A POSSIBLE SEPARATION OF THE RIVER RACES OF KING SALMON IN OCEAN-CAUGHT FISH BY MEANS OF ANATOMICAL CHARACTERS

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A POSSIBLE SEPARATION OF THE RIVER RACES OF KING SALMON IN OCEAN-CAUGHT FISH BY MEANS OF ANATOMICAL CHARACTERS.

By E. A. McGregor.

In connection with certain studies of rather ample series of gill rakers, pyloric coeca, branchiostegals and ova, and a limited number of vertebrae, some very suggestive developments have accrued which appear to bear vitally on the problem of the race analysis of ocean-captured salmon.

In the work of systematists, dealing previously with the Pacific coast salmon species, seemingly they have not had access to large series of specimens or, if they had, possibly they did not go to the trouble of tediously counting large series of the structures listed above. Consequently the ranges in their several series are not so great as might have been, and their data appear not to have aroused serious speculation as to the existence of well defined intraspecific racial differences. Recent studies by Dr. Chas. H. Gilbert, especially in the case of the sockeye salmon, have established the occurrence of several local races in British Columbia and Alaska.

In the following pages we shall attempt to present the data accumulated to date in such a way as to be useful in the future in connection with similar analytical studies of ocean-caught salmon.

Ova Counts.

In another paper[1] the writer has presented data emphasizing the marked difference in the number of ova as between the Klamath River and Sacramento River races of king salmon. Since preparing this paper we have added somewhat to our Klamath series, so we will again present the ova counts of the two races, bringing the comparisons up to date.

Table I presents the full series, consisting of 111 Klamath River king salmon. These were collected at three different times as follows: Those designated "S" were collected by Professor Snyder at Requa in 1920; those marked "R" were collected by the writer at Requa in 1921; those listed as "K" were collected by the writer at Klamathon (towards the head of the river) in 1922.

[1] "Notes on the egg yield of Sacramento River king salmon" (in the present number of CALIFORNIA FISH AND GAME).

TABLE I. KING SALMON OVA COUNTS, KLAMATH RIVER.

No. of ova	Length, cm.	Date	No. of ova	Length, cm.	Date	No. of ova	Length, cm.	Date
R 8406	105	Sept. 1	R 3953	90	Aug. 24	R 3298	74	Aug. 27
R 7946	95	Sept. 5	S 3935	84	Aug. 12	R 3277	100	Sept. 2
R 6468	79	Sept. 2	R 3932	81	Aug. 27	K 3265	71	Oct. 17
R 5975	107	Sept. 3	R 3905	86	Aug. 18	R 3256	86	Aug. 12
R 5658	105	Sept. 6	R 3901	81	Sept. 1	S 3200	82	Aug. 12
R 5656	91	Aug. 9	S 3886	78	Aug. 12	R 3181	69	Aug. 19
R 5159	100	Sept. 3	K 3792	83	Oct. 19	R 3175	84	Aug. 31
K 4977	-------	Oct. 20	S 3781	82	Aug. 11	K 3174	80	Oct. 12
S 4842	87	Aug. 12	R 3743	87	Sept. 2	R 3139	70	Sept. 1
R 4728	93	Aug. 25	S 3731	84	Aug. 11	K 3130	-------	Oct. 20
R 4713	92	Aug. 20	R 3707	84	Aug. 26	S 3110	84	Aug. 11
R 4692	92	Aug. 22	K 3702	81	Oct. 20	R 3101	80	Aug. 24
R 4666	92	Aug. 26	S 3676	83	Aug. 12	S 3083	80	----------
R 4650	90	Aug. 27	S 3672	81	Aug. 12	R 3075	77	Aug. 20
R 4612	95	Sept. 1	R 3645	69	Aug. 12	R 3070	76	Aug. 24
R 4586	89	Aug. 15	S 3630	83	Aug. 12	K 3057	73	Oct. 12
K 4544	86	Oct. 15	R 3625	70	Aug. 20	R 3046	81	Sept. 6
K 4479	84	Oct. 15	R 3623	88	Aug. 25	R 3046	71	Aug. 22
R 4452	-------	----------	S 3614	83	----------	R 3035	-------	----------
R 4429	91	Aug. 9	R 3613	81	Aug. 15	R 2973	68	Aug. 16
R 4399	94	Aug. 16	R 3593	86	Aug. 24	S 2949	77	Aug. 12
S 4392	87	Aug. 12	S 3586	75	Aug. 12	K 2944	72	Oct. 12
R 4322	69	Aug. 1	S 3579	69	Aug. 12	S 2879	72	Aug. 12
R 4305	91	Aug. 18	R 3553	78	Aug. 31	S 2847	77	Aug. 12
S 4300	82	Aug. 12	R 3537	75	Aug. 18	R 2823	70	Aug. 24
S 4200	87	----------	R 3523	82	Aug. 25	K 2830	75	Oct. 15
S 4197	77	Aug. 12	R 3486	91	Aug. 31	S 2745	80	Aug. 12
S 4192	83	Aug. 12	S 3467	81	Aug. 12	R 2738	73	Aug. 31
R 4190	79	Aug. 19	R 3446	88	Sept. 3	S 2700	79	Aug. 12
R 4168	86	Aug. 16	R 3413	71	Sept. 5	R 2695	85	Aug. 16
R 4155	89	Aug. 26	S 3403	79	Aug. 12	R 2632	68	Aug. 15
R 4150	80	Sept. 5	R 3373	73	Aug. 16	R 2601	66	Sept. 2
S 4117	95	Aug. 12	R 3360	71	Aug. 26	R 2501	61	Aug. 12
R 4061	-------	----------	R 3347	77	Aug. 4	R 2471	65	Aug. 27
K 4039	84	Oct. 17	S 3305	71	Aug. 12	S 2146	67	Aug. 28
S 4009	80	---------	R 3305	66	Aug. 18	R 2013	92	Aug. 15
R 3994	93	Aug. 19--	R 3303	86	Aug. 19	K 1718	55	Oct. 13

Mean value, 3760 ova.

It will be noted that there is a wide range in the number of ova, namely, from 1718 to 8406 per female. The computed mean value for the series is found to be 3760 ova. It is not unlikely that a more detailed study of the Klamath River salmon may demonstrate the existence of several more or less recognizable local subraces characteristic of certain tributaries.

It will be further noted that the seven individuals at the maximum extreme of the series constitute (with a single exception) a homogeneous group. All but one returned to the stream during September and all, with one exception, were very large females. As will be seen later, evidence would seem to indicate that the females with over 5000 ova (although taken in the Klamath River) may be of the Sacramento race.

Table II presents our available data dealing with the ova counts of 50 king salmon of the Sacramento system, taken at Martinez, September, 1922.

Here too, we find the existence of a remarkably large range in the number of ova per female. The extremes were, respectively, 4795 and 11,012 ova per female. The computed mean for this series was found to be 7454 ova, almost double the mean of the Klamath series. As we have surmised regarding the Klamath River salmon, so also with the Sacramento run, it is quite likely that more exhaustive studies of the

salmon of this river may bring to light the occurrence of several local subraces.

TABLE II. KING SALMON OVA COUNTS, SACRAMENTO RIVER.

No. of ova	Length, cm.	Date	No. of ova	Length, cm.	Date	No. of ova	Length, cm.	Date
11,012	88	Sept. 6	8300	99	Sept. 6	6635	82	Sept. 6
9619	72	Sept. 7	8231	97	Sept. 6	6620	97	Sept. 6
9518	99	Sept. 6	8136	101	Sept. 6	6586	88	Sept. 6
9312	110	Sept. 7	7861	69	Sept. 6	6347	87	Sept. 6
9025	97	Sept. 7	7776	103	Sept. 6	6345	90	Sept. 6
8971	99	Sept. 7	7703	95	Sept. 6	6209	92	Sept. 6
8949	106	Sept. 6	7404	100	Sept. 6	5978	96	Sept. 6
8862	102	Sept. 6	7356	91	Sept. 6	5939	72	Sept. 6
8767	100	Sept. 7	7241	96	Sept. 6	5890	94	Sept. 7
8584	100	Sept. 7	7214	87	Sept. 6	5808	82	Sept. 6
8533	100	Sept. 6	7077	88	Sept. 6	5587	82	Sept. 7
8504	103	Sept. 7	7043	81	Sept. 6	5564	87	Sept. 6
8458	97	Sept. 6	6966	93	Sept. 6	5398	59	Sept. 6
8334	99	Sept. 6	6905	101	Sept. 7	5329	98	Sept. 6
8329	90	Sept. 6	6885	98	Sept. 6	5153	78	Sept. 6
8320	86	Sept. 7	6836	101	Sept. 7	4795	95	Sept. 6
8307	99	Sept. 6	6638	94	Sept. 7			

Mean value, 7453.8.

Table III contains the ova counts from 58 king salmon taken by troll in the ocean off Noyo River and Shelter Cove, Mendocino County, during the period from June 21 to August 12, 1922.

TABLE III. KING SALMON OVA COUNTS, FORT BRAGG—1922.

No. of ova	Length, cm.	Date	No. of ova	Length, cm.	Date	No. of ova	Length, cm.	Date
9021	79	June 23	5093	83	July 8	3910	66	June 25
8829	73	June 24	5042	81	June 23	3867	77	June 22
8258	70	July 6	4960	88	July 1	3854	80	July 10
7618	95	Aug. 11	4858	82	June 26	3646	81	June 25
7272	67	June 26	4783	88	June 26	3614	76	June 22
7068	77	July 1	4729	83	June 27	3555	82	July 8
6917	77	July 1	4621	85	June 23	3526	93	June 29
6851	78	June 28	4437	83	June 23	3521	77	June 27
6715	85	June 21	4377	75	June 23	3497	78	June 21
6358	109	June 29	4330	75	June 26	3477	73	July 7
6309	77	June 23	4297	98	July 1	3487	79	June 27
6287	90	Aug. 5	4247	98	July 26	3390	78	July 10
6269	61	June 27	4148	74	July 20	3344	------	------
6192	79	June 22	4142	------	------	3321	94	June 21
6008	76	July 3	4062	87	June 26	3317	75	June 30
5972	58	June 25	4035	78	June 22	3266	------	------
5768	93	Aug. 12	4033	76	June 26	3214	------	------
5450	78	June 23	4018	------	------	3147	78	June 27
5370	88	June 26	4008	81	June 29			
5094	72	July 1	3988	98	June 21			

Mean value, 4910 ova.

Again we note a very considerable range, namely, from 3147 to 9021 ova per female. The mean is computed to be 4910.

In figure 32 we have constructed three "curves" based on the data contained in tables I, II and III. In these graphs the data have been recorded in terms of percentage rather than of absolute values. A few very significant facts are to be deduced from the presentation of our data in this manner.

Referring to figure 32 it is at once noticeable that the "curves" representing respectively the Klamath and Sacramento ova series are quite

distinct from one another. Were we to ignore the six aberrant cases of the Klamath series (referred to above as probably belonging to the Sacramento race), we might say there were little, if indeed any, overlapping of the two "curves." The cleavage between the two series would appear to be coincident approximately with the 5200 ordinate.

A third "curve" will be noted in figure 32. This is constructed from the data embracing the ova counts of the series of king salmon females

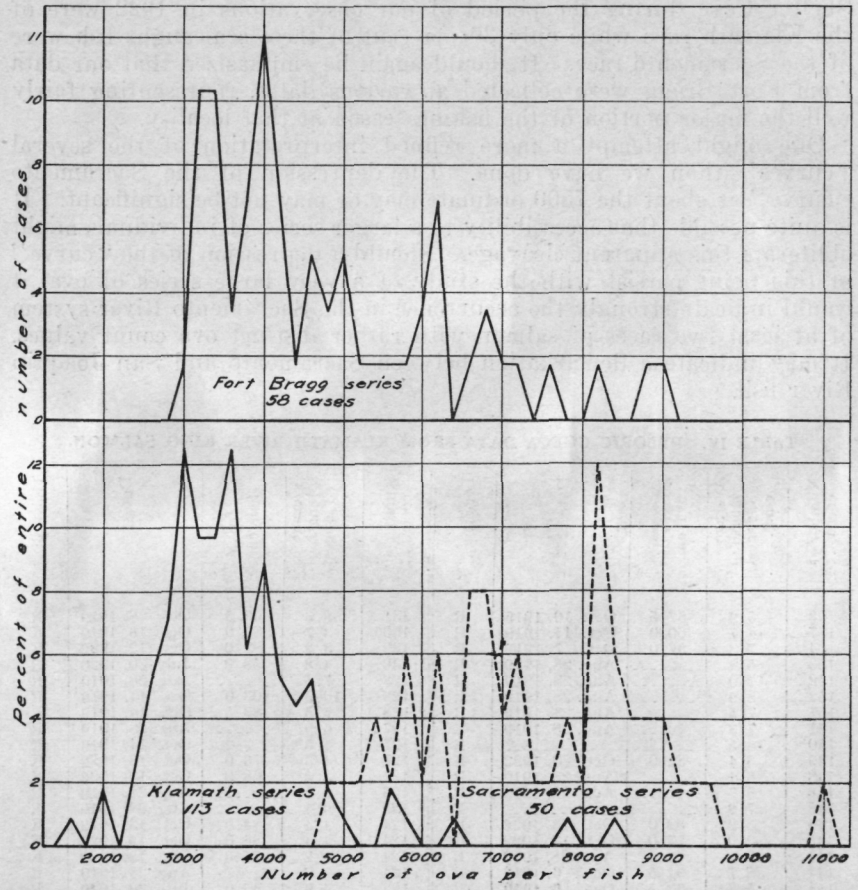

FIG. 32. Graph comparing number of ova per fish in Fort Bragg, Klamath and Sacramento series of salmon.

from the ocean at Fort Bragg. This "curve" is plotted in direct relation with the "curves" of the Klamath and Sacramento series. When considered together, we find that the ocean "curve" is nearly coextensive with the combined Klamath and Sacramento "curves." Corresponding with the cleavage between the series of the two rivers there is seen to be similarly a fairly well defined cleavage at the 5200 ordinate of the Fort Bragg "curve." Below the cleavage there are 41 cases; above the cleavage, 17 cases.

It is possible, of course, that there may be represented in the Fort Bragg series salmon from streams other than the Sacramento and Klamath Rivers. It seems, however, quite reasonable to presume that the great majority of king salmon occurring off Fort Bragg belong to the two California streams which support the major runs of the state. If this supposition be true, our ova data would seem to justify the rough estimate that 70 per cent of the king salmon caught off Fort Bragg and Shelter Cove during the period of our observations in 1922 were of the Klamath race while only 30 per cent of these sea-caught fish were of the Sacramento race. It should again be emphasized that our data from Fort Bragg were collected at various dates, representing fairly well the major portion of the fishing season at that locality.

One might attempt a more refined interpretation of the several "curves" than we have done. The depression of the Sacramento "curve" at about the 7500 ordinate may or may not be significant. It is quite possible that accessibility to a larger series of individuals might obliterate this apparent cleavage. Should a depression of the "curve" at this point persist with the study of a very large series of ova, it would indicate strongly the occurrence in the Sacramento River system of at least two races of salmon with rather distinct ova count values. It may indicate a demarkation between Sacramento and San Joaquin River fish.

TABLE IV. PYLORIC COECA DATA FROM KLAMATH RIVER KING SALMON.

Number of coeca	Average length of 3 longest, cm.	Length of fish, cm.	Date	Locality	Number of coeca	Average length of 3 longest, cm.	Length of fish, cm.	Date	Locality
193	5.9	67.5	Oct. 10, 1919	R	131	8.3	92.5	Oct. 8, 1919	R
187	4.7	60.0	Oct. 11, 1919	R	130	3.7	83.0	Oct. 13, 1919	K
164	7.3	87.0	Oct. 7, 1919	R	130	3.2	82.0	Oct. 12, 1922	K
153	5.4	--------	Aug. 28, 1919	R	130	4.3	53.0	July 30, 1920	R
152	11.0	--------	Aug. 28, 1919	R	128	7.5	--------	Aug. 28, 1919	R
152	8.9	--------	Aug. 28, 1919	R	128	10.5	103.0	Oct. 14, 1919	R
151	7.5	--------	Aug. 28, 1919	R	128	7.5	83.5	Oct. 14, 1919	R
151	7.3	--------	Aug. 28, 1919	R	127	6.9	--------	Aug. 28, 1919	R
150	16.5	--------	--------	R	127	4.5	--------	Oct. 14, 1919	R
149	3.4	81.0	Oct. 20, 1922	K	127	4.3	73.0	Oct. 16, 1922	K
148	6.1	--------	Aug. 28, 1919	R	127	3.5	68.0	Oct. 13, 1922	K
148	9.7	--------	Aug. 28, 1919	R	125	9.1	--------	Aug. 28, 1919	R
148	7.9	--------	--------	R	125	9.4	--------	Aug. 28, 1919	R
146	3.2	82.0	Oct. 13, 1922	K	124	4.4	84.0	Oct. 13, 1922	K
145	2.9	77.0	Oct. 13, 1922	K	124	4.4	86.0	Oct. 15, 1922	K
144	9.2	--------	Aug. 28, 1919	R	124	3.2	74.0	Oct. 13, 1922	K
144	8.7	94.5	Oct. 6, 1919	R	124	7.7	--------	Aug. 28, 1919	R
144	5.8	63.5	Oct. 6, 1919	R	123	5.9	55.0	July 30, 1920	R
144	8.3	97.5	Oct. 7, 1919	R	122	8.5	--------	Aug. 28, 1919	R
142	8.1	--------	Aug. 28, 1919	R	121	8.3	--------	Aug. 28, 1919	R
142	2.7	73.0	Oct. 12, 1922	K	119	7.6	--------	Aug. 28, 1919	R
141	7.1	--------	Aug. 28, 1919	R	119	2.1	52.0	Oct. 14, 1922	K
140	2.8	78.0	Oct. 12, 1922	K	119	2.8	77.0	Oct. 16, 1922	K
138	3.0	96.0	Oct. 12, 1922	K	118	3.6	83.0	Oct. 12, 1922	K
136	7.1	60.0	Aug. 4, 1920	R	117	4.3	41.5	Oct. 6, 1919	R
135	8.7	93.0	Oct. 7, 1919	R	116	6.4	--------	Aug. 28, 1919	R
135	8.0	104.0	Oct. 14, 1919	R	114	2.2	80.0	Oct. 16, 1922	K
135	2.8	81.0	Oct. 13, 1922	K	114	6.5	56.5	Oct. 11, 1919	R
134	8.8	--------	Aug. 28, 1919	R	109	--------	81.0	Oct. 12, 1922	K
133	5.8	--------	Aug. 28, 1919	R	108	5.0	--------	Oct. 14, 1919	R
133	3.6	76.0	Oct. 13, 1922	K	107	4.3	82.0	Oct. 12, 1922	K
133	4.6	84.0	Oct. 17, 1922	K	102	--------	55.0	Oct. 13, 1922	K
132	12.1	97.5	Oct. 14, 1919	R	93	4.2	--------	Oct. 20, 1922	K

Average 132.2.

Pyloric Coeca Counts.

We have made also a good many counts of pyloric coeca from the stomachs of king salmon taken at various localities.

A series of 66 king salmon stomachs were collected on the Klamath River and later examined. These were all from mature fish on their spawning run. Forty-two were taken in the estuary at the mouth of the river, the balance, 24, were collected at the Klamath racks, 170 miles upstream from the coast.

TABLE V. PYLORIC COECA DATA FROM SACRAMENTO RIVER KING SALMON.

Number of coeca	Average length of 3 longest coeca, cm.	Length of fish, cm.	Date	Number of coeca	Average length of 3 longest coeca, cm.	Length of fish, cm.	Date
214	7.7	98	Sept. 6	177	7.1	88	Sept. 6
208	9.7	95	Sept. 6	177	7.5	82	Sept. 6
206	4.6	64	Sept. 7	176	4.6	64	Sept. 6
205	2.8			176	8.1	91	Sept. 6
205	4.4	67	Sept. 6	175	6.0	101	Sept. 7
203	9.2	100	Sept. 7	175	9.7	117	Sept. 6
203	5.6	98	Sept. 6	174	9.2	98	Sept. 7
200	11.7	116	Sept. 6	174	6.7	90	Sept. 6
199	8.6	93	Sept. 7	174	6.2	81	Sept. 6
198	8.0	82	Sept. 7	174	10.5	101	Sept. 6
198	9.4	106	Sept. 6	168	7.9	99	Sept. 6
197	6.8	72	Sept. 7	168	6.8	79	Sept. 6
197	8.8	88	Sept. 6	168	6.8	90	Sept. 6
195	7.8	78	Sept. 7	166	8.9	101	Sept. 6
195		88	Sept. 6	165	8.1	99	Sept. 6
[1]195	3.3	84	Nov. 10	165	6.3	92	Sept. 6
194	4.5	57	Sept. 7	164	9.2	87	Sept. 6
194	7.8	97	Sept. 6	163	8.9	103	Sept. 6
193	7.0	94	Sept. 7	164	8.1	88	Sept. 6
[1]193				162	8.1	87	Sept. 6
192	7.3	100	Sept. 7	162	7.1	97	Sept. 6
192	10.0	95	Sept. 5	[1]162	3.0	68	Nov. 8
192	6.2	67	Sept. 6	161	8.2	97	Sept. 6
192	9.4	80	Sept. 6	160	9.4	101	Sept. 7
[1]191	3.8	86	Nov. 11	158	10.5	96	Sept. 6
189	7.9	98	Sept. 6	157	6.3	97	Sept. 6
188	6.5	100	Sept. 6	156	6.4	69	Sept. 6
187	8.3	87	Sept. 6	155	8.9	114	Sept. 7
187	7.2	100	Sept. 6	[1]155	4.3	84	Nov. 3
[1]187				150	6.8	97	Sept. 6
186	8.8	99	Sept. 6	149	5.6	78	Sept. 6
184	6.7	97	Sept. 7	149	8.2	99	Sept. 6
183	8.1	99	Sept. 7	147	8.4	99	Sept. 6
[1]182	2.8	80	Nov. 8	147	10.0	84	Sept. 6
181	8.3	103	Sept. 7	146	5.7	62	Sept. 6
181	7.2	90	Sept. 6	145	9.8	110	Sept. 7
180	8.4	69	Sept. 6	140	7.9	72	Sept. 6
178	7.3	94	Sept. 7	136	7.3	86	Sept. 7
178	9.2	83	Sept. 6	135	9.0	103	Sept. 7
178	9.4	82	Sept. 6	134	4.5	59	Sept. 6
177	8.0	99	Sept. 6				

Average, 176.4.

[1]NOTE.—The few individuals of November in this table were taken at the Klamathon racks on the Klamath River; being marked fish we know them to be of Sacramento River origin and are included with the balance which were taken at Martinez.

The frequency range of this Klamath River series (see Table IV) is from 93 to 193 coeca per stomach, with a mean value of 132.2 coeca. The three highest counts (164, 187 and 193) appear to fall far out of the regular distribution of the series. This is shown more clearly by referring to the graphic plotting of the data in figure 33. It is very probable that these three aberrant cases are individuals belonging to a race other than that normally inhabiting the Klamath River. We have computed that about 93 per cent of all the coeca cases of the Klamath series are contained between the 107 and the 153 ordinates, inclusive.

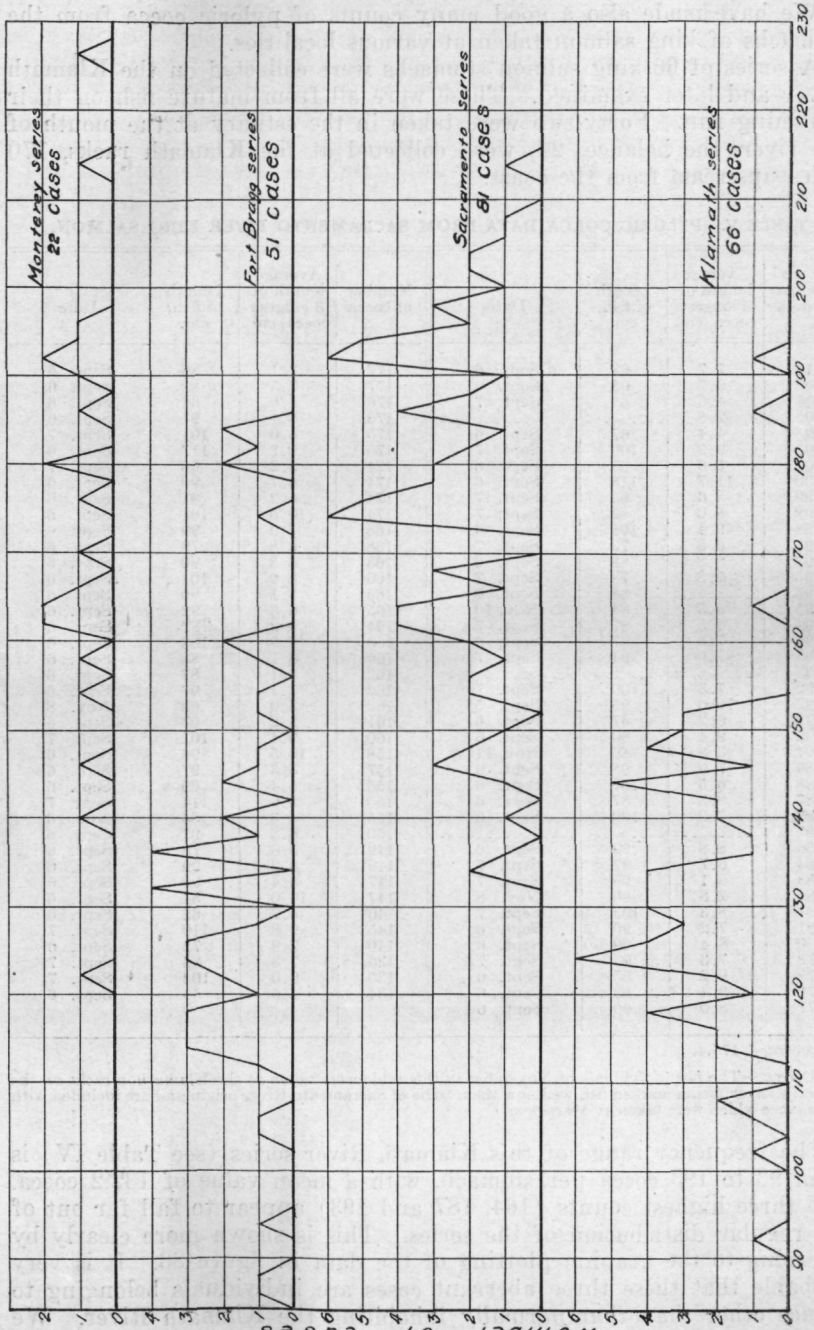

FIG. 33. Comparison of number of coeca in Monterey, Fort Bragg, Sacramento and Klamath series of salmon.

A series of 81 king salmon stomachs were collected at Martinez on Suisun Bay, just below the mouth of the Sacramento River. While there is a possibility that a portion of these individuals may have been heading for the San Joaquin River, still it is more than likely that the great mass, if not all of them, were typical Sacramento River fish and we shall speak of them as such in the present paper.

In Table V we present the coeca counts of this series arranged in orderly sequence. It will be seen that the case distribution ranges from 134 to 214 coeca (about 95 per cent of all the cases occur on the upper side of the 144 ordinate). The mean value for the series is 176.4 coeca.

Referring again to figure 33 we see the coeca counts of the Sacramento River series plotted in relation to the Klamath River counts. As one might expect, there is a degree of overlapping of the "curves" representing the coeca counts of the two great river systems. The striking feature, however, is that the overlapping is so slight! If, arbitrarily, we erect a vertical between the 153 and 154 ordinates, the Sacramento cases below this division line constitute but 13.5 per cent of the entire Martinez lot, while the Klamath cases above this dividing line amount to only 4.5 per cent of all the Klamath River cases. And, as we have suggested above, some of these overlapping cases probably represent straggling individuals from the stream within whose coeca series they appear to fall. Hence, if we could definitely eliminate these disconcerting cases it would be seen that the pyloric coeca values of the Klamath and Sacramento rivers would become strikingly distinct from one another. As it is, they are sufficiently well separated.

We now will consider the coeca counts of king salmon taken by troll in the ocean off Fort Bragg, Mendocino County. In this series there are 51 cases, ranging from 87 to 185 coeca, with the mean value at 134.1 coeca (see Table VI).

TABLE VI. PYLORIC COECA DATA FROM FORT BRAGG KING SALMON.

Number of coeca	Average length of 3 longest coeca, cm.	Length of fish, cm.	Date	Number of coeca	Average length of 3 longest coeca, cm.	Length of fish, cm.	Date
			1922	132	5.6	41	July 10
185	11.6	78	June 23	129	13.5	82	June 26
185	4.5			127	11.0	76	July 3
182	8.4	78	June 28	126	10.3	77	July 1
180	12.2	109	June 29	126	11.1	83	June 23
180	9.7	77	June 23	125	14.1	93	Aug. 12
174	11.4	78	July 20	125	11.9	77	July 1
161		79	June 23	124	11.6	85	June 23
160	9.0	81	June 23	123	10.3	77	June 22
158	12.0			123	13.5	90	Aug. 5
155	7.8	70	July 6	121	13.8	88	Aug. 2
152	13.4			119	10.0	75	June 23
149	9.0	61	June 27	118	12.4	76	June 26
146	8.5	79	June 22	118	11.1	86	July 19
144	9.5	74	June 20	117	11.1	67	June 26
144	8.2	66	June 25	117	11.7		
141	11.1	72	July 1	116	11.5	88	June 26
140	9.8	79	Aug. 2	115	9.5	77	June 27
138	9.5	79	June 27	114	12.2	78	June 27
136	11.3	78	June 21	114	10.3	81	June 29
136	12.7	85	June 21	112		81	June 25
136	7.5	58	June 25	107	13.3	75	June 26
136	13.3	95	Aug. 11	105	11.1	78	June 22
132	14.0	83	June 27	94	9.2	76	June 22
132	14.1	88	July 1	88	12.1	79	July 8
132	11.6			87		75	June 30

Average number of coeca, 134.1; average length of three longest coeca 10.9 cm.

It is of much interest once more to attempt to analyze the Fort Bragg salmon with reference to the particular river systems to which they may belong. Such a diagnosis is facilitated by referring again to figure 33. Here we see the ocean series of pyloric coeca counts plotted with reference both to the Klamath and the Sacramento coeca series. Considering as before the typical Klamath and Sacramento individuals to be separable by an ordinate erected between the 153 and 154 coeca values, it is of significance to note where this vertical cuts the Fort Bragg series. The great mass of the Fort Bragg collection is seen to fall below this ordinate. In fact, 80.4 per cent (41 cases) of the coeca counts from Fort Bragg coincide perfectly with the frequency distribution of the Klamath coeca counts (based on the validity of our selected dividing ordinate).

Naturally one must guard against formulating generalities supported by the study of series no larger than our present one from Fort Bragg. As briefly mentioned above, however, these studies covered the interval between June 20 and August 12, a very considerable portion of the commercial fishing season at that locality. The longest hiatus without data was 13 days (July 20 to August 2); the average interval between collections was 2.8 days. It would seem, therefore, that our 51 pyloric coeca counts from king salmon at Fort Bragg might form a reasonably fair basis upon which to compute a purely tentative analysis of the composition of the catch at that point. We may be justified in stating that our data of 1922 rather strongly indicate that the king salmon caught at sea off Fort Bragg during the period of our investigations were chiefly of the Klamath River type.

By referring to Table VI the following facts are to be noted for the Fort Bragg series (provided the two river races are recognizable in our data). First, the Sacramento fish were restricted to the period prior to and including July 20. Second, all August fish had coeca counts between 121 and 140. Lastly, Klamath River salmon were taken throughout the period from June 20 to August 12 (the entire period of observation).

TABLE VII. PYLORIC COECA DATA FROM MONTEREY KING SALMON.

Number of coeca	Average length of 3 longest coeca, cm.	Length of fish, cm.	Date	Number of coeca	Average length of 3 longest coeca, cm.	Length of fish, cm.	Date
			1920	171	2.94	59	June 11
226	2.19	47	June 11	167	2.87	55	June 11
215	3.31	72	June 24	165	4.62	88	June 22
196	2.37	58	June 24	165	4.81	90	June 24
194	3.50	86	June 11	162	3.19	59	June 11
192	3.50	68	June 24	162	2.50	54	June 24
192	4.25	86	June 22	159	3.43	86	June 22
191	3.43	64	June 24	155	4.62	85	June 24
187	2.31	53	June 24	146	6.87	109	June 11
181	4.12	83	June 24	141	5.87	97	June 22
181	4.00	76	June 24	123	5.50	88	June 22
177	2.37	51	June 11				

Mean, 174.9.

The coeca of 22 king salmon caught in Monterey Bay have been counted. This very limited series was collected at intervals during the period between June 11 and June 24, inclusive. The counts (see

Table VII) varied from 123 to 226, with a mean value of 174.9 coeca—almost identical with the mean value of the pyloric coeca series of the Sacramento River fish. These are also plotted in figure 33 (as were the Fort Bragg coeca counts) in direct relation with the Klamath and Sacramento series. It will be seen that our ordinate, selected to best separate the Klamath and Sacramento fish, cuts the Monterey series in such a way as to throw 19 individuals into the Sacramento group and only three individuals into the Klamath series. Reducing these quotas to terms of percentage, the above diagnosis suggests a Sacramento River representation of 86 per cent and a Klamath River quota of 14 per cent of the Monterey series. This collection is far too small to justify serious conclusions and we have included the data merely for what it may be worth.

Gill Raker Counts.

Our third anatomical character which we have utilized in the separation of the Klamath and Sacramento races of king salmon consists of the number of gill rakers on the first branchial arch. As in the case of the ova and coeca counts, so with the gill rakers, we have three series: One each from the Sacramento and the Klamath systems and one from ocean-trolled fish off Fort Bragg.

The data concerning Sacramento salmon were secured from Martinez (on Suisun Bay) and from hatchery fish. The series consists of 35 cases and the counts are as follows: 21 gill rakers, 1 case; 22 gill rakers, 7 cases; 23 gill rakers, 10 cases; 24 gill rakers, 9 cases; 25 gill rakers, 8 cases. Thus we have a range from 21 to 25 gill rakers with a mean value of 23.5 gill rakers.

The data respecting Klamath River salmon were secured from three sources: The estuary at the mouth of the river; the Klamathon racks, far up the river, and at the hatcheries. In all, 51 gill arches were examined with the following results: 24 gill rakers, 2 cases; 25 gill rakers, 3 cases; 26 gill rakers, 10 cases; 27 gill rakers, 10 cases; 28 gill rakers, 14 cases; 29 gill rakers, 9 cases; 30 gill rakers, 3 cases. This yields a range of 24 to 30 gill rakers and a mean value of 27.4 gill rakers.

Our gill raker data in the case of the Fort Bragg king salmon were secured from a series of 51 individuals as follows: 22 gill rakers, 3 cases; 23 gill rakers, 2 cases; 24 gill rakers, 2 cases; 25 gill rakers, 8 cases; 26 gill rakers, 10 cases; 27 gill rakers, 16 cases; 28 gill rakers, 7 cases; 29 gill rakers, 1 case; 30 gill rakers, 1 case; 31 gill rakers, 1 case. Here we have a range in gill raker values from 22 to 31 with a mean value of 26.2.

TABLE VIII. GILL RAKER COUNTS FOR SACRAMENTO, KLAMATH AND FORT BRAGG KING SALMON.

Gill rakers	21	22	23	24	25	26	27	28	29	30	31	Mean
Sacramento River fish	1	7	10	9	8	----	----	----	----	----	----	23.5
Klamath River fish	----	----	----	2	3	10	10	14	9	3	----	27.4
Fort Bragg fish	----	3	2	2	8	10	16	7	1	1	1	26.2

Again it is of much interest to see what can be done in the way of isolating either Sacramento River or Klamath River salmon from the ocean catch at Fort Bragg, using the gill raker counts. By referring to

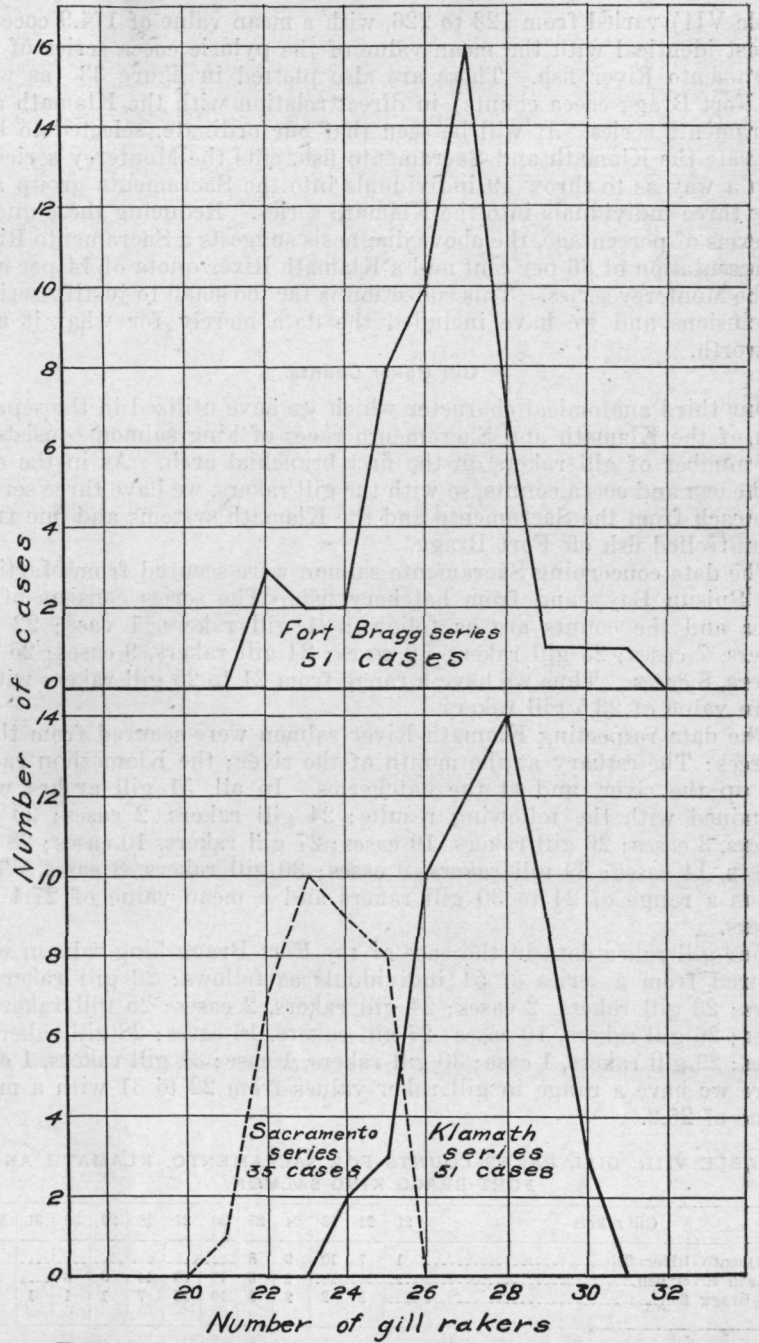

FIG. 34. Comparison of the number of gill rakers in Fort Bragg, Sacramento and Klamath series of salmon.

figure 34 wherein the various gill raker counts have been graphically presented, we are able to fix upon a vertical between the 24 and 25 ordinates as the most logical cleavage line between the gill raker values for the Sacramento and the Klamath River race. It is rather unusual that, whereas in the Sacramento series eight individuals had 25 gill rakers, none had 26. Probably a larger series would contain a few individuals with 26 gill rakers, resulting in a slightly increased overlapping of the "curves." Assuming, then, that five of the Fort Bragg individuals with gill raker counts of 25 are referable to the Sacramento race, we may, on the basis of our assumed dividing ordinate, analyze our Fort Bragg series as follows:

	Number of cases	Per cent
Klamath race	39	76.5
Sacramento race	12	23.5
Totals	51	100

This agrees nicely with the similar analysis of the Fort Bragg series based on the pyloric coeca counts.

In the case of the particular individuals in the Fort Bragg series having coeca counts above our dividing ordinate and suggesting that they may belong with the Sacramento race, we have subjected them to a similar test with reference to the arbitrary gill raker ordinate. Of these nine individuals five are seen to have more than 25 gill rakers, which places them with the Klamath race; the other four fall with the Sacramento series.

Again, we have compared these same individuals with reference to coeca and ova counts and find that every individual whose coeca count indicated it to be of the Sacramento race had ova counts above 5000, thus agreeing in this respect also with the Sacramento characteristics. These comparisons we tabulate below:

Collection number	Coeca	Gill rakers	Ova
1995	185 (S)	28	5450 (S)
2119	185 (S)	27	5093 (S)
1908	182 (S)	22 (S)	6851 (S)
1912	180 (S)	27	6358 (S)
1994	180 (S)	26	6309 (S)
2116	174 (S)	25 (S)	----------
1838	161 (S)	25 (S)	9021 (S)
1992	160 (S)	26	5042 (S)
2023	155 (S)	24 (S)	8258 (S)

With regard, then, to our nine doubtful individuals, four of them (concurring nicely in ova, coeca and gill raker characters) may be placed with much confidence with the Sacramento race. This leaves a residue of only five individuals which appear not to belong with the latter race. These fish seemingly belong to a race which possesses the coeca and ova characteristics of the Sacramento salmon but have the gill raker traits of the Klamath fish.

Therefore, on the basis of this comparative analysis of the few doubtful coeca counts from Fort Bragg, we compute that approximately 82 per cent of the entire Fort Bragg series are of the Klamath race, 8 per cent are of the Sacramento race, while 10 per cent are of a doubtful source.

Vertebra Counts.

The writer has recently conducted some experiments with the use of X-rays for the vertebral examination of fishes. A report of this work, now in manuscript form, will give the details of the technique and we will merely state here that in connection with our X-ray operations we made some radiographs of Klamath River and Sacramento River king salmon. The results of these are listed below.

TABLE IX. VERTEBRA COUNTS OF KING SALMON "FRY" SECURED BY RADIOGRAPHS.

Klamath Estuary Sept. 20 1921	Fall Creek Hatchery (Klamath ova) Sept., 1922	Fall Creek Hatchery (Sacramento ova) Nov., 1919
No. 1=62+6=68 vertebrae	No. 1=61+6=67 vertebrae	No. 1=58+6=64 vertebrae
No. 2=61+6=67 vertebrae	No. 2=60+6=66 vertebrae	No. 2=56+6=62 vertebrae
No. 3=62+6=68 vertebrae	No. 3=61+6=67 vertebrae	No. 3=59+6=65 vertebrae
No. 4=62+6=68 vertebrae	No. 4=60+6=66 vertebrae	No. 4=59+6=65 vertebrae
No. 5=60+6=66 vertebrae	No. 5=60+6=66 vertebrae	No. 5=56+6=62 vertebrae
No. 6=62+6=68 vertebrae	----------	No. 6=59+6=65 vertebrae
Mean, 67.5 vertebrae	Mean, 66.4 vertebrae	Mean, 63.8 vertebrae

The formula here used to express the vertebral count is applied as follows: The second value denotes the number of vertebrae involved in the caudal support; the first value denotes the number of vertebrae preceding those just described; the last value represents the total number of vertebrae (not counting the urostyle).

It will be seen that the number of vertebrae of the Klamath River race exhibits a range of from 66 to 68, with a weighted mean of 67.0. Those of the Sacramento race show a range of from 62 to 65 vertebrae with a mean of 63.8. In this case there is no overlapping of the two series, but this phenomenon might occur to some extent were we to examine a larger number of individuals.

Table X presents in condensed summary form the results of the present investigation.

TABLE X. ANATOMICAL FEATURES OF KING SALMON OF THE KLAMATH AND SACRAMENTO RACES AND OF FORT BRAGG OCEAN-CAUGHT CHINOOK.

	Klamath series		Sacramento series		Fort Bragg series	
	Range	Mean	Range	Mean	Range	Mean
Ova counts	1,718 to 4,977	3,760	4,795 to 11,012	7,453	3,147 to 9,021	4,910
Coeca counts	93 to 193	132.2	134 to 214	176.4	87 to 185	134.1
Gill raker counts	24 to 30	27.4	21 to 25	23.5	22 to 31	26.2
Vertebrae counts	66 to 68	67.0	62 to 65	63.8	----------	---------

The foregoing presentation of the results of our studies of the ova, pyloric coeca, gill rakers, and vertebrae would appear to support the belief that the Klamath and Sacramento races of king salmon possess anatomical differences of sufficient magnitude to enable careful workers to recognize individuals of the two races. Obviously, however, before one would be in a position to eliminate with reasonable certainty all individuals of other neighboring streams, studies similar to the present investigation would need be applied to the remaining forms. As already suggested, though, it seems reasonable to suppose that the chief salmon fisheries of the California littoral are supported in large measure by the fish of the Klamath and Sacramento rivers. If this be true, our data should constitute a preliminary guide for the resolution of our ocean run fish into their two great component groups.

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