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鱗相によるシロザケ系群のクラスター分析

Cluster Analysis of Chum Salmon Stocks based on Scale Pattern

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要　約

系群識別の精度を向上させるために，シロザケ系群の地理的分布と良く対応するクラスター結果を与える鱗相形質を選択した。分析には1986年に太平洋沿岸各地に回帰した0.3歳および0.4歳のシロザケ鱗標本を用いた。その結果，0.3歳魚では(L 1, L 2), (L 1, L 2, L 3), (C 1, L 1, C 2, L 2), (C 1, L 1, C 2, L 2, C 3, L 3) の4組の鱗相形質が，また0.4歳魚では (L 1, L 2) の1組の鱗相形質がアジア系及び北米系の2つの大きな地理的分布と良く対応するクラスター結果を与えることが示された。

は　じ　め　に

さけ・ます類の系群識別は，沖合および沿岸における系群別の資源管理のために重要な仕事である。系群識別の手法としては，標識放流，生物標識としての寄生虫の利用，集団遺伝学的手法，鱗相形質による系群識別等が行われている。鱗相形質による系群識別では，沖合標本の識別精度を向上させるために，各地域の特徴を良く示す鱗相形質を選択して分析に用いる必要がある。

本研究の目的は，いくつかの鱗相形質を用いてクラスター分析を行い，シロザケ系群の地理的分布と良く対応するクラスター結果を与える鱗相形質の組合せを見出すことである。

材料と方法

本研究に用いた材料は1986年に太平洋沿岸各地に回帰したシロザケの鱗標本である。標本採集地を図1に示した。日本の河川溯上魚から採集された鱗標本は，水産庁北海道さけ・ますふ化場，岩手県栽培漁業センター宮古分場および山形県水産試験場より提供されたものである。ソ連，米国およびカナダの河川および沿岸において採集された鱗標本は，それぞれ日ソおよび日米加の国際漁業委員会を通して日本へ提供されたものである。

各標本について雌雄それぞれ50尾，計100尾を無作為に抽出し，年齢査定を行うとともに，大型精密投影機により100倍に拡大し，計測した。測定軸は鱗の最長軸とし，鱗の中心からサーキュリーの外縁，各年帯の外縁および鱗の外縁の位置を測定軸に沿っ1 mm目の方眼紙上に記録した。数値化した鱗相形質を表1に示した。

クラスター分析は，各標本の各鱗相形質の平均値（表2, 3）を入力データとして，農林水産研究

センターの会話型数値分類パッケージプログラム（Conversational Numerical Taxonomy Packaged Program）により行った。なお，距離の尺度としてユークリッド距離を，またクラスターの形成手法として最短距離法（single-linkage method）を用いた。

結　果

0.3歳魚（図2-10）

ベーリング海北部に面する標本（16＝Anadyr River，17＝Kotzebue），日本系（03＝湧別川）及び北米系（26＝Cook Inlet）の1部を除き，アジア系及び北米系の2つの大きな地理的分布と良く対応するクラスター結果を与える鱗相形質は，L1,L2（図6），L1,L2,L3（図7），C1,L1,C2,L2（図9），C1,L1,C2,L2,C3,L3（図10）の4組であった。

0.4歳魚（図11-19）

ソ連系（16＝Anadyr River），日本系（01＝月光川）及び北米系（30＝Excursion Inlet,33＝Puget Sound）の1部を除き，アジア系及び北米系の2つの大きな地理的分布と良く対応するクラスター結果を与える鱗相形質は，L1,L2 の1組であった（図15）。

考　察

沖合標本の系群識別を実施する際には，まずアジア系と北米系が十分識別されるような鱗相形質を選択することが大切である。本研究の結果，0.3歳魚で4組，0.4歳魚で1組の鱗相形質がアジア系及び北米系の2つの大きな地理的分布と良く対応するクラスター結果を与えた。特にL1,L2形質は0.3歳魚および0.4歳魚ともに選択されており，また0．3歳魚のL1,L2形質は他の3組の形質よりアジア系と北米系との間の距離が大きい。それゆえ，この鱗相形質を用いることによって，アジア系と北米系の識別精度は向上するものと考えられる。

一方，アジア系および北米系内でのクラスターを見ると，各形質ともに必ずしも地理的分布と良く対応するクラスター結果を示していない。沖合標本の識別結果を解釈する際には，アジア系および北米系内での識別精度が低いことに注意する必要があろう。

謝　辞

鱗標本及び付帯資料を提供されたソ連，米国，カナダの各研究機関，北海道さけ・ますふ化場，岩手県栽培漁業センター宮古分場および山形県水産試験場に感謝する。

文　献

農林水産技術会議事務局．1985．CONTAX-会話型数値分類パッケージプログラム．農林水産研究センター利用者マニュアル18．

Table 1. Scale characters used for the analysis.

Symbol	Definition
C1	number of circuli in the first year zone.
L1	width of the first year zone in mm (x100) (distance along the longest axis of the scale from the focus to the outer edge of the first winter annulus).
C2	number of circuli in the second year zone.
L2	width of the second year zone in mm (x100) (distance along the longest axis from the outer edge of the first winter annulus to the outer edge of the second winter annulus).
C3	number of circuli in the third year zone.
L3	width of the third year zone in mm (x100) (distance along the longest axis from the outer edge of the second winter annulus to the outer edge of the third winter annulus).

Table 2. Mean value of scale character of 0.3 year chum salmon in each location.

Location	Sample Size	C1	L1	C2	L2	C3	L3
		Scale Character					
Japan							
1 Gakko River	40	31.27	132.48	14.10	56.05	12.55	54.27
2 Tsugaruishi River	69	28.10	122.81	14.35	57.38	11.87	50.32
3 Yubetsu River	58	27.98	117.31	15.45	58.22	11.81	41.03
4 Nishibetsu River	78	32.14	138.03	15.63	60.58	11.96	45.22
5 Tokachi River	55	30.40	124.36	17.09	65.56	13.22	51.02
6 Yurappu River	44	28.61	128.84	15.64	61.77	11.73	46.98
7 Ishikari River	39	30.62	130.82	14.18	53.41	12.44	49.82
U.S.S.R.							
8 Nyiskii	38	26.84	115.76	17.18	72.16	14.11	53.84
9 Amur River(summer run)	74	28.35	129.28	17.55	66.32	15.58	59.68
10 Amur River(fall run)	63	27.57	119.62	17.67	71.59	14.22	58.11
11 Kukhtui River	43	27.95	129.44	17.12	66.81	14.40	60.79
12 Taui River	73	26.12	118.97	16.71	64.12	13.45	52.82
13 Bolshaya River	38	25.26	114.76	16.42	69.42	12.84	53.95
14 Kamchatsk River	78	28.04	125.74	17.49	69.32	14.49	56.50
15 Khailyulya River	72	25.26	124.86	16.89	67.33	12.76	48.56
16 Anadyr River	62	21.11	102.68	17.18	77.81	11.52	50.00
North America							
17 Kotzebue	12	25.75	126.58	21.25	95.17	15.50	55.08
18 Unalakleet	46	28.11	132.87	19.24	81.85	15.22	56.80
19 Yukon (summer run)	27	27.52	137.19	18.67	83.56	15.44	55.85
20 Yukon (fall run)	75	28.53	134.40	18.84	82.05	13.28	53.92
21 Bethel	85	29.54	140.79	19.41	81.69	15.56	58.22
22 Bristol Bay	70	30.00	147.73	19.87	86.99	16.13	60.06
23 Shumagin Island	87	28.76	144.40	18.68	81,68	12.77	46.36
24 Alaska Peninsula	76	28.78	144.75	17.91	77.86	11.79	44.83
25 Kodiak Island	83	28.87	146.29	18.83	76.82	13.28	45.72
26 Cook Inlet	87	29.31	143.25	21.25	93.64	14.23	50.29
27 Prince William Sound	65	33.48	144.86	17.82	74.17	11.78	43.68
28 Taku Inlet	50	31.20	137.06	19.50	78.28	12.32	44.26
29 Lynn Canal	57	32.18	141.21	19.47	79.82	12.68	47.37
30 Excursion Inlet	51	31.73	139.57	18.59	72.43	11.94	42.29
31 Ketchikan	68	32.99	136.29	20.43	80.15	11.44	41.65
32 Fraser River	91	35.86	139.48	20.97	85.20	12.95	47.15
33 Puget Sound	65	39.14	147.48	20.15	76.65	13.05	46.05

Table 3. Mean value of scale character of 0.4 year chum salmon in each location.

Location	Sample Size	Scale Character C1	L1	C2	L2	C3	L3
Japan							
1 Gakko River	13	31.31	136.92	14.92	59.08	10.92	41.38
2 Tsugaruishi River	20	28.40	127.35	13.55	54.15	10.10	39.60
3 Yubetsu River	12	28.00	118.67	14.92	57.33	10.25	35.08
4 Nishibetsu River	4	28.75	120.50	15.25	57.50	12.25	40.00
5 Tokachi River	40	31.05	129.52	15.08	58.67	11.30	41.02
6 Yurappu River	50	28.94	127.96	14.00	55.30	10.82	40.90
7 Ishikari River	17	30.06	125.59	14.53	56.47	10.41	37.41
U.S.S.R.							
8 Nyiskii	48	25.81	117.13	14.98	64.08	11.52	46.21
9 Amur River(summer run)	26	28.27	126.42	15.85	61.69	12.62	43.35
10 Amur River(fall run)	31	27.52	121.26	17.03	68.16	12.23	46.19
11 Kukhtui River	55	25.56	125.65	15.29	64.42	10.73	42.24
12 Taui River	25	24.80	111.92	15.72	62.40	11.36	40.84
13 Bolshaya River	57	23.82	113.77	14.77	65.12	10.75	44.68
14 Kamchatsk River	22	27.59	128.09	15.14	63.64	11.68	45.00
15 Khailyulya River	17	25.59	121.71	16.24	62.82	11.59	42.12
16 Anadyr River	36	19.92	95.31	14.72	65.00	10.22	40.36
North America							
17 Kotzebue	86	25.70	130.58	17.95	75.19	11.60	42.97
18 Unalakleet	52	26.02	127.87	18.44	76.85	12.77	46.08
19 Yukon (summer run)	72	26.07	128.47	18.11	77.72	12.97	49.38
20 Yukon (fall run)	19	26.16	125.47	17.79	74.84	10.74	39.84
21 Bethel	13	28.08	135.23	17.23	74.62	14.92	51.92
22 Bristol Bay	24	26.00	135.08	18.58	81.00	12.29	47.17
23 Shumagin Island	13	27.62	135.08	17.46	77.23	10.62	37.38
24 Alaska Peninsula	20	24.70	127.25	18.15	81.05	10.80	39.85
25 Kodiak Island	17	25.18	131.53	18.41	77.06	11.47	41.59
26 Cook Inlet	13	25.54	128.69	19.69	86.69	12.08	42.00
27 Prince William Sound	32	30.63	138.06	16.56	69.53	10.81	38.09
28 Taku Inlet	49	28.51	129.43	17.04	73.27	11.29	41.08
29 Lynn Canal	39	28.59	130.62	17.00	73.36	10.79	39.51
30 Excursion Inlet	44	27.93	124.84	16.50	67.75	11.16	41.02
31 Ketchikan	27	32.19	131.19	19.00	75.67	9.56	32.07
32 Fraser River	5	33.60	132.80	20.60	79.20	11.80	44.00
33 Puget Sound	11	36.91	144.36	18.91	74.64	11.00	36.18

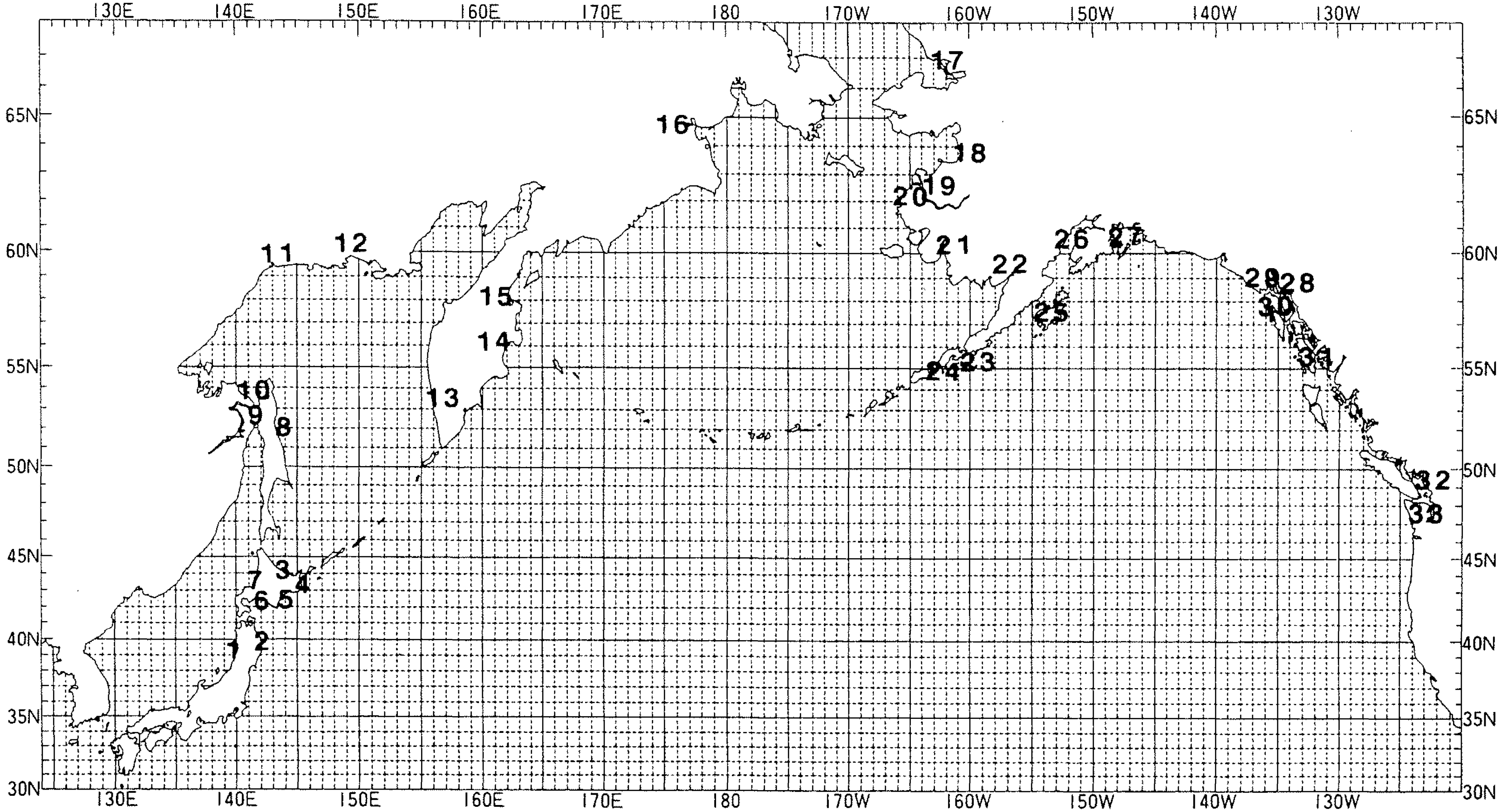

Fig.1. Locations of coastal and spawning ground sampling areas in 1986.
Numerals indicate locations in Tables 2 and 3.

0.3 Age Fish

C1

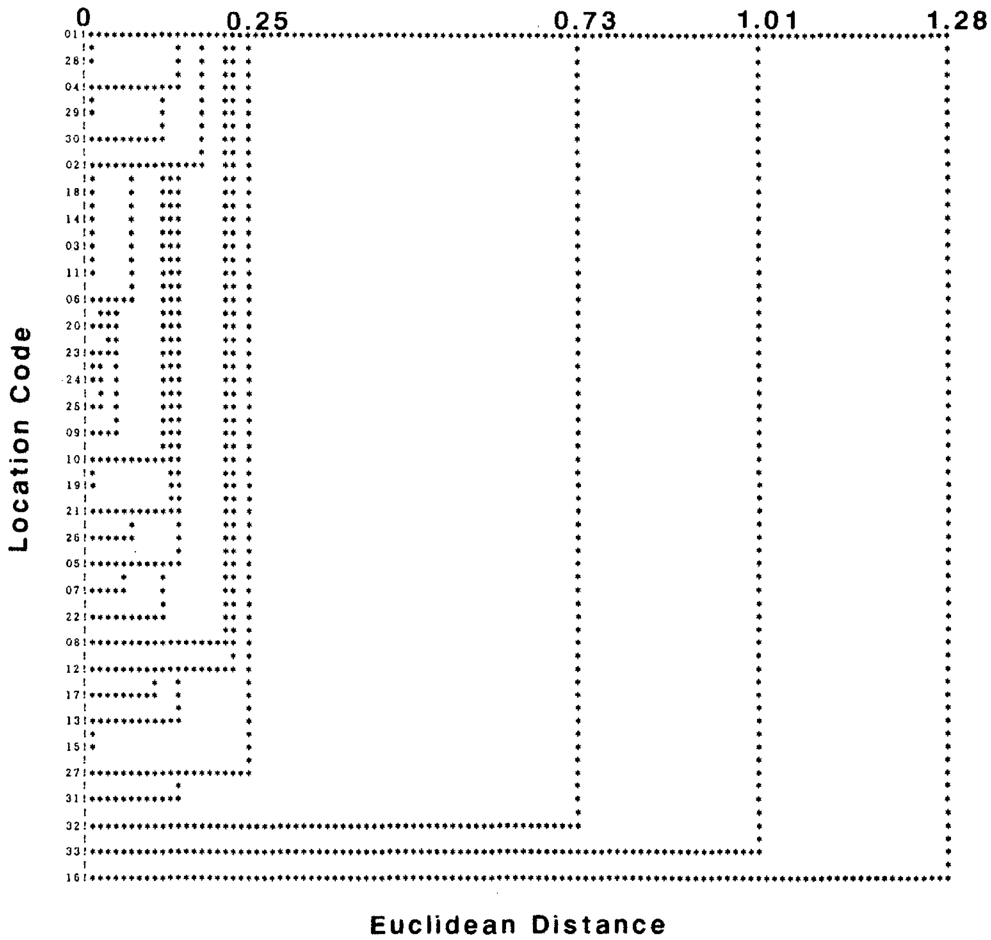

Fig.2. Dendrogram, based on Euclidean distance, for scale character C1 of 0.3 chum salmon in 33 locations.

0.3 Age Fish

C1,C2

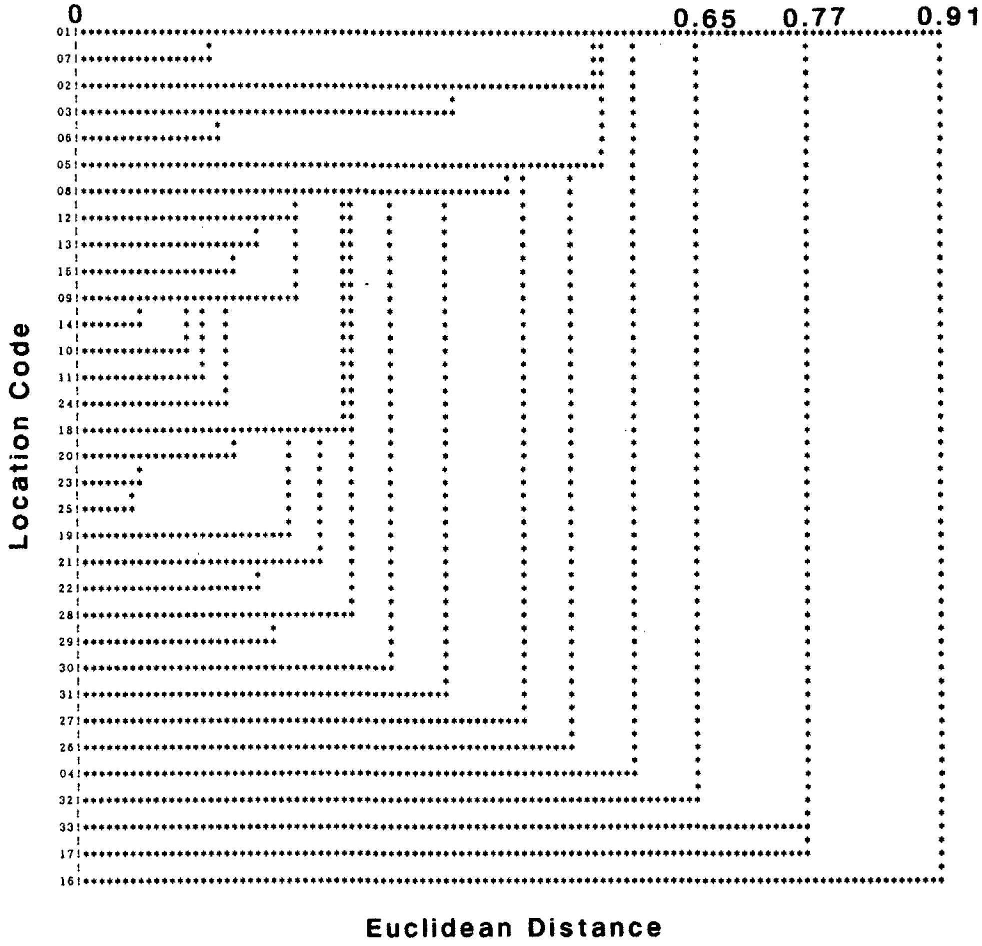

Fig.3. Dendrogram, based on Euclidean distance, for scale character C1,C2 of 0.3 chum salmon in 33 locations.

0.3 Age Fish

C1,C2,C3

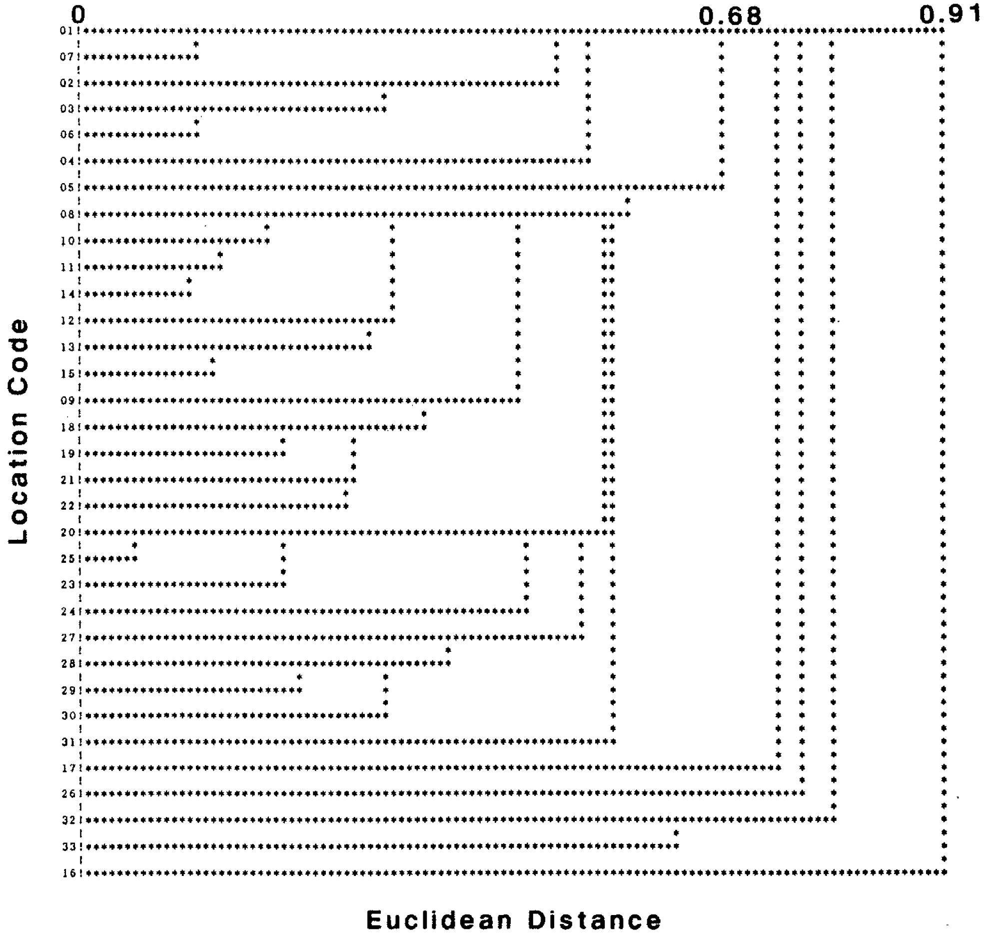

Fig.4. Dendrogram, based on Euclidean distance, for scale character C1,C2,C3 of 0.3 chum salmon in 33 locations.

0.3 Age Fish

L1

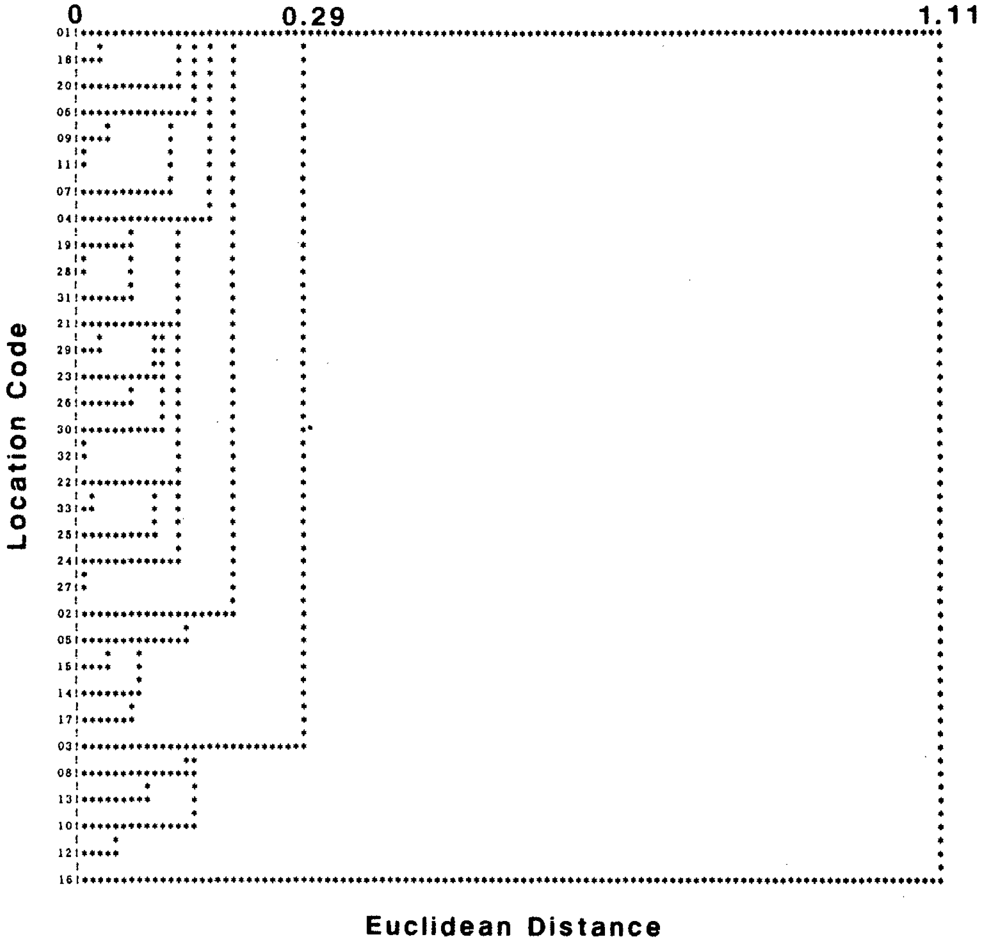

Fig.5. Dendrogram, based on Euclidean distance, for scale character L1 of 0.3 chum salmon in 33 locations.

0.3 Age Fish

L1,L2

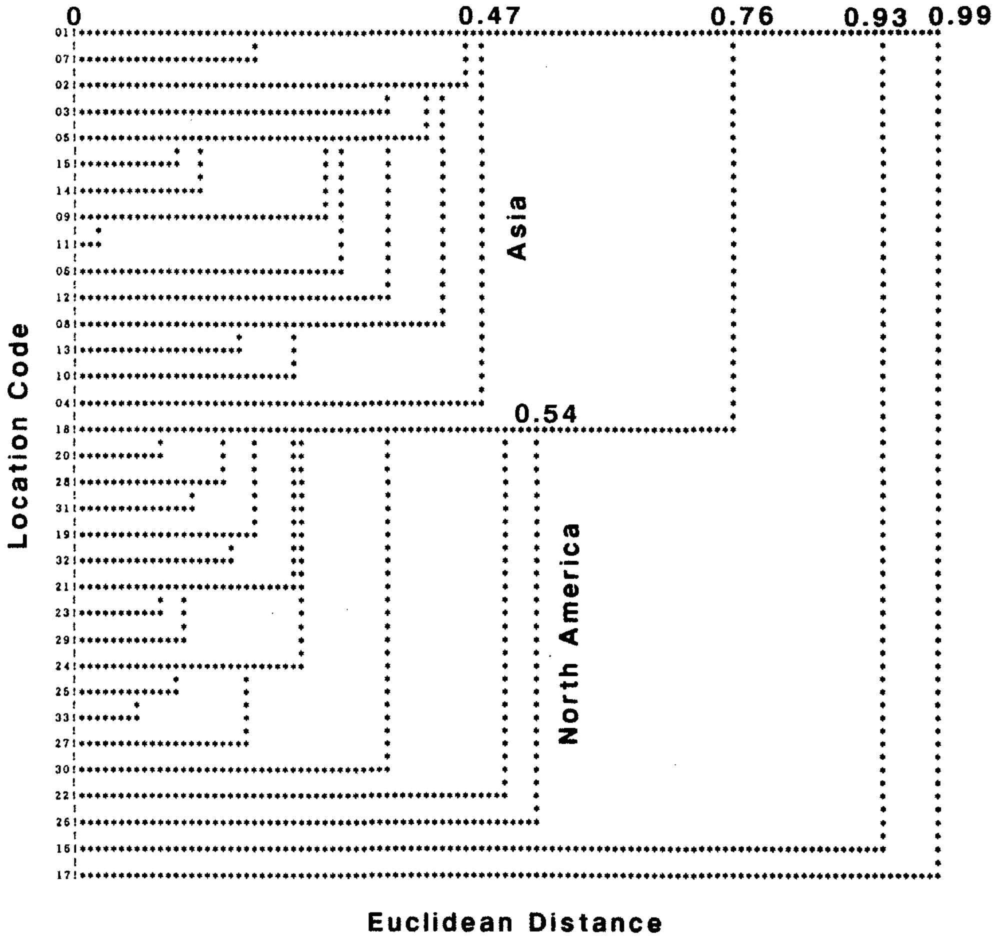

Fig.6. Dendrogram, based on Euclidean distance, for scale character L1,L2 of 0.3 chum salmon in 33 locations.

0.3 Age Fish

L1,L2,L3

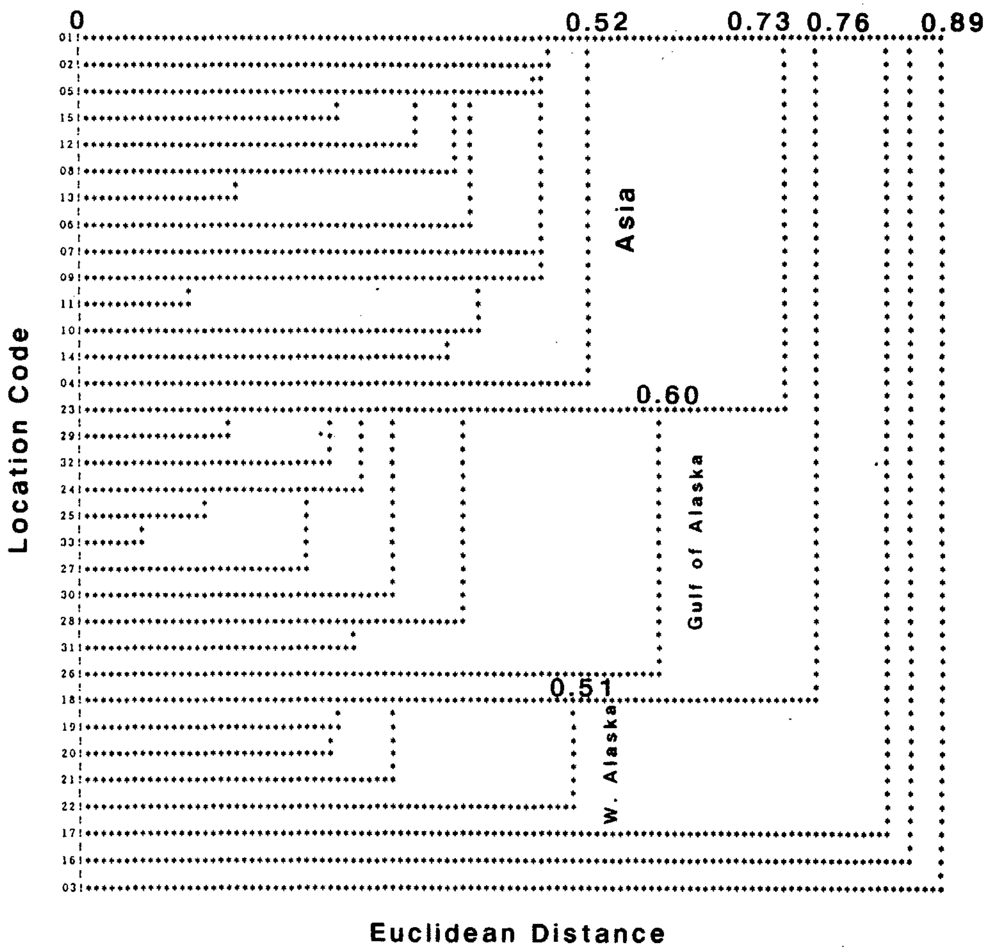

Fig.7. Dendrogram, based on Euclidean distance, for scale character L1,L2,L3 of 0.3 chum salmon in 33 locations.

0.3 Age Fish

C1,L1

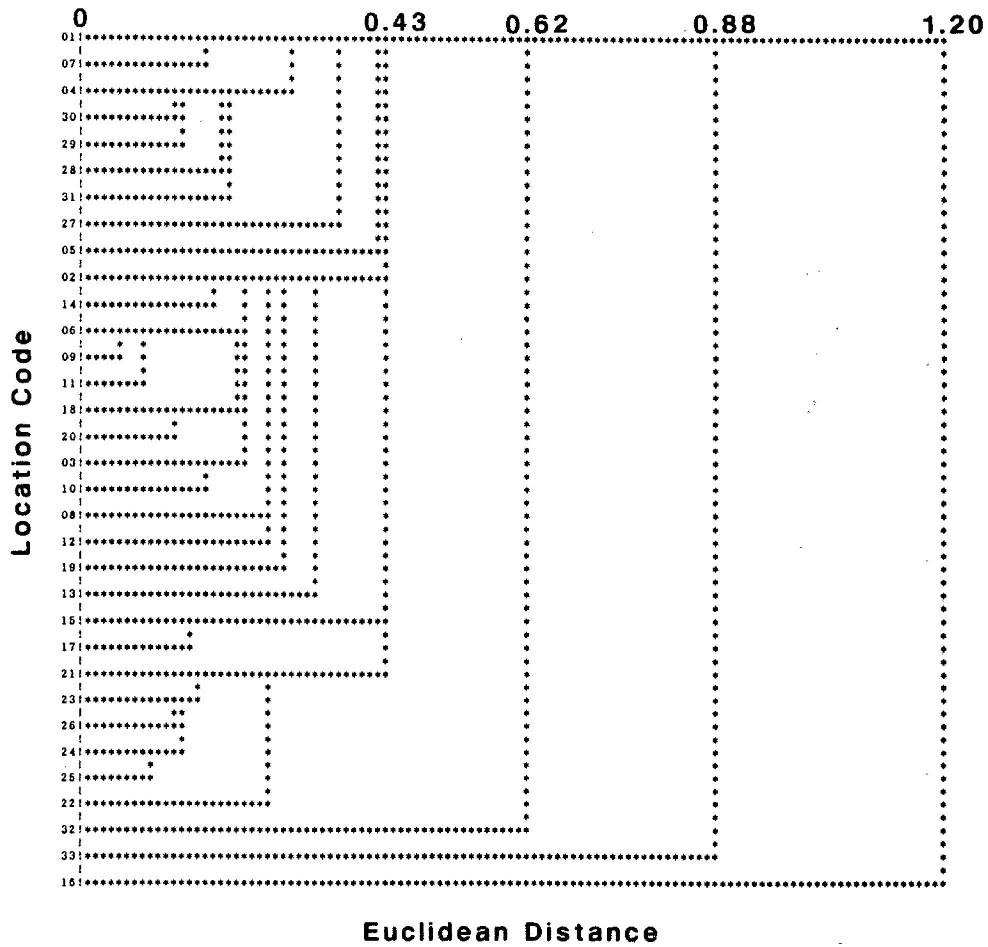

Fig.8. Dendrogram, based on Euclidean distance, for scale character C1,L1 of 0.3 chum salmon in 33 locations.

0.3 Age Fish

C1,L1,C2,L2

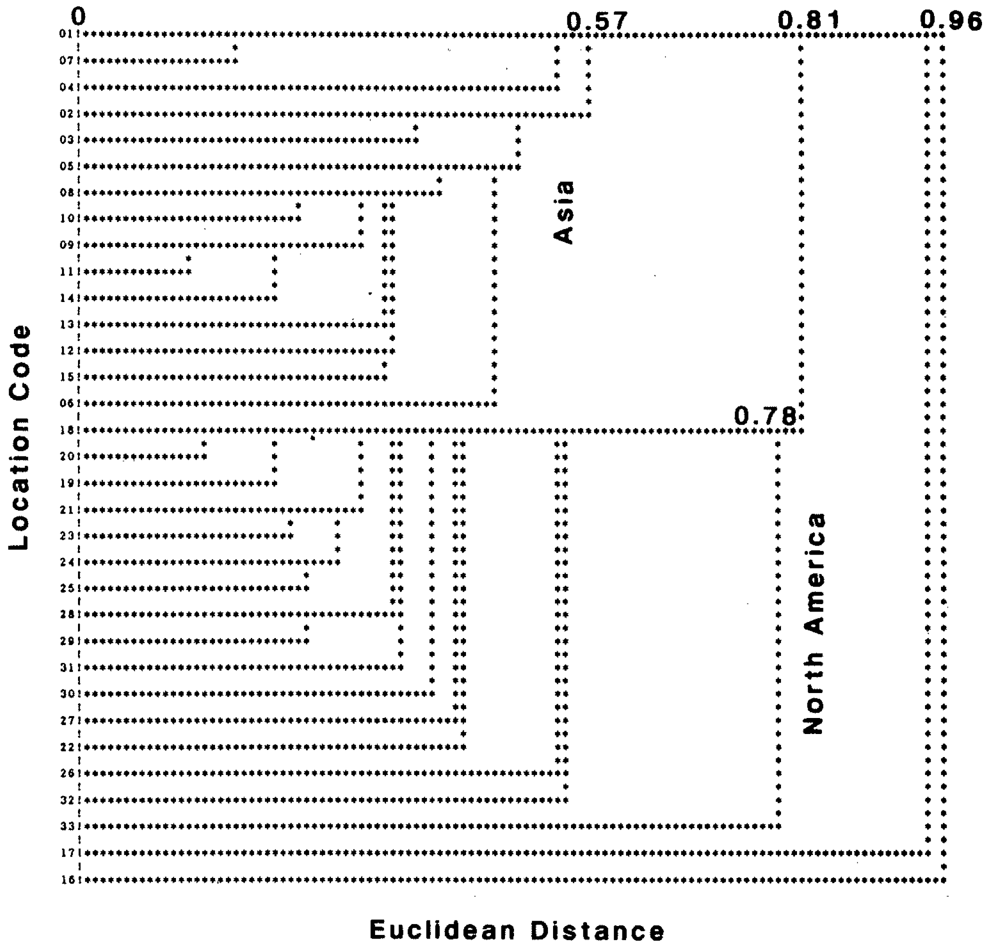

Fig.9. Dendrogram, based on Euclidean distance, for scale character C1,L1,C2,L2 of 0.3 chum salmon in 33 locations.

0.3 Age Fish

C1,L1,C2,L2,C3,L3

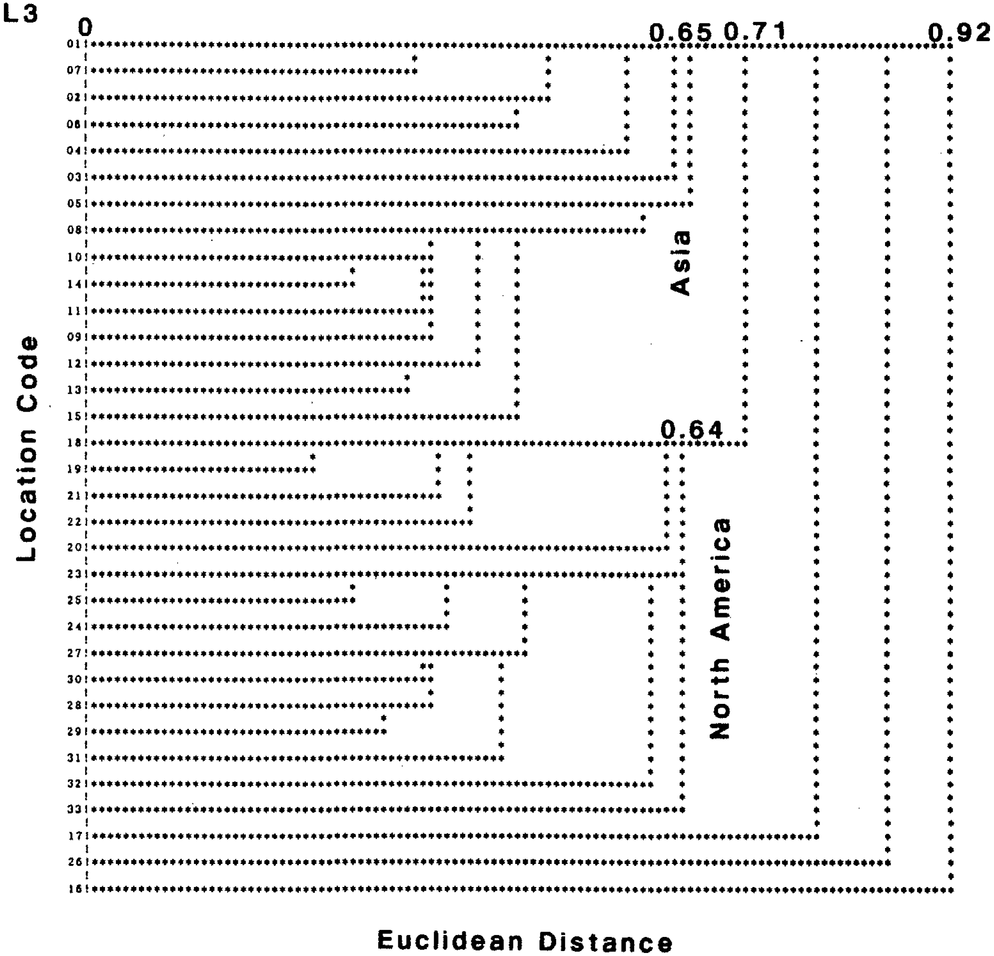

Fig.10. Dendrogram, based on Euclidean distance, for scale character C1,L1,C2,L2,C3,L3 of 0.3 chum salmon in 33 locations.

0.4 Age Fish

C1

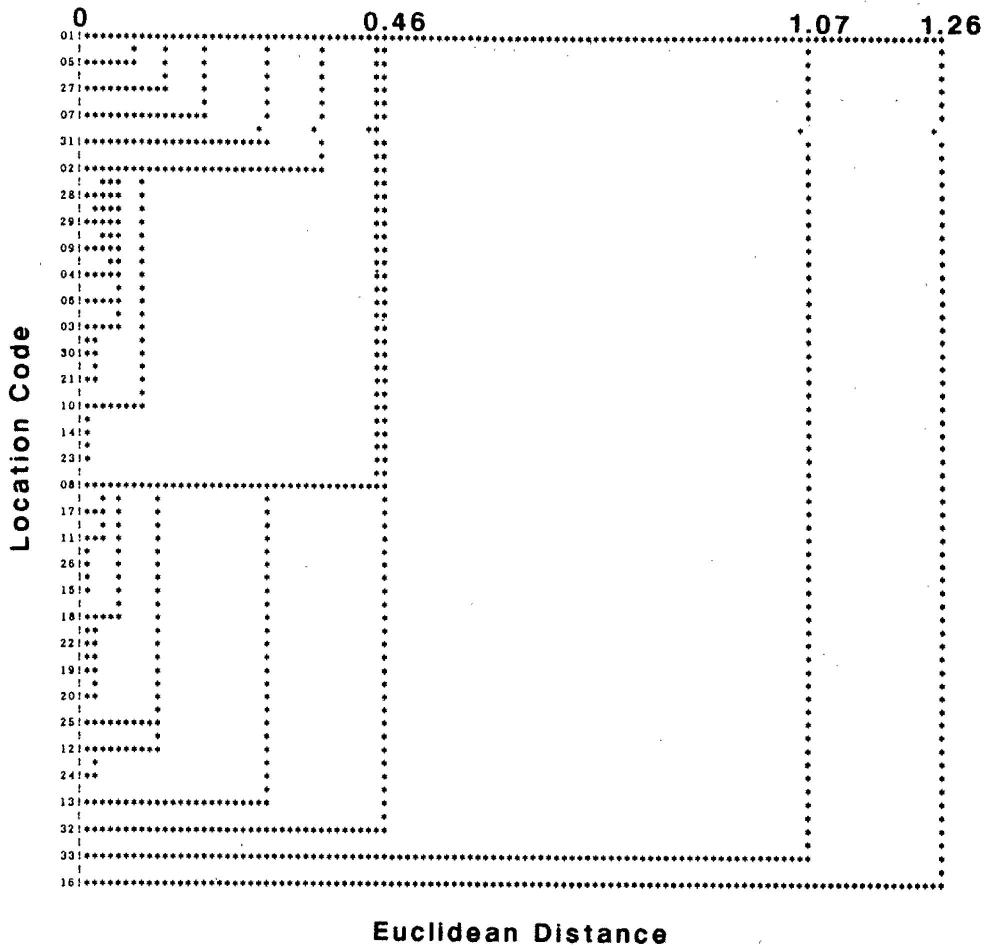

Fig.11. Dendrogram, based on Euclidean distance, for scale character C1 of 0.4 chum salmon in 33 locations.

0.4 Age Fish

C1,C2

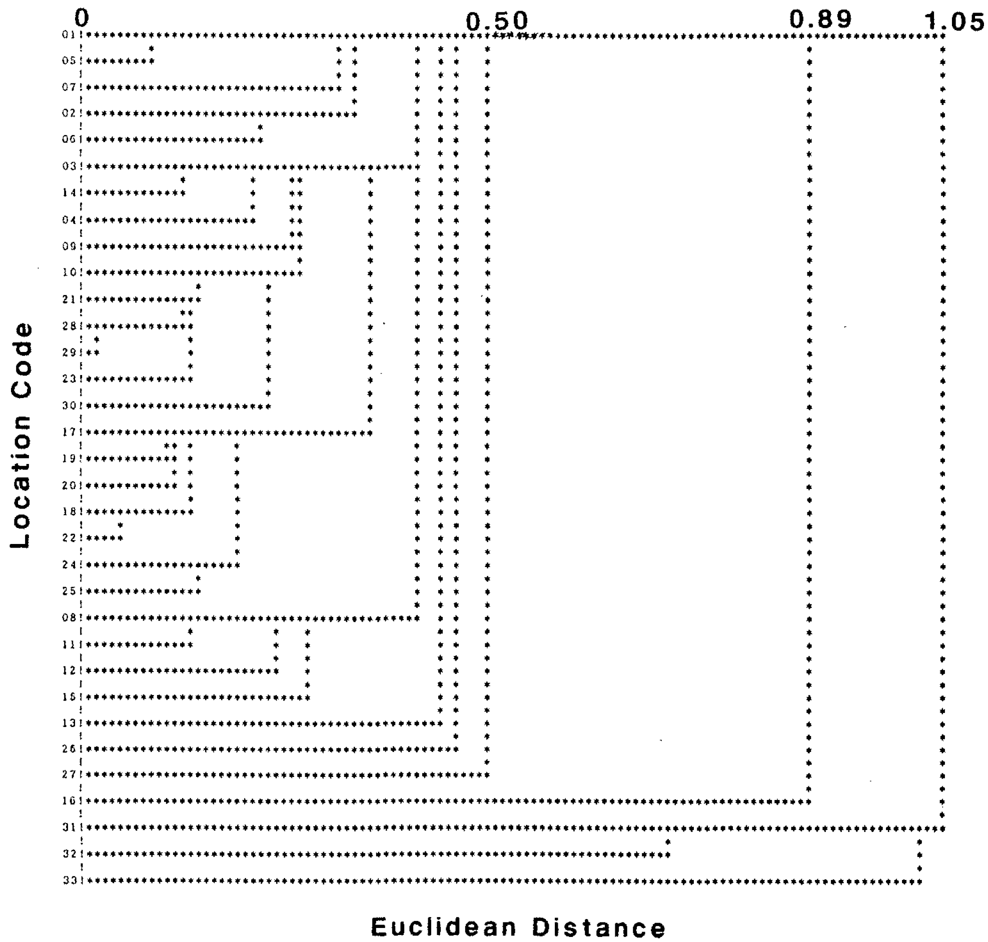

Fig.12. Dendrogram, based on Euclidean distance, for scale character C1,C2 of 0.4 chum salmon in 33 locations.

0.4 Age Fish

C1,C2,C3

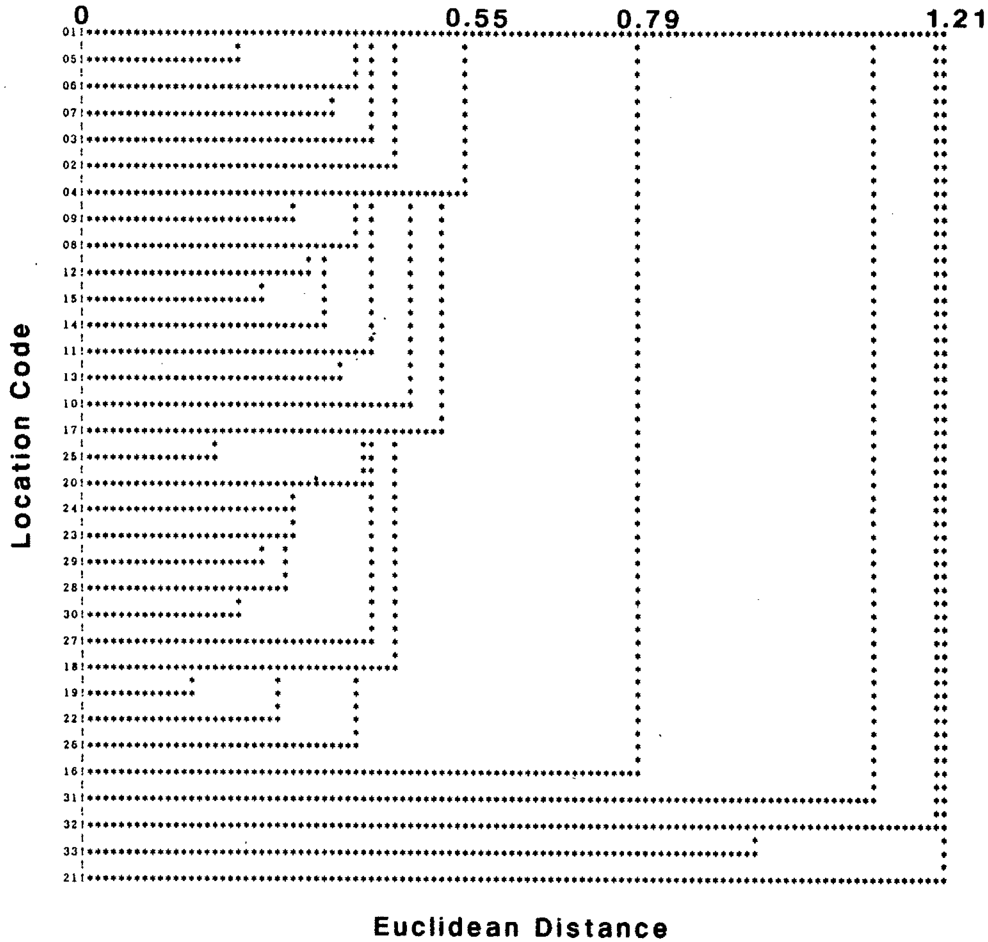

Fig.13. Dendrogram, based on Euclidean distance, for scale character C1,C2,C3 of 0.4 chum salmon in 33 locations.

0.4 Age Fish

L1

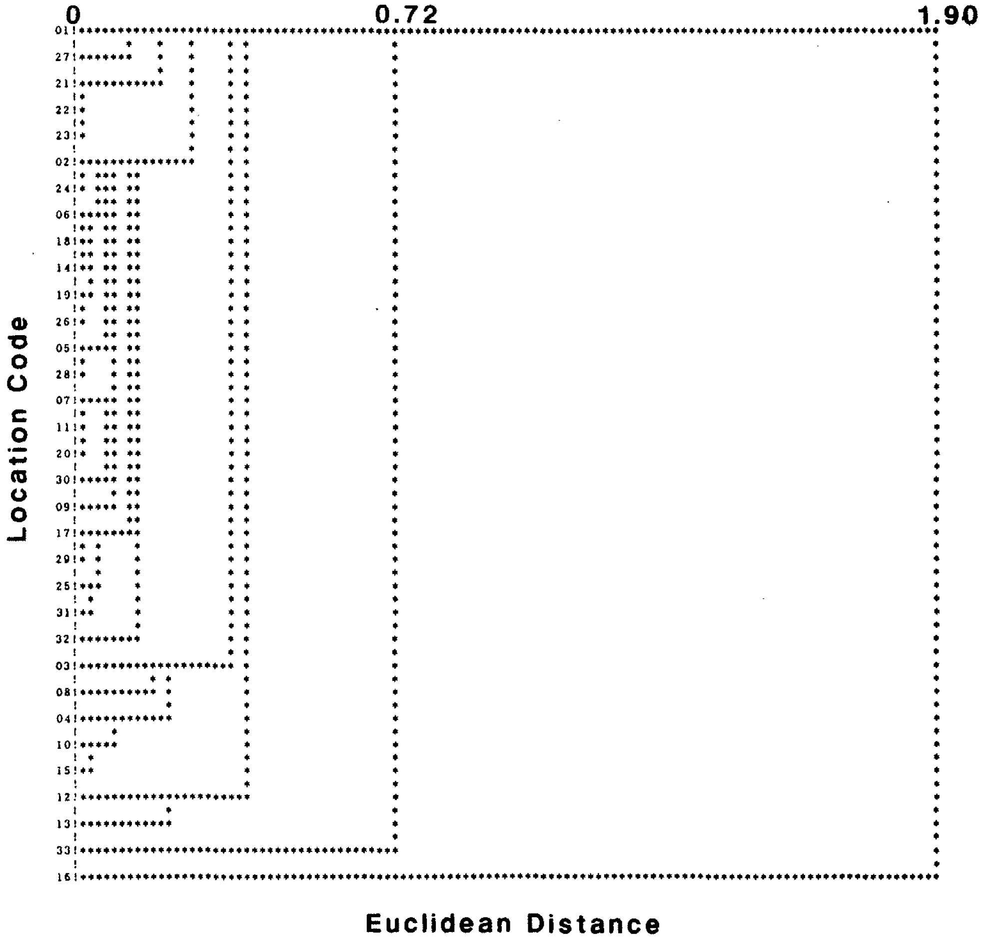

Fig.14. Dendrogram, based on Euclidean distance, for scale character L1 of 0.4 chum salmon in 33 locations.

0.4 Age Fish

L1,L2

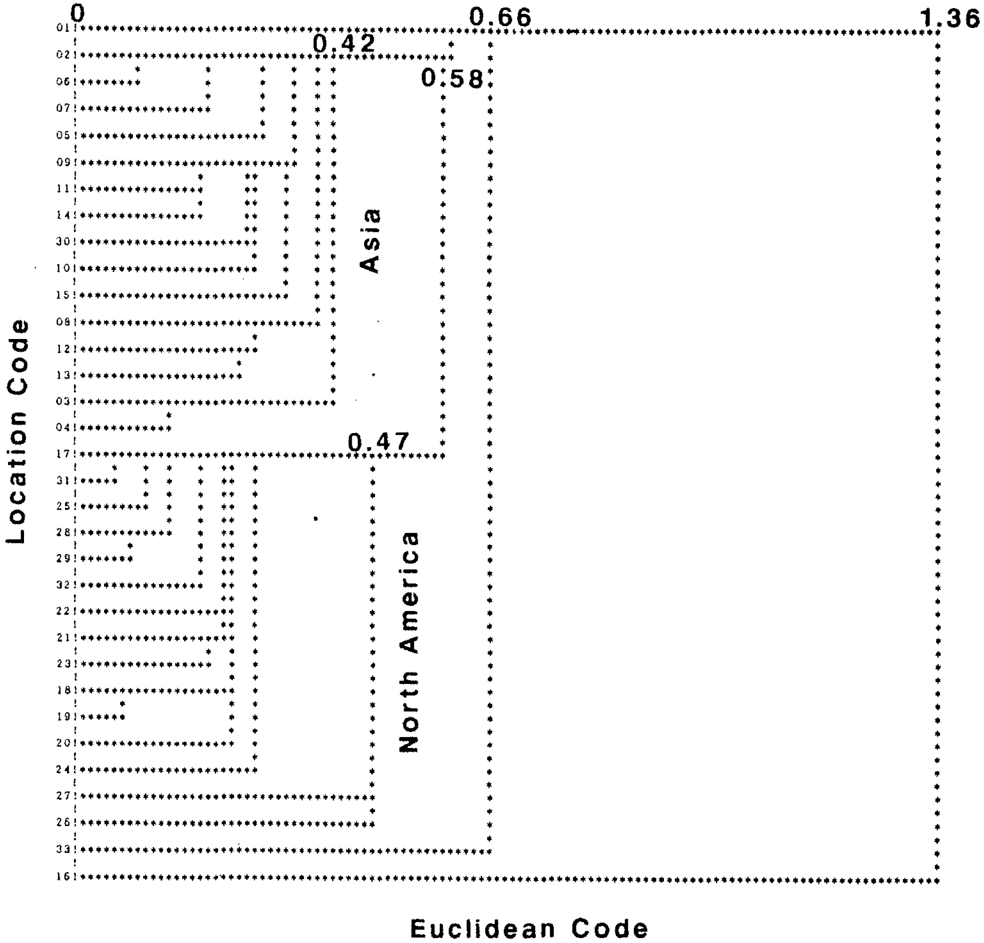

Fig.15. Dendrogram, based on Euclidean distance, for scale character L1,L2 of 0.4 chum salmon in 33 locations.

0.4 Age Fish

L1,L2,L3

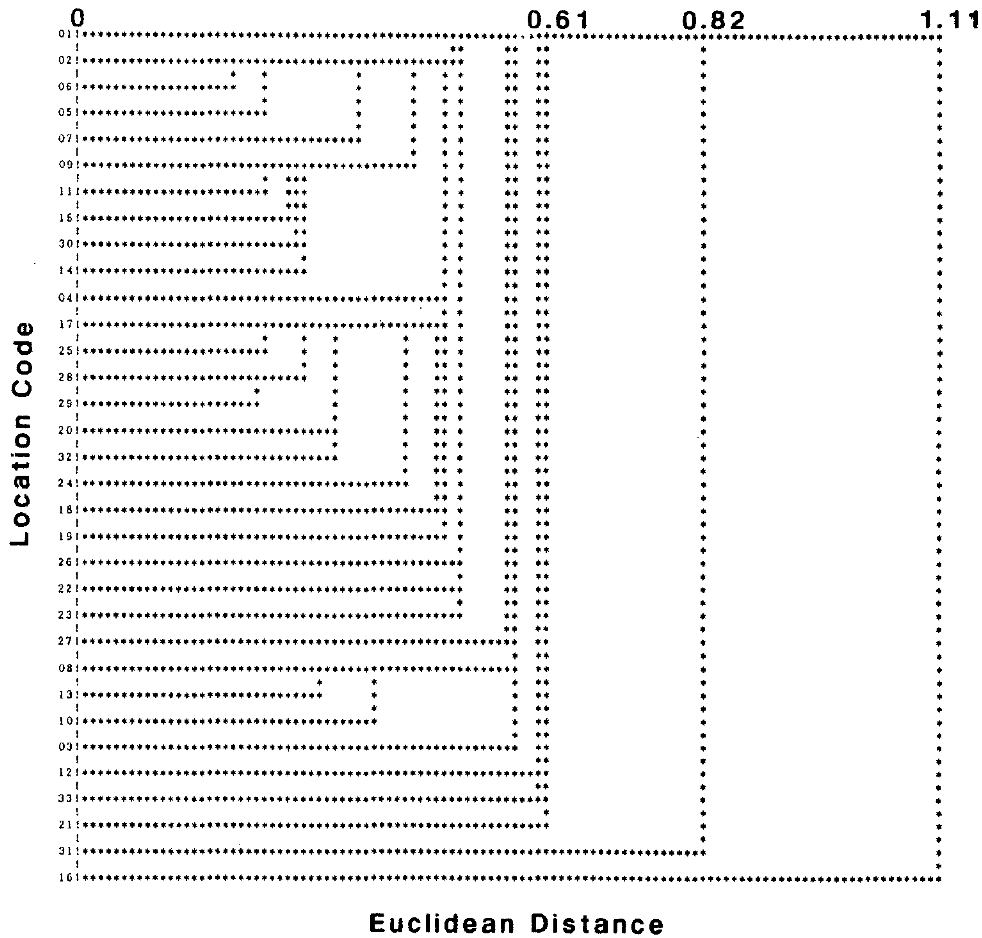

Fig.16. Dendrogram, based on Euclidean distance, for scale character L1,L2,L3 of 0.4 chum salmon in 33 locations.

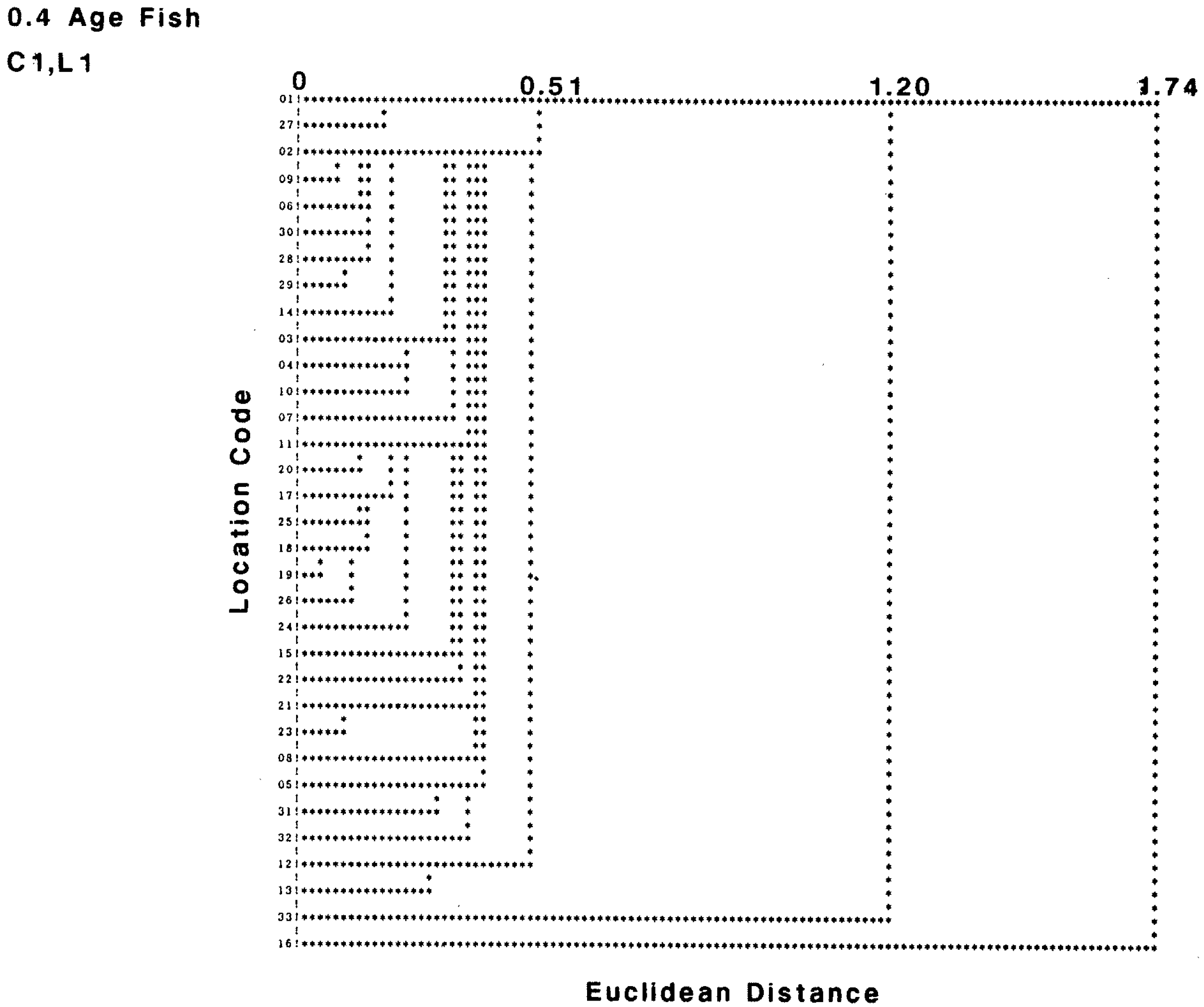

Fig.17. Dendrogram, based on Euclidean distance, for scale character C1,L1 of 0.4 chum salmon in 33 locations.

0.4 Age Fish

C1,L1,C2,L2

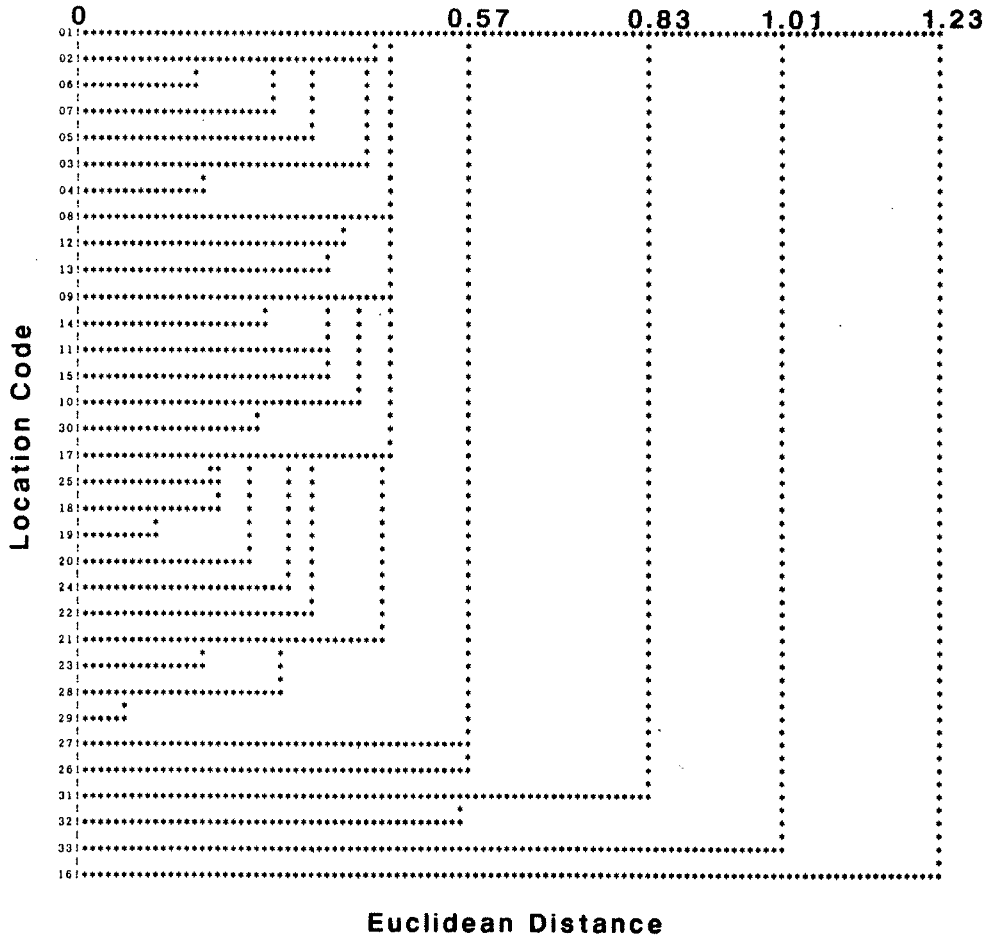

Fig.18. Dendrogram, based on Euclidean distance, for scale character C1,L1,C2,L2 of 0.4 chum salmon in 33 locations.

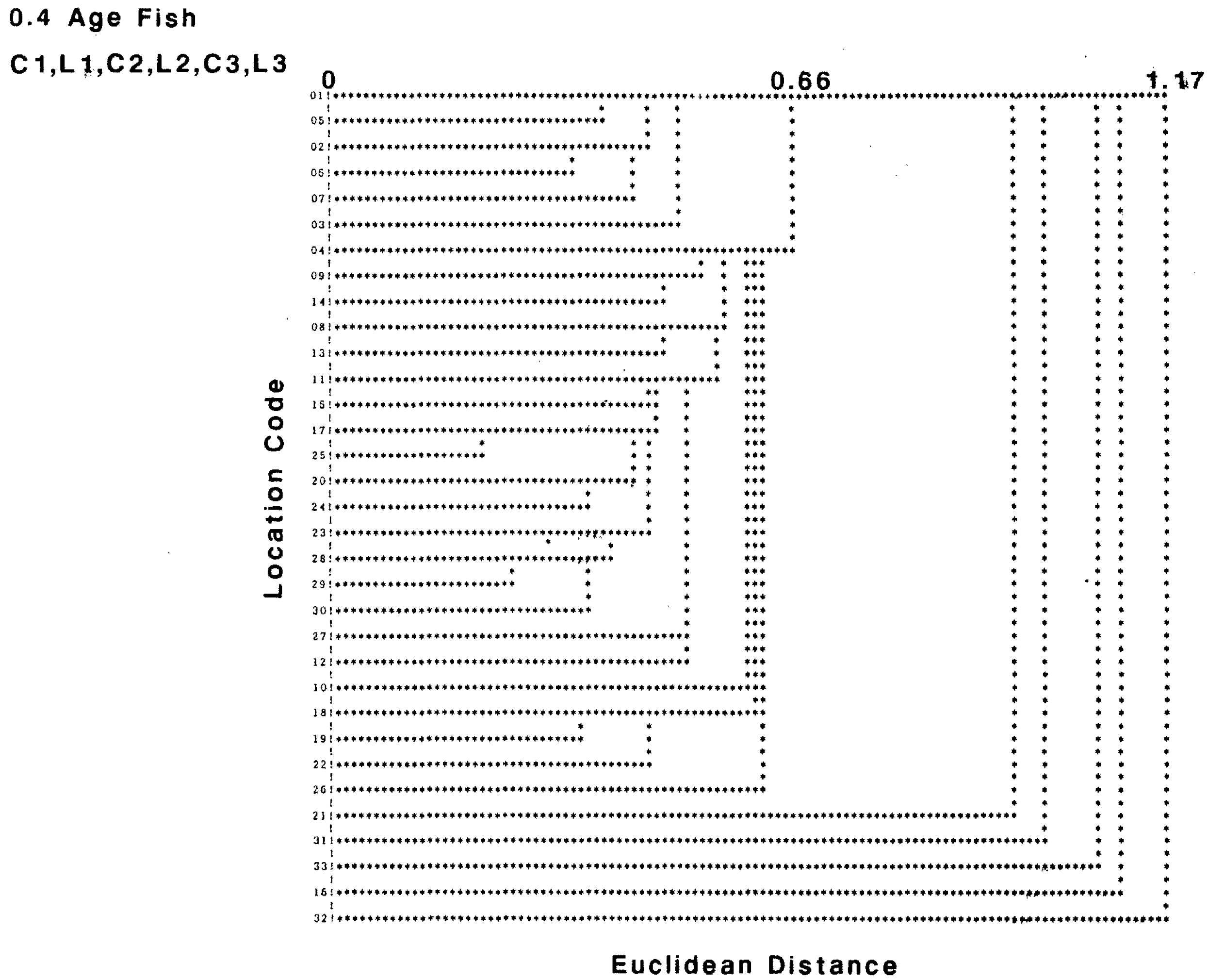

Fig.19. Dendrogram, based on Euclidean distance, for scale character C1,L1,C2,L2,C3,L3 of 0.4 chum salmon in 33 locations.

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TRANSLATION

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ABSTRACT

The scale pattern characters which provide a cluster corresponding to the geographical distribution of chum salmon stocks were selected to improve the accuracy of stock identification. Scale samples of 0.3 and 0.4 age chum salmon which returned to the coastal areas of the Pacific Ocean in 1986 were used for the analysis. The result indicated that four sets of scale pattern characters, (L1, L2), (L1, L2, L3), (C1, L1, C2, L2), (C1, L1, C2, L2, C3, L3) of 0.3 age fish and one set of characters (L1, L2) of 0.4 age fish provide a cluster corresponding to the large geographical distribution of Asian and North American stocks.

Introduction

The stock identification of salmon is important for the resource management of each stock in offshore and coastal areas. Tagging, parasites as biological tags, population genetics procedures, scale pattern characters, etc. are used for stock identification. For stock identification by scale pattern characters, those which are representative of each area should be selected for analysis to improve the accuracy of identification of offshore samples.

The objective of this study was to conduct cluster analyses and found sets of scale pattern characters which provide a cluster corresponding closely to the geographical distribution of chum salmon stocks.

Material and method

Scale samples of chum salmon which returned to various coastal areas of the Pacific Ocean in 1986 were used for the analysis. The sampling locations are shown in Fig. 1. Scale samples collected in Japanese rivers were provided by Hokkaido Salmon Hatchery of the Fisheries Agency of Japan, Miyako Branch of Iwate Prefectural Fish Farming Center and Yamagata Prefectural Fishery Experimental Station. Scale samples collected from rivers and coastal areas of the U.S.S.R., the U.S. and Canada were provided through the Japan-Soviet Fisheries Commission and the INPFC respectively.

From each sample, 50 females and 100 males were randomly selected and age was determined. Scales collected were projected to 100 times by large precision projector and measured. The axis of measurement was the longest axis of a scale. The locations of edge of each circuli, age band and edge of a scale from the focus of the scale were recorded along the axis on plotting paper ruled into 1-millimeter square. The mean values for each scale character are shown in Table 1.

Cluster analyses were conducted by Conversational Numerical Taxonomy Packaged Program of the Research Center of the Ministry of Agriculture, Forestry and Fisheries. The average values of each scale characters from each sample were used as input data. Euclidean distance was used as an index of distance and single-linkage method was used for formation of clusters.

Results

0.3 age fish (Figs. 2-10)

Except for samples from rivers entering the northern Bering Sea (16=Anadyr River, 17=Kotzebue), for a part of samples from Japanese origin (03=Yubetsu River) and from North American origin (26=Cook Inlet), scale characters which provide a cluster of close correspondence to the two major geographical distribution, Asian and North American stocks, were four sets; L1, L2 (Fig. 6), L1, L2, L3 (Fig. 7), C1, L1, C2, L2 (Fig. 9) and C1, L1, C2, L2, C3, L3 (Fig. 10).

0.4 age fish (Figs. 11-19)

Except for samples of U.S.S.R. origin (16=Anadyr River), for a part of samples from Japanese origin (01=Gekkou River) and from North American origin (30=Excursion Inlet, 33=Puget Sound), the scale characters of L1 and L2 provided a cluster of good correspondence to the two major areas of geographical distribution (Fig. 15).

Discussion

When a stock identification study on offshore samples is conducted, first it is important to select scale characters which Asian and North American stocks are well identified. The result of this study showed that four sets of scale pattern characters at age 0.3 and one at age 0.4 provided clusters which corresponded well to the two major geographical distribution of Asian and North American stocks. In particular, scale characters of L1, L2 were selected in both age 0.3 and 0.4, and characters of L1, L2 for age 0.3 have greater distance between Asian and North American stocks than other three sets of characters. Therefore the accuracy of stock identification for Asian origin and North American origin is expected to improve by using this set of scale pattern characters.

On the other hand, when a cluster within either Asian origin or North American origin is examined, each character does not always shows a cluster which has a close correspondence to the geographical distribution. It is necessary to note that the accuracy of stock identification within Asian origin or within North American origin is poor when we examine the results of stock identification on offshore samples.

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Reference

Agriculture, Forestry and Fisheries Technical Bureau. 1985. CONTAX-Conversational Numerical Taxonomy Packaged Program. Agriculture, Forestry and Fisheries Research Center User Manual 18. (Japanese)

Tables 1 to 3 and Figs. 1 to 19 are in English in the Japanese document.