



The Effect of Food-Limitation on Delta Smelt Growth, Reproduction and Health

Meredith Nagel^{1,2}, Joan Lindberg¹, Swee Teh²

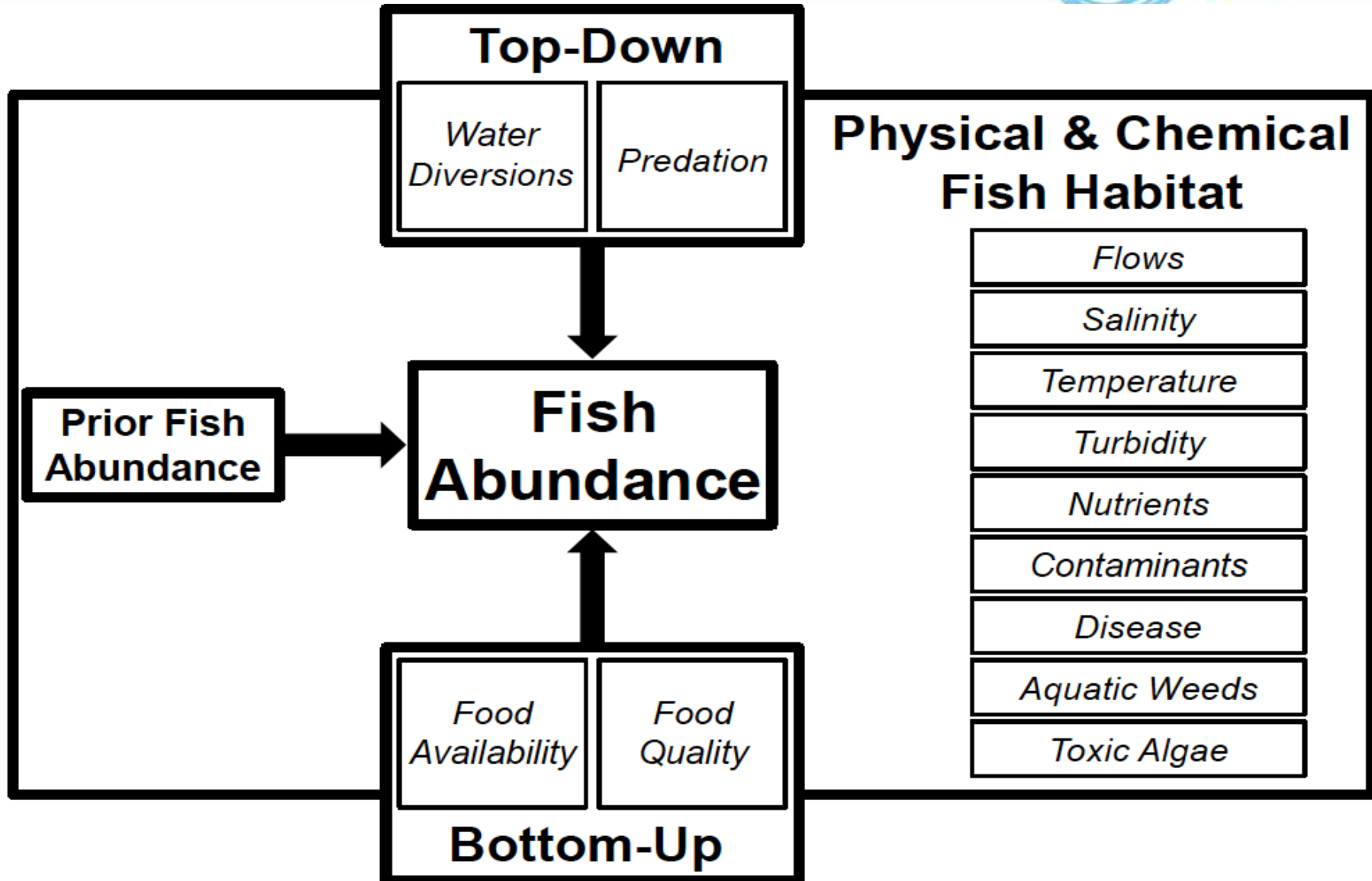
¹ Fish Conservation and Culture Laboratory, UC Davis

² Aquatic Health Program, UC Davis



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Declining Fish Abundances in the Delta



Delta Smelt (*Hypomesus transpacificus*)



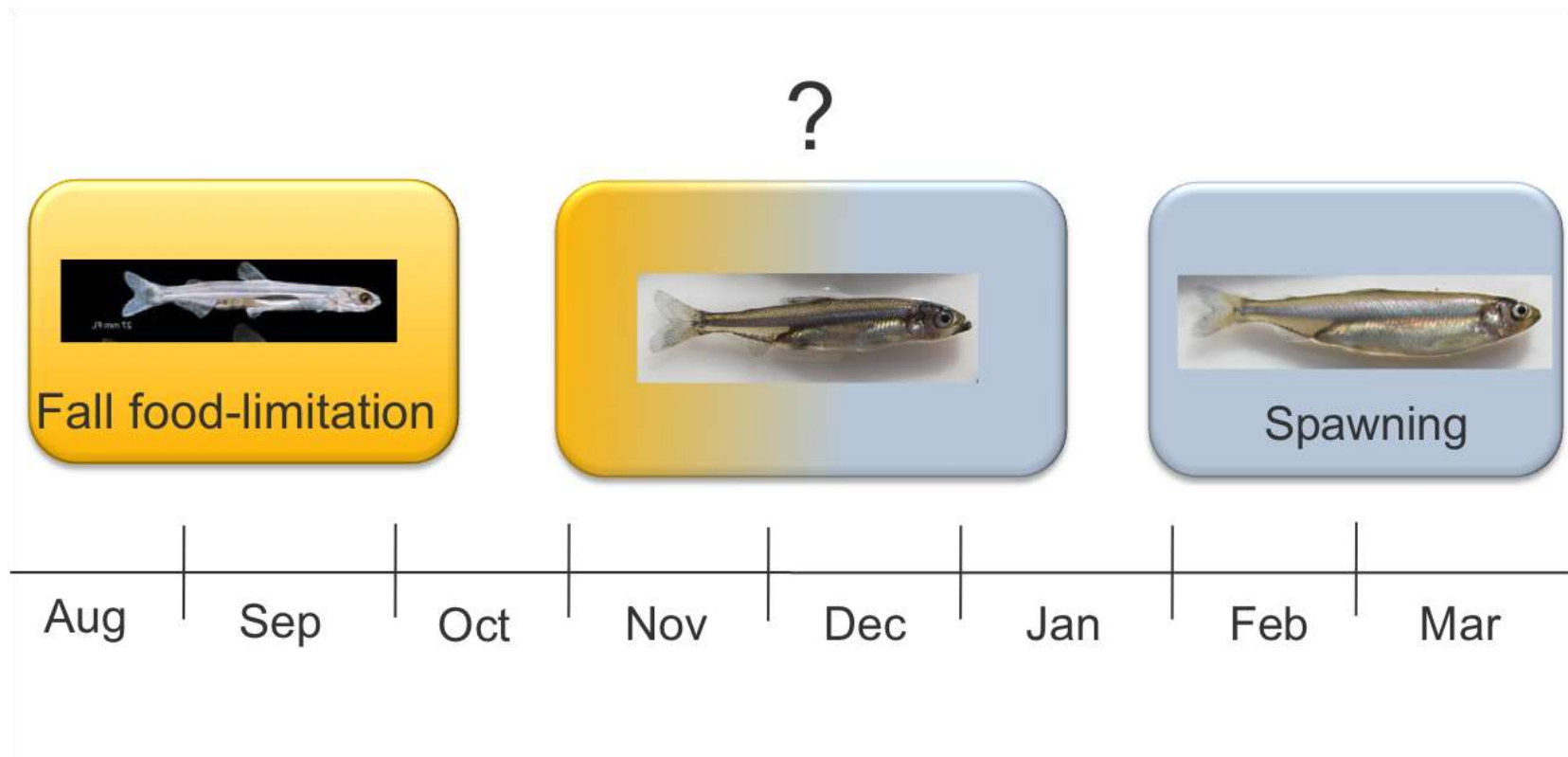
- Endemic to Bay-Delta
- Endangered species status
- Annual life - span
- Spawning season February – June
- Asynchronous batch-spawner (multiple clutches)



Winter Food-Limitation ?



- Potential low food availability in fall, coupled with warmer temperatures
- Less is known about winter food-limitation



Quantifying the Effects of Food-Limitation

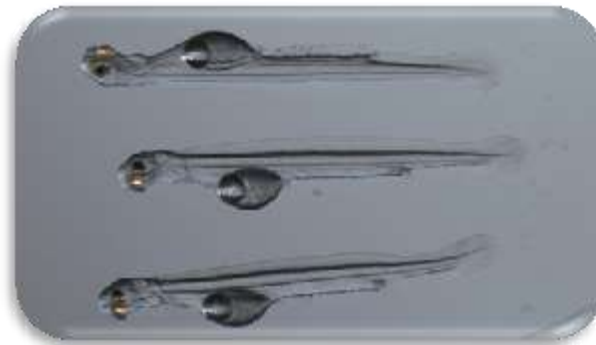


Adult Population

- Reproductive development
- Seasonal fecundity
- Overall fish health

Subsequent Generation

- Egg and larval quality
- Larval survival and growth

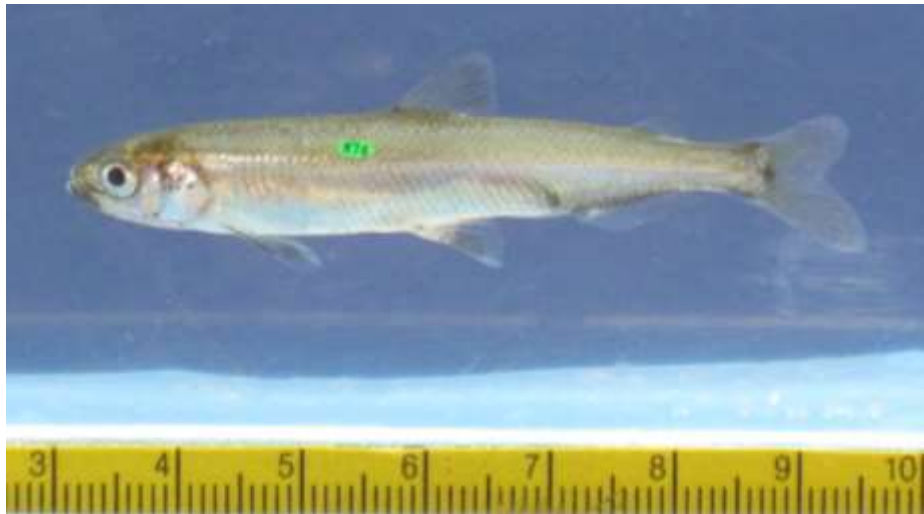


Adult Delta Smelt Winter Food-Limitation Study



Experimental Design

- Three replicates, control and food-limited (n=3)
- 250 fish per tank
- Each fish is uniquely tagged



Photos by Marade Sandford

Experimental Design: Food-limitation



C1

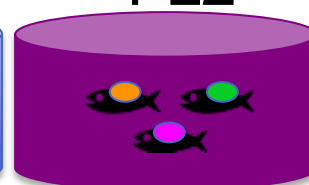
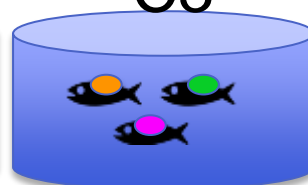
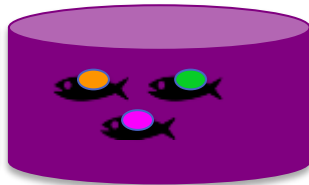
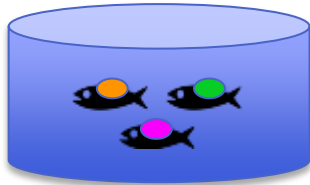
FL1

C2

C3

FL2

FL3



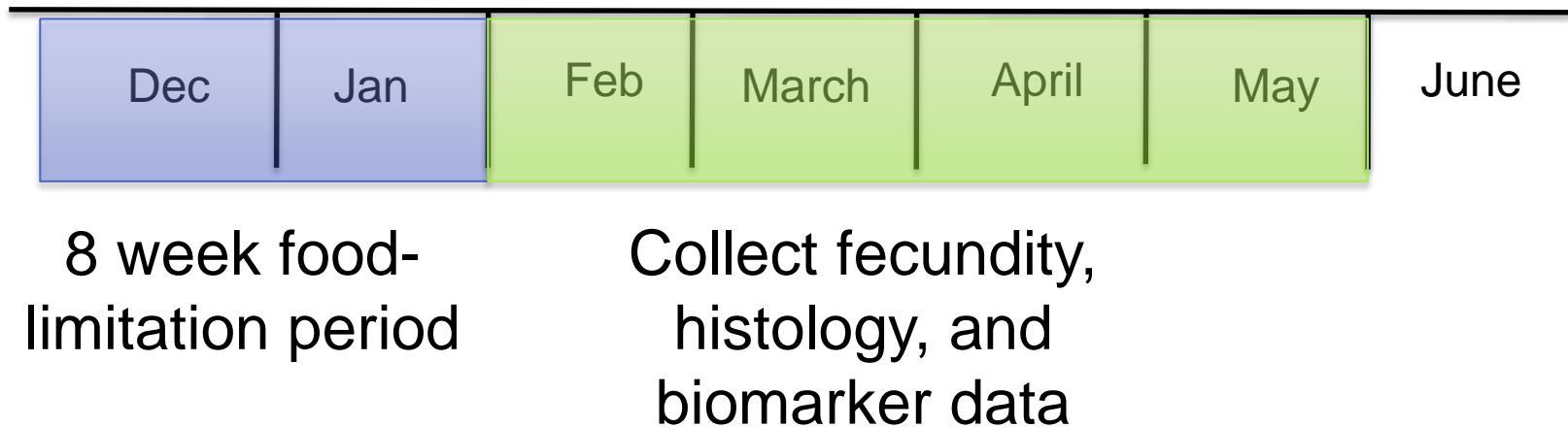
Control tanks fed 2% of
body weight per day

Food-limited tanks fed 2%
of body weight 4 days/week
(40% reduced ration)

Experimental Design:



- 10 -12 fish dissected for biomarker assays
- 40 fish measured for weight and length every 2 weeks
- Constant temperature at 12°C



Nutritional and General Health Biomarkers



- Triglycerides (TAG) – long term energy storage
- Histopathology
- Fatty-Acid analysis
- Disease

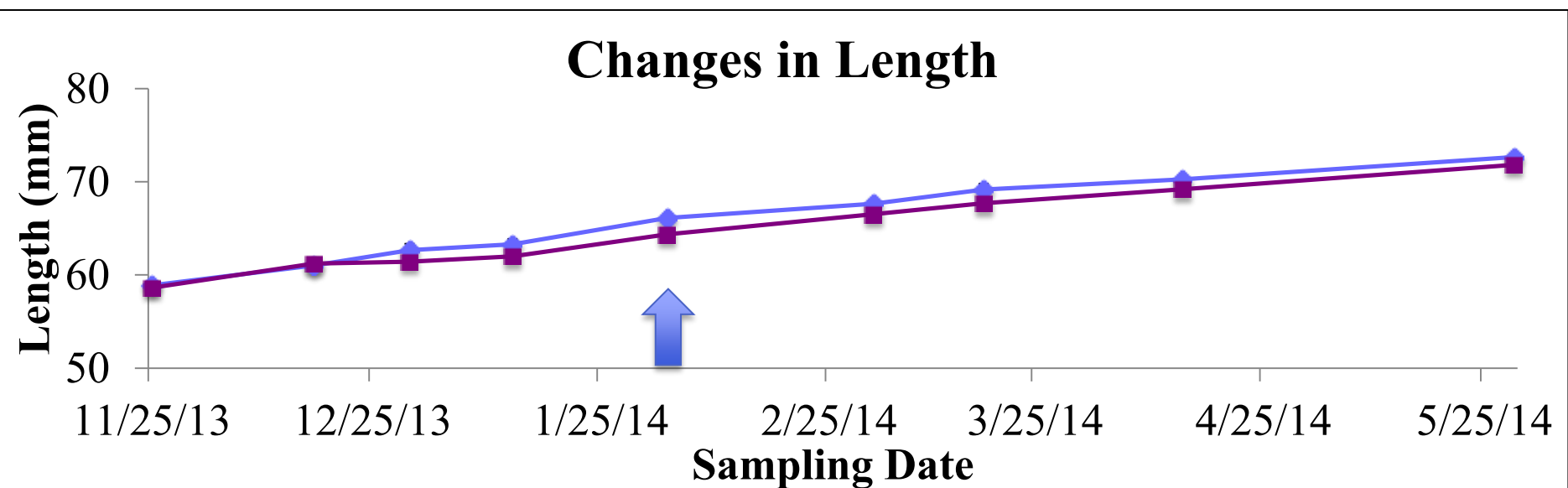
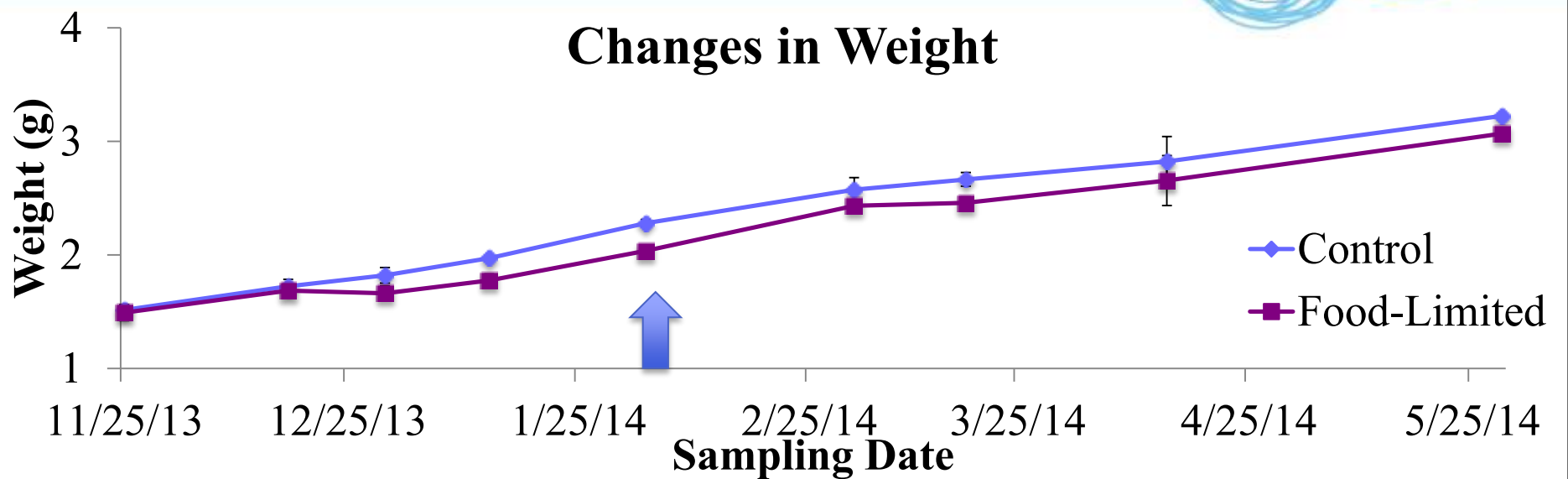
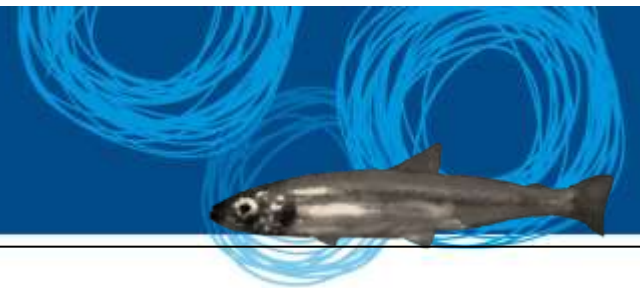
Experimental Design: Fecundity Indices



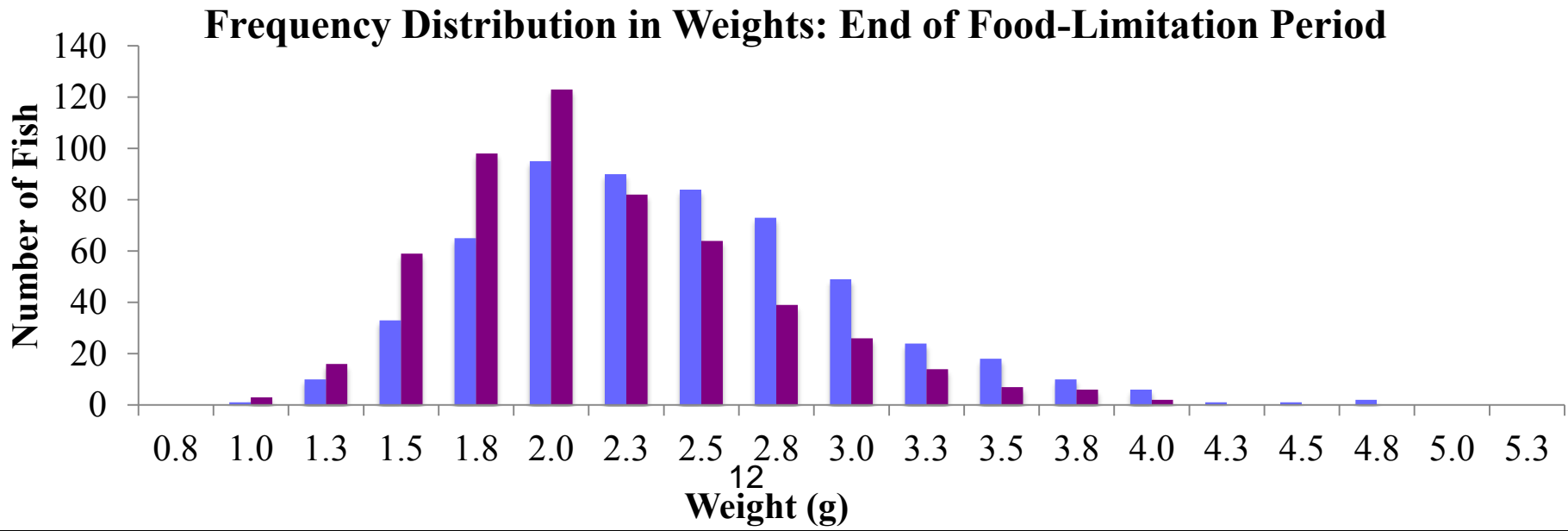
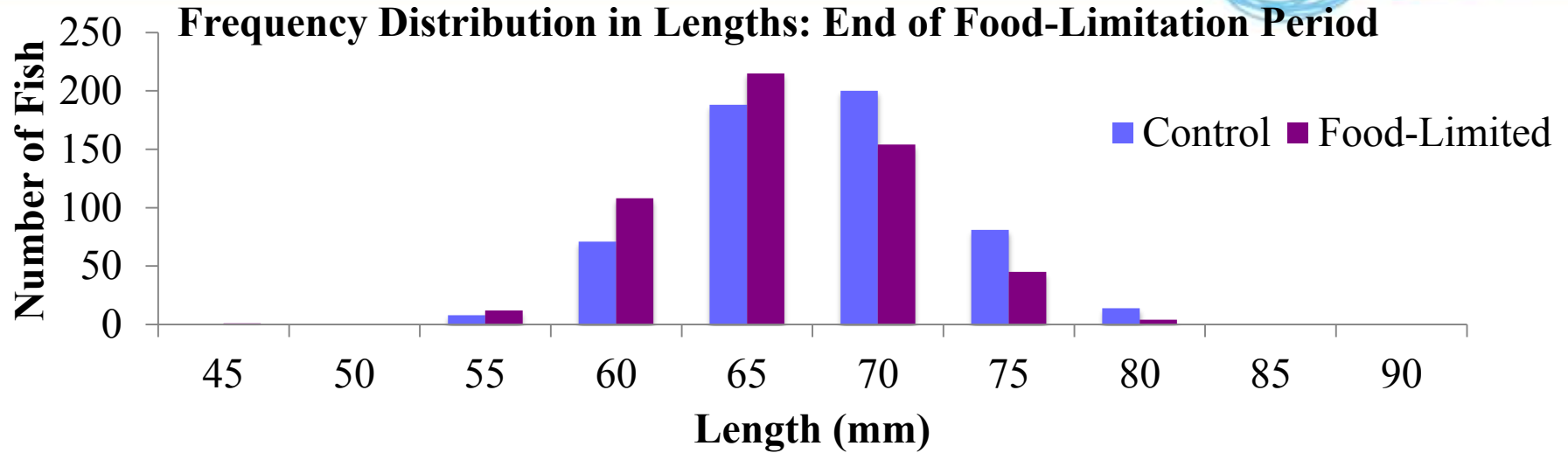
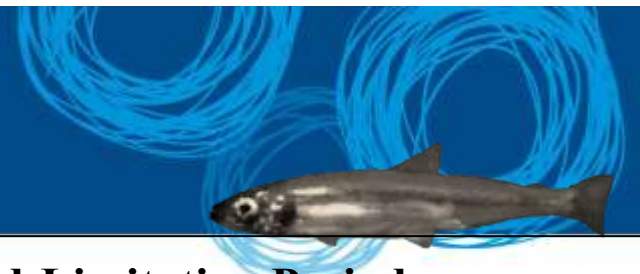
- Measured for weight, length, and ova weight
- Eggs expressed
- Females returned to tank
- Estimate the number of eggs



Results: Growth



Results: Growth



Results: Spawning and Clutch Interval



- Average number of days to first spawn

Control : 350

Food-Limited: 361

- Average number of days between clutches

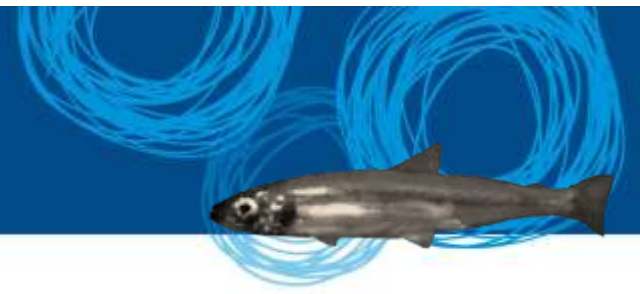
Control and **Food-Limited: 50 days (12° C)**

- Clutch interval at different temperatures

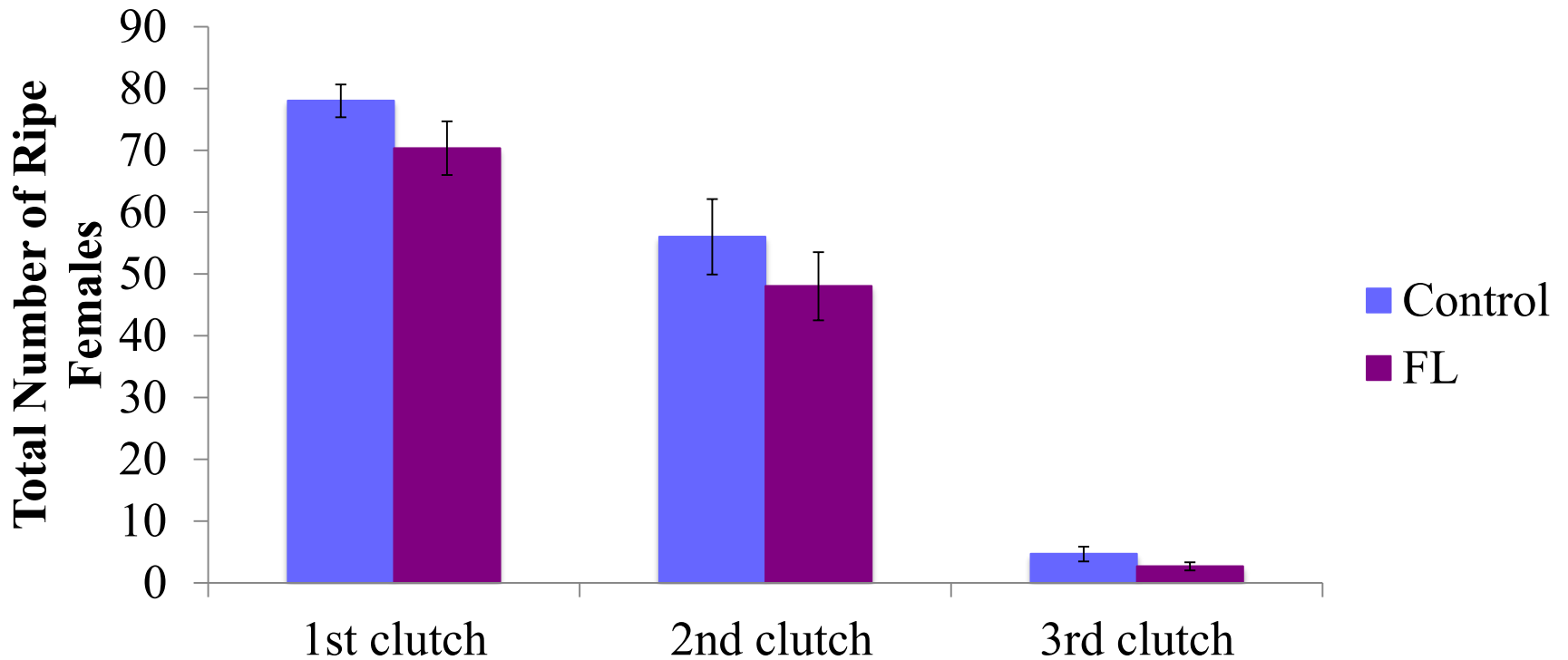
35 days (14° C)

47 days (10° C)*

Results: Spawning



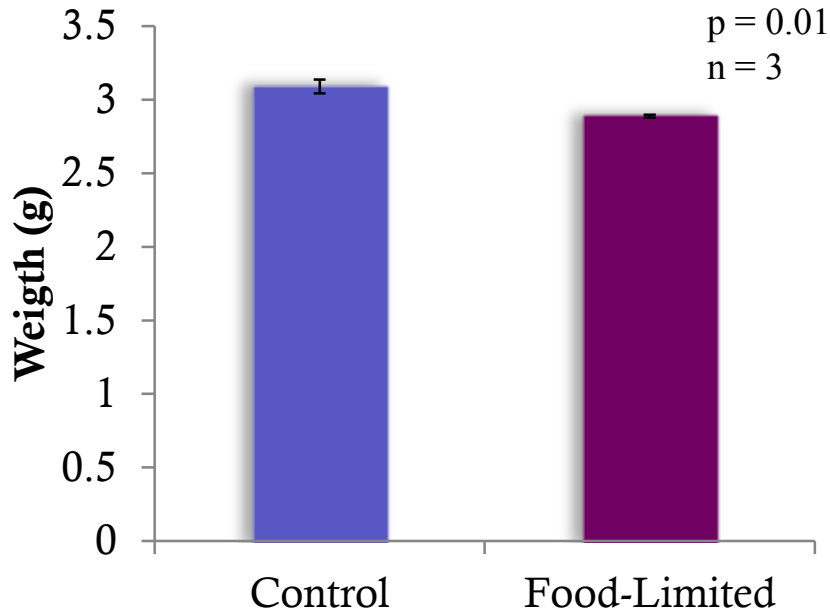
Total Number of Spawners



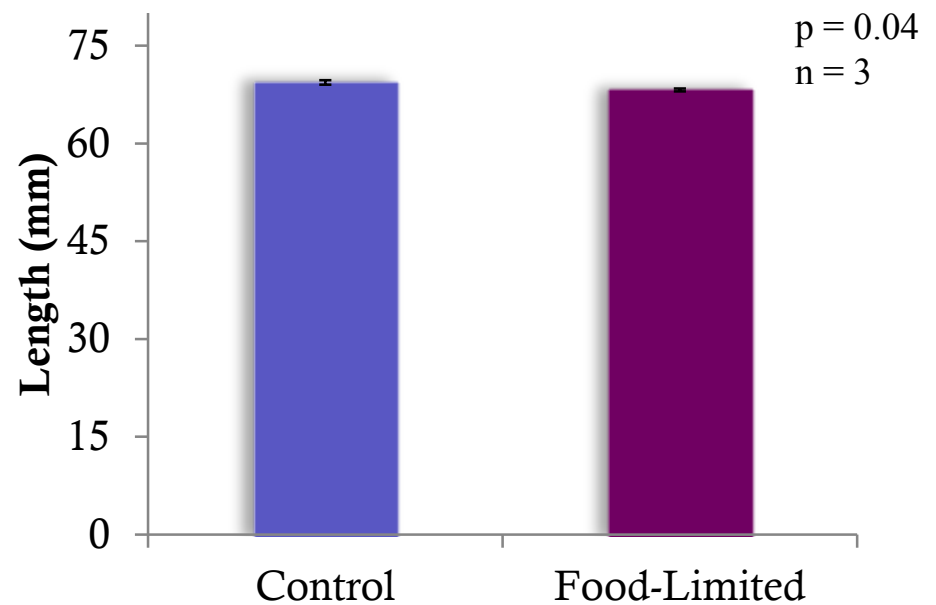
Results: Spawning



Average Weight at First Clutch

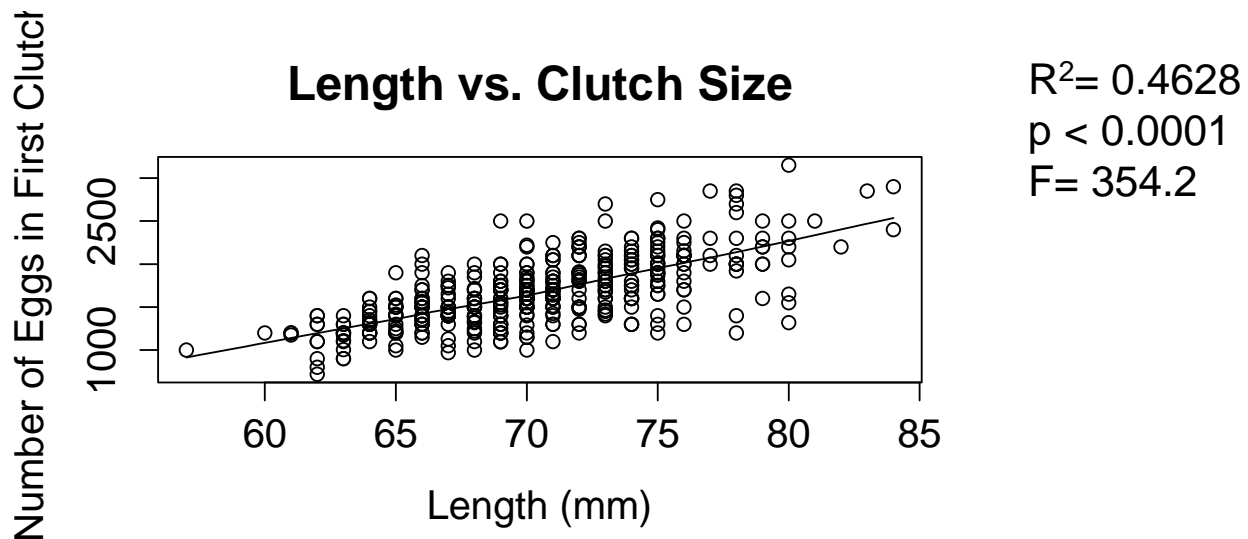
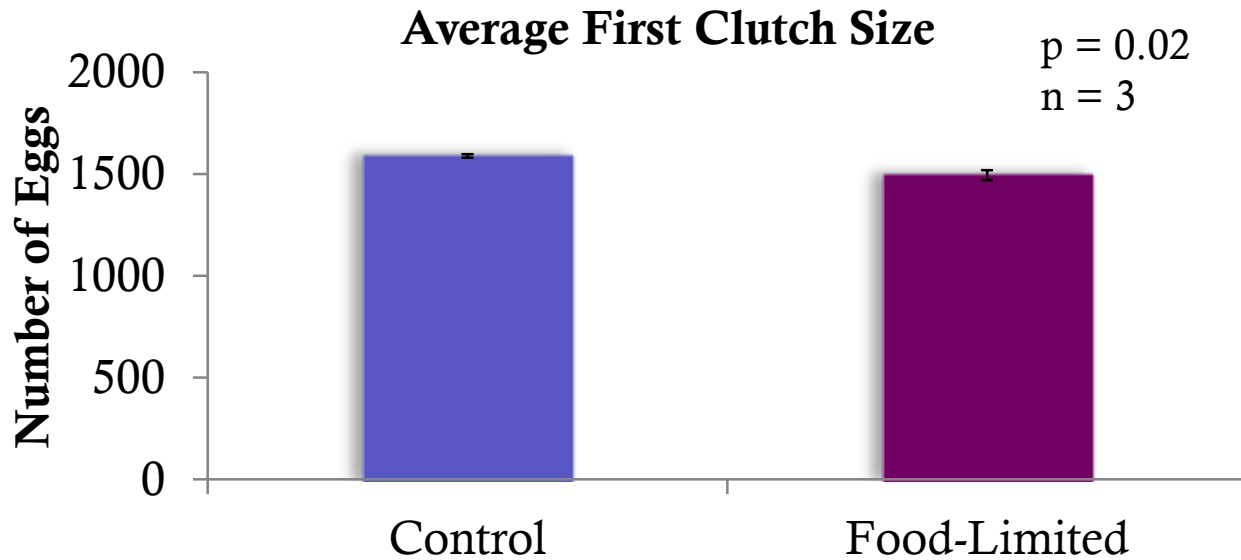
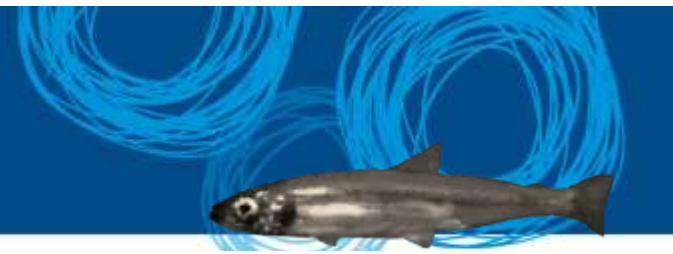


Average Length at First Clutch

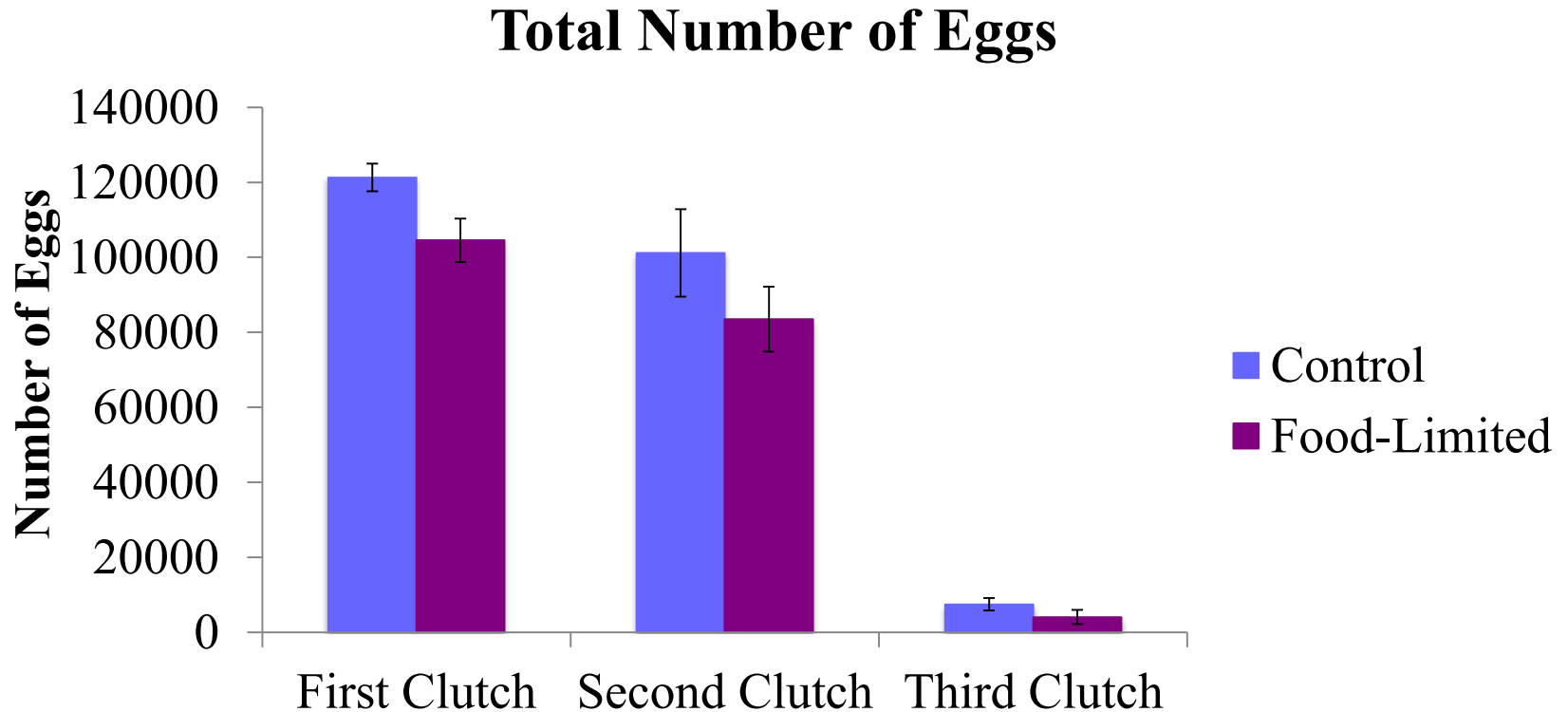
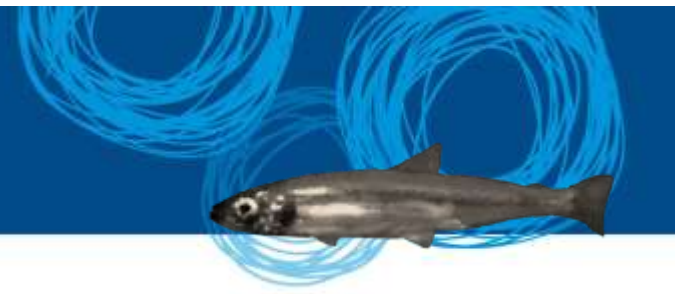


- No significant difference in condition factor

Results: Fecundity

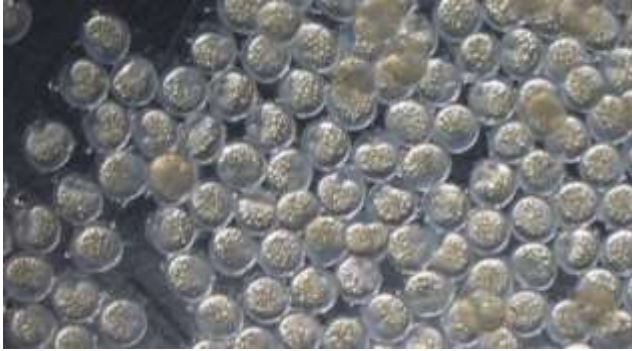


Results: Seasonal Fecundity



Total difference of **113,440** eggs spawned
(20% more eggs)

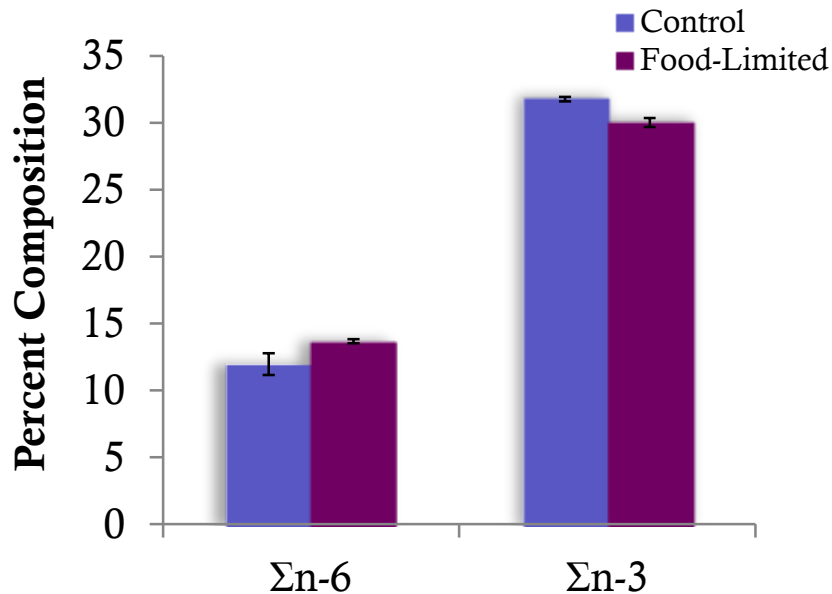
Results: Egg size (Maternal Provisioning?)



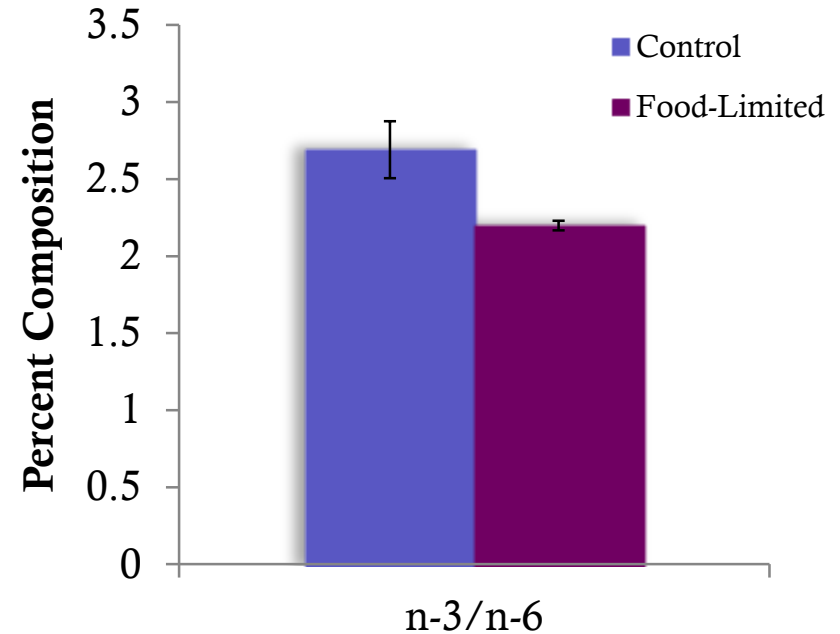
- No difference in egg size between control and food-limited groups (~0.96mm)
- Significant difference in size between clutch 1 and clutch 2
- Second clutch **SMALLER** (~0.92mm)

2013 Pilot Study: Fatty Acid Analysis

Percent Composition of Omega-3 (n-3) and Omega-6 (n-6) Fatty Acids in Eggs



Ratio of Omega-3 (n-3) to Omega-6 (n-6) in Eggs



- Omega-3's important in growth, neural development, and immune system functions
- Omega-3/Omega-6 ratios may have pivotal role in egg and larval quality

Summary



Growth

- Food-limited fish were smaller at the end of the food-limitation period
- Less variation in weight and length frequency distribution

Reproduction and Fecundity

- Smaller clutch size – 20% less eggs spawned over the season
- Egg quality may be affected

Health

- No significant differences in condition factor
- More work to be done with biomarkers

Potential Implications for Delta Smelt



Smaller individuals leads to fewer offspring



Adult food-limitation may affect larval survival by:

- Egg and larval quality



Impacting population abundances in subsequent year



Photo by Marade Sandford



Acknowledgements



- All the staff at the FCCL and AHP!
- Special thanks to Abby Newman, Georgia Ramos, and Alejandro Ruiz



Questions?

