INTERNATIONAL PACIFIC

HALIBUT COMMISSION

Summary of the 2022 data and stock assessment, and decision table for 2023

Agenda item 5.3

IPHC-2022-IM098-11 Rev_1

Summary

- *On the water*:
  - All coastwide indices were down in 2022
  - Both the FISS and fishery have largely transitioned to the 2012 year-class from the 2005 and older year-classes
  - Recent spawning biomass trend is nearly flat, but shifting to young fish
  - Very low recruitment from 2006-2011 continues to reduce the short-term productivity of the stock

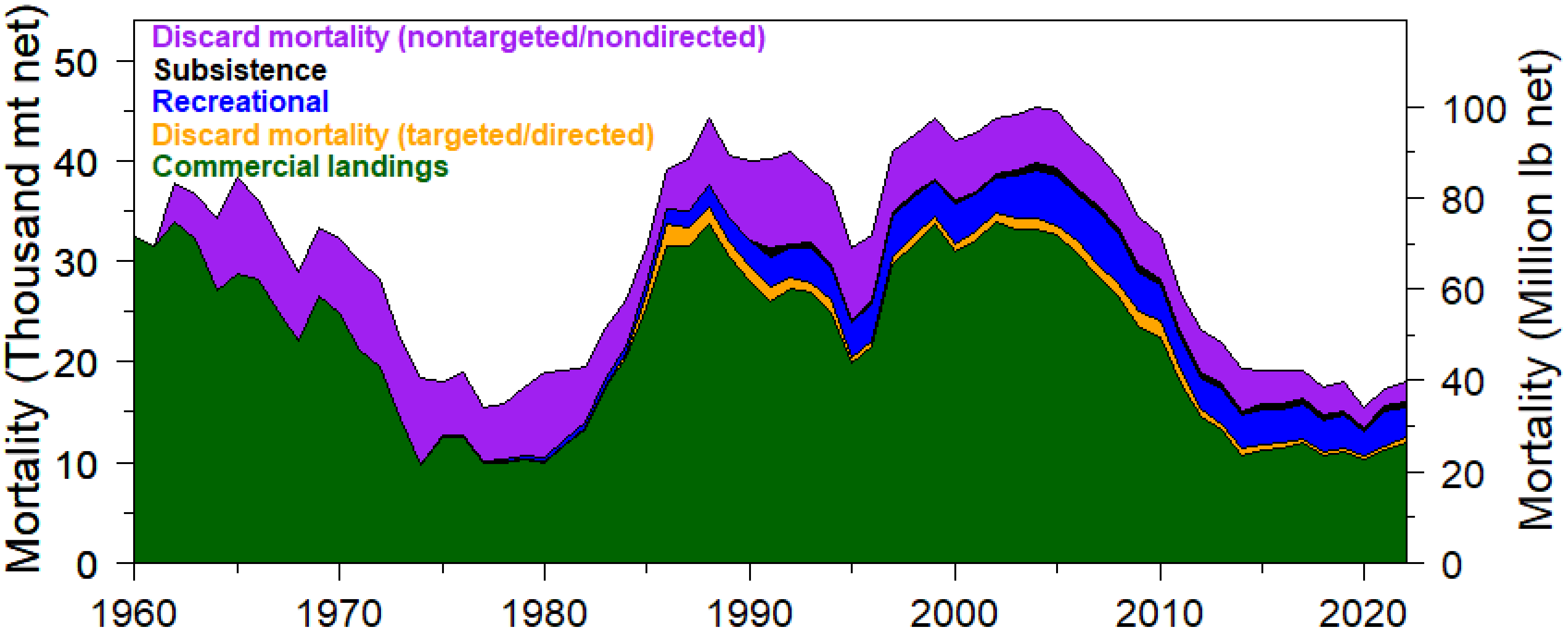
Summary

- *In the models*:
  - Removed an outdated assumption of low natural mortality in 1 of 4 assessment models
    - Now estimated directly from the data
  - Results in larger projected yields at long-term fishing intensity reference points (e.g., $F_{43\%}$)
    - This is independent of recent trends

Outline

- Data sources
- Modelling results
- Projections and decision table

Historical mortality



2022 Mortality

Projected from AM098 based on adopted mortality limits

Year	Commercial Landings	Commercial discards	Recreational	Subsistence	Non-directed discards	Total
2022	28.08	1.17	7.25	0.97	4.98	42.45
					(3-yr avg.)	

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2022	28.08	1.17	7.25	0.97	4.98	42.45

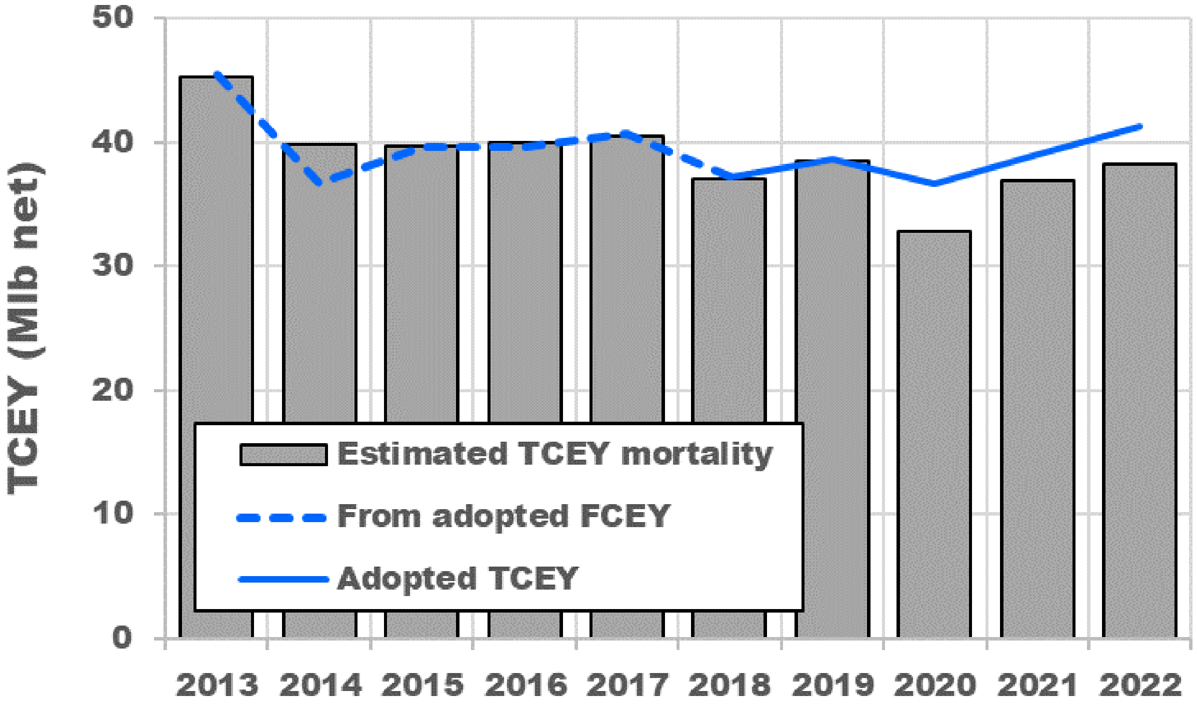
(3-yr avg.)

Estimated for this year's stock assessment analysis

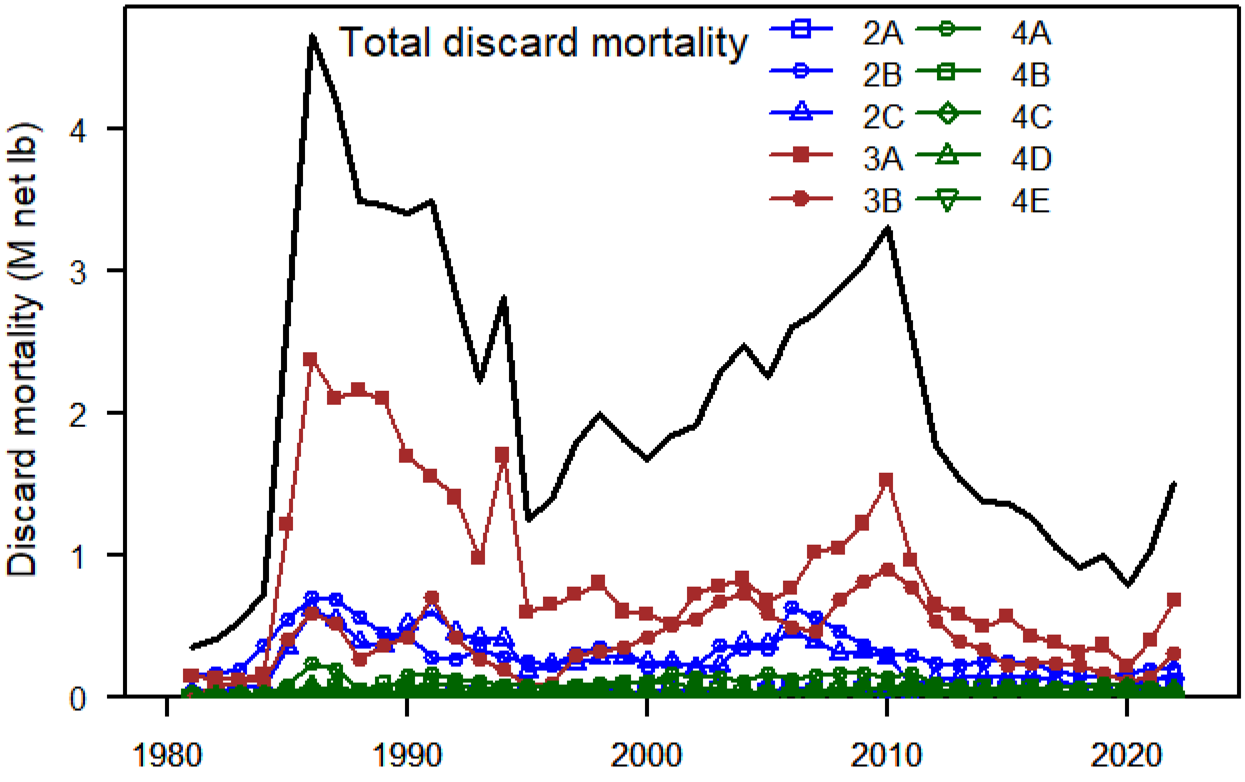
Year	Commercial Landings	Commercial discards	Recreational	Subsistence	Non-directed discards	Total
2022	26.14	1.51	6.60	0.96	4.48	39.69

3-yr avg. = **4.30**

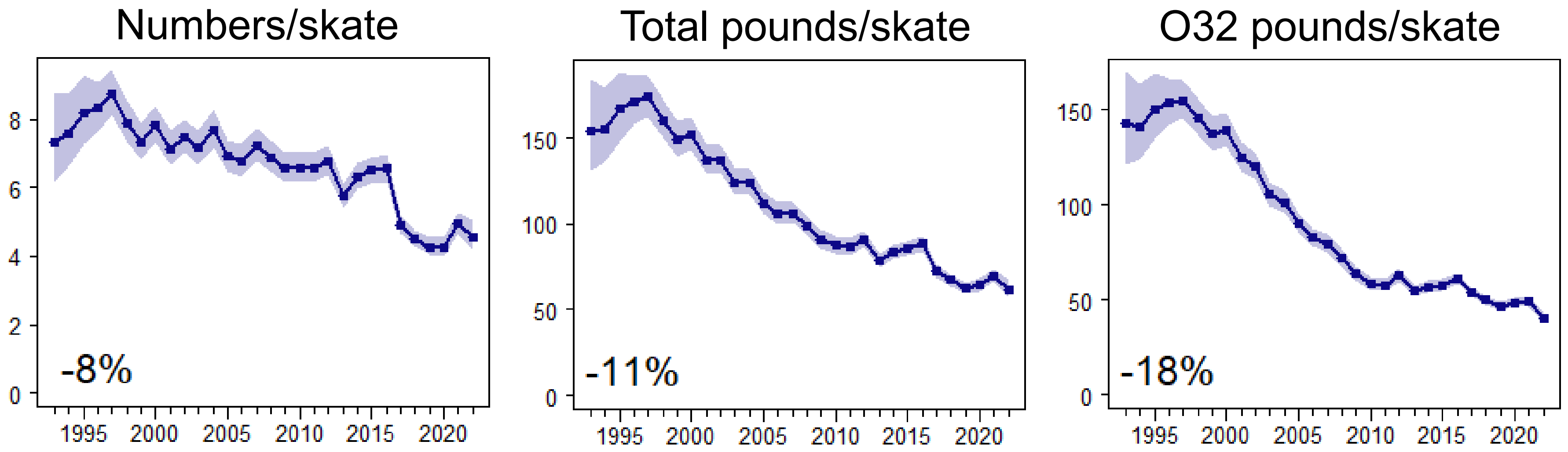
TCEY comparison



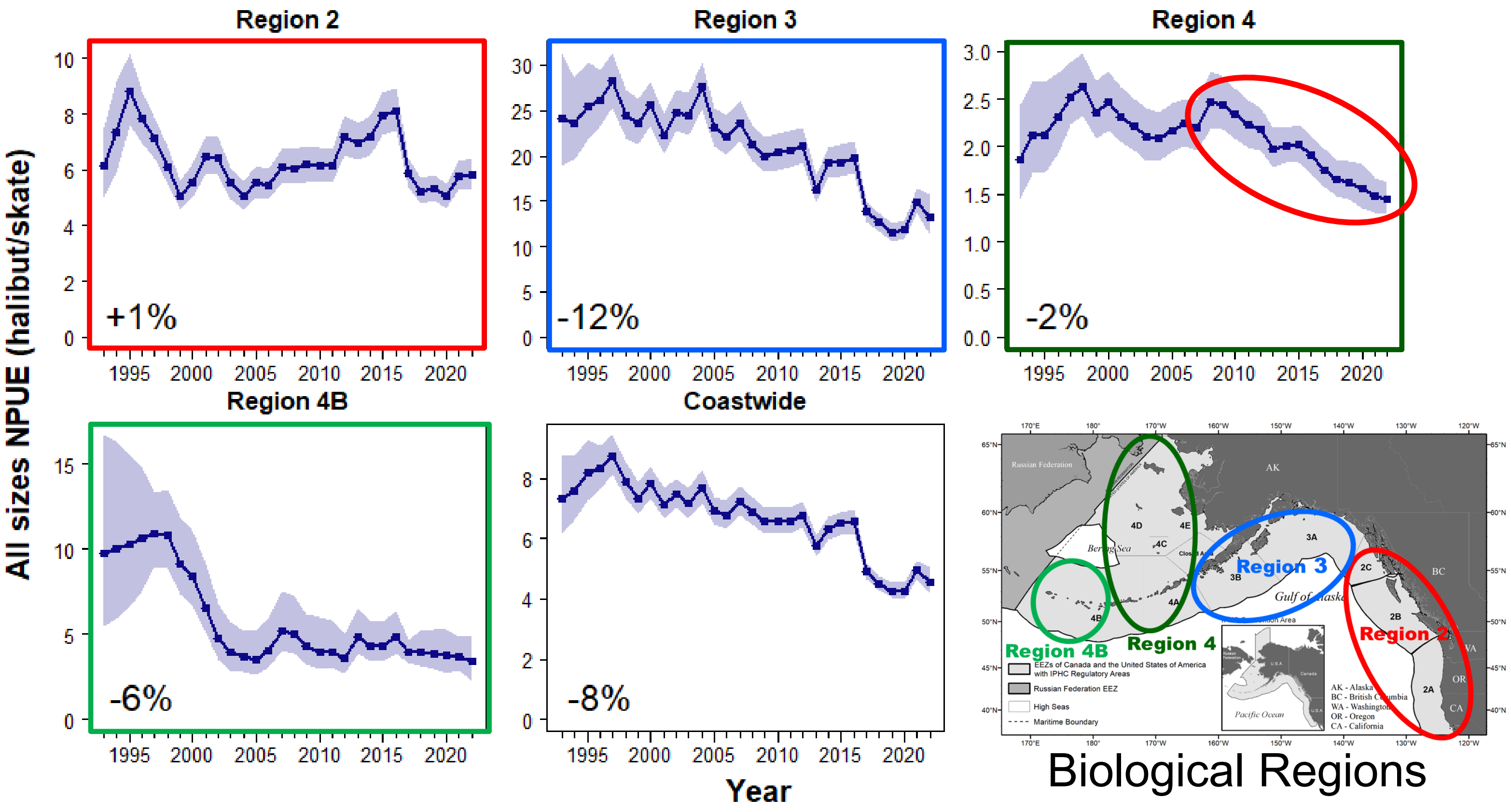
Recent directed commercial discard mortality



Modelled coastwide FISS trends

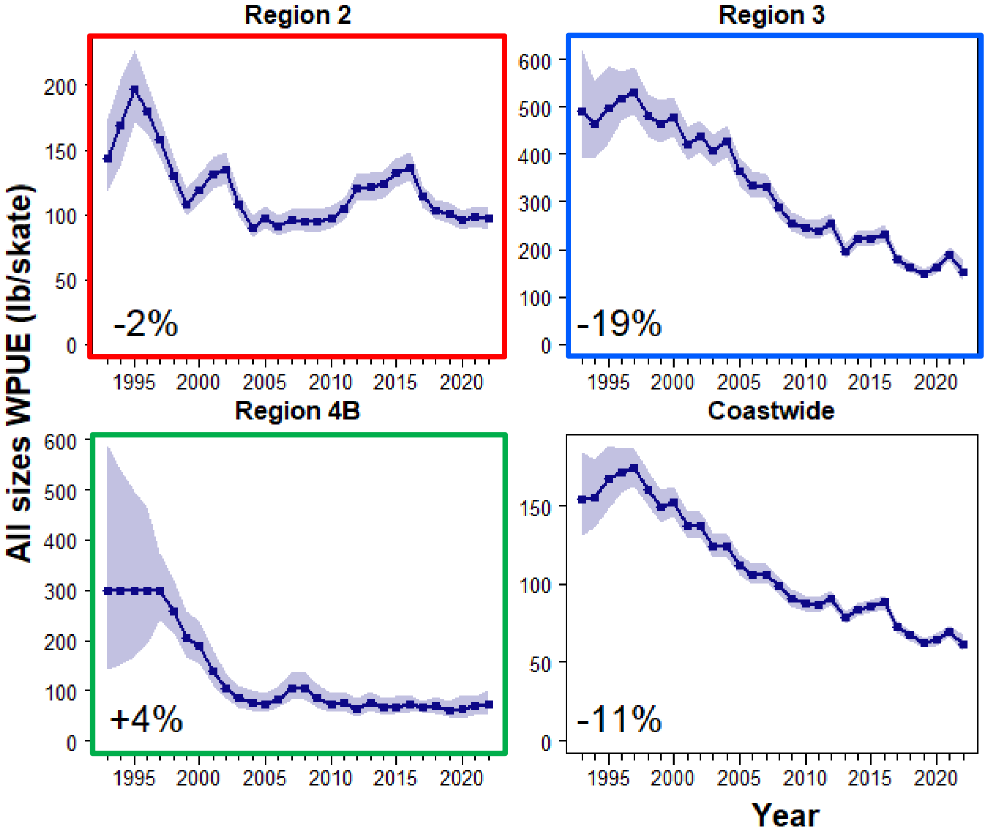


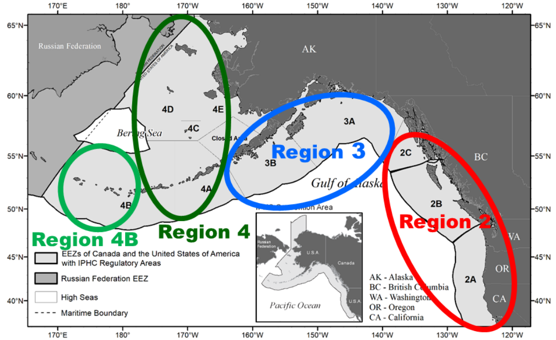
Modelled FISS trends (Numbers)



Biological Regions

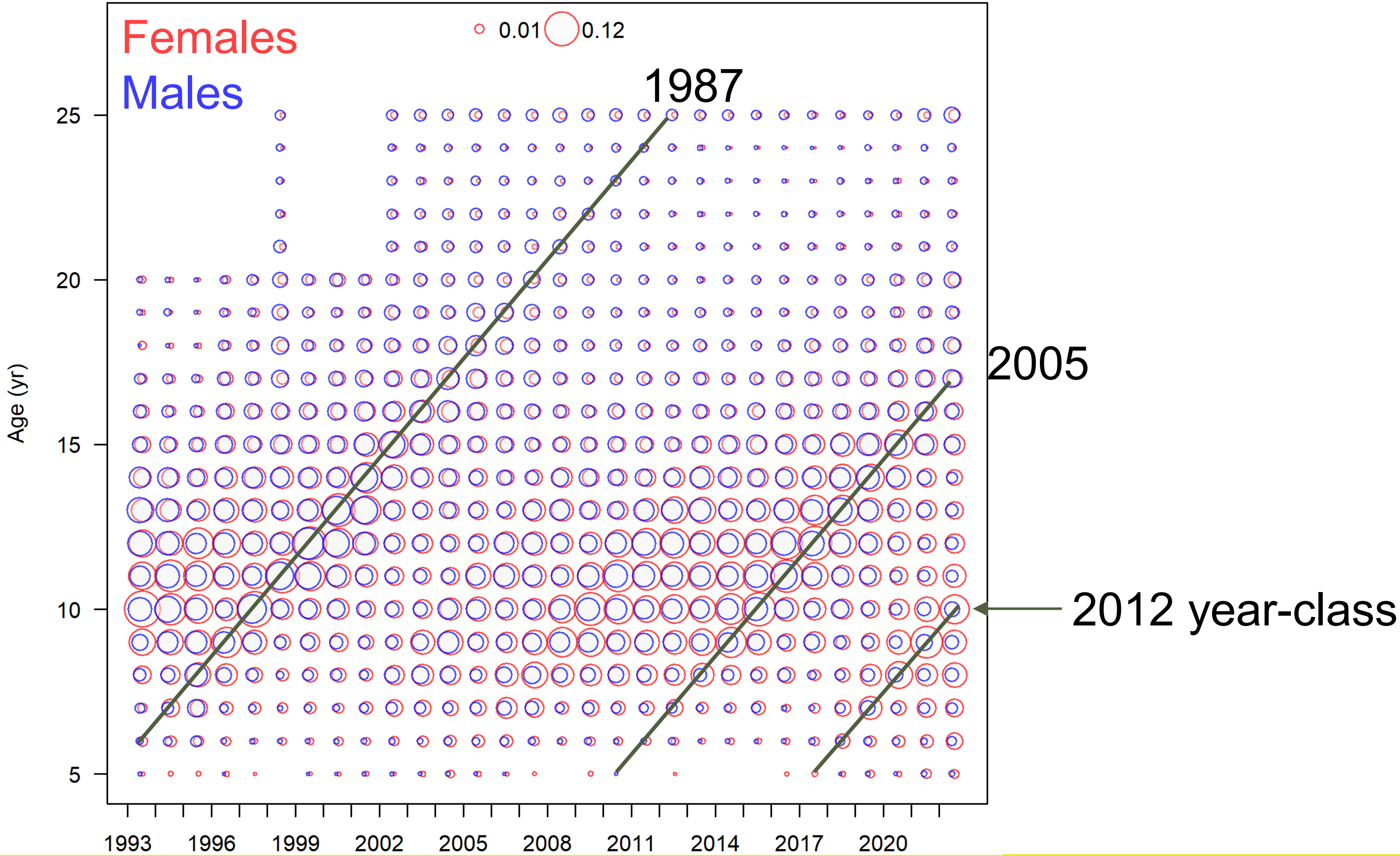
Modelled FISS trends (all sizes WPUE)



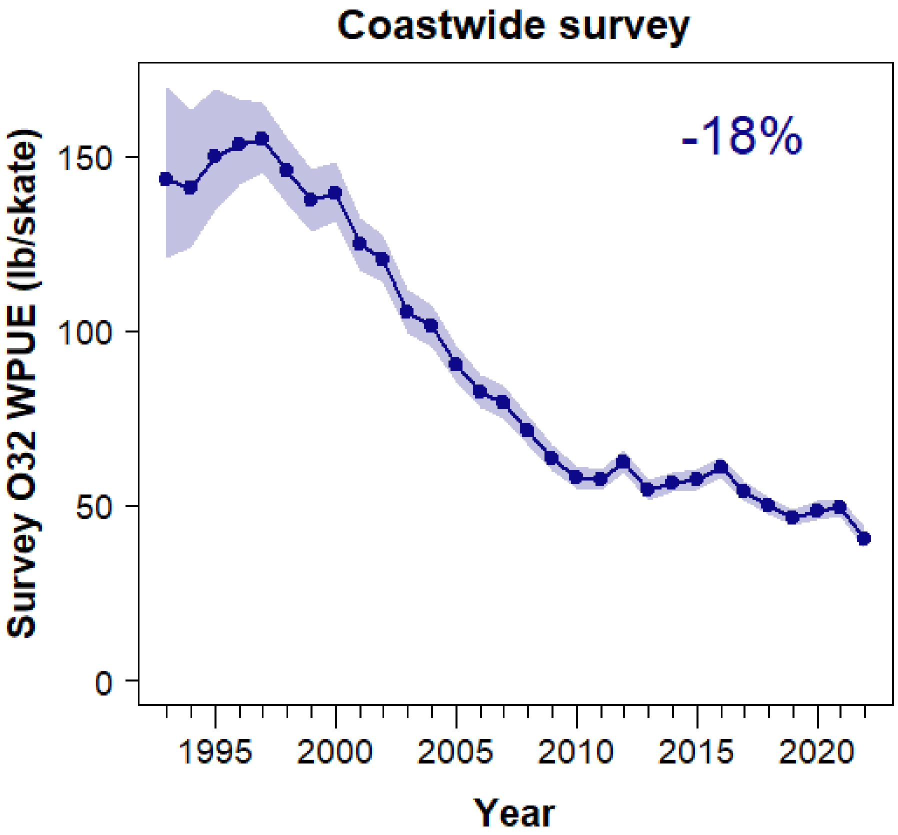


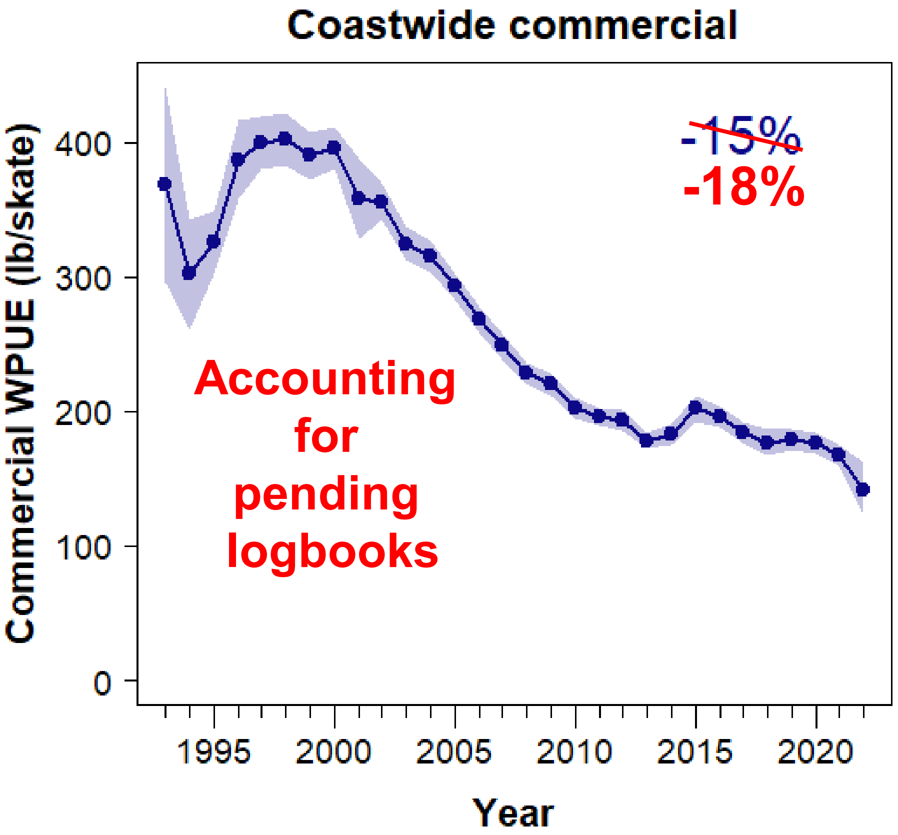
Biological Regions

Recent FISS ages

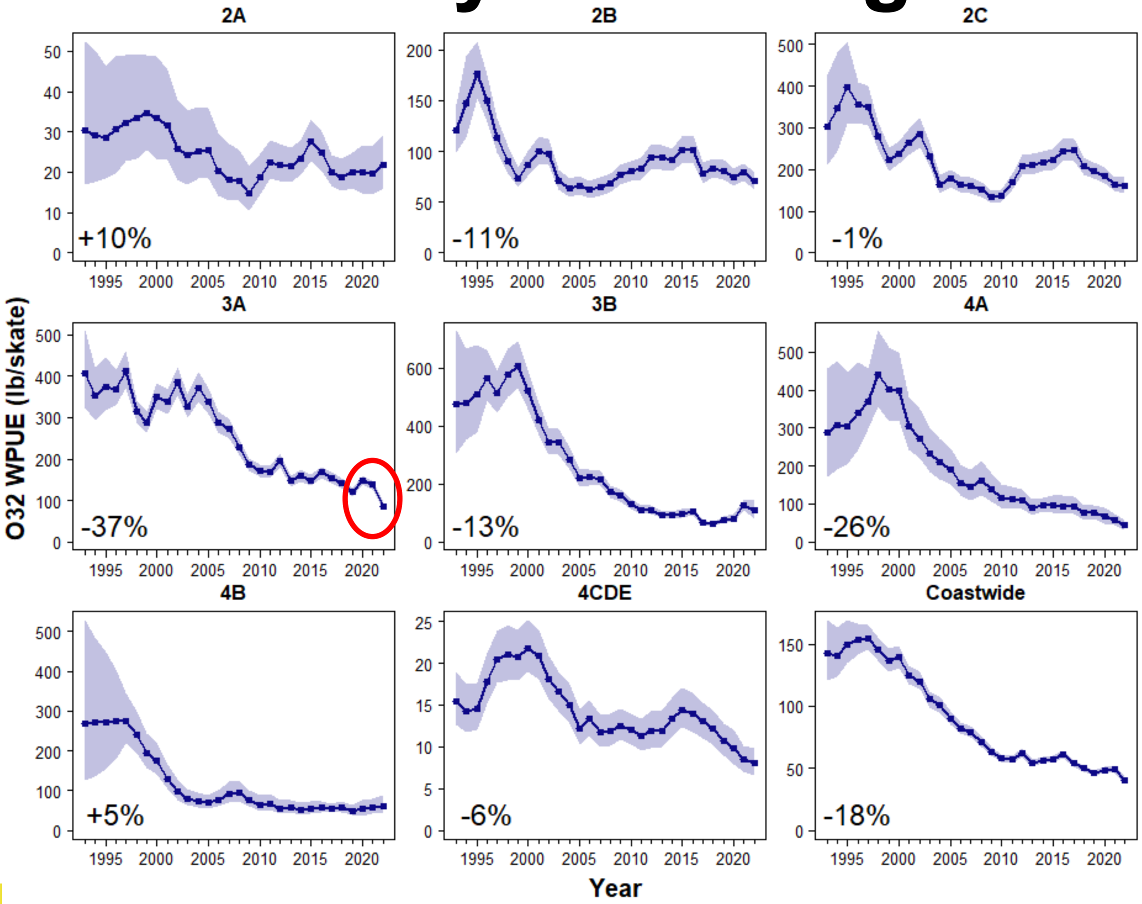


O32 WPUE (lb/skate) trends

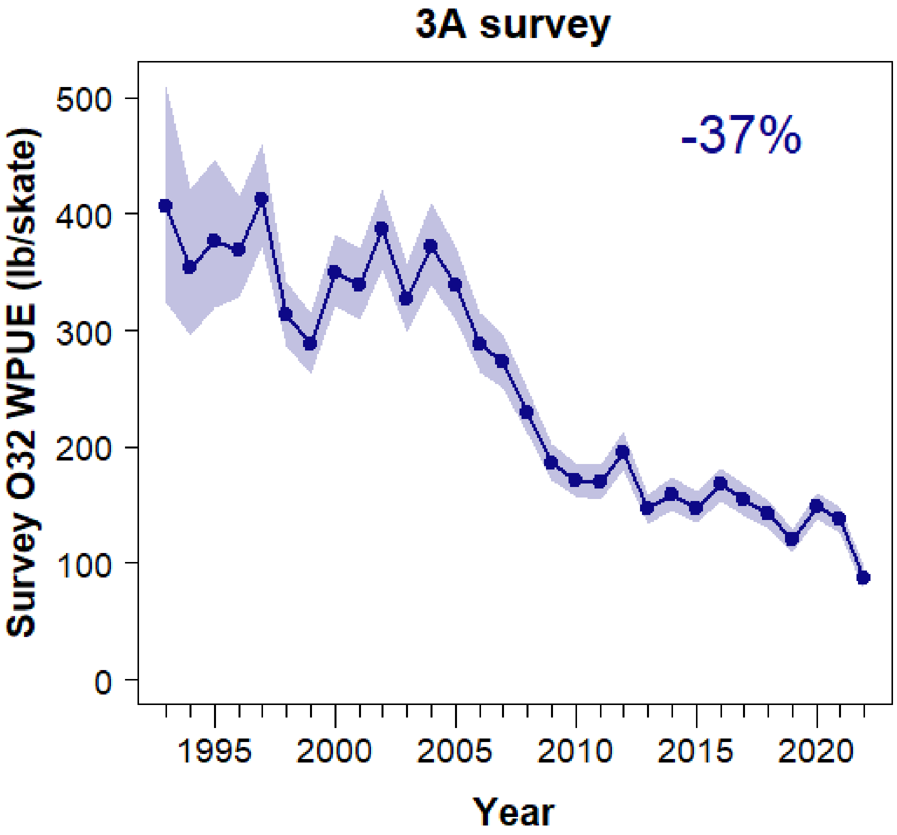


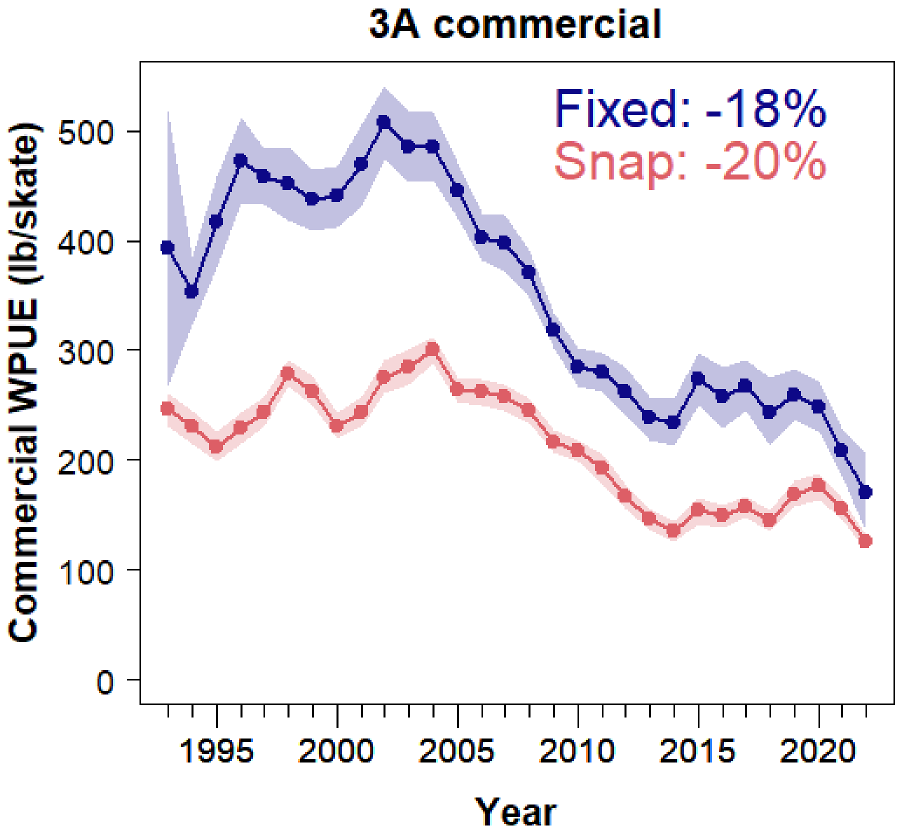


FISS O32 WPUE by IPHC Regulatory Area



O32 WPUE trends by IPHC Regulatory Area



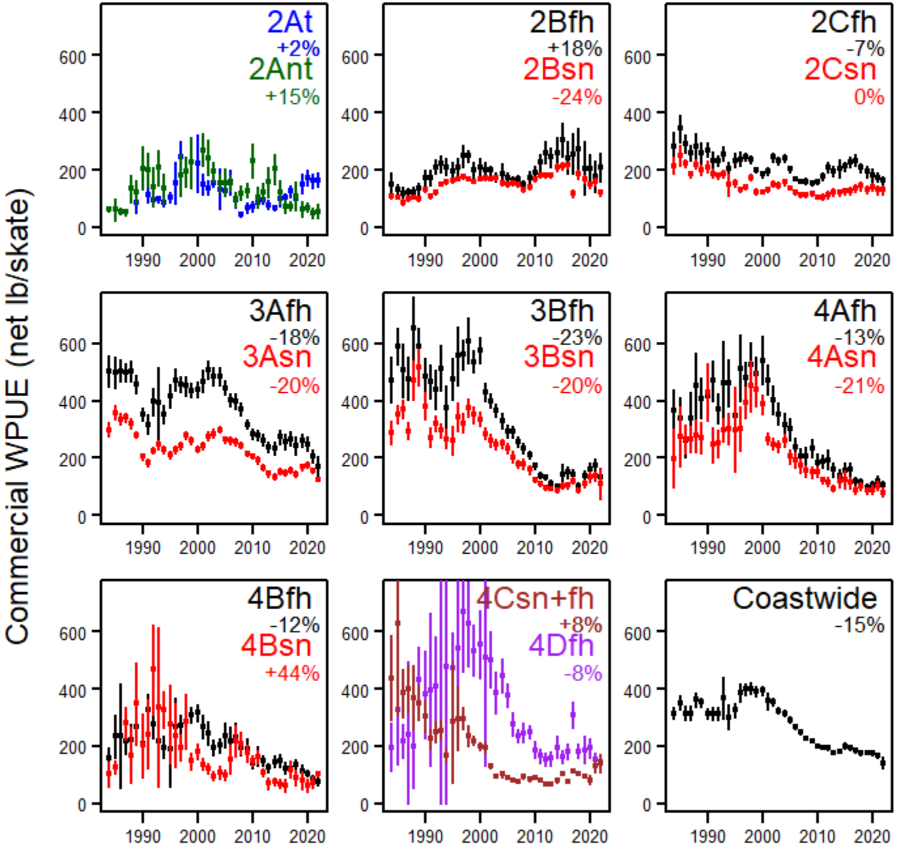


Fishery O32 WPUE by IPHC Regulatory Area

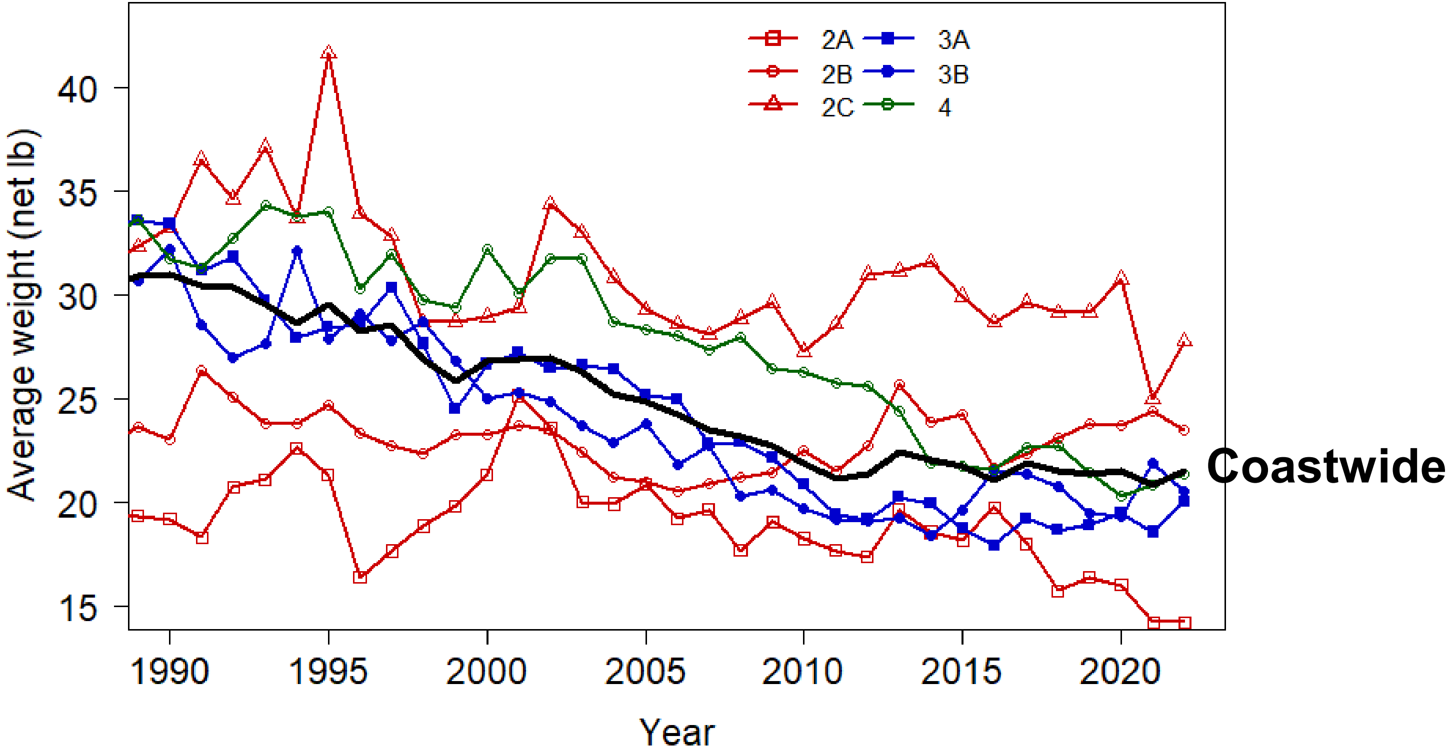
2A Tribal
2A non-Tribal

Fixed hook
Snap

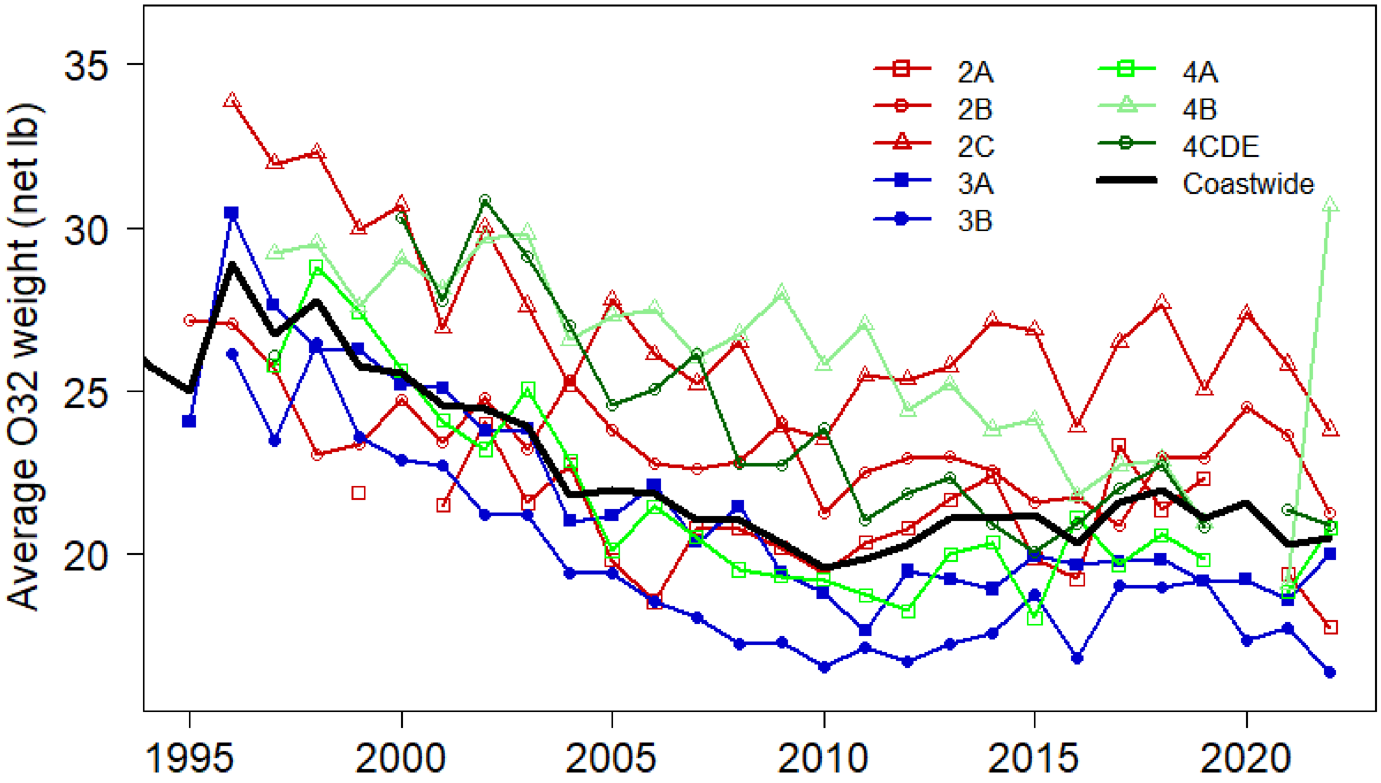
4C
4D



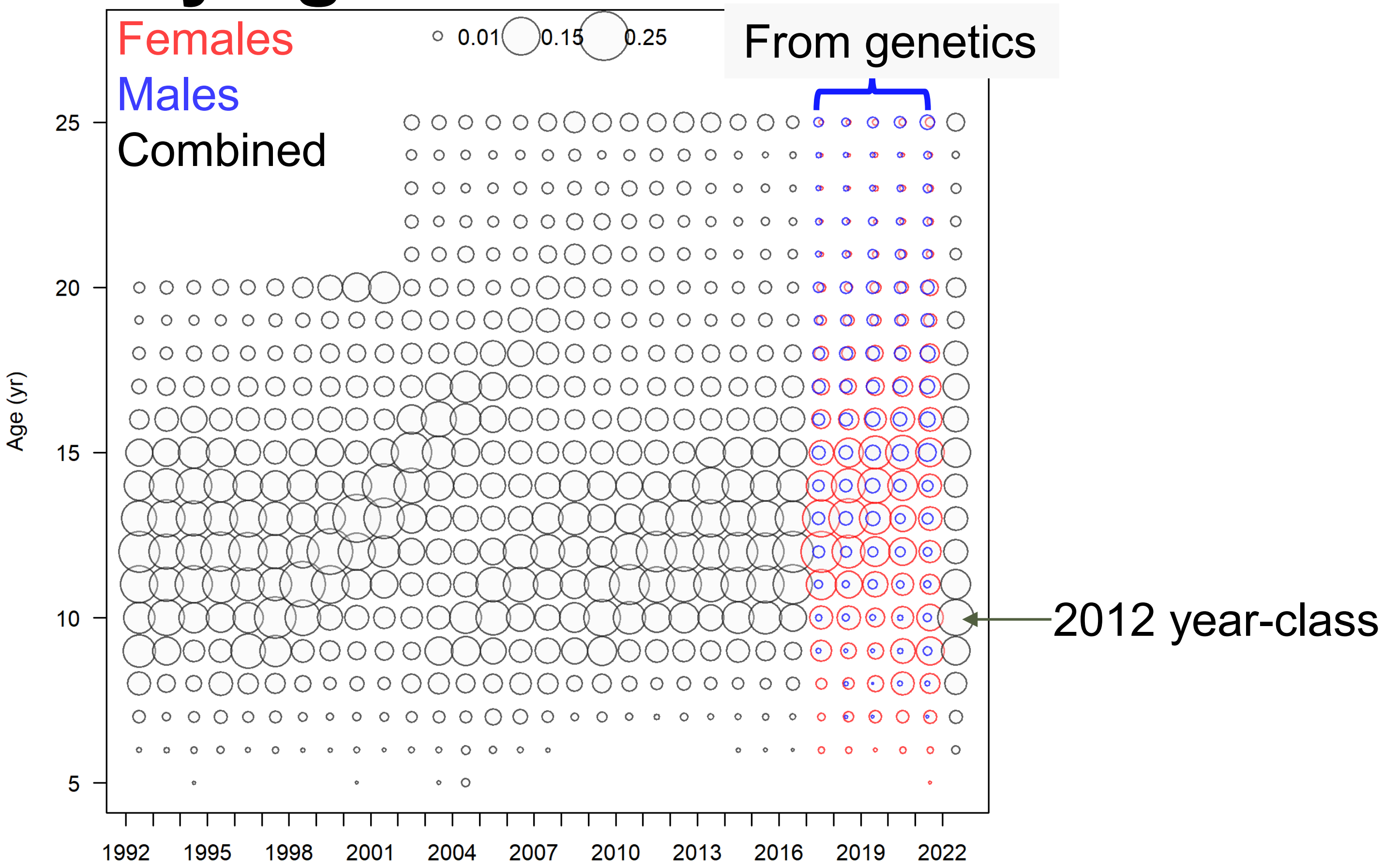
Average weight of landed fish



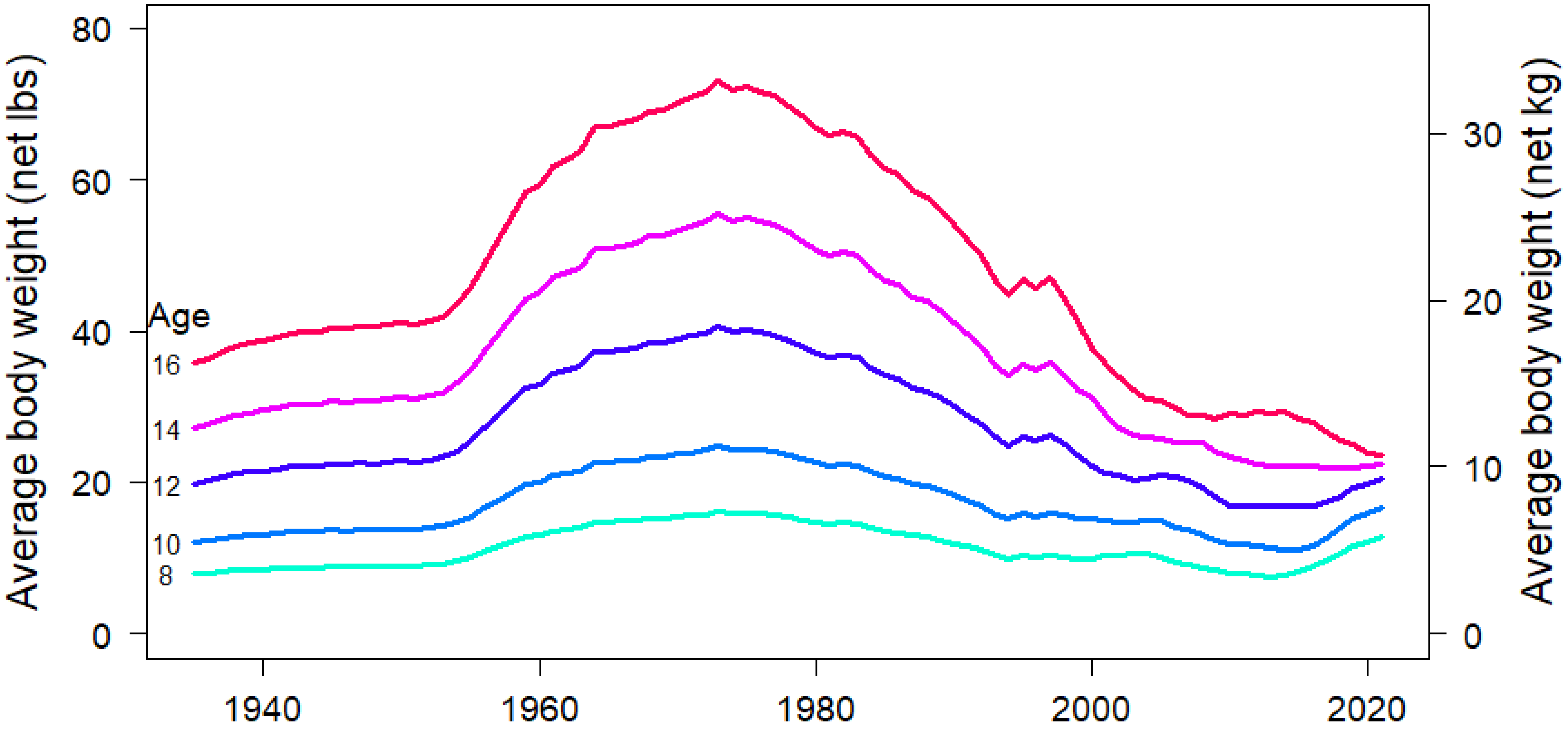
Average weight of FISS O32 fish



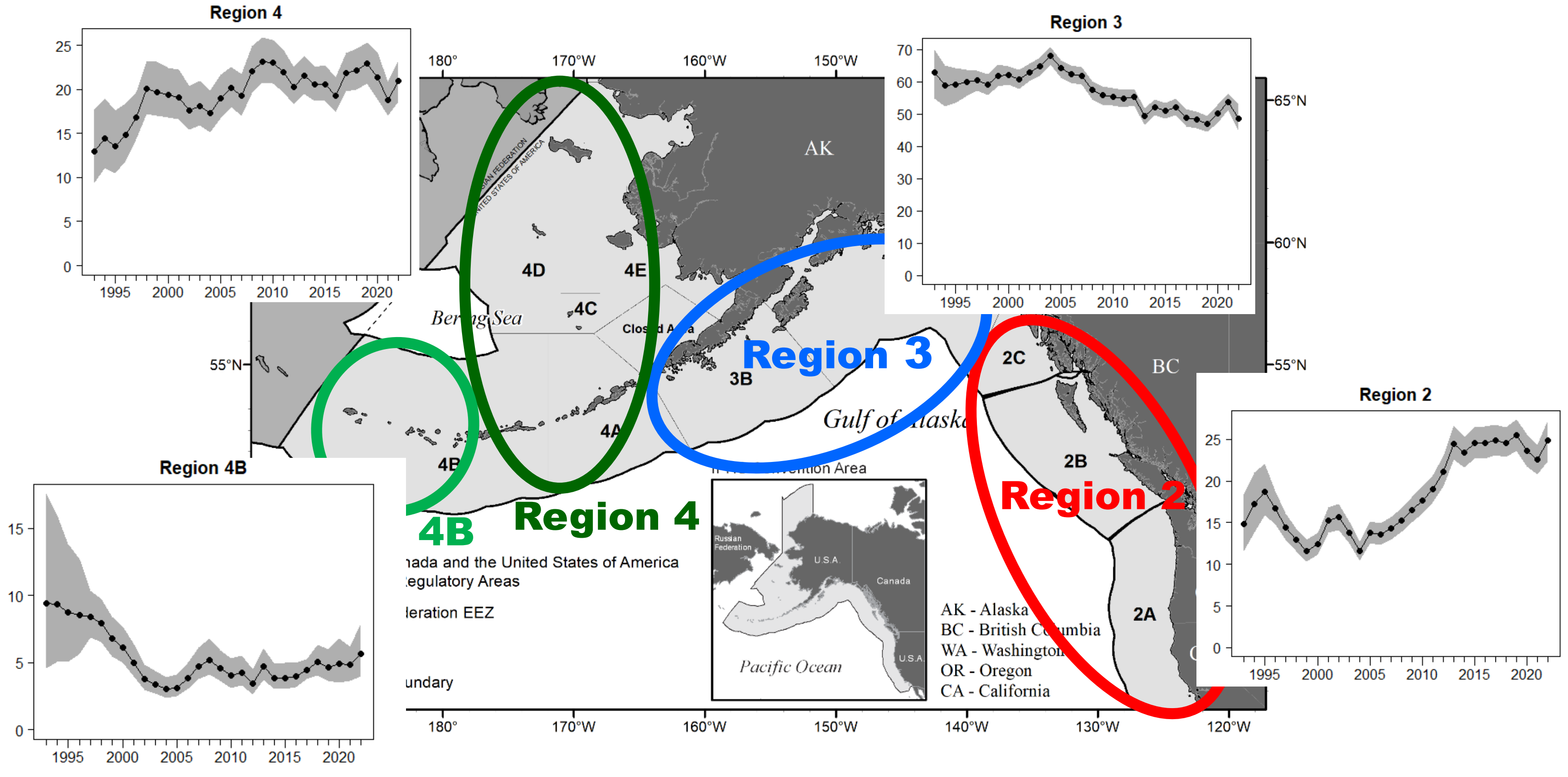
Recent fishery ages



Historical coastwide female weight-at-age



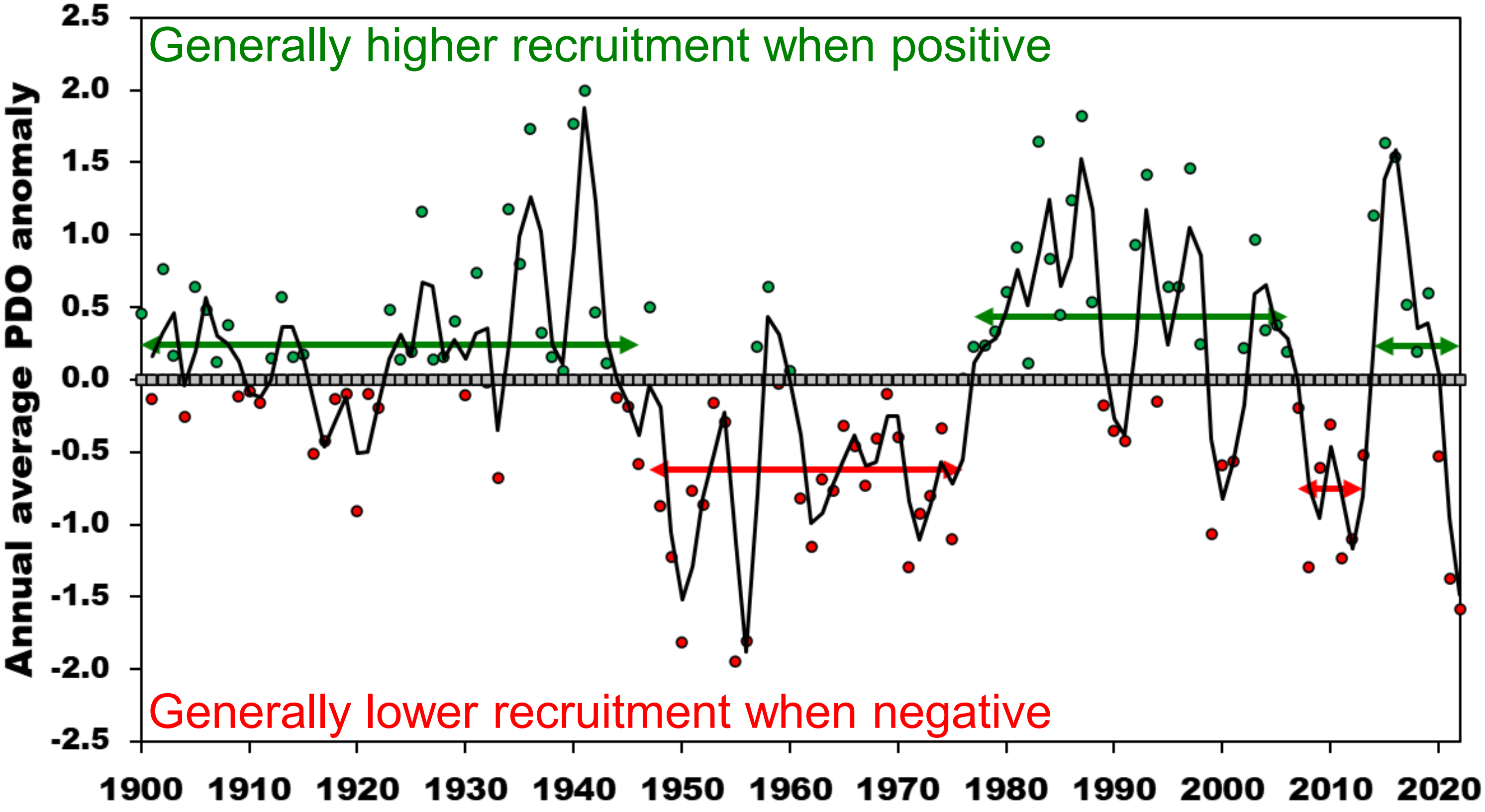
Stock distribution (% of biomass)



Change in O32 stock distribution

	2A	2B	2C	3A	3B	4A	4B	4CDE
2021 (last year's estimates)	1.8%	12.0%	11.3%	33.6%	18.8%	6.9%	5.7%	10.0%
2022	2.6%	13.0%	14.3%	26.3%	20.2%	5.3%	7.5%	10.9%
3-yr Average	2.2%	12.1%	13.3%	32.7%	17.2%	6.0%	6.2%	10.4%

Ecosystem conditions: Pacific Decadal Oscillation



Ecosystem conditions

- *Bering Sea* (2022): closer to average after reduced ice cover in recent years
- *Aleutian Islands* (2022): still some warmer than average temperatures
- *GOA* (2022): continued recovery toward average after 2014-2016 and 2019 heatwaves
- *B.C.* (2021): reduced productivity, warming
- *California current* (2021): cooler, increased productivity, some hypoxia

References (most recent reports):

Bering Sea, Gulf of Alaska, Aleutian Islands, B.C., California current

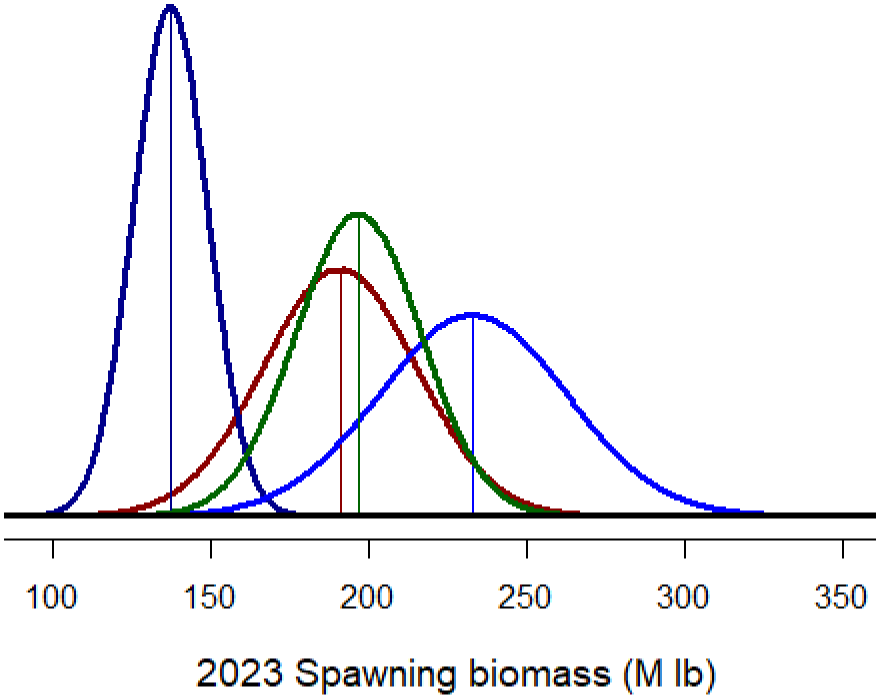
Outline

- Data sources
- Modelling results
- Projections and decision table

The 2022 assessment

- Full analysis of data and models, following updates in 2020 and 2021
- Incremental changes reviewed by the SRB in June and September
- All data updated for 2021 (where needed) and added for 2022

Modelling summary: four individual models



- Four ways to aggregate the data
- Respond differently to trend and age data by Region
- Provide stability from year to year as individual model results change

Analyzed but not changed in 2022

- Whale depredation
- Methods to model recruitment correlations with environmental conditions (PDO)
- Model weighting within the ensemble based on predictive performance of the next year’s FISS

Improved in 2022

- Software updates
- Allowed for elevated natural mortality on very young fish (ages 0-2) in all 4 models
- Age data weighting based on actual sampling in each year (FISS and fishery)
- Estimated female natural mortality in the short Areas-As-Fleets model (already estimated in the 2 long models)

Female Pacific halibut natural mortality (*M*)

- What is *M*?
  - The rate at which fish die of causes other than fishing.
- How do we estimate it?
  - As each year class of fish age, they decrease in abundance. We track how many have been caught. The rest of the decrease is due to *M*. More years of data gives us more information.
- How does it affect productivity?
  - Higher *M* equates to higher productivity and therefore higher long-term sustainable yields.

Female Pacific halibut natural mortality (*M*)

- Prior to 1998: all models used 0.20
- 1998-2012: all models used 0.15
- 2012: natural mortality served as the primary source of uncertainty in the harvest decision table.
- 2013: 1 of 3 models estimated *M*
- 2014: 2 of 4 models estimated *M*
- 2022: 3 of 4 models estimated *M*
  - Estimates range from 0.184 to 0.215; one model retains a fixed value of 0.15

Female Pacific halibut natural mortality (*M*)

Considerations in 1998 (Clark and Parma 1999):

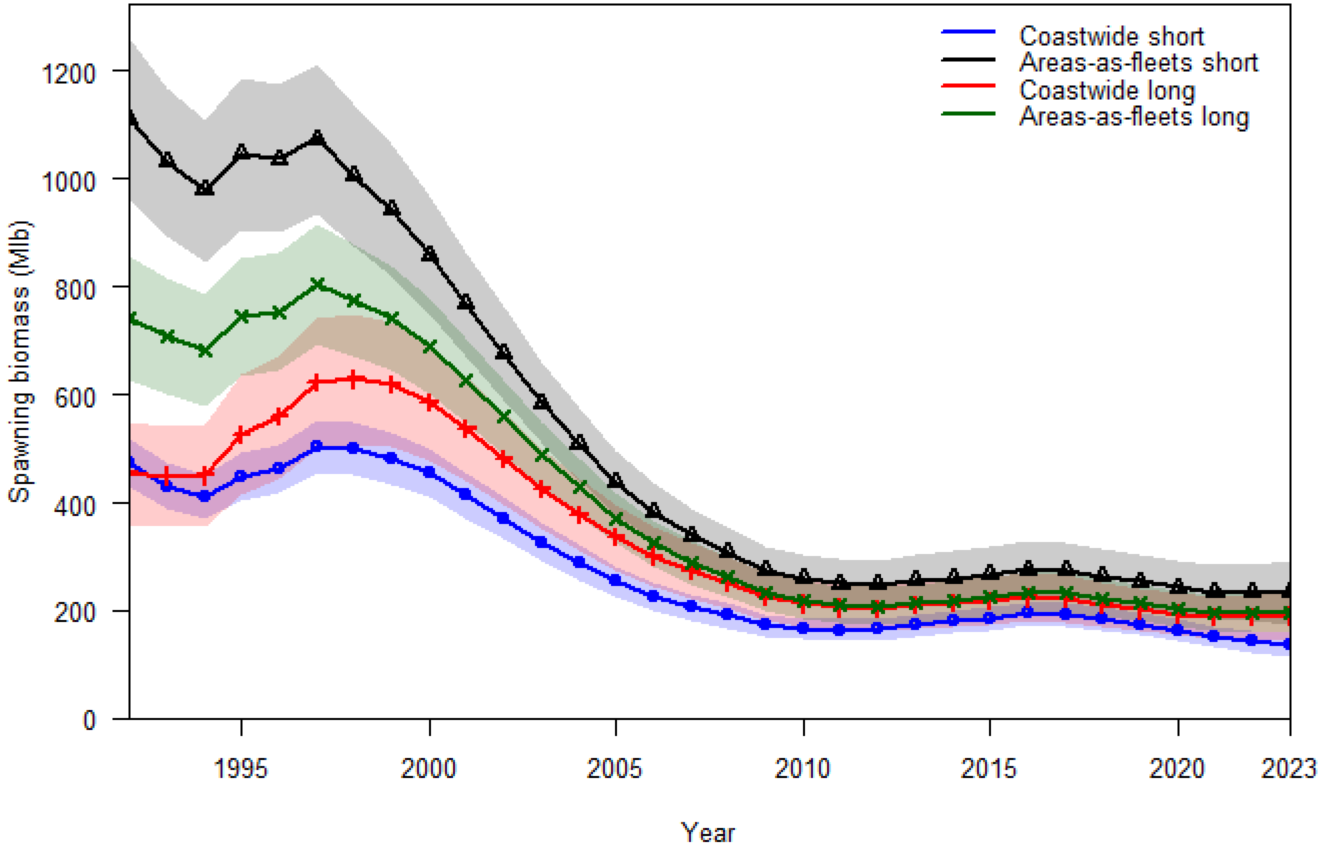
"Until 1998 the estimate of M = 0.20 had been used in all assessments. This estimate is quite imprecise, and analysis done by the staff during the year suggested that a lower working value would be appropriate. The value of M = 0.15 was chosen and used as a standard, which lowered abundance estimates by about 30%."

"Analysis done during the year by the staff showed that in the short term an overestimate of natural mortality could lead to a substantial overestimate of stock size when past fishing mortality rates were low, as they have been for Pacific halibut. On the other side, the consequences of an underestimate of natural mortality are less serious."

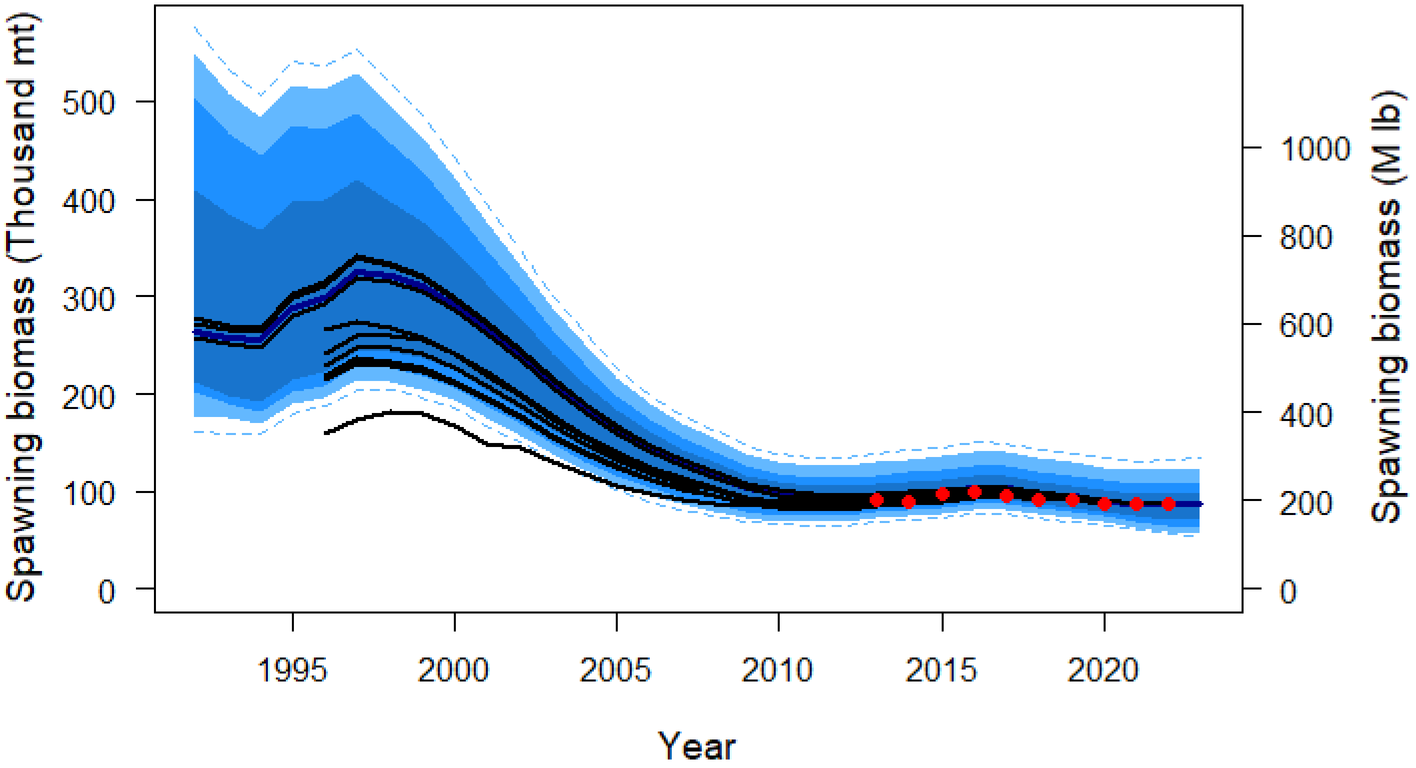
Female Pacific halibut natural mortality (*M*)

- We now have 25 years of additional data to inform our estimates
- Transparent, risk-neutral science: not making a precautionary adjustment to *M* inside the assessment models
- Estimating *M*, rather than using an assumed value represents our best available science

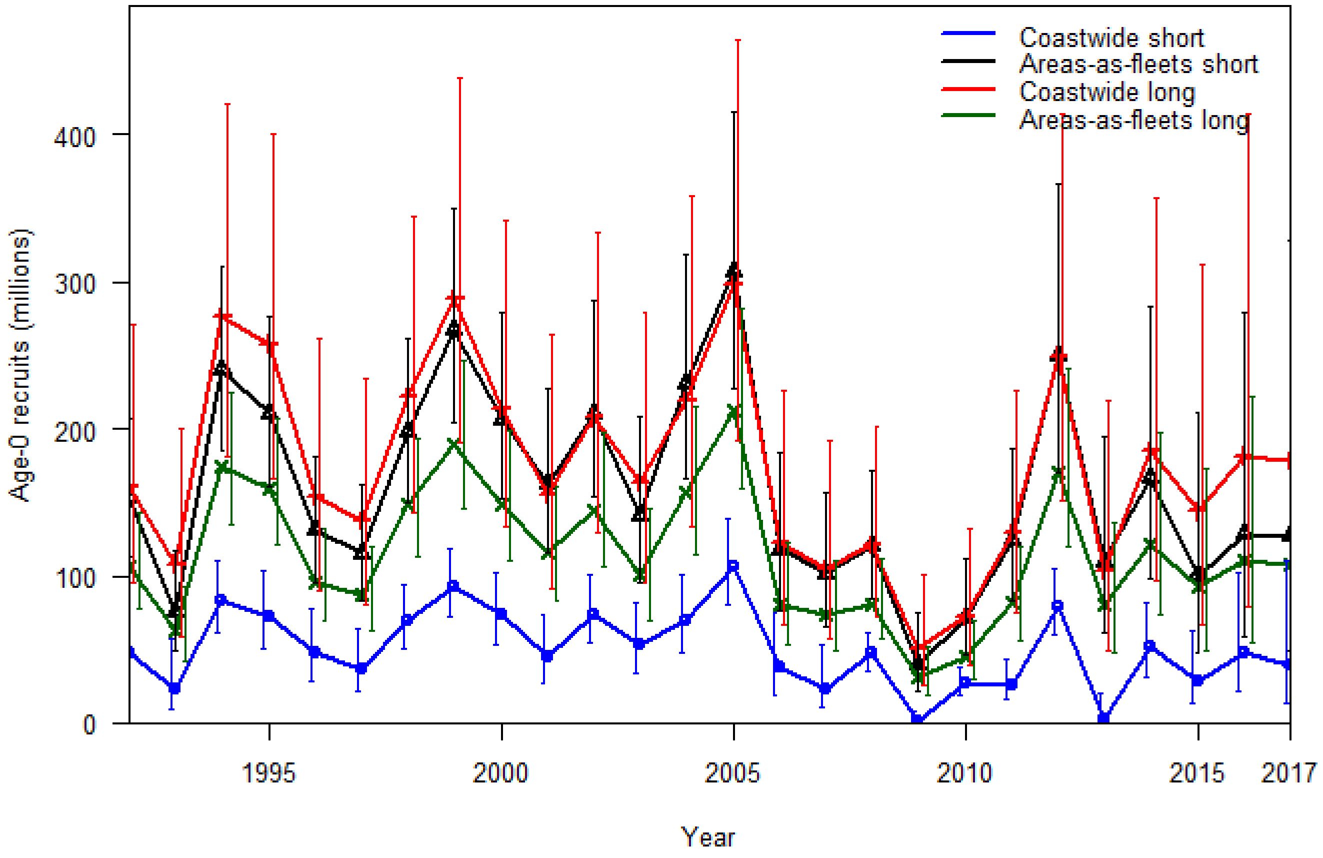
Modelling summary: four individual models



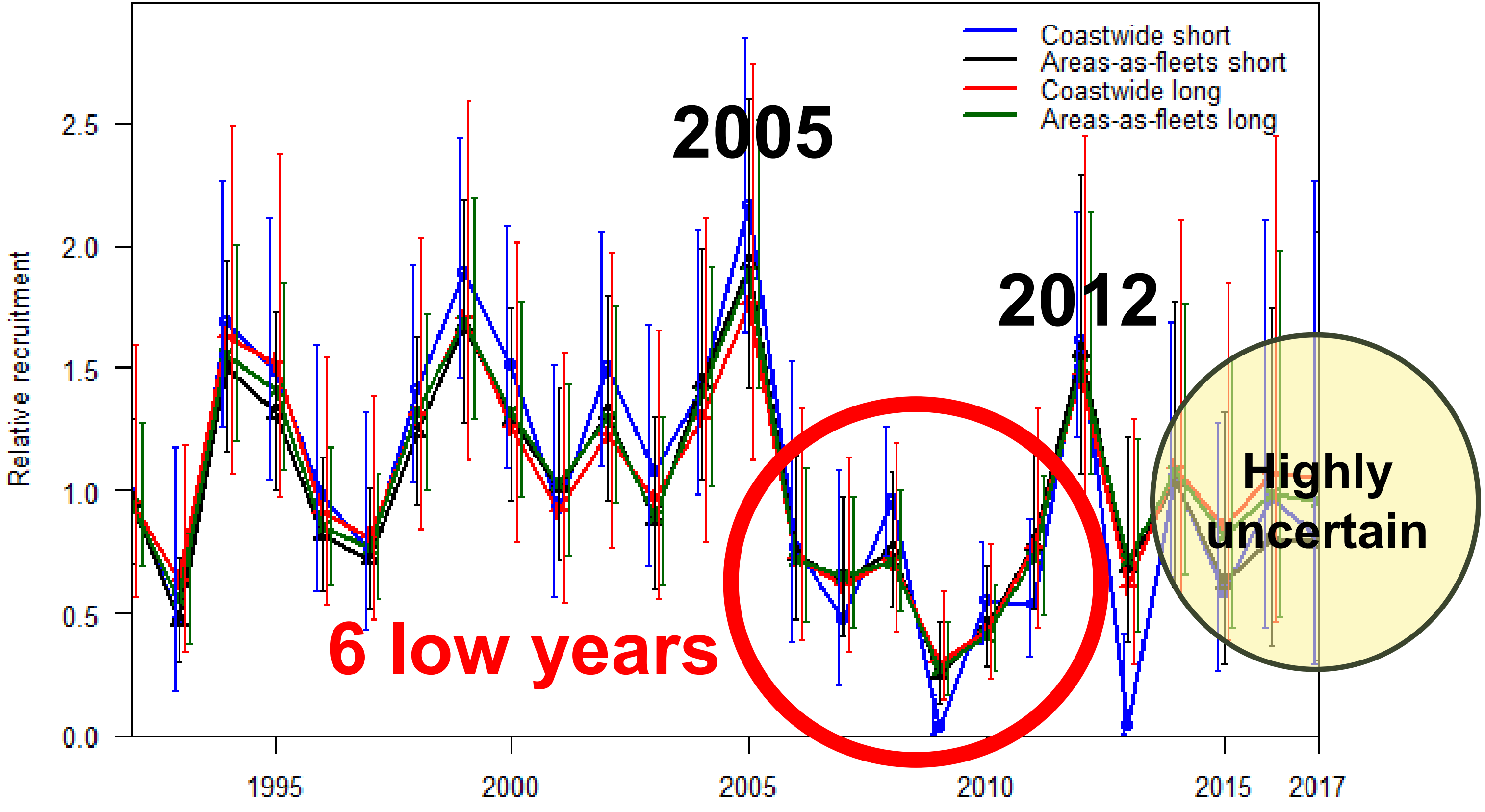
Comparison with previous assessments



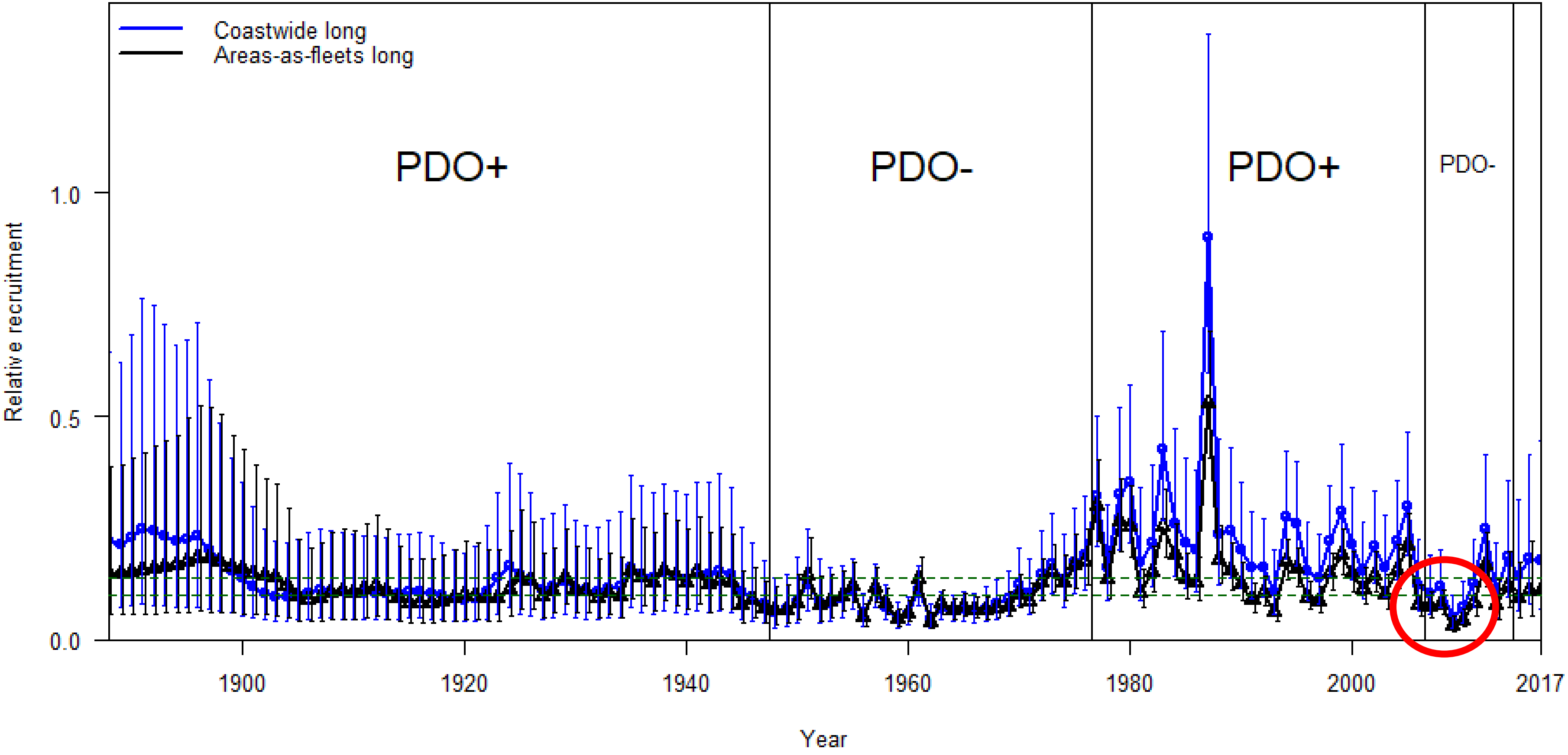
Recruitment estimates



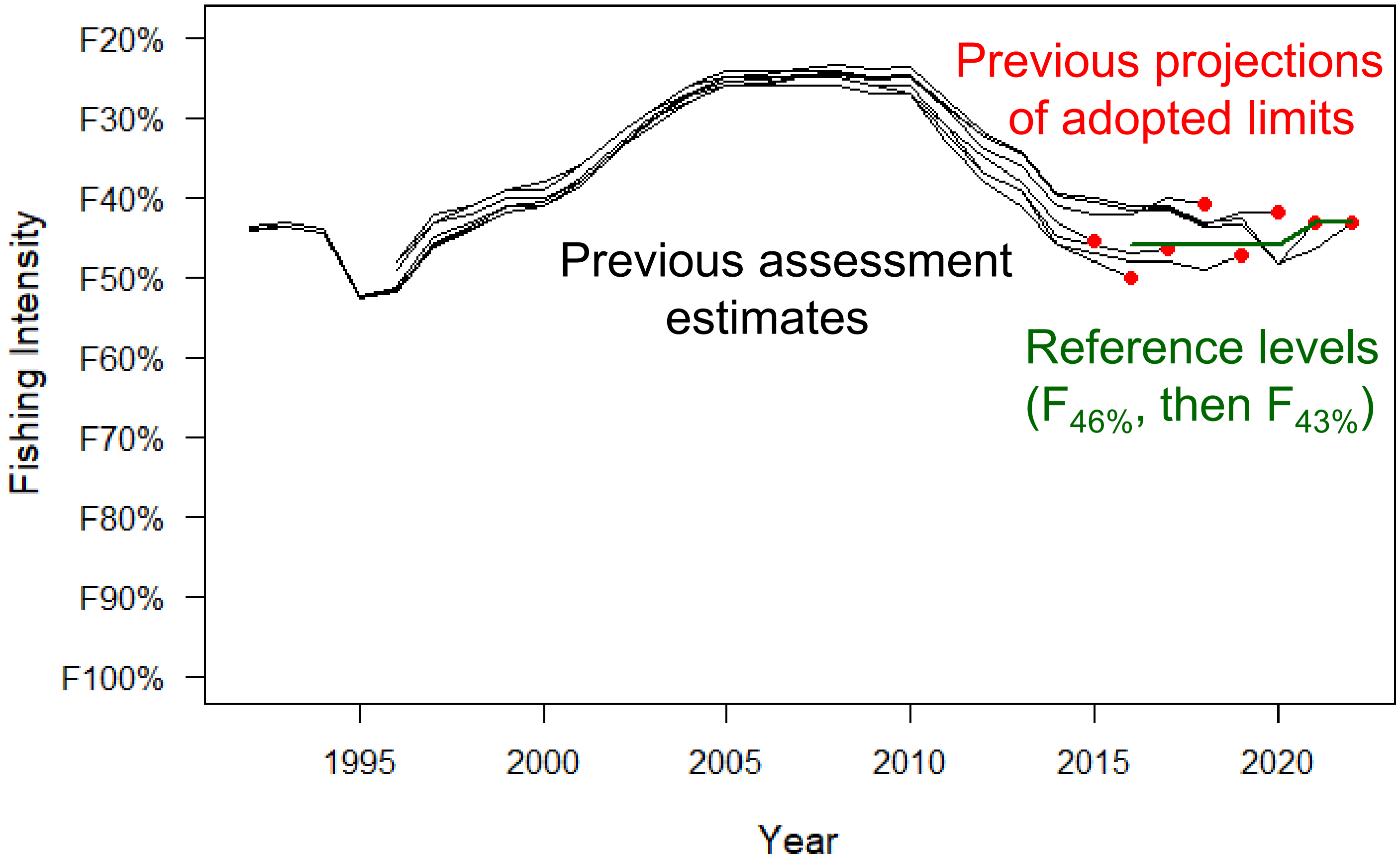
Relative recruitment estimates



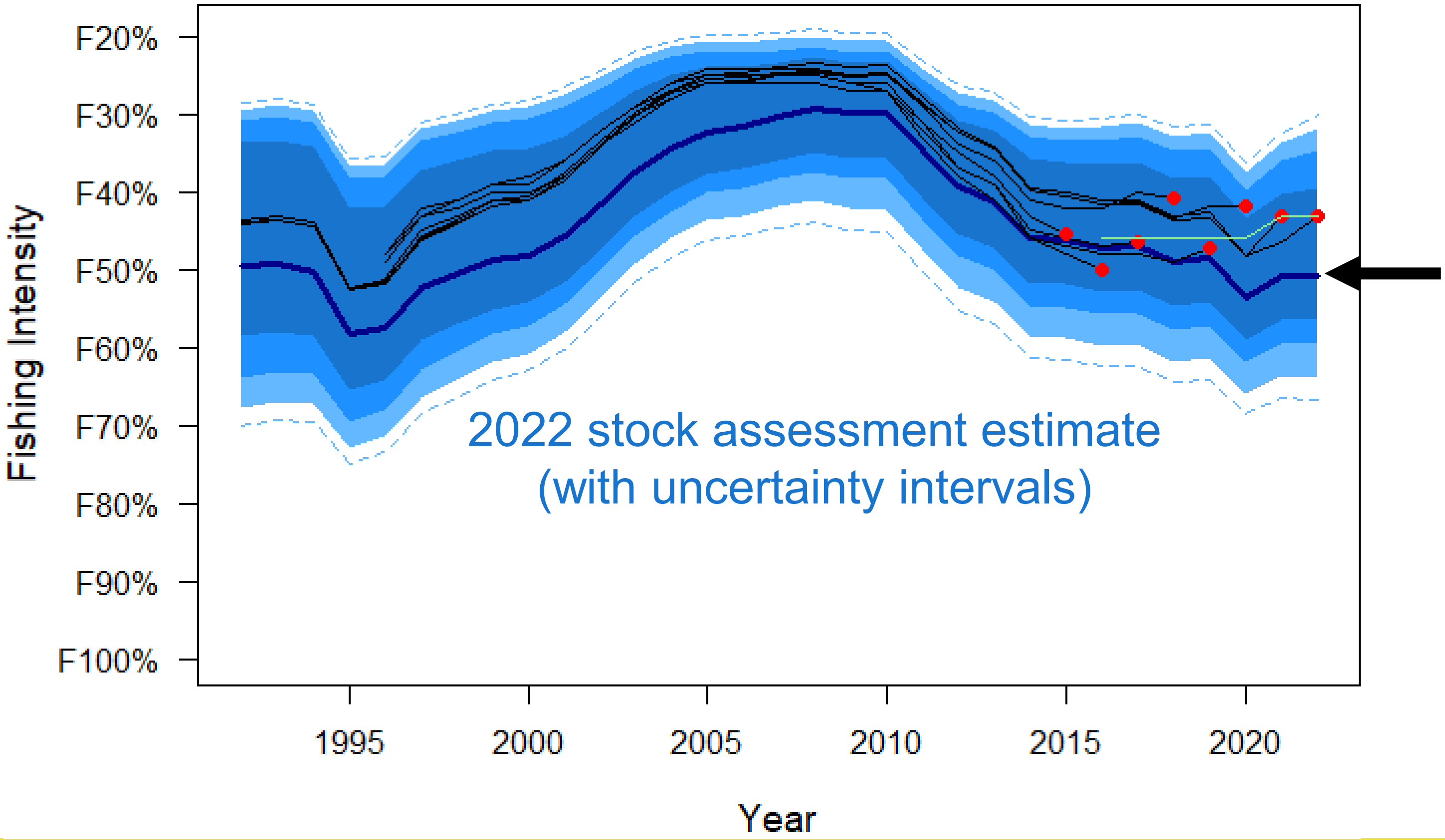
Historical recruitment (2 models)



Fishing intensity (F_{SPR})



Fishing intensity (F_{SPR})

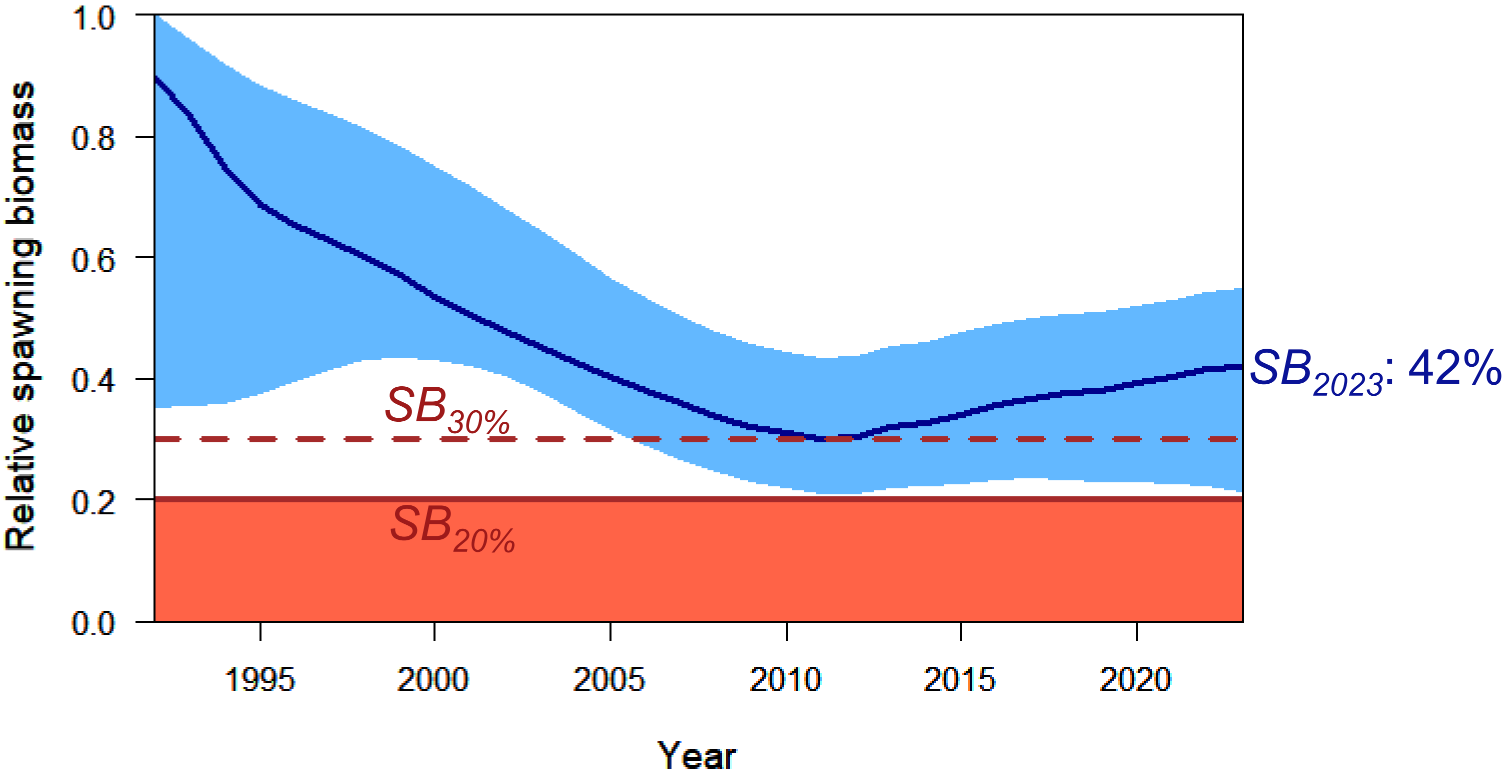


2022

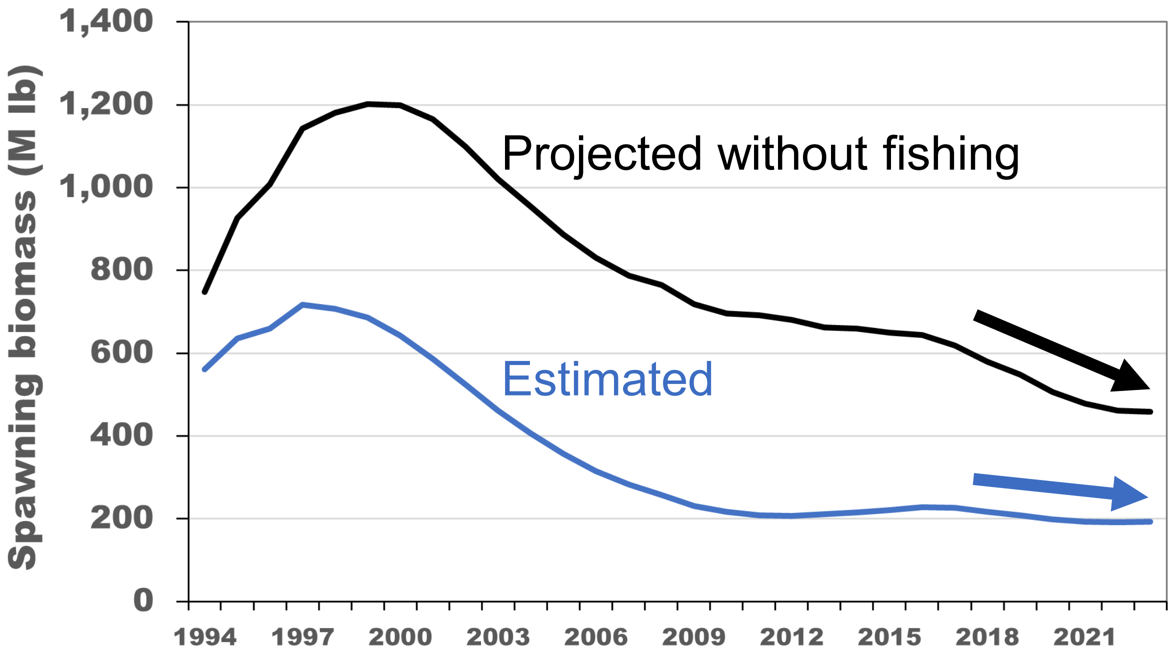
$F_{51\%}$

(32-64%)

Spawning biomass relative to unfished



Spawning biomass relative to unfished



Assessment summary table

Indicators	Values	Trends	Status
BIOLOGICAL			
SPR_{2022}: P(SPR<43%): P(SPR<limit):	51% (32-64%) 27% LIMIT NOT SPECIFIED	FISHING INTENSITY UNCHANGED FROM 2021 TO 2022	FISHING INTENSITY BELOW REFERENCE LEVEL
SB_{2023} (Mlb): SB_{2023}/SB_0: $P(SB_{2023}<SB_{30})$: $P(SB_{2023}<SB_{20})$:	192 (122–272) Mlbs 42% (21-55%) 25% <1%	SB DECREASED 16% FROM 2016 TO 2023	NOT OVERFISHED
Biological stock distribution:	SEE TABLES AND FIGURES	REGION 3 DECREASED FROM 2021 TO 2022	WITHIN HISTORICAL RANGES
FISHERY CONTEXT			
Total mortality 2022: Percent retained 2022: Average mortality 2018-22:	39.69 Mlbs, 18,003 t 85% 38.10 Mlbs, 17,294 t	MORTALITY INCREASED FROM 2021 TO 2022	2022 MORTALITY NEAR 100-YEAR LOW

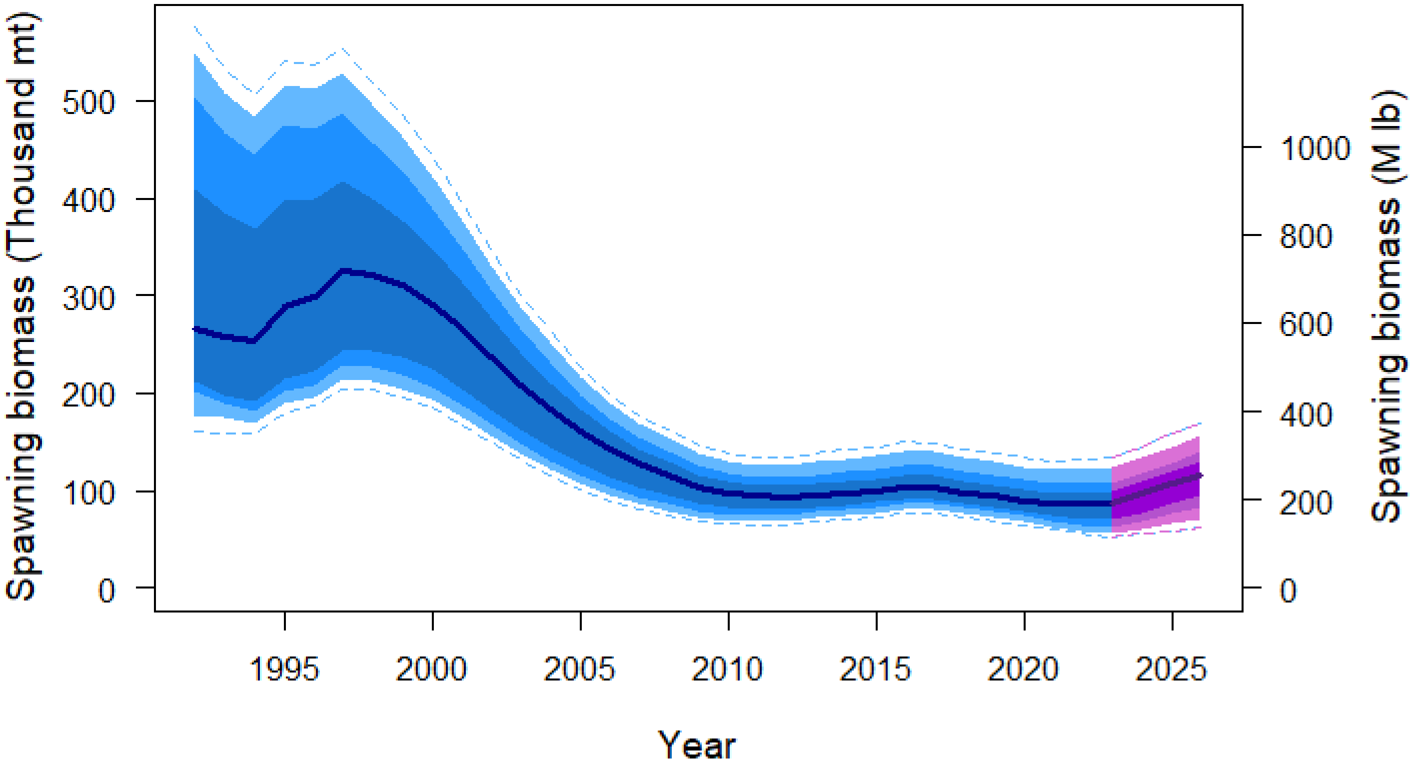
Outline

- Data sources
- Modelling results
- Projections and decision table

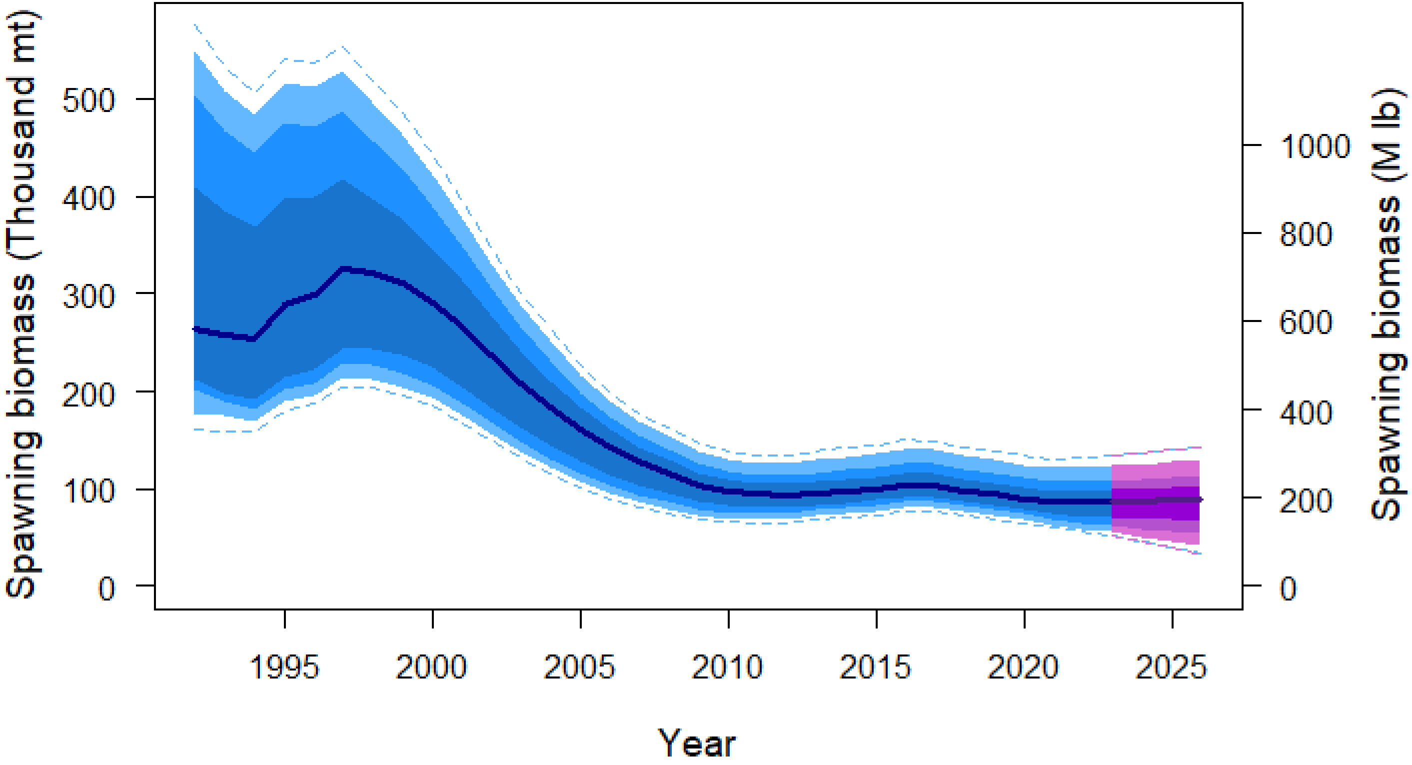
Projections and decision table

- Constant TCEY for the next three years
- Range of mortality, from no fishing mortality to 60 Mlb TCEY, additional detail from $F_{40\%}$-$F_{46\%}$
- 6 specific projections:
  - Reference level: 2023 TCEY estimated to result in $F_{43\%}$
  - 3-year surplus: 50/50 odds of spawning biomass dropping below 2023 estimate by 2026
  - *Status quo*
  - *Status quo -10%*
  - *Status quo -15%*
  - *Status quo -18%*

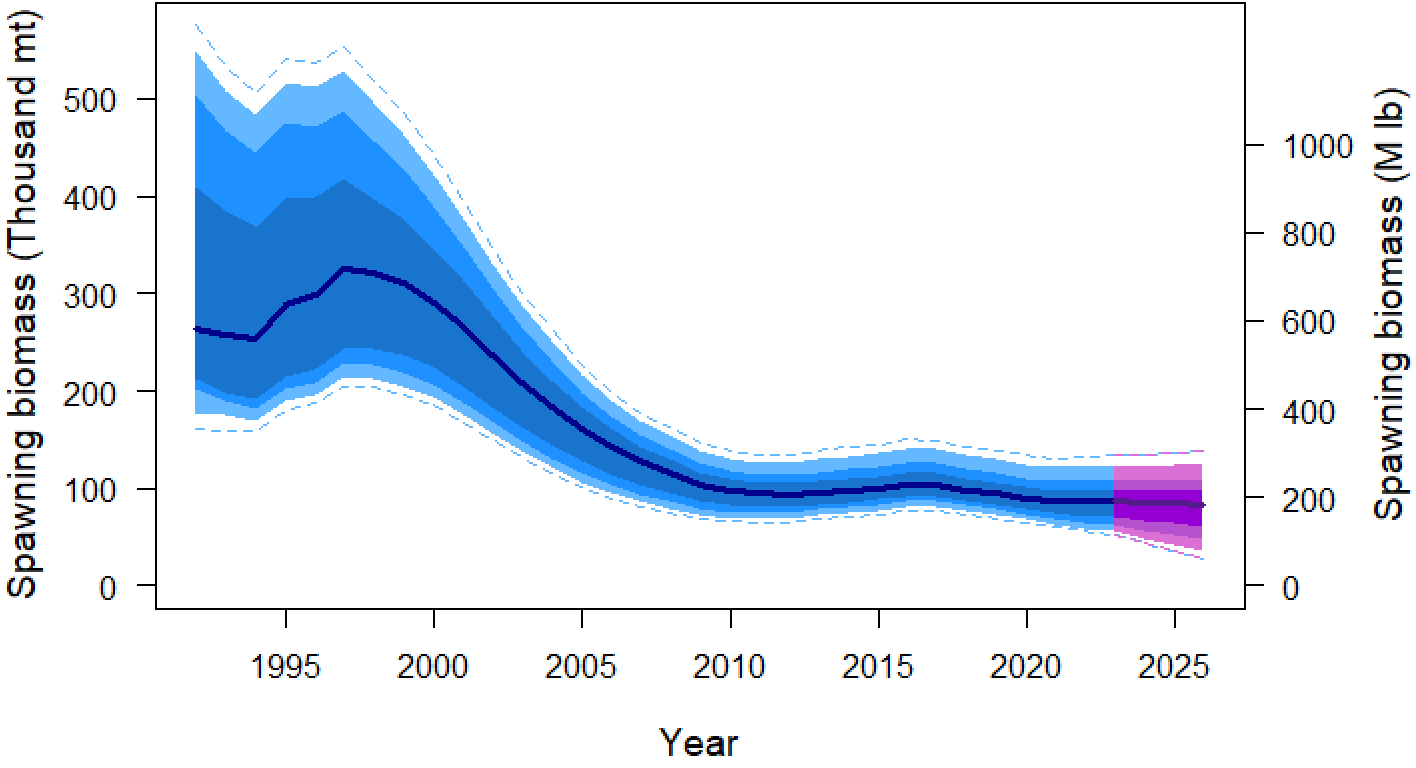
Projections: no fishing mortality



Projections: 3-yr surplus (43.0 Mlb TCEY)



Projections: reference level (52.0 Mlb TCEY)



Decision table

- Risk-benefit trade-offs:
  - Yield vs. probability of stock and fishery trend and status decreases
- Fishery metrics relative to $F_{43\%}$ with an $SB_{30\%}$:$SB_{20\%}$ control rule

Decision table: Yield options

2023 Alternative			*Status quo -18%*	*Status quo -15%*	*Status quo -10%*	*Status quo*	3-Year Surplus				*Reference $F_{43\%}$*				
Total mortality (M lb)	0.0	31.3	35.1	36.4	38.4	42.5	44.3	48.1	49.8	51.5	52.3	55.1	57.1	59.1	61.3
TCEY (M lb)	0.0	30.0	33.8	35.0	37.1	41.2	43.0	46.8	48.4	50.2	52.0	53.8	55.8	57.8	60.0
2023 fishing intensity	$F_{100\%}$	$F_{59\%}$	$F_{55\%}$	$F_{54\%}$	$F_{53\%}$	$F_{50\%}$	$F_{48\%}$	$F_{46\%}$	$F_{45\%}$	$F_{44\%}$	$F_{43\%}$	$F_{42\%}$	$F_{41\%}$	$F_{40\%}$	$F_{39\%}$
Fishing intensity interval	--	37-71%	34-68%	33-67%	32-66%	29-63%	28-62%	26-59%	25-59%	24-58%	24-57%	23-56%	22-55%	21-54%	21-53%

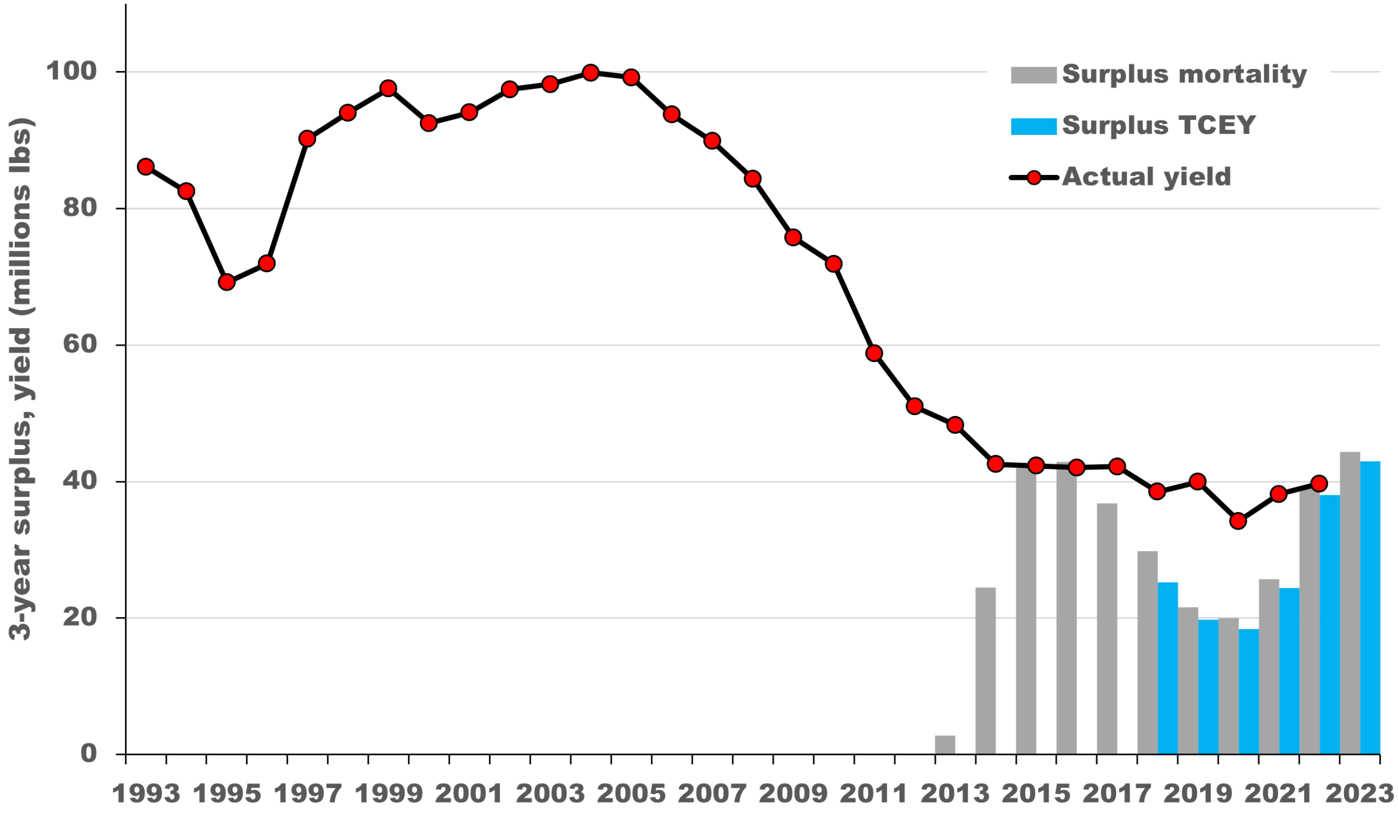
30 Mlb

$F_{46\%}$-$F_{40\%}$

60 Mlb

No fishing mortality

Recent estimates of surplus production



Full decision table

2023 Alternative					Status quo -18%	Status quo -15%	Status quo -10%	Status quo	3-Year Surplus				Reference $F_{43\%}$					
Total mortality (M lb)			0.0	31.3	35.1	36.4	38.4	42.5	44.3	48.1	49.8	51.5	52.3	55.1	57.1	59.1	61.3	
TCEY (M lb)			0.0	30.0	33.8	35.0	37.1	41.2	43.0	46.8	48.4	50.2	52.0	53.8	55.8	57.8	60.0	
2023 fishing intensity			$F_{100\%}$	$F_{59\%}$	$F_{55\%}$	$F_{54\%}$	$F_{53\%}$	$F_{50\%}$	$F_{48\%}$	$F_{46\%}$	$F_{45\%}$	$F_{44\%}$	$F_{43\%}$	$F_{42\%}$	$F_{41\%}$	$F_{40\%}$	$F_{39\%}$	
Fishing intensity interval			--	37-71%	34-68%	33-67%	32-66%	29-63%	28-62%	26-59%	25-59%	24-58%	24-57%	23-56%	22-55%	21-54%	21-53%	
Stock Trend (spawning biomass)	in 2024	is less than 2023	<1	20	29	32	38	49	53	63	67	71	75	79	83	86	89	a
		is 5% less than 2023	<1	2	4	5	7	13	15	22	25	28	31	35	39	43	47	b
	in 2025	is less than 2023	<1	18	27	30	35	46	50	60	64	68	72	76	80	83	87	c
		is 5% less than 2023	<1	6	11	13	16	24	28	36	40	44	48	52	57	62	67	d
	in 2026	is less than 2023	<1	20	28	31	36	46	50	60	63	67	71	75	79	82	85	e
		is 5% less than 2023	<1	10	16	18	22	31	35	43	47	51	55	59	64	68	72	f
Stock Status (Spawning biomass)	in 2024	is less than 30%	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	g
		is less than 20%	<1	<1	<1	1	1	1	1	1	1	2	2	2	2	3	3	h
	in 2025	is less than 30%	18	25	25	25	25	25	25	25	25	25	25	25	25	25	25	i
		is less than 20%	<1	<1	1	1	1	1	2	3	3	4	4	5	6	6	7	j
	in 2026	is less than 30%	6	23	24	24	24	25	25	25	25	25	25	25	25	25	25	k
		is less than 20%	<1	<1	1	1	1	2	3	4	5	6	6	7	9	10	11	l
Fishery Trend (TCEY)	in 2024	is less than 2023	0	17	24	24	25	28	31	38	41	45	50	55	59	64	69	m
		is 10% less than 2023	0	11	20	22	24	26	27	32	35	38	42	46	51	55	60	n
	in 2025	is less than 2023	0	15	22	24	25	28	30	37	41	45	50	55	60	66	71	o
		is 10% less than 2023	0	11	19	21	23	26	27	32	35	38	42	47	52	57	62	p
	in 2026	is less than 2023	0	14	21	23	24	28	30	37	41	46	51	56	62	67	72	q
		is 10% less than 2023	0	10	18	20	22	25	27	32	35	39	43	48	53	58	64	r
Fishery Status (Fishing intensity)	in 2023	is above $F_{43\%}$	0	19	24	25	26	29	31	38	42	46	50	54	59	63	68	s

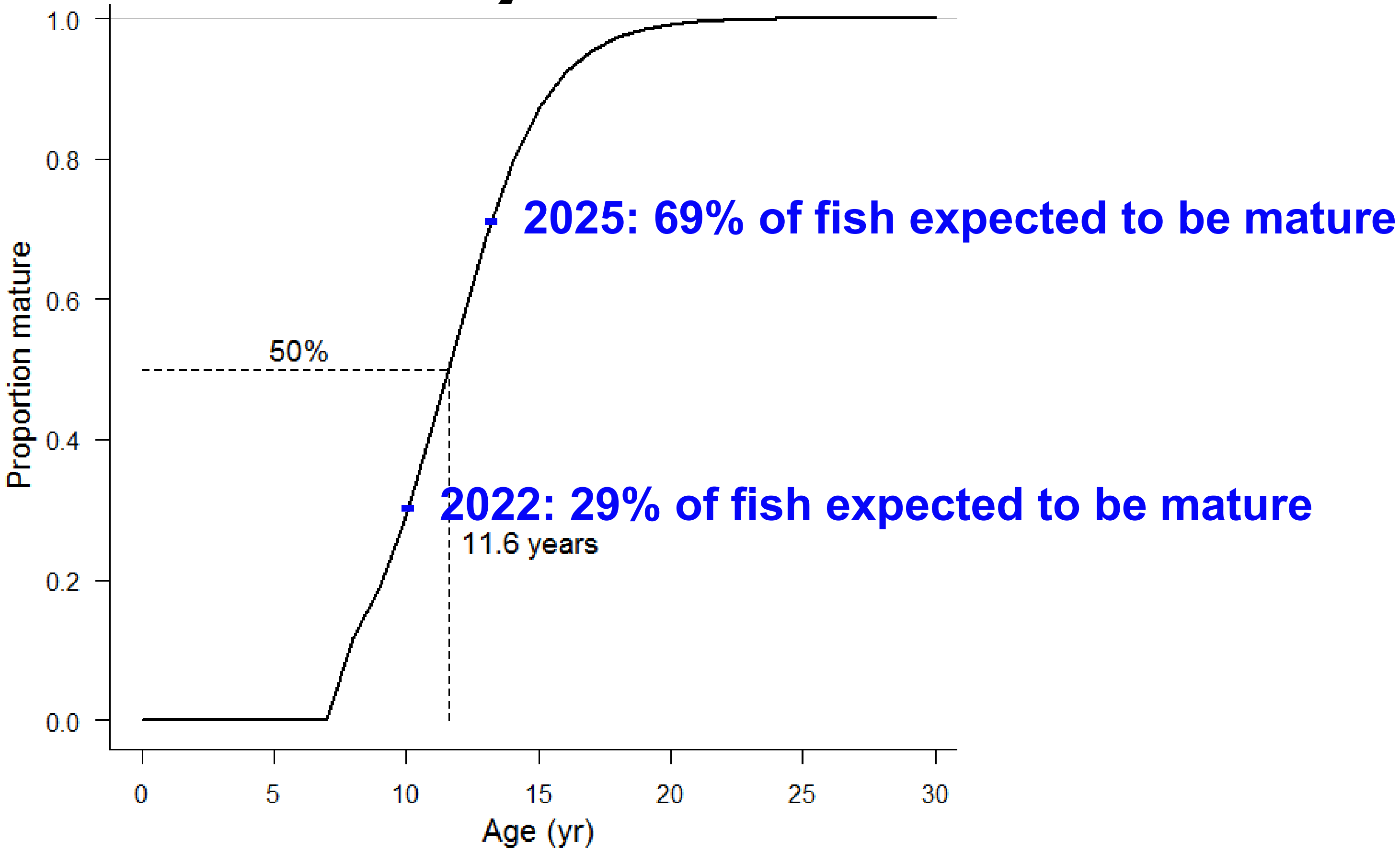
Decision table

- $F_{43\%}$ (52.0 Mlb):
  - 75/100 chance of 1-yr SB decline (71/100 3-yr)
  - 50/100 chance of exceeding $F_{43\%}$
- 3-year surplus (43.0 Mlb):
  - 53/100 chance of 1-yr SB decline (50/100 3-yr)
  - 31/100 chance of exceeding $F_{43\%}$
- Status quo (41.2 Mlb):
  - 49/100 chance of 1-yr SB decline (46/100 3-yr)
  - 29/100 chance of exceeding $F_{43\%}$
- Status quo -10% (37.1 Mlb):
  - 38/100 chance of 1-yr SB decline (36/100 3-yr)
  - 26/100 chance of exceeding $F_{43\%}$
- Status quo -15% (35.0 Mlb):
  - 32/100 chance of 1-yr SB decline (31/100 3-yr)
  - 25/100 chance of exceeding $F_{43\%}$
- Status quo -18% (33.8 Mlb):
  - 29/100 chance of 1-yr SB decline (28/100 3-yr)
  - 24/100 chance of exceeding $F_{43\%}$

Additional risks

- 2022 FISS and directed commercial fishery catch rates were at the lowest values observed in the last 30 years.
- TCEYs greater than 43 million pounds are likely to result in further declines, despite being consistent with long-term sustainable harvest rates.
- The FISS and fishery have transitioned to the 2012 year-class, 29% mature in 2022; projections rely heavily on this year class growing and maturing 'on schedule'.

Maturity of the 2012 year-class



Recent coastwide TCEYs

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
SPR	--	--	--	46%	46%	46%	46%	43%	43%	43%
Reference	33.48	35.48	36.31	39.10	31.00	40.00	31.90	39.00	41.22	51.95
% change	*-9%*	*6%*	*2%*	*8%*	*-21%*	*29%*	*-20%*	*22%*	*6%*	*26%*
Adopted	36.65	39.63	39.59	40.74	37.21	38.61	36.60	39.00	41.22	--
% change	*-19%*	*8%*	*0%*	*3%*	*-9%*	*4%*	*-5%*	*7%*	*6%*	--

Distribution of the TCEY

- *Pending guidance from the Commission*

Recommendations

That the Commission:

1) **NOTE** paper IPHC-2022-IM098-11 which provides a summary of data, the 2022 stock assessment and the harvest decision table for 2023.

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