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6.3 Growth and survival of Columbia River Chinook salmon in the Northern California Current

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NWR NMFS Biop

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Protected Fish Species Review

Density Dependence and its Implications for Fish Management and Restoration Programs in the Columbia River Basin

“Despite the importance of density dependence, very few studies have directly tested or even **Arm wave** density dependence during the ocean stage of Columbia River Basin salmonid populations (Table V.1).”

Carrying capacity, competition (indirect), size dependent

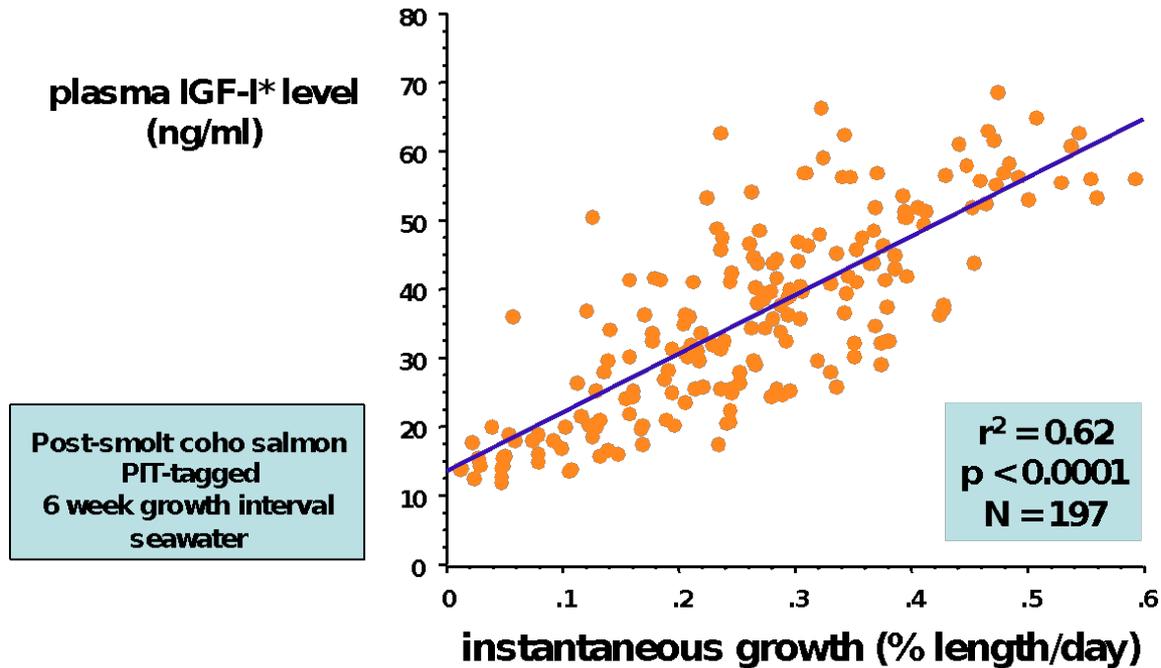
ISAB 2015-1 February 25, 2015

Hypothesis: marine survival of juvenile salmon is directly related to early growth in the ocean

(Ocean Ecology of Pacific Salmon, Pearcy 1992)

- 1. How can growth in the ocean be measured?
Or, why does a physiologist go to sea?**
- 2. How can fish from different populations be distinguished
(Sacramento, Columbia, Fraser)?**

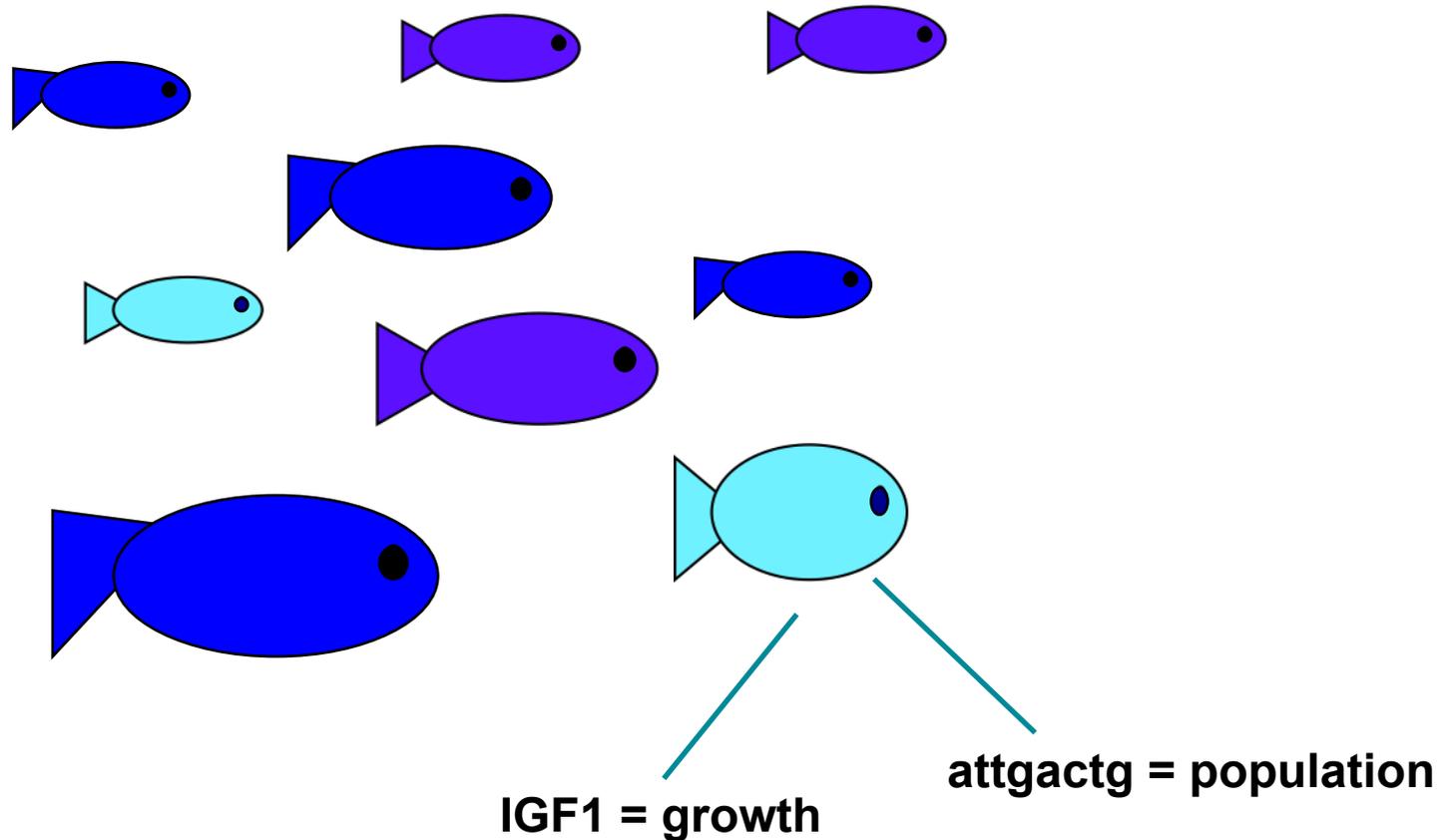
The hormone IGF1 is a growth index



*TRF immunoassay

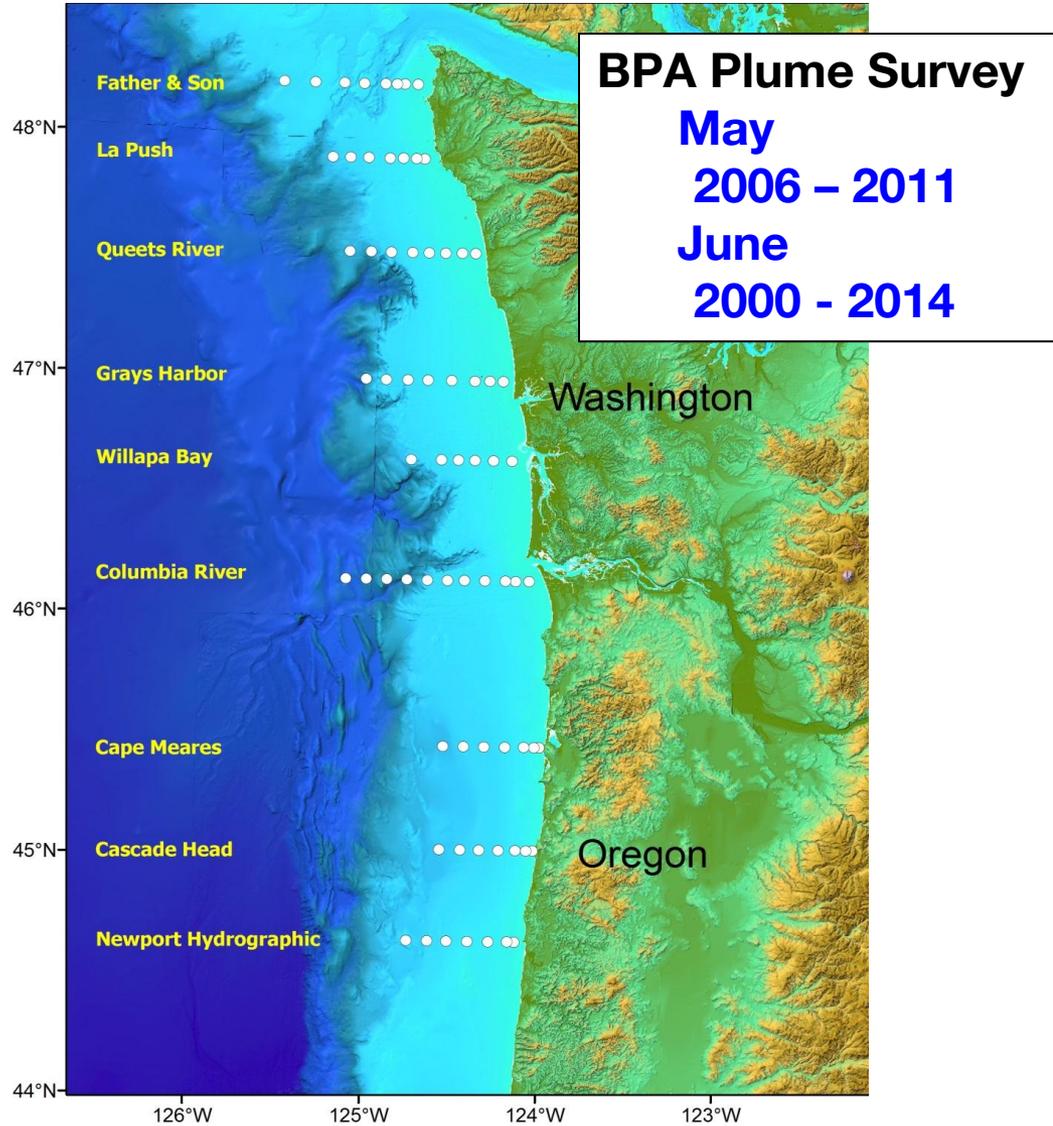
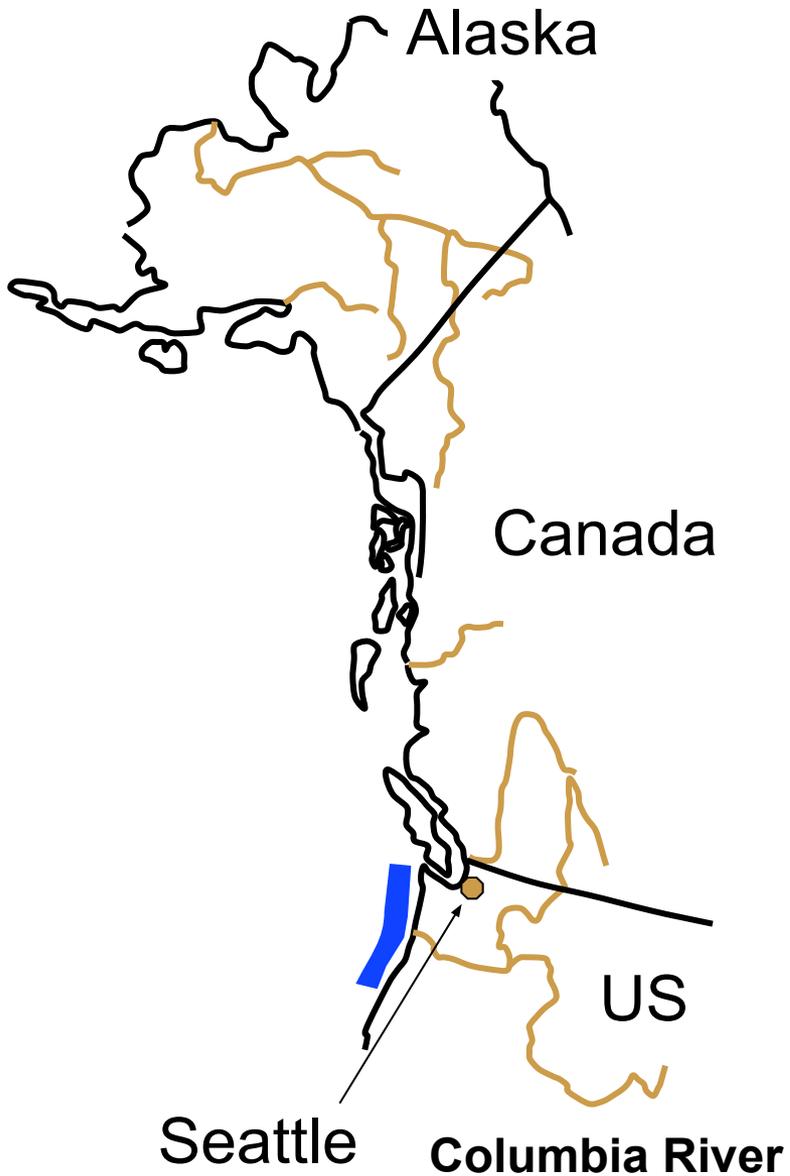
Beckman et al. 2004 TAFS

Technological advances have made it possible to assess growth rate and population of origin from individual fish caught at sea

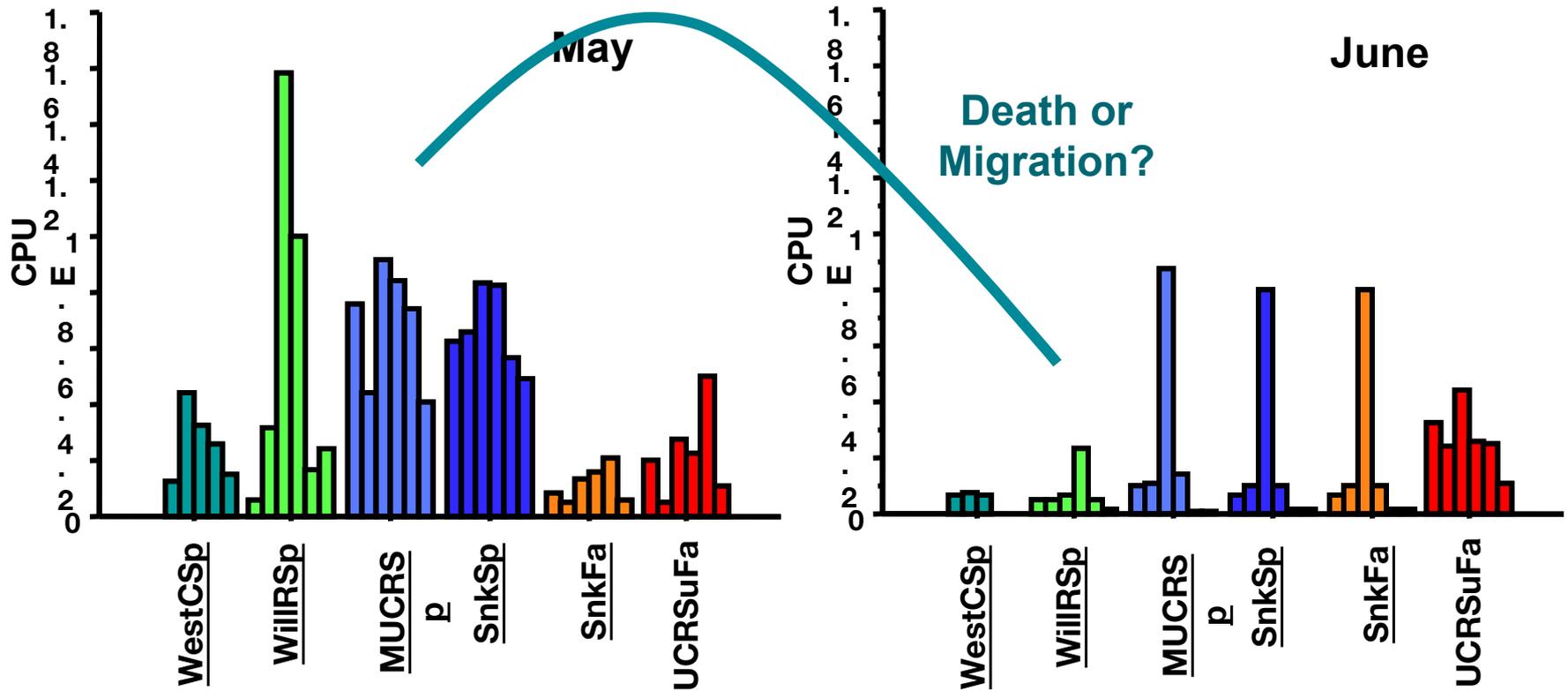


NOAA Juvenile Salmon Ocean Survey





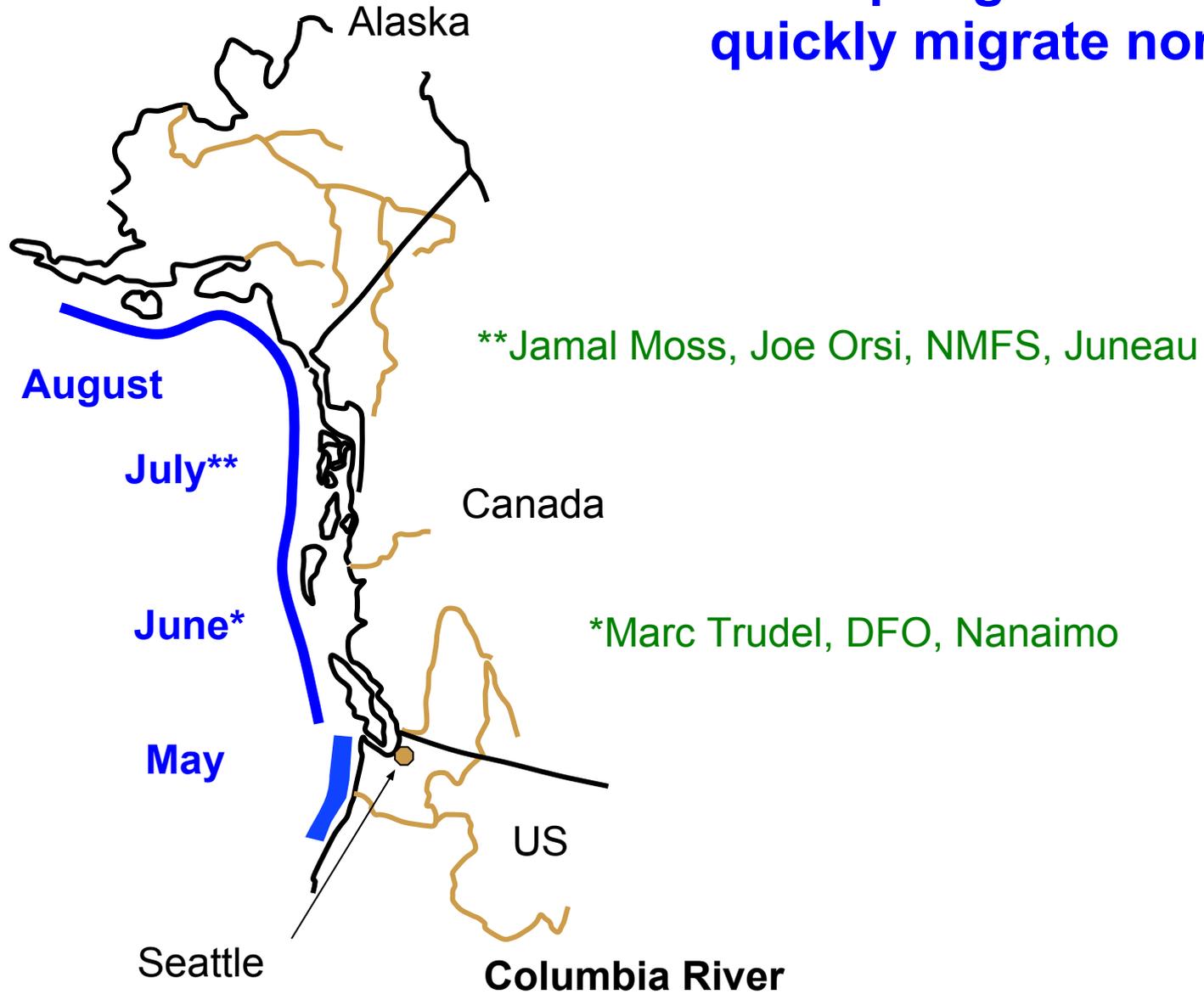
Yearling Columbia River Chinook salmon* abundance in the survey varies by month, stock and year



*6 major stocks of Chinook salmon with yearling migrants
5 are listed under the Endangered Species Act

2006-2011

UCR/Snake spring Chinook salmon quickly migrate north

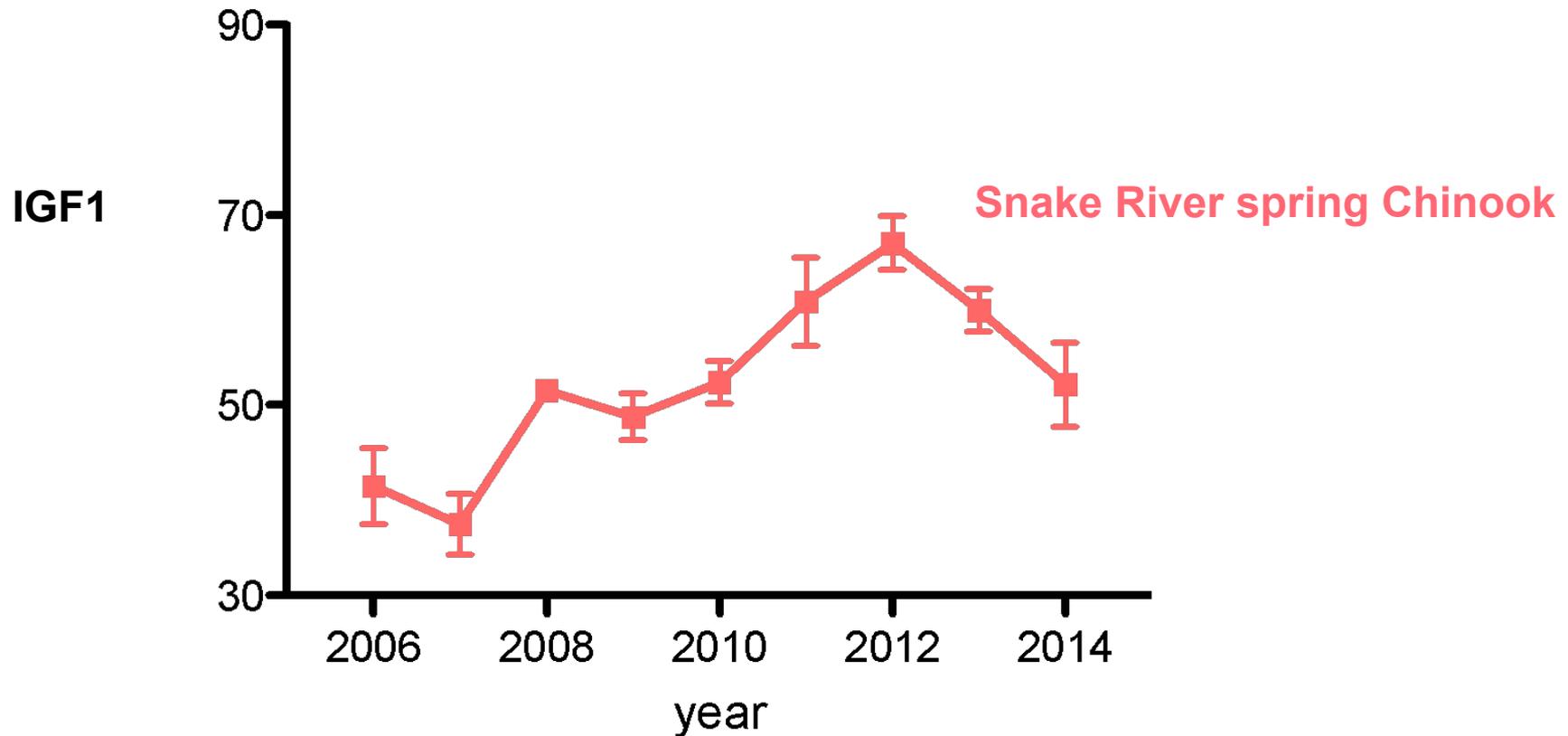


**Study of the marine ecology of
Columbia River Chinook salmon
needs to be spatially and temporally explicit**

Outline

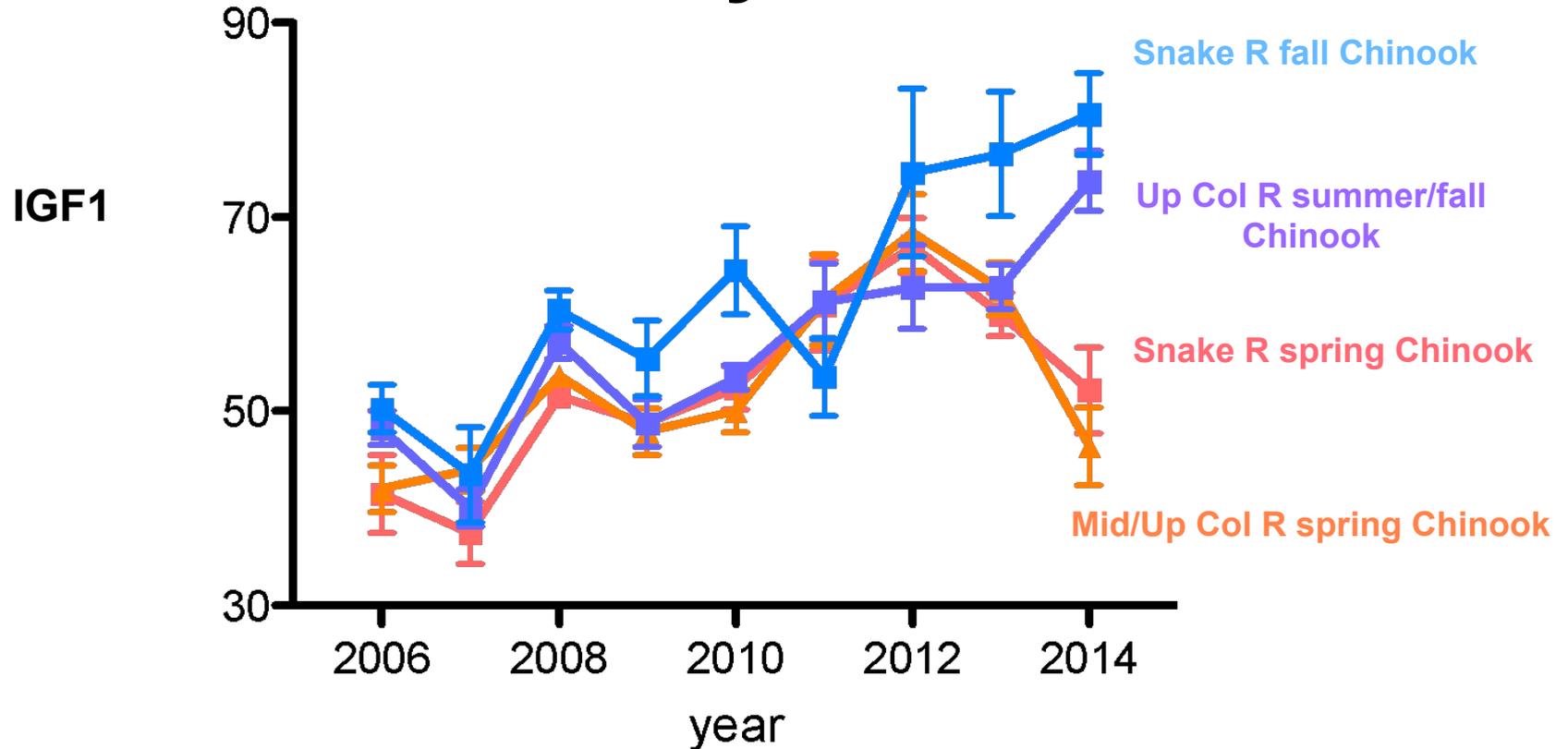
1. Do growth & survival vary? Correlated?
2. Do larger fish grow faster than smaller fish?
3. Do smolts from hatchery stocks vary in size?
4. Some data on biomass
5. Implications of the present state of the NCC
6. Summary

Growth varies inter-annually



June

Growth varies inter-annually and by stock

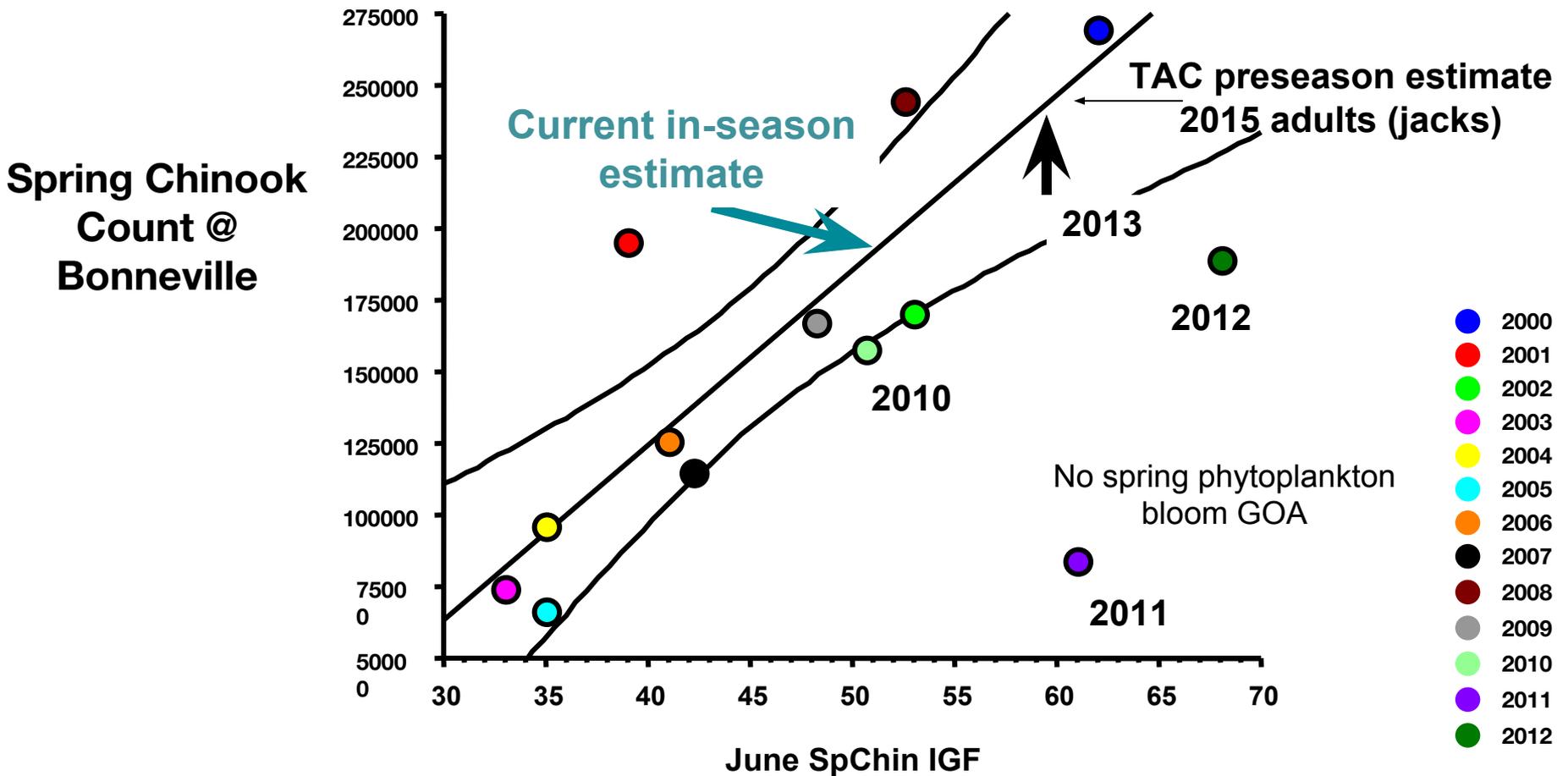


June

Study of the marine ecology of
Columbia River Chinook salmon
needs to be spatially and temporally explicit

**Study of the marine ecology of
Columbia River Chinook salmon
needs to be stock-specific**

Growth is related to survival of spring Chinook (most years)



Low growth = low survival (always)

High growth = high survival (usually)

=> Pearcy was right (usually)

Growth varies (it's not about temperature)

**=> Food is limited
in some years**

If food is limited

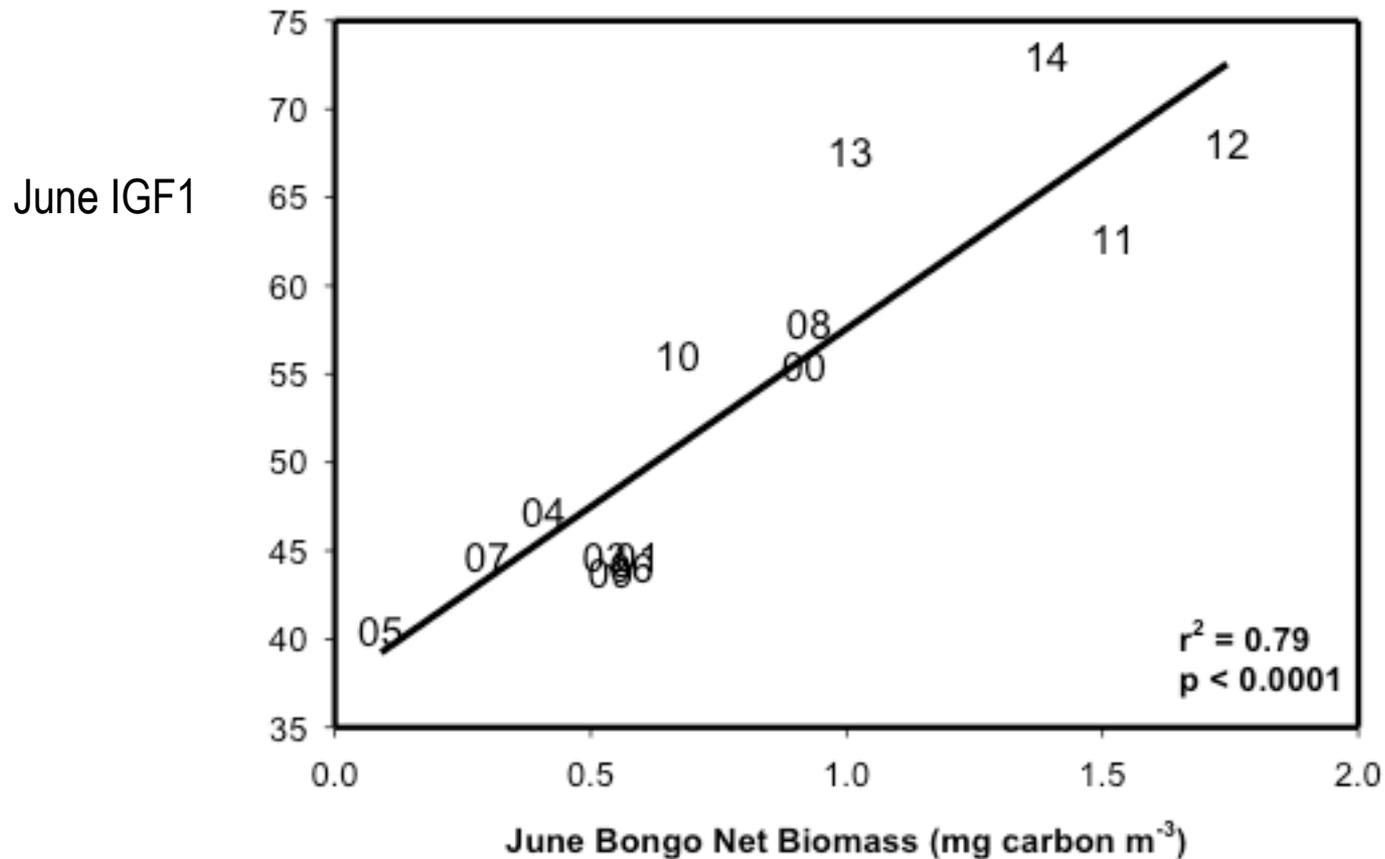
**=> there is competition for food
in some years**

INDEPENDENT SCIENTIFIC ADVISORY BOARD

**Density Dependence and its
Implications for Fish Management
and Restoration Programs
in the Columbia River Basin**

ISAB 2015-1 February 25, 2015

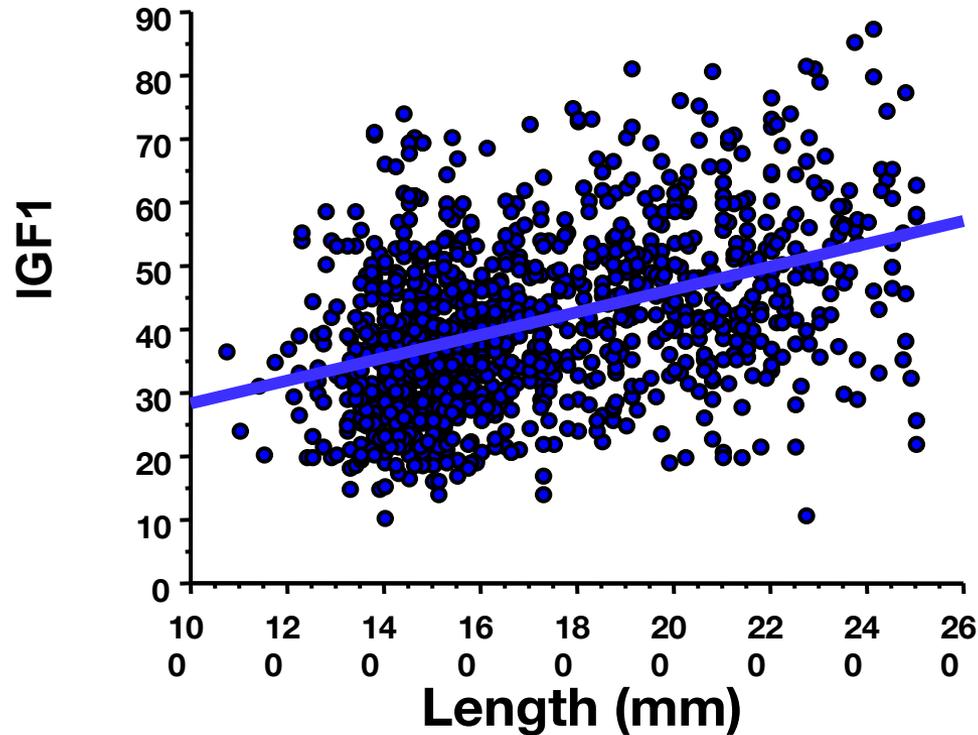
IGF1 is correlated with an index of salmon prey (food)



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Yearling Columbia R Chinook salmon: marine growth varies with size

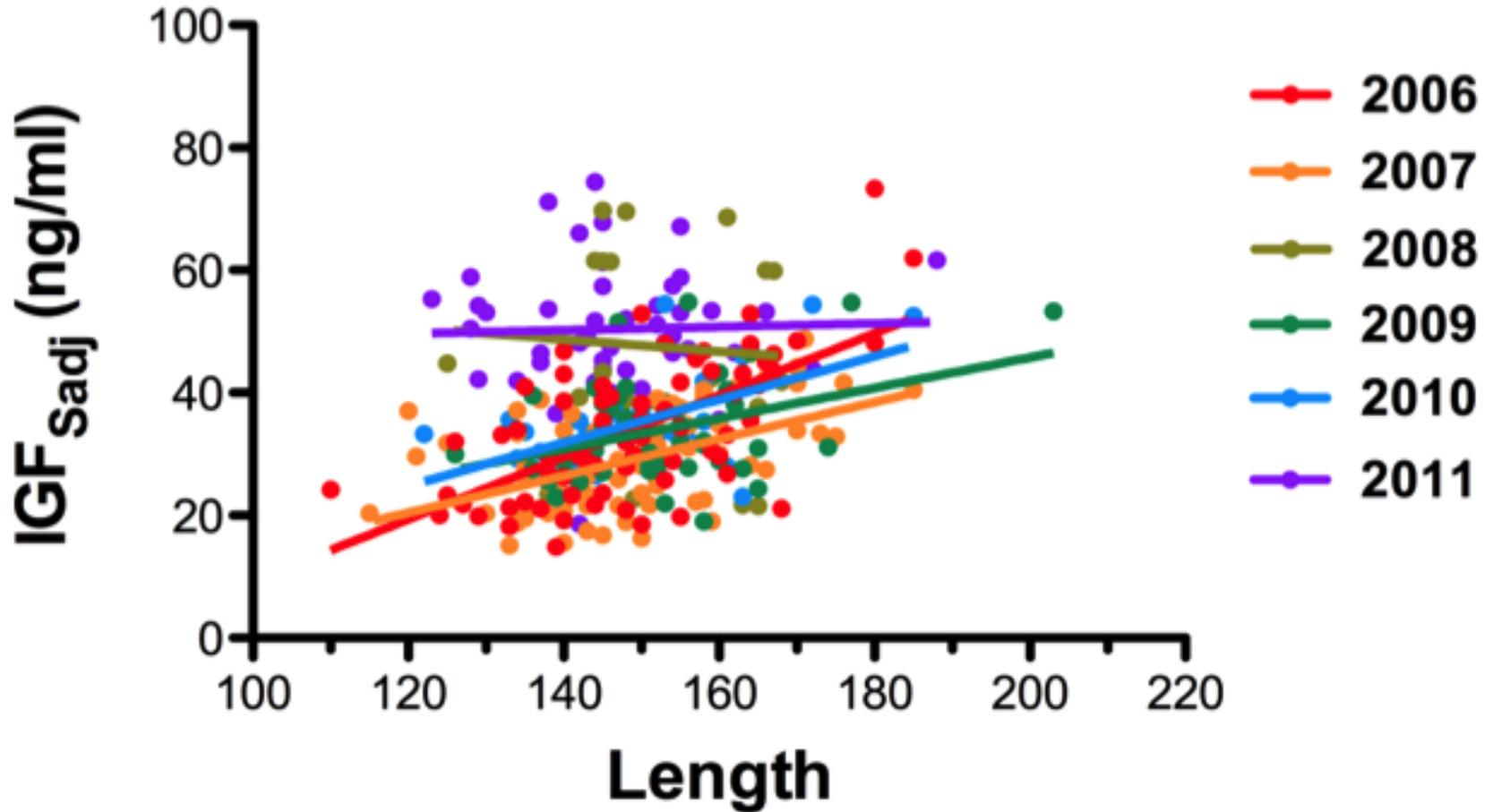


2006 - 2011, May, all
stocks

$p < 0.001$, $r^2 = 0.20$

IGF1 - size relationships vary between years in May

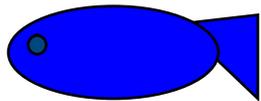
(slope of regression line)



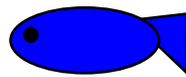
Snake River spring Chinook salmon

Snake R spring Chinook IGF vs length slope varies with ocean conditions

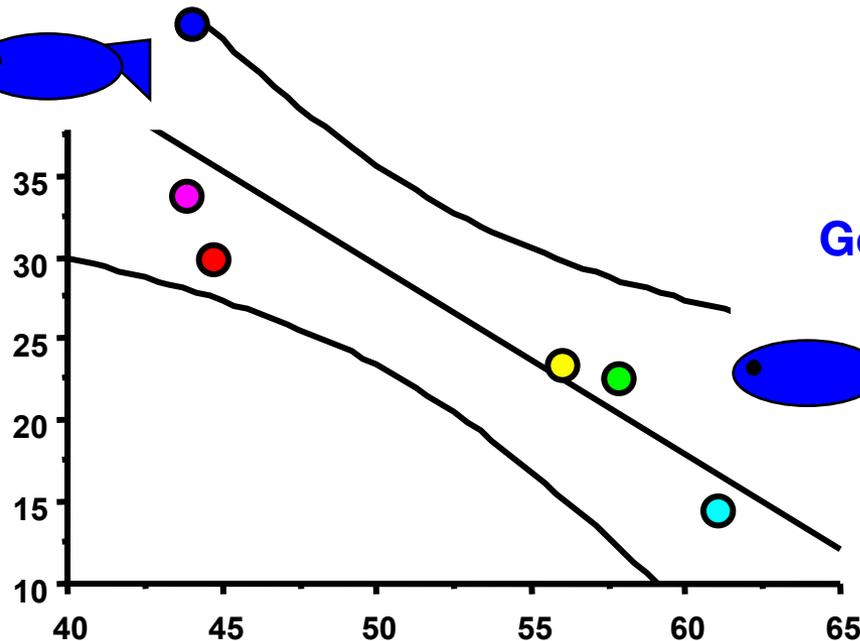
Bad ocean



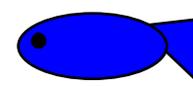
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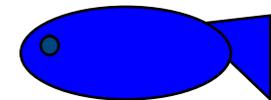
slope



Good ocean



~

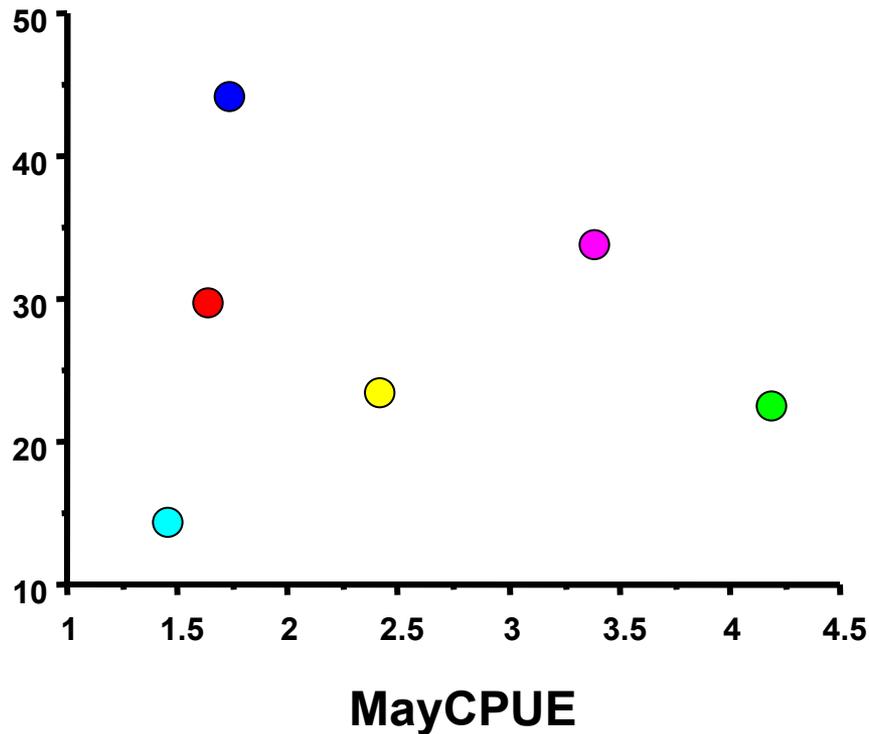


Ocean conditions
Coho salmon IGF1
(PDO also works)

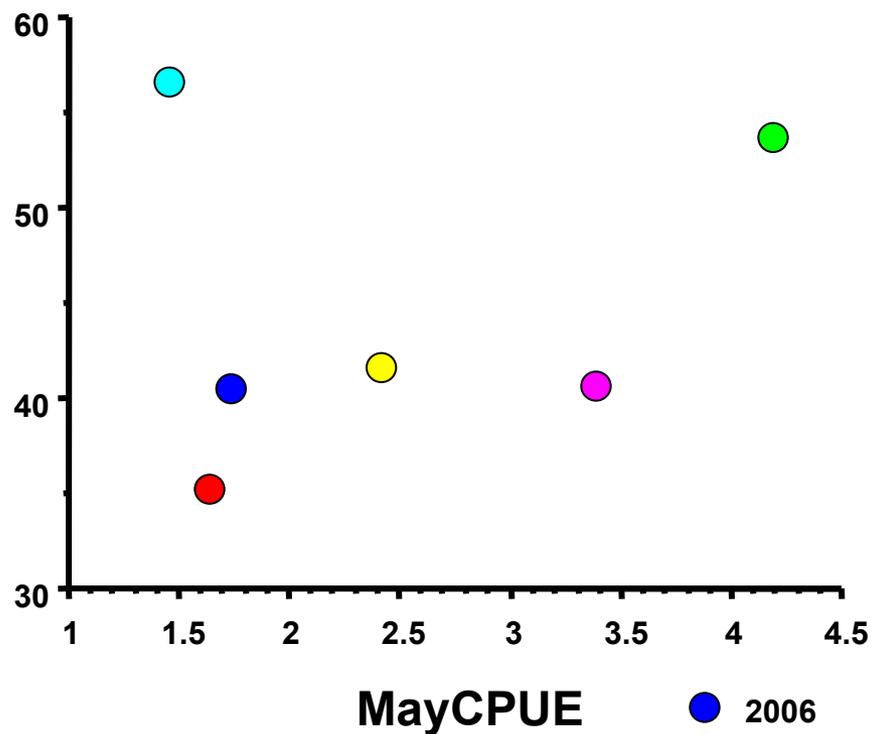
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011

Neither IGF nor slope IGF vs Length are related to CPUE

slope IGF vs LEN



Snake sp IGF



- 2006
- 2007
- 2008
- 2009
- 2010
- 2011

Larger fish grow faster than smaller fish in “bad” ocean years

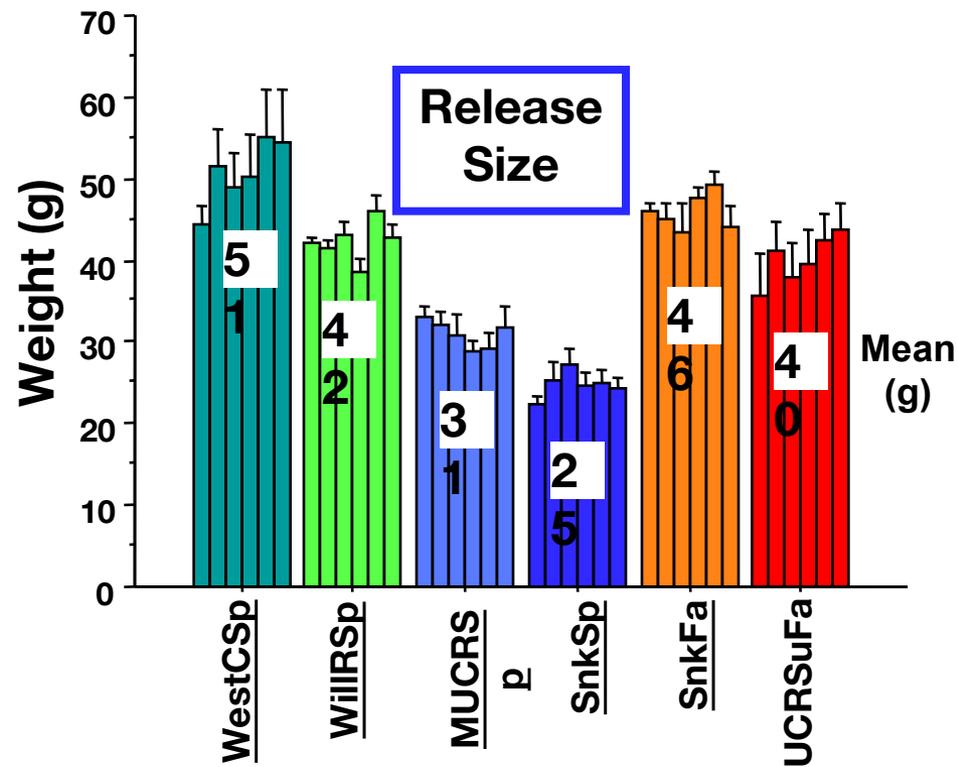
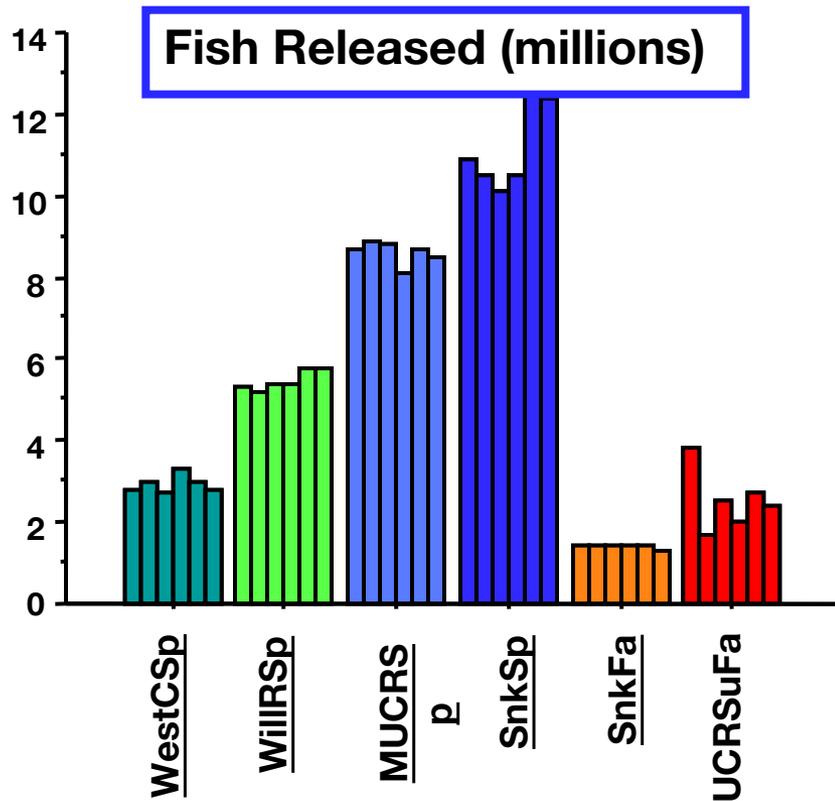


& it's not related to abundance

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Release size of yearling Chinook salmon varies 2-fold by stock



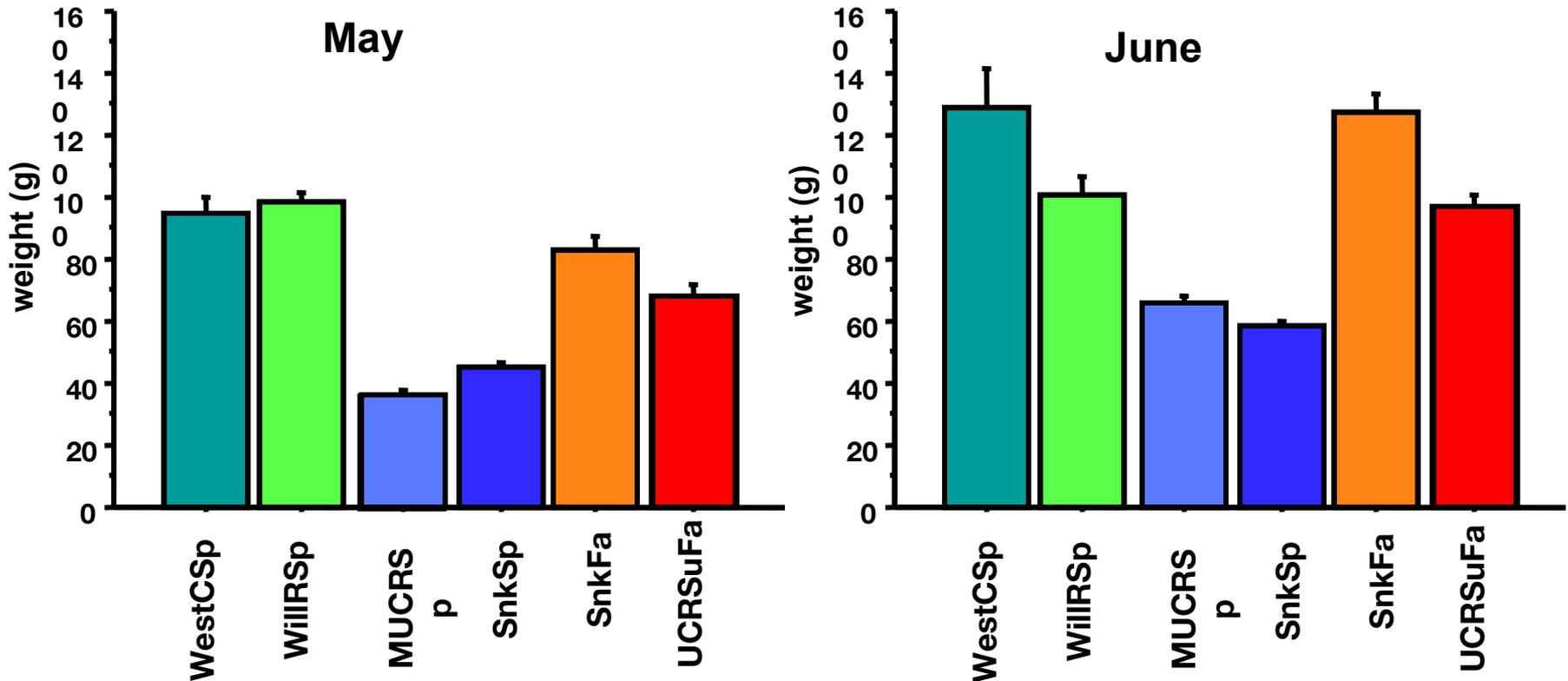
***6 major stocks of Chinook salmon with yearling migrants
5 are listed under the Endangered Species Act**

2006 - 2011

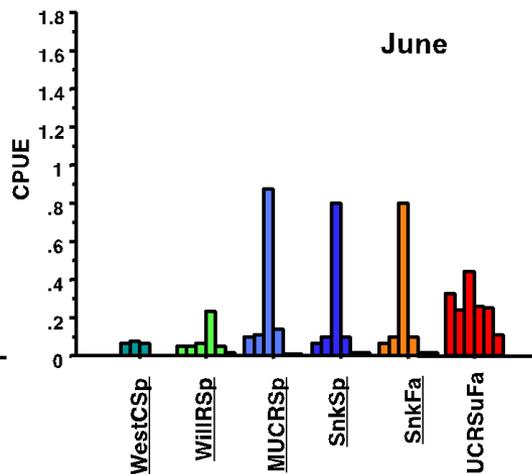
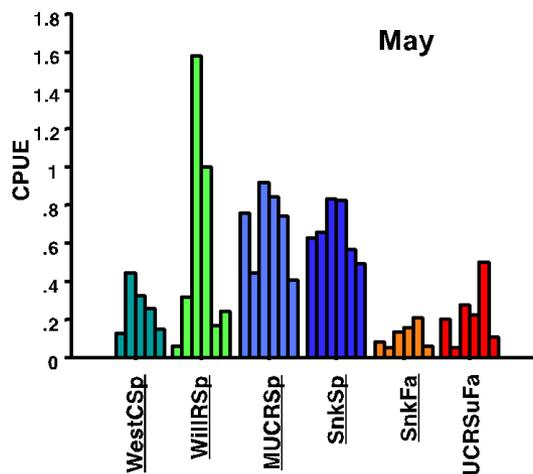
**Fish Passage
Center**

Weight of fish caught in the ocean varies > 2-fold by stock

Is there a potential for biased individual competition between fish from different stocks based on hatchery release size?

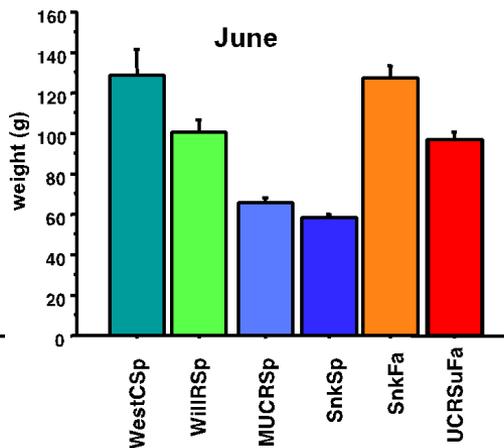
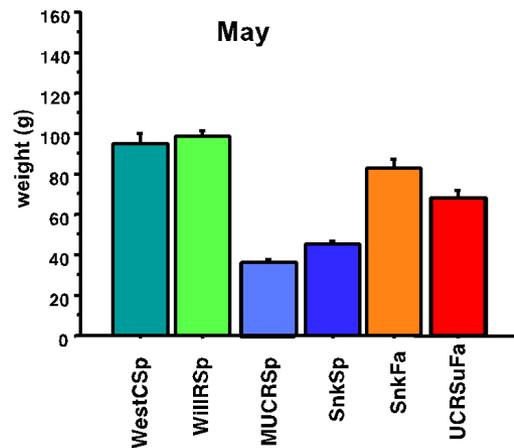


Abundance x Weight = biomass



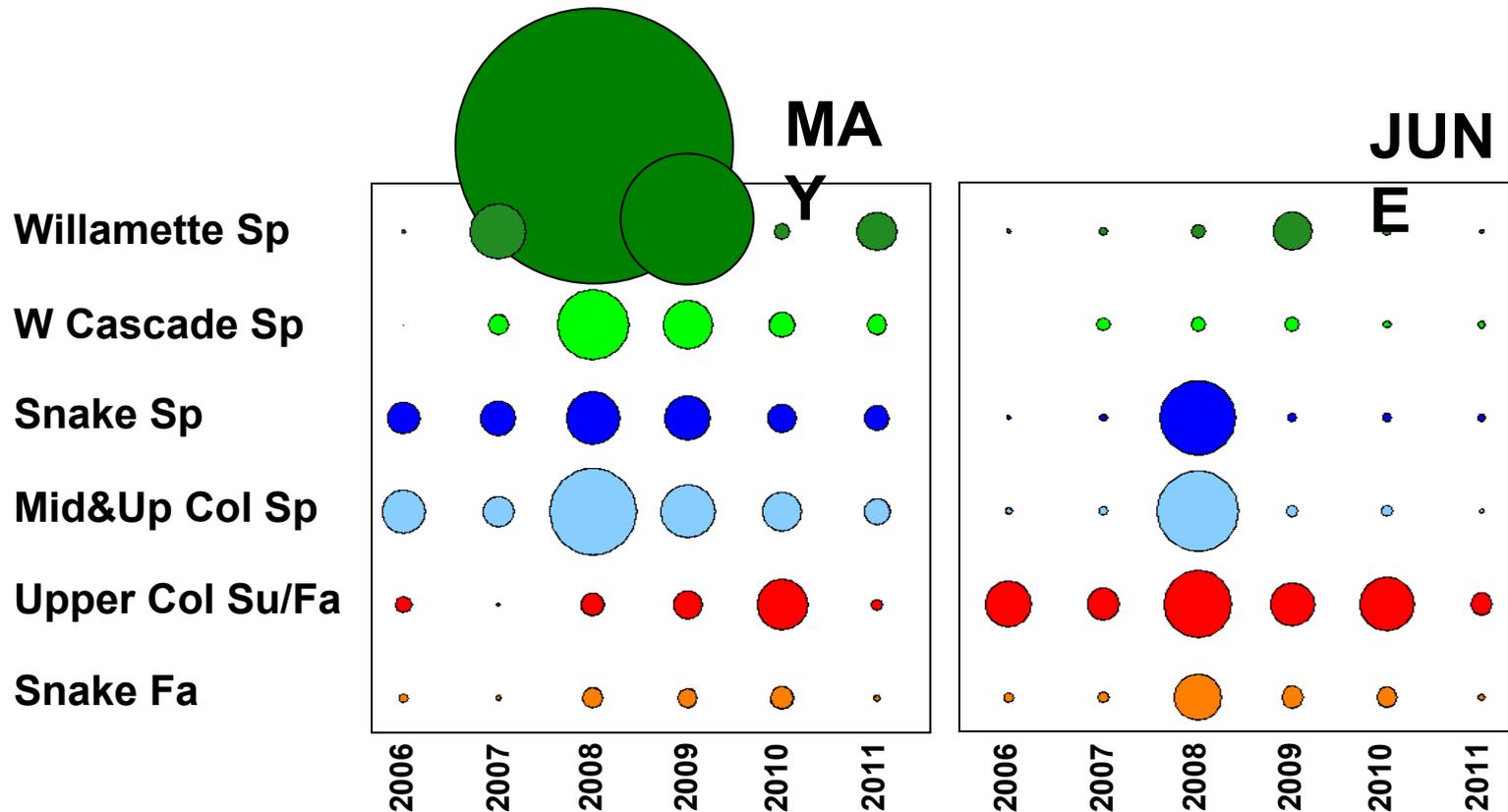
CPUE

**Biomass ~ bioenergetic “load”
on ecosystem**



Weight

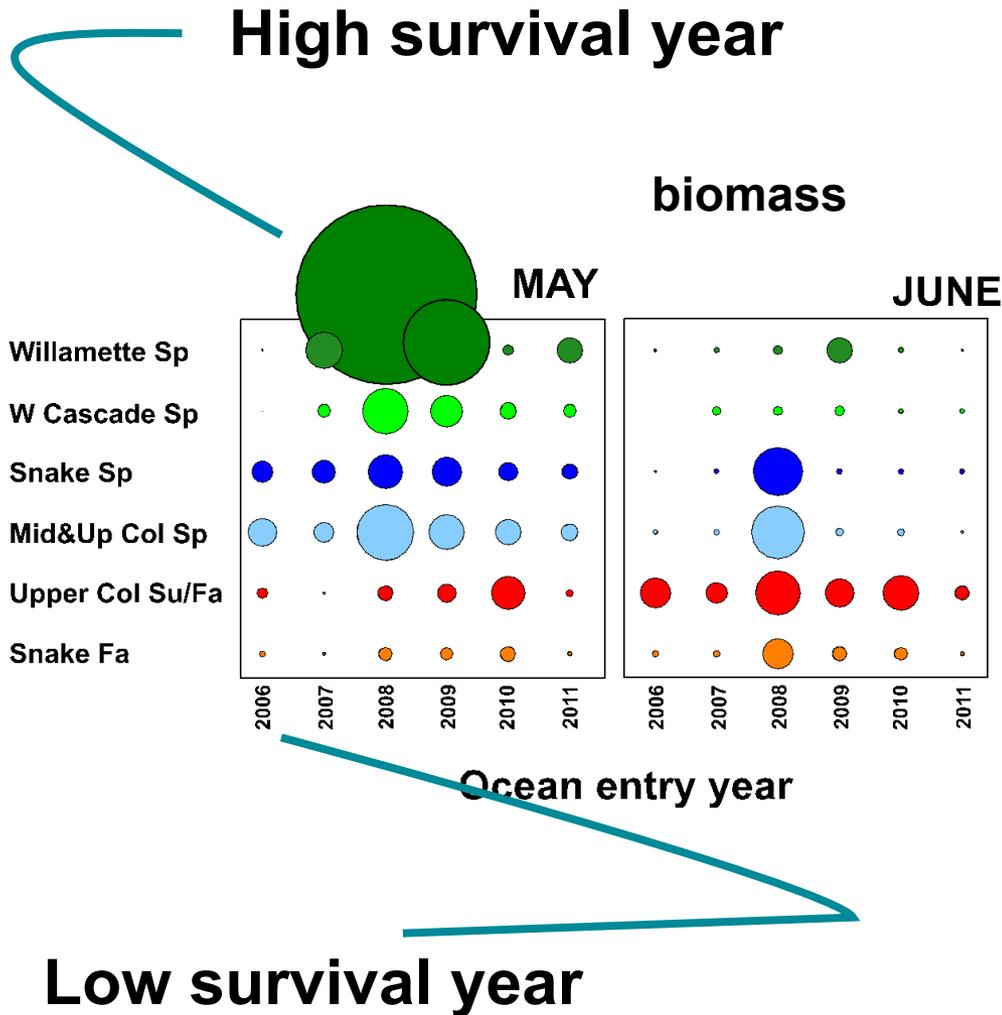
Is there a potential for interactions between different stocks based on ocean biomass?



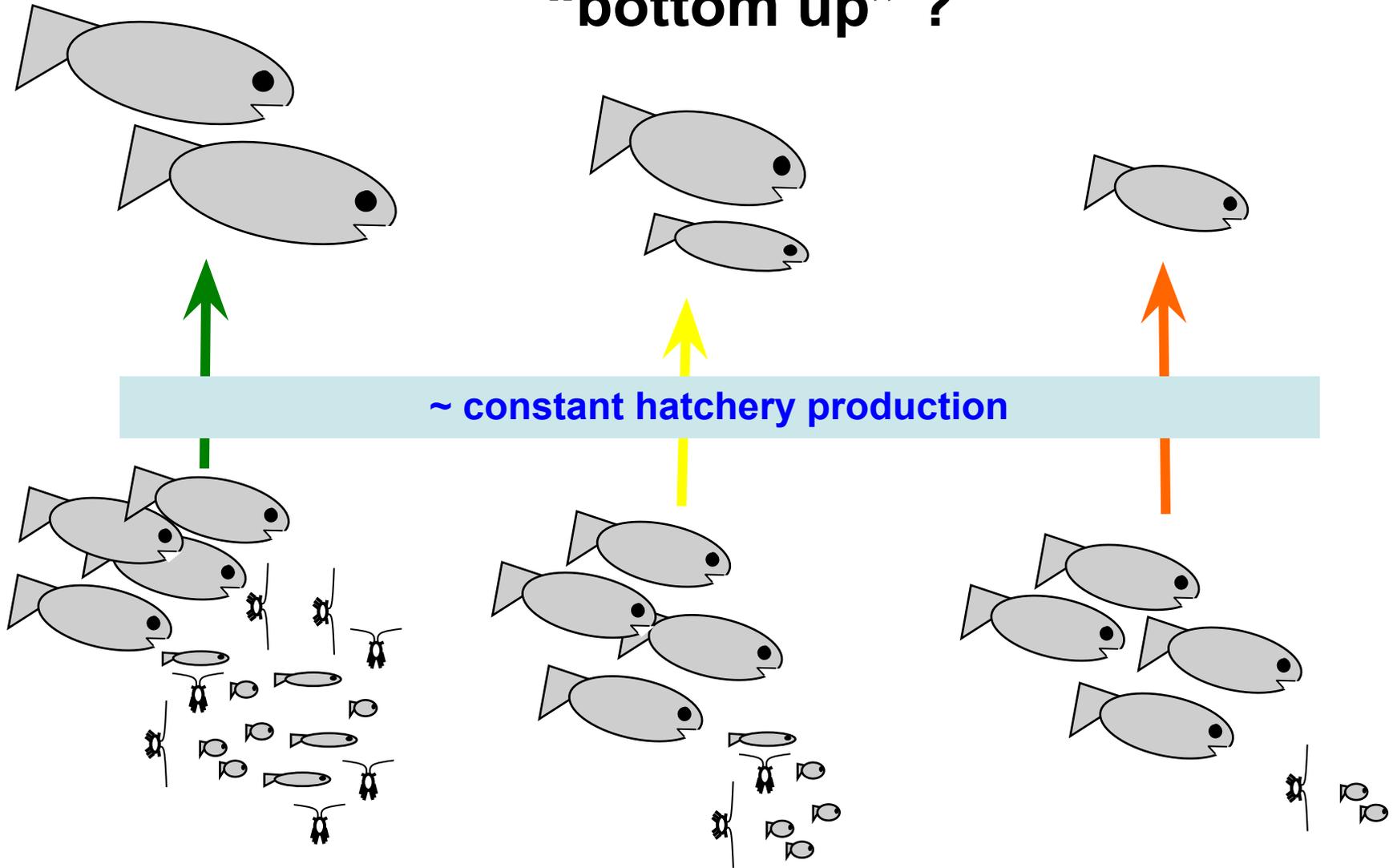
Ocean entry
year

Different stocks have different values:

**Legal
Economic
Cultural
Recreational**



Density dependence: California Current “bottom up” ?



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1900

YEAR	JAN	FEB	MAR	month	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1900	1.32	0.4											
1901	0.79	-0.12	0.3										
1902	0.82	1.58	0.4										
1903	0.8	-0.24	1										
1904	0.63	-0.91	-0.1										
1905	0.73	0.98	0.2										
1906	0.92	1.18	0.83	0.74	0.44	1.24	0.09	-0.53	-0.31	0.08	1.63	-0.54	
1907	-0.3	-0.32	-0.19	-0.36	0.16	0.57	0.63	-0.96	-0.23	0.84	0.66	0.72	
1908	1.88	1.02	0.21	0.23	0.11	0.41	0.6	0.08	0.16	0.1	0.16	0.16	
1909	0.33	1.01	0.54	0.24	-0.39	0.64	0.39	-0.68	-0.89	-0.02	-0.4	-0.01	
1910	-0.25	0.73	0.4	-0.17	-0.06	0.28	0.03	-0.06	0.14	0.6	0.84	0.1	
1911	1.11	0	0.78	0.73	0.17	0.02	0.48	0.43	0.29	0.2	0.86	0.01	
1912	1.72	-0.23	-0.04	-0.38	-0.02	0.77	1.07	-0.84	0.94	0.56	0.71	0.98	
1913	-0.03	0.34	0.06	0.00	0.66	1.41	0.06	0.28	0.73	0.42	0.7	0.3	
1914	0.34	0.29	0.08	1.2	0.11	0.11	0.21	0.11	0.34	0.11	0.03	0.89	
1915	-0.41	0.14	0.14	0.22	0.4	0.32	0.99	1.07	0.17	-0.05	-0.03	0.12	
1916	0.64	0.19	0.11	0.35	0.42	0.82	0.78	0.73	0.77	0.22	0.68	0.94	
1917	-0.79	-0.85	-0.71	-0.34	0.82	-0.03	0.1	-0.22	-0.4	0.35	-0.34	-0.6	
1918	1.13	-0.66	0.15	-0.32	-0.33	0.07	0.98	-0.1	0.59	0.1	0.19	0.85	
1919	-1.07	1.31	0.5	0.08	0.17	0.71	0.47	0.38	0.06	-0.42	0.8	0.76	
1920	-1.18	0.05	0.78	0.82	0.97	0.3	0.3	0.2	0.2	0.2	0.2	0.2	
1921	-1.66	-0.61	0.01	0.93	-0.42	0.4	0.58	0.69	0.78	0.23	1.92	1.42	
1922	1.05	-0.85	0.08	0.43	-0.19	1.05	0.82	-0.93	-0.81	0.84	0.6	0.48	
1923	0.75	-0.09	0.49	0.09	0.2	0.44	1.16	0.84	0.24	1.1	0.6	0.86	
1924	1.29	0.73	1.13	0.02	0.36	0.75	0.55	-0.67	0.48	1.25	0.74	0.11	
1925	-0.09	-0.14	0.2	0.86	0.79	0.78	0.06	-0.86	0.52	0.04	0.89	1.13	
1926	0.3	0.86	0.5	0.88	1.43	1.28	1.05	0.64	1.38	0.65	1	1.05	
1927	1.07	1.73	0.15	-0.18	0.3	0.89	-0.31	0.73	-0.41	0.62	0.07	0.07	
1928	0.86	0.79	0.92	0.81	0.86	0.15	0.3	-0.72	0.48	-0.31	0.14	0.98	
1929	0.97	0.52	0.5	0.55	1.07	0.5	0.06	0.69	0.45	0.21	1.24	0.03	
1930	0.97	-1.08	-0.43	-0.7	0.06	0.58	-0.45	0.53	0.2	-0.38	-0.11	0.2	
1931	0.68	1.58	0.39	1.28	0.66	0.39	1.49	0.02	-0.01	-0.17	0.34	1.03	
1932	-0.26	-0.58	0.51	1.15	0.64	0.1	-0.17	-0.14	-0.4	-0.29	-0.88	0.02	
1933	0.23	0.02	-0.15	-0.05	0.5	-0.48	-0.31	-0.65	-0.31	-0.65	-0.31	-0.65	
1934	0.17	0.64	1.34	1.03	1.33	0.51	0.44	1.54	1.25	0.51	1.63	1.67	
1935	1.01	0.79	-0.11	0.1	0.99	1.39	0.68	0.63	0.68	0.21	0.11	1.79	
1936	1.79	1.75	0.36	1.32	1.71	0.82	0.04	0.7	0.04	0.7	0.04	1.36	
1937	0	-0.49	0.38	0.2	0.51	1.75	0.11	-0.35	0.63	0.76	0.18	0.55	
1938	0.5	0.02	0.24	0.27	-0.25	0.21	-0.21	-0.45	-0.01	0.07	0.48	1.4	
1939	1.35	0.07	0.73	0.33	0.45	0.73	0.21	0.76	0.13	0.68	0.13	0.11	
1940	1.91	1.74	1.89	1.07	1.42	0.71	0.72	1.4	1.1	1.19	0.68	1.96	
1941	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67	
1942	1.01	0.79	0.29	0.79	0.84	1.19	0.32	0.44	0.68	0.54	0.1	0.1	
1943	0.18	0.02	0.26	1.08	0.43	0.68	0.36	0.3	0.49	0.04	0.25	0.58	
1944	0.18	0.17	0.08	0.72	0.35	0.88	0.6	0.51	0.56	0.4	0.33	0.2	
1945	1.02	0.72	0.42	0.4	-0.07	0.56	1.02	0.18	0.27	0.1	0.94	0.74	
1946	-0.91	-0.32	-0.41	-0.78	0.5	-0.86	-0.86	0.36	0.22	-0.36	1.48	0.96	
1947	0.73	-0.29	0.37	0.02	0.17	1.36	0.16	0.13	0.1	0.08	0.17	0.07	
1948	0.11	-0.74	-0.03	1.33	0.23	0.08	0.92	1.56	1.74	1.32	0.89	1.7	
1949	0.81	0.88	0.3	-0.53	0.07	0.87	0.56	0.3	0.3	0.41	0.83	0.8	
1950	2.11	2.91	-1.13	1.2	1.21	1.77	1.91	2.7	3.14	1.94	2.01	0.76	
1951	-1.54	-1.06	-0.9	-0.36	-0.25	-1.09	0.7	1.37	-0.88	-0.37	0.28	1.88	
1952	0.88	0.46	0.13	0.63	0.68	0.8	0.48	0.25	0.6	0.89	0.76	0.8	
1953	-0.57	-0.07	-1.12	0.05	0.43	0.29	0.24	0.05	-0.83	0.09	0.03	0.07	
1954	0.78	1.81	0.52	1.33	1.33	0.01	0.84	0.08	-0.34	0.52	0.79	0.7	
1955	0.2	-1.52	-0.97	-0.21	0.99	0.43	0.88	0.19	0.94	0.52	0.79	0.7	
1956	0.48	0.78	0.58	0.17	-0.41	-1.7	-1.03	-1.16	-0.71	0.3	-0.11	-1.28	
1957	0.52	-0.88	-0.19	-0.58	0.37	1.19	-1.1	0.57	0.19	1.7	0.12	0.35	
1958	0.75	0.62	0.75	1.06	1.28	1.33	0.89	1.06	0.79	0.01	-0.18	0.86	
1959	0.89	-0.43	-0.69	-0.02	0.23	0.44	-0.5	-0.62	-0.85	0.52	1.11	0.06	
1960	1.3	1.52	0.71	0.79	1.09	1.09	0.47	0.38	0.34	0.9	0.73	1.17	
1961	1.18	0.43	0.09	0.34	-0.06	-0.11	-1.22	-1.13	-1.01	-1.21	-1.85	-1.69	
1962	-1.29	-1.15	-1.42	-0.8	-1.22	-1.62	-1.46	-0.48	-1.58	-1.55	-0.37	-0.96	
1963	0.33	-0.16	0.54	0.41	-0.65	0.58	1.1	0.89	0.16	0.16	0.16	0.16	
1964	0.01	-0.21	0.87	1.03	1.91	0.32	0.51	1.03	0.68	0.37	0.8	1.52	
1965	-1.24	-1.16	0.04	0.62	-0.66	0.8	-0.47	0.2	0.59	-0.36	-0.59	0.06	
1966	-0.82	-0.03	-1.29	0.06	-0.53	0.16	0.26	-0.35	-0.33	-1.17	-1.15	-0.32	
1967	-0.2	-0.18	-1.2	-0.89	-1.24	-1.36	0.89	1.24	0.72	0.64	0.05	0.4	
1968	0.95	0.4	-1.11	0.58	-0.53	0.35	0.58	0.19	0.06	0.34	0.44	0.77	
1969	-1.26	-0.95	-0.5	0.44	0.2	0.89	0.1	0.81	-0.66	1.12	0.15	1.38	
1970	0.61	0.41	1.13	0.41	-0.49	0.06	-0.68	-1.03	-1.07	-1.39	0.8	-0.97	
1971	0.14	0.74	-1.08	0.79	-1.05	-1.51	0.89	-0.15	0.21	-0.22	0.29	0.87	
1972	-1.39	-1.83	-2.09	-1.85	-1.57	-1.87	-0.85	0.25	0.17	0.11	0.57	-0.33	
1973	-0.46	-0.61	0.5	0.69	-0.76	0.97	0.57	1.14	0.51	-0.97	-0.81	-0.76	
1974	0.22	0.89	-0.9	-0.52	-0.28	-0.31	-0.08	0.27	0.44	-0.1	0.43	-0.12	
1975	0.84	-0.71	0.54	0.3	0.00	0.86	0.4	0.97	0.23	0.23	0.89	0.62	
1976	1.14	1.85	0.96	0.88	0.68	0.67	0.61	1.28	0.82	1.11	1.22	1.22	
1977	1.85	1.11	0.72	0.3	0.31	0.42	0.19	0.84	-0.55	0.81	0.72	0.89	
1978	1.3	1.45	1.8	1.13	1.24	0.56	-0.44	0.1	-0.07	-0.41	0.1	0.1	
1979	-1.58	-1.33	0.3	0.89	1.09	0.17	0.84	0.52	1	1.06	0.48	-0.42	
1980	-0.11	1.32	1.09	1.49	1.2	-0.22	0.23	0.51	0.1	1.35	0.97	0.1	
1981	0.98	1.46	0.98	1.46	1.75	1.69	0.84	0.18	0.42	0.18	0.68	0.67	
1982	0.34	0.2	0.19	0.19	-0.58	-0.78	-0.58	0.39	0.84	0.37	0.24	0.28	
1983	0.58	1.14	0.81	1.17	1.8	0.89	1.51	1.85	0.91	0.96	1.02	1.69	
1984	1.5	1.21	1.77	1.52	1.3	0.18	-0.18	-0.03	0.67	0.58	0.71	0.82	
1985	1.27	0.94	0.57	0.19	0	0.18	1.07	0.81	0.44	0.79	0.38	0.38	
1986	1.12	1.61	1.4	1.55	1.16	0.89	1.38	0.22	0.22	1	1.77	1.77	
1987	1.88	1.75	1.85	1.85	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	
1988	0.93	1.24	1.42	0.94	1.2	0.74	0.64	0.19	-0.37	0.1	-0.02	-0.43	
1989	-0.95	-1.02	-0.83	-0.32	0.47	0.38	0.83	0.09	0.05	-0.12	0.5	-0.21	
1990	0.83	-1.19	0.74	0.01	0.51	1.47	0.1	0.36	0.65	0.49	0.42	0.09	
1991	0.93	0.31	0.67	0.75	1.54	1.26	1.19	1.44	0.83	0.93	0.93	0.53	
1992	0.05	0.19	0.76	1.21	1.27	0.66	0.05	0.59	1.56	1.41	1.24	1.07	
1993	1.13	0.89	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	
1994	-0.49	0.46	0.75	0.83	1.46	1.27	1.71	0.41	1.16	0.47	-0.28	0.16	
1995	0.59	0.75	1.01	1.46	1.47	1.1	0.77	-0.14	0.24	-0.33	0.09	-0.08	
1996	0.23	0.28	0.65	1.05	1.83	0.76	0.29	0.29	0.79	1.61	1.12	0.67	
1997	0.88	0.36	0.66	1.21	0.7	0.4	-0.05	0.27	0.21	0.29	0.52	0.44	
1998	-0.32	-0.66	-0.31	-0.41	-0.68	-1.3	-0.66	-0.96	-1.53	-1.21	-2.05	-1.63	
1999	-0.2	-0.83	0.29	0.35	-0.06	0.44	-0.66	1.19	1.24	1.3	0.53	0.52	
2000	0.8	0.29	0.45										

What's happening now (2015)?

Carrying capacity may be significantly reduced

Density dependent processes may be magnified

Size-b **A natural experiment is occurring:** wild)?

Surviv **how do we take advantage?**

- NWFSC - 4 day May survey (1st May survey since 2012)
- 10 day June survey
- AFSC survey in Gulf of Alaska (July)

Summary

Growth and survival vary

- Correlated in many years

**Data suggest it might be worth thinking
about density dependence (in some years)**

**Many management, political and scientific issues
to consider along with density dependence**

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