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U.S. DEPARTMENT OF COMMERCE National Oceanic and Atmospheric Administration National Marine Fisheries Service

Annotated Bibliography of Interspecific Hybridization of Fishes of the Subfamily Salmoninae

JAMES R. DANGEL, PAUL T. MACY, and FRED C. WITHLER



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# CONTENTS

INTRODUCTION	1
SOURCES	2
ACKNOWLEDGMENTS	2
SYSTEMATIC INDEX	2
BIBLIOGRAPHY	13



iv

# ANNOTATED BIBLIOGRAPHY OF INTERSPECIFIC HYBRIDIZATION OF FISHES OF THE SUBFAMILY SALMONINAE

JAMES R. DANGEL<sup>1</sup>, PAUL T. MACY<sup>2</sup>, and FRED C. WITHLER<sup>3</sup>

# Abstract

This bibliography of 611 annotated references lists published and unpublished material on hybridization between species of the subfamily Salmoninae and crosses of salmonids with non-salmonids. It does not include crosses within a species. The bibliography is indexed by species for the genera *Brachymystax*, *Hucho*, *Oncorhynchus*, *Salmo*, *Salmothymus*, and *Salvelinus* and certain non-salmonid species.

# Introduction

This bibliography represents an attempt to list all literature on interspecific and intergeneric, but not intraspecific, hybridization of the subfamily Salmoninae, which includes *Brachymystax*, *Hucho*, *Oncorhynchus*, *Salmo*, *Salmothymus*, and *Salvelinus*. The whitefishes and graylings are not included.

The bibliography was begun by the senior author as a result of his interest in the work of Dr. R. E. Foerster, Fisheries Research Board of Canada, in interspecific crossbreeding of Pacific salmon. Foerster (1968) discussed the possibilities of selective crossbreeding of salmon and pointed out the potential commercial advantages if particular characteristics or qualities of fish could be emphasized. He also pointed out that as civilization spreads and waters are used and polluted, conditions for natural propagation of salmon will become less and less favorable. Selective crossbreeding to produce new varieties to fit changing conditions may be necessary.

While they may be more difficult to produce and rear than intraspecific hybrids, interspecific hybrids

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are likely to be more valuable because of their greater potential for heterosis. For this reason the bibliography has been restricted to reports of crosses between species only. With the present growing interest in aquaculture, the bibliography should be particularly useful to individuals and agencies concerned with breeding salmonids for commercial purposes and sport fishing. Systematists also may find the compilation helpful in studies of the interrelationships between species.

Citations marked with a single asterisk (\*) contain no original research findings on salmonid hybrids but are included to save the reader time in searching them. A double asterisk (\*\*) indicates that everything pertinent to salmonid hybrids has been quoted from the reference cited.

Some publications which might be familiar to the reader interested in salmonid hybrids have been omitted intentionally. When books have been printed in more than one edition, only the latest edition available to us has been cited. Also not included were bibliographies that contained no citations not already cited in this report or that were not specifically concerned with hybrids.

In some cases shorter articles, passages of text, abstracts, or summaries have been transcribed verbatim as indicated by quotation marks. In most other cases the annotations were written by the authors after reviewing the papers. Those references for which the paper was unavailable to the authors for review are cited according to our sources, and in

<sup>&</sup>lt;sup>2</sup>NMFS Northwest Fisheries Center, 2725 Montlake Boulevard East, Seattle, WA 98112.

<sup>&</sup>lt;sup>3</sup>Fisheries Research Board of Canada, Pacific Biological Station, Nanaimo, B.C., Canada.

those cases a brief annotation based on the source's statement may be given.

In the annotations and the index we have employed the specific names now currently in use (Bailey et al. 1970) and former specific names are given in parentheses or used as subspecific designations. We have used Dr. R. J. Behnke's advice and publications in assigning most correct specific names for synonyms.

In some cases cross references have been included to refer the reader to other papers and to the correct citations of papers previously cited incorrectly by others. Anonymous papers are listed according to the organization, agency, or publication which produced them.

The authors would appreciate being informed of any references to salmonid hybrids that are not included in this bibliography, as well as corrections or additions to the annotations, so that they may be included in future revisions or addenda.

# Sources

Most of the citations were obtained by crossreferencing literature cited sections of papers. Other sources included Biological Abstracts, Genetics Abstracts, Sport Fishery Abstracts, and Zoological Record. Many authors sent reprints and papers not otherwise known to us. The bibliography by Schwartz (1972) was particularly useful.

Libraries used were those of the Alaska Department of Fish and Game, Juneau, Alaska; the National Marine Fisheries Service (NMFS) Fisheries Laboratory, Auke Bay, Alaska; the Fisheries Research Board of Canada, Pacific Biological Station, Nanaimo, British Columbia; the NMFS Northwest Fisheries Center, Seattle, Washington; and the University of Washington library system.

# Acknowledgments

This bibliography is dedicated to Dr. R. E. Foerster, whose work, past and continuing, inspires interest in hybrids.

The invaluable assistance of Mrs. D. Gailus is gratefully acknowledged. The encouragement and help of Mr. C. E. Atkinson, Mr. E. H. Buck, Mr. G. W. Butrovich, Dr. K. D. Carlander, Mr. W. J. Christie, Miss B. P. Craig, Mr. J.-P. Cuerrier, Dr. A. C. DeLacy, Mr. R. Gordon, Mrs. D. Hoover, Mr. A. J. Novotny, Mr. A. H. Priddy, Miss S. J. Salo, and Dr. F. M. Utter, as well as many authors who have supplied reprints, is greatly appreciated.

Several individuals were particularly helpful. Dr. R. J. Behnke reviewed the manuscript in various stages and made numerous useful suggestions and additions. Dr. F. J. Schwartz reviewed our list of citations, suggested others, and loaned reprints not available to us. L.-R. Séguin also made available his unfinished bibliography which includes many French-language papers, some of which have been included in our list.

# Systematic Index

The species of Salmoninae included are listed by scientific name followed by the common name. To save space in the annotations, the scientific names for splake and tiger trout are not given. They are Salvelinus namaycush  $\heartsuit \times S$ . fontinalis  $\eth$  and Salmo trutta  $\heartsuit \times S$ . fontinalis  $\eth$  respectively. Common names are sometimes used in annotations when they are widely known.

SALMONINAE (genera not identified or a bibliography)

Behrens 1885 Boothrovd 1959 Breder and Rosen 1966 Carlander 1969 Dean 1962 Frv 1854 Green 1874 and 1880c Grieg 1906 Hikita 1962 Huard 1954 Kendall 1920 Lefebvre 1887 Massaro and Markert 1968 Mather 1900 Merriner 1966 Miller, R. B. 1957 Nikolyukin 1964 Overbeck 1883 Prud'homme 1948 Schwartz 1972 Séguin 1955b Smolian 1920 Vivier 1948 Wilimovsky and Freihofer 1957 SALMONINAE (species) Brachymystax lenok (lenok) Behnke 1968a Hsüeh Cheng-yü, Huang Shang-wu, and Yen Jungvüan 1959 Hucho taimen (taimen) Behnke 1968a Hsüeh Cheng-yü, Huang Shang-wu, and Yen Jung-yüan 1959

Oncorhynchus spp. (species not stated) Alm 1955 Chamberlain 1907 Clemens 1953 Collins 1892 Duff and Stewart 1933 Gaylord 1910 Hardy 1961 Hubbs 1955 Maeda 1931 Neave 1958 Simon 1960 and 1963 Stenton 1952 and 1953 Taylor 1969 Tsuyuki, Roberts, and Vanstone 1965 Tsuyuki, Roberts, Vanstone, and Markert 1965 Van Oosten 1957 Vladykov 1963 Oncorhynchus gorbuscha (pink salmon) American Fish Farmer 1970 Arakie 1969 Bakkala 1970 Behnke 1965 Behnke, Ting Pong Koh, and Needham 1962 Berg 1948 Commercial Fisheries Review 1961, 1962a, and 1965 Davisson 1969 Dvinin 1953 Fish Commission of Oregon 1970 Fisheries Research Board of Canada 1967, 1969, and 1971 Fisherman 1969 Foerster 1930, 1935, 1955, and 1968 Fujita 1926 Fukuhara, Murai, LaLanne, and Sribhibhadh 1962 Gaylord, Marsh, Busch, and Simpson 1914 Gibson 1929 Giudice 1967 Hansler 1958 Hikita and Yokohira 1964 Hunter 1949 Inaba 1953 Iversen 1968 Jordan 1906 Kamyshnava 1961 and 1963 Kobayashi 1964 Kobayasi 1963 and 1969 Krykhtin 1962 Kuznetsov 1928 Lagunov 1971 Mac Intyre 1960 Mahnken, Novotny, and Joiner 1970 Milne 1948 Novotny and Mahnken 1971 Pacific Fisherman 1930 Paylov 1959 Roberts 1970 Rounsefell 1962 Simon 1964a, and 1964b Simon and Noble 1968 Slastenenko 1956a Smirnov, A. I. 1953, 1954, 1967, and 1969 Smirnov, I. S. 1950

Soguri 1936 Suzuki 1966 Terao 1970 Utter, Allendorf, and Hodgins, In press Washington State Department of Fisheries 1963 and 1964 Withler 1969 Withler and Morley 1970 World Fishing 1961 Oncorhynchus keta (chum salmon) American Fish Farmer 1970 Andreeva 1953 and 1954 Arakie 1969 Bakkala 1970 Behnke 1965 Behnke, Ting Pong Koh, and Needham 1962 Berg 1948 Commercial Fisheries Review 1961, 1962b, 1964?, and 1965 Current Affairs Bulletin 1960 Davisson 1969 Duff 1932 Fish Commission of Oregon 1970 Fisheries Research Board of Canada 1969 and 1971 Fisherman 1969 Foerster 1930, 1935, 1955, and 1968 Fuiita 1926 Fukuhara, Murai, LaLanne, and Sribhibhadh 1962 Giudice 1967 Hansler 1958 Hikita and Yokohira 1964 Hunter 1949 Inaba 1953 Iversen 1968 Jordan 1906 Kamyshnaya 1961 and 1963 Kobayashi 1964 Kobayasi 1963 and 1969 Kuznetsov 1928 Lagunov 1971 Milne 1948 Novotny and Mahnken 1971 Nyman 1971 Pacific Fisherman 1930 Paylov 1959 Robert 1970 Rounsefell 1962 Sano and Eguchi 1936 Sasaki, Hitotsumachi, Makino, and Terao 1968 Simon 1964a and 1964b Simon and Noble 1968 Slastenenko 1956a Smirnov, A. I. 1953, 1954, 1957, and 1969 Smirnov, I. S. 1950 Soguri 1936 Suzuki 1966 Suzuki and Fukuda 1971a and 1971b Terao 1935 Terao 1966 and 1970 Terao and Hayashinaka 1961 Terao, Kikuchi, Uchiyama, Kurahashi, Matsumoto, and Abe 1964 Terao, Tanaka, and Kurahashi 1965 Terao, Uchiyama, Kurahashi, and Matsumoto 1963, 1965, 1967, and 1968

Terao, Uchiyama, Kurahashi, Matsumoto, Yoshizaki, Abe, and Okuno 1966 Uveno 1972 Washington State Department of Fisheries 1963 and 1964 Withler 1969 Withler and Morley 1970 Yamanaka, Yamaguchi, Hashimoto, and Matsuura 1967 Oncorhynchus kisutch (coho salmon) Bakkala 1970 Behnke 1965 Berg 1948 Bonham and Seymour 1949 Breuser 1961 Foerster 1930, 1935, 1955, and 1968 Fukuhara, Murai, LaLanne, and Sribhibhadh 1962 Gaylord, Marsh, Busch, and Simpson 1914 Hansler 1958 Jordan 1906 Kuznetsov 1928 Lagunov 1971 Mac Intvre 1960 Milne 1948 Pacific Fisherman 1905 and 1930 Rounsefell 1962 Simon 1960 and 1963 Smirnov 1959, 1967, and 1969 Smith 1915 Terao 1970 Uveno 1972 Oncorhynchus masou (masu salmon) Behnke 1965 Breder and Rosen 1966 Christie 1970 Commercial Fisheries Review 1961, 1962a, and 1964 Dvinin 1953 Foerster 1935 Fujita 1926 Hikita 1963 Hiraki 1932 Inaba 1953 Kawashima and Suzuki 1968 Kobayasi 1955 Koshida 1940a Krykhtin 1962 Menasveta 1961 Oshima 1929, 1930, 1934, 1940, 1957, and 1959 Sano and Eguchi 1936 Smirnov 1967 and 1969 Soguri 1936 Suzuki 1966 Suzuki and Fukuda 1971a and 1971b Tanaka 1965 Terao 1970 Terao and Hayashinaka 1961 Tokui 1969 Watanabe 1925-1927 West 1968 World Fishing 1961 Oncorhynchus nerka (sockeye salmon and kokanee) Andreeva 1953 and 1954 Bakkala 1970 Behnke 1965

Berg 1948 Commercial Fisheries Review 1962b Crossman and Buss 1966 Current Affairs Bulletin 1960 Duff 1932 Fisheries Research Board of Canada 1969 and 1971 Foerster 1930, 1935, 1955, and 1968 Fukuhara, Murai, LaLanne, and Sribhibhadh 1962 Gaylord, Marsh, Busch, and Simpson 1914 Gibson 1929 Hansler 1958 Jordan 1906 Koshida 1940b Kuznetsov 1928 Lagunov 1971 Mac Intyre 1960 Merriner 1966 Milne 1948 Novotny and Mahnken 1971 Nyman 1971 Pacific Fisherman 1905 and 1930 Rounsefell 1962 Sano and Eguchi 1936 Sasaki, Hitotsumachi, Makino, and Terao 1968 Shiraishi and Fukuda 1966 Smirnov 1967 and 1969 Suzuki 1966 Suzuki and Fukuda 1971a and 1971b Terao 1966 and 1970 Terao and Hayashinaka 1961 Terao, Kikuchi, Uchiyama, Kurahashi, Matsumoto, and Abe 1964 Terao, Tanaka, and Kurahashi 1965 Terao, Uchivama, Kurahashi, and Matsumoto 1963, 1965, 1967, and 1968 Terao, Uchiyama, Kurahashi, Matsumoto, Yoshizaki, Abe, and Okuno 1966 Uveno 1972 West 1968 Withler 1969 Withler and Morley 1970 Yamanaka, Yamaguchi, Hashimoto, and Matsuura 1967 Oncorhynchus rhodurus (redspot or Biwa salmon) Behnke 1965 Breder and Rosen 1966 Christie 1970 Foerster 1935 Hiraki 1932 Inaba 1953 Kawashima and Suzuki 1968 Kobayasi 1955 Koshida 1940a and 1940b Menasveta 1961 Oshima 1929, 1930, 1934, 1940, 1957, and 1959 Shiraishi and Fukuda 1966 Smirnov 1967 and 1969 Suzuki 1966 Suzuki and Fukuda 1971a and 1971b Tanaka 1965 Terao 1970 Watanabe 1925-1927 West 1968

Oncorhynchus tshawytscha (chinook salmon) Angling Times 1968 Bakkala 1970 Bean 1889b Behnke 1965 Bonham and Seymour 1949 Breuser 1961 Fish Commission of Oregon 1970 Foerster 1930, 1935, 1955, and 1968 Fukuhara, Murai, LaLanne, and Sribhibhadh 1962 Gaylord, Marsh, Busch, and Simpson 1914 Green 1881 and 1907 Hansler 1958 Harris 1969 Jordan 1906 Jousset de Bellesme 1909 Lagunov 1971 Mac Intyre 1960 Mahnken, Novotny and Joiner 1970 Mather 1876 McClane 1965 Milne 1948 Novotny and Mahnken 1971 Pacific Fisherman 1930 Raveret-Wattel and Bartet 1883 Roosevelt 1880 and 1885 Rounsefell 1962 Scientific American 1880 Smirnov 1967 and 1969 Smith 1915 Suzuki 1966 Terao 1970 Utter, Allendorf, and Hodgins, In press Van Oosten 1957 Salmo spp. (species not stated) Black and Williamson 1947 Breder and Rosen 1966 Green 1880b Hubbs and Drewry 1959 Solman 1951 Thomas 1967 Salmo apache (Apache trout) Legendre, Schreck, and Behnke 1972 Miller 1972 Salmo aguabonita (golden trout) Agersborg 1934 Baxter and Simon 1970 Behnke 1965 and 1972 California Fish Commissioners 1907 Evans, Wallis, and Gallison 1961 Gould 1966 Hubbs 1955 Miller 1972 Needham 1938 Needham and Gard 1959 Schreck and Behnke 1971 Wales 1957 Wallis 1952 Salmo chrysogaster (Mexican golden trout) Behnke 1965 Miller 1972 Needham and Gard 1964

Salmo clarki (cutthroat trout) Andrekson 1949 Baxter and Simon 1970 Behnke 1965, 1968b, 1970a, 1971, and 1972 Benson 1953 Brown, C. J. D. 1971 Burkhard 1971 Carl, Clemens, and Lindsey 1967 Cope 1955 Dymond 1932 Ellis 1914 Evans, Wallis, and Gallison 1961 Gilmour 1950 Gould 1966 Hansen 1952 Hanzel 1959 Hartman 1956 Hempel 1970 Henderson and Peter 1969 Holton 1953 Hubbs 1955 Hubbs and Miller 1948 Irving 1953 and 1955 Johnson, R. E. 1945 Johnson, V. K. 1972 Kruse 1959 La Rivers 1962 Legendre, Schreck, and Behnke 1972 Leopold 1918 Madsen 1937 Miller, R. B. 1950 and 1957 Miller and Macdonald 1949 Miller, R. R. 1950, 1960, and 1972 Miller and Alcorn 1945 Nauheim 1972 Needham and Behnke 1962 Needham and Gard 1959 and 1964 Nelson 1965 Nevada Fish Commission 1911, 1913, and 1915 Nevada Fish and Game Commission 1921 Paetz and Nelson 1970 Peters 1964 Peterson 1955 Purkett 1951 Rounsefell 1962 Schreck and Behnke 1971 Sigler and Miller 1963 Simon 1939 and 1946 Simon and Simon 1939 Slastenenko 1956b and 1957 Sport Fishing Institute 1955b Stock 1942 Trojnar and Behnke In press Tuunainen 1967 U.S. Fish and Wildlife Service 1954a and 1954b Van Oosten 1957 Vivier 1955 Wales 1957 Wolf 1954 Zalsman 1914 Salmo gairdneri (rainbow trout and steelhead) Agersborg 1934 Alm 1955

Andrekson 1949 Angling Times 1968 and 1969 Arens 1893 Baxter and Simon 1970 Bean 1889b Behnke 1965, 1966, 1968b, 1970a, 1970b, 1971, and 1972 Benson 1953 Brown, C. J. D. 1971 Brown, E. E. 1970 Buller 1898 and 1900 Bungenberg de Jong 1955 Burkhard 1971 Burrard 1944 Buss and Wright 1956, 1958a, and 1958b California Fish Commissioners 1907 Carl, Clemens, and Lindsey 1967 Cone 1955 Crettiez 1906 Demoll and Steinmann 1949 Dieterich 1939 Dymond 1932 Eipper 1953, 1955, and 1964 Ellis 1914 Evans, Wallis, and Gallison 1961 FAO 1970 Foerster 1935 Fuster de Plaza 1949 Gilmour 1950 Green 1879 and 1881 Haack 1893 Hansen 1952 Hansler 1958 Hanzel 1959 Harris 1969 Harrison 1959 Hartman 1956 Hempel 1970 Henderson and Peter 1969 Hitzeroth, Klose, Ohno, and Wolf 1968 Holton 1953 Hubbs 1955 Hubbs and Miller 1948 Hubbs, Clark 1967 Irving 1953 and 1955 Johnson, R. E. 1945 Johnson, V. K. 1972 Jousset de Bellesme 1909 Kendell 1919 Klose, Hitzeroth, Ritter, Schmidt, and Wolf 1969 Knowles 1969 Kosorić and Vuković 1969 Kruse 1959 La Rivers 1962 Legendre, Schreck, and Behnke 1972 Leon 1970 Leopold 1918 Lieder 1956 LoCascio and Wright 1972 MacCrimmon, Marshall, and Gots 1970 Madsen 1937 Manwell and Baker 1970 McClane 1959 and 1965 Meehan 1898 and 1900

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6

Miller, R. B. 1950 and 1957 Miller and Macdonald 1949 Miller, R. R. 1950, 1960, and 1972 Miller and Alcorn 1945 Mulch and Gamble 1954 Nauheim 1972 Needham 1938 Needham and Behnke 1962 Needham and Gard 1959 and 1964 Nelson 1965 Nevada Fish Commission 1911, 1913, and 1915 Nevada Fish and Game Commission 1921 Oregon State Game Commission 1948 Paetz and Nelson 1970 Peters 1964 Peterson 1955 Phillipps 1922, 1923, and 1926 Podubsky 1956 Prévost 1955a Purkett 1951 Richmond 1919 Roosevelt 1880 and 1885 Rounsefell 1962 Sanders 1964 Sanders and Wright 1962 Sano and Eguchi 1936 Savvaitova 1972 Schreck and Behnke 1971 Scientific American 1880 Séguin 1957 Serebryakova 1969 Shiraishi and Fukuda 1966 Sigler and Miller 1963 Simon 1939 and 1946 Simon and Simon 1939 Slastenenko 1956b and 1957 Smith 1961 Soldwedel 1968 Sport Fishing Institute 1955b and 1956 Stock 1942 Stokell 1949 Suzuki 1966 and 1968 Suzuki and Fukuda 1971a and 1971b Tanner 1959 Taylor 1969 Tsuyuki and Roberts 1965 Troinar and Behnke In press Tuunainen 1967 Underdown 1958 U.S. Fish and Wildlife Service 1954a and 1954b Van Oosten 1957 Vivier 1954 and 1955 Vogel, Arens, and Linke 1898 Vutskrits 1910 Wahl 1960 Wales 1957 Wallis 1952 West 1968 Winge and Ditlevsen 1948 Wolf 1954 Wright 1952 and 1955 Wright and Buss 1958 Zalsman 1914

Salmo gilae (gila trout) Behnke 1965 and 1970b Legendre, Schreck, and Behnke 1972 McClane 1965 Miller, R. R. 1950, 1960, and 1972 Mulch and Gamble 1954 Salmo marmoratus Behnke 1965 and 1968a FAO 1970 Kosorić and Vuković 1969 Nümann 1964 Tortonese 1953-54 Salmo mykiss Behnke 1966 Savvaitova 1972 Salmo newberri (redbanded trout?) Agersborg 1934 Salmo salar (Atlantic salmon) Abakumov 1960 Ackermann 1898 Alabaster and Durbin 1964 Alm 1955, 1959, and 1961 American Naturalist 1884 Arens 1893 and 1894 Ashworth and Ashworth 1853 Atkins 1884 Ausland 1872 Baird 1874 Baumann 1954 Behnke 1965 Boothroyd 1959 Burrard 1944 Buschkiel 1931 Buss and Wright 1956 Catt 1950 Chernenko 1969 Cordier-Goni 1939 Crettiez 1908 Dahl 1927 Davisson 1969 Davy 1840 Day 1882a, 1882b, 1884b, 1885a, 1885b, 1885c, 1886, 1887, and 1890 Demoll and Steinmann 1949 Duke 1970 Evropeitseva and Belvaeva 1963 Fehlmann 1926 Foerster 1935 Forest and Stream 1873 and 1890b Fuster de Plaza 1949 G., T. 1834 Gaylord, Marsh, Busch, and Simpson 1914 Giard 1892 Grimm 1881 Haack 1880 and 1894 Haen and O'Rourke 1968, 1969a and 1969b Hansler 1958 Hardy 1961 Harrison 1959 and 1961 Henking 1929 and 1931 Hickling 1962 Hodgson, Home, and Robertson 1967

Hofer 1909 Jones 1948 and 1959 Joyce 1943 Kirpichnikov 1938 Kobayashi 1962 and 1966 Kobayasi 1963 and 1965 Kusakina 1958 and 1959 La Blanchère 1885 Lacepède 1825 Lamond 1916 La Rivers 1962 Leon 1970 Lestage 1939 Leuckart 1882a and 1882b Lieder 1954 Mac Intyre 1960 Malloch 1910 Makino 1956 Manwell and Baker 1970 Matthey 1949 McClane 1959 and 1965 Nall 1930 Nature 1885 Neresheimer 1937 Norman 1963 Nygren, Nilsson, and Jahnke 1972 Nyman 1965, 1967, and 1970 Overbeck 1880 Payne, Child, and Forrest 1972 Peggington and Rees 1967 Piggins 1964, 1965, 1966, and 1970 Pincher 1948 Prévost 1955a Prokofieva 1934a and 1934b Rasch 1867 Rees 1967 Regan 1911 Roberts 1964 and 1970 Roth and Geiger 1972 Rounsefell 1962 Runnström 1950-1953 and 1955 Salmon Research Trust of Ireland 1960-1970 and 1966 Scheuring 1930 Séguin 1957 Selys-Longchamps 1887 Serebryakova 1969 Skinner 1938 Smirnov 1969 Soguri 1936 Sómme 1954 Spaas and Heuts 1958 Suzuki 1965 and 1966 Svärdson 1945 Swarup 1957 Tegner 1969 Terao 1970 Tsuyuki and Roberts 1965 Underdown 1958 Viktorovskii 1969 Vivier 1954 Vogel, Arens, and Linke 1898 Vutskrits 1910

Wahl 1960 Went 1964 West 1968 Wiggins 1950 Willughby 1686 Wright 1955 Salmo trutta (brown trout and sea trout) Abakumov 1960 Ackermann 1898 Alabaster and Durbin 1964 Alm 1955, 1959, and 1961 American Naturalist 1884 Andersson 1942 Angling Times 1969 Arens 1893 and 1894 Ashworth and Ashworth 1853 Atkins 1884 Bade 1902 Baird 1874 Baumann 1954 Baxter and Simon 1970 Bean 1880, 1889c, 1897, 1903a, and 1903b Behnke 1965 and 1968a Black and Williamson 1947 Bouck and Ball 1968 Brasch, McFadden, and Kmiotek 1962 Bridges 1958 Brown, C. J. D. 1966 and 1971 Brown, E. E. 1970 Brumsted 1957 Bruyant 1910 Buller 1908 Bungenberg de Jong 1955 Burrard 1944 Buschkiel 1931 Buss 1956 and 1959 Buss and Wright 1956, 1958a and 1958b Catt 1950 Chernenko 1969 Cordier-Goni 1939 Crettiez 1906 and 1908 Curry-Lindahl 1969 Dahl 1927 Davis 1971 Davisson 1969 Davy 1840 Day 1882a, 1882b, 1884a, 1884b, 1885a, 1885b, 1885c, 1886, 1887, and 1890 Demoll and Steinmann 1949 Dieterich 1939 Duff 1970 Eddy and Surber 1947 Eipper 1953 and 1964 Evropeitseva and Belyaeva 1963 FAO 1970 Fehlmann 1926 Fitzinger 1875 and 1876 Eperster 1935 Forest and Stream 1890b Fowler 1942 and 1946 Fraas 1854 Francese 1962 Freshwater Biological Association 1968

8

Fuster de Plaza 1949 G., T. 1834 Giard 1892 Goldberg 1969 Greeley 1962 Grimm 1881 Haack 1880, 1883, and 1894 Haen and O'Rourke 1968, 1969a and 1969b Hansler 1958 Harris 1969 Harrison 1959 and 1961 Henking 1929 and 1931 Hickling 1962 Hitzeroth, Klose, Ohno, and Wolf 1968 Hodgson, Home, and Robertson 1967 Hofer 1909 Hubbs 1955 Inaba 1953 Jaboulay 1908 Jones 1948 and 1959 Jordan and Evermann 1896 Jousset de Bellesme 1909 Joyce 1943 Kirpichnikov 1938 Klose, Hitzeroth, Ritter, Schmidt, and Wolf 1969 Kner 1865 Knoch 1884 Knowles 1969 Kobayashi 1962 and 1966 Kobayasi 1965 Kosorić and Vuković 1969 Kusakina 1958 and 1959 La Blanchère 1885 Lacepède 1825 Lamond 1916 La Rivers 1962 Leon 1970 Lestage 1939 Leuckart 1882a and 1882b Lieder 1954 and 1956 LoCascio and Wright 1972 MacCrimmon and Campbell 1969 MacCrimmon, Gots, and Campbell 1971 MacCrimmon, Marshall, and Gots 1970 Mac Intyre 1960 MacPhee 1966 Malloch 1910 Makino 1956 Manwell and Baker 1970 McClane 1959 and 1965 Meehan 1908 Merriner 1966 Morrison and Wright 1966 Mullan and Tompkins 1959 Nall 1930 Nature 1885 Neresheimer 1937 Norman 1963 Nümann 1964 Nygren, Nilsson, and Jahnke 1972 Nyman 1965, 1966, 1967, and 1970 Oregon State Game Commission 1948 Otterstróm 1914

Overbeck 1880 Paetz and Nelson 1970 Payne, Child, and Forrest 1972 Peggington and Rees 1967 Pevrer 1876 Phillipps 1922, 1923, and 1926 Piggins 1964, 1965, 1966, and 1970 Pincher 1948 Podubsky 1956 Prévost 1955a Prokofieva 1934b Rasch 1867 Raveret-Wattel and Bartet 1883 Rees 1967 Regan 1911 Richmond 1919 Roberts 1964 and 1970 Roth and Geiger 1972 Rounsefell 1962 Rubaschev 1935 and 1937 Runnström 1950-1953 and 1955 Salmon Research Trust of Ireland 1960-1970 and 1966 Sanders 1964 and 1970 Sanders, Bleifeld, and Friedman 1964 Scheuring 1930 Séguin 1957 Selvs-Longchamps 1887 Serebryakova 1969 Simon and Noble 1968 Skinner 1938 Smith 1961 Soguri 1936 Somme 1954 Sormunen and Kajosaari 1963 Sowards 1959 Spaas and Heuts 1958 Sport Fishing Institute 1956 Stock 1942 Stokell 1949 Suzuki 1965 and 1966 Suzuki and Fukuda 1971a and 1971b Svärdson 1945 and 1949 Swarup 1957 Tanner 1959 Tegner 1969 Terao 1970 Tortonese 1953-54 Tsuyuki and Roberts 1965 Underdown 1958 U.S. Fish and Wildlife Service 1954b Viktorovskii 1969 Vivier 1945, 1954, and 1955 Vogel, Arens, and Linke 1898 Voigt 1958 Vutskrits 1910 Wagner 1950 Wahl 1960 Wales 1957 Webster 1955-1972 and 1960 Went 1964 West 1968 and 1970 Wheeler and Maitland 1973 Whitmore and Goldberg 1969

Wiggins 1950 Willughby 1686 Winge and Ditleysen 1948 Wolf 1954 Wright 1952 and 1955 Wright and Buss 1958 Zalsman 1914 Zoological Society of London 1888 Zoologische Garten 1875 Salmothymus obtusirostris oxyrhynchus FAO 1970 Kosorić and Vuković 1969 Salvelinus spp. (species not stated) Breder and Rosen 1966 Green 1880b Jones 1959 Rounsefell 1962 Smirnov 1967 Solman 1951 Vladykov 1954 Salvelinus alpinus (Arctic char) Ackermann 1898 Alm 1955, 1959, and 1961 American Naturalist 1884 Atkins 1884 Bade 1902 Bean 1880, 1889b, 1889c, and 1890 Behnke 1965 and 1972 Bridges 1958 Bruvant 1910 Buschkiel 1931 Chimits 1963 Crettiez 1906 and 1908 Curry-Lindahl 1969 Day 1882a, 1882b, 1885a, 1885b, 1886, 1887, and 1890 Demoll and Steinmann 1949 Fitzinger 1875 and 1876 Foerster 1935 Forest and Stream 1890b Gaylord, Marsh, Busch, and Simpson 1914 Grimm 1881 Gritsenko 1970 Hansler 1952 Hickling 1962 Inaba 1953 Jaboulay 1908 Jordan and Evermann 1896 Kner 1865 Knoch 1884 Kobayasi 1963 La Blanchère 1885 La Rivers 1962 Laurent 1972 Mac Intvre 1960 MacPhee 1966 Malloch 1910 McClane 1965 McPhail 1961 Menasveta 1961 Merriner 1966 Nikolyukin 1964 Norman 1963

Nyman 1965 and 1967 Paetz and Nelson 1970 Pappenheim 1909 Peyrer 1876 Prévost 1955a Rasch 1867 Rounsefell 1962 Runnström 1950-1953 and 1955 Schindler 1938 Séguin 1957 Selys-Longchamps 1887 Soguri 1936 Sómme 1954 Sormunen and Kajosaari 1963 Suzuki 1966 Svärdson 1945 and 1949 Takashima and Hibiya 1972 Tsuyuki and Roberts 1965 Vivier 1945 and 1954 Vladykov 1963 Vogel, Arens, and Linke 1898 Vutskrits 1910 Wahl 1960 West 1968 and 1970 Zoologische Garten 1875 Salvelinus fontinalis (brook trout, speckled trout) Ackermann 1898 Ali 1964 Allan 1953 Alm 1955, 1959, and 1961 American Naturalist 1884 Andersson 1942 Arakie 1969 Arens 1893 Babcock 1971 Bailey, Fitch, Herald, Lachner, Lindsey, Robins, and Scott 1970 Baldwin 1956 Baxter and Simon 1970 Bean 1889a, 1889b, 1890, 1897, 1903a, and 1903b Behnke 1965 Berst and Spangler 1970 and 1972 Black and Williamson 1947 Blaxter 1969 Boothroyd 1959 Bouck and Ball 1968 Brasch, McFadden, and Kmiotek 1962 Bridges 1958 Brown, B. E. 1961 Brown, C. J. D. 1966 and 1971 Brumsted 1957 Brynildson and Kempinger 1970 Budd 1957 and 1959 Buller 1908 Burkhard 1961 and 1962 Burrows 1971 Buschkiel 1931 Buss 1956 and 1959 Buss and Wright 1956, 1958a and 1958b Butler 1968 California Fish Commissioners 1894 Chimits 1963

Christie 1960 and 1968 Coble 1966 Commercial Fisheries Review 1959 Conservationist 1961 Crossman 1968 and 1969 Crossman and Buss 1966 Cuerrier 1954 Curry-Lindahl 1969 Davis 1971 Davisson 1969 Day 1882a, 1882b, 1884a, 1884b, 1885a, 1885b, 1886, 1887, and 1890 Demoll and Steinmann 1949 Dubuc 1954 Dunbar 1969 Eddy and Surber 1947 Eipper 1953, 1955, and 1964 Eschmeyer 1957 Ferguson 1958 and 1969 Flick and Webster 1964 Foerster 1935 Forest and Stream 1873, 1889a, 1889b, 1890a, and 1890b Fowler 1942 and 1946 Francese 1962 Fraser 1972 Freshwater Biological Association 1968 Fry and Gibson 1953 Fuster de Plaza 1949 Garside and Frv 1959 Gaylord, Marsh, Busch, and Simpson 1914 Giudice 1967 Goldberg 1966 and 1969 Goldberg, Cuerrier, and Ward 1967 and 1969 Greelev 1962 Green 1879, 1880a, 1881, and 1907 Grimås, Nilsson, and Wendt 1972 Haack 1893 Hagen and O'Connor 1959 Hansler 1958 Harrison 1959 and 1961 Hickling 1962 Hochachka 1966 Hodgins, Ames, and Utter 1969 Hubbs 1955 Ihssen 1971 Inaba 1953 and 1963 Janes 1956 Jousset de Bellesme 1909 Kato 1966 Kendell 1919 Klein 1966a, 1966b, and 1967 Klein and Finnell 1969 Kleinert, Degurse, and Wirth 1968 Kmiotek and Oehmcke 1959 Kobayasi 1963 Koshida 1940b Lamond 1916 La Rivers 1962 Laurent 1972 Leik 1959, 1960a, and 1960b Lin 1966 LoCascio and Wright 1972 MacCrimmon and Campbell 1969

MacCrimmon, Gots, and Campbell 1971 Mac Intyre 1960 Makino 1956 Malloch 1910 Manwell and Baker 1970 Martin 1960, 1965, and 1967 Martin and Baldwin 1960 Martin and Fry 1972 Martin and Scott 1959 Massaro and Markert 1968 Mather 1876 Matthey 1949 McCauley and Tait 1970 McClane 1959 and 1965 McFarland and Munz 1965 Meehan 1908 Menasveta 1961 Merriner 1966 Michigan Conservation 1966 Miller, R. B. 1957 Moenkhaus 1911 Moon and Hochachka 1971 Morrison 1970 Morrison and Wright 1966 Morton and Miller 1954 Mueller 1962 Mullan and Tompkins 1959 Munz and McFarland 1965 New York Commissioners of Fisheries 1879 Nikolyukin 1964 Norman 1963 Northern Sportsman 1952, 1954, and 1957 Nyman 1965 and 1967 Ohno, Muramoto, Klein, and Atkin 1969 Ontario Department of Lands and Forests 1962, 1966a, and 1966b Oregon State Game Commission 1948 Otterstrøm 1914 Outdoor California 1956 Paetz and Nelson 1970 Pappenheim 1909 Paust 1955 Pearson 1952 Pennsylvania Reports of the State Commissioners of Fisheries 1887-1901 Plosila, Keller, McCartney, and Robson 1972 Prévost 1955a and 1955b Prokofieva 1934a and 1934b Reckahn 1970 Regier 1966 and 1968 Roosevelt 1880 and 1885 Rounsefell 1962 Rubaschev 1935 Runnström 1950-1953 and 1955 Sanders 1964 and 1970 Sanders, Bleifeld, and Friedman 1964 Sanders and Wright 1962 Sano and Eguchi 1936 Schindler 1938 Scientific American 1880 Scott 1956 and 1967 Scott and Crossman 1969

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Gadus macrocephalus Simon and Noble 1968 Terao 1935 Leuresthes tenuis Hubbs 1967 Lota marmorata (lotte) Ackermann 1898 Dean 1962 Fraas 1854 Jousset de Bellesme 1909 La Blanchère 1885 Simon and Noble 1968 Perca flavescens (vellow perch) Buller 1898 and 1900 Meehan 1898 and 1900 Thymallus vulgaris Day 1890 Tribolodon hakonensis Suzuki 1968

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Ashworth, E., and T. Ashworth.

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Baxter, G.T., and J.R. Simon.

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1889c. Saibling and brown trout hybrid. Forest and Stream 32:401.

Drawing and description of S. trutta (fario)  $\times$  S. alpinus hybrid received at the U.S. National Museum from Norway.

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Gives morphometric data on artificial hybrids of S. trutta (fario)  $\times$  S. fontinalis.

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"I suspect that mykiss and gairdnerii, if crossed, would prove to be fully fertile and might properly be considered only subspecies." Behnke now reports (personal communication, Sept. 1971) that more recent information suggests that S. mykiss and S. gairdneri are synonymous.

\*\*1968a. A new subgenus and species of trout, Salmo (Platysalmo) platycephalus, from southcentral Turkey, with comments on the classification of the subfamily Salmoninae. Mitt, Hamburg, Zool. Mus. Inst. 66:1-15.

p. 7—"Because S. marmoratus freely hybridizes with S. trutta producing hybrid swarms, Nümann (1964) considered S. marmoratus as only a subspecies of S. trutta." Since S. marmoratus occurred sympatrically with native S. trutta before exotic S. trutta were introduced, Behnke recognizes S. marmoratus as a full species.

p. 10—"Se, Huan and Yuan [Hsüeh Cheng-yu, Hüang Shang-wu, and Yen Jung-yüan] (1959) described natural hybrids of *B. lenok* and *H. taimen* from the Amur River system in China."

1968b. Rare and endangered species: the native trouts of western North America. Proc. West. Assoc. Game Fish Comm. 48:530-533.

"Introductions of rainbow trout into interior waters where only the cutthroat trout is native, and subsequent hybridi-

<sup>1970.</sup> Wyoming fishes. Wyoming Game Fish Dep., Bull. 4. 168 p.

<sup>1903</sup>b. Catalogue of the fishes of New York. N.Y. State Mus. Bull. 60 (Zool. 9). 784 p.

Behnke, R.J.

zation between the two, has been a major factor in the decline of populations of native interior cutthroat trout."

- 1970a. The application of cytogenetic and biochemical systematics to phylogenetic problems in the family Salmonidae. Trans. Am. Fish. Soc. 99(1):237-248.
  - "When rainbow trout are introduced into cutthroat trout populations in interior waters where rainbow trout is not native, hybrid swarms are the typical result."
- 1970b. Rare and endangered species report: new information on gila trout, Salmo gilae. Rep. Colo. Coop. Fish Unit, Colo. State Univ., Fort Collins, 12 p. (Unpublished).

"Hybridization with introduced rainbow trout is the major reason for the almost complete elimination of pure populations of S. gilae. Hybrids may be recognized by the intermediacy of several characters such as spotting pattern, number of scales, vertebrae and pyloric caeca and some morphometric comparisons."

- \*\*1971. Cutthroat trout Salmo clarki Richardson. In W.H. Everhart and W.R. Seaman, Fishes of Colorado, p. 28-29. Colorado Game, Fish and Parks Div., Denver.
  - "Cuthroat and rainbow trout freely hybridize if they occur together. The resultant offspring is a rather gaudily colored trout possessing characteristics of both parent species."

1972. The systematics of salmonid fishes of recently glaciated lakes. J. Fish. Res. Board Can. 29(6):639-671.

Genetic diversity of salmonid species is reportedly affected by introductions, eutrophication, and exploitation. Includes mention of hybridization of *S. alpinus* and *S. malma*, and *S. aguabonita*, *S. clarki*, and *S. gairdneri*.

Behnke, R.J., Ting Pong Koh, and P.R. Needham.

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p. 172 (p. 179 of transl.)—Refers to Kuznetsov (1928) and hybridization of *Oncorhynchus*.

Berst, A.H., and G.R. Spangler.

1970. Population dynamics of F<sub>1</sub>splake (Salvelinus fontinalis × S. namaycush) in Lake Huron. J. Fish. Res. Board Can. 27(6):1017-1032.

"Planted F<sub>1</sub> splake tended to remain in the general vicinity of the planting sites. They fed upon smelt and alewives, which are presently abundant in Lake Huron. The hybrids grew more rapidly at ages 1 through VIII than native and planted lake trout and contributed to a commercial fishery within 2 years of planting. A considerable number of splake survived to maturity in the presence of an intensive commercial fishery and a lamprey population that was unaffected by chemical control. We believe that these attributes of splake will be preserved and enhanced in a stock of hybrids selected through several generations for early maturity."

1972. Lake Huron: effects of exploitation, introductions, and eutrophication on the salmonid community. J. Fish. Res. Board Can. 29(6):877-887.

p. 884—Splake selected for early maturity and ability to occupy deep water first planted in 1969.

Black, J.D., and L.O. Williamson.

\*1947. Artificial hybrids between muskellunge and northern pike. Trans. Wisc. Acad. Sci. Arts Lett. 38:299-314.

"Since the early studies of Francis Day, notably those reporting the development of the zebra trout and other trout hybrids by artificial fertilization (1884-1885), there has been considerable interest in the study of the characteristics of fish hybrids."

Blaxter, J.H.S.

\*1969. Development: eggs and larvae. *In* W.S. Hoar and D.J. Randall (ed.), Fish physiology, Volume III, p. 177-252. Academic Press, New York.

p. 238—"Garside and Fry (1959), using normal and reciprocal hybrid fry of speckled trout, *Salvelinus fontinalis*, and lake trout, *S. namaycush*, found that the mean myomere count was lower where the fish developed on the speckled trout yolks, which were smaller."

Bonham, K., and A.H. Seymour.

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Gives morphometric and meristic data for a natural hybrid of *O. kisutch* and *O. tshawytscha*. Also reports natural cross-mating observed by Mr. Elmer Quistorff, superintendent of the Washington State Department of Fisheries Issaquah Salmon Hatchery.

Boothroyd, E.R.

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Includes extensive review of Prokofieva's (1934a) and Svärdson's (1945) works.

# Bouck, G.R., and R.C. Ball.

1968. Comparative electrophoretic patterns of lactate dehydrogenase in three species of trout. J. Fish. Res. Board Can. 25(7):1323-1331.

"The total number of LDH isozymes in tissue extracts of brook-brown trout (F<sub>1</sub>) hybrids were difficult to assess but showed essentially the same number of LDH isozyme systems as did the parent types. The outstanding difference in the hybrid specimens was that the total number of isozymes rose markedly within a given system. Also, a given isozyme system occupied essentially the same space but it contained so many isozymes that the total number could not be counted accurately. At least 27 were counted in the extracts of one hybrid specimen but only 25 were counted in the other specimens. These numbers must be viewed as representing minimum counts."

<sup>\*1953.</sup> Seasonal fluctuations in the feeding of brook trout in the Pigeon River, Michigan. Trans. Am. Fish. Soc. 83:76-83. Mentions S. gairdneri × S. clarki hybrids. Brief review of Purkett's (1951) study.

Brasch, J., J. McFadden, and S. Kmiotek.

1962. The eastern brook trout. Wisc. Cons. Dep. Publ. 226. 11 p.

Brief discussion on splake and natural tiger trout.

- 1966. Modes of reproduction in fishes. Am. Mus. Nat. Hist., Natural History Press, Garden City, New York. 941 p. Brief discussion of salmonid hybrids.
- Breuser, R.N.
  - 1961. Chinook and silver salmon spawning together. Fish Comm. Oreg., Res. Briefs 8(1):78.

Report of natural spawning together of O. tshawytscha and O. kisutch.

## Bridges, C.H.

1972. A compendium of the life history and ecology of the brook trout *Salvelinus fontinalis* (Mitchill). (Revised.) Mass. Div, Fish, Game, Fish, Bull, 23, 38 p.

The report briefly reviews S. fontinalis  $\times$  S. trutta, S. trutta  $\times$  S. alpinus, and S. fontinalis  $\times$  splake hybrids.

Brown, B.E.

1961. Behavior of splake and brook trout fingerlings. Trans. Am. Fish. Soc. 90(3):328-329.

"In these observations domesticated trout behaved exactly as in previous tests carried out by Vincent (1960). Splake, however, showed a contrasting behavior in all trials attempted. In this respect they resembled the wild brook trout observed by Vincent in having a welldeveloped hiding reaction, a tendency to seek depths, and negative phototropism. The latter trait is characteristic of young lake trout reared in New York hatcheries. It is concluded that the responses of this domesticated stock of brook trout relative to these traits were not transferred to the F<sub>1</sub> hybrid."

# Brown, C.J.D.

1966. Natural hybrids of *Salmo trutta* × *Salvelinus fontinalis*. Copeia 1966(3):600-601.

Gives morphometric and meristic data for three natural tiger trout from Montana.

1971. Fishes of Montana. Big Sky Books, Montana State Univ., Bozeman. 207 p.

Mentions natural rainbow × cutthroat and tiger trout hybrids. P. 64—"The lake trout has been artificially hybridized with brook trout and Dolly Varden but no natural hybrids of these have been reported."

#### Brown, E.E.

1970. Hybrid vigor reported. Prog. Fish-Cult. 32(1):8.

Description of "rainbros" produced at the Eagle Mountain Trout Farm in Georgia by crossing *S. trutta*  $\bigcirc$  and *S. gairdneri*  $\bigcirc$  .

#### Brumsted, H.B.

\*1957. A workshop for sportsmen. Trans. N. Am. Wildl. Conf. 22:607-619.

Reports on a fishing experiment in a one-acre farm pond which included brook  $\times$  brown trout hybrids.

#### Bruyant, C.

1910. Hybrides de truite et d'omble-chevalier. Ann. Sta. Limnol. Besse 2:125-133.

According to Dean (1962), discusses S. trutta (fario)  $\times$  S. alpinus (umbla) in France.

Brynildson, O.M., and J.J. Kempinger.

1970. The food and growth of splake. Wisc. Dep. Nat. Resources, Res. Rep. 59. 41 p.

Comprehensive study of the stomach contents and growth rates of splake in Pallette Lake, Vilas County, Wisconsin.

# Budd, J.

1957. Introduction of the hybrid between the eastern brook trout and the lake trout into the Great Lakes. Can. Fish Cult. 20:25-28.

"Marked yearling hybrids between eastern brook trout and common lake trout were planted in South Bay in northern Lake Huron in the spring of 1954. Growth was rapid and after one year in the lake the hybrids averaged 13.9 inches in fork length. A number of the fish were tagged and subsequent recarputer data recorded. Seven tags were returned from distances up to 100 miles. Two of the tagged fish had entered streams while the other five were taken by commercial gear. Ripe male hybrids were taken in South Bay during late October and early November."

1959. The use of the hybrid between eastern brook trout and lake trout in fishery management. Trans. Northeast Wildl. Conf. 1:115-116.

Discusses advantages of splake.

Buller, W.

- 1898. Western station. [Pennsylvania] Rep. State Comm. Fish. for the year 1898, p. 39-44.
  - Reports on preliminary S. gairdneri  $\times$  Perca flavescens crosses. See also Buller (1900).
- 1900. Western station. [Pennsylvania] Rep. State Comm. Fish. for the year 1899, p. 98-104.

Five fry of 4,000 S. gairdneri eggs fertilized by Perca flavescens (yellow perch) survived hatching. See also Mechan (1900).

1908. Reports of hatchery stations. Corry hatchery, station no. 1. Rep. Dep. Fish. Commonwealth of Pennsylvania, December 1, 1906, to November 30, 1907, p. 88-93.

Reports on hybrids of S. trutta  $\times$  S. fontinalis. See also Meehan (1908).

#### Bungenberg de Jong, C.M.

1955. Cytological studies on *Salmo irideus*. Genetica 27(5-6):472-483.

The cleavage rate of *S. gairdneri* (*irideus*) exceeds that of *S. trutta* considerably—3 hours against 4 hours per cleavage at  $9^{\circ}$ C. "The reciprocal crosses between these two species have a cleavage rate that is identical to that of the mother species."

# Burkhard, W.T.

1961. Job completion report. In Quart. Rep. Colo. Coop. Fish. Res. Unit 7:41-52.

Reports on the life history of the splake trout in Parvin Lake.

1962. A study of the splake trout in Parvin Lake, Colorado. M.S. Thesis, Colorado State Univ., Fort Collins. 91 p.

"The present study has followed Leik's (MS, 1960) and has expanded on his material and included two new age groups not previously available for study. With the inclusion of 3- and 4-year-old fish, the important aspects of splake trout maturation and reproduction were included."

\*\*1971. Rainbow trout *Salmo gairdneri* Richardson. *In* W.H. Everhart and W.R, Seaman, Fishes of Colorado, p. 30-31. Colorado Game, Fish and Parks Div., Denver.

Breder, C.M., Jr., and D.E. Rosen.

"When rainbow trout are introduced into cutthroat trout waters the two fish may interbreed and produce hybrids. Thus, fishing in the same lake or pool you may catch rainbows, cutthroats, and hybrids between the two."

×.

# Burrard, G.

1944. The hybridisation of trout. Game and Gun and Angler's Mon., November 1944:299-300.

Popular account of Sir Ernest Wills and Mr. H.J. Skinners' reciprocal hybridization of *S. salar*  $\times$  *S. trutta* and *S. trutta*  $\times$  *S. gairdneri.* Incompletely cites an article about the former cross in the August 1933 issue of the same magazine. *See also* Joyce (1943) and Skinner (1938).

#### Burrows, R.E.

\*\*1971. Man-made fish. In Michael Walker (ed.), Sport fishing USA, p. 337-345. U.S. Dep. Interior, Bur. Sport Fish. Wildl., Washington, D.C.

"The splake, a fertile hybrid cross between the brook and the lake trout, has proved to have many of the traits sought for in a lake fish. It grows faster, matures more rapidly, and spawns in the same type of rocky reefs as the lake trout. It is now being stocked extensively in Lake Huron and many of the smaller northern lakes."

# Buschkiel, A.L.

1931. Salmonidenzucht in Mitteleuropa. Handbuch der Binnenfischerei Mitteleuropas 4(2):155-348.

Mentions tiger trout, S. salar  $\mathcal{Q} \times S$ . trutta  $\mathcal{T}$ , and S. alpinus  $\mathcal{Q} \times S$ . fontinalis  $\mathcal{T}$  hybrids of Arens.

Buss, K.

1956. The splake. Pennsylvania Angler 25(5):2-7.

A popular account of published data on splake and discussion of work at the Benner Springs Research Station.

1959. Trout and trout hatcheries of the future. Trans. Am. Fish. Soc. 88(2):75-80.

"Only the 'splake' (lake trout  $\times$  brook trout) and a few rainbow  $\times$  brook trout (Buss and Wright, 1958) have shown any degree of fertility."

1956. Results of species hybridization within the family Salmonidae. Prog. Fish-Cult. 18(4):149-158.

A preliminary report of hybridization of *S. salar sebago*, *S. trutta*, *S. gairdneri*, *S. namaycush*, and *S. fontinalis*. *See also* Buss and Wright (1958a).

1958a. Appearance and fertility of trout hybrids. Trans. Am. Fish. Soc. 87:172-181.

"Mature hybrids among brook trout (Salvelinus fontinalis), brown trout (Salno trutta), rainbow trout (Salvelinus gairdneri), and lake trout (Salvelinus namaycush) involving reciprocal crosses, backcrosses and three-way crosses were utilized to test fertility and to present photographic records of external characteristics. Fertile hybrids found among the fish tested were splake (lake trout × brook trout) and the backcross progeny of splake × brook trout. Limited fertility was found in one 'tiger' trout male (brown trout female × brook trout male) and in nine yearling males originating from crosses of rainbow trout females × brook trout males. These fertile individuals have been backcrossed to the parental species with limited results to date."

1958b. Hybrid trout studies. Pennsylvania Angler 27(11):2-4. Popular account of Buss and Wright's (1958a) work. Butler, L.

1968. The potential use of selective breeding in the face of a changing environment. Ont. Dep. Lands Forests, Res. Rep. 82:54-72.

Discusses genetics of temperature tolerances and deep swimming capacity of splake.

California Fish Commissioners.

- 1894. Thirteenth Bienn. Rep. State Board Fish Comm. of the State of California, for the years 1893-1894. 143 p. p. 24—S. fontinalis × S. malma hybrids reported at the Sisson hatchery. Earlier reports not available to us.
- 1907. Nineteenth Bienn. Rep. State Board Fish Comm. of the State of California, for the years 1906-1907. 112 p.

p. 21—The report mentions that 200 golden  $\times$  rainbow hybrids 3-6 inches in length were on hand.

p. 51—The report comments that the hybrids were 1½ years old, resembled the golden trout, and were female golden trout crossed with male rainbow trout.

Carl, G.C., W.A. Clemens, and C.C. Lindsey.

1967. The freshwater fishes of British Columbia. (4th ed.). British Columbia Prov. Mus. Handb. 5. 192 p.

p. 70—"Cutthroat and rainbow which occur naturally together do not often hybridize and are probably kept apart by differences in behaviour rather than by physical inability to cross. On the other hand, in areas which originally contained only one of the species, the artificial introduction of the other often results in extensive hybridization and the production of offspring combining characters of both parents. Such hybrids were at one time produced deliberately and planted in certain waters in the Cranbrook area. These trout were referred to as 'Cranbrook trout.'"

Carlander, K.D.

1969. Handbook of freshwater fishery biology, Vol. 1. Iowa State Univ. Press, Ames, Iowa. 752 p.

Summarizes many papers on hybrids of freshwater Salmonidae.

# Catt, J.

1950. Some notes on brown trout with particular reference to their status in New Brunswick and Nova Scotia. Can. Fish Cult. 7:25-27.

Reports that in New Brunswick S. trutta  $\times$  S. salar hybrids were fertile. See also Wiggins (1950).

Chamberlain, F.M.

1907. Hybridization. In Some observations on salmon and trout in Alaska, p. 10-11. Rep. U.S. Bur. Fish. 1906 (Doc. 627). Discusses the question of natural hybrids of trout and of salmon, and mentions the latter in commercial catches.

Chernenko, E.V.

1969. Ob évolyutsii i tsitotaksonomii lososevykh ryb semeistva Salmonidae (Evolution and cytotaxonomy of the family Salmonidae). Vop. Ikhtiol. 9[6(59)]:971-980. (English translation from the Russian *in* Problems of Ichthyology 9(6): 781-788.)

"In salmon  $\times$  sea trout hybrids the sizes of the parental chromosomes are maintained." (S. salar  $\times$  S. trutta)

Chimits, P.

1963. Un hybride pour la salmoniculture en eaux froides: l'omble-saumon. Bull. Fr. Piscic. 35(209):147-153. (In French)

Discusses hybrids of *S*. fontinalis  $\mathcal{Q} \times S$ . alpinus  $\mathcal{T}$  and *S*. fontinalis  $\mathcal{Q} \times S$ . namaycush  $\mathcal{T}$ .

Buss, K., and J.E. Wright, Jr.

Christie, W.J.

- 1960. Variation in vertebral count in  $F_2$  hybrids of *Salvelinus* fontinalis  $\times$  *S. namaycush.* Can. Fish Cult. 26:15-21.
  - "The wide range of vertebral number in this sample and perhaps also the range in size, appear to be good evidence of normal pairing of chromosomes and subsequent segregation in the F<sub>2</sub> generation...We can therefore tentatively conclude that the splake is a true hybrid, from recently evolved parent species, and selection for desirable characters to produce a new form is theoretically possible."
- 1968. The potential of exotic fishes in the Great Lakes. Ont. Dep. Lands Forests, Res. Rep. 82:73-91.

p. 79-Early maturing splake discussed.

- 1970. A review of the Japanese salmons Oncorhynchus masou and O. rhodurus with particular reference to their potential for introduction into Ontario waters. Ont. Dep. Lands Forests, Res. Inf. Pap. (Fish.) 37. 46 p.
  - "Oshima (1957) demonstrated in hybridization experiments that the red spots of *O. rhodurus* are genotypic, and recessive to the *O. masou* coloration."

#### Clemens, W.A.

1953. On some fundamental problems in the biology of Pacific salmon. Trans. Roy. Soc. Can., Ser. 3, 47, Sect. 5:1-13. "That the separation of the species [of Oncerhynchus] may have been comparatively recent date is indicated by the fact that cross-breeding is possible, as shown by the cross-fertilization experiments carried out by Foerster (1935)."

# Coble, D.W.

1966. Alkaline phosphatase in fish scales. J. Fish. Res. Board Can. 23(1):149-152.

Reports that alkaline phosphatase does not appear to be present in splake scales.

Collins, J.W.

1892. Report on fisheries of the Pacific Coast of the United States. U.S. Comm. Fish and Fish., Rep. Comm. 1888:3-269.

Mention of unreliable report of a hybrid (not classified) from the Columbia River is included in a list of the names of 12 salmon. "This matter is referred to in order to remove a quite common error."

## Commercial Fisheries Review.

1959. Splake—hybrid produced by crossing lake trout and brook trout. Commer. Fish. Rev. 21(11):24.

Brief account of splake.

1961. Sixth species of salmon caught in Alaskan waters. Commer. Fish. Rev. 23(1):17.

"It was thought that it was a hybrid or possibly a species that occurs on the Siberian Coast (Oncorhynchus masou or the Masu salmon)."

Behnke, Koh, and Needham (1962) also speculate that the O. masou caught could have been a Russian hybrid of O. keta and O. gorbuscha. Behnke (personal communication, February 4, 1972), after seeing additional data, now believes the fish was definitely not O. masou but a hybrid.

1962a. New breed of salmon developed. Commer. Fish. Rev. 24(1):63 "Fish breeders on the U.S.S.R. island of Sakhalin (north of Japan) reportedly have evolved a new type of salmon from the masu [O. masou] and humpback [O. gorbuscha] species. The new breed weighs more than three times its progenitors at any stage of development and grows to a weight of about 10 pounds. The Soviets have done extensive research on the breeding and transplanting of Pacific salmon. (*World Fishing* October 1961.)"

\*1962b. Japanese crossbreed salmon and trout. Commer. Fish. Rev. 24(3):58.

Report of crossing "ocean salmon"  $\times$  sockeye (freshwater trout). We suspect it refers to *O. keta*  $\times$  *O. nerka* hybrids produced by Terao.

\*1964. Soviet scientists develop new species of salmon and sturgeon. Commer. Fish. Rev. 26(5):76.

"Soviet scientists of the Pacific Fisheries and Oceanography Research Institute (TINRO) are reported to have produced a hybrid salmon from the small but prolific mesu [sic] salmon of the Indian Ocean and the larger but less fertile Pacific salmon. At first the crossing produced sterile fish. But after 18 months of experimenting young were produced which were capable of reproducing themselves while maintaining the size and birthrate qualities of the original species. The average size of the new hybrid is from 4-5 kilograms (8.8-11.0 pounds), which is about 3 times as large as the Indian Ocean salmon. The new salmon is said to have an excellent taste."

1965. Salmon hybrid announced by Soviets. Commer. Fish. Rev. 27(3):92.

"The development of a new salmon hybrid has been announced by the Soviet Union. The salmon hybrid was developed on the Pacific Coast at the Kalinin fish-breeding plant on Sakhalin Island, according to the Soviet newspaper Tass. (Editor's Note: It is not clear what species of salmon were crossed to produce the hybrid. There are some indications that the cross involved chum and pink salmon, or salmon similar to those species.) The Soviets claim that the new hybrid salmon combines early maturity with good size. (*The Fisherman*, Vancouver, B.C., November 13, 1964.)" (includes photographs)

## Conservationist.

1961. Record splake. Conservationist (Wisconsin) 140:5. Reports a 25 inch, 7 pound 2 ounce splake caught in Little Bass Lake, Oneida County. Planted as 4-5 inch fingerlings in 1958.

# Cope, O.B.

1955. The future of the cutthroat in Utah. Proc. Utah Acad. Sci. Arts Lett. 32:89-93.

"When rainbow-cuthroat hybridization occurs in the wild, the rainbow stock seems to dominate over the cutthroat, and the cuthroat strain diminishes or disappears."

Cordier-Goni, P.

1939. Hypothese sur un hybride du saumon et de la truite (Salmo salar L.—Salmo (Trutta) fario L.). Riviera Scientifique (Nice) 26(1-2):3-10. (In French.)

Reports that a female *S. salar* was observed spawning with a male *S. trutta* (*fario*) after male *S. salar* was captured. Reciprocal never seen. A sterile hybrid found from the Chapeauroux.

# Crettiez, J.

1906. De la culture de l'omble-chevalier de Leman à l'établissement de pisciculture de Thonon. Métis et hybrides de ce salmonidé. C.R. Assoc. Franç. Avanc. Sci. 35:119, 498-506.

According to Dean (1962), discusses S. gairdneri  $\bigcirc \times$ 

S. alpinus (umbla)  $\bigcirc$  and S. trutta (fario)  $\times$  S. alpinus (umbla) hybrids in France.

Crettiez, M.J.

1908. De la culture de l'omble-chevalier, du lac Léman. Métis et hybrides de ce salmonidé. Bull. Suisse Pêche 8:4-7, 26-29. According to Schwartz (1972), mentions S. alpinus × S. salar and S. trutta hybrids.

Crossman, E.J.

\*\*1968. Changes in the Canadian freshwater fish fauna. Ont. Dep. Lands Forests, Res. Rep. 82:1-20.

p. 11—"The other dramatic addition of our fauna is the hybrid splake which has shown great promise as a sport fish on a wide scale. The highly selected strain of splake developed in Ontario is expected to be a prime part of the rehabilitation of some of the Great Lakes."

p. 20—Reports splake introduced in Manitoba, British Columbia, and Alberta.

\*\*1969. The Canadian freshwater fish fauna (Fauna sladkovodných rýb Kanady). Ac. Rer. Natur. Mus. Nat. Slov., Bratislava 15(2):137-152. (In English, with Czech abstract.)

p. 147—"The other dramatic addition to the Canadian fauna is the hybrid splake which has shown great promise as a sport fish which could be liberated on a wide scale. The highly selected strain of this hybrid between the brook trout and the lake trout which has been developed in Ontario is expected to be a prime part of the rehabilitation of some of the Great Lakes. Rigid selection for faster growth, faster maturity, and other characters which might enable it to survive even under predation pressure from the lamprey, has been exerted through many generations of this hybrid."

Introduced in Quebec, Manitoba, British Columbia, and Alberta.

Crossman, E.J., and K. Buss.

1966. Artificial hybrid between kokanee (Oncorhynchus nerka) and brook trout (Salvelinus fontinalis). Copeia 1966(2):357-359.

The two *S. fontinalis*  $\mathcal{Q} \times O$ . *nerka*  $\mathfrak{I}$  individuals described "...were the only survivors of two attempts to produce hybrids from kokanee and brook, brown, and rainbow trout." (reciprocal crosses)

Cuerrier, J.-P.

1954. The splake: this trout is a great fighter! Forest and Outdoors (May):17-18.

Review of Stenton's (1950 and 1952) work. F<sub>2</sub> splake planted in Agnes Lake, Banff National Park (Alberta), in 1953.

Current Affairs Bulletin.

\*1960. Fish breeding. Indo-Pacific Fish. Council, Current Affairs Bull. 29:7.

Reprinted in Commercial Fisheries Review (1962b).

Mentions hybrids of *S*. *fontinalis* and *S*. *alpinus*. In hatcheries splake and tiger trout were produced.

Dahl, K.

1927. The "Blege" or dwarf salmon: a landlocked salmon from Lake Bygglandsfjord in Setesdal. Skrifter utgitt av Det Norske Videnskaps-Akademi i Oslo, I. Mat. Naturv. Klasse No. 9. According to Winge and Ditlevsen (1948), "Knut Dahl (1927) describes, from the Bygglandsfjord in Norway, hybrid between the dwarfish 'land-locked salmon' (called 'Blege') found there and the trout. It is a female of 21 cm; in most respects it is an intermediate between the the trout. Tail coefficient 1: 1.0, tail coefficient II: 2.3, number of scales 15. The vomer, the hyoid bone and the gill rakers are not mentioned." (*S. salar* and *S. trutta*).

Davis, R.M.

1971. Limnology of a strip mine pond in western Maryland. Chesapeake Sci. 12(2):111-114.

Reports that tiger trout were included in fish stocked in Little Meadow Lake from 1967 to 1969.

Davisson, M.T.

1969. Cytogenetic analysis of two teleost families, Salmonidae and Esocidae. Ph.D. Thesis, Penn. State Univ., University Park. 118 p.

Splake were used in the study. Reviews other hybridization work.

Davy, H.

1840. Salmonia, or days of fly-fishing; in a series of conversations: with some account of the habits of fishes belonging to the genus *Salmo. In J.* Davy (ed.), The collected works of Sir Humphrey Davy, Bart. Smith, Elder and Co., Cornhill, London, 9:7-205.

p. 48-49—Discussion on early salmon and trout hybrids. Day, F.

1882a. On hybrids between salmon and trout. Proc. Zool. Soc. London 1882:751-753.

Early report of hybrids of S. salar, S. trutta, S. fontinalis, and S. alpinus.

1882b. On variations in form and hybridism in Salmo fontinalis.J. Linn. Soc. London (Zool.) 17:13-19.

Gives morphometric and meristic data on a sterile hybrid of S. fontinalis  $\times$  S. trutta.

1884a. Salmon-breeding. Nature 30:488.

Brief review of Day's (1884b) work.

- 1884b. On races and hybrids among the Salmonidae. Parts I-III. Proc. Zool Soc. London. 1884:17-40, 376-380, 581-593. Reports on continuation of Day's (1882a) work with additional crosses and backcrosses.
- 1885a. On races and hybrids among the Salmonidae. Part IV. Proc. Zool. Soc. London. 1885:241-243.

Gives additional information about Day's (1884) work.

1885b. On the breeding of salmon from parents which have never descended to the sea. Trans. Linn. Soc. London, Ser. 2 (Zool.), 2, pt. 15:447-468.

Mentions Day's earlier papers.

1885c. Hybridization among Salmonidae. Nature 31:599-600. Review of previous S. salar and S. trutta hybrids of Day, and comment on hybridizing landlocked salmon and trout.

1886. On the hybridisation of Salmonidae at Howietoun. Meet. Brit. Assoc. Adv. Sci. Rep. 55:1059-1063.

Summary of Day's earlier reports. Review of earlier hybridization without references.

1887. British and Irish Salmonidae. Williams and Norgate, London. 312 p.

Very extensive review and discussion of Day's hybridization work on *S. salar, S. trutta, S. fontinalis* and *S. alpinus.* 

1888. See Zoological Society of London (1888).

Curry-Lindahl, K.

<sup>1969.</sup> Fiskarna i farg. (7th ed.). Almqvist and Wiksell, Stockholm. 248 p. (In Swedish.)

1890. Notes on hybridization of fish. Proc. Cotteswold Nat. Field Club 9:334-373.

Review of his previous work with some new crosses. Also mentions *S. trutta* × *Thymallus vulgaris* hybrid in Societe d'Acclimatation de la France, 1877, page 495.

Dean, B.

1962. A bibliography of fishes. (Vol. 1, 1917, 718 p.; Vol. 2, 1916, 702 p.; and Vol. 3, 1923, 707 p.). Am. Mus. Nat. Hist., New York. (Reissued by Russell and Russell, Inc., New York.)

Gives brief abstracts of many old references.

Demoll, R., and P. Steinmann.

1949. Praxis der Aufzucht von Forellenbesatzmaterial. E. Schweizerbart'sche Verlagsbuchhandlung (Erwin Nagele), Stuttgart. 99 p.

Reports that *S. salar* and *S. trutta*, tiger trout, *S. gairdneri*  $\times$  *S. trutta*, *S. gairdneri*  $\bigcirc \times$  *S. fontinalis*  $\bigcirc$  , splake, and *S. nanaycush*  $\times$  *S. trutta* hybrids gave poor results. *S. fontinalis*  $\times$  *S. alpinus* hybrids were fertile and called "Elsässer Saibling."

#### Dieterich, E.

1939, Die Hydrocoele embryonalis (Dotterblasenwassersucht) der Salmoniden. Z. Fisch. deren Hilfswiss. 36(4):605-642. "Hybrids of Salmo [gairdneri] irideus and Salmo trutta regularly get hydrocoele embryonalis [blue-sac disease] and almost all perish from it." (Transl. from German by P.T.M.)

Dubuc, P.-H.

1954. Truite de lac: quelques notes sur les splakes. Chasse and Pêche. 5(55):14-15.

Mentions splake (cited in Séguin 1955b).

- Duff, D.C.B.
  - 1932. Furunculosis on the Pacific coast. Trans. Am. Fish. Soc. 62:249-255.

Reports that an outbreak of furunculosis in British Columbia was noted among three year old hybrids of *O*. *nerka*  $\times$  *O*. *keta*.

"Furunculosis, the disease of fishes due to *Bacillus salmonicida* Emmerich and Weibel, has been identified ...among hybrid Pacific salmon in retaining-ponds at Cultus Lake, B.C."

#### Duke, E.

1970. Contributions to 6th Annual Meeting, Freshwater Res. Group, Dublin, Ireland.

According to Piggins (1970), reports that LDH isozymes of  $F_2$  hybrids of *S. salar* and *S. trutta* were completely trout-like, although the  $F_1$  hybrids showed a typical mixed pattern.

#### Dunbar, C.E.

1969. Lymphosarcoma of possible thymic origin in salmonid fishes. U.S. Dep. Health, Educ. Welfare, Natl. Cancer Inst. Monogr. 31:167-171.

"Because of the cytologic similarities between the tumors in brook trout and in splake, and because such tumors have not been reported in lake trout, it seems likely that a predisposition of splake to develop thymic lymphoma is genetically transmitted from the brook trout." See also C.E. Smith (1971). Dvinin, P.A.

1953. Opyty iskusstvennogo kormleniya molodi lososei i ikh gibridov (Experiments in artificial feeding of young of salmon and their hybrids). Rybn. Khoz. 1953(5):41-42. (In Russian.) Reports on experiments in feeding young hybrids of O. gorbuscha × O. masou in southern Sakhalin.

Dymond, J.R.

1932. The trout and other game fishes of British Columbia. Fish. Res. Board Can., Bull. 32. 51 p.

p. 35—Reports that fertile hybrids were produced at the Cranbrook hatchery (British Columbia) from *S. gairdneri* and *S. clarki*. F<sub>2</sub> fry were raised in 1927 and 1928.

Eddy, S., and T. Surber.

1947. Northern fishes with special reference to the Upper Mississippi Valley. (2nd ed.). Charles T. Branford Co., Newton Centre, Mass. 276 p.

p. 108—The S. trutta  $\times$  S. fontinalis hybrid "...is an extremely handsome fish, marked like a zebra, and apparently immune to many of the diseases that at times destroy whole stocks of brook trutt. However, it is a 'mule'; all attempts to breed it have proved futile."

Eipper, A.W.

- \*\*1953. Fisheries research in New York farm ponds. N.Y. State Conserv. 8(1):9-11.
  - "...experiments are now being conducted to evaluate the survival of hybrid trout, such as crosses between brook trout and rainbows or browns; it is possible that such hybrids may fail to reach maturity until late in life, if at all."
- 1955. Investigation of farm fish ponds and bait ponds in New York State. Typewritten job completion report, Dingell-Johnson Project F-4-R-3.

According to Buss and Wright (1956), discusses hybrids of *S. namaycush*  $Q \times S$ . *fontinalis*  $\Im$  and *S. fontinalis*  $Q \times S$ . *gairdneri*  $\Im$ .

1964. Growth, mortality rates, and standing crops of trout in New York farm ponds. Cornell Univ., Agric. Exp. Stn. Mem. 388, 67 p.

Reports that S. trutta  $\heartsuit \times S$ . gairdneri  $\heartsuit$ , S. gairdneri  $\heartsuit \times S$ . fontinalis  $\heartsuit$ , reciprocal S. trutta  $\times S$ . fontinalis, and reciprocal S. namaycush  $\times S$ . fontinalis hybrids used in the study. Survival data given.

- Ellis, M.M.
  - 1914. Fishes of Colorado. Univ. Colo. Studies 11(1):5-136. Gives a discussion of the possibility of hybridization in nature of S. clarki and S. gairdneri in Colorado.

1957. The lake trout (*Salvelinus namaycush*). U.S. Fish Wildl. Serv., Fish. Leafl. 441. 11 p. (Reprinted, 1964, as Fish. Leafl. 555, 8 p.)

Short discussion about splake.

Evans, W.A., O.L. Wallis, and G.D. Gallison.

\*\*1961. Fishes of Yosemite National Park. (7th revised ed.). Yosemite Nat. Hist. Assoc. and Natl. Park Serv., Yosemite, Calif. 31 p. (1st ed. published as: Evans, W.A. 1944. Fishes of Yosemite National Park. Yosemite Nature Notes 23(1):1-20.).

"The golden/rainbow hybrid trout, Salmo agua-bonita × Salmo gairdneri irideus, is found in waters where rainbow and golden trout have the opportunity to interbreed. This hybrid was first reported in Yosemite in 1950."

"...Dr. Carl L. Hubbs suggests that where rainbow trout

Duff, D.C.B., and B.J. Stewart.

<sup>1933.</sup> Studies on furunculosis of fish in British Columbia. Contrib. Can. Biol. Fish. (N.S.) 8(8):103-122.

Eschmeyer, P.H.

have been stocked in the same waters, they almost invariably eliminate the cuthroats by competition and by hybridization."

Evropeitseva, N.V., and G.V. Belyaeva.

1963. Éksperimental'no-ékologicheskii analiz molodi gibridov Baltiiskikh lososya (Salmo salar L.) i kumzhi (Salmo trutta trutta L.), vyrashchennykh v prudakh (Experimentalecological analysis of the fry of the hybrids of the Baltic salmon (Salmo salar L.) and of sea trout (Salmo trutta trutta L.), grown in ponds). In Gidrobiologiya i ikhtiologiya vnutrennikh vodoemov pribaltiki. Akad. Nauk Latv. SSR, Inst. Biol., Rybnoe Khozyaistvo Vnutrennikh Vodoemov Latviiskoi SSR 7:297-308. (In Russian.) Reports on S. salar × S. trutta hybrids.

#### FAO.

\*\*1970. Hybridization. FAO Fish Culture Bull. 2(4):2-3.

"The Biological Institute of the University of Sarajevo, Yugoslavia, recently carried out hybridization experiments with Salmo trutta fario, S. trutta marmoratus, S. gairdneri and Salmothymus obtusirostris oxyrhynchus at the Blagaj hatchery on the river Buna. Out of a total of six reciprocal crossings, only those between S. trutta fario and S. obtusirostris oxyrhynchus were successful. The experiments are being continued." See also Kosorić and Vuković (1969).

# Fehlmann, W.

1926. Die Ursachen des Rückganges der Lachsfischerei im Hochrhein. Beilage z. Jahresbericht der Kantonsschule Schaffhausen. 112 p.

Alm (1955) and Winge and Ditlevsen (1948) have reviewed the work done by Fehlmann on hybrids of S. salar  $\times$ S. trutta.

#### Ferguson, R.G.

1958. The preferred temperature of fish and their midsummer distribution in temperate lakes and streams. J. Fish. Res. Board Can, 15(4):607-624.

Reports that in two Algonquin Park lakes thermal stratification varied considerably in depth and constitution in the different years, but the thermal position of the splake remained similar.

1969. Key to salmon and trout in the Great Lakes. Ont. Dep. Lands Forests, Res. Inf. Pap. (Fish.) 36. 16 p.

p. 9—Reports that  $F_1$  splake were best identified by a count of 70 to 80 pyloric caeca, which count is intermediate and distinct from that for either parent.

# Fish Commission of Oregon.

1970. Cooperative studies. In Development and improvements of hatchery techniques for Pacific salmon and steelhead trout, p. 3-4. Annu. Rep. Fish Comm. Oreg., Fish Cult. Div., Hatchery Biol. Sec.

"Results of preliminary studies on hybrid salmon indicate that crosses between chinook males and pink or chum females produce viable fry which adapt quickly to fullstrength sea water. Early indications from this work suggest that hybrid salmon exhibit good growth in sea water during early juvenile stages."

Fisheries Research Board of Canada.

1967. Sockeye and pink salmon hybrids, p. 94. In Review of the Fisheries Research Board of Canada 1965-1966. Ottawa, Canada.

Brief mention of sockeye and pink salmon crosses.

- 1969. Salmon hybrids, p. 5. In Review of the Fisheries Research Board of Canada 1967-1968. Ottawa, Canada.
  - Brief mention of pink  $\times$  sockeye and sockeye  $\times$  chum hybrids.
- 1971. Salmon hybridization, p. 20. In Review of the Fisheries Research Board of Canada 1969-1970. Ottawa, Canada. Reports on determining transmitted characteristics of Pacific salmon(Oncorhynchus) by hybridization. See also Withler and Morley (1970).

Fisherman.

1969. Scientists develop hybrid between Siberian and humpback salmon. Fisherman (Vancouver, Canada) 32(26):12. Shows two photographs of hybrids of O. keta × O. gorbuscha developed at the Kalinin fish breeding plant on Sakhalin Island, USSR.

Fitzinger, L.

- 1875. Bericht über die an den oberösterreichischen Seen und in den dortigen Anstalten für künstliche Fischzucht gewonnenen Erfahrungen bezüglich der Bastardformen der Salmonen. Sitzber. Akad. Wiss. Wien, Math.-nat. Cl. 70, I. Abth.:394-400. Also separate; Wien, 1875. 7 p.
  - According to Dean (1962), reports that Salmo schiffermülleri Bloch (Silberlachs), because of similarity of bred examples, is considered to be a sterile natural hybrid of S. trutta (fario)  $\times$  S. alpinus (salvelinus) in Austria. (See also Zool. Garten 1875.)
- 1876. Bericht über die an den Seen des Salzkammergutes, Salzburgs und Berchtesgadens gepflogenen Nachforschungen über die Natur des Silberlachses (Salmo schiffermülleri Bloch). Sitzber. Akad. Wiss. Wien, Math.-nat. Cl. 72, 1. Abth.:235-240.

According to Dean (1962), Salmo schiffermülleri Bloch (Silberlachs), because of similarity of bred examples, is considered to be a sterile natural hybrid of S. trutta (fario) × S. alpinus (salvelinus) in Austria. Also abstracted in Zoological Record 1876.

#### Flick, W.A., and D.A. Webster.

1964. Comparative first year survival and production in wild and domestic strains of brook trout, *Salvelinus fontinalis*. Trans, Am. Fish, Soc. 93(1):58-69.

Reports that some splake backcrossed to female brook trout were used in the study.

#### Foerster, R.E.

1930. The hybridization of salmon. Biol. Board Can., Prog. Rep. (Pac.) 6:6-8.

First report of hybridization at Cultus Lake. See also Foerster (1935).

1935. Inter-specific cross-breeding of Pacific salmon. Trans. Roy. Soc. Can., Ser 3, 29, Sect. 5:21-33.

The first comprehensive study of crossing of all five species of North American *Oncorhynchus*. Reciprocal crosses made and some backcrosses and  $F_2$  hybrids. Literature review.

1955. The Pacific salmon (genus Oncorhynchus) of the Canadian Pacific coast, with particular reference to their occurrence in or near fresh water. Int. N. Pac. Fish. Comm., Bull. 1:1-56.

Brief mention of Foerster's (1935) work.

1968. The sockeye salmon, Oncorhynchus nerka. Fish. Res. Board Can., Bull. 162. 422 p.

p. 400-404-Includes a review of Foerster's (1935) work,

Russian hybridization, and possibilities of selective crossbreeding of salmon.

Forest and Stream.

- 1873. The production of hybrid fish. Forest and Stream 1:22. Mentions S. fontinalis, S. namaycush, and possibly S. salar hybrids.
- 1889a. Lake and brook trout hybrid. Forest and Steam 31:520. Description of S. fontinalis × S. namaycush hybrid. Refers to Report of the Pennsylvania Fish Commission for 1886.
- 1889b. Crossing of salmon and trout. Forest and Stream 33:321. Presents a short discussion about S. fontinalis and S. namaycush hybrids in New York.
- 1890a. A supposed hybrid trout. Forest and Stream 35:377. Reports a S. fontinalis × S. namaycush hybrid caught by E. Sterling. Reference to a figure of a splake in May 9, 1889, Forest and Stream.
- 1890b. Is the golden trout a hybrid? Forest and Stream 35:429. Gives a discussion about hybrids of S. salar, S. trutta, S. alpinus, and S. fontinalis. Cited by Dean (1962) as Bean (1910).
- Fowler, H.W.
  - 1942. The salmon-like fishes of Pennsylvania. Penn. Board Fish Comm., Bienn. Rep. for period ending May 31, 1942, p. 55-63.
  - According to C.J.D. Brown (1966), Fowler describes two dwarf brown trout which Brown recognizes as hybrids.
  - 1946. Notes on Pennsylvania fishes obtained in 1943, 1944 and 1945. Penn. Board Fish Comm., Combined Bienn. Rep. for period ending May 31, 1946, p. 99-103.
    - p. 100—Mentions *S. trutta* [tiger trout?] hybrid like those figured in Fowler (1942, p. 60).
- Fraas, C.N.
  - 1854. Die künstliche Fischerzeugung nach den Erfahrungen der künstliche Fischzucht-Anstalt der General-Comité des Landwirthschaftlichen-Vereins von Bayern. (2nd ed.). Liteur-artist Anstalt, München. 84 p.
    - According to Dean (1962), mentions hybrids of *S. trutta* (*fario*) and *Lota marmorata* obtained by artificial fertilization.
- Francese, V.

1962. Tiger trout. Conservationist (New York) 17(2):44. Letter to the editor about listing tiger trout as a record game fish. See also Greeley (1962).

Fraser, J.M.

1972. Recovery of planted brook trout, splake, and rainbow trout from selected Ontario lakes. J. Fish. Res. Board Can. 29(2):129-142.

"Planted splake and rainbow trout generally yielded higher returns, in weight, than brook trout in comparable situations."

Freshwater Biological Association.

\*\*1968. Trout. Freshwater Biol. Assoc. (U.K.), Annu. Rep. 36:42.

"Five 'zebra trout' (hybrids between Salmo trutta, brown trout, and Salvelinus fontinalis, American brook trout) were caught in Wise Een Tarn. These fish were 3-4 years old, and must be natural hybrids; they show as good if not better growth than the brown trout in the tarn."

Fry, F.E.J., and M.B. Gibson.

1953. Lethal temperature experiments with speckled trout × lake trout hybrids. J. Heredity 44(2):56-57.

"At 15°C, acclimation the hybrids approach the median resistance times of the *fontinalis* parent much more closely than they do the *namaycush* parent, and at 20°C, acclimation this trend appears to be even more pronounced."

1854. A complete treatise on artificial fish-breeding. D. Appleton and Co., N.Y. 188 p.

p. 51-52—Includes mention of unknown hybrids (cited in Séguin 1955b).

Fujita, T.

1926. On the characteristics of hybrids (F<sub>1</sub>) among Japanese salmon and trout. Dobutsugaku Zasshi 38(448):39-51. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1062, 1968.) (English abstract *In* Jap. J. Zool. 2:83.)

Discusses reciprocal crosses between O. keta, O. masou, and O. gorbuscha. The hybrid of O. masou  $\heartsuit$  and O. keta  $\Im$  was the only cross not described and discussed fully beyond the fry stage.

Fukuhara, F.M., S. Murai, J.J. LaLanne, and A. Sribhibhadh. 1962. Continental origin of red salmon as determined from morphological characters. Int. N. Pac. Fish. Comm., Bull. 8:15-109.

p. 18—Gives brief discussion of Oncorhynchus hybrids. Fuster de Plaza, M.L.

1949. Obtencion de hibridos entre "Trucha arcoiris" Salmo iridea Gibbons y "Trucha de Arroyo" Salvelinus fontindis (Mitchil) Jordon [isi] [Hybridization between Salmo iridea (Gibb.) and Salvelinus fontinalis (Jord.)]. Argentina Min. Agric. Ganad., Publ. Misc. 319, 12 p. (Transl. from Spanish, Fish, Res. Board. Cam, Transl. Ser. 13.)

**Describes hybrids between** *S. fontinalis*  $\bigcirc$  and *S. gaird-neri*  $\bigcirc$  . Mention of *S. trutta*  $\times$  *S. salar sebago* and *S. fontinalis*  $\times$  *S. trutta* hybrids.

G.,T.

1834. The salmon par [sic] is neither a hybrid, nor a distinct species, of the genus *Salmo*, but a state of the common salmon. Mag. Nat. Hist. 7(42):521-522.

Discusses the question of parr being a hybrid of *S. salar* and *S. trutta*.

Garside, E.T., and F.E.J. Fry.

1959. A possible relationship between yolk size and differentiation in trout embryos. Can. J. Zool. 37(4):383-386.

"Myomere numbers were counted in samples of reciprocal hybrids of lake and speckled [brook] trout. The fish which developed on speckled trout yolks, which are the smaller, had a lower mean myomere number. Myomere numbers of normal lake trout, speckled trout, and the  $F_1$  hybrid (lake trout egg) were compared with myomere numbers of their respective Siamese twins. An inverse relationship between myomere number and degree of twinning was found in speckled trout but not in the lake trout or the hybrid. Since this relationship is not evident in fish developed on larger yolks it is assumed that there is a certain critical yolk size below which it becomes limiting and prevents the formation of the normal myomere complement."

Gaylord, H.R.

1910. An epidemic of carcinoma of the thyroid gland among fish. J. Am. Med. Assoc. 54(3):227.

"Another observation of importance is the discovery that lots of fish are immune. This is particularly shown in hybrid fish, in which one lot of hybrid salmon one year old were

Fry, W.H.

reduced from 1,043 in April to 44 sound fish remaining in August, whereas another lot of yearling hybrid salmov, although badly exposed by being placed in ponds into which the water from infected ponds ran, remained free from the disease throughout." See also Gaylord et al. (1914).

Gaylord, H.R., M.C. Marsh, F.C. Busch, and B.T. Simpson. 1914. Carcinoma of the thyroid in the salmonoid fishes. Bull.

U.S. Bur. Fish. 32:363-524. Hybrids of S. fontinalis  $\varphi \times S$ . salar sebago  $\overline{\circ}$  and S.

Hyperbolic Constraints  $\varphi \sim S$  such a score  $\varphi = 0$  and S. fortunalis  $\varphi \sim S$ . alphinus aureolus  $\Im$  reported to be hardy (mature) and exhibit some immunity to tumor formation. Hybrids of O. kisutch  $\varphi$  and O. gorbuscha  $\Im$ , O. kisutch  $\varphi$  and O. tshawytscha  $\Im$ , O. nerka  $\varphi$  and O. sporbuscha  $\Im$ , and O. gorbuscha  $\varphi$  and O. nerka  $\Im$ were not hardy and were highly susceptible to tumor formation.

# Giard, A.

1892. Quelques remarques sur la truite de mer. C.R. Hebd. Seances Mem. Soc. Biol. Paris 44:872-876.

Discounts the idea that sea trout may be a *S*. salar  $\times$  *S*. trutta hybrid. The *S*. salar  $\times$  *S*. trutta hybrid is easily produced.

#### Gibson, R.

\*\*1929. The spawning-beds of the Skeena River. Prov. British Columbia, Rep. Comm. Fish. 1928:50-52.

"An unusual incident was noticed by Mr. Hearne—a female pink spawning with a male sockeye. This female chased the males of its own species away in order to spawn with the sockeye. At the time there was no scarcity of male pinks or female sockeye."

# Gilmour, W.M.

1950. A study of the Lower Bow River trout with special reference to taxonomy. M.S. Thesis, Univ. of Alberta, Edmonton. 59 p.

Reports that neither the native *S. clarki* nor the introduced *S. gairdneri* seem to be present in the Bow River as a true species. "This leads to the supposition that the Bow River trout is a hybrid between the rainbow and the cutthroat."

#### Giudice, J.J.

\*1967. The production and comparative growth of three buffalo hybrids. Proc. Annu. Conf. S.E. Assoc. Game Fish Comm. 18:512-517.

Includes a brief discussion of salmonid hybrids.

#### Goldberg, E.

1966. Lactate dehydrogenase in trout: hybridization in vivo and in vitro. Science 151(3714):1091-1093.

"Speckled (brook) trout and lake trout contain five forms of lactate dehydrogenase, but a different electrophoretic distribution of isozymes characterizes each species. The hybrid splake, which is produced artificially by fertilizing lake trout eggs with speckled trout sperm, contains nine isozymes. This complement of isozymes in vivo could be produced in vitro by recombination of subunits from tissues of the parent species. In the splake trout, this complement is the result of heterozygosity at the gene locus responsible for synthesis of LDH-5. Extracts of trout eyes contain at least two additional forms of LDH which could not be demonstrated in other tissues." 1969. Ontogeny of lactate dehydrogenase isozymes in trout. In O.W. Neuhaus and J.E. Halver (ed.), Fish in research, p. 195-205. Academic Press, N.Y.

Includes a discussion about LDH in splake and in brown × brook trout hybrids.

Goldberg, E., J.-P. Cuerrier, and J.C. Ward.

1967. Lactate dehydrogenase isozymes, vertebrae and caeca numbers in an isolated, interbreeding population of splake trout. Naturaliste Can. 94(3):297-304.

"Distribution of lactate dehydrogenase (LDH) isozymes genotypes has been studied with an isolated population of splake trout. LDH genes have been shown to be evolutively [sic] stable. However, this genetic equilibrium does not seem to apply to the total gene pool since determination of pyloric caeca and vertebrae numbers does not show such a stability."

1969. Lactate dehydrogenase ontogeny, paternal gene activation, and tetramer assembly in embryos of brook trout,

lake trout, and their hybrids. Biochem. Genet. 2:335-350. "Measurement of lactate dehydrogenase in reciprocal hybrids of trout during development revealed that a maternal effect was involved in the regulation of enzyme levels until resorption of the yolk sac was completed.

"Malate dehydrogenase specific activities were the same in these embryos and larvae...Activation of the paternal A gene in reciprocal hybrids occurred at a relatively late stage with the LDH subunit specific to the retina appearing after hatching."

# Gould, W.R.

1966. Cutthroat trout (Salmo clarkii Richardson) × golden trout (Salmo aquabonita Jordan) hybrids. Copeia 1966 (3):599-600.

Presents color, meristic, and morphometric data about *S. aguabonita*  $\bigcirc \times S$ . *clarki*  $\bigcirc^{n}$  hybrids.

#### Greeley, J.R.

1962. Tiger trout. Conservationist (New York) 17(2):44. Answer to a letter to the editor (see also Francese 1962).

#### Green, S.

1874. Seth Green on shad and black bass, and hybrid fish. Am. Sportsman 3:378.

Cited by Schwartz (1972).

1879. Hybrid trout. Forest and Stream 13:885.

Reports on S. fontinalis  $\times$  S. gairdneri (California mountain trout) hybrids.

1880a. Fertile hybrids. Forest and Stream 15:366. Reports on S. fontinalis × S. namaycush (salmon trout)

hybrids. 1880b. Hybrid trout. Chicago Field 14:284. Reference obtained from Dean (1962).

1880c. Fish culture, fishing tackle, hybridization and pound nets. Proc. Centr. Fish Cult. Soc., p. 56-59.

Cited by Schwartz (1972).

1881. Hybridizing fishes. Trans. Am. Fish Cult. Assoc., New York. 10:5-9.

Reports that fertile hybrids of *S*. fontinalis  $\Im \times S$ . namaycush (Lake Ontario salmon trout)  $\Im$  produced  $\mathbb{F}_2$  generations as well as backcrosses with both parents. Only female hybrids with eggs too large to pass through the vent were produced crossing *S*. fontinalis  $\Im$  and *O*. tshawytscha (California salmon)  $\Im$ . No eggs hatched when fertilized with *S*. fontinalis milt. Also mentions without results a cross of *S. fontinalis* × *S. gairdneri* (California mountain trout). Species are identified in Bean (1889b).

1907. Cross-breeding of fish. In his Home fishing and home waters, p. 78-81. Orange Judd Co., N.Y.

Review of Green's (1881) work. Mentions a successful crossing till hatching of a white fish (*Coregonus albus?*) and salmon trout (*S. namaycush*).

#### Grieg, J.A.

1906. Karnsformet ørret. Norsk. Jager-og Fisker-Forenings Tidsskrift. 35:67.

According to Dean (1962), "miscellaneous and unimportant" report of hybridization in Salmonidae.

Grimås, U., N.-A. Nilsson, and C. Wendt.

\*\*1972. Lake Vättern: effects of exploitation, eutrophication, and introductions on the salmonid community. J. Fish. Res. Board Can. 29(6):807-817.

p. 815—"Splake—In 1968 500 splake were introduced and subsequent recaptures totalled 25%. Most of the fish were caught around the release site. The maximum weight was rather low, around 0.5 kg. No further decisions have been made concerning this hybrid."

#### Grimm, O.A.

1881. Zametka o skreshchivanii ryb (A note concerning the cross-breeding of fish). Tr. S.-Petersburg. O-va. Estestvoispyt. 12(1):52-57. (In Russian.)

Discusses hybrids of S. salar, S. trutta, S. trutta fario, S. alpinus (salvelinus), Coregonus oxyrhynchus, C. lavaretus, and C. lavaretus baerii. Contains earlier references.

# Gritsenko, O.F.

1970. O gibride gol'tsa s kundzhei [Salvelinus alpinus (L)  $\times$  S. leucomaenis (Pallas)] (A hybrid of Salvelinus alpinus and

S. leucomaenis). Zool. Zh. 49(8):1252-1253. (In Russian, with English summary.)

Describes a natural hybrid of *S. alpinus* [*S. malma; see* Behnke's editorial note *in* J. Ichthyol., 1971, 11(4):555.] and *S. leucomaenis* in Sakhalin.

# Grote, Vogt, and Hofer.

See Hofer, B. 1909.

#### Haack, H.

1880. Die Fortpflanzungsfähigkeit der Bastarde. Oesterr.ungar. Fisch. Ztg., p. 59.

According to Dean (1962), reports that infertile S. salar  $\times$  S. trutta (fario) hybrids were produced at Hüningen, Alsace.

1893. Bastardirung der Forelle durch den Bachsaibling. Allg. Fisch. Ztg. 18(14):210.

Reports few survivors of *S. trutta*  $Q \times S$ . *fon-tinalis*  $\bigcirc$  hybrid cross. The cross had no practical value, confirming conclusions by Arens [1893 and 1894] and by Schillinger. Crossing *S. gairdneri* with *S. trutta* and *S. fontinalis* also was not successful.

1894. Lachsbastarde auf der Schweizerischen Fischerei-Ausstellung in Zürich. Allg. Fisch. Ztg. 19:280-281.

Reports on infertile S. salar  $\bigcirc \times S$ . trutta  $\bigcirc$  hybrids exhibited in Switzerland.

# Haen, P.J., and F.J. O'Rourke.

1968. Protein and haemoglobins of salmon-trout hybrids. Nature 217(5123):65-67.

Reports that hybrids of S. salar  $\times$  S. trutta were compared by electrophoresis for eye lens, muscle and serum proteins, and for haemoglobins, with both parents.

1969a. Comparative electrophoretic studies of soluble eyelens proteins of some Irish freshwater fishes. Proc. Roy. Irish Acad., Sect. B, 68(4):67-76.

Reports that S. salar  $\times$  S. trutta hybrids have an electrophoretic pattern for eye lens proteins unlike either parent species.

1969b. Comparative electrophoretic studies of the watersoluble muscle proteins of some Irish freshwater fishes. Proc. Roy. Irish Acad., Sect. B, 68(7):101-110.

Reports that relatively little difference was detected between the patterns of muscle proteins in *S. trutta*, *S. salar*, and their hybrids.

Hagen, W., and J.P. O'Connor.

- 1959. Public fish culture in the United States, 1958. A statistical summary. U.S. Fish Wildl. Serv., Circ. 58. 44 p.
  - Includes tables of distribution of splake from hatcheries in Michigan, Minnesota, New Hampshire, New York, and Wyoming.

Hallock, C.

See Forest and Stream (1873).

Hansen, D.W.

1952. Life history studies of the trout of Pathfinder Reservoir, Wyoming. M.S. Thesis, Iowa State College, Ames. 55 p. According to Carlander (1959), the report discusses S. *clarki × S. gairdneri* hybrids.

Hansler, D.D.

1958. Some effects of artificial selection upon a stock of cutthroat trout, *Salmo clarkii clarkii*, with related hybridization studies. M.S. Thesis, Univ. Washington, Seattle. 102 p. Reviews interspecific hybridization.

Hanzel, D.A.

1959. The distribution of the cutthroat trout (Salmo clarki) in Montana. Proc. Mont. Acad. Sci. 19:32-71.

"Hybrids between rainbow and cutthroat trout have appeared in practically all drainages where rainbow trout were introduced. These hybrids are numerous in most places which makes identification of the cutthroat trout and the determination of its present range extremely difficult. The effects of hybridization on the future of the cutthroat trout are not known."

Hardy, E.

1961. New salmon in Europe—and research leading to the introduction of Pacific Oncorhynchus. Salmon and Trout Mag. 163:132-138.

Mentions Oncorhynchus hybrids in British Columbia and the unlikelihood of Oncorhynchus crossing with Salmo salar when introduced in Europe.

1969. Hybrids—success or failure? Trout and Salmon Mag. July:31, 33, 35.

Reviews hybrids (Salmonidae) in general and the "sunbeam" (*see also* Knowles 1969) and the "ten-ton" trout in particular. The sunbeam is a backcross of a *S*.

gairdneri  $\mathcal{Q} \times S$ . trutta  $\mathcal{O}$  hybrid to a S. trutta  $\mathcal{O}$ .

For a discussion of the "ten-ton" trout *see* Angling Times (1968).

H[arrison], A.C.

1959. [Review of] New trout for tomorrow, by A.J. McClane (fishing editor) "Field & Stream," New York, March 1959. With reference to a recent paper by Keen Buss and James

<sup>1873.</sup> 

Harris, G.

E. Wright of Pennsylvania in "Transactions of the American Fisheries Society" entitled "Appearance and fertility of trout hybrids." Piscator 13(45):42-43.

Reviews the trout hybridization work of Buss and Wright. Harrison, A.C.

1961. Tiger trout (Salmo trutta female × Salvelinus fontinalis male). Piscator 14(50):85-93.

Gives a quite complete review of the literature on the cross, as well as work on tiger trout in South Africa.

Hartman, G.F.

1956. A taxonomic study of cutthroat trout Salmo clarki clarki Richardson, rainbow trout Salmo gairdneri Richardson and reciprocal hybrids. M.A. Thesis, Univ. British Columbia, Vancouver, 71 p.

Reports that fish bearing some of the distinguishing features of each species occurred naturally and suggested hybridization. S. clarki and S. gairdneri were reciprocally hybridized with no loss in viability.

Hayaguri, M. 1936.

See Soguri, M. 1936.

Hempel, G.

\*\*1970. Fish-farming, including farming of other organisms of economic importance. Helgoländer Wiss. Meersunters. 21(4):445-465.

p. 461—"All rainbow trout (*Salmo gairdneri*) reared in German trout farms are supposed to be the result of interbreeding of *Salmo clarkii*, *S. shasta* and *S. irideus*."

1969. Distribution of fishes of southern Alberta. J. Fish. Res. Board Can. 26(2):325-338.

Mentions S.  $clarki \times S$ . gairdneri hybrids in the headwaters of the Bow and Oldman Rivers.

Henking, H.

1929. Untersuchungen an Salmoniden mit besonderer Berücksichtigung der art- und rassefragen. Teil I. (Investigations of Salmonidae with particular attention to specific and racial questions. Part I). Cons. Perm. Int. Explor. Mer, Rapp. Proc.-Verb. Réun. 61. 103 p. (Transl. from German, Fish. Res. Board Can., Transl. Ser. 1819, 1971.)

"It has not been decided with certainty whether hybridism of salmon, sea-trout and trout occurs in freedom. That hybridism is easily produced has been demonstrated by hatcheries. It is, however, as yet unknown what becomes of such hybrids. I have been able to show that a marked fish (0.313) which had originated from artificial fertilization was, probably, a hybrid between a salmon and a sea-trout. An illustration of this fish is given in the report."

1931. Untersuchungen an Salmoniden mit besonderer Berücksichtigung der art- und rassefragen. Teil II. (Investigation of Salmonidae with particular attention to specific and racial questions. Part II). Cons. Perm. Int. Explor. Mer, Rapp. Proc.-Verb. Réun. 73. 122 p. (Transl. from German, Fish. Res. Board Can., Transl. Ser. 1820, 1971.)

"Professor Scheuring of Munich was, as far as I know, the first to broach the question of 'artificial hybridism' of salmon and trout with remarkable results (p. 18). The work is not yet finished. Such investigations are the most important we have."

Hickling, C.F.

1962. Fish culture. Faber and Faber, London. 295 p. p. 258-259—Discusses Alm's (1955) work. Hikita, T.

1962. Ecological and morphological studies of the genus Oncorhynchus (Salmonidae) with particular consideration on phylogeny. Sci. Rep. Hokkaido Salmon Hatchery 17:1-97. (In English with Japanese summary.)

Refers to Makino's (1956) listing of hybrids.

1963. On a salmonid fish known as "Iwame" in local name within Hokkaido. Sci. Rep. Hokkaido Fish Hatchery 18:41-43. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1912, 1971.)

Reports occurrence of natural hybrids of *O. masou* × *S. leucomaenis* called *Oncorhynchus iwame*.

Hikita, T., and Y. Yokohira.

1964. Biological study on hybrids of the salmonid fishes. A note of F<sub>1</sub> hybrids between chum (Oncorhynchus keta) and pink salmon (Oncorhynchus gorbuscha). Sci. Rep. Hokkaido Salmon Hatchery 18:57-65. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1064, 1968.)

Gives observations on fry produced by reciprocal hybridization of *O. keta* and *O. gorbuscha*. Adults had not returned at time of publication. *See* Simon and Noble (1968) for a review.

Hiraki, O.

1932. On the hybrid between "Masu" and "Amago." Tokyo-fu Suisan-Kaiho 6:81-84. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 2037, 1972.)

Reports on early history of hybridization of *O. masou* and *O. rhodurus* in Japan.

Hitzeroth, H., J. Klose, S. Ohno, and U. Wolf.

1968. Asynchronous activation of parental alleles at the tissuespecific gene loci observed on hybrid trout during early development. Biochem. Genet. 1(3):287-300.

"By using three genetic markers, the asynchronous activation of parental alleles during embryonic development was studied on interspecific hybrids between the male brown trout and the female rainbow trout."

Hochachka, P.W.

1966. Lactate dehydrogenases in poikilotherms: definition of a complex isozyme system. Comp. Biochem. Physiol. 18:261-269.

"The liver LDH patterns for the hybrid trout (Splake) are a unique consequence of hybridization. Out of about 70 brook and lake trout examined, Splake kind of liver LDH patterns were never found."

Hodgins, H.O., W.E. Ames, and F.M. Utter.

\*1969. Variants of lactate dehydrogenase isozymes in sera of sockeye salmon (Oncorhynchus nerka). J. Fish. Res. Board Can. 26(1):15-19.

Mentions Morrison and Wrights' (1966) work.

Hodgson, R., D.M. Home, and A. Robertson.

1967. Reports on the natural history and habits of salmonoids in the Tweed and its tributaries. W. Blackwood and Sons, Edinburgh. 129 p.

According to Schwartz (1972), the report discusses  $S.salar \times S.$  trutta hybridization.

Hofer, B.

1909. Die Süsswasserfische von Mittel-Europa. Verlag Schlüter & Mass, Halle am S. 558 p.

Alm (1955) reports that Hofer says only hybridization between *S. salar*  $\bigcirc \times S$ . *trutta*  $\bigcirc$  is possible and not the opposite cross. ("Ubrigens lassen sich Forelleneier von Lachsmilch überhaupt nicht befruchten.") Cited by

Henderson, N.E., and R.E. Peter.

Schwartz (1972) as W. Grote, C. Vogt, and B. Hofer. Holton, G.D.

- \*1953. A trout population study on a small creek in Gallatin County, Montana, J. Wildl, Manage. 17(1):62-82.
  - Reports that rainbow × cutthroat trout hybrids were probably present.

Hsüeh Cheng-yü, Huang Shang-wu, and Yen Jung-yüan.

1959. Lenok and taimen and their natural hybrids in the Helung-chiang basin. Acta Hydrobiol. Sinica 2:215-220. (In Chinese, with Russian resumé.)

Gives morphological and meristic data on natural hybrids of *B. lenok* and *H. taimen* from the river Huma. The three hybrids caught were intermediate between the two parent species. Cited incorrectly by Behnke (1968a) as Se, Huan, and Yuan (1959).

#### Huard, J.B.S.

1954. Une nouvelle truite. Chasse et Pêche 5(54):6-7.Includes mention of unknown hybrids (cited by Séguin 1955b).

Hubbs, Carl L.

\*\*1955. Hybridization between fish species in nature. Syst. Zool. 4(1):1-20.

"Among the trout we find occasional intergeneric hybrids in nature as well as in culture. Most of these are between the native brook trout and the introduced brown trout. In the West the cutthroat and rainbow trouts, both belonging to the genus Salmo, live side by side with little or no crossing in many coastal streams, but in the interior, where the cutthroat alone was native, the introduction of rainbows has repeatedly led to very extensive hybridization and frequently to the elimination of the cutthroat, through a combination of hybridization and superior competition. The rainbow and golden trouts hybridize similarly. In the hatcheries many crosses have been produced between good species of chars, trouts, and salmons. Some of these produce fertile offspring, and by mating one hybrid with one of another cross, four species of the Pacific salmons have been combined in one individual (among the poeciliids we have thus combined as many as five species and twelve subspecies or races). One combination, between the brook trout and the lake trout, is being propagated in Canada with promise of use in fish management. The parental species were formerly classed as distinct genera, but in the current lumping spree both are put in Salvelinus-which action does not lessen the difference between the species."

Hubbs, Carl L., and R.R. Miller.

\*\*1948. The zoological evidence: correlation between fish distribution and hydrographic history of the desert basins of western United States. Bull. Univ. Utah, Biol. Ser. 10(7):17-166.

p. 38—"The trout, 'Salmo aquilarum,' which Snyder described from Eagle Lake as an endemic representative of the Pacific-drainage rainbow trout series, appears from a re-examination of the types to have been based on hybrids between the native cutthroat and an introduced rainbow trout (Salmo gairdnerii). This conclusion is in line with expectation."

Hubbs, Clark.

1967. Analysis of phylogenetic relationships using hybridization techniques. Bull. Natl. Inst. Sci. India 34:48-59.

Reports that Fundulus parvipinnis and Leuresthes tenuis

eggs were exposed to *S. gairdneri* sperm and no gastrulation was noted. "One lot of *Atherinops affinis* eggs was exposed to *S. gairdneri* sperm and no development was noted." "Four lots of *Salmo gairdneri* eggs were exposed to *Atherinops affinis* and *Anchoa compressa* sperm and no development was noted. Two lots were exposed to *Clupea pallasi* sperm and cleavages producing a mass of disorganized cells were noted. Although the data are scanty it seems as if the *C. pallasi* sperm is more compatible with *S. gairdneri* eggs than either of the others. The eggs were incubated at 6 and 15°C."

Hubbs, Clark, and G.E. Drewry.

\*\*1959. Survival of F<sub>1</sub> hybrids between cyprinodont fishes, with a discussion of the correlation between hybridization and phylogenetic relationship. Publ. Inst. Mar. Sci. 6:81-91. p. 87—"Rubaschev (1935) reported on hybrids between members of the genera Salmo and Coregonus. None of them hatched. These failures support Jordan's (1923) separation of the two groups on the familial level."

Hunter, J.G.

- 1949. Occurrence of hybrid salmon in the British Columbia commercial fishery. Fish. Res. Board Can., Prog. Rep. Pac. 81:91-92.
  - Gives meristic and morphometric data on natural hybrids of O. gorbuscha  $\times O$ . keta.

Ihssen, P.

1971. The inheritance of thermal resistance in hybrids of Salvelinus fontinalis (Mitchill) and Salvelinus namaycush (Walbaum). Ph.D. Thesis, Univ. Toronto, Ontario. 226 p. "The present study suggests that the two species, the brook trout and the lake trout, differ in thermal resistance to high temperatures due to a genetic difference for only a few loci."

Inaba, D.

1953. On the breeding and hybridization among the salmonoid fishes I. J. Tokyo Univ. Fish. 39(2):215-224.

Reports on hybridization between S. fontinalis and O. masou, and between the former and O. rhodurus and rearing of the young. Study and review of the hybrids. Includes mention of hybrid S. trutta  $\times$  O. keta which were destroyed in 1944.

1963. Proliferation of fresh water resources. Kosei-sha Koseikaku. (In Japanese.)

According to Suzuki (1966) the report mentions natural hybridization of *S. malma*  $\times$  *S. fontinalis*.

- Irving, R.B.
  - 1953. Ecology of the cutthroat trout, Salmo clarki Richardson in Henry's Lake, Idaho. M.S. Thesis, Utah State Agric. College, Logan, 101 p.

According to Carlander (1969), the report discusses S. *clarki*  $\times$  S. *gairdneri* hybrids.

Rainbow  $\times$  cutthroat hybrids were seen feeding on freshwater snails when they were floating on the lake surface on foggy mornings. The snails made up 59% by volume of the diet of the hybrids compared with 3% of the diet of the cutthroat trout.

Iversen, E.S.

\*\*1968. Farming the edge of the sea. Fishing News (Books) Ltd., London. 301 p.

<sup>1955.</sup> Ecology of the cutthroat trout in Henrys Lake, Idaho. Trans. Am. Fish. Soc. 84:275-296.

p. 86-"An experiment involving hybrids is underway in

Puget Sound, Washington, to produce a salmon more desirable to the consumer from two species of eastern Pacific salmon found in this area. The chum salmon, Oncorhynchus keta, which run every year, have a fine flavor but the meat color is light and less appetizing that other salmon, and they will not take a fishing lure. The pink salmon ('humpies'), O. gorbuscha, are abundant only during odd-numbered years, have a pink meat, and will take lures. These two species have been crossed with the hope of producing a hybrid with desirable features of both species. First catches of the returning adult hybrids, called 'chumpies,' are stronger fish than the pinks and have darker meat than the chums. Still to be determined is the possibility of this hybrid reproducing on its own, and the establishment of even-year runs. If this can be done, it will aid the commercial fishery and someday perhaps help in making salmon farming possible."

Jaboulay, M.

1908. Poissons atteints de goitres malins héréditaires et contagieux. Lyon Médical 110:335-336.

According to Mac Intyre (1960), the report cites Crettiez with regard to spontaneous thyroid tumors in hybrid "Trout, *?Salmo trutta* × Char, *?Salvelinus alpinus.*"

Janes, T.

1956. That new game-fish. Outdoor Life 117(2):38-39, 147-149. Discusses angling for splake in New Hampshire.

Johnson, R.E.

\*\*1945. Ever hooked a hybrid? [Minnesota] Conserv. Volunteer 8(49):18-22.

p. 22—"Some hybrids between rainbow and cutthroat have been produced in hatcheries and released in western streams."

\*\*1972. The great Pyramid Lake water war. Pisces (Calif.-Nev. Chapter Am. Fish. Soc.) 2(3):3, 8.

"The State of Nevada has produced an experimental fish, the bow-cut, which is derived by hybridizing male rainbow and female cutthroat trout. The resulting fish have shown excellent success; some planted in Pyramid during the spring of 1970 have returned during November 1972 at a weight of near 16 pounds. They not only exhibit the native cutthroat's tolerance for high alkalinity of the lake, but also portray the rainbow's excellent fighting qualities and are as easily reared as rainbows. Marked fish have also indicated a much greater return to the angler than equivalent plants of native cutthroat have shown. Public interest in these hybrids continues to grow."

Jones, J.W.

- 1948. Salmon and trout hybrids. Proc. Zool. Soc. London 117(4):708-715.
  - Description of hybrids of S. salar  $\heartsuit$  and S. trutta  $\heartsuit$ , including a backcross of same with S. salar  $\circlearrowright$ .
- 1959. The salmon. Harper and Brothers, New York. 192 p. Includes a review of S. salar  $\times$  S. trutta hybrids.

Jordan D.S.

1906. Salmon hybrids. Science (N.S.) 23(585):434.

Reports J.A. Richardson crossed all of the North American species of *Oncorhynchus*. He found the *O*. gorbuscha  $\Im \times O$ . nerka  $\Im$  hybrid superior to the other hybrids.

Jordan, D.S., and B.W. Evermann.

1896. The fishes of North and Middle America: a descriptive

catalogue of the species of fish-like vertebrates found in the waters of North America, North of the Isthmus of Panama. Part I. Bull. U.S. Natl. Mus. 47. 954 p. (Reprinted 1963, for the Smithsonian Institution by T.F.H. Publications, Inc., Jersey City, N.J.)

p. 512-514—Mentions S. alpinus × S. trutta (fario) hybrids. Discounts theory that S. alpinus aureolus is derived from this hybrid.

Jousset de Bellesme, [G.L.M.F.].

Reports that fertile hybrids of *S. gairdneri* × *S. trutta* and *O. tshawytscha* × *S. trutta* were raised at the Trocadero Aquarium in Paris. Hybrids between *O. tshawytscha* and *Lota marmorata* (lotte) were not successful. According to Richmond (1919), the report discusses *S. fontinalis* × *S. trutta* hybrids.

Joyce, H.S.

1943. Hybrid trout. Game and Gun and Angler's Mon., June 1943:155-157.

A popular report of hybrids of S. salar and S. trutta caught by angling.

Kamyshnaya, M.S.

1961. O biologii gibrida kety i gorbushi [Oncorhynchus keta (Walbaum) infrasp. autumnalis Berg × O. gorbuscha (Walbaum) sem. Salmonidae] [On the biology of the hybrid between chum and pink salmon: Oncorhynchus keta (Walbaum) infrasp. autumnalis Berg × O. gorbuscha (Walbaum)—family Salmonidae]. Nauchnye Dokl. Vysshei Shkoly, Biol. Nauki 1961(4):29-33. (Transl. from Russian, Fish. Res. Board Can., Transl. Ser. 403, 1962.)

Reports hybrids of *O*. keta  $\bigcirc \times O$ . gorbuscha  $\bigcirc^3$  in Sakhalin hatcheries as having fast growth, early maturity, and excellent eating qualities.

1963. Gibridy kety s gorbushei v rekakh severa (Hybrids of chum × pink salmon in the rivers of the north). Rybn. Khoz. 1963(4):24-26. (In Russian.) (Japanese translation *in* Soren hokuyō-gyogyo kankei bunkenshū, Hokuyōshigen Kenkyu Kyōgikai, No. 54.)

Gives morphological and meristic data on hybrids of O.  $keta \times O$ . gorbuscha in the commercial catch in the rivers of the northern territories of the USSR (Barents and White Seas).

- Kato, T.
  - 1966. Studies on the techniques of salmon- and trout-culturing 3. Growth and survival rate of Salvelinus pluvius, Salvelinus fontinalis fontinalis and the hybrid, Salvelinus pluvius Q × Salvelinus fontinalis of . Bull. Freshwater Fish. Res. Lab. (Tokyo) 16(1):59-65. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 2035, 1972.)

Reports that fertile hybrids of *S. malma* (*pluvius*)  $\bigcirc \times S$ . *fontinalis*  $\bigcirc^n$  were intermediate in growth rate to the two parents.

Kawashima, K., and R. Suzuki.

1968. Lepidological study in some Japanese salmons. Bull. Freshwater Fish. Res. Lab. (Tokyo) 18(1):49-59. (In Japanese with English summary.)

Reports on hybridization of an unknown *Oncorhynchus* sp. with *O. rhodurus* and *O. masou* to show that the unknown species was actually *O. rhodurus*.

# Kendall, W.C.

1919. A hybrid salmonid. Copeia 1919(72):61-63.

Johnson, V.K.

<sup>1909.</sup> La pisciculture en France. J.-B. Bailliere et Fils, Paris. 532 p.

Gives morphometric and meristic data on a natural hybrid of *S*. *fontinalis*  $\times$  *S*. *gairdneri*.

\*1920. What are rainbow trout and steelhead trout? Trans. Am. Fish, Soc. 50:187-199.

Mentions intraspecific hybridization of S. gairdneri. Reference to Day's work.

Kirpichnikov, V.S.

1938. Gibridizatsiya ryb i problema geterozisa (Hybridization of fish and the problems of heterosis). Izv. Akad. Nauk SSSR, Ser. Biol. 1938(4):957-974. (In Russian, with English summarv.)

Reports on heterosis in interspecific hybrids of S. salar and S. trutta.

#### Klein, W.D.

1966a. The summer movement of hybrid and brook trout into an inlet stream. Prog. Fish-Cult. 28(3):146-151.

"Hybrid trout (Salvelinus fontinalis  $\times$  S. namaycush) and brook trout (Salvelinus fontinalis) were recovered in a trap in the inlet of Parvin Lake during the summer of 1962."

1966b. Mortality of trout caught on artificial lures and released by fishermen. Trans. Am. Fish. Soc. 95(3):326-328.

Includes mention of splake.

1967. Evaluation of a pulsating direct-current shocking device for obtaining trout from a lake for population estimates. Prog. Fish-Cult. 29(3):140-149.

Reports that splake are numerous in Parvin Lake, Colorado.

Klein, W.D., and L.M. Finnell.

1969. Comparative study of coho salmon introductions in Parvin Lake and Granby Reservoir. Prog. Fish-Cult. 31(2):99-108.

Mentions splake in Parvin Lake.

Kleinert, S.J., P.E. Degurse, and T.L. Wirth.

1968. Occurrence and significance of DDT and dieldrin residues in Wisconsin fish. Wisc. Dep. Nat. Resources, Tech. Bull. 41, 43 p.

Splake were included in the study.

Klose, J., H. Hitzeroth, H. Ritter, E. Schmidt, and U. Wolf. 1969. Persistence of maternal isoenzyme patterns of the lactate dehydrogenase and phosphoglucomutase system during early development of hybrid trout. Biochem. Genet. 3:91-97. "In unfertilized eggs as well as in embryos from fertiliza-

tion onward, isoenzymes of the LDH and PGM systems are seen in all four fish types examined (the two parental species and their reciprocal hybrids)." *S. trutta* and *S. gairdneri* were used in this study.

Kmiotek, S., and A.A. Oehmcke.

1959. Will the splake make good? Wisconsin Conserv. Bull. 24(6):23-24.

Reports on reciprocal crosses of *S. namaycush* and *S. fontinalis*. Splake described and discussed.

Kner, R.

1865. Ueber Salmoniden-Bastarde. Verh. Zool.-Bot. Ver. Wien 15:199-202. Abstract in A. Gesam. Naturwiss. Berlin 27:453-454.

According to Dean (1962) the report includes mention of S. trutta (fario and including Trutta lacustris)  $\times$  S. alpinus (salvelinus) hybrids in Bärau near Gmunden, Autria. Also abstracted in Zoological Record 1865.

Knoch, J.

1884. Die künstliche Zucht der Lachse, Lachsforellen, Forel-

len und der Bastarde derselben, sowie ihre Verpflanzung und Acclimatisation in den Flüssen Welikaja, Pskowa und in dem Pleskauer See. Corresp.-Bl. Riga 27:1-13.

According to Dean (1962), the report mentions S. trutta (fario)  $\times$  S. alpinus (salvelinus) hybrids produced at various localities in Germany and Russia.

#### Knowles, A.

1969. How 1 bred the 'Sunbeam.' Trout and Salmon Mag., July:30, 32-33.

An account about Durleigh Reservoir (U.K.) hatchery's fast-growing hybrid backcross of *S. gairdneri*  $\bigcirc \times S. truita \bigcirc to S. truita \bigcirc to s. truita \bigcirc to support of the sup$ 

Kobayashi, Hiromu.

\*1962. Morphological and genetical observations in hybrids of some teleost fishes I. J. Hokkaido Gakugei Univ., Sec. 11 B, 13 (suppl.), 112 p.

Includes very brief reference to S. salar  $\times$  S. trutta hybrids.

1964. Biological study on hybrids of the salmonid fishes. Cytological observation of fertilization in the cross between the chum-salmon and the pink-salmon. Sci. Rep. Hokkaido Salmon Hatchery 18:67-72. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1050, 1968.)

Reports that the results of the cytological study on the fertilization in reciprocal crosses of *O*. *keta* and *O*. *gorbuscha* coincided with those for normal *O*. *keta*.

1966. A chromosome study in funa-loach hybrids. J. Hokkaido Gakugei Univ., Sec. II, 16(2):114-120.

According to Schwartz (1972), the report includes mention of S. salar  $\times$  S. trutta hybrids.

Kobayasi [sic], Hiromu.

1963. Some cytological observations on fertilization in the cross between the dog-salmon and the pink-salmon. Cytologia 28(4):365-375.

"The process of fertilization and the course of early cleavages in the cross between the dog-salmon (Oncorhynchus keta) and the pink salmon (Oncorhynchus gorbuscha), and in its reciprocal cross were found to proceed in normal manner. There occurred no de- and poly-spermic condition in insemination. The behavior of chromosomes during early cleavage of the hybrid egg showed nothing unusual. There was no lag or elimination of any chromosomes. "There is no evidence to show that the spermatozoa acted as a parthenogenetic agent."

1965. A chromosome study in inter-family hybrids between the funa and the loach. Nucleus 8(1):1-6.

Includes a brief discussion of Svärdson's (1945) work. 1969. The testicular development of 2 kinds of hybrid fishes.

Proc. Jap. Soc. Syst. Zool. 5:32-36 (In Japanese, with English abstract.)

p. 32—"The hybrids from O, keta  $Q \times O$ , gorhuscha  $\mathcal{O}$ : The testes were taken out of two immature males and a mature male in the breeding season. In the apperance [sic] the testes were similar to those of both parent species. The immature testes showed spermatogenetic activity, in the peripheral region of each seminiferous tubule there were germ cells in process of meiotic division surrounding the mass of spermatozoa in the central part. The mature testes were filed [sic] with the mass of finished spermatozoa. But the spermatozoa of the hybrids were less rare in density than those of both parent species."

#### Kobayasi, Hisao.

- 1955. Comparative studies of the scales in Japanese freshwater fishes, with special reference to phylogeny and evolution. Jap. J. Ichthyol. 4(1-3):64-75.
  - Discusses the scales of hybrid O. masou (macrostoma)  $\times$  O. rhodurus.
- Koshida, H.

1940a. Ecological study of trout and hybridization experiments. Part 1. Ecological study of trout. Suisan Kenkyushi 35(7):180-183. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1165, 1968.)

Discusses coloration of fertile *O*. masou  $\bigcirc \times O$ . rhodurus  $\bigcirc$  hybrids.

- 1940b. Ecological study of trout and hybridization experiments. Part 2. Hybridization tests of the trout family. Suisan Kenkyushi 35(8):201-203. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1166, 1968.)
  - Reports that O. nerka var. adonis  $\heartsuit \times O$ . rhodurus  $\eth$  and O. nerka var. adonis  $\heartsuit \times S$ . fontinalis  $\eth$ crosses all died before reaching complete germination. S. fontinalis  $\heartsuit \times O$ . rhodurus  $\eth$  hybrids were healthy young. (In the translation O. nerka var. adonis should be substituted for "rainbow trout" and O. rhodurus for "Salmo mocrostoma.")

Kosorić, D., and T. Vuković.

1969. Ispitivanja mogućnosti hibridizacije salmonidnih vrsta sliva Neretve (A research of possibilities of hybridization of salmonidae species of the Neretva river confluence). Ichthyologia (Sarajevo) 1(1):57-67. (Transl. from Croatian, Fish. Res. Board Can., Transl. Ser. 2275, 1972.)

"There are no data in literature concerning possibilities of artificial hybridization of salmonidae and particularly endemic fish species in the Neretva River Yugoslavia. This paper offers the first data concerning the success of reciprocal crossing as well as the conditions in which the experiments were carried out. These first attempts of artificial crossing do not cover, for the time being, research of breeding and fecundity of hybrids of F1 generation, but our further work will cover that problem as well. In the completed experiments we used the following species: 1. Genus Salmo-a) brown trout (Salmo trutta m. fario L.); b) rainbow trout (Salmo gairdneri irideus Gib.); c) Neretva salmon (Salmo marmoratis [sic] Cuv.); and 2. Genus Salmothymus-a) Neretva softmouth (Salmothymus obtusirostris oxyrhynchus Steind.)." (Authors' abstract)

Krykhtin, M.L.

1962. Materialy o rechnom periode zhizni simy (Data on the stream period of life of masu salmon). Izv. Tikhookean. Nauchn.-issled. Inst. Rybn. Khoz. Okeanogr. 48:84-132. (In Russian.)

p. 108-111—Reports on some peculiarities of embryonic and larval periods of development of hybrids of *O. masou* and *O. gorbuscha*.

Kusakina, A.A.

1958. Teploustoichivost' muskulaturu lososya i lososyataimeni (Heat-resistance of the musculature of the salmon and of the salmon × salmon-trout). Tez. Dokl. Nauch. Sessii Inst. Tsitol., Akad. Nauk SSSR, Posvyashch. XL Godovshch. Vel. Okt. Sots. Rev. [Theses of Reports of the Scientific Session of the Institute of Cytology of the Academy of Sciences USSR Devoted to the Fortieth Anniversary of the Great October Socialist Revolution]:12. Cited in Kusakina (1959).

1959. Tsitofiziologicheskoe issledovanie myshechnoi tkani pri geterozise u nekotorykh mezhvidovykh gibridov ryb (Cytophysiological investigation of muscle tissue in certain interspecific fish hybrids with heterosis). Tsitologiya 1(1):111-119. (Transl. from Russian, U.S. Dep. Commer.,

Natl. Tech. Inf. Serv., Springfield, Va. as JPRS-1802-N.) "Hybrids of the Baltic salmon (Salmo salar L.) and the salmon-trout [taimen] (S. trutta L.), of the vendace (Coregonus albula infraspecies ladogensis Pravdin) and the lavaret (C. lavaretus ludoga Poliakov) were the object of the study...the interspecies cross-breeding in the two investigated cases led to an increase in the resistance of the cells of the hybrids, and this phenomenon, in our opinion, is associated with a change in cell proteins." Biol. Abstr. 45(14), No. 59684 incorrectly reports "salmon, taimen (Hucho taimen Pall.) and their hybrids." (Original seen).

Kuznetsov, I.I.

\*1928. Nekotorye nablyudeniya nad razmnozheniem Amurskikh i Kamchatskikh lososei (Some observations on the spawning of the Amur and Kamchatka salmons). Izv. Tikhookean. Nauchn.-Promysl. Stn. 2(3). 195 p. (Transl. from Russian by N.B. Notkin, Fish.-Oceanogr. Library, Univ. Washington, Seattle, Microfilm B 341.)

p. 109—"It is worthwhile to note that the external species characteristics of certain fish sometimes were shown so indistinctly that experienced Japanese sorters made mistakes determining species and threw a chum in with the sockeye and vice versa. In such cases the determination of the species was made by us by the color of the meat, which gave a sharp contrast from one species to another. The crossing of the characteristics of the fish (which has effect, one must suppose, in some degree or other, also on their fecundity), is probably the result of the chum and the sockeye spawning in the same place, giving a crossbreed. At any rate, the experience of crossbreeding on the Amur pink and summer chum points out the possibility of obtaining hybrids also between the chum and the sockeye or with the coho."

p. 165— "Also an interesting fact was the spawning together of chum and sockeye. In one case 1 saw a large male chum drive off the sockeye males and then spawn for some days alone with a sockeye female. On the other hand, in another place the chum female in the process

Kruse, T.E.

<sup>1959.</sup> Grayling of Grebe Lake, Yellowstone National Park, Wyoming, U.S. Fish Wildl. Serv., Fish. Bull. 59:307-351. Reports that 5. gairdneri (in 1907) and S. clarki (in 1912) were planted in Grebe Lake. "Since that time the two salmonid species have hybridized to such an extent that by 1952 no fish were found which were definitely pure strains of cutthroat or rainbow trout, but with a red slash on each side of the hyoid membrane. Hyoid teeth, a cutthroat characteristic, were present in all specimens examined. Body forms range from the typical elliptical shape of the cutthroat to the blunt, stocky, high-shoulder outline of the rainbow."

of spawning finished with a male sockeye." (Transl. from Russian by J.R.D.)

La Blanchère, H. de.

- 1885. La pêche et les poissons: noveau dictionnaire général des pêches. Librarie Ch. Delagrave, Paris. 859 p.
  - p. 504—Reports that S. salar crossed with S. trutta produce mules. Dr. Fraës crossed S. trutta with Lota marmorata? (lotte). Also reports that the cross of S. alpinus × Coregonus lavaretus is fertile.

Lacepède, [E.] de.

1825. Le salmone truite-saumonée, p. 567-570. Histoire naturelle des quadrupèdes ovipares, serpents, poissons et cétacées. (Nouvelle édition). Tome quatrième. A. Eymery, Libraire-éditeur, Paris. 585 p.

Reports that hybrids of *S. trutta* and *S. salar* are infertile. Lagunov, I.I.

\*\*1971. [Review of] "The sockeye salmon (Oncorhynchus nerka)" by R.E. Foerster. Bulletin of the Fisheries Research Board of Canada, No. 162. Ottawa, 1968; 422 pp + XV. Vop. Ikhtiol. 11[1(66)]:178-180. (English transl. from the Russian in J. Ichthyol. 11(1):149-152.)

"The monograph ends with a brief account of the question of hybrids between the sockeye and other salmon. Experiments have been carried out on the crossing of males of each of five species of Pacific salmon with females of the other four species. The young of the following hybrids were found to be fully viable: chinook × sockeye, sockeye × chum, chum × pink salmon, chum × sockeye, pink salmon × chinook."

Lamond, H.

1916. The sea-trout: a study in natural history. Sherratt and Hughes, London. 219 p.

Includes a note on Day's hybridization work.

La Rivers, I.

1962. Fishes and fisheries of Nevada. Nevada State Fish and Game Comm. 782 p.

Includes review of trout hybridization.

Laurent, P.J.

\*\*1972. Lac Léman: effects of exploitation, eutrophication, and introductions on the salmonid community. J. Fish. Res. Board Can. 29(6):867-875.

p. 873—"Tentative introduction of hybrids of "spring salmon" (Salvelinus fontinalis)  $\heartsuit \times$  char (Salvelinus alpinus)  $\heartsuit$  have met with mediocre success: they exhibit low growth rates and tend to migrate rapidly to the rivers."

Lefebvre, A.

1887. Etudes sur la pisciculture. Bull. Soc. Linn. Amiens France, p. 38.

Includes mention of unknown hybrids (cited by Séguin, 1955b).

1972. Taximetric analysis of selected groups of western North American *Salmo* with respect to phylogenetic divergences. Syst. Zool. 21(2):292-307.

"In such cases where the cutthroat trout populations have probably never been exposed to the natural presence of rainbow trout in their evolutionary history, hybrid swarms are the typical result, Isolating mechanisms allowing sympatric occurrence evidently are lacking in all the diverse populations of western North American Salno, except for the rainbow trout and coastal subspecies of cutthroat trout. Massive hatchery propagation and stocking of rainbow trout, and to a lesser extent, transplants of cutthroat trout, have produced large scale hybridization causing the virtual disappearance of indigenous genotypes of several subspecies of cutthroat trout and of the Gila and Apache trouts."

Leik, T.H.

1959. Job completion reports. In Quart. Rep. Colo. Coop. Fish. Res. Unit 5:53-67.

Reports on ecology and life history of the splake trout, downstream migration studies, and creel census of hybrid S. namaycush  $\times$  S. fontinalis in Parvin Lake, Colorado.

1960a. Job completion reports. In Quart. Rep. Colo. Coop. Fish. Res. Unit 6:1-35.

Gives an evaluation of the splake trout. See also Leik (1960b).

1960b. Immature splake trout in a lentic environment. M.S. Thesis, Colorado State Univ., Fort Collins. 98 p.

Reports on an initial 2-year study dealing with morphological characteristics, growth and food habits, distribution, environmental requirements, and harvest of splake.

Leon, K.A.

1970. Some aspects of the comparative biology of an interracial hybrid rainbow trout and the two parental stocks. Ph.D. Thesis, Univ. Washington, Seattle. 125 p.

Reviews previous papers on hybridization.

Leopold, A.

1918. Mixing trout in western waters. Trans. Am. Fish. Soc. 47(3):101-102.

Discusses the phenomenon of planted trout hybridizing with each other and native trout. Mentions fishermen's reports of rainbow and cutthroat (native black-spotted) trout cross.

Lestage, J.A.

1939. L'hybridation truite fario et saumon. Pêche et Piscic. (12):316-317.

Mentions hybridization of *S. trutta (fario)* and *S. salar* (cited in Séguin, 1955b).

1882a. Hybridism in fishes. Arch. Naturges., Ser. 48, 2:309-315.

According to Dean (1962), this is a review of Overbeck's (1880) report.

1882b. Ueber Bastardfische. Berlin. 9 p.

According to Dean (1962), this is a review of Overbeck's (1880) report.

- 1954. Chromosomestudien an Knochenfischen. III. Über den Einfluss anormaler Temperaturen auf die Mitoseverhältnisse im Fischei. Z. Fisch. deren Hilfswiss., N.F. 3(6/7/8):479-488. Reviews chromosome work of Svärdson (1945) on S. salar × S. trutta hybrids (2n=70).
- 1956. Chromosomenstudien an Knochenfischen. IV. Die Chromosomenverhältnisse bei der Regenbogen- und Bachforelle und Ihren Bastarden (Chromosome studies of bony fishes. IV. The chromosome complement of rainbow trout, brown trout, and their hybrids). Z. Fisch. deren Hilfswiss. N.F. 4(7):858-594.

Reports that the diploid number for *S*. gairdneri  $\times$  *S*. trutta hybrids is 70.

Lin, E.C.

1966. Thermal resistance and the correlation in inheritance among certain characters in F<sub>2</sub> lake trout, Salvelinus nanaycush × brook trout, S. fontinalis hybrids. M.A. Thesis, Univ. Toronto, Ontario. 34 p. (irregular pagination.)

Legendre, P., C.B. Schreck, and R.J. Behnke.

Leuckart, R.

Lieder, U.

"The resistance in  $F_2$  lake  $\times$  brook trout hybrids to high temperatures were examined in this study. There is an indication that the  $F_2$  response to lower upper lethal temperature is closer to that of the brook trout rather than the lake trout.

"Three characters which differ in the parent species namely resistance to high temperature, vertebral count and the ability to retain gas in the swimbladder while under slight hydrostatic pressure were significantly correlated in the F<sub>2</sub> individuals."

LoCascio, N.J.T., and J.E. Wright, Jr.

\*1972. The impact of genetics on the trout industry. Mar. Fish. Rev. 34(9-10):31-32. (Reprinted 1973 in Am. Fishes and U.S. Trout News 17(5):18.)

Brief discussion of the potential advantages of the use of fertile trout hybrids in the trout industry and of identification of species by electrophoresis.

MacCrimmon, H.R., and J.S. Campbell.

1969. World distribution of brook trout, Salvelinus fontinalis.

J. Fish. Res. Board Can. 26(7):1699-1725.

"Liebmann and Reichenbach-Klinke state that, in some waters [in West Germany], brook trout cross with brown trout (Salmo trutta L) and give rise to the sterile hybrid (Tigerfisch)." In Poland the high vulnerability of brook trout to angling pressure and natural hybridizing with brown trout limit its numbers. In South Africa "...male brook trout are now kept at the Jonkershoek Hatchery solely for crossing with the brown trout (S. trutta) to produce the 'Tiger Trout' hybrid."

MacCrimmon, H.R., B.L. Gots, and J.S. Campbell.

\*\*1971. World distribution of brook trout, Salvelinus fontinalis: further observations. J. Fish. Res. Board Can. 28(3): 452-456.

"Both brook trout and tiger trout (brown  $\times$  brook hybrid) have been stocked in Rhodesian waters."

MacCrimmon, H.R., T.L. Marshall, and B.L. Gots.

- \*\*1970. World distribution of brown trout, Salmo trutta; further observations. J. Fish. Res. Board Can. 27(4):811-818. "The species [brown trout] is now naturalized in the mountain waters of the Oriental and Real ranges [Bolivia], and hybridization with the rainbow trout occurs (Terrazas, personal communication)."
- Mac Intyre, P.A.
  - 1960. Tumors of the thyroid gland in teleost fishes. Zoologica (New York) 45(11):161-170.
- Cites spontaneous thyroid tumors in hybrid salmonids as reported by Gaylord *et al.* (1914) and Jaboulay (1908). MacPhee, C.
  - \*\*1966. Influence of differential angling mortality and stream gradient on fish abundance in a trout-sculpin biotope. Trans. Am. Fish. Soc. 95(4):381-387.

"At the end of a summer period, Svärdson (1949) found that a hatchery trough environment favored the survival of alpine chars over char × trout hybrids and these hybrids survived better than brown trout when all three fish were mixed together."

Madsen, D.H.

1937. Protection of native fishes in the National Parks. Trans. Am. Fish. Soc. 66:395-397.

Mentions natural S. clarki  $\times$  S. gairdneri hybridization. Maeda, K.

1931. Cross breeding of salmon. Keison-iho 3(2):7-8.

According to Inaba (1953), this is a translation into Japanese of a Pacific Fisherman (1930) report on Foerster's work.

Mahnken, C.V.W., A.J. Novotny, and T. Joiner [Joyner].

1970. Salmon mariculture potential assessed. Am. Fish Farmer 2(1):12-15, 27.

Reports that hybrids of *O. tshawytscha* and *O. gorbuscha* were used in experimental floating pens in Puget Sound. Makino, S.

1956. An atlas of the chromosome numbers in animals. (2nd ed.). Iowa State College Press, Ames, Iowa. 290 p.

p. 225-226—Refers to chromosome numbers reported in Prokofieva's (1934a) and Svärdson's (1945) hybrid work. Malloch, P.D.

- 1910. Life-history and habits of the salmon, sea-trout, trout, and other freshwater fish. Adam and Charles Black, London. 264 p.
  - Refers to Day's (1887) work with illustration of a zebra trout (*S. fontinalis* and *S. trutta*).

Manwell, C., and C.M.A. Baker.

1970. Molecular biology and the origin of species. Univ. Washington Press, Seattle. 394 p.

Refers to biochemical work on salmonid hybrids.

Martin, N.V.

1960. Annotated bibliography of the eastern brook trout × lake trout hybrid (Salvelinus fontinalis × Salvelinus namaycush). Ont. Dep. Lands Forests, Res. Inf. Pap. (Fish.) No. 7. 12 p.

Bibliography of splake literature through 1960.

1965. Wendigo—the not-so-evil spirit. Ontario Fish Wildl. Rev. 4(3):12-18.

Popular account of splake or wendigo, including information on spawning.

\*\*1967. Investigation of European fishes for introduction to Ontario waters. Ont. Dep. Lands Forests, Res. Inf. Pap. (Fish.) 32. 47 p.

"Splake (Salvelinus namaycush  $\times$  Salvelinus fontinalis) were introduced into two Swedish lakes in 1964."

Martin, N.V., and N.S. Baldwin.

1960. Observations on the life history of the hybrid between eastern brook trout and lake trout in Algonquin Park, Ontario, J. Fish. Res. Board Can. 17(4):541-551.

"In most features investigated, the hybrid trout has a greater affinity to the brook trout than to the lake trout. In angling, depth distribution, food, maturity, fecundity, and time and duration of spawning the hybrid trout is closer to the brook trout than the lake trout. Length-weight relation-ship, and place of successful spawning, are more similar to the lake trout. The hybrids grow faster than either parent, and school more strongly. Their spawning behaviour shows characteristics of each parent."

Martin, N.V., and F.E.J. Fry.

1972. Lake Opeongo: effects of exploitation and introductions on the salmonid community, J. Fish. Res. Board Can. 29(6):795-805.

p. 797—"Although in nearly every case survival has been low, both planted lake trout and hybrid trout [splake] have been taken in ripe condition from native lake trout spawning beds."

Martin, N.V., and D.C. Scott.

1959. Use of tricaine methanesulfonate (M.S. 222) in the trans-

port of live fish without water. Prog. Fish-Cult. 21(4):183-184.

Reports on transport of splake hybrids by aircraft in Ontario.

- Massaro, E.J., and C.L. Markert.
- 1968. Isozyme patterns of salmonid fishes: evidence for multiple cistrons for lactate dehydrogenase polypeptides. J. Exp. Zool, 168(2):223-238.

"...salmonids arose by tetraploidization of a primitive ancestor, in our view probably through allotetraploidization of a hybrid ancestor." Mention of splake.

Mather, F.

1876. Hybrid Salmonidae. Forest and Stream 6:69. Discusses Green's *S. fontinalis*  $\Im \times O$ . *tshawytscha*  $\Im$  hybrids in the Caledonia hatchery.

1900. Modern fish culture in fresh and salt water. Forest and Stream Publ. Co. 332 p.

According to Schwartz (1972), this report mentions hybrids in Salmonidae.

Matthey, R.

1949. Les chromosomes des vertébrés. Librairie de l'Université, F. Rouge-Lausanne. 356 p.

p. 38—Mentions Svärdson's (1945) and Prokofieva's (1934a) work.

\*\*1970. Preferred temperature of yearling lake trout, *Salvelinus namaycush*. J. Fish. Res. Board Can. 27(10):1729-1733.

"...the lake trout, like *Oncorhynchus keta* and brook  $\times$  lake trout hybrid (Pearson, MS 1952), belongs to type 5 of Zahn's classification characteristic of species having a moderate degree of stenothermality."

# McClane, A.J.

1959. New trout for tomorrow. Field and Stream 63(11):68-71, 116-119.

Reviews trout hybrids' usefulness for stocking for anglers. McClane, A.J. (ed.).

1965. McClane's standard fishing encyclopedia and international angling guide. Holt, Rinehart and Winston, New York. 1057 p.

Mentions tiger trout and, under the heading of Fish Culture, contains a review of hybrid trout.

#### McFarland, W.N., and F.W. Munz.

1965. Codominance of visual pigments in hybrid fishes. Science 150(3699):1055-1057.

Reports that visual pigments of *S. namaycush* and *S. fontinalis* are based on two different proteins. "Both proteins are present in first-generation hybrids between these species and they segregate in second-generation and backcross hybrids, as expected of a single-factor difference."

#### McPhail, J.D.

1961. A systematic study of the Sahvelinus alpinus complex in North America. J. Fish. Res. Board Can. 18(5):793-816. "The validity of doubful species pairs can be established if they occur sympatrically without mass hybridization. Occasional hybridization may occur, but as long as the hybrids are rare the species can be considered valid. In Karluk and Fraser Lakes S. malma and S. alpinus occur sympatrically. The evidence indicates that within these lakes hybridization between S. malma and S. alpinus rarely, if ever, occurs.

"From the data presented, S. alpinus and S. malma are considered as discrete species, each subject to geographic variation, which occur sympatrically in certain areas of Alaska with little or no hybridization."

Meehan, W.E.

1898. Hybrids between genera. In Report of the assistant secretary and statistician, p. 29-32. [Pennsylvania] Rep. State Comm. Fish., for the year 1898.

Discusses hybridization and reports on preliminary *S*. gairdneri  $\times$  Perca flavescens crosses. See also Meehan (1900).

1900. Hybrid trout-perch. In Report of the assistant secretary and statistician, p. 48-53. [Pennsylvania] Rep. State Comm. Fish., for the year 1899.

Remarks on S. gairdneri × Perca flavescens hybrids. See also Buller (1900).

1908. Hybrids between brook and brown trout, p. 55. Rep. Dep. Fish. Commonwealth of Pennsylvania, December 1, 1906, to November 30, 1907.

Remarks on S. trutta  $\times$  S. fontinalis hybrids of Buller (1908).

Menasveta, D.

1961. Effects of interracial hybridization on growth, mortality, and yield of rainbow trout (*Salmo gairdneri*, Richardson). Ph.D. Thesis, Univ. Washington, Seattle, 154 p. (Diss. Abstr. 23(7):2644.)

Discusses interspecific hybridization briefly.

Merriner, J.V.

1966. Artificial intergeneric hybridization among four centrarchid genera with an evaluation of egg size as a factor in determining hybridization success. M.S. Thesis, North Carolina State Univ., Raleigh. 81 p.

Briefly reviews salmonid hybridization experiments and effects of egg size.

Michigan Conservation.

1966. Birth of the splake maybe? Mich. Conserv. 35(5):32. Reports on F₂ hybrids of S. namaycush Q × S. fontinalis ♂ mentioned in The First Annual Report of Fish Culture by Michigan's Fish Commissioners (1880).

Miller, R.B.

1950. Recognition of trout in Alberta. Can. Fish Cult. 6:23-25. Describes rainbow × cutthroat hybrids in Alberta.

1957. Have the genetic patterns of fishes been altered by introductions or by selective fishing? J. Fish. Res. Board Can. 14(6):797-806.

"Changes in some salmonids may be assigned to introgressive hybridization, particularly where rainbow and cutthroat trout have been put together on the Eastern Slopes. In many cases, however, exotics have apparently failed to contribute to the gene pool of the resident population, and most hybrids, when they occur, have been of low fertility." Limited review of other works.

Miller, R.B., and W.H. Macdonald.

1949. Preliminary biological surveys of Alberta watersheds 1947-1949. Alberta Dep. Lands and Forests. 139 p. Reports that S. clarki × S. gairdneri hybrids are not uncommon in Alberta.

Miller, R.R.

1950. Notes on the cutthroat and rainbow trouts with the description of a new species from the Gila River, New Mexico. Occas. Pap. Mus. Zool., Univ. Mich. 5291-43. Discusses hybrid trout. "A possible hybrid origin for S. gilae is discussed in detail and discounted."

1960. Review of Rainbow trout in Mexico and California with notes on the cutthroat series, by P.R. Needham and R.

McCauley, R.W., and J.S. Tait.

Gard. Univ. Calif. Publ. Zool. 67:1-124. Prog. Fish-Cult. 22(2):94-96.

Reviews Needham and Gard (1959). Suggests that introduced trout may have hybridized with native stocks in Mexico. The native trout of the Gila River basin in New Mexico and Arizona are said to be reduced in numbers through hybridization and introgression of characters.

1972. Classification of the native trouts of Arizona with the description of a new species, *Salmo apache*. Copeia 1972(3):401-422.

Discusses hybridization and evolution of *S. apache, S. aguabonita, S. chrysogaster, S. clarki, S. gairdneri,* and *S. gilae.* 

1945. The introduced fishes of Nevada, with a history of their introduction. Trans. Am. Fish. Soc. 73:173-193.

Reviews hybridization in Nevada of S. gairdneri and S. clarki.

Milne, D.J.

1948. The growth, morphology and relationship of the species of Pacific salmon and the steelhead trout. Ph.D. Thesis, McGill Univ., Dep. Zool., Montreal, Canada. 101 p. Includes review of Foerster's (1935) work.

Moenkhaus, W.J.

1911. Cross fertilization among fishes. Proc. Indiana Acad. Sci. 1910:353-393.

Reports that one cross of *S. namaycush*  $\heartsuit \times S$ . *fon-tinalis*  $\circlearrowleft$  was made with a large percentage impregnation. Hybrids were hatched and reared to fingerlings.

Moon, T.W., and P.W. Hochachka.

1971. Effects of thermal acclimation on multiple forms of the liver-soluble NADP+-linked isocitrate dehydrogenase in the family Salmonidae. Comp. Biochem. Physiol. 40B(1): 207-213.

"Three members of the family Salmonidae have been examined for multiple forms of the liver-soluble form of NADP+-linked IDH; species included were the lake, splake and brook trout. The number of enzyme subunits differed in these species, being one in lake, two in splake and four in brook trout. In some cases, the effect of thermal acclimation was found to shift the isozyme pattern to a dominant form, suggesting a temperature induction phenomenon. The significance of this is discussed."

Morrison, W.J.

1970. Nonrandom segregation of two lactate dehydrogenase subunit loci in trout. Trans. Am. Fish. Soc. 99(1):193-206. "Two of the five lactate dehydrogenase (LDH) subunit loci known to exist in salmonid fishes were obtained in heterozygous condition in the hybrid of lake trout (Salvelinus namaycush Walbaum) × brook trout (S. fontinalis Mitchill) and linkage tests were performed."

Morrison, W.J., and J.E. Wright.

1966. Genetic analysis of three lactate dehydrogenase isozyme systems in trout; evidence for linkage of genes coding subunits A and B. J. Exp. Zool. 163:259-270.

"Various crosses and backcrosses involving *S. fontinalis* and *S. namaycush* demonstrate that subunits A and B are each coded by different autosomal genes (LA and LB).

"Comparison of patterns of *S. fontinalis* and *S. trutta* and their hybrid seems to indicate that two additional subunits are involved in a third series of five isozymes found in the skeletal muscle of each species examined." Morton, W.M., and R.R. Miller.

1954. Systematic position of the lake trout, Salvelinus namaycush. Copeia 1954(2):116-124.

Reviews hybridization of *S. namaycush* and *S. fontinalis*. Mueller, J.

1962. Hybrid trout. Wyoming Wildl. 26(5):4-7.

Popular account of splake and its reciprocal cross brookinaw.

Mulch, E.E., and W.C. Gamble.

The Arizona native trout, Salmo gluae Miller "... is native to the headwaters of the Gila River watershed and has hybridized with the rainbow trout. The fish is now (1954) restricted to the upper headwaters of Eagle Creek in Greenlee County in its pure strain, and is probably also present in hybrid form in the Black and White Rivers and the streams of Mount Baldy."

Mullan, J.W., and W.A. Tompkins.

1959. Trout pond management in Massachusetts. Mass. Div. Fish Game. 132 p.

According to Schwartz (1972), this report mentions splake and S. fontinalis  $\times$  S. trutta hybrids.

Munz, F.W., and W.N. McFarland.

1965. A suggested hereditary mechanism for visual pigments of chars (*Salvelinus* spp.). Nature 206(4987):955-956.

"...it appears that the opsins of each parental species are both present in the hybrid splake."

Nall, G.H.

1930. Hybrids. In his Life of the sea trout, p. 204-208. Seeley Services and Co., London.

Reviews S. trutta  $\times$  S. salar hybridization in Scotland.

Nature.

1885. In Notes. Nature 31:563.

Reports on hybridization proposal of landlocked salmon and trout by the National Fish Culture Association. *See also* Day (1885c).

# Nauheim, B.

1972. Pilgrimage to Pyramid. Outdoor Life 150(5):72-75, 140-145.

S. gairdneri  $\times$  S. clarki hybrids were stocked in Pyramid Lake by Nevada Division of Fisheries. A 4- and a 7pound hybrid were caught by anglers.

Neave, F.

1958. The origin and speciation of *Oncorhynchus*. Trans. Roy. Soc. Can., Ser. 3, 52, Sect. 5:25-39.

Reports that most of the species of *Oncorhynchus* show a high degree of interfertility.

Needham, P.R.

\*\*1938. Trout streams. Comstock Publ. Co., Inc., Ithaca, New York. 233 p.

p.43—"In streams where both rainbow and golden have been planted it is often possible to catch pure examples of either species, and hybrids which will show some of the characteristics of each."

Needham, P.R., and R.J. Behnke.

1962. The origin of hatchery rainbow trout. Prog. Fish-Cult. 24(4):156-158.

Mentions introgression of S. clarki genes into S. gairdneri.

Needham, P.R., and R. Gard.

1959. Rainbow trout in Mexico and California with notes on the cutthroat series, Univ. Calif. Publ. Zool. 67(1):1-124.

Miller, R.R., and J.R. Alcorn.

<sup>1954.</sup> Game fishes of Arizona. Publ. Arizona Game Fish Dep. 19 p.

Mentions natural hybrids of *S. gairdneri* with *S. aguabonita* and *S. clarki*.

- 1964. A new trout from central Mexico: Salmo chrysogaster, the Mexican golden trout. Copeia 1964(1):169-173.
- Believe Salino chrysogaster was derived from hybridization of a primitive S. gairdneri with a primitive S. clarki. Nelson, J.S.
  - 1965. Effects of fish introductions and hydroelectric development on fishes in the Kananaskis River system, Alberta. J. Fish. Res. Board Can. 22(3):721-753.

p. 732—Refers to Gilmour (1950) and stocking of S. clarki  $\times$  S. gairdneri hybrids.

1937. Die Lachsartigen (Salmonidae). I Teil. Handbuch der Binnenfischerei Mitteleuropas 3(5):219-370.

p. 273—States that natural hybrids of *S*. *salar* and *S*. *trutta* not uncommon. Artificial hybrids also produced.

Nevada Fish Commission.

- 1911, 1913, and 1915. State of Nevada, Bienn. Rep. State Fish Comm. 1909-1910, 1911-1912, and 1913-1914. Various pagination.
  - Reports on hybridization of *S. gairdneri* and *S. clarki* and distribution records in Nevada. *See also* Miller and Alcorn (1945).

1921. State of Nevada, Bienn. Rep. Nevada Fish and Game Comm. 1919-1920. 19 p.

Includes stocking record for *S. gairdneri*  $\times$  *S. clarki* hybrids in the Humboldt River, Nevada.

New York Commissioners of Fisheries.

1879. Eleventh Rep. Comm. Fish. of the State of New York. 1879:7-10.

According to Martin (1960), the report notes splake were raised at Caledonia Hatchery. By 1881 the hatchery had a small brood stock and plantings made but never followed up.

1964. Gibridizatisya ryb i ee znachenie v akklimatizatsii (Hybridization of fishes and its role at acclimatization). Tr. Vses. Nauchn-issled. Inst. Morsk. Rybn. Khoz. Okeanogr. 55:29-46. (In Russian, with English summary.)

Reviews hybridization among Salmonidae.

Norman, J.R. (revised by P.H. Greenwood).

1963. A history of fishes. (2nd ed.). Ernest Benn Ltd., London. 398 p.

Refers briefly to Day's hybridization work.

- Northern Sportsman.
  - 1952. Monkeying with nature. Northern Sportsman (Fort Francis, Ont.) 7(4):14-15, 27.

According to Martin (1960), "Brief mention that Ontario Department of Lands and Forests and Canadian Wildlife Service hybridizing lake trout and brook trout."

- 1954. Splake hybrids. Northern Sportsman 9(2):15.
- A popular account on history and potential of splake. 1957. "Splake" may be taken this year by angling. Northern

Sportsman 12(5):32. A short note on limits, size, and seasons for splake in Ontario.

Novotny, A.J., and C.V.W. Mahnken.

1971. Farming Pacific salmon in the sea: from the ``womb to the tomb.'' (Part 1 of a 2 part series). Fish Farming Ind. 2(5):6-9. Reports on salt water rearing of Pacific salmon and their interspecific hybrids, in particular reciprocal hybrids of *O*. *gorbuscha* and *O*. *tshawytscha*.

Nümann, W.

1964. Formenkreise der italienischen, jugoslawischen und adriatischen Forellen, zugleich ein Beitrag über den Wert einiger meristischer Merkmale für Art- und Rasseanalysen. Schweiz. Z. Hydrol. 26(1):102-146. (In German, no English summarv.)

Reports on natural hybrids of S. trutta  $\times$  S. marmoratus.

Nygren, A., B. Nilsson, and M. Jahnke.

- 1972. Cytological studies in Atlantic salmon from Canada, in hybrids between Atlantic salmon from Canada and Sweden and in hybrids between Atlantic salmon and sea trout. Hereditas 70(2):295-305.
  - "Hybrids between Atlantic salmon [S. salar] and sea trout [S. trutta] have chromosome numbers around 2n=69. In the meiosis rodshaped units only, and no rings, are formed together with a high number of univalents. Thus, apparently, reciprocal translocations have caused the occurrence of multivalents in the meiosis of salmon and not autopolyploidy as was earlier assumed."

Nyman, [O.] L.

- 1965. Variation of proteins in hybrids and parental species of fishes, Rep. Swed. Salmon Res. Inst. 1965(13):1-11.
- Reports that electrophoresis protein patterns were summations of the parental species, with few exceptions, in the hybrid "bröding" (*S. adpinus × S. fontinalis*). In splake the patterns were not distinguishable from *S. fontinalis*.
- 1966. Geographic variation in Atlantic salmon. Rep. Swed. Salmon Res. Inst. 1966(3):1-6.

Reports that all the diverging electrophoretic protein bands in the parental species were summed up in the  $F_1$  hybrids of *S. salar* × *S. trutta*.

1967. Protein variations in *Salmonidae*. Rep. Inst. Freshwater Res. Drottningholm 47:5-38.

S. salar × S. trutta, S. fontinalis × S. alpinus, S. fontinalis × S. namaycush, and S. namaycush × S. alpinus hybrids were studied by starch gel electrophoresis. "Examples of species specificity, ontogenetic variation, geographic variation and various polymorphisms are presented and discussed, together with problems concerning the segregation of proteins in hybrids."

1970. Electrophoretic analysis of hybrids between salmon (*Salmo salar* L.) and trout (*Salmo trutta* L). Trans. Am. Fish. Soc. 99(1):229-236.

Reports on electrophoretic analysis of the hybrids of Piggins (1965).

1971. Plasma esterases of some marine and anadromous teleosts and their application in biochemical systematics. Rep. Inst. Freshwater Res. Drottningholm 51:109-123.

Reports on codominance of enzyme inheritance of artificially produced chum × sockeye hybrids. Chinook in text should read sockeye (O.L. Nyman, personal communication, 28 July 1972).

Ohno, S., J. Muramoto, J. Klein, and N.B. Atkin.

1969. Diploid-tetraploid relationship in clupeoid and salmonoid fish. Heredity 22, Suppl. Vol. Chromosomes Today 2:139-147.

Briefly reviews Morrison and Wrights' (1966) work.

Ontario Department of Lands and Forests.

1962. Status of fisheries research projects for the year 1961.

Neresheimer, E.

Nevada Fish and Game Commission.

Nikolyukin, N.I.

Ont. Dep. Lands Forests, Res. Branch, Sec. Rep. (Fish.) No. 44. 61 p.

According to Regier (1966), the report states that J.S. Tait and F.E.J. Fry have worked on a selection program to obtain a deep-swimming strain of splake.

\*\*1966a. Splake, p. 38. In Highlights 1966. Annu. Rep. Minister Dep. Lands Forests, Part II.

"In 1965 an international agreement was made between Canadian and United States agencies to undertake the rehabilitation of Lake Huron by stocking with highly selected splake hybrids rather than with lake trout. It was planned that the Fisheries Section of the Research Branch would allocate highly selected brood stock to production hatcheries in Ontario and Michigan. The first stock will be ready for planting in 1969 or 1970. This agreement arose out of the success of a breeding program started by the Research Branch in 1957. By 1965 the first small number of adequately selected splake were produced at the Southern Research Station. Additional numbers are in culture and will come through the selection procedures during 1966 and subsequent years.''

1966b. Status of fisheries research projects 1966. Ont. Dep. Lands Forests, Res. Branch, Sec. Rep. (Fish.) No. 64. 151 p.

The report reviews the splake program of the Selective Breeding Unit.

- Oregon State Game Commission.
  - 1948. A hybrid trout from Fish Lake. Oreg. State Game Comm. Bull. 3(6):7.

Describes a tiger-trout-like hybrid. The lake contains only *S. gairdneri* and *S. fontinalis*.

Oshima, M.

- 1929. Two or three findings on the classification and life history of yamame (Oncorhynchus masou) and amago (Oncorhynchus rhodurus). Shizen Kagaku (Nat. Sci.) 4:129-150. (In Japanese.)
  - According to Terao (1970), the report says that  $F_1$  hybrids were found in natural rivers.
- 1930. The distribution of yamame (Oncorhynchus masou) and amago (Oncorhynchus rhodurus). Rigaku-kai (Nat. Sci. Assoc.) 28:29-30. (In Japanese.)
  - According to Terao (1970), the report states that  $F_1$  hybrids were found in natural rivers.
- 1934. Life-history and distribution of the freshwater salmons found in the waters of Japan. Proc. Fifth Pac. Sci. Cong. (1933) 5:3751-3773.
  - Discusses reciprocal crosses, backcrosses and  $F_2$  hybrids of *O*. masou and *O*. rhodurus. At the time, the cross was carried out extensively and great numbers of  $F_1$  liberated into the streams.
- 1940. Sakana (Fish). Sanseido Co., Tokyo. (In Japanese.) According to Kobayasi (1955), the report mentions hybrids of O. masou (macrostoma) and O. rhodurus. P. 135-140 cited by Terao and Hayashinaka (1961).
- 1957. Studies on the dimorphic salmons, Oncorhynchus masou (Brevoort) and Oncorhynchus rhodurus Jordan & McGregor, found in Japan and adjacent territories. Nire Shobo (Nire Book Company), Sapporo, Japan. 81 p. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 2104, 1972.)

Reports on hybridization of *O. masou* and *O. rhodurus*. 1959. Occurrence of the natural hybrid between *Oncorhynchus* masou and *Oncorhynchus rhodurus* in the upper stream of Tenriu River. Dobutsugaku Zasshi 68(7):259-262. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1098, 1968.)

Describes naturally-produced hybrids between *O. masou* and *O. rhodurus* which are then given a new name, *Oncorhynchus hybridus* sp. nov.

Otterstrøm, C. V.

1914. Danmarks Fauna. No. 15. Fisk II. Blødfinnefisk, G.E.C. Gads Forlag., Kobehaven. 351 p.

According to Schwartz (1972), this book mentions S. trutta  $\times$  S. fontinalis hybrids.

Outdoor California.

1956. First splake trout caught by anglers. Outdoor Calif. 17(7):3.

Reports that splake were planted in Lower Salmon and Deer Lakes in 1955.

Overbeck, G.

- 1880. Sind Bastardfische fruchtbar oder steril? Dtsch. Fisch.-Ztg. 3:67.; Oesterr.-ungar. Fisch.-Ztg. 1:36.
  - Both references cited by Dean (1962). The first reference seen by us and mentions breeding 2-year-old salmon hybrids [Lachsbastard—S. salar × S. trutta (fario)?], but does not give results.
- 1883. Über Salmoniden-Bastarde. Dtsch. Fisch.-Ztg. 40:326. Cited by Schwartz (1972).
- Pacific Fisherman.

\*\*1905. Hybrid salmon. Pac. Fisherman 3(2):13.

- "Saml. Haigh, in a letter to the Vancouver Province, says: "Last October I saw several of the hybrid sockeye and cohoe salmon from Bon Accord hatchery. They were about the size of the sockeye, and like this salmon, the headand back were dark-blue, with the spots characteristic of the cohoe. As I was not aware that the hatchery folk had been crossing them I was puzzled to account for their appearance. The flesh was as dark a red as the sockeye. I saw about twenty of these hybrids during the season, though there might have been a great many more than that."
- 1930. Cross-breeding of salmon. Pac. Fisherman 28(11):20. An account of Foerster's (1930) work.

Paetz, M.J., and J.S. Nelson.

1970. The fishes of Alberta. Government of Alberta, The Queen's Printer, Edmonton. 281 p.

Includes mention of splake, S. malma  $\times$  S. fontinalis, tiger trout, S. fontinalis  $\times$  S. alpinus, and S. clarki  $\times$ S. gairdneri hybrids in Alberta.

Pappenheim, P.

1909. V. Pisces (inkl. Cyclostomata), Fische. In A. Brauer (ed.), Die Süsswasserfauna Deutschlands Heft 1: Mammalia, Aves, Reptilia, Amphibja, Pisces, p. 90-201. Verlag von Gustav Fischer, Jena. (Reprinted 1961, Verlag von J. Cramer, Weinheim.)

p. 122-123—Reports that S. alpinus (salvelinus)  $\times$  S. fontinalis hybrid is a popular hatchery fish because of rapid growth.

Paust, G.

1955. Canada creates a great new trout. Sports Illus. 3(2):36-39. A popular account of Stenton's (1950, 1952) work.

Pavlov, I.S.

1959. Opyty gibridizatsii Tikhookeanskikh lososei (Experiments on the hybridization of Pacific salmon). Rybn. Khoz. 35(6):23-24. (Transl. from Russian, Fish. Res. Board Can., Transl. Ser. 263, 1960.)

Reports meristic and morphological data on *O*. *keta*  $\bigcirc \times O$ . *gorbuscha*  $\bigcirc$  hybrids, which returned in two years with average weight in excess of *O*. *keta*.

Payne, R.H., A.R. Child, and A. Forrest.

1972. The existence of natural hybrids between the European trout and the Atlantic salmon. J. Fish Biol. 4(2):233-236. "Natural hybrids between Atlantic salmon (*Salmo salar* L.) and European trout (*S. trutta* L.) have been detected in a sample of 4431 fish which appeared to be Atlantic salmon. The methods of analysis for serum protein, serum esterase and serum lactic dehydrogenase are given. The possible occurrence of hybrids having the appearance of European trout and the effect of introgression on salmon stocks are discussed."

Pearson, B.E.

1952. The behaviour of a sample of hybrid trout (Salvelinus fontinalis × Cristivomer namaycush) in a vertical temperature gradient. Rep. Ont. Fish. Res. Lab., Univ. Toronto. 24 p. (Unpublished.)

"The distribution of hybrid trout in a tank of uniform temperature was influenced by their feeding habits. Their distribution was not affected by light intensity. Their activity was affected by light intensity, being greater in bright light. The mean of the distribution in a vertical temperature gradient i.e. the preferendum, did not vary with change in acclimation temperature over the range studied but remained constant at the 12°C. level."

Pegington, C.J., and H. Rees.

1967. Chromosome size in salmon and trout. Chromosoma (Berlin) 21(4):475-477.

"Measurements of a specific chromosome, *S*, of the salmon [*S. salar*] complement and of another, *S*<sup>1</sup>, of the trout [*S. trutta*] complement in nuclei of parent species and of the hybrid show that the difference in size is maintained in hybrid nuclei."

[Pennsylvania] Reports of the State Commissioners of Fisheries, for the years 1887-1901.

Cited by Martin (1960) as referring to splake. Those reports available to us for review included scant information on unspecified "hybrid trout" from the Western Hatchery, Corry, Pennsylvania, with distribution lists. *See* Buller (1898 and 1900) and Meehan (1898 and 1900). Possibly *S. fontinalis* × *S. namaycush* (Forest and Stream 1889a).

Peters, J.C.

1964. Age and growth studies and analysis of bottom samples in connection with pollution studies. Montana Fish Game Dep., Dingell-Johnson Job Completion Rep. F-23-R-6. 76 p. (Mimeo.)

Gives age data for S. clarki × S. gairdneri hybrids.

Peterson, L.W.

1955. Winter fisheries investigation on Buffalo Bill Reservoir-1955. Wyo. Game Fish Comm., Fish. Tech. Rep. No. 1. 21 p.

Mentions rainbow  $\times$  cutthroat hybrids. *See also* abstract in Sport Fishing Institute (1955b).

Peyrer, C.

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1876. Fisheries and fishery laws in Austria and of the world in general. U.S. Comm. Fish and Fish., Rep. Comm. 1873-4 and 1874-5:571-679.

"In Upper Austria, the eggs of the Salmo salvelinus [S.

*alpinus*] are mostly impregnated with the milt of brooktrout [*S. trutta*]."

Phillipps, W.J.

1922. Hybridism of *Salmo irideus* and *Salmo fario* in Australasia. N.Z.J. Sci. Technol. 5(2):98-100.

Reviews hybridization of *S. gairdneri* and *S. trutta* and traces the results of experiments in hybridization of same in Australasia.

1923. Hybridism of *Salmo irideus* and *Salmo fario* in Australasia. Salmon and Trout Mag. 31:100-103.

Reprint of Phillipps (1922) with minor addition.

1926. Hybridism of brown and rainbow trout: No. 2. N.Z.J. Sci. Technol. 8(4):255-256.

Provides some additional information to Phillipps (1922). Piggins, D.J.

1964. Salmon and sea trout hybrids. Salmon Res. Trust Ireland, Annu. Rep. 1964:27-37.

"F.1 hybrids of salmon and sea trout (almost 5 years old at the end of 1964) reached an average length of 17.3" and were stripped for the third time. F.2 hybrids resulting from earlier strippings were reared in ponds and released into a land-locked lake where their average size as 1+ fish was 10", with some specimens of over 12" in length."

1965. Salmon and sea trout hybrids. Atl. Salmon J. 1965 (Fall): 3-5.

Reports that S. salar  $\mathcal{Q} \times S$ . trutta  $\mathcal{O}$  hybrids showed hybrid vigor for their first two years. Backcrosses of both sexes to both species have been successful.

1966. Further studies on the specific characteristics of brown trout and salmon-sea trout hybrids. Salmon Res. Trust Ireland, Annu. Rep. 1966:29-32.

"There was approximately 50% survival to underyearlings of salmon × sea trout hybrids obtained by fertilizing grilse ova with milt from sea trout in 1965. The complementary cross using sea trout ova and milt from grilse was a failure. Some 480, 2+ hybrid smolts were allowed to go to the sea in 1966, of which 18 have been recaptured resembling sea trout finnock, as in 1965. Rod-fishing for land-locked hybrids continued in 1966 when the fish averaged 1½ lbs. in weight at 3+ years of age."

1970. Salmon × sea trout hybrids, (1969-70). Salmon Res. Trust Ireland, Annu. Rep. 1970, 15:41-58.

Comprehensive report of the *S. salar*  $\times$  *S. trutta* hybridization carried on during the years 1960-1970.

# Pincher, C.

\*\*1948. A study of fish. Duell, Sloan and Pearce, New York. 343 p.

p. 262—"The salmon and trout, which belong to the same genus, *Salmo*, hybridize commonly in British rivers and seem to afford the only instance of such a cross there."

Plosila, D.S., W.T. Keller, T.J. McCartney, and D.S. Robson. 1972. Effects of sperm storage and dilution on fertilization of brook trout eggs. Prog. Fish-Cult. 34(3):179-181.

Reports that the need to transport gametes to produce splake led to experimentation with short-term storage and transport of brook trout sperm.

Podubský, V.

1956. Bastardace pstruha obecného f. potočni (*Trutta trutta morpha fario* L.) se pstruhem americkým duhovým (*Trutta gairdneri irideus* Gibb.) [Crossbreeding of common brook trout (*Trutta trutta morpha fario* L.) with

American rainbow trout (*Trutta gairdneri irideus* Gibb.)]. Sbornik Cesk. Akad. Zemedel. ved. Živočisna vyroba. 29(8):611-618. (In Czech, with Russian, English, and German summaries.)

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Reciprocal hybrids of *S. trutta* and *S. gairdneri* were produced. The best results were obtained by using *S. gairdneri* females and *S. trutta* males.

1955a. Tenth report of the biological bureau. Prov. Quebec, Dep. Game and Fish. 24 p.

Brief review of Séguin's hybridization work.

1955b. La moulac. J. de bord de l'Office de Biol. [Quebec], p. 17.

Includes mention of splake (cited by Séguin 1955b). Prokofieva, A.

1934a. On the chromosome morphology of certain Pisces. Cytologia 5(4):498-506.

Reports that chromosome diploid numbers for *Coregonus* lavaretus baeri  $\times$  S. fontinalis hybrids were 80, and 70 for S. salar  $\times$  S. fontinalis hybrids.

1934b. Issledovanie morfologii khromozom nekotorykh ryb i amfibii (Investigation on the chromosome morphology of some Pisces and Amphibia). Dokl. Akad. Nauk SSSR 1(2):80-84. (In Russian, with English summary.)

Essentially same as Prokofieva (1934a).

Prud'homme, J.G.

1948. Les hybridizations chez les poissons d'eau douce. Au bord de l'Eau, Paris 145:5.

Includes reference to unknown hybrids (cited by Séguin 1955b).

Purkett, C.A., Jr.

1951. Growth rate of trout in relation to elevation and temperature. Trans. Am. Fish. Soc. 80:251-259.

Gives lengths of S. gairdneri  $\times$  S. clarki hybrids.

Rasch, H.H.

1867. Resultatet af nogle af ham anstillede bastarderingsforsøg mellem forskjellige arter af ørretartede fiske. Förhandl. Vidensk. Selsk. Christiania 1866(1867):326-327.

According to Dean (1962), "miscellaneous and unimportant." Zool. Rec. (1867) reports that Rasch discusses the hybridization of S. alpinus, S. trutta, and S. salar. Raveret-Wattel, and Bartet.

1883. Sur la reproduction du saumon de Californie, à l'aquarium du Trocadèro (Reproduction of California salmon in the aquarium of Trocadero). C.R. Hebd. Séances Acad. Sci. Paris 96(12):796-797. (Transl. from French by M. McDonald in Bull. U.S. Fish Comm. 3:207-208, 1883.)

Reports on an unsuccessful attempt to fertilize O. tshawytscha eggs with the milt of S. trutta.

Reckahn, J.A.

1970. Ecology of young lake whitefish (Coregonus clupeafornis) in South Bay, Manitoulin Island, Lake Huron. In C.C. Lindsey and C.S. Woods (ed.), Biology of coregonid fishes, p. 437-460. Univ. Manitoba Press, Winnipeg.

p. 453—"Twenty-five yearling splake (speckled trout × lake trout hybrids) were caught in 1967 in trawl tows near the base of the metalimnion, particularly in 12°C waters." In 1969 16 splake were reportedly also caught by gill net. Rees, H.

1967. The chromosomes of Salmo salar. Chromosoma (Berlin) 21(4):472-474.

Reports a chromosome number of 2n=58 for S. salar and

2n=69 for S. salar  $\times$  S. trutta hybrids.

Regan, C.T.

1911. The freshwater fishes of the British Isles. Methuen and Co., London. 287 p.

p. 32-33-"When Salmon [S. salar] are on the spawningbeds they are often attended by male Trout [S. trutta]. which seize any opportunity which presents itself, such as the temporary absence of the male Salmon in pursuit of an intruder, to shed their milt on the ova; hybrids may thus be formed, but they would be extremely difficult to recognize; it may be, however, that certain examples which occasionally occur, and which it is not easy to refer with certainty to either species, are really hybrids. It has been ascertained experimentally that the hybrid offspring of Salmon and Trout are deficient in vitality, often malformed, and seldom, in the case of the males probably never, come to maturity; however, eggs obtained from ripe female hybrids were milted from a Lochleven Trout, and a large proportion of them hatched, and the young fish did well."

Regier, H.A.

1966. A perspective on research on the dynamics of fish populations in the Great Lakes. Prog. Fish-Cult. 28(1):3-18.

p. 13—Mentions development of a deep-swimming strain of splake to avoid lamprey predation.

1968. The potential misuse of exotic fish as introductions. Ont. Dep. Lands Forests, Res. Rep. 82:92-111.

p. 104—Reviews the question of politics and commercial fishing affecting Ontario's splake project.

Richmond, F.G.

1919. About rainbow trout. Salmon and Trout Mag. 20:63-73. States that he knows of no natural S. trutta × S. gairdneri hybrids. Discusses S. gairdneri hybrids and Jousset de Bellesme's (1909) book.

Roberts, F.L.

1964. A chromosome study of the Centrarchidae. Ph.D. Thesis, N.C. State Univ., Raleigh. 136 p.

According to Schwartz (1972), the thesis includes mention of S. trutta  $\times$  (S. salar  $\times$  S. trutta) hybrids.

1970. Atlantic salmon (Salmo salar) chromosomes and speciation. Trans. Am. Fish. Soc. 99(1):105-111.

Mentions S. salar  $\times$  S. trutta and O. keta  $\times$  O. gorbuscha hybrids.

Roosevelt, R.B.

1880. Hybrids. Trans. Am. Fish Cult. Assoc., New York. 9:8-13.

Briefly describes S. namaycush  $\Im \times S$ . fontinalis  $\Im$  hybrids. Hybrid of S. fontinalis  $\Im$  and O. tshawytscha (California salmon)  $\Im$  produced only females, with eggs too large to pass through the vent; eggs artificially fertilized with S. fontinalis milt failed to produce fry. Reciprocal crosses of S. fontinalis and S. gairdneri (California mountain trout) impregnated about 80% of the eggs used. Also records crossing S. namaycush  $\Im$  and Coregonus albus  $\Im$  and S. fontinalis  $\Im$  and C. clupeaformis  $\Im$  but gives results for neither.

1885. Fertility in hybridization. Proc. Am. Assoc. Adv. Sci. 33:510-515.

Reviews Roosevelt's (1880) work.

Roth, H., and W. Geiger.

1972. Brienzersee, Thunersee, and Bielersee: effects of exploi-

Prévost, G.

tation and eutrophication on the salmonid communities. J. Fish. Res. Board Can. 29(6):755-764.

Reports that introduction of *S. salar*  $\times$  *S. trutta* hybrids made no impression on fish catches and apparently did not give rise to reproducing populations—perhaps because of the small number's stocked.

Rounsefell, G.A.

1962. Relationships among North American Salmonidae. U.S. Fish Wildl. Serv., Fish. Bull. 62:235-270.

A detailed discussion and review of hybridization in Salmonidae.

Rubaschev, S.J.

1935. Abweichungen von der Elternformen in der embryonalen Entwicklung der Bastarde von Coregonus baeri Kessl. × Salmo fario lac. L. Acta Zool. (Stockholm) 16(3):387-408. (In German.)

Preliminary comprehensive study of embryos of hybrid S. trutta (fario)  $\times$  Coregonus larvaretus baeri.

1937. Embryonic development of hybrids of trout (Salmo fario lac. L.) and gwiniad (Coregonus lavaretus baeri Kessl.).

Acta Zool. (Stockholm) 18(3):345-374.

A comprehensive study of embryos of hybrid S. trutta (fario)  $\times$  Coregonus lavaretus baeri.

Runnström, S.

1950-1953 and 1955. Director's report(s) for the year(s) 1949-1952 and 1954. Rep. Inst. Freshwater Res. Drottningholm 31:5-18; 32:5-14; 33:5-16; 34:5-13; and 36:5-12. Briefly mention Alm's hybrid work.

Salmon Research Trust of Ireland.

- 1960-1970. Salmon × sea trout hybrids. Salmon Res. Trust Ireland, Annu. Rep. 1960-1970. Various pagination. Gives data on Piggins' hybrids.
- 1966. Ten years work by the Salmon Research Trust of Ireland. St. James' Gate, Dublin. 11 p.

Summarizes Piggins' work to that date.

Sanders, B.G.

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1964. Electrophoretic studies of serum proteins of three trout species and the resulting hybrids within the family Salmonidae. In C.A. Leone (ed.), Taxonomic biochemistry and serology, p. 673-679. The Ronald Press Co., New York.

"The two hybrid species gave electrophoretic patterns characteristic of one of the parental types. The patterns of the tiger trout sera differed from those of the brook trout, but were very similar to the patterns obtained with brown trout sera. Seven fractions were obtained in the tiger trout sera, and the mobilities of these were similar to those obtained with brown trout serum. Brownbow (rainbow  $Q \times brown \ O$ ] trout sera had 6 fractions, and were similar to rainbow trout 2 but different from rainbow trout 1 and brown trout."

1970. Hemoglobin studies in three species and a hybrid trout (Salmonidae). Copeia 1970(2):367-370.

Brown, brook, and tiger trout hemoglobin exhibited four electrophoretic components with similar mobilities; however, rainbow hemoglobin exhibited five electrophoretic components with three components having mobilities common to brown and brook trout and the other two components having distinct mobilities. Electrophoretic, solubility, and crystalline differences were not found in brown and brook trout. Therefore, the tiger trout hybrid hemoglobin resembled brown and brook trout parents. Should hemoglobin similarities be used as a criterion for phylogenetic relationships, such studies would suggest that brook and brown trout are more closely related than rainbow and brook trout.

- Sanders, B.G., C. Bleifeld, and S. Friedman.
  - 1964. Electrophoretic, solubility, and crystalline studies of hemoglobin from three trout species and the resulting hybrid within the family Salmonidae. (Abstract). Genetics 50(2):283.

Abstract of a report on tiger trout later published (Sanders, 1970).

Sanders, B.G., and J.E. Wright.

\*\*1962. Immunogenetic studies in two trout species of the genus Salmo. Ann. N.Y. Acad. Sci. 97(1):116-130.

p. 128—"Thus blood group marker genes have become available for use as a tool in management studies, as a means of studying racial diversity in this species, and possibly as a means of studying relationships of trout species and their hybrids (Buss and Wright, 1956, 1958). Reaction of cells of rainbow × brook hybrids from one rainbow female have been recorded with the R2 reagent."

Sano, S., and H. Eguchi.

1936. (Interspecific hybridization among salmonid fishes). Hokkaido Sakemasu Fukajo (Hokkaido Salmon-Trout Hatchery). 13 p. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1164, 1968.)

Reports on hybrids of O. keta, O. nerka, O. masou, S. gairdneri, and S. fontinalis.

Sasaki, M., S. Hitotsumachi, S. Makino, and T. Terao.

1968. A comparative study of the chromosomes in the chum salmon, the kokanee salmon and their hybrids. Caryologia 21(4):389-394.

"The somatic chromosomes were studied in the chum salmon (Oncorhynchus keta), the kokanee salmon (O. nerka) and their hybrids, by application of the routine air-drying method. The diploid numbers were 74 for the chum salmon and 58 for the kokanee salmon. Their hybrids showed 66 chromosomes corresponding to a total sum of the haploid number of the parent species.

"The chromosome formula based on the total numbers of chromosome arms were 100+6m=106 for the chum salmon, 102+2m=104 for the kokanee salmon and 101+4m=105 for the hybrids."

Savvaitova, K.A.

\*\*1972. Kamchatskaya mikizha—perspektivnyi ob``ekt forelevodstva i akklimatizatsii (Kamchatka mikizha—a prospective object for trout breeding and acclimatization.) Rybn. Khoz. 1972(8):32-33. (In Russian.)

"The similarity of Kamchatka trout [S. mykiss] to steelhead and rainbow trout [S. gairdneri] opens prospects for production between them of fertile hybrid forms capable of heterosis." See also Behnke (1966).

Scheuring, L.

1930. Beobachtungen über die Erbrütung und Aufzucht von Lachsen und Bastarden zwischen Lachs und Bachforelle. Badische Fisch.-Ztg. 7(3):33-38.

The paper describes experimental reciprocal crosses of *S. salar* and *S. trutta* and rearing of the offspring.

Schindler, O.

1938. Über Larven und Jungfische der Kreuzungen zwischen Seesaibling und Bachsaibling. Int. Rev. Ges. Hydrobiol. Hydrogr. 37(4/5):385-404.

Reports on morphometric and meristic characteristics of

larvae and juveniles of reciprocal hybrids of *S. alpinus* and *S. fontinalis*.

Schreck, C.B., and R.J. Behnke.

- 1971. Trouts of the Upper Kern River Basin, California, with reference to systematics and evolution of western North American Salmo. J. Fish. Res. Board Can. 28(7):987-998. "It is evident from field observations that S. aguabonita readily hybridize with both S. gairdneri and S. clarki and the hybridize must be relatively fertile."
- Schwartz, F.J.
  - 1972. World literature to fish hybrids with an analysis by family, species, and hybrid. Gulf Coast Res. Lab., Ocean Springs, Miss., Publ. Gulf Coast Res. Lab. Mus. 3, 328 p.

Includes many references to salmonid hybrids.

Scientific American.

1880. Hybrid fish. Sci. Am. 42(17):263.

Reviews Roosevelt's (1880) work.

- Scott, W.B.
  - 1956. Wendigo the hybrid trout. Roy. Ont. Mus., Div. Zool. Palaeontol., Toronto. 7 p.
    - Popular article about splake.
  - 1967. Freshwater fishes of eastern Canada. (2nd ed.). Univ. Toronto Press. Ontario. 137 p.
  - p. 25-Brief review of the use of splake in Canada.

Scott, W.B., and E.J. Crossman.

- 1969. Checklist of Canadian fishes with keys for identification. Roy. Ont. Mus., Life Sci. Misc. Publ. 104 p. Includes splake in the checklist.
- Séguin, L.-R.
  - 1953. La truite moulac. Ephémérides Off. Biol. [Quebec] 1(10):59-61. (In French.)

Reports that  $F_1$  splake were planted in Quebec.  $F_2$  splake discarded because of lack of uniformity.

1954. The "splake." Ephemerides Quebec Biol. Bur. 1(1):21-22.

English edition of Séguin's (1953) report.

1955a. Moeurs et méthodes de'élevage des truites du Québec. Le Jeune Naturaliste 5(7):146-176. (In French.) (Reprinted June 1964.)

Brief review of splake history and use in Quebec.

- 1955b. Tabular data on hybridization of salmon and trout. Unfinished paper. 21 p. (Université du Québec à Montréal.) Cites hybrid papers included in this list and others unavailable for review.
- 1956. Truite moulac ensemencée dans le Lac Lyster en 1944.

J. de bord de l'Office de Biol. [Quebec], p. 81. Includes splake (cited by Séguin 1955b).

1957. Scientific fish culture in Quebec since 1945. Trans. Am. Fish. Soc. 86:136-143.

Reports on artificial hybridization using the following species: S. fontinalis, S. namaycush, S. alpinus marstoni, S. gairdneri, S. trutta, and S. salar. The best growth was for S. fontinalis  $\mathcal{Q} \times S$ . alpinus marstoni  $\mathcal{O}$  hybrids.

1959. Habits and rearing methods of Quebec trout. [Quebec Game Fish. Dep.] 32 p. (2nd English ed.)

English edition of Séguin's (1955a) report.

1961. Artificial trout ponds in Quebec. Propagation (Mon. Rep. Eastern Townships Station, Fish. Game Dep., Coaticook, Quebec) 1(8):3-15.

p. 6—"...yearling splake trout (Salvelinus namaycush × Salvelinus fontinalis) planted at 3 to 5 inches grew to 5 to 10.5 inches during one summer with a survival percentage of 7.4.4 to 95.3." Selys Longchamps, E. de.

1887. Revision des poissons d'eau douce de la Faune belge. Bull. Acad. Roy. Belg., Ser. 3, 14:1021-1098. (In French.) p.1089—The report mentions S. salar  $Q \times S$ . trutta (fario) O, S. alpinus (salvelinus)  $Q \times S$ . trutta (lacustris) O, and S. trutta (fario)  $Q \times S$ . alpinus (salvelinus O hybrids in aquaria at the Berlin Exposition. Refers to the Rapport au Ministre de l'Intérieur sur l'Exposition de pèche et le Congrès de pisciculture de Berlin (1880).

Serebryakova, E.V.

1969. Nekotorye dannye o khromosomnykh kompleksakh osetrovykh ryb (Some data on the chromosome complexes in Acipenseridae). In B.I. Cherfas (ed.), Genetika, selektsiya i gibridizatsiya ryb, p. 105-113. Izdatel'stvo "Nauka," Moscow. (Transl. from Russian, 1972, p. 98-106 in B.I. Cherfas (ed.), Genetics, selection, and hybridization of fish, avail. U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, Va. 22151 as TT 71-50112.)

Refers to chromosome work of Svärdson (1945) and Wahl (1960).

Shapovalov, L., W.A. Dill, and A.J. Cordone.

1959. A revised check list of the freshwater and anadromous fishes of California. Calif. Fish Game 45(3):159-180.

- Mentions planting of splake in Sierra County.
- Shiraishi, Y., and Y. Fukuda.

1966. The relation between the day length and the maturation in four species of salmonid fish. Bull. Freshwater Fish. Res. Lab. (Tokyo) 16(2):103-111.

Reports that modified photoperiods were used to make the maturation of *O. nerka*, *O. rhodurus*? (Hon-masu), *S. fontinalis*, and *S. gairdneri* coincide. Fourteen pairs of hybrids were produced. "Some of these fishes grew healthier than the original species of fishes." No further data on the hybrids. *See also* Suzuki and Fukuda (1971a and b).

Sigler, W.F., and R.R. Miller.

- 1963. Fishes of Utah. Utah State Dep. Fish and Game. 203 p.
  - p. 194—"Salmo clarki × Salmo gairdneri. Cutthroat by rainbow trout hybrids are rather common in Utah and other intermountain states. The native species, the cutthroat trout, is being replaced over much of its range in this region by its introduced relative, through hybridization and competition. Where the two species naturally live together, in coastal streams from northern California to Alaska, no hybridization has been reported. This cross was recorded from the Southwest as early as 1918."

Simon, J.R.

1939. Yellowstone fishes (2nd ed., 1953). Yellowstone Interpretive Ser. No. 3. 39 p. Yellowstone Libr. Mus. Assoc., Yellowstone Park, Wyoming.

Reports that S.  $clarki \times S$ . gairdneri hybrids are abundant in Grebe Lake and Fall River below Cave Falls.

1946. Wyoming fishes. (Revised, 1951). Wyoming Game Fish Dep., Bull. 4. 129 p.

Reports the presence of natural and artificial hybrids of *S. clarki* and *S. gairdneri* in Wyoming. *See also* Baxter and Simon (1970).

Simon, J.R., and F. Simon.

1939. Check list and keys of the fishes of Wyoming. Univ. Wyoming Publ. 6(4):47-62.

Reports that hybrids of various subspecies of *S. clarki* and *S. gairdneri* are common in Wyoming. Distributions given.

#### Simon, R.C.

1960. A comparative study of numbers and gross morphology of chromosomes in Pacific salmon (*Oncorhynchus*). M.S. Thesis, Univ. Washington, Seattle. 62 p.

Brief review of hybridization in Oncorhynchus.

1963. Chromosome morphology and species evolution in the five North American species of Pacific salmon (Oncorhynchus). J. Morphol. 112(1):77-97.

States that the discrepancy between 112 arms in *O*. *kisutch* and 102-104 arms in the other North American species of *Oncorhynchus* may be caused by the use of 1  $\mu$  as the minimum length of an arm by definition, or the difference may be of real significance in explaining the failure of *O*. *kisutch* crosses with other *Oncorhynchus* (as noted by Foerster (1935)).

\*\*1964a. Chromosome studies on salmonids. *In* Research in fisheries...1963, p. 55. College of Fish., Univ. Washington, Seattle.

"The materials employed in hybridization study were  $F_2$  hybrids of chum and pink salmon, supplied by the Washington State Department of Fisheries..." See also Simon and Noble (1968).

1964b. Cytogenetics, relationships and evolution in Salmonidae. Ph.D. Thesis, Univ. Washington, Seattle. 76 p. (Diss. Abstr. 25(5):2721.)

Includes cytological and morphological study of hybrids of *O. gorbuscha* and *O. keta*.

Simon, R.C., and R.E. Noble.

1968. Hybridization in Oncorhynchus (Salmonidae). I. Viability and inheritance in artificial crosses of chum and pink salmon, Trans. Am. Fish. Soc. 97(2):109-118.

"Survival and fertility are substantial in first-generation hybrids. Morphological features in the  $F_i$  are either like one parent, unlike either parent, or intermediate. Failure of hybrids to be intermediate in some parental attributes is contrasted to carlier reports. Hybrid fertility is equated to persistence of parental traits in the phenotype of the  $F_i$ . Multiple and additive gene systems are assumed to be operative wherein dominance is suspected in two characteristics. Viability data are provided of  $F_i$ ,  $F_i$ , reciprocal, and backcross hybrids. Morphological descriptions contained provide some basis for recognizing natural chum-pink hybrids."

Skinner, H.J.

1\_\_\_\_\_.

1938. Salmon and trout hybrids. Field, July 30, 1938:258. Discusses fertile S. salar × S. trutta hybrids.

Slastenenko, E.P.

1953a. Estudio de hibridos artificiales entre Salvelinus fontinalis Mitchill y Salvelinus namaycush Walbaum. Rev. Soc. Mex. Hist. Nat. 14(1-4):63-69.

Provides morphological data on splake.

1953b. El crecimiento en los hibridos de Salvelinus fontinalis y Salvelinus namaycush. Rev. Soc. Mex. Hist. Nat. 14(1-4):71-76.

Provides data on the growth of splake.

1954. The relative growth of hybrid char (Salvelinus fontinalis × Cristivomer namaycush). J. Fish. Res. Board Can. 11(5):652-659.

"Hybrid char from Banff were intermediate between the

two parental species, lake trout and eastern brook trout, in respect to relative growth of some characters; in others they approximated one or other of the parent species."

1956a. Hybridization as a factor of evolution. İstanbul Üniv. Fen Fak. Mecm. (Revue de la Faculte des Sciences de L'universite D'Istanbul), Seri B, 21(3):149-156.

Reviews Smirnov's (1953) and Slastenenko's (1954) work. 1956b. Una lista de los hibridos naturales de peces del mundo. Rev. Soc. Mex. Hist. Nat. 17(1-4):63-84.

An earlier Spanish version of Slastenenko's (1957) report.

1957. A list of natural fish hybrids of the world. İstanbul Univ. Fen Fak. Hidrobiol. (Pub. Hydrobiol. Res. Inst., Fac. Sci., Univ. Istanbul), Seri B, 4(2-3):76-97.

Lists natural hybrids of S. clarki  $\times$  S. gairdneri and S. gairdneri  $\times$  S. fontinalis.

Smirnov, A.I.

1953. Nekotorye osobennosti mezhvidovogo gibrida keta osennyaya × gorbusha [(Oncorhynchus keta (Walbaum) infraspecies autumnalis Berg × O. gorbuscha (Walbaum) sem. Salmonidae]. (Some characteristics of the interspecific hybrid between autumn chum salmon and pink salmon [Oncorhynchus keta (Walbaum) infraspecies autumnalis Berg × O. gorbuscha (Walbaum), family Salmonidae]). Dokl. Akad. Nauk SSSR 91(2):409-412. (Transl. from Russian, Fish. Res. Board Can., Transl. Ser. 957, 1967.)

Reports high percentage of fertilization and heterosis of the hybrid of chum and pink salmon.

1954. Voprosy ratsionalizatsii biotekhniki razvedeniya lososei na Sakhaline (Problems of rationalization of the biotechnique of salmon breeding on Sakhalin). Akad. Nauk SSSR, Tr. Soveshch. Ikhtiol. Kom. 4 (Trudy soveshchaniya po voprosam lososevogo khozyaistva Dal'nego Vostoka):94-110. (Transl. from Russian, Fish. Res. Board Can., Transl. Ser. 1110, 1968.)

Describes reciprocal hybrids of *O*. keta and *S*. leucomaenis, *O*. gorbuscha and *S*. leucomaenis, and *O*. keta  $\bigcirc$  and *O*. gorbuscha  $\bigcirc$ .

1959. Mezhrodovaya gibridizatsiya tikhookeanskikh lososei (Intergeneric hybridization of Pacific salmon). Priroda 1959(6):98-100. (Transl. from Russian, Fish. Res. Bd. Can., Transl. Ser. 231, 1960.)

States that hybrids of *S. leucomaenis*  $\bigcirc$  and *O. kisutch*  $\overrightarrow{O}$  result in cyclops-like embryos.

1967. Gibridy tikhookeanskikh lososei roda Oncorhynchus, osobennosti ikh razvitiya i perspektivy ispol'zovaniya (Hybrids of Pacific salmon, genus Oncorhynchus, particularly their development and perspectives of their utilization). In Tezisy dokladov k nauchnomu soveshchaniyu po voprosam genetiki, selektsii i gibridizatsii ryb, p. 33-35. Akad. Nauk SSSR, Leningrad.

Summaries of reports presented at a scientific conference on "Problems Concerned in the Genetics, Selection and Hybridization of Fish." *See* Smirnov (1969).

1969. Gibridy tikhookeanskikh lososei roda Oncorhynchus, osobennosti ikh razvitiya i perspektivy ispol'zovaniya (Hybrids of Pacific salmon of the genus Oncorhynchus, characteristics of development and prospects of utilization). In B.1. Cherfas (ed.), Genetika, selektsiya i gibridizatsiya ryb, p. 139-159. Izdatel'stvo "Nauka," Moscow. (Transl. from Russian, 1972, p. 131-147 in B.1. Cherfas (ed.), Genetics, selection, and hybridization of fish, avail. U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, Va. 22151 as TT 71-50112.)

Extensive review of hybridization of Salmonidae in the USSR.

Smirnov, I.S.

1950. Sledite za gibridami kety i gorbushi (The need for observation of chum and pink salmon hybrids). Rybn. Khoz. 1950(4):28. (In Russian.)

Appeal to the fishermen and workers to look for hybrids of *O. keta* and *O. gorbuscha* produced in 1947 in Sakhalin. Smith, C.E.

\*\*1971. An undifferentiated hematopoietic neoplasm with histologic manifestations of leukemia in a cutthroat trout (Salmo clarki). J. Fish. Res. Board Can. 28(1):112-113.

"Dunbar (1969) reported lymphosarcomas in three brook trout, Salvelinus fontinalis, and two hybrid splake (brook trout  $\times$  lake trout). He suggested that the tumors were most likely of thymic origin."

- Smith, E.V.
  - 1915. Salmon hybridization. Trans. Pac. Fish. Soc. 1:71-78. Reports on reciprocal crosses of O. tshawytscha  $\times O$ . kisutch with growth and color data.

Smith, S.B.

1961. Selectivity and hybridization in management of fish stocks. Can. Fish Cult. 29:25-30.

The report includes brief, general discussion of use of hybrids in fisheries management.

\*\*1970. Trends in fishery management of the Great Lakes. In N.G. Benson (ed.), A century of fisheries in North America, p. 107-114. Am. Fish Soc., Washington, D.C., Spec. Publ. 7.

p. 113—"By agreement between Michigan and Ontario, Lake Huron will be stocked with the splake, a lake troutbrook trout (Salvelinus fontinalis) hybrid that has been selected for several generations to develop a strain that will occupy deep water, grow fast, and mature early. Sea lamprey control may be achieved in Lake Huron by the early 1970's when the first major plantings of splake are scheduled."

1972. The future of salmonid communities in the Laurentian Great Lakes. J. Fish. Res. Board Can. 29(6):951-957.

States that splake having fast growth and early maturity may establish perpetuating populations in the presence of reduced sea lamprey stocks in Lake Huron.

1920. Merkbuch der Binnenfischerei. Berlin, Vol. 2, p. 628. Includes unknown hybrids (cited by Séguin, 1955b).

Soguri (Hayaguri), M.

1936. On hybrids among trouts (Hybridization of trout). Suisan Kenkiu-shi31(5):251-258. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1167, 1968.)

Reports on reciprocal hybridization of *S. malma* (pluvius), *S. fontinalis*, and *O. masou*.  $F_i$  of *S. malma* (pluvius) and *S. fontinalis* backcrossed to *S. fontinalis*. The hybrids of *S. malma* (pluvius) and *O. masou* did not mature.  $F_i$ *S. fontinalis* and *O. masou* were maturing at time of publication. Soldwedel, R.H.

1968. Brookbows. N.J. Outdoors 18(10):20.

A report of natural hybrids of S. fontinalis  $\times$  S. gairdneri occurring in Spruce Run Creek, New Jersey.

Solman, V.E.F.

1951. The creel census in the National Parks of Canada. Trans. North Am. Wildl. Conf. 16:225-233.

Reports that the use of trout hybrids in mountain lakes in Canada started in 1950.

Solman, V.E.F., J.-P. Cuerrier, and W.C. Cable.

1952. Why have fish hatcheries in Canada's national parks? Trans, North Am. Wildl. Conf. 17:226-234.

Refers to splake—states they are faster growing and better acclimated to cold water than are brook trout.

Somme, I.D. (revised by K.W. Jensen).

1954. Ørretboka. (4th ed.). Jacob Dybwads Forlag, Oslo. 617 p.

p. 325—Reports that tiger trout showed poor survival and were planted in freshwater ponds. Brown trout × arctic char hybrids showed high survival and were planted in ponds and lakes. Brown trout × Atlantic salmon hybrids were planted in lakes with poor success.

Sonstegard, R.A., and L.A. McDermott.

1971. Infectious pancreatic necrosis of salmonids in Ontario.J. Fish. Res. Board Can. 28(9):1350-1351.

Reports that no IPN was found in 84 splake tested.

Sormunen, T., and H. Kajosaari.

\*\*1963. Försök med kanadaröding i Finland (A try with lake trout in Finland). Fiskeritidskr. för Finland 7(1):9-13. (In Swedish.) [Simultaneously published as: Kanadannieriän hoitokokeiluja suomessa. Suomen Kalastuslehti 70(1):6-10. (In Finnish.)]

"In Porla on 16 October 1961 a hybrid experiment was made with eggs of arctic char (*Salmo salvelinus salvelinus*) [*S. alpinus*] fertilized with milt of lake trout. As a result of the experiment there are now several one year olds with a length of 10-12 cm. The appearance of the fish is almost identical to lake trout. In the fall of 1961 milt of the lake trout was delivered to Sweden where corresponding experiments gave similar results."

"Hybrid experiments (lake trout × arctic char) were repeated in the fall of 1952 [1962], at this time eggs of the lake trout were used. The development of the fry was similar to the lake trout. At the same time—19 September 1962—an experiment was made fertilizing eggs of the lake trout with milt of havsöring [S. trutta funta], insjööring [S. trutta lacustris], and bäcköring [S. trutta funta]. Fertilization was a success but the hatching which started before Christmas 1962 has given weak fry with a high mortality." (Transl. by N.R. Lindgren.)

- Sowards, C.L.
  - 1959. Experiments in hybridizing several species of trout. Prog. Fish-Cult. 21(4):147-150.

"The  $F_1$  generation of brookinaw was obtained by crossing a brook trout female and a lake trout male. The hatching success was 73 percent, with good survival. Hatching success for 2 lots of the  $F_2$  generation averaged 68 percent. Hatching success of a back-cross with a brook trout male was 94.1 percent, and that of a backeross with a brook trout female was 82.2 percent. A cross between a brookinaw female and a brown trout male yielded a hatching success of 4.8 percent; a cross between a brown trout female and a

Smith, S.H.

<sup>1968.</sup> Species succession and fishery exploitation in the Great Lakes. J. Fish. Res. Board Can. 25(4):667-693. Mentions splake in Ontario.

Smolian, K.

brookinaw male yielded a hatch of 32.2 percent. The hatching success of a cross between a lake trout female and a brook trout male was 38.5 percent."

- Spaas, J.T., and M.J. Heuts.
- 1958. Contributions to the comparative physiology and genetics of the European Salmonidae. II. Physiology and genetics of embryonic development. Hydrobiologia 12(1):1-26. (Transl. from French, Fish. Res. Bd. Can., Transl. Ser. 2077, 1972.)

Includes reciprocal hybrids of *S. salar* and *S. trutta* in a study of mortality, rate of development, rate of growth, and oxygen consumption.

Sport Fishing Institute.

1955a. Ontario. Sport Fish. Inst., Washington, D.C., SFIBull. 38:40.

Mentions splake in Ontario.

1955b. Wyoming winter fishing. Sport Fish. Inst., Washington, D.C., SFI Bull. 47:4.

Abstracts Peterson's (1955) paper. Cutthroat  $\times$  rainbow hybrids make up 1.6% by weight of the catch.

1956. Pennsylvania. Sport Fish. Inst., Washington, D.C., SFI Bull. 50:44.

Refers to Buss and Wrights' (1956 and 1958) hybrid studies in Pennsylvania.

1957a. Burst bubble. Sport Fish. Inst., Washington, D.C., SFI Bull. 69:7.

Refers to failure of planting Chryster Lake, Ontario, with splake.

1957b. Splake. Sport Fish. Inst., Washington, D.C., SFI Bull. 72:5.

Refers to Scott's (1956) work.

- 1971. Distribution and characterization of hexose 6-phosphate dehydrogenase in trout. Biochem. Genet. 5:579-589.
  - "F<sub>1</sub> hybrid splake exhibit the three expected phenotypes resulting from Hpd-L/Hpd-B<sup>1</sup>, Hpd-L/Hpd-B<sup>2</sup>, and Hpd-L/Hpd-B<sup>3</sup> genotypes."
- Stenton, J.E.
- 1950. Artificial hybridization of eastern brook trout and lake trout. Can. Fish Cult. 6:20-22.

Reports on reciprocal crosses of *S. namaycush* and *S. fontinalis.* 

1952. Additional information on eastern brook trout × lake trout hybrids. Can. Fish Cult. 13:15-21.

Reports meristic and morphological data on fertile hybrids of splake.

1953. Anglers will have a new opponent. Northern Sportsman 8(5):12-13.

A popular account of Stenton's work on splake in Alberta. Stock, A.W.

1942. Experimental crossing of trout species. Wyoming Wild Life 7(3):6-7.

Reports that *S. fontinalis*  $\bigcirc \times S$ . *trutta*  $\bigcirc$  hybrids failed to eye. *S. trutta*  $\bigcirc \times S$ . *fontinalis*  $\bigcirc$  hybrids died before eyeing or before end of yolk sac period. *S. clarki*  $\bigcirc \times S$ . *gairdneri*  $\bigcirc$  hybrids gave 20% hatch.

Stokell, G.

1949. The numerical characters of five hybrid trout. Rec. Canterbury Mus. (New Zealand) 5:209-212.

Presents meristic data for hybrids of *S. gairdneri* and *S. trutta*.

Suzuki, R.

\*1965. Hybridization experiments in cyprinid fishes. VIII. Two kinds of reciprocal crosses, Pseudogobio esocinus × Pseudorasbora parva and Biwia zezera × Pseudorasbora parva. Jap. J. Ichthvol. 13(1/3):64-68.

Brief reference to early work in hybridization of Salmonidae.

1966. Thremmatological aspects on the hybridization in fish. Bull. Jap. Soc. Sci. Fish. 32(8):677-688. (Transl. from

Japanese, Fish, Res. Board Can., Transl. Ser. 2011, 1972.) Comprehensive preliminary report on many salmonid hybrids and review of many other hybrid studies.

- 1968. Hybridization experiments in cyprinid fishes X1. Survival rate of F<sub>1</sub> hybrids with special reference to the closeness of taxonomical position of combined fishes. Bull, Freshwater Fish. Res. Lab. (Tokyo) 18(2):113-155.
  - Reports that interordinal cross with spermatozoa of *S*. gairdneri and eggs of female *Tribolodon hakonensis* did not develop at all.

Suzuki, R., and Y. Fukuda.

- 1971a. Survival potential of F<sub>1</sub> hybrids among salmonid fishes. Bull. Freshwater Fish. Res. Lab. (Tokyo) 21(1):69-83.
- Reports extensively on reciprocal hybridizations of S. malma (pluvius), S. fontinalis, S. gairdneri, S. trutta, O. rhodurus, O. masou, O. nerka, and O. keta.
- 1971b. Growth and survival of  $F_1$  hybrids among salmonid fishes. Bull. Freshwater Fish. Res. Lab. (Tokyo) 21(2):117-138.

A continuation of Suzuki and Fukudas' (1971a) work. "Hybrids from 32 combinations survived beyond the fry stage. Nine of them showed heterosis; that is, their survival rates were higher than those of the controls and their growth rates were better than or similar to those of the controls."

Suzuki, R., and T. Kato.

1966. Hybridization in nature between salmonid fishes, Salvelinus pluvius × Salvelinus fontinalis. Bull. Freshwater Fish. Res. Lab. (Tokyo) 16(2):83-90.

Reports that meristic and color characteristics were intermediate to those of the parental species in natural and artificial hybrids of *S. malma (pluvius) × S. fontinalis.* 

- Svärdson, G.
  - 1945. Chromosome studies on Salmonidae. Medd. Statens Unders. Försöksanst. Sötvattensfisket [Rep. Inst. Freshwater Res. Drottningholm] 23. 151 p.

Chromosome study of S. salar  $\times$  S. trutta, S. trutta  $\times$  S. alpinus, and S. fontinalis  $\times$  S. trutta hybrids.

1949. Competition between trout and char (Salmo trutta and S. alpinus). Rep Inst. Freshwater Res. Drottningholm 29:108-111.

Reports that *S. trutta* and *S. alpinus* hybrids were intermediate in growth to the parent species in the competition experiment.

#### Swarup, H.

\*\*1957. Production of haploidy in experimentally treated eggs of Gasterosteus aculeatus (L). Proc. Natl. Acad. Sci. (India), Allahabad, 27, Sect. B, Pt. V1:274-278.

p. 274—"Among the Pisces Svärdson (1945) obtained three haploid embryos of Salmo salar by treating the eggs of Salmo salar with sperm of Salmo trutta and subjecting the eggs to a cold shock. These haploid embryos were

Stegeman, J.J., and E. Goldberg.

squashed at cleavage stages for chromosome analysis and their further development was not studied by Svärdson."

- Tait, J.S.
  - 1970. A method of selecting trout hybrids (Salvelinus fontinalis × S. namaycush) for ability to retain swimbladder gas. J. Fish. Res. Board Can. 27(1):39-45.

"A method was developed for selecting hybrid trout for deepswimming ability, for use in a breeding program to combine in one strain the early-maturing character of brook trout(*Salvelinus fontinalis*) with the deep-swimming ability of lake trout (*S. namaycush*). The method involves testing hybrids in pressure tanks and selecting individuals that, like lake trout, retain most of their swimbladder gas during the test period. For a sample of  $F_2$  hybrids the range of pressures at which the fish floated when anaesthetized was almost entirely between the medians for samples of the two parent species. Successive tests of marked individuals showed good repeatability of flotation measurements. The method is concluded to be reliable for large-scale selection of fish with ability to retain swimbladder gas."

Takashima, F., and T. Hibiya.

1972. Fibrosarcoma in pond-cultured hybrids of *Salvelinus*. Jap. J. Ichthyol. 19(2):97-102. (In English, with Japanese summary.)

A report on tumors in two  $F_i$  Salvelinus [alpinus?] miyabei  $Q \times S$ . fontinalis  $\mathcal{J}^*$  hybrids.

Tanaka, S.

\*1965. Salmon of the North Pacific Ocean—Part IX. Coho, chinook and masu salmon in offshore waters. 3. A review of the biological information on masu salmon (Oncorhynchus masou). Int. N. Pac. Fish. Comm., Bull. 16:75-135.

Refers to Oshima's (1957)  $F_2$  O. masou  $\times$  O. rhodurus hybrids.

Tanner, H.A.

- 1959. New trout for Colorado? Colorado Outdoors 8(4):12-15. Discusses trout hybrids, relative success of various crosses, and use of selective breeding to get desirable characteristics.
- Taylor, D.M.
  - \*1969. Japan and the sea. Ocean Ind. 4(12):43-49.

Refers to Ryo Suzuki, "...by cross-breeding rainbow trout and salmon, he has produced mutants that are healthy, have long lives and are a delight for fish lovers. But like most mutants, they cannot reproduce," Salmon not identified.

Tegner, H.

1969. Mongrels amongst fishes. Aquarist and Pondkeeper 34(6):185.

Short criticism of tiger trout in the aquarium at the London Zoo and brown trout  $\times$  salmon hybrids in Ireland.

Terao, A.

1935. Cross between the cod, *Gadus macrocephalus* Tilesius ♂, and the salmon, *Oncorhynchus keta* (Walbaum ♀, Jap. J. Genetics 9(3):183.

Describes fry displaying mostly maternal characteristics. Terao, T.

1966. Rearing of hybrids—fish (current situation and problems concerning breeding of chum salmon × kokanee salmon hybrids). Suisan Zoshoku (Marine Production) 13:146-148. (In Japanese.)

Reference obtained from Terao et al. (1967).

1970. Studies on the breeding and artificial crosses of chum, Oncorhynchus keta (Walbaum), and kokanee salmon, Oncorhynchus nerka var. adonis (Jordan et McGregor) in salmonoid fishes. Sci. Rep. Hokkaido Fish Hatchery 25:1-101. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 2076, 1972.)

Comprehensive study and review of Terao et al.'s previous work.

Terao, T., and H. Hayashinaka.

- 1961. On the artificial hybridization among the salmonid fishes. I. Sci. Rep. Hokkaido Fish Hatchery 16:51-62. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1047, 1968.) Reports on reciprocal crosses of O. keta, O. nerka, and O. masou. The best results for fertilization, hatching, and
- growth were obtained from reciprocal crosses of *O. keta* and *O. nerka*. Good results were also obtained from the hybrid between *O. keta*  $\Im$  and *O. masou*  $\Im$ .

Terao, T., S. Kikuchi, M. Uchiyama, S. Kurahashi, H. Matsumoto, and H. Abe.

1964. Studies on the interspecific salmonoid hybrids between chum salmon Oncorhynchus keta (Walbaum) and kokanee salmon O. nerka var. adonis (Jordan et McGregor)-II. Transplantations of salmonoid hybrids to Lake Shikotsu and Lake Okotampe (1). Sci. Rep. Hokkaido Fish Hatchery 19:43-63. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1061, 1968.)

Records observations of the growth of two year old hybrids of *O*. *keta*  $\heartsuit \times O$ . *nerka*  $\eth$ , and one year old *O*. *nerka*  $\heartsuit \times O$ . *keta*  $\eth$  hybrids, after lake residence. Includes meristic and morphometric data.

Terao, T., T. Tanaka, and S. Kurahashi.

1965. Sea water resistance of chum salmon  $\times$  kokanee salmon (F<sub>1</sub>) parts. Sakana to Tamago (Fish and Eggs) 1965(110):15-18. (In Japanese.)

Reference obtained from Terao et al. (1967).

Terao, T., M. Uchiyama, S. Kurahashi, and H. Matsumoto. 1963. Studies on the interspecific salmonoid hybrids between chum salmon, Oncorhynchus keta (Walbaum) and kokanee salmon, Oncorhynchus nerka var. adonis (Jordan et McGregor)-I. Survival and growth from fertilized eggs to fry. Sci. Rep. Hokkaido Fish Hatchery 18:45-58. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1060, 1968.)

Reports on reciprocal crosses which produced hybrids which compared favorably with their parents in hatching rate and which grew faster in their first year.

1965. Studies on the interspecific salmonoid hybrids between chum salmon Oncorhynchus keta (Walbaum) and kokanee salmon Oncorhynchus nerka var. adonis (Jordan et McGregor)-III. On some external characteristics and fertility of F<sub>1</sub> hybrids. Sci. Rep. Hokkaido Fish Hatchery 20:29-36. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1073, 1968.)

"The mature reciprocal F<sub>1</sub> hybrids were backcrossed to chum salmon and were crossed between female and male of chum female × kokanee salmon male. In these experiments, the former showed a very good result, but latter was interior [sic] to the result obtained between male and female of the parent species."

1967. Studies on interspecific salmonoid hybrids between chum salmon, Oncorhynchus keta (Walbaum) and kokanee salmon, Oncorhynchus nerka var. adonis (Jordan et McGregor)-V. Comparison of variations of some ecological characters in hybrids (F<sub>3</sub>) and parent fishes cultured in rearing pond. Sci. Rep. Hokkaido Fish Hatchery 22:33-49. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 2007, 1972.)

"It was clarified from the present study that the ecological characters of both hybrids are found to be intermediate between those of the parent species similarly as in the case of the meristic characters of the hybrids reported previously."

1968. Studies on interspecific salmonoid hybrids between chum salmon, Oncorhynchus keta (Walbaum) and kokanee salmon, Oncorhynchus netka var. adonis (Jordan et McGregor)-VI. Growth and distribution of chum Q × kokanee salmon ♂ hybrids planted at Shikotsu lake. Sci. Rep. Hokkaido Fish Hatchery 23:23-34. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 2093, 1972.) "Although the hybrid fish were recaptured even in the surface water and coastal areas of the lake, such a wide distribution of them was considered to be sebsequent [sic] upon their inherent nature habitable in the wider range of water temperature as compared with the parent fishes."

Terao, T., M. Uchiyama, S. Kurahashi, H. Matsumoto, I. Yoshizaki, H. Abe, and A. Okuno.

1966. Studies on interspecific salmonoid hybrids between chum salmon, Oncorhynchus keta (Walbaum) and kokanee salmon, Oncorhynchus nerka var. adonis (Jordan et McGregor)-IV. Morphological comparison of variation in some meristics characters of hybrids (F<sub>1</sub>) and parent species. Sci. Rep. Hokkaido Fish Hatchery 21:13-41. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1074, 1968.) "It was found from the present study that each of the reciprocal hybrids displays characters irrespective of both age and environment. Consequently, it may be said that these characters of the hybrids are being controlled more strongly by some hereditary factors rather than by the secondary ones."

# Thomas, T.B.

1967. Cross-breed trout in the west country. Field 230:426. Discusses the use of *Salmo* hybrids for sport fishing. Cited in Zool. Rec. (1967), 104(15):84.

#### Tokui, T.

1969. Masu salmon (Oncorhynchus masou) transplanted from Hokkaido to Canada. Sakana to Tamago (Fish and Eggs) 20(3):3-8. (Transl. from Japanese, Fish. Res. Board Can., Transl. Ser. 1504, 1970.)

Mentions hybrid of the masu salmon (O. masou) and the amemasu (S. leucomaenis) being released in Numasawa Marsh, Fukushima Prefecture.

#### Tortonese, E.

1953-54. I pesci del Parco Nazionale del Gran Paradiso (Alpi Graie). Boll. Ist. Mus. Zool. Univ. Torino 4(6):95-118. (In Italian.)

Reports that natural hybrids of *S. marmoratus* and *S. trutta* are not rare in Cogne, Italy.

#### Trojnar, J.R., and R.J. Behnke.

In press. Management implications of ecological segregation between two introduced populations of cutthroat trout in a small Colorado lake. Trans. Am. Fish. Soc.

S. clarki and S. gairdneri have hybridized in the North Michigan River, Colorado.

Tsuyuki, H., and E. Roberts.

1965. Zone electrophoretic comparison of muscle myogens and blood proteins of artificial hybrids of Salmonidae with their parental species. J. Fish. Res. Board Can. 22(3):767-773. "Starch-gel zone electropherograms of the muscle myogens and blood hemoglobins and disc electropherograms of the serum proteins of a number of artificial hybrids involving the Salmo, Salvelinus, and Cristivomer genera are compared to their respective parental species."

Tsuyuki, H., E. Roberts, and W.E. Vanstone.

1965. Comparative zone electropherograms of muscle myogens and blood hemoglobins of marine and freshwater vertebrates and their application to biochemical systematics. J. Fish. Res. Board Can. 22(1):203-213.

Reports that the myogen patterns of Anoplopoma fimbria from different areas have a center pattern including all the zones of the other two patterns. "This is parallel to the results shown by artificially produced  $F_i$  hybrids of the salmonid family (Tsuyuki, unpublished data)...extensive natural hybridization may be taking place within A. fimbria as was also found in the genus Oncorhynchus in an unexpectedly greater frequency than was formerly thought."

Tsuyuki, H., E. Roberts, W.E. Vanstone, and J.R. Markert. \*\*1965. The species specificity and constancy of muscle myogen and hemoglobin electropherograms of Oncorhynchus. J. Fish. Res. Board Can. 22(1):215-217.

"Instances of myogen pattern variations observed in other species of fish as well as the occasional samples of *Oncorhynchus* have been discussed in relation to natural and artificial hybridization studies (Tsuyuki et al., 1965). The results of this study emphasize the usefulness of myogen and hemoglobin patterns for phylogenetic purposes."

1967. Lohikalojen sukulaisuussuhteista (On the relationship of salmon fish). Suomen Kalastuslehti 1967(1):1-4. (Transl. from Finnish, Fish. Res. Board Can., Transl. Ser. 1476, 1970.)

Reports that *S. gairdneri* and *S. clarki* easily hybridized and genetically very close to each other.

Underdown, H.

1958. Hybrid trout. Field, Sept. 4, 1958:410.

Reviews Skinner's (1938) paper and reports on S. trutta  $\times$  S. gairdneri hybrids.

\*1954a. Creel census and expenditure study, North Fork Sun River, Montana, 1951. Prepared in Office of Missouri River Basin Studies, Billings, Montana. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 120, 39 p.

p. 18—Records rainbow × cutthroat hybrids from North Fork Sun River and the two onstream reservoirs in Montana.

1954b. Creel census and expenditure study Madison River, Montana, 1950-52. Prepared in Office of Missouri River Basin Studies, Billings, Montana. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 126. 40 p.

p. 10—Records apparent rainbow × cutthroat hybrids and one apparent rainbow × brown trout hybrid (in collection of the Montana State College, Bozeman).

Tuunainen, P.

U.S. Fish and Wildlife Service.

Utter, F.M., F.W. Allendorf, and H.O. Hodgins.

In press. Genetic variability and relationships in Pacific salmon and related trout species based on protein variations. Syst. Zool.

Reports that, for creatine kinase, O.  $tshawytscha \times O$ . gorbuscha hybrids expressed the sum of the bands of both parent species, i.e. seven. The fast muscle protein forms a double-banded pattern with reduced intensity in the hybrids, in contrast to single bands in the parent species.

# Uyeno, T.

1972. Chromosomes of offspring resulting from crossing coho salmon and brook trout. Jap. J. lchthyol. 19(3):166-171. (In English, with Japanese summary.)

"Chromosome numbers of the hybrids between Oncorlynchus kisutch (2n=60) and Sabelinus fontinalis (2n=84) were 2n=60 in the cross O. kisutch  $\bigcirc \times S$ . fontinalis  $\circlearrowleft$ , and 2n=72 in the reciprocal cross. The karyotype of offspring from the former cross was identical with that of the female parent, but the karyotype of offspring from the reciprocal cross was intermediate of karyotypes of both parents."

#### Van Oosten, J.

1957. Exotics and hybrids in fish management. Proc. Annu. Meet. Assoc. Midwest Game and Fish Comm. 24:17-22.

The report includes a general review of the value of hybridization.

# Viktorovskii, R.M.

1969. O vozmozhnosti poliploidii v évolutsii ryb (Possibilities of polyploidy in the evolution of fish.) *In* B.1. Cherfas (ed.), Gentika, selektsiya i gibridizatsiya ryb, p. 98-104. Izdatel'stvo "Nauka," Moscow. (Transl. from Russian, 1972, p. 91-97 *in* B.1. Cherfas (ed.), Genetics, selection, and hybridization of fish, avail. U.S. Dep. Commer., Natl. Tech. Inf. Serv., Springfield, Va. 22151 as TT 71-50112.)

Discusses Svärdson's (1945) polyploidy hypothesis for the evolution of salmonids. S. salar  $\times$  S. trutta hybrids are considered to support the theory.

1960. Some influences of domestication upon three stocks of brook trout (*Salvelinus fontinalis* Mitchill). Trans. Am. Fish Soc. 89(1):35-52.

Reports on backcross of splake  $\vec{\circ}$  to brook trout Q.

#### Vivier, P.

- \*\*1945. Louis Kreitmann (1884-1939). Ann. Stn. Cent. Hydrobiol. Appl. 1:7-21.
  - p. 9—Records that "Salmo thononensis," hybrid S. alpinus  $\times$  S. trutta (fario), was produced by J. Crettiez at the Station de Thonon.
- 1948. Note sur les eaux douces du Maroc et sur leur mise en valeur: La pisciculture. Bull. Fr. Piscic. 150:25.

Includes mention of unknown hybrid (cited by Séguin, 1955b).

1954. La pisciculture. Presses Universitare de France, Paris. 127 p. (In French.)

p. 16-19 — Discusses hybridization of S. gairdneri, S. salar, S. trutta, S. alpinus, and S. fontinalis.

1955. Sur l'introduction des Salmonidés exotiques en France. Verh. Int. Ver. Limnol. 12:527-535.

Reports on exotic *S. gairdneri* and *S. clarki* and probably also their hybrids in France. Reportedly neither species crosses with *S. trutta* there. Vladykov, V.D.

1954. Taxonomic characters of the eastern North American chars (*Salvelinus* and *Cristivomer*). J. Fish. Res. Board Can. 11(6):904-932.

Mentions unspecified hybrids of Salvelinus.

1963. A review of salmonid genera and their broad geographical distribution. Trans. Roy. Soc. Can., Ser. 4, 1, Sect. 3:459-504.

Brief summary of hybridization among Salmonidae.

Vogel, P., C. Arens, and R.G. Linke.

1898. Die Forellenzucht in Teichen und die sogenannte künstliche Fischzucht (Trout culture in ponds and the socalled artificial fish culture). Theil 11. *In* P. Vogel, Ausführliches Lehrbuch der Teichwirtschaft, p. 293-372. Emil Hübners Verlag, Bautzer.

p. 308-311—Reports on hybrids of S. salar and S. trutta, S. alpinus and S. trutta and some intraspecific crosses. Crosses of S. alpinus and S. trutta with S. gairdneri were unsuccessful.

Voigt, W., Jr.

\*1958. Fish Commission accomplishments June 1, 1957 to May 31, 1958. Pennsylvania Angler 27(11):22-24.

Records 16 tiger trout approximately 18 to 24 inches long among a list of stocked fish.

- Vutskrits [Vutskits?], G.
  - \*1910. A halkorcsakról (On fish hybrids). Halaszát 12(6):41-43; 12(7):51-53. (In Hungarian.)

The first reference is Part 111 in a series on fish hybrids. Mentions that Bade in "Die mitteleuropäische Süsswasserfische" included 6 hybrids of Salmonidae.

The latter reference is Part IV and includes mention of the salmonid hybrids *S. trutta × S. salar*, *S. trutta (fario)* × *S. alpinus* (salvelinus), *S. trutta (fario) × S. gairdneri* (*iridea*), and *S. salar × S. trutta (fario)*.

Wagner, H.

\*\*1950. Beobachtungen am Bachsaibling (Salmo fontinalis) in Kärnten (Observations on Salmo fontinalis in Carinthia). Carinthia II (Austria) 58/60:131-134.

Discusses importation of rainbow trout (Salmo gairdneri) and brook char (S. fontinalis) from America in late 19th century. P. 134 states—"The brook char, which has approximately the same spawning time as the brook trout [S. trutta], crosses with it, and the female brook char and the male brook trout produce the wonderful but infertile 'Tigerfish,' which one catches now and again in wild waters." (Transl. from German by P.T.M.)

Wahl, R.W.

1960. Chromosome morphology in lake trout Salvelinus namaycush. Copeia 1960(1):16-19.

"Hybridization experiments and cytological evidence indicate that a close chromosome similarity exists among the charrs; closer even than among some members of the genus Salmo."

#### Wales, J.H.

1957. Trout of California. (5th printing, 1968). Calif. Dep. Fish Game, Species Bookl. 6. 56 p.

Mentions splake, natural tiger trout, and natural hybrids of rainbow and golden trout, and rainbow and cutthroat.

Wallis, O.L.

1952. The golden/rainbow hybrid trout of Yosemite National Park. Yosemite Nature Notes 31(5):46.

States that S. aguabonita × S. gairdneri hybrids resulted

Vincent, R.E.

from stocking rainbows in waters previously planted with golden trout.

- 1963. Pink salmon. Wash. State Dep. Fish., Olympia., 73rd Annu. Rep. 1963:90-91, 97.
  - Records preliminary data and photo of *O. gorbuscha*  $\bigcirc$ × *O. keta*  $\bigcirc$  hybrid. See also Washington State Department of Fisheries (1964).
- 1964. Hybrid chum-pink studies. Wash. State Dep. Fish., Olympia, 74th Annu. Rep. 1964:109-111.

Summary of "chumpy" (O. gorbuscha  $\heartsuit \times O$ . keta  $\heartsuit$  hybrid) work by Washington Department of Fisheries.

Watanabe, K.

1925-1927. Gifu-ken Suisan-kai, Suisan zöshoku shikenjö gyömu seiseki hökoku (Report of the Gifu Prefectural Fisheries Experimental Station, [Japan]) for the years 1924, 1925, and 1926, 2(1):18-20; 3(1):22-23; 4(1):40-49.

According to Inaba (1953), the report mentions pond culture of O. masou (sea-run form)  $\times$  O. rhodurus hybrids which showed fast growth.

Webster, D.A.

1955-1972. Adirondack League Club Fishery Management Reports for 1954-1971. Various pagination.

Reports planting of tiger trout and splake including backcrosses of splake to female *S. fontinalis* in New York.

1960. Toxicity of the spotted newt, Notophthalmus viridescens, to trout. Copeia 1960(1):74-75.

"Observations reported here were prompted by the collection of a recently dead 'tiger' trout (hybrid *S. fontinalis S. trutta*) in Green Lake located on the Adirondack League Club near Old Forge, New York. This specimen appeared in perfect health but its stomach contained a recently ingested newt."

Went, A.E.J.

1964. Irish salmon. A review of investigations up to 1963. Sci. Proc. Roy. Dublin Soc. 1A(15):365-412.

Discusses Piggins' work on S. salar  $\times$  S. trutta hybrids. West, J.L.

1968. The growth and reproduction of three intergeneric centrarchid hybrids. Ph.D. Thesis, N.C. State Univ., Raleigh. 143 p.

According to Schwartz (1972), the thesis includes reference to hybridization of *O. mason, O. nerka, O. rhodurus, S. gairdneri, S. salar, S. rutta, S. alpinus, S. fontinalis,* and *S. namaycush.* 

\*1970. The gonads and reproduction of three intergeneric sunfish (family Centrarchidae) hybrids. Evolution 24(2):378-394. Refers briefly to Svärdson's (1945) work.

Wheeler, A., and P.S. Maitland.

\*\*1973. The scarcer freshwater fishes of the British Isles 1. Introduced species. J. Fish Biol. 5(1):49-68.

p. 52—"Brook charr [S. fontinalis] and brown trout [S. trutta] are capable of hybridizing, and the first of these hybrids (commonly known as 'zebra-trout') in the British Isles were produced artificially at a hatchery in Scotland (Day, 1887). Recently, several natural hybrids were found in Wise Een Tarn in the Lake District in England...[Freshwater Biol. Assoc. 1968]."

Tiger trout were used in the study.

Wiggins, W.G.B.

\*\*1950. The introduction and ecology of the brown trout (Salmo trutta Linnaeus) with special reference to North America. [M.A. Thesis], Univ. Toronto, Canada. 109 p.

At the St. John hatchery in New Brunswick hybrids were produced from a *S. trutta* female and a *S. salar* male. "These hybrids were fertile and many were distributed to waters of the Little River and Loch Lomond watersheds. In addition hybrids were crossed with brown trout until a strain of one eighth *Salmo salar* blood was reached, and these were also distributed. Fish of mixed ancestry are still found in the waters of introduction." Cites personal communications and Annual Reports Department of Marine and Fisheries, Ottawa, Canada.

Wilimovsky, N.J., and W.O. Freihofer.

1957. Guide to literature on systematic biology of Pacific salmon, U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 209. 266 p.

Lists eleven authors of reports on hybridization, including annotations.

Williscroft, S.N., and H. Tsuyuki.

1970. Lactate dehydrogenase systems of rainbow trout—evidence for polymorphism in liver and additional subunits in gills, J. Fish. Res. Board Can. 27(9):1563-1567.

Brief review of work on LDH in splake.

#### Willoghby, F.

1686. De historia piscium. Libri quatuor, jussu et sumptibus Societatis Regiae Londinensis editi. Ed. J. Raius, Oxford. According to Schwartz (1972), the work includes mention of salmon × trout hybrids.

Winge, Ö., and E. Ditlevsen.

1948. A study on artificial hybrids between salmon (Salmo salar) and brown trout (Salmo trutta). C.R. Lab. Carlsberg, Sér. Physiol. 24(23):317-345.

Reports that the reciprocal hybrids produced were intermediate in appearance and less resistant than the parent species. The females at 2 years of age contained few eggs and were considered sterile. The males of both crosses were backcrossed to *S. trutta*; the embryos were nonviable.

Withler, F.C.

1969. Visit to Hokkaido hatcheries, 1964. Fish. Res. Board Can., MS Rep. Ser. (Biol.) 1014. 36 p.

Refers to Sano's and Hikita's hybrid work.

Withler, F.C., and R.B. Morley.

1970. Sex-related parental influences on early development of Pacific salmon. J. Fish. Res. Board Can. 27(12):2197-2214. Reports on an extensive study of reciprocal hybrids of O. keta, O. gorbuscha, and O. nerka to determine parental origins of early development characteristics.

Wolf, K.

1954. Progress report on blue-sac disease. Prog. Fish-Cult. 16(2):51-59.

Reports that blue-sac disease was found in rainbow  $\times$  cutthroat hybrids in Utah. Cites Dieterich (1939) finding blue-sac disease in brown trout  $\times$  rainbow trout hybrids.

Wooding, F.H.

According to Martin (1960), the book contains a general history of splake and their angling qualities.

Washington State Department of Fisheries.

Whitmore, D., and E. Goldberg.

<sup>1969.</sup> Molecular heterogeneity of alkaline phosphatase in trout. Physiol. Chem. Physics 1:339-347.

<sup>€159.</sup> The angler's book of Canadian fishes. Collins Press, Don Mills, Ont. 303 p.

World Fishing.

\*\*1961. A new-type salmon from U.S.S.R. World Fishing 10(10):47.

"Fish-breeders on the U.S.S.R. island of Sakhalin (north of Japan) have claimed that they have evolved artifically a new type of salmon which weighs more than three times as much at any stage of development than the Masu and humpback [O. gorbuscha], from which it is evolved, and which matures very early. The new breed is distinguished by its broad body, thick back and short, fat tail and grows to a weight of about 10 lbs. This is the second success of its kind to be achieved by Sakhalin fish breeders."

Wright, J.E., Jr.

1952. Genetics and trout breeding. Pennsylvania Angler 21(4):6-7.

Includes general recommendations regarding the value of hybrids and hybridization. *See also* Buss and Wright (1956, 1958a).

1955. Chromosome numbers in trout. Prog. Fish-Cult. 17(4):172-176.

Discusses relationship between chromosome numbers and hybridization success.

Wright, J.E., Jr., and L.M. Atherton.

- 1970. Polymorphisms for LDH and transferrin loci in brook trout populations. Trans. Am. Fish. Soc. 99(1):179-192.
- Refers to Morrison's (1970) LDH work on splake.

Wright, J.E., and K. Buss.

1958. Barriers to artificial hybridization of certain species of the Salmonidae. (Abstract). Proc. 10th Int. Congr. Genetics 2:322.

Summarizes Buss and Wrights' (1958a) work.

Wuntch, T., and E. Goldberg.

1970. A comparative physico-chemical characterization of lactate dehydrogenase: isozymes in brook trout, lake trout and their hybrid splake trout. J. Exp. Zool. 174(3):233-251. "Peptide maps and amino acid composition of LDH crystallized from skeletal muscle extracts of brook trout (*Salvelinus fontinalis*) and lake trout (*S. namaycush*) are similar to these of the hybrid splake trout."

Yamanaka, H., K. Yamaguchi, K. Hashimoto, and F. Matsuura. 1967. Starch-gel electrophoresis of fish hemoglobins—III. Salmonoid fishes. Bull. Jap. Soc. Sci. Fish. 33(3):195-203.

Reports that O. keta  $Q \times O$ . nerka  $\bigcirc$  hybrids showed hemoglobin patterns comparable to those of the parents, or had one or two additional bands.

Zalsman, P.G.

1914. Experiments in fish culture. Trans. Am. Fish Soc. 43:161-163.

Reports on crosses of S. fontinalis, S. trutta, S. clarki, S. gairdneri, and S. namaycush.

Zilliox, R.G.

1957a. Splake [Answer to letter to the editor by H.A. Hosley]. N.Y. State Conserv. 11(3):47.

Reports on the stocking of splake in New York.

1957b. New trout for none. N.Y. State Conserv. 11(5):26-27. Reports on planting of splake in reclaimed waters in New York.

Zoological Society of London.

1888. [Exhibition and remarks on a specimen of Spanish loach (Cobitis taenia) and two specimens of hybrid Salmonidae.] Proc. Zool. Soc. London 1888:3.

An account of Day's hybrids removed from the ponds at Howietoun on Dec. 1, 1887. Description of fertile females of reciprocal crosses of *S. fontinalis* and *S. trutta*.

Zoologische Garten.

1875. Sind Fischbastarde fruchtbar. Zool. Garten 16(4):156-157.

The report briefly reviews work reported by Fitzinger (1875) with reciprocal hybridization of *S. alpinus (salvelinus)* and *S. trutta (lacustris)* in Austria.







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