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Comment on "Rapid Evolution of Egg Size in Captive Salmon" (II)
Terry D. Beacham, *et al.*
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TECHNICAL COMMENT

Comment on "Rapid Evolution of Egg Size in Captive Salmon" (II)

Heath *et al.* (*1*) suggested that hatchery enhancement of wild chinook salmon populations in British Columbia results in the evolution of smaller egg size, which could lead to reduced survival and seriously limit the success of enhancement and conservation efforts for salmon. As supporting evidence, they reported that egg size had declined in two populations where major hatcheries are located (Quinsam River, 1980 to 1997; Robertson Creek 1977 to 1996). However, the ocean rearing environment changed substantially during this period, with regime shifts (marked changes in ocean climate influencing fish survival, growth, and recruitment) occurring in 1977, 1989, and 1998 (*2, 3*), and considerable variation in female length at the hatcheries has been observed (Fig. 1). After accounting for both regime shifts and the fact that female length and egg size are correlated in salmon (*4, 5*), there is no evidence that there has been any significant decline in egg size between 1977 and 2002 (Table 1). Heath and colleagues incorrectly attributed a marine environmental effect and female size variation on egg size to a genetic change as a result of hatchery enhancement.

The Yellow Island Aquaculture Limited (YIAL) broodstock studied by Heath *et al.* matures at a much smaller body size than normally observed in natural populations (*6*), and has unusually small eggs (*5*). Heath *et al.* reported a marked decline in egg size in the YIAL broodstock reared under standard aquaculture conditions and suggested that this should reflect trends in other broodstocks and indeed natural populations with supplemental enhancement. However, the YIAL broodstock—developed to satisfy a niche market—is unusually small when compared with other chinook salmon broodstocks used in aquaculture, and in which no decline in egg size has been observed (Fig. 2). Egg size trends observed in the YIAL broodstock are unique, and extrapolation of results to enhanced or aquaculture broodstock chinook salmon populations in British Columbia is unwarranted.

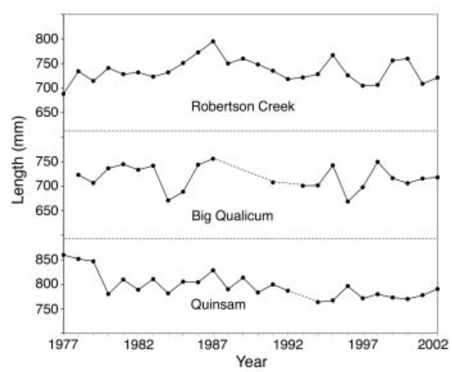

Fig. 1. Mean observed postorbital-hypural length for females sampled at Robertson Creek, Big Qualicum River, and Quinsam River from 1977 to 2002.

Table 1. Mean standardized egg size in three major chinook salmon hatcheries on Vancouver Island, British Columbia, at the Robertson Creek (ml), Big Qualicum River (mg), and Quinsam River (mg) for three regimes (1977 to 1988, 1989 to 1997, 1998 to 2002). Values have been standardized to a female postorbital-hypural length of 737, 718, and 797 mm for Robertson Creek, Big Qualicum, and Quinsam, respectively. Egg size was standardized to a common length with the equation $E_s=E_o(L_m/L_o)^b$, where E_s is the standardized egg size, E_o is the observed egg size, L_m is the mean female length in the population, L_o is the observed length in a particular year, and b is the regression coefficient of the ln E_o on ln L_o in each regime in each population. Egg size data in each regime in each population were standardized separately to the overall mean length in each population. If the regression was not significant in the population and regime combination, a value of b = 1.00 was assumed for the standardization (*7*). Standard deviation is in parentheses. N is the number of years for which data on both egg size and length were available in each regime. The 1989 to 1997 regime was marked by poor growth and survival in many species (*8, 9*). Analysis of variance indicated that there was no significant difference in standardized egg size among the three regimes in the Robertson Creek and Quinsam River populations (both $P > 0.05$), but egg size during the period from 1989 to 1997 was significantly smaller in the Big Qualicum population than in the other two regimes ($P < 0.05$), concurrent with poor marine conditions.

Population	1977 to 1988	1989 to 1997	1998 to 2002
Robertson Creek	0.45 (0.04)	0.44 (0.02)	0.43 (0.05)
N	8	9	5
Big Qualicum River	352 (12)	325 (11)	342 (10)
N	7	3	5
Quinsam River	417 (20)	400 (16)	409 (22)
N	12	8	5

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References and Notes

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7. The assumption of b = 1.00 is a conservative assumption with respect to the effect of female body length on egg size. Previously published esti-

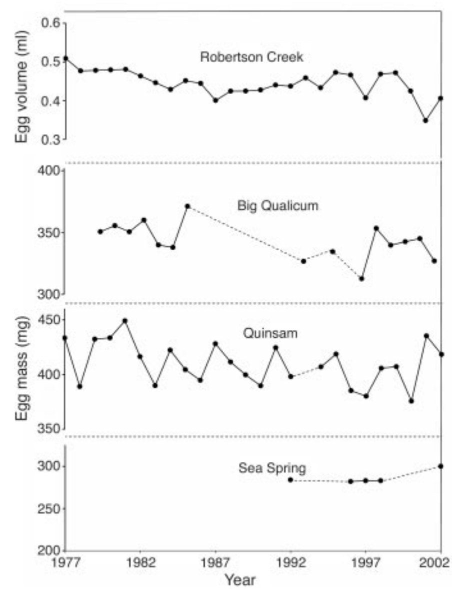

Fig. 2. Mean standardized egg size for females sampled at the Robertson Creek, Big Qualicum River, and Quinsam River hatcheries from 1977 to 2002. Values have been standardized to a common female postorbital-hypural length: Robertson Creek, 737 mm; Big Qualicum River, 718 mm; Quinsam River, 797 mm. Mean eyed egg mass (mg) for a chinook salmon aquaculture broodstock at Sea Spring Salmon Farm Ltd. from 1992 to 2002 is also indicated. Eyed egg mass was not available for the 2002 brood year, so green egg mass was converted to eyed egg mass by the equation: eyed egg mass (mg) = 51.8 + 0.7987 × green egg mass (mg), where the regression was highly significant ($P < 0.001$, $r^2 = 0.78$), based upon observations from 20 females in 1996. Mean female mass was 9.6 kg, about twice the size of female mass in the YIAL broodstock.

mates of the slope of the regression ranged from 0.8 to 2.5 for five species of salmonids (*5*). A value of 1.00 indicates that there is no allometric relationship between female length and egg size, so that changes in female length are directly proportional to changes in egg size.

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10. I thank D. Ewart (Quinsam River), B. Dunsmore (Big Qualicum River), R. Volk (Robertson Creek), A. Martin (length data), and C. Wallace (figure preparation) of the Department of Fisheries and Oceans for their assistance, as well as P. Griffiths and D. Groves of Sea Spring Salmon Farm Ltd.

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