GROWTH OF PACIFIC HERRING IN PRINCE WILLIAM SOUND, ALASKA, FROM 1973 THROUGH 1987

by

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and

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INTRODUCTION

The Alaska Department of Fish and Game has routinely collected herring for age, weight, and length analysis since the beginning of the Prince William Sound spring sac roe fishery in 1973. Sandone (1988a, 1988b, 1988c) and Sandone et al. (1988) compiled summaries of these observations for 1973 through 1987. In this paper we further analyze this information, fitting von Bertalanffy growth curves to the length at age and weight at age information, and fitting an allometric model to the weight-length information.

METHODS

Samples of Pacific herring were collected for age, weight, length, and sex analysis from each sac roe purse seine and gill net fishery opening in each management district from 1973 through 1987. Approximately 300 fish per opening were collected for each gear type from 1973 through 1984, and approximately 600 fish per opening were collected for each gear type from 1985 through 1987. In addition to the catch samples from commercial openings, herring were collected from test fishing samples by commercial vessels prior to commercial openings. Some herring were also collected by the Alaska Department of Fish and Game using test fishing gear. Data collected from these samples included the sex, standard length (mm), round weight (g) and age of individual specimens. Ages were determined from scales read under magnification on micro-fiche readers. Detailed descriptions of sample collection methods, and data summaries of age, sex, and size are given by Sandone (1988a) for the 1973 through 1983 information and by Sandone (1988b) for 1984 through 1987.

Catch samples from the commercial pound fishery were excluded from the growth analyses because specimens obtained in pound fishery samples often had at least partially spawned. Specimens obtained from purse seine, gillnet and test fishing gear were usually in a reproductive "ripe" condition, but had not yet spawned. Excluding the pound fishery samples provided a more consistent criteria for specifying weight at age as the round body weight of whole herring just prior to spawning.

Mean lengths (Table 1) and mean weights (Table 2) were estimated for each age in each harvest year by taking the arithmetic mean of all fish in the samples of each age in each year. A von Bertalanffy growth model was used to describe length (L) as a function of age (t):

$$L(t) = L_\infty \left(1 - e^{-K(t-t0)} \right) \qquad (1)$$

Parameters L_∞, K, and t_0 were estimated using Marquardt's method of nonlinear least squares, weighting each annual mean length at age by the sample size. An allometric weight-length model was used to describe the relationship between

length (L) and weight (W):

$$W = a \cdot L^b \tag{2}$$

Parameters a and b were also estimated using Marquardt's method of nonlinear least squares, weighting by sample size. The allometric weight-length model (2) and the von Bertalanffy length at age model (1) were algebraically combined to derive a von Bertalanffy model of weight at age, $W(t)$:

$$W(t) = (aL_\infty^b) \cdot (1 - e^{-K(t-t_0)})^b \tag{3}$$

where aL_∞^b is equivalent to the conventional von Bertalanffy model asymptotic weight at age W_∞.

RESULTS AND DISCUSSION

The von Bertalanffy model length at age model, equation (1), with estimated parameters L_∞ = 239.31, K = 0.293, and t_0 = -1.689 provides a reasonable description of Prince William Sound herring length at age over the period 1973-1987 (Figure 1). The tendency for the variability of length at age to increase with age was at least partially compensated by the weighting of the mean lengths at age by sample size. Sample sizes for older, larger fish were smaller than for younger fish, which in this case would be approximately equivalent to weighting by the inverse of the variance of length at each age, which is one of the methods for dealing with this problem when estimating parameters by least squares.

The weight-length model with parameters $a = 5.007 \cdot 10^{-6}$ and b = 3.196 provides a good description of the weight-length relationship (Figure 2). The von Bertalanffy asymptotic weight parameter W_∞ estimated from the algebraic combination of equation (1) and equation (2) is 200.943. There is considerably more variability in the mean weight at age observations (Figure 3), but the von Bertalanffy weight at age model algebraically derived from the length at age and allometric weight-length models appears to provide a reasonable description of weight at age.

These growth curves describe average conditions over the 1973 through 1987 period. Because sample sizes were larger in recent years and mean lengths and weights at age were weighted by sample size, the growth curves would tend to describe recent growth conditions more closely than earlier growth conditions, if growth had changed over the period.

LITERATURE CITED

Sandone, G.J. 1988a. Age, sex, and size composition of Pacific herring sampled from the Prince William Sound Management area, 1973-1983. Alaska Department of Fish and Game, Division of Commercial Fisheries, Prince William Sound Management Area Report 88-06, Anchorage.

Sandone, G.J. 1988b. Age, sex, and size composition of Pacific herring sampled from the Prince William Sound Management area, 1984-1987. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A88-08, Anchorage.

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Sandone, G.J., S. Sharr, and J.A. Brady. 1988. Prince William Sound commercial harvest of Pacific herring, 1984-87. Fishery Research Bulletin 88-08, Alaska Department of Fish and Game, Juneau.

Table 1. Mean standard length (mm) for Pacific herring from Prince William Sound age-weight-length samples from commercial and test fishing samples, 1973 through 1987.

	Age											
Year	2	3	4	5	6	7	8	9	10	11	12	13
1973		178	200	214	224	225	243	252	225			
1974		182	197	216	225	229	223					
1975	155	176	194	205	225	234						
1976		165	185	199	208	216	227	232				
1977		177	191	207	217	221	230	234				
1978		170	185	190	200	207	215	216		215		
1979	129	181	187	209	220	224	229	228				
1980	150	180	192	201	219	222	224	230				
1981		180	195	205	213	224	223					
1982	145	168	185	204	214	214	219					
1983		183	193	207	216	220	221	222	249			
1984	146	178	191	204	216	223	226	229	239	235		
1985	159	188	204	212	219	227	233	234	232	228		
1986	148	181	191	205	212	217	222	226	229	230	208	
1987	167	178	195	207	215	221	227	232	235	237	240	230
Mean	150	178	192	206	216	222	226	230	235	229	228	230

Table 2. Mean round weights (g) for Pacific herring from Prince William Sound age-weight-length samples from commercial and test fishing samples for 1973 through 1987.

	Age											
Year	2	3	4	5	6	7	8	9	10	11	12	13
1973		69	99	124	142	151	193	196	180			
1974		100	101	129	148	152						
1975	46	70	96	114	154	166						
1976		62	92	115	130	150	171	166				
1977		65	86	112	133	145	165	179				
1978		68	83	94	108	123	134	128		152		
1979	28	75	81	108	125	137	148	136				
1980	42	79	99	113	146	150	165	179				
1981		72	101	115	126	138	136					
1982	35	60	83	116	134	136	139					
1983		85	101	125	143	155	161	155	204			
1984	35	73	90	112	139	154	162	167	203	173		
1985	47	82	108	127	142	160	175	183	180	173		
1986	46	86	102	129	146	156	171	180	187	190	174	173
1987	63	77	103	127	146	160	169	182	189	196	191	
Average:	43	74	95	118	138	149	162	170	191	179	192	173

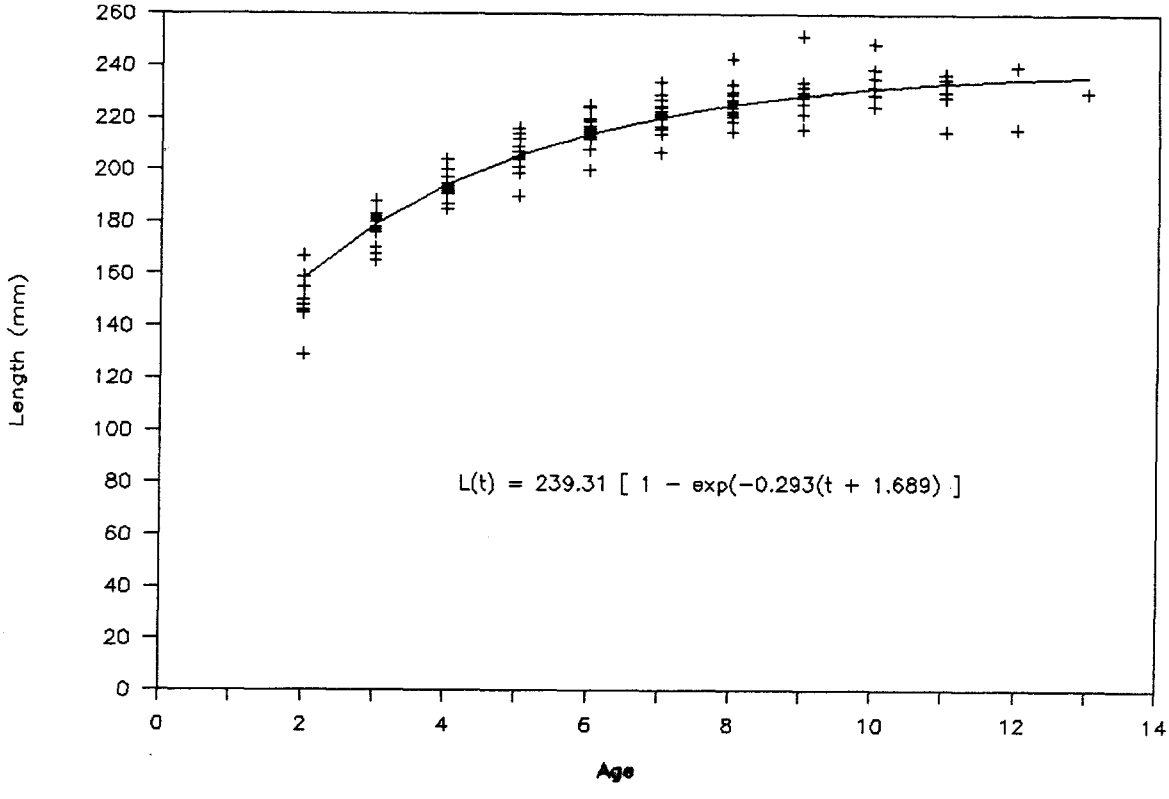

Figure 1. Prince William Sound herring length-age relationship, using combined commercial and test fishing samples for each year, 1973 through 1987, and the von Bertalanffy length-age growth model estimated by weighted nonlinear least squares.

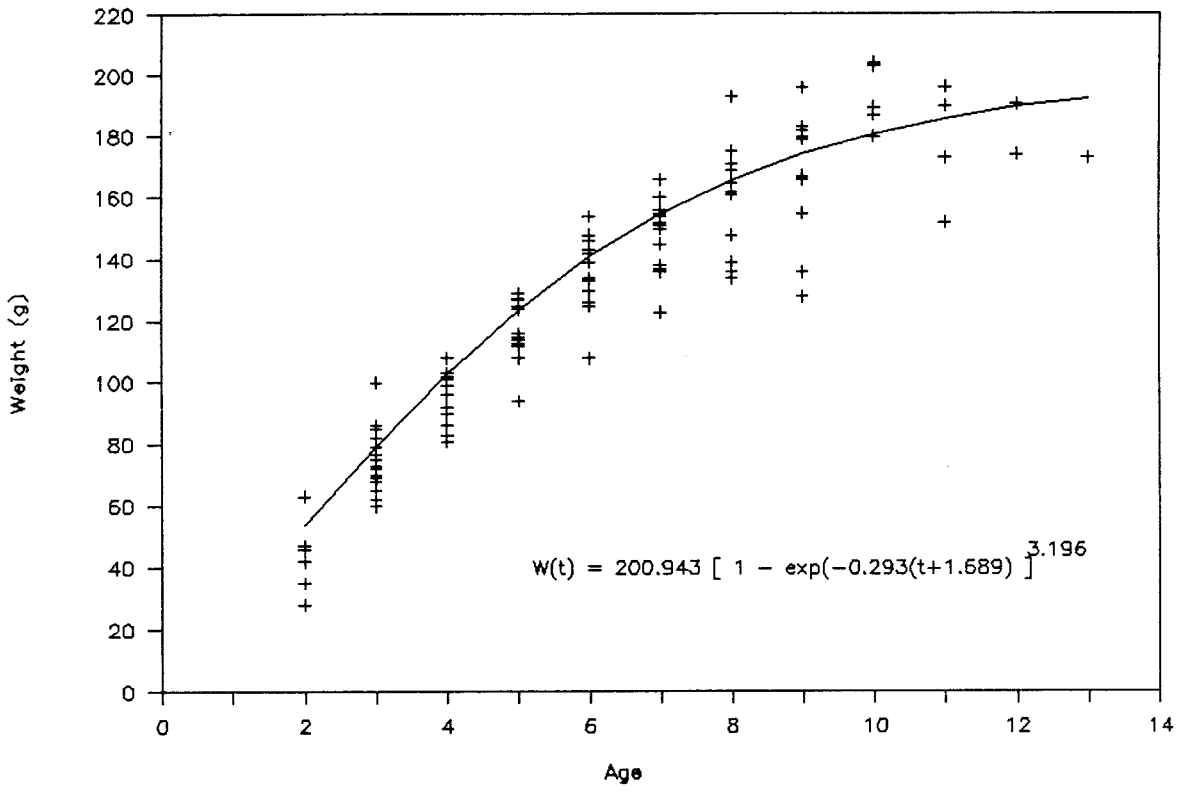

Figure 2. Prince William Sound herring length-weight relationship, using annual mean length and weight at each age from combined commercial and test fishing samples for each year, 1973 through 1987, and the allometric model estimated from nonlinear least squares, weighted by the sample size at each age and year.

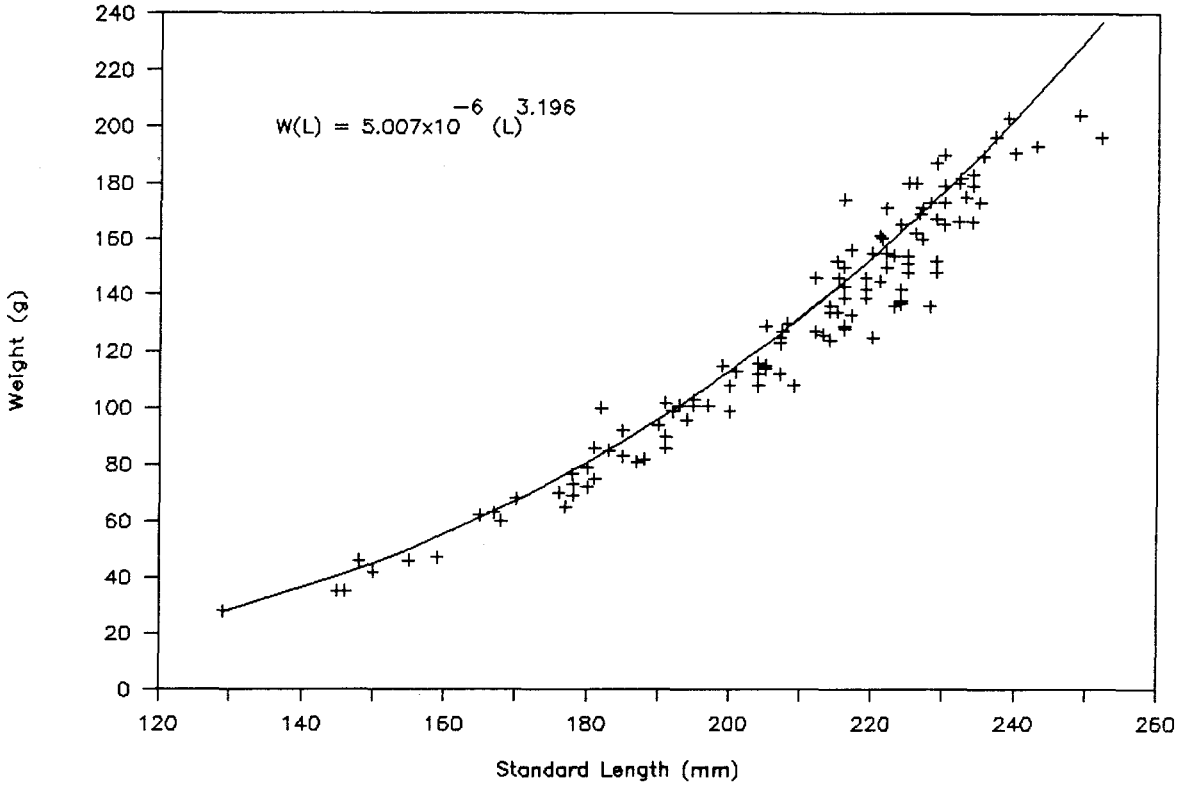

Figure 3. Prince William Sound herring weight-age relationship, using combined commercial and test fishing samples for each year, 1973 through 1987, and the von Bertalanffy weight-age model estimated by algebraically combining length-age and length-weight relationships.