Weight-Length Relationship for Pacific Ocean Perch *(Sebastes alutus)* Collected off British Columbia in 1969

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FISHERIES RESEARCH BOARD OF CANADA

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WEIGHT-LENGTH RELATIONSHIP FOR PACIFIC OCEAN PERCH (SEBASTES ALUTUS) COLLECTED OFF BRITISH COLUMBIA IN 1969

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Biological Station, Nanaimo, B. C.

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INTRODUCTION

The weight-length relationship is an essential component for growth analysis, and is useful for converting commercial landing records from weight to numbers of fish, if representative size composition data are available. Weight-length relationships have been reported for Pacific ocean perch (Sebastes alutus) in the Oregon-Washington area by Alverson and Westrheim (1961), and for the western Gulf of Alaska by Westrheim (1967). No weight-length relationship has been reported, to the authors' knowledge, for the British Columbia area.

This report deals with weight-length formulae obtained during 1969, for Pacific ocean perch caught off British Columbia.

MATERIALS AND METHODS

Data Collection

Pacific ocean perch weight-length data were collected aboard the C.G.S. G.B. REED, in 1969, off southwest Vancouver Island during February, June, and September, and in Queen Charlotte Sound during June and September (Table 1). Ocean perch are not abundant on the commercial fishing grounds in Queen Charlotte Sound during the winter. During each collection period, the total catch of ocean perch from one or two hauls was placed in metal tubs (ca. 95-lb capacity). Each tub was covered with a wet gunny sack to prevent desiccation of the fish. The vessel then steamed inshore and anchored in a sheltered inlet where weighing of individual fish took place. Weighing began about 5 hr after collection and terminated about 10 hr after collection. Fish were weighed individually, to the nearest gram, on a direct-reading balance (5000-g capacity). Weights were collected from no more than 10 fish per sex per centimeter interval (10.0-10.9, 11.0-11.9, etc.) (Appendix Table I). These data were recorded on special forms designed to facilitate computer processing of data.

Data Processing

The weight-length relationships were derived using an additive, non-linear model program (ALOMA) after Pienaar and Thomson (1969). Where the sample size exceeded 400, the maximum number allowed by the program, a random-number generator was used to pick the appropriate sample for calculation.

Testing for differences by covariance methods was limited to the relationships derived by the common logarithmic transformation of both variables in a multiplicative model to conform with previously published results.

Empirical Tests

The all-B.C. formulae (males, females, and sexes combined) were empirically tested by applying them to ocean perch length-frequency samples for

which the weight was known. One group consisted of 85 ocean perch length-frequency samples from G.B. REED catches off Oregon, Washington, British Columbia, and southeastern Alaska, during 1965-69. Sample weights ranged from 200 to 500 lb. The other group consisted of 11 ocean perch length-frequency samples from commercial landings in British Columbia during 1962-68. Sample weights ranged from 140 to 600 lb. In each test, two estimates of weight were obtained. First, the male (female) length-weight formula was applied to male (female) length-frequencies, and computed weights from both sexes were summed. Second, combined-sexes weight-length formula was applied to combined-sexes length-frequencies. Following this, the per cent deviation of the estimated weights from the known weights was computed for each sample.

RESULTS

Formulae

A total of 2088 ocean perch were weighed -- 994 males and 1094 females (Table 2). Parameters of individual formulae for month-area-sex cells usually differed significantly, based on covariance tests. However, these criteria were deemed excessively sensitive, and their results are not included. Off Vancouver Island and in Queen Charlotte Sound, male ocean perch greater than 30 cm exhibited a seasonal increase in weight -- as much as 12% from February to September off Vancouver Island (Table 3). Female ocean perch weights, at each size interval greater than 30 cm, were maximal in February, due to ripe gonads, minimal in June, and maximal again in September. February and September weights were as much as 12% higher than corresponding June weights. However, for both males and females in the more common size intervals, 35-40 cm, the maximum seasonal variation in weight was only 2-8%.

Therefore all data were combined, and general formulae were computed by sex, and sexes combined, from 400-fish randomized samples of each sex. The results are shown in Fig. 1 and below:

$$\text{Males:}\quad \hat{W} = 0.011348L^{3.08614}$$

$$\text{Females:}\quad \hat{W} = 0.0078571L^{3.16734}$$

$$\text{M + F:}\quad \hat{W} = 0.0088955L^{3.13325}$$

Calculated weights by centimeter interval, in grams and pounds, are shown in Appendix Table II.

Empirical Tests

For 87 empirical tests of the all-B.C. weight-length formula (sexes combined) applied to G.B. REED catches, 74% (64 tests) yielded weight estimates within ±5% of the known weights, and 98% (85) yielded estimates within ±10% of the known weights (Table 4). Virtually the same results were obtained using

the individual male and female formulae and summing the estimates. Geographically, the B.C. formula appeared to underestimate known weights of samples collected off Oregon (September 1965) and to overestimate known weights of samples off southeastern Alaska (September 1967). However, these biases may be illusory. September 1965 samples collected off southwest Vancouver Island were likewise underestimated. Observed weights may have been inaccurate, or the ocean perch weight-length relationship may vary among years. Similarly, we are unable to explain the three underestimations noted as "dubious data" in Table 4.

For the 67 empirical tests of samples collected off British Columbia, 76% (51 tests) yielded weight estimates within ±5% of known weights, and 99% ±10%.

For the 11 empirical tests applied to ocean perch length-frequency samples collected from commercial landings, 36% (4 tests) yielded weight estimates within ±5% of known weights, and 82% (9), ±10% (Table 4). The two extreme deviations (+12.1% and −18.9%) cannot be explained at this time.

Other Formulae

Two other ocean perch weight-length formulae are available for comparison. One was based on a random sample of 244 males and 230 females collected during 1950-52 from commercial landings in Oregon (Alverson and Westrheim, 1961; Westrheim, 1967). The other was based on a stratified sample of 371 males and 339 females collected during 1963-64 aboard the G.B. REED in the western Gulf of Alaska. The Oregon and British Columbia results are similar, but both differ from those for Alaska (Table 5). The larger Oregon and British Columbia fish are heavier per unit length than the Alaska fish.

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Table 1. Location, time, depth, and ocean perch catch (lb) for G.B. REED hauls from which weight-length samples were collected.

Area	Month	Haul[a]	Depth Interval (fm)	Ocean perch catch (lb)
S.W. Vancouver Island	February	69-1-3	160-179	2,776
		-4	140-159	330
	June	69-2-1	160-179	5,145
	September	69-3-2	120-139	4,096
		-3	80-99	95
Queen Charlotte Sound	June	69-2-5	140-159	2,346
	September	69-3-28	80-99	1,659

[a]GBR 69-1 (Westrheim, Davenport, Harling, Smith, and Wowchuk, MS 1969).
GBR 69-2 (Westrheim, Davenport, Smith, and Bianchin, MS 1969).
GBR 69-3 (Harling, Davenport, Smith, and Wilson, MS 1969).

Table 2. Parameters of weight(gm)-length(cm) formulae for Pacific ocean perch collected off British Columbia in 1969, by sex, month, and area. (Pre-iteration log-log formulae in parentheses.)

Month	S.W. Vancouver Island			Queen Charlotte Sound		
	N	b	a	N	b	a
Males						
February	214	2.92688 (2.98978)	0.018178 (-1.83767)	0	-	-
June	134	3.02445 (3.13180)	0.013013 (-2.05259)	159	2.97785 (3.04109)	0.015392 (-1.91110)
September	223	3.10345 (3.11673)	0.010214 (-2.010692)	265	3.16313 (3.11841)	0.0081281 (-2.021681)
Females						
February	209	3.25468 (3.14486)	0.0059132 (-2.05855)	0	-	-
June	153	2.94851 (2.91992)	0.017014 (-1.72491)	184	3.00687 (2.97378)	0.013637 (-1.81408)
September	249	3.10601 (3.12849)	0.010234 (-2.025487)	299	3.23785 (3.098296)	0.0061276 (-1.99418)

Table 3. Calculated mean weights (gm) of Pacific ocean perch for selected size intervals, using individual and combined weight-length formulae.

Fork	S.W. Vancouver Island						Queen Charlotte Sound				All Areas		
length	February		June		September		June		September		All months		
(cm)	M	F	M	F	M	F	M	F	M	F	M	F	M+F
10.5	18	12	16	17	15	15	17	16	14	12	15	13	14
15.5	55	44	52	55	51	51	54	52	47	44	51	46	48
20.5	126	110	121	125	120	121	124	120	115	108	119	112	115
25.5	238	224	234	239	237	239	238	231	229	220	232	224	227
30.5	402	401	401	405	413	417	405	396	403	392	402	395	398
35.5	626	657	635	633	661	668	636	625	651	641	641	639	640
40.5	921	1008	946	934	995	1006	942	929	988	982	959	970	968
45.5	1295	1473	1346	1317	1428	1445	1332	1319	1427	1431	1371	1402	1394
50.5	1757	2068	1845	1791	1974	1997	1817	1804	1985	2006	1887	1951	1932

Table 4. Empirical tests of the all-B.C. weight-length formula (sexes combined) for Pacific ocean perch, by region and month. (Numbers in parentheses are deviations resulting from using the W. Gulf formula of Westrheim (1967)).

		G.B. REED Catches													B.C. Commercial Landings
%[a]	Oregon	S.W. Vancouver Island							Queen Charlotte Sound		S.E. Alaska			Queen Charlotte Sound
Dev.	SEP	FEBRUARY		MAR	APRIL		MAY	JUN	SEP	SEPTEMBER		AUG	SEP	TOTAL	TOTAL
	1965	'67	'69	'67	'67	'68	'68	'68	'65	'67	'69	'65	'67		1962-1968
+13	..	..	..	..	..	1[b]	..	..	..	..	..	..	..	1	..
+12	..	..	..	..	..	0	..	..	..	..	..	..	..	0	1
+11	..	..	..	..	..	0	..	..	..	..	..	..	..	0	0
+10	..	..	..	..	..	0	..	..	..	..	..	..	2	2	0
+ 9	..	..	..	..	..	0	1	..	..	..	..	..	1	2	0
+ 8	..	..	..	..	..	1	2	..	..	..	..	..	0	3	1
+ 7	..	..	..	..	..	1	1	2	..	..	..	..	0	4	0
+ 6	..	..	..	..	..	1	0	0	..	1	..	..	1	3	3
+ 5	..	..	..	1	2	0	2	0	..	2	..	..	1	8	0
+ 4	..	1	..	1	1	2	0	0	..	0	1	1	1(1)	8	0
+ 3	..	1	..	0	0	1	0	0	..	2	2	1	1	8	1
+ 2	..	0	..	0	0	..	0	1	..	0	3	1	0	5	1
+ 1	..	2	1	1	2	..	0	0	..	2	1	0	0(1)	9	0
0	..	2	2	0	0	..	1	1	..	0	0	0	0	6	0
- 1	..	..	2	1	1	..	0	1	..	0	0	2(1)	0	7	0
- 2	..	..	0	..	..	..	0	2	2	0	0	0	0	4	0
- 3	1	..	0	..	..	..	0	..	0	0	0	0(1)	0(1)	1	0
- 4	1	..	0	..	..	..	0	..	2	0	0	0	0	3	2
- 5	2	..	0	..	..	..	0	..	1	0	1	1	0	5	0
- 6	1	..	0	..	..	..	0	..	2	0	..	..	0	3	1
- 7	0	..	0	..	..	..	0	..	..	1[b]	..	..(1)	0	1	..
- 8	0	..	1[b]	..	..	..	0	..	..	..	..	..(1)	0	1	..
- 9	0	..	..	..	..	..	1[b]	..	..	..	..	..	0(2)	1	..
-10	1	..	..	..	..	..	..	..	..	..	..	..	0	1	..
-11	..	..	..	..	..	..	..	..	..	..	..	..	0	0	..
-12	..	..	..	..	..	..	..	..	..	..	..	..	0	0	..
-13	..	..	..	..	..	..	..	..	..	..	..	..	1[b]	1	..
-14	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
-15	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
-16	..	..	..	..	..	..	..	..	..	..	..	..	(1)[b]	..	..
Total	6	6	6	4	6	7	8	7	7	8	8	6(4)	8(6)	87	10[c]

[a] % Deviation = $\frac{(\text{Calculated Weight} - \text{Observed Weight})}{(\text{Observed Weight})}$ (100) − 100

[b] Dubious data. See text.

[c] Excluding one at -18.9%, considered dubious.

Table 5. Calculated mean weights (lb) of Pacific ocean perch for selected lengths, using the Oregon, British Columbia, and Alaska formulae[a] (sexes combined).

Fork length	Oregon	British Columbia	Alaska
(cm)	(lb)	(lb)	(lb)
10	0.03	0.03	0.04
20	0.22	0.23	0.26
30	0.81	0.83	0.78
40	2.03	2.05	1.72
50	4.15	4.13	3.16

[a] $\log W = 3.08686 \log L - 4.64329$ (Oregon) (W = lb)
$\log W = 3.13325 \log L - 2.05083$ (B.C.) (W = gms)
$\log W = 2.72733 \log L - 4.15100$ (Alaska) (W = lb)

Appendix Table I. Numbers weighed (N) and mean weights ($\bar{w}$ = gm), by centimeter interval, for Pacific ocean perch collected off British Columbia, by area, month, and sex, 1969.

Fork length[a]	S.W. Vancouver Island												Queen Charlotte Sound							
	February				June				September				June				September			
	M		F		M		F		M		F		M		F		M		F	
(cm)	N	$\bar{w}$	N	$\bar{w}$	N	$\bar{w}$	N	$\bar{w}$	N	$\bar{w}$	N	$\bar{w}$	N	$\bar{w}$	N	$\bar{w}$	N	$\bar{w}$	N	$\bar{w}$
12.5	..		..		..		..		4	25	1	27	..		..		..		..	
13.5	..		..		..		..		7	29	4	31	..		..		..		..	
14.5	..		..		..		..		0	..	3	38	..		..		..		..	
15.5	..		..		..		..		1	51	0	..	..		..		..		..	
16.5	..		..		..		..		1	58	3	54	..		..		10	58	7	61
17.5	..		..		..		..		4	76	7	74	..		..		10	72	6	72
18.5	3	88	..		..		..		10	88	10	84	..		..		10	85	10	83
19.5	1	92	4	99	..		..		5	105	3	100	..		..		10	95	10	104
20.5	1	120	0	..	..		..		5	120	2	114	..		..		10	120	10	118
21.5	7	139	4	134	..		..		6	144	7	144	1	129	..		10	141	10	140
22.5	10	157	4	142	..		..		5	173	6	168	0	..	..		10	157	10	162
23.5	10	182	10	178	..		..		4	186	2	189	0	..	..		10	182	10	178
24.5	10	205	10	206	1	185	..		5	235	4	224	7	207	1	204	10	213	10	204
25.5	10	233	10	240	2	204	..		6	252	10	256	7	231	1	217	10	235	10	229
26.5	10	262	10	277	3	241	1	264	7	291	6	288	6	280	6	266	10	268	10	268
27.5	10	318	8	316	1	274	0	..	6	313	6	308	10	284	10	263	10	286	10	301
28.5	10	329	10	338	6	331	1	361	6	338	5	353	10	322	10	335	10	335	10	338
29.5	10	386	10	379	10	352	8	376	7	367	5	378	10	363	10	354	10	396	10	374
30.5	10	402	10	404	10	390	10	408	10	397	10	413	10	391	10	395	10	399	10	409
31.5	10	430	10	452	10	458	10	451	10	429	10	457	10	461	10	444	10	447	10	439
32.5	10	489	12	504	10	499	10	488	10	472	10	496	10	485	10	465	10	481	10	479
33.5	10	521	10	514	10	536	10	519	10	529	10	527	10	536	10	549	10	502	10	509
34.5	10	567	10	583	10	597	10	593	10	600	10	589	10	582	10	582	10	556	10	578
35.5	10	626	10	627	10	624	10	624	10	667	10	666	10	663	10	636	10	645	10	615
36.5	10	684	10	671	10	695	10	706	10	758	10	718	10	684	10	693	10	712	10	672
37.5	10	743	10	782	10	743	10	729	10	769	10	797	10	742	10	720	10	768	10	761
38.5	10	806	10	839	10	825	10	786	10	848	10	898	10	842	10	769	10	858	10	799
39.5	10	844	10	944	10	881	10	866	10	933	10	929	10	886	10	824	10	927	10	866
40.5	10	927	3	950	10	930	10	938	10	1008	10	972	7	929	10	944	10	987	10	994
41.5	10	992	7	1108	1	1024	10	1003	10	1099	10	1098	1	772[b]	10	993	10	1072	10	1072
42.5	0	..	6	1247	..	..	10	1097	10	1141	10	1209	..	..	10	1077	5	1156	10	1174
43.5	2	1101	6	1261	..	..	10	1151	3	1217	10	1260	..	..	10	1161	..	..	10	1222
44.5	..	..	2	1372	..	..	3	1221	1	1283	10	1383	..	..	6	1258	..	..	10	1302
45.5	..	..	2	1482	..	..	..	..	..	..	10	1415	..	..	..	..	..	..	10	1452
46.5	..	..	1	1607	..	..	..	..	..	..	4	1531	..	..	..	..	..	..	6	1586
47.5	..	..	..	..	..	..	..	..	..	..	1	1540	..	..	..	..	..	..	..	..
Total	214		209		134		153		223		249		159		184		265		299	

[a]Measured to nearest lower centimeter.

[b]Probably incorrect weight.

Appendix Table II. Length-weight relationship for Pacific ocean perch, by sex and combined sexes, for combined areas and seasons, British Columbia, 1970.

Fork length (cm)	Males		Females		M + F		Fork length (cm)	Males		Females		M + F	
	(gm)	(lb)	(gm)	(lb)	(gm)	(lb)		(gm)	(lb)	(gm)	(lb)	(gm)	(lb)
5	1.6	0.003	1.3	0.003	1.4	0.003	5.5	2.1	0.005	1.7	0.004	1.9	0.004
6	2.8	0.006	2.3	0.005	2.4	0.005	6.5	3.5	0.008	3.0	0.007	3.1	0.007
7	4.4	0.010	3.7	0.008	4.0	0.009	7.5	5.5	0.012	4.6	0.010	4.9	0.011
8	6.7	0.015	5.7	0.013	6.0	0.013	8.5	8.0	0.018	6.9	0.015	7.3	0.016
9	9.5	0.021	8.3	0.018	8.7	0.019	9.5	11	0.025	9.8	0.022	10	0.023
10	13	0.029	12	0.025	12	0.027	10.5	15	0.034	13	0.030	14	0.031
11	18	0.039	16	0.034	16	0.036	11.5	20	0.045	18	0.040	19	0.041
12	23	0.051	21	0.045	21	0.047	12.5	26	0.058	23	0.052	24	0.054
13	29	0.065	27	0.058	28	0.061	13.5	33	0.073	30	0.066	31	0.068
14	37	0.081	34	0.074	35	0.076	14.5	41	0.091	37	0.083	39	0.085
15	46	0.10	42	0.092	43	0.095	15.5	51	0.11	46	0.10	48	0.11
16	56	0.12	51	0.11	53	0.12	16.5	61	0.13	56	0.12	58	0.13
17	67	0.15	62	0.14	64	0.14	17.5	73	0.16	68	0.15	70	0.15
18	80	0.18	74	0.16	76	0.17	18.5	87	0.19	81	0.18	83	0.18
19	94	0.21	88	0.19	90	0.20	19.5	102	0.23	96	0.21	98	0.22
20	110	0.24	104	0.23	106	0.23	20.5	119	0.26	112	0.25	115	0.25
21	128	0.28	121	0.27	124	0.27	21.5	138	0.30	130	0.29	133	0.29
22	148	0.33	140	0.31	143	0.32	22.5	158	0.35	151	0.33	153	0.34
23	169	0.37	162	0.36	164	0.36	23.5	181	0.40	173	0.38	176	0.39
24	193	0.43	185	0.41	188	0.41	24.5	206	0.45	197	0.44	200	0.44
25	219	0.48	210	0.46	213	0.47	25.5	232	0.51	224	0.49	227	0.50
26	247	0.54	238	0.53	241	0.53	26.5	261	0.58	253	0.56	256	0.56
27	277	0.61	268	0.59	272	0.60	27.5	293	0.65	285	0.63	288	0.63
28	309	0.68	301	0.66	304	0.67	28.5	327	0.72	319	0.70	322	0.71
29	345	0.76	337	0.74	340	0.75	29.5	363	0.80	355	0.78	359	0.79
30	382	0.84	375	0.83	378	0.83	30.5	402	0.89	395	0.87	398	0.88
31	423	0.93	416	0.92	419	0.92	31.5	444	0.98	437	0.96	440	0.97
32	466	1.03	460	1.01	463	1.02	32.5	489	1.08	483	1.06	486	1.07
33	512	1.13	507	1.12	509	1.12	33.5	536	1.18	532	1.17	534	1.18
34	561	1.24	557	1.23	559	1.23	34.5	587	1.29	584	1.29	586	1.29
35	613	1.35	611	1.35	613	1.35	35.5	641	1.41	639	1.41	640	1.41
36	669	1.47	668	1.47	669	1.47	36.5	698	1.54	698	1.54	699	1.54
37	727	1.60	728	1.61	729	1.61	37.5	758	1.67	760	1.68	760	1.68
38	789	1.74	792	1.75	793	1.75	38.5	821	1.81	826	1.82	826	1.82
39	855	1.88	860	1.90	860	1.90	39.5	889	1.96	896	1.98	895	1.97
40	924	2.04	932	2.06	931	2.05	40.5	959	2.12	970	2.14	968	2.13
41	996	2.20	1008	2.22	1006	2.22	41.5	1034	2.28	1048	2.31	1045	2.30
42	1072	2.36	1088	2.40	1084	2.39	42.5	1112	2.45	1130	2.49	1126	2.48
43	1153	2.54	1172	2.58	1167	2.57	43.5	1194	2.63	1216	2.68	1211	2.67
44	1237	2.73	1261	2.78	1255	2.77	44.5	1281	2.82	1307	2.88	1300	2.87
45	1325	2.92	1354	2.98	1346	2.97	45.5	1371	3.02	1402	3.09	1394	3.07
46	1417	3.12	1451	3.20	1442	3.18	46.5	1465	3.23	1502	3.31	1492	3.29
47	1514	3.34	1554	3.43	1543	3.40	47.5	1564	3.45	1607	3.54	1595	3.52
48	1615	3.56	1661	3.66	1648	3.63	48.5	1667	3.68	1716	3.78	1702	3.75
49	1720	3.79	1773	3.91	1758	3.88	49.5	1775	3.91	1831	4.04	1815	4.00
50	1830	4.03	1890	4.17	1873	4.13	50.5	1887	4.16	1951	4.30	1932	4.26

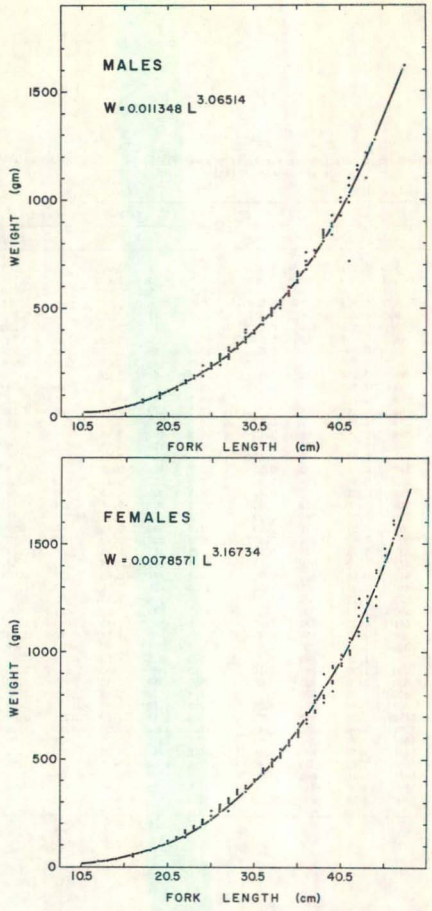

Fig. 1. Weight-length relationship for male and female Pacific ocean perch caught off British Columbia, 1969. (Solid dots indicate observed values. Congruent points not indicated.)