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by

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ABSTRACT

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A taxonomic and life history study of the inconnu was carried out on populations from the Kobuk, Chatanika, and upper Yukon Rivers, and Selawik, Alaska.

Data on 24 morphological measurements and 11 meristic counts show little difference among: 1) males and females; 2) young and older inconnu; and 3) fish from the upper Yukon River, Chatanika River, Selawik, and Kobuk River in Alaska and the Ob River, USSR. Based on close agreement of these counts and measurements, the inconnu in Alaska is designated as *Stenodus leucichthys nelma* (Pallas).

For an arctic fish, the inconnu exhibits a rapid growth rate. Growth rates for males and females are similar, but females live longer than males.

Alaskan inconnu become sexually mature quite late in life (for Selawik males, 9 years; females, 10 years). Spawning behavior is described. Spawning occurred in the Kobuk River above Kobuk the last days of September at water temperatures between 1.4 and 4.6 C.

Older inconnu are mainly piscivorous while the younger fish feed on invertebrates and fish. The least cisco, *Coregonus sardinella*, was the main food item of the Selawik inconnu.

The estimated catch in Northwest Alaska in 1965 was between 34,200 and 37,000 fish, 85% of which were taken for subsistence.

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TAXONOMY AND ECOLOGY OF THE INCONNU, *STENODUS LEUCICHTHYS NELMA*, IN ALASKA

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INTRODUCTION

The inconnu, *Stenodus leucichthys* (Guldenstadt), is a member of the whitefish family Coregonidae and is distributed halfway around the world, mainly in arctic and subarctic North America and Siberia. Despite its large size and its importance as a fish with subsistence, commercial and sport value, virtually no research has been carried out on the inconnu in Alaska.

By contrast, Russian fishery biologists have been studying the inconnu since before the turn of the century and have built up a vast storehouse of knowledge concerning its life history. Inconnu have been raised in hatcheries in Russia since the 1920's.

L. S. Berg (1908, 1916, 1932, and 1948) carried out much early research on the distribution, description, and systematics of the inconnu. Systematic relationships have been worked out by Menshikov (1935). Detailed age and growth studies were conducted by Chumayevskaya-Svetovidova (1930). Romanova (1937), Revnin (1937), and Kirilov (1962) studied the food habits of the inconnu. Work on the spawning, embryology, and early development of the young was carried out by Evteeva (1940), and Smolyanov (1957). Parasites of the inconnu were thoroughly studied by Zaxvanthin (1938) in Zaysan Lake. Monographic works on the inconnu from the Ob and Yenesei Rivers were completed by Vork (1948a, 1948b). In addition to basic life history studies, Russian scientists are far advanced in their studies of the fishery industry and pisciculture of the inconnu. Boricov (1923) conducted a fundamental industrial-biological study of the inconnu from the lower Ob basin, and these subjects were further developed by Yudanov (1935) and Sydakov (1939).

Canadian research has dealt mainly with records of distribution, taxonomy, and zoogeography. Fuller (1955) published a general life history study of the inconnu in Great Slave Lake.

Previous published information on the inconnu in Alaska consists mainly of short notes on distribution and records of occurrence (e.g. Dall, 1870;

Turner, 1886; Townsend, 1887; and Bean, 1892). Walters (1955) presented information on the zoogeography of the inconnu in Alaska.

The present study was oriented toward taxonomy, basic biology, and ecology with emphasis on determining the systematic relationship between the inconnu in Alaska and the inconnu in Canada and Russia. Data on food habits, distribution, age and growth are also presented. Spawning observations were conducted on the upper Kobuk River in 1965 and 1966.

ACKNOWLEDGMENTS

Upper Yukon River research was financed by National Science Foundation Grants G17383 and GB2171 to Dr. James E. Morrow. Research at Selawik and the Kobuk River was financed by grants from the Sport Fishing Institute to Dr. Morrow.

I would like to express my appreciation to Dr. James E. Morrow, Professor of Fisheries Biology, for his help and guidance throughout the study and for his critical reading of the manuscript. Dr. Frederick C. Dean, Head, Department of Wildlife Management and Dr. David R. Klein, Leader, Alaska Cooperative Wildlife Research Unit, critically read the manuscript. Special thanks are due Mr. Samuel J. Harbo, Instructor in Biometrics, who spent many hours on the biometric analysis of taxonomic data and age and growth information. Dr. L. P. Schultz, U. S. National Museum, and Dr. Norman Wilimovsky, University of British Columbia, supplied the Ob River specimens. Gratitude and appreciation are also extended to the residents of Selawik, Kotzebue, and the Kobuk valley for their cooperation and warm hospitality during my research study in northwestern Alaska.

STUDY AREA

The present study was conducted in two Alaskan watersheds, the Yukon River in eastcentral Alaska and the Selawik-Kobuk drainage in northwest Alaska.

Research in the upper Yukon River was carried out from Circle, 1,900 km (1,200 miles) from the mouth of the Yukon River, to Eagle, covering an approximate area from 141° to 144° W Long. and from 64°55′ to 66° N Lat. (Fig. 1). Five tributary rivers enter the Yukon in the 288 km (180 mile) stretch between the two villages. The Charley and Seventymile Rivers enter from the south, while the Kandik, Nation, and Tatonduk Rivers enter from the north. During the summer these five rivers are rapid, clear streams, in contrast to the silt-laden Yukon River. The ichthyofauna of the study area has been described by Chen (1965).

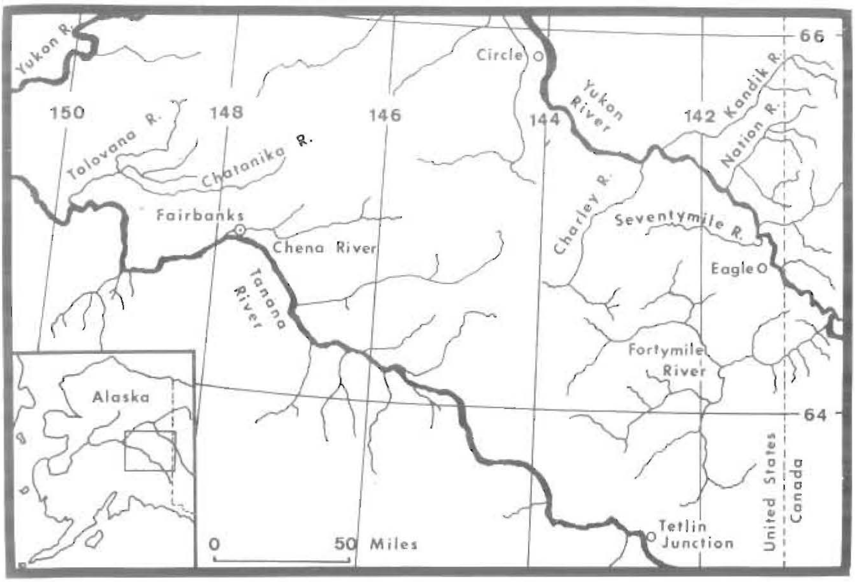


Figure 1. Map showing upper Yukon and Chatanika River study area. Reproduced from U.S.G.S. Alaska Map E.

The Chatanika River is in the Yukon-Tanana drainage and empties into the Tanana via the Tolovana River. Specimens from the Chatanika were taken at approximately 149° W Long. and 65° N Lat. at Mile 29 on the Steese Highway (Fig. 1).

The Selawik-Kobuk study area is located largely above the Arctic Circle and encompasses an area from approximately 154° to 162°30′ W Long. and from 66°20′ to 67°20′ N Lat. (Fig. 2).

Selawik Lake is relatively shallow and connected to Hotham Inlet. It is approximately 40 km (25 miles) long by 24 km (15 miles) wide, and the average depth is reported to be 5.4 m (18 ft). The Selawik area is low tundra with an abundance of lakes and slow-moving streams. The lower Selawik River meanders through the tundra, and the water is dark colored. Above the mouth of the Kugaruk River, as the Selawik River emerges from spruce forests, the water becomes clear and the current swift; the bottom changes from mud and sand to sand and gravel. The headwaters are in the Purcell Mountains. The Selawik and Tuklomarak Rivers empty into Selawik Lake. Tuklomarak River is merely a natural channel transporting water from Inland Lake, Fox River, and Tuklomarak Lake into Selawik Lake and has little current. Formerly there

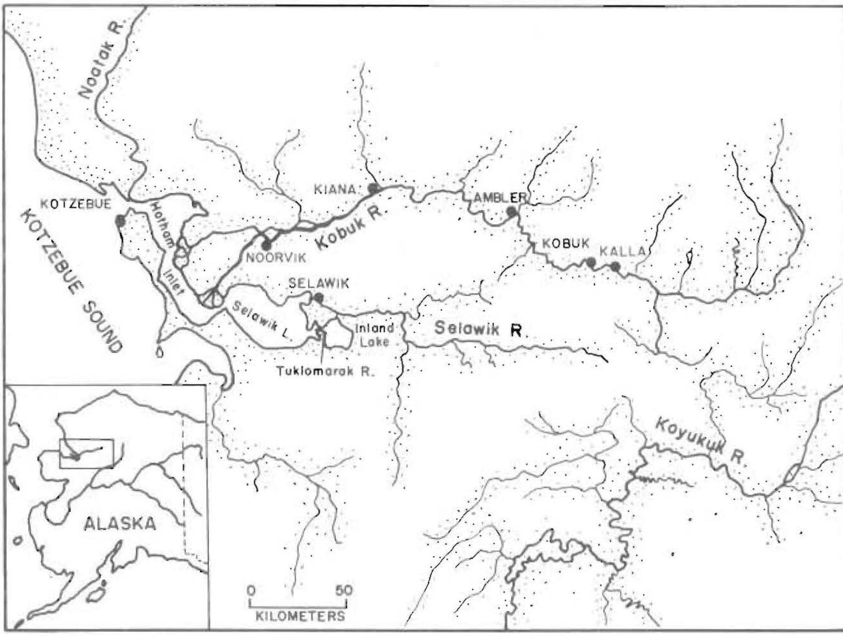


Figure 2. Map of northwest Alaska showing Selawik and Kobuk River study area. Reproduced from U.S.G.S. Alaska Map E.

were no connections between Selawik River and Tuklomarak River, except at flood stage, but since 1960 two man-made channels have been dug. One, about 27 km (17 river miles) up Selawik River, allows part of the Selawik River flow to enter Inland Lake, and the other connects Middle Lake to Tuklomarak River 4.5 km from the mouth.

Hotham Inlet (locally called Kobuk Lake) empties into Kotzebue Sound. It is reportedly a shallow inlet with an average depth of 3 meters, and, since it is influenced by tidal action, is considered brackish water.

The Kobuk River is a relatively shallow river, nearly 800 km (500 miles) long, and has a large delta area with interconnecting sloughs and lakes. In years of low water, such as 1964, upriver travel beyond Kiana is difficult. Water current from the mouths of the Kobuk up to Kiana is relatively slow, being less than 3 mph. Proceeding upriver the velocity increases until maximum velocity is encountered in riffle areas above Kobuk village. Associated with the increased velocity is a change in the stream bottom from silt and sand in the lower reaches, to sand and gravel in the middle reaches, and to a predominantly sand and coarse gravel bottom above Kobuk village. The Kobuk valley is composed of fluvial deposits and contains an abundance of sloughs and small tundra lakes. A narrow band of spruce trees follows the course of the Kobuk River and its tributaries. Headwater regions are above Walker Lake in the Schwatka Mountains of the Brooks Range. The river is clear in periods of normal water level.

The fish associations of the Selawik-Kobuk drainages are arctic in character. The following 18 species were collected during the 1965 field season:

Scientific name	Common name
Kobuk River	
Oncorhynchus keta	chum salmon
Oncorhynchus gorbuscha	pink salmon
Salvelinus namaycush	lake trout
Salvelinus alpinus (malma)	arctic charr-Dolly Varden cx.
Coregonus nasus	broad whitefish
Coregonus lavaretus pidschian	humpback whitefish
Coregonus sardinella	least cisco
Coregonus autumnalis	arctic cisco
Prosopium cylindraceum	round whitefish
Stenodus leucichthys nelma	inconnu
Thymallus arcticus	grayling
Osmerus dentex	rainbow smelt
Catostomus catostomus	northern sucker
Esox lucius	northern pike
Dallia pectoralis	blackfish
Lota lota leptura	burbot
Cottus cognatus	slimy sculpin
Selawik Lake and Selawik River	
Oncorhynchus keta	chum salmon (Selawik R.)
Salvelinus alpinus (malma)	arctic charr-Dolly Varden cx. (Selawik R.)
Coregonus nasus	broad whitefish
Coregonus lavaretus pidschian	humpback whitefish
Coregonus sardinella	least cisco
Stenodus leucichthys nelma	inconnu
Thymallus arcticus	grayling
Osmerus dentex	rainbow smelt
Catostomus catostomus	northern sucker
Esox lucius	northern pike
Dallia pectoralis	blackfish (Selawik R.)
Lota lota leptura	burbot
Pungitius pungitius	ninespine stickleback (Selawik R.)
Cottus cognatus	slimy sculpin (Selawik R.)

METHODS AND MATERIALS

Of the 683 fish utilized in the present study, 109 were taken in the Yukon River between Circle and Eagle in the summers of 1961 and 1964; 18 Chatanika River inconnu were taken in the vicinity of the spawning grounds near Mile 29, Steese Highway, in September 1964; 18 were collected in Selawik Lake in April and May 1964, and 261 were taken in the Selawik area between 17 April and 30 June 1965; 105 Kobuk River fish were taken between 1 July and 1 October 1965, and 153 were taken from the spawning grounds above Kobuk in September 1966; and 19 were from the Ob River, USSR. Most inconnu from the Selawik area used in the present study were taken in Selawik Lake at the mouth of the Tuklomarak River. However, fish were also taken from the Selawik River, Fox River, Inland Lake, and Tuklomarak River, and therefore the term "Selawik inconnu" is used to designate fish taken from the Selawik area.

Yukon River specimens were taken by 2-inch and 4-inch (bar measure) gill nets, quarter-inch (bar measure) seine, and sport fishing tackle. All Chatanika River fish were taken by sport fishing tackle. Fish taken at Selawik during April and May were taken through the ice at Selawik by jigging. Nearly all specimens taken after breakup were taken by hook and line. A small part of the gill net catch of native subsistence fishermen was utilized in the study. Kobuk River fish were taken by 2-inch, 2.5-inch, 4-inch, and 5-inch (bar measure) gill nets; beach seine; and sport fishing tackle, and were captured only in the main Kobuk River. Fish from the Ob River, USSR, were on loan from the University of British Columbia and the U. S. National Museum.

Taxonomic measurements on specimens collected during this study were taken almost immediately after capture. The detailed description of these measurements will be found in the section on taxonomy. A Chatillon 15 kg × 20 gr spring scale was used in recording weights, with an 80 lb × 1 lb spring scale being used for larger specimens. Stomachs were placed in 10% formalin in the field and analyzed later at the Department of Wildlife Management, University of Alaska. Insects were identified only to order, since all were partially digested. Sex was determined by gross examination of gonads. It was usually possible to sex all fish over 4 years of age. Biometric analysis of taxonomic data and age and growth information was made using an IBM 1620 computer.

DISTRIBUTION

Stenodus ranges from the White Sea at 40° E Long., to the Anderson River, N.W.T., Canada, at 128° W Long. It is widely distributed in Asia but comparatively local in North America (Dymond and Vladykov, 1934) (Fig. 3). Two landlocked subspecies exist at the extremes of the range, *Stenodus l. leucichthys* at the west in the basin of the Caspian Sea, and

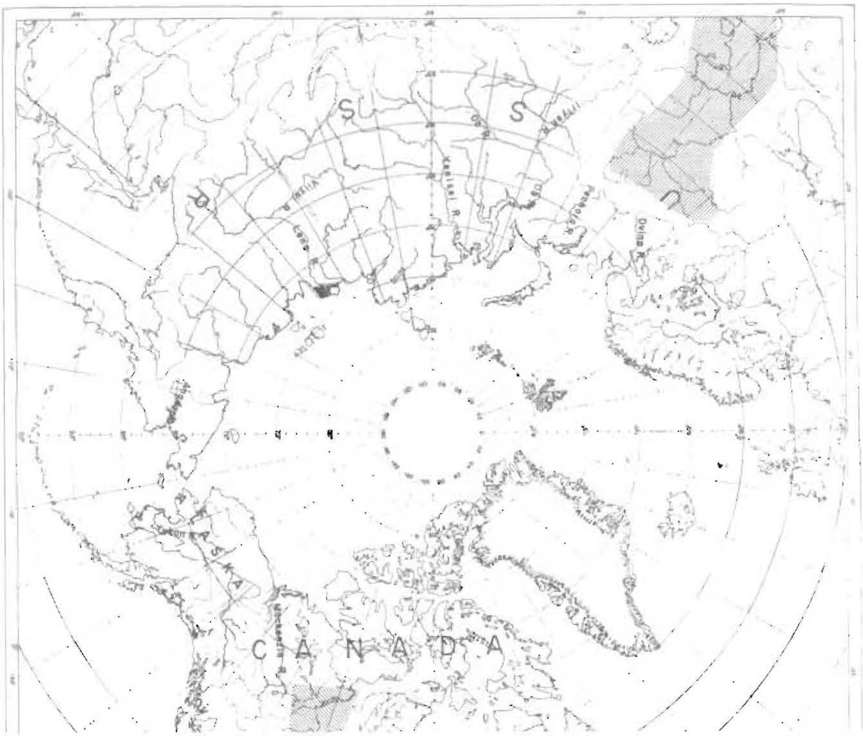


Figure 3. Geographical distribution of *Stenodus leucichthys*. /// *Stenodus leucichthys leucichthys*; ::: *Stenodus leucichthys nelma*; \\\ *Stenodus leucichthys mackenziei*. Russian data mainly from Dymond and Vladykov (1934) and Berg (1932).

Stenodus l. mackenziei at the east in the basin of Great Slave Lake. *Stenodus* is tolerant of wide changes in turbidity and salinity. Some populations are semi-anadromous (migrate from brackish water to fresh water to spawn), while other populations never leave fresh water.

In Russia, *Stenodus leucichthys nelma* is present in the great northern rivers from the White Sea eastward and including the Ponoy, Onega, Dvina, Mezen, Pechora, Ob, Irtysh, Yenisei, Lena, Vilyui, Indigirka, Kolyma, and Anadyr Rivers as well as many of their tributaries. The nominate subspecies *Stenodus l. leucichthys* is landlocked in the temperate Caspian Sea and its tributaries at 47° N Lat.

Bean (1892) gave the Alaskan distribution of the inconnu as from the Kuskokwim to the Kuwuk (Kobuk) River. Alaskan inconnu distribution is discontinuous (Fig. 1). The southernmost occurrence in Alaska is in the Kuskokwim River system (60° N Lat.) and the northernmost occurrence is in the Kobuk River (67° N Lat.). Inconnu are found throughout most of the Yukon River drainage in Alaska and Canada. They enter the Andreavsky, Koyukuk, Porcupine (and its tributaries the Black, Sheenjek, and Coleen??) as well as countless other smaller Yukon River tributaries. Experimental gill nets set in the Chandalar River in 1962 did not take inconnu (Dale Evans, pers. comm.). Inconnu were reported in the Melozitna River (Corps of Engineers, 1964). They enter the Tanana River and are known from some of its tributaries (Tolovana, Chatanika and Chena Rivers). It had been thought that the species was absent from Norton Sound and the Seward Peninsula. However, Matson (1962) stated that natives have reported taking inconnu from the Pikmiktalik and Unalakleet Rivers on Norton Sound. John Nelson (*viva voce*) took two specimens at Deering, and Matson (1962) indicated that inconnu are present in the Buckland River. These records may indicate only casual visitors. The Kobuk and Selawik River drainages (including Hotham Inlet and Selawik Lake) apparently support the largest inconnu populations in Alaska. They inhabit the freshened part of Kotzebue Sound and are taken at Kotzebue and occasionally at Sheshalik. They are not found in the Noatak River except as occasional visitors. The species is absent north of Kotzebue Sound, all across the Arctic Slope until it is again encountered in rivers east of Demarcation Point (Bud Helmericks, Max Brewer, pers. comm.). Inconnu numbers increase eastward from the Firth River area until they are quite abundant in the Mackenzie Delta. The Anderson River was given as the eastern limit in North America (Wynne-Edwards, 1952). The southernmost limit of *Stenodus leucichthys nelma* in Canada is Teslin Lake (Yukon system) where Clemens (1944) took six specimens. Carl, Clemens, and Lindsey (1959) reported the inconnu from the Muskwa River in the Liard-Mackenzie system.

Stenodus leucichthys mackenziei is found in Great Slave Lake, Canada, and utilizes tributary streams of Great Slave Lake for spawning.

Smith (1957) hypothesized that *Stenodus* originated in the rivers of Siberia. Walters (1955) felt that unglaciated Siberian drainages of the Ob, Yenisei, and Lena Rivers were reservoirs for many freshwater fishes including *Stenodus*. He believed that *Stenodus* spread to Alaska either during or after land bridge times and became distributed via brackish water transfer associated with the melting of the Wisconsin stage of glaciation. *Stenodus* then invaded Canada from Arctic Alaska via the Northern Coast in the brackish glacial meltwater, or possibly reached the Mackenzie River from the Yukon valley by headwater transfer.

TAXONOMY

The inconnu is considered to be a single species *Stenodus leucichthys* (Guldenstadt), with three subspecies: *Stenodus leucichthys leucichthys* (Guldenstadt) in the basin of the Caspian Sea, *Stenodus leucichthys nelma* (Pallas) in the basin of the Arctic Ocean, and *Stenodus leucichthys mackenziei* (Richardson) in the basin of Great Slave Lake. The following taxonomic history of the inconnu is taken from Berg (1932):

Genus *Stenodus* Richardson, 1836

Stenodus Richardson In: Back. Narrative of the Arct. Exp. L. 1836, p 521 (Type *Salmo mackenzii*).
Luciotrutta Gunther. Cat. Fish., 1866, Vol. 6, p 164 (type *C. mackenzii*).

Stenodus leucichthys (Guldenstadt), 1771

Salme leuchthys [sic] Guldenstadt. Novi Comment. Petropol., XVI (1771), 1772, pp 533–540 (from the Caspian Sea in winter it comes to the Volga and Urals).
Salmo nelma Pallas. Reise, II, 1773, p 216 (River Toor), p 716 (Siberian distribution).
Sālmo leucichthys Pallas. Zoogr. rooso-asiat., III, 1781, p 392 (Ob, Lena, Kolyma, Indigirka Rivers), p 395 (Kubenskage Lake).
Salmo mackenzii Richardson. Narrative of a journey to the shores of the polar sea, in the years 1819, 20, 21, and 22. 1823, p 207. Murray, London (Mackenzie River).
Coregonus lucius Nilsson. Scand., fauna, IV, 1853, p 446 (Archangel).
Stenodus nelma Smitt. Kritisk Forteckning ofver de i Rikomuseum befintliga Salmonider, 1886. Sv. Ak. Handl., XXI, No. 8, p 207 (Northern Dvina near Archangel).
Coregonis lucichthys Eokhelson. Geography, 1898, No. 3–4, p 75 (Kolyma R., spawning).
Stenodus nelma Varpakhovski. Ann. Zool. Mus. Acad. Sci., IV, 1899, p 329 (Ob River).

The inconnu was first placed in the genus *Salmo* (*Salme* of Guldenstadt) by early taxonomists. When it became evident that it was so morphologically distinct from *Salmo* as to warrant separate generic status, the name *Stenodus,* first suggested by Richardson in 1836, was accepted. The species name *leucichthys* was first advocated by Guldenstadt in 1771 (spelled *leuchthys*) and antedated Pallas' name of *nelma* by two years. Guldenstadt's original description was undoubtedly for *Stenodus leucichthys leucichthys*, since the area listed was the basin of the Caspian Sea. Pallas in 1781 amended the species name to *leucichthys*. Since the species had been described from the Caspian basin, the nominate subspecific name was applied to this form when it was divided into subspecies. In naming the subspecies from Siberia, Berg in 1916 applied the name *Stenodus leucichthys nelma*.

The Alaskan inconnu was formerly considered a distinct species, *Stenodus mackenziei* (Richardson) (Evermann and Goldsborough, 1907). Later it was designated as *Stenodus leucichthys* (Guldenstadt) (Wilimovsky, 1954) and even considered by some to be the same subspecies as the Great Slave Lake form, namely *Stenodus leucichthys mackenziei*. Dymond (1943), Berg (1948), and Walters (1953, 1955) synonymized *Stenodus mackenziei* with *Stenodus leucichthys* and classified the Alaskan inconnu as *Stenodus leucichthys nelma*.

The main meristic characters used in separating the three subspecies have been counts of gill rakers and lateral line scales. Dymond (1943) considered gill raker counts to be the most stable character of northwestern North American coregonine fishes.

Krasikova (1949) gave the mean number of gill rakers of *S. l. leucichthys* as 22.7 (19–26) and for *S. l. nelma* from the Yenisei River as 21 (18–25). Fuller (1955) indicated a mean gill raker count of 23.1 (20–25) for *S. l. mackenziei* from Great Slave Lake, Canada. Mean counts for Alaskan samples ranged from 19.7 to 21.0.

Dall (1870) first recorded the inconnu from Alaska (lower Yukon River) under the name *Luciotrutta leucichthys* (Pallas). Common names given were: English—great whitefish, Russian—naylima, and native—nt'lagn. The first record of the inconnu in northwest Alaska was a specimen taken in 1885 by Townsend (1887) in the Kowak (Kobuk) River. Turner (1886) recorded it from St. Michael on the Yukon River, and Nelson (1887) reported it from the lower Yukon River at Kotlik in 1881.

DESCRIPTION AND COMMON NAMES

A description of the inconnu from Selawik based on measurements of 214 specimens (76 males, 132 females and 6 sex unknown) is given below. The range of the values is shown in the section on results. This description is also applicable to Kobuk River and Yukon River inconnu since measurements and counts are in close agreement.

Head long, 26% of standard length; head width 36% of head length, head depth 49% of head length. Upper jaw 37% of head length. Lower jaw 53% of head length, strong and projecting, reaching a vertical through middle or sometimes posterior of eye. Dentition very feeble, teeth disposed in velvet-like bands; maxillary toothless; vomer, palatines and tongue each with a narrow band of villiform teeth. Nostrils two-flapped. Snout 23%, interorbital width 17%, and orbit diameter 15% of head length. Body elongate and compressed, predorsal length 51% of standard length. Body depth 21%, body width 10%, caudal peduncle depth 6%, dorsal base 11%, dorsal height 16%, adipose base 4%, adipose length 7%, anal base 11%, anal height 13%, P_1 length 16%, and P_2 length 15% of standard length. D. 3 to 4, 11 to 13; A. 2 to 5, 12 to 14; P_1 14 to 17; P_2 11 to 12; lateral line scales 106 (99 to 115); scales above lateral line 13 (12 to 14); scales below lateral line 11 (10 to 14); gill rakers 4 to 7+1+12 to 16; branchiostegals 9 to 12; pyloric caeca 185 (144 to 211), and vertebrae 63 to 67 plus 3 rudimentary. Color silver, upper part of body somewhat darker; dorsal and caudal fins dusky at margins, other fins immaculate. Weight rarely up to 23 kg (50 pounds) although weights of 27 kg (60 pounds) have been reported from the Kobuk River. Dymond (1943) reported a weight of 28.6 kg (63 pounds) from the Mackenzie, and Wynne-Edwards (1952) mentioned a Siberian record of 40 kg (88 pounds). Maximum weight of upper Yukon River inconnu reported is around 6.8 kg (15 pounds). Females grow larger and live longer than males.

A joint committee of the American Fisheries Society and the American Society of Ichthyologists and Herpetologists (Bailey, 1960) had recommended "inconnu" as the acceptable common name for *Stenodus leucichthys*. Sheefish was rejected according to their list of principles governing common names. In Alaska the common name most often used is sheefish, but shee, inconnu, cony, and shovelnose whitefish are also used. In Siberia, the vernacular nel'ma is in common usage, but the common name belorybitsa (whitefish) is also used. The name inconnu originated with early French-Canadian explorers who gave the name *poisson inconnu*, meaning unknown fish.

TAXONOMIC DATA

In the present study 24 body measurements and 11 meristic counts were made on 421 fish (218 from Selawik, 53 from the Kobuk River, 114 from the upper Yukon River, 13 from the Chatanika River, and 19 from the Ob River, USSR).

Counts and measurements were taken on the left side of the body according to the method of Hubbs and Lagler (1957), with the following clarification:

1. Lateral line scale counts were taken to the end of the lateral line.
2. Gill raker counts were made on the first arch to the left side. All

rudimentary rakers were included in the counts. The count was given as the number on the upper limb, plus the number on the angle of arch (always 1) and the number on the lower limb. Thus a fish with 20 gill rakers might be designated as 6+1+13.

3. Vertebrae counts. The last three upturned vertebrae were separated from the typical vertebrae. Thus the total number of vertebrae for a fish with 65 typical and three upturned would be 68.
4. Dorsal and anal rays. Both principal and branched dorsal and anal fin ray counts were taken. The branched ray count is used by many Russian ichthyologists while the common practice in North America is to use the principal ray count. Principal ray counts are presented in Figures 1 and 5. In this count, all rays at least two-thirds the length of the longest ray are counted as principal rays while the rest are designated as rudimentary rays.
5. Standard length is taken from the tip of the snout to the caudal base.
6. Fork length is taken from the tip of the snout to the tip of the middle rays of the caudal fin.
7. Head length is taken from the tip of the snout to the most posterior part of the operculum, excluding the membrane.
8. Postorbital length is the greatest distance between the posterior edge of the bony orbit and the posterior edge of the operculum, excluding the membrane.
9. Interorbital width is measured using least bony width.
10. Orbit diameter is the greatest horizontal distance between free orbital rims.

Dividers and dial calipers were used for measurements. Readings were taken to the nearest millimeter. In most cases measurements were made within a few hours of capture. In addition, data were taken on 60 preserved specimens from the upper Yukon River, including 45 young-of-the-year (age-class 0+); 18 from Selawik; and 19 from Russia. No correction factor was used, and measurements were lumped with those of unpreserved fish.

In reading Russian published data on the morphological measurements and meristic counts, it became evident that methods for taking these measurements and counts were not defined. In order to compare validly my results with Russian results, 19 Russian inconnu from the Ob River were obtained from the University of British Columbia and the U. S. National Museum. Standard lengths of the Russian specimens were from 9.4 to 18.4 cm.

In this study, body measurements are expressed as percentages of

TABLE 1. MORPHOMETRIC CHARACTERS OF YUKON RIVER, ALASKA, INCONNU

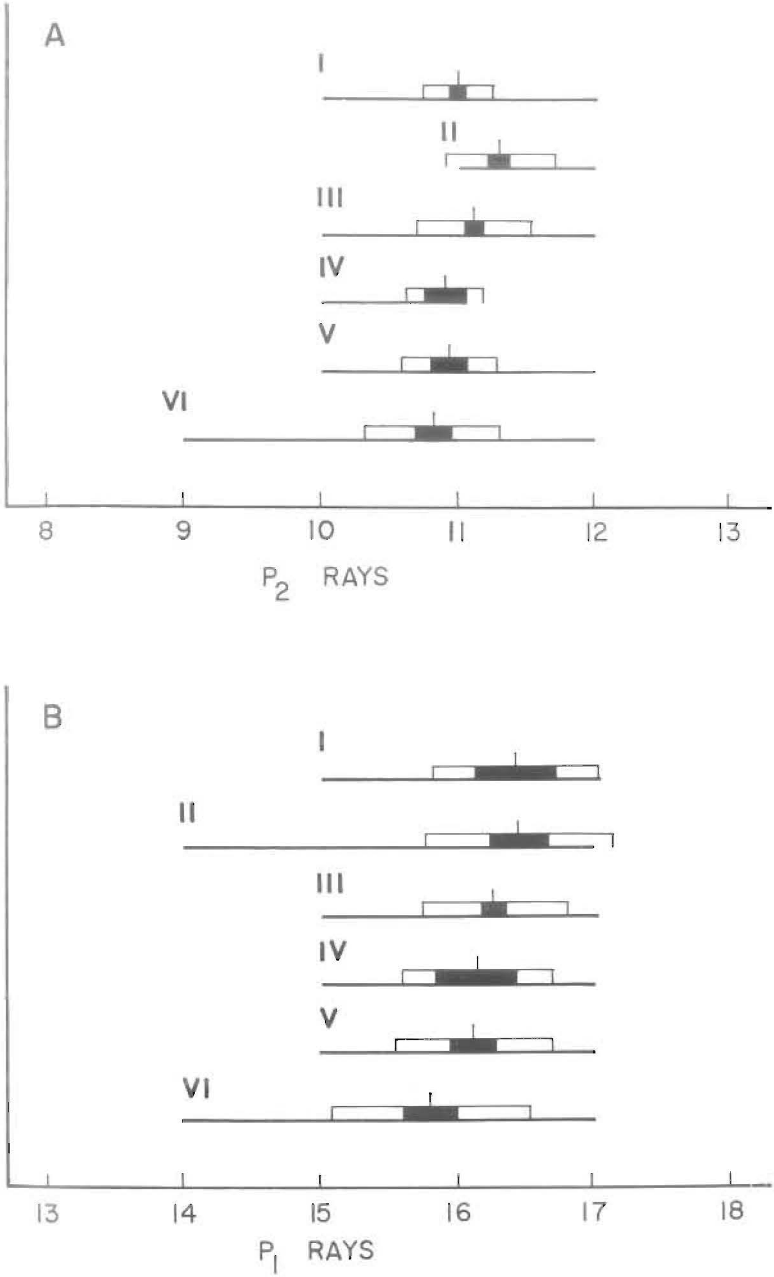
	Age: more than 3 years									Less than 3 years		
	Females			Males			Sexes lumped			Sexes lumped		
Character	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
Morphometry of the head												
In % of S.L.												
head length	26	1.1	24	26	1.3	12	26	1.2	51	29	0.2	58
head depth	14	1.3	23	14	1.4	12	14	1.2	50	12	1.4	56
head width	18	0.7	23	10	1.4	12	10	1.1	50	10	0.9	56
upper jaw length	10	0.4	24	10	0.4	12	10	0.5	51	12	1.2	58
lower jaw length	14	0.7	24	14	0.6	12	14	0.8	51	15	1.0	58
snout length	6	0.4	24	6	0.5	12	6	0.4	51	7	0.8	58
postorb. length	16	0.6	24	16	0.8	12	16	0.7	51	15	1.0	58
interorb. width	4	0.3	24	4	0.2	12	4	0.3	57	6	0.8	58
orbit diameter	5	0.5	24	5	0.6	12	5	0.6	51	7	1.0	58
In % of head length												
snout length	22	1.3	24	22	1.8	12	22	1.3	51	23	1.9	58
head depth	52	5.4	23	52	5.0	12	52	4.6	50	44	5.5	56
head width	38	3.2	23	38	4.2	12	39	3.6	50	36	3.4	56
upper jaw length	37	1.9	24	38	2.0	12	37	1.8	51	41	3.1	58
lower jaw length	52	2.0	24	53	2.2	12	52	2.5	51	53	3.3	58
postorb. length	60	1.9	24	61	1.9	12	60	1.8	51	51	2.9	58
interorb. length	16	1.1	24	16	0.9	12	16	1.0	51	19	2.5	58
orbit diameter	18	1.6	24	18	1.1	12	18	1.8	51	26	3.2	58
In % length of lower jaw												
upper jaw length	71	4.5	24	71	4.2	12	72	4.2	51	78	6.0	58
Morphometry of the body												
In % of S.L.												
body depth	20	1.5	24	21	1.5	12	21	1.6	51	19	1.5	58
predorsal length	50	2.0	24	50	1.9	12	50	2.2	51	51	3.7	58
body width	11	1.5	24	12	1.3	12	11	1.5	39	10	1.3	57
caudal ped. length	12	0.8	24	12	0.6	12	12	1.1	51	12	1.8	58
caudal ped. depth	7	0.5	24	7	0.6	12	7	0.6	50	8	0.7	58
dorsal base	11	0.7	24	11	0.7	12	11	0.7	51	13	1.1	58
dorsal height	17	1.4	24	18	1.0	12	18	1.6	51	22	1.5	58
adipose length	7	0.6	24	7	0.9	12	7	0.8	51	9	1.1	53
adipose base	3	0.5	24	4	0.6	12	3	0.5	51	6	1.0	53
anal base	12	0.8	24	12	0.6	12	12	0.8	51	14	1.1	58
anal height	14	0.9	24	15	0.7	11	14	0.9	50	15	1.2	57
P_1 length	16	0.7	24	16	0.8	12	16	0.9	51	16	1.2	58
P_2 length	15	0.9	24	16	0.6	12	16	0.9	51	17	1.1	58

TABLE 2. MORPHOMETRIC CHARACTERS OF OB RIVER, USSR, INCONNU

Character	Sexes lumped		
	Mean	S.D.	N
	Morphometry of the head		
In % of S.L.			
head length	28	2.4	19
head depth	13	1.7	19
head width	11	1.2	19
upper jaw length	11	0.8	19
lower jaw length	15	1.1	19
snout length	7	0.5	19
postorb. length	15	1.5	19
interorb. width	5	0.6	18
orbit diameter	6	0.8	19
In % of head length			
head depth	44	5.4	19
head width	37	3.6	19
upper jaw length	40	3.1	19
lower jaw length	52	4.2	19
snout length	23	1.2	19
postorb. length	54	2.4	19
interorb. width	18	2.3	18
orbit diameter	23	1.9	19
In % length of lower jaw			
upper jaw length	78	4.2	19
	Morphometry of the body		
In % of S.L.			
body depth	21	1.5	19
predorsal length	51	1.9	19
body width	11	1.4	19
caudal ped. length	10	1.0	19
caudal ped. depth	8	0.5	19
dorsal base	13	1.6	19
dorsal height	22	1.8	19
adipose length	9	1.9	18
adipose base	5	0.8	18
anal base	15	0.8	19
anal height	15	1.0	19
P_1 length	17	1.2	19
P_2 length	17	1.1	19

→

Figure 4. Distribution of A) P_2 and B) P_1 fin rays of *Stenodus leucichthys nelma*. The range of variation is shown by the heavy base line, with the mean being indicated by the single vertical line. One standard deviation and two standard errors on each side of the mean are shown by the white and black bars respectively. I) Ob River, USSR; II) Kobuk River, Alaska; III) Selawik, Alaska; IV) Chatanika River, Alaska; V) Yukon River, Alaska, age less than three years; VI) Yukon River, Alaska, age more than three years.


A
I
II
III
IV
V
VI
8
9
10
11
12
13
P2 RAYS
B
I
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IV
V
VI
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14
15
16
17
18
P1 RAYS

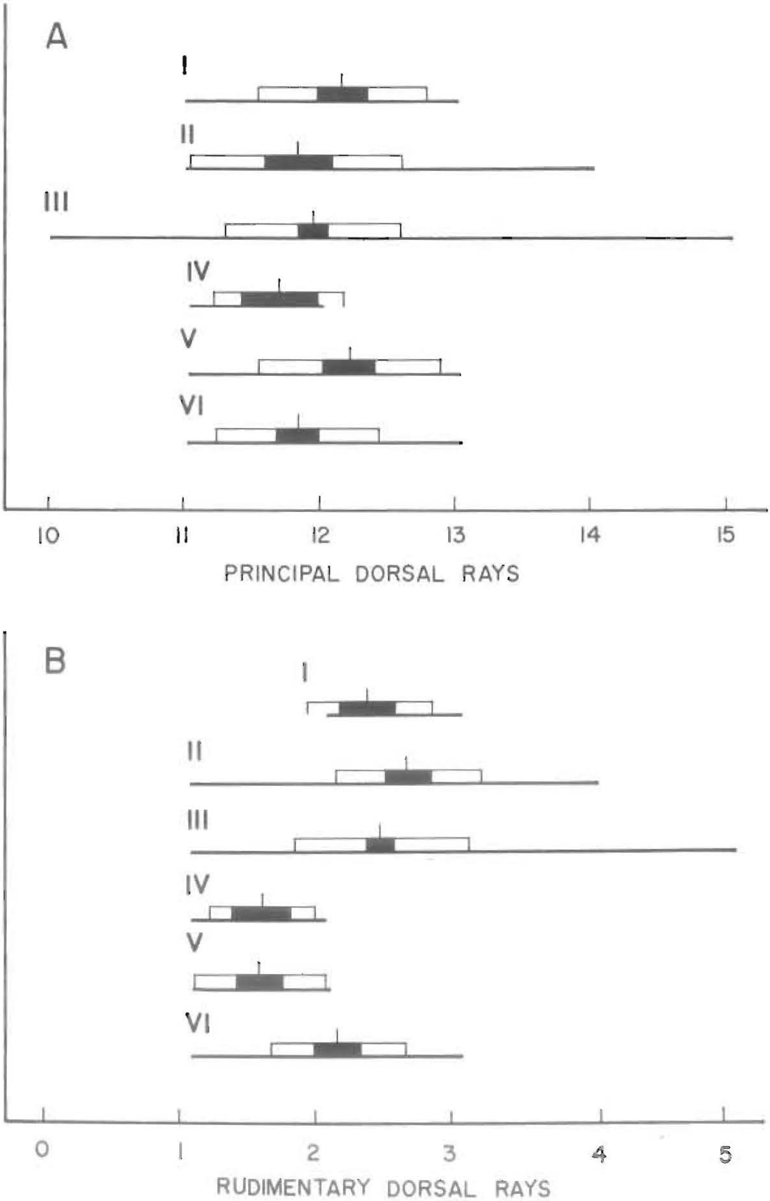

Figure 5. Distribution of A) principal and B) rudimentary dorsal fin rays. Legend as in Figure 4.

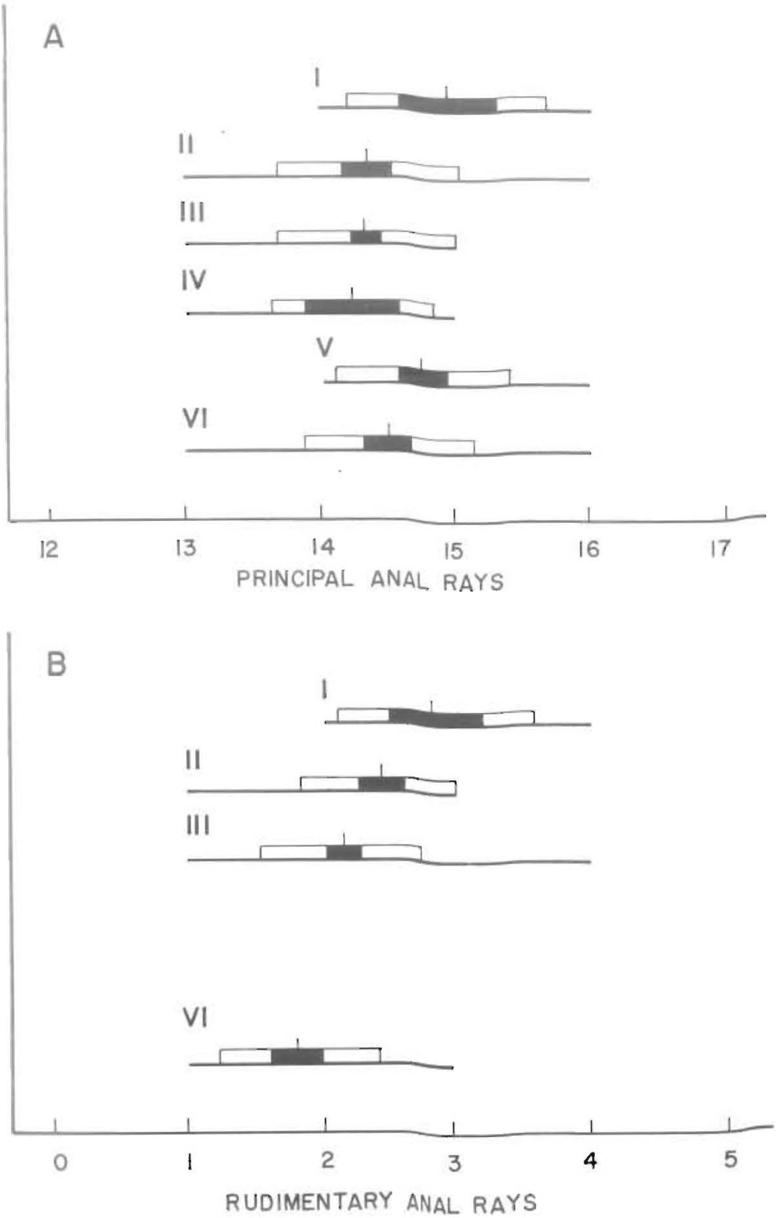

Figure 6. Distribution of A) principal and B) rudimentary anal fin rays. Legend as in Figure 4.

TABLE 3. MORPHOMETRIC CHARACTERS OF SELAWIK, ALASKA, INCONNU

Character	Females			Males			Sexes lumped		
	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
				Morphometry of the head					
In % of S.L.									
head length	26	1.1	132	26	1.1	76	26	1.1	214
head depth	13	1.0	130	13	0.9	75	13	1.0	211
head width	9	1.0	130	9	1.0	75	9	0.9	211
upper jaw length	9	0.5	132	9	0.5	76	9	0.5	214
lower jaw length	14	0.7	132	14	0.6	76	14	0.7	214
snout length	6	0.3	132	6	0.4	76	6	0.4	214
postorb. length	16	0.7	132	16	0.8	76	16	0.7	214
interorb. width	4	0.3	131	4	0.4	75	4	0.3	212
orbit diameter	4	0.4	132	4	0.4	76	4	0.4	214
In % of head length									
head depth	49	3.7	130	49	3.2	75	49	3.5	211
head width	36	2.9	130	36	3.1	75	36	2.9	211
upper jaw length	36	1.8	132	36	1.5	76	36	1.7	214
lower jaw length	54	2.6	132	53	2.0	76	53	2.4	214
snout length	23	1.1	132	23	1.1	76	23	1.1	214
postorb. length	63	1.9	132	62	1.5	76	62	1.7	214
interorb. width	17	1.4	131	17	1.3	75	17	1.3	212
orbit diameter	15	1.6	132	15	1.4	76	15	1.6	214
In % length of lower jaw									
upper jaw length	67	3.7	132	67	3.4	76	67	3.6	214
				Morphometry of the body					
In % of S.L.									
body depth	21	2.4	131	20	1.7	74	21	2.4	211
predorsal length	51	2.5	132	51	2.1	76	51	2.4	214
body width	11	1.0	131	10	1.1	74	10	1.0	211
caudal ped. length	12	0.8	132	12	0.9	76	12	0.8	214
caudal ped. depth	6	0.4	131	6	0.4	75	6	0.4	212
dorsal base	11	0.8	130	11	0.6	75	11	0.8	211
dorsal height	16	1.8	127	16	1.4	72	16	1.7	205
adipose length	7	0.8	131	7	0.7	76	7	0.8	213
adipose base	4	0.5	131	4	0.5	75	4	0.5	212
anal base	11	0.8	132	11	0.8	76	11	0.8	214
anal height	13	0.8	128	13	0.8	70	13	0.8	204
P_1 length	16	0.6	131	16	0.7	76	16	0.6	213
P_2 length	15	0.9	131	15	0.9	76	15	0.9	213

standard length or head length. In the analysis of morphological characters, the samples were separated by location and sexes were kept separate. Fish less than 3 years old were treated as one category in the Yukon River sample, while fish older than 3 years made up another category. In the determination of meristic characters, sexes were lumped,

TABLE 4. MORPHOMETRIC CHARACTERS OF KOBUK RIVER, ALASKA, INCONNU

	Females			Males			Sexes lumped		
Character	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
	Morphometry of the head								
In % of S.L.									
head length	25	0.8	18	25	1.2	32	25	1.0	52
head depth	12	1.1	17	12	1.2	31	12	1.2	50
head width	9	0.7	17	9	0.8	31	9	0.7	48
upper jaw length	9	0.4	18	9	0.5	32	9	0.5	52
lower jaw length	14	0.6	18	13	0.8	32	13	0.7	52
snout length	6	0.3	18	6	0.4	32	6	0.4	52
postorb. length	16	0.5	18	16	0.8	32	16	0.7	52
interorb. width	4	0.4	17	4	0.2	32	4	0.3	51
orbit diameter	3	0.2	18	3	0.2	32	3	0.4	52
In % of head length									
head depth	50	4.1	17	49	4.2	31	49	4.1	50
head width	37	2.8	17	37	2.5	31	37	2.5	48
upper jaw length	35	1.4	18	36	1.3	32	36	1.5	52
lower jaw length	55	1.7	18	54	2.2	32	54	2.1	52
snout length	23	1.0	18	23	0.9	32	23	0.9	52
postorb. length	64	0.9	18	63	0.9	32	63	1.0	52
interorb. width	18	1.5	17	18	0.8	32	18	1.0	51
orbit diameter	13	1.1	18	14	0.8	32	14	1.6	52
In % length of lower jaw									
upper jaw length	65	3.3	18	67	2.8	32	66	3.7	52
	Morphometry of the body								
In % of S.L.									
body depth	22	3.5	17	19	1.3	31	20	2.5	50
predorsal length	50	1.7	18	50	2.2	32	50	2.0	52
body width	11	0.9	17	11	0.9	31	11	0.9	50
caudal ped. length	12	0.9	18	12	0.6	32	12	0.7	52
caudal ped. depth	6	0.4	17	6	0.3	32	6	0.4	51
dorsal base	11	0.5	18	11	1.3	32	11	1.1	52
dorsal height	14	1.4	18	14	1.2	32	14	1.3	50
adipose length	7	0.6	17	7	0.7	31	7	0.7	49
adipose base	4	0.5	17	4	0.6	31	4	0.5	49
anal base	11	0.8	18	11	0.8	32	11	0.8	52
anal height	12	0.9	18	12	0.8	32	12	0.8	50
P_1 length	15	0.7	18	15	0.7	32	15	0.7	52
P_2 length	14	0.8	18	14	0.8	32	14	0.8	52

but two age divisions were kept, as Krasikova (1949) and Menshikov (1935) found that the number of gill rakers often decreases with age.

Data were placed on punch cards and analyzed using an IBM 1620 computer. Statistical values determined were: mean, range, standard deviation and standard error.

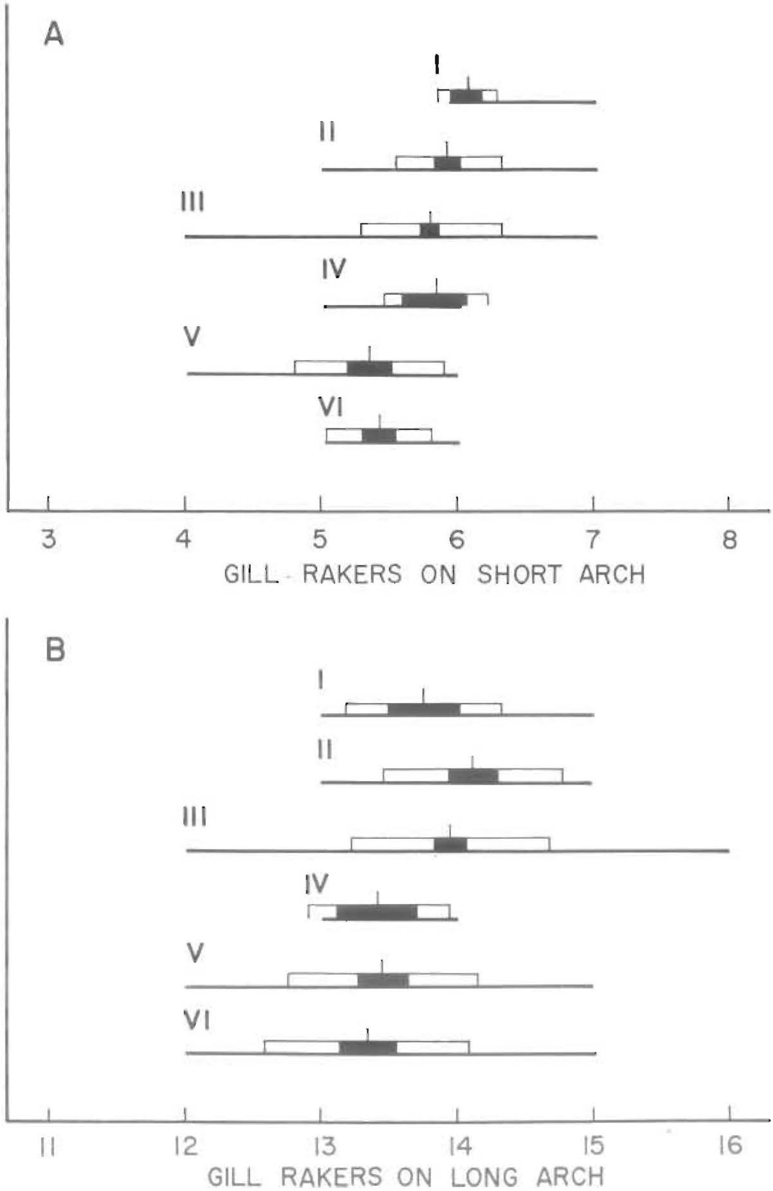

Figure 7. Distribution of gill rakers A) on short arch (upper limb) and B) on long arch (lower limb). Gill raker on angle of arch not included in counts. Legend as in Figure 4.

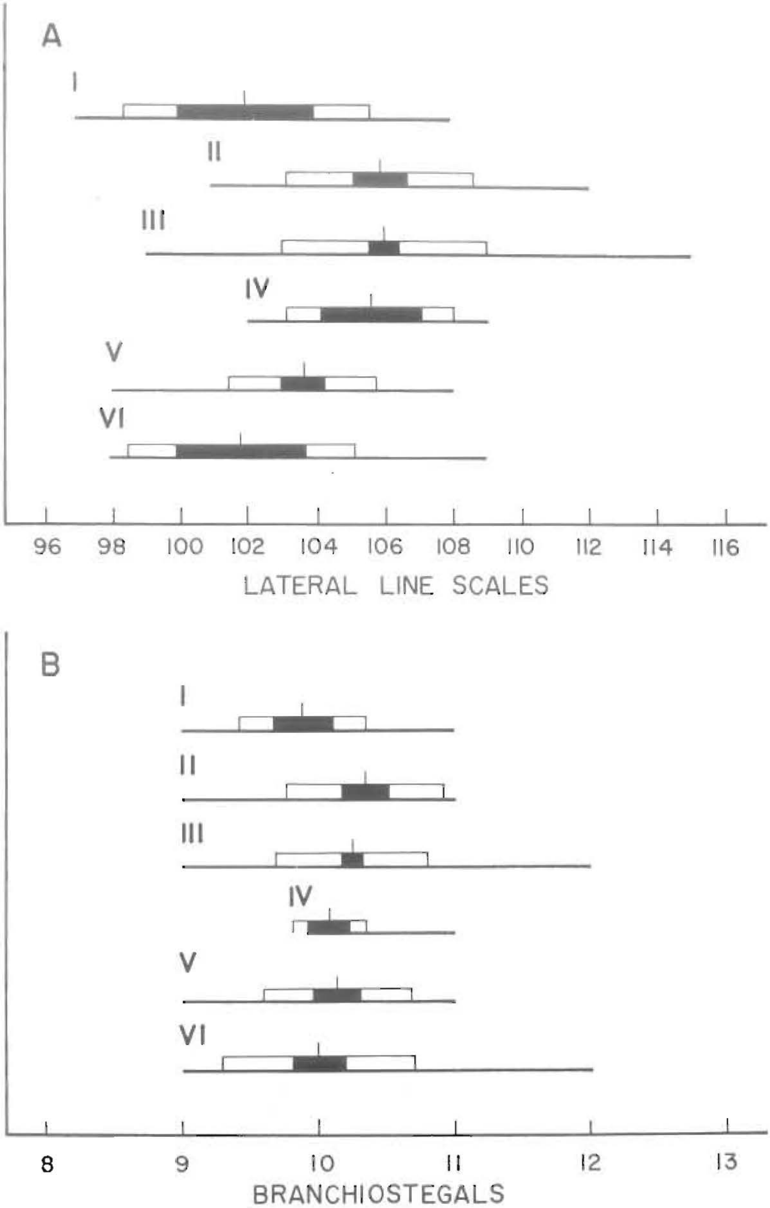

Figure 8. Distribution of A) lateral line scales, and B) branchiostegals. Legend as in Figure 4.

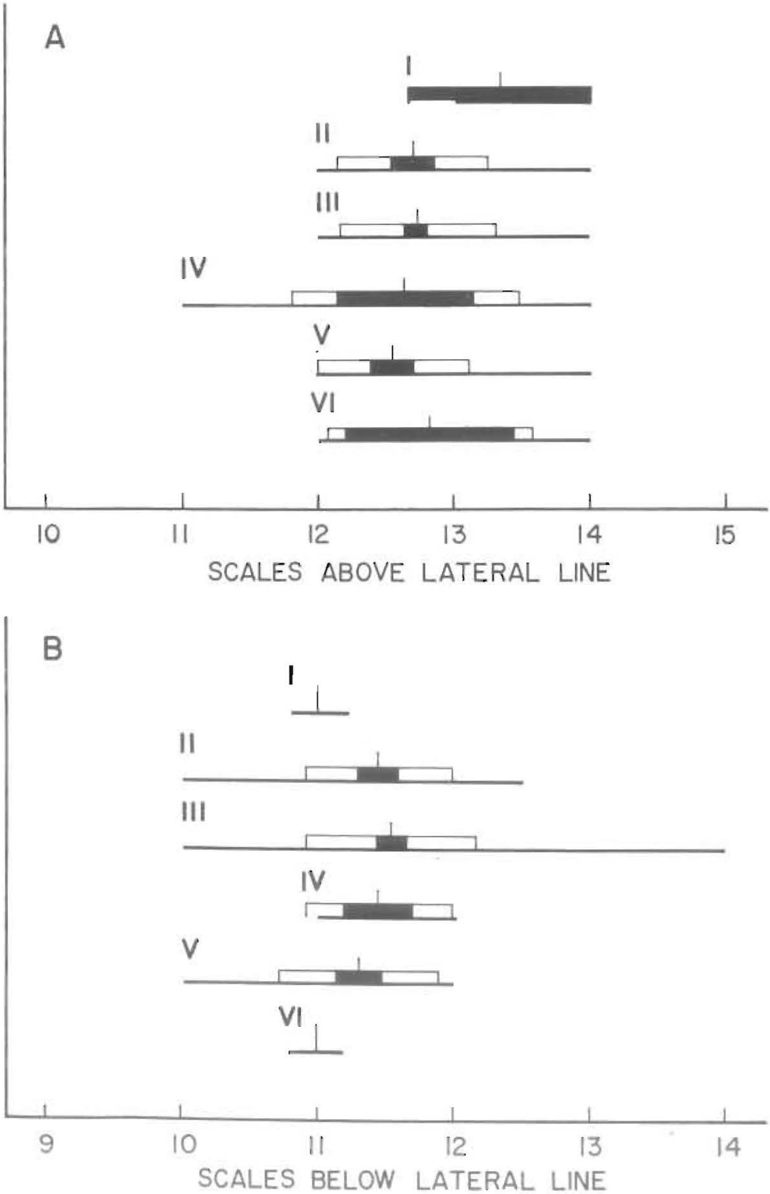

Figure 9. Distribution of A) scales above the lateral line, and B) scales below the lateral line. Legend as in Figure 4.

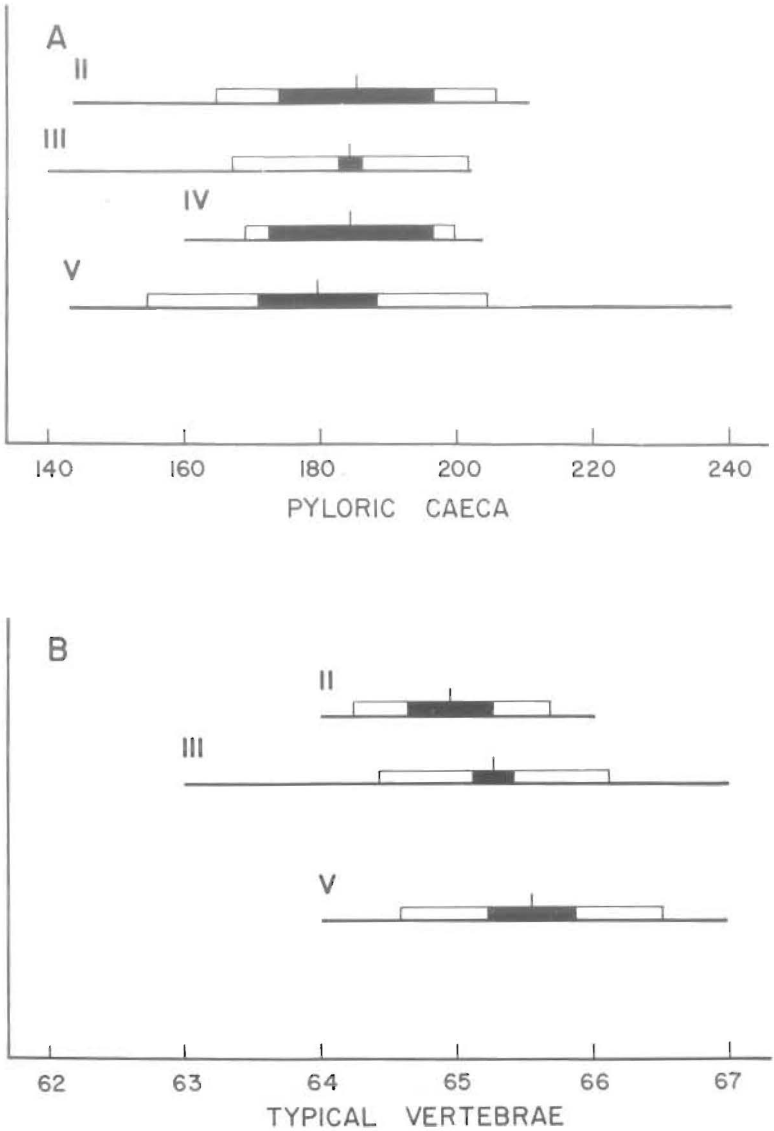

Figure 10. Distribution of A) pyloric caeca and B) typical vertebrae. Legend as in Figure 4.

RESULTS

Table 1 lists proportional body measurements of upper Yukon River inconnu. In order to determine if there was a change in rate of growth with age, the two age groups were treated separately. Data have been presented for males, females, and lumped sexes for the older fish; and only for lumped sexes for young inconnu. The inconsistency between total sample number and male and female totals is due to the fact that sex was unknown on a number of immature specimens. Data on Ob River inconnu are presented in Table 2. Fish in this sample were between 9.4 and 18.4 cm standard length and should be compared with young Yukon River inconnu. Morphological data on Selawik and Kobuk River inconnu are presented in Tables 3 and 4 respectively.

Data on meristic characters are presented in graphic form in Figures 4 to 10. For each count the mean, range, one standard deviation, and two standard errors on each side of the mean are given. The blackened area in each graph represents two standard errors. In Figure 6 the rudimentary anal ray counts have not been given for Chatanika River and older Yukon River specimens. Pyloric caeca and vertebrae counts were not taken on all samples.

Mean gill raker counts for inconnu from the various areas are as follows: upper Yukon River (young inconnu)—19.8; upper Yukon River (older inconnu)—19.7; Chatanika River—20.0; Selawik—20.8; Kobuk River—21.0; and Ob River, USSR—20.8. Pyloric caeca counts were extremely variable in all populations sampled and therefore are considered of minor importance in this taxonomic study. Counts ranged from 140 to 240 with a mean of about 185. Vertebrae counts shown in Figure 10 do not include the three upturned, rudimentary vertebrae that are present in each fish. Thus the mean vertebrae count for Selawik inconnu is 65.3+3 for a total mean count of 68.3.

DISCUSSION

A comparison of proportional measurements between young and older upper Yukon River inconnu (Table 1) shows a change in growth rate between body parts. The head is relatively longer in young inconnu. Measurements of lower and upper jaw, snout length, and orbit diameter are also relatively greater in young inconnu than in older fish, but postorbital length is relatively less. The head is wider but not as deep. Interorbital width is also greater in young inconnu. The upper jaw is longer in relation to length of lower jaw in the young fish, and the lower jaw projects very little. All fins have relatively longer bases and greater lengths in young fish. Caudal peduncle depth is greater but caudal peduncle length is less. These differences are not statistically and probably not biologically significant.

Comparison of measurements from young Ob River and young Yukon River inconnu shows very little difference (Tables 1 and 2). In all measurements, the standard deviations of each population overlap, and the differences are only slightly greater than those observed among Alaskan populations. Evidently there is much variation in proportional measurements in Siberian fish, as Krasikova (1949) found that Yenisei River inconnu differ considerably in morphometric characters from inconnu in other Siberian rivers.

In comparing morphometric characters, little difference was found between males and females (Tables 1, 3, and 4). Females from Selawik and Kobuk have deeper bodies than males. The difference is greater in the Kobuk sample, which is to be expected, since most females were taken on the spawning grounds just prior to spawning and contained well developed eggs.

Differences in proportional measurements of inconnu (sexes lumped) from Selawik, Kobuk River and upper Yukon River are small and all the standard deviations overlap (Tables 1, 3, and 4). Values for the Selawik and Kobuk samples are closer to each other than to the Yukon sample. This would be expected since the Yukon sample is a separate population while Selawik and Kobuk fish may actually constitute a single population.

Krasikova (1949) indicated a decrease in the number of gill rakers with increase in age, correlated with changes in feeding habits. However, in the present study no change in the number of gill rakers with age was noted in the upper Yukon River sample (19.8 for fish less than age three, 19.7 for older fish). Examination of other meristic counts indicates little variation in counts between young and older inconnu.

Data have been presented in Figures 4 to 10 in such a manner that if the blackened areas (two standard errors on each side of the mean) overlap, we can be confident at the 95% level that the differences are mathematically nonsignificant. Examination of these figures shows overlap for all samples studied including the Ob River sample.

It is interesting to note that in most cases the values for meristic characters of Selawik and Kobuk River fish are very close. This again strengthens the belief that Selawik and Kobuk River fish constitute a single population.

In general, inconnu from Selawik and the Kobuk River show higher meristic counts than Yukon River fish, although this generalization does not hold true for vertebrae counts.

TABLE 5. MERISTIC CHARACTERS OF INCONNU FROM VARIOUS SIBERIAN AND ALASKAN RIVERS

Character	Yukon Present study N = 52	Selawik Present study N = 213	Kobuk Present study N = 52	Lena Boricov (1923) N = 22	Vilyui Kirilov (1962) N = 70	Yenisei Krasikova (1949) N = 89	Ob Present study N = 19	Irtysh Menshikov (1935) N = 61
Gill rakers	19.7 4–6+1 +12–15	20.7 5–7+1 +13–15	21.0 5–7+1 +13–15	20 18–21	20.7 19–23	21 18–25	20.8 6–7+1 +13–15	21 18–23
Lateral line scales	103.7 98–108	106 99–115	105.9 101–112	112 107–115	110 101–109	110 102–122	102 97–108	104–105 96–112
Branchio-stegals	10.1 9–11	10.3 9–12	10.4 9–11		10 9–11		9.9 9–11	
Branched dorsal rays		10 9–13	10.5 9–12	10–12		10–14	10.2 9–11	10–13
Unbranched dorsal rays		4.0 3–5	3.9 3–4	4		3–5	4.2 3–5	3–5
P_1 rays	16.1 15–17	16.3 15–17	16.4 14–17				16.4 15–17	
P_2 rays	10.9 10–12	11.1 11–12	11.2 11–12				10.9 10–11	
Branched anal rays		13.2 12–14	13.3 12–15	12–15		11–16	13.8 13–15	13–16
Unbranched anal rays		3.3 2–5	3.5 2–4	3–4		1–5	3.7 2–5	3–5

Meristic counts of Ob River specimens are closest to Yukon River values except for P_1 rays, scales above the lateral line, and total gill raker counts. Table 5 shows that values for Alaskan inconnu are within the range of values for Siberian inconnu. There seems to be a wide variation in lateral line scale counts for Siberian populations of *S. l. nelma*, and although the mean Siberian counts are often higher, the Alaskan fish are within these limits. Kirilov (1962) found many differences in meristic counts and morphological measurements between inconnu populations from various Siberian watersheds. Main differences were in anal fin ray counts and lateral line scale counts. He divided the inconnu (*nelma*) into three geographical forms: 1. European (Pechora River), 2. Siberian (Ob River), and 3. Laptev Sea and East Siberian Sea.

Lateral line scale counts probably should not be used to separate subspecies. Some authors have reported mean lateral line scale counts for *S. l. leucichthys* and *S. l. mackenziei* that are within the range reported for *S. l. nelma*. Both Berg (1948) and Krasikova (1949) listed the mean number of lateral line scales for *S. l. leucichthys* as 109. Fuller (1955) and Dymond (1943) gave the mean number of lateral line scales for *S. l. mackenziei* from the Great Slave Lake basin as 97.9 and 103 respectively, but these counts were taken only to the end of the caudal peduncle. Mean counts for *S. l. nelma* ranged from 98.7 (Clemens, 1944) to 112 (Boricov, 1923). So if the three subspecies of *S. leucichthys* warrant subspecific designation, gill raker counts should be the deciding factor.

On the basis of data presented, all populations of inconnu studied, and probably all Alaskan inconnu in general, should be designated as *Stenodus leucichthys nelma* (Pallas). This conclusion is based on the morphological similarity and close agreement of meristic counts of the Alaskan and Siberian populations, especially in gill raker counts.

AGE AND GROWTH

A sample of scales from 399 inconnu was read in an attempt to determine growth rate, longevity, and age at sexual maturity. Sixty-six were taken in the upper Yukon River, 212 from Selawik, 103 from the Kobuk River, and 18 from the Chatanika River.

The use of scales for determination of age in fishes has been proven valid by many authors (e.g. Van Oosten, 1923 and 1929; Cooper, 1951; and Cable, 1956). Van Oosten worked with *Coregonus sp.* while Fuller (1947), and Chumayevskaya-Svetovidova (1930), worked specifically with *Stenodus.*

Criteria used in annulus determination of inconnu were:

1. Cutting across must occur in the postero-lateral radii. (The last few circuli laid down at the end of the growing season are not complete in the posterior field. The first circulus laid down at the beginning of the new growing season, being complete, "cuts across" the ends of these circuli.)
2. It must be possible to follow the first circulus of the new year's growth completely around the scale.
3. There should be a definite break in the anterior field. The break is formed by irregularities in one or more circuli.
4. There should be a clear unsculptured region in the posterior field. (Circuli laid down toward the end of the growing season are incomplete, resulting in unsculptured areas.)
5. Circuli laid down at the end of the growing season should be close together while those laid down at the beginning of the growing season should be far apart.

It should be mentioned that the use of only one characteristic is not sufficient to identify a true annulus, but rather a combination of characteristics should be used. The first two criteria were almost always met. More significance was attached to "cutting across" than to the other criteria.

Situations were often found where two annuli were very close together; however, most other criteria for annulus determination were met. It was assumed that each group of circuli represented a total year's growth and was a true annulus. There was no general pattern of occurrence of this phenomenon, but it was usually observed between the second and eighth annuli. Either growth was very slow in these years or else the rings are false annuli caused by a slowing down, then a resumption, of growth during the growing season.

AGE ASSESSMENT

In the present study, age of a fish was given as the number of completed annuli. Cooper (1951) said that the scale must begin to grow anew before the annulus could be identified. This method has been followed by Chumayevskaya-Svetovidova (1930), and was utilized in the present study. Fuller (1947) assigned his specimens an age at the end of the growing season in September.

Growth beyond the outer annulus (marginal growth) is indicated by a plus sign. A fish in early June, before annulus formation, having passed through five winters, would show four annular rings and be designated as 4+ years old. An annulus terminating the previous year's growth was detectable and new growth rings representing growth of the current season were present on scales of Selawik inconnu taken in late June. Annulus formation therefore occurred in early to mid-June. Examination of scales from 18 fish from the Kobuk River taken between 14 and 28 July showed that all had formed an annulus and a number of circuli representing the current year's growth. The time of annulus formation in Yukon River fish is probably in June also, since scales of inconnu taken in mid-July showed an annulus and some marginal growth.

USE OF BODY-SCALE RELATIONSHIP IN GROWTH CALCULATIONS

The body-scale relationship depends on the premise that, since the number of scales on a fish remains constant throughout life, the scales must grow at a rate proportional to that of the body. This method of calculating rate of growth from scales has gained widespread acceptance (Lea, 1910; Taylor, 1916; Creaser, 1926; Van Oosten, 1929).

In some fish, the mathematical relationship between length of scale and length of fish is not a straight line one, but curvilinear. For these fishes the logarithm of fish length and scale length exhibits a straight line relationship. Shumayevskaya-Svetovidova (1930) found that the value of the ratio between length of fish and length of scale (l/s) of inconnu decreases with increase in length of fish. She used the logarithmic method worked out by Monastyrsky (1926).

The direct proportion method is used in this study. In this method (Van Oosten, 1929), the standard length attained by the fish at the end of year X is determined by the following expression in which the third term is unknown:

$$\frac{\text{Length of scale included in annulus of year X (S')}}{\text{Total length of scale radius (S)}} = \frac{\text{Length of fish at end of year X (L')}}{\text{Length of fish at time of capture (L)}} \quad \text{or} \quad \frac{S'}{S} = \frac{L'}{L}$$

A limitation of the direct proportion method is that it does not take into account the length of the fish at the time of scale formation. Scales of three inconnu of standard length 4.8, 4.7, and 4.3 cm taken in the upper Yukon River contained five, three, and three circuli respectively. On this basis it was assumed that body length at time of scale formation is 2 cm for purposes of this study. In the modified formula, then, the fourth term should read: Length of fish at time of capture (L) minus length of fish at time of scale formation (C).

In back-calculating lengths of fish at the end of each year of life, computations were made using the anterior scale radius. The reason for using the anterior radius was that annuli were often difficult to locate in the posterior field, especially in older fish. However, it has been generally accepted (Cable, 1956; Van Oosten, 1929) that when the anterior radius is used, values tend to be lower (at least in early years of life) than if scale diameter had been used. Van Oosten (1929) explained that, since

> The scale hypothesis really assumes a correlation between the increase in length of the body and length, not radius, of the scale, it might be possible to eliminate the discrepancy between the calculated and actual values by the employment of diameters instead of anterior radii.

Fuller (1947) compared calculated rate of growth in a sample of inconnu, using both the radius and diameter of the scale, with that of a sample of males and females of known length at time of capture. He found that the growth curve based on measurements of the diameter exceeded the average while that based on the radius was lower than average in early years of life. I obtained similar results in comparing growth rates based on anterior and posterior scale radii in that the posterior measurements exceeded the average in early years of life. Chumayevskaya-Svetovidova (1930) used the anterior scale radius in back-calculating lengths of Ob River inconnu.

PROCEDURE

Scale samples were taken in an area midway between the lateral line

TABLE 6. MEAN BACK-CALCULATED LENGTHS OF EACH AGE-CLASS OF UPPER YUKON RIVER INCONNU (SEXES LUMPED)

Age at capture	N	Mean standard length at end of each year of life in centimeters								
		L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9
1+	12	10.4								
2+	1	7.5	16.0							
3+	–									
4+	11	10.8	18.9	25.3	31.0					
5+	15	11.0	18.3	23.9	28.7	33.5				
6+	6	13.5	21.5	28.4	33.5	38.1	42.6			
7+	10	13.2	21.3	27.0	32.8	39.0	44.6	49.8		
8+	5	13.6	21.7	28.6	36.2	42.1	46.6	51.2	53.1	
9+	6	10.5	18.7	25.7	30.7	37.3	43.0	49.3	54.9	58.6
N = 66		Mean length for all age classes								
		11.3	19.5	26.5	32.2	38.0	44.2	50.1	54.0	58.6

and the origin of the dorsal fin. Scales were soaked in water, then scrubbed to remove mucous and epidermal covering. Two scales from each fish were mounted between glass slides in a water medium. After the first reading, the slides were taped together, making a permanent dry mount. All scales were read twice, and three times when the first two readings did not agree. If no agreement could be reached, scales were discarded. A Bausch and Lomb Tri-Simplex Micro-Projector at magnifications of 15× and 30× was used in scale reading, with a magnification of 45× being used in difficult cases. Annuli were marked on note cards. This information was later used in the calculation of the annual growth rate. There were many regenerated scales in which the normal, well-defined focus was replaced by a large central area with no circuli. These scales were discarded.

Since fish length is often published in the literature as fork length, the following formula for conversion of fork length to standard length was established:

Age less than 3 years; N = 77 SL = .89(FL)
Age greater than 3 years; N = 329 SL = .91(FL)

RESULTS

Annual increment of growth for each fish was calculated using the body-scale relationship. In this way it was possible to follow the growth of each individual age-class and get some insight into growth rate during early years of life. In the original analysis, length was back-calculated for both males and females. However, since no difference was observed

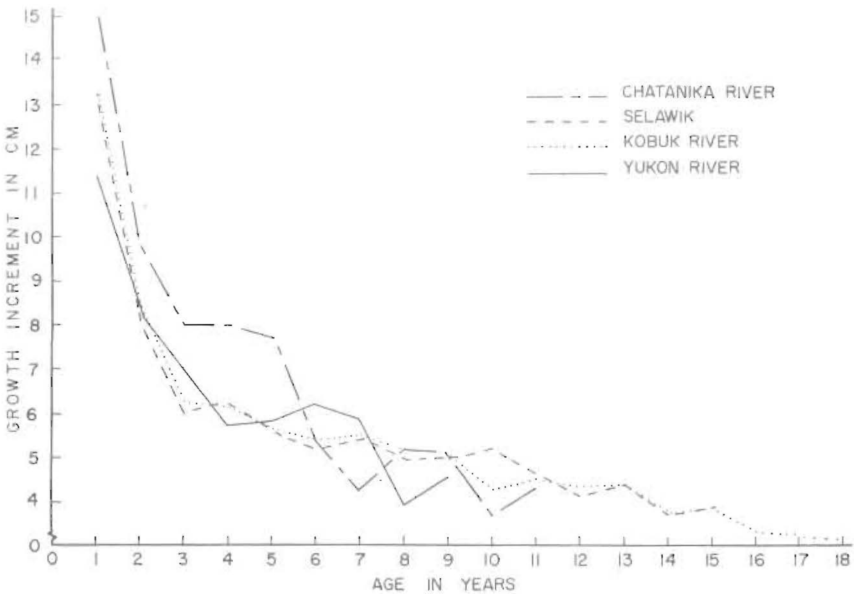

Figure 11. Average annual increment of growth in cm standard length for Alaskan inconnu.

between the sexes, data presented in Tables 6 to 9 are back-calculated lengths at end of each year of life for lumped sexes. These data are shown graphically in Figure 11. The growth curve for the Selawik sample was determined using only fish between ages 4 and 15 since there was only a small number of specimens in the older age-classes. In the Kobuk

TABLE 7. MEAN BACK-CALCULATED LENGTHS OF EACH AGE-CLASS OF CHATANIKA RIVER INCONNU (SEXES LUMPED)

Age at capture	N	Mean standard length at end of each year of life in centimeters										
		L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}
5+	2	15.0	25.0	37.0	47.0	54.4						
6+	2	15.5	27.9	35.7	45.0	53.7	59.0					
7+	3	15.4	26.2	35.7	43.1	48.9	53.9	58.9				
8+	7	16.5	27.5	35.6	45.1	53.0	59.9	65.1	68.9			
9+	1	15.1	27.0	34.4	40.9	48.8	54.0	58.6	62.9	68.0		
10+	2	15.8	22.7	28.1	35.7	42.0	47.8	52.7	60.5	67.3	72.3	
11+	1	10.0	16.0	22.0	28.0	39.0	49.0	56.0	61.4	66.0	71.0	76.0
N = 18		Mean length for all age-classes										
		14.8	24.6	32.6	40.6	48.5	53.9	58.2	63.4	67.1	71.7	76.0

TABLE 8. MEAN BACK-CALCULATED LENGTH OF EACH AGE GROUP OF SELAWIK INCONNU (SEXES LUMPED, ALL FISH OVER AGE 13 ARE FEMALES)

Age at capture	N	Average standard length at end of each year of life in centimeters																			
		L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}	L_{14}	L_{15}	L_{16}	L_{17}	L_{18}	L_{19}	L_{20}
4+	2	14.5	23.5	31.7	38.8																
5+	28	13.2	22.1	28.3	33.4	39.2															
6+	48	13.4	22.8	29.2	34.6	40.1	46.4														
7+	21	13.1	23.0	28.9	34.4	40.2	46.2	52.3													
8+	8	13.0	20.9	27.0	34.2	40.4	44.8	51.0	55.2												
9+	9	12.5	21.2	27.2	33.5	40.0	44.0	49.1	54.2	59.5											
10+	12	13.5	21.2	27.1	33.4	39.2	45.8	51.1	57.1	62.6	66.8										
11+	14	14.5	22.6	28.7	35.0	40.7	45.8	51.0	56.4	62.1	68.3	73.0									
12+	20	12.1	20.2	26.4	32.1	38.3	43.9	50.0	55.5	60.0	65.6	71.3	76.2								
13+	26	13.1	20.2	25.4	31.0	37.2	42.2	47.3	52.3	57.4	63.1	69.2	74.5	79.5							
14+	17	12.5	18.8	23.3	29.5	35.5	40.9	46.0	51.2	56.3	61.3	66.7	72.0	77.5	82.0						
15+	4	12.6	20.6	26.3	31.6	38.9	43.8	49.7	56.0	60.6	64.5	68.0	72.6	77.5	82.0	85.9					
16+	–																				
17+	1	11.4	21.0	27.9	34.0	37.3	44.4	50.0	55.0	59.0	63.0	69.0	75.0	79.3	85.5	92.0	95.9	99.4			
18+	1	14.0	20.8	24.3	33.0	37.5	42.0	45.4	48.4	53.0	57.4	60.9	66.0	70.5	77.0	82.8	87.0	91.0	96.0		
19+	–																				
20+	1	12.7	21.0	27.0	31.0	36.7	40.0	44.0	46.3	52.0	56.0	63.0	70.0	75.4	82.0	87.8	90.7	93.0	96.0	98.4	101.9
N = 212		Mean length for all age-classes																			
		13.1	19.1	27.2	33.3	38.6	44.0	48.9	53.4	58.3	62.9	67.6	72.3	76.6	81.7	87.1	91.2	94.5	96.0	98.4	101.9

TABLE 9. MEAN BACK-CALCULATED LENGTH OF EACH AGE GROUP OF KOBUK RIVER INCONNU (SEXES LUMPED, ALL FISH OVER AGE 14 ARE FEMALES)

Age at capture	N	Average standard length at end of each year of life in centimeters																		
		L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}	L_{13}	L_{14}	L_{15}	L_{16}	L_{17}	L_{18}	L_{19}
5+	1	15.2	27.0	33.6	38.0	42.0														
6+	1	10.3	19.0	24.3	30.5	37.0	43.0													
7+	7	13.6	22.6	28.6	35.1	41.2	47.1	54.0												
8+	10	13.3	24.6	30.5	36.2	42.7	47.9	53.5	59.1											
9+	8	13.1	24.5	34.1	40.7	47.1	53.6	58.1	64.7	71.1										
10+	6	12.1	21.2	29.2	37.0	44.1	48.6	55.3	60.5	66.1	72.6									
11+	12	13.7	20.5	27.4	33.9	40.0	46.3	52.6	57.9	64.8	69.7	74.6								
12+	15	13.5	21.2	27.5	33.6	38.8	44.5	49.9	55.5	61.2	67.0	72.2	76.2							
13+	20	13.8	20.6	26.4	32.9	38.2	43.3	48.8	54.1	59.6	65.2	71.2	76.6	81.5						
14+	9	13.5	20.3	25.8	30.7	36.1	41.9	47.4	52.4	57.9	62.9	68.4	73.5	78.2	82.4					
15+	3	11.8	18.9	24.1	30.0	34.0	39.0	43.9	51.2	56.0	62.5	68.0	74.2	79.4	83.8	86.7				
16+	2	13.7	23.1	28.0	34.4	38.5	42.5	46.5	52.2	56.4	61.3	66.0	70.2	75.0	78.5	83.3	87.0			
17+	5	12.4	20.0	26.4	30.6	34.8	39.3	43.9	48.9	54.2	60.0	64.8	70.5	75.1	80.3	84.1	87.3	90.5		
18+	3	12.7	21.4	27.0	32.9	40.3	46.9	52.7	57.1	62.3	66.3	72.6	77.8	81.8	86.7	90.9	94.4	97.3	100.0	
19+	1	12.8	21.0	27.6	35.2	41.0	47.0	51.9	59.2	64.0	69.0	72.4	78.0	84.0	88.3	93.5	96.5	102.0	105.2	108.0
N = 103		Mean length for all age-classes																		
		13.0	21.7	28.0	34.1	39.7	45.1	50.6	56.1	61.2	65.6	70.0	74.6	79.3	83.3	87.7	91.3	96.6	102.6	108.0

River sample, fish from age-classes 5, 6, and 19 were not used in compiling Figure 11 because of the small number of fish in these age classes. Despite a small sample, age and growth information is presented for the Chatanika River fish because they exhibit such a rapid rate of growth.

As revealed by Figure 11, all samples show a high growth increment the first year of life, then a rapid decrease the second and third years of life. The annual increment of growth for the Yukon River fish continues to decrease until the fourth year. It then levels off until the seventh year when it again shows a rapid drop. The Chatanika sample shows a rapid decrease after age five. Maximum size reported for upper Yukon River fish is 6 kg (Dymond, 1943). In the present study, a specimen weighing 5 kg was 9 years old.

Growth rates of Selawik and Kobuk River fish parallel each other (Fig. 11). Except for age 10, the growth curves are almost superimposed. Growth rate for the two samples is quite steady from age 3 to age 10 (age 9 for Selawik fish) with the annual increment decreasing by only 1 cm (from 6 cm per year to 5 cm per year) during these 7 years. After age 10 there is a gradual decrease in annual growth increments, but by age 15 the annual increment is still almost 4 cm.

Growth of Alaskan inconnu is compared with growth of Siberian inconnu in Table 10. Data for *S. l. leucichthys* and *S. l. mackenziei* are also included. There appear to be differences in growth rates between various populations of inconnu. In general, growth rates for Alaskan inconnu are slower than those for the Siberian fish. Pechora River inconnu grow more slowly than the Alaskan fish until age 10. The largest inconnu reported in the literature are Kirilov's (1962) record of 135 cm fish and Andriyashev's (1954) record of a 141 cm (probably fork length) specimen. On the basis of information at hand, one can only speculate on the reasons for the slower growth rates of Alaskan inconnu. Longer Russian growing seasons as well as differences in basic productivity of the watersheds may be contributing factors. It would be worthwhile to obtain growth information on known-age specimens to determine if and when false annuli are formed.

Growth rate of Caspian Sea *S. l. leucichthys* is phenomenal. The length at the end of age four is in most cases over twice the length reported for *S. l. nelma*. However, the Caspian Sea inconnu apparently does not live as long as the subspecies *nelma*, as Berg (1948) stated that maximum age of females was 9+ years and of males 8+ years.

Growth rates of *S. l. mackenziei* from Great Slave Lake are faster than growth rates of Alaskan inconnu utilized in this study, but intermediate among growth rates of various Russian populations.

TABLE 10. GROWTH OF INCONNU FROM NORTH AMERICA AND THE USSR

Area	Length at various ages in centimeters																	
Age:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Yukon River Present study N = 52	11.3	19.5	26.5	32.2	38.0	44.2	50.1	54.0	58.0									
Selawik Present study N = 202	13.1	19.1	27.2	33.3	38.6	44.0	48.9	53.4	58.3	62.9	67.6	72.3	76.6	81.7	87.1	91.2	94.5	96.0
Kobuk R. Present study N = 101	13.0	21.7	28.0	34.1	39.7	45.1	50.6	56.1	61.2	65.6	70.0	74.6	79.3	83.3	87.7	91.3	96.6	102.6
Vilyui R. Kirilov (1962)[1] N = 72							65.0	73.0	79.0	80.0	86.0	90.0	95.0	108	118	124	114	
Ob R. Chumayevskaya- Svetovidova (1930) N = 433	13.2	20.6	26.8	34.2	42.0	48.5	54.9	61.5	67.7	72.1	76.5	81.3	84.6	89.9	98.9			
Pechora R. Berg (1948)	9.9	17.9	24.4	30.0	37.5	43.6	50.8	57.3	64.6	67.5	71.1	76.5	81.9	84.6	87.6	90.4		
Caspian Sea Podlesnyi (1947)[2]		Males		81.9	86.6	90.8	93.7											
		Females		89.3	91.1	94.4	100	101										
Great Slave Lake Fuller (1955)[3] N = 298	14.6	24.7	31.2	40.3	47.3	52.9	57.2	61.0	65.7	68.8	72.7							

[1] All fish mature and taken on spawning ground; empirical data only. Measurements on Russian fish probably in fork length, Alaskan data in standard length.

[2] *Stenodus leucichthys leucichthys.*

[3] *Stenodus leucichthys mackenziei*, measurements in fork length.

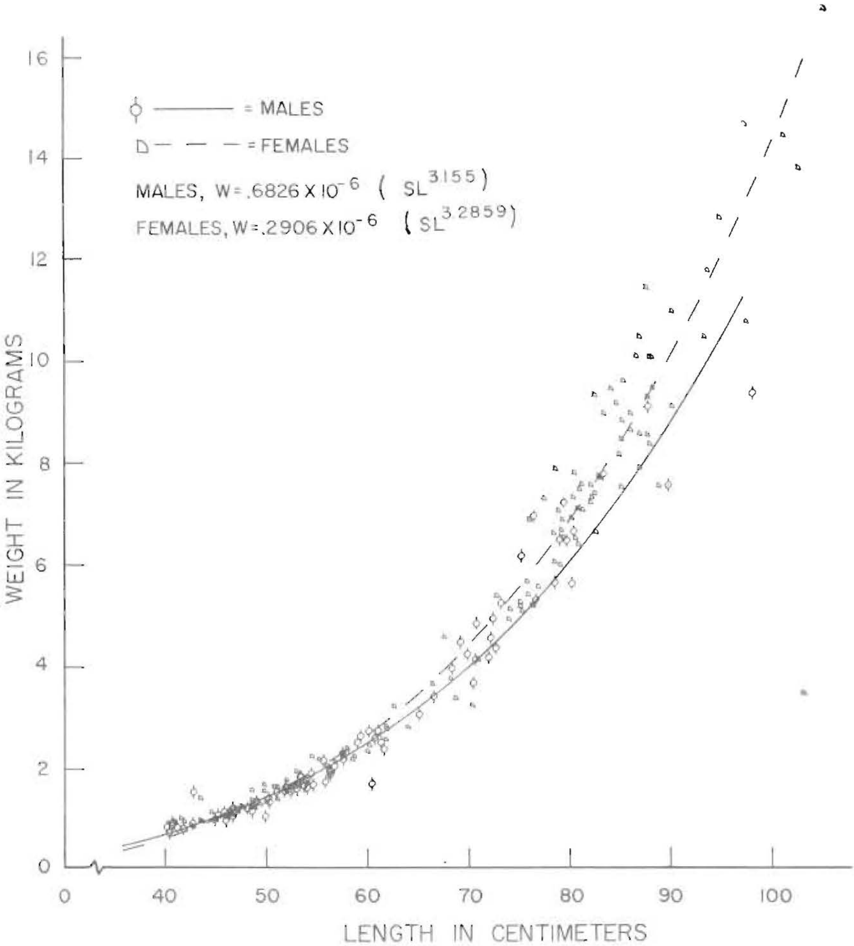

Figure 12. Length-weight relationship for males and females from Selawik, Alaska.

LENGTH-WEIGHT RELATIONSHIP

Weight of inconnu at capture was plotted against standard length at capture to determine the relationship between length and weight. Plotting was done by an IBM 1620 computer. Length-weight information was recorded for Yukon River, Selawik, and Kobuk River fish. Length-weight curves were also fitted to the data using the following equations:

Upper Yukon River, sexes mixed	$W = 1.830 \times 10^{-7} L^{3.0070}$
Selawik, males	$W = 6.826 \times 10^{-7} L^{3.1555}$
Selawik, females	$W = 2.906 \times 10^{-6} L^{3.2859}$
Selawik, mixed sexes	$W = 3.314 \times 10^{-7} L^{3.2090}$

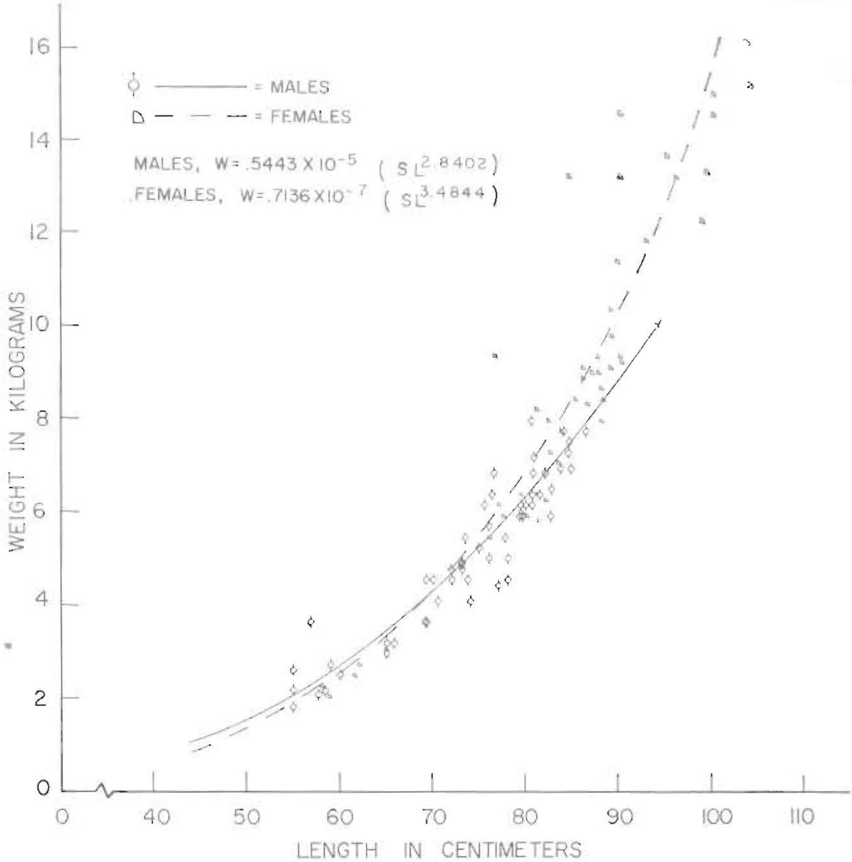

Figure 13. Length-weight relationship for males and females from the Kobuk River, Alaska.

Kobuk River, males	$W = 5.443 \times 10^{-6} L^{2.8402}$
Kobuk River, females	$W = 7.136 \times 10^{-8} L^{3.4844}$
Kobuk River, mixed sexes	$W = 2.005 \times 10^{-7} L^{3.2700}$

where W = weight in grams and L = standard length in millimeters. Length-weight curves, as well as actual values for Selawik males and females, are plotted in Figure 12, while the curves for Kobuk River males and females are plotted in Figure 13. The length-weight curves for inconnu (mixed sexes) from the upper Yukon River, Selawik, and the Kobuk River are presented in Figure 14.

The length-weight equation for the Yukon River sample was determined using a large number of small fish. The largest specimen was 68 cm

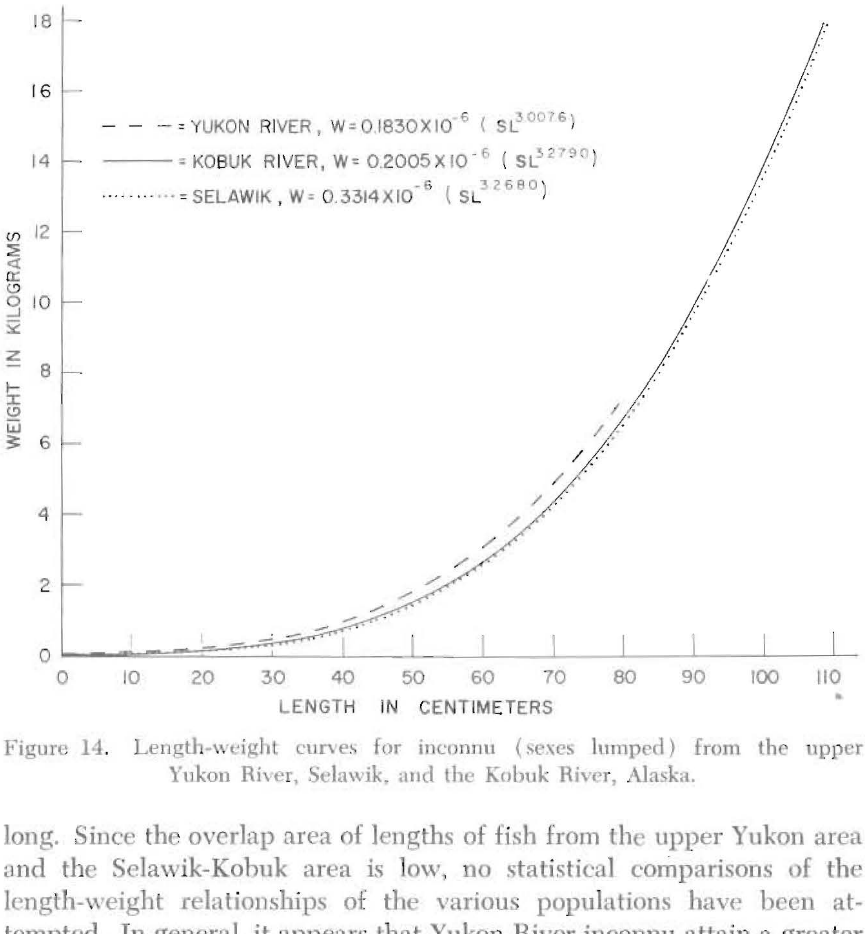

Figure 14. Length-weight curves for inconnu (sexes lumped) from the upper Yukon River, Selawik, and the Kobuk River, Alaska.

long. Since the overlap area of lengths of fish from the upper Yukon area and the Selawik-Kobuk area is low, no statistical comparisons of the length-weight relationships of the various populations have been attempted. In general, it appears that Yukon River inconnu attain a greater weight per unit length than Selawik-Kobuk fish.

The length-weight curves of Selawik and Kobuk River inconnu are almost identical (Fig. 14). The Kobuk River curve is steeper than the Selawik curve after a standard length of about 69 cm is reached, but the difference is very slight and probably due to the fact that most fish in the Kobuk sample are ripe and about to spawn while a large proportion of the Selawik sample consists of immature and unripe fish. It is felt, however, that the increase in body weight brought about by further maturation of the gonads in the Kobuk River fish is almost offset by the loss of body fats in migrating upstream without feeding.

For the Kobuk and Selawik samples, length-weight curves were plotted for both males and females. Examination of Figures 12 and 13 shows that males are heavier than females among smaller fish while females are heavier per unit length than males among older fish. For the Kobuk fish this relationship has been derived from a sample of fish between 54 and 103 cm standard length taken during the summer, prior to spawning. The point of intersection is at a standard length of 69 cm, which corresponds to a weight of 4.2 kg and an age of 9 to 11 years. This roughly corresponds to the age at sexual maturity for females. It seems likely that greater ovary weights accounted for most of the difference observed in the two curves. A 20 kg female taken at Kobuk on 16 August 1965 contained 4 kg of eggs, or 20% of total weight. In general appearance, the larger males seemed longer and slimmer than females of the same weight, even discounting gonad size. Examination of Figure 12 shows that, among Selawik inconnu, females of length greater than 46 cm weigh more than males of comparable length. The length range of Selawik fish was 40 to 105 cm and contained many immature fish.

Since the samples from which the length-weight equations have been determined were taken during a limited period of time, comparisons should be made with fish captured at the same time of the year. Fish taken during the winter in Hotham Inlet, for example, might show a different length-weight relationship than the Kobuk River summer sample. Feeding can also change the length-weight relationship. Inconnu taken at the mouth of the Tuklomarak River in early June had been feeding heavily prior to capture and contained heavy fat deposits as well as a large proportion of full stomachs. The ideal situation would be to have adequate samples covering the entire year.

MOVEMENTS AND SPAWNING

MOVEMENTS IN THE UPPER YUKON RIVER

Inconnu populations in Alaska can be classified as fluvial or semi-anadromus (estuarine anadromus). It appears likely that the upper Yukon River fish do not migrate to the mouth of the Yukon but are a local population. Wintering areas for these fish are probably in the main Yukon River. Menshikov (1935) mentioned that inconnu are year round local residents in the Irtysh River and its tributaries.

In 1964, the first inconnu taken at Circle, 1,900 km (1,200 miles) up from the mouth, was caught on 4 June. In July and August the fish are found near the mouths of tributary rivers of the Yukon and in adjacent, slack-water areas of the main Yukon River. Spawning grounds of upper Yukon River fish are in tributary rivers of the Yukon. These are clear-water streams and contain suitable spawning gravel. The time of entry into the spawning streams is variable. In 1961 a 6 kg mature female was taken approximately 80 km (50 miles) up the Fortymile River in July. In 1964 mature females were taken throughout August in the Yukon River, and on 3 September a mature female was taken at the mouth of the Charley River. Since spawning grounds are located only a short distance up tributary rivers, the spawning migration could be delayed until September. Spawning activity was not observed in the Yukon River.

MOVEMENTS IN THE KOBUK-SELAWIK AREA

Inconnu from the Selawik-Kobuk drainages winter in Selawik Lake and Hotham Inlet, arriving in large numbers in September and October. Immature inconnu are taken in Selawik Lake throughout the year (Vera Skin *viva voce*). Local residents say there is an intermingling of Selawik Lake and Hotham Inlet fish during the winter. It is not known for certain if the Selawik Lake population spawns exclusively in the Selawik River drainage and if the Hotham Inlet population spawns exclusively in the Kobuk River, or if there is an interchange. Similarities in morphological and meristic characters, growth rates, and the physical connection between the two bodies of water would indicate close association.

Movement in Selawik Lake seems to be that of a school or schools moving constantly in search of a schooling prey species (*Coregonus sardinella*). Main concentrations of inconnu in Selawik Lake during the spring were off the mouths of the Tuklomarak and Selawik Rivers. In 1965, the ice went out of the Selawik River on 2 June and out of the Tuklomarak River on 5 June. Nine inconnu were taken by rod and reel in Selawik River 25 km up from the mouth on 3 June. Inconnu enter the Tuklomarak River as soon as the ice goes out, and large numbers are taken by native fishermen at this time. Many of the fish entering the Tuklomarak are fish that would spawn in the fall. Assuming that all spawning occurs in the Selawik River, these mature fish would enter Selawik River via the Tuklomarak River, Tuklomarak Lake, Fox River, Inland Lake route. It is not known how fish from the Tuklomarak River reached Selawik River to spawn before the man-made channel was dug in 1960.

The upriver migration, at least in the lower reaches of the Tuklomarak, consist of both mature and immature fish. Selawik residents report that many of the immature inconnu ascending the Tuklomarak River spend the summer in the Tuklomarak and Inland Lake area and return to Selawik Lake in late August and September.

Spawning areas of Selawik Lake inconnu are located approximately

200 km (125 miles) up the Selawik River (Ted Davis *viva voce*). Downstream migrants are taken in the slow moving water of the Selawik River at Selawik in October, November, and December on their return to Selawik Lake.

In 1965, the spawning migration up the Kobuk River began immediately after ice-out (31 May), and many fish were taken at Noorvik on 2 June. Both mature and immature fish start the spawning migration. A number of immature inconnu were taken at Kiana, 99 km (62 miles) upriver, on 14 July 1965. The only other immature fish observed was a 2.1 kg male taken at Kobuk on 27 August. Immature fish probably spend the summer in the Kotzebue Sound—Hotham Inlet area and/or in the lower reaches of the Kobuk River. The upstream migration is quite protracted, and fish may remain in deep pools and eddies for some time before continuing upstream. On 17 July 1965, inconnu were taken at Ponoktorak, 48 km (30 miles) below Ambler, by hook and line. The first fish had been taken at Shungnak and Kobuk by mid-July. Kobuk residents reported that some upstream migrants reached the mouth of Reed River, 670 km (420 miles) from the mouth of the Kobuk River, and start downstream prior to spawning. Gill nets set in this area on 1 and 2 September failed to take any inconnu. The species has been reported as far upstream as Lower Kobuk Canyon, where rapids and falls act as a barrier to further movement. The fish arrive in the vicinity of the spawning grounds in late August and early September and are found in areas of deep, relatively slow moving water, and occasionally off gravel bars.

MOVEMENTS OF YOUNG INCONNU

In 1964, 81 inconnu young-of-the-year, 12 of age-class 1+ and 1 of age-class 2+ were taken by seine in the upper Yukon River between 27 July and 31 August (Fig. 15). Fish were taken in shallow, silty, slack-water areas of the Yukon River near mouths of Yukon River tributaries. Sampling by seine and hoop net upstream in tributary rivers failed to take young inconnu.

Efforts to capture young inconnu by seining in the Kobuk and Selawik areas were unsuccessful in 1965. The youngest specimen taken belonged to age-class 4+, so fish of age-class 0+, 1+, 2+ and 3+ remained unsampled. Residents of Selawik and the Kobuk valley did not recall observing young inconnu. Consequently, the view held by Russian workers (e.g., Kirilov, 1962) that young inconnu are carried by the spring floods to the lower reaches of the rivers or into brackish water where the early years of life are spent, appears to be supported by negative evidence.

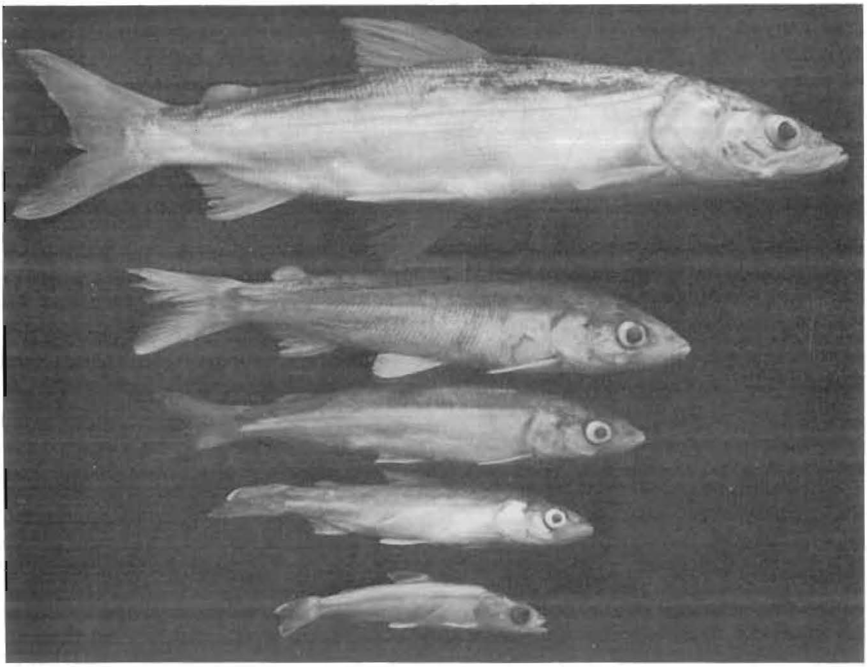

Figure 15. Young inconnu taken in the upper Yukon River, Alaska, between 28 July and 26 August 1964. Top fish—age-class 1+, standard length 15 cm; other fish all age-class 0+, standard length from 4.3 to 10 cm. Note that the lower jaw projects even in small fish.

SPAWNING

The spawning migration up the Kobuk River was followed by boat from 13 July through September 1965. After interviewing approximately 30 people from Kotzebue, Selawik, and the Kobuk valley, it was concluded that Kobuk River inconnu spawned in the upper Kobuk River in late September. Many residents had actually observed inconnu spawn. The Kobuk River from Kobuk village to 24 km (15 miles) above Reed River was examined for spawning habitat. A study area was set up from Kalla, 35 km (22 miles) above Kobuk, to an area 69 km (43 miles) above Kobuk, since the bottom in this area was similar to spawning habitat as described by Kobuk residents. Camp was set up at Kalla and temperatures were taken three times daily. Spawning observations were made from 27 to 30 September at Kalla. In 1966, the period from 14 to 30 September was spent in the area of the spawning grounds. Weather data were taken, 153 fish were examined, and spawning observations were carried out from 26 to 29 September.

Maturity and Fecundity—Gonads were well developed in all mature inconnu examined on the Kobuk River in 1965. Eggs increased very little in diameter from 24 July, when they were slightly less than 2.5 mm in diameter, to the time of spawning when average egg diameter was 2.5 mm. Weight of the ovaries averaged between 20 and 25% of body weight at the time of spawning. A 20 kg female examined on 25 August contained 4 kg of eggs which averaged 2.5 mm in diameter. An 18 kg female contained 4.1 kg of eggs, and a 10.1 kg fish taken from the spawning ground on 28 September contained 148,000 eggs (1.7 kg) of 2.5 mm diameter. According to Russian data, inconnu fecundity might vary between 100,000 and 350,000 eggs per female.

On 27 August 1965, testes were turning white and becoming milky. Eggs were still in a solid cluster. On 16 September, eggs were still in clusters, but milt could be expelled with application of pressure. On 19 September, milt was running freely. On 24 September, eggs could be expelled by applying pressure, but it was not until 27 September, the first day of spawning observations, that eggs were observed running freely. In 1966, milt was running freely from males on 14 and 15 September, but then, with a general rise in temperatures, milt was not observed running again until 24 September.

One could follow the decrease in body fat as the fish migrated up the Kobuk River. Except for a few males, inconnu on the spawning ground had utilized all excess visceral fat.

In 1965, 68 inconnu were taken from the vicinity of the spawning grounds between 15 and 30 September by gill net, beach seine, and hook and line. No immature or non-spawning fish were taken on the spawning grounds in either 1965 or 1966. The 32 males averaged 5.1 kg (range 2.6 kg to 8 kg), and 36 females averaged 9.7 kg (range 5.4 to 16.1 kg).

In 1966, 163 inconnu were taken from the vicinity of the spawning grounds between 14 and 30 September by hook and line, beach seine, and gill net. The 88 females averaged 9.4 kg (range 4.8 to 22.3 kg), while the 65 males averaged 4.6 kg (range 2.7 to 9.1 kg). It is felt that this sex ratio of 1.4 females per male does not reflect the true sex ratio. The only spawning ground sex ratios found in the literature are mentioned by Kirilov (1962) and Vork (1948a). Kirilov, who gave the composition as 65% males and 35% females, mentioned that the sex ratio changed from year to year. He also stated that C. V. Averintsev (1933) found that females spawn accompanied by two males, and that P. L. Preshnikov took the sex ratio to be nearly 1:1. Vork stated that females spawn in accompaniment with two males and gave the percent of males on the spawning ground during the spawning period as: beginning of spawn-

TABLE 11. AGE AT SEXUAL MATURITY OF ALASKA INCONNU (M = MALES, F = FEMALES)

Area	Sex		Age ≤6+	7+	8+	9+	10+	11+	12+	≥13+
Selawik N = 212	M	Imm.	34	13	3	2	1	1	0	0
		Mature	0	0	0	2	5	6	5	4
	F	Imm.	39	7	5	5	1	0	0	0
		Mature	0	0	0	0	5	7	15	46
Kobuk R. N = 103	M	Imm.	1	4	2	0	0	0	0	0
		Mature	0	2	4	8	5	8	12	3
	F	Imm.	1	1	4	0	0	0	0	0
		Mature	0	0	0	0	1	4	3	20
Yukon R. N = 37	M	Imm.	7	4	1	0	0	0	0	0
		Mature	0	0	0	0	0	0	0	0
	F	Imm.	10	4	1	2	0	0	0	0
		Mature	0	1	3	4	0	0	0	0
			5+ 6+							
Chatanika River N = 18	M	Imm.	0 0	0	0	0	0	0	0	0
		Mature	2 2	3	5	0	1	0	0	0
	F	Imm.	0 0	0	0	0	0	0	0	0
		Mature	0 0	0	2	1	1	1	0	0

ing, 59%; end of spawning, 69%. The reason given for this change is that males linger on the spawning ground longer and one male probably fertilizes eggs from more than one female. In 1966, a female accompanied by a single male was observed swimming back upstream on the spawning ground during spawning. No observations were made in 1965 or 1966 to indicate that two males accompany a female during spawning.

Age at sexual maturity, as shown in Table 11, is as follows: Selawik males, 9 years; females, 10 years; Kobuk males, 7 to 8 years; females, 10 years; Upper Yukon—no mature males, but probably 6 to 8 years; females, 8 to 9 years; and Chatanika River males, 5 to 6 years; and females, 8 years. Berg (1948) gave the age at sexual maturity of Pechora Rivĕr inconnu as not less than 13 years old; males in the lower reaches of the Yenesei River as 8 to 9 years, and females as 9 to 10; and Kolyma River males as 11 to 12 years, and females from 14 years. The smallest mature male taken from the spawning grounds on the Kobuk River weighed 2.5 kg and the smallest female weighed 4.8 kg.

Temperature—Optimum water temperatures for spawning vary from watershed to watershed and possibly from year to year. The 1965 Kobuk River air and water temperatures are presented in Figure 16. In 1965, spawning activity occurred at water temperature between 1.4 and 4.4 C (optimum 2.6 to 3.2 C), while in 1966 water temperature remained constant at 4.4 to 4.6 C during the spawning period. Major spawning activity in 1965 was between 27 and 29 September and in 1966 occurred between 25 and 29 September, although some spawning occurred before that date in both years. Fuller (1955) indicated that Great Slave Lake inconnu spawn the first week in October. Vork (1948a) reported that Ob River fish spawn in October at water temperature between 1.5 and 8.2 C (optimum 7.6 C). Kirilov (1962) stated that Vilyui River fish spawn from 1 to 20 October at temperatures between 0 and 5.8 C. The spawning grounds of Alaskan inconnu are located farther north than the spawning grounds of Russian fish, and this fact might account for the differences in spawning temperatures and dates.

Spawning Habitat—Spawning occurred in the Kobuk River in the relatively swift main current, both where it moved along the cut bank and also in the center of the channel as the current swung to the opposite shore. No spawning was observed on gravel bars on the inside curve of the river where the current was slower. Major spawning grounds were located between 38 and 48 km (24 and 30 miles) above Kobuk village. Water depth in 1965 was between 1.8 and 2.7 m. In 1966, spawning occurred in water depths of 1.2 to 2.4 m with the major spawning activity in water from 1.5 to 1.8 m. In optimum spawning habitat, the bottom is composed of differentially-sized, coarse gravel with no silt and some sand present. Some spawning occurred over uniformly-sized gravel, and twice fish were seen spawning over a bottom 50% covered by sand. Interstices between the larger gravel are filled with smaller gravel and sand. Swift current keeps the bottom silt-free. It appears that the presence of differentially sized gravel is a prerequisite to insure lodging of the eggs. With a bottom of uniformly sized gravel, the eggs might fail to lodge, due to the swift current, and be carried out into the slow-moving water where there is more silt, thus reducing changes for survival.

Spawning Behavior—In 1965, inconnu were observed spawning in the main current off the upper end of a gravel bar 38 km above Kobuk at 3 PM on 27 September (Fig. 17). At this time the Kobuk River crested at .9 to 1.2 m above normal following heavy rain and snow falls. The normally clear water was extremely turbid. Six spawning splashes (probably three females) were heard on this spawning ground between 3 and 3:30 PM, six splashes between 5:07 and 5:31 PM, and six again

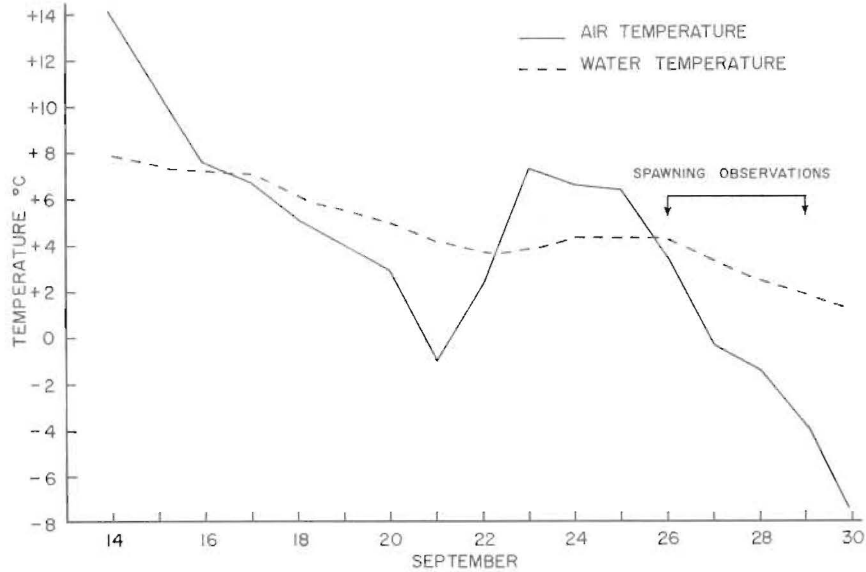

Figure 16. Temperatures taken on the spawning grounds on upper Kobuk River in September 1965. Temperature shown is mean of readings taken at 6 AM, noon, and 9 PM.

between 7:30 and 8 PM. Between 3:50 and 4:45, two spawning fish were observed on the spawning ground near Harvey's fish storage shed (locally called Harvey's Bar) 45 km (28 miles) above Kobuk. The mornings of 28 and 29 September were spent on the spawning grounds, but no spawning was observed; however, fish were seen leaving the shallow water areas close to shore. Spawning activity evidently does not begin until late afternoon. On 28 September no spawning was observed off the Harvey Bar between 2:20 and 3:44 PM, but one fish was observed spawning at 3:45 PM. There was much spawning activity off the bar 38 km (24 miles) above Kobuk between 4:04 and 5:30 PM. This was the peak of spawning (water temperature 2.6 C). Spawning occurred along a 360 m length of channel off the Harvey Bar, and often two females were observed spawning at the same time but in different areas. On 29 September 1965 spawning commenced at 4:20 PM, and four spawning splashes were observed from this time to 4:46. One fish spawning at this time was taken by hook and line as it entered the shallow water near shore after two spawning spurts (#355, partially spent 10.4 kg female). At 5:10 PM a beach seine haul on the gravel bar below the spawning area took four inconnu and hundreds of grayling and whitefish which had

Figure 17. Spawning ground located 38 km (24 miles) above Kobuk on the Kobuk River, Alaska. This was a major spawning area in 1965.

been feeding on inconnu eggs. Between 4:46 and 5:40 PM, six spawning splashes were heard, and from 5:40 until 10 PM only two spawning splashes were heard. Air temperature was –8.3 C and water temperature was 1.7 C. No fish were observed spawning on 30 September, and slush ice was running in the Kobuk River. Although historical spawning grounds in the Kalla area (35 to 38 km above Kobuk) and above the mouth of the Mauneluk River (64 km above Kobuk) were frequently checked, no spawning activity was observed on them in 1965.

In 1966, inconnu began spawning 45 km (28 miles) above Kobuk off the Harvey Bar on 26 September, and most spawning activity was completed by the evening of 29 September at 8.30 PM when observations were completed. The peak of spawning in this area occurred on 26 and 27 September. Fifty inconnu (some spent) were taken on 26 September by beach seine 48 to 51 km (30 to 32 miles) above Kobuk, suggesting that some spawning had occurred on 25 September or earlier in this area. The water was clear and about 1.2 m lower than on 27 September 1965. Spawning occurred in the same areas each year, but in 1965 the fish were spawning closer in to shore. Spawning duration and dates of spawning were similar in both years. In 1966 spawning generally commenced later in the day (5:52 PM on 28 September and 4:14 PM on 29 September).

A general description of inconnu spawning behavior taken from 1966 observations is as follows: Inconnu left the deep water areas 42 km (26 miles) above Kobuk about 24 September. There is evidently movement from this area both upstream and downstream to spawning grounds. Of 40 inconnu tagged here, one was recovered 4 days later 6 km above the tagging site, and another was recovered 6 days later 3.2 km below the tagging site. The fish were still in small schools at this time. As the time for spawning is at hand, the fish move onto the spawning grounds, one or two pairs at a time. Pairing evidently occurs immediately before the onset of spawning. The females spawn on the surface of the water, and the males follow close behind and immediately fertilize the eggs. Males normally do not come to the surface of the water, although sometimes a male was observed breaking the surface of the water behind a female. The female first comes to the surface at the upper part of the spawning ground and after the first spawning spurt (each spawning spurt lasts from 1 to 3 seconds) is carried downstream where she will come to the surface to spawn again. It is not known how many spawning spurts are required to extrude all the eggs, but one female came to the surface six times in one spawning pass. Some fish continue downstream after the first spawning pass, but others were observed swimming back upstream close in to shore after completing a pass over the spawning ground. The second spawning pass usually begins in the lower half of the spawning ground. As a female would come to the surface with a loud splash, the tail would appear above the water, then the dorsal fin and sometimes part of the dorsal surface of the body. With a vigorous writhing of the body, she would skitter across the water, expelling eggs. This movement usually is perpendicular to the direction of current flow. In most instances the dorso-ventral body axis is in a vertical plane (dorsal fin straight up), but in some instances the body axis is tilted as much as 120° in an almost horizontal plane, with the current pressing almost directly on the abdomen.

Between 7:05 and 8:30 PM on 27 September 1966, 63 spawning splashes were heard off the Harvey Bar; 47 were heard during this time on 28 September; and only 24 spawning splashes were heard the evening of 29 September. On 28 September, spawning observations were carried out from 3 to 9 PM. Spawning began at 5:42, and from this time until 9 PM, 162 spawning splashes, probably representing between 30 and 40 females, were heard. Main activity was around 6 PM.

Grayling were found in large numbers on the spawning grounds and took many inconnu eggs before they had a chance to lodge in the coarse gravel. In addition, whitefish, grayling, suckers, and charr feed on eggs that are carried into shallow water of slow current.

Spent fish were quite active, and no dead fish were observed in 1965 or 1966. Ovarian examination of two spent females revealed that 70 and 200 eggs were retained respectively. Tiny eggs of future spawnings were present.

Downstream Movement—After spawning, a downstream movement occurs. The fish do not head downstream immediately after spawning, as spent fish were taken by gill net in eddies near the spawning ground in 1965, and three spent females were taken by gill net at Kobuk between 28 and 30 September 1966. Residents of lower Kobuk River villages indicated that the main downstream movement had passed their village by the first days of October in 1965. Few inconnu are taken during the downstream migration in the Kobuk River. Inconnu, mainly spent fish, are present in the slow-moving water of the Selawik River in the vicinity of Selawik from the 10th of October until the first of January, and during this period many are taken through the ice by gill net.

Development—No information concerning time of hatching is available for Alaskan inconnu. However, Vork (1948a) mentioned that Ob River inconnu had an average incubation period of 182 days and hatched between 15 and 25 April. Smolyanov (1957) stated that Kubena River inconnu hatch between 14 and 22 April at a length of 12 to 13 mm and that maximum spawning activity had occurred on 9 October. It seems likely that the incubation period of inconnu from Alaska would be similar.

Spawning Frequency—There is some question as to whether inconnu spawn every year. Nikolsky (1954) indicated that inconnu spawn at intervals of 3 to 4 years. Berg (1948) suggested that some mature inconnu enter the Pechora River in autumn and do not spawn until the following autumn. No inconnu were taken at the mouth of the Kobuk River, but all mature fish taken from Kiana and further upriver had well-developed gonads and probably would spawn in the fall. At Selawik, where most fish were taken at the mouth of the Tuklomarak River, two stages of gonad development were observed in mature females. About 70% of the mature females examined in early June had well-developed eggs (1.2 to 1.5 mm in diameter) and contained large amounts of visceral fat. The remainder of the females examined contained some eggs of less than 1 mm in diameter and many less than .5 mm in diameter and had only small amounts of visceral fat. This condition was not observed in mature males. The females containing eggs in the early stages

TABLE 12. STOMACH CONTENTS OF SELAWIK, ALASKA, INCONNU TAKEN IN 1965. OF 283 STOMACHS EXAMINED, 202 CONTAINED FOOD

Food organism	Number of organisms	Stomachs in which organisms occurred	
		Number	Per cent occurrence in feeding fish
Fish:			
Least Cisco *Coregonus sardinella*	316	86	42.6
Rainbow smelt *Osmerus dentex*	26	18	8.9
Ninespine stickleback *P. pungitius*	63	14	6.9
Coregonus species (*C. nasus* and *C. lavaretus pidschian*)	37	14	6.9
Broad whitefish *C. nasus*	13	7	3.5
Burbot *Lota lota maculosa*	7	6	3.0
Humpback whitefish *C. lavaretus pidschian*	4	4	2.0
Blackfish *Dallia pectoralis*	3	2	1.0
Arctic charr-Dolly Varden ex.-*Salvelinus alpinus* (*malma*)	1	1	0.5
Unidentified fish remains	–	64	31.7
Crustacea:			
Isopod *Mesidotea entomon*	263	29	14.4
Opossum shrimp *Mysis relicta*	870	22	10.9
Amphipods	3	3	1.5
Insects:			
Diptera larvae	3	2	1.0
Tricoptera adult	1	1	.5
Unidentified insect remains	–	1	.5

of development possibly spend the summer feeding and would spawn the following year. Assuming that males spawn every year and females do not, one would expect the spawning ground sex ratio to favor males; but this is not the case on the Kobuk River. The fact that males mature earlier in life should be offset by the fact that females have a longer life span.

FOOD HABITS

In the present study, stomach contents of 365 inconnu from Selawik and the Yukon River were examined. In addition, stomachs of 104 Kobuk River inconnu and 13 of Chatanika River inconnu were examined, but these fish were on the spawning migration and had empty stomachs. Except for 81 fish taken in April and May through the ice at Selawik Lake, the data presented represent summer food habits of inconnu.

Results of stomach analysis are expressed as frequency and number of occurrence. In the frequency of occurrence analysis, each food item is given equal weight regardless of amount or size of the organism consumed. Percentage occurrence of each food item was obtained by dividing the number of stomachs containing a specific food item by the total number of stomachs containing food.

Food habits data of fish from the upper Yukon River and Selawik, collected in 1964, have already been published (Alt, 1965).

RESULTS

Two hundred and two of the 283 Selawik inconnu stomachs collected in 1965 contained food and 81 were empty. Food items and the number of each item eaten by Selawik fish are presented in Table 12. Fish comprise the major part of the diet of Selawik inconnu, with the least cisco, *Coregonus sardinella*, being the most important food item. The 316 ciscoes represent an average of 3.6 per feeding inconnu. Other coregonids, smelt, sticklebacks, *Mesidotea entomon*, and *Mysis relicta* are of secondary importance in the diet. The relatively small size of sticklebacks decreases their importance as a food item, since they weigh less than the isopod, *Mesidotea entomon*.

DISCUSSION

A change with time was observed in feeding habits of the Selawik inconnu. In April and May, while feeding under the ice in Selawik Lake, inconnu ate mainly *Coregonus sardinella* and *Mysis relicta*. Fish at this time were feeding about 1.5 to 3.2 km out in Selawik Lake. The number of ciscoes in each stomach was less and the number of empty stomachs was greater than observed in June. Examination of 18 stomachs from fish caught in April and May in 1964 showed that *Mysis relicta* formed a significant part of the late winter diet (Alt, 1965). The larger sample from 1965 probably reflects the true situation and shows that *Mysis* was of minor importance during late winter and early summer. Fuller (1947) noted that even though *Mysis relicta* is present in Great Slave Lake, inconnu do not feed on it during the summer.

In early June, after the ice went out, inconnu were concentrated in Selawik Lake at the mouths of the Selawik and Tuklomarak Rivers. Most of the specimens examined were taken at the mouth of the Tuklomarak River. Nine specimens taken at Inland Lake between 3 and 5 June contained mainly *Coregonus sardinella*, but also a high proportion of ninespine sticklebacks, humpback, and broad whitefish, burbot, blackfish, and the isopod, *Mesidotea entomon*. In early June, the diet of inconnu caught at the mouth of the Tuklomarak River consisted almost entirely of

Coregonus sardinella. This was definitely the period of greatest feeding activity. At this time (6 to 15 June) nearly all stomachs examined contained food, and the number and size of prey items was greater. Most *C. sardinella* found in stomachs at this time were between 20 and 30 cm long. A 14 kg fish contained 17 ciscoes of 100 to 200 gr each. Since inconnu must swallow their food whole, these larger ciscoes were probably beyond the ability of the smaller inconnu to handle. At this time smaller inconnu were feeding on *Mesidotea*, *Mysis*, and small coregonids. Some of the larger inconnu had also fed heavily on *Mesidotea*.

After 15 June it appeared that food abundance went down and feeding habits changed slightly. The diet shifted to more *Mesidotea* and small coregonids (less than 12 cm long). Some sticklebacks and mysids were also taken. The larger, mature *Coregonus sardinella* had probably left Selawik Lake. Smelt started to occur in the diet on 19 June and were quite important during the remainder of the month. All smelt were about 15 cm long and appeared ready to spawn. As June progressed, the percentage of stomachs containing food decreased. Of 92 stomachs examined from 22 to 27 June, 69 contained food while 38 were empty.

In early June, inconnu were feeding close to the surface. They would often jump almost completely out of the water as they pursued *Coregonus sardinella*. On 7 June, inconnu were observed jumping constantly at the mouth of the Tuklomarak River and from 2 to 5 PM I could count up to 25 fish jumping in a 10-sec period. These periods of intense feeding activity may reflect prey availability, as they were irregular in occurrence. Fishing with hook and line was most productive at this time.

In late June, as air and water temperature increased, fish were not found near the surface, and best fishing success was encountered at depths of 2 to 3 m.

Data from the present study indicate that, while larger inconnu are mainly piscivorous, insects and crustaceans form an important part of the late winter and summer diet. This is especially true of Selawik inconnu.

Other food habits studies have indicated that young inconnu feed largely on invertebrates. Kirilov (1962) mentioned that yearling and 2-year-old inconnu in the Vilyiu River, USSR, feed on fish-leeches and insect larvae, mainly tendipedids. Nikolsky (1954) stated that inconnu become piscivorous in the second year of life. Fuller (1955) mentioned that P. A. Larkin examined stomachs of small inconnu in Big Buffalo River, Canada, and found them to contain 70% ephippia of *Daphnia* sp., 25% chironimid larvae, and 5% other aquatic insects, but no fish remains. Fuller concluded that these fish do not change to a fish diet until they reach Great Slave Lake at about the third year of life. Vork (1948a) found that in early summer, Ob River inconnu of age 0+ had eaten plankton, benthic organisms, and a small percentage of fish. After 20 July, plankton was no longer found, while fish and benthic organisms grew more important. In early July, 11% of the small inconnu had fed only on fish but later in the year 33% were feeding only on fish. In the second year of life, 67% were feeding only on fish, and at age 3 all fish examined by Vork had fed entirely on fish. Data published by Alt (1965) show that fish formed an important part of the diet of upper Yukon River inconnu of age classes 0+ and 1+.

One hundred four inconnu taken during the spawning migration and on the spawning grounds in the Kobuk River between 14 July and 30 September all had empty stomachs. Fish taken late in September, both before and after spawning, appeared to be in good condition. Although Kirilov (1962) stated that inconnu feed during the spawning migration, and on the spawning ground, Nikolsky (1954) reported a cessation of feeding during the spawning period. Vork (1948a) reported that feeding gradually decreases during the spawning migration and stops completely in the upper reaches of the Ob River. Vork mentioned that inconnu will still take a lure at this time. After spawning, feeding is intensified. Four spent fish taken in the vicinity of the Kobuk River spawning grounds in 1965 had not resumed feeding, but Kobuk valley residents reported that inconnu do feed in the lower reaches of the river on the postspawning migration.

THE FISHERY

At the present time major utilization of the inconnu in Alaska is as subsistence food for Alaska natives and their dogs. Alaska Department of Fish and Game reports give the 1963 inconnu subsistence catch for the Yukon River drainage (excluding the Koyukuk River) as 6,129 and in 1964 it was 4,177 fish. No records are available for the Koyukuk River. The 1963 subsistence catch on the Kuskokwim River was reported as 2,301 and the 1964 catch as 1,244 fish. These records should be regarded as minimum figures and are not intended to show changes in abundance.

In 1965, records were kept of the late winter inconnu subsistence catch from Selawik Lake. These catch records indicate that from 17 April to 28 May the residents of Selawik (population 430) took 7,240 inconnu. Residents of the lower Kobuk River villages of Noorvik and Kiana were reported to have taken an estimated 4,000 to 5,000 additional inconnu from Selawik Lake. The 1965 estimated total inconnu catch from the Selawik area is as follows:

7,240	Taken through the ice at Selawik Lake by Selawik residents in late April and May
4,000– 5,000	Taken through the ice at Selawik Lake by residents of Noorvik and Kiana in late April and May
4,000	Caught by hook and line and gill net in Selawik area in June
4,000– 6,000	Caught by hook and line and gill net in Selawik area from 1 July to 31 December
19,240–22,000	Total estimated catch at average weight of 2.3 to 2.5 kg (5 to 5½ pounds)

Approximately 900 kg (2,000 pounds) of this catch were sold commercially.

A commercial fishery has been operating in the Kotzebue—Hotham Inlet area and in past years has yielded up to 45,000 kg (100,000 pounds) yearly (Wigutoff and Carlson, 1950). In general, the commercial catch has been on the decline since then. Michael Geiger (pers. comm.), of the Alaska Department of Fish and Game, estimated that the Kotzebue commercial catch from 23 November 1964 to 24 January 1966 was 3,940 fish at an average weight of 3 kg (6.6 pounds) to give a total weight of 11,700 kg (25,700 pounds). Most of these fish were taken by gill net through the ice at Hotham Inlet between late October 1965 and late January 1966. Complete records of the subsistence catch from Kotzebue Sound—Hotham Inlet are not available for 1965. However, Michael Geiger (pers. comm.) indicated that from October 1965 to May 1966, approximately 11,000 fish were taken for subsistence purposes. He stated that the catch during this period was higher than in the previous few years. Average weight of the fish in the subsistence catch was about 2.5 kg (5.5 pounds). Using a 1965 Kotzebue Sound—Hotham Inlet subsistence catch figure of 8,000 fish, the total estimated catch from the Kotzebue Sound, Hotham Inlet, and Kobuk River for 1965 was about 15,000 fish which includes both the commercial and subsistence catch. Thus the estimated inconnu catch from Northwest Alaska in 1965 was between 34,200 and 37,000 fish.

In the USSR, the inconnu is of considerable value to the fishing industry, especially in the lower reaches of the Siberian rivers. Nikolsky (1954) gave the 1936 to 1940 total catch of *Stenodus leucichthys nelma* from Siberian waters as being between 4 and 4.3 million kg (8.7 and 9.4 million pounds) annually. Largest catches were obtained from the basin of the Ob River while the Lena and Yenisei yielded smaller amounts. Drag seines and gill nets were the main types of fishing gear used.

Future utilization of the inconnu as a sport fish in Alaska holds great promise. Its large size, fighting ability, limited distribution, and fine table qualities make it a much-sought-after fish. An increase in fishing

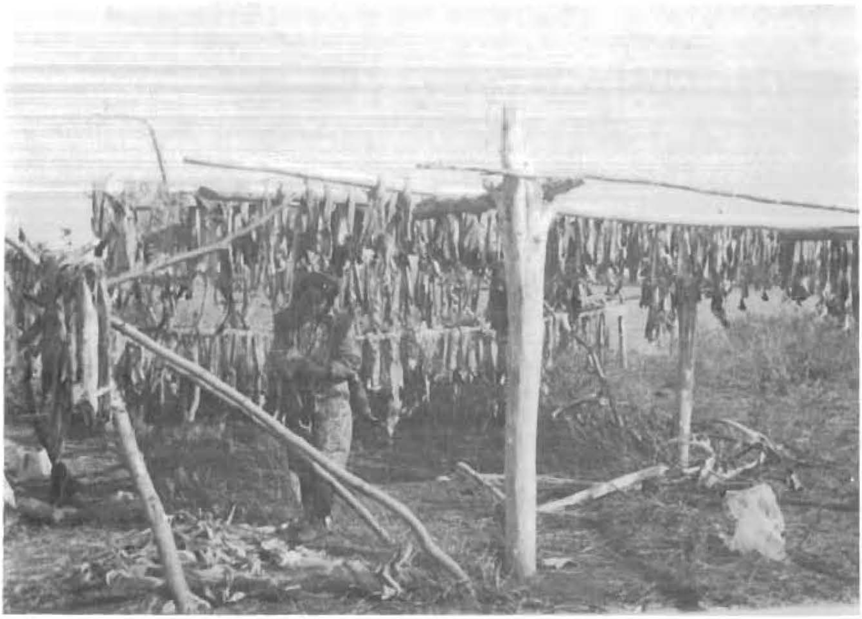

Figure 18. Native utilization of inconnu. Fish taken by subsistence fishermen during the summer are split, then hung to dry in the sun. Major use of these fish, taken at the mouth of the Tuklomarak River, Alaska, in June, will be for dog food. Fish were taken by gill net and by hooking (rod and reel or jigging stick).

pressure can be expected as the sporting qualities of the fish are advertised and accommodations for fishing guests are provided. Outside of a few areas near Fairbanks, accessible by the highway system, nearly all sport fishing for inconnu requires travel by bush plane and/or boat. Good sport fishing success can be enjoyed on the Kobuk River; the Holitna River, a tributary of the Kuskokwim River; clearwater tributaries of the Yukon River; at Hughes on the Koyukuk River; and Selawik Lake, Selawik River, and Tuklomarak River in the Selawik area.

CONSERVATION

In recent years there has been talk of expanding the commercial fishery for inconnu at Hotham Inlet and establishing a commercial fishery at Selawik. The inconnu represents a potential commercial industry in an area with a low economic base. However, there are indications that at present levels, and especially at past levels, of utilization, the inconnu is being overharvested. This resource has commercial, sport, and subsistence value, and one must ask what is the most important use of the resource.

Native subsistence utilization, of course, should be given top priority. In 1965, over 85% of the total inconnu catch in Northwest Alaska was utilized by the Eskimos for subsistence (Fig. 18). Fish taken through the ice in Selawik Lake in April and May are needed by the Eskimos, as the winter supply of food for themselves and their dogs is usually depleted by this time. Selawik residents are more dependent upon the inconnu for subsistence than are residents of the Kobuk valley. In Selawik, inconnu comprise approximately 60% by weight of the fish subsistence catch from 1 June to 1 October and approximately 95% of the subsistence catch from 1 October until breakup the following year. On the Kobuk River there is less dependence on inconnu. There, whitefish (four species of *Coregonus*) provide the main subsistence food, and their relative importance is becoming greater as the runs of chum salmon and inconnu have been declining. Of the Kobuk River villages, Noorvik took the largest number of inconnu followed by Kobuk, Ambler, Shungnak, and Kiana in that order. In Kobuk, the majority of the catch is taken by beach seine at Kobuk village and from the spawning grounds upstream. In 1965, the inconnu catch comprised an estimated 8 to 10% of the total subsistence fish taken at Kobuk.

The only indications we have of a decline in the number of inconnu in Northwest Alaska are statements by natives and commercial fishermen that there are fewer inconnu now than previously. The almost complete lack of information on catch and catch trends related to effort, as well as size composition of the catch, precludes making a more definite statement. John Nelson (*viva voce*, 1965), who has been fishing commercially for inconnu for many years at Hotham Inlet, reports that his catch per unit of effort has been declining steadily.

Overfishing, both subsistence and commercial, may have been responsible for the supposed decline. Possibly the yearly commercial catches of up to 45,000 kg around 1949, coupled with high subsistence catches in those years, may have started a decline from which the population has not been able to recover.

In order to sustain a total catch of 34,200 to 37,000 fish per year, the population(s) must be quite large. The fish are first subjected to the fishery between ages 4 and 5. Since the inconnu reaches sexual maturity so late in life (Table 11), it experiences fishing pressure for a number of years before it has a chance to spawn. This important aspect of the life history of the inconnu should be taken into account when considering expansion of the fishery.

Even though the causes of a decline in inconnu numbers in Northwest Alaska are not fully understood, it appears that the population has been declining while absorbing a yearly catch of approximately 36,000 fish (1965 figure). If this is true, then inconnu should not be subjected to increased fishing pressure and the establishment of a large scale commercial fishery in northwest Alaska should be viewed with extreme caution.

SUGGESTED AREAS OF FUTURE RESEARCH

From a management standpoint, top research priority should be given to determining inconnu movements, if any, between Selawik Lake and Hotham Inlet, and estimating the total inconnu population in Northwest Alaska. A large-scale tagging program carried out at Selawik and the Kobuk River would resolve the movement question and at the same time shed some light on the population question. Accurate yearly records of the subsistence, commercial, and sport catch should be kept to determine population trends and age composition of the catch. Other areas of future research include: determination of spawning frequency; movement and location of young inconnu of age-classes 0+, 1+, 2+, and 3+; sport fishing potential; parasites; and spawning ground checks on the Kobuk and Selawik Rivers.

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