2025 Update Assessment for Pacific sardine (*Sardinops sagax*)

Presentation for the PFMC SSC CPS subcommittee

February 26, 2025

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2025 Update Assessment

- Northern subpopulation of Pacific sardine
- Same model configuration as 2024 benchmark assessment
- Semester-based model: S1 (July-December); S2 (January-June)
    - Calendar year: Jan-Dec 2024; Model year: July 2024-June 2025

Calendar Y-S	Model Y-S	Months
2024-1	2023-2	January - June
2024-2	2024-1	July - December

2025 Update Assessment

- Fleet configurations
  - MexCal_S1 (Ensenada, Mexico; southern and central California)
  - MexCal_S2 (same regions, different time period)
  - PNW (Oregon; Washington; British Columbia, Canada)

Data updates

- Catch through **model** year-semester 2024-1 (July - December, 2024)
- Fishery age compositions through 2023-2 (January - June, 2024)
- Fishery weight-at-age through 2023-2
  - Re-ran the state-space model with new data
- Survey biomass estimates (core AT + nearshore purse-seine) from 2024

- Minor correction: 2023 survey age comps sample size updated from 9 to 17

- *Data not updated:*
  - Survey age compositions and weight-at-age from 2024

Landings by region (mt)

Calendar Y-S	Model Y-S	ENS Total	ENS NSP	SCA Total	SCA NSP	CCA	OR	WA	BC
2020-1	2019-2	74,817	0	681	67	328	0	0	0
2020-2	2020-1	74,687	0	1,204	0	429	0	0	0
2021-1	2020-2	48,988	0	603	187	37	3	0	0
2021-2	2021-1	74,710	0	1,093	90	3	9	3	0
2022-1	2021-2	73,385	0	663	192	2	0	0	0
2022-2	2022-1	79,533	0	988	52	116	7	2	0
2023-1	2022-2	39,810	0	493	374	14	0	0	0
2023-2	2023-1	96,556	0	1,053	292	152	1	0	0
2024-1	2023-2	114,368	0	493	324	75	0	0	0
2024-2	2024-1	43,829	0	762	257	10	0	0	0

Landings by fleet (mt)

Calendar Y-S	Model Y-S	MexCal S1	MexCal S2	PNW
2020-1	2019-2	0	395	0
2020-2	2020-1	429	0	0
2021-1	2020-2	0	224	3
2021-2	2021-1	93	0	12
2022-1	2021-2	0	193	0
2022-2	2022-1	168	0	9
2023-1	2022-2	0	387	0
2023-2	2023-1	445	0	1
2024-1	2023-2	0	399	0
2024-2	2024-1	267	0	0

Calendar Y-S	Model Y-S	MexCal S1	MexCal S2	PNW
2023-1	2022-2	0	387 (340)	0
2023-2	2023-1	445 (152)	0	1
2024-1	2023-2	0	399 (0)	0
2024-2	2024-1	267	0	0

Parentheses indicate the 2024 benchmark values

Survey biomass estimates

Region	Number	Area	Transects	Distance	Clusters	Individuals	Biomass estimate (mt)	CI (lower 5%)	CI (upper 95%)	CV
Core	3	3,877	9	392	3	61	20	5	43	51
Core	4	1,885	6	203	1	1	3	0	6	60
Core	5	8,768	18	861	4	570	314	42	865	74
Core	Total	14,530	33	1,456	8	632	**337**	64	892	69
Nearshore	1	238	14	53	4	149	34,060	5,601	48,627	32
Nearshore	2	317	12	49	3	101	43,223	4,787	126,693	76
Nearshore	3	84	3	13	1	549	129	0	270	81
Nearshore	4	103	4	16	1	1	0	0	1	84
Nearshore	5	66	4	10	1	1	0	0	1	72
Nearshore	Total	808	37	141	10	801	**77,412**	21,736	155,856	45
TOTAL		15,338	70	1597	18	1433	**77,750**	21,800	156,748	45

Preliminary results presented to SSC CPS Subcommittee

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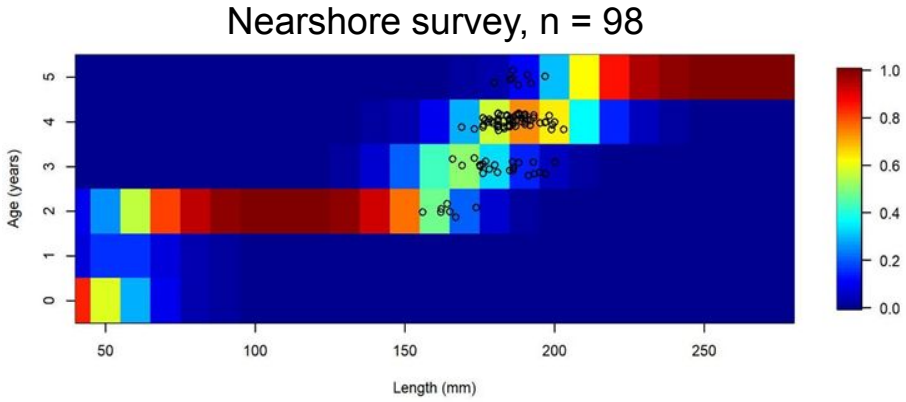
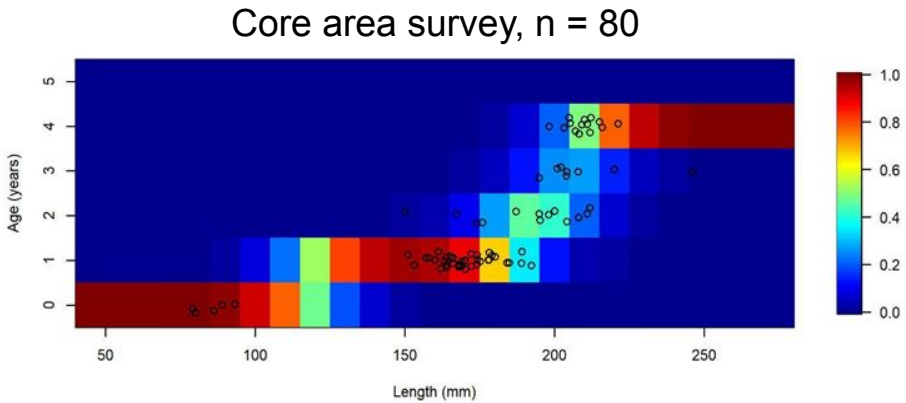
Survey biological sample data

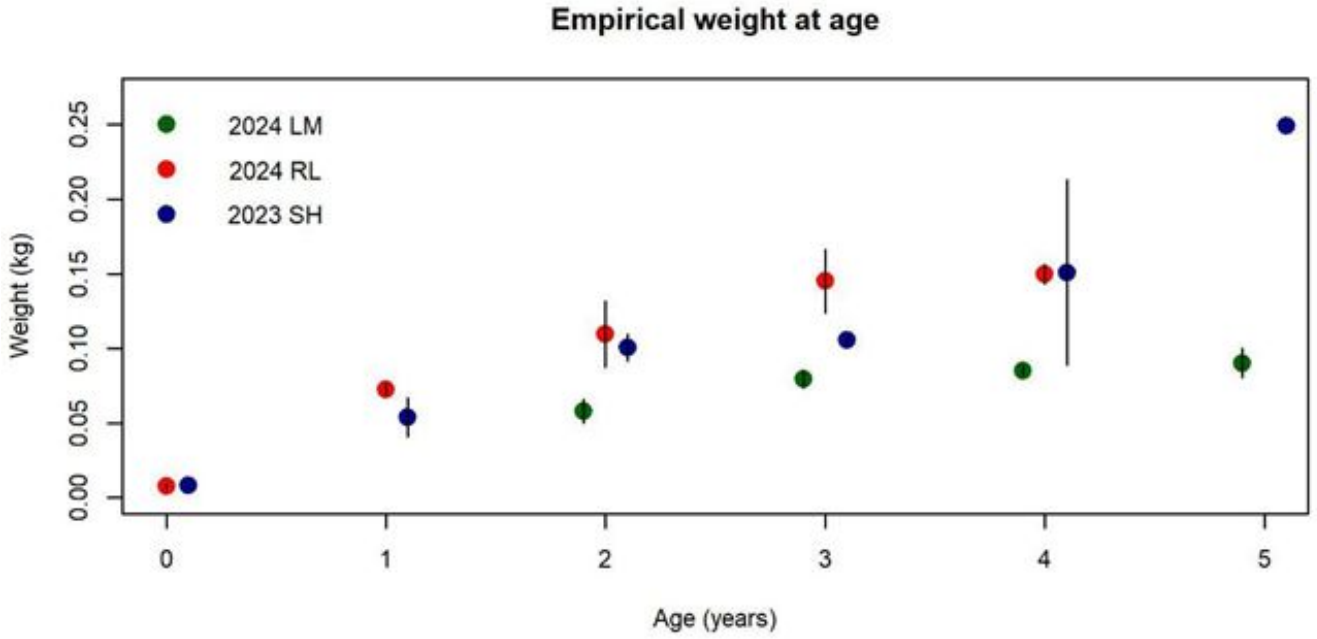




- The survey age composition and weight-at-age data were not included for 2024
- Core area: 80 individuals
- Nearshore: 98 individuals (99% biomass, from two strata)

Model-year	age-0	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8
2024	0.003	0.002	0.065	0.231	0.599	0.100	0.000	0.000	0.000

Survey weight-at-age data



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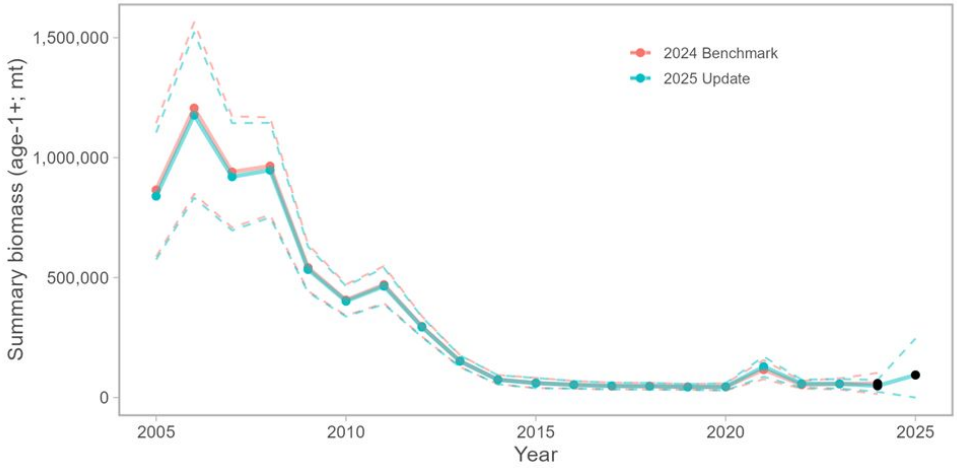
Forecast F (catch in mt)

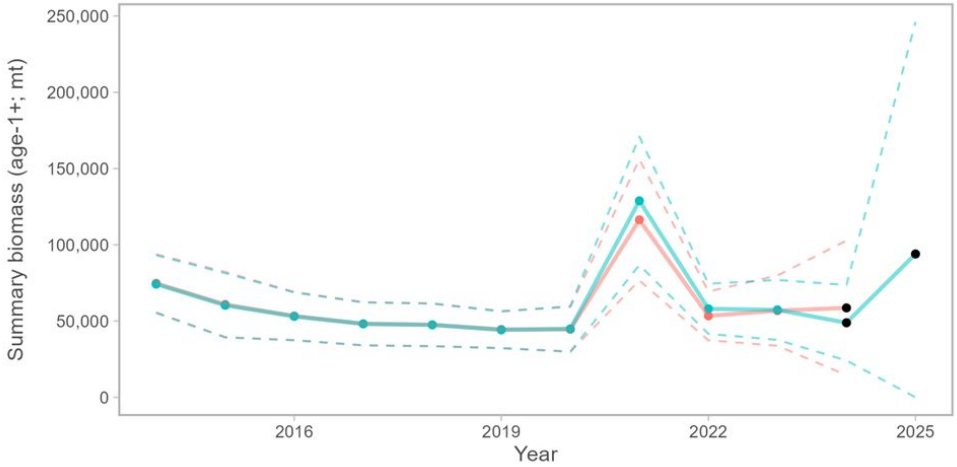
Calendar Y-S	Model Y-S	MexCal S1		MexCal S2		PNW	
		Catch	F (yr^{-1})	Catch	F (yr^{-1})	Catch	F (yr^{-1})
2024-1	2023-2	0	0.00	399	0.04	0	0.00
2024-2	2024-1	267	0.04	0	0.00	0	0.00

Model updates

Model configuration details	Benchmark	Update
Time period	2005-2023	2005-2024
Fishery fleets	3, commercial	3, commercial
Survey fleets	1, AT	1, AT
Natural mortality (M)	Estimated (prior)	Estimated (prior)
Growth	Fixed (WAA)	Fixed (WAA)
Spawner-recruit relationship	Beverton-Holt	Beverton-Holt
Equilibrium recruitment (R0)	Estimated	Estimated
Steepness (h)	Fixed (0.65)	Fixed (0.65)
Total recruitment variablitly (sigmaR)	Fixed (1.2)	Fixed (1.2)
SR regime offset	Estimated	Estimated
Catchability (q)	Fixed (1 for 2005-2014; 0.73 for 2015-2019; variable 2020-2023)	Fixed (1 for 2005-2014; 0.73 for 2015-2019; variable 2020-2024)
Selectivity	Estimated	Estimated
Fishery selectivity	Dome-shaped and asymptotic	Dome-shaped and asymptotic
Age compositions	Yes	Yes
Form	Age-specifc, random walk (MexCal) / Logistic (PNW)	Age-specifc, random walk (MexCal) / Logistic (PNW)
Time-varying	Yes (2dAR)	Yes (2dAR)
Survey selectivity	Asymptotic	Asymptotic
Age compositions	Yes	Yes
Form	Age-specific, asymptotic	Age-specific, asymptotic
Time-varying	Yes (age-0)	Yes (age-0)
	Random walk (option 17)	Random walk (option 17)
Data weighting	No	No

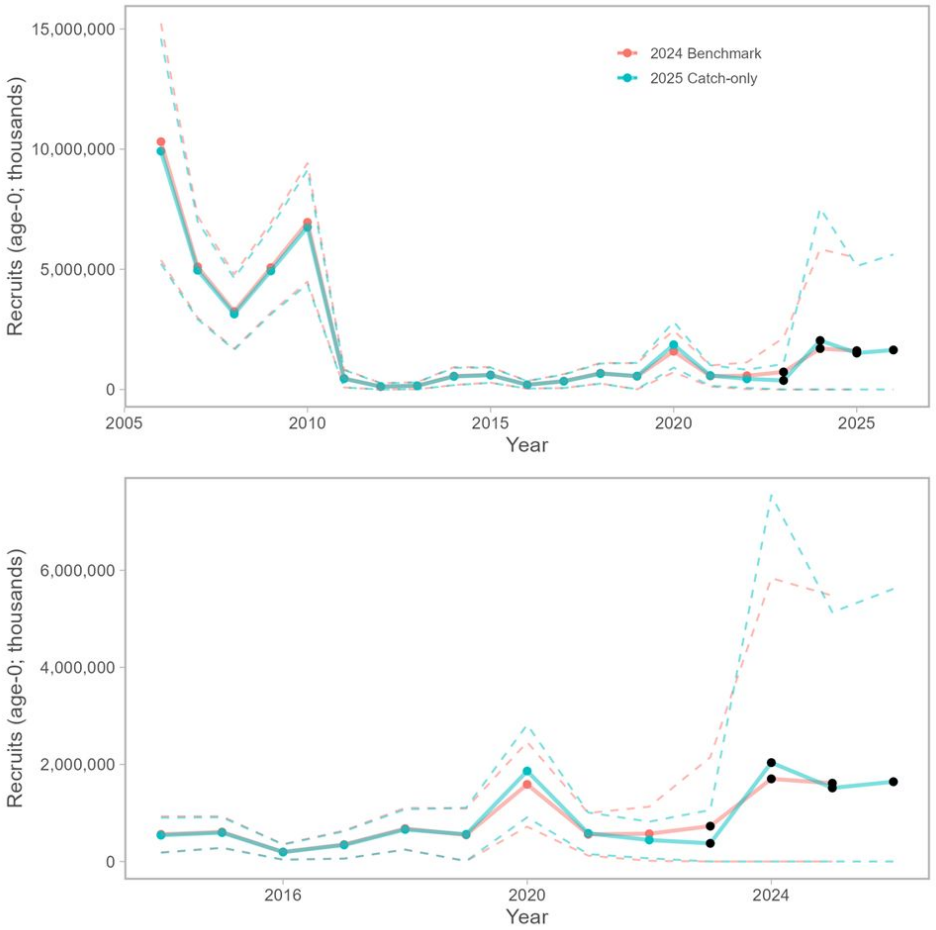
Biomass





Black points for 2024 and 2025 are forecast years driven by the stock-recruit relationship

Recruitment



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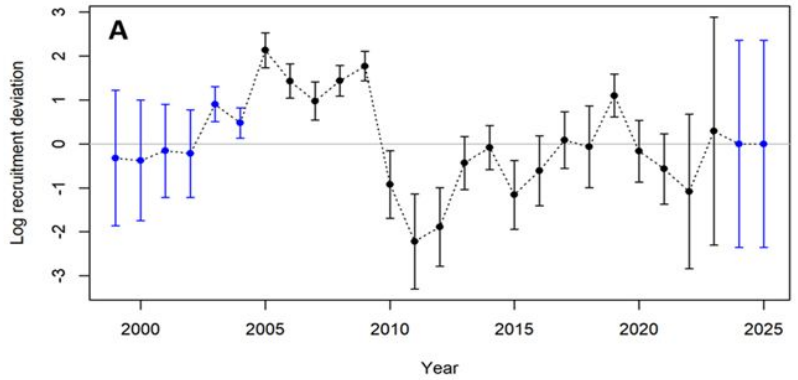
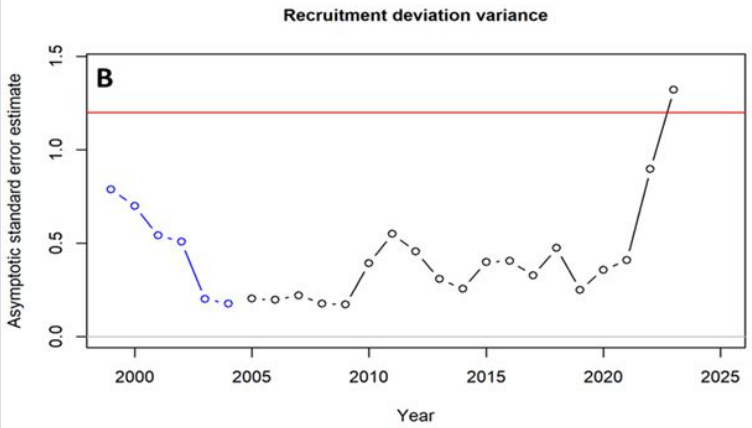
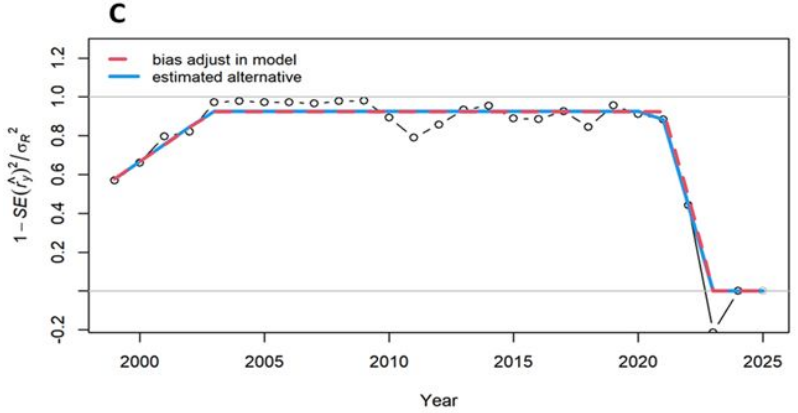
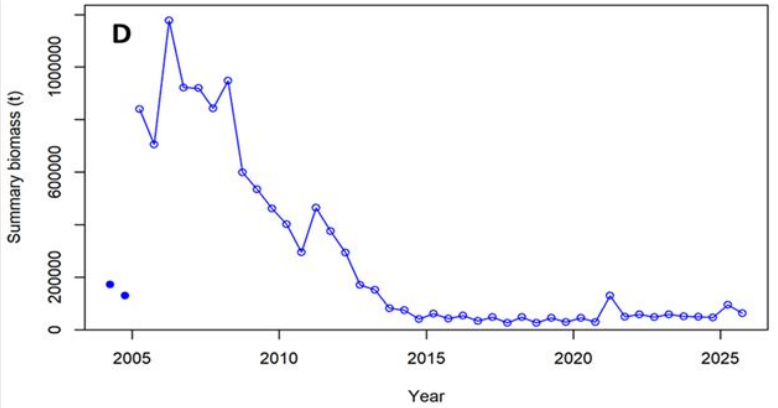
Model fits









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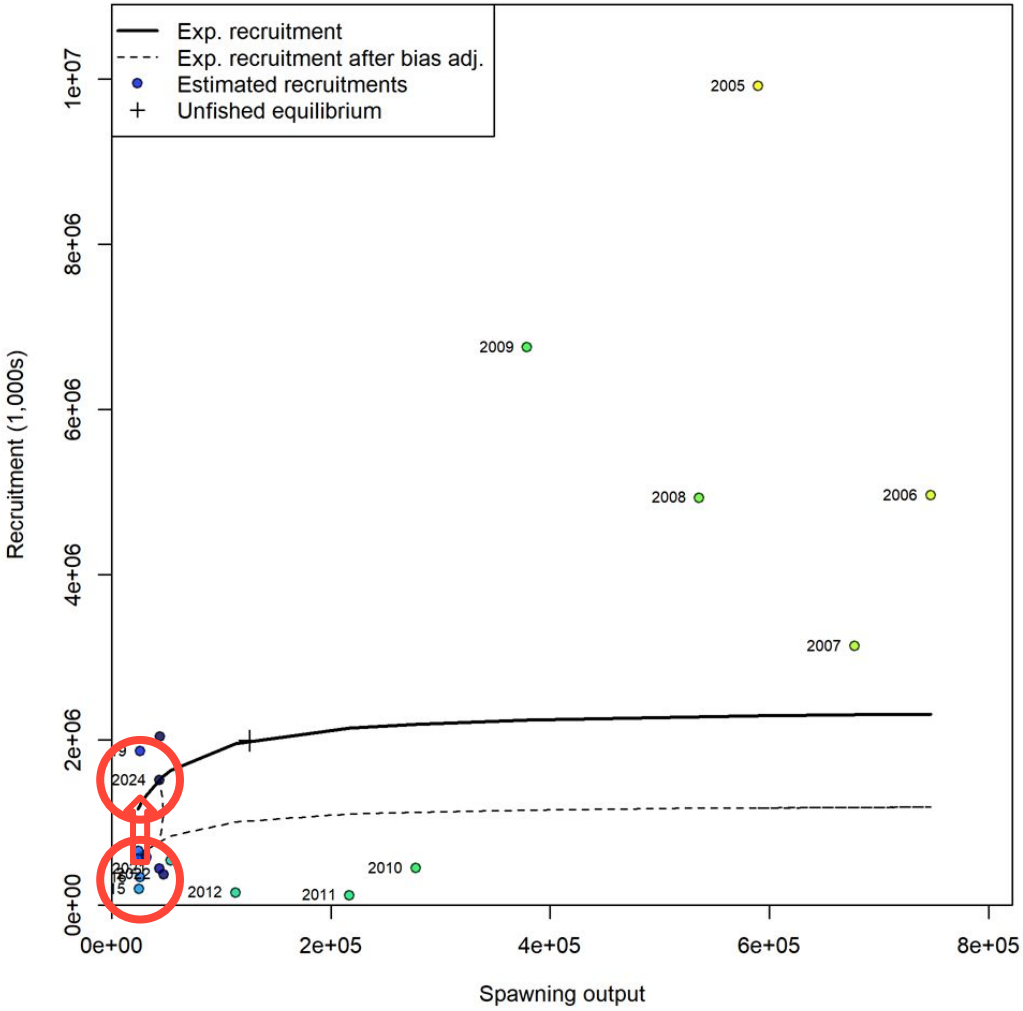
Model fits

2024 reversion to a higher mean stock-recruit curve than seen in recent years results in a 2024 recruitment spike, followed by a 2025 doubling of projected biomass.



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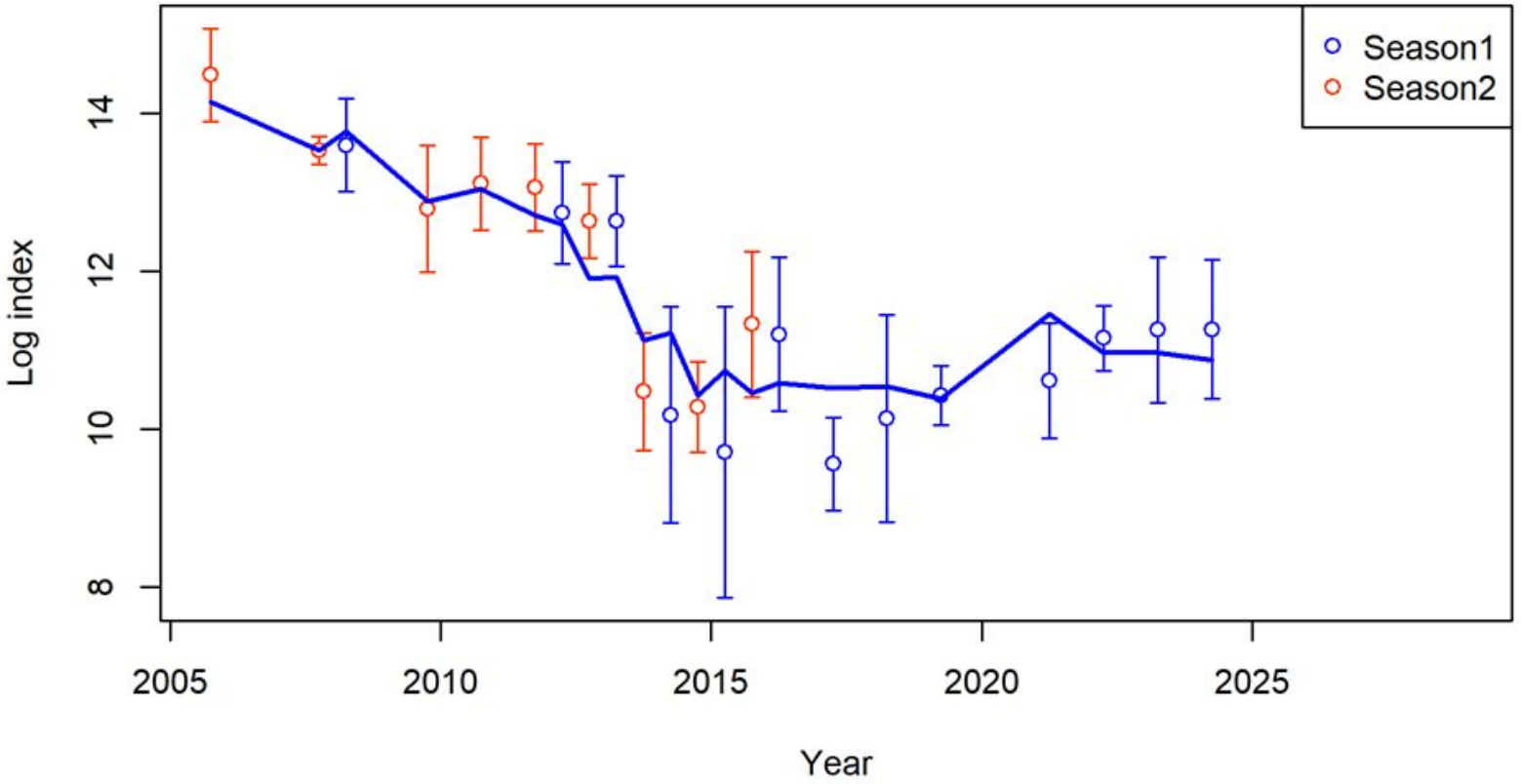
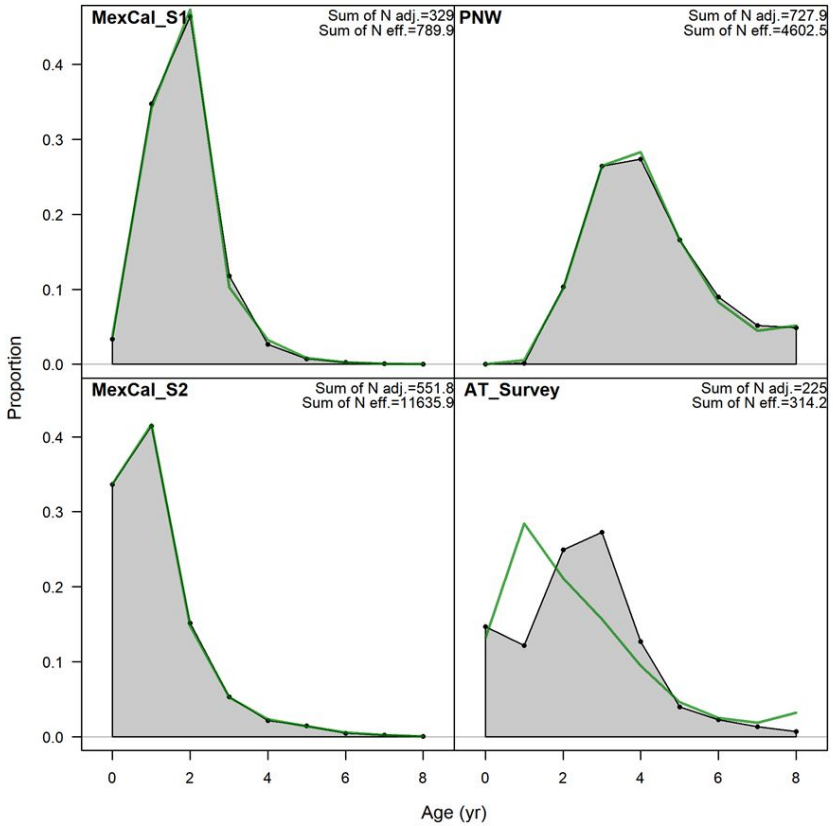
Model fits - Index



Model fits - Age compositions



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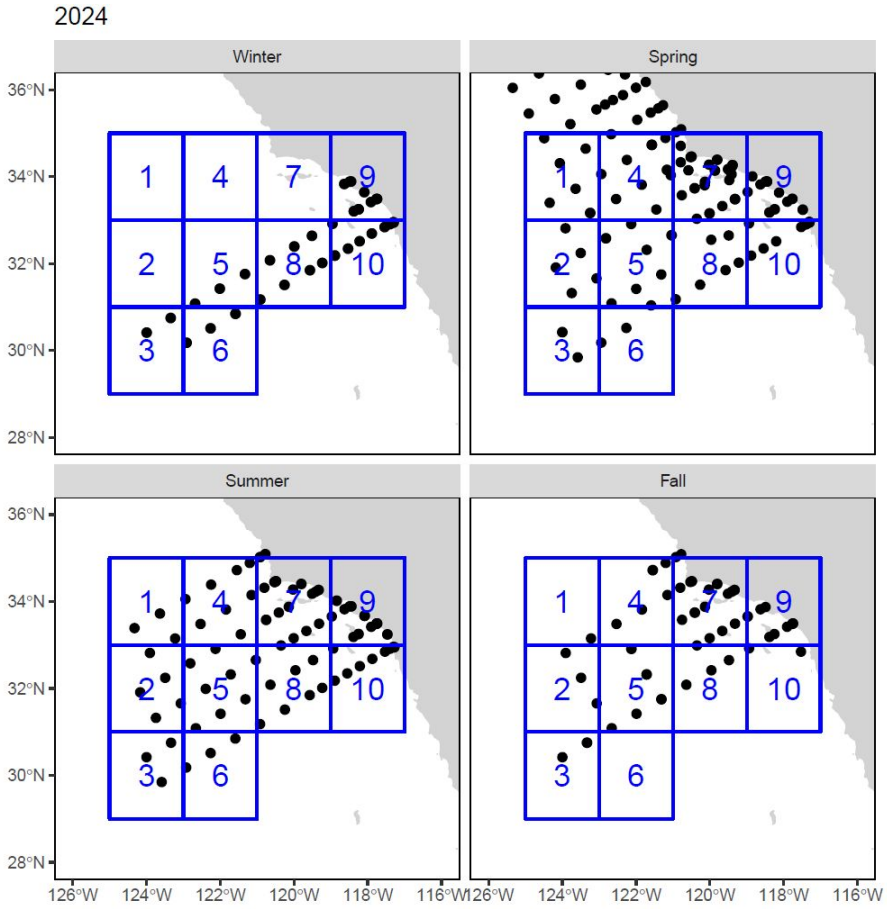
CalCOFI SST

- CalCOFI sea-surface temperature (SST) of 15.69 (average for 2022-2024), resulting in an EMSY of 0.1771

- Followed Ed Weber's method: CalCOFI mean SST, using ERSST satellite data to fill in for cruises with low coverage.



Harvest guidelines

Harvest Control Rule Formulas									
OFL = BIOMASS * E_{MSY} * DISTRIBUTION; where E_{MSY} is bounded 0.00 to 0.25									
$ABC_{P\text{-}star}$ = BIOMASS * $BUFFER_{P\text{-}star}$ * E_{MSY} * DISTRIBUTION; where E_{MSY} is bounded 0.00 to 0.25									
HG = (BIOMASS – CUTOFF) * FRACTION * DISTRIBUTION; where FRACTION is E_{MSY} bounded 0.05 to 0.20									
Harvest Guideline Parameters									
BIOMASS (ages 1+, mt)	**93,972**								
P-star	0.45	0.4	0.35	0.3	0.25	0.2	0.15	0.10	0.05
ABC $Buffer_{Tier\ 1}$	0.8756	0.765	0.6654	0.5744	0.4901	0.4107	0.3343	0.258	0.1757
ABC $Buffer_{Tier\ 2}$	0.8514	0.723	0.6106	0.511	0.4216	0.3404	0.2653	0.1938	0.1217
ABC $Buffer_{Tier\ 3}$	0.7778	0.6025	0.4627	0.3504	0.2595	0.1858	0.1258	0.0771	0.0373
CalCOFI SST $_{(2022\text{-}2024)}$	15.69								
E_{MSY}	0.1771								
FRACTION	0.1771								
CUTOFF (mt)	150,000								
DISTRIBUTION (U.S.)	0.87								
Harvest Control Rule Values									
OFL =	**14,475**								
$ABC_{Tier\ 1}$ =	12,675	11,074	9,632	8,315	7,094	5,945	4,839	3,735	2,543
$ABC_{Tier\ 2}$ =	12,324	10,466	8,839	7,397	6,103	4,927	3,840	2,805	1,762
$ABC_{Tier\ 3}$ =	11,259	8,721	6,698	5,072	3,756	2,690	1,821	1,116	540
HG =	**0**								

Recent harvest (mt)

*2024-2025 catch is preliminary through Dec. 31, 2024.

Mgmt. Year	OFL	ABC	HG or ACL	Tot. Landings	NSP Landings
2020-21	5,525	4,288	4,000	2,276	657
2021-22	5,525	3,329	3,000	1,772	298
2022-23	5,506	4,274	3,800	1,620	565
2023-24	5,506	3,953	3,600	1,774	844
2024-25*	8,312	6,005	5,500	*772*	*267*

Sensitivity analyses

- The 2024 age comps were not considered to be representative of the population
  - Sampled from mainly the nearshore with purse seines
  - Nearshore represented ~99% biomass
- 2024 weight-at-age data not considered to be representative
  - Similar issues as age comps
  - No age-0 fish in the nearshore samples
- Data sensitivities explored
  - Add 2024 weight-at-age
  - Add 2024 age comps
  - Add both
- Alternative models explored: stock-recruit uncertainties

Sensitivity analyses

- Without age comps, model attributes survey biomass to recruitment
  - Results in a huge 2024 recruitment event, leading to a doubling of forecasted biomass for 2025
  - Explore model results when age comps were included

- The large recruitment event is due to the model reverting to a mean stock-recruit relationship that is much higher than recently observed data.
  - The modeling solution was to add a stock-recruit regime block

Sensitivity: data modifications

- 2025.1a - Base model: 2023 weight-at-age used for 2024, no 2024 age composition, last recruitment deviation in 2023

- 2025.1b - add 2024 weight-at-age
- 2025.1c - add 2024 weight-at-age and age comps
- 2025.1d - add 2024 weight-at-age and age comps and set last recruitment deviation to 2024

Alternative model results

Model	Model name	Change type	2023 1+bio	2024 1+bio	2025 1+bio	2023 recr	2024 recr	2025 recr	OFL
2025 Base	2025.1a	Base	57,318	48,865	**93,972**	373,932	2,037,160	1,515,520	14,475
2024 waa only	2025.1b	Data	59,381	44,205	**84,562**	574,699	2,094,550	1,581,900	13,026
2024 survey data, early redev	2025.1c	Data	62,217	36,200	**30,382**	209,485	296,964	1,301,960	4,680
2024 survey data update	2025.1d	Data	62,214	36,190	**30,158**	209,191	289,283	1,391,300	4,645

Sensitivity: model modifications

- 2025.1a - Base model: 2023 weight-at-age used for 2024, no 2024 age composition, last recruitment deviation in 2023

- 2025.2a - change last recruitment deviation to 2022
- 2025.3a - 2022 rec dev and stock-recruit regime added for 2021-2022
- 2025.4a - 2022 rec dev and stock-recruit regime added for 2015-2022
- 2025.5a - 2022 rec dev and stock-recruit regime added for 2005-2022

Alternative model results

Model	Model name	Change type	2023 1+bio	2024 1+bio	2025 1+bio	2023 recr	2024 recr	2025 recr	OFL
2025 Base	2025.1a	Base	57,318	48,865	**93,972**	373,932	2,037,160	1,515,520	14,475
Early recdev	2025.2a	Model	57,521	49,191	**77,477**	380,191	1,441,230	1,481,420	13,385
Recent regime	2025.3a	Model	55,677	43,263	**42,504**	212,428	334,468	310,398	6,547
Closure regime	2025.4a	Model	55,241	44,529	**62,391**	274,397	1,024,460	978,206	9,611
Full ts regime	2025.5a	Model	53,382	45,381	**57,219**	355,201	830,794	759,118	8,814

Remaining uncertainties

- Further investigation of the stock-recruit parameterization
- Movement dynamics
    - Low abundance in the core survey area, with concentrated abundance in the Central California nearshore area
- Japanese sardine overlap with Pacific sardine

Acknowledgements

So many thanks to so many groups and individuals!

State partners at CDFW, ODFW, and WDFW
Nearshore survey participants: captains and crew of *F/V Lisa Marie and F/V Long Beach Carnage*, CWPA, WCPCG, and CDFW and WDFW partners
INAPESCA for Ensenada landings
SWFSC staff, especially AST and LHG groups
Colleagues at NWFSC for model support (Ian Taylor and Jason Cope).
Stock assessment teammates at SWFSC

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Questions and discussion

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