NOAA FISHERIES

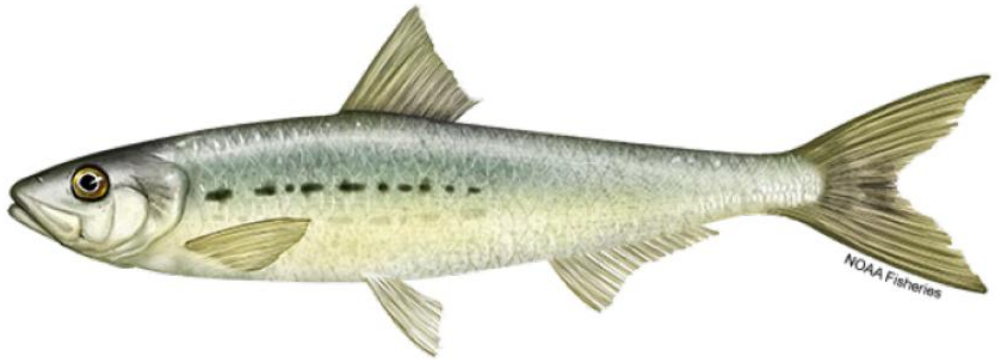
SWFSC

Age and growth of Pacific Sardine (*Sardinops sagax*) in United States waters during the recent period of low population biomass, 2012-2021

Unpublished (In Review)

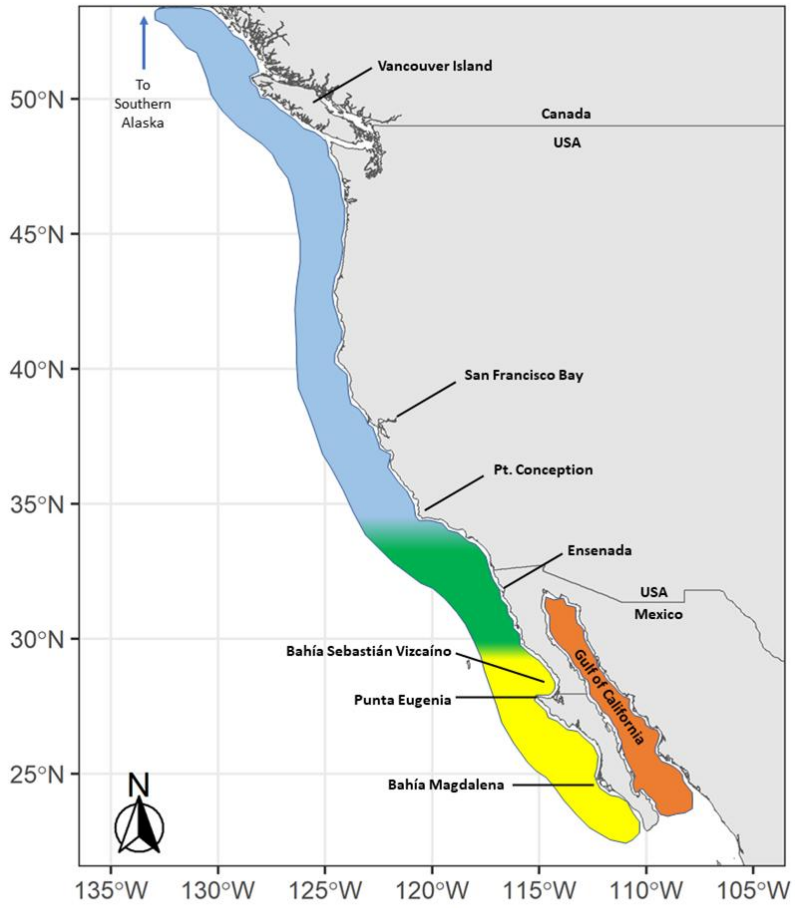
K.C. James, J.M. Walker, B.D. Schwartzkopf, E. Dorval, and B. Erisman*

07 May 2026



Pacific Sardine Distribution and Abundance in Northeast Pacific

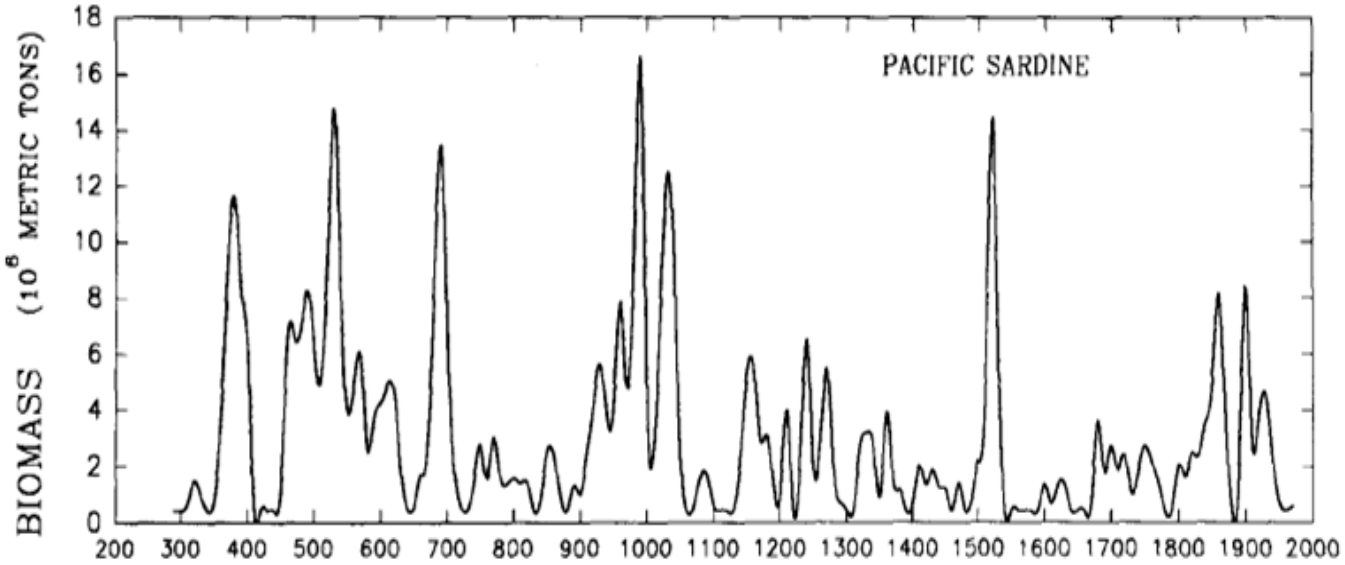
Range: SW Canada to NW Mexico



Craig et al. (2025)

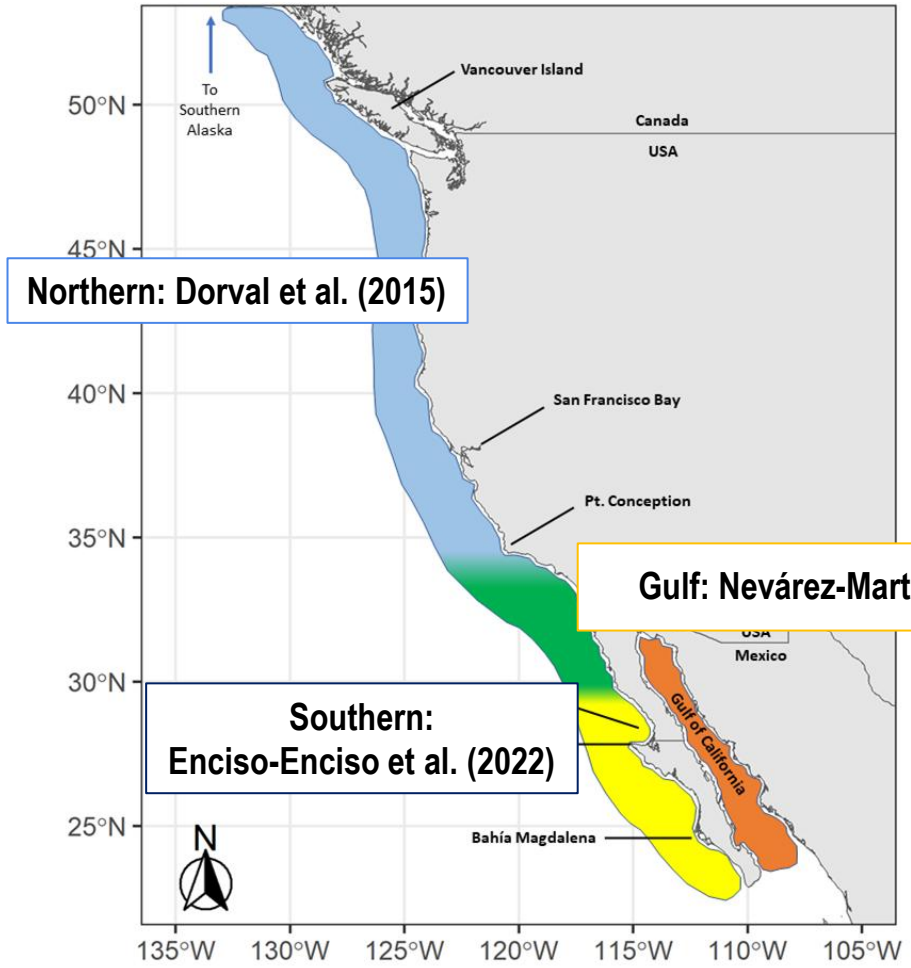
Population Dynamics: Boom and Bust; Expand and Contract

Opportunistic Life History Strategy



Baumgartner et al. (1992)

Regional growth studies focused on hypothesized subpopulations

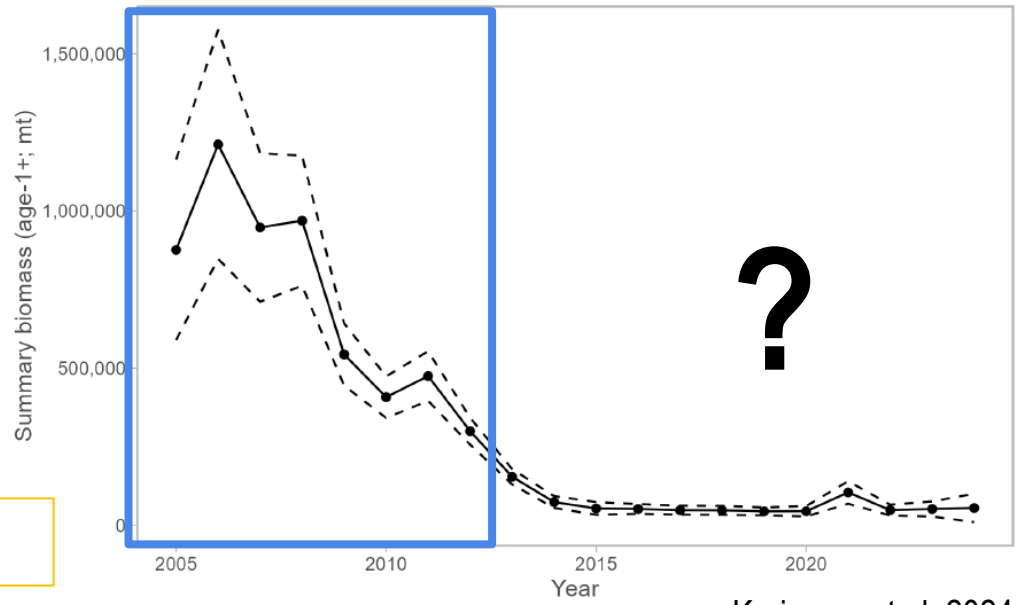


Northern: Dorval et al. (2015)

Gulf: Nevárez-Martínez et al. (2019)

Southern: Enciso-Enciso et al. (2022)

Dorval et al. (2015): High Biomass of Northern



Kuriyama et al. 2024

Temporal changes in growth?

Regional differences in growth?

Objectives

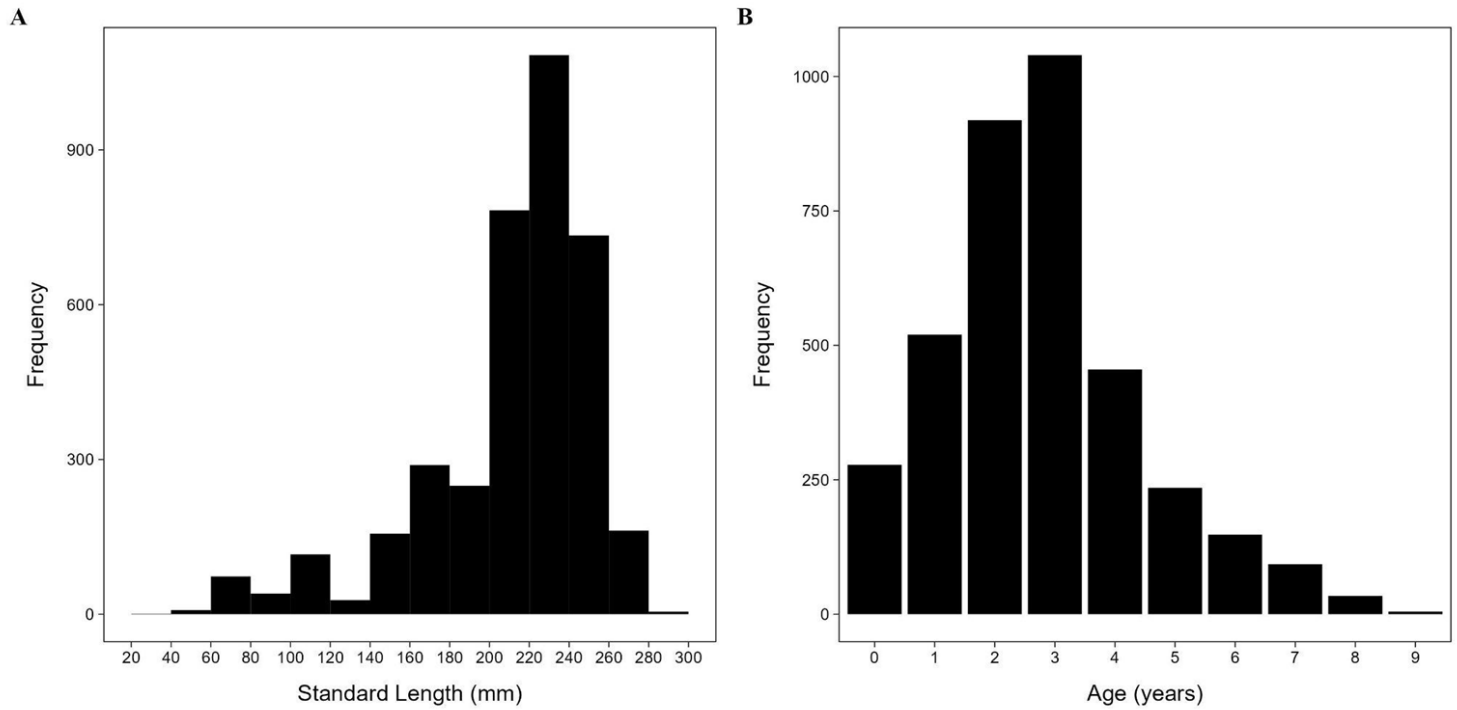
1. Generate a growth model for Sardine in U.S. waters during recent period of low biomass

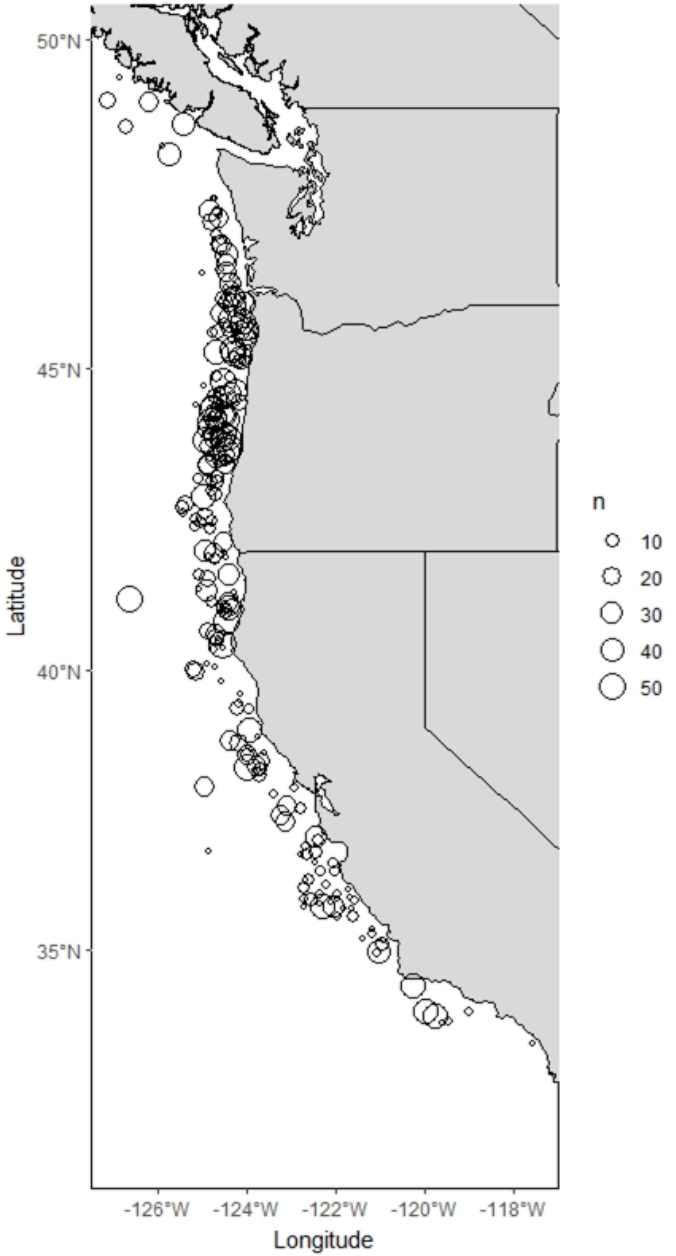
2. Compare growth parameters among studies
   a. Northern subpopulation: current study vs. Dorval et al. (2015)
   b. Regional comparisons
   c. Evaluate plausible explanations for observed differences

NOAA SWFSC Trawl Survey (Fishery-independent)

- Annually from 2012 to 2021 (June – September)
- n = 3,228 samples from 226 trawl locations
- Complete length and age distribution

Unpublished data (In Review)

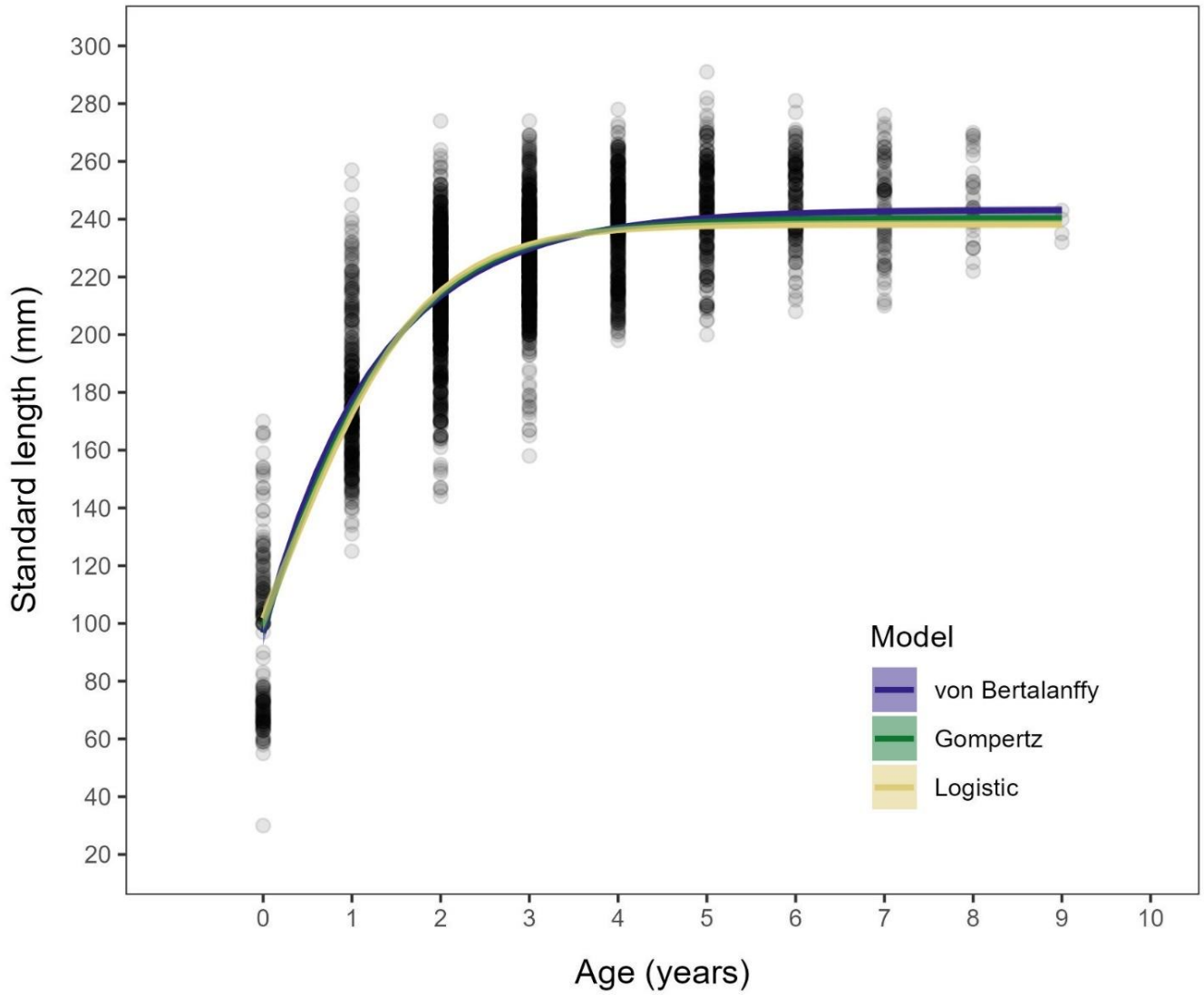




Growth best explained by a von Bertalanffy Growth model (VBM)

Unpublished data (In Review)

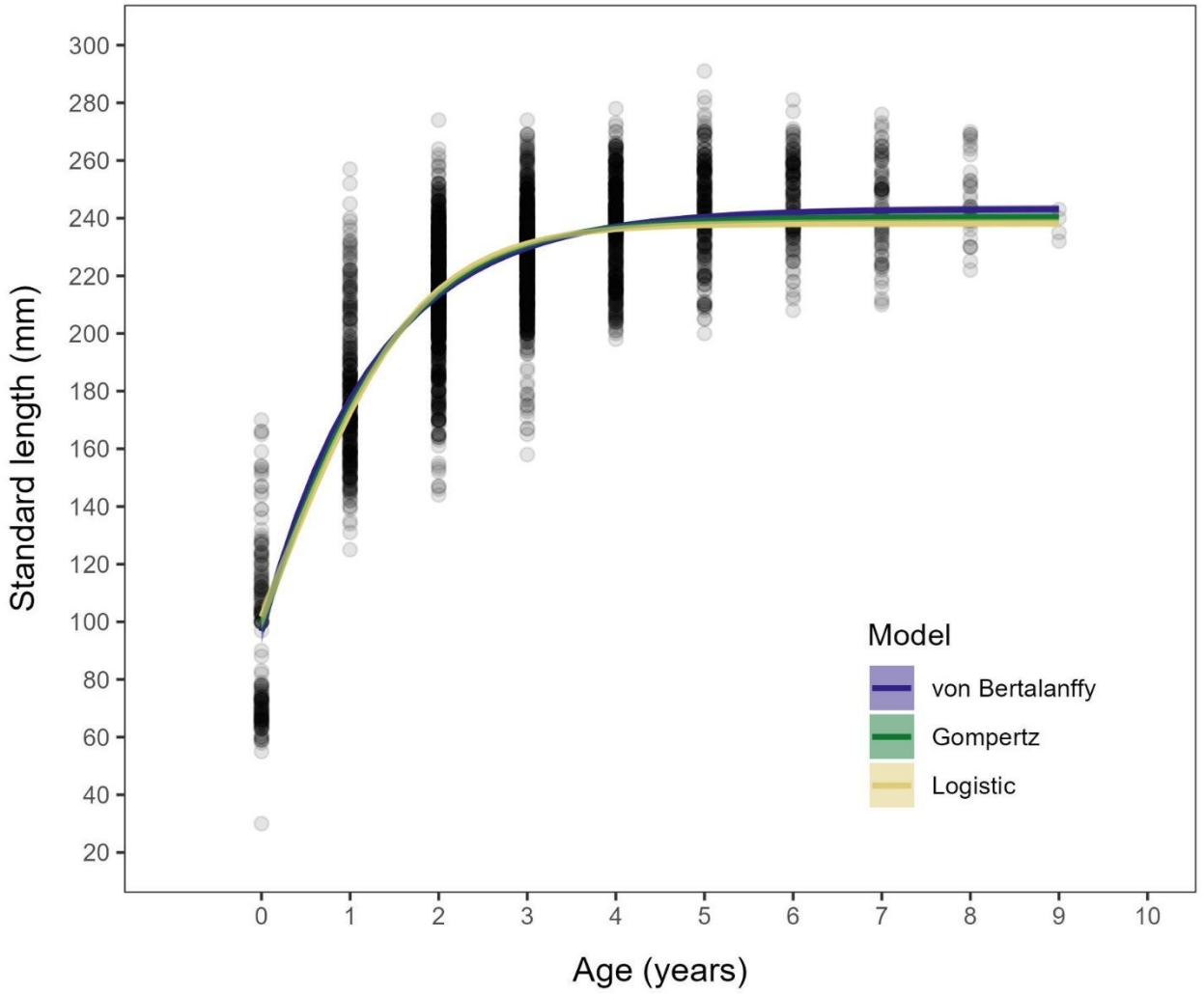
Model	df	AIC	ΔAIC	Parameter	Value	LCI	UCI
VBM	4	28379.15	0	L∞ (mm)	243.22	241.80	244.73
				k (year-1)	0.795	0.764	0.827
				t0 (year)	-0.638	-0.682	-0.601
GM	4	28433.97	54.83	L∞ (mm)	240.36	239.09	241.65
				g^*	1.021	0.985	1.058
				t^* (year)	-0.118	-0.150	-0.089
LM	4	28506.82	127.67	L∞ (mm)	238.24	236.95	239.50
				$g_{-\infty}$	1.264	1.216	1.313
				t^*(year)	0.233	0.205	0.263



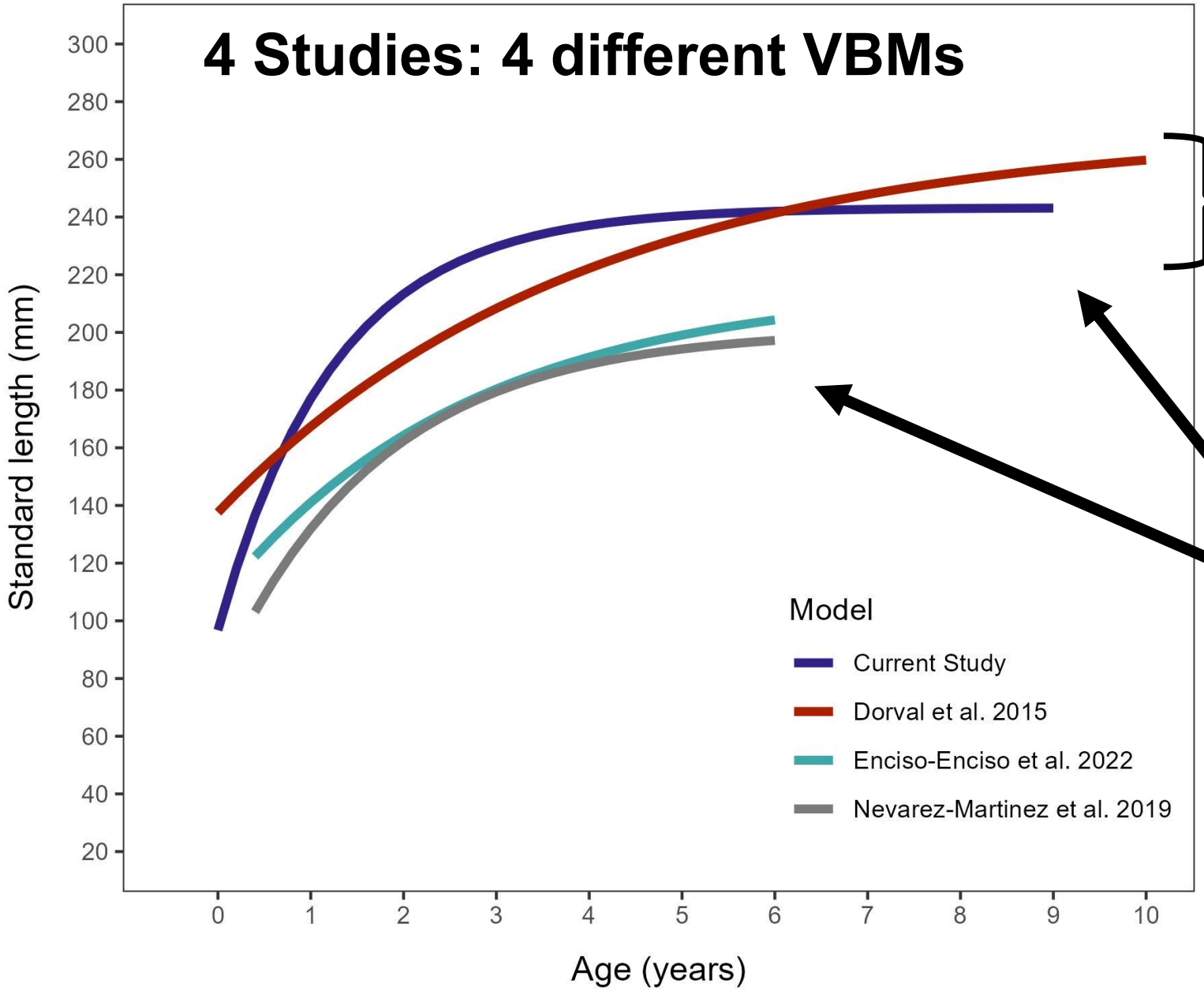
Phenotypic Plasticity in Growth (Erisman et al. 2025)

- High individual variation in length-at-age
- Predicted for species with:
  - Broad geographic ranges that span large environmental gradients
  - Ontogenetic shifts in habitat & movement patterns
  - Large seasonal migrations
  - Protracted spawning seasons
- Confounds ability to detect spatial (regional) and temporal (annual) variations in growth

Unpublished data (In Review)



4 Studies: 4 different VBMs



Temporal change in growth?
Density-dependent growth?

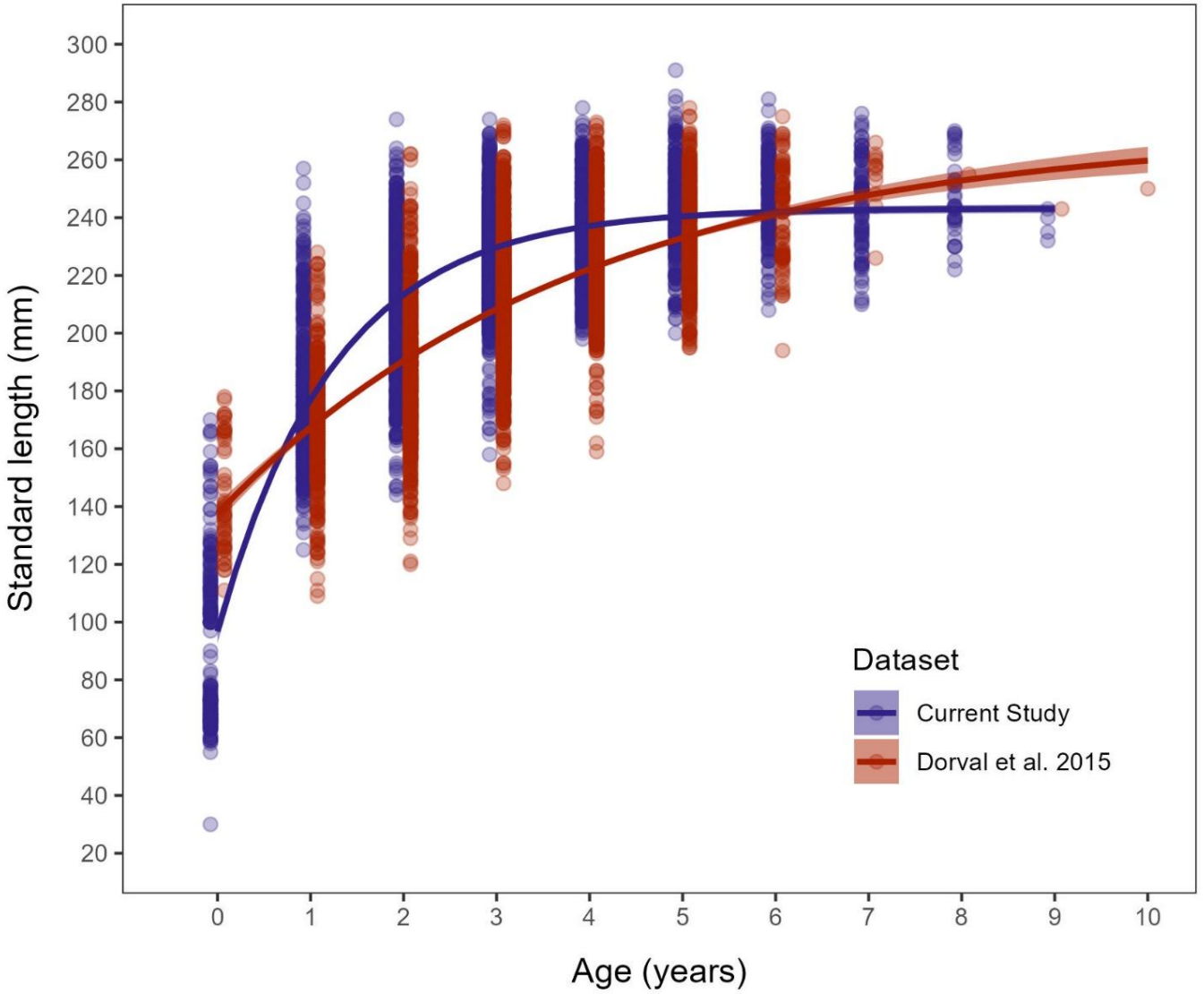
Regional differences in growth?

Comparison with previous work

Unpublished data (In Review)

Source	**Current Study**	**Dorval et al. 2015**	**Enciso-Enciso et al. 2022**	**Nevárez-Martínez et al. 2019**
Sample Years	2012-2021	1994, 2004-2010	2005-2014	2010-2013
Season	Summer	Spring	All Year	Oct-Jul/Aug
Region	Pacific Coast U.S.	California Coast U.S.	Baja California MX	Gulf of California MX
Subpopulation	NSP	NSP	SSP	GOCSP
Number of Samples	3228	4440	3509	1195
Size Range SL (mm)	30-291	120-290	114-226	98-208
Age Range	0-9	0-10	0.5-6	0.5-6
L∞ (mm)	243	273	216	201
K (year-1)	0.795	0.264	0.372	0.581
t0 (year)	-0.638	-2.884	-1.845	-0.839

Density-Dependent Growth in Pacific Sardine?



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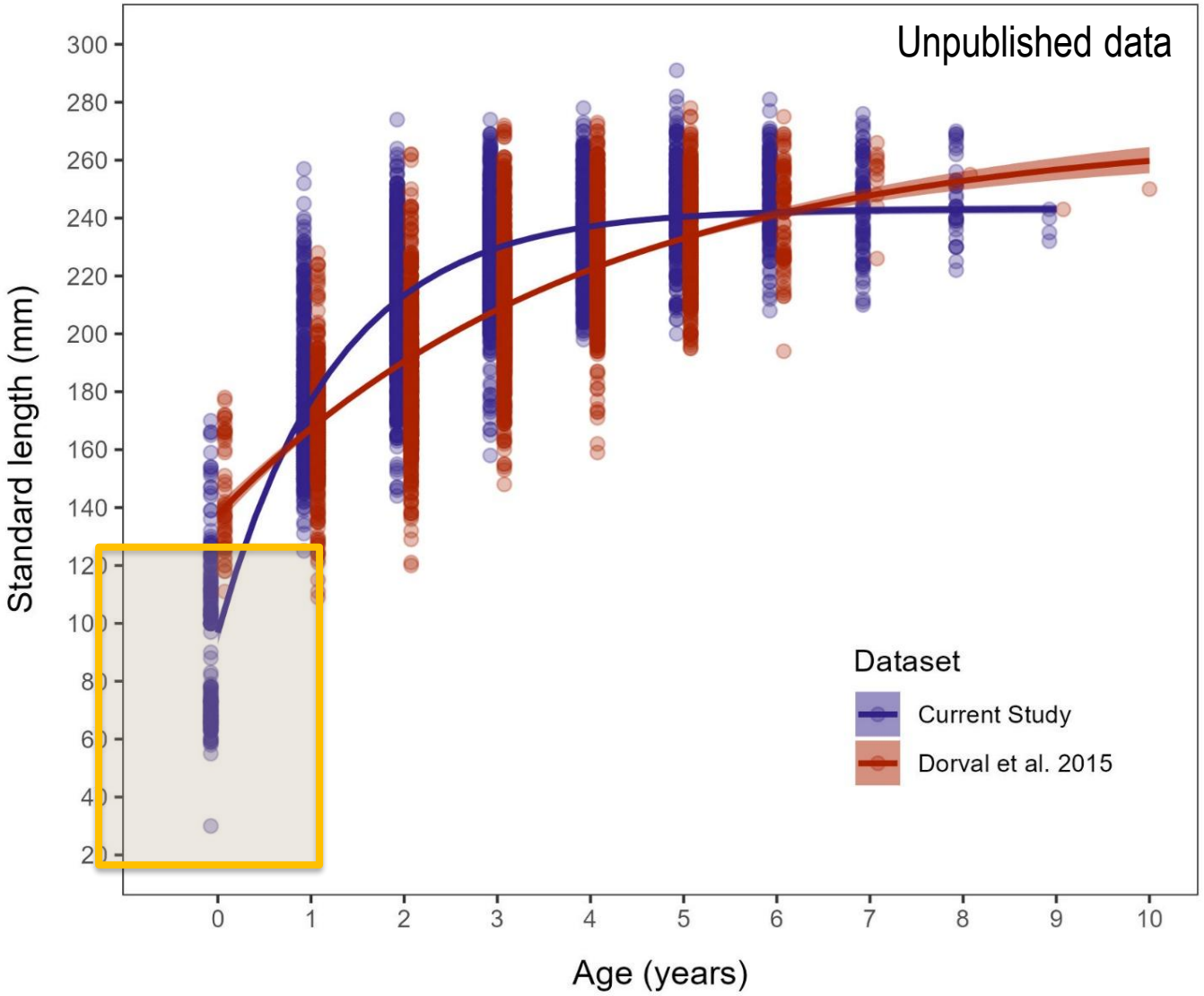
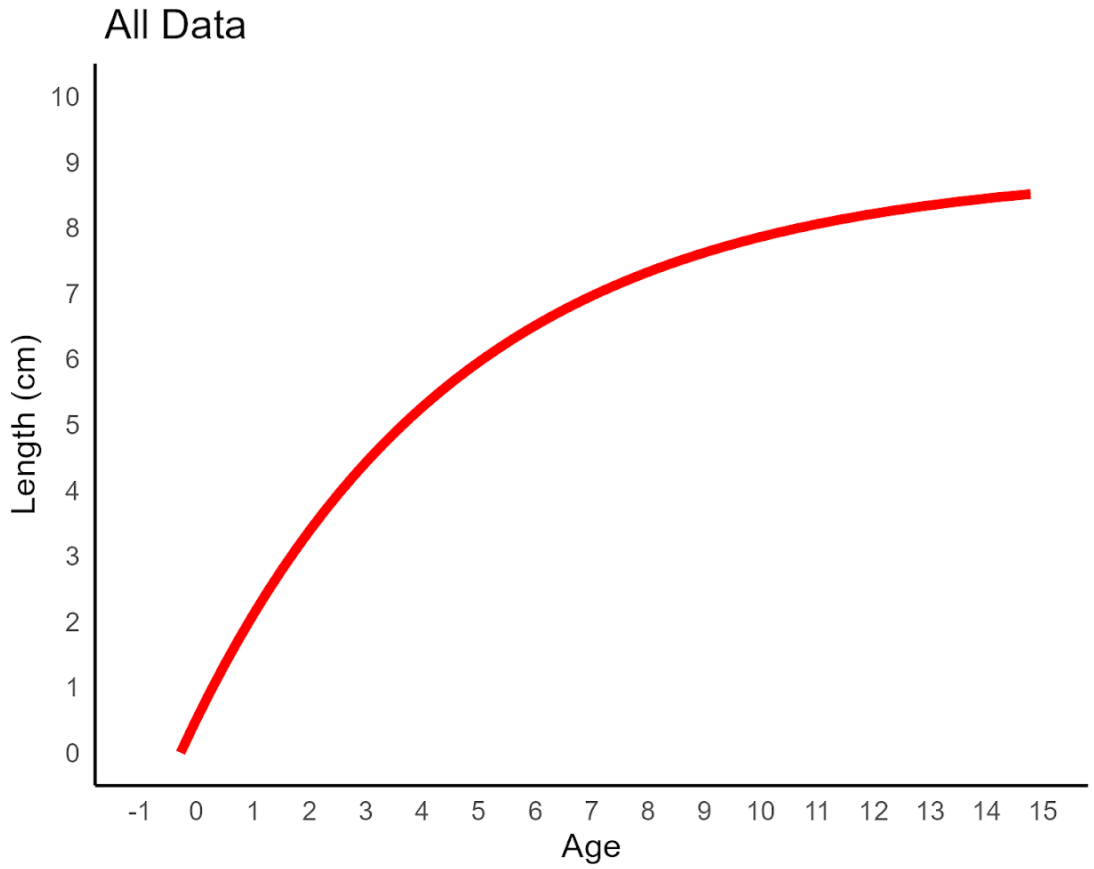
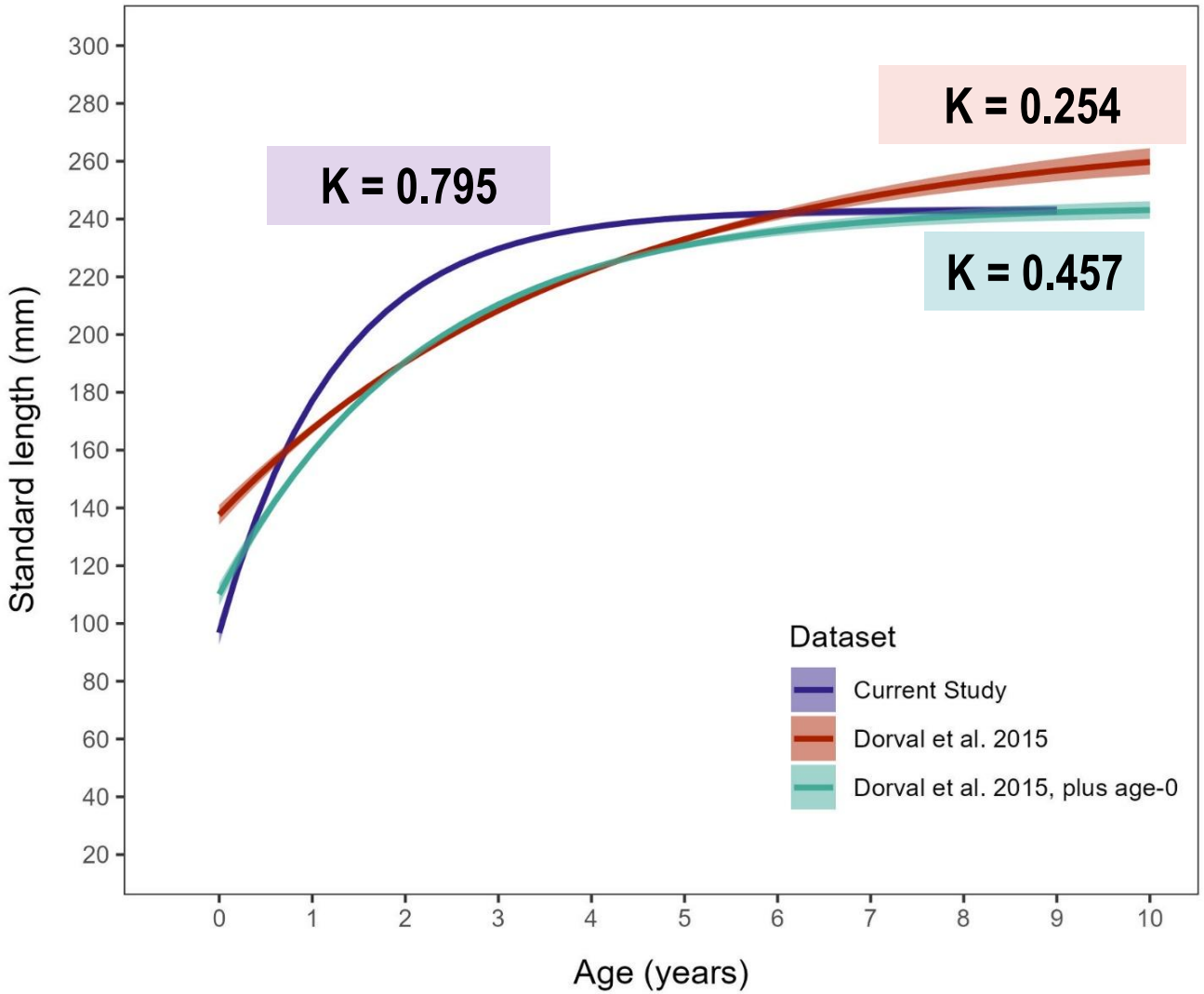


Key Differences:

- Sampling location & timing
- Sample (length) distribution

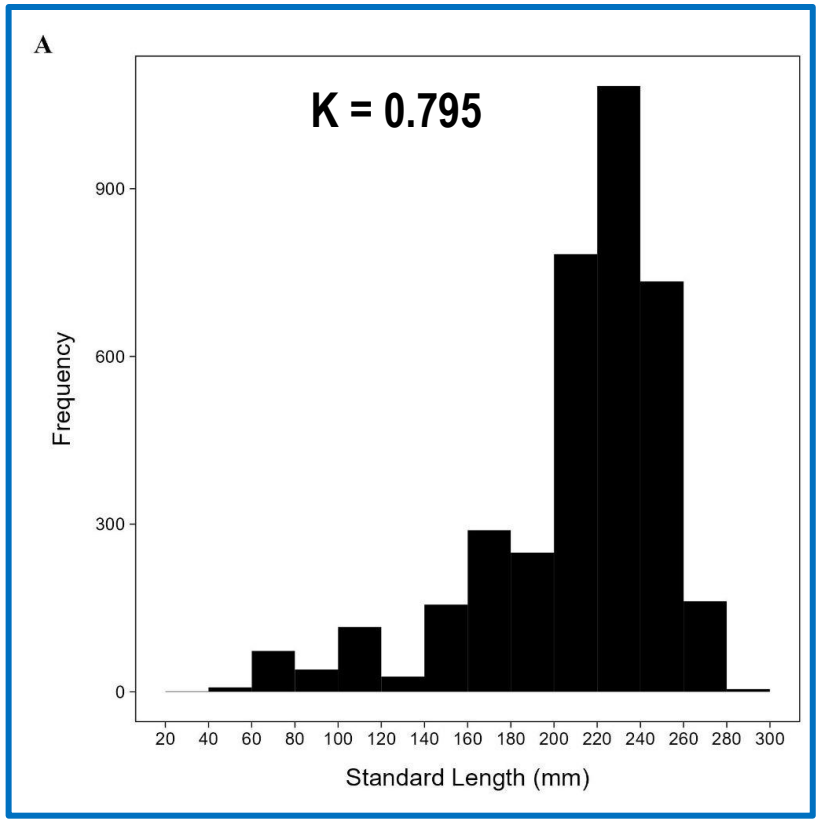
VB Growth Models are Highly Sensitive to Sample Distribution



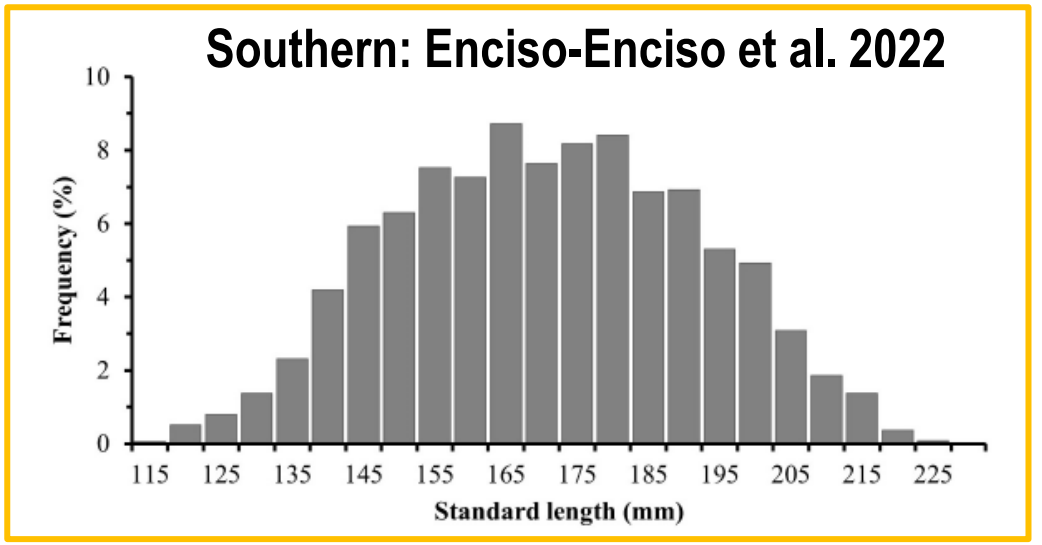


Sample Distributions Differ Greatly Among Regional Studies

Northern: Current Study
30 – 290 mm SL

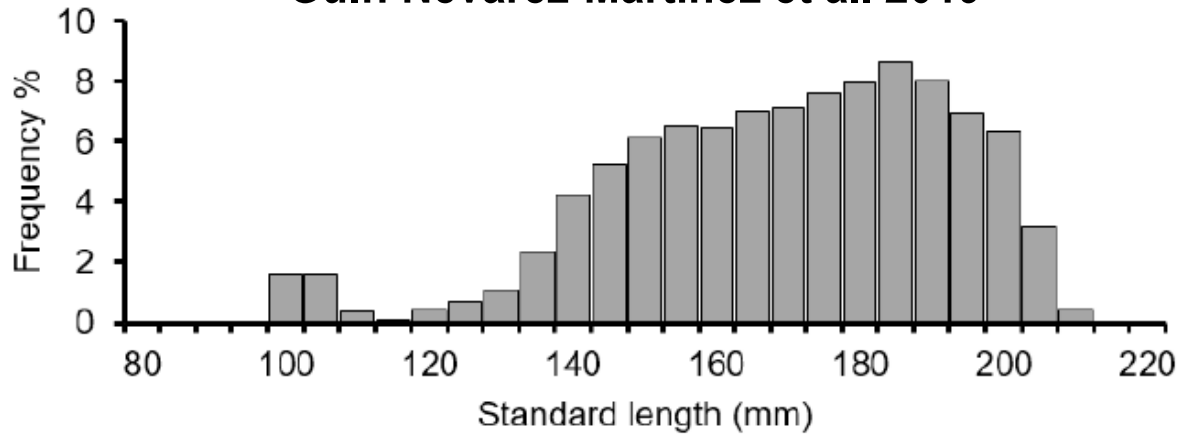


Southern: Enciso-Enciso et al. 2022



114 – 226 mm SL
K = 0.372

Gulf: Nevárez-Martínez et al. 2019



98 - 208 mm SL
K = 0.581

Regional Comparisons: Important Considerations

1. Collection Methods & Sample Distributions
   - Fishery-independent vs Fishery-dependent
   - Gear (size) selectivity
   - Capture locations in relation ontogenetic shifts in habitat

2. Data Independence
   - Study regions overlapped (Northern vs Southern)
   - Individuals migrate from central Baja to Pacific NW

3. Aging Protocols Across Labs
   - No cross-readings
   - July birth date assignment in U.S. (± 1 year)

Summary & Conclusions

- Updated model to describe growth in Pacific Sardine off the U.S. West Coast
- Emphasis: Individual variation in length-at-age is HIGH for Pacific Sardine
- Variability in VBM parameters across studies influenced by:
  - Phenotypic plasticity
  - Sample distribution & collection methods
  - Data (Non)independence
  - Aging protocols

- No definitive evidence of temporal shifts or regional differences in growth

Acknowledgments

- SWFSC Acoustic Trawl Participants
- NOAA Ship Lasker, NOAA Ship Shimada, NOAA Corps, and Crew
- SWFSC and CDFW Pacific Sardine Agers
- Matthew Craig
- Derek Bolser