Variation in Scales Sampled from Different Body Areas of Adult Pink Salmon

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ABSTRACT

Bilton, H. T. 1985. Variation in scales sampled from different body areas of adult pink salmon. Can. Tech. Rep. Fish. Aquat. Sci. 1360: 15 p.

Scales were removed from 18 body areas from each of 12 Bella Coola and 10 Kodiak, Alaska adult pink salmon (Oncorhynchus gorbuscha). One scale from each of the body areas was examined microscopically. The width of the first ocean zone was measured and the number of curculi in the zone was counted. The average first ocean zone width and number of circuli on scales from each body area were computed. For one of the Bella Coola pink salmon an outline drawing was made of each of the projected images of the scales from each body area. The results indicated considerable variations both in first ocean width and circulus number among scales from the various body areas. Scales from just above the lateral line between the origin of the dorsal fin and the origin of the adipose fin, exhibited both the greatest width and the highest and quite similar numbers of circuli in the first ocean zone. Scales from areas below and above the lateral line and anterior to the origin of the dorsal fin had in most cases markedly fewer circuli, and considerably narrower first ocean zones. There was considerable variation in the shapes of scales from the different body areas. Because of the distinctive shape of scales from the different body areas it may be possible to develop a "scale map" that could be used by a scale reader to determine the body area of the fish from which scales had been removed. Results of this study point out the need for further studies of this kind, not only for pink salmon, but for the other four species of Pacific salmon and for steelhead trout as well.

RÉSUMÉ

Bilton, H. T. 1985. Variation in scales sampled from different body areas of adult pink salmon. Can. Tech. Rep. Fish. Aquat. Sci. 1360: 15 p.

Des écailles ont été prélevées sur 18 zones corporelles de saumon rose (Oncorhynchus gorbuscha) adulte capturé à Bella Coola (12) et à Kodiak (10), en Alaska. Une écaille de chaque zone a été examinée au microscope; on a mesuré la largeur du premier annulus océanique et compté le nombre de circuli sur les écailles de chaque zone corporelle, puis on a fait la moyenne de ces données. Une esquisse des projections d'écailles a été réalisée pour un des saumons provenant de Bella Coola. Les résultats révèlent des variations considérables entre les écailles des diverses zones corporelles pour la largeur du premier annulus océanique et le nombre de circuli. Les écailles échantillonnées juste au-dessus de la ligne latérale entre la naissance de la nageoire dorsale et celle de la nageoire adipeuse possédaient les annuli les plus larges et le plus grand nombre de circuli dans le premier annulus océanique, nombre d'ailleurs semblable pour toutes ces écailles. Celles recueillies dans les zones au-dessous et au-dessus de la ligne latérale et en avant de la naissance de la nageoire dorsale avaient, dans la plupart des cas, nettement moins de circuli et des premiers circuli océaniques moins larges. Il existait une variation considérable de la forme des écailles prélevées sur les différentes zones corporelles. À cause de la forme distinctive des écailles de chaque zone, il serait sans doute possible de dresser une "carte d'écailles" qui servirait au lecteur pour déterminer de quelle zone corporelle provient une écaille. Les résultats de la présente recherche soulignent le besoin d'études plus poussées du genre, non seulement sur le saumon rose mais aussi sur les quatre autres espèces de saumon peuplant le Pacifique et la truite arc-en-ciel anadrome.

INTRODUCTION

Scales of adult Pacific salmon (Oncorhyncnus) for many years have been used to estimate their ages (Gilbert 1914-1925). In latter years their scales have also been used to identify the country, region or river from which they originated (Messinger and Bilton 1974; Mosher 1972; Bilton 1970; Clutter and Whitesel 1956). Work of this nature was and still is carried out extensively as a part of the research conducted under the auspices of the International North Pacific Fisheries Commission (INPFC), to determine the distribution of these fish in the North Pacific Ocean. Because of the importance of this work, it was essential that techniques of scale removal were more or less standardized between the three member countries (Japan, United States and Canada (see INPFC Annual Report for 1955).

It has been known for some time (Esdaile 1912; Paget 1920; Parrott 1934) that scales from different parts of the body of the same fish vary in width and number of circuli formed. The reason for this variability is believed to be associated with the fact scales do not form simultaneously over the skin of the fish. In the case of Salmo trutta, Parrott (1934) observed that they first formed in one area (above the lateral line slightly posterior to the dorsal fin) and then gradually developed in an anterior and posterior direction above the lateral line, at the same time spreading dorsally and ventrally until the whole surface was covered. Work by Klaatch (1890), Paget (1920) and Neave (1936) also suggested that scale formation in Salmo does not begin uniformly over the fishes body. For example, Neave found that the first papillae appear nearly simultaneously along the anterior and middle region of the lateral line. However, the region of most rapid subsequent scale formation seemed to lie farther back than where the papillae first appeared. A more recent study (Bilton 1984) of juvenile sockeye salmon (O. nerka) indicated considerable variation in scale size and number of circuli among scales from various body areas. The greatest scale size and circulus number occurred just above the lateral line midway between the insertion of the dorsal fin and the origin of the anal fin. Hence, it was suggested that in sockeye, scales probably first form and develop just above the lateral line, midway between the dorsal and adipose fins, then spread both towards the head and the tail and dorsally and ventrally along the sides of the fish.

These studies serve to point out the importance of standardizing the method of selecting scale samples from fish. In the case of pink salmon, scales are used to identify origin of stocks in catches made both in the nearshore and offshore areas of the North Pacific Ocean (Bilton 1970). Various measurements of scale characters are made (e.g. number of circuli, distance and spacing of circuli within various zones on the scale are measured). These measurements must be precise in order to detect differences among stocks which can, in many cases, be relatively small. Hence, standardmethods must be used both in the collection of the scales and in the making of measurements of scale characters. Non-standardized method of sampling for scales, could influence the precision of measurements of scales characters that would be used to define each stock and thereby lead to incorrect identification of the stocks and inaccurate estimates of their contribution to the catch.

The purpose of this report is to: (a) reinforce the recognized necessity for consistency in scale sampling by providing a comparison of measurements of several characters of scales taken from various body areas and: (b) to provide a diagnostic tool based on scale shape, that will enable the scale reader to determine the likely body area from which a scale was removed.

METHODS AND MATERIALS

SAMPLING

Scales from 12 Bella Coola (central area of British Columbia) and 10 Kodiak (Alaska) adult pink salmon were obtained from the catch in 1964.

Scales were removed from 18 areas on the left side of the body of each fish as follows:

Area	Description
1.	Preferred scale (INPFC 1955) diagonal row down from insertion of dorsal fin to second row above the lateral line.
2.	Perpendicular to origin of dorsal fin, second row above lateral line.
3.	First scale behind insertion of anal fin.
4.	Tenth scale posterior to head, second row above lateral line.
5.	Beneath pectoral fin, third row posterior to its insertion.
6.	Second row up from origin of fleshy appendage.
7.	Along the same diaganol row as preferred scale, ten rows below lateral line.
8.	Perpendicular to origin of adipose fin, three rows above lateral line.
9.	Perpendicular to origin of adipose fin, three rows below lateral line.
10.	Perpendicular to origin of caudal fin, two rows above lateral line.
11.	Perpendicular to origin of caudal fin, two rows below lateral line.
12.	Second row up from origin of anal fin.
13.	On ventral surface, midway between origins of pelvic fins.
14.	On ventral surface, midway between insertions of pectoral fins.
15.	Midway, and in a straight line between origins of pectoral and pelvic fins.
16.	Midway on dorsal surface of fish, perpendicular to origin of lateral line.

17. On dorsal surface, midway between area 16 and Origin of dorsal fin.
18. Perpendicular to the point midway between area 16 and origin of dorsal fin, and ten rows above lateral line.

Each scale was mounted on a gummed card and impressions were made using methods similar to those described by Clutter and Whitesel (1956).

Scale Examination

The image of the scale impression was projected at a magnification of 100 times onto a sheet of graph paper divided into 1 mm squares. A Leitz Prado-X microprojector equipped with plamo lenses was used. The graph paper was oriented so that one of the lines on the paper lay along the longest axis of the scale from the focus to the edge. The outer edge of the image of each circulus, from the scale focus to the last circulus of the annulus was then marked on the graph paper. The following counts and measurements were made from scales of the pinks from the two stocks.

C_1= the number of circuli in the first ocean zone from the scale focus to the ocean annulus.

A_1 = width of the first ocean zone from the scale focus to the ocean annulus.

In addition to the measurement of scale characters of scales from various body areas, the images of scales from one pink salmon, were projected, and the outline of each scale was traced onto individual sheets of paper.

RESULTS

For both the Bella Coola and the Kodiak pinks the results indicate considerable variation in the average number of circuli and the average width to the ocean annulus on scales removed from various body areas of the fish (Fig. 1 and 2; Table 1).

For the Bella Coola pink scales, the mean number of circuli (C_1) ranged from a low of 17.57 (area 16 - midway on dorsal surface of fish, perpendicular to lateral line) to a high of 26.60 (area 10 - perpendicular to origin at caudil fin, two rows above lateral line), a difference on average of 9.03 circuli (Fig. 1; Table 1). For the Kodiak pink scales, the mean number of circuli ranged from a low of 14.63 (area 5 - beneath pectoral fin, third row posterior to its insertion), to a high of 23.00 (area 1 - the preferred scale), a difference on average of 8.37 circuli. The coefficients of variation among the means of number of circuli was slightly higher on average for the Bella Coola than for the Kodiak pinks, indicating there tended to be a greater variability in circulus number among Bella Coola scales. (Table 1).

The mean width of the first ocean zone (A_1), (Fig. 2; Table 1) among scales from the Bella Coola pinks ranged from a low of 54.50 mm (area 5) to a high of 84.67 mm (area 1 - preferred scale), a difference on average of 30.17 mm. For the Kodiak pink scales the mean values of A_1 ranged from a low of 54.25 mm (area 14 - on ventral surface, midway between insertions of pectoral fins) to a high of 94.67 mm (area 1 - preferred scale), a difference on average of 40.42 mm. There was little difference in the coefficients of variation among the means of width in the first ocean zone between scales from Bella Coola and Kodiak pinks, indicating the variability was about the same (Table 1) amongst scales of fish from both stocks.

Among scales sampled from various body areas of pinks from the two stocks, there was a high significant positive correlation between circulus number and width of the first ocean zone in both cases (Fig. 3), (Bella Coola r=0.91, and Kodiak r=0.94). The data in Figure 3 also indicates that the relationship appeared to be different between the two stocks. Scales of Bella Coola pinks formed more circuli per unit increase in width of the scale than did the Kodiak pink scales. Hence, the former had more closely spaced circuli than did the latter.

The shapes of scales from various body areas of one of the Bella Coola pinks are shown in Figure 4. As can be seen, there was considerable variability in the shapes of the scales, ranging from the quite symmetrical shape of the preferred scale (area 1) to the irregular shape of the scales from area 11. Hence, scales from various body areas are often quite distinctive, making it possible to identify the area of the fish from which they had been removed.

DISCUSSION

There was considerable variation in both the number of circuli and in the width of the first ocean zone on scales from various body areas of adult Bella Coola and Kodiak adult pink salmon. In both cases, scales from just above the lateral line between the origin of the dorsal fin and the origin of the adipose fin, including the preferred scale, exhibited the highest and quite similar numbers of circuli in the first ocean zone (Fig. 2). On the other hand, scales from areas both below and above the lateral line anterior to the origin of the dorsal fin had in most cases markedly fewer circuli. Such was also the case for the mean width of the first ocean zone (Fig. 1). Scales from just above the lateral line between the origin of the dorsal fin and the origin of the adipose fin, including the preferred scale all had the highest widths on average. Scales from other body areas had considerably narrower first ocean zones.

The results of this study serve to further emphasize the need for a consistent method of sampling salmon for their scales. However, it would appear that for pink salmon at least, that the area that provides the most information from the scales is considerably broader, in the anterior -

posterior direction and narrower in the dorsal - ventral direction than that area designated as the "preferred area" (this is defined as the area that includes all scales between the insertion of the dorsal fin to a point midway to the origin of the adipose fin, and the fourth scale rows above and below the lateral line) by INPFC. Hence, this study suggests that a new definition of the "preferred area" may be in order for pink salmon. It is therefore suggested that the "new preferred area" includes any scales within the area between the origins of the dorsal and adipose fins, and between the first and third rows of scales above the lateral line. The study also indicates there is little advantage to selecting only the so-called "preferred scale" within this area, as there was little change in either circulus number or the width of the first ocean zone among scales from this area. Therefore if it is not possible to obtain the "preferred scale", as it often is, the effect of using other scales from this area should not significantly influence data derived from examination of these scales. However, for the sake of ensuring consistency in the data obtained, every effort should be made to continue to obtain the "preferred scale" when sampling pink salmon for their scales.

As was previously noted, there was considerable variation in the shapes of scales from the different body areas. Because of the distinctive shape of scales from the different body areas, it may be possible to develop a "scale map" that could be used by a scale reader to determine the body area of the fish from which scales had been removed. Such a "map" would have two advantages: (a) enable the reader to determine if a particular scale was from the "preferred area", thus providing the basis for rejecting or including a particular scale in any analysis, and: (b) provide the reader with the means to evaluate the quality of the scale data collected, and to advise on improvement if indicated.

In conclusion, the results of the present study serves to point out the need for further studies of this kind, not only for pink salmon, but for the other four species of Pacific salmon and for steelhead trout as well. These studies should be in-depth, including examination of scales from many more body areas than was considered in the present study. Also, scales from a greater number of fish of each species and from more than one stock should be included in these studies. Development of "scale maps" based on data from more than one individual of each species and stock should be initiated using either photographic or drafting techniques.

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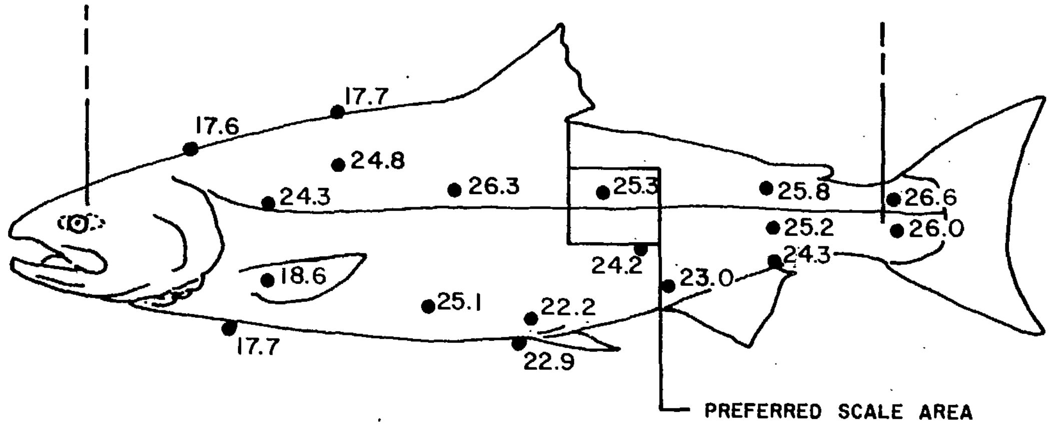
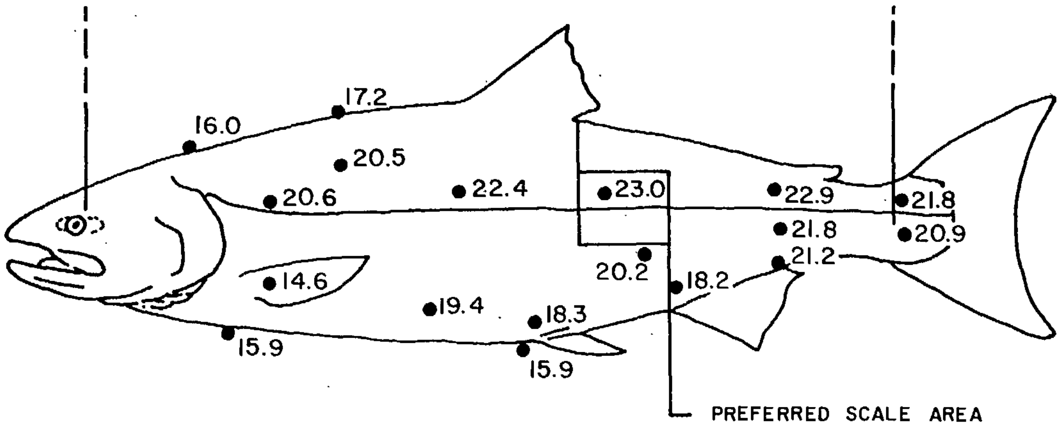
Table 1. Average circulus number and width (x100) to ocean annulus of scales obtained from various areas of the left sides of adult pink salmon from the Bella Coola and Kodiak stocks. Also shown are the standard deviations and coefficients of variation.

		Scale character					Coefficient Variation for	
	Body	C_1		A_1				
Stock	area	$\bar{x}$	SD	$\bar{x}$	SD	N	C_1	A_1
Bella Coola 1964	1	25.33	2.61	84.67	10.94	12	10.30	12.92
	2	26.29	2.93	84.43	9.88	7	11.14	11.70
	3	24.30	3.37	74.82	17.93	10	13.87	23.96
	4	24.33	2.50	75.00	10.59	10	10.27	14.12
	5	18.60	2.63	54.50	10.01	10	14.14	18.37
	6	22.22	2.73	75.22	14.39	9	12.29	19.13
	7	24.22	2.73	77.44	8.08	9	11.27	10.43
	8	25.78	2.91	84.11	13.41	9	11.29	15.94
	9	25.25	3.11	77.38	14.25	8	12.32	18.41
	10	26.60	2.59	78.00	8.50	10	9.74	10.90
	11	26.00	2.05	73.45	9.07	11	7.88	12.35
	12	23.00	2.93	72.58	13.05	11	12.74	17.98
	13	22.86	3.55	57.29	11.58	14	15.53	20.21
	14	17.67	2.39	48.00	8.53	12	13.52	17.77
	15	25.08	3.75	71.46	15.60	12	14.95	21.83
	16	17.57	2.23	50.86	9.51	7	12.69	18.70
	17	17.70	3.30	52.00	5.68	10	18.64	10.92
	18	24.80	2.25	80.73	10.57	11	9.07	13.09
	$\bar{x}$						12.31	16.10
Kodiak 1964	1	23.00	1.56	94.67	7.07	10	6.78	7.46
	2	22.40	2.59	90.00	7.15	10	11.56	7.94
	3	21.20	1.69	82.50	9.85	10	7.97	11.93
	4	20.60	1.58	82.44	10.14	10	7.67	12.30
	5	14.63	1.69	58.00	9.01	8	11.55	15.53
	6	18.33	2.25	80.14	16.04	6	12.27	20.01
	7	20.25	3.01	76.13	17.51	8	14.86	23.00
	8	22.89	1.83	96.89	11.93	9	7.99	12.31
	9	21.78	2.22	87.44	12.36	9	10.19	14.14
	10	21.78	1.56	79.11	10.83	9	7.16	13.69
	11	20.86	2.27	79.88	12.52	7	10.88	15.67
	12	18.20	3.56	63.00	12.65	5	19.56	20.08
	13	15.89	2.09	60.22	12.53	9	13.15	20.80
	14	15.88	2.23	54.25	13.30	8	14.04	24.52
	15	19.38	1.77	79.11	9.28	8	9.13	11.73
	16	16.00	1.56	61.00	8.23	10	9.75	13.49
	17	17.22	2.22	63.56	10.44	9	12.89	16.42
	18	20.50	1.31	80.22	12.02	8	6.39	14.98
	$\bar{x}$						10.77	15.33

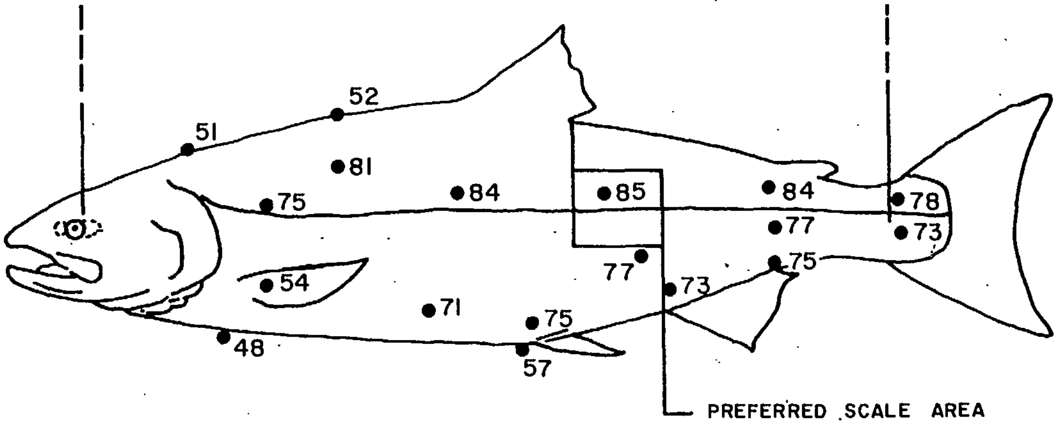


BELLA COOLA PINK

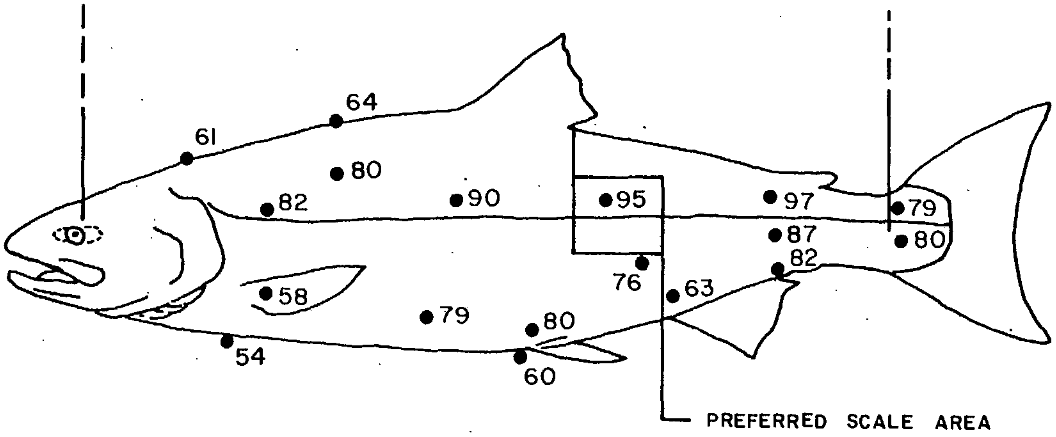


KODIAK PINK

Fig. 1. Average number of circuli in first ocean zone of scales taken from 18 areas of the left side of pink salmon adults from Bella Coola and Kodiak stocks, 1964.



BELLA COOLA PINK



KODIAK PINK

Fig. 2. Average width of first ocean zone of scales taken from 18 areas of the left side of pink salmon adults from Bella Coola and Kodiak stocks, 1964.

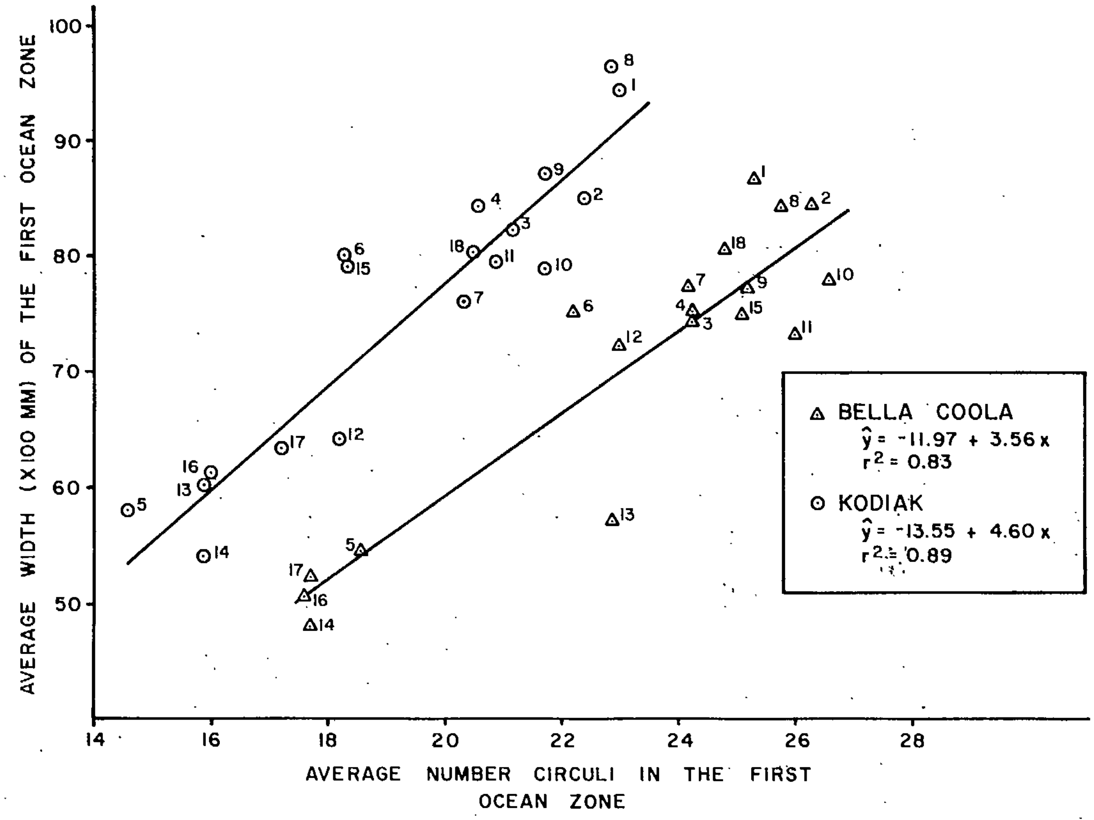


Fig. 3. Relationship between average number circuli in first ocean zone and average width of first ocean zone among scales from different body areas of Bella Coola and Kodiak adult pink salmon.

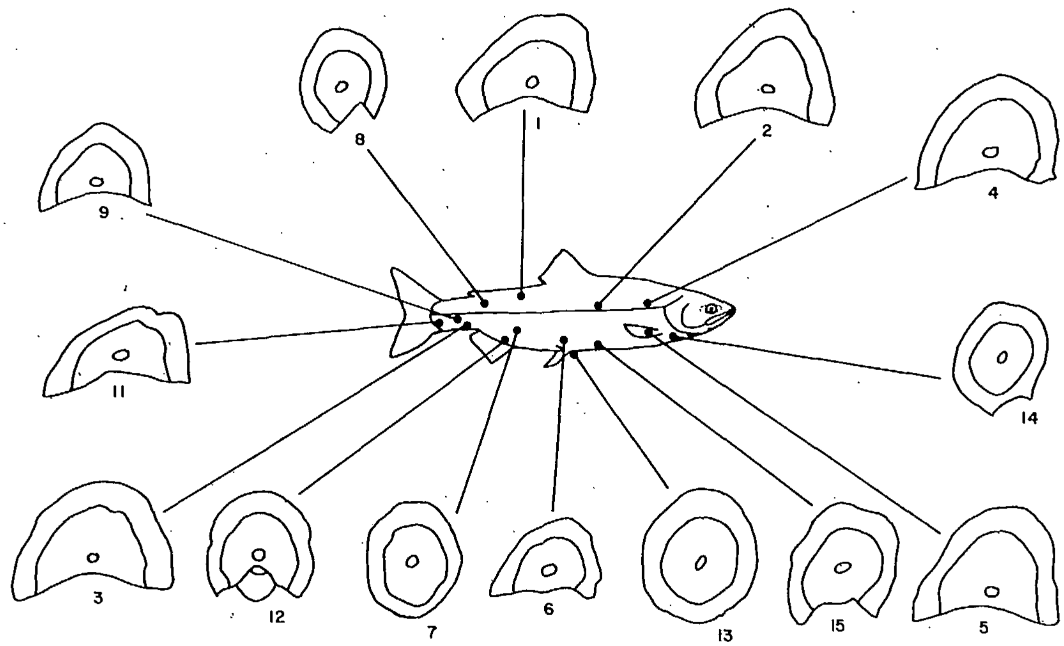


Fig. 4. The shapes of scales removed from 14 different body areas of one Bella Coola adult pink salmon. NOTE, numbers under each figure correspond to body positions given in Table in section under Materials and Methods.