Counter gradient variation in juvenile chum salmon growth

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Counter gradient variation

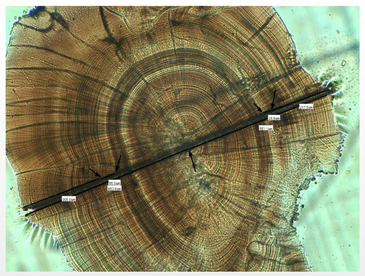
Counter-gradient variation occurs when genetic and environmental influences on phenotypes oppose one another and diminish the change in mean trait expression across environmental gradients. Coherent trends in growth rate and latitude in fish populations is a common example of counter gradient variation (Conover et al. 2009).

Variation in growth (phenotype), *Vp*, is the result of genetic, *Vg*, and environmental, *Ve*, variability can be partitioned as:

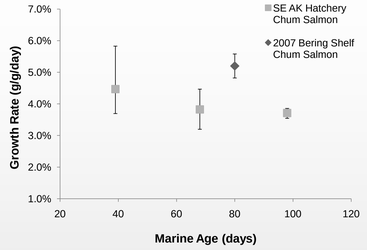
$$V_P = V_G + V_E + V_{GxE} + 2Cov(G,E)$$

Counter gradient variation is expressed as a negative covariance term, *2Cov(G,E)*, in genetic and environmental variability, and occurs when natural selection favors traits that compensate for environmental sources of mortality.

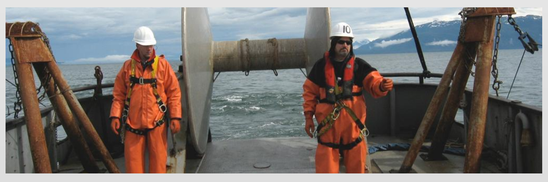
Juvenile chum salmon growth



Otolith microstructure of juvenile chum salmon revealing daily growth bands and growth checks associated with exogenous feeding and smolting.



Otolith-based growth rate estimates of juvenile chum salmon from Southeast Alaska and Bering Sea.



- Although day length plays a key role in increased growth capacity of fish at higher latitudes, experimental studies have revealed that counter-gradient growth is generally the result of growth compensation for shorter growing seasons at higher latitudes and overwinter size selection.
- Marine growth rates of Bering Sea juvenile chum salmon are higher than Southeast Alaska chum salmon (Bering Sea: 5.19%; southeast Alaska: 3.75%). However, marine habitats are warmer in Southeast Alaska (SEAK), no evidence exists for forage limitation in SEAK chum salmon, and juvenile chum salmon from SEAK migrate over latitudes similar to southern Bering Sea chum salmon. Growing season length may be the key difference between these juvenile populations as hatchery stocks in SEAK begin their summer growth approximately three months earlier than Bering Sea chum salmon.
- We suggest that Bering Sea chum salmon compensate for shorter growing seasons through higher marine growth rates and that these data provide evidence for counter-gradient variation in juvenile chum salmon growth.

	Southeast Alaska (2002-2007)	Southern Bering Sea (2007)	Northern Bering Sea (2007)
Average marine growth rate over the summer growing season (% body weight/day)	3.75%	5.19%	5.19%
Average SST (3m)	10.6 – 13.5 °C	8.9 – 12.6 °C	8.6 – 11.0 °C
Average marine entry date.	3/7 – 3/16	6/12	6/28
Estimated average marine entry size.	0.38 – 0.44 (g)	0.50 (g)	0.78 (g)
Average hatchery release date	5/13 – 5/20		
Average hatchery release size	1.51 – 2.10 (g)		

Literature

- Conover, D. O., T. A. Duffy, and L. A. Hice. 2009. The covariance between genetic and environmental influences across ecological gradients. In. The Year in Evolutionary Biology 2009. Ann. N.Y. Acad. Sci. 1168: 100-129.

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