Density Dependence

A data (and thought) exploration

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Density-dependence

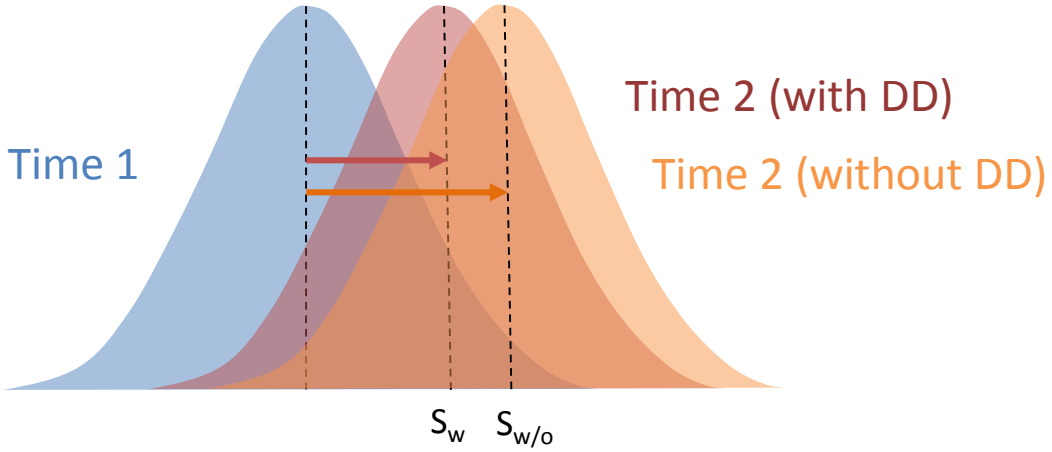
(limiting factors that depend on population size)

What exactly depends on density?

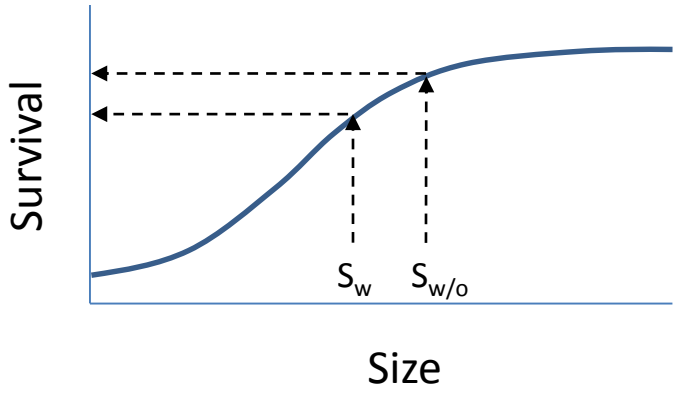
- Feeding/Growth
  Direct competition for prey resources
- Movement/Behavior/Habitat Use
  Physical and behavioral competition for space
- Survival
  Predator rates, cannibalism, antagonistic behavior

Why is density-dependence important?

DD reduces growth and impacts size distribution

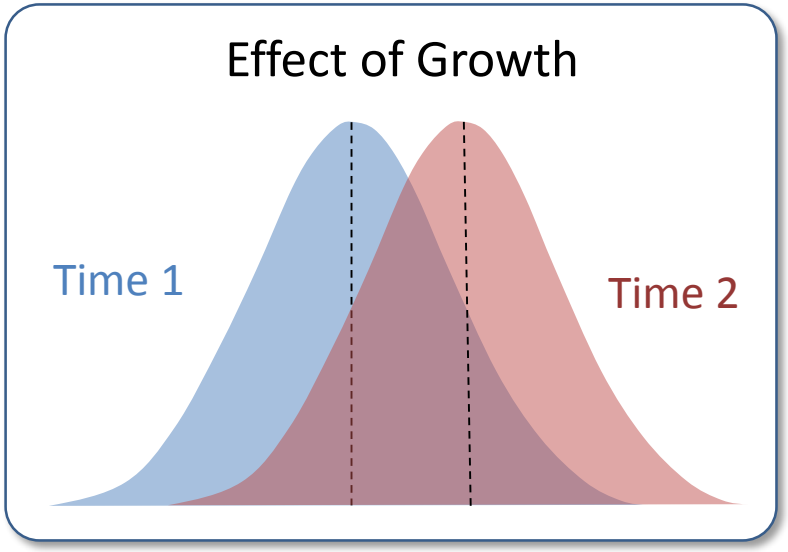


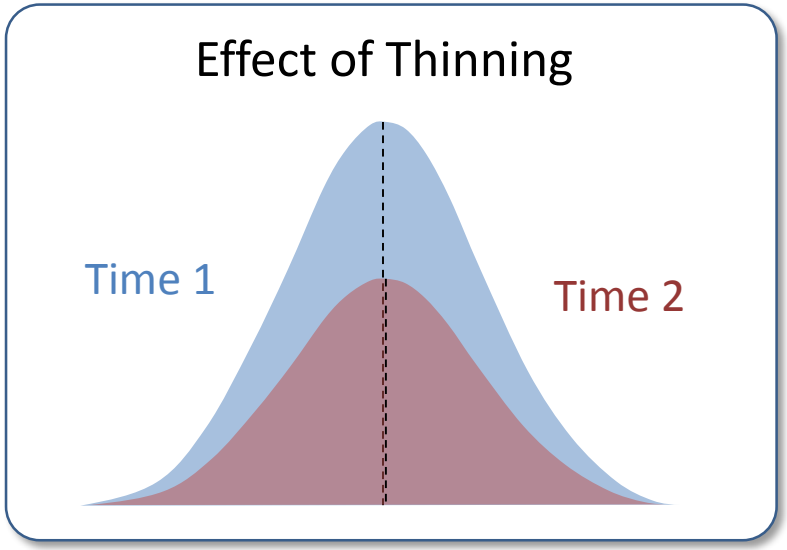
Size-dependent survival

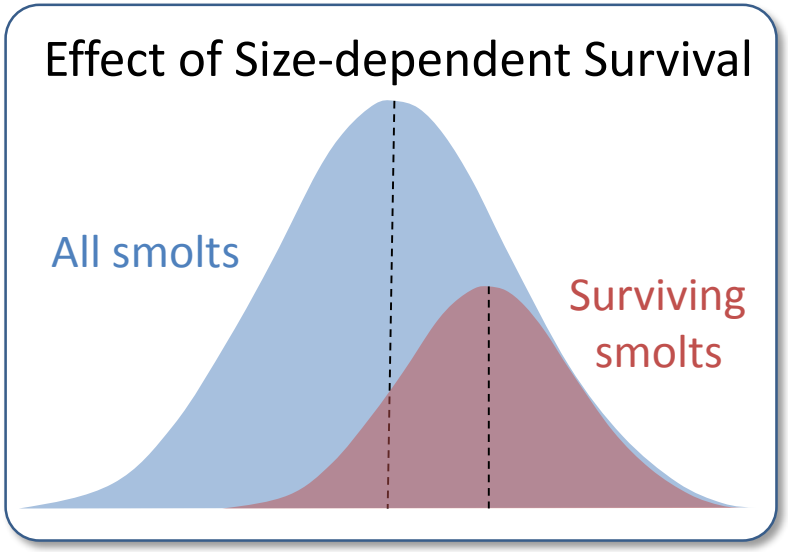


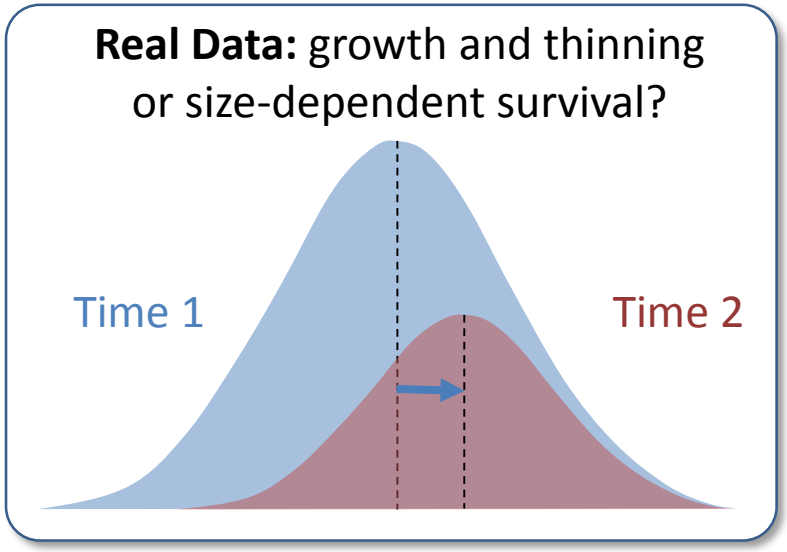
Can we just look at size distributions to study DD?

Changes in Length Distributions



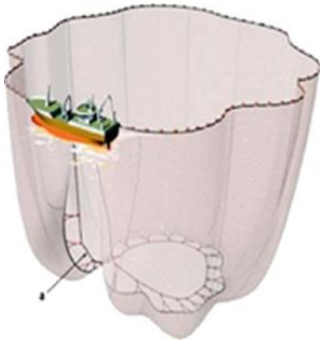




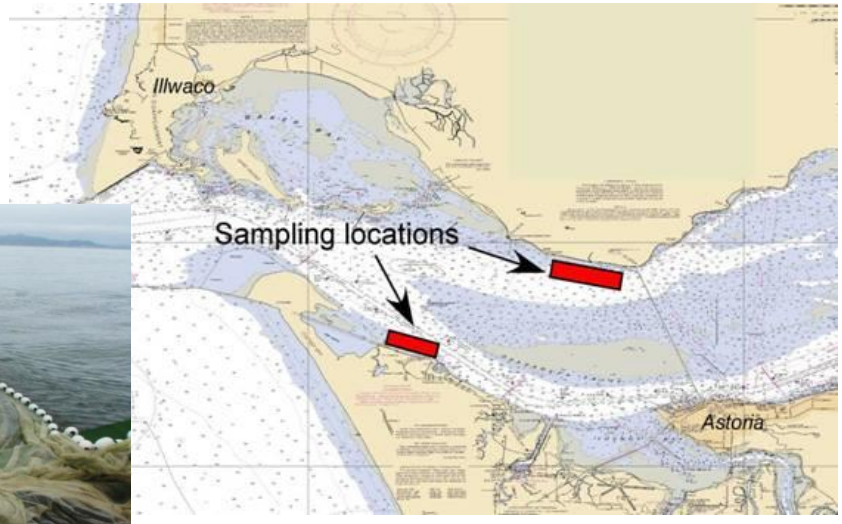


No, we can’t just look at size distributions. We must study the mechanisms.

Methods



- 1,897 stomachs analyzed
- 1,411 hatchery fish (H) and 486 not tagged (W)
- 4 species groups (Chinook sub, Chinook yr, Coho yr, and Steelhead)
- 6 years (2007-2012)
- 2 stations (North Channel and Trestle Bay)
- Between 6 and 10 cruises per year, which included multiple hauls at each of the two stations



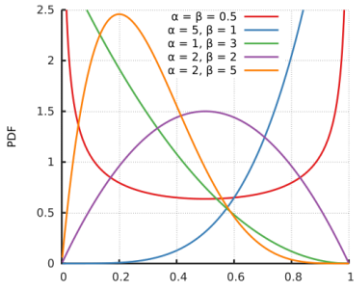
Response variable

% BW (percent body weight) = weight of stomach contents / weight of fish

I lazily called this % BW, but it's a proportion, so ranges from 0 to 1

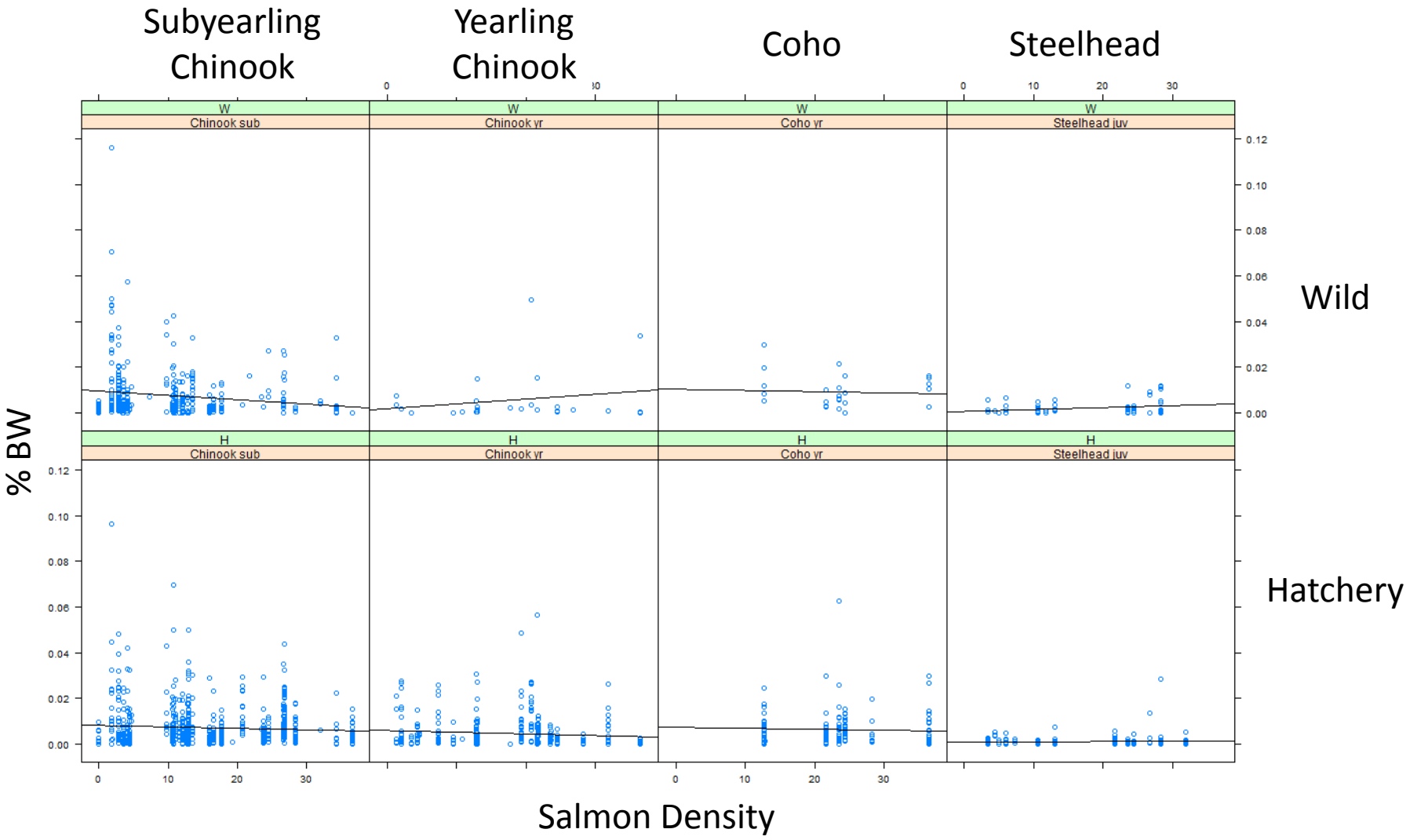
Model

% BW ~ salmonDensity * species/LHT * H/W + year + day + station



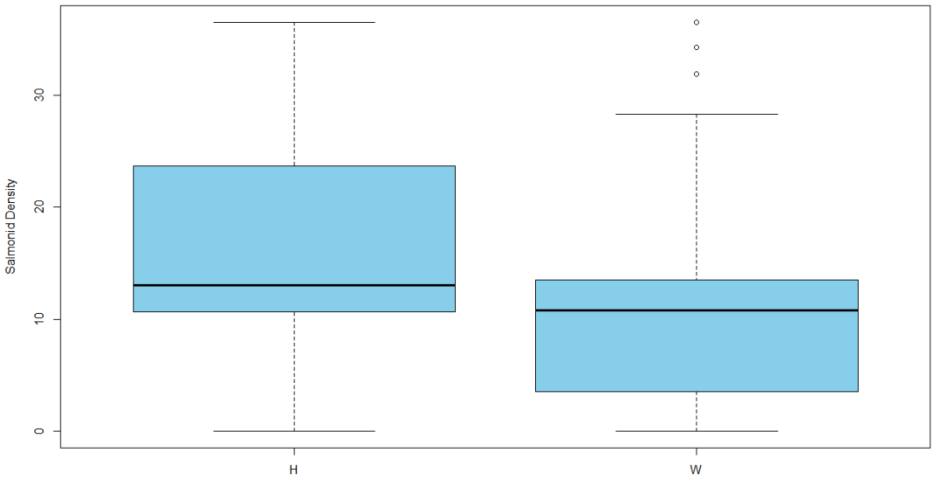
Beta regression, link="loglog"

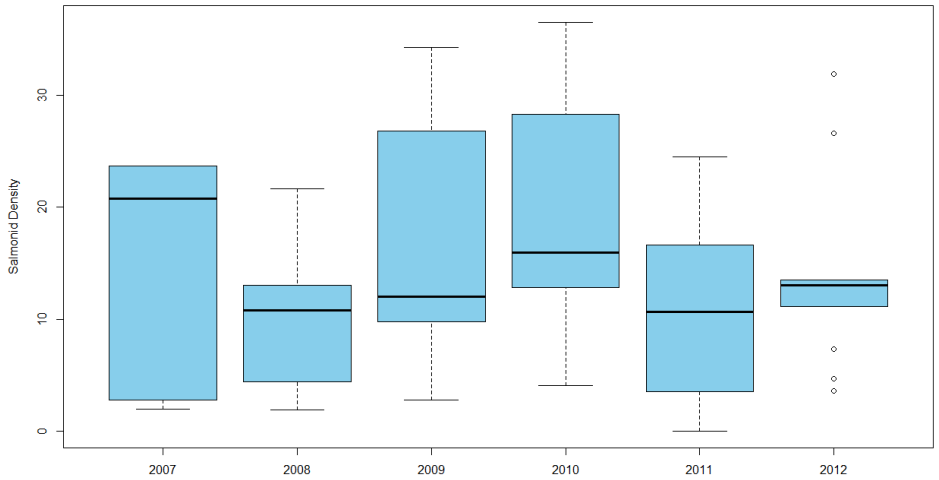
What we had when we initially brought this up as a possible Ocean Forum topic



Density varies across many factors (hatcher/wild, year, species, timing)

Subyearling Chinook

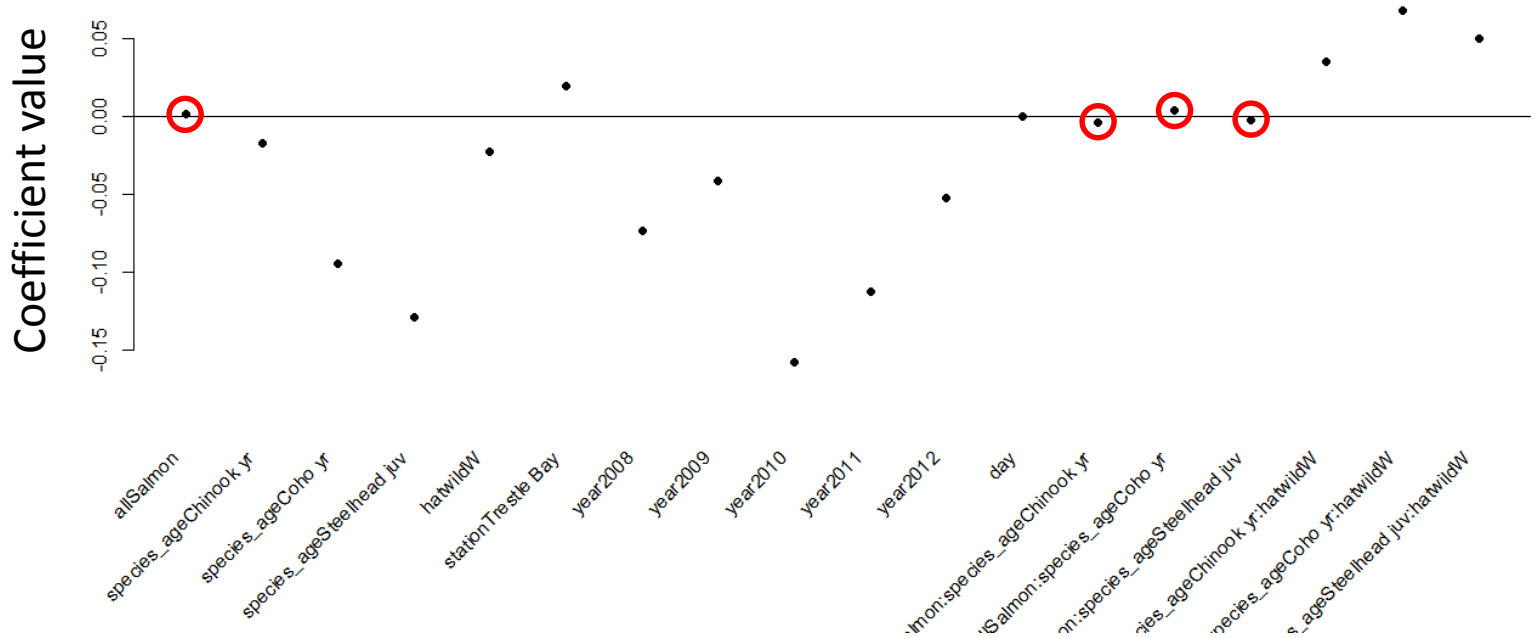




Model Results

Coefficients (mean model with loglog link):

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-1.6430421	0.0391660	-41.951	< 2e-16	***
allSalmon	0.0021382	0.0007651	2.795	0.00519	**
species_ageChinook yr	-0.0171318	0.0255450	-0.671	0.50244	
species_ageCoho yr	-0.0944385	0.0496873	-1.901	0.05735	.
species_ageSteelhead juv	-0.1283440	0.0277555	-4.624	3.76e-06	***
hatwildW	-0.0222196	0.0115642	-1.921	0.05468	.
stationTrestle Bay	0.0197273	0.0086065	2.292	0.02190	*
year2008	-0.0730788	0.0154154	-4.741	2.13e-06	***
year2009	-0.0408124	0.0161459	-2.528	0.01148	*
year2010	-0.1573894	0.0161351	-9.754	< 2e-16	***
year2011	-0.1124735	0.0161818	-6.951	3.64e-12	***
year2012	-0.0523495	0.0181181	-2.889	0.00386	**
day	0.0004534	0.0001580	2.869	0.00412	**
allSalmon:species_ageChinook yr	-0.0036725	0.0011685	-3.143	0.00167	**
allSalmon:species_ageCoho yr	0.0041281	0.0019389	2.129	0.03324	*
allSalmon:species_ageSteelhead juv	-0.0019922	0.0012588	-1.583	0.11351	
species_ageChinook yr:hatwildW	0.0355027	0.0346695	1.024	0.30582	
species_ageCoho yr:hatwildW	0.0684460	0.0361496	1.893	0.05830	.
species_ageSteelhead juv:hatwildW	0.0503721	0.0256221	1.966	0.04930	*



Summary

- This is not conclusive.
- I was forced to separately account for the effect of year and location because there may be inherent differences in productivity, prey availability, predator density, etc. I wouldn't want to attribute low stomach contents to fish density if it was mainly due to interannual differences in productivity, for example.
- If we had an independent estimate of food availability, we could account for these effects directly.
- Similar effect with differences between hatchery and wild fish. Hatchery fish had less food in their stomachs and were often found in higher densities, but this doesn't necessarily imply a cause and effect relationship – it could also have been due to differences in migration timing. Independent estimates of prey availability at varying levels of abundance would be required to refine this analysis.