— big skin of Dolly Varden fm. Mont. — didn't know where — made plea to furnish locality fm. letter

Bean, T. H. 1888. Eastern limit of Dolly Varden. Am. Angler 13(3). 44 — quote fm. letter (Mr. Boring to Mr. Magoun) "I caught it in a stream which joins the upper & lower St. Marys Lakes, ~~in~~ Thinks Belly R. Last year caught two others in same place one of 6 lb. never seen them in any other stream." —

Portello, J. M. T. 1888. Some fishes of the Yellowstone. ibid 13(4): 57-58.

Yellowstone full of trout to junction w/ Big Horn — few after — Tongue R. up 100 miles in Mts. many trout.

— Bean, T. H. 1888. 13(4): 59-60 Distribution of the lake trout — Specimens. — last Nov. Mr. Gilman Sawtell sent 3 specimens of lake trout fm. Henry's Lake Idaho —

— · 13(5): 77 · Lake trout in St. Mary's Lake, Mont. — received salted skin and excellent photographs of a lake trout fm. St. Mary's L. + 2 other fish which seem to be Clarki trout.

1. Manuscript for proceeding of the symposium should be send not later than 31 Oct.

2. Editor's Commission will send a copy of the manuscript to chairman of each session

3. Each chairman must read the manuscript as a ~~ref~~ 1st referee. If necessary, send it to adequate 2nd refree.

4. As Japanese participants are usually unskillful to write English. Please, rewrite sentence, if necessary

5. ~~Style of paper~~ About the style of paper refer editorial memorundam of Japan.

J. Ichthyology, please

Cavender & Kimura (1989). Cytotaxonomy and interrelationships of Pacific-basin *Salvelinus*

H. perryi 2N = 62 NF 104

acrocentr.
42 meta, submetacentrics 4 subtelocentr. 16 telocentr.

Hensel & Hočik (83) - *H. hucho* 2N = 82

24-32 msm + 52-58 t

Dorofeeva (cited Viktorovsky) - *taimen* 2N = 84 18 + 66 = $\overset{NF}{102}$

O. masou 2N = 66 NF 102

36 msm 22 ST 8 acrocent.

rhodurus identical except for NOR position

S. leucomaenis leucomaenis 2N 84 NF 100

same for *imbrius* 16 msm 68 ST+T

" " *pluvius* * only 8 biarmed-metacent. - also only

8 meta. - in southern *malma*, *fontinalis* & *namaycush* = primitive

confluentus 2N = 78 NF 100 22 + 56

same as *kronocius* - but *kronocius* gillrakers, derethmoid & ethmoid fontanelles all similar to *malma*.

S. malma kraschenninikovi - Hokkaido - 2N = 82 NF 98

16 sms + 66 ST+T

lordi same w/ 'big' marker acrocentric very long acrocentric

according to Viktorovsky's photos - same 'marker' in *malma malma*.

(?) - *malma malma* 18-20 sms, 56-60 ST+T

2N = 76-78 NF 96

NOR's AK *malma* differ from Hokkaido *malma*

miyabe 16 + 66 2N = 82 NF 98 but differs in NOR

Information for Contributors

1. Articles in the Journal consist of original reports, notes, book reviews, news and comments, proceedings and others which are written in Japanese with English summary or in English. Contribution to the Journal is open only to the members of the Society.

2. Manuscripts are to be submitted in duplicate (original and copy) to the Managing Editor: Torao Sato, Misaki Marine Biological Station, University of Tokyo, Koajiro, Miura 238–02, Japan. The author(s) should retain one copy. Manuscripts must be clearly typewritten, double-spaced (about 60 letters × 30 lines), on one side of bond or other good quality paper. The manuscript should be written in the following order: title, author's name(s), abstract, text ending in acknowledgment(s), literature cited, and institution with address. Title and abstract in Japanese are added at the end of the article. Unless they are given by the author(s) they will be prepared by the editors.

3. Authorship of the scientific names should be included in the title only when nomenclatorial problems are involved. Footnotes should be avoided whenever possible. Nothing in the manuscript should be underlined except Latin names of genera and species. Common abbreviations and symbols, such as μm, mm, cm, m, g, °C (for Celsius), cc, %, and so forth, should be used. Periods are only rarely used with abbreviations. Measurements should be given in metric units.

4. Tables and figures, with their headings and legends written in English, should be self-explanatory, not requiring reference to the text. Their placement should be indicated on the left-hand margin in the text. Each table should start on a separate page, numbered with an Arabic numeral. Material in the text should not duplicate that in the tables. Vertical lines should be avoided in the tables.

5. Each figure should be on a separate sheet, numbered with an Arabic numeral. As a rule, maps, drawings, and photographs should be numbered as figures. Figures should be drawn in black India ink on Bristol board, good quality paper, or faintly bluelined graph paper. Copies of the illustrations and photographs must be submitted with the text. Illustrations larger than 21.5×28 cm should be avoided. Related diagrams should be grouped to form a single figure suitable for eventual reduction to a size not exceeding 13 × 18 cm. Parts of figures should be labelled A, B, C, etc (e.g., Fig. 1A, B). The name(s) of the author(s), the number of the figure and the intended reduction should be clearly marked on the covers of the illustration and/or photograph. Legends for figures should be typewritten on a separate sheet.

6. All papers referred to in the text should be arranged alphabetically and chronologically in the "Literature cited". The following examples may be of assistance:

   Hennig, W. 1966. Phylogenetic systematics. Univ. Illinois Press, Urbana, 263 pp.

   Hubbs, C. L. 1960. The spiny-rayed cyprinid fishes (Plagopterini) of the Colorado River system. Misc. Publ. Mus. Zool., Univ. Mich., (115): 1–39, pls. 1–3.

   Farris, J. S. 1981. Distance data in phylogenetic analysis. Pages 3–23 *in* V. A. Funk and D. R. Brooks, eds. Advances in cladistics: Proceedings of the first meeting of the Willi Hennig Society. New York Botanical Garden, New York.

7. Proof should be corrected immediately on receipt. Cost of excessive changes in proof from the original copy will be charged to the author(s). For an article, publication charges of ¥30,000 (major paper) or ¥20,000 (short report) are paid by the Society, and excess cost will be charged to the author(s). Copies of reprints and covers will be furnished at cost price.

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Air Mail

SYNTHESIS OF INFORMATION FOR A PHYLOGENETIC INTERPRETATION OF SALVELINUS

Robert J. Behnke
Colorado State University
Fort Collins, Colorado

Since my 1980 and 1984 papers on charr systematics, considerable new information has been compiled, particularly from the areas of karyology and biochemical genetics. In view of the latest information, I have modified my former concepts of relationships in the subgenus *Salvelinus*.

It is now apparent that organismal (morphological) and molecular evolution may proceed at very different rates, particularly among sympatric populations selected for different niches. Problems associated with a best interpretation of available information concern decisions on primitive vs. derived character states and convergent evolution. Ongoing studies of mitochondrial and ribosomal DNA and chromosomal banding, particularly of nuclear organizing regions, imply that much greater resolution and refinement for phylogenetic analysis will be possible.

Some controversial aspects of *Salvelinus* systematics, such as species criteria, are not amenable to resolution by quantification. A realm for qualitative speculation will always remain for future symposia.

Thingvallavatn

Magnusson, K.P. and M.M. Ferguson. 1987. Genetic analysis of four sympatric morphs of arctic charr, Salvelinus alpinus, from Thingvallavatn, Iceland. Environmental Biology of Fishes 20(1): 67-73.

– small SB benthivore, large LB benthivore, PL planktivorous, and PI piscivorous predaceous "morphs" – 5 of 36 enzyme loci were polymorphic Est 2 Gpi 3, Ldh 4, Mdh 4,5 and Pgm 2. all very closely related Nei's D value from .00004 to .00126 – small benthivore most divergent.

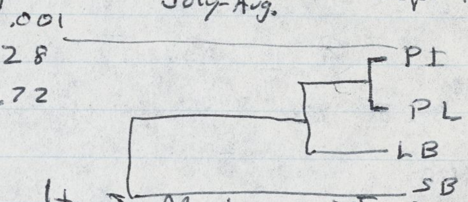
· Benthic forms feed mainly on snails (Lymnaea peregrea) and to lesser extent on chironomids. planktivore & piscivore more pelagic – planktivore eats mainly Daphnia longispina and Cyclops abyssorum, some chironomids. Piscivore mainly on 3-spine stickleback

– Benthic char dark color, rounded snout, subterminal mouth. – Pelagic char – slender, lighter silvery colors, pointed snouts, terminal mouth.

SB mature 3-5 yrs. (at 7-20cm) PL · 5-6 yrs. (18-22cm) LB & PI 6-10 yrs. (25-50cm)

spawn July-Sept. – north. Sept-Nov. – south | Sept-Oct ~~July-Aug~~ | July-Aug. | Sept-Nov.

Mdh 4,5	SB			
100	.42	.33	.25	.28
130	.58	.67	.75	.72



Sandlund, O.T., B. Jonsson, H.J. Malmquist, R. Gydemo, T. Lindem, S. Skulason, S.S. Snorrason, and P.M. Jonasson, 1987. "Habitat use of arctic char, Salvelinus alpinus, in Thingvallavatn, Iceland." Ibid 20(4): 263-274.

– last glacial retreat 11,500 yrs. B.P.
84 km² max depth 114m – only few brown trout &
3-spine stickleback – – Great niche diversity – selection to divide up resources – –

Loch Rannoch

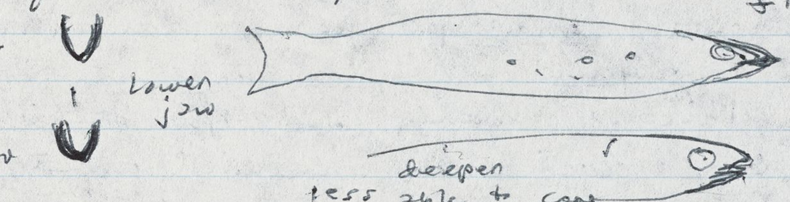
Walker, A.F., R.B. Greer, and A.S. Gardner, 1988. Two ecologically distinct forms of Arctic charr, Salvelinus alpinus (L.), in Loch Rannoch, Scotland. Biological Conservation 43(1): 43-61.

– small headed, claret colored (described by Maitland 1881) & other large headed, pale color.

* – 2 'morphs' – diet more distinct non-overlapping than genera – Salmo – Salvelinus etc –

L. Rannoch, Tayside, Scotland.
small-headed form is pelagic – mainly zooplankton
large-headed form benthic – mainly benthic insects
pelagic form spawns sublittorally in Oct. early Nov.
benthic form found ripe in Nov. at head of Loch
in ~~[illegible]~~ inflow zone of River Gaur – main inlet
S. struanensis Loch Rannoch – Maitland 1881
Loch Rannoch – long, deep (max 134 m) – 16.7 km. long
el. 204 m. 1902 ha., of which about 25% < 15 m. deep.
+ pike, perch, eels, 3 spine stickleback, Phoxinus p., S. salar,
& S. trutta. – Trutta average < 300g. but occasional 'ferox' to 10 kg.

Qualitative
* Iwame form most Iwana physio mode
only Japan 3 Is.
why?



finer gillrakers
claret
salmon-pink spots
& transparent fins

pale, grey-brown
lemon fins, no obvious spots
thicker, shorter gillrakers

pelagic charr – ~~7~~95% Cladocera
4-5% insects
benthic charr ~~stonefly~~ caddis – 38% ~~[illegible]~~ 20% debris, 13% clams Pisidium,
6% chironomids 4% fish. ; 1% Cladocera some Gammarus
4 of largest fish had eaten small charr,
largest fish of 375 mm. contained 180 mm. charr (48% of its length)
max size – pelagic ca 250-260 mm age 2-8 (4.3)
benthic – 375 mm. 2-12 (6.1)
only 1 of 243 fish > 240 mm. (= No. 1 375 mm)

max changed
202 mm. at age 8 (1970)
260 mm VII (1955)

– differ in MDH allele freq.
– Loch Ericht (which now enters L. Rannoch thru hydro plant) – reported to have large (1134 g) benthic char by Malloch 1910 – gillnetted L. Ericht found charr closely resembling Rannoch benthic form – preliminary data – Loch Ness also seems to have benthic & pelagic forms, but less distinct. also L. Awe.

Sparholt 1985. J. Fish Biol. 26: 313-34 –
Greenland lake charr – ≠ 2 forms by age growth
but no sig. dif. est. so concludes all one pop.?

Hindar, K., N. Ryman, and G. Ståhl. 1986. Genetic differentiation among local populations and morphotypes of arctic charr, *Salvelinus alpinus*. Biol. Jour. Linnean Soc. 27(3): 269-285.

drawf, normal, & anadromous pop. compared EST alleles - no consistant diff. - not monophyletic 3 sp. - all from recent common ancestor.

Some sympatric drawf - normal have signif. dif. of alleles, some do not. - Char introduced into barren lakes 1910 - now have drawf-normal in some lakes w/o detected genetic dif. - suggest - ecological - trophic polymorphism - like Cuarto Cienga cichlids.

Hindar, K., N. Ryman, and G. Ståhl. 1986. Genetic differentiation among local populations and morphotypes of Arctic charr, *Salvelinus alpinus*. Biol. Jour. Linnean Soc. 27(3): 269-285

ecological polymorphs – Quatro cichlids Cienegas – disruptive selection

some sympatric dwarf - normal signif. dif. – others not – some lakes. introduced char developed normal-dwarf forms. no evidence of evol. lines = common ancestor fr. 1 anadrom. 2 – dwarfs & normal char   no relation between 1-2-3 & EST. allele freq. → all Scandanavian char fm. one recent common ancestor. – lake spawning promotes sympatric speciation – + lake-stream.

c + same issue "Sympatric speciation: when is it possible? 201-223 – *Alexeev 1983 – lenok of Amur R. – Uda R. – Zool. Zhur. 62: 1057-68.

Wilson, A. C., et. al 1985 - Mitochondrial DNA and two perspectives on evol. genetics. Ibid. 26(4): 375-400.

* Zool. Zhur. 61(9):1372 DNA

K

QH 431 A194 * Genetica 1983 19(4):584-93

* Oecologia - 61:319-25 opt. reprod. age

Gene~~tics~~ 111:905-15

QH 506 .M 6612 * Mol. Biol. Evol. 1:183-94

Proc. Nat. Acad Sci. 80:1397-00

~~J. Fw. Ecol~~

* Environ. Biol. Fish. Alley & Reed microhab. segregation

Foley, P.L. (ed.) The Evolving Biosphere

Conservation Biology - Frankel, O.H. & M.E. Soulé. 1981

Conservation & Evolution

~~Darlington, C.S. Zoogeography~~ - Soule & Wilcox. 1980

Conserv. Biol.

QL T86 [Zool. Res. 4(3):227-34

+ 27(4):433-40

~~Can. J. Genetics & Cytology~~ - ca. June 85 - RBxcott - Myra Ferguson

16(4)

Mont. Outdoors - 1985! - cutt. broodstock genetics -

QH1 C143 * Critique IFG - 42(4):825-31 + 785-90 - visual prey - + 42(3):449-

McCrimmon & Gots - 1979 36:422-57 42(2):791.

~~Biochem. Genet.~~ 23(7-8):557-70 RBxCT - no incompatability

Eisenberg QL 708.5 E57

QL 614 J68 ~~J. Fish Biol. 27(1):73-79~~ + 26(6):691-99

* Aquaculture 46(4):341-51 + 47(2-3):105-11

43(1-3):105, 323; 44(2):83

Sindermann Q 175 .S569

* J. Fish. Biol. 26(2):318-char

QH1 J6 * J. Nat. Hist. 18(6):927-58 Oman cavefish

+ Bamidgeh 37(1):27-31 coho-Galilee

Sci. Rep. Hokkaido Fish Hatchm no 39 Dolly Varden

Drotningholm Rep.

16:497- Reid

cyprinid phylogeny

vomer palatine

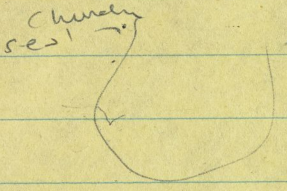
Brook trout – Kerguelen Islands in Indian Ocean

–Subsp– type N.Y. Samuel Mitchill 1814–

← west limit Manitoba to Seal R. (Hudson Bay)

– Knife

– Churchill rivers



– Severn

– &

– N.E. Georgia · Broad, Savannah, Chattahoochee, Catawba ^

Thunder Bay Huron

Grand Traverse Bay Mich

only grayling

~~[illegible]~~

C. J. F. A. S. 1986. Riget, Nygaard, & Christensen. S. alpinus Greenland – 3 groups exhibiting incipient sympatric speciation. 43(4): 985-92.

- Integration HRM - waters

- Riparian
- Birds

QH1
C143

42(12):1946
43(1):243, 2-11
C.J.F.A.S. - all of 86 - -
43(4), (5), (7).

FAVRO 43(4):896

brook trout: 1969 26:1699
1971 28:452

SRP - 43:1093 Mather
43:1022-93

QH98
I55

Int. Ver. Theor. Angew. Limnol. Verh.
20(3):2040
:2070
:2065
22(4):2516 *SRP
:2509
:2631

SH328
N6

Am. J. Fish. Mgt. 6(2):296 - brown trout Col.

Drottningholm SH287
D73

SRP? - Ecology - 67(4):898 - cutt. invent. drift
- Environ. Biol. Fishes - 16(4):220-.

SRP - S.W. Nat. 30:129 - March - 1985

USFWS E.S. Bull. 11(10,11):3

Loach minnow - proposed June 85 - threatened - final rule Oct. 28, 1986 - Critical Habitat postponed till June 87
- ~~only~~ 1985 found S. Fk. White R. -

- Nehring Stream Fish. Invest. 1986 - - flow investigating
Fed Aid Proj. F-51-R

Klemetsen, A., P. E. Grotnes, H. Holthe, & K. Kristoffersen. 1985. Bear Island Charr. Rep. Inst. FW Res. Drottningholm 62: 98-119.

– several lakes – only fish sp. S. a. –

2 'morphs' – small, spawn younger, shorter life, less bright darker coloratn – Esterase – ~~no dif. in a between~~ NO DIF. between morphs. morphs – . dif. ~~lake~~ 7 allele .75 – 1.00 –

– ~~but~~ caeca: small charr .35 large char

"may have genetic basis" . Ellasjoen 36 " 45

'Stevatn 35 Oyangen 46

Small char 23-24 rakers, large .24-25

– ~~Stevatn – 2 morphs dif. esterase freq. – isolated pop.~~ → .

QH431
A1G4

Kartavtsev, Yu. Ф., M.K. Glubokovsky, & I.A. Chereshnev. 1983 Genetic differentiation and level of variability of two sympatric char species (*Salvelinus*, Salmonidae. Genetika 19(4): 584-593
- 28 protein loci - *S. malma*, *S. taranetzi*
Chukotsk - Dif. freq. of alleles at Idh & Est-2 loci - and unique fixed alleles at Acph-1 locus
- Thus no doubt distinct sp. D = .08

Bon Voyage
493-8511

Larry Reno
534-1700

BOZEMAN

① Gresswell - coming CSU ?

② Field Trip — Yellowstone

Mont. - - ____ Glacier

overnite camping

PBS-TV cutthroat Marty Stouffer on Yellowstone

Bozeman transportation -

Jerry Wells - 586-5410 Mont. 9x7
994-3551

Rob Leary
Dolly Varden, Arctic Char
(Dolly Varden L.) - ca 6 of each ; ca 3 dif. wks
ca 40 loci - only few allele at 2 loci
show any real dif.
Bull trout - 2 loci

IV

585 malma 7 pop.	756 taranetzi
caeca 17-36 (26.9)	31-64 (45.4)
range x̄s 26.1-27.8	43.1 - 48.7

of 756 taranetzi spec. 12 (1.5%) have less than 35 (31-34) caeca.

of 585 malma 7 (1.2%) had 35 or 36 ca.

but specimen readily classified on basis of spot size, body shape ( ) lat. compressed malma ( ) taranetzi rounded, fin & mouth coloration.

gill rakers -- no intermediatory - no hybrids.

range of overlap of caeca 31-36 - clearly identif. as malma or taranetzi

19 of 1314 specimens (1.4%) thus 98.5% separate on caeca.

13.1 | 19.00
1314
5860
5256

verbal legerdemain

- Volobuev et al. - form I, form II (Kolenka R.), "hybrid"
ignore Chereshnev's diagnosis - <30 caeca, >35 ca, 30-40 -
almost desperate but feeble, naive attempt of ill reflection - "conclude no reprod. isol. - single polymph. sp. - The

Chereshnev skillfully dissected arguments & data of Volobuev et al. demolished the "hybrid" & hopefully put to rest once and for all the "single polymorphic sp. concept to explain all diversity of Far Eastern charrs -

- also all over Chukotsk Pen native people no trouble recognizing the sp. - Dolly Varden is "Kimgyn" and Taranetz charr - on phenotypic dif "Lyginnen".

- Chereshnev correctly emphasizes that the "single polymorphic sp concept is a "very negative influence on char fisheries" by considering little no hereditary basis for dif in-mater. lipid - ignor "stock" concept of modern fish mgt. -

SH 287
.D73

Nyman, et. al 1980 81 (?) Drottningholm Rep. 59: 128-141

alpinus complex extreme low level of polymorphism - seem to lack genetic variability - heterozygosity but ecol. plasticity -

3 species based on esterase allelelic freq. - Behnke (1980) asked what 3 sp.. alpinus, salvelinus (Alpine L. (Austria)), stagnalis (Greenland)

no data type localities - all "3 species" in N. Europe.

V

electroph. limitation - cladistic - tax.
- Ferguson - isozymes
- STOC - lake trout - ciscoes

★ meristics prime. type

- Nyman - no attempt correl. est. w/ other tax. chars
(~~note~~ - 'species' assigned by other pu - but esterase labile - 'red shiner' - Kornfield -- ~~if~~ ~~Ex~~ Nyman intelli[illegible]
, but suppose - track over fish sp. data -- ~~[illegible]~~ [illegible] data on polymorphism - - how utterly foolish to assign 'species' to arbitrarily allelic freq. -- - complete range - what it.
"adds new dimension to view of treating all Mendelian polymorphism as simple pop. markers" - right! - trout or sp. markers

mention
* [STOC Symposium -
Stockholm - Gene pools -

Ryman & Stahl (81) . STOC 38(12): 1562 .
37 loci 9 Swedish lakes . . 5 showed no single polymorphism (no heterozygosity detected) - EST-2 - 4 w/ polymorph also only one w/ MDH-4 polymorphism . ! - correlation - phyletic implications

Ferguson (81) - only EST
EST-1 slow (100) = "S" of Nyman .
EST-1 fast (115)

variable . 9 lakes
8 Irish lakes
+ 2 pop. Windermere
* >60 loci ?

rakers
7 Irish lakes . 22.5 - 24.7
Coomasaharn 29.1 N=15
Windermere autumn 21.15 . N 19
spring 25.33 - 12

Stoneking et al (81) p. 810
data 39 loci
Gen. distance (Nei) sim.
brook-lake = .353 (.647)
brook-bull - .373 (.627)
bull-lake = .267 (.733)
— Leary Allendorf

6 no alleles in
4 [illegible]

Jap. book

Kornfield et al.
polymorph. only (>2%)
EST-4
except LDH "5" . only Arctic char polymorph
+ PGI - 105 unique -

all monomorphic in alpinus

	confluentus	fontinalis
Aat-1	100	54, 191
CK-1	85	100
Idh-4	106, 135	135, 82
Ldh-1	54	0
Ldh-4	76	28
Mdh-1	144	110
Me-1	110	56, 110
Me-4	95, 97	97
Sdh	120, 125	190
Sod	177	97

VI

Clayton & Ihssen (80)

· x LDH "E" · Nettling L., Baffin Is.

AA	AB	BB
5	5	2

Table 1 LDH E (A allele incl. Cambridge Bay. (56%)
freq = 3% to 75%)

6 samples N.W. territory

but Matamek L. (Quebec) - intermed- [illegible] - 0 freq.

Globokovsky and Chereshner 81

Unresolved problem.

Barsukov (1960) - suggested - all [illegible] - Arctic ch. [illegible] - one polytypic sp. - [illegible]

and vigorously championed by Savvaitova and colleagues.

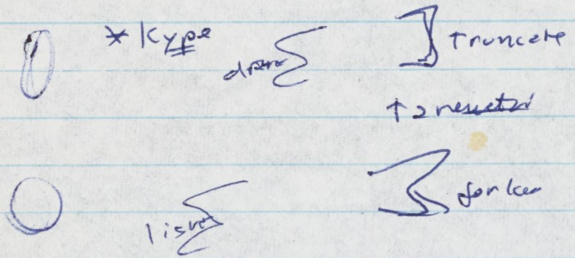
- Numerical Tax (overall phenotypic sim) 60 characters of skull ~~bone~~

spots

malma malma 18-25 (21-23) long, thin

65-69 (32-36 ab., 30-35 caudal)

18-36 (25-28) thin, rel. long



tarenetzi

23-26 (25) - short, thick

65-68 (34-36 ; 31-32)

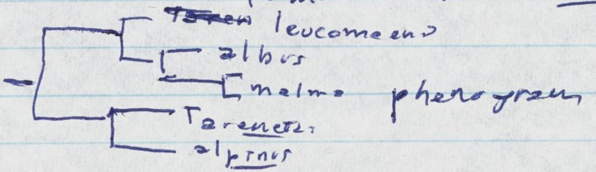
39-52 (46) rel. short, thick

Anguema & Erguveem river basins + malma, ~~alb~~ tarenetzi,

alpinus sympatric

leucomaenis sympatric

Kamchatka R. - malma albus



phenogram

disagree w/ phenogram

Cladistic interpretation of characters [illegible] concludes alpinus, tarenetzi + leucomaenis more primitive traits malma albus more derived character - but

characters - bone shape - weak basis for prim. der. - subject to convergence &

independent [illegible] to re. + phylogeny [illegible] - & selective use -

origins too recent for 'kype' - south most [illegible] low [illegible]

trenchant osteological dif. sufficient for

valid basis cladistic interpr.

"Liver esterases"

McCart 1980 Can. Arctic - all eastern charr (S. a. erythrinus, Cambridge) have "fast" pattern (dwarfs as Nyman) - but largest of all alpinus - world record - but 98.6% of west.

S. m. malma have "slow" esterase

- but to 11 kg. S. a.c.

VII

p 221 Thesis – Mayr – speciation

McCart (cont)

"Liver esterase" (EST-1) — Nyman

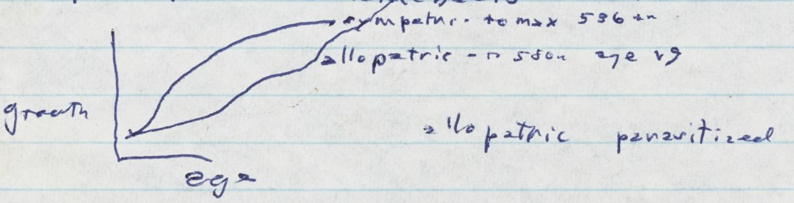
East Arctic (alpinus)
78 spec., 5 pop. – 100% "fast" = alpinus
West Arctic (malma)
212 spec. 13 pop. 209 "slow" (98.6%) stagnalis
3 "fast" (1.4%)

Table 6 meristic data

				range $\bar{x}$'s	range
13 pop. N=617	rakers	$\bar{x}$	21.5	19.4 – 23.4	
N=618	caeca	$\bar{x}$	29.6 (18-45)	27-33	– 18-45
N=201	vert.		68.0	67.1-68.9	66-70

– Trend for small isol. resident pop. for lower meristics

Fraser 81 MS. thesis – The interactive segregation
arctic, lake, brook charr, southern Ungava. Quebec.
No Name L. all 3 sp. – alpinus: gastropods, Gammarus. 378 ha
Ducreux L. – only alpinus – piscivorous $\bar{x}$ depth 10 – max 32
charr + 3 spine sticklebacks
3 sp. charr, sticklebacks, + few burbot $\bar{x}$ depth 2 m max 6.2 407 ha
alpinus predaceous – 20-30cm > 40 cm ca 100% predat 95% fish sq. rodent –
but overwhelmingly canibalize own young in pref. to stickleback.
L. Nonamo – alpinus all sizes (to > 50cm) virtually no fish
in diet – zooplankton to 30cm than snails, Gammarus.
(snails & Gammarus only few % in Ducreux – main invert. Trichoptera.
– ~~+ Table 5~~ . namaycush – predominantly fish from smallest size (25cm)
fontinalis – mainly benthic insects . caddis, larger more snails
lake trout – sticklebacks dominate to 50cm then charr (+ burbot)



allopatric mature at 4+ 5+ (15-20cm)
symp. 8+ (>30 cm)

Cavender (this vol.): S. malma "lordi" 2N = 82, 98 arms – identical to Krasheus
confluentus 2N = 78 102 arms
alpinus 80 100 arms

4(AM)

W 205

VI

Hindar and Jonsson (1982) - Habitat and food segregation of dwarf ~~and normal~~ Arctic charr (S. a.) from Vangsvatnet Lake, western Norway. Can. J. Fish. Aquat. Sci. 39(7): 1030-1045.

Nordeng this symp. "solution to charr problem" -
dwarfs 25.2 x̄ rakers + no spawning colors
normal 25.5 x̄ " - bright colors
change from parr → normal charr corresponds to
parr → smolt transformation in anad. charr.
sharp niche segregation dwarf + parr) + (normal)
called "morphs" implied ~~but~~ not explicitly stated that
dwarf + normal are polymorphism non-he w/in single pop (no data given on
spawning - do ~~only~~ dwarfs spawn only w dwarfs norm w n ?? -) -
influenced by Nordeng (this [illegible] symposium)
- May be genetic polymorph as w Cuatro Cienegas mex. cichlid c. m.
(Kornfield 83).

Kornfield, et. al. 1981
samples of ~~blueback charr~~ 5 pops.
Sunapee (Floods Pd.) 1
Quebec red charr 1
Arctic charr, Cambridge Bay N.W.T. 1
elec. pattern enzymes products of ~~26~~ gene loci examined surveys.
~~2 esterase~~ enzymes - EST-4 variable allele 100 - ~~96~~ 95 Wadleigh 04 96 % Quebec 98.50 1.05
*LDH-5 all monomorphic for 100 allele)
Selectivity, interpret needed: except Arctic only 40% 100 50% 92
only 1 fish Arctic sample +PGI-3 80% occurrence of 105 allele, not found at all in others - 6 of 7 hom
"However when all data for all loci "homogenized" the overall great impact of monomorphic loci "for quantified genetic similarities" masks dif. and Arctic char not stand as "numerical", leading to ~~[illegible]~~ erroneous conclusion that separate subspecies recognition for "Arctic as "may" not be biol. reality" (~~[illegible]~~ recognized as 'overall phenotypic similarity' or "S. a. alpinus" by authors)
a. - but Hudson B. Arctic [illegible] - differ from oquassa by 6-7 more rakers, 4 vert. - no way this dif. explained simply by any genetic info.

★ genetic struc. as [illegible] see Allendorf - - sturgeon -

See Can. J. of STOCK

G. S. Homo sapiens subspp. chimpanzee

Esterase ★ red shiners Brazos R.

VIII

Russian book

Chereshnev - size Pac. salmonids

for IGEA * ~~malma~~ • to 830mm. (33 in) 5 700 gr. (12.5 lb.)
~~Levanidov~~ ~~zarentetzi~~ to 680mm (27in) (6.6 lb.)

— E. Sakhalin charr 21-25 caecs malma ?
21 rakers
60-62 vert.

Viktorovsky et. al. : Charrs of the genus Salvelinus from Lake Elgygytkhyn (Central Chukotka)

Mountain L. El. located "border" ant. division of ~~basin~~ Anadyr R and Chaunsk Bay drainages ~ 489m el. - never submerged by late Pleistocene marine transgression — 12 km. diameter, 169m max. depth - summer temp. hypolimnion 2.5-3°C

if refuge - pre glacial relict - expect Coregonus

besides Salvelinus only Cottus cognatus and Thymallus arcticus which both occur in Anadyr R. and Enmyveem R.

July - Sept. 79 115 charr collected from 17 - 70 cm.

2 forms well separated -

	S. boganidae	S. elgyticus
	N = 38	N = 67 D 8 A 7
caeca	42 - 66	25 - 58
rakers	23 - 31 (27.32)	39 - 51 (44.03)

fig. 1 - small mouth - max only to ant. eye sparse, large spots -

fig 2 "S. boganidae" - sparse, ~~la~~

~~ap~~ one of forms appear close to S. ~~boganidae~~ Berg 1926, 48, but with slightly more rakers (27)

fig 3 skull - chondocranium S. e., S. b.

S. b. - prob > 1 m. in L. E.

S. elgyticus Viktorovsky et Glubokovsky.

"Malorotaya" charr (smallmouth charr)

Holotype ЗИН 45397 large spots, no red spots,

feeds only on plankton

L. E. - reported - meteorite crater lake of late Pliocene

B. (1980) - across interior ~~Siberia~~ Siberia - isolated lakes ca. 29-36 rakers 'erythrinus' interior Lena - Indigir Kolyma - ony

p. 456 - states Chukotsk charr long thin rakers = alpinus
wrong!! short, stubby " = malma

Ferguson (80)
EST 1 (100) allele = slow or "S" Nyman
EST 1 (115) " = fast " "F" "

Nyman serum esterase
S. alpinus - Linn. Swedish Lappland
"F" charr . F (or 115 allele) = .9 - 1.0
least competitive, stunted sympatry, may be large in allopat

So. Sweden
L. Vattern - — S. salvelinus Linn lake Austria.
large, predatory "N" - normal
.4 - .7 of 115 allele - *but may be fixed at 1.0! (how dif. fr. alpinus)

S. stagnalis - Greenland.
115 allele .0 - .2
"- introgression?

COPY

January 5, 1982

Professor Y. Yasue
Nakamachi 5-17-0
Setagaya-ku
Tokyo 158, Japan

Dear Professor Yasue:

I received the special publication on Salvelinus. It is a beautiful work and I send my sincere thanks. I received another copy of this same work from the "Freshwater Fishes Preservation Society", Osaka, but there was no letter revealing the name of the person who sent it to me. If you know who sent me the additional copy, please give him my thanks for his thoughtfulness. I will give the extra copy to Dr. Ted Cavender who also has an interest in the taxonomy of Far Eastern Salvelinus.

I also received your abstract on the comparison between Formosan and Japanese O. masou. There is much additional data supplementing my publication of 20 years ago. I would suggest that you publish an English translation of this paper in the Japanese Journal of Ichthyology. If you can make a "rough" English translation and send it to me I can edit it for you for publication.

Sincerely,

Robert Behnke

3 forms Arctic char
L. Greenland
- may change into each other
- transitional stage for speciation
and isolation 1986
CJFAS 43(5): 985-92

Cosmos Sid Reiner
(212) · 832 · 7550

— visa — Russia
— Japan
— passport
— tickets — if more Denver ?

Review —

Syst. — Tax.

— study of exp. diversity — actual alsorit.

— main change — 1950 — pluvial Dolly Varden
— [illegible] Dolly Varden gov. sp.
[illegible]

Dolly Varden → alpine
between bull, stone — 78 Soviet form ? 82 [illegible]

Theoretical frame but not good pleasure resolve classificatory state

sympatric r-p
— Iceland Drottningholm
Lydene — Sweden Cirq
— Thingvallavatn
1984
1988

— new pap.
how may do
— Greenland
— Scotland?
morph. — vs — genetic

1980 book — character states phylogen. DX. cladistics
— w/o firm knowl. of plus-sp.
+ base branch of sister grs. — playing games.
— ex. karyotypes — chromosomal banding — detect (NOR) — homologies — Ifto. — taxonomy comm.

— Welcome comments — why study — interest — emotional — qual. — 2 the — quest.
— critical qual remain unknown

— review changes open 1980 book — 1901 — (Su)

may we look for major contributions in electrophoresis gene genetic —

— hope Dolly — char continues put to rest to all D
(V. I. — — Amur — leucichthys alpinus polymorph.)

— L. Elgygytgyn — smallmouth
by next symp. — perhaps — phylogenetic posit.
smallmouth — undescribed ?

— 3 Sp. in EST — —

— profundus — elgygytgyn new sp. — material work 2 divide with — don't make sense

human nature once committed to position — —

— white — 55
— longhead — 10

internat. coop.

— electro, chr. banding, NOR, DNA RNA, mtDNA, mtRNA
→ DNA hyb.
— cladistic — prim. vs. derv. state — G.D. 1.0 — > 40 . .
< 2
— Isthmus Panama — > 10 v.

— My major change — leucomaenis
bull — stone
— malma alpinus

but new genus!

— Conf. — 3.
— Stages of sympat. divergence

— lake subgenera — bull — Nemaycush
alpinus — malma
leucomaenis — alpinus
profundus 2 sl. — white
— longhead

— why — how do adapt
ecol. polymorphism
w/ monomorphic loci?
— structural loci vs. regulatory gen.
— ne. Conserv. Biol. — 'inbreeding'
danger. S.R. cutts — krill.
quant. wgt. — qual. — life hist.

limits modern techniq.

— electro. gene loci

Ferguson et al. —
Oncorhynchus sal. vs Salmo

R.B. — cutts
— sub sp.

overall phen.
— not cladistic

— but Allendorf
malma — alpinus
conflicts

* new [illegible]

— Karyotypes
— — — no. ma
[illegible] — low
— but indefinite —
some change
new
and gen.

x . 78 — alpinus
— [illegible]
8 — confl.

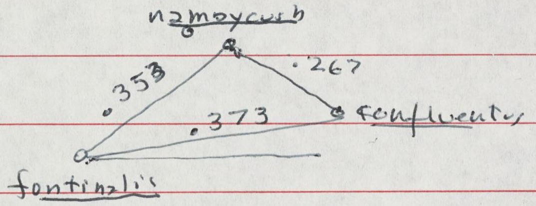
convergence
— as of nakedly
no. vent
costs

— predent
alpine
— vomer teeth

Stoneking et al 1981 : 810

Leary + Allendorf – Syst. 2001.

G.D.



but Turgeon

salvelinus alpinus
to Salmo
or Oncor.

need electm – 40 lu – ne

leucomaenis

stw albu

malma – north ..

profundus

* elgyg *

L. Elgygytyn –

tax.
rule autonomy
S. salvelinus

malma all 98% s/100 –
EST-1 - 100
Arctic alpinus including
all fast loci
EST-1 - 115
-PGI-

L. Elgygytyn – why no Coregonus ??

– Katavtsev, Glubokovsky, + Chereshnev 83 –

28 loci – malma + taranetzi Chukotsk

Idh + EST-2 freq. dif. – but fixed dif.

at Acph-1 – D. .08

60 64 64
1 60
58 - 64

60
64 2x independ.
+ 64 cutth.

— sub genera Cristivomer Baione Sal
84 84 80

leucomaenis 84 NF 100

(1) Cavender (100)?
confluentus 78 - 102
Phillips - Arrow L. B.C. 12th metacentric
of Cavender actually large acrocentric
w/ NOR on short arm

S. malma southern
82 - NF 98

alpinus
78
~~98~~ - 98

all west. Pacific Sal.
1 pr. NOR.

— conserv. Biol.
— why such ecol.-environ. plasticity at such low levels heterozygosity ??
— inbreeding to — what overlooked in quant. genetics

Phillips

— Although all sp. Salmo & Oncorhynchus have NOR on only 1 pr.
NOR's on several chromosome prs. of namaycush, fontinalis
alpinus —

malma — Juneau AK

total no. NORs / genome 4-10 fontinalis
4-12 namaycush 2-6 alpinus

variation on NOR placement in chromosome between individ.
i.e. — "constant" sites & "variable" sites

+ leucomaenis?
— Confluentus similar NOR to fontinalis + namaycush plesiomorph
— malma + alpinus have synapomorph — NOR on largest submetacent.

malma (southern) & alpinus share derived acrocentric which
is 2X longer ~~than~~ any acrocentric in other Salvelinus.

☆ — malma → alpinus by electroph. — karyology
— other than leucomaenis — confl.
— NOR location
on sub
translocation
synapomorphy

* NOR's alpinus 2 in N.W. Terr. — 6 in Scotland
— miyabe — great dif. NOR placement long-short.

Leary — enzymes at 40 loci — no real dif. so. AK malma — AK alpinus Taranets
2 loci distinct w/ bull trout.

Sparholt 1985 J. Fish Biol. 26: 313-31

lake in Greenland. 2 forms differ age-growth,

no sig. dif. & conclude one pop. —

1. rapid morphol. dif
— little genetic change

Walker, Greer, & Gardner 1988. — Biol. Conserv. 43(1): 43-61

2 forms. Loch Rannoch.

dull color - pale — ralsen
benthic large head 1% cladocera

claret colour
pelagic small head 95% cladocera

niche separation
esp. feeding
reproduction

— Norway
— introduce
divide into
Ⓐ 2 types -100 yrs
schooling?
— Greenland
-1
1? 1000 yrs
— Iceland
1 4 — Thing

— Nyman: 3 sp. esters:

—

divide
— redivide

Magnusson & Ferguson 1987. — Gen. Analysis Sympatric morphs. Thingvallavatn. — Environ. Biol. Fishes 20(1): 67-73

Small benthivore, large benthivore, planktivore, piscivore

D values ~ .00004 — .00126 re. Loch Melvin trout — much greater longer? or Salvelinus

Sandlund et al (Sydemo) 1987 ibid. 20(4): 263.

habitat use. last glacial retreat 11,500 yrs. B.P.

'polymorphism'
Cuatro Cienga cichlids
one system
fr one sp. to exploit niches –

– why? – increase abundance sp. – but reprod. isol.

Nature – Nurture

mgt. vs. sympathetic Scandinavian – re. – Conserv. Biol.
classify like ~~Hammer~~ many ancient sp. taxon – re. preserving distinct sp. diversity – few lions – Pyramid cutt, Greenback cutt., Lahontan – = eco. polym.

Riget et al. 1986 C. J. F. A. S. 43(4): 98

S. alpinus Greenland 3 groups exhibiting incipient, sympatric speciation.

(Emerald L.) CO. 100 yrs

Klemetsen, et. al 1985. Drottningholm Rep. 62: 98-119

Loch Rannoch

Bear Is. charr – several lakes S. alpinus only fish sp. – find 2 'morphs' – small, young early spawning, short life – vs. larger – + coloration

esterase – no signif. dif. all predom. "7" est

re. Lough Melvin 3 brown trout

but – caeca — small rakers 23-24 — large 24-25
L. Ellasjoen 36 — 45
L. Stevatn 35 — 46

Hindar, Ryman Stahl et. al. 1986 – Biol. J. Linn. Soc. 27(3): 267-85

– ex. of known introductions ~~<100~~ 1910 yrs. – some lakes – 'normal' and 'dwarf' appear ... (schooling?). – Review evidence. 3 sp ancestral sp. Sea

1. Anadromous 2 dwarf 3 normal – no relation in EST allelic freq.

– All Scandinavian charr – one, recent common ancestor
– lake spawning promotes sympat. spec. –
(see same issue – re. when symp. spec. possible: 201-223)
– Cuanto –

charr L. Elgygytgyn – smallmouth – perhaps by next charr sy mos better understands + phylogenetic posit. ×
1984 "hopefully the erroneous notions that malma – alpinus one sp. – put to rest for all time."
– V. I. – Savvaitova w/ Maksimov / 3 lakes
Amur + ... Kamchatka

– Gydemo 1984 1981 symp. – Thingvallavatn Iceland "it is clear that all of the species from Scandinavia as defined by Nyman et al. (1981) are present in Iceland also". – "The landlocked charr of Iceland were already separated into species when immigration occurred." – 1987 – Environ. Biol. Fish. "The arctic charr of in Thingvallavatn is polymorphic. Genetically the four morphs are very closely related ... the morphs are conspecific and do not represent different evolutionary lineages". – "The morphs in Thingvallavatn have probably developed within the lake, and the morphs are locally adapted to different niches".

compare w/ L. Elgygytgyn

Convergence benthic – pelagic growth, age at maturity, life span, more sp.
– head, jaws, rakers, caeca
– convergence – but Dolly V. alpinus vers.
– early stage

Hindar, Jonsson 1982 – Vangsvatnet – dwarf, pale morph, large, colored ~~Tr~~ van same gillraker no. – niche segregation – local phenomenon in relation to lake morphometry, spec. assoc., niche availability) –

– dif. – color, growth, age maturity, – not gillrakers, (caeca?) etc.

Andersson, Ryman, Stahl -83- Ryman wrong.

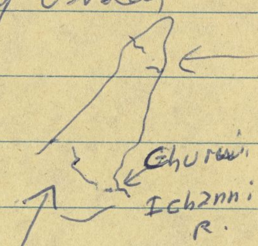
2N: pluvius - leucomaenis → Kuril Is.
curilensis

see MS

Sea-run silvery specimens Oketchiushi R. a
Shoji R. - Shiretoko Pen. Hokkaido

Hokkaido Dolly Varden		- "silver" sps
D	9-10	11-12
rakers	~~[illegible]~~-22	18-19
Br.	11/12 13/14	10/11
caeca	28, 32	18; 20, 23, 25
vert.	66, 66	58, 60, 60, 61

← stone charr albus



S. m. krasheninnikovi 19-23
61-63 vert.
25-30 caeca

Viktorovsky
2N = 82-84 98 arm
76-78 96 S. m. malma
84-86 = leucomaenis + curilus
100 arms

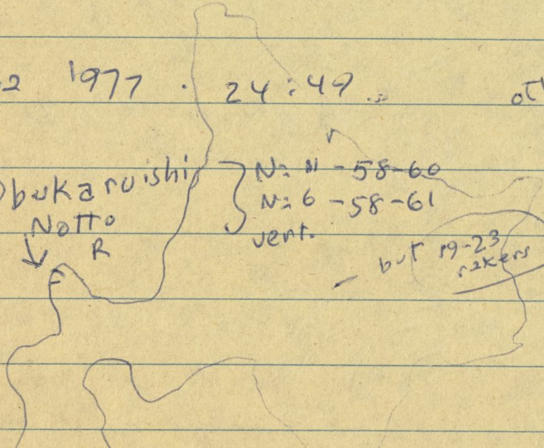
Kur
← except Hokkaido
Honshu

19-22
61-63

Maekawa 1977. 24:49.

other 19 localities Hokkaido
typically 61-64 vert. krasheninnikovi

- Nemo 65-70 vert
Okhost S. m. malma



Obukaruishi
Notto R

N: 11 - 58-60
N: 6 - 58-61
vert.

- but 19-23 rakers

— Impact assessment 400 cfs depletion.

- (Squawfish), humpback chub, razorback (De Beque), channel catfish

protective

: Mitigation - enhancement measures.

- flow no way valid flow requirements

- 2 of 3 yrs. . . Aug. - - temp more input flow above 2000-3000

- need actual study - - - :

FWS HEP IFG — Use FWS own [illegible] - Miller - 75% exceedence flow (Aug.) . - not to drop below.

- go over steps 1-2-3 best success - 1980 : IFG (depletion work good) -

75% exceedence flow - -.

· flush flow)

— Status of squawfish "Archer" - - not valid. - no Colo. R. -

- actually more adults found recent yrs - no data < 1975

rationale assessment - background - in-depth info available to GCC

-1975 - north

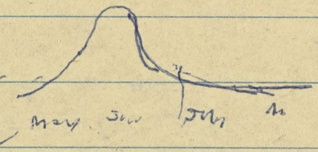
- actually. humpback little Co.

bonytail - gone

razorback - rare

squawfish. better than

flow rec. hydrogr



Aug 2200

$\bar{x}$ = 500 cfs

- normal yrs. - wet yr (1) - low (2) — very low (3)

no. less than 10-20 years ago. may still be declining

- err on side of endisp. maintain - calculate

- ploy; need more than present conditions - - Archer - 66% decline juv. adult - 1960-80

94% YOY 1960 - 1980 . . . Vanicek - - - Holden - -

squawfish - 30 days 20° + spawning larvae 24° & on

humpback . 16-18 spawning 20-26 egg larval develop. 24-26 growth

- regulated rivers reduce peak - increase base beneficial to aquatic life

— Balon's Reprod. Guilds

I

pl<u>uvi</u>us = le<u>ucomaenis</u> – convinced by Japanese ichth + Cavender (?) gillraker morphology

②: Far East Dolly – southern – sub sp. Hokkaido
19-23 rakers – 61-63 vert. (kra<u>shenninikovi</u>) – also <u>2N</u> chromosomes
-- . Komiyama et. al. 1821 = "Dolly Varden"
c<u>urilensis</u> 2N : : Shiretoko Pen. E. Hokkaido . – color photo
plu. "pl<u>uvius</u>-like 58-61 vert. , 18-25 caeca,

		rakers	caeca
Viktorovsky –	<u>krascheninnikovi</u>	15-21	16-31
	<u>leucom aenis</u>	12-20	11-33

2N Viktorovsky (78) – but aware of

small spots
fewer rakers

Dolly – low caeca
x̄ < 35
alpinus
> 35 (except Labrador)

gill ra x̄ < a

		NF	cav		S. gairdneri 58 chr
<u>malma malma</u>	76-78	– 96			
m. <u>krasheninnikovi</u>	82-84	– 98 –	98-82	<u>lonli</u>	w/o robust morgan
<u>curilus</u>	84-86	– 100			prim 58
<u>schmidti</u>	78-82	– 100			–2–>
<u>Kronocius</u>	78-82	– 100 –	102-78	confluentus	
<u>leucomaenis</u>	84-86	– 100			
		80 – 100 <u>alpinus</u>			

3rd group predator <u>leucomaenis</u> – bull, stone, kron<u>ocius</u>

<u>Kronocius</u> 63-68 vert. (66)
18-26 (24) rakers
24-43 caeca

s<u>chmidti</u> 15-24 (20) rakers
63-68 (66) vert.
23-37 caeca

③ Voloboyev's et al (78) – cast doubt Kukchan. K. – a
– S. elegyrh.

III

Dolly Varden
~~light~~ dark
mouth coloration
mature ♂ w/ kype
longer jaw

Chereshnev '82 / taranetz charr
light mouth color
— no kype

Maekawa 1977 miyabe
Hokkaido vert.
2 on ~~east~~ west coast (58-61)
others x̄ 61-63
rakers - 19-23 x̄ 21
others x̄ 20-22 miyabe 25+
caeca c 30 / personal comm.

1983 MS Dempson & Misra
samples fr 7 ~~[illegible]~~ pop. Labrador charr
vent. 64.8 - 65.5 62-72
rakers 23.9 - 25.7 20-30
no caeca counts 20-21 —— 27-28

Chereshnev 1982 V.I. 22(6): 922-36

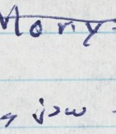
S. taranetzi. Kaganovsky, A.G. 1955.
~~To~~ Golets iz basseina Beringova Morya. V.I. (3): 54-56.

illustration : fbw, small spots, long jaw - prob. malma
rakers = (23)-25 caeca malma (32) - (42) - certainly alo
morphomet. data table 1 10 spec. 165-257 mm T.L. - young = syntypes if found
S. taranetzi coll. 12 Aug. 1948 by P.G. Nikulinym
L. Achchen
but meristic data - Table. 2 - no. specimens not given
no info given on fate specimen ~~–~~ museum? museum no. (workers at TINRO — Pacific Ocean. Fish. Res. Inst.
Compare w/ my. data

taranetzi lectotype redescribed

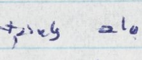
Barsukov (1960) - Berg's type #ZI 31107 of andriashevi ~~– but~~ w/ 14 rakers, but reexamin. of this spec. shows 19 rakers on right, 21 left side.

- Chereshnev (cont.) A fig. 1 rakers malma

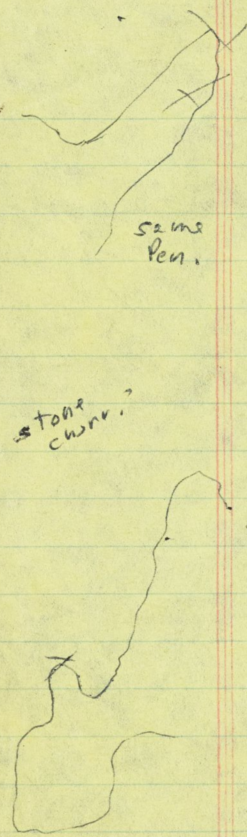


584 malma 7 pop. | sympatric 756 taranetzi
18-26 (22.1) rakers | 21-30 (25.4)
x̄ - 21.8 - 22.5 | 25.0-25.75
L. Achchen 20-26 (22.5) | 22-30 (25.75)

taranetzi



- denticles
as leucomaenis
karyotypes



Unanswered Questions

Hokkaido — Iwama —

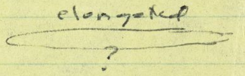
Komiyama et al. 84(2?)

Searun silvery specimens Oketchiushi R. & Shoju R., Shiretoko Pen., Hokkaido

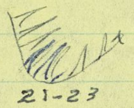
Hokkaido Dolly Varden		silver specimens
D	9-10	11-12
g.r.	22	18-19
caeca	28, 32	18, 20, 23, 25?
Branch.	11/12 13/14 ?	10/11
Vert.	66, 66 ?	58, 60, 60, 61

> leucomaenis

Maekawa 1977 : 19 Hokkaido localities Dolly Varden 61-64 vert. - but Obukaruishi R., Notto R. -
N=11 58-60 N=6 58-61 typical leucomaenis
rakers 19-23 typical malma



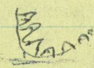
Chereshnev - Chukotsk. - malma



21-23

taranetzi

Alaska type

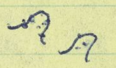


23-26

andriashevi

26-28

E, Arctic, form? N. Slope AK

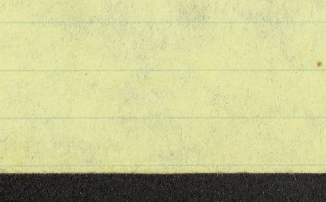


anadromous ...

anadrom.?

N-S Dollies AK 1957 -
AK Willow Crk - near Ancorhage - south - north D.V. sympatry ??-
simply count gillrakers. !! no one look since??
Kenai R. -9-10 lb - taranetz · anadromous AK ??
Savvaitova - Hass - confluentus - ecol. equivalent of stone charr (river predator)
white, longnose, snout charr Kronotskoe - not stone charr. albus not stone charr

Savi open. pores



Ⓘ

Welcome comments >35 yr. Sendai - Okunakawa on R.R.
Iwana, Yamame -- before formal higher ed. - but set direction

This Int. Symp. - Proc. - 3rd major vol. devoted
to Salvelinus - Note range info - ecology, physiol.,
culture, disease, conservation - but our Sect. B
Taxonomy & Systematics -- the heart of the matter -
The PROBLEM Then unanswered questions, disagreements, controversies
- w/o this controversy - probably not sustain interest
to get all people together for another meeting of
charr fanatics - so let us agree to disagree in friendly condition
— Thus in anticipation for next symposium
I do not want to do away w/ the stimulus
of controversy by telling you that I have
now indisputably resolved all issues - and
all will surely agree! — Chereshnev's new
sp. - genus - let's us know what is yet to be discovered
— But re. PROBLEMS - re.
& Taxonomy & Systematics - perhaps helpful
if attempt to separate - Taxonomy - actual
classification - ordering of patterns observed into
phylogenetic framework - Systematics - attempt
to understand the processes of evolution.
- Re. sibling sp. - sympatric pop. - N. Europe
matter of systematics - not taxonomy disagreement
Nyman — Not 3 ancient phylogenies - but if 3 coexist
pattern of test alleles
= 3 "biol. sp" - 3 niches for mgt. - for conservation
Re. How can charr do this?? - How can such
ecol. polymorphic sp. be so rapidly genetically monomorphic?
- Questions of systematics - the processes of evol.
→ When phylogenies separate for sufficient time
ca 100,000 - mil years - identif. & classif. of them
= taxonomy - Thus malma - alpinus matter of
tax. and species recognition -
- Dont expect Nyman conversion - you're correct -
we're wrong. - Belief system - — —
Personally - open minded, flexible, changeable
when new info available - wishy-washy - non-fanatic.
— Let's Review my earlier position 1980 book
1981 symp. (1984 pub.)

banjo for benjo
zealot
less reason
- even spelling
r vs. rr

Patterns
&
Processes

polyphyletic
not
monophyletic

II

- Assess 'Progress' - or/ Hindsight more accurate than foresight 1980 book - (written 10 years ago). Re. interpretation of phylogenies - assessing evidence for classification -
" Without a sound basis for ~~determining~~ establishing plesiomorphic and apomorphic character states (prim.- derived condition) for determining phylog. branching sequences and 'sister groups', we are only playing games".

~~198~~ Nyman (Drottningholm school - Svardson - Mayr) - esterase allelic freq. for phylogenetic markers (O.K. for 10,000 yrs not 1 mil) - 81 - 3 sp. paper - Taxonomy <u>alpinus</u>, <u>salvelinus</u>, <u>stagnalis</u> - Gydemo 1984 book - Iceland - Thingvallavatn
" It is clear that all of the species from Scandanavia as defined by Nyman et al. 1981 are present in Iceland also". - "The landlocked charr of Iceland were already separated into species when immigration occurred."
- Gydemo (1987 as coauthor) - Environ. Biol. Fishes. -
" The arctic charr in Thingvallavatn is polymorphic. Genetically the four morphs are very closely related (G.D. .0004). The morphs are conspecific and do not represent different evolutionary lineages. The morphs in Thingvallavatn have probably developed within the lake and the morphs are locally adapted to different niches." (- As Thingvallvatn ≃11,000 years ← mil - sp. flock - rival cichlids of L. Malawi) -

- * Major change outlook sep. syst. - tax. - not 3 "species" - but sympat. reprod. isol. pop. real. - not single 'polymorphic' pop. term "morphs" - not good - such as Cuatro Cienegas cichlids -

RC - Symp. review all evidence <u>malma</u> - <u>alpinus</u>
- 1984 book "Any reasonable standard for sp. recognition <u>malma</u> & <u>alpinus</u> are separate sp. - -" Hopefully the erroneous notion that Dolly Varden & Arctic charr are only polymorphic forms of single sp. put to rest once & for all". -
- Then V.I. - Moscow school - <u>S.</u> <u>alpinus</u> Kamchatka - Amur - Sakhalin. (Sov. 1988 need for Int. Coop.) -

- My changes 1980-84 - <u>pluvius</u> from <u>malma</u> - <u>leucomaenis</u>
re. 1984-1988 - <u>slide</u> - re. subgenus <u>Salvelinus</u>

III

malma + alpinus (super sp. - complex) -

leucomaenis - ~~bott~~ confluentus - albus - Why

Ruth Phillips 'Covenant'

- Karyotypes NOR - - N7 .100 w. 9p
electroph. - 40 loci Univ. Mont. malma - alpinus - now confluentus - 2 of 40 !

Predicting ahead

- Needs - electroph. limited but profiles - leucomaenis, L. Kronotskoe Kamchatka - 3 - longhead, white, snout - stone charr
Elgygytyn - profiles - karyotypes - but so remote - Europe
- profundus Tiefseesaibling Bodensee - no data !
- mtDNA mtRNA -
But limitations - overall phenotypic sim. = numerical - non-phylogenetic tax. w/ prim - derived states -
- Recognize not constant rate divergence between any lines any characters - Morphol. - ecol. (niche filling) - can be very rapid - electroph. - mtDNA - variable
- Isthmus Panama - Ann. Rev. Ecol. Syst. (1987) - Hillis
- Karyotypes - NOR - banding - next best hope for cladistic arrangements - but NOR. stable vs. variable + local variation ~ (miyabei - quite distinct)

Cont. to (?) lines

Rev. since 81

Addenda

Strong ANTI sympat. spec.

Mayr - revisionist

- Anatomy of
- Controversy - Mayr 1940's sympatry, repred. isol. = sp. "biol. sp. concept" - to taxonomy - Drottningholm school - belief system
Svardson - Coregonus - Outstanding systematics - wrong taxonomy. - non ancient phylogenies = polyphyletic sp.
- Some Pleistocene period - 100,000 - - 1 mil yea = ancient lineages - - - - 3 sp. charr alpinus complex - - -

Rev. lit.

→ Early stages : ① Hindar et al. 1986 (Biol. J. Linn. Soc.)
Norway - 1910 some lakes stocked w/ common stock - now dwarfs - normal pop. (spawning - isol.)? -
EST freq. - a question of sp. - "All Scandanavian charr from one recent common ancestor" - no 3 sp.

② Hindar - Jonsson 1982-84 - Vangsvatnet Norway - no taxi dif.

Emerald L.

? convergence ; divergence

- ③ Klemetsen et al. (1985) Drottningholm Rep. - Bear Ir. sympat. pop. - no EST dif. (if introgressed to common gene pool - then no 2 pop) - dif. rakers (1-2) - caeca (10) dwarf - normal.

④ Riget et al. (1986) CJFAS - 3 forms charr lake Greenland - early stage of incipient sympat. speciation

IV

- more advanced - Thingvallavatn - 11,000 years
benthic - pelagic Then again = 4 w/ little genetic - good morph.
"niche" filling - low overlap. -

⑤ Loch Rannoch Scotland - Walker et al. 1988. Biol. Conserv.
- sharp morphol. divergence . benthic - pelagic -

Loch Melvin Trotts

alpinus - - polyphyletic, rapid divergence
(
but convergence

conclude

	benthic	pelagic
size	smaller, slower growing	larger, faster
age	shorter life span earlier reproduction	
color	dull, pale	bright coloration esp. spawning
rakers	shorter, fewer	
caeca	fewer	
head morphol.	blunt snout subterminal jaws, short, Thick maxillary	

Conclude - sibling sp
reprod. isol. - not
taxonomic sp.
but -

Thingvallavatn


Conservation
Ex rapid morph. chr
w/o genetic quantif.
- Gila robusta
cypha
elegans
Gasterosteus aculeatus

Why only alpinus? alpina - fontinalis - malma - leucomaenis.

chub

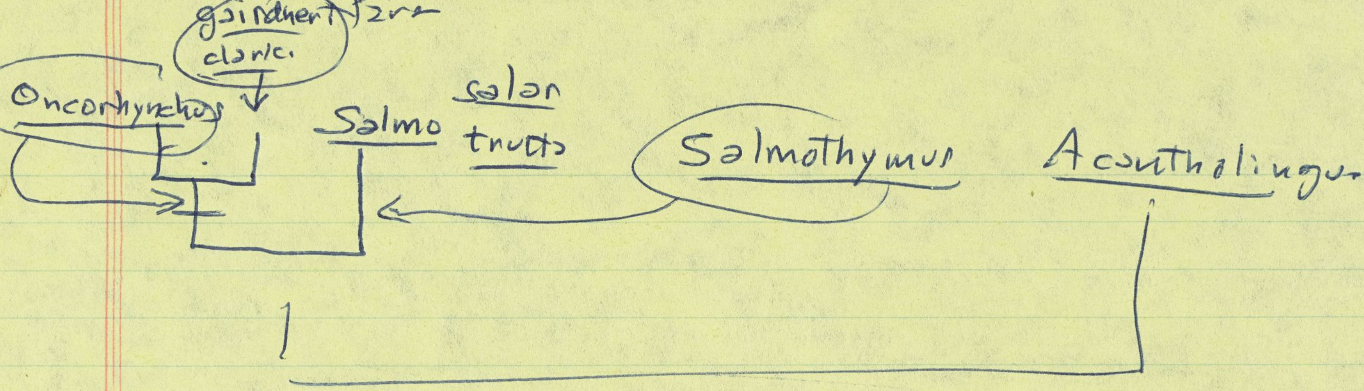
- Message protect Biodiversity (book)
course - Society - - Danger quantitative (pop.) genetics - if no dif. not gen. ~~differ~~
(nature - nurture) - what highlight protection
ecol. distinct, dif. life history types -
• Do not manage on 7 or 5 alleles - can lose great diversity -

Human mind seeks order - Illusion technique
order fm. chaos. - Quant. vs Qual. - learn to live w/ and appreciate chaos, - Polytypic sp.
Vitus viniffera - can electroph. profile - DNA character -
tell us how to make all Chateau de Rothschild -
both nature - nurture - involved.

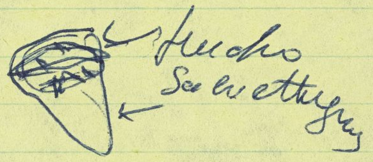
return to look ahead to present my charge

create mistake Biol. Reality

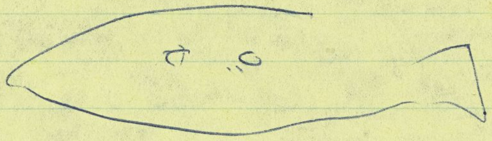
slides
- if live to 100
- look forward.
future meet of charr fanatics

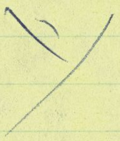


Parasalmo in genus Oncorhynchus



1984. Kendall and Behnke





Pravda

10:30

Biodiversity - - so good to see again Tovarich Barrols T
- 23 years: - but few hrs. of arrival - first bite of
charmy Kleb - as if 23 years but a day
- Editor for English V. L. G. K. - stay up-to date Soviet fisheries
~~My~~ Topic - Preservation biodiversity - - Conservation Biology
society ~ 2000 members & journal - intraspecific diversity
- wine - grape Vitus vinifera -
w/in sp. - Let me demonstrate w/ slides
ex ~~ample~~ Species - cutthroat trout S. clarki -
"Klark's forel" - ~~even~~ only Dorofeeva - Barsukov - even Amer -
- but - once great distrib. - - - Rock - Colo. - only trout -
- big brown, RB - 100 yrs ago only cutthroat - - ->95% gone
- What look like - Great Diversity - 14 subsp. - many races
30 years many believed extinct - discovered - S. c. utah -
- Greenback - Colo. - E. Cont. Divide -
- Why - what benefits - beauty - spiritual ~~nourishment~~ [illegible]
~~* L. Baical - Techno Mul~~ Illustrate similar ~~Nat~~ Conservation
Problems - Technocrats - vast forest - wood - paper - horrendous
pollution - stink - Nation aroused - - blight on ~~[illegible]~~ [illegible]
- first great victory -
- Practical values - unique genetic resources
Caspian ⟷ Pyramid L. cutthroat 1938 - why save? - subsp. not extra
- Kura R. - Redband - 28-29°C -
51 kg. - save - Chukotsk - Kamchatkan charr - golets, paliya -
how many sp. - Moscow school. - - Do not let
classif. controversy block preservation - S. t. caspius -
save Kura R. winter popn - (stock L. Michigan when alewives clupeids)
* 8 yr. 1st spawning - Genetic resources ton saved. -
- Educational - Lit. - St. - Fed. Wat - Public -
Progress Conservation of Nat. Resour - evolutionary - slow grad
not revol. - - awareness - ed. - change attitudes -
Gen Kutuzov - Napoleon

-

cost per $ Pechora 15-20 kg salmon - 100 r R [illegible] - age
vs. commercial - - logging wood, hydropower

Karluk R. —

allele   allele

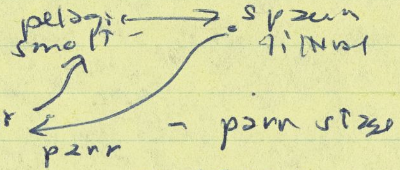
(liver) Aat (perhaps? Aat 4 (pinks - chum)) 100 Dolly Varden 30 char

~~PGI~~ 1-2 — mainly pattern dif. — mobility simin but intensity, size of band.

Leucyl - leucyl peptidase - LLP - dominant char allele is very rare in Dolly Varden (may essentially be 0 in Dolly) - only explainable — total loci: 27

— Wilmot - N. Slope - stock repetoire
US FWS Anchorage —

— Sympatric spec.



- parr stage reproduces in deep water

— Play free & loose w/ taxonomy - if taxonomists analogously played so free - unsubstantiated - wild speculation - on ecol. subjects - ex. - looks appear ridiculous -.

- ex. type locality - EST Ferry. Fn. - type locality salvelinus stagnalis

taxa - dolm plus

- p blood thick at thin blood   ecology - fat rider coarse ground habit

*but salvelinus valid sp.

Scandinavian

S. a.

S. s.

Alpine

NO
— Cherashnev - gen'l (problem)

— Resolve problems - not all but up to date 1980 - 81 - 84 - 5 - helpful

I Taxonomy & Systematics Patterns & Processes

patterns — processes — taxonomic disagreement not necessarily systematic disagreement or problem — Ex. 3 sp. Scand. N. Europe - Iceland - S. a. alpinus :

flexible - open minded - to assimilate new information - new evidence —

Review : 10 yrs. ago 1980 I wrote " " . more specifically

EST 7-5 not - type of plesio - apo - character state for identifying ancient evol. lineages - so date all lit. agrees

∴ — ex. Thingvallavatn Iceland

tax. S. salvelinus taxonomy

— sympatric speciation - - - 1-4-5 rapid -

varying degrees

— convergence = — —

re. taxonomy S. a. alpinus 1 tax unit = 2-3-4 symp. repeat

nides - mgt. — —

alpinus - malma - Savvaitova not here - it —

— — — — — 2+2=4 - insist =5 ?

II present - look ahead. — albus

subgenus Salvelinus confluentus

change - malma — alpinus leucomaenis → malma - alpinus

— N 7 100 - NOR... + Leary. Allendorf 40 loci. — 3 sub gen

— Unanswered questions -

— mtDNA rbDNA

— . electroph. profile - leucomaenis (40 loci) -

• Krohotskie - 3 longhead white snout ?

— profundus

— Elgygytyn -

human mind — Recognize limitations - plesio - apo - vs - overall phenotypic - numerical tax

deluded by Illusion Technique — Panama — 1987 Ann. Rev. Ecol. Syst.

quant - qual. - NOR : ? — miyabei

objective, quantitative = correct, biol. reality

— Conclude — preserve biodiversity. vitus vinifera Chateau R. some EST 6, 2011

— Slides

— future - 100 - still going - still problems.

by word mouth

send MS

Swedish postage stamp

Salvelinus salvelinus

- Canadian - Le Grandee

evidence - 'Hold up in court' 3 ancient lines Polls Us

fanatic - unreason

——— G

- 1~~0~~ - 14
- 1~~7~~ +type Fri send by 2~~1~~
- 24' sell - airmail
- 31

- Int Coop.

- forms L. Elgy~~[illegible]~~ - headups - 9Ascid Siberian ms

L. Krandtskae

G.D. mDNA

- but nDNA - leucomaenis

- malma - N.S.

profundus - alpine

Arctic Char ~~[illegible]~~ - Bodcanses

Svetovidovi - genus? - subsp.

- how pr 2N 84 = 100 -

kluchi B

perryi

- Want to play the game - first learn the rules.

- violation of any standard of 1. Type - topotypes - EB - if salvelinus

on what basis - sub - no!

2. s~~[illegible]~~ [illegible] 27-28

Characters.

Sub gen Salvelinus

sub. A leucom confluent alpinus

B alpinus malma profundus - NS. - salm - alpin

Km Ev leuco - alpinus conf malma alpin

why symp. esp. 21 esp. 2.2.

~~Pacific~~ - bull - anc

stone

Dolly Varden

- recent 50,000 yrs

N-S. - 400,000

m-a - 7500 km

- anadromy

- lakes few sp

Drottningholm school belief system

- sympat. pr = ancm

Mayr - Svardson - Nyman admits = fanatics

Formosa - Oshimai 1920 specimens

← st. to c/c other waters

← C & R. regs - Jap. st.

– Systematics – Big Picture – Subgenus [illegible]

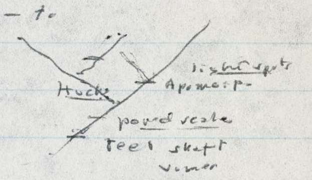
– Cristivomer – Baione – Salvelinus – Chevertner –

– electroph. – bull trout – homozygous – fontinalis
slight dif.

alpinus – malma – no dif. 40 loci
EST-1 – malma 100
alpm 115 North

– Chevertner – Acph-1 – Taranetz
malma

Salvelinus
Cladistics
– light spots
– to



– but real signif
not if gen
but living resource
for testing hypoth.

Need leucomaenis – stone-albus

– Kronotskoe – white, longhead, rare char

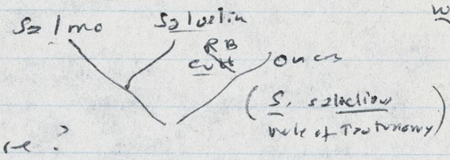
– elgygytyn – new sp.

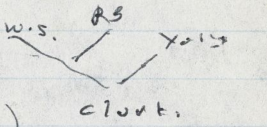
– But understand limitations – dif.

between G.D. or G.I.S. scores & cladistics – branch.,

numerical tax. – overall phenotypic sim. –

Ferguson –





DNA hybrid. – since 1950 – noise?

mt. DNA rb DNA – some limitation – elect – more correct –
supporting, supp. –

but

1987
Ann. Rev. Ecol. Syst.
Hillis

– Review evidence uneven rates

3.5 mil yr Isthmus Panama — — 30 x dif sea urchins

calibrate G.D. 1.0 = 1 – 540 mil yr.

Hillis – – –

Karyotypes – NOR's – w/ banding – great hope for tracing phylogenetic – branch. changes – –.

Int. Coop.

– Bias – micro-macro – big picture – provincialism Forest / Trees

profile – – leucomaenis, Kronotskoe L. – L. Elgygytyn –

– Bodensee profundus. ? After all years –

– Karyotypes – NF 100 – all 3 subgenera plesiom

98 – apomorph malma alpinus

no. 84 ples. – 82 – 78 – both north. malma

convergence
78 confluentus
stone ch

convergent.? – alpinus

1 pr. NOR – Salmonidae – but homozygous fontinalis, alpinus
supplementary NOR
significance?

NF 98 – electroph.

malma – alpinus synapomorph.

" NOR – translocation of NOR
on large acrocentric 2x long –

– miyabei – distinct type NOR
more constant characte
– phyl-genetic indicator
– more stable.?

positive electro inbreeding
selection diversity
because.

Because it one w/ 2n no. – in
Illusion Technique

Finish w/ Conservation message – 1984 – char watch. Conserv. Biol.
– 100 yrs old – attend char conf.

light-mild)
(warm |
Yoppie Sake

schedule
1/2 hr. 1
if final 2
5 min ok. 3
4

happy god
- special god - Ebisu for fishermen

— After so many years - Here JAPAN first began obsession with study of salmonid fishes - Sendai - Okunikawa
IWANA - YAMAME (books) - What are these beautiful trouts?

—— ~~This~~ Proceedings of this symp. = 3rd major vol. on Salvelinus → Note range of interests ecology, physiology, culture, disease, conservation but - Sect. B Taxonomy & Systematics is heart of matter - 'Problems' & unanswered & 'Controversies', - That stimulate & sustain interest & enthusiasms necessary to get people from Holarctic region together for another symp. — Jap. J. Ichthyol. --- "Arctic charr fanatics" — "Fanatics" - "strong" word - zealot - emotional based belief system immune to reason - closed mind - - - Perhaps good term.

*Advise open mind 'wishy-washy'

— Perhaps best, even if possible, to answer all ~~un~~answered questions, solve all problems, That we complete this symp. with sufficient unresolved problems for next int. symp. -- expect if live to 100 - still be charr problems for future -

- Ex. Chereshnev - dramatic, exciting discovery new "genus" - but in perspective - all other represent. - 3 sub genera - Salvelinus (alpinus) Cristivomer (lake charr) Baione (fontinalis) - last sp. described 1814 - 175 years ago -

T, U, - other trout - charr ~~[illegible]~~ - Sunapee, Dolly Varden, Brook trout, lake trout

pop. genetics vs. evol. genetics

Smith & Todd 84 introgression spec.
. - Gila chubs

- neutral alleles - not expected + change

mtDNA - O. - S. masou - C.J.Z. 1 mil yr
for 10,000

V

Taxonomy & Systematics & To see what problems ~~can~~ we might resolve from past 1980 (Balon) 1981 symp (1984 publ) - I review problems & some work to present — Helpful define tax. & syst. terms of patterns & processes + evolutn

tax. = assessment of patterns we observe of evol. differentiation for classification - w/o reference to the processes causing the differentiation (Can have good tax. w/o ref. to evol. Linnaeus - tide tables - sun rise-set - calenders - flat earth)

Syst. = processes that produce the patterns. - understanding phylogeny - the evol. & zoogeogr. processes - the evidence used to interpret.

— Thus If there still disagreement - more precisely focus on it a taxonomic problem (of classif.) or systematic prob. of origin-cause of differentiation -

1 ~~Problem~~ Ex. Sympatric sibling sp. problem -

I said ~~N. E~~ Scandanavia, Iceland, Great Britain 1 sp-subsp. S. a. a. - i.e. one common ancestor form charr established during & since last glacier - i.e. all ~~for~~ monophyletic to ancestor < 50,000 yrs. - most 10-20,000

pop. genetics vs. evol. genetics

Nyman (81) - 3 ancient sp. - alpinus, salvelinus, stagnalis → ~~befo~~ 3 sp. estab. < last glaciatn separate invasions - ~~my~~ evidence

—— Hindsight more accurate than foresight. but - 1980 book - "Without sound basis for establishing plesiomorphic & apomorphic character states (prim.-derived). for determining

should be basis in present.

II

phylogenetic branching sequences and sister groups, we are only playing games".

– Re. tax.-syst. sympat. sibling sp. - more precise "The ~~A~~ Allelic freq. at one esterase gene locus is not sufficient basis for plesio-apo. state and should not be used ~~as~~ basis for I.D. ancient ~~phylo~~ evol. lines -..

Ex.
Changing viewpoint

→ 1981 Symp. (1984 book) Gydemo charr of Iceland (Thingvallavatnt sympatry) -

" It is clear that all of the species from Scandanavia as defined by Nyman et al. (1981) are present in Iceland also" - The landlocked charr of Iceland were already separated into species when immigration occurred."

clear statement 3 sp. of theory

— Gydemo (et al.) 1987 - Environ. Biol. Fishes

" The Arctic charr in Thingvallavatn is polymorphic. Genetically the 4 morphs are very closely related. The morphs are conspecific (all one sp.) and do not represent different evolutionary lineages. The morphs in Thingvallavatn have probably developed within the lake and the morphs are locally adapted to different niches" - Thingv. 11,000 yrs (~~L. Malawi,~~ 4 pop. symp. reprod. isol. - L. Malawi 300 sp. cichlids) -

* Sympatric speciation

* Biol sp.

syst. vs. tax.

– i.e. for mgt. - different niches - different functional roles in ecosystem - mgn. as species - tax. - NO!

— ~~Studies~~ Studies influencing ~~new acceptance~~ rejection of 3 sp. Theory:

1. Hindar et al. 1986 (Biol. J. Linn. Soc.)

Norway - lakes stocked 1910, common ancestor

III

~75 yrs. – some lakes w/ dwarf + normal (reprod. isol. ?) – re. EST allele freq. –

Hindar Jonsson 1981-84

"All Scandanavian charr are derived from one recent common ancestor" – No 3 sp. involved.

3. Klemetsen et al. 1985 (Drottningholm Rep) –

Bear Is. Arctic Ocean – several lakes sympat. char

No dif. EST. but rakers ~1-2 caeca 10. (i.e. convergence (introgression of 2-3) or divergence (1 common ancestor) – recent) – if EST homogeneous – no dif. rakers + caeca.

4. Riget et al (1986) – C.J.F.A.S. – 3 forms Greenland lakes "early stages of incipient sympatric speciation".

5. Walker et al. (1988) . Biol. Conserv. – Loch Rannoch

Advanced stage

Scotland. – sharp morph. divergence benthic-pelagic head, jaws... – Loch Melvin S. trutta 3 sp –

∴ Summary of sibling sp. problem

– S. a. alpinus strong tendency in lakes (esp. where sole or dominant fish) – strong selection to diverge to ~~become~~ more efficient resource

utiliz.

(= selection increase sp.) . divide into benthic special. + pelagic.

consistent, convergent trends –

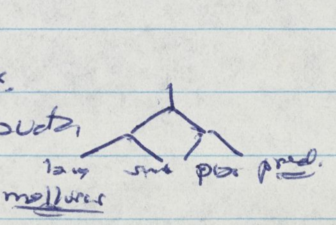
	benthic – pelagic
size	smaller
maturation	slower growing → earlier, smolts
age	∴ shorter lifespan
color	– dark, dull, pale
rakers	– shorter, fewer
caeca	– fewer
head morph.	– blunt, snout short jaw thick max.

exception

or Windermere

Sympatric [illegible]

– Thingvallavatn



looks like 2-3 ancest. sp. – but not – 10,000 yrs.

IV

not leucom. fontin. + malma - [illegible]

- Why only alpinus - why only Europ subsp ?
lakes - lake spawning - few other sp. - where anad. - no .

— Present - Future : electroph. G.P. limitations
- mt DNA rb DNA - some limit. - plesiomorph - apomorph
- numerical tax. - overall phenotypic sim. - addition evidence — Karyotypes - NORs - esp hopeful for phylogenies esp. banding ~~—~~ to hear more about - but led me to change since 81 - malma → alpinus, leucomaenis confluentus albus

how can so polymorphic be so monomorphic?? 40 loci. 3 subgenera

mol. clock
Isthmus Panama
10-30 x dif.
1987 Ann Rev Ecol. Syst.

— Plea for broader scope - characterize Vegetation of Hokkaido - ~~don't~~ counting sp. in garden or park of limited value. - —

ex. Europe Tiefsee saibling - what is it? what is closest relative? - electroph. - karyotypes - mt DNA rb DNA

- N. Am. - S. - n. Dolly Varden - sympatric? 1957 Susitna - northern - count gillrakers!

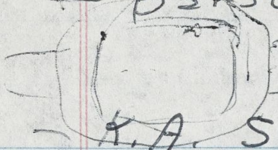
- Kamchatka - L. Kronotskoe - longhead, white snout? - what are they??

- electroph. profile - mt DNA etc. - leucomaenis link w/ ?

Slides.

- sticklebacks.
- Gila chub - Lahontan
- Colo. R.

– Barsukov – get batteries for CASIO digital watch



– K.A. Savvaitova, Dept. Ichthyology, Moscow St. Univ.
Moscow 119899. USSR – copies abstracts – reprints
documenting distrib. of 2 sp. Brachymystax. – Marnell et al.
– Lavrosky? – C.S.U. stuff

– Dr. Norihiro Okada – phylogeny papers
Inst. Biol. Sciences, Univ. of Tsukuba
Tsukuba City 305, Japan.

–history
invite article Japan trout-charr fly
– Herbst (pipes) T.U. Japan – Daiwa card (charr books
Sapporo
after send Trout & brook, lake, Sunapee, Dolly Varden – Cortland Pro Shop
Fred Kircher T.U. souveniers – Schullery –

– Martin Bohl – after Nov 1 – slide of shasta – steelhead type
– article Shasta RB (– stuff on European –

1697 Hitsudai. Hitomi: Hontya Shokkun
(Encyclopaedia) – Recently fly fishing discovered at River
Ôi (Shizuoka Prefecture) & for ayu – as independent
– Kawanabe origin
charr & slow electroph. – Tony Gharrett
– Dick Wilmot, USFWS, AK Field Station, ~~1011 Tudor~~
1011 E. Tudor Rd. Anchorage. 99503

Nyman 84 "Taxonomic arrangements are the result of human reasoning". – thus they only "approximate translations of biol. truth".

84 & 4 "Taxonomy is not a matter of whether osteology holds the key to sound systematics . . . but rather the drawing together of conclusions from whatever methods provide convergent results." – EST – , scale row rakers, karyotypes, etc. –

– re character weighting correct in total no. fins more weight than no. rays in any fin. –

– then abandon all reasoning = total weights .. EST &

re. Non showing of allele at loci . non impt. ..

et al. (Sip) – "new dimension added to view of treating all Mendelian polymorphism as pop. marker"

divine power

Before moving into interspecific problem it would useful to elucidate clarify difference between population markers characteristic and phylogenetic markers that denote = [illegible] so used for sp. criteria – to quote Dreft, Nyman views ...

By what divine power are we endowed with the ability to say that all polymorphism exposed by electrophoresis have equal resolving power as population and species discriminants pop. & sp. Cont Dri'pe

& reflective judgement

Inter

if D.V. [illegible] consistent – [illegible] – Isthmus Panama –

if species marker

– S. Zool. – methods –

① – No taxonomist would give equal taxonomic weight to the number of rays found in a particular fin compared to the total number of fins when separating two species of fish.

– precisely! – If Nyman the divine power that we are endowed – [illegible] is the complex contraction of neural development call brain particularly the cerebrum or gray matter, devoid in fish etc.

Mendelian polymorphism w/o corroborating evidence
not valid marker

Nyman et al. (1981) EST-1 (115) allele 'A' = alpinus .9 - 1.0 smallest
largest - 'N' salvelinus .4 - .7
'S' stagnalis .0 - .2 large

type localities - .
redescription of topotype? specimens
- all 3 "sp" in New Sea sub sp. oquassa

[illegible] eastern Arctic - *15 1.0 for =
if same 66-70 vert 25-30 rakers
malma - malma .01 = stagnalis - m
sex dim type - slab body - m - - -
ex. how morphol. taxa can
- observe? - ex. Australian native bushpeople -
distinction morphol. - if colony
exists Sweden - -

caution
electroph
not cladistic
but.

*taxon. recognition - sympat.
pop - ..
- EST freq. "gen. Mendel - - - ."

POP' genetics

quote Nyman but - "By what devine power are we to say that all polymorphism exposed by electrophoresis have equal resolving power as population and species discriminants?" - All Divine power bee concern our mind & brain allows for eval. of empiricism professional judgement = common sense. - When seen that allele EST-1 as pop. marker - warns individual dual diverse subsp. alpinus, in malma - -
If indeed, EST 100 / 115 only.
pop. not taxa!
Can alpinus sympatric pop.

beg from hot .05
"alpinus"
model only
23-25 rakers
63-65 vert

Klemetsen - p. 71 fig. 2
No Norway fixed for (115)
.2 in South

Fennoscandian charrs may be descended from one ancestor from east and one from southwest.

White Sea
low raker
18-21

Eam
25-30

Copeia, 1989(1), pp. 47–53

Patterns of Chromosomal Nucleolar Organizer Region (NOR) Variation in Fishes of the Genus *Salvelinus*

RUTH B. PHILLIPS, KAY A. PLEYTE AND PETER E. IHSSEN

The chromosomal locations of the nucleolar organizer regions (NORs) in two North American species of *Salvelinus, S. confluentus* and *S. malma,* are reported. This brings the total number of species of *Salvelinus* examined for chromosomal NORs to six, and the total number of species of salmonid fishes examined for NORs to 17. Arrangement of the NOR differences into a phylogenetic hypothesis supports morphological, biochemical, and cytogenetic data which group *S. malma* with *S. alpinus.* The relationship between these species and the other species of *Salvelinus* remains unresolved.

THE chromosomal locations of the nucleolar organizer regions (NORs) of three of the five North American species of *Salvelinus* were determined previously by using chromomycin A3 (CMA3) staining and silver staining (Phillips and Ihssen, 1985). The fluorochrome chromomycin A3 (CMA3) stains active and inactive NORs in amphibians and fishes (Schmid, 1982; Amemiya and Gold, 1986). Although all the species in the related genera of *Salmo* and *Oncorhyncus* have only one chromosome pair with NORs (Phillips and Ihssen, 1985; Phillips et al., 1986), the NORs were found on several different chromosome pairs in these three species of *Salvelinus*: *S. namaycush* (lake trout), *S. fontinalis* (brook trout) and *S. alpinus* (arctic char). In this paper the chromosomal location of the NORs in the other two species, *S. malma* (Dolly Varden char) and *S. confluentus* (bull trout), is described and a phylogenetic hypothesis for relationships among these species using these data is presented.

The five North American species of the genus *Salvelinus* have been assigned to three subgenera by Behnke (1965, 1980). These are the subgenus *Cristovomer* including *S. namaycush,* the subgenus *Baione* including *S. fontinalis,* and the subgenus *Salvelinus* which includes the species in the arctic char complex. This latter group includes *S. alpinus,* which has a circumpolar distribution in the arctic, *S. malma,* which occurs in sympatry with *S. alpinus* in the north Pacific, and *S. confluentus,* which is found in the Rocky Mountains (Cavender, 1980). In the Far East another species, *S. leucomaenis* (2n = 84) is considered to be more closely related to *S. namaycush* by Savvaitova (1980) and Viktorovsky (1978), but is placed in the subgenus *Salvelinus* by Behnke (pers. comm.). Behnke divides the subgenus *Salvelinus* into the *S. alpinus*—*S. malma* complex and a group comprising *S. confluentus, S. leucomaenis* and *S. albus,* which is found in the Kamchatka peninsula.

The possible phylogenetic relationships

among the North American species of *Salvelinus* were discussed in a paper by Cavender (1984), in which he summarizes his work and that of others in the cytotaxonomy of *Salvelinus.* He presented two alternative cladograms based on chromosome number (2n) and chromosome arm number (NF). A major point of uncertainty is whether *S. confluentus* has a sister-group relationship to *S. malma* and *S. alpinus,* or is more closely related to *S. fontinalis, S. namaycush* and *S. leucomaenis.* The data on NORs provide some additional evidence relevant to this problem, which remains unresolved.

MATERIALS AND METHODS

Eggs of *S. confluentus* were obtained from fish in Arrow Lake, British Columbia and eggs of *S. malma* were obtained from fish collected near Juneau, Alaska. Chromosome preparations were made from embryos from fertilized eggs using methods described previously (Phillips and Zajicek, 1982). Embryos of approx. 180° d were dissected from the eggs, incubated in culture media with 25 μg/ml colchicine and fixed after 4 h with 3:1 methanol : acetic acid fixative. Chromosome slides were made according to the methods of Kligerman and Bloom (1977), in which fixed material was pulverized in 45% acetic acid and the material dropped onto heated slides. Slides were stained with the silver staining procedure of Howell and Black (1980) to visualize the Ag-NORs, and with chromomycin A3 followed by counterstaining with distamycin A as described in Phillips and Hartley (1988). Slides were viewed with a Zeiss Universal microscope on bright field for the Giemsa-stained and silver-stained slides and with a HB 200 mercury lamp with BG 12 excitation filter and 47 or 50 barrier filter for the CMA3 fluorescent stained slides. Six figures were examined for each individual. Photographs were made using Kodak Technical Pan film, developed with D-19 and 8 × 10 prints were made for karyotyping.

RESULTS

Location of NORs.—The locations of the NORs in *S. confluentus* and *S. malma* were identified by silver staining and CMA3 staining. In these two species, the NORs were found at one location on one chromosome pair in all individuals examined. There was a complete correspondence between NORs as identified by CMA3 staining and silver staining. In *S. malma,* the NORs were found at a telomeric location on the short arm of the largest submetacentric chromosome and, in *S. confluentus,* the NORs comprised the entire short arm of a large acrocentric chromosome (Fig. 1).

The locations of the NORs in five species of *Salvelinus* are illustrated in Figure 1 and summarized in Table 1. In the other three species the location of the NORs was multi-chromosomal (Phillips and Ihssen, 1985). Considerable variation among individuals in the number of chromosomes with NORs was found in all three of these species, although the location of the NORs was constant for all of the cells of a given individual. The total number of NORs per genome varied from 4–10 in *S. fontinalis,* 4–12 in *S. namaycush,* and 2–6 in *S. alpinus.*

In each species with multichromosomal NORs some of the NORs were found at the same location in almost every individual, while other NORs were quite variable between individuals (Phillips et al., 1988a, 1988b). The constant NOR sites were present on both members of the putatively homologous chromosomes, while the variable sites were often present on only one of the two homologous chromosomes. (Exact identification of homologous chromosomes would require G-banding or meiotic studies which were not done. The chromosomes were grouped according to size and centromere position.) The constant NOR site in *S. alpinus* was at the telomeres of the short arms of the largest submetacentric chromosome pair in the genome. The constant NOR sites in *S. fontinalis* were on the short arms of two acrocentric chromosome pairs. In *S. namaycush,* they were on the short arms of one acrocentric chromosome pair and the telomeres of the long arms of another acrocentric chromosome pair.

Phylogenetic analysis of NOR character states.—Differences have been found between related fish species in the haploid number of chromosomal NORs, the specific chromosome(s) on which the NORs are located, and the precise chromosomal location in the Salmoninae (Phillips and Ihssen, 1985; Phillips et al., 1986) and Cyprinidae (Gold, 1984; Gold and Amemiya, 1985).

In order to arrange NOR character states into a phylogenetic hypothesis, one must identify homology of character states between species and determine character state polarity. In order to determine character state polarity, the character states of species in related taxa must be examined so that the plesiomorphic character

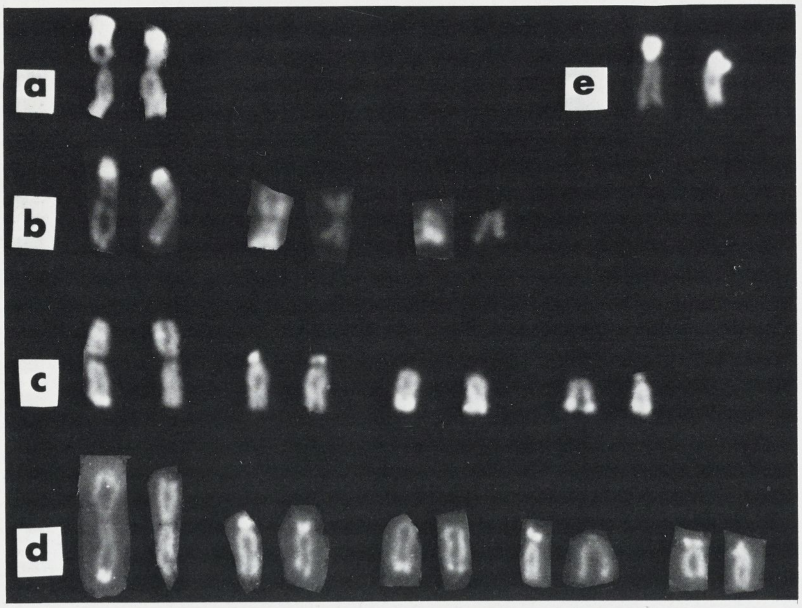


Fig. 1. Partial CMA3 stained karyotypes showing the location of NORs in the five species of *Salvelinus*. In the species with multi-chromosomal location of NORs, intraspecific differences occur in the number and location of the variable NORs which are found on only one of the two homologous chromosomes, so that the partial karyotype shown is only one of several found for that species. a) *S. malma,* b) *S. alpinus,* c) *S. namaycush,* d) *S. fontinalis,* e) *S. confluentus.*

state can be determined. The NOR phenotypes of 17 salmonid species analyzed to date are presented in Table 2. Fourteen of the 17 species have the NOR on one chromosome pair, and nine including at least one species in each genus have the NOR on the short arms of an acrocentric chromosome (Type A in Table 2). An additional four species have the NOR on the short arms of a submetacentric chromosome (Type A′). This is considered a minor change, because it is often simply the result of additional heterochromatin added to the region flanking the NOR on the short arm (Phillips and Hartley, 1988). Because NOR phenotype A is found in each genus including one species in the related Coregoninae (Phillips, unpubl.), we have assumed that this phenotype is plesiomorphic for the Salmoninae. Thus *Coregonus clupeaformis* could be considered an outgroup for the Salmoninae.

NOR phenotype A is also found in the majority of fishes (Gold and Amemiya, 1985) and this type is also thought to be primitive for most vertebrates (Hsu et al., 1975; Schmid, 1978). If this is the case, then the initial ancestral tetraploid salmonid fish would have had two pairs of acrocentric chromosomes with the NORs on the short arms, and the NORs must have been

TABLE 1. NUMBER OF NORS PER DIPLOID GENOME IN DIFFERENT SPECIES OF *Salvelinus* FROM NORTH AMERICA. Numbers indicate the range of NORs found in different individuals of a given species.

Species	Number of specimens examined	Chromosomal location of NORs				Total NORs
		Acrocentric short arms	Acrocentric telomeres	Submetacentric telomeres	Metacentric telomeres	
S. confluentus	12	2	—	—	—	2
S. fontinalis	20	2–8*	0–2	—	0–1	4–10
S. namaycush	91	2–6*	2–4*	—	0–2	4–12
S. alpinus	60	—	0–2	2*	0–3	2–6
S. malma	12	—	—	2	—	2

* Indicates major NOR sites in species with NORs at more than one chromosomal location.

Table 2. Number and Chromosomal Location of NORs in Different Salmonid Species.

	Major NORs		Minor NORs	
Species	Number/2n	Location*	Number/2n	Location
Coregoninae:				
Coregonus:				
C. clupeaformis	2	A		
Salmoninae:				
Salvelinus:				
S. alpinus	2	C′	0–6	A, B, C
S. confluentus	2	A		
S. fontinalis	2–4	A	2–6	A, B, C
S. leucomaenis	2	A		
S. malma	2	C′		
S. namaycush	2–4	A, B	2–8	A, B, C, C′
Salmo:				
S. clarki	2	A′		
S. gairdneri	2	A′		
S. salar	2	A′		
S. trutta	2	A		
Oncorhynchus:				
O. gorbuscha	2	D		
O. keta	2	B		
O. kisutch	2	A		
O. masu	2	A		
O. nerka	2	A′		
O. tshawytscha	2	A		

* A = acrocentric short arms, A′ = submetacentric short arms, B = acrocentric telomeres, C = metacentric telomeres, C′ = large submetacentric telomeres, D = metacentric adjacent to centromere.

consolidated to the short arms of one acrocentric chromosome pair or lost altogether from one pair shortly after tetraploidization. Studies of several tetraploid cyprinid fishes (Takai and Ojima, 1982) have revealed only one chromosome pair with NORs, suggesting that consolidation of NORs to one chromosome pair may be a common event in tetraploids.

If we consider NOR type A as the plesiomorphic NOR character state for the Salmoninae, then *S. confluentus* and *S. leucomaenis* (Ueda and Ojima, 1983) would have the plesiomorphic NOR character state, and the other species in the genus *Salvelinus* would be placed into two groups in which the members of at least one group share derived character states (synapomorphies).

In order to define the synapomorphies precisely, a sequential method involving G-banding for identification of chromosomes followed by CMA3 staining or CMA3 staining of meiotic chromosomes in hybrids would be required. Because a reliable G-banding method was not available, chromosomes were divided into groups on the basis of size and centromere position.

Salvelinus fontinalis and *S. namaycush* have a very similar pattern with a constant NOR site on the short arms of the largest acrocentric chromosome pair and additional NORs on 5–12 different chromosome pairs in three different types of locations: short arms of acrocentric pairs, telomeres of acrocentric pairs, and telomeres of metacentric pairs. The only NOR in *S. confluentus* is on the largest acrocentric pair, which is similar in size to the acrocentric chromosome with the constant NOR found in *S. fontinalis* and *S. namaycush*. *Salvelinus malma* and *S. alpinus* share a synapomorphy because the only NOR chromosome pair in *S. malma*, and the constant NOR chromosome pair in the North American *S. alpinus*, is the largest submetacentric chromosome in the karyotype. In order to be completely certain of this synapomorphy, homology of the two chromosomes would have to be shown using G-banding, which has not yet been accomplished. However, the gross karyotypes of these two species are quite similar to one another (Cavender, 1984), so this is a plausible assumption. G-banding might also reveal shared derived character states between *S. fontinalis* and *S. namaycush* because several of the minor NOR sites may be identical between these two species. However, without G-banding, the minor sites must be considered autapomorphic in both species. One possible cladogram summarizing all of the chromosome data is shown in Figure 2.

Discussion

Examination of the NOR character states in the species of *Salvelinus* supports the other chromosome data which indicate a major split between *S. namaycush* and *S. fontinalis* on the one hand and *S. alpinus* and *S. malma* on the other. Analysis of the other karyotype data suggests that *S. leucomaenis* from Japan should be grouped with *S. fontinalis* and *S. namaycush*, because all three species have 2n = 84, NF = 100, and eight metacentric chromosome pairs which are all larger than the 34 acrocentric pairs, a karyotype considered primitive by Cavender. However, if we are correct in assuming that *S. leucomaenis* also has the primitive NOR character state, its

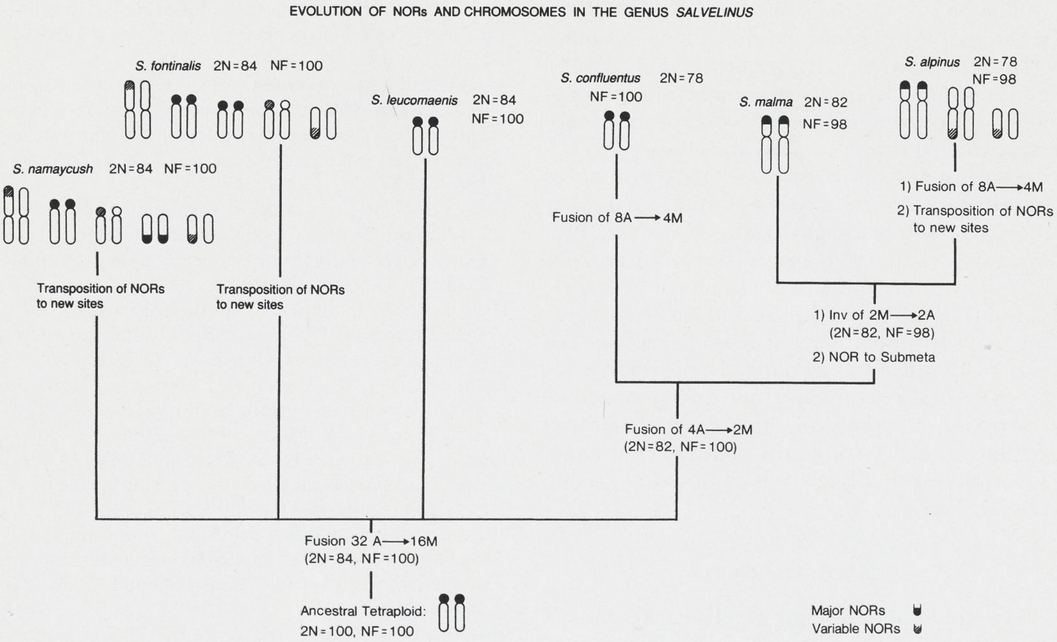


Fig. 2. One possible cladogram showing relationships between species of *Salvelinus* based on chromosome data. The locations of the major NORs which are always found on both members of a homologous pair in all members of the species are shown in black. The locations of the variable NORs which show intraspecific variation in number and chromosomal location and are usually found on only one member of a chromosome pair are shown in stippling. The chromosome data for all of the species except *S. leucomaenis* are based on karyotypes prepared from representatives of the five North American species of *Salvelinus.*

placement with respect to the other species cannot be resolved using NOR data alone. There is some question about this, because the location of NORs in the karyotype of *S. leucomaenis* was deduced from the description by Ueda and Ojima (1983) of satellites identical to those found by us on the large acrocentric chromosome pair with NORs in *S. confluentus,* and from the report of positive N-banding of these sites (Ueda, 1987). Because N-banding is usually considered equivalent to silver staining, this assumption is probably valid. The three other species have derived karyotypes, with 2n = 78, NF = 102, and 12 metacentric pairs for *S. confluentus,* 2n = 78, NF = 98 and 10 metacentric pairs for *S. alpinus,* and 2n = 82, NF = 98 and eight metacentric pairs for the southern form of *S. malma* in North America. The northern form of *S. malma* in North America has not been karyotyped. A close relationship between *S. alpinus* and *S. malma* is suggested because they share a derived large acrocentric chromosome, which is twice as large as the others or any of the acrocentrics in the other species of *Salvelinus.*

Cavender (1984) suggested that the closest relative to *S. confluentus* may be *S. kronicus* (also called *S. albus*) from the Kamchatka River basin, which was reported to have 2n = 78 and NF = 100 with 11 metacentric chromosome pairs. Our results from the karyotyping of *S. confluentus* from Arrow Lake, British Columbia, suggest that *S. confluentus* and *S. kronicus* may have identical karyotypes. Silver staining reveals that the 12th metacentric pair in the karyotype of *S. confluentus* prepared by Cavender is actually a large acrocentric chromosome pair with the NOR comprising its entire short arm.

The chromosome data support the morphological data, which suggest that there are five distinct species in North America subdivided into three groups: 1) *S. fontinalis* and *S. namaycush*; 2) *S. malma* and *S. alpinus*; and 3) *S. confluentus.* A recent electrophoretic survey of protein loci in the five species (Leary et al., pers. comm.) found that *S. malma* and *S. alpinus* shared alleles at all loci, while the other three species were distinct from each other and the *S. malma—S. alpinus* complex.

The NORs are the sites of the 18S and 28S ribosomal RNA genes in animal chromosomes (Hsu et al., 1975). The genes for the 18S and 28S ribosomal RNA are present in multiple copies of a repeating unit which contains both rapidly evolving spacer regions and conserved coding regions. Comparison of DNA sequences between the different species should yield many more characters for phylogenetic analysis. Preliminary restriction maps of the rRNA cistrons in *S. namaycush* and *S. fontinalis* have been prepared (Popodi et al., 1985), and we are preparing maps for the other species of *Salvelinus*. We plan to identify phylogenetically informative regions in these cistrons and then do fine structure restriction mapping or sequencing of selected regions in order to obtain multiple characters for a phylogenetic analysis of *Salvelinus* using rDNA.

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A New Arctic Char, *Salvelinus alpinus sp.*, from Western Alaska

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Abstract.- A previously unknown char, *Salvelinus sp.*, was discovered in certain lakes in the Kigluaik Mountains on the Seward Peninsula of western Alaska during routine inventories of fish and their habitats durin summer, 1987. The fish from two of these lakes were judged to belong to the Arctic char complex, *S. alpinus*, based on morphometric and meristic features attributed to this group. Until the discovery of these populations only Dolly Varden, *S. malma,* were known from this area of western Alaska. Additional examination of physical features have revealed some apparently unique characteristics compared to other populations of the *alpinus* group in Alaska and perhaps elsewhere. Also, the populations from the two lakes are different from each other in that the sexually mature individuals from one lake have neotenic features (i.e., parr marks) and the sexually mature adults in the other lake do not exhibit neoteny. Subsequent examination of these fish in which the sequence of the ribsomal DNA first internal spacer retion (rDNA ITS1) was determined, indicated that these fish were different from other Arctic char that were available for comparison which included *S. alpinus sp.* from the Kenai Peninsula in southcentral Alaska and *S. alpinus erythrinus* from Nayuk Lake in the Northwest Territories, Canada. Further genetic anlysis using mitochondrial DNA restriction site fragment length polymorphisms (RFLPs) indicates that the populations from the two lakes are also different from each other. This study provides further insight into the ongoing effort by char specialists to explain the postglacial dispersal and distribution of the Arctic char complex in North America and Asia.

Morphological and meristic characteristics that are used to identify and discriminate among the different subspecies of other fish species often are unsatisfactory when trying to determine the subspecies status of different Arctic char populations. Evidence of this difficulty is demonstrated by comparing the opinions of several char specialists (Benhke, 1984, 1989; Mcphail, 1961; and Wilson et al., 1996) when discussing the subspecies status of Arctic char from the Kenai Peninsula, Alaska. Recent taxonomic studies have increasingly relied on employing techniques and methods of molecular systematics to determine the subspecies status of different Arctic char populations. Biologists with the U. S. Bureau of Land Management discovered a char, Salvelinus sp., inhabiting several of the glacially formed lakes of the Kigluaik Mountains on the Seward Peninsula of western Alaska in 1987. Additional char were collected from Crater Lake and Fall Creek Lake in 1992, 1995, 1996 and 1997.

Methods

Fish were captured using variable mesh monofilament gill nets and hook and line. Fish were identified to the species level using standard taxonomic keys (Scott and Crossman, 1973; Morrow, 1980). The physical characters used to determine the species to which these populations belonged were the numbers of pyloric caeca and gill rakers, the relative abundance and size of lateral spots, and whether the caudal fin was strongly or shallowly forked.

Subspecies determination was accomplished by using molecular systematic techniques in which the DNA is compared to the DNA from previously known and identified populations. Kigluaik Arctic char DNA was compared to DNA from tissues available from specimens taken from populations endemic to the following lakes: Storvatn, Norway (S. a. alpinus); Nauyuk Lake, Northwest Territories (S. a. erythrinus) and East Finger Lake, Kenai Peninsula, Alaska (S. alpinus sp.). In addition, the Kigluaik char were compared to Dolly Varden char (S. malma lordi) from the Fox River, Kenai Peninsula, Alaska.

Two genetic markers were examined in the Kigluaik char. The ITSI sequence was selected because previous work showed that the three subspecies of Arctic char have different sequences for this region (Phillips et al., 1995). The mitochondrial RFLPs method was selected because of variation in several restriction enzyme sites among the subspecies examined previously (Grewe et al.,1990 and Wilson et al., 1996). For nuclear ribosomal analysis the DNA was extracted from three fish from Falls Creek Lake and two fish from Crater Lake using standard methods. The ITS1 of the ribosomal DNA was amplified from each fish. The products were cloned into pGEM and sequenced. The sequences were aligned and phylogenetic trees were constructed using maximum parsimony of the PAUP computer program (Swofford, 1997) and the neighbor joining method of the MEGA program (Kumar and Nei,1993). For mitochondrial analysis the DNA was extracted from six fish from Fall Creek Lake and five fish from Crater Lake using standard methods. Approximately 50% of the mtDNA molecule was amplified using the Expand Template PCR System (Boehringer Mainheim). The products were subjected to single and double digests with four enzymes: BamH1, HindIII, Nco1 and Sma1.

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hybrids ~~Skagit~~ R. - CJFAS 54: 421-29.
Peace R.
♀ bull x sneaker ♂ DV

upper Col. chinook
Utter et al. 1995 - Evol. Signif. Units.
Symp. 17: 149-68

This paper contains much detailed, new information on the movement of Dolly Varden and is worthy of publication after some minor corrections and revision.

In the introduction (p. 3), the range of the southern Dolly Varden is given "south to Oregon" citing Behnke (1980). This cited range was made when bull trout were considered as Dolly Varden. To date, all native *salvelinus* known from the Columbia River basin have proved to be bull trout. The present southernmost documented range of Dolly Varden are Puget Sound drainages of Washington.

Also in the introduction, it is stated that "all Dolly Varden generally reside in near-shore subtidal waters." "All" means the species *S. malma*. Later, De Cicco (1992) is cited for records of North America-Asia migrations of the northern subspecies (Fred has more records which might be added as personal communication) and on p. 14, Dolly Varden caught in the ocean in February is mentioned. The sentence should be: It has been commonly believed that anadromous Dolly Varden generally utilize inshore regions of the sea --- but ---.

The mention on p. 14 of capture of Dolly Varden in February in the sea north of Auke Bay requires more details because this is the first report of Dolly Varden "in the sea" in winter. Who caught them? By what means? Precise location? Any data on water temperature, depth, distance from shore? How many? Sizes?

This winter capture record evidently biased the authors to assume all of the "anomalous" fish spent their winter in the sea. Considering the limited sites sampled, the recapture data showing considerable movement in the sea, and the fact that some northern Dolly Varden of Alaskan origin overwinter in Russian rivers, it should be assumed that in a non-spawning year, many southern Dolly Varden may overwinter in distant non-natal freshwater sites.

The statement on p. 14 that failure to return every winter to freshwater is a trait of coastal cutthroat is not correct. I know of no marine winter record for coastal cutthroat. They may not all return to the sampling sites but not to return to freshwater for overwintering is certainly not a "trait" of coastal cutthroat.

TRANSACTIONS of the AMERICAN FISHERIES SOCIETY

MANUSCRIPT REVIEW

Manuscript Number: T 94-162-1

Author(s): Bernard et al.

Title: Some Tests of the "Migration Hypothesis"...

Summary Recommendation:
Publish with minor revision X. Publish with major revision ______. Unacceptable ______.

This paper contains much detailed, new information on the movement of Dolly Varden and is worthy of publication after some minor corrections and revision.

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T94-1624

TRANSACTIONS
OF THE AMERICAN FISHERIES SOCIETY

GUIDE FOR REVIEWERS

The accompanying manuscript has been submitted for publication in the *Transactions of the American Fisheries Society*. We ask your assistance in judging its technical competence. Please address yourself to the following basic concerns.

(1) Is the paper understandable, scientifically sound, and technically reliable?

(2) Are the statistical tests, if any, appropriate for the data and correctly applied?

(3) Are the conclusions adequately supported by the data?

(4) Is the contribution sufficiently integrated with existing knowledge?

(5) Does the paper represent a substantial, a marginal, or a trivial advance beyond existing knowledge? Is it relevant to its field?

(6) Is the information new, or has it been published elsewhere in one form or another outside the institutional or contractual report literature?

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You may range as widely in your commentary as you wish, but you need not be concerned about journal style or format, which will be checked by the Editor. Additional remarks may be placed directly on the manuscript. Whenever possible, please make your criticisms constructive. It will be helpful to both author and Editor if you will point out the paper's strong points as well as its weak ones.

Please begin your review on the reverse side of this sheet, and continue on additional sheets as needed. Remember to check your summary recommendation. We would like two copies of the review, one of which will be forwarded to the author. We encourage reviewers to sign their critiques, though this is not a requirement, and urge a civil tone even for unfavorable assessments.

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AFS AMERICAN FISHERIES SOCIETY

UDC 597.5 C 1990

Salvethymus svetovidovi gen. et sp. nova - A New Endemic Fish ~~from~~ of the Subfamily Salmoninae from Lake El'gygytgyn (Central Chukotka) *

I. A. Chereshnev and M. B. Skopets
Institute for the Biological Problems of the North,
Far East Division, Academy of Sciences of the USSR, Magadan

A description is given of a new ~~endemic~~ genus and species of salmonid, Salvethymus svetovidovi - Svetovidov's long-finned char, ~~caught in the~~ from ancient lake El'gygytgyn. This species differs from all other salmonid genera in the coloration of the fins, in the shape and structure of the chondrocranium cartilaginous skull and many of the bones of the head, in the reduction of the orbitosphenoid (to the point of complete disappearance) and of the basisphenoid, of the teeth ~~and~~ on the vomer, and in reductions in the number of predorsals, ~~of~~ in the axillary process lobes and ~~of~~ in a number of dermal bones of the head. The new species is morphologically more similar to chars of the genus Salvelinus and it is apparently ~~a form~~ phylogenetically ~~similar~~ close to the ancestors of that group. It is suggested that the chars should be ~~erected~~ revised as a separate tribe of the subfamily with four genera: Salvelinus Richardson, Baione Dekay, Cristivomer Gill et Jordan, Salvethymus Chereshn~~ev~~ et Skopetz.

ev/

The systematics, fauna and geographic range of salmonids of the subfamily Salmoninae have ~~apparently now~~ been almost completely investigated at the generic level. There is not usually any disagreement concerning the generic status of such taxa as the Pacific salmons, Oncorhynchus Suckley, the Atlantic salmons, Salmo Linnaeus, the chars, Salvelinus (Nilsson) Richardson, the ~~sea-trouts~~ (taimen), Hucho Günther, the ~~genus~~ lenok, Brachymystax . Günther, and the endemic ~~salmons of the~~ Balkan~~s~~ trout, Salmothymus Berg (Chernavin, 1923; Berg, 1948; Svetovidov, 1975; Dorofeeva et al., 1980; Viktorovskiy, 1978; Glubokovskiy, 1983; Vladykov, 1963). ~~(the list is not exhaustive).~~ Current views diverge only as regards the rank of some groups of salmonids that are fairly clearly segregated with respect to a number of characters. In particular, doubt is cast on the generic status of Salmothymus (Norden, 1961), but separate genera ~~are erected~~ have been recognized for the North American lake char~~s~~,

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* Originally published in Voprosy Ikhtiologii, No. 2, 1990, pp. 201-213.

4/18/90

Hi Bob,

Thanks for the fishery notes, especially the 1936 PFC reference. Enclosed is another bull trout paper by Fraley & Shepard. I reviewed it for NW Sci. about a year ago. Fraley, incidently, was one of the reviewers for our CJFAS paper.

See note about Fred's fish getting croaked — Jesus!

Any chance you'll make it up to GNP this summer? I hear our next Sci. Council meeting will be in March of 91'.

Leo

Chlorine ruins UM trout lab

Weekend water treatment destroys 238 fish from 8-year genetic study

Egad!

By PATRICIA SULLIVAN
of the Missoulian

Missoulian, Thursday, March 29, 1990

Missoula's episode with tainted water has claimed the lives of more than 200 trout, virtually wiping out the basis of an 8-year-old federally funded research project at the University of Montana.

Six families of trout died of chlorine poisoning after Mountain Water Co. put the chemical into the coliform bacteria-contaminated water system Saturday afternoon. Only two of the approximately 240 trout survived.

"I was livid," said Kathy Knudsen, the research specialist who's spent eight years on the project with one of UM's leading researchers, Fred Allendorf. "I lost several years from my life Sunday afternoon."

"It's a tragic thing and it's a real mess," said Ray Murray, associate vice president for research.

UM officials still aren't sure exactly how the fish kill occurred. Knudsen was in Utah during the weekend, so she didn't know about the water contamination and subsequent decision to chlorinate the water Saturday. A graduate student who works on the project also was out of town.

Phil Bowman, manager of UM's animal experiment laboratory, said he didn't know the water had been chlorinated until he got a phone call Sunday morning from a UM maintenance employee.

"Obviously, by that time it was too late," Bowman said. "I don't think it reflects how we care about or for the animals under our care. ... It was an obvious miscommunication with some pretty tragic results."

Murray said he's still investigating whether or why the proper authorities at UM were not notified in time to prevent the accident.

"There was a tremendous amount of concern" for mammals that make up most of UM's research population, Murray said. They are susceptible to diseases carried by coliform bacteria, as are humans, but are little affected by chlorination of the water.

The fish are part of an evolutionary genetics project in which six families of trout were bred and cross-bred for specific genes. Male trout mature at two years and females at three years, so the loss of adult members of the basic stock puts the project at least three years behind, Knudsen said.

The two surviving trout, circling in a small tank Wednesday afternoon, looked sluggish.

"I don't know if they'll make it," Knudsen said. "Chlorine damages the gill tissue, so they can't respire. They suffocate. Their tissue is still damaged. I was really amazed that anything was alive, because chlorine is really toxic."

UM's fish tanks do not have a dechlorinator, no separate water supply and no backup generator, Knudsen said.

"We need a probe in each tank to monitor the temperature, water levels ... but, dream on," she said. "It's always been in the back of my mind that we need a generator. If we lose power for more than a couple hours, we lose the trout."

Knudsen said research findings based on the trout have been published in at least 30 articles. Some fish have died before, but nothing of this magnitude, she said.

"This was a setback, but it didn't totally trash" the last eight years of work, she said. In addition to the articles, the research has been worth "several hundred thousand dollars" of federal grant money to UM. Murray confirmed that the trout research represents "one of our biggest projects" at the university.

Knudsen has started to review records to begin figuring out how to continue the research. But she has not yet reached Allendorf, who is on a sabbatical leave to the National Science Foundation, and who still does not know about the fish kill.

John J. Fraley and **Bradley B. Shepard,** Montana Department of Fish, Wildlife and Parks
P.O. Box 67, Kalispell, Montana 59903

Life History, Ecology and Population Status of Migratory Bull Trout (*Salvelinus confluentus*) in the Flathead Lake and River System, Montana

Abstract

Life history, ecology, and population trends of migratory bull trout (*Salvelinus confluentus*) were investigated in the Flathead Lake and River system of northwest Montana and southeast British Columbia. We conducted these studies to obtain information to manage the species in light of threats posed by timber harvest, hydropower development, and a proposed coal mine. We estimated that about half the adult bull trout in Flathead Lake embarked on a spawning migration from May through July, swimming 88-250 km to reach tributaries of the North and Middle Forks of the Flathead River. Bull trout entered the tributaries when water temperatures dropped below 12°C, and spawned from late August through early October after water temperatures were below 9°C. They spawned in areas of tributaries with low gradient, loosely compacted gravel, groundwater influence, and cover. After spawning, females left the tributaries and returned to the lake sooner than males. Most spawners were six or seven years old and they averaged 628 mm in length. Juveniles were found close to the substrate in streams with summer maximum temperatures less than 15°C. Juveniles migrated out of the tributaries to the river system from June through August, at age I (18%), II (49%), III (32%), and IV (1%). Population status was monitored through redd counts and estimates of juvenile abundance in natal tributaries. The population may be limited by quantity and quality of rearing and spawning habitat, and spawning escapement. Specific requirements for spawning and rearing habitat, and general sensitivity of each life stage, make the bull trout an excellent indicator of environmental disturbance.

Introduction

The bull trout (*Salvelinus confluentus*) is the largest species of fish native to the Flathead drainage, attaining a length of nearly one meter and a weight of 10 kg. The bull trout inhabiting the inland waters of northwestern North America is considered a separate species from the smaller, coastal Dolly Varden (*Salvelinus malma*) (Cavender 1978). The bull trout population in the Flathead system is largely migratory, growing to maturity in lakes and migrating through the river system and into the tributaries to spawn. Juveniles live in tributary streams from one to four years before migrating to the lakes.

Much information has been published concerning the life history of coastal Dolly Varden (e.g., Blackett 1968, Armstrong and Morton 1969, Armstrong and Morrow 1980, Balon 1980). Published information on the bull trout is limited. McPhail and Murray (1979), Leggett (1969), and Allan (1980) studied various aspects of the life history of bull trout in British Columbia and Alberta. Gould (1987) described the characteristics of larval bull trout.

The Montana Department of Fish, Wildlife and Parks has studied the bull trout population in the Flathead drainage since 1953 (Block 1955, Hanzel 1976). More intensive work was undertaken from 1979-1984 during the EPA-sponsored Flathead River Basin Studies (Graham *et al.* 1980, Fraley *et al.* 1981, Shepard *et al.* 1982, 1984b, Graham *et al.* 1982, Fraley and Graham 1982, Graham and Fredenberg 1982, Leathe and Graham 1982). We studied bull trout age and growth both in the lake and in the river system, harvest by anglers, the adult spawning migration, spawning site selection and use, and the densities, habitat selection, and emigration of juveniles growing in tributaries. Methods included tagging, gillnetting, stream trapping and electrofishing, creel survey, otolith and scale analysis, redd counts, and substrate analysis (Graham and Fredenberg 1982, Shepard and Graham 1983).

In this paper we summarize our findings on the life history, ecology, and population status of adfluvial bull trout in the Flathead Lake and inlet river system and compare our information to the results of other investigators.

Study Area

The Flathead Lake and River system is a headwater drainage of the Columbia River Basin (Figure 1). Flathead Lake is a large oligomesotrophic lake with a surface area of 476 km² and a mean depth of 32.5 m (Potter 1978). The upper 3 m of Flathead Lake is regulated by Kerr Dam, constructed on the outlet in 1938. The Flathead River enters the north end of the lake. This study

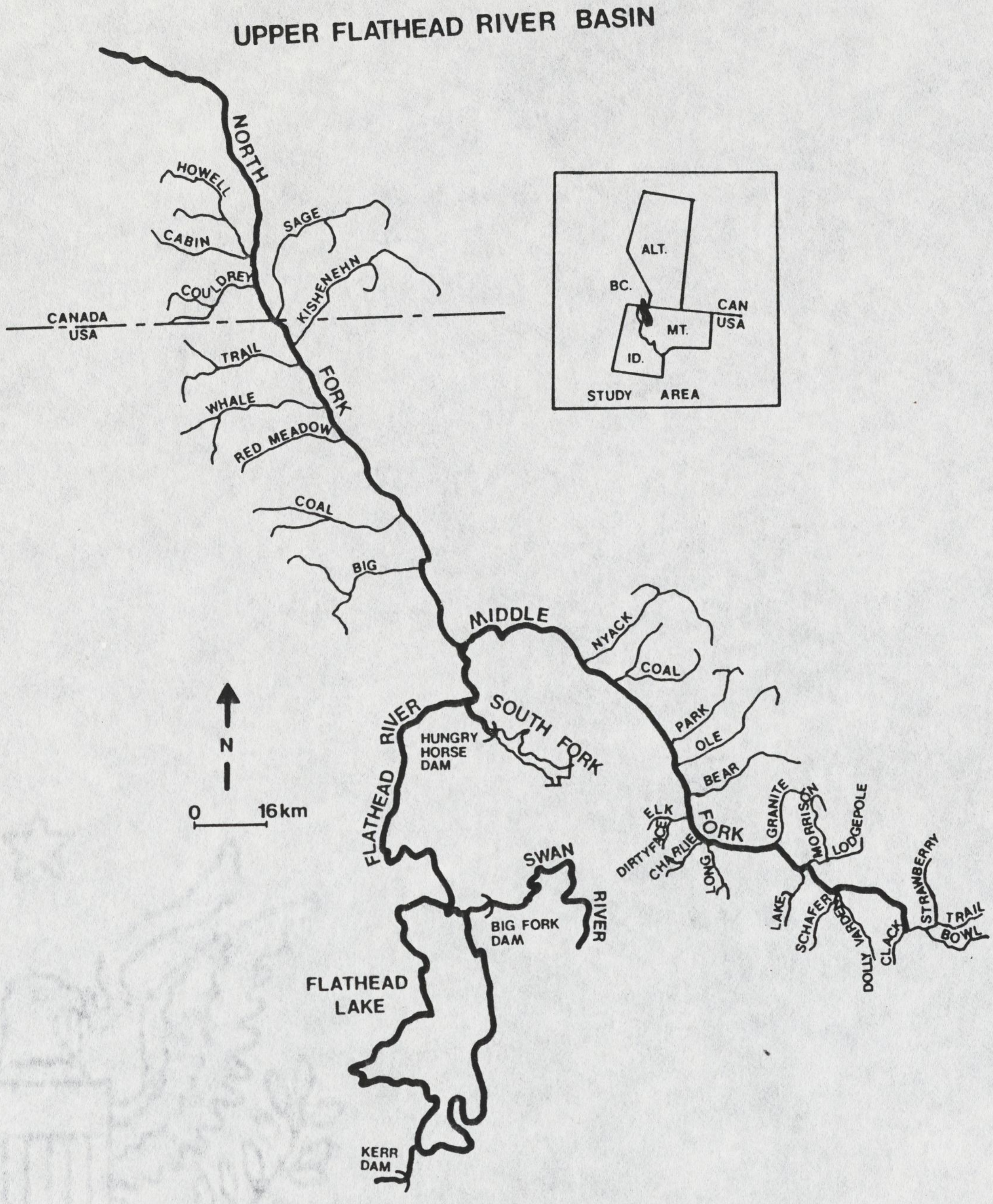

Figure 1. The upper Flathead River Basin. The 28 tributaries shown were used by spawning bull trout.

was conducted in the upper Flathead Basin which includes Flathead Lake and the river system upstream from Flathead Lake.

The South, Middle and North forks drain areas of approximately equal size in portions of the Great Bear and Bob Marshall wildernesses, Glacier National Park and the Flathead National Forest. The upper North Fork drains southern British Columbia. The South Fork is regulated by Hungry Horse Dam, located 8 km above its mouth. The Swan River enters Flathead Lake near the mouth of the Flathead River. Bull trout coexist with 23 other species of fish in the Flathead Lake and River system (Leathe and Graham 1982).

Most bull trout that spawn in the North and Middle Fork drainages mature in Flathead Lake, but fish maturing in large lakes of Glacier National Park may spawn in some tributaries. There are a few populations of bull trout in tributaries of the North Fork that spend their entire lives in the streams.

Bull trout originally used the tributaries of all forks of the Flathead and the Swan rivers. The construction of Bigfork Dam in 1902 blocked bull trout migrations into the Swan River. Limited numbers of bull trout move downstream from the Swan drainage via a marginal fish ladder, as evidenced by tag returns. Hungry Horse Dam, a 164.6-m structure which was closed in 1951, blocked all movements of bull trout into the South Fork drainage and probably resulted in a substantial reduction of the population in Flathead Lake.

The 28 tributaries used by spawning bull trout in the North and Middle Fork drainages (Figure 1) are characterized by gravel-rubble substrate, low flows of 0.057-1.70 m^3/sec, and maximum summer water temperatures less than 15°C.

Results and Discussion

Life History

Lake Residence

Bull trout populations residing in Flathead Lake were found to include recently arrived juveniles from the Flathead River system, subadult fish less than about 450 mm in length, and mature fish five to six years or more in age. Most bull trout in Flathead Lake matured at age VI. A similar age of maturity was reported for bull trout in Arrow Lakes, British Columbia (McPhail and Murray 1979).

The diet of bull trout in the lake consisted almost exclusively of fish. Whitefish species and yellow perch (*Perca flavescans*) were the most important food items, followed by kokanee (*Oncorhynchus nerka*) and nongame species (Table 1). Small bull trout have been found to feed incidentally on *Mysis* in Flathead Lake. *Mysis relicta* was discovered in Flathead Lake in 1981 and densities increased dramatically through 1986. Kokanee were the major food item for bull trout in Pend Oreille Lake, Idaho (Jeppson and Platts 1959), while whitefish were the major food in Upper Priest Lake (Bjornn 1961).

The annual growth increment for bull trout in Flathead Lake, based on analysis of scales, ranged from 60-132 mm (Table 2). Back calculations of length at annulus formation were made from 1,813 scale samples. Aging was checked with otoliths from 451 of the fish. Agreement of aging between otoliths and scales ranged from 100 percent for fish zero to three years of age, to 52 percent for older, mature fish. Growth of lake-resident fish was relatively constant after age IV. Growth rates of bull trout in Flathead Lake were similar to those reported for Priest and Upper Priest Lakes, Idaho (Bjornn 1961).

Not all mature bull trout spawned annually. Adult-size fish were relatively less abundant in the lake during the summer and fall, as compared to the spring. It appeared that 38 to 69 percent (average 57%) left the lake each spring and summer to spawn. The frequency of successive year spawning varied by age and sex (Leathe and Graham 1982). Alternate year spawning has been reported for inland Dolly Varden char (Armstrong and Morrow 1980).

Upstream Migration

Bull trout maturing in Flathead Lake began their spawning migration into the river system during April and moved slowly upstream, arriving in the North and Middle forks during late June and July. They traveled more than 250 km to spawn in some North Fork tributaries in British Columbia. The shortest distance traveled from Flathead Lake was 88 km to the mouth of Canyon Creek in the North Fork drainage. Observations and tag returns from 1974-1982 indicated that adult bull

TABLE 1. Composition by number, weight, and frequency of occurrence and calculated index of relative importance (IRI, George and Hadley 1979) for major food items in the stomachs of 95 bull trout collected between November and January, 1979, 1980 and 1981 in Flathead Lake.

Item	Number	(%)	Wet weight -g.	(%)	Index of Relative Importance (IRI)
Pygmy whitefish	5	(2.4)	37.0	(4.0)	3.2
Lake whitefish	1	(0.5)	104.1	(11.2)	4.3
Mountain whitefish	1	(0.5)	24.3	(2.6)	4.4
Unidentified whitefish	11	(5.3)	281.2	(30.3)	15.0
Total whitefish	18	(8.7)	446.6	(48.1)	23.5
Kokanee	2	(1.0)	82.8	(8.9)	4.0
Unidentified trout/salmon	2	(1.0)	13.2	(1.4)	1.5
Total trout/salmon	4	(1.9)	96.0	(10.3)	5.1
Sculpin	3	(1.5)	7.6	(0.8)	1.8
Redside shiner	5	(2.4)	15.0	(1.6)	2.0
Peamouth	1	(0.5)	3.6	(0.4)	0.7
Sucker	2	(1.0)	74.4	(8.0)	3.7
Yellow perch	83	(40.3)	105.1	(11.3)	24.6
Total nongame	94	(45.6)	205.7	(22.1)	31.0
Unidentified fish	90	(43.7)	181.1	(19.5)	41.4

TABLE 2. Back calculated lengths at annulus formation of bull trout in the upper Flathead Basin (n in parentheses). Calculations were made based on methods in Hesse (1977).

	Total length (mm) at annulus								
Drainage	I	II	III	IV	V	VI	VII	VIII	IX
Adults and Juveniles									
Upper Flathead (1968-81)	66 (1,813)	121 (1,538)	196 (1,161)	292 (927)	385 (669)	475 (349)	566 (129)	657 (32)	731 (4)
Flathead Lake (1968-81)	68 (931)	129 (931)	204 (928)	291 (853)	384 (603)	472 (291)	566 (102)	658 (28)	731 (4)
North Fork of the Flathead River drainage (1975-81)	73 (533)	117 (306)	165 (60)	301 (12)	440 (8)	538 (7)	574 (3)	— —	— —
Middle Fork of the Flathead River drainage (1980-81)	52 (349)	100 (300)	165 (172)	297 (61)	399 (57)	488 (50)	567 (24)	655 (4)	
Juveniles Only									
North Fork drainage	73 (525)	117 (298)	155 (52)	228 (4)	—	—	—	—	—
Coal Creek	75 (145)	124 (62)	202 (23)	323 (14)	—	—	—	—	—
Red Meadow Creek	65 (145)	113 (113)	168 (29)	360 (7)	—	—	—	—	—
Trail Creek	74 (473)	119 (264)	158 (46)	228 (4)	—	—	—	—	—
Whale Creek	56 (52)	98 (34)	139 (6)	—	—	—	—	—	—

trout remained at the mouths of spawning tributaries for two to four weeks during which time feeding was thought to be limited.

Based on observations at stream trapping sites, adult bull trout entered tributary streams at night from July through September; the majority entered in August. Because most bull trout moved through the traps in pairs, we believe bull trout formed pairs near the mouth of the spawning tributary. Bull trout which entered the spawning tributaries were generally not in final spawning condition, but held in the tributaries for up to a month or more in deeper holes or near log or debris cover before spawning. Similar prespawning behavior and spawning timing was reported for bull trout in Mackenzie Creek (McPhail and Murray 1979) and John Creek (Leggett 1969) in British Columbia.

Most bull trout spawners in the North and Middle Forks were six or seven years of age (Table 3) whereas most spawners in the Swan system were five or six years old (Leathe and Enk 1985).

TABLE 3. Age of bull trout spawners in the Flathead system.

Stream	Percent by Age				
	5	6	7	8	9
North Fork Flathead River 1954 (N = 41)	24	39	34	3	0
Middle Fork Flathead River 1981 (N = 31)	10	48	35	10	0
Swan River 1983 (N = 57)	33	35	23	9	<1
Swan River 1984 (N = 76)	43	37	17	3	0

Spawning

Most bull trout spawned during September and early October in the Flathead River system, as did adfluvial bull trout in Idaho (Heimer 1965) and British Columbia (McPhail and Murray 1979). Initiation of spawning in the Flathead appeared to be related largely to water temperature, although photoperiod and streamflow probably also played a part. Spawning began when water temperatures dropped below 9-10°C. McPhail and Murray (1979) reported that 9°C was the threshold temperature for the initiation of spawning in Mackenzie Creek, British Columbia.

Bull trout spawners selected areas in the stream channel characterized by gravel substrates, low compaction and low gradient (Table 4). Groundwater influence and proximity to cover also were important factors influencing spawning site selection. These relatively specific requirements resulted in a restricted distribution of spawning in the Flathead drainage. Bull trout from Flathead Lake spawned in only 28 percent of the 750 km of available stream habitat according to basin-wide surveys from 1980-1982.

TABLE 4. Mean measurements of physical habitat variables in 34 stream reaches where no redds were located, 29 reaches where redd frequency averaged 1.2 redds/km (low), and 31 reaches where redd frequency averaged 6.9 redds/km (high).

Parameter	Redd frequency categories		
	None	Low	High
Stream order	3.0	3.1	3.6
D-90 (cm; the size of material larger than 90% of the substrate)	51	37	33
Gradient (percent)	3.2	1.8	1.5
Boulder (percent of substrate)	16	12	10
Gravel-Cobble (combined percent of substrate)	54	62	62
High quality pool (percent of stream)	5	7	8
Overhang cover (percent)	14	10	11
Total cover (percent)	16	15	13

Average length of adult spawners in the Flathead River system was 628 mm (Table 5). The female chose a spawning site and constructed the redd, while the male defended the area. Male bull trout in Trail Creek, a North Fork tributary,

TABLE 5. Average total lengths of adult bull trout spawners in the Flathead drainage.

Stream	Year	Average Length (mm)	Number of Fish
North Fork	1979	638	36
	1977	645	32
	1953	617	165
Middle Fork	1980	618	35
	1957	622	87
Both Forks	1975	628	46

remained near the redd an average of two weeks after spawning. Bull trout redds in the Flathead drainage averaged 2.0 m long x 1.0 m wide, and sometimes overlapped. Block (1955) observed one male spawn with three females in succession; the size of the redd expanded each time. McPhail and Murray (1979), Leggett (1969), and Block (1955) provided detailed descriptions of spawning behavior and spawning site activities. After spawning, the spent adults moved out of the tributaries and downstream to the lake, possibly feeding on mountain whitefish (*Prosopium williamsoni*) during the journey.

Fecundity varied with fish size, averaging 5,482 eggs per female for a sample of 32 adults averaging 645 mm. One female bull trout weighed 15 pounds and contained 12,000 eggs. Bull trout in Arrow Lakes, British Columbia, were smaller and contained fewer than 2,000 eggs per female (McPhail and Murray 1979). The sex ratio of bull trout spawners averaged 1.4 females per male in Trail Creek in the North Fork drainage, and 1.37 females per male in the Swan drainage.

Incubation and Emergence

After deposition by early October, bull trout embryos incubated in the redd for several months before hatching in January. The alevins then remained in the gravel and absorbed the yolk sac, with the first fry appearing in electrofishing samples in mid April. Emergence occurred approximately 200 days after egg deposition. Newly emerged fry averaged 23-28 mm and more than doubled their length during the first summer of growth (see Table 2).

Weaver and White (1985) found that incubation time was dependent on temperature. Bull trout eggs required 113 days (340 temperature units) to 50 percent hatch in Coal Creek, a tributary of the North Fork of the Flathead River. The fry emerged from the gravel 223 days (635 temperature units) after egg deposition. Intergravel temperatures during the incubation period (October-March) in Coal Creek ranged from 1.2-5.4°C. Survival to emergence in Coal Creek averaged 53 percent. McPhail and Murray (1979) reported the best survival of bull trout embryos at 2-4°C.

Juvenile Occurrence and Emigration

Juvenile bull trout were present in about half of the stream reaches surveyed during studies in the upper Flathead River Basin. Juveniles were present in many reaches that were not used by adult spawners; they apparently swam upstream to these sections to grow. Distribution also was influenced by water temperature as juvenile bull trout were rarely observed in streams with summer maximum temperatures exceeding 15°C. Oliver (1979), Allan (1980) and Pratt (1984) also reported that bull trout distribution was affected by temperature.

Young-of-the-year bull trout were generally found in side channel areas and along the stream margins in Flathead tributaries. Blackett (1968) reported a similar habitat preference for juvenile Dolly Varden char in southeast Alaskan streams. McPhail and Murray (1979) found young-of-the-year bull trout in areas of low velocity near stream edges.

Densities of bull trout juveniles in Flathead tributaries were greatest in pools, and lower but generally similar in runs, riffles and pocketwater habitat. Juvenile bull trout were found closely associated with stream substrate. Pratt (1984) studied microhabitat preferences in the Flathead drainage and reported that juvenile bull trout (less than 100 mm) usually remained near the stream bottom, close to streambed materials and submerged fine debris. Juveniles 100 mm or longer also remained near cover, including larger instream debris. As the juvenile bull trout grew, they became less associated with the streambed.

During stream residence, juvenile bull trout were opportunistic feeders, mainly ingesting aquatic invertebrates (especially Diptera and Ephemeroptera) in similar percentages as they were available in the stream (Fraley *et al.* 1981). Bull trout larger than 110 mm also ate small trout and sculpin.

Snorkeling estimates of juvenile bull trout densities in Flathead drainage tributaries averaged 1.5 fish/100 m² of stream surface area (range: 0.1-7.1). Juvenile bull trout are difficult to observe because of their close association with the stream bottom, so these numbers are probably underestimates. Electrofishing estimates ranged as high as 15.5 fish/100 m² in certain streams.

Most juvenile bull trout in the Flathead drainage remained in the tributaries for one to three years before emigrating to the river system. Of 246 juvenile bull trout captured in downstream migrant traps placed in three tributaries to the North and Middle forks, about half (49%) were age II, a third (32%) age III, and 18 percent age I (Table 6). Only 1 percent of the emigrants were age IV. The ages of emigrating juveniles were similar in Idaho and British Columbia (Bjornn 1961, Oliver 1979, McPhail and Murray 1979). The average lengths at annulus formation of Age I, II, and III juvenile bull trout in tributaries of the North Fork Flathead were 73, 117 and 155 mm, respectively (Table 2).

TABLE 6. Percent and number of age I, II, III and IV bull trout emigrating from tributary streams.

Location	Years of migration sampling	Age Classes I	II	III	IV
Red Meadow Cr.	1973, 79	6 (3)	76 (42)	18 (10)	0 (0)
Trail Creek	1977, 79	34 (41)	43 (52)	19 (23)	3 (4)
Geifer Creek	1981	0 (0)	37 (26)	63 (45)	0 (0)
All Sites	(%) (number)	18 (44)	49 (120)	32 (78)	1 (4)

Emigration of juveniles from the tributaries into the Flathead River system took place largely from June through August (Table 7), similar to the emigration period reported for the Wigwam drainage, British Columbia (Oliver 1979). After juvenile bull trout entered the river system they appeared to move rapidly downstream into the main stem Flathead River, arriving below the South Fork during August and September. Although juvenile bull trout were captured by electrofishing in the main stem throughout the year, their numbers peaked during the fall months (McMullin and Graham 1981). Snorkel observations indicated that some juveniles lived along the shallow margins of the Middle and North forks. Residence in the lower Flathead River before entry into Flathead Lake has not been well documented.

Trends in Spawner Abundance

Drainage-wide counts of bull trout redds in 1980 (568), 1981 (714), 1982 (1138), and 1986 (814) were used to index the number of adfluvial bull trout which successfully spawned in the river-tributary system. We converted the redd counts to approximate fish numbers by making the following assumptions: 1) 75 percent of all redds were located, and 2) an average of 3.2 spawners entered the tributary for each completed redd. From partial trapping results on several tributaries in 1977-1981, we estimated a spawner:redd ratio of 3.2:1. In 1953, 55 bull trout entered Trail Creek and constructed 18 redds for a spawner:redd ratio of 3.2:1 (Block 1955). During 1954, 160 bull trout constructed 48 redds in Trail Creek, yielding a ratio of 3.3:1. Based on these assumptions, we calculated that an average of 3,450 bull trout successfully spawned annually in the Flathead drainage during our period of record.

Bull trout spawned in 28 tributaries to the North and Middle forks (see Figure 1), but only a small percentage of the stream reaches were used for spawning. Important spawning tributaries in the North Fork were Howell, Trail, Whale, Big and Coal creeks. Major spawning tributaries in the Middle Fork were Morrison-Lodgepole, Granite, Ole, Trail and Dolly Varden creeks. The portion of the drainage in Canada supported 23-31 percent (mean 29%) of the spawning in the North Fork drainage during the 1980-82 period. Howell Creek supported 13-19 percent (mean 16%) of all North Fork spawning.

Monitoring of bull trout spawning at selected sites indicated that escapement was highest in 1982 (Table 8). These sites are considered representative of the drainage, and comprised 32, 30, 31, and 43 percent of the total drainage-wide counts in 1980, 1981, 1982, and 1986, respectively. Monitoring areas reflected drainage-wide trends.

Juvenile bull trout densities have been used as an index of population status. Juvenile bull trout populations in sections of Coal and Morrison creeks have been monitored for a six-year period (Table 9). Numbers of juvenile bull trout in these sections were highest in 1987 for both streams. Continued population estimates in these streams will provide valuable baseline information for future monitoring.

Sampling for bull trout in Flathead Lake indicated that the population had been relatively stable through 1981. Average catches of bull trout in sinking nets were 1.2 to 2.1 fish per net

TABLE 7. Number of stream trapping days, number of juvenile bull trout passed downstream through traps, and number of trapped juvenile bull trout per trap day by month from North Fork tributaries during 1976 to 1980 and Middle Fork tributaries during 1981.

	June	July	August	September	October
North Fork tributaries (1976-1980)					
Trap days	42	443	424	264	131
Number of fish	42	709	340	116	6
Fish/trap day	1.00	1.60	0.80	0.44	0.04
Middle Fork tributaries (1981)					
Trap days	43	74	62	14	—
Number of fish	60	28	19	8	—
Fish/trap day	1.40	0.38	0.26	0.57	—

TABLE 8. Bull trout redd counts for selected areas of tributaries chosen for monitoring in the Flathead Drainage.

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
North Fork:										
Big	10	20	18	41	22	9	9	12	22	19
Coal	38	34	23	60	73	61	40	13	48	52
Whale	35	45	98	211	141	133	94	90	143	136
Trail	34[a]	31[a]	78	94	56	32	25	69	64	62
Total North Fork	117	130	217	406	292	235	168[b]	184	277	269
Middle Fork:										
Morrison	25[a]	75	32[a]	86	67	38	99	52	49	50
Granite	14	34	14[a]	34	31	47	24	37	34	32
Lodgepole	32	14	18	23	23	23	20	42	21	19
Ole		19	19	51	35	26	30	36	45	59
Total Middle Fork	71	142	83	194	156	134	173[b]	167	149	160
Total Drainage Monitoring Areas	188	272	300	600	448	369	341	351	426	429

[a] Counts may be underestimated due to incomplete survey.

[b] High flows may have obliterated some of the redds.

TABLE 9. Juvenile bull trout densities in sections of a North Fork tributary (Coal Creek) and a Middle Fork tributary (Morrison Creek) from 1980-1985.

	Date	Population Estimate (Number/150 m section)	95% Confidence Interval
Coal Creek (at Deadhorse Bridge)	08/05/82	130	±36
	03/23/83	99	±33
	08/31/84	89	±27
	08/26/85	167	±66
	08/12/86	149	±45
	09/01/87	179	±55
Morrison Creek	09/23/80	91	±48
	09/01/82	93	± 5
	08/18/83	62	±11
	09/25/85	93	±27
	08/27/86	114	±15
	08/25/87	138	±10
	08/30/88	126	±23

in 1967-1970, 2.2 to 2.9 fish per net in 1980-81 (Leathe and Graham 1982). Average length of bull trout sampled in Flathead Lake increased by 24 mm from 1967 to 1980. A larger percentage of the fish were greater than 500 mm in the 1980-81 sampling period. The percentage of trophy fish (greater than 634 mm) was similar in both sampling periods. Migrating spawners, captured in the river system, were similar in size from 1953 through 1981 (see Table 5).

Sensitivity to Environmental Disturbance

All bull trout life stages are sensitive to environmental disturbances. The population in the Flathead system is threatened by several major forms of resource development. The proposed Cabin Creek coal mine in the North Fork drainage in British Columbia received preliminary approval by the Canadian government and was referred by the U.S. and Canadian governments to an International Joint Commission for review (Flathead International Study Board 1988). This mining activity could harm bull trout spawning and rearing habitat in the upper North Fork and in Howell Creek, the major spawning tributary in the Canadian portion of the drainage. The major concerns are increased sedimentation, alteration of flow and water quality degradation (Biological Resources Committee 1987). In addition, timber harvest and road construction in both the North and Middle Fork drainages are potential threats to bull trout spawning and rearing habitat.

Increased fishing pressure is often associated with resource development. Because of the restricted distribution of bull trout spawning in the basin and the limited size of the known annual escapement (3,000-4,000 individuals), harvest of fish by anglers could reduce the population. Any increase in harvest by anglers in a particular area or subbasin could result in a loss of recruitment from that site, in turn reducing the overall population in Flathead Lake.

The long overwinter incubation and development phase for bull trout embryos and alevins (223 days in Coal Creek) leaves them particularly vulnerable to increases in fine sediments and degradation of water quality. In laboratory experiments, survival was shown to be inversely related to the percent fine material (<6.35 mm) in the gravels (Weaver and White 1985). Survival to emergence ranged from nearly 50 percent in substrates which contained 10 percent fines, to zero percent in mixtures which contained 50 percent fines. Juvenile bull trout could be affected by streambed changes because of their close association with the substrate. Shepard *et al.* (1984a) found a significant relationship ($r^2 = 0.40$, $P < .01$) between substrate score (a measure of unimbedded instream rock cover) and juvenile bull trout densities in tributaries of the Swan River.

As our studies of bull trout in the Flathead River system continue, we hope to define more precisely the factors which negatively affect the population. It is not clear whether the tributaries are at carrying capacity for juvenile bull trout, nor whether juvenile densities are limited by spawner escapement levels. The answer to these questions will require monitoring of the escapement levels and resulting juvenile densities in the tributaries over a longer period of time. McPhail and Murray (1979) suggested that limitations in juvenile rearing habitat may form an "ecological bottleneck," greatly affecting overall population levels of bull trout.

Bull trout in the Flathead River system are dependent on habitat quality and management of the interconnected river, lake, and tributaries. Cumulative losses of spawning and rearing habitat would reduce the bull trout population in Flathead Lake.

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