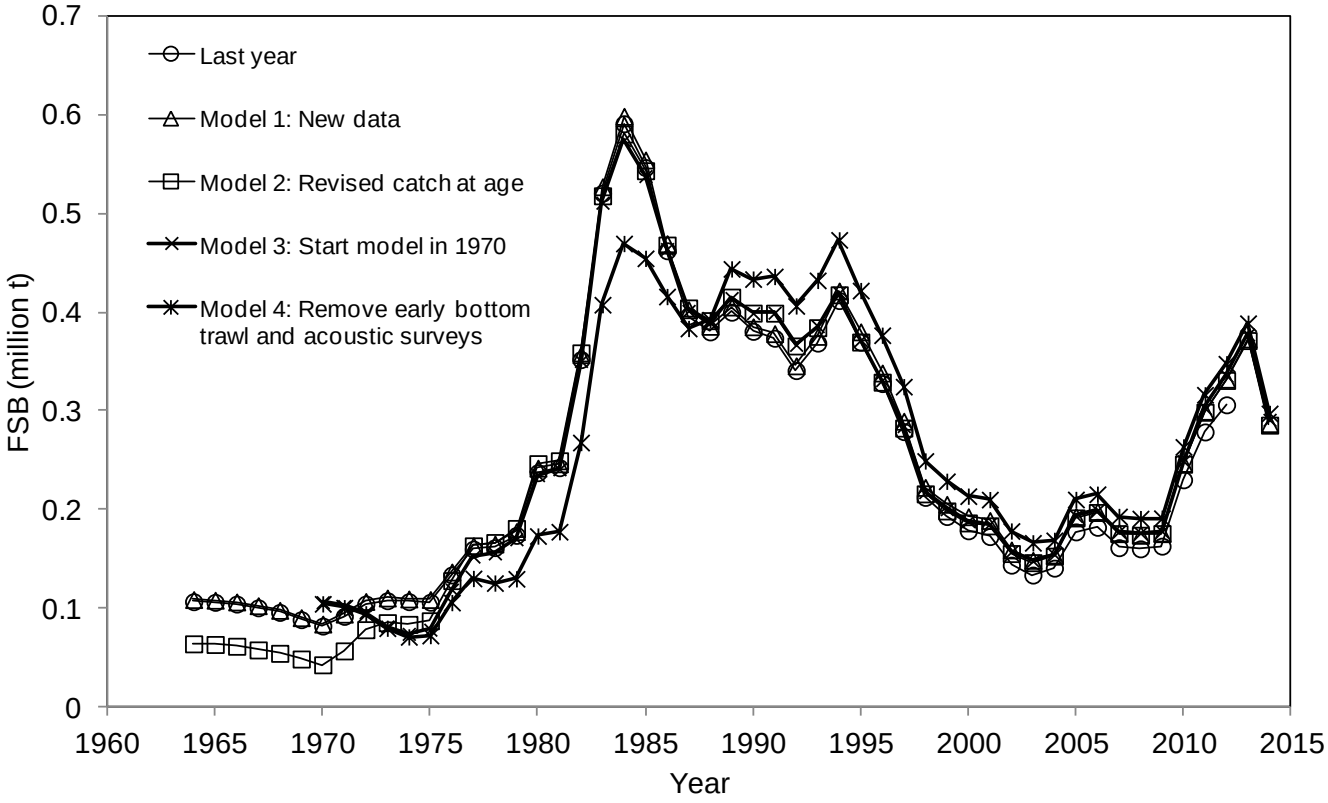
Model parameters

Population process modeled	Number of parameters	Estimation details
Recruitment	Years 1970-2014 = 45	Estimated as log deviances from the log mean; recruitment in 1970-77, and 2013 and 2014 constrained by random deviation process error.
Natural mortality	Age-specific= 10	Not estimated in the model
Fishing mortality	Years 1970-2014 = 45	Estimated as log deviances from the log mean
Mean fishery selectivity	4	Slope parameters estimated on a log scale, intercept parameters on an arithmetic scale
Annual changes in fishery selectivity	2 * (No. years-1) = 88	Estimated as deviations from mean selectivity and constrained by random walk process error
Survey catchability	No. of surveys + 1 = 6	Catchabilities estimated on a log scale. Two catchability periods were estimated for the acoustic survey.
Survey selectivity	8 (acoustic survey: 2, BT survey: 2, ADFG survey: 2)	Slope parameters estimated on a log scale.
Total	108 estimated parameters +88 process error parameters + 10 fixed parameters = 206	

Model input changes

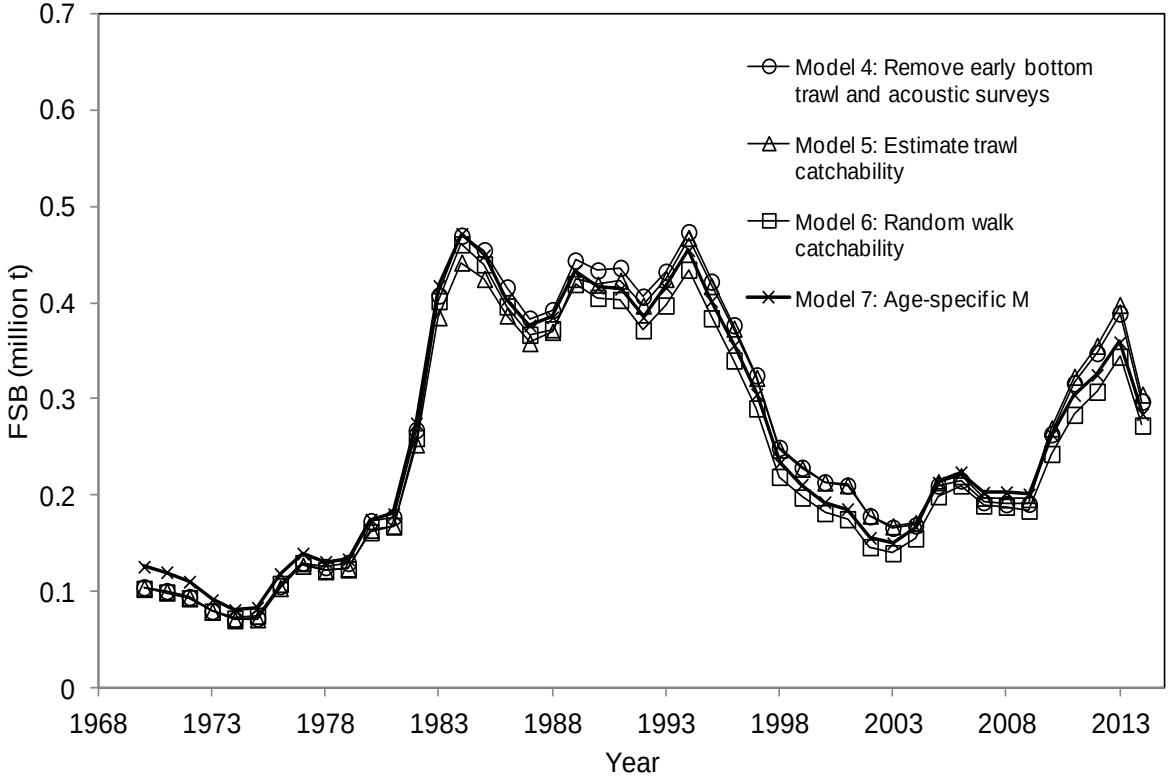
- Fishery: 2013 total catch and catch at age.
- Shelikof Strait acoustic survey: 2014 biomass and age composition.
- NMFS bottom trawl survey: 2013 age composition.
- ADFG crab/groundfish trawl survey: 2014 biomass.
- Total catch for all years was re-estimated from original sources
- Fishery catch at age and weight at age were re-estimated for 1975-1999 from primary databases maintained at AFSC.

Alternative Models



Model 1 updates the 2013 assessment model with new data but makes no changes to the model configuration.
Model 2 incorporates re-estimated total catch, catch at age and fishery weight at age for 1975-1999 and corrects several minor coding errors.
Model 3 starts in 1970 and remove fishery length composition data for 1964-1971.
Model 4 removes bottom trawl surveys in 1984 and 1987, and acoustic surveys in Shelikof Strait for 1981-1991. Model changes are cumulative, i.e., each model includes the features of previous models.

Alternative Models



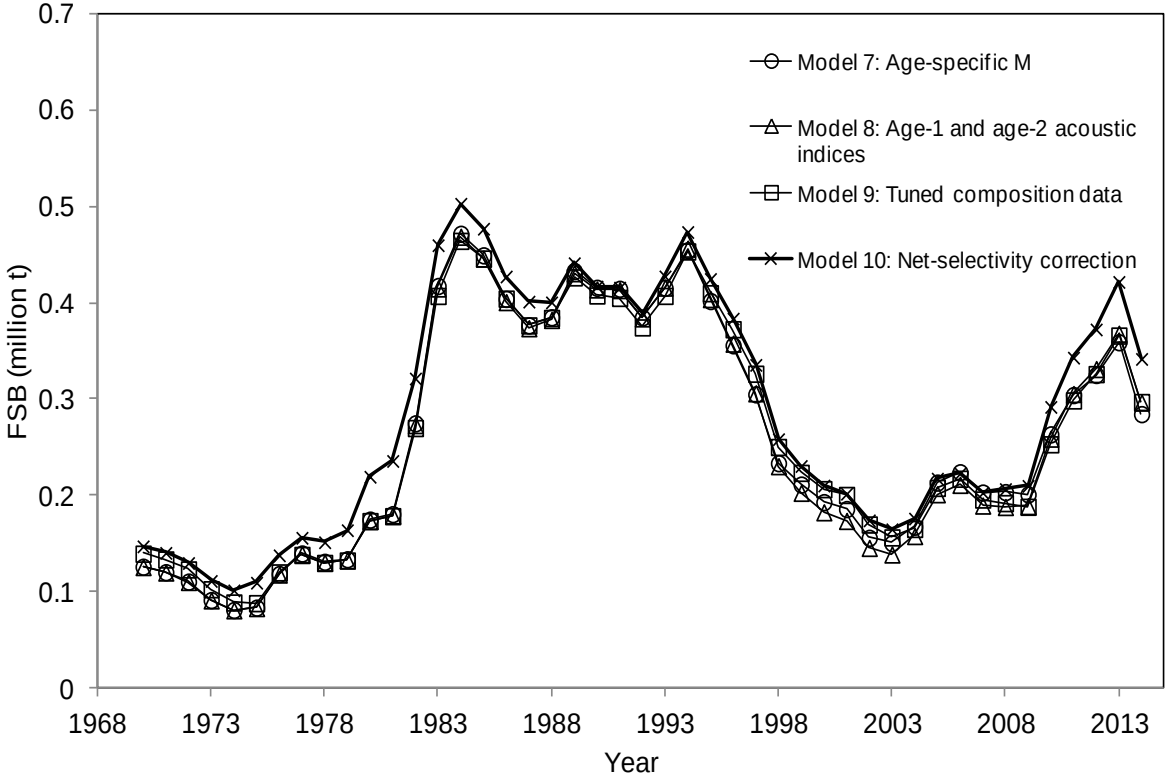
Model 4 removes bottom trawl surveys in 1984 and 1987, and acoustic surveys in Shelikof Strait for 1981-1991.

Model 5 estimates summer bottom trawl survey catchability, adds prior for catchability to the likelihood function, and assumes that selectivity is asymptotic for the trawl survey.

Model 6 uses random walks in fishery selectivity parameters to model fishery selectivity instead of blocks, and assume no interannual variation in the descending portion of the curve.

Model 7 uses an age-specific natural mortality schedule based on an ensemble average of several methods.

Alternative Models



Model 7 uses an age-specific natural mortality schedule based on an ensemble average of several methods.

Model 8 uses separate indices for age-1 and age-2 pollock in the acoustic survey.

Model 9 iteratively tunes the age-composition data so that the input sample size is close to the harmonic mean of effective sample size.

Model 10 evaluates acoustic biomass and age-composition estimates corrected for net selectivity.

Tuning details—Initial and ending input N

Fishery age composition:

Initial N: Use the number of tows/deliveries for the age composition sample if number of tows < 200, otherwise use 200

Ending N: 107

Bottom trawl survey

Initial N = 60

Ending N = 27.9

Acoustic survey

Initial N = 60

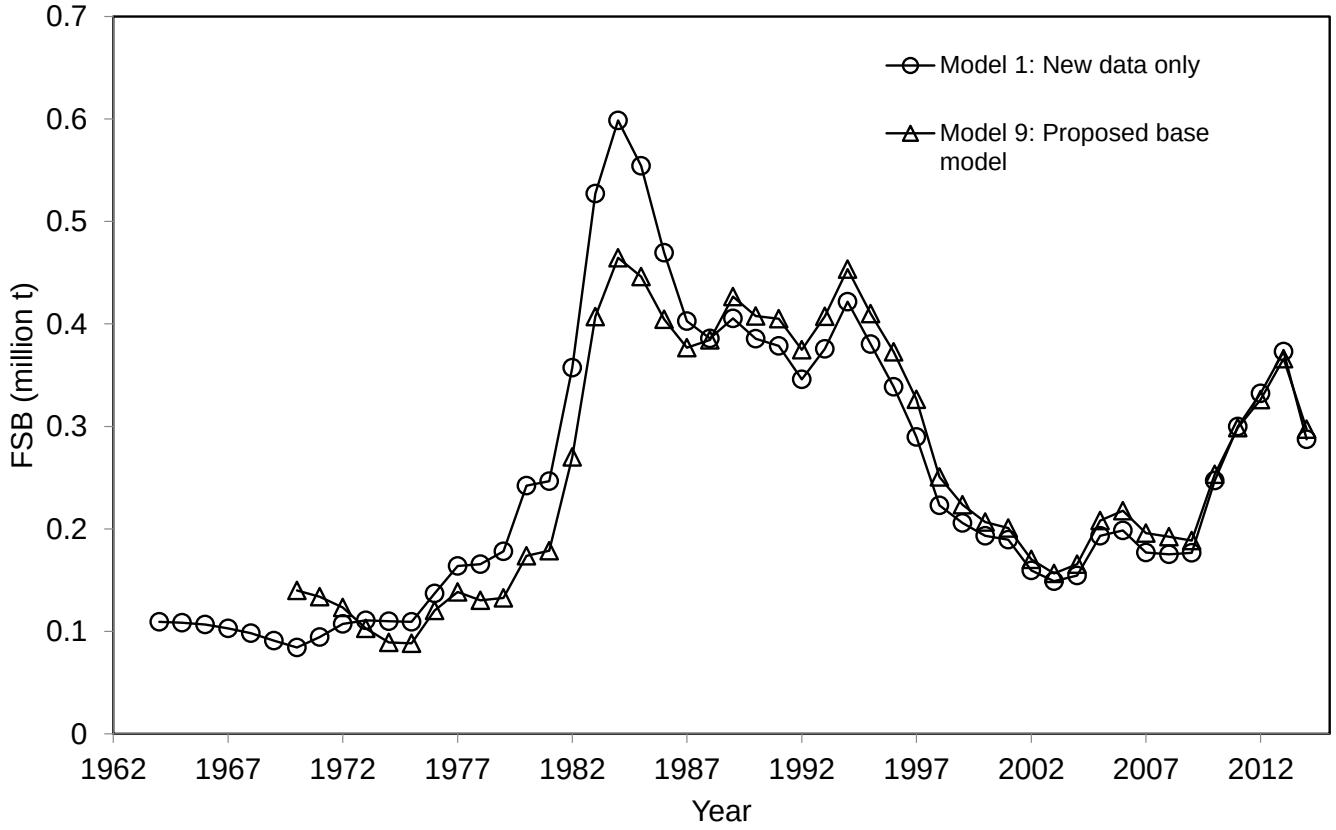
Ending N = 10.4

ADFG survey

Initial N = 30

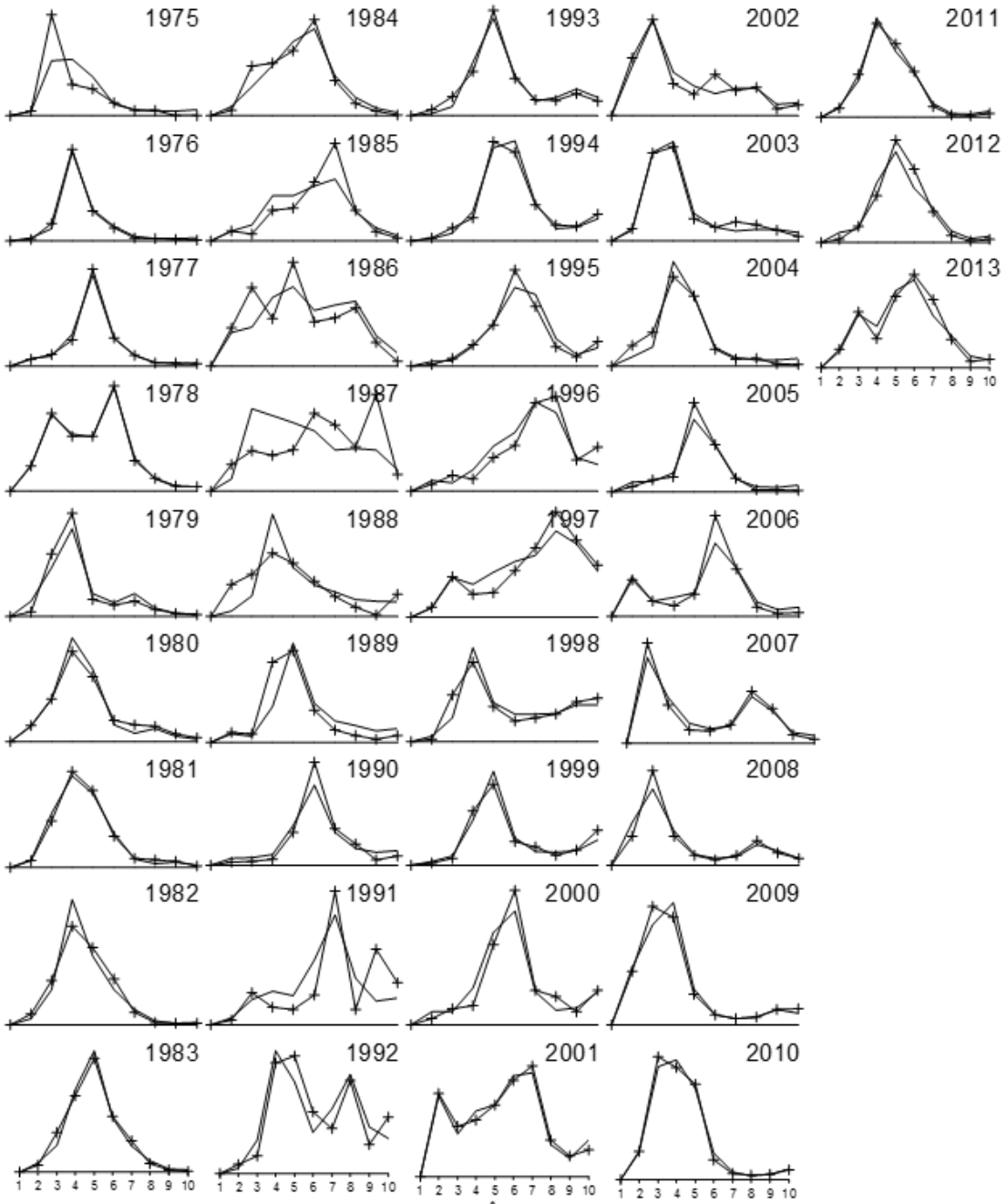
Ending N = 30

Alternative Models

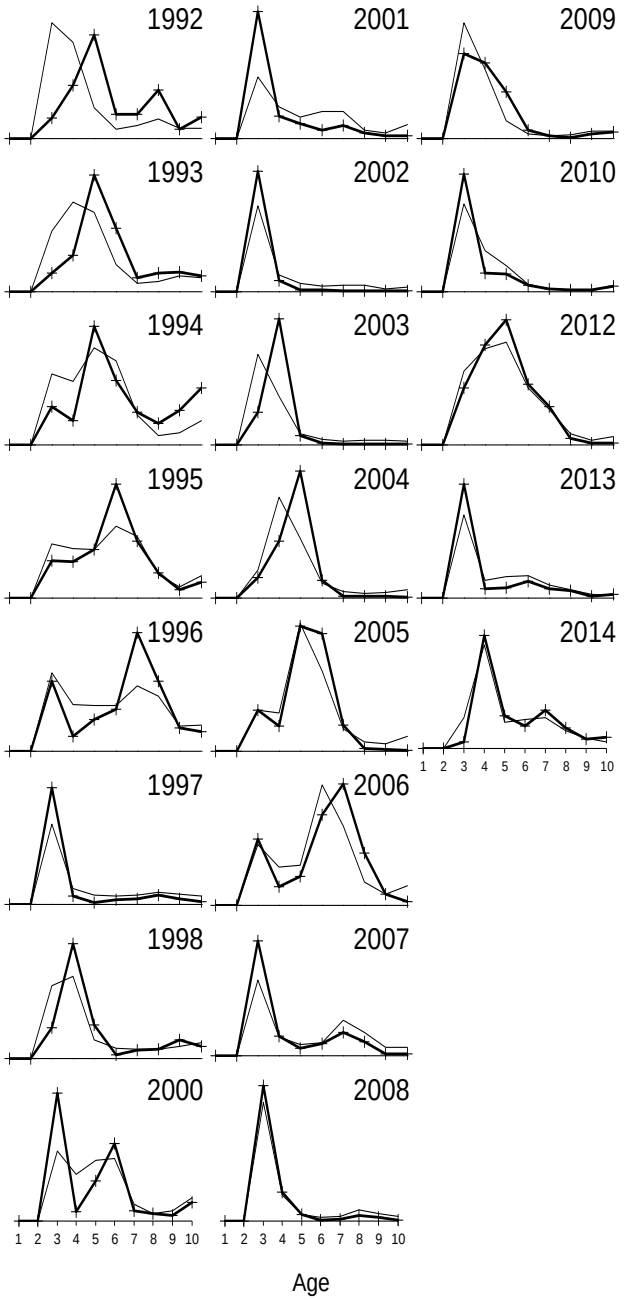


Model 1: New data only.
Model 9 Proposed base model.

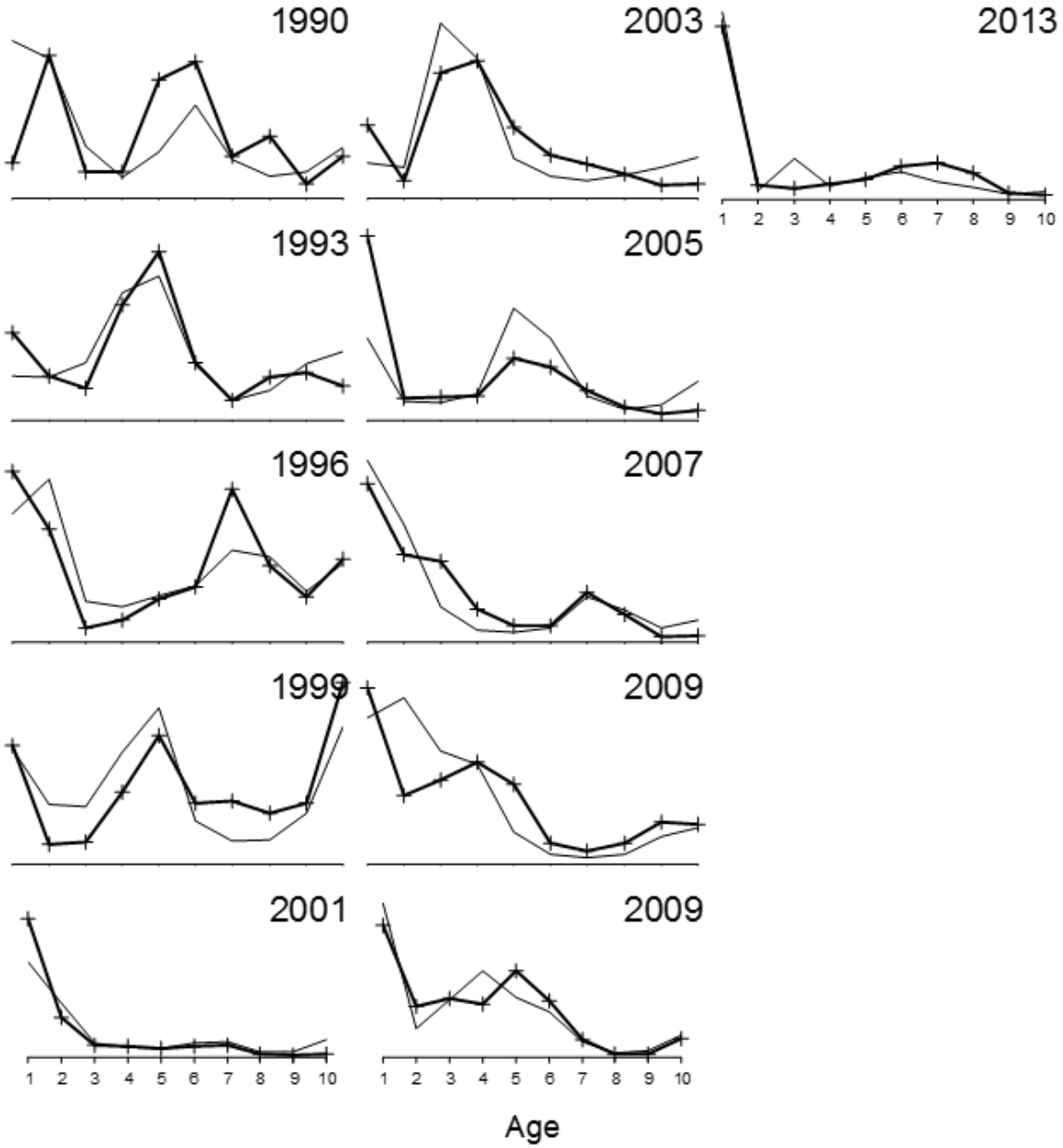
Fishery age composition (predicted vs observed)



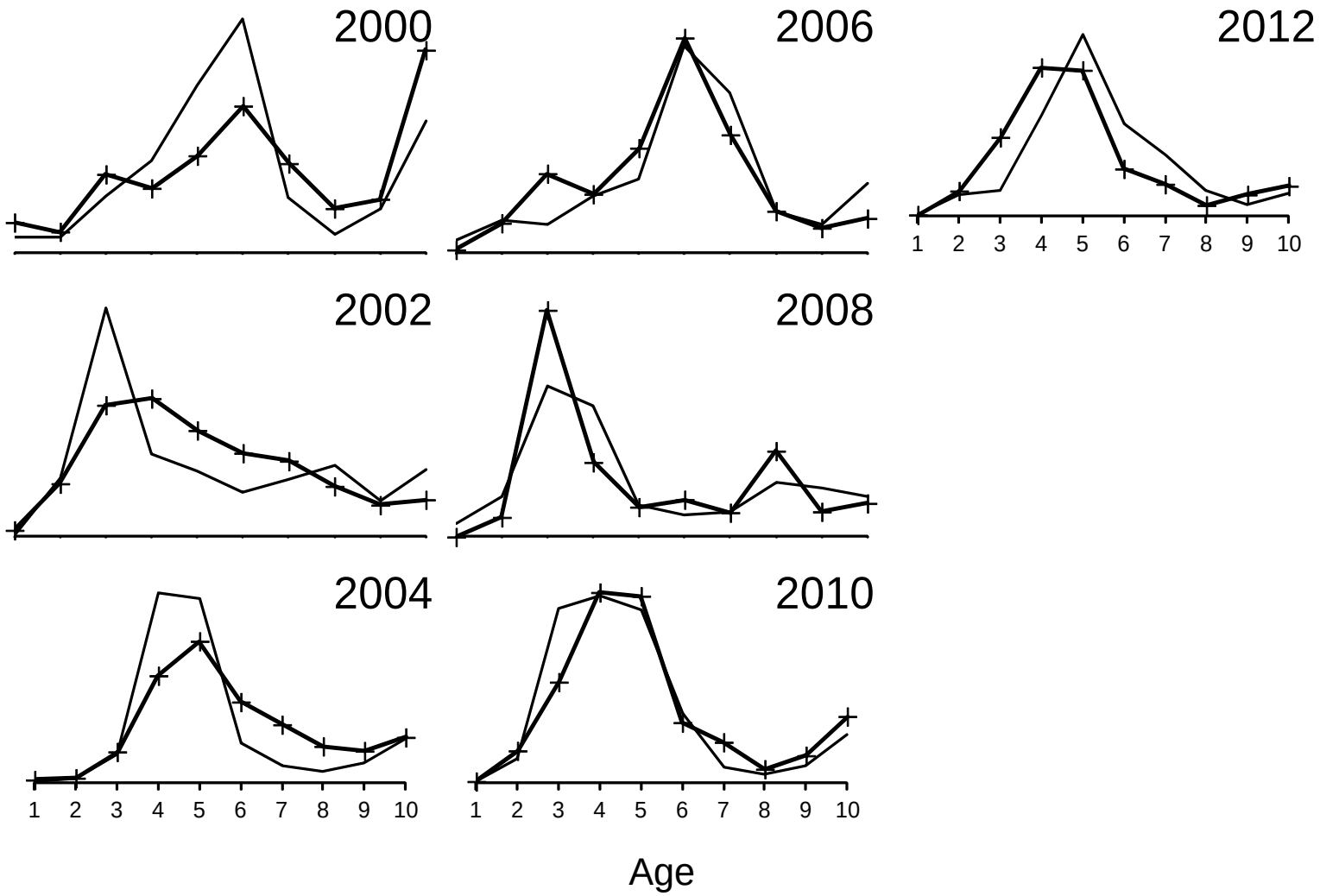
Shelikof Strait EIT age composition (predicted vs observed)



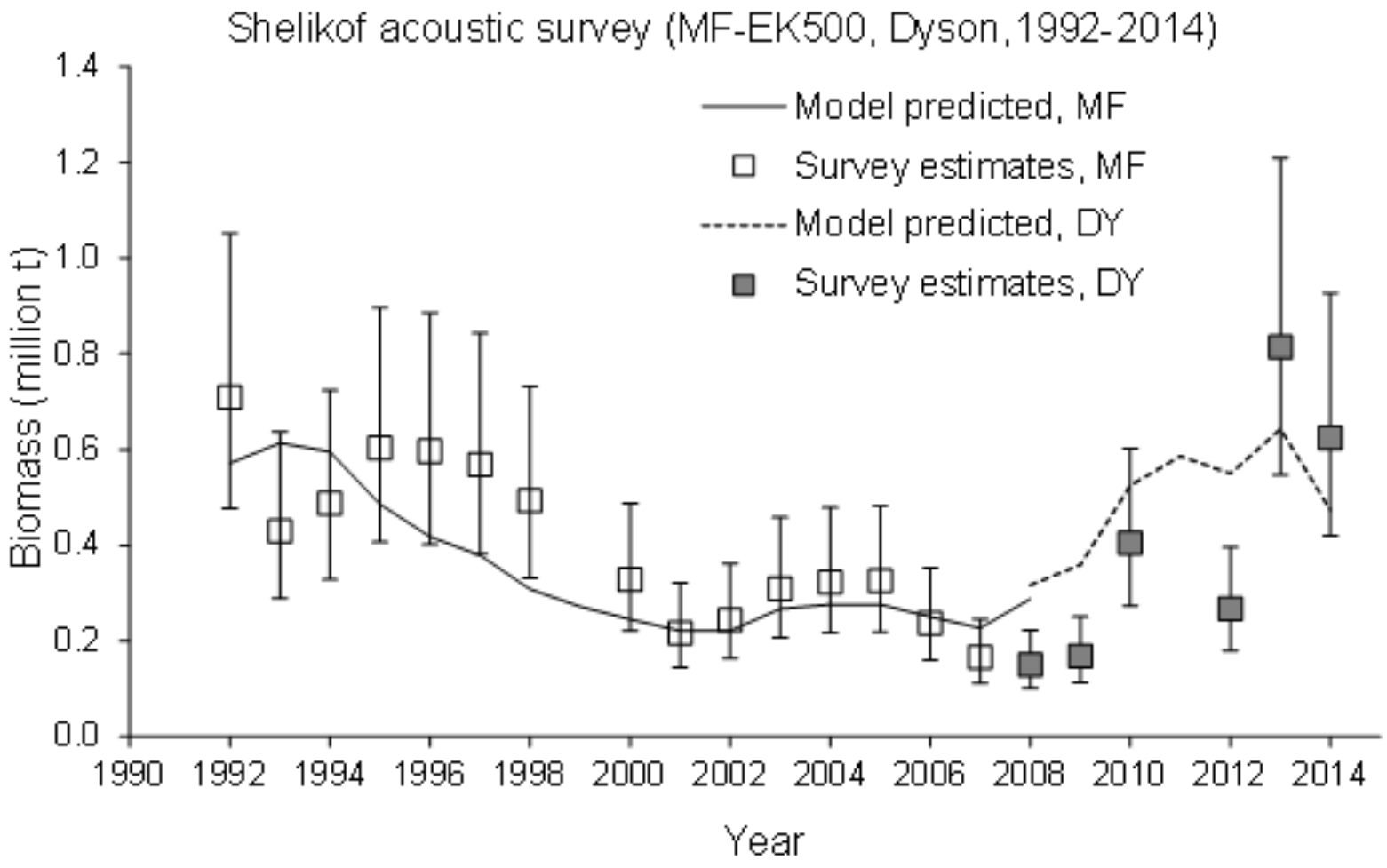
NMFS bottom trawl age composition (predicted vs observed)



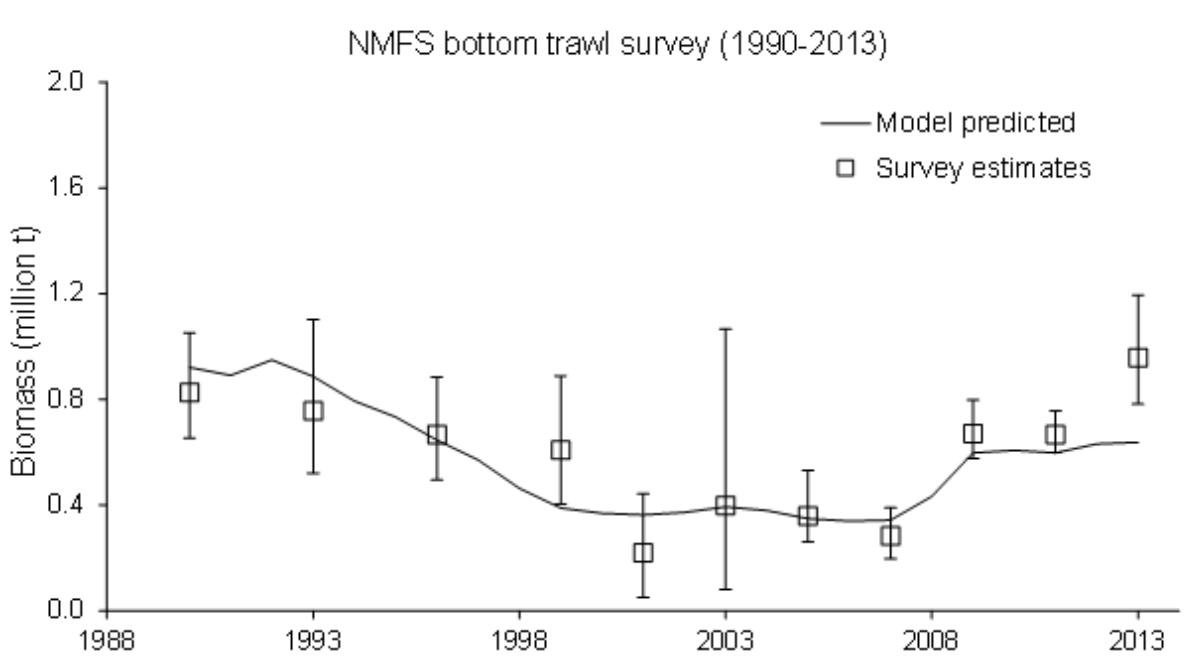
ADFG bottom trawl age composition (predicted vs observed)



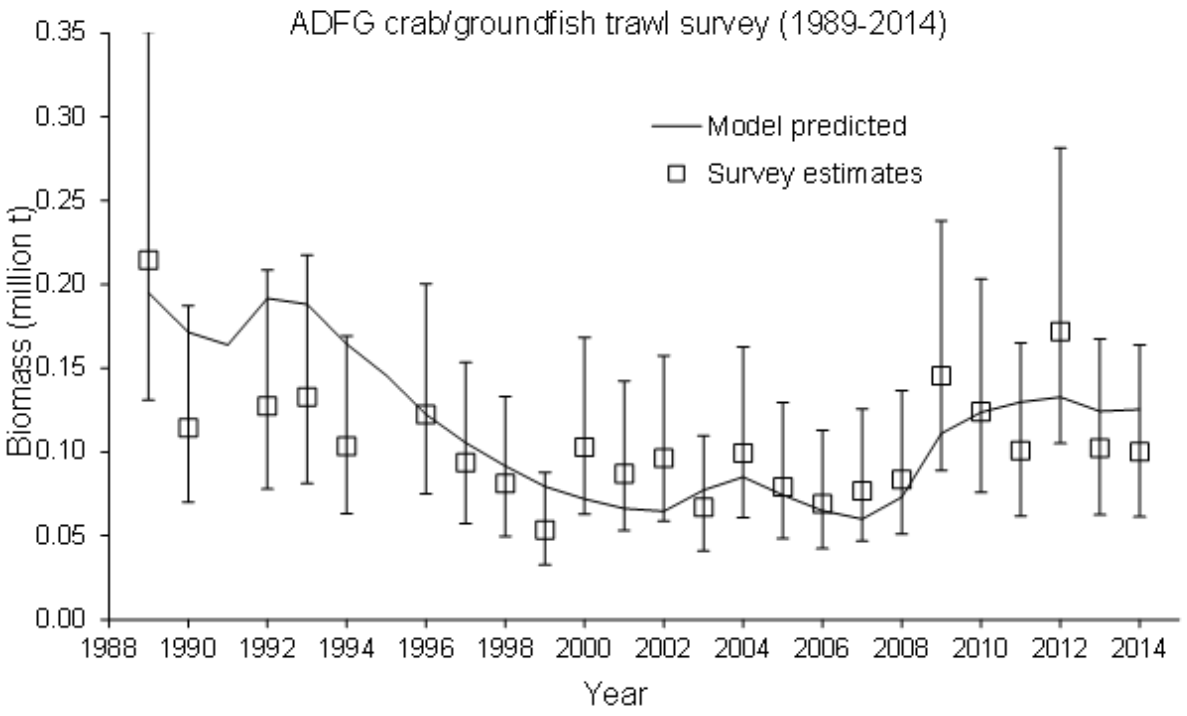
Fit to Shelikof Strait acoustic survey,1992-2013



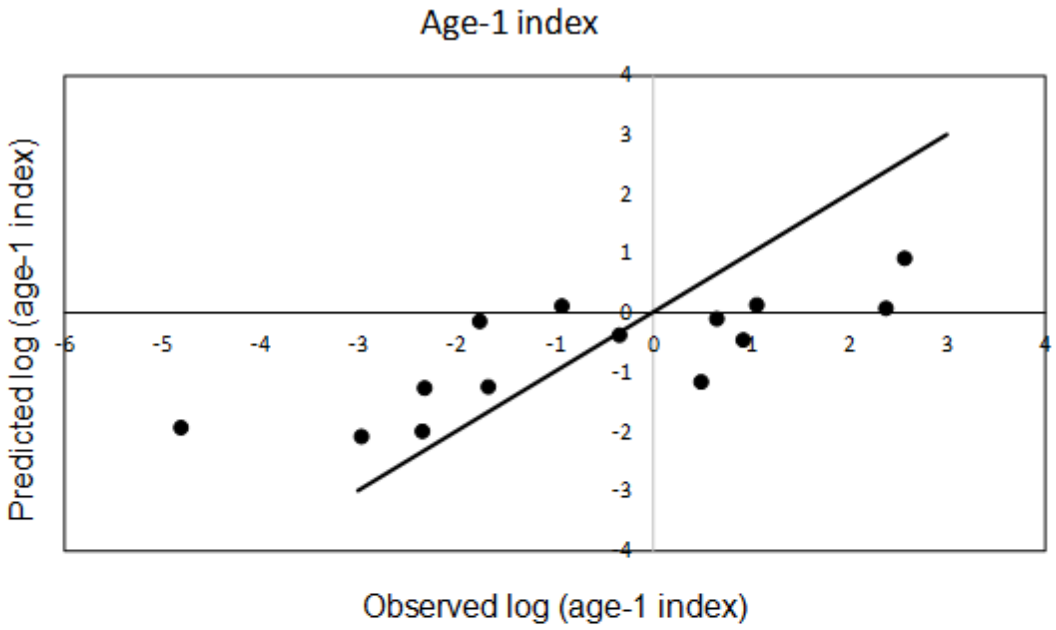
Fit to NMFS bottom trawl survey



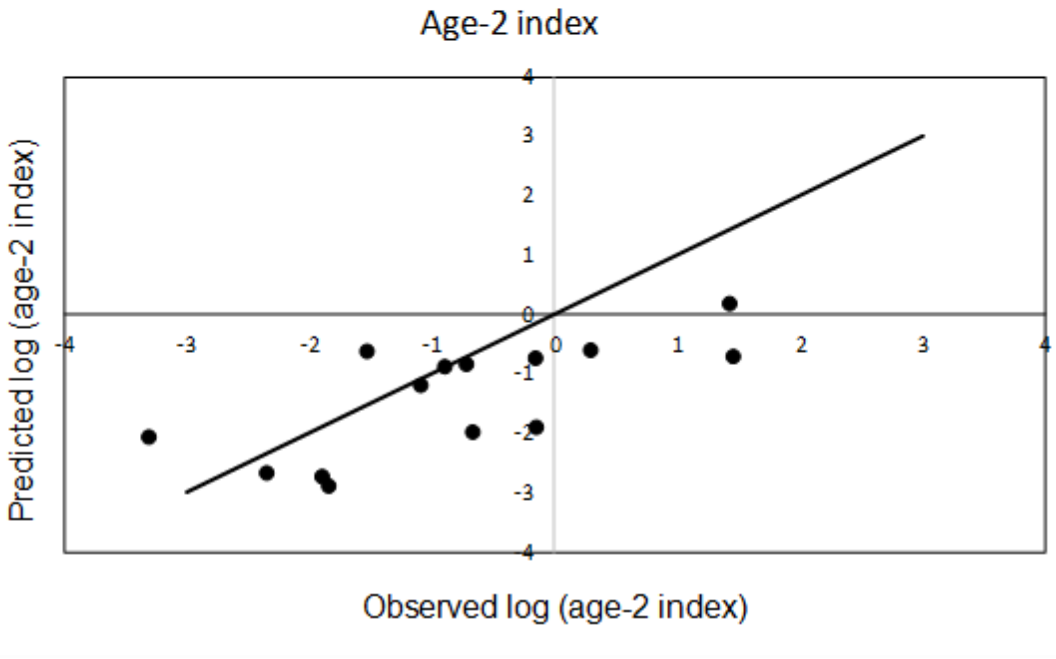
Fit to ADFG survey



Fit to Age-1 index

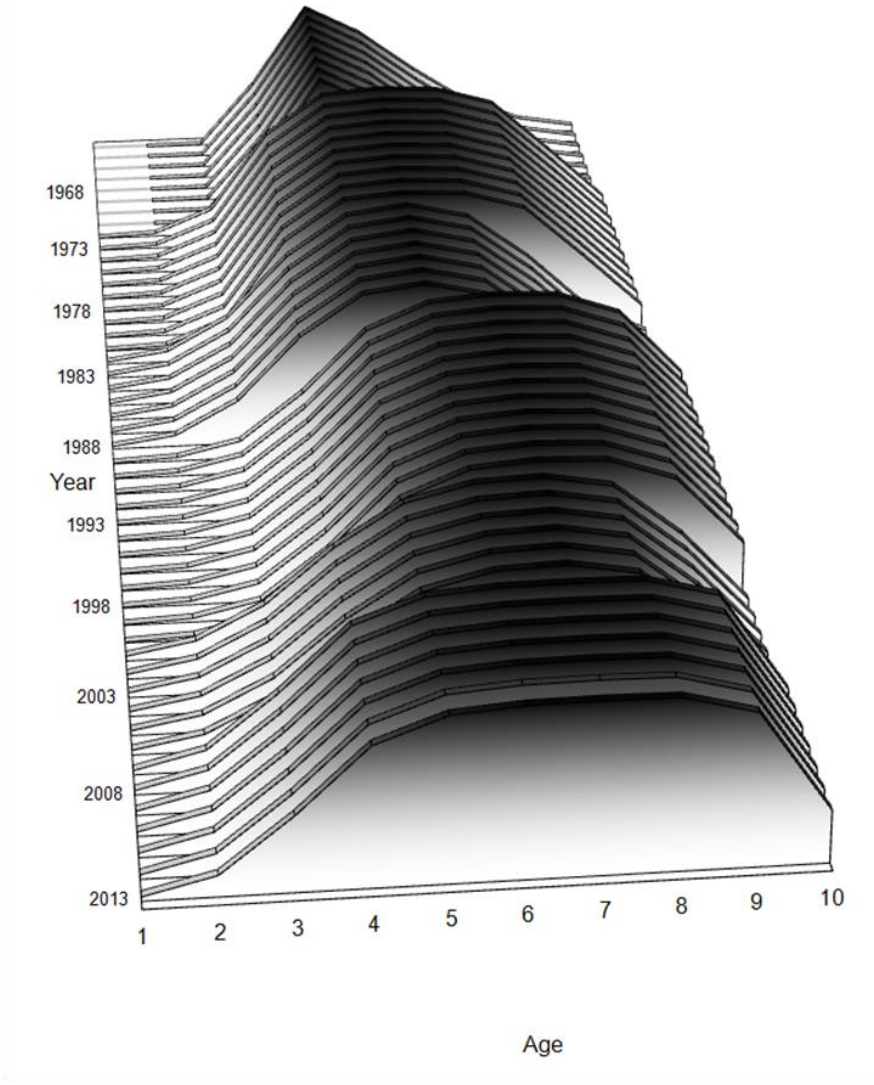


Fit to Age-2 index

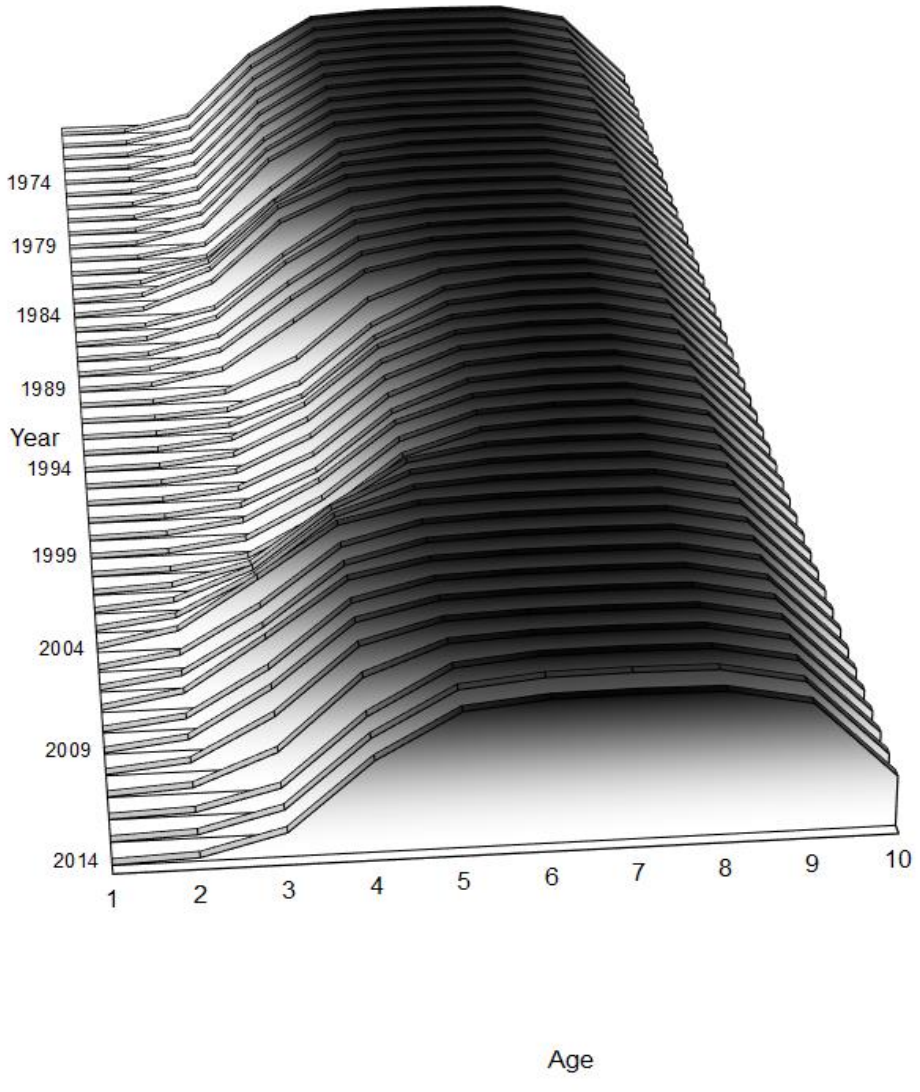


Fishery selectivity

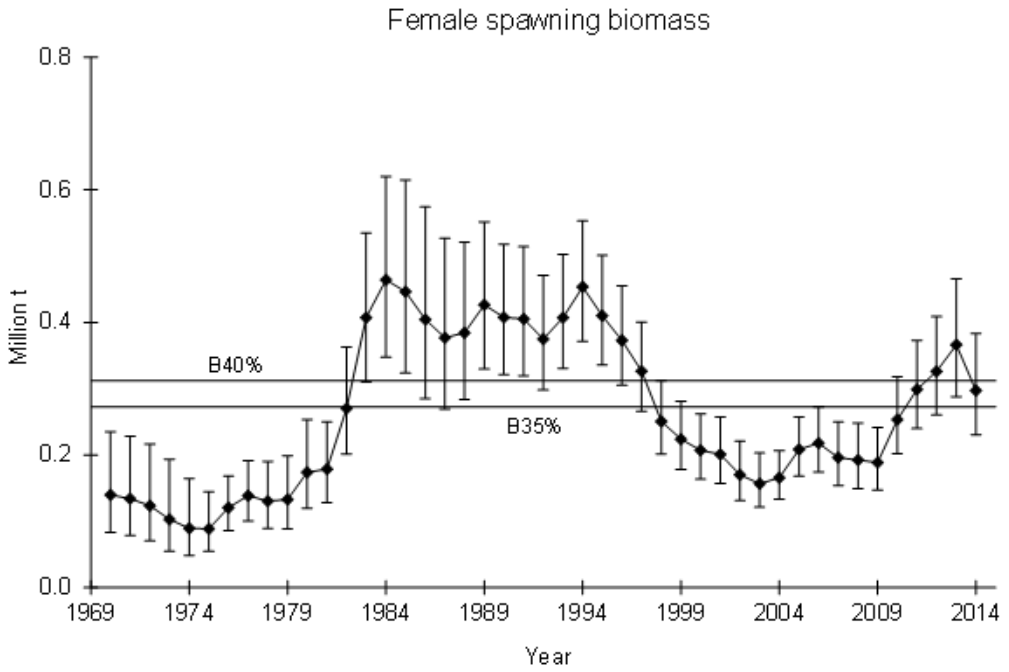
Old



New

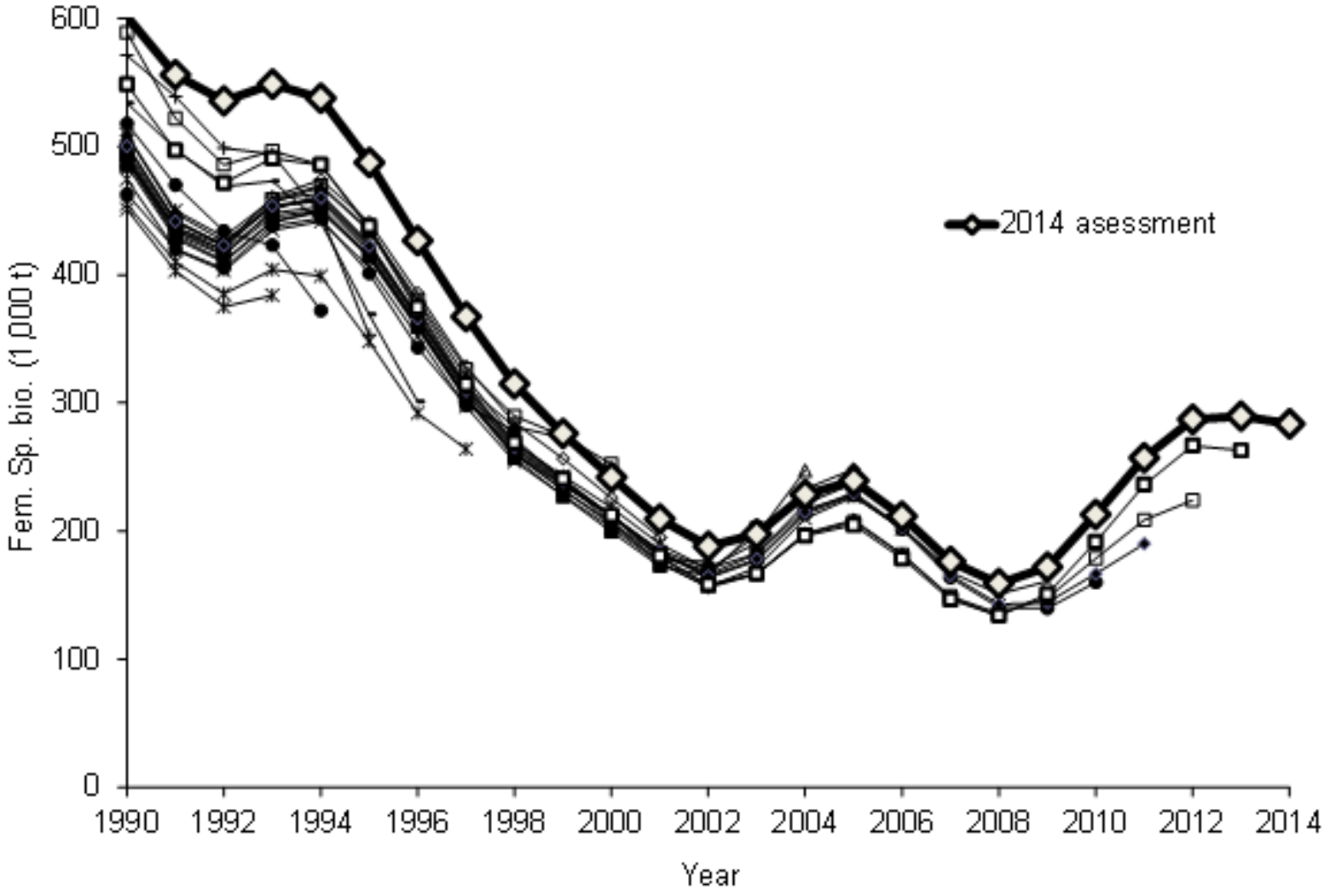


Spawning biomass

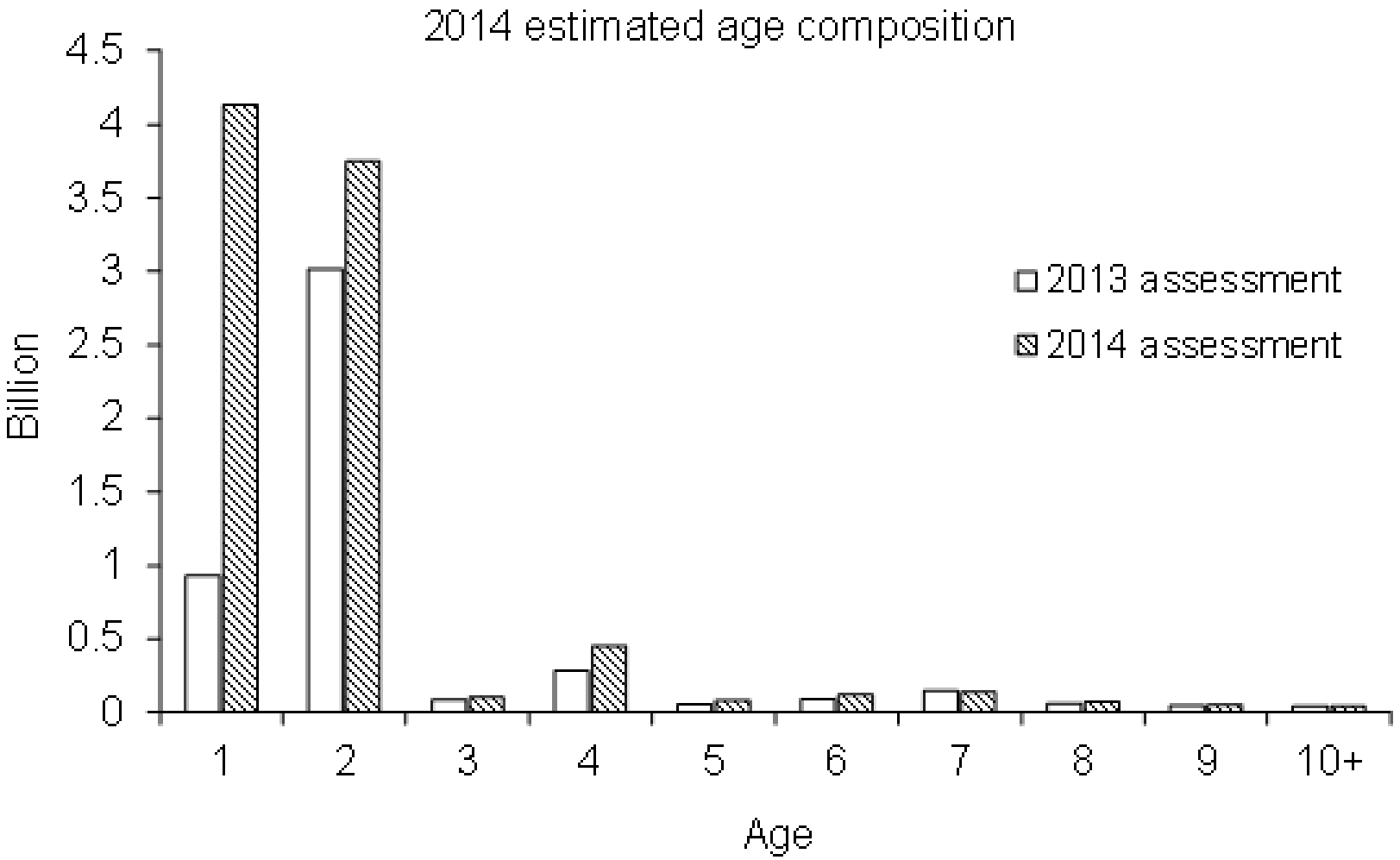


Recruitment

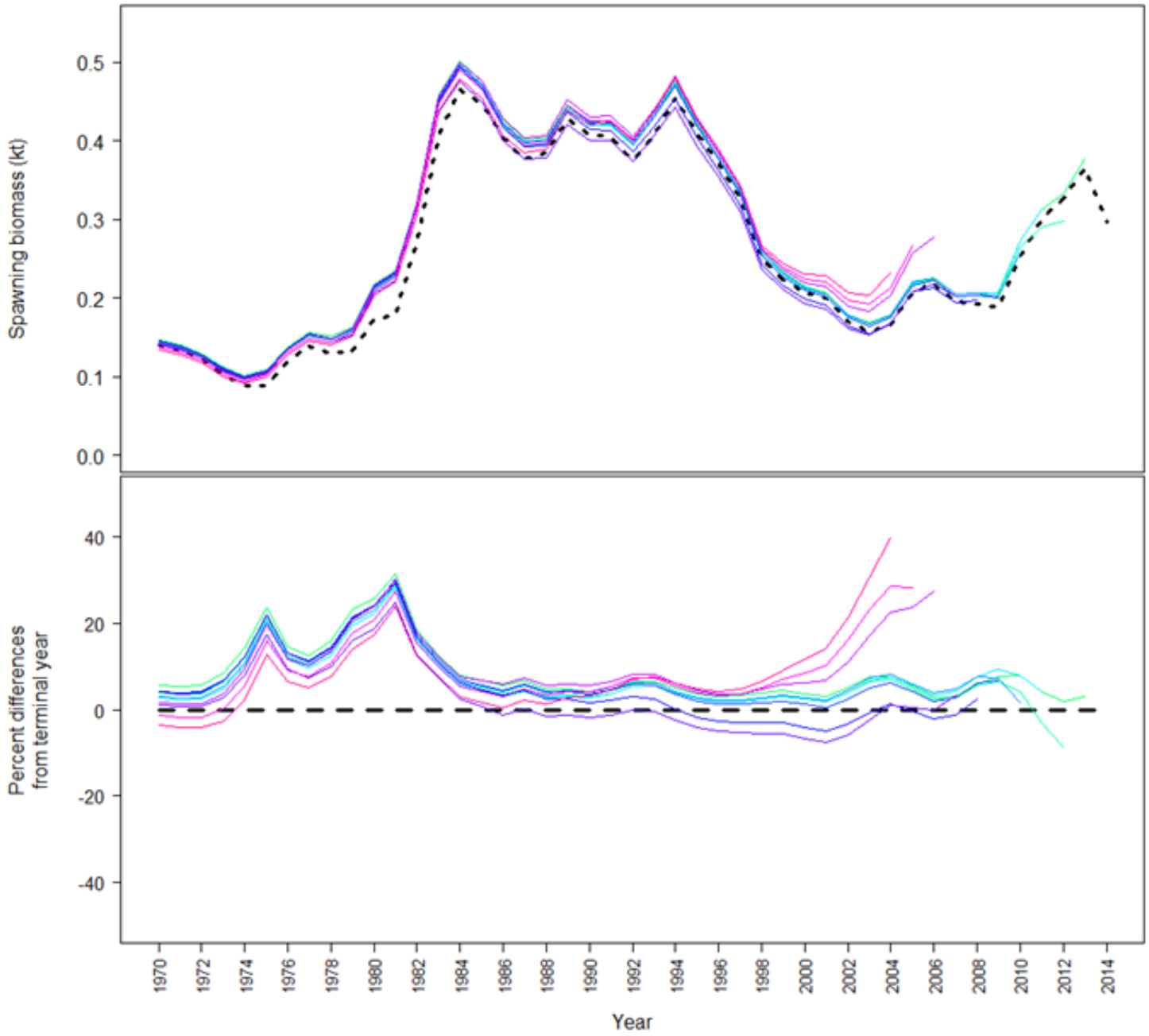
Retrospective patterns



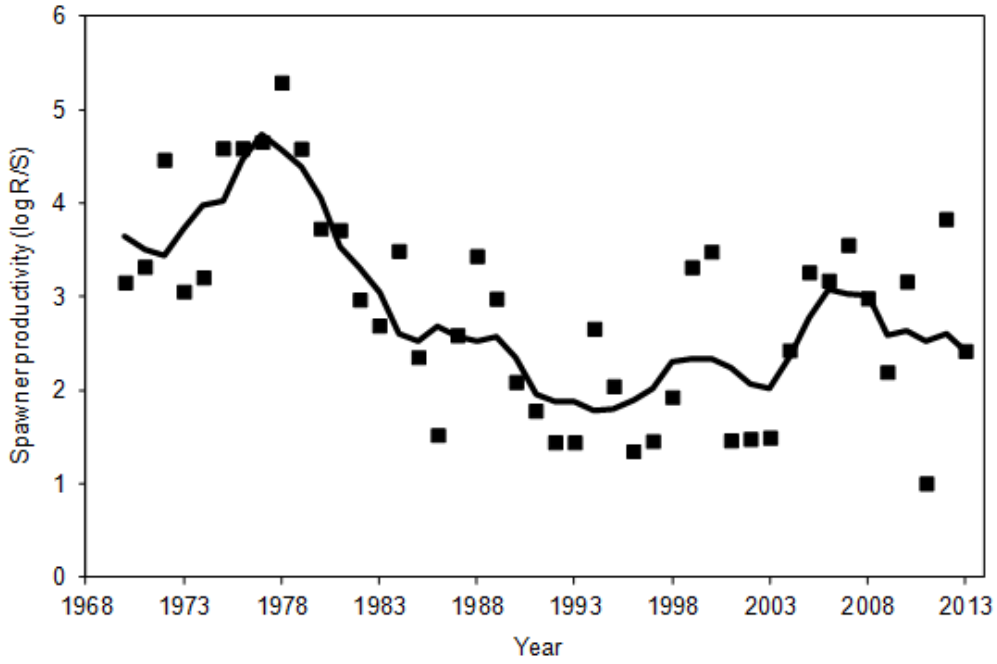
Changes in estimated age composition

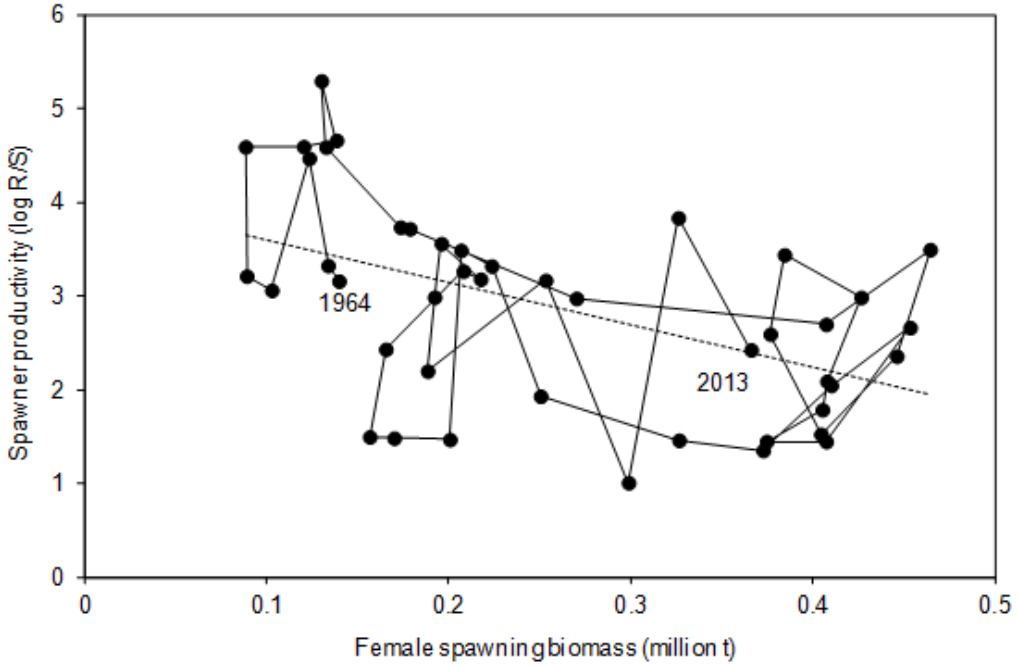


Retrospective plot

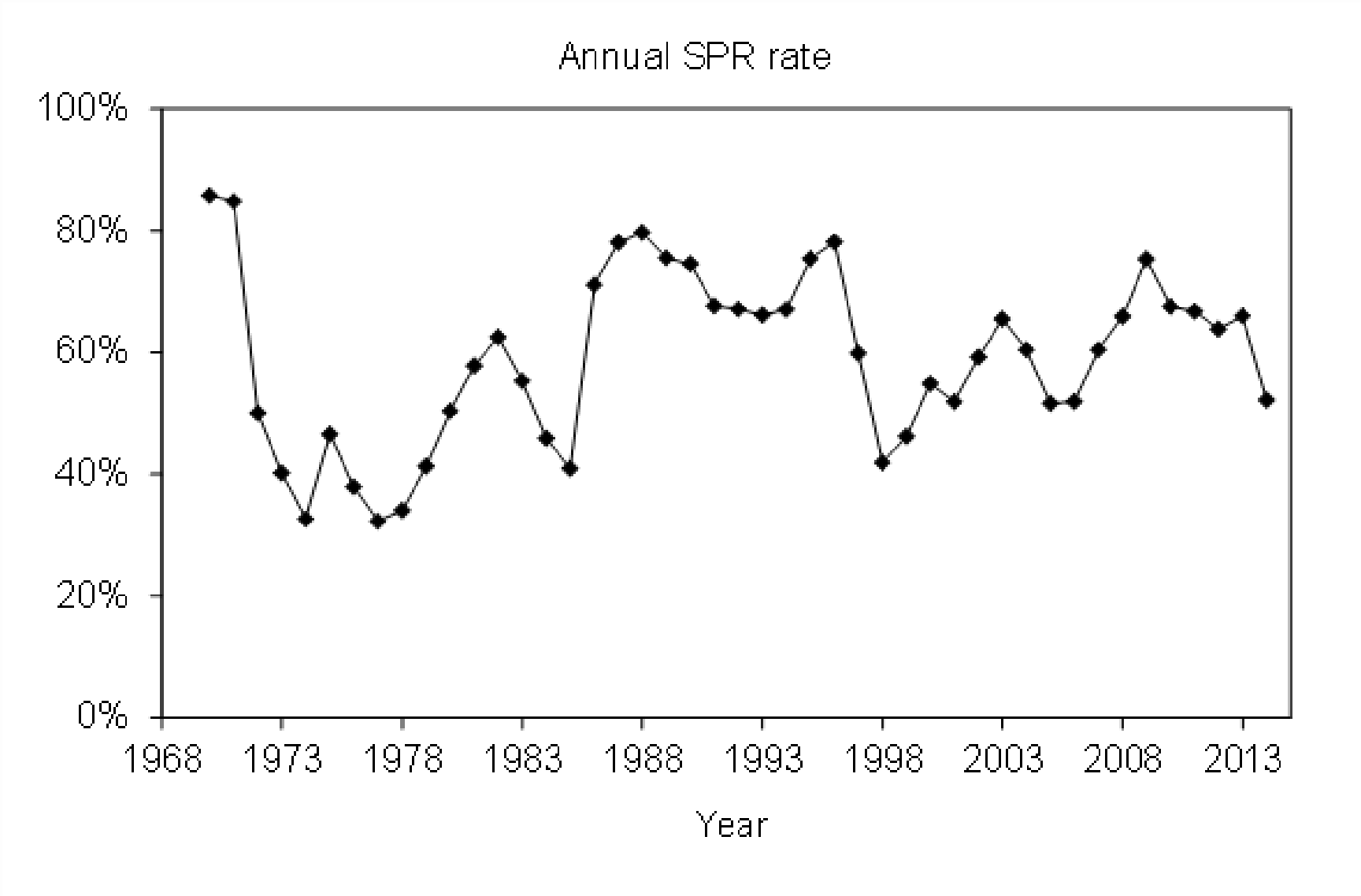


Spawner productivity

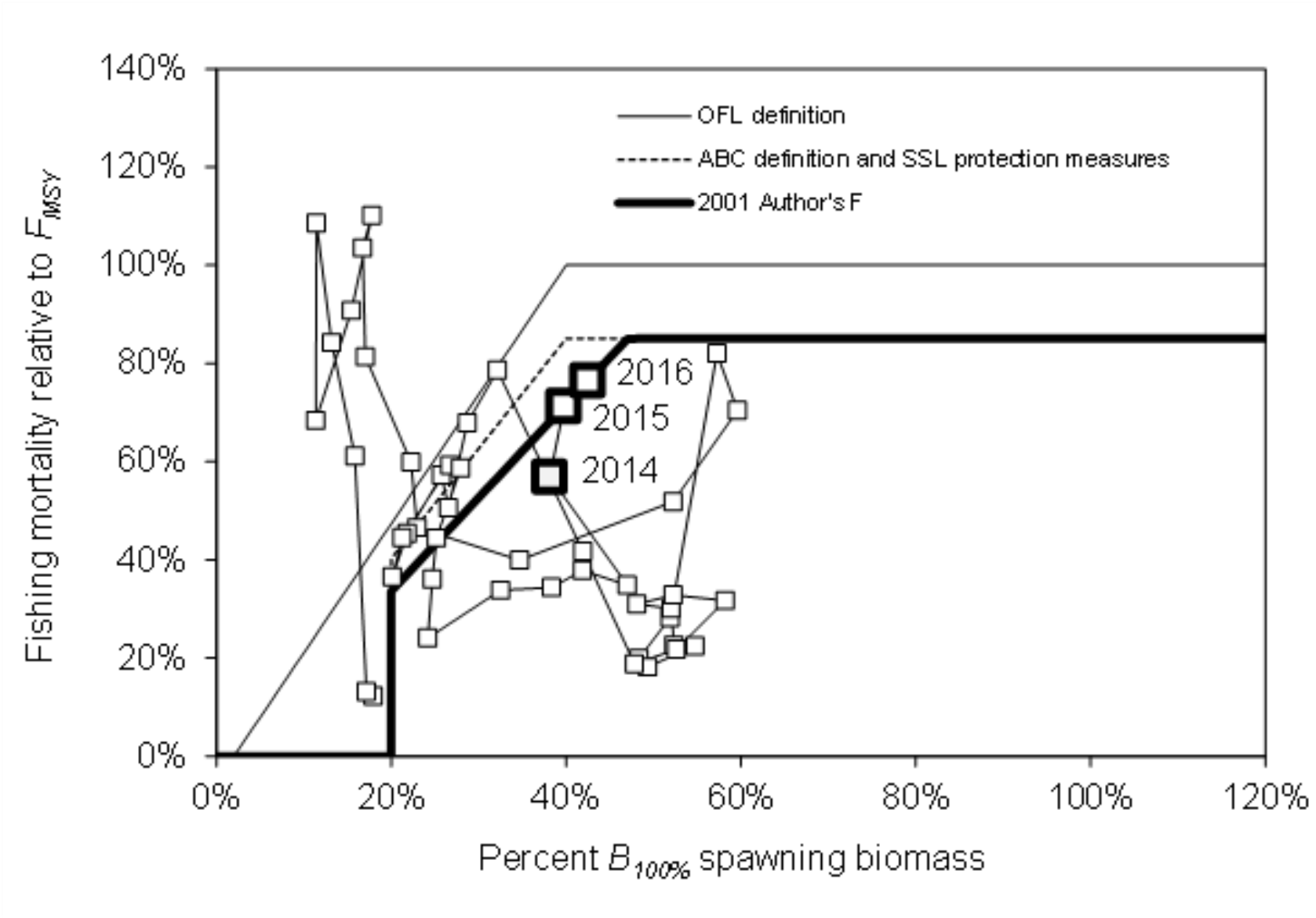




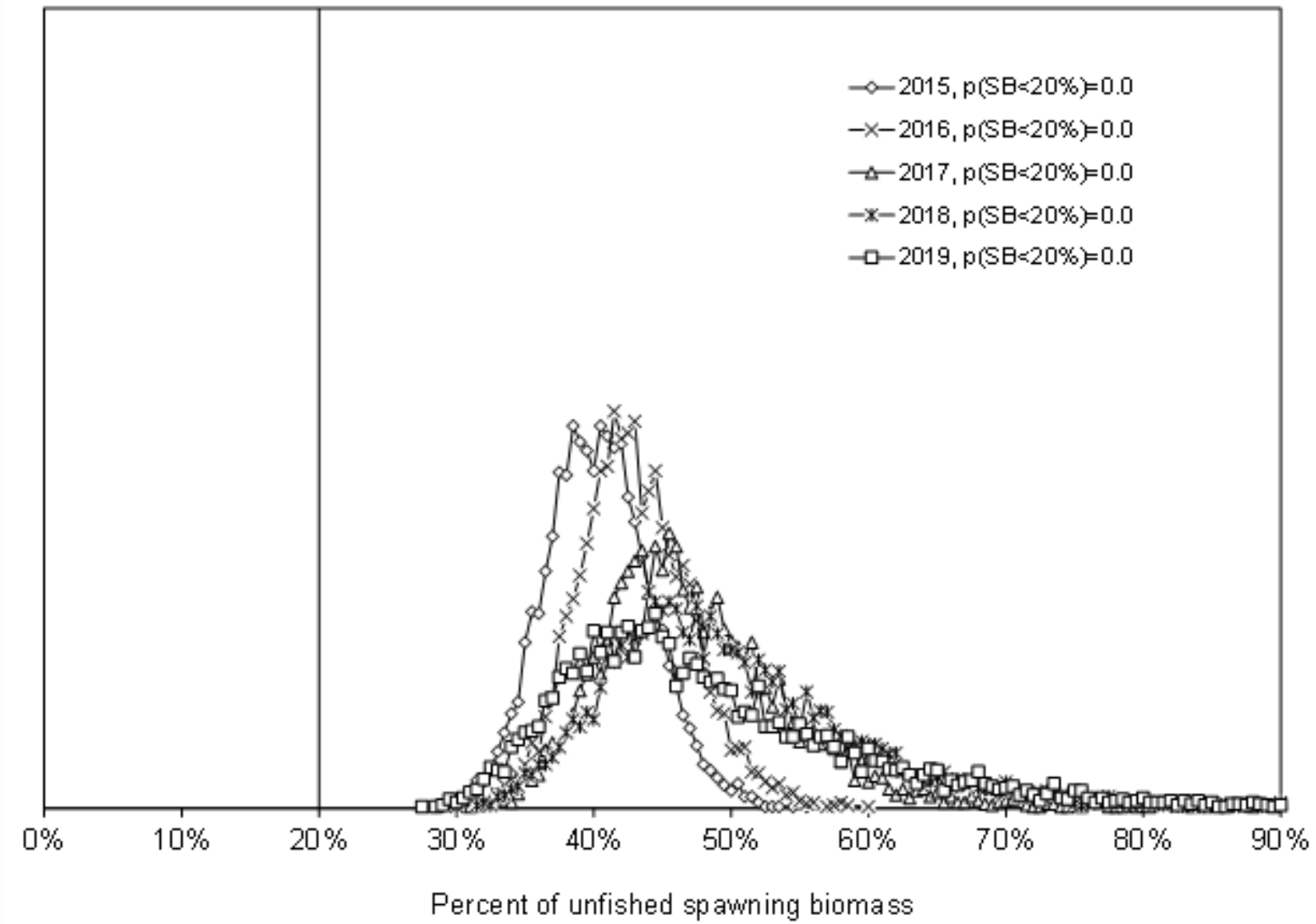
Annual SPR rate



Spawning biomass vs fishing mortality

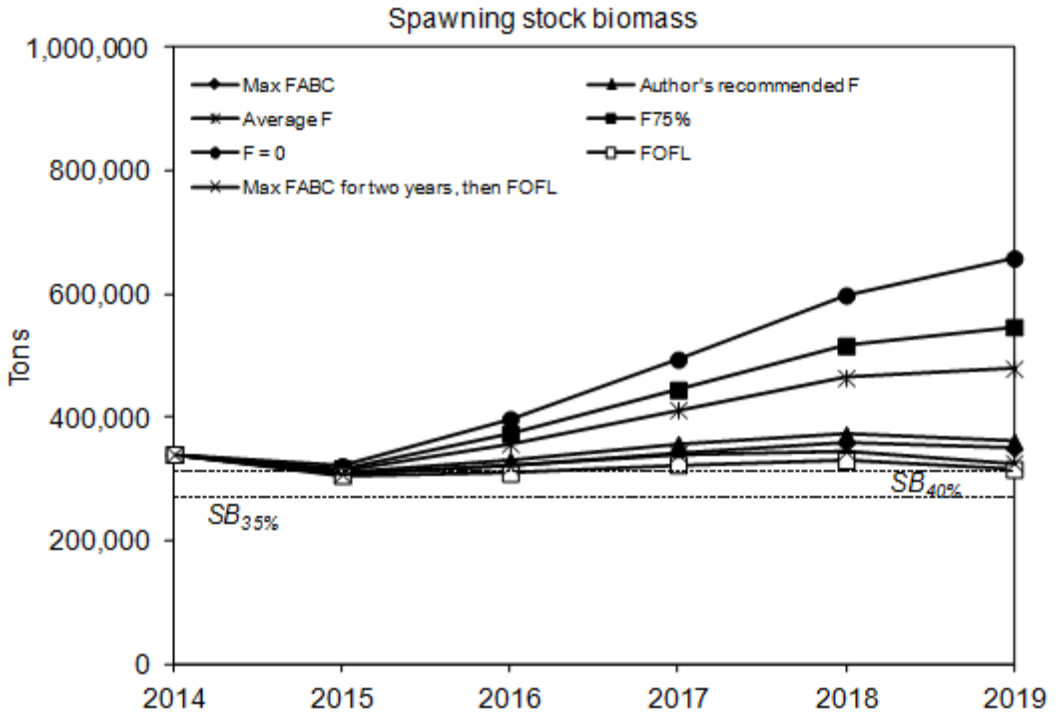


5-year pr(SB<B20%)

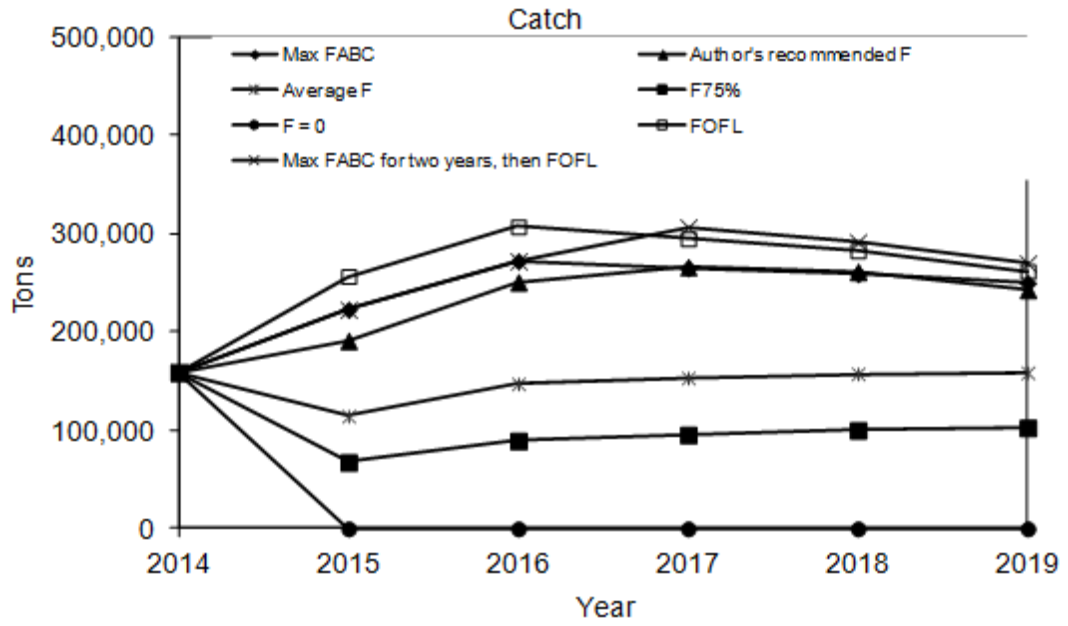


5-year projections

Mean spawning biomass



Mean yield



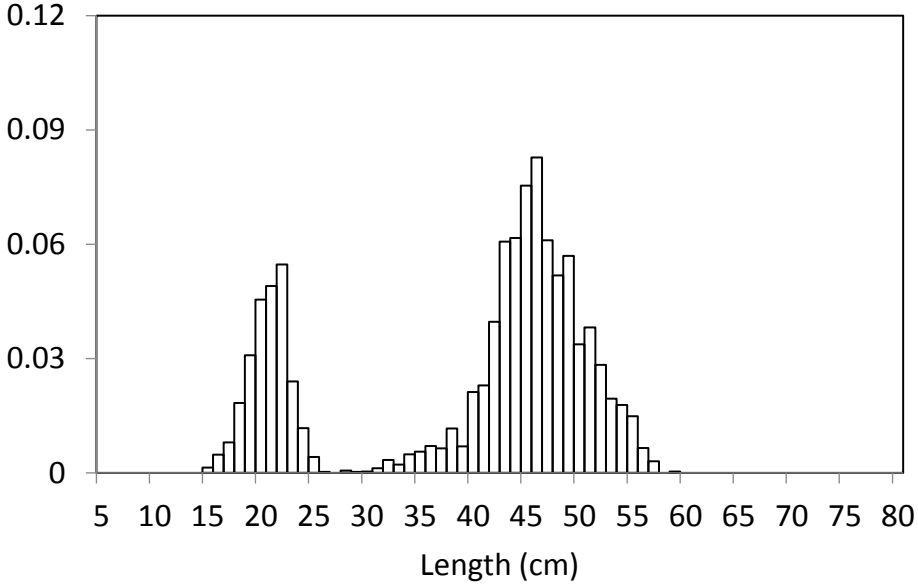
Summary table

Quantity/Status	As estimated or specified *last* year for 2014	2015	As estimated or specified *this* year for 2015	2016
M (natural mortality rate)	0.3	0.3	0.3	0.3
Tier	3a	3b	3b	3a
Projected total (age 3+) biomass (t)	972,750	1,723,060	1,883,920	1,927,010
Female spawning biomass (t)				
Projected				
Upper 95% confidence interval	379,861	319,342	406,382	432,820
Point estimate	308,541	267,477	309,869	330,497
Lower 95% confidence interval	250,611	224,035	236,081	253,194
$B_{100\%}$	726,000	726,000	779,000	779,000
$B_{40\%}$	290,000	290,000	312,000	312,000
$B_{35\%}$	254,000	254,000	273,000	273,000
F_{OFL}	0.26	0.22	0.28	0.28
$maxF_{ABC}$	0.22	0.20	0.24	0.24
F_{ABC}	0.20	0.17	0.20	0.22
OFL (t)	211,998	248,384	256,545	321,067
maxABC (t)	183,943	210,071	222,774	272,165
ABC (t)	167,657	185,830	191,309	250,824

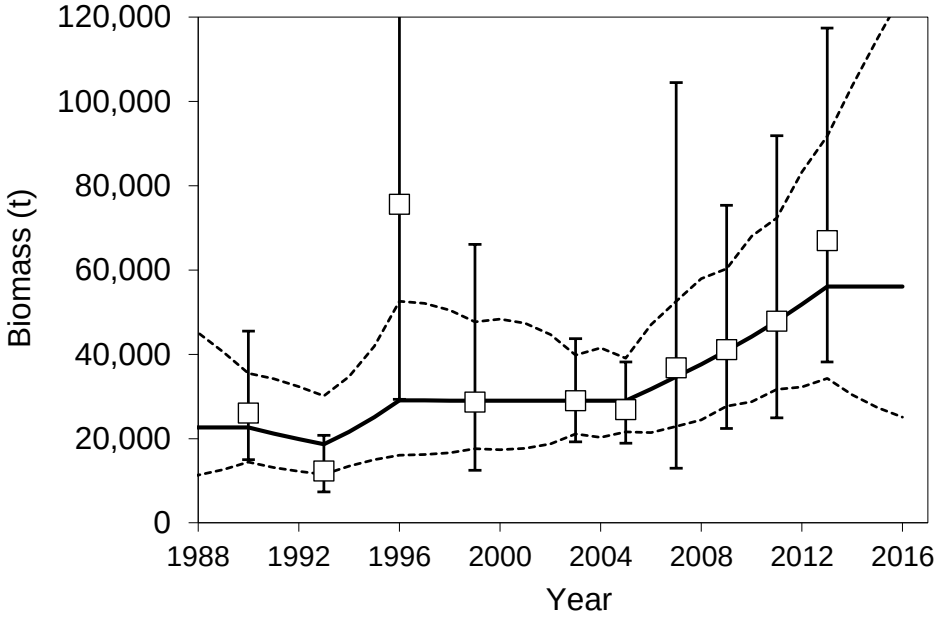
Status	As determined *last* year for 2012	2013	As determined *this* year for 2013	2014
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Southeast Alaska Assessment

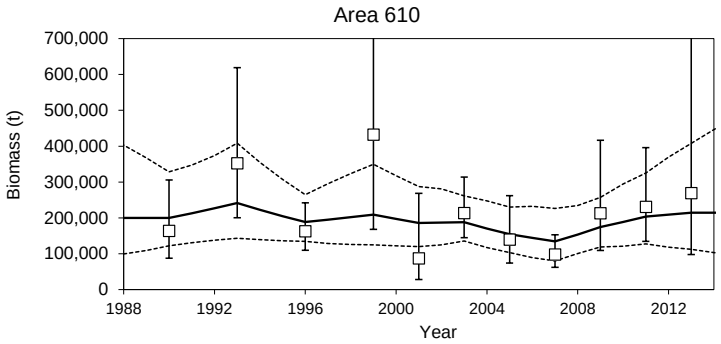
2013 length composition

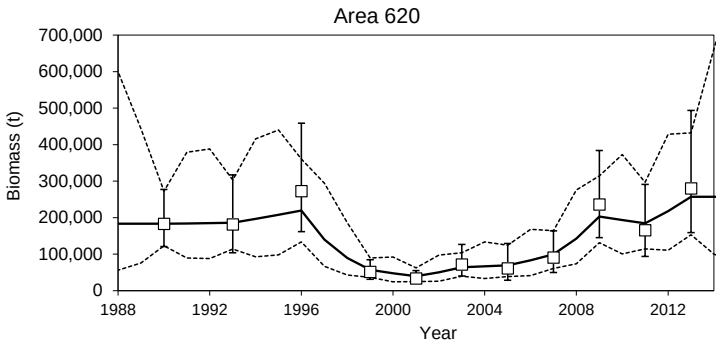


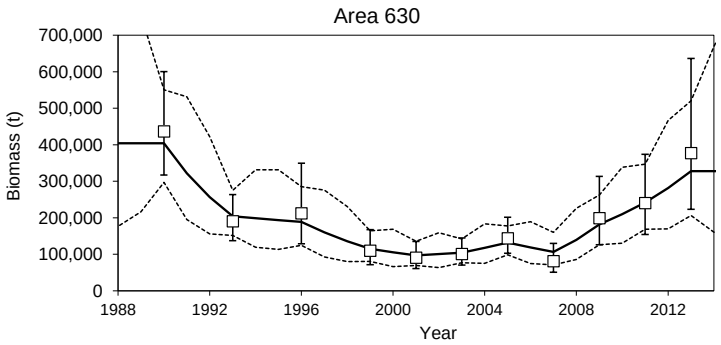
Biomass trend

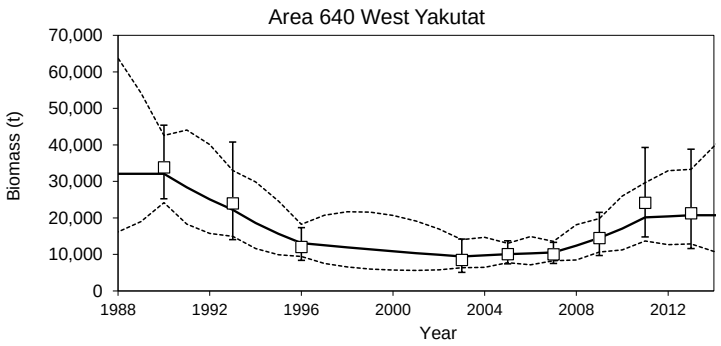


NMFS trawl survey summer biomass distribution

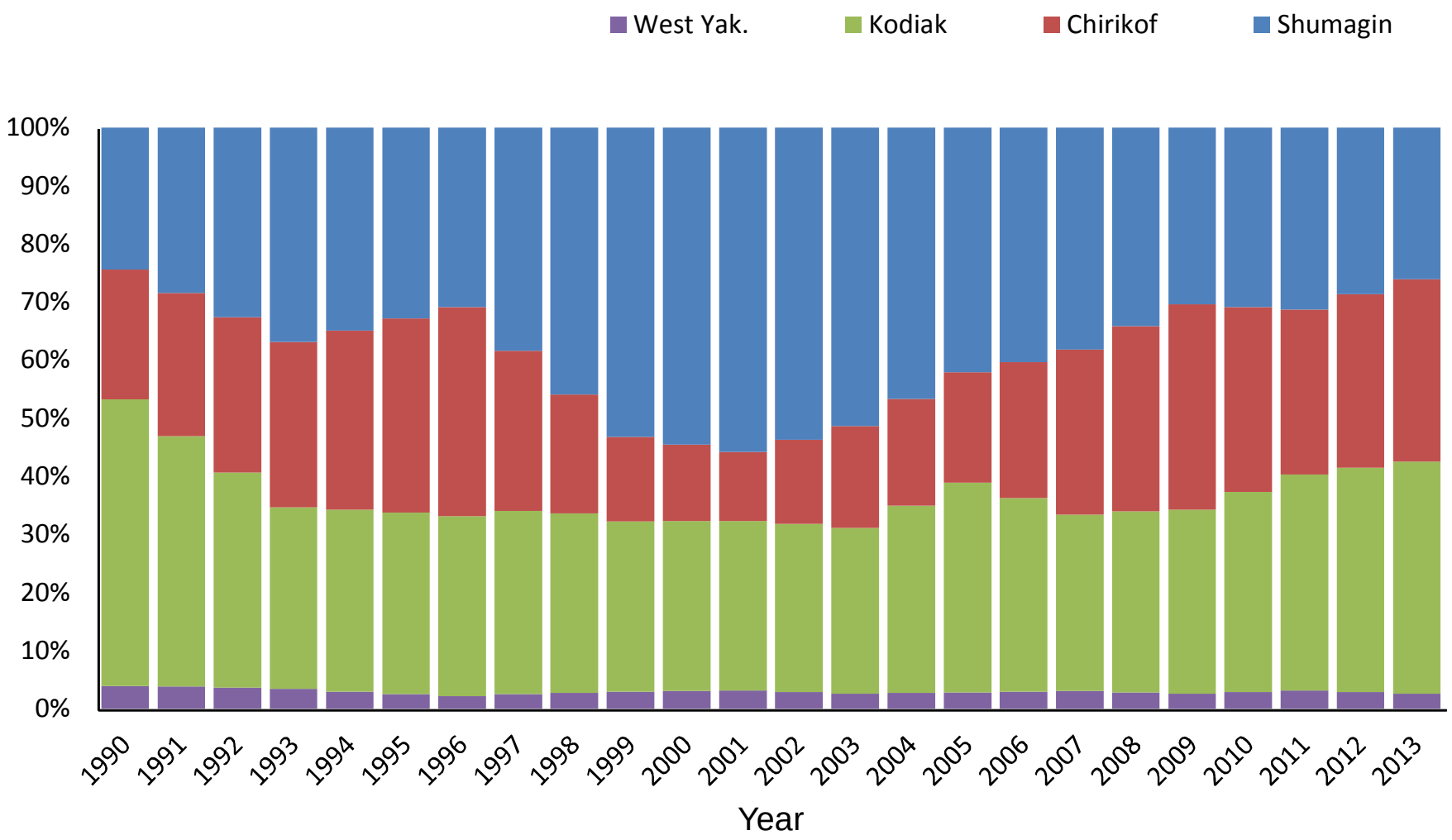








NMFS trawl survey summer biomass distribution



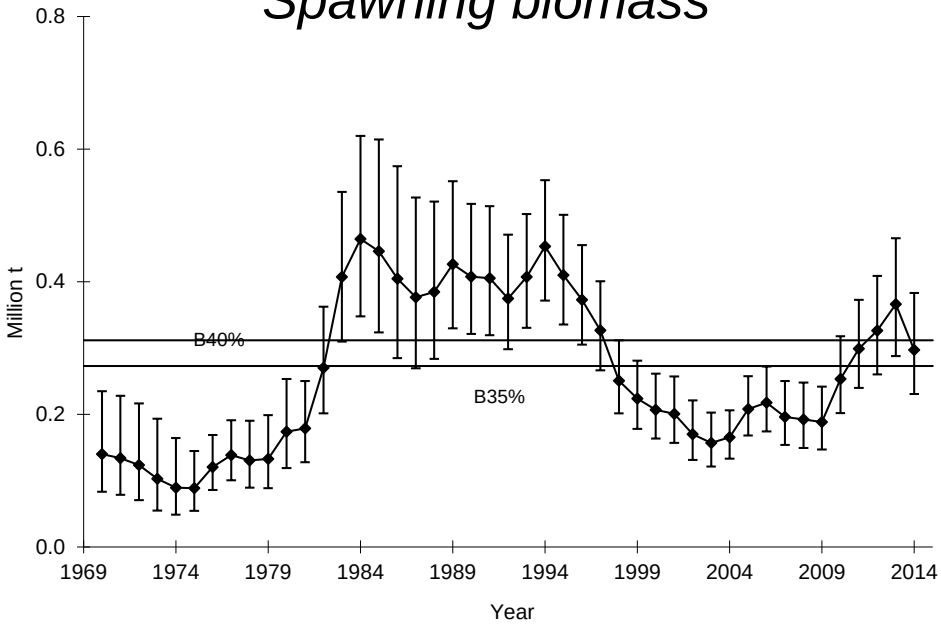
Winter apportionment table (example calculations for one area)

Survey	*Year*	*Model estimates of total 2+ biomass at spawning*	*Survey biomass estimate*	*Multiplier from vessel comparison (OD/MF)*	*Percent*	*Percent by management area*		
						Area 610	*Area 620*	*Area 630*
Shelikof	2010	1,062,110	429,730	1.00	40.5%	0.0%	93.7%	6.3%
Shelikof	2012	1,103,010	335,836	1.00	30.4%	0.0%	96.0%	4.0%
Shelikof	2013	1,187,700	831,486	1.00	70.0%	0.0%	95.0%	5.0%
Shelikof	2014	1,057,580	883,177	1.00	83.5%	0.0%	96.7%	3.3%
Shelikof	Average				56.1%	0.0%	95.4%	4.6%
	Percent of total 2+ biomass					0.0%	53.3%	2.6%

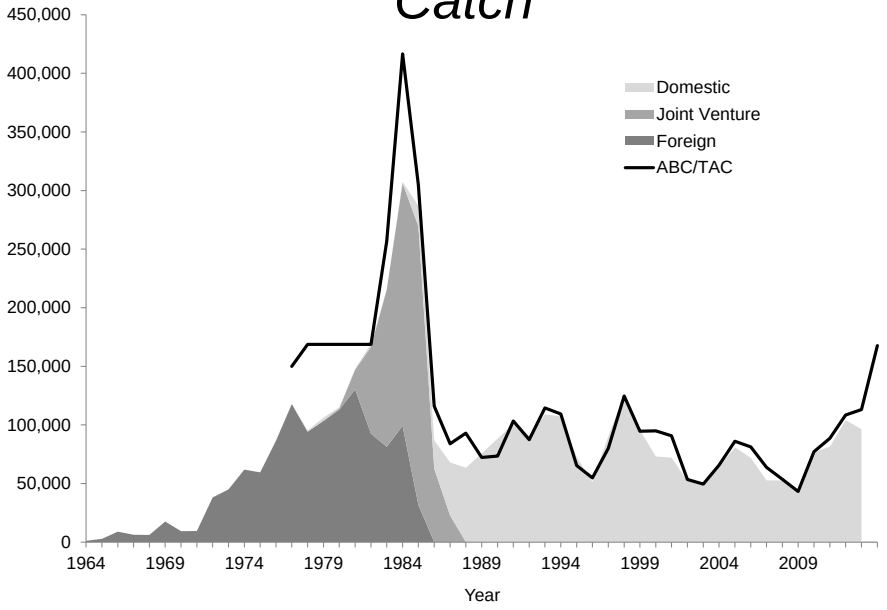
Winter apportionment table

			Percent by management area		
Survey		*Percent*	*Area 610*	*Area 620*	*Area 630*
Shelikof	Average	56.1%	0.0%	95.4%	4.6%
	Percent of total 2+ biomass		0.0%	53.3%	2.6%
Chirikof	Average	2.0%	0.0%	20.8%	79.2%
	Percent of total 2+ biomass		0.0%	0.4%	1.6%
Marmot	Average	1.5%	0.0%	0.0%	100.0%
	Percent of total 2+ biomass		0.0%	0.0%	1.5%
Shumagin	Average	2.9%	73.2%	26.8%	0.0%
	Percent of total 2+ biomass		2.1%	0.8%	0.0%
Sanak	Average	1.9%	100.0%	0.0%	0.0%
	Percent of total 2+ biomass		1.9%	0.0%	0.0%
Mozhovoi	Average	1.2%	100.0%	0.0%	0.0%
	Percent of total 2+ biomass		1.2%	0.0%	0.0%
Total		65.46%	5.23%	54.47%	5.76%
Rescaled total		100.00%	7.99%	83.21%	8.80%

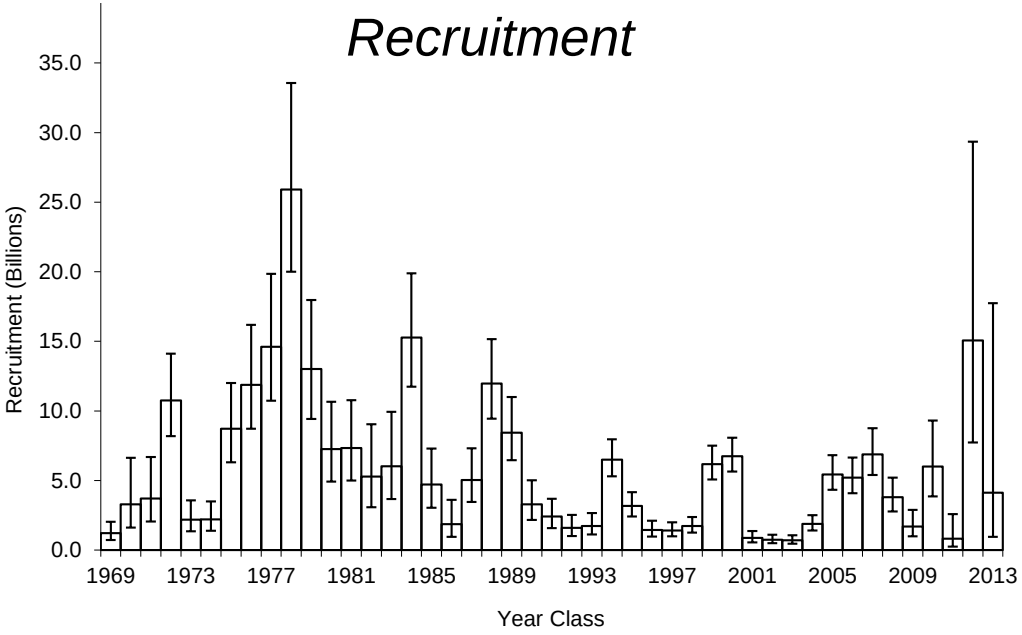
Spawning biomass



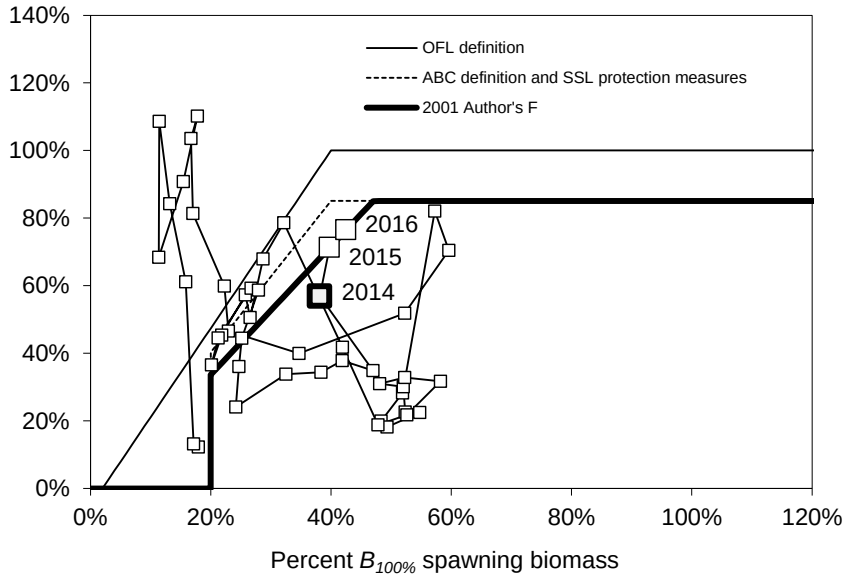
Catch



Recruitment

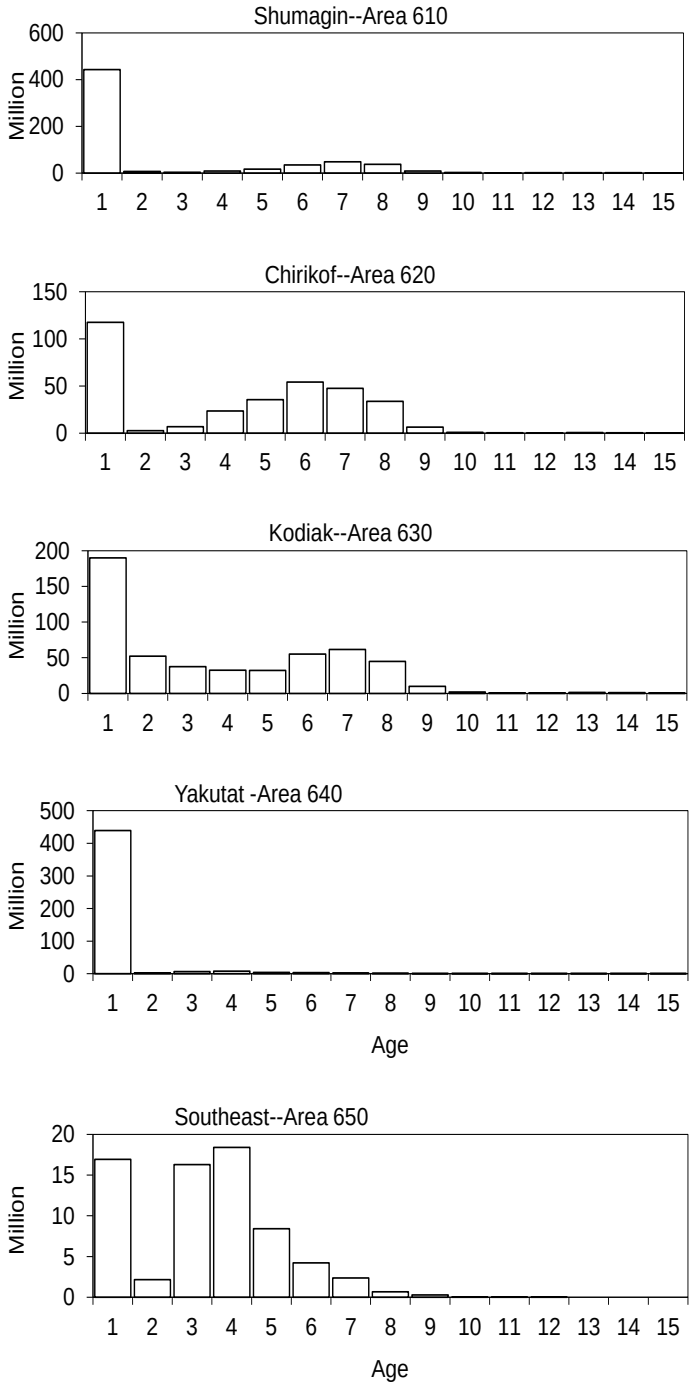


Status phase plot

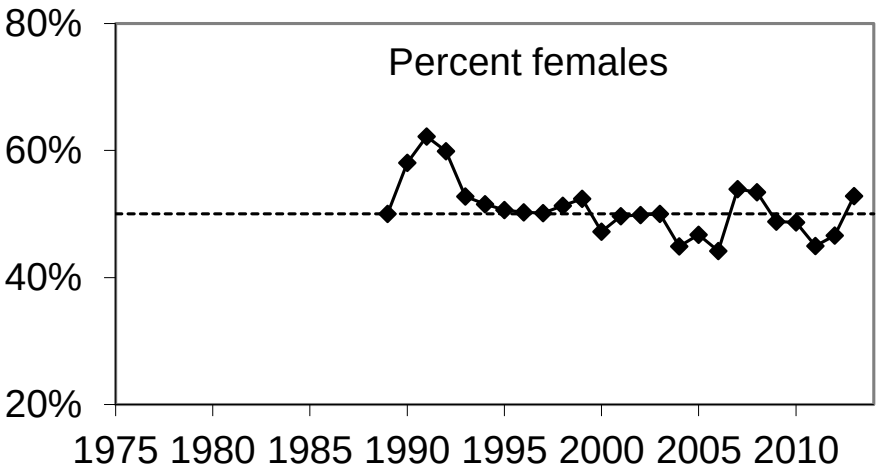


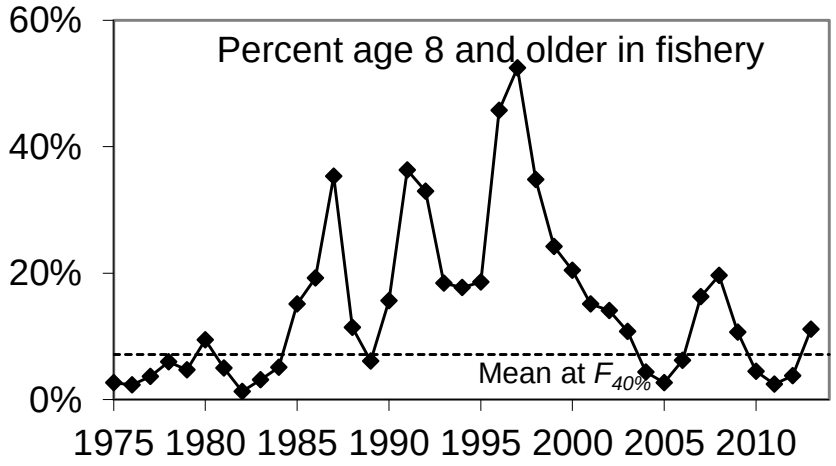
Extras

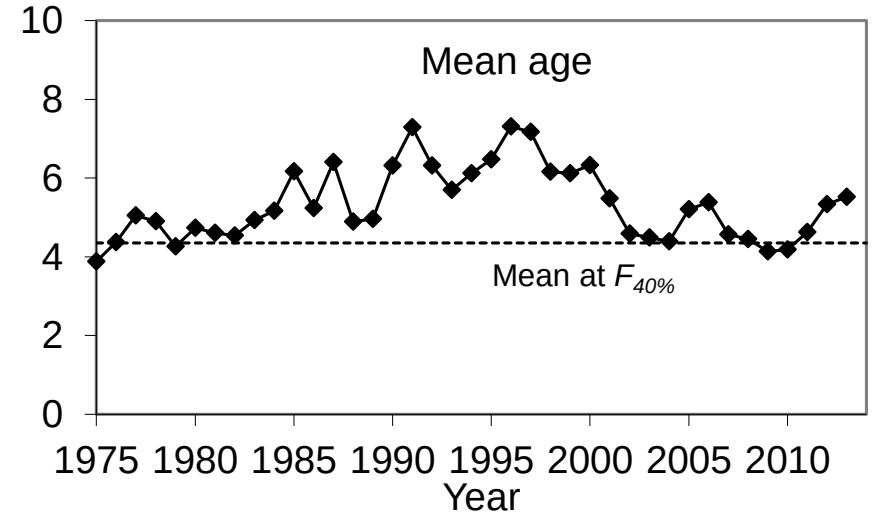
NMFS bottom trawl survey
(2013 age composition)

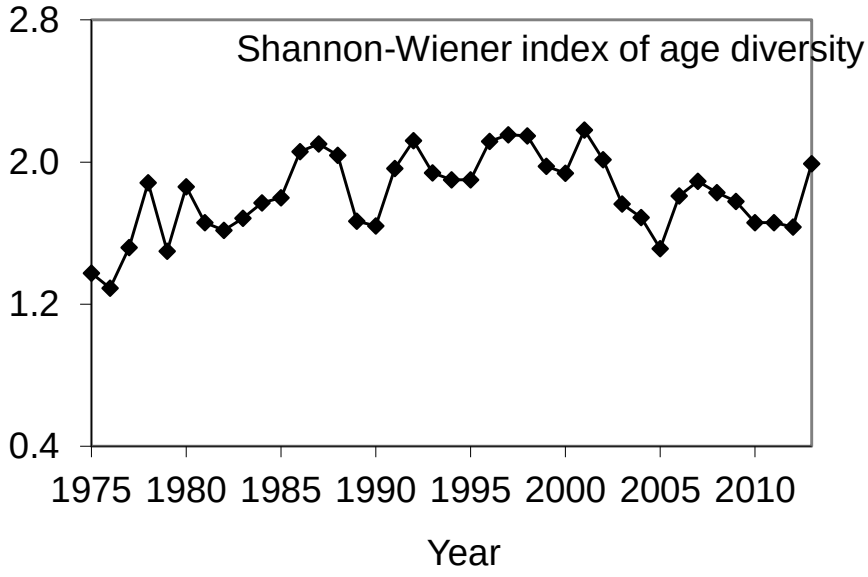


Fishery catch characteristics









Model changes

- Start the model in 1970 rather than 1964 and removing fishery length composition data for 1964-1971.
- Remove summer bottom trawl surveys in 1984 and 1987 and Shelikof Strait acoustic surveys in 1981-1991.
- Estimate summer bottom trawl catchability using a prior rather than fixing catchability and modeling selectivity with an asymptotic curve.
- Use random walk for changing fishery selectivity parameters rather than time blocks.
- Use an age-specific mortality schedule with higher juvenile mortality
- Model age-1 and age-2 pollock in the winter acoustic surveys as separate indices.
- All composition data sets were tuned so that input sample sizes were close to the harmonic mean of effective sample.