The effect of variations in timing and magnitude of euphausiid productivity on return variability of Somass River sockeye (*Oncorhynchus nerka*) salmon

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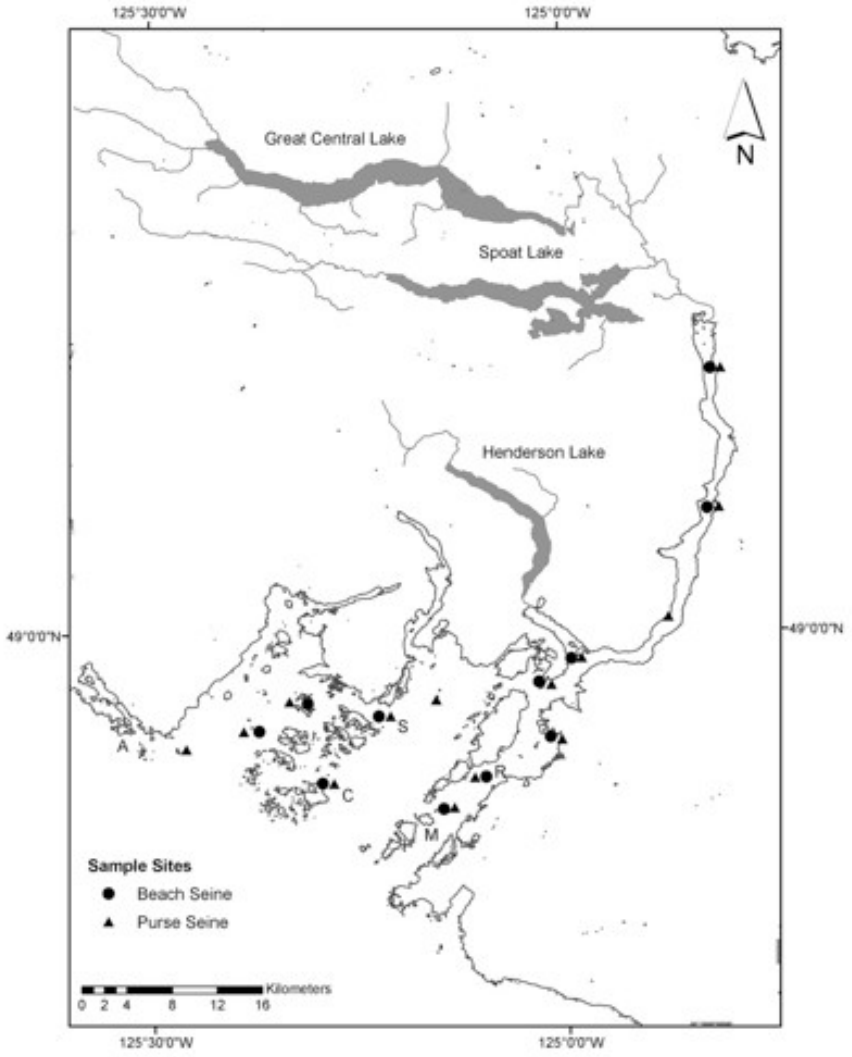
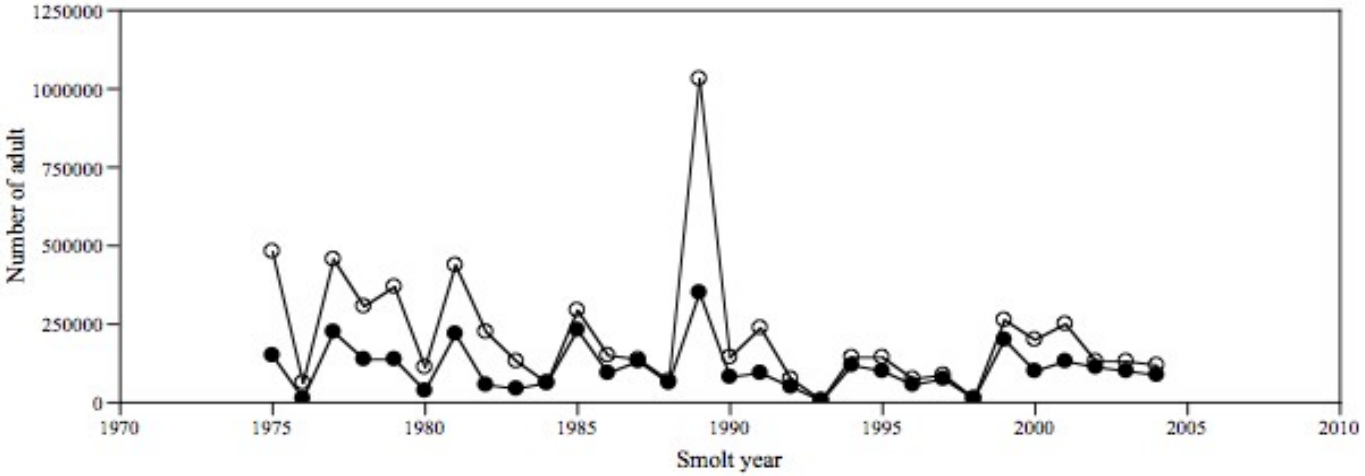
Data

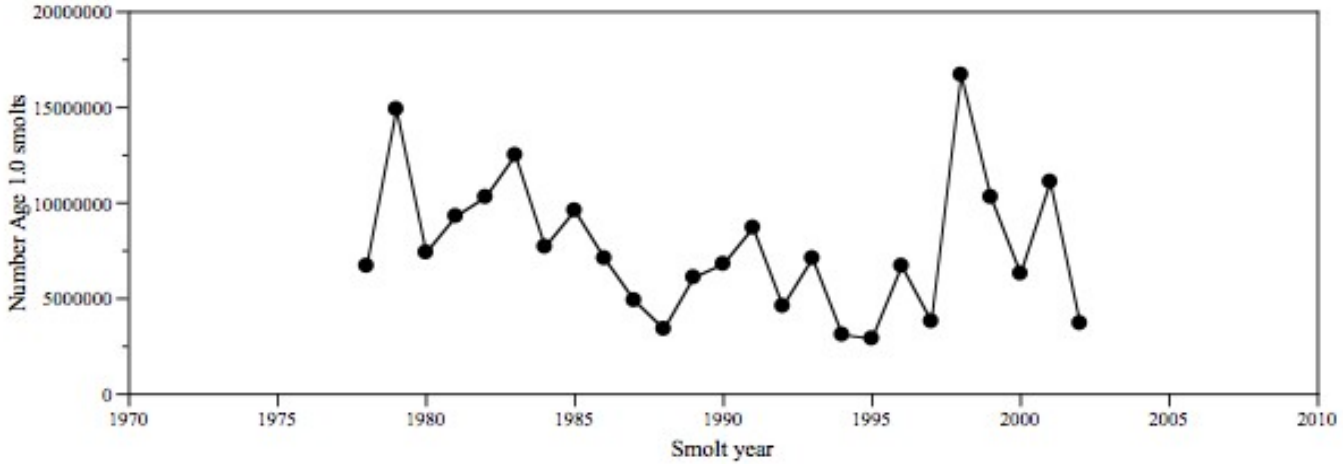


Barkley Sound Study Area. Circles - purse-seining sites; Triangles - beachseining sites; C, M, R, S - euphausiid/zooplankton sampling sites; A - Amphitrite Point lighthouse.

Somass River Sockeye



Total return - open circles; escapement - Closed circles, 1975 - 2004

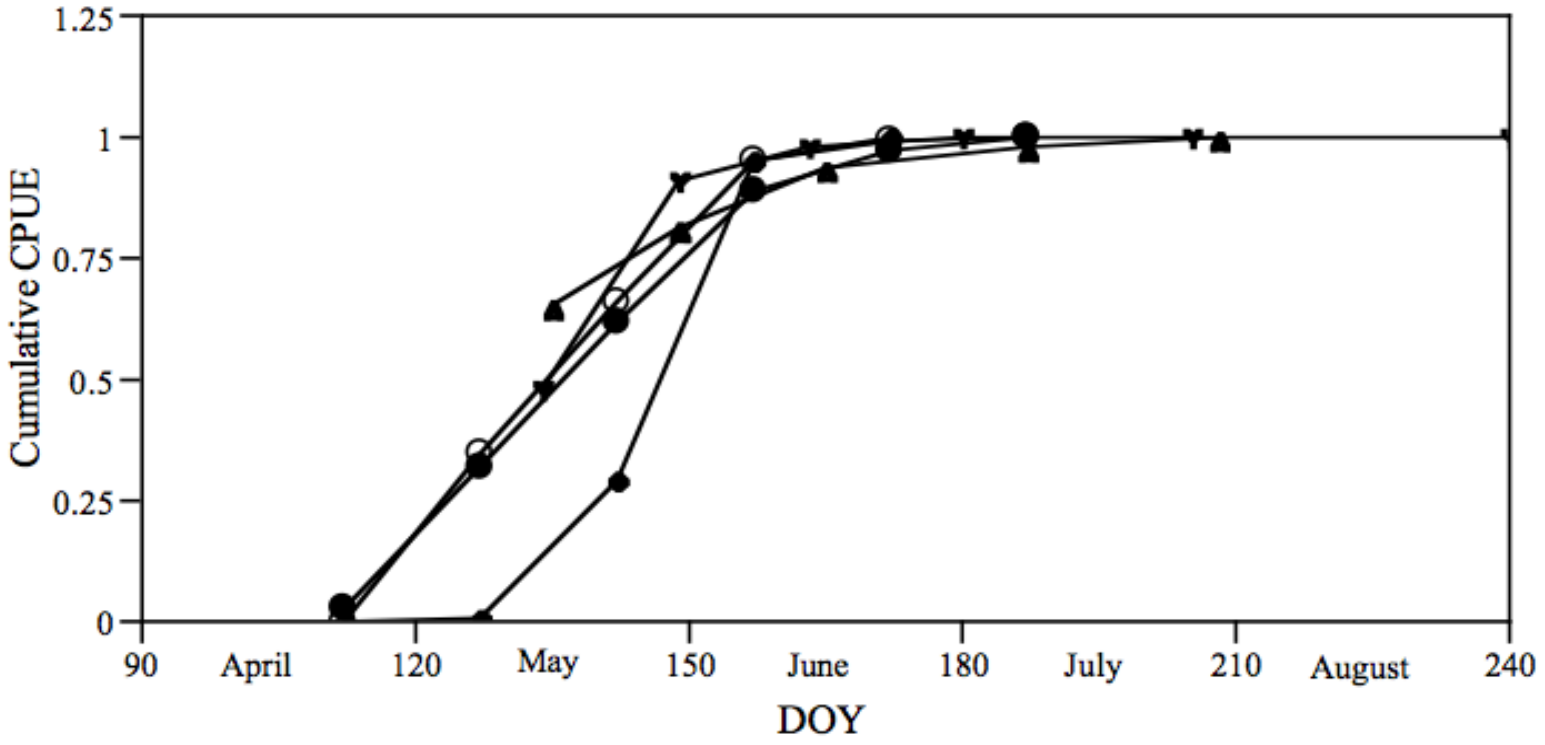


Smolt escapement, 1978 - 2002

Catches of juvenile salmon, Barkley Sound, 2000-01

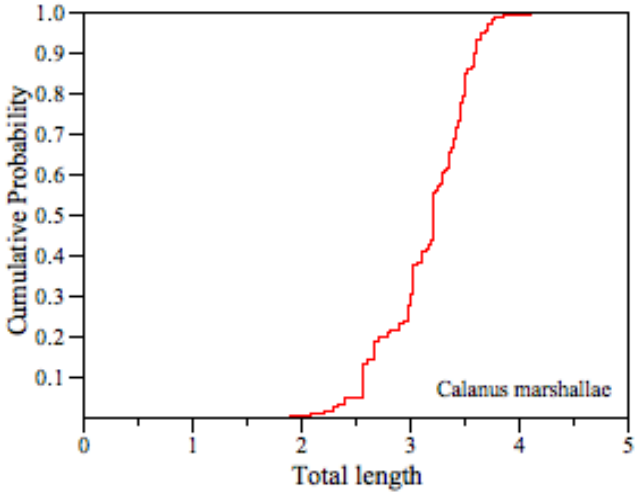
Date	Species					
	Chinook	Coho	Sockeye	Chum	Steelhead	Total
			2000			
May 15-16	135	167	4545	3082	431	8360
May 29-30	119	308	1605	2815	3	4850
Jun 13-14	2779	78	1316	1630	1	5804
Jul 5-6	2446	12	418	15	0	2891
Jul 26-27	976	10	132	89	0	1207
Total	6454	575	8016	7631	435	23111
			2001			
May 14-15	1	28	16805	11023	2	27860
May 29-30	37	259	15100	6906	21	22323
Jun 12-13	1725	136	2554	2494	0	6909
Jun 29	1288	49	384	5	0	1725
Jul 24-25	430	9	159	14	0	612
Aug 28-29	85	1	1	0	0	87
Total	3564	482	35003	20443	23	59515

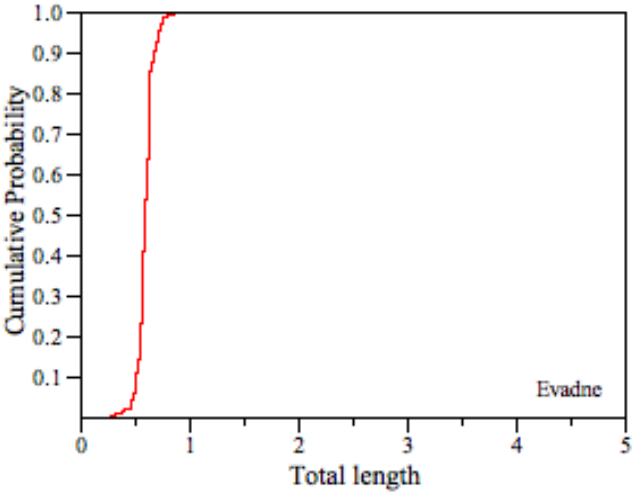
Juvenile migration timing

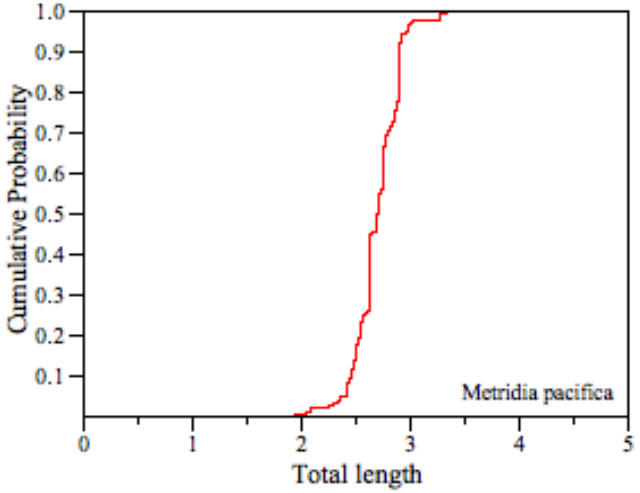


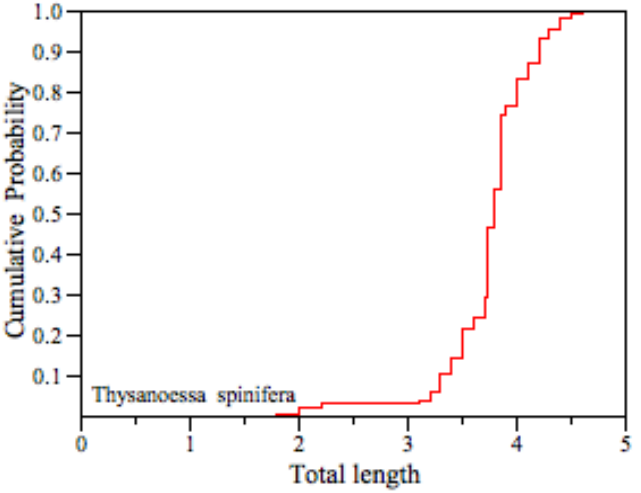
Migration timing for Barkley Sound sockeye. Closed circles – 1988; open circles 1989; closed diamond – 1989; closed triangle – 2000; Y – 2001. Sockeye leave consistently by the end of May. 1988-89 data courtesy of B. Hargreaves.

Juvenile sockeye diet, n=218 stomachs, 3904 prey items

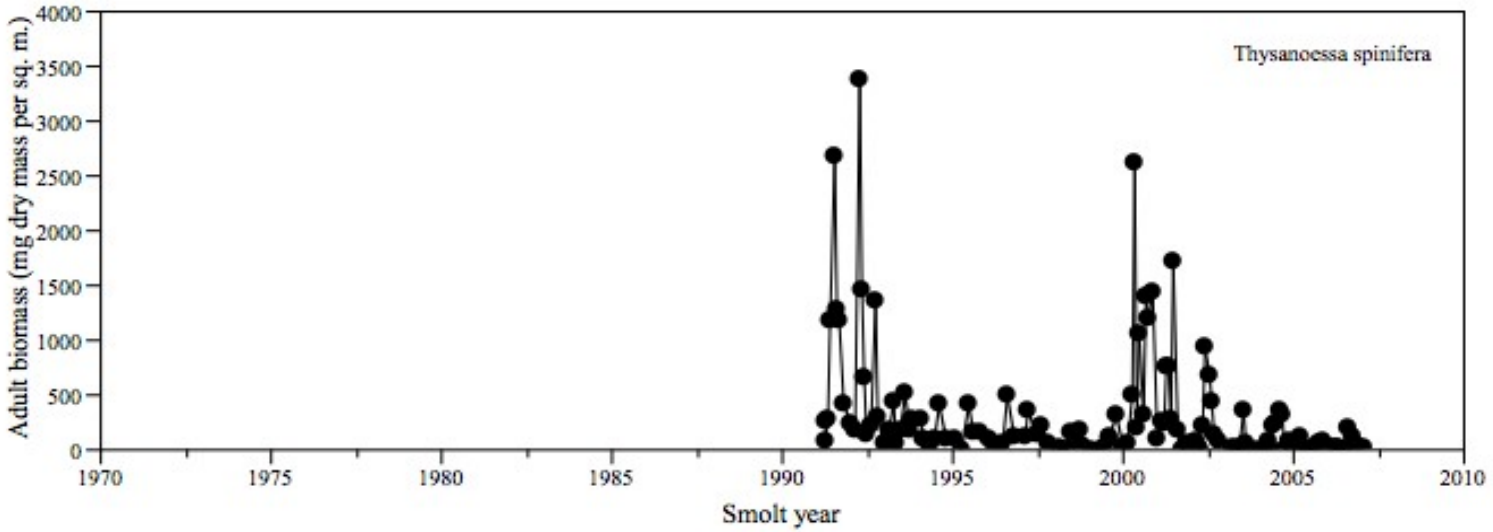








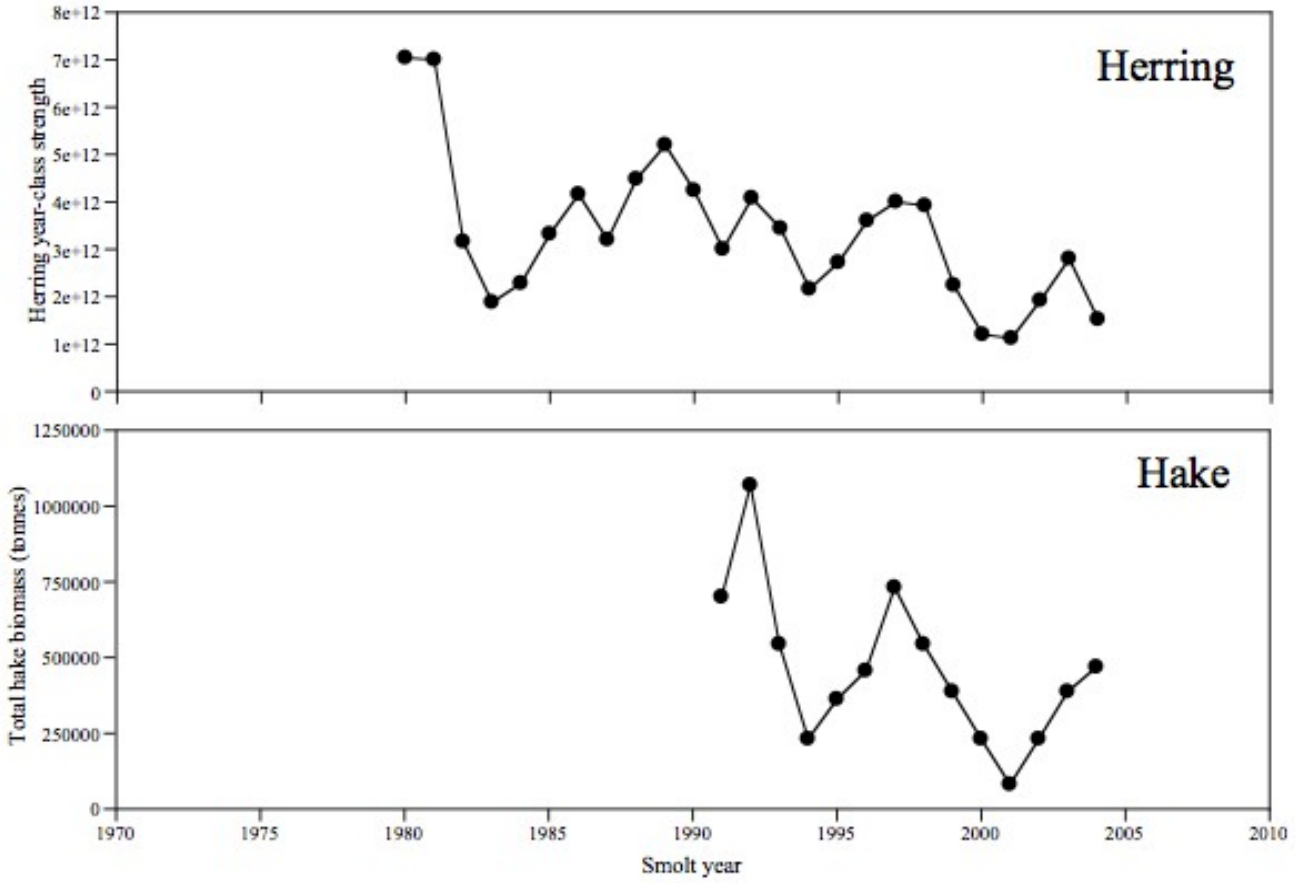
Prey biomass time series



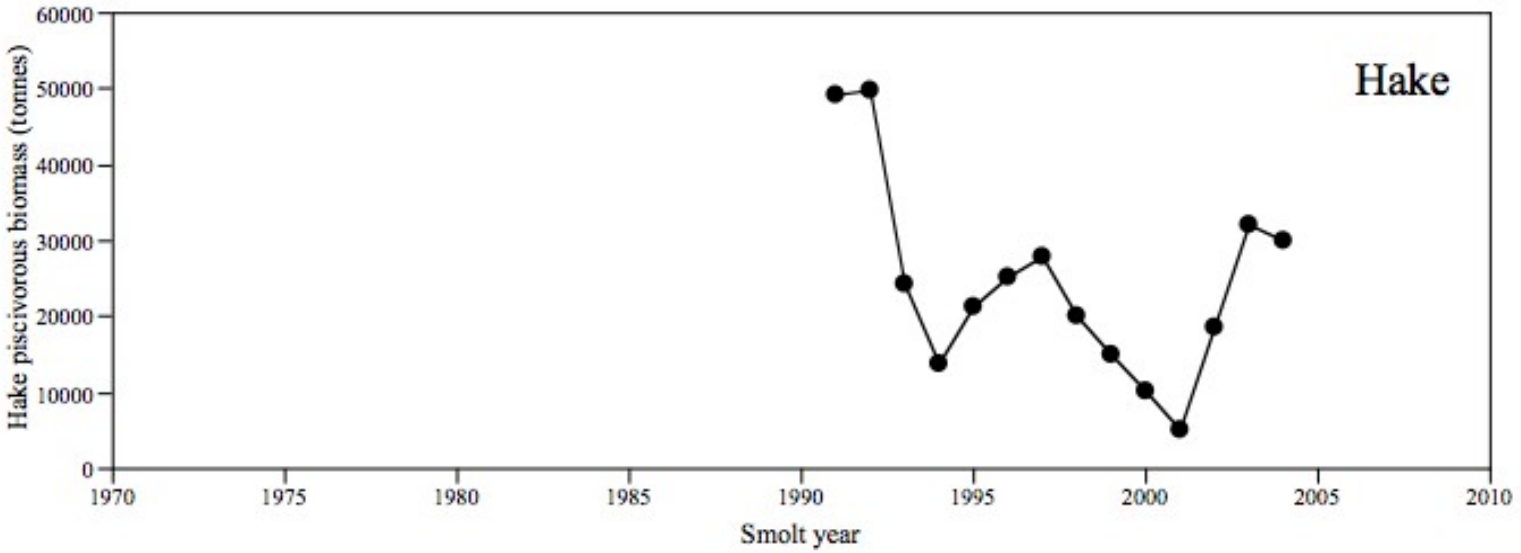
Euphausiids - 1991-2006; 127 cruises; 130,664 individuals measured

Copepods etc. - 1991-2004 (in part); 106 cruises; 88,924 individuals measured

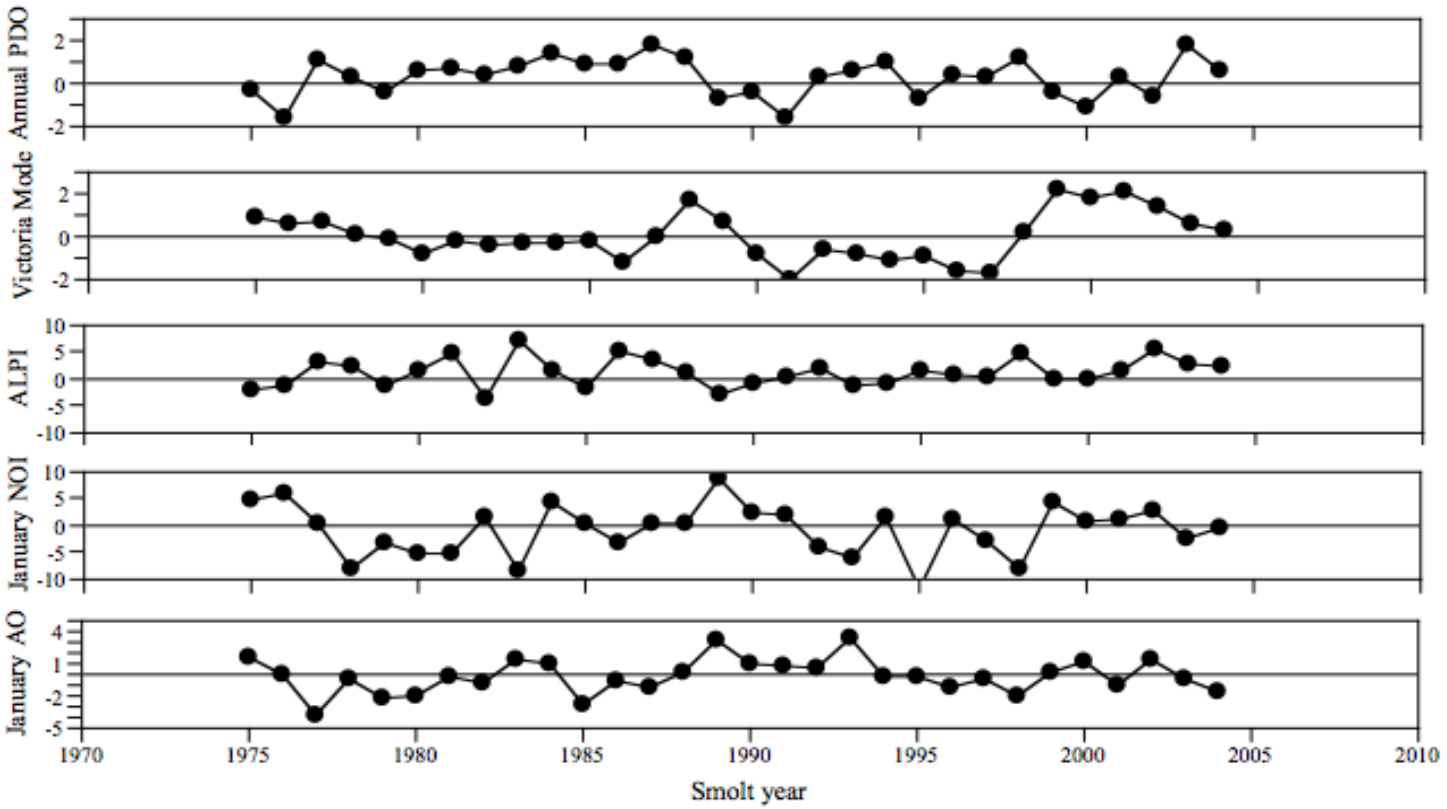
Potential competitors



Potential predators



Ocean climate indices



Monthly (January - May) included when available; Amphitrite Point SSS and SST corrected to 50 m; current velocity index (upwelling) pending

Analyses

- Analyses consisted of conducting all possible simple and two factor multiple regressions to test for effects on lake- and age-specific (ages 3.2, 4.2, 4.3, 5.2, 5.3, and 6.3) total sockeye return

- Regressions based on log-transformed variables were appropriate as indicated by residual distributions

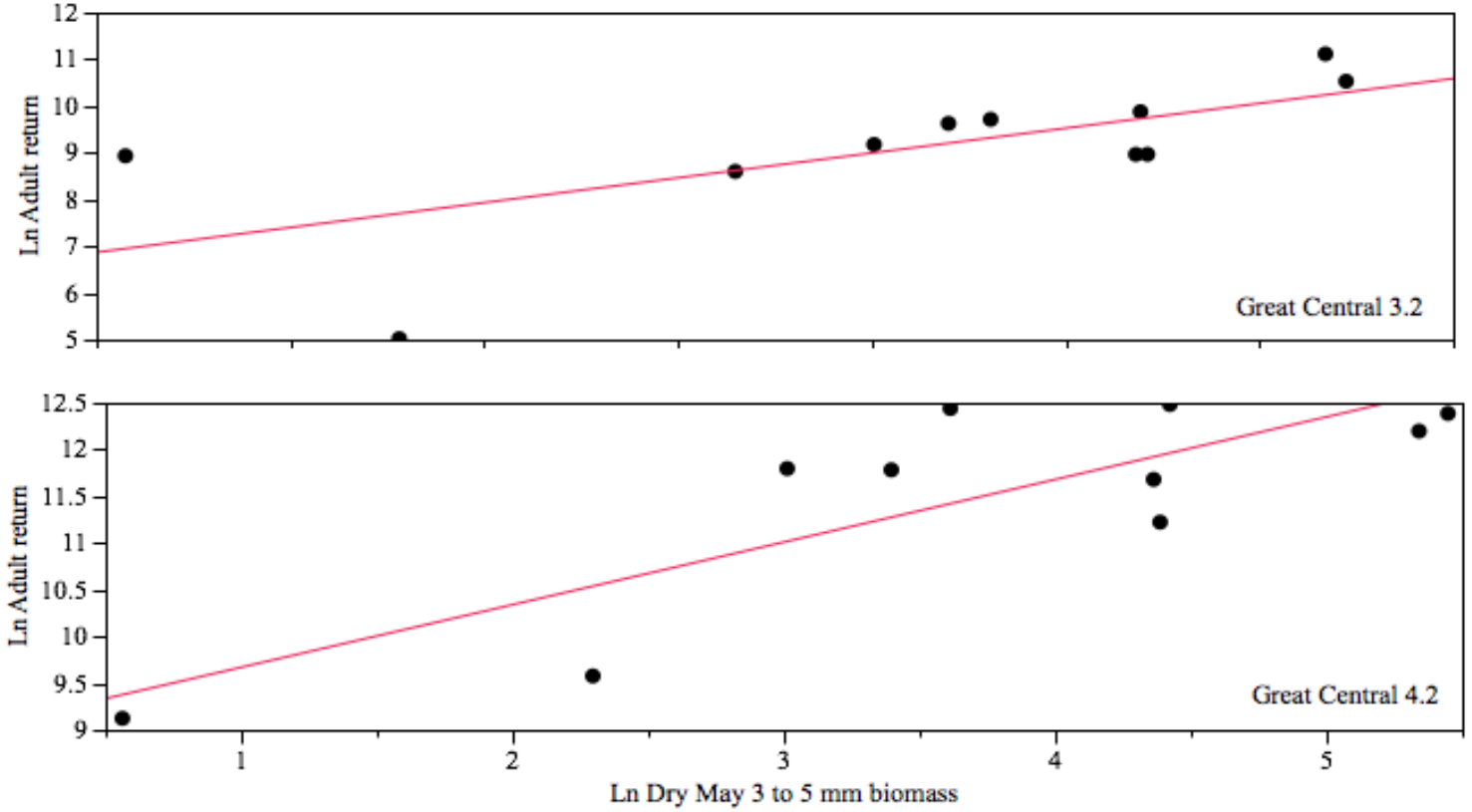
- Environmentally-dependent Ricker stock-recruit relationship used to test for stock effect

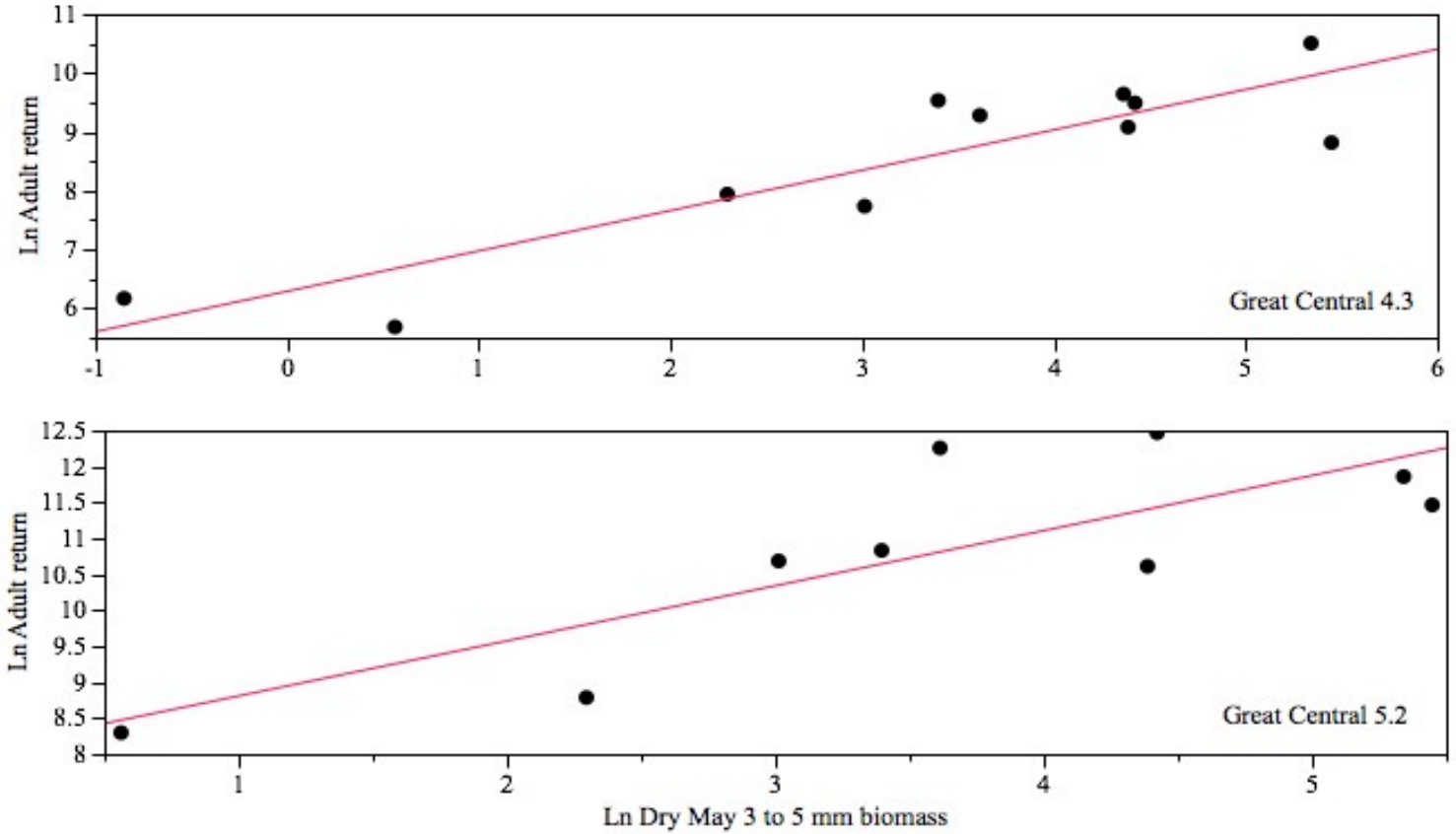
- 1880 regressions were estimated for each lake- and age-group

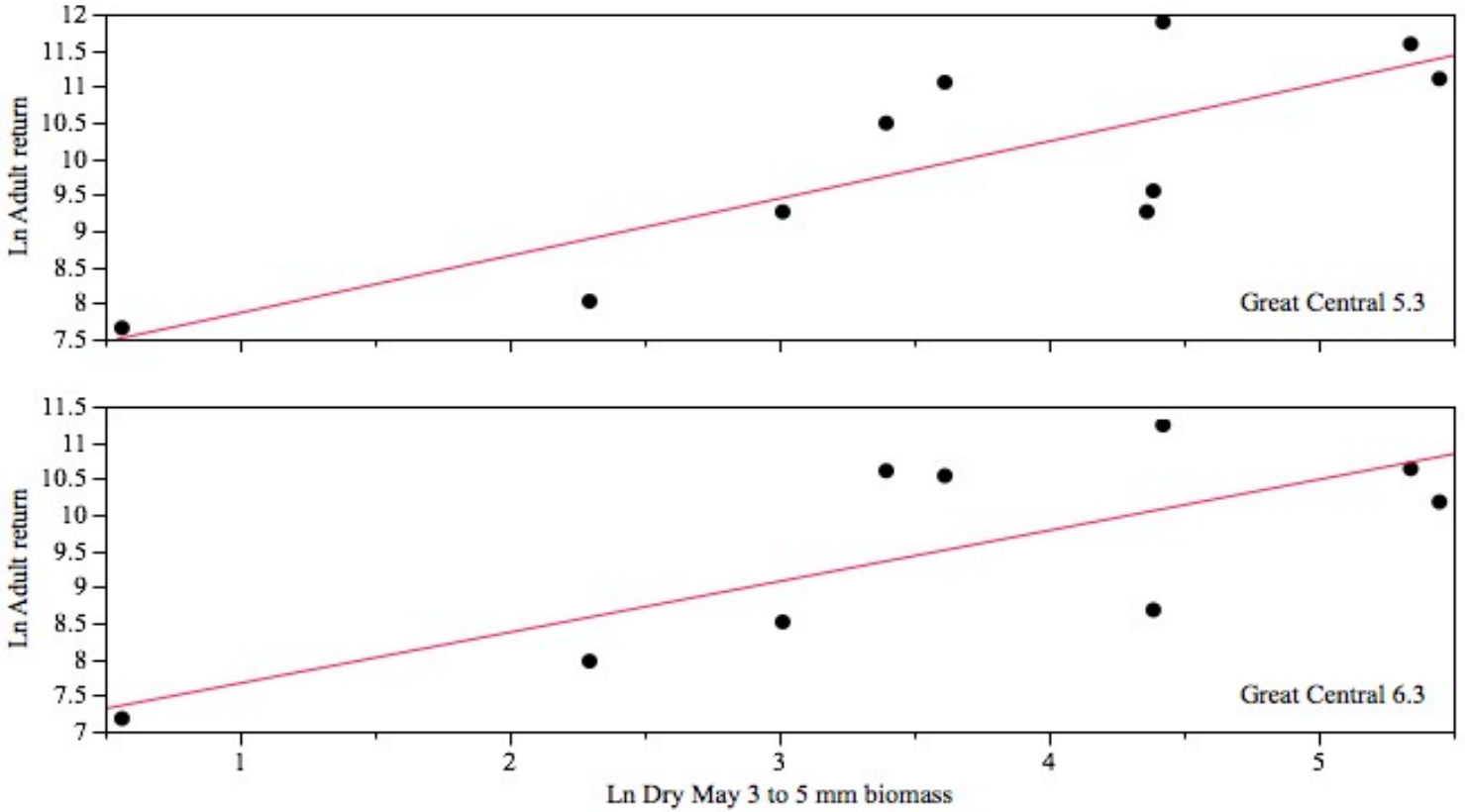
- The regression model with the highest ranking over all lake- and age-groups was selected to minimise the likelihood of selecting a spurious relationship

Results

Total return variation is explained best by variations in the biomass of 3-5 mm *T. spinifera* in May




Ln Adult return
11
10
9
8
7
6
-1
0
1
2
3
4
5
6
Great Central 4.3
Ln Adult return
12.5
12
11.5
11
10.5
10
9.5
9
8.5
8
1
2
3
4
5
Great Central 5.2
Ln Dry May 3 to 5 mm biomass


Ln Adult return
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Great Central 5.3
Ln Adult return
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Great Central 6.3
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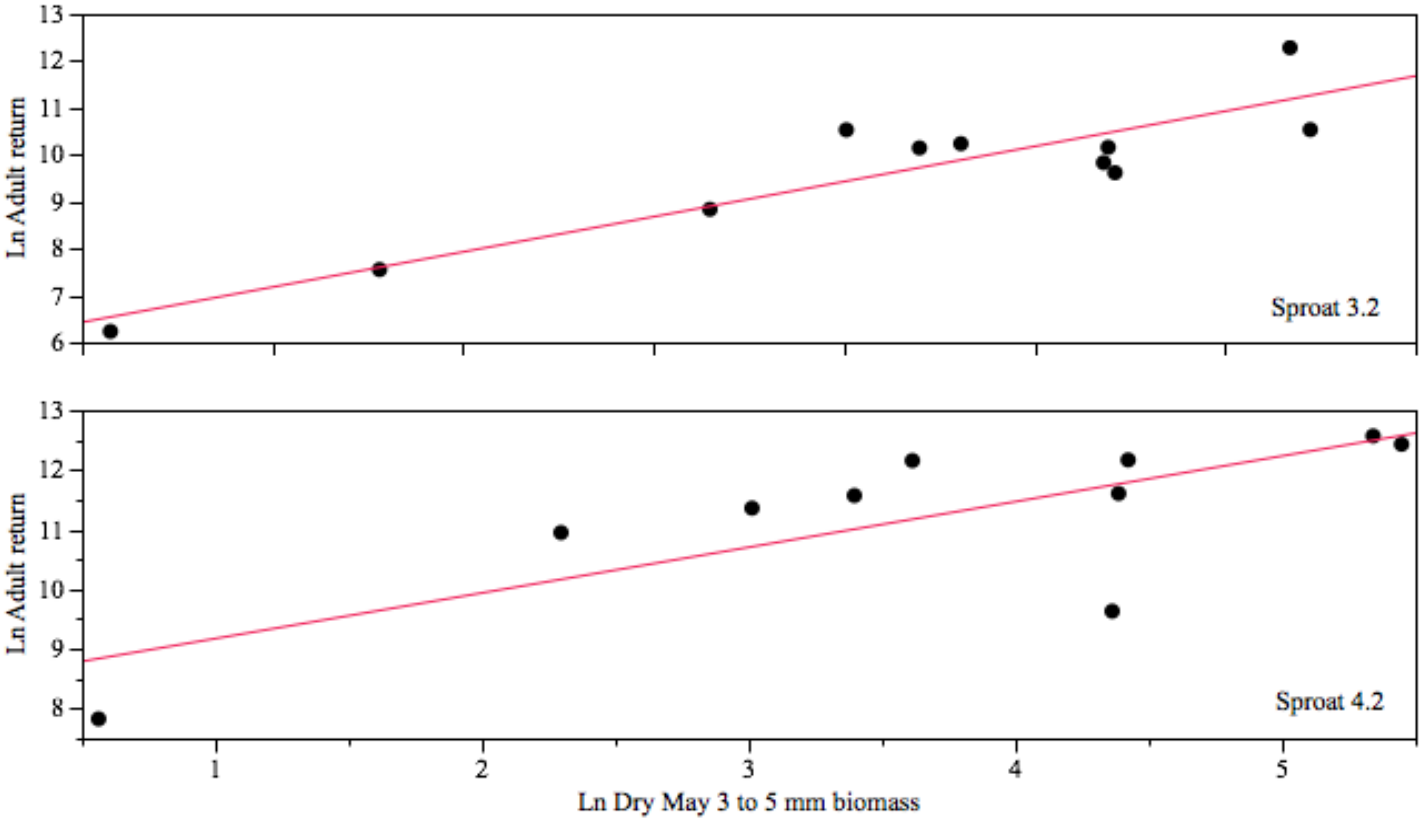
Ln Dry May 3 to 5 mm biomass


Ln Adult return
13
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Sproat 3.2
Ln Adult return
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Sproat 4.2
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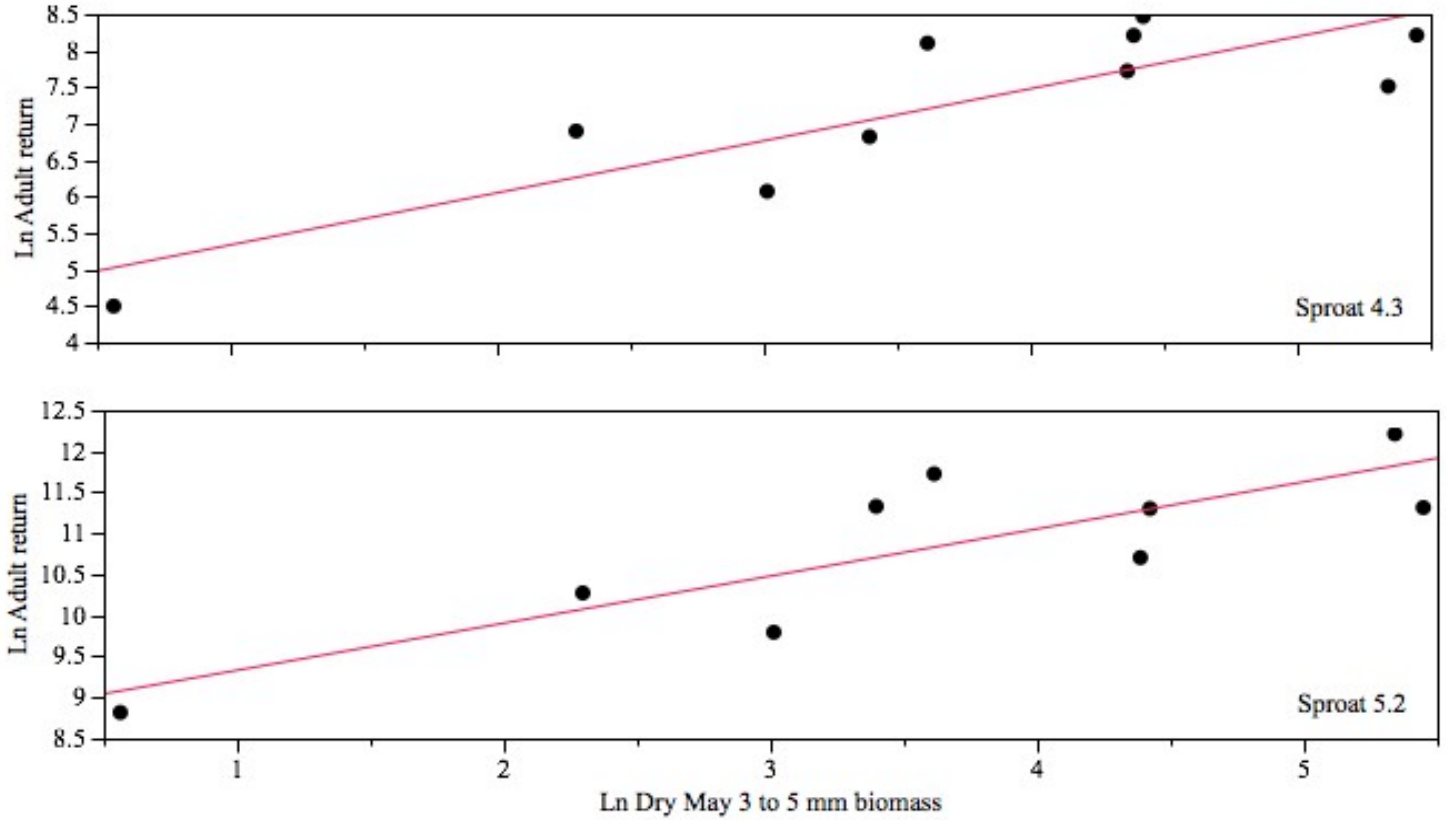
Ln Dry May 3 to 5 mm biomass


Ln Adult return
8.5
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Sproat 4.3
Ln Adult return
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Sproat 5.2
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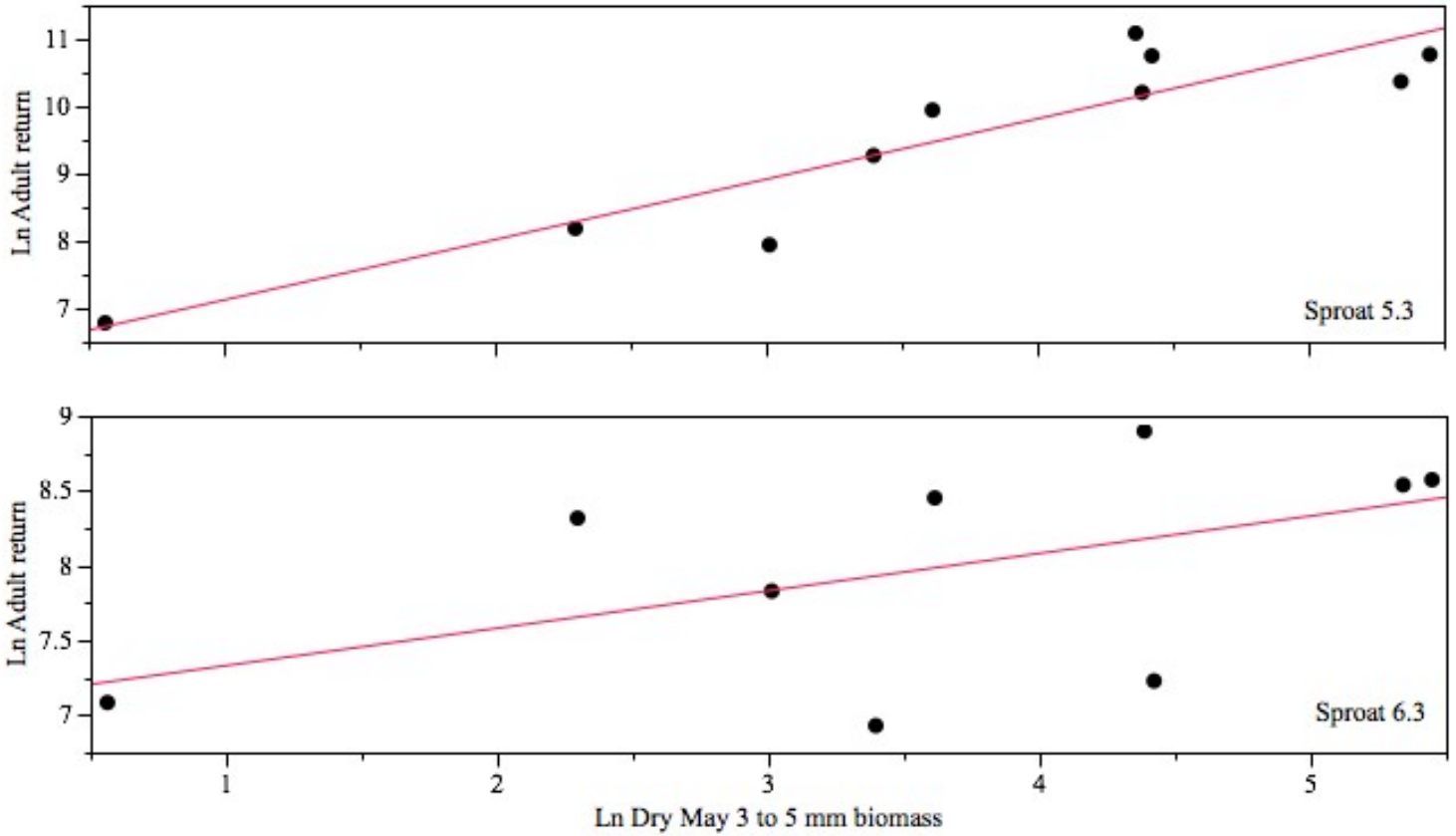
Ln Dry May 3 to 5 mm biomass


Ln Adult return
11
10
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Sproat 5.3
Ln Adult return
9
8.5
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7.5
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Sproat 6.3
1
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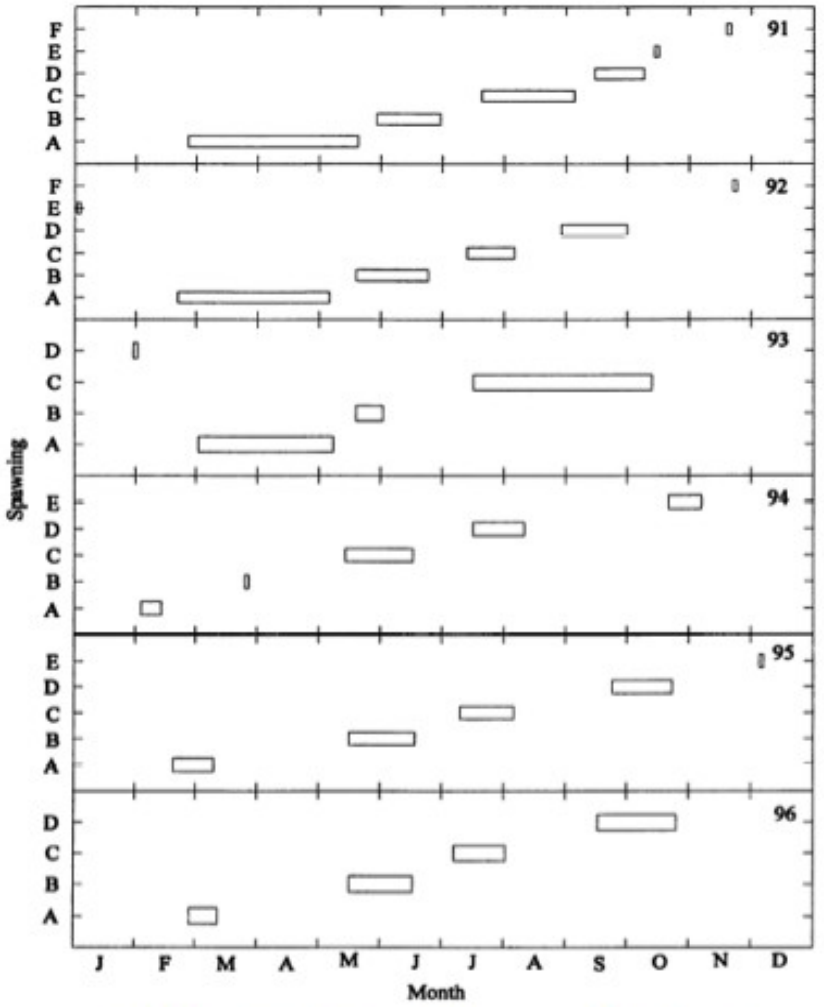
5
Ln Dry May 3 to 5 mm biomass

Regression statistics summary

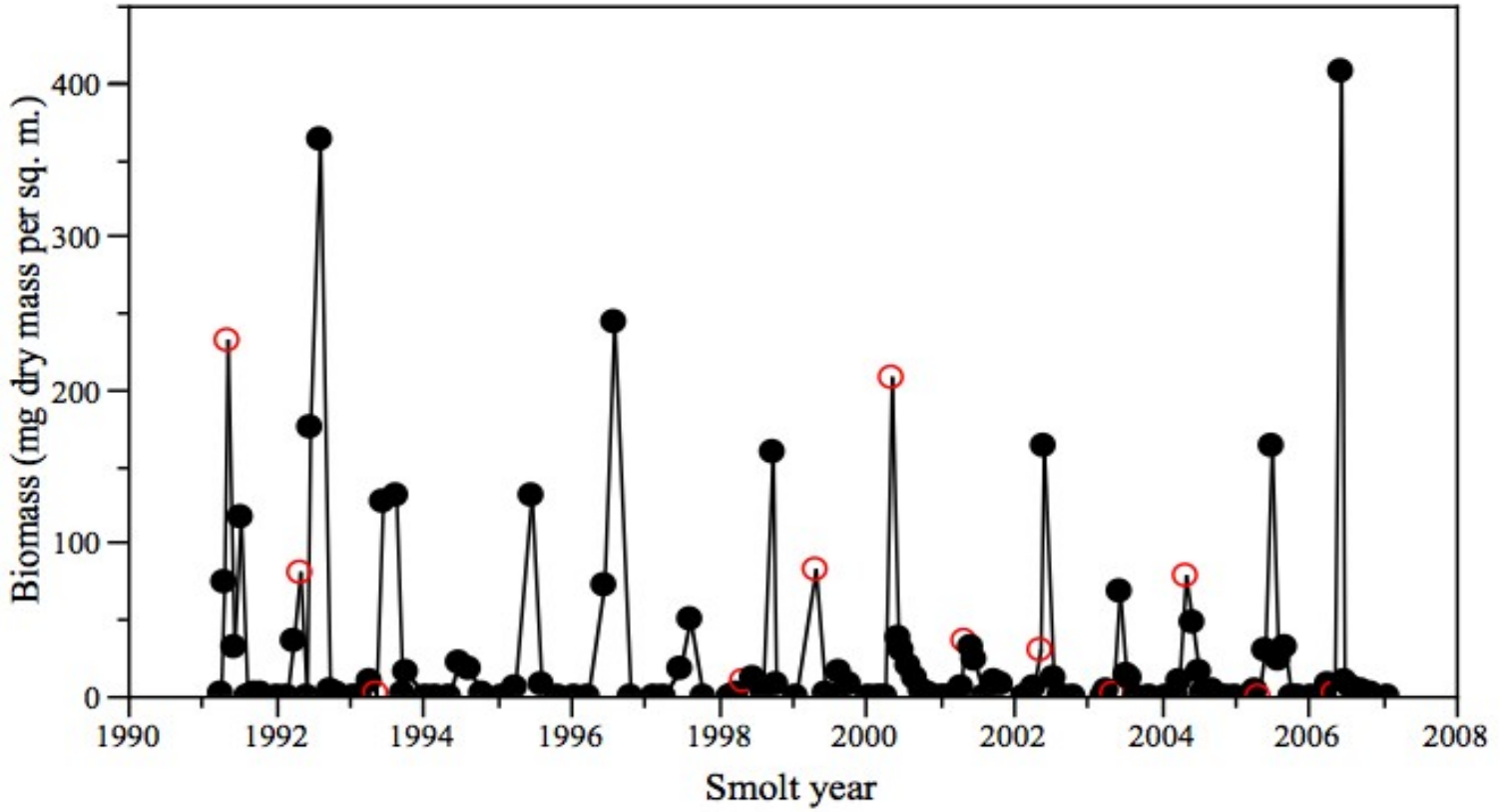
Age	n	Median run size	Adjusted R-square	Slope		Intercept	
				Estimate	p-value	Estimate	p-value
				Great Central Lake			
3.2	11	17433	0.38	0.53	0.02	7.40	<0.0001
4.2	10	142786	0.65	0.67	0.003	9.00	<0.0001
4.3	11	3633	0.77	0.69	0.0002	6.29	<0.0001
5.2	10	117730	0.62	0.77	0.0074	8.04	<0.0001
5.3	9	37796	0.59	0.79	0.0058	7.07	<0.0001
6.3	11	17861	0.51	0.70	0.0178	6.96	<0.0001
				Sproat Lake			
3.2	11	25622	0.80	0.75	0.0001	7.18	<0.0001
4.2	10	157595	0.54	0.76	0.0096	8.41	<0.0001
4.3	11	2217	0.70	0.71	0.0016	4.62	<0.0001
5.2	10	83589	0.67	0.57	0.0044	8.76	<0.0001
5.3	9	25406	0.82	0.90	0.0002	6.22	<0.0001
6.3	11	5293	0.17	0.25	0.15	7.08	<0.0001

Match-mismatch?

T. spinifera spawning events



There appears to be variability in the timing and duration of spawning; we don't know magnitude because we can't identify *T. spinifera* eggs



There was a match in juvenile sockeye migration timing and a peak in 3-5 mm *T. spinifera* biomass in 6 of the 12 years when total return and euphausiid biomass data were available. Open circles - May.

Summary and Conclusions

1. We used data on stock (number of parents and recruits per spawner, brood- and smolt-year number of smolts, total return), as well as migration timing, diet, prey availability, competitive fish biomass, piscivorous fish biomass, and ocean climate indices to learn about the biological basis of Somass River sockeye return variability

2. Results showed that return variability is determined by the biomass of 3-5 mm *Thysanoessa spinifera* in May, when juveniles migrate through Barkley Sound

3. Sockeye migration timing and peaks of *T. spinifera* biomass co-occurred in six of 12 years; this shows how the match of migration timing to euphausiid production seasonality can affect return variability