Estimation of age-based selectivity of Chinook salmon by killer whales

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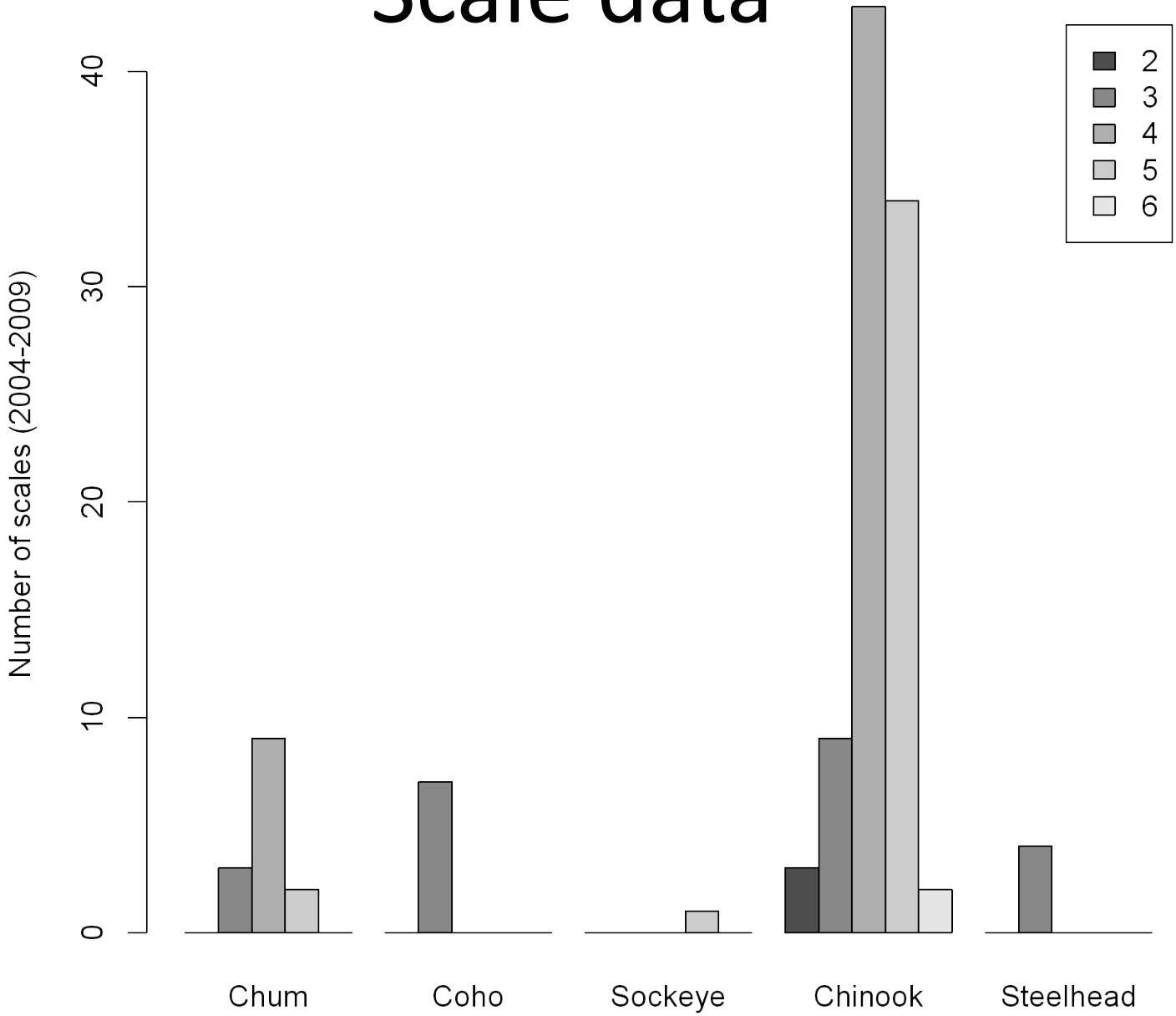
Scale data



Source: Brad Hanson

Chinook scales

- 87 Chinook scales, 2004-2008
  - 11 age3 (12.6%), 42 age4 (48.3%), 34 age5 (39.1%)
- 12 FRAM "periods"
  - Oct-Apr, May-June, July-Sept
  - Each period in each year has slightly different age structure
  - Overall age comp. is roughly:

    60% age-2, 30% age-3, 7% age-4, 3% age-5

FRAM = “Fishery Regulation Assessment Model”
http://www.pcouncil.org/wp-content/uploads/FRAM_Overview_Final_1008.pdf

FRAM abundance in August over time

August	Age-2	Age-3	Age-4	Age-5
2004	0.62	0.29	0.07	0.02
2005	0.67	0.23	0.08	0.01
2006	0.62	0.29	0.08	0.01
2007	0.56	0.31	0.11	0.01
2008	0.59	0.33	0.07	0.01

Age 4/5 Chinook more common in diet than would be expected by abundance

Chinook age	FRAM Abundance	Hanson scales	F&E scales
2	59	3.6	0.7
3	25.8	12.5	11.3
4	13.4	48.2	55.9
5	1.7	35.7	31.5

~85% of scales are 4/5 – while age 4/5 Chinook make up ~ 15% of total #s

F&E = Ford & Ellis (2006)

Assumptions:

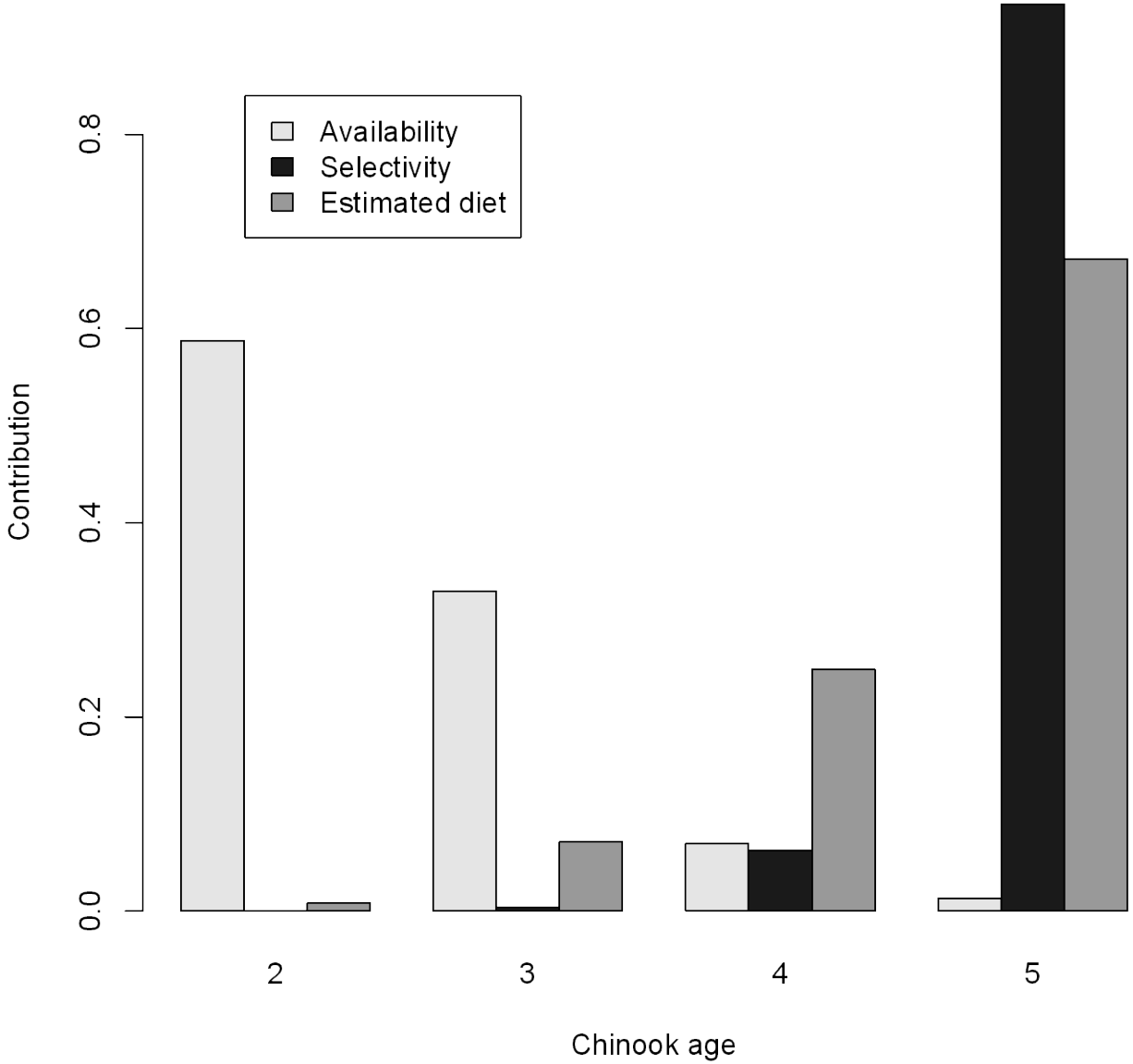
- Assume scales collected during prey sampling are representative of entire kw diet
  - No additional size selectivity in what they bring to the surface (B. Hanson / fecal samples)
- Giant pool of predators and prey
  - Assume selectivity has no spatial component, no time trend, and is the same for all individual kws
- Assume ’vulnerable' salmon is derived from the FRAM model, and the age distribution of encountered salmon is that of the FRAM model

How do we calculate predicted diet?

	Estimated diet		Relative Abundance at age (known)		Selectivity **(the parameters)**
Age 3	9.8%		0.3		0.013
Age 4	31.4%	$\propto$	0.07	$\times$	0.178
Age 5	58.8%		0.03		0.777

Selectivity is often used to model vulnerability of fish to fishing gear. We can apply the same models here…

Turning selectivity parameters into diet



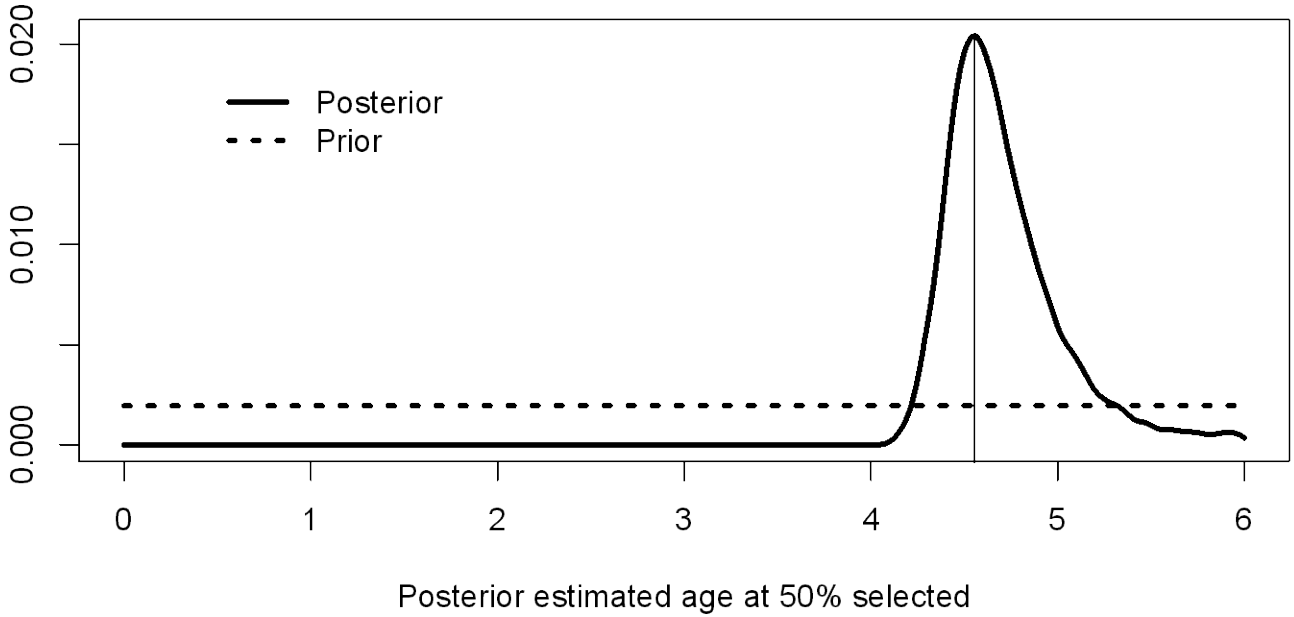
The model

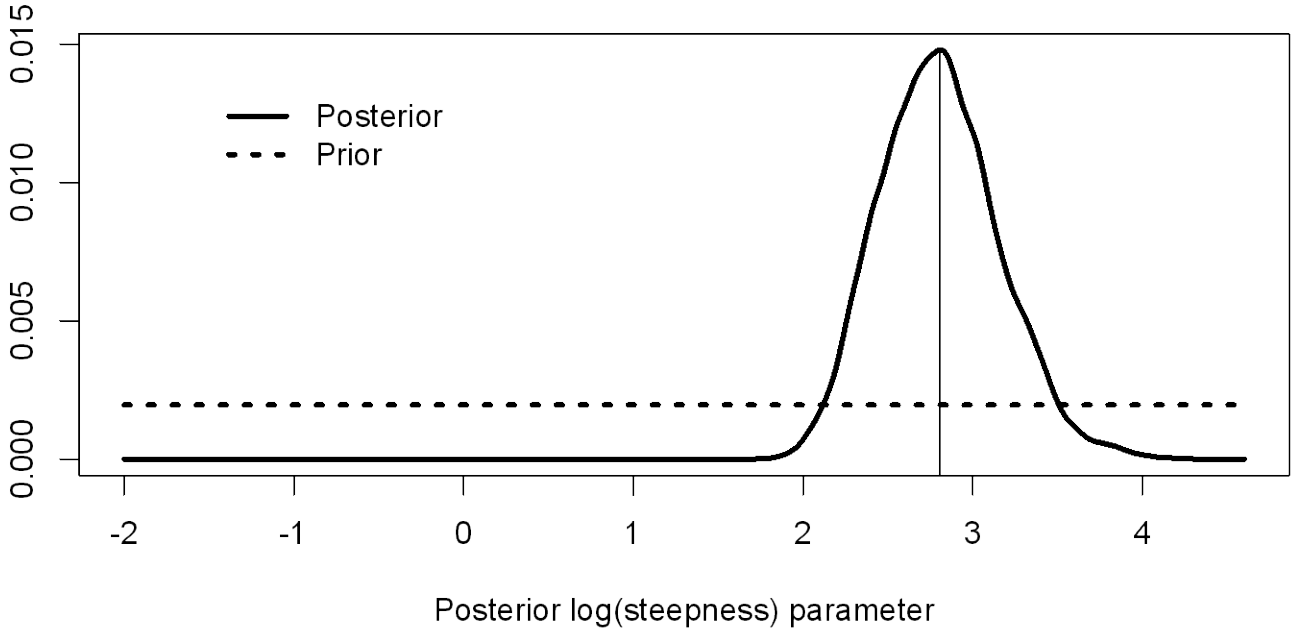
- Logistic selectivity
  - Flexible, behavior well understood
  - Can be modeled as function of size or age
  - 2 parameters (Sa, S50)

- Bayesian

Bayesian Results

Uninformative priors



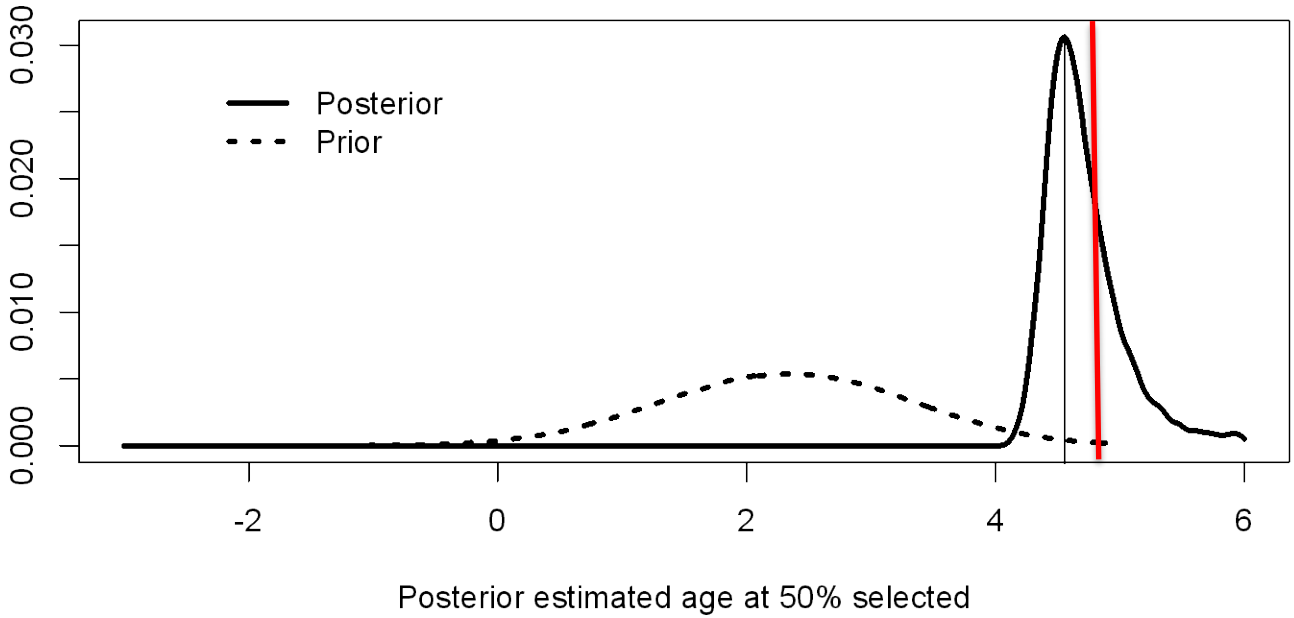


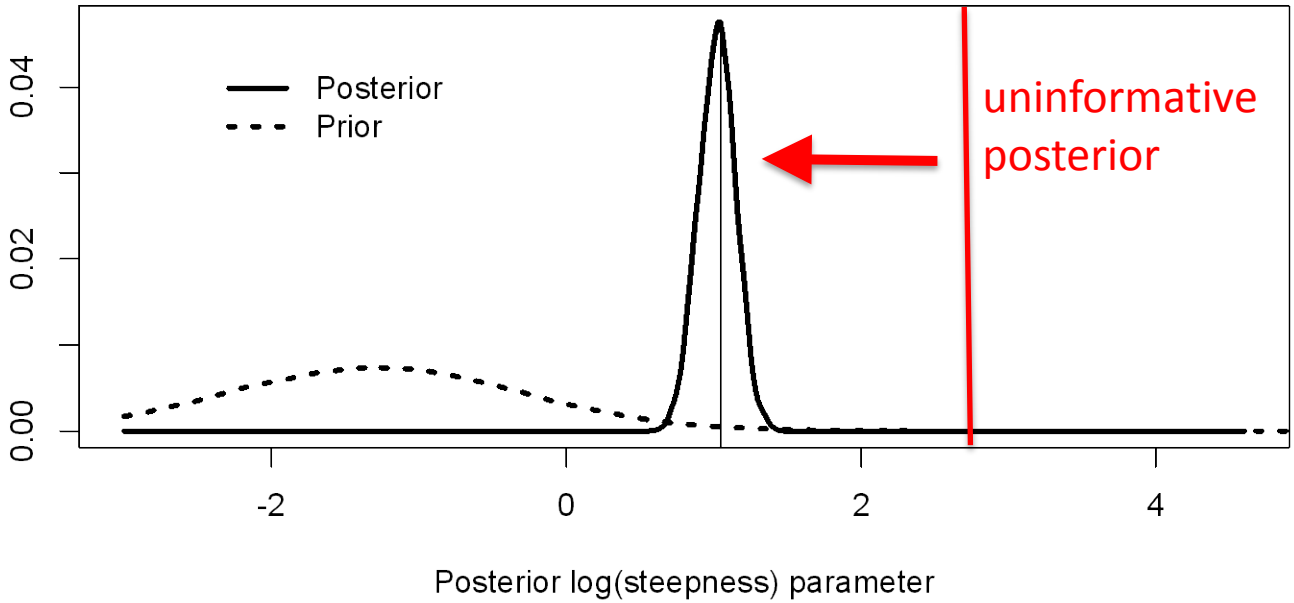
Sensitivity to informative priors

- Bayes posterior = prior beliefs x likelihood of data
- Difference between posterior and prior is a measure of how much you 'learn' by seeing data

- **Q: What if we had strong a priori beliefs that whales consumed salmon in proportion to their abundance?** ~ (0.6, 0.3, 0.07, 0.03)

Informative priors





- **Q: What if we had strong a priori beliefs that whales consumed salmon in proportion to their abundance?**

- **A: Prior is completely contradicted by scale data. The weight of the data is so strong that the prior belief doesn't change the end result (informative, uninformative results similar in that older fish are favored)**

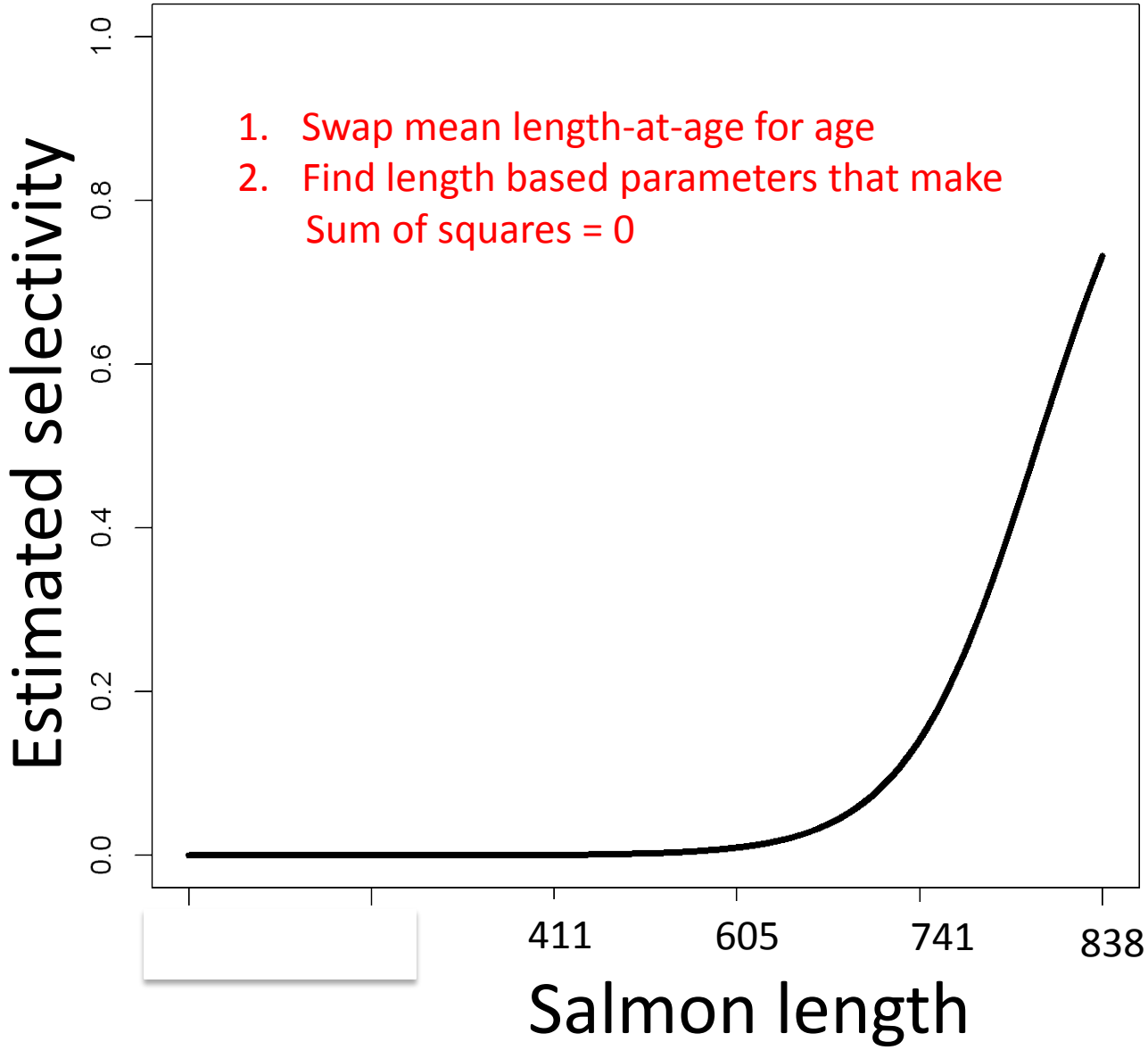
Converting age- to length-based selectivity

- FRAM model includes stock specific length-at-age
- Young individuals have relatively large variation in lengths (example from 1 year below)
- Fish age / grow over a year

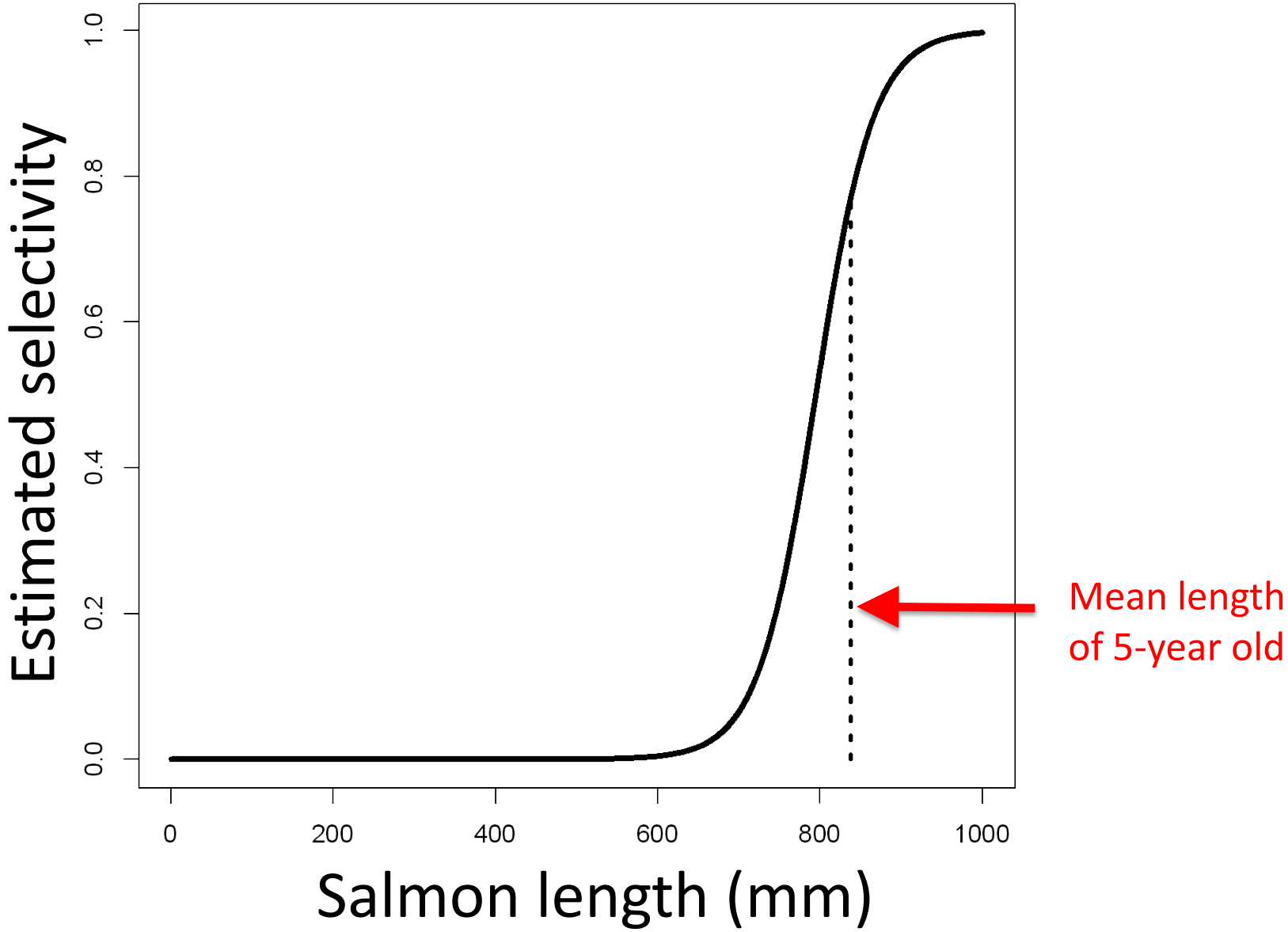
Age	Mean FL (mm)	SD	CV
2	406.23	67.05	0.17
3	603.33	46.99	0.08
4	738.97	49.14	0.07
5	834.68	59.78	0.07

Selectivity curve from age model

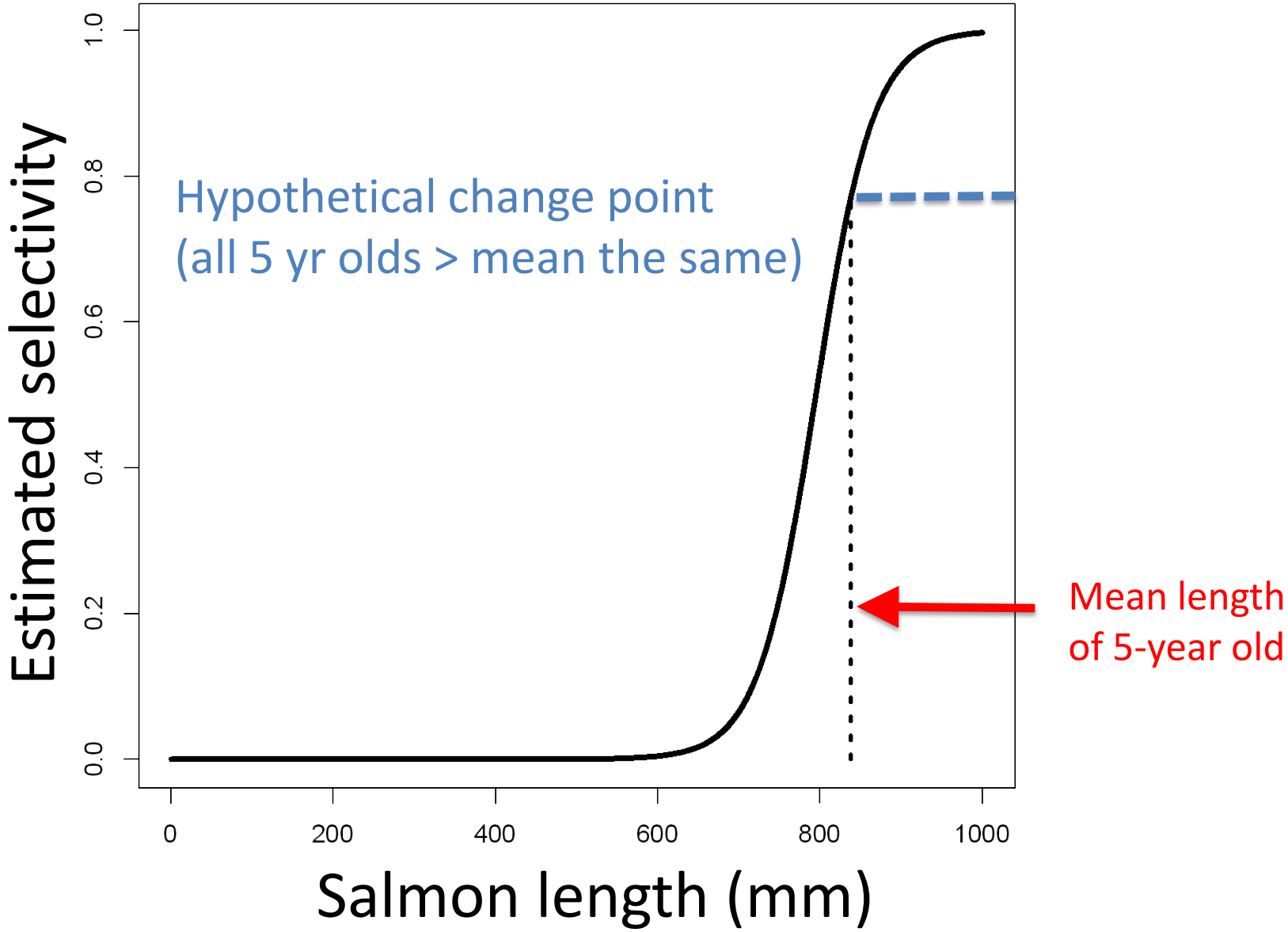
Selectivity curve from age model



New length-based curve



Age- or Length-based selectivity?

- Ongoing tinkering (sensitivity explored by myself & L. LaVoy)
- Mean 5 year old Chinook aren't 100% selected (only biggest 5 year olds)
  - Fish > mean length don't have selectivity = 1
  - Change point / hockey stick??
- Size matters; not all stocks equivalent
  - Puget Sound stocks generally smaller
  - Large variation in lengths, esp. for smaller fish
  - Length matters for L-weight / L-kcal regressions (S O'Neill)
  - FRAM model allows fish to grow between periods within year
- Selectivity is a relative measure

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