Systematics of Six Demersal Fishes of the North Pacific Ocean

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FISHERIES RESEARCH BOARD OF CANADA

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SYSTEMATICS OF SIX DEMERSAL FISHES OF THE NORTH PACIFIC OCEAN

by

N. J. Wilimovsky, A. Peden and J. Peppar

Institute of Fisheries
University of British Columbia
Vancouver, B. C.

FISHERIES RESEARCH BOARD OF CANADA

Biological Station, Nanaimo, B. C.

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Index

Introduction

During the last decade there has been an ever-increasing utilization of the groundfish resources in the North Pacific by Japan and the USSR. Most of their efforts have been concentrated in the eastern and northern Bering Sea. Recently, fishing activities have extended eastward into the Gulf of Alaska and in addition there has been an expansion of the Canadian and United States fisheries for demersal species. Rational exploitation and management on a sustained yield basis is dependent on knowledge of catch composition and biology of the species landed. While the former information is being assembled by various agencies in varying degrees of detail (e.g. by F.A.O., I.N.P.F.C., P.M.F.C., F.R.B.) there is little data available on the latter. There is, for example, no general agreement on the systematic nature of the stocks of major demersal fishes in the North Pacific Ocean, that is, whether each of the forms is composed of one or several species or sub-species. The question of discreteness of stocks is of paramount importance in management.

With the above thoughts in mind the Minister of Fisheries of Canada through the Fisheries Research Board of Canada entered into a contract in 1964 with the University of British Columbia at Vancouver, B. C. Under this contract the University agreed to collect, in collaboration with the Board, "samples from throughout the North Pacific basin sufficient to assess the systematic nature of the stocks of six major demersal fishes in the North Pacific Ocean." Investigation of six of nine named species was to be conducted "to determine whether each of these forms is composed of one or several species or sub-populations" and a report on the investigations prepared.

Summary reports follow on the investigations for each of the six forms studied. The groups analyzed were: arrowtooth flounders (Atheresthes), rock soles (Lepidopsetta), pollock (Theragra), Pacific cod (Gadus), flathead soles (Hippoglossoides), and a shortspine rock fish (Sebastolobus).

The reports present data on the distribution, synonymy and variability of each of the forms studied. The synonymies and the distributional ranges derived therefrom represent, to our knowledge, all the published data on the forms. Variational data include analyses of all specimens available for study. Where appropriate, systematic conclusions and nomenclatural decisions have been made.

These reports represent one of the first attempts to analyze the systematic nature of populations of commercially important demersal fishes. The numbers studied far exceed any similar analysis published to date. Nevertheless, in many instances it is the lack of sufficient material that limits the conclusion or circumscribe their applicability. These voids dramatically demonstrate the need for large collections of fishes, containing extensive geographical series.

The extent of data presented for each of the species is variable but in every case is based on the scanning and assessment of a large number of morphological criteria. Those reported upon represent the most sensitive and diagnostic characters.

Although these reports are, to the best of our ability, complete, it is to be recognized that, because of the limitation of available specimens, particularly from far northwestern waters, the studies leave much room for improvement. As such, in considering publication, some of the conclusions must be considered provisionally or, alternatively, specifically limited to the areas for which there are adequate data.

Acknowledgements

The analyses were performed by a group of investigators. These included in addition to the authors, Mr. Garry I. McT. Cowan and Miss Grace Haythorne.

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Distribution, Synonymy and Variation in the Pollock *Theragra chalcogrammus* (Pallas)

Index

Introduction

The wide ranging pollock Theragra chalcogrammus has long been considered to comprise two subspecies, T. c. chalcogrammus (Pallas) of Northeastern Asia and Alaska, and T. c. fucensis (Jordan and Gilbert) from Puget Sound, Washington. This subspecific separation was originally based on only four specimens from Puget Sound and three from Alaska.

In 1953, Schultz and Welander in an attempt to evaluate the grounds for the subspecific separation of Theragra chalcogrammus made additional fin-ray and vertebral counts for Alaska (30 specimens) and Puget Sound (27 specimens) but came to no firm conclusions.

The present investigation further quantifies meristic variation and also provides data on morphometric variation. The number of specimens examined has been greatly enlarged over previous studies and collections cover almost the complete range of the species.

The subspecific separation of T. chalcogrammus has been based mainly on differences between median fin-ray counts. The separation was based on differences between counts of Bering Sea specimens and those from Puget Sound, Washington. As previously noted, this separation was developed using four specimens from Puget Sound and three from Alaska.

The nominal differences are expressed by the diagnostic key given by Svetovidov (1948) and have been the basis for identification to the present time.

- ID 12-14, IID 12-18, IIID 20-21, IA 19-23, IIA 21-23......
  Theragra chalcogrammus chalcogrammus (Pallas).

- ID 11-13, IID 12-15, IIID 14-19, IA 15-19, IIA 15-19......
  Theragra chalcogrammus fucensis (Jordan and Gilbert).

Interestingly the range of variation for these fin-ray counts was known to be greater. On the basis of larger samples Schultz and Welander (1935) presented the following meristic variation:

Character	T. c. chalcogrammus (Alaska, n=30)	T. c. fucensis (Puget Sound, n=27)
ID	10-13 (11.90)	11-13 (11.44)
IID	14-18 (15.38)	12-15 (13.23)
IIID	15-20 (17.70)	14-19 (16.44)
IA	17-22 (20.10)	15-19 (17.80)
IIA	16-21 (18.67)	15-19 (17.26)
Vertebrae	50-52 (51.26)	49-51 (49.96)

These authors concluded that the difference in the number of fin-rays between Puget Sound and Alaska is not great and that the character may not prove usable for the subspecific determination of additional specimens from intermediate localities. However, they did not venture to synonymize the two forms.

Synonymy

Theragra chalcogrammus

Gadus chalcogrammus -- Pallas, Zoogr. rosso-asiat., 3, 1811: 198 (Sea of Okhotsk and at shore of Kamchatka). -- Gunter, Cat. 4: 340, 1862. -- Jordan and Gilbert, Bull. U. S. Nat. Mus. 16: 807, 1883. -- Lucas, in: Jordan and Gilbert, Rept. Fur-Seal Invest., 3, 1899: 486.

Gadus periscopus Cope, Proc. Amer. Phil. Soc. Phila., 1873: 30 (Unalaska).

Pollachius chalcogrammus Jordan and Gilbert, Proc. U. S. Nat. Mus., 3, 1881: 454 (Puget Sound, Monterey Bay). -- Jordan and Gilbert, ibid., 4, 1882: 66 (occasionally in Seattle, rare at San Francisco). -- Jordan, Cat. Fish. N. Amer. 1887: 918. -- Jordan and Gilbert, Rept. Fur Seal Invest., 3, 1899: 486 (Bering Sea and adjacent waters).

Gadus minor -- Doderlein, in: Steindachner u. Doderlein, Beitz. Kenntn. Fisch. Japan, 4, 1887: 21 (Tokyo).

Pollachius chalcogrammus fucensis Jordan and Gilbert, ibid., 16, 1894: 315 (Puget Sound at Tacoma).

Theragra chalcogrammus -- Lucas in: Jordan and Evermann, Bull. U. S. Nat. Mus. 47, 3, 2535 (Bering Sea and neighbouring waters). -- Jordan and Gilbert, Rept. Fur Seal Invest., III, 1899: 486 (Bering Sea and adjacent waters). -- Scofield, in: Jordan and Gilbert, ibid., 1899: 507 (fin-ray counts of Bering Sea specimens). -- Scott, Sci. Invest. Fish. Bd. Scott., 20, 1901: 468. -- Scott, ibid., 21, 1902: 218. -- Evermann and Goldsborough, Bull. U. S. Bur. Fish. 26, 1907: 346 (Bering Sea southward from Aleutians and Alaska). -- Pavlenko, Fish. Peter the Great Bay, Kazani Trd. Obsc. jest., 42(2), 1910: 55. -- Jordan, Stanf. Univ. Publ. Biol. Sci., III (2), 1923. -- Soldatov and Lindberg, Obzor Ryb Dal'Nevost Morei, 1930: 512 (Sea of Japan and Sea of Okhotsk). -- Mori and Uchida, Journ. Chosen Nat. Hist. Soc., 19, 1934: 22. -- Andriyashev, Issled, Morei. SSSR, 22, 1935: 136 (Bering Sea). -- Kamiya, Journ. Imp. Fish. Inst., 21, 3, 1935: 27 (spawning, develop., eggs). -- Schultz and Welander, Copeia, 1935 (3): 127-139 (Alaska and Puget Sound). -- Shiwada, Bull. Jap. Soc. Sci. Fish. Tokyo, 4, 1935: 9-14. -- Schultz, Univ. Wash. Pub. Zool., 2 (4), 1936: 103-228. -- Schultz and DeLacy, Mid-Pacific Mag., Jan-

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Fac. Fish. Hokkaido Univ. 13 (4), 1963: 181-185 (I. lipids pollock heart). -- Sama, ibid., 13 (4), 1963: 186-192 (II. lipids pollock heart). -- Alverson, Pruter and Ronholt, Inst. Fish. Univ. B. C., 1964: 123-143 (Chapter 6 - roundfishes). -- Kobayashi, Bull. Fac. Fish. Hokkaido Univ. 14 (2), 1963: 55-63 (larvae and young).

Theragra fucensis Jordan and Evermann, Bull. U. S. Nat. Mus. III, 1898: 2536 (from Vancouver to Monterey Bay).

Eleginus navaga (non Pallas) Evermann and Goldsborough, Bull. U. S. Bur. Fish. 26, 1907: 347 (in part).

Range of Theragra chalcogrammus

As shown by the records listed in the synonymy, the species ranges from Korea, through the northern Japan, Okhotsk and Bering seas, north to St. Lawrence Island, and south along the American coast to central California.

Variation and Systematic Status of Theragra chalcogrammus

In this study, material from almost the entire range of the species has been examined. The data following give the full range of variation exhibited by the species latitudinally and allow a further assessment of the grounds for the specific separation.

Morphometric characters analyzed

The following characters were measured over a wide size range of specimens: pre-dorsal and pre-anal distances, body depth, head length, length of pectoral fin, length of pelvic fins, and eye diameter. The first five measurements named were converted into frequency in the standard length and the last three measurements into head length.

Hubbs and Lagler (1958) methods of measurement were usually employed. Body depth was the only exception, and was taken as the perpendicular distance from dorsal surface to anus, between the first two dorsal fins.

Meristic characters analyzed

The following eight meristics were examined: rays of the three dorsal fins, rays of the two anal fins, rays of the left pectoral fin, pre-caudal and total vertebral counts.

Dorsal and anal counts include the last two elements as one ray, in all specimens examined. All visible rays in the pectoral fin were counted. The hypural complex was not included in the total vertebral count.

Results

Morphometric analysis

Table I summarizes the variation in morphometric data obtained for all specimens examined, grouped by five geographic areas.

Differences between the means of the various areas were not great and did not show consistent clinal increases or decrease with latitude. Body depth, head length and eye diameter show the best trends, with each increasing in size from north to south, but still not consistently. The body depth cline for example has a mean of 6.85 (5.03-9.00) in the Bering Sea, and 5.45 (4.78-6.11) in northern Washington (values being frequencies into standard length). As the differences among the means of areas were not great and within variation quite large (as for example, body depth), statistical analysis of the means was not considered of value. Such analysis was performed on the meristic data, as the differences were of greater magnitude.

Meristic analysis

Tables II, III and IV summarize the variation in meristic data obtained for all specimens examined from the seven geographic areas of collection.

To assess whether differences obtained among area means were statistically significant, a one-way analysis of variance was performed on each of the counts. Results of these analyses did not indicate significance. Thus, the means of the northern and southern extremes of the range, Bering Sea, Alaska and Puget Sound, Washington, even though appearing quite distinct, are not statistically different from each other, or their adjacent populations.

Counts obtained show to varying degrees, clinal trends in north-south reduction. This trend is shown best for the median fin-ray counts and less consistently for the pectoral and vertebral counts. For example, Dorsal III and Anal I clined from 18.43 (17-20) to 16.79 (15-19) and 19.92 (18-21) to 18.35 (17-21) respectively. The same trend for the pectoral fin-ray count was 20.13 (19-21) to 19.98 (19-21) and for the total vertebrae count, 50.86 (49-52) to 49.19 (48-50). The latter is probably not meaningful as the vertebral counts are not representative of the whole range of the species.

Because of the clinal nature of the counts and statistical analysis of the mean differences indicating lack of statistical significances among means, analysis was attempted to assess whether the area differences could be interpreted in terms of racial differences and representing racial stocks.

Racial analysis

Area differences within the data were assessed by further subdivision of the major areas of collection (meristics only) and comparisons of our data with published records.

Subdivision of the geographic area was made as follows: the original Aleutian area was divided into three areas - central, eastern and gulf. Southeast Alaska was separated into two areas - S. E. Alaska and Northern B. C. As meristics were the only characters showing good clinal trends,morphometric data was not re-examined.

Clinal trends did not remain uniform upon re-examination of the subdivided areas. All characters do give indications of a clinal decrease from north to south but the changes are disruptive. As shown, there is no strong evidence for racial subdivision using these geographic areas (Table V).

International Pacific Halibut Commission (IPHC) (1961, 1962) and G.B. Reed (1965) catch records were plotted over the area from Unimak Pass to Washington and compares with data from the present study.

IPHC records indicate good concentrations of *Theragra* eastward along the Aleutians, from about Unga Island to Prince William Sound in the Gulf. Catches from Prince William Sound (approximately Kayak Island) southward to Cape Spencer decrease rather strongly and do not indicate concentrations of any magnitude as the latter area. The catch data from cruises of the G.B. Reed indicate good concentrations of *Theragra* in S.E. Alaska. Further information to the south is not available.

The data indicate a concentration of *Theragra* along the eastern Aleutian chain to Prince William Sound, separated from another concentration of *Theragra* in S.E. Alaska.

The meristic analysis combined Aleutian and Gulf areas (eastern Aleutians and Prince William Sound) as one area. When treated in such a way it was shown that fish of this area did show higher average meristic counts than fish of S.E. Alaska. A cline was evident from Bering Sea to S.E. Alaska and southward to Southern B. C. If the area between Prince William Sound and S.E. Alaska is really relatively devoid of Theragra as catch data indicates, there is a possibility that mixing of Theragra between the Aleutian areas and S.E. Alaska may be small and the two areas may contain separate stocks.

Conclusion

The preceding analyses of *Theragra chalcogrammus* from seven geographic areas, in both morphometric and meristic characters, suggests that the separation of this species into two subspecies is not valid. Statistical analysis of the meristic counts for the various areas showed that the means were not statistically different at the 5% level. The average differences which exist, therefore, are less than subspecies level.

In an attempt to establish whether racial differences exist, geographical areas were further subdivided but showed no firm evidence for separate stocks.

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Appendix I.

Record of Specimens used in this Investigation

Sea of Okhotsk -- Abe collection (16)

Western Bering Sea -- Japanese Mothership collection (20)

Bering Sea

BC62-565	St. George Is. (2)	BC65-709	55°45', 166°45' (2)
63-1113	Elson Lagoon (6)	65-713	55°30', 166°30' (13)
63-1192	54°35', 173°38' (2)	65-716	56°30', 167°30' (6)
63-1211	57°34', 166°36' (3)	65-717	56°45', 167°45' (2)
65-708	57°30', 161°30' (7)	65-730	57°45', 164°45' (3)

Aleutian Islands and Peninsula

BC59-486	Kodiak Is. (1)	BC62-915	53°30', 165°00' (4)
62-424	55°08', 160°19' (1)	63-349	Unimak Is. (1)
62-427	54°00', 165°00' (4)	63-1026	Kodiak Is. (3)
62-442	Stn. 31-J (2)	65-78	54°26', 159°52' (3)
62-526	56°54', 155°00' (1)	65-84	55°10', 161°02' (2)
62-644	Stn. I & J (1)	65-85	55°04', 160°47' (3)
62-651	56°48', 155°00' (1)	65-90	Stepovak Bay (14)
62-674	Stn. 19-I (6)	65-110	54°35', 164°04' (2)
62-719	55°13', 161°47' (2)	65-158	Cape Douglas (2)

Gulf of Alaska

BC62-608	Naked Is. (6)	BC63-394	Olsen Bay (2)
62-954	59°16', 147°48' (3)	63-516	Simpson Bay (2)
62-991	Kasitsna Bay (1)	63-517	Simpson Bay (1)
62-998	Kachemak Bay (3)	65-559	Wingham Is. (1)

S.E. Alaska

BC62-580	Port Armstrong (4)	BC63-1255	Little Port Walter (5)
62-586	Port Armstrong (1)	63-1269	Little Port Walter (2)
62-604	Admiralty Is. (1)	63-1316	Icy Straits (1)
62-610	Auke Bay (1)	65-385	Dall Is. (2)
62-790	Saginaw Channel (1)	65-389	56°20', 139°20' (1)
63-103	Little Port Walter (1)	65-493	Muir Inlet (1)
63-163	Tebenkof Bay (1)	65-548	Chichagof Is. (3)
63-236	Craig (1)	65-553	Icy Straits (1)
63-237	Herring Bay (1)	65-568	Ocean Cape (2)
63-253	Auke Bay (2)	65-701	Petersburg (2)
63-281	Baranof Is. (1)		

Northern B.C.

BC59-669	Hecate Strait (4)	BC62-51	Nass Bay (14)
62-50	Work Channel (1)	65-57	Smith Inlet (1)

Southern B.C.

BC53-40A	English Bay, Vancouver (1)	58-401	Bidwell Bay (1)
53-49	Burrard Inlet (4)	59-530	Indian Arm (23)
53-127	Burrard Inlet (5)	60-244	Comox (3)
55-355	Stanley Park, Vancouver (6)	62-49	Departure Bay (1)
56-8	Vancouver (1)	62-874	Sooke (4)
57-53	Vancouver (1)	65-375	Malaspina Strait (1)

Northern Washington

UW2238 (6)	UW5779 (6)
2535 (5)	17732 (6)
2667 (13)	2282 (1)
	2566 (4)

Legend: BC = Institute of Fisheries, University of British Columbia.
UW = School of Fisheries, University of Washington.
Abe Collection = Institute of Fisheries, University of B. C.
Japanese Mothership Collection = Institute of Fisheries, University of B. C.

Table I. Variation of body proportion in *Theragra chalcogrammus*.

Locality	Predorsal distance	Preanal distance	Body depth	Head length	Length pect.	Length pelvic	Eye dia.
	As proportion of standard length				As proportion of head length		
Bering Sea							
mean	3.08	2.04	6.85	4.01	1.34	1.59	3.76
range	2.74-3.39	1.92-2.24	5.03-9.00	3.64-4.44	1.20-1.50	1.23-1.83	3.00-4.89
number	30	29	27	30	21	21	27
Aleutians							
mean	2.97	2.09	6.29	3.81	1.39	1.63	3.65
range	2.57-3.24	1.88-2.23	4.60-7.89	3.21-4.43	1.18-1.59	1.24-1.98	3.00-4.89
number	58	56	53	58	47	45	55
S. E. Alaska & Northern B. C.							
mean	2.99	2.07	5.76	3.77	1.43	1.65	3.67
range	2.83-3.26	1.90-2.32	4.66-6.62	3.39-4.04	1.26-1.64	1.36-1.87	2.89-4.81
number	45	45	41	46	42	39	41
Southern B. C.							
mean	2.95	2.04	6.00	3.65	1.35	1.61	3.30
range	2.81-3.21	1.93-2.22	5.02-6.71	3.48-3.90	1.21-1.52	1.35-2.07	2.73-3.93
number	36	36	33	36	31	32	35
Northern Washington							
mean	3.06	2.02	5.45	3.76	1.34	1.57	3.94
range	2.74-3.39	1.86-2.16	4.78-6.11	3.57-4.05	1.19-1.49	1.31-1.75	3.24-4.88
number	34	34	31	34	34	32	34

Table II. Mean fin count in <u>Theragra chalcogrammus</u> by geographical area

Locality	I Dorsal	II Dorsal	III Dorsal	I Anal	II Anal	Left Pectoral
Sea of Okhotsk						
mean	11.60	15.64	18.43	19.92	19.62	20.13
range	10-13	14-17	17-20	18-21	18-23	19-21
number	15	14	14	13	13	16
Western Bering Sea						
mean	12.37	15.50	18.18	19.25	19.74	20.00
range	11-14	14-17	16-20	17-22	18-22	18-21
number	19	16	17	20	19	20
Bering Sea						
mean	12.15	15.28	18.53	19.46	19.26	20.16
range	10-14	13-18	17-21	16-22	16-23	19-22
number	39	40	40	39	38	38
Aleutians						
mean	11.79	14.56	17.87	18.90	19.08	19.73
range	10-13	13-18	16-20	17-21	18-22	19-21
number	52	52	52	51	52	51
S. E. Alaska and Northern B. C.						
mean	11.53	13.84	17.68	18.58	18.55	19.58
range	10-13	12-16	15-20	17-21	16-22	17-21
number	49	45	47	48	49	48
Southern B. C.						
mean	11.36	14.04	16.67	17.85	18.11	19.61
range	10-13	12-16	16-19	16-20	17-20	18-21
number	28	26	27	26	28	28
Northern Washington						
mean	11.35	14.23	16.79	18.35	18.03	19.98
range	10-13	13-16	15-19	17-21	16-21	18-21
number	40	35	38	37	38	40

Table III. Variation in counts of *Theragra chalcogrammus*.

	Sea of Okhotsk	Western Bering Sea	Bering Sea	Aleutians	S.E. Alaska & Northern B.C.	Southern B.C.	Northern Washington
First dorsal							
10	1	..	1	1	3	6	5
11	6	3	7	15	22	10	19
12	6	8	17	30	19	8	13
13	2	6	13	6	5	4	3
14	..	2	1	..	..	..	..
No.	15	19	39	52	49	28	40
Mean	11.60	12.37	12.15	11.79	11.53	11.36	11.35
Second dorsal							
12	..	..	..	..	5	4	..
13	..	..	3	10	16	3	7
14	3	3	6	20	13	9	15
15	4	4	16	10	9	8	11
16	2	7	8	8	3	2	2
17	5	2	5	3	..	..	..
18	..	..	2	1	..	..	..
No.	14	16	40	52	45	26	35
Mean	15.64	15.50	15.28	14.56	13.84	14.04	14.23
Third dorsal							
15	..	..	..	..	1	..	2
16	..	1	..	3	9	13	11
17	4	1	11	18	9	11	19
18	2	10	12	17	16	2	5
19	6	4	5	11	9	1	1
20	2	1	9	3	3	..	..
21	..	..	3	..	..	..	..
No.	14	17	40	52	47	27	38
Mean	18.43	18.18	18.53	17.87	17.68	16.67	16.79

continued...

Table III (cont'd.)

	Sea of Okhotsk	Western Bering Sea	Bering Sea	Aleutians	S.E. Alaska & Northern B.C.	Southern B.C.	Northern Washington
First anal							
16	..	..	1	..	..	3	..
17	..	1	2	1	13	7	8
18	2	5	6	11	10	10	16
19	3	7	8	21	11	3	6
20	2	3	15	9	12	3	6
21	6	3	5	9	2	..	1
22	..	1	2	..	..	..	..
No.	13	20	39	51	48	26	37
Mean	19.92	19.25	19.46	18.90	18.58	17.85	18.35
Second anal							
16	..	..	1	..	4	..	3
17	..	..	2	..	8	7	9
18	2	2	7	19	9	12	15
19	6	7	10	16	17	8	7
20	2	6	14	12	8	1	3
21	2	2	3	4	2	..	1
22	..	2	..	1	1	..	..
23	1	..	1	..	..	..	..
No.	13	19	38	52	49	28	38
Mean	19.62	19.74	19.26	18.08	18.55	18.11	18.03
Left pectoral							
17	..	..	..	..	1	..	..
18	..	1	..	..	3	3	2
19	4	7	9	22	14	7	11
20	6	4	16	21	27	16	13
21	6	7	11	8	3	2	14
22	..	1	2	..	..	..	..
No.	16	20	38	51	48	28	40
Mean	20.13	20.00	20.16	19.73	19.58	19.61	19.98

continued...

Table III (cont'd.)

	Sea of Okhotsk	Western Bering Sea	Bering Sea	Aleutians	S.E. Alaska & Northern B.C.	Southern B.C.	Northern Washington
<u>Total vertebrae</u>							
48	..	..	..	1	..	2	..
49	..	..	1	12	4	18	..
50	..	..	2	12	18	7	..
51	..	..	10	1	8	..	..
52	..	..	2	..	..	..	..
No.	..	..	15	26	30	27	..
Mean	..	..	50.86	49.50	50.13	49.19	..

Table IV. Mean vertebral number in <u>Theragra chalcogrammus</u> by geographical area.

	Bering Sea	S.E. Alaska and Northern B.C.	Aleutians	Southern B.C.
Mean	50.86	50.13	49.50	49.19
Range	49-52	49-51	48-51	48-50
Number	15	30	26	27

Table V. Variations in counts in <u>Theragra chalcogrammus</u>. - detailed geographic breakdown.

Locality		First Dorsal	Second Dorsal	Third Dorsal	First Anal	Second Anal	Left Pectoral	Total Vertebrae
Sea of Okhotsk								
	Mean	11.6	15.64	18.43	19.92	19.62	20.13	
	Number	15	14	14	13	13	16	
Western Bering Sea								
	Mean	12.37	15.5	18.18	19.25	19.74	20.0	
	Number	19	16	17	20	19	20	
Bering Sea								
	Mean	12.15	15.28	18.53	19.46	19.26	20.16	50.86
	Number	39	40	40	39	38	38	15
Aleutians (central)								
	Mean	11.91	14.47	17.91	19.48	19.13	19.66	50.50
	Number	32	32	32	31	32	32	8
Aleutians (eastern)								
	Mean	11.43	14.86	17.00	19.00	18.57	19.43	50.75
	Number	7	7	7	7	7	7	4
Gulf of Alaska								
	Mean	11.69	14.62	18.23	18.92	19.23	20.08	50.00
	Number	13	13	13	13	13	12	3
S.E. Alaska								
	Mean	11.27	13.86	17.39	18.69	18.09	19.41	51.38
	Number	33	29	31	32	33	32	13
Northern B. C.								
	Mean	12.06	13.81	18.25	18.38	19.50	19.94	50.80
	Number	16	16	16	16	16	16	15
Southern B. C.								
	Mean	11.36	14.04	16.67	17.85	18.11	19.61	49.19
	Number	28	26	27	26	28	28	27
Northern Washington								
	Mean	11.35	14.23	16.79	18.35	18.03	19.98	
	Number	40	35	38	37	38	40	

Distribution, Synonymy and Variation in the Pacific cod *Gadus macrocephalus*

Index

Introduction

The purpose of the present study of Gadus macrocephalus Tilesius through analysis of morphometric and meristic characters has been to show extent of variation and possibility of existence of localized races of the species.

According to Schultz and Welander (1935) specimens of G. macrocephalus from Japan seem to differ from specimens from Puget Sound, Washington, and Alaska, chiefly in having a shorter barbel, longer first dorsal fin, darker lateral line, more slender body in the adult and possibly a wider interorbital space. They were not prepared to make any definite judgment on the status of the Japanese form at that time. They also concluded that G. macrocephalus does not seem to differ from the European G. morhua or G. ogac in regard to the number of fin-rays, vertebrae, or numerous measurements involving various parts of the body and fins.

Svetovidov's (1948) monograph on the gadids treats the Pacific cod as a subspecies of the Atlantic G. morhua. His key expresses the differences as follows:

1. (8) Head narrow, interorbital space represents 15-22% of head length.

2. (5) Horn-like processes of swim bladder in adults generally long, bent at the base toward the mid-line and at the apex, then directed laterally. Coloration not bright, without sharp dark spots.

3. (4) Fishes reaching large dimensions and possessing rapid growth rate. Pectoral and pelvic fins short. Northern part of the Atlantic Ocean. Gadus morhua morhua

4. (3) Fishes not reaching over 50 cm in length and possessing slower growth rate. Pectoral and pelvic fins and barbel longer. White Sea. Gadus morhua morhua n. hiemalis

5. (2) Horn-like processes of the swim bladder in adults generally still longer with their whole processes coiled in balls. Coloration bright with distinct brown spots.

6. (7) Head narrow, interorbital space 16-21% of its length. Coloration spotty. Baltic Sea. Gadus morhua callarias

7. (6) Head somewhat wider, interorbital space represents 17.5-22% of its length. Coloration still more spotty. Mogil'noe Lake on Kil'din Is. Gadus morhua kildinensis

8\. (1) Head broad, interorbital space constituting 18-25% of its length.

9\. (10) Horn-like processes of the swim bladder in adults generally long, bent at the base toward the mid-line and at the apex laterally. Coloration usually dark. White Sea. G. morhua maris-albi

10\. (9) Horn-line processes of the swim bladder short, bent only toward the center line.

11\. (12) Caudal peduncle deep, about 4.5-5% of body length. Coloration usually dark. Hudson Bay and western coast of Greenland. Gadus morhua ogac

12\. (11) Caudal peduncle somewhat lower, 3.5-4.5% of body length. Coloration paler. Northern part of the Pacific Ocean and adjacent seas. Gadus morhua macrocephalus

Though their existence is suggested, no data are presented by Svetovidov on local races.

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Range of *Gadus macrocephalus*

As shown by the records listed in the synonymy the species ranges throughout the northern part of the Pacific Ocean, its extreme range extending from the Yellow Sea, Korea and Japan, throughout the Okhotsk Sea, Bering Sea almost to Bering Strait northward, to the Aleutian Chain, south along the American coast to Oregon.

Variation and Systematic Status of *Gadus macrocephalus*

Most investigators studying the Pacific cod have reported morphological differences of greater or lesser degree between localities. However, variability is equally great within a locality, as for example reported by Suvorov and Shchetinina (1935) for 104 examples from Kamchatka.

	Range	Mean
I D	13-16	(14.4)
II D	14-20	(17.18)
III D	17-21	(18.5)
I A	18-25	(20.9)
II A	17-22	(18.7)
Gill rakers	18-24	(20.1)
Vertebrae	50-55	(53.2)

These differences in many instances have been also apparent in growth rate, fecundity and other life history characteristics. Nevertheless, because of the migratory nature of Pacific cod and the potential effect of current on dispersal no local stocks have been morphologically delimited.

In this study collections of *G. macrocephalus* were initially subdivided into four geographic areas: Bering Sea, Aleutians, S.E. Alaska and British Columbia. The specimens were examined using both morphometric and meristic characters.

Morphometric characters analyzed

Over a wide range in size, the following characters were examined: body depth at the pelvics and anus, head length, length of first dorsal fin, length of barbel, depth of caudal peduncle and interorbital width. Methods of measuring of Hubbs & Lagler (1958) were employed.

Meristic characters analyzed

The following characters were counted: the dorsal and anal fin-rays, left pectoral fin, gill raker and total vertebrae.

Dorsal and anal counts include the last two elements as one ray. All visible rays in the pectoral were counted. The hypural complex was not included in the total vertebral count.

Results

Morphometric analysis

Table I summarizes data on body proportion for the four geographic areas examined. Both body depth measurements and head length have been expressed as proportion of the standard length; the other characters as proportion of head length.

From Table I it is apparent that no consistent clinal trends are evident. Similar inconsistency in ranges and means are exhibited.

Data obtained from the morphometric analysis give no evidence to indicate any racial differences among cod from the Bering Sea to British Columbia, the geographic range examined.

Meristics analysis

Tables II, III and IV summarize the means and variation in counts. Kamchatka data from the literature are included, though there is some indication that the counts of fin-rays were made differently than by us.

The meristic data, in contrast to the morphometric data, show clinal trends, with varying degrees of regularity.

Dorsal I and Dorsal II counts show a consistent north-south decrease in count, from 12.38 to 11.42 (Bering Sea to British Columbia) for Dorsal I, and 15.95 to 14.22 for Dorsal II. The third dorsal count is not a regular decrease although a clinal trend is suggested.

The two anal counts produced similar results. From the Bering Sea to the Aleutians, a slight increase in count was obtained. From the Aleutians to British Columbia, however, a north-south clinal trend was obtained, from 18.72 to 17.00 for Anal I, and 16.94 to 16.15 for Anal II.

The count of the left pectoral shows a regular clinal decrease from the Bering Sea to British Columbia. The decrease in count, however, is not great - 20.20 to 19.74.

Gill raker counts also show a regular but reversed trend from south to north. From British Columbia to the Bering Sea the change is 20.89 to 20.15.

Vertebrae (total count) shifts from the Bering Sea to British Columbia by 53.43 to 52.33.

Racial analysis

In order to determine if this variation contained evidence of racial groupings, the data were further divided geographically. The Bering Sea was left as a unit, the Aleutians were divided into two areas, the southeast Alaska division was retained and British Columbia was split into two parts forming a total of six areas. Because of lack of any trends, morphometric data were not analyzed and only the meristic counts were tested.

Table V presents the results of these analyses. In most characters an irregular cline is exhibited, suggesting the strong likelihood that northern and western Bering Sea material represents a stock distinct from Southeast Alaska and similarly the southern British Columbia specimens seem to represent a separate stock.

An attempt was made to correlate this suggestion with catch data, without success.

Catch records of the International Pacific Halibut Commission (1961 and 1962) and the G.B. Reed (1965) were plotted from Unimak Pass, Alaska to Washington. Somewhat uniform concentrations of Gadus along the Aleutians eastward to Prince William Sound in the Gulf of Alaska were apparent. Catches from Prince William Sound (Montague Island), southward to Cape Spencer, decrease rather sharply and do not indicate concentrations of similar magnitude to the south. Another explanation is that the separate stocks, if real, are not of the same general magnitude.

Conclusions

Until sufficient data are available on the variability of stocks of Gadus it appears that the Pacific cod should be considered a full species. In the area from which specimens were studied in detail, from western Aleutians to northern British Columbia, meristic data show clines in median fin-ray counts. The breaks are indicative of a separate northern and western Bering Sea stock, Alaska stock and southern British Columbia population of Pacific cod, but sample size was too small to delimit the populations precisely.

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Appendix I.

Record of Specimens used in this Investigation

(All material deposited in the University of British Columbia Institute of Fisheries)

Bering Sea

BC62-565	St. George Is. (1)	BC65-710	58°00', 160°00' (2)
63-1040	Cape Yushin (1)	65-713	55°30', 166°30' (4)
63-1453	St. Paul Is. (2)	65-714	57°45', 168°45' (1)
65-708	57°30', 161°30' (3)	65-716	56°30', 167°30' (5)
65-709	55°45', 166°45' (2)	65-728	57°00', 160°00' (2)

Aleutian Islands and Peninsula

BC62-427	54°00', 165°00' (2)	BC63-1035	Amchitka Is. (3)
62-534	Kodiak (4)	63-1308	Caton Is. (3)
62-995	Kachemak Bay (2)	63-1315	Little Koniuji Is. (1)
63-882	Attu Is. (1)	65-86	Unga Is. (1)
63-905	Adak Is. (1)	65-89	55°25.4', 159°59.8' (1)
63-911	Kiska Is. (8)	65-91	Unga Is. (15)
63-1009	Attu Is. (5)	65-101	Akun Is. (4)

S.E. Alaska

BC62-557	Chatham Strait (1)	BC63-1255	Little Port Walter (4)
62-576	Port Armstrong (3)	65-388	Little Port Walter (1)
62-591	Port Armstrong (1)	65-584	Chicagof Is. (1)
63-284	Baranof Is. (1)		

British Columbia

BC53-204	Goose Is. Banks (2)	BC59-507	Vancouver Is. (N. end)(2)
55-50	Qualicum Beach (1)	60-416	Queen Charlotte Is. (2)
55-55	Swanson Channel (3)	63-774	Strait of Georgia (1)
55-57	Swanson Channel (1)	63-784	Hope Is. (2)
56-519	Vancouver (Docks) (1)	64-141	Hecate Strait (2)
57-53	Near Vancouver (4)	64-272	48°57', 126°00' (1)
58-424	Queen Charlotte Strait (1)	64-273	48°56', 126°04' (1)
59-471	Goose Is. (1)	65-338	Hecate Strait (2)

Table I. Variation of body proportion in *Gadus macrocephalus*.

	Depth at pelvics	Depth at anus	Head length	Length dorsal I	Length barbel	Depth caudal peduncle	Inter-orbital width
	As proportion of standard length			As proportion of head length			
Bering Sea							
mean	4.44	4.81	3.53	1.62	4.96	5.46	3.68
range	4.16-4.95	4.30-5.53	3.06-3.77	1.47-1.75	4.49-5.52	5.07-5.75	3.46-3.98
number	13	10	16	15	15	15	16
Aleutians							
mean	4.92	5.18	3.68	1.57	5.43	5.50	3.83
range	4.50-5.55	4.52-5.94	3.49-3.98	1.41-1.72	4.56-6.94	5.00-6.70	3.42-4.31
number	25	25	26	26	26	26	26
S. E. Alaska							
mean	4.46	4.78	3.44	1.58	5.07	5.21	3.46
range	4.05-4.87	4.18-5.60	3.08-3.74	1.44-1.73	4.35-6.60	4.73-5.93	3.11-4.18
number	11	11	12	12	10	12	10
British Columbia							
mean	4.69	4.95	3.60	1.60	4.79	5.21	3.91
range	4.28-5.32	4.32-5.63	3.37-3.78	1.48-2.02	4.24-5.84	4.52-6.60	3.26-4.32
number	16	15	23	21	21	23	23

Table II. Mean fin count in <u>Gadus macrocephalus</u> by geographical area.

	First dorsal	Second dorsal	Third dorsal	First anal	Second anal	Left pectoral	Gill rakers
Kamchatka (from literature)							
mean	14.4	17.18	18.5	20.9	18.7	..	20.1
range	13-16	14-20	17-21	18-25	17-22	..	18-24
number	104	104	104	104	104	..	104
Bering Sea							
mean	12.38	15.95	16.67	18.68	16.90	20.20	20.15
range	11-14	14-18	15-18	16-20	16-18	19-21	19-23
number	21	21	21	19	21	20	20
Aluetians							
mean	12.26	15.61	15.82	18.73	16.94	20.18	20.38
range	11-14	14-18	14-18	18-22	16-19	19-21	18-22
number	34	33	34	33	34	34	34
S. E. Alaska							
mean	11.92	15.00	16.27	18.17	16.64	19.83	20.58
range	11-14	13-17	15-18	16-19	14-19	19-21	19-22
number	12	11	11	12	11	12	12
British Columbia							
mean	11.42	14.22	15.81	17.00	16.15	19.74	20.89
range	10-13	13-16	14-17	16-19	15-18	19-22	19-23
number	26	27	27	26	26	27	27

Table III. Variation in counts of Gadus macrocephalus.

	Kamchatka	Bering Sea	Aleutians	S.E. Alaska	British Columbia
First dorsal					
10	..	..	..	..	5
11	..	4	5	4	11
12	..	6	17	6	10
13	..	10	10	1	2
14	..	1	2	1	..
No.	..	21	34	12	26
Mean	14.4	12.38	12.26	11.92	11.42
Second dorsal					
13	..	..	..	1	6
14	..	2	2	3	10
15	..	5	15	3	10
16	..	8	11	3	1
17	..	4	4	1	..
18	..	2	1	..	..
No.	..	21	33	11	27
Mean	15.95	15.61	15.00	14.22	14.22
Third dorsal					
14	..	..	1	..	4
15	..	3	5	2	6
16	..	4	11	5	11
17	..	11	12	3	6
18	..	3	5	1	..
No.	..	21	34	11	27
Mean	..	16.67	15.82	16.27	15.81
First anal					
16	..	2	1	1	8
17	..	1	..	1	13
18	..	4	17	5	2
19	..	7	8	5	3
20	..	4	4	..	..
21	..	1	2	..	..
22	..	..	1	..	..
No.	..	19	33	12	26
Mean	..	18.68	18.73	18.17	17.00

cont'd.

Table III (cont'd.)

	Kamchatka	Bering Sea	Aleutians	S.E. Alaska	British Columbia
Second anal					
14	..	..	..	1	..
15	..	..	..	2	..
16	..	7	11	1	13
17	..	9	15	4	7
18	..	5	7	2	1
19	..	..	1	1	..
No.	..	21	34	11	26
Mean	..	16.90	16.94	16.64	16.15
Left pectoral					
19	..	4	8	6	11
20	..	8	13	2	13
21	..	8	12	4	2
22	..	..	1	..	1
No.	..	20	34	12	27
Mean	..	20.20	20.18	19.85	19.74
Gill rakers					
18	..	..	1	..	..
19	..	9	4	1	3
20	..	4	14	5	4
21	..	3	11	4	14
22	..	3	4	2	5
23	..	1	..	..	1
No.	..	20	34	12	27
Mean	..	20.15	20.38	20.58	20.89
Vertebrae					
50	..	..	..	..	1
51	..	..	..	1	..
52	..	1	3	..	3
53	..	2	4	5	5
54	..	4	5	..	..
No.	..	7	12	6	9
Mean	..	53.43	53.17	52.67	52.33

Table IV. Mean vertebral number in *Gadus macrocephalus* by geographical area.

	Bering Sea	Aleutians	S. E. Alaska	British Columbia
Mean	53.43	53.17	52.67	52.33
Range	52-54	52-54	51-53	50-53
Number	7	12	6	9

Table V. Mean of counts in <u>Gadus macrocephalus</u>. Bering Sea - British Columbia

	First dorsal	Second dorsal	Third dorsal	First anal	Second anal	Left pectoral	Gill rakers	Vertebrae
Bering Sea								
mean	12.38	15.95	16.67	18.68	16.90	20.20	20.15	53.43
number	21	21	21	19	21	20	20	7
Aleutian (1) (western)								
mean	12.88	15.77	16.77	18.87	17.00	19.66	20.11	..
number	9	9	9	8	9	9	9	..
Aleutian (2) (central)								
mean	12.09	15.55	16.30	18.65	16.96	20.35	20.48	..
number	23	22	23	23	23	23	23	..
S. E. Alaska								
mean	11.92	15.00	16.27	18.17	16.64	19.83	20.58	52.67
number	12	11	11	12	11	12	12	6
British Columbia (1) (northern)								
mean	11.31	14.23	15.46	17.17	16.00	19.77	20.62	..
number	13	13	13	12	12	13	13	..
British Columbia (2) (southern)								
mean	11.54	14.21	16.14	16.86	16.29	19.71	21.14	..
number	13	14	14	14	14	14	14	..

Distribution, Synonymy and Variation in the arrowtooth flounders, Atheresthes

Index

Introduction

Two forms of the genus Atheresthes are presently recognized. Norman's (1934) monograph on the flatfishes lists A. stomias Jordan and Gilbert (1881) and A. evermanni Jordan and Starks (1904) as species but suggests that additional data might show them to constitute one species. Most recent workers recognize two species although few adeqate data have been published to demonstrate this.

Among other characters, Norman (1934) mentions that the 10 gill rakers on the lower portion of the first arch and the eye below the dorsal profile of the head are characteristic of A. evermanni while 11 or 12 rakers and the eye extending on to the dorsal profile of the head distinguish A. evermanni.

A. evermanni is known from the northwest Pacific Ocean and supposedly is replaced by A. stomias in North American waters. Because of the implied allopatry a geographic variational study was undertaken.

Synonymy

Atheresthes stomias

Platysomatichthys stomias Jordan and Gilbert, Proc. U. S. Nat. Mus. 3, 1881: 51 (description).

Atheresthes stomias Bean, Proc. U. S. Nat. Mus., 4, 1882: 242 (distribution). -- Jordan and Gilbert, Proc. U. S. Nat. Mus., 4, 1882: 66 (length and distribution). -- Jordan and Gilbert, Bull. U. S. Nat. Mus., 16, 1883: 820-821 (description and distribution). -- Bean, Proc. U. S. Nat. Mus., 6, 1884: 354 (distribution). -- Eigenmann and Eigenmann, Ann. N. Y. Acad. Sci., 6, 1892: 358 (distribution). -- Gilbert, Rept. U. S. Comm. Fish., 19, 1895: 393-476 (depth and geographic distribution). -- Jordan and Evermann, Bull. U. S. Nat. Mus., 47(3), 1898: 2609-10 (distribution, description, synonymy, relationships). -- Evermann and Goldsborough, Bull. U. S. Bur. Fish., 26, 1907: 350 (distribution, description). -- Hubbs, Proc. U. S. Nat. Mus., 48, 1915: 473 (description). -- Starks, Calif. Fish and Game, 4(4), 1918: 165 (figure, range, description, commercial importance). -- Jordan, Evermann and Clark, Rept. U. S. Comm. Fish., (2), 1930: 221 (distribution, name). -- Norman, Brit. Mus. (Nat. Hist.) London, 1, 1934: 286-7 (synonymy, description, range, figure, keys). -- Smith, Rept. State Washington Dept. Fish. Biol., 36B, 1936: 1-61 (abundance, spawning season). -- Townsend, Rept. Int. Fish. Comm., Seattle, 11, 1936: 10-21 (fin-ray counts). -- Andriashev, U. S. Fish. Wildl. Serv., Spec. Sci. Rept.- Fish.,.

145, 1937: 40 (depth and temperature distribution, commercial importance, distribution). -- Clemens and Wilby, Fish. Res. Bd. Canada, Bull. 68, 1946: 311 (figure, description, length, range, commercial importance, abundance, depth distribution). -- Roedel, Calif. Fish and Game, Fish. Bull., 91, 1953: 57 (range, description, figure, commercial importance, common names). -- Nikolskii, Spec. Ichthyol., Off. Tech. Serv. Transl. (1961), 1954: 439 (range, spawning season, food, commercial importance, depth distribution). -- Palutov and Tikhonov, Izvest. Pac. Inst. Fish. Ocean. Vladivostok, 45, 1957: 197-198 (Kamchatka). -- Clemens and Wilby, Fish. Res. Bd. Canada, Bull. 68, 1961: 183, Fig. 97 (description, length, range, commercial importance, abundance, depth distribution). -- Pruter and Alverson, J. Conseil Expl. Mer., 27, 1962: 85 (distribution). -- Batts, Copeia (4), 1964: 668-671 (description of scales). -- Alverson, Pruter and Ronhold, H. R. MacMillan Rec. Fish., Inst. Fish., Univ. B. C., 1964: 61-67 (length,depth and geographic distribution, commercial importance).

Atheresthes evermanni

Atheresthes evermanni Jordan and Starks, Proc. U. S. Nat. Mus., 31, 1904: 196-8 (description and figure). -- Hubbs, Proc. U. S. Nat. Mus., 48, 1915: 473-4 (distribution and description). -- Norman, Brit. Mus. (Nat. Hist.) Lond., 1, 1934: 288 (synonymy, description, geographic range). -- Jordan and Hubbs, Mem. Carnegie Mus., 10(2), 1925: 298. -- Andriashev, U. S. Fish and Wildl. Serv., Spec. Sci. Rept.- Fish., 145, 1937: 40 (measurements, food, distribution). Schmidt, P. A., Trudy Tikhook. Komiteta, VI, Akad. Nauk SSSR, 1950: 224 (name, synonymy, depth distribution). -- Moiseev, Fish. Res. Bd. Canada, Transl. Ser. No. 119, 1953: 243 (depth, distribution, growth, age, food, spawning season). -- Nikolskii, G. V., Spec. Ichthyology, 1954: 439 (range, age at maturity, food, depth distribution). -- Kasahara, Bull. Tohoku Regional Fish. Res. Lab., 4, 1955: 147-55 (age).

Range of Atheresthes

Atheresthes evermanni is distributed from Northern Japan (Hokkaido) through the Sea of Okhotsk to the Western Bering Sea north to Anadyr Gulf. It is replaced in the Eastern Bering Sea by Atheresthes stomias which ranges south along the American coast to California.

Variation and Systematic Status of the Species of *Atheresthes*

Characters analyzed

After preliminary scanning the following criteria were selected for systematic analysis: gill raker count, dorsal and anal fin-rays, caudal vertebral number, and eye - dorsal fin distance. There is some indication that lateral line pore and scale counts might be useful; however, the desired degree of accuracy seemed unobtainable on our specimens as scales in *Atheresthes* are quite fragile and deciduous. Obviously, specimens which have been roughly handled during trawling operations, would have damaged scales and lateral lines. Other proportional measurements showed only slight differences, probably due to allometric growth.

Results

Morphological criteria

As Table I indicates, our example of *Atheresthes* from the western North Pacific Ocean have lower gill raker counts than those from the eastern North Pacific Ocean. Eastern specimens (*A. stomias*) have a mean count of about 15, while there is a mean count of about 12 or 13 for western specimens (*A. evermanni*). Specimens from throughout the northern and eastern Bering Sea have a large range and variance in gill raker counts. The samples are rather small and there is too much overlapping in counts to distinguish the two different forms of *Atheresthes*.

Similar to gill raker counts, vertebral numbers from the Bering Sea vary widely between counts of the eastern and western forms. Western Pacific *Atheresthes* have more caudal vertebrae than specimens in the eastern Pacific Ocean (Table II). The average is about 37 vertebrae in the east and much more than 38 in the west.

Dorsal and anal counts are extremely variable in *Atheresthes* (Tables III and IV). Means of counts of samples from all areas are quite similar, and thus quite large samples will be needed to show even slightly significant differences. Dorsal and anal counts appear to be of little use to distinguish geographical forms.

The most easily examined and reliable external character which can be used to distinguish the species of *Atheresthes* is the position of the eye. Specimens from the western Pacific Ocean (*A. evermanni*) have the upper eye completely over on the right side of the head, while in eastern specimens (*A. stomias*) it is on top and interrupts the dorsal profile of the head (Table V).

However, this character is difficult to quantify. A usable measurement is one obtained between the base of the first dorsal ray and the anterior-most margin of the eye. Obviously, this measurement can be affected by other variables besides the position of the eye. The origin of the dorsal fin and eye diameter can vary and consequently may partially obscure the intended description of the eye position.

Character index

Since gill rakers, vertebrae, and eye position indicate some differences but do not completely separate two forms of *Atheresthes*, these characters were pooled in such a manner as to give the best separation of the respective forms. Table VI gives partial separation when the number of gill rakers on the first arch were subtracted from the number of caudal vertebrae. Those with a value of 23 or less separate *A. stomias* from *A. evermanni* with a value of 25 or more. The identity of the four individuals with a value of 24 cannot be determined from this index. Better separation is obtained when the dorsal origin to anterior eye distance is compared to the eye diameter. This latter ratio is multiplied 5 times and then subtracted from the original index as in the following equation:

$$\text{Character index} = \text{Caudal Vertebral number} - \text{gill raker number} - 5\left(\frac{\text{Distance from anterior eye margin to dorsal origin}}{\text{Eye diameter}}\right)$$

In Table VII good separation of the respective species is obtained using this index. Only the identity of the individuals with an index of 20.5 is in doubt.

Conclusion

The genus *Atheresthes* is composed of two species, *Atheresthes stomias* and *Atheresthes evermanni*. In the area where the species are in proximity (Bering Sea) a character index employing both counts and measurement can be used to distinguish them.

Literature Cited

Norman, J. R. 1934. A systematic monograph of the flatfishes (*Heterosomata*). British Mus., I, 459 p.

Appendix I.

Record of Specimens used in this Investigation

(All material deposited in the University of British Columbia Institute of Fisheries)

Okhotsk Sea

BC64-248 52°31', 155°43' E

1A + 5 + 10A (28)
36 (505, 507, 508) (3)
37 (511) (1)
38 (506, 509) (2)
39 (500, 513, 567) (3)
42 (199) (1)
54 (382) (1)
61 (501) (1)

BC65-339 Japanese fish boats (no data) (9)

Bering Sea

BC64-247 60°57', 179°26'

26B + 27B (11)
26A + 25A (2)

BC63-367 Bristol Bay (1)

BC62-565 Bering Sea (St. Paul Is.) (5)

BC62-563 North of Unimak Is. (7)

Aleutians

W64-188	55°41.5', 159°57' (10)	W65-717	56°45', 167°45' (5)
64-151	53°17.2', 166°34' (9)	65-709	55°45', 166°45' (2)
64-160	54°22', 163°20' (28)	65-716	56°30', 167°30' (3)
65-728	57°00', 160°00' (2)		

British Columbia

BC54-95	Burrard Inlet (9)	GBR62-2	(8)
58-339	Gulf of Georgia (2)	64-2	Smith Sound (8)
57-53	Vancouver (3)		
63-784	Hope Island (7)		
56-91	Prince Rupert (4)		

Table I. Frequency of gill raker counts in *Atheresthes*.

	10	11	12	13	14	15	16	17	Number	Mean
British Columbia										
BC 54-951 58-339; 57-53; 56-9	..	..	..	..	3	8	6	..	17	15.18
63-784	..	..	..	..	3	5	1	..	9	14.77
GBR 62-2	..	..	..	..	1	3	4	..	8	15.37
Aleutian Islands										
W64-138	..	..	..	..	4	8	7	..	19	15.16
W64-160	..	..	..	..	5	18	6	..	29	15.03
S. E. Bering Sea,										
Bristol Bay and St. Paul	..	..	4	4	2	5	2	..	17	13.82
N. W. Bering Sea	..	1	..	..	1	..	..	..	2	12.50
26B + 27B	..	1	2	..	2	4	2	..	11	13.82
BC 65-339	1	3	6	4	1	..	..	..	15	12.22
Sea of Okhotsk	..	3	15	12	1	..	..	..	31	12.35

Table II. Frequency of vertebrae in <u>Atheresthes</u>.

		36	37	38	39	40	Number	Mean
British Columbia	58-339; 57-53; 54-95	4	9	..	..	..	13	36.69
	63-784	1	5	1	..	..	7	37.00
	56-91	..	3	1	..	..	4	37.25
Aleutian Islands	W64-137	1	10	2	..	..	13	37.01
	W64-160	4	18	5	1	..	28	37.11
	W64-151	..	7	2	..	..	9	37.22
	65-728; 65-717; 65-709; 65-716; 62-565	..	6	5	4	1	16	38.00
N. W. Bering Sea	26B + 27B	1	4	4	1	1	11	37.72
	26A + 25A	..	..	1	1	..	2	..
	BC 65-339	..	..	5	8	3	16	38.87
Sea of Okhotsk	1A + 5 + 10A	..	..	11	16	4	31	38.77
	36	..	..	1	2	..	3	38.67
	37	..	..	..	1	..	1	39.00
	38	..	..	..	2	..	2	39.00
	39	..	..	..	3	..	3	39.00
	42	..	..	1	..	..	1	38.00
	54	..	..	..	2	..	2	39.00
	61	..	..	..	..	1	1	40.00

Table III. Frequency of dorsal ray counts in *Atheresthes*.

	GBR 64-2	British Columbia	Aleutians Islands & Alaskan Peninsula	S.E. Bering Sea	26B + 27B	BC 65-339	Sea of Okhotsk
92	..	1	..	..	..	..	..
93	..	..	..	..	..	..	..
94	..	..	..	..	..	..	..
95	..	..	..	..	..	..	1
96	..	..	..	..	..	..	..
97	..	1	1	..	..	..	2
98	..	..	..	..	..	..	2
99	..	1	..	1	..	..	2
100	..	..	..	..	1	2	..
101	..	1	..	1	1	..	2
102	..	2	3	..	1	..	1
103	..	2	3	..	1	..	1
104	2	..	..	..	1	..	..
105	..	1	2	..	1	2	5
106	1	2	3	..	..	..	1
107	..	1	1	3	..	1	6
108	2	3	3	1	2	2	2
109	3	1	2	..	..	..	..
110	..	..	1	..	..	..	..
111	..	..	..	..	1	..	1
112	..	..	..	..	..	..	1
113	..	..	..	..	..	1	..
114	..	..	..	..	..	..	..
115	..	..	..	1	..	..	..
Number	8	16	19	7	..	8	28
Mean	106.50	103.50	105.21	106.29	104.67	105.75	104.00

Table IV. Frequency of anal ray counts in *Atheresthes*.

	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	No.	Mean
British Columbia	1	..	..	..	..	1	2	2	1	..	2	2	2	2	1	..	..	..	1	..	..	17	82.19
Aleutian Islands and Alaska Peninsula	..	..	..	..	..	..	..	2	..	..	2	1	4	4	3	..	1	2	..	..	..	19	84.47
S. E. Bering Sea	..	..	..	..	..	..	..	1	..	..	1	1	1	1	1	..	..	..	..	..	1	7	84.43
26B + 27B	..	..	..	..	..	..	..	..	..	1	..	1	..	3	1	2	..	1	..	..	..	9	85.33
Sea of Okhotsk	..	..	..	1	..	1	..	1	5	3	4	1	4	2	5	2	1	1	..	..	1	32	83.25
65-339	..	..	..	..	..	..	..	..	..	2	..	1	2	2	..	..	..	..	.1	..	..	8	84.13

Table V. Variation in anterior orbit to dorsal origin distance in *Atheresthes*.

	.30	.35	.40	.45	.50	.55	.60	.65	.70	.75	.80	.85	.90	.95	Number	Mean
British Columbia																
58-339; 57-53; 54-95	..	..	..	..	..	..	..	..	..	9	3	2	1	..	15	0.783
56-91	..	..	..	..	..	..	..	1	..	2	..	1	..	..	4	0.750
Aleutians																
W64-160	..	..	..	..	..	1	2	13	6	2	..	2	2	..	28	0.693
W64-151	..	..	..	..	..	..	..	3	3	1	1	..	..	..	8	0.700
65-728; 65-717; 65-709; 65-716	..	1	..	3	..	2	3	1	3	1	2	1	..	..	17	0.621
Bering Sea																
26B + 27B	..	..	..	..	1	1	2	4	..	2	1	..	..	..	11	0.650
BC 65-339	..	..	2	2	2	3	..	..	..	..	..	..	..	..	9	0.483
Sea of Okhotsk																
1A + 5 + 10A	..	1	4	7	7	3	2	4	..	..	..	..	..	..	28	0.502
	..	2	6	12	10	10	9	26	12	17	7	6	3	..	..	..

Table VI. Distribution of character index of vertebrae count less gill raker count in <u>Atheresthes</u>.

		20	21	22	23	24	25	26	27	28	29	Number	Mean
British Columbia	58-339; 57-53; 54-95	..	6	7	..	..	..	..	..	..	..	13	21.54
	63-784	..	2	3	2	..	..	..	..	..	..	7	22.00
	56-91	..	..	2	2	..	..	..	..	..	..	4	22.50
Aleutian Islands	W64-138	..	3	5	2	..	..	..	..	..	..	10	21.9
	W64-160	2	5	11	8	1	..	..	..	..	..	27	22.01
	W64-151	..	2	4	3	..	..	..	..	..	..	9	22.11
65-728; 65-717; 65-709; 65-716; BC 62-565		..	2	3	2	1	2	3	3	..	..	16	24.19
S.E. Bering Sea	26B-27B	..	2	3	2	1	..	1	..	2	..	8 + 3	22.25-27.33
	26A+25A	..	..	..	..	..	1	..	1	..	..	2	
	BC 65-339	..	..	..	..	..	1	3	3	..	2	9	26.89
Sea of Okhotsk	1A + 5 + 10A	..	..	..	..	1	2	8	11	2	..	24	26.45
	36	..	..	..	..	..	..	1	1	1	..	3	27.00
	37	..	..	..	..	..	..	..	..	1	..	1	28.00
	38	..	..	..	..	..	..	2	..	..	..	2	26.00
	39	..	..	..	..	..	..	..	3	..	..	3	27.00
	42	..	..	..	..	..	1	..	..	..	..	1	25.00
	54	..	..	..	..	..	..	..	..	1	..	1	28.00
	61	..	..	..	..	..	..	..	..	1	..	1	28.00
		2	22	39	21	4	7	18	22	7	2		

Table VII. Distribution of character index (vertebrae minus gill raker minus eye to dorsal distance) in Atheresthes.

	British Columbia (BC54-95; BC58-339; BC57-53; BC65-91; BC63-784; GBR 62-2)	Aleutian Islands		S.E. Bering Sea	26B + 27B	BC65-339	Sea of Okhotsk	Total
		W64-160	W64-151					
16.0	3	1	..	..	..	..	..	4
16.5	1	2	..	..	..	..	..	3
17.0	3	2	..	1	..	..	..	6
17.5	3	6	3	..	1	..	..	13
18.0	4	1	1	3	4	..	..	13
18.5	..	5	2	2	..	..	..	9
19.0	2	4	3	1	1	..	..	11
19.5	1	5	..	..	..	..	..	6
20.0	..	..	..	..	..	..	..	..
20.5	..	..	..	..	..	..	..	..
21.0	..	..	..	..	..	..	..	..
21.5	..	..	..	1	..	1	..	2
22.0	..	..	..	1	..	1	2	4
22.5	..	..	..	1	1	..	2	4
23.0	..	..	..	2	..	2	1	5
23.5	..	..	..	1	..	3	5	9
24.0	..	..	..	..	..	3	3	6
24.5	..	..	..	1	2	..	6	9
25.0	..	..	..	1	..	2	2	5
25.5	..	..	..	..	..	..	..	..
26.0	..	..	..	..	..	..	..	..
26.5	..	..	..	..	..	2	..	2
Number	17	26	9	15	9	14	21	..
Mean	17.50	18.15	18.28	20.80	20.06	23.93	23.74	

Distribution, Synonymy and Variation in the Pacific forms of *Hippoglossoides*

Index

Introduction

Hippoglossoides Gottsche (1835) was considered by Jordan and Evermann (1898) as divisible into four species: H. platessoides, H. elassodon, H. robustus and H. hamiltoni. Norman (1934) in his Monograph of the Flatfishes, recognized the following four species: H. platessoides (two subspecies, limandoides (European), platessoides (American), H. elassodon, H. robustus and H. dubius (Asian).

The species are variable and the limits of distribution, particularly in the Bering Sea, are not clearly known. Published data indicate H. robustus is a more northern species possessing a smaller number of rays in dorsal and anal, smaller number of gill rakers on lower part of first gill arch, larger upper eye, more elongate body, etc., which separate it from the other two Pacific species. However, most of the meristic characters of H. dubius overlap with H. elassodon.

Synonymy

(The Atlantic species, H. platessoides, will not be considered)

Genus Hippoglossides Gottsche

Hippoglossoides Gottsche, Arch. Naturgesch., I, 2, 1835, p. 164 (type: H. limanda Got. = Pleuronectes limandoides Bloch). -- Norman, Flatfishes, 1934, p. 294.

Drepanopsetta Gill, Proc. Acad. Nat. Sci. Phila. (Suppl.), 1861, p. 50 (type: P. platessoides Fabr.). -- Smitt, Scand. Fish., I, 1893, p. 420.

Cynopsetta (Schmidt) Jordan and Starks, Proc. U.S. Nat. Mus., 31, 1906, p. 188 (type: H. dubius Schon.).

Citharus Reinhardt, Kong. Dansk. Vid. Selsk., 1838, p. 116. (platessoides); not Citharus Bleeker, 1862.

Pomatopsetta Gill, Proc. Acad. Nat. Sci. Phila., 1864, p. 217, ("dentata" = platessoides).

Hippoglossoides elassodon Jordan and Gilbert

Hippoglossoides elassodon Jordan and Gilbert, Proc. U. S. Nat. Mus., 3, 1881: 278 (Seattle, Tacoma; type no. ibid, 1881: 454). -- Bean, ibid., 1882: 242. -- Jordan and Gilbert, Synopsis, 1883: 826. -- Bean, ibid., 1883: 20. -- Jordan, Nat. Hist. Aquat. Anim. 1884: 188 (Pl.52). -- Jordan and Goss, Rev. Flounders and Soles, 1889: 241 (Pl. 5). -- Eigenmann and Eigenmann, Ann. N.Y. Acad. Sci. 6, 1892: 358 (distribution). -- Jordan and Evermann, Bull. U. S. Nat. Mus. 47, III, 1898: 2615. -- Jordan and Gilbert, Rept. Fur Seal Invest., 1898. -- Schmidt, Pisc. Mar. Orient., 1904: 225. -- Jordan and Starks, Proc. U. S. Nat. Mus., 31, 1906: 189. -- Evermann and Goldsborough, Bull. U. S. Bur. Fish. 26, 1907: 352. -- Gilbert and Burke, Bull. U. S. Bur. Fish., 30, 1912: 95. -- Jordan, Tanaka and Snyder, J. Coll. Sci. Tokyo, 33(1), 1913: 320. -- Hubbs, Proc. U. S. Nat. Mus., 48, 1915: 466. -- Norman, Flatfishes, 1934: 299-300 (fig. 221). -- Townsend, Copeia, 1937: 92-103. -- Moiseev, 1953: 244, 275. -- Clemens and Wilby, Bull. Fish. Res. Bd. Canada, 68, 1961: 185 (fig. 99).

Hippoglossoides elassodon elassodon Schmidt, Ann. Mag. Nat. Hist., (8) 16, 1915: 307. -- Soldatov and Lindberg, Bull. Pac. Sci. Fish. Invest., 5, 1930: 1395.

Hippoglossoides (Cynopsetta) elassodon Hubbs, Annot. Zool. Jap., 9, 1918: 373.

Hippoglossoides robustus Gill and Townsend

Hippoglossoides robustus Gill and Townsend, Proc. Biol. Soc. Wash., 1897, 11 (Sept. 17, 1897), p. 234 (Bering Sea, Lat. 56°14'N, Long. 164°08'W). -- Jordan and Evermann, Bull. U. S. Nat. Mus., 47, 1898, p. 2616. -- Norman, Flatfishes, 1934, p. 302, fig. 223 (eastern Kamchatka, northern Japan). -- Andriyashev, Issl. Morei SSSR, 25, 1937, p. 323 (Chuckchi Sea and northern part of Bering Sea; comparison with H. elassodon Jordan and Gilbert).

Hippoglossoides hamiltoni Jordan and Gilbert in: Jordan and Evermann, Bull. U. S. Nat. Mus., 47, III, 1898, p. 2616. -- Jordan and Gilbert, Fish. Bering Sea, 1899, p. 489, pl. 84 (Avachinskaya Bay). -- Hubbs, Proc. U. S. Nat. Mus., 47, 1915, p. 466.

Hippoglossoides elassodon robustus Schmidt, Ann. Mag. Nat. Hist., (8), 16, 1915, p. 299-308 (Sea of Okhotsk, Avachinskaya Bay; meristic features, measurements). -- Soldatov and Lindberg, Obzor ryb dal'nevost, morei, 1930, p. 395 (Cape Terpenie, Avachinskaya Bay, and Ozernyi Bay). -- Tarenets, Kr. opredelit. ryb Dal'n. Vost., 1937, p. 142.

Hippoglossoides propinquus Hubbs, Proc. U. S. Nat. Mus. 48, 1915: 449-496.

Hippoglossoides (Cynopsetta) robustus Hubbs, Annot. Zool. Jap., 9, 1918: 374.

Hippoglossoides (Cynopsetta) hamiltoni Hubbs, Annot. Zool. Jap., 9, 1918: 374.

Hippoglossoides (Cynopsetta) propinquus Hubbs, Annot. Zool. Jap., 9, 1918: 374.

Hippoglossoides dubius

Hippoglossoides dubius Schmidt, Pisc. Mar. Orient., 1904: 227 (fig.). -- Snyder, Proc. U. S. Nat. Mus., 42, 1912: 439. -- Hubbs, ibid., 48, 1915: 466. -- Jordan and Hubbs, Mem. Carnegie Mus., 1925: 298. -- Hanna, Honma, Coll. and Breeding, 20(2), 1958: 62.

Cynopsetta dubia Jordan, Tanaka and Snyder, J. Coll. Sci. Tokyo, 33(1), 1913: 320.

Hippoglossoides katakurae Snyder, Proc. U. S. Nat. Mus., 40, 1911: 546. -- Snyder, ibid., 42, 1912: 439 (fig.). -- Jordan, Tanaka and Snyder, J. Coll. Sci. Tokyo, 33(1), 1913: 320. -- Schmidt, Ann. Mag. Nat. Hist., 16, 1915: 299-308.

Hippoglossoides elassodon dubius Schmidt, Ann. Mag. Nat. Hist., 16(8), 1915: 307. -- Soldatov and Lindberg, Bull. Pac. Sci. Fish. Inst., 5, 1930: 394. -- Schmidt, C. R. Akad. Sci. Russ., 1931: 316. -- Moiseev, 1953: 244.

Hippoglossoides (Cynopsetta) dubius Hubbs, Annot. Zool. Jap., 9, 1918: 374.

Range of Hippoglossoides

The genus ranges throughout the northern parts of the Pacific and Atlantic Oceans. H. platessoides (which is not considered herein) is found on both coasts of the North Atlantic Ocean. H. robustus ranges from northern Japan, Sea of Okhotsk, western and central Bering Sea, north to the Chukchi Sea. H. elassodon occurs from the Okhotsk Sea through the Bering Sea to Washington on the North American coast. H. dubius is found from the southern Okhotsk Sea, through the Sea of Japan, south to Korea.

Variation and Systematic Status of the Pacific Forms of *Hippoglossoides*

In the present investigation specimens of *Hippoglossoides* were examined from the Sea of Okhotsk, western North Pacific, western and eastern Bering Sea, the Chukchi Sea, Alaska Peninsula to southern British Columbia and Washington.

Morphometric and meristic characters analyzed

Although previous studies indicated little promise for distinguishing the species on the basis of morphometric analysis an attempt was made to determine the variability of body depth, head length, jaw length and orbit diameter for specimens encompassing a broad length range throughout their distribution. The data, when treated either as a regression or as a proportion, failed to be of analytic use as characters merged indistinguishably. Consequently, the analysis of the material was based on counts of systematically sensitive body parts - dorsal, anal, gill raker and lateral line counts. Hubbs and Lagler's (1958) methods of measurement were employed.

Results

Results of the meristic analysis are presented in Tables I, II, III and IV. Similar results were obtained for each of the four meristic counts.

In the area from east Bering Sea and Alaska Peninsula to the east and southward, a general clinal decrease can be observed in the mean values of the counts. This trend is shown most regularly for the anal fin-ray count, less evidently for the dorsal fin-ray count and then less consistently for the remaining two counts. The clinal decrease is regular and does not suggest the existence of different stocks within the area.

There is no doubt that in this geographic area a single species is involved. The high fin-ray counts, with correspondingly high gill raker counts, equate with the species described as *H. elassodon*. However, the geographic limits of this form to the south are diffuse and there is a broad range of overlap in meristic data with *H. robustus* and *H. dubius*.

The low counts of specimens from the Chukchi Sea and St. Matthew Island areas correlate well with descriptions for *H. robustus*. Examination of the range of meristic information indicates a broad area of overlap. If these characters are considered in the light of latitude and clinal information, a separation becomes possible. For example, gill rakers in H. robustus range from 9 to 13, whereas in the H. elassodon "complex" the number is greater than 14 except in the Okhotsk Sea. Whether the Okhotsk Sea examples are H. elassodon with a high count due to the cold temperatures or whether the specimens are transitional between H. robustus and H. elassodon cannot be determined without additional material.

The situation is not as clear in the other geographic areas examined. The western North Pacific counts fall entirely within the ranges of descriptions of H. elassodon and H. dubius. Of all criteria the gill raker lower arch count appears to be the most sensitive. Nevertheless, the distinction between H. elassodon and H. dubius is not trenchant.

Conclusions

In spite of the large numbers of specimens covering a broad geographical area which were examined, no firm statement as to the systematic status of the Pacific members of Hippoglossoides can be made. There is almost a complete transition in morphological and meristic characters tested. Provisionally it appears that northern H. robustus may represent a distinct form, characterized by low counts and larger orbit. The fishes inhabiting the water from Japan to Washington probably represent another single species, H. elassodon. Whether H. elassodon and H. robustus are conspecific must await additional material.

Literature Cited

Hubbs, C. L., and K. F. Lagler. 1958. Fishes of the Great Lakes region. Cranbrook Inst. Sci., Ann Arbor, Michigan.

Jordan, D. S., and B. W. Evermann. 1898. The fishes of North and Middle America. Bull. U. S. Nat. Mus., 47, III, 2183-3136.

Norman, J. R. 1934. A systematic monograph of the flatfishes (Heterosomata). British Mus. I, 459 p.

Appendix I.

Record of Specimens used in this Investigation

(All material deposited in the University of British Columbia Institute of Fisheries)

Chukchi Sea

BC61-66	67°13.5', 165°55' (1)	BC61-99	68°47.5', 166°54' (8)
61-77	67°27', 165°32' (4)	61-405	67°43.8', 166°35' (1)
61-78	67°13.5', 166°23' (1)	61-441	65°44', 168°38' (1)
61-80	67°30', 166°47' (1)	65-339	Japanese fishboats - no data (23)

Okhotsk Sea

BC63-395	52°00', 155°00' (18)	BC63-402	52°30', 155°10' (4)
63-398	60°29', 176°32' (3)	63-673	52°43', 155°41' (30)
63-399	60°37', 175°25' (5)		

Bering Sea

BC62-563	N. of Unimak Pass (1)	BC62-565	St. George Is. (4)

Western North Pacific

BC63-403	50°30', 175°20' (15)	BC63-690	60°29', 178°44' (10)
63-678	60°57', 179°26' (1)		

Aleutian Islands and Peninsula

BC62-475	54°26', 149°48' (4)	BC64-133	55°4.8', 160°47' (5)
62-530	56°42', 154°30' (30)	W64-138	55°41.5', 159°57' (10)
64-131	55°18.4', 160°57.6' (4)	64-142	54°33.5', 160°55' (8)
64-132	55°10', 161°02' (20)		

British Columbia

BC53-301	Denman Island (10)	BC63-775	Malcolm Island (7)
55-56	Nanaimo (10)	65-68	Smith Inlet (off Indian Is.) (6)
59-530	Indian Arm (17)		

Washington

BC55-292	Friday Harbour (2)

Table I. <u>Hippoglossoides</u>: Frequencies and means of anal fin ray counts.

	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	No.	Mean
Chuckchi Sea	..	..	2	1	2	1	1	2	4	2	..	2	1	1	..	..	..	..	..	..	..	19	58.21
Sea of Okhotsk	..	..	..	..	..	1	4	5	5	4	5	6	8	6	2	3	..	1	1	..	..	51	61.55
West N. Pacific	..	..	..	..	..	..	..	..	..	..	..	2	1	4	2	4	..	1	1	..	..	15	64.87
West Bering Sea	..	..	..	..	..	1	1	..	..	1	1	3	2	..	2	6	3	1	..	..	..	21	63.81
St. Matthew Is.	1	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	3	55.67
East Bering Sea (+ Alaska Penn.)	..	..	..	..	..	..	..	..	..	1	3	3	6	11	10	8	7	5	1	1	..	56	64.93
Kodiak + Alaska Penn.	..	..	..	..	..	..	..	..	1	1	2	4	8	7	6	5	6	2	2	2	..	46	64.72
Gulf of Alaska	..	..	..	..	..	..	..	..	..	..	1	1	..	..	1	1	1	..	..	..	..	5	64.20
Yakutat	..	..	..	..	..	..	1	1	5	7	12	16	19	11	12	12	6	1	..	..	..	103	63.07
British Columbia	..	..	..	..	1	1	..	2	..	2	4	6	4	3	4	4	1	1	..	..	..	33	62.61
Indian Arm, B. C.	..	..	..	..	..	..	..	1	3	3	4	8	7	4	..	..	..	..	..	..	..	30	61.73
Washington	..	..	..	..	..	..	2	4	4	6	5	12	7	5	6	4	..	1	2	1	1	60	62.55

Table II. Hippoglossoides: Frequencies and means of dorsal fin ray counts.

	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	No.	Mean
Chuckchi Sea	1	..	..	1	..	..	..	..	4	3	2	11	2	1	1	..	..	..	..	..	..	..	..	..	..	26	75.81
63-399	..	..	..	..	..	..	..	..	..	..	..	1	1	3	1	2	2	2	..	3	5	1	2	..	..	23	83.09
Sea of Okhotsk	..	..	..	..	1	..	..	..	1	4	3	3	8	8	3	6	5	1	3	2	..	1	1	..	..	50	79.30
Western North Pacific	..	..	..	..	..	..	..	..	..	..	1	..	1	2	2	1	..	..	5	1	2	..	..	..	..	15	82.00
Western Bering Sea	..	1	..	..	..	..	..	..	1	..	1	3	1	..	2	1	6	1	1	..	..	..	..	..	..	18	79.53
St. Matthew Is.	1	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	70.67
East Bering Sea (+ Alaska Penn.)	..	..	..	..	..	..	..	..	..	..	..	..	3	2	2	7	5	10	7	5	7	4	1	..	1	54	83.31
Kodiak + Alaska Penninsula	..	..	..	..	..	..	..	..	..	..	..	..	1	4	5	4	8	7	4	3	4	5	..	..	1	46	82.90
Gulf of Alaska	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	2	..	2	..	2	..	1	1	..	9	84.22
Yakutat	..	..	..	..	..	..	..	..	..	3	4	5	12	19	9	12	12	10	7	5	3	1	1	..	..	103	80.50
British Columbia	..	..	..	..	..	..	..	..	..	1	2	5	5	1	1	5	4	3	4	1	..	..	..	..	..	32	80.13
Indian Arm, B. C.	..	..	..	..	..	..	..	..	..	2	2	2	5	1	8	1	2	2	1	1	..	..	..	..	..	27	79.44
Washington	..	..	..	..	..	..	..	2	..	5	4	2	5	6	9	7	7	2	1	1	4	1	..	1	2	59	80.30

Table III. Hippoglossoides: Frequencies and means of gill raker counts - lower arch

	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Number	Mean
Chuckchi Sea	2	1	6	4	2	1	2	1	..	..	..	..	..	..	..	..	..	19	13.00
Sea of Okhotsk	..	..	..	1	1	7	10	6	7	7	5	5	1	2	..	..	..	52	17.60
West. N. Pacific	..	..	..	..	..	..	..	..	..	3	3	1	4	2	1	1	..	15	21.40
West. Bering Sea	..	1	..	2	..	..	1	..	3	3	3	3	2	..	..	..	..	18	18.39
St. Matthews Is.	..	..	1	1	..	..	..	1	..	..	..	..	..	..	..	..	..	3	14.00
East Bering Sea (+ Alaska Penn)	..	..	..	..	..	..	..	1	2	15	15	14	8	1	1	1	1	59	20.44
Gulf of Alaska	..	1	..	..	..	1	..	1	2	1	2	1	..	..	..	..	..	9	18.50
British Columbia	..	..	..	..	..	..	..	2	4	5	11	4	2	..	2	2	..	32	20.22
Indian Arm, B. C.	..	..	..	..	..	..	1	3	..	5	10	6	3	1	1	..	..	30	20.03

Table IV. *Hippoglossoides*: Frequencies and means of lateral line counts.

	85	86	87	88	89	90	91	92	93	94	95	96	97	Number	Mean
Sea of Okhotsk	..	..	1	2	..	1	2	2	..	5	..	..	..	13	91.46
West. N. Pacific	..	..	..	..	1	4	2	..	2	..	..	..	..	9	90.78
West. Bering Sea	..	..	1	..	3	4	1	..	..	..	..	..	..	9	89.44
St. Matthew Is.	..	..	..	..	1	..	..	..	1	..	1	..	..	3	91.67
East. Bering Sea (+ Alaska Penn.)	1	1	1	4	3	12	9	8	3	3	..	..	1	46	90.65
British Columbia	..	1	2	4	6	8	5	..	..	..	..	..	..	26	89.27

Distribution, Synonymy and Variation in the rock soles, Lepidopsetta

Index

Introduction

The genus Lepidopsetta is easily distinguished from other pleuronectine flatfishes by the distinct arch and supratemporal accessory branch of the lateral line. The only other North Pacific genus with which it could be confused, Limanda, does not possess an accessory branch of the lateral line. Northern flatfishes such as Parophrys and Isopsetta also have the accessory lateral line branch. Although there can be a low curve on the lateral line of these two genera, this curve is never as highly arched as it is in Lepidopsetta.

Four specific names have been proposed within Lepidopsetta. This group of flounders was first known from Ayres' (1854) description of Platessa bilineata from San Francisco. This form was placed in the distinct genus Lepidopsetta by Gill in 1864. Girard (1857) described Platichthys umbrosus from Puget Sound, Washington which was later considered a northern race or subspecies of Lepidopsetta. Norman (1934) indicated the possibility of several forms of L. bilineata including umbrosa, which might occur off western North America. Most authors have considered the form, Pleuronectes perarcuata, of Cope (1873) to be conspecific with L. bilineata. Lepidopsetta mochigarei Snyder (1912) has been generally applied to Japanese specimens. Several recent Russian authors (Shmidt, 1950; Moiseev, 1953) consider this form to be a subspecies, L. bilineata mochigarei.

The purpose of our investigation was to determine morphological variability and relationships of the species or subpopulations of Lepidopsetta.

Synonymy

Lepidopsetta bilineata bilineata

Platessa bilineata Ayres, Proc. Acad. Nat. Sci. Cal., 1, 1855: 40 (description and distribution, nomenclature).

Platichthys umbrosus Girard, Proc. Acad. Nat. Sci. Phila., 8, 1857: 36 (description). -- Girard, U. S. Pac. R.R. Surv., X, Fishes, 1858 (name).

Pleuronectes umbrosus Gunter, Cat. Fish. Brit. Mus., 4, 1862: 454 (description and distribution).

Pleuronectes bilineatus Gunther, Cat. Fish. Brit. Mus., 4, 1862: 444 (description, distribution). -- Jordan and Gilbert, Bull. U. S. Nat. Mus., 16, 1883: 833 (description, range).

Lepidopsetta bilineata Lockington, W.H., Proc. U. S. Nat. Mus., 2, 1880: 103 (synonymy, description). -- Jordan and Gilbert, Proc. U.S. Nat. Mus., 3, 1881, 453 (distribution). -- Bean, Proc. U.S. Nat. Mus., 6, 1884: 353 (distribution). -- Jordan and Evermann, Bull. U.S. Nat. Mus., 47, 1898: 2643 (description, synonymy, range, abundance). -- Jordan and Goss, Rept. U.S. Fishes and Fish. Comm., 15, 1889: 286. -- Eigenmann and Eigenmann, Ann. N.Y. Acad. Sci., 6, 1892: 358 (distribution). -- Jordan and Starks, Proc. U.S. Nat. Mus., 31, 1902: 203 (in part: description, distribution, synonymy, figure, abundance). -- Shmidt, Pisc. Mar. Orient., 1904: 232 (in part). -- Starks, Calif. Fish & Game, 4(4), 1918: 175 (description and range - in part). -- Villadolid, Ann. Carnegie Mus., 27, 1927: 396 (description). -- Jordan, Evermann and Clark, Rept. U. S. Fish. Comm., 2, 1930: 226 (distribution, synonymy). -- Norman, Brit. Mus. (Nat. Hist.) London, 1, 1934: 330 (in part: description, figure, key, range). -- Townsend, Rept. Int. Fish. Comm., Seattle, 11, 1936: 10-21 (in part: range, description). -- Smith, Rept. State of Wash. Dept. Fish. Biol., 36B, 1936: 1-61 (distribution, depth, age, size, time of reproduction, egg and young characters, foods, fisheries). -- Clemens and Wilby, Fish. Res. Bd. Canada, Bull. 68, 1946: 317, fig. 237 (description, figure, relative abundance, range, commercial industry). -- Roedel, Calif. Fish & Game, Bull. 91, 1953: 63 (common names, range, description, figure, commercial importance). -- Andriashev, Fishes Northern Seas of USSR. (English Transl., 1964) Office Tech. Serv. 1954: 524-525 (in part: diagnosis, nomenclature, description, spawning season, weight, range, length). -- Nishishimamoto, Thesis, Univ. Wash., 1958: 130 p. (age and growth). -- Rass, T.S.J. Conseil Expl. Mer., 24, 1959: 245-246 (egg character, species association). -- Clemens and Wilby, Fish. Res. Bd. Canada, Bull. 68, 1961: 197, fig. 108 (description, figure, abundance, range, commercial industry). -- Percy, J. Conseil. Expl. Mer., 27, 1962: 232-235 (egg characteristics). -- Alverson, Pruter and Ronholt, H.R. MacMillan Lect. Fish., Inst. Fish. Univ. B. C., 1964: 73-74 (in part: depth, distribution, geographic distribution, abundance, lengths). -- Batts, Copeia (4), 1964: 669-672 (description of scales). -- Forrester, J. Fish. Res. Bd. Canada, 21(6), 1965: 1533-1534 (time of reproduction, time when eggs hatch). -- Levings, B.Sc. Thesis, Dept. Zool., Univ. B. C., 1965: 1-57 (in part: range, depth, age, growth, sexual dimorphism, disease, spawning season).

Lepidopsetta bilineata var. umbrosa Eigenmann and Eigenmann, Ann. N.Y. Acad. Sci., 6, 1892: 358 (distribution). -- Jordan and Evermann, Bull. U. S. Nat. Mus., 47, 1898: 2643 (in part: description and distribution). -- Starks, Ann. Carnegie Mus., 7(2), 1911: 204 (in part: description and distribution).

Lepidopsetta bilineata umbrosa Moiseev, Inst. Rybnovo-Khoz. i Okeanogr., 40, 1953 (range). -- Andriashev, E. Sopredelbnbik Vod. Ezd. Leningrad Gos. Oonev., 187 Str. 1939.

Lepidopsetta bilineata bilineata Andriashev, E. Sopredelbnbid Vod. Ezd. Leningrad Gos. Oonev., 187 Str. 1939. -- Shmidt, Trudy Tikhook

Komiteta, VI, Akad. Nauk SSSR, 1950: 230 (description, synonymy). -- Moiseev, Inst. Rybnovo-Khoz. i Okeanogr., 40, 1953 (range, common name, depth distribution, migration, biochemical composition of liver, abundance, lengths, weights, maturity, spawning period, seasonal feeding habits).

Lepidopsetta bilineata peracuata

Pleuronectes peracuatus Cope, Proc. Amer. Phil. Soc., 13(90), 1873: 32 (nomenclature, description).

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Lepidopsetta bilineata mochigarei

Lepidopsetta mochigarei Snyder, Proc. U.S. Nat. Mus., 40, 1911: 547 (nomenclature, description). -- Snyder, Proc. U.S. Nat. Mus., 42, 1912: 440, pl. 58, fig. 2 (description). -- Jordan, Tanaka, Snyder, J. Coll. Sci. Imper. Univ. Tokyo, 33, 1913: 326. -- Hubbs, Proc. U.S. Nat. Mus., 48, 1915: 476 (distribution and description). -- Hubbs, Annot. Zool. Japan, 9, 1918: 370. -- Jordan and Hubbs, Mem. Carnegie Mus., 10, 1925: 299 (description and distribution). --

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Range of Lepidopsetta

The eastern Pacific typical subspecies Lepidopsetta bilineata bilineata (Ayres) ranges from San Nicholas Island and Monterey, California to the Queen Charlotte Islands, British Columbia where it intergrades with the northern subspecies Lepidopsetta bilineata peracuata (Cope). This form occurs from southeast Alaska, through the Aleutian Islands and Bering Sea north to the Gulf of Anadyr south to the northern Kurile Islands and northern Sea of Okhotsk. The western Pacific subspecies Lepidopsetta bilineata mochigarei Snyder intergrades with the northern form in the southern Sea of Okhotsk and southern Kurile Islands, ranging south through the Sea of Japan to Korea.

Variation and Systematic Status of Lepidopsetta

Characters analyzed

The criteria tested for systematic significance in this genus were: gill rakers, lateral line pores, head pores, dorsal and anal rays, fin-ray asymmetry, vertebral number, body depth, orbit diameter and nature of squamation. Hubbs and Lagler's (1958) standardized method of measurements were employed.

Results

Lepidopsetta from the western Pacific Ocean and Bering Sea have higher gill raker counts than eastern specimens (Table I). Over the large area between the northeast Sea of Okhotsk and southeast Alaska the range is between about 10 or 11 rakers. South of this region, on the American coast, the counts reduce to 7 or 8. The area of transition is centered near the Queen Charlotte Islands region and could be interpreted either as a break in the cline or a zone of intergradation between two populations. The range and overall variation is greatest in samples from this area and apparently introgression of this character is occurring in each direction.

Our samples from northern Washington were of the 7 or 8 gill rakered form. Norman (1934) provides counts of specimens from California, Puget Sound and Nanaimo, B. C. He counted rakers on the lower arch only. Specimens with a total of 7 gill rakers usually have 5 on the lower arch and 2 on the upper arch. It is apparent that his 5 specimens from California with the 5 or 6 rakers on the lower arch are also the 7 or 8 gill rakered form.

A similar pattern in gill raker number probably occurs in the western North Pacific Ocean; however, large samples from this area were not available for study. Three specimens studied from Japan possess 7 or 8 gill rakers. Of these the holotype of L. mochigarei possesses 7 rakers. Hubbs (1915) records 8 specimens with 7 gill rakers and another 7 specimens with 8 gill rakers.

Though the variation in lateral line pore counts is great in any single sample, there is a trend similar to that found in the gill raker counts. Lateral line counts decrease from west to east (Table II), with a break or step near the Queen Charlotte area. The mean counts of various samples range from 89 to 90 in the western Bering Sea and Sea of Okhotsk to 84 or 85 in the Gulf of Alaska or southeast Alaskan region. South of the Queen Charlotte Islands the mean counts are about 80.

Specimens from Japan have much higher lateral line counts than northern or eastern specimens. Norman (1934) used this character to separate L. mochigarei from L. bilineata. Norman did not have access to specimens from the Bering Sea, which appear to bridge the gap in counts between Japanese and far eastern Pacific specimens. By themselves, lateral line counts do not adequately separate forms of Lepidopsetta but the mean counts do suggest the pattern of the populations.

Mucous pores on the head have been used by Norman (1934) to distinguish L. mochigarei from L. bilineata. Our Japanese L. mochigarei have prominent pores; however, other specimens of Lepidopsetta were variable in the prominence of the pores. No difference in pore development was noted between eastern and western populations of Lepidopsetta.

Fin-ray counts are extremely variable in samples of pleuronectids and offer poor systematic characters for the separation of different populations. Dorsal rays (Table III) and anal rays (Table IV) show no significant patterns and have a relatively similar mean count throughout their range. Table V documents usual correlation between number of anal and number of dorsal rays and the extent of asymmetry is shown in Table VII by the higher counts of pectoral rays on the right side of the body than on the left side.

Vertebral counts vary significantly between different geographic areas; unfortunately they are not useful in differentiating between populations (Table V). The data suggest that there is a cline with lower counts towards the eastern part of the Pacific Ocean. Near the Queen Charlottes, which is the area of intergradation of gill raker counts, there are the lower mean vertebral counts. However, further south in British Columbia the mean counts are very high.

Norman (1934) used body depth as one criterion to distinguish _L. mochigarei_ from _L. bilineata_. The three specimens of _L. mochigarei_ available for this study appear to have greater body depth than the other _Lepidopsetta_. However, larger specimens of _Lepidopsetta bilineata_ are relatively deep-bodied and supposedly no clear separation of _L. mochigarei_ and _L. bilineata_ is possible. There appears to be little difference in body depth between northern and southern American _Lepidopsetta_.

Orbit diameter shows much variability in western and eastern _Lepidopsetta_, and cannot be used to separate populations.

Northern _Lepidopsetta_ in the eastern Pacific were reported to have rougher scales than southern forms. This character was highly variable in our example. The outer edge and upper surface of the scales had variable development of spinules or prickles. These are more numerous in larger specimens; however, development varies greatly on scales from different areas of the body, on different specimens within the sample, and between samples from different areas. This variability is shown in samples throughout a large portion of the range of _Lepidopsetta_. Specimens of the low gill-rakered form from Puget Sound and the high gill-rakered form from the Gulf of Alaska were equally variable in the smoothness or roughness of their scales. This character, which was supposed to distinguish the form _umbrosa_, does not appear to adequately separate any forms of _Lepidopsetta_.

It is to be noted that when comparing the growth rates of _Lepidopsetta_ from off Vancouver Island, Gulf of Alaska and Bering Sea, Levings (B.Sc. thesis) demonstrated much faster growth for Vancouver Island specimens. Environmental factors and differential commercial fishery mortality were suggested in part as contributory to these differences. However, since the northern Vancouver Island specimens have low gill-rakered forms, genetic differences in growth must be seriously considered.

Conclusions

Gill rakers and lateral line counts provide the most useful morphological characters for the separation of the forms of Lepidopsetta. On the basis of the criteria, three subspecies of Lepidopsetta bilineata are considered valid: L. b. mochigarei from Asian waters, the northern L. b. peracuata and the west coast L. b. bilineata. The recognition of L. b. peracuata as a valid subspecies is done here for the first time.

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Appendix I.

Record of Specimens used in this Investigation

(All material deposited in the University of British Columbia Institute of Fisheries)

Japan

BC56-355	no date (2)

West North Pacific

BC63-403	50°30', 175°20' (19)

Okhotsk Sea

BC63-395	52°00', 155°00' (18)	BC63-404	44°30', 156°40'E (1)
63-402	52°30', 155°10' (3)		

Bering Sea

BC62-565	St. George Is. (2)	BC63-1040	Cape Yushin, USSR (3)
63-679	60°20', 178°33' (4)	63-1456	St. Paul Island (1)
63-684	60°54', 179°44' (9)		

Aleutians and Bristol Bay

BC62-424	55°08', 160°19' (1)	BC63-1015	Amchitka Is. (2)
62-427	54°00', 165°00' (2)	63-1077	Unimak Is. (1)
62-455	55°03', 159°45' (2)	63-1308	Caton Is. (1)
63-131	Unalaska Is. (1)	63-1338	Caton Is. (1)
63-297	Amchitka Is. (1)	63-1339	Unalaska Is. (1)
63-358	Bristol Bay (6)	63-1375	Unalaska Is. (1)
63-891	Attu Is. (1)	63-1422	Adak Is. (2)
63-1009	Attu Is. (5)	W64-31	Adak Is. (14)

Gulf of Alaska

BC62-466	56°24', 153°30' (10)	BC63-1156	Craig (1)
63-174	Cordova (1)	W65-56	Wingham Is. (4)
63-430	Prince William Sd. (2)	65-51	Wingham Is. (1)
63-1026	Kodiak (Woody Is.) (10)	65-55	Wingham Is. (6)

S. E. Alaska

BC63-259	Port Walker, Baranof Is. (1)	BC63-261	Port Walker, Baranof Is. (1)
		W65-9	Prince of Wales Is. (5)

British Columbia

BC53-301	Denman Is. (7)	BC61-610	Work Channel (2)
55-14A	Vancouver (3)	61-674	Nescall Bay (10)
55-58	Strait of Georgia (10)	61-686	Vargus Is. (1)
58-405	Howe Sound (1)	62-93	Nass Bay (13)
59-507	Mexicana Point (1)	62-94	Sydney Inlet (1)
60-416	Gillet Arm (Queen Charlottes) (7)	62-874	Sooke (1)
		63-732	Keats Is. (12)
61-232	Hecate Strait (1)	63-782	Hope Is. (6)
61-393	Bute Inlet (3)	65-131	West coast Vancouver Island (14)
61-609	Bute Inlet (7)		

Table I. Variation of gill raker counts in *Lepidopsetta*.

	5	6	7	8	9	10	11	12	13	14	15	Number	Mean
Japan (+ type)	..	..	1	..	2	..	..	..	..	..	..	3	8.33
West. N. Pacific	..	..	..	..	..	6	7	5	1	..	..	19	11.05
Sea of Okhotsk	..	..	..	..	..	3	8	8	1	..	..	20	11.35
Commander Islands	..	..	..	..	..	1	2	..	..	..	..	3	10.67
Bering Sea	..	..	..	..	..	1	7	5	..	..	..	13	11.31
Pribilof Islands	..	..	..	..	..	2	1	..	..	..	..	3	10.33
Bristol Bay	..	..	..	..	3	2	1	..	..	..	..	6	9.67
Attu Island	..	..	..	..	1	1	3	1	..	..	..	6	10.67
Amchitka Island	..	..	..	..	..	1	5	..	..	..	..	6	10.83
Adak Island	..	..	..	..	1	6	5	4	..	..	..	16	10.75
Umnak Island	..	..	..	..	..	..	1	1	2	..	..	4	12.25
Alaska Peninsula	..	..	..	..	2	2	1	..	..	..	..	5	9.80
Kodiak	..	..	..	..	2	5	8	3	2	..	..	20	10.90
Cordova and Prince William Sound	..	..	..	..	..	2	9	2	..	..	..	13	11.00
Baranof, Craig	..	..	..	2	1	2	4	..	..	..	..	9	9.89
Hecate Strait	..	1	..	1	1	7	3	1	..	..	..	14	10.15
Trail Bay	..	1	1	2	2	..	..	..	..	..	..	6	7.83
Aero	..	..	..	..	1	3	2	1	..	..	..	7	10.43
Noca Bay	..	1	..	1	5	4	2	..	..	..	..	13	9.31
Dean Channel	..	1	..	2	1	2	1	1	..	..	..	8	9.25
West Vancouver Island	..	..	8	2	3	..	..	..	..	..	..	13	8.31
Hope Island	..	..	7	2	..	..	..	..	..	..	..	9	7.22
Bute Inlet	..	1	5	2	2	..	..	..	..	..	..	10	7.50
Denman Island	..	..	5	2	..	..	..	..	..	..	..	7	7.29
Gabriola Island	..	1	6	1	1	..	..	..	..	..	..	9	7.22
Keats Island	..	..	5	5	2	..	..	..	..	..	..	12	7.75
Puget Sound	..	1	5	7	4	..	1	..	..	..	..	18	8.00

Table II. Variation in lateral line pores in Lepidopsetta.

Locality	Lateral line pores																													Number	Mean
	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102-114	115		
Japan (+ Hubbs + type)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	2	..	..	1	..	1	7	100
West. N. Pacific	..	..	..	..	..	..	..	..	..	..	1	..	1	1	5	1	2	4	2	..	1	..	..	1	..	..	..	..	..	19	90.73
Sea of Okhotsk	..	..	..	..	..	..	..	..	1	1	..	3	3	3	..	4	3	2	1	..	..	..	..	..	..	..	..	..	..	22	88.86
Bering Sea + Commander Islands	..	..	..	..	..	..	..	..	..	..	1	3	1	1	3	2	2	2	1	..	..	..	..	..	..	..	..	..	..	16	89.00
Pribilof Islands	..	..	..	..	..	..	..	..	..	1	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	85.67
Bristol Bay	..	..	..	..	..	..	..	..	..	1	1	1	..	1	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	5	87.20
Attu Island	..	..	..	..	..	..	..	..	..	1	..	2	..	..	..	1	..	1	..	..	..	1	..	..	..	..	..	..	..	6	89.00
Amchitka Island	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	85.00
Adak Island	..	..	..	..	..	2	1	2	4	3	..	..	1	..	1	1	1	..	..	..	..	..	..	..	..	..	..	..	..	16	84.13
Umnak Island	..	..	..	..	..	..	1	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	84.00
Kodiak	..	..	..	..	..	..	..	..	..	2	3	4	2	2	1	3	2	1	..	..	..	..	..	..	..	..	..	..	..	20	87.50
Cordova and Prince William Sound	..	..	..	1	..	..	..	..	2	1	2	1	1	1	1	1	1	..	1	..	..	..	1	..	..	..	..	..	..	14	87.07
Baranof, Craig	..	..	..	..	1	1	..	..	1	1	2	..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8	83.88
Hecate Strait	..	..	..	1	..	..	2	5	..	3	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		
Trail Bay	..	..	..	..	..	..	..	1	1	2	1	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	7	85.86
Aero, Queen Charlottes	..	..	..	1	..	1	1	2	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	81.50
Noca Bay	..	..	..	..	1	..	1	3	4	2	2	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	13	83.08
Dean Channel	..	..	..	..	1	..	1	..	1	1	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	83.10
West Vancouver Island	..	1	..	1	2	1	2	2	2	1	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	14	81.28
Hope Island	..	..	..	1	..	..	2	1	..	1	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	83.50
Bute Inlet	..	..	2	1	1	..	..	2	2	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10	81.10
Denman Island	..	..	..	2	..	1	1	..	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	80.86
Gabriola Island	..	..	..	..	1	..	2	1	1	2	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10	82.10
Keats Island	2	..	2	3	..	1	2	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	12	78.61
Puget Sound	..	..	2	1	3	3	4	2	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	18	80.39

Table III. Variation of dorsal rays in Lepidopsetta.

	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	Number	Mean
Japan 56-355 (+ Hubbs)	..	..	..	..	..	..	..	1	2	1	1	..	1	..	1	..	..	..	7	74.71
West. N. Pacific	..	..	..	..	..	..	..	4	1	4	4	1	1	1	2	1	..	..	19	75.05
Sea of Okhotsk	..	..	..	..	1	1	2	1	1	3	3	4	3	..	1	1	..	..	21	74.62
Commander Islands	..	..	..	..	..	..	..	..	..	..	2	1	..	..	..	..	..	..	3	75.33
Bering Sea	..	..	..	..	..	..	..	1	..	2	3	2	1	2	..	1	..	1	13	76.31
Pribilof Islands	..	..	..	..	..	..	1	..	..	..	..	2	..	..	..	..	..	..	3	74.33
Attu Island	..	..	..	..	..	..	..	..	..	..	4	..	1	..	1	..	..	..	6	76.00
Adak Island	..	..	..	..	..	..	1	1	3	2	1	3	1	..	..	2	..	..	14	75.00
Kodiak	..	..	..	..	1	..	..	..	2	3	1	3	2	4	..	3	..	1	20	76.40
Cordova and Prince William Sound	..	..	..	..	..	..	..	..	1	2	1	..	2	2	1	..	1	..	10	76.60
Baranof, Craig	1	..	1	..	..	..	1	..	1	1	1	..	..	..	..	..	..	..	6	70.83
Trail Bay	..	..	..	..	..	..	..	..	..	1	..	2	..	..	..	1	..	..	5	78.00
Aero, Queen Charlottes	1	..	..	1	2	..	..	..	2	..	..	..	1	..	..	..	..	..	7	70.57
Noca Bay	..	..	..	1	..	1	1	3	1	3	0	2	1	..	..	..	..	..	13	73.00
Dean Channel	..	1	..	1	2	..	2	..	..	..	1	1	..	..	..	..	..	..	8	70.62
West Vancouver Island	..	..	..	..	..	..	..	1	..	1	3	2	3	4	..	1	..	1	16	76.75
Hope Island	..	..	..	..	..	..	..	..	..	..	..	1	2	1	1	1	..	..	6	77.83
Bute Inlet	1	..	..	1	1	..	..	1	1	..	1	3	..	1	..	..	..	..	10	72.80
Denman Island	..	..	..	..	..	..	..	1	2	2	1	..	1	..	..	..	..	..	7	74.00
Gabriola Island	..	..	..	..	..	..	1	..	..	3	..	3	..	..	2	1	..	..	10	75.90
Keats Island	..	..	..	..	..	..	..	1	1	1	2	3	1	1	1	..	1	..	12	75.15
Denman Island	..	..	..	..	..	..	..	1	2	2	1	..	1	..	..	..	..	..	7	74.00
Puget Sound	..	..	..	..	..	1	..	3	2	1	1	3	2	2	1	..	..	..	18	73.72
45°N	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	1	73.00

Table IV. Variation of anal rays in <u>Lepidopsetta</u>.

	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	No.	Mean
Japan (+ Hubbs + type)	..	..	..	..	..	..	..	2	..	3	1	1	..	..	..	..	7	58.86
W. N. Pacific	..	..	..	..	1	1	1	3	1	6	3	1	2	..	..	..	19	59.10
Sea of Okhotsk	..	..	..	..	..	..	1	8	1	4	3	4	..	1	..	..	22	58.77
Commander Islands	..	..	..	..	..	..	1	..	1	1	..	..	..	..	..	..	3	57.67
Bering Sea	..	..	..	..	..	..	2	..	4	3	1	..	..	1	..	..	13	58.08
Pribilof Islands	..	..	..	..	1	..	..	1	1	..	..	..	..	..	..	..	3	56.33
Attu Island	..	..	..	..	..	..	..	2	2	..	2	..	..	..	..	..	6	58.33
Adak Island	..	..	..	..	..	..	2	1	2	3	3	3	..	..	..	..	14	59.07
Kodiak	..	..	..	..	..	1	1	3	2	3	3	4	2	..	..	..	19	59.10
Cordova and Prince William Sound	..	..	..	..	..	..	1	4	2	1	2	1	..	..	..	..	11	58.18
Baranof, Craig	..	1	1	..	..	1	1	1	1	..	..	..	..	..	..	..	6	54.83
Trail Bay	..	..	..	..	1	..	1	..	..	..	1	2	..	..	..	..	5	58.40
Areo, Queen Charlottes	1	1	..	2	..	1	1	..	1	..	..	..	..	..	..	..	7	53.71
Noca Bay	..	..	..	..	4	..	2	3	4	..	..	..	..	..	..	..	13	56.23
Dean Channel	..	..	1	1	1	2	2	..	..	..	1	..	..	..	..	..	8	55.13
West Vancouver Island	..	..	..	..	1	..	1	2	1	2	6	1	1	..	1	1	17	59.53
Hope Island	..	..	..	..	..	..	1	..	1	..	4	..	..	..	..	1	7	59.86
Bute Inlet	..	..	1	..	2	..	1	1	3	..	1	1	..	..	..	..	10	56.80
Gabriola Island	..	..	..	..	..	2	..	2	2	..	2	1	1	..	..	..	10	58.30
Keats Island	..	..	..	..	..	..	3	1	5	1	1	1	..	..	..	..	12	58.08
Denman Island	..	..	..	..	..	..	..	4	1	..	1	1	..	..	..	..	7	58.14
Puget Sound	1	1	..	..	..	3	3	3	2	1	3	..	1	..	..	..	18	56.77

Table V. Variation of vertebrae counts in Lepidopsetta.

Locality	Precaudal Vertebrae		Caudal Vertebrae					Total Vertebrae					
	10	11	28	29	30	31	Mean	39	40	41	42	Number	Mean
Japan BC 56-355	..	2	..	..	2	..	30.00	..	..	2	..	2	41.00
W. N. Pacific BC 63-403	..	14	..	2	11	1	29.93	..	2	11	1	14	40.93
Sea of Okhotsk BC 63-395	1	12	1	3	9	..	29.62	2	2	9	..	13	40.54
Aleutian Islands + Bristol Bay BC 63-917; BC 63-1422; BC 63-1009	..	10	..	5	5	..	29.50	..	5	5	..	10	40.50
Gulf of Alaska BC 65-56; BC 63-1026; BC 58-205; BC 62-466; W65-51; W65-55	..	21	1	9	10	..	29.45	1	9	10	..	20	40.45
Queen Charlotte Islands BC 60-416; BC 62-93	..	26	2	16	8	..	29.08	2	16	8	..	26	40.08
Southern British Columbia BC 53-301; 55-58; 61-610; 61-609; 61-393; 62-94; 62-874; 63-732	..	33	..	5	25	3	29.94	..	5	25	3	33	40.94

Table VI. Correlation between dorsal and anal rays in _Lepidopsetta_.

	53	54	55	56	57	58	59	60	61	62	63
69	..	..	..	..	1	..	..	..	..	..	..
70	..	..	..	..	1	..	..	..	..	..	..
71	..	..	..	..	1	..	..	1	..	..	..
72	..	1	..	2	2	..	1	..	..	..	..
73	1	..	..	..	..	..	1	..	..	..	..
74	..	..	..	1	5	2	2	..	..	..	..
75	..	..	1	1	1	2	4	1	1	..	..
76	..	..	..	1	1	1	2	2	1	..	..
77	..	..	..	..	..	..	3	1	1	..	..
78	..	..	..	..	..	..	2	..	..	1	..
79	..	..	..	..	..	..	..	1	1	1	..
80	..	..	..	..	..	..	..	..	1	..	2
81	..	..	..	..	..	..	..	..	..	..	..
82	..	..	..	..	..	..	..	1	..	..	..

Table VII. Asymmetry of pectoral fin-ray counts in Lepidopsetta.

B.C. Numbers used	Locality	Left or Right	Pectoral Rays 8	9	10	11	12	13	Number	Mean
63-403	W. N. Pacific	R	1	..	1	13	4	..	19	11.00
		L	..	..	2	14	3	..	19	11.05
679, 684	W. Bering Sea	R	..	..	1	7	5	..	13	11.31
		L	..	..	1	6	6	..	13	11.38
31, 891, 63-1009, 1375	Aleutian Islands	R	..	..	2	17	2	..	21	11.00
		L	..	..	6	14	1	..	21	10.76
406, 1026	Kodiak	R	..	..	7	8	4	1	20	10.95
		L	..	..	10	6	4	..	20	10.70
W55, W56, W57	Prince William Sound area	R	..	..	1	8	2	..	11	11.09
		L	..	1	3	7	..	..	11	10.55
61-610, 674, 61-609, 61-393	Dean Channel, Bute Inlet, Work Channel	R	..	..	..	12	8	..	20	11.40
		L	..	..	1	17	2	..	20	11.05
405, 53-301, 63-732, 55-58	Denman Island, Gabriola Island, Keats Island	R	..	..	2	19	7	1	29	11.24
		L	..	..	3	20	6	..	29	11.10
Cumulative Total	Alaska to USSR	R	1	..	12	53	17	1	84	11.05
		L	..	1	22	47	14	..	84	10.88
	British Columbia	R	..	..	2	31	15	1	49	11.31
		L	..	..	4	37	8	..	49	11.08
	Locality	N	L	R		100 (L + R) / N		100 R / (L + R)	100P	
Hubbs & Hubbs	Alaska to USSR	103	9	25		33.001		73.53		
	British Columbia	77	6	26		41.558		81.25		

Distribution, Synonymy and Variation in the shortspine channel rockfish, *Sebastolobus alascanus* Bean

Index

Introduction

The North Pacific genus Sebastolobus Gill is comprised of three species, broadly distributed geographically and vertically in depth.

A single species occurs in Japan and two others range from Bering Sea to Baja California in the eastern Pacific where they occur to depths of at least 800 fathoms. The group has not been studied in detail and little is known of their systematic variability. Only specimens of Sebastolobus alascanus Bean are available in sufficient number and form the basis for the present analysis.

Synonymy

Sebastolobus alascanus Bean, Proc. U.S. Nat. Mus. V., 13, 1890: 44 (original description). -- Gill, Rept. Smithson. Inst., 375, 1880 (description of genus). -- Eigenmann and Eigenmann, Ann. New York Acad. Sci., 6, 1892: 349 (depth, distribution and synonymy). -- Eigenmann and Beeson, Proc. U. S. Nat. Mus., V,17, 1894: 380 (revision of fishes of the subfamily Sebastinae). -- Gilbert, Rept. U.S. Comm. Fish & Fish., 1893: 409, 468 (description). -- Jordan and Evermann, Bull. U.S. Nat. Mus., 47(2), 1898: 1761. -- Jordan and Gilbert, Rep. Fur-Seal Invest. 1896, II, 1899: 445. -- Gilbert, Rept. U.S. Comm. Fish & Fish., 1899: 25 (Santa Catalina Island and Monterey Bay). -- Evermann and Goldsborough, Bull. U.S. Bur. Fish., 26, 1907: 279 (Alaska). -- Gilbert and Burke, Bull. Bur. Fish., 30, 1912: 35 (Bering Sea and Kamchatka). -- Gilbert, ibid., 1915: 328. -- Townsend and Nichols, Bull. Amer. Mus. Nat. Hist., 52, 1925: 1-20 (intergradation). -- Hubbs, Am. Mus. Nov., 216, 1926: 1 (supposed intergradation between alascanus and altivelis). -- Jordan, Evermann and Clark, Rept. U.S. Fish Comm. 1928, pt. II, 1930: 364. -- Taranetz, Vest. D.N. Fil. SSSR, 1933, 1-3: 67 (Okhotsk record). -- Clark, Calif. Fish & Game, 21, 1, 1935: 85 (Description alascanus, habitat, range). -- Schultz, Univ. Wash. Pub. Zool. 2(4), 1936: 103-228 (Keys to the fishes of Washington, Oregon and closely adjoining regions.). -- Barnhart, Bull. Scripps Inst. Oceanog. Techn. Ser. 3, 1937: 87 (habits, eggs and young). -- Phillips, Comm. Fish. Catch of Calif., 1937: 43. -- Phillips, Calif. Fish & Game, 25(3), 1939: 217, 219 (common names, channel rockfish, fagiano, scorpion, deep sea rock cod, fishery uses). -- Phillips, Comm. Fish Catch of Calif., 1949: 116. -- Shmidt, Trudy Tikhook. Komiteta, VI Akad. Nauk SSSR, Moskvo, 1950: 129 (synonymy). -- Alverson, U.S. Fish & Wildl. Serv., Comm. Fish. Rev., 13(11), 1951: 8 (deep-water trawling survey off Washington). -- Cleaver, Oreg. Fish. Comm., No. 16, 1951: 15. -- Alverson and Welander, Copeia, 3, 1952: 140 (key). -- Roedel, Calif. Dept. Fish & Game, Fish Bull., 91, 1953: 136 (scales on branchiostegals of altivelis lacking on alascanus).-- Wilimovsky, Stanf. Ichthy. Bull., 4(5), 1954: 284 (List of the fishes of Alaska). -- Phillips, Calif. Dept. Fish & Game, Fish Bull., 104, 1957: 36 (review of the rockfishes of California). -- Phillips, Calif. Dept. Fish & Game, Fish Bull., 105, 1958: 19 (spawning & catch). -- Wilimovsky, Fish. Res. Lab., U.S. Fish & Wildl. Serv., 1958, 49 (Provisional keys to the fishes of Alaska). -- Clemens and Wilby, Bull. Fish. Res. Bd. Canada, 68, 1961: 280 (Fig. description, common name, length, keys [artificial], range, depth distribution). -- Inter-Pacific Halibut Comm., Rept. Trawl Survey 1961-1962 (distribution and depth). -- Pearcy, J. Fish. Res. Bd. Canada, 19(6), 1962: 1169 (depth, distribution, 400-600 fms. for adults; post larvae and egg figures; Sebastolobus egg and young characteristics). -- Alverson, Pruter and Ronholt, H.R. MacMillan Lect. Fish., Inst. Fish., Univ. B. C., 1964: 90 (Fishes and fisheries of the northeastern Pacific Ocean).

Range of Sebastolobus

The known occurrence of Sebastolobus alascanus is from the Bering Sea, along the Aleutian Islands south to Baja California. The Okhotsk Sea record (Taranetz, 1933) has not been confirmed.

The suggested intergradation of Sebastolobus alascanus with S. altivelis by Townsend and Nichols (1925) has been shown by Hubbs (1926) to be in error due to mis-identification of their collections.

Variation and Systematic Status of Sebastolobus

The meristic and morphometric characters used to separate the species of Sebastolobus have been chiefly number and relative size of dorsal spines. In addition to these characters we have analyzed dorsal, anal and pectoral fin-rays, gill-raker numbers, lateral line pores, body depth and vertebral count. Measurements have been made according to the methods of Hubbs and Lagler (1958) except for body depth which was taken as the distance from the anterior tip of the dorsal fin base to the base of the pelvic fins.

Collections of Sebastolobus alascanus have been examined from the Bering Sea, Alaska, to off the mouth of the Columbia River, Washington. Because of the broad vertical range of the species variation in morphometric and meristic characters was analyzed both in terms of geographic distribution and depth strata.

The five geographic areas tested were Bering Sea, Aleutian Islands, southeast Alaska, British Columbia and Washington. Depth data were categorized by 50-fathom intervals.

Results

The morphometric data obtained for all specimens are summarized by geographic area in Table I. Differences between the means for each morphometric character measured are small and do not show any consistent trends latitudinally. An analysis of variance was not considered because of the very small differences shown.

Table II summarizes differences for the three morphometric characters examined by depth. The differences between means among four different depth ranges are small but do show more consistent trends than do the geographic changes. The spine lengths increase with greater depth and body depth decreases with increasing depth. The differences are small and probably do not indicate any racial differences.

The meristic counts are summarized in Table III for each geographic area. Differences among the means do not show any consistent trends. The clinal trend shown by upper gill-raker counts is strong but is probably insignificant in terms of population structure, as shown by the total count.

Table IV summarizes these same meristic counts examined by depth. As with latitudinal differences, the mean differences shown are not great, and no consistent trends are expressed.

Conclusions

As a result of the significant increase in numbers of specimens used in the present analysis most of the criteria used previously for systematic assessment in Sebastolobus have been shown to possess much greater variation than had been expected.

Analyses of morphometric and meristic data indicate only small differences between character means, both geographically and in depth. Clinal trends were not evident and there is no firm indication of racial groupings.

Trends for morphometric data by depth stratum were evident but mean differences were not statistically significant. Thus, on the basis of present knowledge, Sebastolobus alascanus seems to represent a single species with only incipient clinal differences.

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Townsend, C. H., and J. T. Nichols. 1925. Deep sea fishes of the "Albatross" Lower California Expedition. Bull. Amer. Mus. Nat. Hist., 52: 1-20.

Appendix I.

Record of Specimens used in this Investigation

Bering Sea

BC63-687 59°36', 177°41' (4)

Aleutians

BC62-425	54°20'40", 160°01'20" (1)	BC65-72	Simeonof Island (5)
62-738	55°39', 155°11' (1)	65-73	Bird Island (16)
65-59	Chirikof Island (3)	65-78	Bird Island (1)
65-60	Chirikof Island (16)	65-97	Tigalda Island (35)
65-65	Semidi Islands (11)	65-97	Tigalda Island (7)
65-69	Simeonof Island (1)	65-109	Cape Prominence, Unalaska (9)

S. E. Alaska

MD65-3-9	57°48', 136°50.5' (24)	MD65-3-15	57°13', 136°09' (20)
65-3-10	57°48', 136°50.5' (20)	65-3-32	55°29', 134°57.5' (22)

British Columbia

MD65-3-41	48°49.5', 126°30' (10)	MD65-3-45	48°49', 126°36.5' (10)
65-3-42	48°49.5', 126°30' (9)	65-3-49	48°51.5', 126°23.2' (9)
65-3-44	48°49', 126°36.5' (15)	65-3-52	48°21.5', 125°53' (10)

Washington (Columbia)

BC65-682	46°00', 124°00' (4)	18490	46°00', 124°00' (10)
65-686	46°00', 124°00' (2)	11744	San Juan Island (3)
#11673	45°19.9', 124°23' (1)	10126	Destruction Island (1)
11761	Off Cape Flattery (4)	11743	San Juan Island (1)
18479	46°00', 124°00' (3)	16703	San Juan Island (1)

BC = University of British Columbia, Institute of Fisheries

MD = University of British Columbia, Institute of Fisheries

= University of Washington, College of Fisheries

Table I. Variation of body proportion in *Sebastolobus alascanus*.

		Third Dorsal Spine length	Fourth Dorsal Spine length	Body Depth
		As proportion of standard length		
Aleutians	Mean	7.80	7.00	4.13
	Range	5.94-10.47	5.63-10.14	3.62-4.93
	Number	96	100	105
S.E. Alaska	Mean	7.72	6.89	4.13
	Range	6.89-10.26	6.34-8.86	3.79-4.87
	Number	57	59	66
British Columbia	Mean	7.90	7.04	4.19
	Range	6.22-10.77	5.65-8.27	3.76-4.93
	Number	47	46	52
Washington	Mean	7.81	6.94	4.04
	Range	6.92-9.28	6.31-7.26	3.81-4.51
	Number	18	19	21

Table II. Variation of body proportions according to depth in <u>Sebastolobus alascanus</u>

Fathoms		Third Dorsal Spine length	Fourth Dorsal Spine length	Body Depth
		As proportion of standard length		
50-100	Mean	8.79	7.70	3.97
	Number	11	9	11
100-150	Mean	7.61	6.88	4.16
	Number	88	92	99
150-200	Mean	7.80	6.88	4.20
	Number	42	44	48
200-250	Mean	7.59	6.84	4.29
	Number	54	54	60

Table III. Variation in counts of _Sebastolobus alascanus_.

	Bering Sea	Aleutians	S.E. Alaska	British Columbia	Washington
Right pectoral					
20	1	13	18	3	5
21	..	71	67	42	10
22	3	22	22	16	7
23	..	1	1	2	2
No.	4	107	108	63	24
Mean	21.5	21.1	21.1	21.2	21.3
Left pectoral					
20	1	15	24	4	5
21	..	68	69	41	9
22	3	24	15	17	9
23	..	..	..	1	1
No.	4	107	108	63	24
Mean	21.5	21.1	20.9	21.2	21.2
Dorsal spines					
14	..	1	..	..	1
15	..	5	..	..	1
16	2	85	61	49	19
17	2	16	1	4	3
No.	4	107	62	53	24
Mean	16.5	16.1	16.0	16.1	16.0
Dorsal rays					
8	1	10	..	2	..
9	3	82	56	46	19
10	..	15	6	5	4
No.	4	107	62	53	23
Mean	8.8	9.1	9.1	9.1	9.2

continued...

Table III (cont'd.)

	Bering Sea	Aleutians	S.E. Alaska	British Columbia	Washington
Lateral line pores					
30	..	3	..	..	..
31	..	8	9	2	..
32	2	51	68	30	9
33	1	32	19	22	6
34	1	3	3	2	1
35	..	2	..	..	..
No.	4	99	99	56	16
Mean	32.8	32.3	32.2	32.4	32.5
Pre-caudal vertebrae					
10	..	55	49	35	..
11	..	26	3	6	4
No.	..	81	52	41	4
Mean	..	10.3	10.1	10.2	11.0
Caudal vertebrae					
18	..	..	1	..	..
19	..	16	..	4	2
20	..	59	48	31	2
21	..	6	3	6	..
No.	..	81	52	41	4
Mean	..	19.9	20.0	20.1	19.5
Total vertebrae					
29	..	5	1	1	..
30	..	60	53	34	2
31	..	22	7	9	2
No.	..	87	61	44	4
Mean	..	30.2	30.1	30.2	30.5

continued...

Table III (cont'd.)

	Bering Sea	Aleutians	S.E. Alaska	British Columbia	Washington
Upper gill rakers					
5	..	4	7	1	..
6	4	57	55	31	6
7	..	29	44	24	12
8	..	3	2	6	3
No.	4	93	108	62	21
Mean	6.0	6.3	6.4	6.6	6.9
Lower gill rakers					
11	..	..	..	..	..
12	..	6	1	1	2
13	..	50	48	13	6
14	4	32	49	36	12
15	..	5	9	10	1
16	..	..	1	2	..
No.	4	93	108	62	21
Mean	14.0	13.4	13.6	14.0	13.6
Total gill rakers					
18	..	7	6	..	2
19	..	37	27	7	1
20	4	30	43	28	7
21	..	14	25	17	8
22	..	4	5	7	3
23	..	1	2	3	..
No.	4	93	108	62	21
Mean	20.0	19.8	20.0	20.5	20.4

Table IV. Variation in counts according to depth in Sebastolobus alascanus.

Fathoms	Right Pectoral	Left Pectoral	Dorsal Spines	Dorsal Rays	L.L. Pores	Pre-caudal Vertebrae	Caudal Vertebrae	Total Vertebrae	Lower Arch Rakers	Upper Arch Rakers	Total Gill Rakers
50-100											
Mean	21.4	21.6	16.1	9.0	32.7	10.4	19.9	30.2	7.0	13.7	20.7
Number	9	9	9	9	9	7	7	9	9	9	9
100-150											
Mean	21.1	21.0	16.1	9.1	33.2	10.2	19.9	30.1	6.4	13.6	20.1
Number	90	90	90	90	80	70	70	77	90	90	90
150-200											
Mean	21.1	21.0	16.0	9.1	32.2	10.1	20.0	30.1	6.3	13.7	20.0
Number	48	48	48	48	41	44	44	48	47	47	47
200-250											
Mean	21.1	21.1	16.1	9.0	32.2	10.3	19.9	30.2	6.4	13.3	19.7
Number	61	51	51	51	50	53	53	58	51	51	51