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Review article

Finfish health in the United States (1609–1969): historical perspective, pioneering researchers and fish health workers, and annotated bibliography

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Abstract

The importance of fish health studies prior to the 1970s is largely ignored by US fish health investigators. This is because today's literature searches rarely obtain research information prior to 1970. The absence of this earlier literature can result in the duplication of research efforts and missing data that could change the course of a scientific investigation. This is particularly true for studies in fish parasitology. Much of the descriptive literature done between 1900 and 1950 is still valid today and may be the only work available for reference. Older data is also important to understanding disease origin and disease etiology. Information on diseased fish from the geographic region, now known as the United States of America, was first recorded in about 1609 when Captain John Smith described a fish kill. In the 19th century, more than 250 pieces of literature written by US investigators were retrieved that described diseases and parasites of fish. After 1899, only the studies of more prominent fish health specialists, as determined by publication records, have been highlighted. In general, this review documents the development of fish health studies in the US. It serves as a historical document, but more importantly as a resource of older works important to today's scientific studies. Published by Elsevier Science B.V.

Keywords: Fish health; Fish disease; Fish parasitology; History; Annotated bibliography; History of fish health; United States; Fish health history

The United States has an abundance of fresh, brackish and salt water sources within or surrounding its borders. These waters, both natural and artificial provide recreation, economic opportunities, food and transportation for humanity; food and shelter for many animal species living near the water; and the environment required to meet life needs of countless species of aquatic organisms. The finfish in freshwater rivers and lakes of the

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Table 1
Listing of early records found regarding fish pathogen descriptions or other major accomplishments in U.S. fish health

Descriptions or accomplishments	Investigator (s)	References	Date[a]
Early description of a crustacean	Benjamin H. Latrobe	(Latrobe, 1802)	1797
Early description of a leech	Augustus A. Gould	(Gould, 1841)	1841
Early description of a nematode	Joseph P. Leidy	(Leidy, 1852a)	1851
Early description of an acanthocephalan	Joseph P. Leidy	(Leidy, 1852b)	1851
Early description of a digenetic trematode	Joseph P. Leidy	(Leidy, 1852b)	1851
Early description of a tumor or carcinoma	Henry D. Thoreau	(Thoreau, 1852)	1852
Associated stress with disease	Joseph P. Leidy	(Leidy, 1859a)	1858
Early description of fungi	J.P. Leidy, J.H. Slack and J.J. Woodward	(Leidy, 1859a; Slack, 1859; Woodward, 1859)	1858
Early description of a cestode	Joseph P. Leidy	(Leidy, 1859b)	1858
Use of salt as a chemotherapeutant	Livingston Stone	(Stone, 1872)	1872
Early description of a monogenetic trematode	Livingston Stone	(Stone, 1872)	1872
Early description of a protozoan (*Trichodina*)	Livingston Stone	(Stone, 1872)	1872
Early description of the occurrence of nutritional deficiencies	Frederick Mather	(Mather, 1878a)	1878
Early description of an environmental problem—Non-cured cement kills fish	R.H. Lodge	(Smiley, 1886)	1883
Early attempt to visualize bacteria in fish using stains	Stephen A. Forbes	(Forbes, 1890)	1884
Early use of histological techniques in the diagnosis of a fish disease problems	Stephen A. Forbes	(Forbes, 1890)	1884
Early description of a sporozoan on fish	Edwin Linton	(Linton, 1891c)	1889
Early description of a protozoan (*Ichthyophthirius multifiliis*)	William P. Seal	(Seal, 1892)	1890
Early recognition that lamprey were parasitic	Simon H. Gage	(Gage, 1893)	1893
Use of copper sulfate as a chemotherapeutant	Charles W. Stiles	(Stiles, 1894a)	1893
Use of hydrogen peroxide as a chemotherapeutant	Charles W. Stiles	(Stiles, 1894a)	1893
Use of potassium permanganate as a chemotherapeutant	Charles W. Stiles	(Stiles, 1894a)	1893
Early description of a glochidia infection	Frank R. Lillie	(Lillie, 1895)	1895
Early discussion of an environmental problem (gas bubble disease)	Frederic P. Gorham	(Gorham, 1898)	1898
First fish pathologist hired part time	Millard C. Marsh, Department of Commerce	(Bowen, 1970)	1899
Use of formaldehyde as a chemotherapeutant	Millard C. Marsh	(Marsh, 1901b)	1901
Early study in fish hematology	Millard C. Marsh	(Marsh, 1902)	1902
Early description of a toxin (zinc) that kills fish	Millard C. Marsh	(Marsh, 1904)	1904
First fish pathologist hired full time	Herbert S. Davis, Department of Commerce	(Bowen, 1970)	1915
First fish health publication by a U.S. woman	Emmeline Moore	(Moore, 1922)	1921
Early description of Columnaris Disease	Herbert S. Davis	(Davis, 1922)	1922
Early work involved in the selection of disease resistant fish	George C. Embody and Charles O. Hayford	(Embody and Hayford, 1925)	1925
First university fish health program established	Oregon State University	(Shaw et al., 1934)	1932
First fish health diagnostic service established	Herbert S. Davis and Frederic F. Fish	(Higgins, 1935)	1934

Table 1 (*continued*)

Descriptions or accomplishments	Investigator (s)	References	Date[a]
Early description of a viral disease (Lymphocystis)	R. Weissenberg, R.F. Nigrelli and C.E. Smith	(Weissenberg et al., 1937)	1937
Early fish health training	Herbert S. Davis	(Abt and Bullock, 1996)	1941
Early study in fish immunology (study of antibodies)	John E. Cushing	(Cushing, 1942)	1942
Use of sulfa drugs as chemotherapeutants	James S. Gutsell	(Gutsell, 1946)	1946
Early study involved in vaccine preparation[b]	Stanislas F. Snieszko and S.B. Friddle	(Snieszko and Friddle, 1949)	1949
First fish health inspection program	Harold Wolf–California	[c]	1956
Early use of cell cultures for viral detection	Ken Wolf	(Wolf, 1956)	1956
Early isolation of a viral pathogen	K. Wolf, S.F. Snieszko and C.E. Dunbar	(Wolf et al., 1959)	1959

[a] Date of first reporting.

[b] D.C.B. Duff, who wrote a paper on the oral immunization of trout against *Bacterium salmonicida* in 1942, was a Canadian.

[c] John C. Modin, C.A. Rancho Cordova, personal communication.

U.S. and Canada and the fish found along the Atlantic and Pacific Ocean shores to a depth of 200 m amount to more than 2400 species (Robins et al., 1991). These many fish host much greater numbers of animal parasites, bacteria, virus, and fungi. These pathogens, along with many non-infectious diseases adversely affect the health of fish in the aquatic environment. Learning about the health of the fish, and the relationship of the pathogen, the host, and the environment is paramount to understanding and protecting this great resource we call finfish. Pioneering investigators, including scientists, physicians, architects, explorers, ship captains, clergymen, and hatchery workers, some over 200 years ago, eagerly studied many aspects of fish health, paving the way to understanding and managing finfish disease problems.

The following history describes the people and the institutions in the U.S. that were involved in studying or reporting some aspect of the health of finfish from as early as 1609. In particular, care was taken to include all those contributing to this field prior to 1900. It is recognized that many of the early fish health scientists, particularly the naturalists and parasitologists, had primary interests in the taxonomy of the invading organism and little interest in the pathogen's effect on the health of the host. From 1900 to 1939, the people included in this history have been selected mainly on their publication record. It was not the intent of this review to evaluate the scientific merit of these contributions because to do so would require a massive review effort for each individual and would likely be a matter of some controversy (the importance of taxonomic studies verses the importance of applied studies, for example). Those selected from 1940 to 1969 were chosen based on publication record and their reputation in the field of fish health. Also, an attempt was made to include at least the name of all state fish health pathologists who worked in this period. Information on personnel or institutions that began their fish health careers or programs after 1969 is not included. This is because their inclusion would likely result in some key institutions and people

Table 2
This table serves as a reference source giving the name of the investigator, decade of the investigator's first fish health publication (1800 through 1960), and the investigator's area of expertise

Area of expertise	Fish health investigator (decade of first publication)
Protozoa	R. Allison (1950s); C.D. Becker (1960s); H. Beckert (1960s); R.E. Burrows (1930s); H.S. Davis (1910s); F.F. Fish (1930s); S.A. Forbes (1890s); G.L. Hoffman (1940s)[a]; R.R. Kudo (1910s)[a]; D.H. Lewis (1960s); E. Linton (1880s); F.P. Meyer (1960s); E. Moore (1920s); J.F. Mueller (1930s); R.F. Nigrelli (1930s); E.R. Noble (1930s); R.M. Overstreet (1960s); W.A. Rogers (1960s); D.C. Saunders (1950s); W.P. Seal (1880s); C.E. Smith (1960s); C.W. Stiles (1890s); L. Stone (1870s); J.R. Uzmann (1950s); J.H. Wales (1930s); T.L. Wellborn Jr. (1960s); L.E. Wolf (1930s)
Sporozoa	C.D. Becker (1960s); F.F. Bonds (1930s)[a]; H.S. Davis (1910s); F.F. Fish (1930s); R.R. Gurley (1890s)[a]; G.L. Hoffman (1940s)[a]; G.W. Klontz (1960s); R.R. Kudo (1910s)[a]; E. Linton (1880s)[a]; P.A. Meglitsch (1930s)[a]; D.L. Mitchum (1960s); R.F. Nigrelli (1930s); E.R. Noble (1930s); R.M. Overstreet (1960s); R.E. Putz (1960s); C.E. Smith (1960s); H.B. Ward (1890s); K. Wolf (1950s); E.M. Wood (1950s); W.T. Yasutake (1950s)
Monogenetic trematodes	R.V. Bangham (1920s); G.C. Embody (1920s); W.J. Hargis (1950s)[a]; G.L. Hoffman (1940s); G.R. LaRue (1910s); S.D. Lewis (1960s); W.M. Lewis (1960s); G.A. MacCallum (1910s)[a]; J.D. Mizelle (1930s)[a]; J.F. Mueller (1930s)[a]; R.F. Nigrelli (1930s); H.L. Osborne (1900s)[a]; R.M. Overstreet (1960s); E.W. Price (1920s)[a]; W.A. Rogers (1960s); J.A. Ryder (1880s); L. Stone (1870s); J.R. Uzmann (1950s)
Digenetic trematodes	R.V. Bangham (1920s); C.M. Cable (1930s)[a]; M.S. Ferguson (1930s)[a]; J.H. Fischthal (1940s); G.L. Hoffman (1940s); S.H. Hopkins (1930s)[a]; R.C. Hughes (1920s)[a]; G.W. Hunter III (1920s)[a]; G.R. LaRue (1910s)[a]; J.P. Leidy (1850s); W.M. Lewis (1960s); E. Linton (1880s)[a]; G.A. MacCallum (1910s)[a]; H.W. Manter (1920s); D.L. Mitchum (1960s); J.F. Mueller (1930s); R.F. Nigrelli (1930s); H.L. Osborne (1900s); R.M. Overstreet (1960s); R.E. Putz (1960s); J.A. Ryder (1880s); B.T. Simms (1920s); C.E. Smith (1960s); C.W. Stiles (1890s); F.W. True (1880s); J.R. Uzmann (1950s); H.B. Ward (1890s); E.M. Wood (1950s)
Cestodes	R.V. Bangham (1920s); C.D. Becker (1960s); H.M. Benedict (1850s); F.H. Bradley (1870s); H.E. Essex (1920s)[a]; J.H. Fischthal (1940s); F.V. Hayden (1870s); G.L. Hoffman (1940s); G.W. Hunter III (1920s)[a]; W.A. Jones (1870s); J.P. Leidy (1850s)[a]; E. Linton (1880s)[a]; G.R. LaRue (1910s); J.S. Mackiewicz (1950s)[a]; F.P. Meyer (1960s); J.W. Milner (1870s); E. Moore (1920s); R.F. Nigrelli (1930s); R.M. Overstreet (1960s); W.A. Rogers (1960s); L.J. Thomas (1920s)[a]; F.W. True (1880s); J.R. Uzmann (1950s); H.B. Ward (1890s)
Nematodes	R.V. Bangham (1920s); G.W. Hunter III (1920s); J.P. Leidy (1850s)[a]; E. Linton (1880s); M.C. Meyer (1940s); R.M. Overstreet (1960s); W.A. Rogers (1960s); L.J. Thomas (1920s)[a]; F.W. True (1880s); J.R. Uzmann (1950s); H.B. Ward (1890s)
Crustaceans	A. Agassiz (1860s); R.V. Bangham (1920s); E.D. Cope (1870s); J.D. Dana (1830s)[a]; J.E. Dekay (1820s); N. Fasten (1910s)[a]; C.F. Gissler (1880s); G.B. Goode (1870s); A.A. Gould (1840s); O. Harger (1870s)[a]; T.W. Harris (1830s); G.L. Hoffman (1940s);

Table 2 (*continued*)

Area of expertise	Fish health investigator (decade of first publication)
Crustaceans	D.S. Kellicott (1870s)[a]; S. Kneeland (1850s); B.H. Latrobe (1800s); J.P. Leidy (1850s); C.A. LeSueur (1820s); J.W. Milner (1870s); J.F. Mueller (1930s); R.F. Nigrelli (1930s); R.M. Overstreet (1960s); G.H. Parker (1890s); A.S. Packard (1860s)[a]; C. Pickering (1830s); R. Rathbun (1870s)[a]; W.A. Rogers (1960s); J.A. Ryder (1880s); T. Say (1810s); S.I. Smith (1870s)[a]; L. Stone (1870s); D.H. Storer (1830s); R.S. Tarr (1880s); F.W. True (1880s); L.M. Underwood (1880s); J.R. Uzmann (1950s); A.E. Verrill (1870s)[a]; J.C. White (1850s); C.B. Wilson (1900s)[a]
Leeches	R.V. Bangham (1920s); C. Girard (1850s); A.A. Gould (1840s); J.P. Leidy (1850s); F.P. Meyer (1960s); M.C. Meyer (1940s)[a]; J.W. Milner (1870s); A.E. Verrill (1870s)[a]
Acanthocephala	O.M. Amin (1960s)[a]; R.V. Bangham (1920s); J.P. Leidy (1840s); E. Linton (1880s); S. Lockwood (1870s); G.W. Hunter III (1920s); J.F. Mueller (1930s); R.F. Nigrelli (1930s); H.V. VanCleave (1910s)[a]
Glochidia	R.V. Bangham (1920s)[a]; J.H. Fischthal (1940s); A.D. Howard (1910s)[a]; G. LeFevre (1900s)[a]; M.C. Meyer (1940s); J.F. Mueller (1930s); C.T. Simpson (1890s); C.J. Sindermann (1950s); C.B. Wilson (1900s)
Lamprey	V.C. Applegate (1940s); S.H. Gage (1890s); J.H. Howell (1950s); H.A. Surface (1890s)
Bacteria—coldwater	D.F. Amend (1960s); C.D. Becker (1960s); D.L. Belding (1920s); G.L. Bullock (1950s)[a]; H.S. Davis (1910s); C.E. Dunbar (1950s); F.F. Fish (1930s); S.A. Forbes (1880s); J.L. Fryer (1950s); P.J. Griffin (1950s)[a]; J.S. Gutsell (1940s); G.W. Klontz (1960s); M.C. Marsh (1900s); E.J. Ordal (1940s)[a]; R.E. Pacha (1960s); T.J. Parisot (1950s); R.R. Rucker (1940s); C.E. Smith (1960s); S.F. Snieszko (1940s); L.E. Wolf (1930s); E.M. Wood (1950s); J.W. Wood (1950s); W.T. Yasutake (1950s)
Bacteria—warmwater	C.D. Becker (1960s); G.L. Bullock (1950s); H.S. Davis (1910s); D.H. Lewis (1960s); F.P. Meyer (1960s); E.J. Ordal (1940s); R.E. Pacha (1960s); J.A. Plumb (1960s)[a]; W.A. Rogers (1960s); S.F. Snieszko (1940s)
Bacteria—marine	G.L. Bullock (1950s); D.H. Lewis (1960s)[a]; D.L. Mitchum (1960s); R.F. Nigrelli (1930s); A.J. Ross (1950s); R.R. Rucker (1940s); C.J. Sindermann (1950s); S.F. Snieszko (1940s)
Virus, chlamydia, and other similar organisms	D.F. Amend (1960s)[a]; L.W. Clem (1960s); C.E. Dunbar (1950s); J.L. Fryer (1950s)[a]; G.L. Hoffman (1940s); G.W. Klontz (1960s); D.H. Lewis (1960s); B. Nicholson (1960s)[a]; R.F. Nigrelli (1930s); T.J. Parisot (1950s); K.S. Pilcher (1960s)[a]; J.A. Plumb (1960s)[a]; A.J. Ross (1950s); R.R. Rucker (1940s); M. Michael Sigel (1960s); C.E. Smith (1960s); S.F. Snieszko (1940s); R. Walker (1940s); G.A. Wedemeyer (1960s); R. Weissenberg (1930s); T.L. Wellborn Jr. (1960s); W.H. Wingfield (1960s); K. Wolf (1950s)[a]; E.M. Wood (1950s)
Tissue culture	L.W. Clem (1960s); J.L. Fryer (1950s)[a]; B. Nicholson (1960s); J.A. Plumb (1960s); M.M. Sigel (1960s)[a]; K. Wolf (1950s)[a]
Fungi	C.G. Atkins (1870s); R.E. Burrows (1930s); G.N. Calkins (1890s); F.N. Clark (1880s); F.W. Clark (1870s); G.P. Clinton (1890s); H.S. Davis (1910s); C.W. Dodge (1890s); F.F. Fish (1930s); S.A. Forbes (1890s); T. Garlick (1850s); W.R. Gerard (1870s);

(continued on next page)

Table 2 (*continued*)

Area of expertise	Fish health investigator (decade of first publication)
Fungi	L.W. Green (1880s); Harkness (1880s); Hine (1870s); G.L. Hoffman (1940s); J.P. Leidy (1850s); S. Lockwood (1890s); M.C. Marsh (1900s); F.P. Meyer (1960s); R.F. Nigrelli (1930s); T. Norris (1860); C.N. Page (1890s); C.H. Peck (1880s); R. Rathbun (1890s); W. de C. Ravenel (1890s); H.J. Rice (1880s); Robson (1880s); W.A. Rogers (1960s); A.J. Ross (1950s); R.R. Rucker (1940s); J.A. Ryder (1880s); M. Samuel (1890s); G.A. Seagle (1890s); W.P. Seal (1880s); L. Stone (1870s); W. Trelease (1880s); E.M. Wood (1950s); S.G. Worth (1890s); W.T. Yasutake (1950s)
Treatments	R. Allison (1960s); D.F. Amend (1960s); G.L. Bullock (1950s); R.E. Burrows (1930s)[a]; F.N. Clark (1880s); G.P. Clinton (1890s); H.S. Davis (1910s); C.W. Dodge (1890s); C.E. Dunbar (1950s); G.C. Embody (1920s); F.F. Fish (1930s); S.A. Forbes (1890s); J.L. Fryer (1950s); S. Green (1870s); J.S. Gutsell (1940s)[a]; R.L. Herman (1960s); G.L. Hoffman (1940s); S.D. Lewis (1960s); M.C. Marsh (1900s); F.P. Meyer (1960s)[a]; M.E. O'Brien (1890s); C.N. Page (1890s); R.G. Piper (1950s); J.A. Plumb (1960s); H.J. Rice (1880s); W.A. Rogers (1960s); A.J. Ross (1950s); R.R. Rucker (1940s); J.A. Ryder (1880s); M. Samuel (1890s); G.A. Seagle (1890s); W.P. Seal (1880s); C.E. Smith (1960s); S.F. Snieszko (1940s); C.W. Stiles (1890s); L. Stone (1870s); L.E. Wolf (1930s); E.M. Wood (1950s); S.G. Worth (1890s); W.T. Yasutake (1950s)
Immunology and vaccines	D.F. Amend (1960s)[a]; D.P. Anderson (1960s)[a]; L.W. Clem (1960s)[a]; J.E. Cushing (1940s)[a]; J.L. Fryer (1950s); G.W. Klontz (1960s); G.E. Krantz (1960s)[a]; D.H. Lewis (1960s); R.F. Nigrelli (1930s); J.A. Plumb (1960s); G. Post (1950s); W.A. Rogers (1960s); A.J. Ross (1950s); M.M. Sigel (1960s); S.F. Snieszko (1940s)
Tumors	L.M. Ashley (1960s)[a]; H.R. Gaylord (1900s)[a]; J.E. Halver (1950s)[a]; J.P. Leidy (1850s); D. Marine (1910s)[a]; M.C. Marsh (1900s)[a]; R.F. Nigrelli (1930s); R.M. Overstreet (1960s); R.R. Rucker (1940s); C.E. Smith (1960s); S.F. Snieszko (1940s); H.D. Thoreau (1850s); J.H. Wales (1930s); H. Wolf (1940s); E.M. Wood (1950s); W.T. Yasutake (1950s)
Toxicity studies	L.M. Ashley (1960s); D.L. Belding (1920s); D.E. Ferguson (1960s)[a]; J.L. Fryer (1950s); J.E. Halver (1950s); J.B. Hunn (1960s)[a]; W.M. Lewis (1960s); L.L. Marking (1960s)[a]; M.C. Marsh (1900s); R.M. Overstreet (1960s); J.A. Plumb (1960s); W.A. Rogers (1960s); C.J. Sindermann (1950s); C.E. Smith (1960s); G.A. Wedemeyer (1960s); T.L. Wellborn Jr. (1960s)
Diagnostic methods	D.F. Amend (1960s); D.P. Anderson (1960s); G.L. Bullock (1950s); H.S. Davis (1910s); F.F. Fish (1930s); J.L. Fryer (1950s); P.J. Griffin (1950s); G.L. Hoffman (1940s); G.W. Klontz (1960s); D.H. Lewis (1960s); B. Nicholson (1960s); E.J. Ordal (1940s); S.F. Snieszko (1940s); G.A. Wedemeyer (1960s)
Histopathology	G.N. Calkins (1890s); C.E. Dunbar (1950s)[a]; S.A. Forbes (1890s); R.L. Herman (1960s)[a]; H.R. Gaylord (1900s); C.E. Smith (1960s)[a]; E.M. Wood (1950s)[a]; W.T. Yasutake (1950s)[a]
Disease resistant strains	G.C. Embody (1920s); N.F. Ehlinger (1960s); S.F. Snieszko (1940s); L.E. Wolf (1930s)

Table 2 (*continued*)

Area of expertise	Fish health investigator (decade of first publication)
Stress and disease	S.F. Baird (1880s); G.W. Klontz (1960s); J.P. Leidy (1850s); M.C. Marsh (1900s)[a]; F.P. Meyer (1960s); E. Moore (1920s); J.A. Plumb (1960s); H.J. Rice (1880s); S.F. Snieszko (1940s)[a]; G.A. Wedemeyer (1960s)[a]
Noninfectious problems	L.M. Ashley (1960s); C.D. Becker (1960s); D.L. Belding (1920s); H.S. Davis (1910s); G.C. Embody (1920s); F.M. Endlich (1880s); F.F. Fish (1930s); F.P. Gorham (1890s); J.E. Halver (1950s); R.L. Herman (1960s); D.H. Lewis (1960s); W.M. Lewis (1960s); R.H. Lodge (1880s); M.C. Marsh (1900s)[a]; F. Mathers (1870s); R.G. Piper (1950s); W.A. Rogers (1960s); R.R. Rucker (1940s); C.E. Smith (1960s); S.F. Snieszko (1940s); J.H. Wales (1930s); G.A. Wedemeyer (1960s)[a]; T.L. Wellborn Jr. (1960s); L.E. Wolf (1930s)[a]; E.M. Wood (1950s); J.W. Wood (1950s); W.T. Yasutake (1950s)

[a]The investigator had major contributions in the given field of fish health.

being overlooked because of the large amount of information involved. Fish health information from 1970 till the present is therefore limited to those persons or institutions who began their involvement prior to 1970.

This paper has been organized chronologically by individuals and not by accomplishments. In most cases, the accomplishments of an individual have been placed in the time period of his or her first work. For example, a researcher starting in 1910 will have all career accomplishments (even if he worked for the next 50 years) highlighted in the section "Fish health from 1900 to 1919". This was done because it would be beyond the purview of this paper to put all the work of individuals in a chronological order; the purpose here is to credit the individuals with their accomplishments. For readers more interested in accomplishments than individuals, Table 1 has been included. It highlights some of the early pathogen descriptions and major contributions (probably the first in the U.S.), the individual(s) responsible for the work, the reference, and the date of the report (report dates often precede the publication dates). The entries in this table are given in chronological order.

One of the benefits of reading this history is that it acquaints the reader with a number of investigators and their works that have been lost to the scientific community for information and reference purposes. Such older works are not picked up by today's computer database searches. Table 2 has been prepared as a quick way to relate an investigator with his or her area of expertise and decade of their first publication. Throughout the tables and text of this review, I have given the first and middle names or initials of the investigators in order to facilitate the procurement of their papers.

Several publications have been excluded from this review article. Not included are reports or descriptions of fish parasites if a fish host is not mentioned; therefore, some fish parasites found on animals other than fish, some dredging reports that include fish parasites, and some listings of regional fauna that include fish parasites are not included. Excluded for the above reasons are some frequently referenced pre-1900 papers by C.S. Fellows, Augustus A. Gould, Oscar Harger, Joseph P. Leidy, Sidney I. Smith and Addison E. Verrill. Also excluded are translations and reports of fish parasites and

diseases in U.S. publications by foreign[1] authors. Some of the pre-1900 foreign authors mistaken for U.S. authors are H.M. Benedict, C. Kerbert, M.A. Robson, J. Salter, A.B. Stirling and Robert R. Wright. Several translations of papers by British and German authors that include information on parasites and diseases of fish are found in the bulletins and reports of the United States Commission of Fish and Fisheries. It should also be noted that some titles are misleading. As an example, one paper entitled *Vegetable Parasites of Codfish* describes bacterial contamination of stored fish, not a parasitic or disease condition of a live fish (Farlow, 1887). Lastly, Ellis (1763) is referenced by some reviewers as describing a fish parasite found off the coast of South Carolina. The paper describes a sea pen (Pennetula), a non-parasitic animal related to the corals and Ellis gives no indication in the paper that he thought the sea pen was a parasite.

The history of fish health in the U.S. is of relatively recent origin compared to that of other countries, particularly countries in and bordering Europe. The history of fish health can be dated to 1450 BC when a tilapia with a grossly enlarged abdomen, probably from a disease, was painted on a wall in Egypt (Mawdesley-Thomas, 1972). Most would put the origin of fish health at 350 BC when Aristotle wrote of a parasitic crustacean found on swordfish and tuna (Post, 1987). More detailed descriptions of fish parasites began to show up in the late 1600s. In a French publication, S.P. Boccone described a crustacean, probably a *Pennella* from a sword fish in 1671 (McGregor, 1963), and Linnaeus in 1746 gave a very detailed description of a parasitic crustacean (*Lernaea*) (Linnaeus, 1746). By way of comparison, the first description of a fish parasite in the U.S. was made in 1797 (Latrobe, 1802), 51 years after Linnaeus' description. I found 257 publications and reports on fish parasites and other fish health concerns in the U.S. prior to 1900 written by 113 authors. 18 of these 257 are reports contained within four publications (Bean, 1896a; Goode, 1883; Smiley, 1886; Stone, 1888).

1. Fish health prior to 1776

Two early reports predate the formation of the United States of America in 1776 and these both mention fish kills in natural waters that would become part of the U.S. Between 1607 to 1609, Captain John Smith (Fig. 1) reported crowded, surfacing, and dead fish in natural waters (Lankford, 1967). He seems not to have considered the fish sick or stressed and reported, "Of mines we were all ignorant, but a few beavers, otters, bears, martins, and minks [skins] we found, and in divers places that abundance of fish, lying so thick with their heads above the water, as for want of nets (our barge driving amongst them) we attempted to catch them with a frying pan: but we found it a bad instrument to catch fish with: neither better fish, more plenty, nor more variety for small fish, had any of us ever seen in any place so swimming in the water, but they are not to be caught with frying pans. Some small cod also we did see swim close by the shore by

[1] Most are British, Canadian, or German authors.

Fig. 1. Captain John Smith (1580–1631). Smith made the first description of a fish kill from North America around 1608. Engraving of John Smith by Simon van de Passe, taken from the Encyclopedia Americana, 1999 edition. Copyright 1999 by Grolier. Reprinted with permission.

Smiths Isles, and some as high as Rocky Point. And some we found dead upon the shore." Smith's report indicates that he considered the fish to be in good shape without obvious lesions ("neither better fish"). But finding fish crowded together, swimming about with heads above the water, swimming close to the shore, and some dead on the shore suggests a serious problem. Parasites or infectious diseases are possible causes, but they usually do not infect several fish species simultaneously, bring large numbers to the surface, or occur without causing some obvious lesions. Low dissolved oxygen is a possibility, however, since only small fish were reported (large fish usually succumb to low oxygen first) the cause is more likely a natural or introduced toxin in the water.[2] Another early report came from the Council Papers of Virginia in 1698. These papers reported that great fish kills resulted from the killing and processing of whales in the

[2] Opinion about the possible cause of this fish health problem is that of the author.

Table 3
Reports of parasitic crustacea and leeches associated with fish prior to 1850

Investigator	Parasites reported	References
James D. Dana	*Argulus catostomi* on suckers	(Dana and Herrick, 1836, 1837)
James E. DeKay	*Caligus* (*Pennatula*), *Argulus*, *Livoneca* (*Cymotha*), and *Lernaea* on various fish species	(DeKay, 1822, 1844)
Augustus A. Gould	*A. alosae*, *Caligus*, *Anthosoma*, an isopod, and *Phylline hippoglossi* (leech) on fish	(Gould, 1841)
Thomas W. Harris	*Argulus*	Harris, 1839
Benjamin H. Latrobe	*Oniscus praegustator* in mouth of Menhaden *Brevoortia tyrannus*	(Latrobe, 1802)
Charles A. LeSueur	*Lerneopenna* on flying fish and *Lernaea* (*Lerneocera*) *cruciata* and *L. radiata* on the rock bass and Menhaden	(LeSueur, 1824)
Charles Pickering with James D. Dana	*Caligus americanus* on cod	(Pickering and Dana, 1838)
Thomas Say	*Livoneca* (*Cymothoa*), *Pandarus sinuatus* and *C. piscinus* on various fishes	(Say, 1818a,b)
David H. Storer	*Pennella sagitta* from a sunfish	(Storer, 1839)

Chesapeake; "great quantities of fish are poisoned and destroyed and the rivers also made noisome and offensive" (Davidson et al., 1997).

2. Parasitological observations of naturalists prior to 1850

Naturalists[3] first reported the presence of parasites on fish in the U.S. Prior to 1850, nine naturalists published 12 articles on the parasites of fish (Table 3). Being educated in geology, botany, zoology, paleontology, and medicine, the American naturalists of the 19th century had a broad range of interests covering all fields of natural sciences. It was not uncommon for them to make geological, paleontological, botanical, and zoological observations of an entire ecosystem. Included in these observations were fish parasites, particularly the macroscopic parasitic crustaceans. It should be noted that their descriptions also included some microscopic characterization of the parasites. When describing fish parasites, often little interest was given to the health of the fish unless there were obvious problems.

Benjamin Henry Latrobe (Fig. 2) was appointed by Thomas Jefferson as the Surveyor of Public Buildings in charge of the White House and the Capitol from 1803 to 1811 (Anonymous, 1992). He became sick in March of 1797 and spent several days convalescing at a friend's house on the York River in Virginia (Latrobe, 1802). While there, he took walks down to the river and observed menhaden (Latrobe called the fish

[3] A term often used in the 19th and early 20th centuries to describe scientists who investigated of one or more disciplines of natural science and who emphasized field studies.

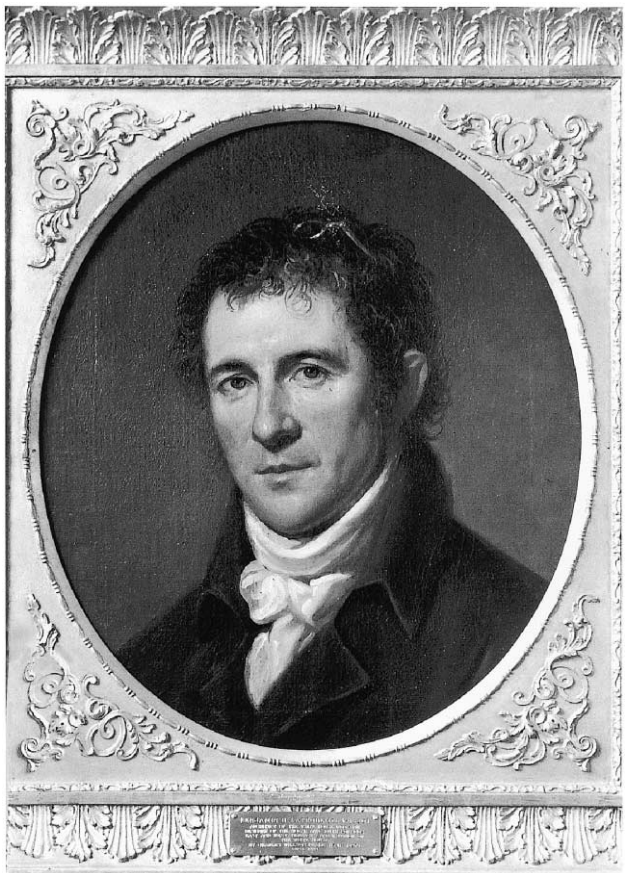

Fig. 2. Benjamin Henry Latrobe (1764–1820). Latrobe described the first parasite from fish in the United States in 1797. Painting of Latrobe by Charles Willson Peale; permission to reproduce this picture was obtained from the White House Historical Association, Washington, DC.

"bay alewives") from fishermen's catches. These fish had in their mouths a large crustacean that the fisherman called a louse. He described the parasite (Fig. 3), made a careful drawing of it, called it *Oniscus praegustator* (meaning cupbearer or the one who first tastes the food) and published the information in *Transactions of the American Philosophical Society, held at Philadelphia for Promoting Useful Knowledge*, in 1802. He mentioned that removing the parasite caused the fish to die (Latrobe, 1802). At a later time, the parasite he described has been called *Lernaeenicus radiatus* (Kabata, 1979; LeSueur, 1824).

In 1818, Thomas Say (Fig. 4), who is considered to be the founder of descriptive entomology (Encyclopaedia Britannica, 1983) in the U.S., described a crustacean, *Pandarus sinuatus*, from a dogfish taken from the Atlantic Coast (Say, 1818b). He also reported on another common parasitic crustacean, *Caligus piscinus*, on codfish, and several crustacea of the genus *Cymothoa* found on marine fishes (Say, 1818a). He

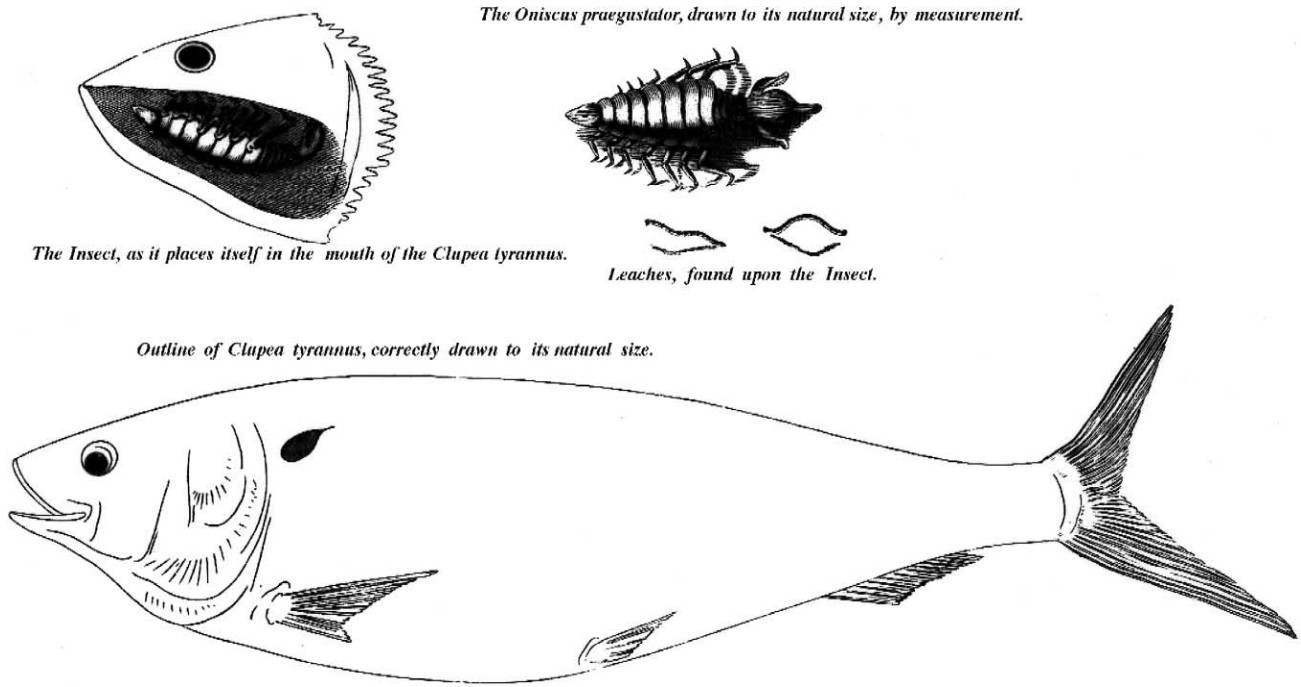

Fig. 3. Latrobe's drawing of a crustacean from the mouth of a menhaden published in the Transactions of the American Philosophical Society held at Philadelphia for Promoting Useful Knowledge in 1802. Permission to reproduce the drawing was granted by the Ewell Sale Stewart Library, The Academy of Natural Sciences of Philadelphia.

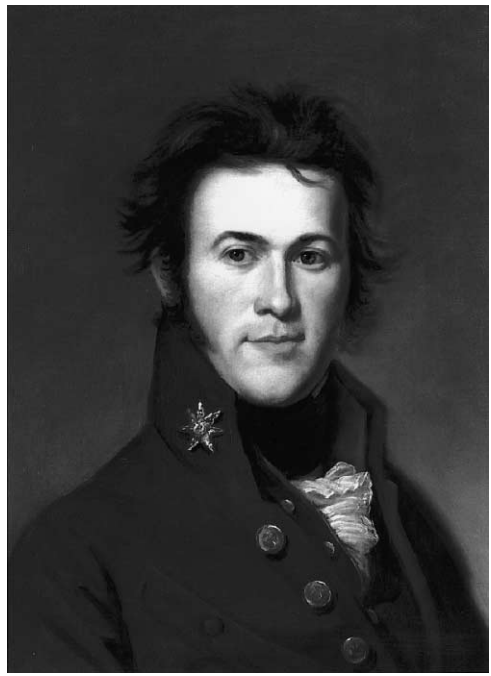

Fig. 4. Thomas Say (1787–1834). Say was a naturalist who wrote two papers describing crustacea from marine fish in 1818. Painting of Say by Charles Willson Peale. Permission to reproduce the photograph was granted by the Ewell Sale Stewart Library, The Academy of Natural Sciences of Philadelphia.

published his findings, and preserved and stored some specimens at the Philadelphia Academy of Natural Sciences (Say, 1818a,b). Say was curator of the American Philosophical Society in Philadelphia and a professor of natural history at the University of Pennsylvania (Encyclopaedia Britannica, 1983).

Charles A. LeSueur (Fig. 5) was a naturalist affiliated with the Philadelphia Academy of Natural Sciences. In 1824, he described three parasitic crustacea of the genus *Lernaea* from Lake Erie (LeSueur, 1824). Following LeSueur, James Dwight Dana, a naturalist and earth scientist, who became a professor at Yale College in 1856, published a description of a large, parasitic copepod of fish called *Argulus catostomi* (fish louse) in 1836 and 1837 (Encyclopaedia Britannica, 1983; Dana and Herrick, 1836, 1837). In 1838, he was second author with Charles Pickering (both members of the Yale Natural History Society) on an article concerning a crustacean called *C. americanus* that was parasitizing cod (Pickering and Dana, 1838). Dana (1852) wrote a synopsis on the characters of parasitic copepods and he described another crustacean fish parasite from the genus *Salmincola* (Dana, 1853). James Dana was one of the most prolific writers of scientific literature in his time (Gillispie, 1971).

Another prolific writer was the naturalist James E. DeKay, who published two papers on parasitic crustaceans of fish (DeKay, 1822, 1844). In his 1822 publication, he reported a crustacean that he called *Pennatule fleche* (the name of a non-parasitic coral

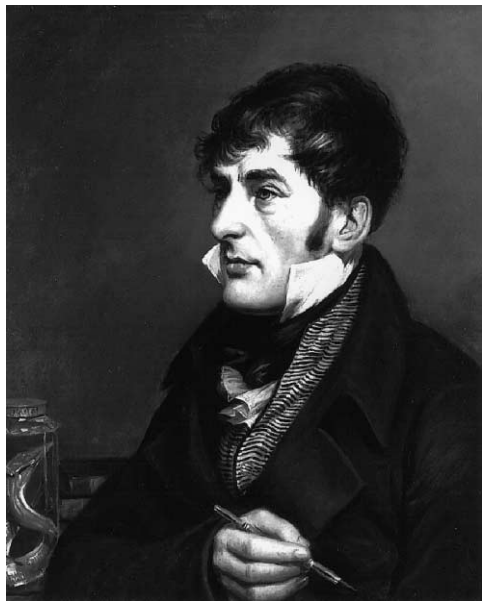

Fig. 5. Charles Alexandre LeSueur (1778–1846). LeSueur described crustacea from fresh and salt water fish in 1824. Painting of LeSueur by Charles Willson Peale. Permission to reproduce the photograph was granted by the Ewell Sale Stewart Library, The Academy of Natural Sciences of Philadelphia.

relative called a sea pen) but he actually was describing a crustacean, probably a *Caligus* sp., that was parasitizing a porcupine fish (*Diodon pilosus*). Gould (1841), a naturalist and physician from Massachusetts who specialized in mollusks, crustaceans, and insects (Encyclopeadia Britannica, 1983), published one paper on parasitic fish crustaceans as did Harris (1839) and Storer (1839). Gould described a leech, *Phylline hippoglossi*, from a marine fish; this was the only non-crustacean parasite of fish described in the U.S. prior to 1850 (Table 3).

3. Fish health from 1850 to 1899

American naturalists continued to describe macroscopic fish parasites including nematodes, trematodes, cestodes, and acanthocephalans, as well as crustaceans and leeches. Some began to specialize and work exclusively with fish parasites. In the 1860s, massive fish kills began to be recorded and reported from U.S. waters. Concerns over the health of cultured and aquarium displayed fish arose because of the establishment of fish culture in the U.S. in the 1850s (Bean, 1910; Raveret-Wattel, 1883) and the importance of aquarium exhibits set up in the 1880s (Seal, 1889). Losses of fish in aquaria and culture systems gave rise to the development of treatments, management practices to prevent disease, the development of some pathological methods for the diagnosis of fish disease, and the discovery of some microscopic organisms.

3.1. Fish parasitology: 1850 to 1899

In this period, 35 naturalists and parasitologists produced 105 publications or reports on fish parasites in the U.S. The investigators, a brief synopsis of the contents of their publications, and the references for their publications are given in Table 4.

One of the most prolific naturalists of the 19th century was Joseph P. Leidy (Fig. 6). He wrote about 600 scientific notes and articles (Osborne, 1913) including 23 publications on fish health from 1852 through 1891 (Leidy, 1852a,b, 1854a, 1856, 1857, 1859a,b, 1871, 1872, 1879, 1883, 1886a,b,c, 1888a,b, 1889a,b,c,d,e, 1890, 1891). Some of Leidy's fish health interests went beyond just fish parasites, making him unique among the naturalists of his time. In 1858, he reported what he called carcinomatous-like cells on a minnow, fungi on goldfish, and he stated that stressed or weakened goldfish appear to be predisposed to attack by fungi infestations (Leidy, 1859a).

The majority of Joseph Leidy's fish health reports were in parasitology. He is credited with describing the first acanthocephalan, nematode, cestode, and digenetic trematode from fish in the U.S. (Leidy, 1852a,b, 1859b). Although no protozoa parasitic to fish were described by Leidy, he had expertise and experience with these smaller parasites and described the microscopical characters of three parasitic protozoa of frogs in 1853 (Leidy, 1854b). In 1875, he described a sporozoan from a mallard duck. He made a statement that the sporozoa were reported by European researchers in fish and that the mallard may have been infected by eating a fish (Leidy, 1875).

Leidy was a physician and one of the most versatile scientists of his time. Leidy made important contributions in the fields of paleontology, comparative anatomy and parasitology. He worked at the Philadelphia Academy of Natural Sciences as a curator and then chairman of the Board of Curators, and finished his career in 1891 as the director of the Biology Department at the University of Pennsylvania in Philadelphia (Encyclopaedia Britannica, 1983). Thirteen years after his death in 1891, his last paper concerning fish parasites was published by his son (Leidy, 1904).

The other dominant figure of this period was the parasitologist, Edwin Linton (Fig. 7), professor of geology and biology at Washington and Jefferson College, Washington, PA. In 1884, the United States Commissioner of Fish and Fisheries, Spencer Baird, encouraged Linton to "take as his specialty" the entozoa (internal parasites) of marine fishes (Moore, 1939). Linton complied and took on this virgin field and published more than 100 papers, including 63 on fish parasites (Guido and Little, 1959; McGregor, 1963; Yamaguti, 1958, 1959). Nineteen of the sixty-three were written from 1887 to 1899 (including two 1899 reports published in 1901) (Linton, 1887, 1889a,b, 1891a,b,c,d,e, 1892a,b, 1893, 1894, 1897, 1898a,b,c,d, 1901a,b). His fish parasitology papers detailed information on numerous protozoa, sporozoa, trematodes, cestodes, nematodes and acanthocephala of freshwater and marine fish species in the U.S. from 1886 to 1934. Several of these papers exceeded 50 pages in length, not including figures, and one was 181 pages (Linton, 1891a). His last two papers were published in 1940 and 1941, shortly after his death in 1939. Linton did much of his work in association with the Marine Biological Laboratory of Woods Hole, Massachusetts. He not only worked with wild fish populations but was called on to examine blind trout for the U.S. Fish Commission in 1890 (Rathbun, 1893). Edwin Linton was one of the first

Table 4
Reports and publications on parasitology from 1850 through 1899

Investigator	Parasites reported	References
Alexander Agassiz	Crustacea (*Pennella orthagorisci*) on an ocean sunfish	(Agassiz, 1865)
Frank H. Bradley	Cestodes (*Diphyllobothrium*) in trout	(Bradley, 1872)
Edward Drinker Cope	Crustacea (*Cauloxenus*) on cave fish	(Cope, 1871, 1872)
James D. Dana	Crustacea (*Caligus*, *Argulus*, and *Salmincola*) on fish	(Dana, 1852, 1853)
Simon Henry Gage	Lamprey are destructive to fish and controls are needed	(Gage, 1893)
Charles Girard	Leech (salt water) on skate	(Girard, 1851)
C.F. Gissler	Crustacea (*Caligus*) on Pacific salmon	(Gissler, 1883)
G. Brown Goode	Crustacea and leeches on swordfishes and menhaden; lamprey mentioned as a possible parasite	(Goode, 1883, 1884)
Revere R. Gurley	Sporozoan parasites of fish	(Gurley, 1893, 1894)
Oscar Harger	Crustacea (five genera of parasitic isopods)	(Harger, 1879, 1880)
Ferdinand Vandiveer Hayden	Cestodes (*D. cordiceps*) in trout	(Hayden, 1872)
W.A. Jones	Cestodes in trout	(Jones, 1873)
David S. Kellicott	Crustacea (*Argulus* and *Lernaeocera*)	(Kellicott, 1877, 1878, 1879a,b, 1880a,b,c,d, 1881, 1882, 1886)
Samuel Kneeland	Crustacean (*Lernaea* sp.) on sunfish	(Kneeland, 1858)
Joseph P. Leidy	Acanthocephala, trematodes, nematodes, cestodes, crustacea, and leeches of fish	(Leidy, 1852a,b, 1854a, 1856, 1857, 1859b, 1871, 1872, 1879, 1883, 1886a,b,c, 1888a,b, 1889a,b,c,d,e, 1890, 1891)
Frank R. Lillie	Glochidia in fish gills	(Lillie, 1895)
Edwin Linton	Acanthocephala, trematodes, nematodes, cestodes, protozoa, and sporozoa of fish	(Linton, 1887, 1889a,b, 1891a,b,c,d,e, 1892a,b, 1893, 1894, 1897, 1898a,b,c,d, 1901a,b[a])
Samuel Lockwood	Acanthocephala (*Echinorhychus*) in eel	(Lockwood, 1872)
James W. Milner	Acanthocephala, crustacea, leeches, and cestodes of white fish	(Milner, 1874)
J. Percy Moore	Leeches (*Piscicola*, *Trachelobdella*, and *Pontobdella*) on fish	(Moore, 1899)
Alpheus Spring Packard	Crustacea (*Cauloxenus*, *Achtheres*, *Aega*, and *Lerneonema*) and acanthocephala on fish	(Packard, 1867, 1873, 1874, 1875a,b,c)
George Howard Parker	Crustacea (*Argulus*) on killifish	(Parker, 1891)
Richard Rathbun	Crustacea of marine fishes	(Rathbun, 1882, 1885, 1887, 1888; Verrill and Rathbun, 1879)
John A. Ryder	Trematode of a cunner	(Ryder, 1884a)
Genio C. Scott	Lamprey, thought it absurd that it would attach to fish	(Scott, 1869)
Charles T. Simpson	Glochidia in fish gills, fins and scales	(Simpson, 1899)
Sidney Irving Smith	Crustacea of marine and freshwater fishes	(Smith, 1874, 1884)

Table 4 (*continued*)

Investigator	Parasites reported	References
Charles W. Stiles	Protozoan (*Ichthyophthirius*) on catfish; trematodes of fish	(Stiles, 1894a,b, 1898)
Livingston Stone	Crustacean (sea louse) on salmon	(Stone, 1878)
H.A. Surface	Lamprey (*Petromyzon marinus*) causing destruction to fish in New York waters, also mentions that fungi kill lamprey and that lamprey control is needed to protect fish	(Surface, 1899a,b)
Ralph Stockman Tarr	Crustacea (*Penella*) on swordfish	(Tarr, 1886)
Frederick William True	Trematode, nematodes, cestodes and crustaceans of swordfish	(Goode, 1883)
Lucien Marcus Underwood	Crustacea of seven genera on fish	(Underwood, 1886)
Addison Emery Verrill	Leeches and crustacea of marine fishes	(Verrill, 1870, 1872, 1873, 1874; Verrill and Rathbun, 1879; Verrill et al., 1873)
Henry B. Ward	Acanthocephala, trematodes, nematodes, and cestodes in fish	(Ward, 1894a,b)
James C. White	Crustacea (*P. filosa*) of the ocean sunfish	(White, 1859)

[a] Reports from 1899.

in the U.S. to concentrate his career efforts primarily in an area of fish health (parasitic disease organisms). He rightfully could be given the title of "Father of Fish Parasitology in the U.S." Linton and Leidy alone, wrote 41 (39%) of the 105 papers and reports, I found, concerning parasites of fish published in the U.S. prior to 1900 (Table 4).

Only four other naturalists published five or more fish parasitology papers from 1850 to 1899. Eleven papers on the parasitic crustaceans of feral fish were produced by David S. Kellicott, a zoologist from the University of Ohio (Rathbun, 1896), between 1877 and 1886 (Kellicott, 1877, 1878, 1879a,b, 1880a,b,c,d, 1881, 1882, 1886). Six papers, five on parasitic crustacea and one on acanthocephala of fish, were written by Alpheus Spring Packard Jr. (1867 to 1875), an invertebrate zoologist, geologist, entomologist, and professor at Brown University (Packard, 1867, 1873, 1874, 1875a,b,c, Gillispie, 1974). Addison Emery Verrill, renowned taxonomist, zoologist, entomologist, and professor of zoology at Yale College and curator of zoology at the Peabody Museum of Natural History, also wrote six papers. He reported on parasitic leeches and crustacea of fish from 1870 to 1879 (Verrill, 1870, 1872, 1873, 1874; Verrill and Rathbun, 1879; Verrill et al., 1873; Encyclopaedia Britannica, 1983). His remarkable facility for distinguishing morphological features led him to describe at least 1000 marine invertebrates in every phylum except protozoa (Gillispie, 1977). Richard Rathbun, who worked with the United States Fish Commission, listed and described parasitic marine crustaceans in five papers (1882 to 1893) and also reported on two fish kills and one fish hatchery disease problem (Rathbun, 1882, 1885, 1887, 1888, 1893, 1895, 1896; Verrill and Rathbun, 1879).

Henry B. Ward of the University of Illinois at Urbana published 21 papers on acanthocephala, cestodes, trematodes, nematodes, and sporozoa of fish from 1894 to

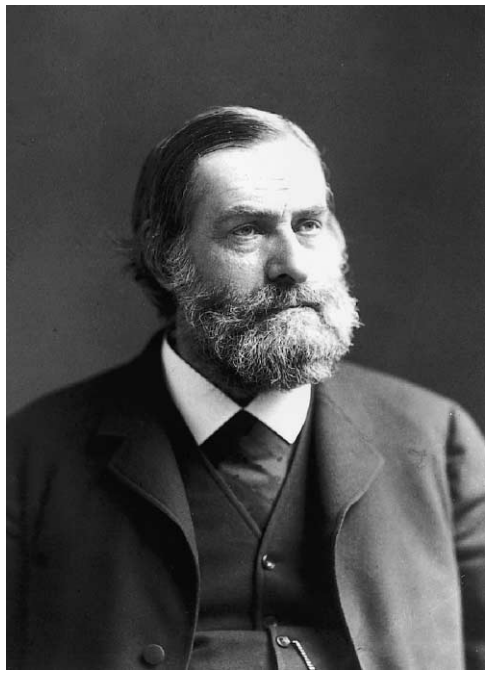

Fig. 6. Joseph P. Leidy (1823–1891). Leidy, a leading scientist of his day, produced more than 20 papers on the parasites of fish. Permission to reproduce Leidy's photograph was granted by the Ewell Sale Stewart Library, The Academy of Natural Sciences of Philadelphia.

1935 (Ward, 1894a,b; Hoffman, 1967; McGregor, 1963; Yamaguti, 1958, 1959). Two of these were prior to the turn of the century. Ward authored his renowned work, *Freshwater Biology*, with G.C. Whipple in 1918 (Ward and Whipple, 1918).

Several other famous naturalists made at least one contribution to fish parasitology. Crustacean parasites of fish were reported by Edward Drinker Cope, an author in vertebrate paleontology with the U.S. Geological Survey and professor at the University of Pennsylvania (Encyclopaedia Britannica, 1983; Cope, 1871, 1872), Alexander Agassiz, a marine zoologist, oceanographer, and mining engineer (Agassiz, 1865; Encyclopaedia Britannica, 1983; Leidy, 1889c), and Sidney Irving Smith, a zoologist specializing in marine invertebrates at Yale College and active in the foundation of the Woods Hole Oceanographic Institution (Gillispie, 1975; Smith, 1874, 1884). Ferdinand Vandiveer Hayden, who was a geologist and physician with the U.S. Geological Survey, reported on cestodes in trout (Encyclopaedia Britannica, 1983; Hayden, 1872). Charles Wardell Stiles, a parasitologist working with the Bureau of Animal Industry of the Department of Agriculture, definitively identified the protozoan *Ichthyophthirius* on channel catfish in 1893 (Gillispie, 1976; Stiles, 1894a).

It is of interest to note that the largest parasite of fish, the lamprey, was not noted definitely as a parasite until the 1890s. Simon Henry Gage (Gage, 1893) recognized the destructive and parasitic nature of lampreys and made a proposal for their control. In 1898, H.A. Surface of the Department of Zoology, Pennsylvania State College gave

Fig. 7. Edwin Linton (1855–1939). First researcher to devote a full time effort to the field of fish parasitology in the United States. Permission to publish Linton's photograph was obtained from the Washington and Jefferson College Historical Collections, Washington, PA.

information on the negative impact of the lamprey on the fishery and included numerous pictures of the damage lamprey caused to several species of fish. He also recognized the need for lamprey control (Surface, 1899a,b). Lampreys were described much earlier; in 1815 Samuel B. Mitchill and in 1818 Charles A. Lesueur described lampreys of a genus later known to be parasitic, but neither mentioned the parasitic tendency of lamprey (Mitchill, 1815; LeSueur, 1818). A number of icthyological descriptions of a lamprey in the U.S. occurred prior to the 1890s, but only two were found that indicated the possibility that lamprey could be parasitic. It is of interest that one writer, Genio C. Scott (Scott, 1869) stated that Doctor Gunther of Europe held the absurd idea that lamprey attach to other fish. This may have been the first statement by someone in the U.S. that indicated the possibility of a lamprey being parasitic, even though Scott thought it absurd. A second statement was made by G. Brown Goode in 1884. Goode reported that lampreys were considered semi-parasitic by some, and were suspected of being destructive to food fish that enter estuaries and rivers (Goode, 1884; Smith, 1995).

Table 5
Reports and publications on wild fish kills (1850 to 1899)

Investigator	Information reported	References
A. Leath Adams	Fish kill of mostly American Herring from the northern coast of Maine caused by a strong gale	(Adams, 1868)
Anonymous[a]	Fish kills in the Gulf of Mexico; of tile fish off the Atlantic coast; of fish in Wisconsin lakes; and of fish killed by pollution in streams	(Anonymous, 1883, 1884, 1886, 1899)
Captain J.W. Collins	Fish kill of tile fish off the coasts of New Jersey, Delaware, and Maryland	(Collins, 1884)
Philo Dunning	Fish kill in Lake Mendota, WI, also reports earlier white fish kill in 1844	(Dunning, 1884)
Captain Edwards	Fish kill of tautog due to cold waters in New England	(Edwards, 1873)
F.M. Endlich	Fish kill in the Gulf of Mexico	(Endlich, 1882a,b)
W.G. Farlow	Examined water from fish kill in Gulf of Mexico	(Farlow, 1882)
Stephen Alphred Forbes	Pathological examination of fish from a fish kill in Lake Mendota, WI	(Forbes, 1890)
W.R. Gerard	Fish kill with fungi on fish in the Passaic River, NJ	(Gerard, 1879)
W.C.W. Glazier	Fish kill (1880) in the Gulf of Mexico, also reports of kills in 1865 and 1878	(Glazier, 1882a,b)
A.H. Glennan	Fish kill (1885) in the Gulf of Mexico possibly due to red tide	(Glennan, 1887)
G. Brown Goode	Fish kill of menhaden in the Merrimac River, MA, also reported fish kill in about 1836	(Goode, 1879)
Loren W. Green	Fish kills of rainbow trout; of salmon; and report of fungus on spawning salmon in the McCloud River, California	(Green, 1885, 1887; Stone, 1888)
Harkness and Moore	Fungi on salmon, probably spawned out salmon	(Harkness and Moore, 1880)
Ernest Ingersoll	Fish kills (1880) in the Gulf of Mexico, also reports kills in 1844, 1854, 1878 and 1879	(Ingersoll, 1882a,b)
J.P. Jefferson	Fish kills (1878) in the Gulf of Mexico	(Jefferson, 1879; Jefferson et al., 1879)
S.H. Johnson	Fish kill (1880) in the Gulf of Mexico	(Johnson, 1882)
David Starr Jordan and C.H. Gilbert	Fungi and gill parasites on Pacific salmon	(Jordan and Gilbert, 1881)
Herbert M. Knowles	Fish kill of small herring-like fish at Point Judith, RI	(Knowles, 1887)
Joseph P. Leidy	Carcinomatous cells on fish from Schuylkill River, PA	(Leidy, 1859a)
Charles C. Leslie	Fish kill of codfish between Hatteras and Cape Henry	(Leslie, 1883)
J. Percy Moore	Fish kill of bluefish at the beginning of the 19th-century	(Moore, 1898)
M.A. Moore	Fish kills (1878) of several fish species in the Gulf of Mexico, volcanic activity blamed	(Moore, 1882a,b)
A.P. Ohlmacher	Sarcoma in the pike (*Esox lucius*), tumor was analyzed using histological techiques	(Ohlmacher, 1898)
H.D. Pierce	Fish kills of mostly bluefish in the Gulf of Mexico, an 1876 and 1880 fish kill also are mentioned	(Pierce, 1883, 1884)
Richard Rathbun	Fish kills in a Wisconsin Lake; of alewives in Lake Ontario associated with fungi	(Rathbun, 1893, 1895)
W. de C. Ravenel	Fish kills in the Mississippi and Illinois Rivers; of salmon in the McCloud River, CA due to pollution; and report on the return of the tile fish in 1892	(Ravenel, 1898a,c, 1900[b])

Table 5 (*continued*)

Investigator	Information reported	References
J.H. Slack	Fungi found killing fish	(Slack, 1859)
Charles W. Smiley	Fish kill of menhaden along the South Carolina coast	(Smiley, 1886)
Hugh M. Smith	Fish kill of alewives in Lake Ontario, possible causes included fungi, lack of food, storms, and temperature	(Smith, 1892)
Livingston Stone	Fish kills of salmon in the McCloud River, CA; and fungi on dying spawned out salmon	(Stone, 1882a, 1884a, 1897)
S.B. Swett	Fish kill of perch and a scarcity of other fish due to pollution from refuse of a gas works in the Squamscot River, NH	(Swett, 1883)
Henry David Thoreau	Melanomas in brown bullheads	(Thoreau, 1852, 1858)
William Trelease	Fungi on fish	(Trelease, 1884)
S.T. Walker	Fish kill (1880) in the Gulf of Mexico due to eruptions of poisonous gases	(Walker, 1884)
John G. Webb	Fish kill in the Gulf of Mexico	(Webb, 1887)
W.A. Wilcox	Fish kill of a cod-like fish off the coast of Massachusetts	(Wilcox, 1889)
Joseph Willcox	Fish kill (1885) in the Gulf of Mexico and cold water at the river inlets was to blame	(Willcox, 1887)
W.M. Wood	Fish kill in the Connecticut River, MA, caused by pollution	(Wood, 1882)
J.J. Woodward	Fungi on killifish from the Schuylkill River, PA	(Woodward, 1859)

[a] No investigators' names were given for these four reports.
[b] Published on material reported prior to 1900.

Glochidia, larval clams that can attach to fish gills and fins, were observed for years before they were recognized as fish parasites. Naturalists, including the renowned mollusc expert, Isaac Lea, observed these larval clams but they were reported from the gills of clams, not from fish (Lea, 1860). The first two U.S. reports found of glochidia in fish gills were by Frank R. Lillie (Lillie, 1895) and Charles T. Simpson (Simpson, 1899). Simpson's report gives some details on the attachment of the larval mussels to the gills, scales, and fins of fish and the host response to the mussels.

3.2. Wild fish kills and diseases: 1850 to 1899

Wild fish kills and non-parasitic diseases of wild fish were frequently reported during this period (Table 5). There were 46 reports of wild fish kills prior to 1900. Fish kills among freshwater and marine fishes were first found reported in the 19th century (two reports were previously mentioned from the 17th century) in the U.S. by Adams (1868). However, within these publications were references to fish kills as early as 1836 (Goode, 1879). There was one report by J. Percy Moore of "a great fatality among the bluefish in the beginning of the century (19th century)", but no date was given (Moore, 1898).

The most massive fish kill reported in the 19th century took place in 1882 off the coasts of Maryland, Delaware, and New Jersey. According to a lengthy report by

Captain Collins, a conservative estimate of over 14 billion pounds of tile fish *Lopholatilus chameleonticeps* (Fig. 8) were found floating in the Atlantic Ocean (Collins, 1884). This astounding poundage was calculated using 1/20th of the reported numbers estimated per square mile of ocean and a weight known to be less than the average weight of tile fish. Dead fish by the multi-millions were found in an area 170 miles long by at least 25 miles wide. The fish died during the months of March and April 1882. There were no signs of disease or parasites on the fish and many were cooked and eaten.

Reason ventured as the cause of the fish kills ranged from sudden temperature changes in the waters to submarine volcanic eruptions. One skipper gave the following explanation. "There has been convulsions of nature under the seas. Now, you see, mates, these here loafer latter lushisses is deep-sea fish. There comes the deuce to pay down below—their bladders gets busted, and up they comes like balloons. That's a pint no fish-sharp has studied up yet; don't you see." (Collins, 1884). No tile fish were caught or seen again until 1892 (Ravenel, 1898c). Fish kills were quite common in the Gulf of Mexico and accounted for almost 40% (18 reports) of those reported in the 19th century. Most of these occurred along the coast of Florida and fish mortalities were reported for the years 1844, 1854, 1856 or 1857, 1865, 1876, 1878 (at least two kills), 1879, 1880, 1881, and 1885 (Farlow, 1882; Glazier, 1882a; Glennan, 1887; Ingersoll, 1882a; Jefferson et al., 1879; Pierce, 1884; Willcox, 1887). Earnest Ingersoll (Ingersoll, 1882a) stated that during an 1880 fish kill, "nearly all kinds of fish that inhabit these waters were dying except for the ray family". The die-off lasted 6 weeks and the stench was so bad it was impossible to go to the beach. He mentioned four other years (1844, 1854, 1878 and 1879) when fish kills occurred in the Gulf and that an "excessive fatality" occurred among fish in the 1878 episode. During one of the 1878 kills, Ingersoll stated that "discolored water appeared in long patches or streaks, sometimes 100 yards wide, drifting lengthways with the flow of the tide." As to possible causes, he mentioned that just before the 1880 deaths occurred, the shock of an earthquake was felt throughout the whole southwestern end of the peninsula of Florida and another earthquake may have

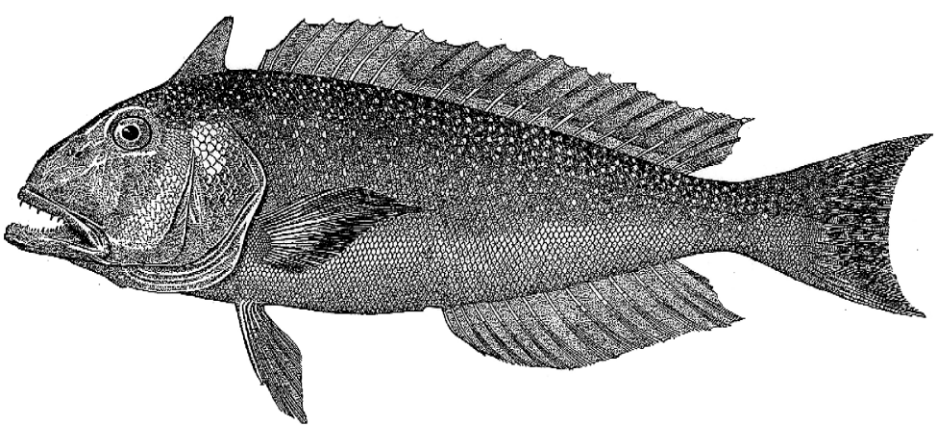

Fig. 8. The most massive fish kill reported in the 19th century involved the tile fish (*Lopholatilus chamaeleonticeps*) off the Atlantic coast. The drawing was taken from the U.S. Commission of Fish and Fisheries report for 1882, published in 1884.

occurred before the 1878 fish kill. Glennan (1887) reported an 1885 Gulf fish kill that, from his description, was likely caused by red tide. He stated that "Large shoals of dead fish have been met with between Egmont Key Light and Charlotte Harbor, of the mainland, and vessels have been several hours in passing through them. A few weeks ago the fishing schooner City of Havana, Capt. John Curry, lost two loads of live fish, which were killed in sailing through strips of this poisoned water. It is said to be of a reddish color, and distinguishable for some distance from the surrounding water." Glazier (1882a) and Jefferson et al. (1879) reported fish kills in 1856 or 1857 and 1878 from poisoned discolored water. Walker (1884) observed dead fish and birds from an 1880 Gulf fish kill. On three occasions during the kill, he reported hearing a roaring sound similar to the blowing off of steam and he believed that the fish deaths resulted from "sub-aqueous eruptions of poisonous gases" from the sea floor. Freshwater entrapment of salt water fish (Johnson, 1882), volcanic activity (Moore, 1882a), cold water inversions and hurricanes (Pierce, 1884; Anonymous, 1886), heavy rainfall (Johnson, 1882), toxic water released from underground channels into the Gulf (Webb, 1887), and parasitic algae (Endlich, 1882a) were also reported as responsible for some of the massive fish kills in the Gulf.

Fish kill reports from inland lakes and freshwater streams and rivers were not as frequent as those from marine waters (Table 5). A very large kill in Lake Mendota, WI drew considerable interest. A reported 200 tons of dead fish were removed from the lake (Dunning, 1884). In 1884, U.S. Fish Commissioner Baird sent Stephen Alphred Forbes, whom he considered one of the most eminent biologists in the West, to evaluate the massive fish kill (Anonymous, 1886). His work, using histological techniques and bacteriological stains, was probably the first fish pathological work done in the U.S. He found high numbers of micrococci or pigment granules in the fish (Forbes, 1890). Dr. Forbes, the director of the State Laboratory of Natural History at Champaign, IL (Bean, 1896b), is credited with being the first fish histopathologist in the U.S. and will be discussed later.

A large kill of alewives on Lake Ontario was also reported (Rathbun, 1895; Smith, 1892). Hugh M. Smith gave lack of food, storms, fungal infections, and temperature changes as possible causes. In 1898, W. de C. Ravenel reported that fish were dying by the thousands in the Illinois and Mississippi Rivers (Ravenel, 1898a).

There were 11 reports of diseased fish in the wild that were not parasitized or part of a notable fish kill (Table 5). Included in these reports are two defensible descriptions of melanomas on brown bullheads by Henry David Thoreau (Thoreau, 1852, 1858). The descriptions are legitimized based partly on the recent findings of 10 brown bullhead catfish from the same approximate location with grossly similar tumors that were histologically diagnosed as melanomas (Harshbarger and Clark, 1990). In Thoreau's own words, in 1858, he describes the bullheads (pouts) as follows: "I see a pout this afternoon in the Assabet, lying on the bottom near the shore, evidently diseased. He permits the boat [to] come within two feet of him. Nearly half the head, from the snout backward diagonally, is covered with an inky-black kind of leprosy, like a crustaceous lichen. The long feeler on that side appears to be wasting, and there stands up straight in it, about an inch high, a little black tree-like thorn or feeler, branched at top. It moves with difficulty."

Two renowned naturalists observed and reported fungi growing on wild fish. These were William Trelease, a botanist, entomologist, and bacteriologist from the University of Wisconsin (Gillispie, 1976) and David S. Jordan, a descriptive ichthyologist from the University of Indiana (Gillispie, 1973; Anonymous, 1891). Jordan also reported on a parasitic gill worm on Pacific salmon.

3.3. Fish health in the early fish hatcheries: 1850 to 1899

Several significant observations and discoveries in fish health were recorded by early American fish culturists and fisheries commissioners after 1850. Livingston Stone (Fig. 9), a clergyman who became a fish culturist for the U.S. Fish Commission, was the most observant culturist in respect to fish diseases. He described 23 diseases of domesticated trout in his 1872 book (Stone, 1872). Stone drew rough sketches of the protozoan *Trichodina* and the monogenetic trematode *Gyrodactylus* on trout. He was the first in the U.S. to report the use of salt to treat fungi on fish eggs (Stone, 1872). He understood the importance of aeration for fish and wrote "If the aeration is forgotten or neglected, though only for a moment or two beyond the limit of safety, the fish are certain to die" (Stone, 1882b). In six of his hatchery reports, he discussed diseases of cultured fish and in three he discussed diseases of wild fish (Stone, 1872, 1880, 1882a,b, 1884a,b, 1888,

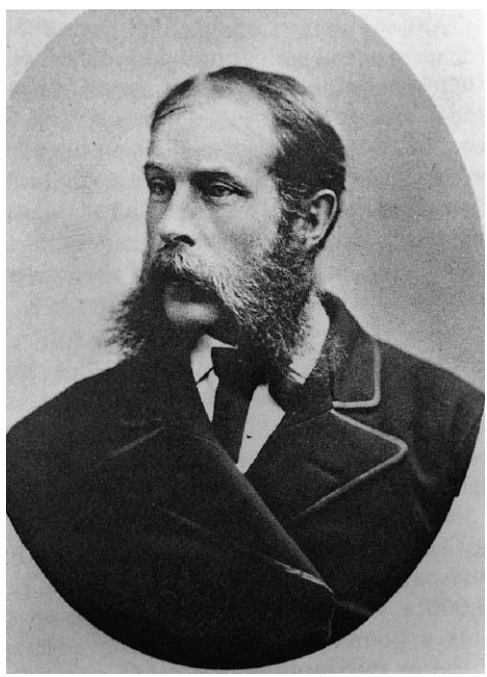

Fig. 9. Livingston Stone (1836–1912). Stone was an early fish culturist who described more than 20 diseases of hatchery fish. Stone's photograph was taken from *A Century of Fisheries in North America*, Special Publication 7 of the American Fisheries Society, Bethesda, MD, edited by N.G. Benson, in 1970. Permission to reproduce the photograph was granted by the American Fisheries Society.

1889, 1897). Stone was considered one of the premier fish culturists in the nation and was one of the founders of the American Fisheries Society (Bowen, 1970; Hedgpeth, 1941). He was an experienced adventurer and made yearly trips to the West Coast to stock fish, build hatcheries and spawn and hatch salmon. Stone dealt with hostile Indians, desperados, flooding waters,[4] panthers, scorpions, rattlesnakes, tarantulas, and a train wreck caused when a bridge gave way, crushing one man and drowning two others (Stone, 1880, 1882b, 1884a; Hedgpeth, 1941). He used his boxing skills to maintain seining rights (Hedgpeth, 1941). Stone wrote lengthy hatchery reports that included many personal observations, some not related to any aspect of fisheries. One example follows: "During the first week in July an Indian named Chicken Charlie, called on me and said his father was going to die soon, and he wanted a coffin made. We made the coffin, and after a while, when they supposed the Indian was dead, they put him in the coffin and proceeded to bury him; but before they had finished burying him, he came to life again, and they took him out and waited a while longer. The next time he really died, and the following day he was buried again" (Stone, 1880).

Although none seem to equal the flair and achievements of Livingston Stone, several other culturists made important observations that are noteworthy. Charles G. Atkins, Fish Commissioner in Buckport, ME, wrote five reports that included descriptions of salmon egg, fry, and adult diseases. These included coagulated yolk problems, an eye disease, and fungal infestations (Atkins, 1872, 1880, 1884, 1885, 1898). Frank N. Clark, an early fish culturist and superintendent of the U.S. Fish Commission Stations in Michigan, observed and made five reports on egg and fry diseases of shad and trout diseases (Clark, 1884a,b, 1889, 1898a,b).

Frederick Mather, a fish culturist from New York, who published three reports with disease descriptions, was apparently the first to discuss the effects of nutritional deficiencies on the health of fish in 1878 (Mather, 1878a,b, 1884). He also described a massive epidemic at the Cold Spring Harbor Hatchery in New York among brown trout in 1890 (Bowen, 1970).

Spencer F. Baird, a Commissioner for the United States Commission of Fish and Fisheries understood the effects of stress on fish diseases. He discussed the effect of starvation and handling on the development of fungi on fish in 1883 (Smiley, 1886). John A. Ryder, also of the U.S. Fish Commission, Washington, DC and later a professor at the University of Pennsylvania, (Anonymous, 1892) was an observant fish culturist and researcher. He published two reports on diseases or treatments of cultured fish and two on the diseases of aquarium-held fish (Ryder, 1882, 1883, 1884a,b). He described fungi on fish eggs, a heavy infestation of *Gyrodactylus* (gill fluke) on goldfish, and a digenetic trematode on a cunner (Ryder, 1882, 1884a,b). He tested carbolic acid for its possible control of fungi on eggs (Ryder, 1883).

Loren W. Green wrote three reports that included two detailed descriptions of trout diseases (possible viral or bacterial etiology) and three descriptions of disease problems affecting wild fish (Green, 1885, 1887; Stone, 1888).

[4] The McCloud River, with a fall of 40 ft/mile, rose over 26 ft above the summer level, destroying the entire hatchery in an unprecedented flood (Stone, 1884a).

Table 6
Reports and publications on diseases of cultured fish from 1850 through 1899

Investigator	Information reported	References
George T. Agar	Carp disease	(Smiley, 1886)
Anonymous[a]	Egg and fry diseases of salmonids, black bass and cod, including coagulated yolk	(Anonymous, 1893, 1894)
Charles G. Atkins	Fungi, coagulated yolk, and eye disease of salmon	(Atkins, 1872, 1880, 1884, 1885, 1898)
Spencer F. Baird	Stress predisposing carp to fungi	(Smiley, 1886)
Tarleton H. Bean	Disease of trout and salmon fry and adults and lightning kills of black bass and trout	(Bean, 1892, 1896a)
Gary N. Calkins	Disease of trout including fungi, nematodes, and crustacea	(Calkins, 1899)
Frank N. Clark	Fungi on American shad and salmonid eggs, also blue-sac disease in trout fry	(Clark, 1884a,b, 1889, 1898a,b)
E. Dexter	Fungi on Atlantic salmon eggs	(Dexter, 1870)
Charles Wright Dodge	Fungi on trout	(Dodge, 1895)
H.G. Ewart	Fungi on common carp	(Smiley, 1886)
Henry J. Fenton	Fungi on common carp	(Smiley, 1886)
George Finley	Common carp mortality	(Smiley, 1886)
Emmanuel H. Frantz	Common carp mortality, possibly due to low oxygen	(Smiley, 1886)
A.P. Gardener	Trout mortality	(Gardener, 1883)
Theodatus Garlick	Fungi on salmonid eggs	(Garlick, 1858)
Loren W. Green	Trout mortality	(Green, 1885; Stone 1888)
Seth Green	Fungi on common carp	(Green, 1878; Smiley, 1886)
B.E.B. Kennedy	Fungi on common carp	(Smiley, 1886)
R.H. Lodge	Uncured concrete kills common carp	(Smiley, 1886)
Frederick Mather	Nutritional deficiencies, blue-sac disease and coagulated yolk of salmon fry, and fungi on salmon eggs	(Mather, 1878a,b, 1884)
Samuel McClelland	Fungi on common carp	(Smiley, 1886)
S.P. McFall	Common carp mortality	(Smiley, 1886)
Thaddeus Norris	Fungi on fish eggs	(Norris, 1868)
M.E. O'Brien	Trout mortality	(O'Brien, 1895)
Charles Horton Peck	Fungi on fish	(Peck, 1886)
Richard Rathbun	Adult trout mortality	(Rathbun, 1896)
W. de C. Ravenel	Fungi, black gill fever, spreading sores, *Gyrodactylus*, coldwater disease, and Furunculosis on salmonids, also fungi on black bass and codfish and egg diseases	(Ravenel, 1896, 1898a,c, 1899, 1900[b], 1901[b])
Henry J. Rice	Fungi on fish, handling stress associated with fungal infestation	(Rice, 1884)
E.M. Robinson	Fungi and probably Ichthyophthirius (Ich) on salmon fry	(Bean, 1896a)
John A. Ryder	Fungi on American shad eggs	(Ryder, 1882, 1884b)
George A. Seagle	Fungi, blue-sac and other diseases of trout fry and adults	(Seagle, 1897, 1898)
W.H. Siems	Fungi on common carp	(Smiley, 1886)
Charles W. Smiley	Channel catfish mortality	(Smiley, 1887)

Table 6 (*continued*)

Investigator	Information reported	References
Hugh M. Smith	Cod fish and trout mortalities, pathological report was made and bacterial cultures were taken	(Smith, 1899, 1900[b])
Livingston Stone	Describes 23 diseases of salmonids including fungi, blue-sac, *Trichodina*, *Gyrodactylus*, and possibly Columnaris Disease, also treatments with salt	(Stone, 1872, 1880, 1882b, 1884b, 1888, 1889)
J.J. Stranahan	Fungi on whitefish eggs	(Stranahan, 1898)
R.O. Sweeny	Mortality (possibly bacterial) in common carp	(Smiley, 1886)
Z.L. Tanner	Fungi, and probably bacteria, infecting American shad	(Tanner, 1884)
Samuel Wilmont	Salmon mortality caused by black spots, possibly a digenetic trematodes	(Wilmont, 1883)
James F. Wilson	Common carp mortality	(Smiley, 1886)
Stephen G. Worth	Fungi on shad eggs, trout egg problem, fry mortality, leech and protozoan (probably Ich) problems in salmonids	(Worth, 1895, 1898)

[a] No investigators' names were given for these two reports.
[b] Reports from 1898 or 1899.

W. de C. Ravenel, special agent in charge of fish culture for the U.S. Fish Commission (Bean, 1896b), included disease reports in seven of his publications, but there is no evidence that he worked directly with any diseased fish (Ravenel, 1896, 1898a,b,c, 1899, 1900, 1901). These and other culturists are reported in Table 6.

3.4. Fish health in the early aquarium-held fish: 1850 to 1899

Twenty reports were found on the parasites or diseases of aquarium fish prior to 1900 (Table 7). Eighteen of these were written after the mid-1870s, about the time when the first public aquaria were established.

In 1858, Joseph P. Leidy reported that the fungus (*Achlya prolifera*) was common on goldfish (Leidy, 1859a). Frank W. Clark also described fungi on goldfish in 1874 and he reported that fin tissue was regenerated in the healing process (Clark, 1874).

William P. Seal, the director of the U.S. Fish Commission Aquarium at Central Station, Washington, DC, discussed fish disease problems in aquaria in two publications (Seal, 1889, 1892). He was the first to report *Ichthyophthirius* in 1890 from fish in the U.S. (Seal, 1892). He reported that catfish, sunfish, white perch, trout, and other fish were infested in the winter with *Chromatophagus parasiticus*, a name later shown to be synonymous with *I. multifiliis* (Stiles, 1894a).

In 1898 and 1899, Frederic P. Gorham, Brown University, Providence, RI, studied and wrote about the relationships between effects of reduced pressure and gas bubble disease among marine fish held in aquaria (Gorham, 1898, 1901). This is the first written discussion found concerning this environmental disease of fish in the U.S. He co-authored another paper with Millard C. Marsh (to be discussed later), on gas bubble disease in fishes in 1905 (Marsh and Gorham, 1905).

Table 7
Reports and publications on diseases of aquarium fish from 1850 through 1899

Investigator	Information reported	References
Anonymous[a]	Fungi and protozoa, probably Ich	(Anonymous, 1896)
Frank W. Clark	Fungi on goldfish, including tail regeneration upon healing	(Clark, 1874)
G.P. Clinton	Fungi on fish	(Clinton, 1894)
Stephen Alphred Forbes	Fungi on fish, protozoa (Ich) on catfish	(Forbes, 1894)
Frederic P. Gorham	Gas bubble disease in marine fish	(Gorham, 1898, 1901[b])
Hine	Fungi on perch and sunfish held in an aquarium	(Hine, 1878)
Joseph P. Leidy	Fungi on goldfish	(Leidy, 1859a)
Samuel Lockwood	Fungi on sunfish	(Lockwood, 1890)
Charles Nash Page	Fungi, Ich, anoxia, consumption, and other diseases	(Page, 1898)
Charles Horton Peck	Fungi on fish	(Peck, 1886)
W. de C. Ravenel	Fungi on fish collected for aquarium display	(Ravenel, 1898b)
John A. Ryder	Fungi and monogenetic trematodes (*Gyrodactylus*) on goldfish	(Ryder 1883, 1884a)
Mark Samuel	Fungi and other diseases on goldfish	(Samuel, 1894)
Charles W. Scudder	Dead or dying common carp	(Smiley, 1886)
William P. Seal	Fungi, Ich and other protozoa on fish	(Seal, 1889, 1892)
Hugh M. Smith	Nutritional deficiencies and Ich on salmonids and other fish, gas bubble in fish	(Smith, 1898, 1900[b])
Charles W. Stiles	Ich on catfish	(Stiles, 1894a)

[a] No investigators' name was given for this report.
[b] Reports from 1898 or 1899.

3.5. Disease treatments: 1850 to 1899

Treatments of aquarium and cultured fish are summarized in Table 8. Eighteen of the 21 authors, providing information on treatments, reported the use of salt or salt solutions. Most of these references gave little information on treatment rates and times; however, some were very specific and others were rather unusual. For example, Livingston Stone used a tablespoon of salt in a pint of water and kept the fish in the solution until the fish turned over on their backs, at which time they were immediately put in cold running water (Stone, 1872). On the other hand, George Richardo, Fish Warden of Bergen County, NJ, mentioned treating fish eggs for 15 to 20 min in salt water strong enough "to bear up a potato" (Rice, 1884).

A number of other treatments were tried prior to 1900. Six investigators reported on earth, swamp earth, mud, or muck treatments for fungi and other problems. These were often combined with salt treatments. Three reported on the use of carbolic acid and two on asphalt, digitalis (a heart medication with the active ingredient taken from a plant called the purple foxglove) and salicylic acid. Charles W. Stiles (discussed previously) tested 17 chemicals (Table 8) against *Ichthyophthirius* on channel catfish (Stiles, 1894a). His tests were the first use in the U.S. of the common fishery chemicals copper sulfate, potassium permanganate, and hydrogen peroxide. A very interesting treatment was given by Charles W. Scudder, who revived almost dead common carp with two

Table 8
Reports and publications on attempts to treat fish disease from 1850 through 1899

Investigator	Treatment information	References
Anonymous[a]	Salt and earth were given daily for brook trout fry diseases	(Anonymous, 1894)
Charles G. Atkins	Salt was used against fungi and salt and mud treatments were used to treat coagulate yolk in salmon	(Atkins, 1898)
Spencer F. Baird	Salt was used against fungi on common carp	(Smiley, 1886)
Frank N. Clark	Swamp earth and salt were applied for fungi on eggs and diseases of salmonid fry	(Clark, 1898a,b)
G.P. Clinton	Salt was used for fungi on fish	(Clinton, 1894)
Charles Wright Dodge	Electrozone was used against fungi on trout	(Dodge, 1895)
Stephen Alphred Forbes	Salt and carbolic acid were used against fungi on fish and salt against Ich on channel catfish	(Forbes, 1894)
Seth Green	Salt was given to help weak fish	(Green, 1878)
M.E. O'Brien	Salt was used for a trout disease	(O'Brien, 1895)
Charles Nash Page	Salt, bi-chloride of mercury, and silver nitrate were used for fungi; salt solutions and digitalis for other diseases of fish	(Page, 1898)
W. de C. Ravenel	Salt and muck were applied as a general remedy	(Ravenel, 1896)
Henry J. Rice	Salt, tar, asphalt, and salicylic acid were used against fungi on fish	(Rice, 1884)
E.M. Robinson	Salt was applied to eliminate fungi and parasites on fish	(Bean, 1896a)
John A. Ryder	Carbolic acid and asphalt were applied for fungi on goldfish	(Ryder, 1883)
Mark Samuel	Salt and digitalis were applied for fungi and other diseases of goldfish	(Samuel, 1894)
Charles W. Scudder	Brandy was used to revive common carp	(Smiley, 1886)
George A. Seagle	Salt for parasites and other diseases of rainbow trout	(Seagle, 1897)
William P. Seal	Salt, washing soda and carbolic acid were used against microscopic parasites and fungi on fish	(Seal, 1889, 1892)
Charles W. Stiles	Several chemicals including salt, potassium permanganate, copper sulfate, hydrogen peroxide, eosin, methylene blue, kerosene, creosote, vinegar, salicylic acid, chlorinated soda, ichthyol, tannic acid, ferrous sulphate, potassium ferrocyanide, pepsin and methyl violet were tested against Ich	(Stiles, 1894a)
Livingston Stone	Salt and earth were used to treat fish diseases	(Stone, 1872, 1888, 1889)
Stephen G. Worth	Salt and earth were used on parasites and other diseases of salmonid fry	(Worth, 1895)

[a]No investigator's name was given for this report.

applications (6 h apart) of one drop of a 50:50 mix of brandy and water placed in the fishes' mouths (Smiley, 1886).

3.6. Fish pathologists: 1850 to 1899

Most of the early fish pathologists performed their work on hatchery fish with disease problems. However, as previously stated, in 1884 Steven A. Forbes, the first to do

pathology work on fish, took histological sections and did bacteriological staining on fish tissues from wild fish taken from a large kill in a Minnesota lake (Forbes, 1890). In 1885 he performed another histological analysis of rainbow trout sent from the McCloud River Station, CA (Stone, 1888, 1889).

Between 1889 and 1891, Revere R. Gurley, assistant to the United States Fish Commission, was assigned to study disease problems of fishes (Rathbun, 1893). In 1892, he was sent to Wytheville Station, VA to examine rainbow trout mortalities (Worth, 1895). In 1893, he was dispatched to Lake Ontario to study a mortality among alewives (Rathbun, 1895). He also investigated a spring mortality among adult brook trout at Northville, MI and a black bass kill that occurred after a thunder storm at Neosha Station, MO in 1894 (Bean, 1896a; Rathbun, 1896). In about 1894, with considerable care and labor, he wrote a manuscript entitled *The Vermine and Crustacean Parasites of Fresh Water Fishes*, but it was never published (Wilson, 1904).

There was recognition by U.S. Fish Commission employees that the health of cultured fish must become a priority in 1898. They strongly urged that the Commission be provided with a permanent expert in fish pathology (Smith, 1899). In the same year, the Bureau of Fisheries (an agency of the Commission) employed one pathologist, Millard C. Marsh, on a part time basis (Bowen, 1970). In 1898, he was assigned to a disastrous disease outbreak among yearling brook trout at Northville, MI. The fish had signs of bacteria and the blood was teeming with *Streptococcus* (Smith, 1900). Before the investigation was completed, Marsh was assigned to other duties and replaced by C.M. Blackford Jr. (Anonymous, 1892; Smith, 1900). Since Marsh's first publication was in 1901, his contributions are covered in the next section. Blackford, in December of 1898, also examined white fish eggs reported in poor condition from the Alpena Station, MI (Ravenel, 1900), but found no problem.

Two other fishery-oriented biologists and one medical doctor did pathology on fish prior to 1900. Frederic P. Gorham, previously mentioned, made a careful bacteriological examination of the water of the aquaria and of the tissues of fishes but found no bacteria associated with the gas bubble disease (Gorham, 1898, 1901; Smith, 1900). He later co-authored a review on the blood of fishes (Marsh and Gorham, 1906). Gary N. Calkin, of the New York State Commission of Fisheries, Game, and Forests, did a thorough study of an epizootic among brook trout in 1899. His studies included several histological sections of the internal organs of the fish (Calkins, 1899). In 1898, A.P. Ohlmacher, Director of the Pathological Laboratory of the Ohio Hospital for Epileptics, Gallipolis, OH, gave a detailed pathological description of a sarcoma in pike (Ohlmacher, 1898).

4. Fish health from 1900 to 1919

Between 1900 to 1919, fish health efforts were buttressed by the prolific writings of several scientists. Their efforts still primarily involved the microscopic characterization and identification of parasites. Protozoa parasitic to fish received increased attention. Some obvious noninfectious problems, including toxins and tumors, also began to receive a research effort. During this period, bacterial pathogens were first definitively determined as the cause of diseases in fish in the U.S., and the bacteria were described and characterized biochemically. Standards for blood parameters in fish were first

established in this period. Fish pathology work continued and increased in importance. In 1911 there was a strong recommendation by the commissioner (U.S. Commission of Fish and Fisheries) to establish an experimental station for the study of fish diseases (Wood, 1953). The recommendation was evidently not approved, but a full-time fish pathologist, Herbert S. Davis was hired by the commission in 1915 (Bowen, 1970).

There are 13 researchers highlighted in this period. Four are discussed in the text and nine are listed in Table 9.

Millard Caleb Marsh (Fig. 10), Bureau of Fisheries, published at least 19 papers from 1901 to 1914 on various aspects of fish health including the description of Furunculosis in trout and the biochemical characterization of the causative bacteria (Chapin, 1929; Gaylord et al., 1914; Marsh, 1901a, 1903b; Marsh and Gorham, 1905; McGregor, 1963). He worked in the bacteriological and pathological laboratories of the Johns Hopkins University, and isolated over 20 bacteria from water and diseased fish (Smith, 1902). He studied ulcer disease of trout but isolated no bacteria (Marsh, 1905). Marsh also worked on an epithelioma, a thyroid tumor and its relationship to nutrition, and zinc poisoning from galvanized containers. He studied and reported on gas-related disease problems including a discussion on how oxygen and nitrogen can become supersaturated in the

Table 9
Some other important researchers beginning their careers between 1900 and 1920

Researcher	Dates[a]	Number of papers and area of expertise	References
Nathan Fasten	1912–1922	Eight papers on parasitic organisms, mostly copepods of feral and hatchery fish	(Hoffman, 1967; Wilson, 1915)
Harvey R. Gaylord	1906–1912	Ten papers on thyroid tumors in fish. He was director at the State Institute for the Study of Malignant Disease, Buffalo, NY	(Gaylord et al., 1914)
A.D. Howard	1914–1917	Five papers on glochidia infecting fish	(Jones, 1950)
George R. LaRue	1911–1957	Seven descriptive works on trematodes and cestodes of fish through 1932 and then in 1957 he wrote a classification of trematodes	(Hoffman, 1967; Yamaguti, 1958, 1959)
George Lefevre	1908–1912	At least five papers involving the parasitic nature of glochidia in fish	(Lefevre and Curtis, 1912)
G.A. MacCallum	1913–1927	Seventeen papers on monogenetic and digenetic trematodes of fish	(Hoffman, 1967; McGregor, 1963; Yamaguti, 1958, 1963)
David Marine	1910–1914	At least six papers on a thyroid condition in trout	(Davis, 1947a; Gaylord et al., 1914)
H.L. Osborn	1902–1919	Eight papers on the trematodes of fish collected from the northern U.S.	(Hoffman, 1967; McGregor, 1963)
Harley V. VanCleave	1919–1952	More than 30 papers on helminths, mostly on acanthocephala of freshwater fishes. Because of his pioneering work with acanthocephala he is called the "father of the phylum Acanthocephala".	(Hoffman, 1967; Price and McMahon, 1967)

[a] Range of dates when fish health publications were found.

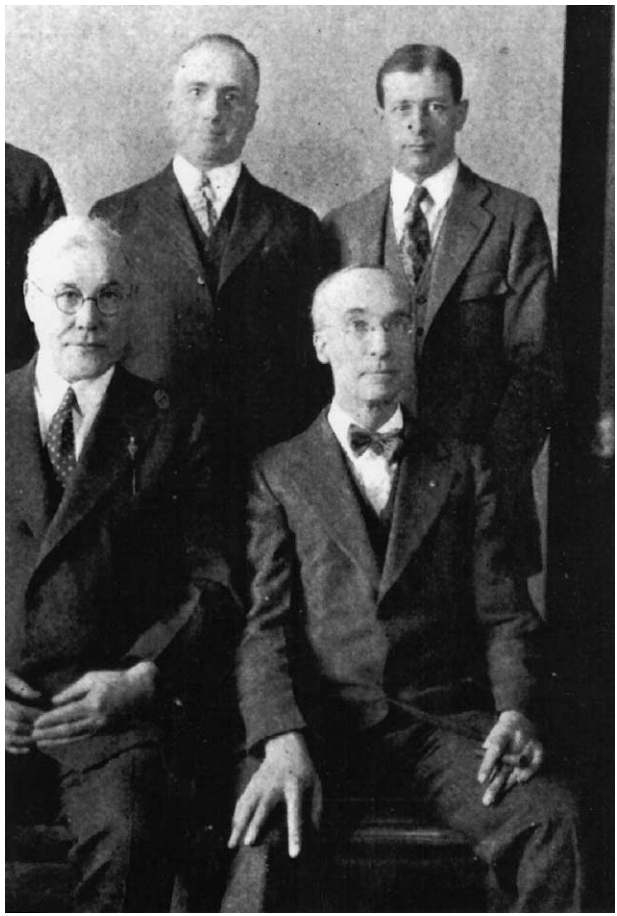

Fig. 10. Millard Caleb Marsh (1872–1936). Marsh (bottom row, right side) was a fish pathologist who did pioneering work in fish bacteriology, hematology, and toxicology and in the study of fish tumors and other noninfectious diseases at the turn of the 20th century. His picture was obtained from Edwin A. Mirand of the Roswell Park Cancer Institute for use in this publication.

water (Gaylord et al., 1914; Marsh, 1903a, 1904, 1905, 1914; Marsh and Gorham, 1905). His publications included information on pond disinfectants, fish disease treatments, including the first formaldehyde treatment in 1901, nutritional inadequacies of hatchery diets, factors affecting the immune system, and effects of overcrowding on fish health (Marsh, 1901b, 1905). Millard C. Marsh was part of a team that did a histological analysis of thyroid tumors in trout (Gaylord et al., 1914). He also established hemoglobin estimations and blood cell counts for some fish (Marsh, 1902; Marsh and Gorham, 1906). Millard C. Marsh's work probably was the first sustained effort by a researcher that was directly beneficial for the management or control of fish diseases on a fish hatchery. His work was unique for this period in that it dealt mostly with bacterial, environmental, and noninfectious problems.

From 1902 to 1944, Charles B. Wilson of the State Normal School, Westfield, MA, worked closely with the Bureau of Fisheries at Woods Hole and at the United States Biological Station, Fairport, IA. He was very prolific, publishing 39 papers on parasitic copepods of fish, most of them being lengthy detailed species descriptions (Hoffman, 1967; McGregor, 1963; Sumner et al., 1913; Wilson, 1916, 1917). In 1944, he published the treatise *Parasitic Copepods of the United States* (Wilson, 1944). He is considered by many to be the foremost researcher of parasitic crustaceans of fish in the U.S.

In the mid-1910s, Herbert Spencer Davis (Fig. 11) began a long and productive career in fish health. He produced many publications on fish diseases that have made his name synonymous with fish health. Davis' first work, on sporozoan parasites of fish, was published in 1916 based on research done at the University of Florida prior to 1915 (Davis, 1916). He authored many publications through 1953, including at least 25 relating to fish diseases or parasites (Davis, 1947a,b, 1953). In 1915, he became a Fish Pathologist with the U.S. Bureau of Fisheries, Department of Commerce (Bowen, 1970). His work covered viral, bacterial, parasitic, and fungal diseases, environmental, nutritional, and other noninfectious disease problems and many cultural aspects of cold and warmwater fish species (Davis, 1953; Davis and James, 1924). Davis (1922) provided the first description of Columnaris Disease and the bacterium associated with the disease. Davis' efforts were directly beneficial to fish culturists who needed to control

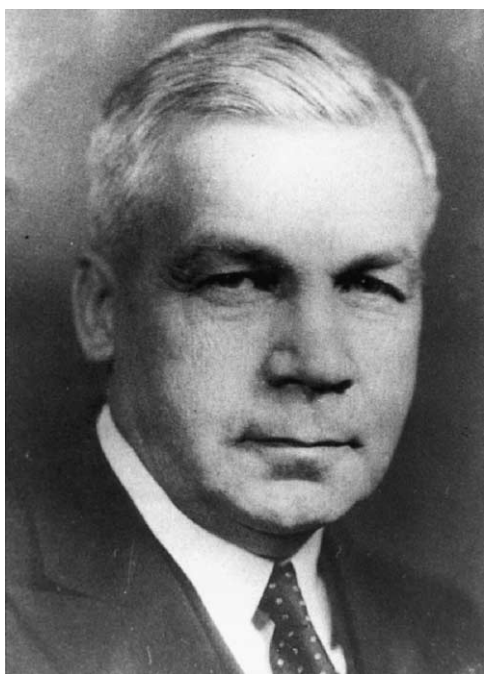

Fig. 11. Herbert Spencer Davis (1875–1958). Davis worked extensively with the diseases of cultured fish and is considered by many as the "Father of Fish Health in the United States." His picture was reprinted from Ken Wolf: "Fish Viruses and Fish Viral Diseases." Copyright 1988, by Cornell University. Used by permission of the publisher, Cornell University Press.

fish disease problems. His work culminated in the publication of the book *Culture and Diseases of Game Fishes* in 1953 (Davis, 1953). He is considered by many to be the "Father of Fish Health" in the U.S.

In 1934, H.S. Davis along with Frederic F. Fish (to be discussed later) established a disease diagnostic service for federal, state, and commercial fish producers (Higgins, 1935). Davis's laboratory was originally located in Washington, DC, then moved to Leetown, WV, while Fish's was located in Seattle, WA. The diagnostic service was basically a mail-in service. Davis and Fish had been doing mail-in diagnostics for several years prior to 1934, but it was not a publicized service (Fish, 1935). In about 1930, Davis established a laboratory in Leetown, WV, that became renowned for its fish health work (Abt and Bullock, 1996). He also initiated fisheries training in 1941, which included instructions in aspects of fish health (Abt and Bullock, 1996).

Richard R. Kudo, who worked at the University of Illinois, Urbana, IL, was considered one of the foremost taxonomic protozoologists in the world. He had many publications to his credit but his crowning achievement was his 1931 textbook, *Protozoology* (Kudo, 1954). Richard Kudo's interest in protozoa caused him to study many parasitic protozoa of fish. He had at least 20 publications from 1918 to 1963, concerned with sporozoan, ciliated or flagellated parasites of fish (Lom and Dykova, 1992; Shul'man, 1966).

5. Fish health from 1920 to 1939

From 1920 to 1939 the study of fish parasites was still the major emphasis in fish disease work. There was an expansion of work specializing in particular groups of parasites and this period may have been the pinnacle of fish parasitology in the U.S. Internal as well as external protozoan diseases were often studied (Moore, 1922, 1924; Mueller, 1932). The study of the diseases of cultured fish also continued to grow, and there was an increased emphasis on microbial, nutritional, and environmental problems of cultured species (Belding et al., 1924; Davis, 1922; Davis and James, 1924). There was a further characterization of bacterial diseases and toward the end of the 1930s viral diseases were receiving attention. Diseases due to dietary problems, such as vitamin deficiencies, and excesses such as high fat diets, received more attention from researchers (Davis and James, 1924; Hess, 1935). Histological techniques were still only occasionally used to describe diseased tissues (Hess, 1935). Diagnostic services were offered and therapy and control measures were recommended (Fish, 1935). Selective breeding of salmonids for disease resistance was first begun in the U.S. during this period (Embody and Hayford, 1925). Work with marine fish also increased during this time.

Throughout the 1920s and 1930s, several scientists made significant contributions to fish health. Three of these, David L. Belding, George Charles Embody, and Emmeline Moore, each contributed 5 to 10 papers on important aspects of fish diseases (Beckman, 1955; Chapin, 1929; Davis, 1947a). Their studies on parasites and diseases were oriented to cultured fish species. All three scientists had fisheries publications prior to 1920 but none of these publications concerned fish health issues.

Fig. 12. Emmeline Moore (1872–1963). Moore was the first woman to be actively involved in fish health in the United States. Her photograph was taken from *A Century of Fisheries in North America*, Special Publication 7 of the American Fisheries Society, Bethesda, MD, edited by N.G. Benson, in 1970. Permission to reproduce the photograph was granted by the American Fisheries Society.

David L. Belding of the Department of Bacteriology and Experimental Pathology, School of Medicine, Boston University, published his fish health studies from 1921 to 1935. He worked on the effects of pollutants and toxicants on fish and studied Furunculosis in trout (Belding, 1921; Belding et al., 1924).

George C. Embody of Cornell University, NY, published from 1921 to 1931. He and Charles O. Hayford of Hackettstown, NJ, were the first to report on the successful breeding of disease-resistant fish (Embody and Hayford, 1925). They selected brook trout brood stock from survivors of Furunculosis outbreaks for three straight generations and increased survival from 3% to 69%. Embody also studied the effects of nutrition on fish health and tested chemicals for their ability to control monogenetic trematodes infesting trout gills (Embody and Gorden, 1924; Embody and Laird, 1931), namely the use of prolonged treatments of salt, potassium permanganate, and copper sulfate.[5]

Emmeline Moore (Fig. 12) of the New York Conservation Commission, Albany, NY, was the first woman in the U.S. to publish a paper on a fish disease problem—a 1922 publication on a parasitic protozoan (*Octomitus salmonis*) infecting the intestinal tract of trout (Moore, 1922). In addition to protozoa, she studied the effects of tapeworms on

[5] Letter sent by Frederic Fish to G.L. Hoffman on Jan. 31, 1969—on file in author's collection, includes information on prolonged treatments.

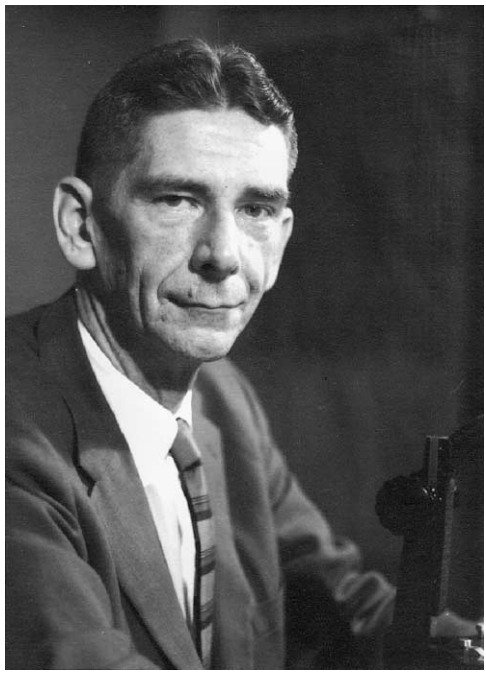

Fig. 13. Frederic Forward Fish. Fish did pioneering work with the diseases of cultured salmonids in the western U.S. Photograph obtained from Lydia Fish, daughter of Fred Fish and used with permission.

hatchery fish and the effects of aeration on the incidence of disease (Chapin, 1929; Moore, 1929). Because of her strong interest in fish health, she was given the title of "The Mother of American Fish Pathology" by her contemporaries (Glenn L. Hoffman, Leetown, WV, personal communication). She also was the first state agency employee whose main job was fish pathology.

In 1926, B.T. Simms of the Oregon State Agricultural College, Corvallis, OR along with other authors, published research results on the salmon poisoning fluke. Simms had five papers on the subject by 1934 (Donham et al., 1926; Millemann and Knapp, 1970; Shaw et al., 1934). Toxins produced by this fluke could kill animals that ate the carcass of parasitized salmon. Simms was one of the first veterinarians to work with fish diseases in the U.S.

One of the most notable researchers in this period was Frederic Forward Fish (Fig. 13) of the U.S. Bureau of Fisheries. Fish's work dealt with many aspects of fish culture. Between 1933 and 1947, he published 24 papers on various fish health issues, including protozoan infestations, salmonid bacterial diseases and treatments for diseases (Anonymous, 1996). His research centered on diseases and parasites of hatchery-reared fish and potential treatments,[6] including the use of formalin, boric acid, salt, copper sulfate,

[6] Letter sent by Frederic Fish to G.L. Hoffman on Jan. 31, 1969—on file in author's collection, includes information on roccal, formalin, and PMA.

roccal, and PMA (Fish, 1940). Frederic Fish worked primarily with salmonids and was an authority on fish health matters in the Western U.S. In the mid- to late-1930s, he worked on the characterization and identification of the bacteria causing Furunculosis and ulcer disease. As previously mentioned, Frederic Fish, along with H.S. Davis, established a diagnostic service for federal, state, and commercial fish producers.

Another notable fish health professional of this period was Ross F. Nigrelli (Fig. 14). He worked for the New York Aquarium and published over 200 papers, at least 60 of which were directly concerned with aspects of fish health. His work included studies on the viral, bacterial, fungal, protozoan, sporozoan, crustacean, trematode and cestode diseases from 1934 to 1989, more than 55 years (Fish and Fisheries Worldwide, 1999; Hoffman, 1967; Nigrelli, 1952; Sindermann, 1966). Nigrelli did considerable work on lymphocystis starting in the late 1930s and on tumors of fish. He not only dealt with freshwater fish diseases, but also was involved with diseases among salt water fish held in captivity.

Richard Weissenberg, who worked with Lymphocystis Disease since 1914 in Germany, was forced out of his country when the Nazi ministry took away his academic position in 1936 (Nigrelli and Ruggieri, 1965; Wolf, 1988). In 1937, he moved to the U.S. where he became a permanent resident and continued his research on this disease. In the same year he published two papers on lymphocystis disease (his first publications

Fig. 14. Ross F. Nigrelli (1903–1989). Ross Nigrelli worked with a broad spectrum of fish disease problems from both salt and fresh water fish and was an authority on aquarium fish diseases. This picture was obtained for use in this publication as a courtesy of Paul Cheng of the New York Aquarium.

Table 10
Fish parasitologists who began their careers in the 1920s and 1930s

Parasitologist	Dates[a]	Affiliation	Number of papers and area of expertise	References
Ralph V. Bangham	1925–1972	College of Wooster, Wooster, OH	About 25 papers, mostly concerned with trematodes and cestodes of feral fishes	(Bangham, 1941, 1972; Hoffman, 1967)
F.F. Bonds	1937–1939	Affiliation unknown	Ten papers on sporozoan parasites of fish	(Hoffman, 1967; Shul'man, 1966)
C.M. Cable	1935–1956	Affiliation unknown	Twenty-four papers on digenetic trematodes of marine and freshwater fishes	(Hoffman, 1967; Yamaguti, 1958)
Hiram E. Essex	1926–1938	Affiliation unknown	Eleven papers on the cestodes of feral fishes	(Hoffman, 1967; Yamaguti, 1959)
M.S. Ferguson	1936–1943	Affiliation unknown	Thirteen papers on trematodes of feral and hatchery fishes	(Yamaguti, 1958)
Sewell H. Hopkins	1931–1956	Agriculture and Mechanical College of Texas, College Station	Seventeen papers on digenetic trematodes of feral fishes	(Hoffman, 1967; Hopkins, 1956; Yamaguti, 1958)
R. Chester Hughes	1927–1929	Affiliation unknown	Thirteen papers on the trematodes of feral fishes	(Hoffman, 1960, 1967; Mitchum, 1995; Yamaguti, 1958)
George W. Hunter III	1926–1949	Wesleyan University, Middletown, CT	Fifty or more papers on the trematodes, nematodes, acanthocephalans and cestodes of feral fishes	(Bangham, 1972; Hoffman, 1967; Hunter, 1942; Hunter and Dalton, 1939; Mitchum, 1995; Yamaguti, 1958, 1959)
Harold W. Manter	1925–1969	Affiliation unknown	Forty-five or more publications on the trematodes of marine and fresh water fishes	(Bullock, 1970; Fish and Fisheries Worldwide, 1999; Hoffman, 1967; Yamaguti, 1958, 1961, 1963)
Paul A. Meglitsch	1937–1963	Drake University, Des Moines, IA	Nine papers on sporozoan parasites of fishes	(Shul'man, 1966)
John D. Mizelle	1936–1970	Sacramento State College, Sacramento, CA	About 40 publications on monogenetic trematodes of feral fishes	(Fish and Fisheries Worldwide, 1999; Hoffman, 1967; Mizelle and Kritsky, 1967; Yamaguti, 1963)
Justus F. Mueller	1930–1940	New York College of Forestry, Syracuse, NY	Twenty-three papers on monogenetic and digenetic trematodes, acanthocephalans, ciliated protozoa, and copepods of feral fishes	(Hoffman, 1967; Hunter, 1942; Hunter and Rankin, 1939; Yamaguti, 1958)
Elmer R. Noble	1938–1989	University of California, Santa Barbara	More than 30 papers on protozoa, mostly sporozoan parasites, of marine and freshwater fish. He authored a text book entitled *Parasitology, the Biology of Animal Parasites*	(Fish and Fisheries Worldwide, 1999; Hoffman, 1967; Lom and Dykova, 1992; Noble and Noble, 1961; Shul'man, 1966)
Emmett W. Price	1929–1966	U.S. Bureau of Animal Industry	More than 30 papers on the monogenetic trematodes of fish	(Hoffman, 1967; Price and McMahon, 1967; Yamaguti, 1963)
L.J. Thomas	1929–1953	Affiliation unknown	Fifteen papers on the nematodes and tapeworms of fish	(Bangham, 1941, 1972; Hoffman, 1967; Mitchum, 1995; Yamaguti, 1959)

[a]Range of dates when fish parasite publications were found.

in the U.S.) (Weissenberg et al., 1937). These papers were the first reports on lymphocystis written in the U.S. by a researcher who understood that the etiology of this disease was viral.[7] Between 1937 and 1965, he published 16 reports on this virus (Wolf, 1988).

Joseph H. Wales was the first biologist with the California Department of Game and Fish to work on fish parasites. He began his work in 1931 and then relocated to Oregon State University in the early 1950s (John C. Modin, personal communication). Wales did work on hematomas in trout, protozoan diseases, and the microscopic anatomy of salmonids. He had at least 12 publications from 1939 to 1983 (Wales, 1970; Wales and Wolf, 1955; Yasutake and Wales, 1983).

From 1935 to 1951, Louis E. Wolf (State Fish Hatchery, Rome, NY) published about 20 papers on protozoan, bacterial and noninfectious diseases (including nutritional diseases), and treatments of hatchery raised fish (Beckman, 1955; Davis, 1953; Fore, 1966). Wolf was best known for his work on bacterial diseases and the selection of Furunculosis resistant strains of trout (John H. Schachte, Rome, NY, personal communication).

Roger E. Burrows (U.S. Fish and Wildlife Service, Winthrop, WA) participated in various studies concerning fish health, but mostly tested chemical treatments for fungi, external bacteria, and protozoa. He authored or co-authored about 15 fish health related publications from 1939 to 1964 (Beckman, 1955; Hoffman, 1967; Anonymous, 1996).

Information on 15 fish parasitologists starting their careers during the 1920s and 1930s is given in Table 10. Several of these were very prolific writers with over 100 publications in the field of parasitology. The number of papers, given for each researcher in Table 10, reflects only their publications on fish parasites. There is no question that these parasitologists were committed to their work. In fact, it was reported that one parasitologist volunteered his alimentary tract as a site for the development of the maturing tapeworms (Peter G. Walker, Brush, CO, personal communication).

6. The modern era of fish health from 1940 to 1969

Since the 1940s, the field of fish health has developed so rapidly that it is difficult even to highlight the milestones. Specialized work on parasitic diseases continued, but no longer dominated as it had in the past. With the advent of tissue culture cell lines in fish culture, research on fish viruses greatly increased. New viral and bacterial pathogens were isolated and characterized, providing accurate etiologies for several diseases improperly diagnosed or whose causes were previously unknown. Extensive research was carried out on bacterial and viral diseases of fish. For the first time, antibiotics were used against bacterial diseases and treatments for bacterial and parasitic diseases became common place in large scale aquaculture facilities. Diagnostic services were provided at a number of sites nationwide, and histopathological analysis of diseased fish became a

[7] Lymphocystis disease was described earlier in Wisconsin on *Stizostedion vitreum* in 1918 but the cause was interpreted to be a protozoan (Nigrelli and Ruggieri, 1965).

part of the diagnostic procedure instead of an occasionally used research tool. Environmental stressors and their role in fish disease became an important consideration for the diagnostician. Several studies were initiated on genetic disease resistance of fish species and strains. The effect of environmental toxins on fish health began to be studied and associated with mortality of fish. Many studies were performed on the effects of feed, nutritional deficiencies, and contaminants on fish health. Disease inspection and certification programs were established. Detection methods for subclinical infections of some pathogens were being sought and developed. Immunological studies on fish began and there were efforts to develop bacterins to aid in the fight against bacterial diseases. Fish health training programs were also established nationwide and fish health research on cultured fish equaled or exceeded that done on wild fish.

Because of the number of new important persons and institutions involved with fish health work, three separate sections are used to organize the information for this modern era. These include the efforts of investigators in the Federal Government, the academic institutions and the state agencies. A short introduction for each section gives information prior to 1940, and that duplicates, for the sake of clarity, some information given earlier.

6.1. The modern era: the efforts of investigators in the Federal Government

The federal effort in fish health work began about the same time the first fisheries agencies were set up in the 1870s. Although no formal programs on fish diseases were set up until the 1930s (Higgins, 1935), much of the early fish health effort was conducted by individuals associated with the U.S. Commission of Fish and Fisheries or the U.S. Fish Commission. The need for full-time fish pathologists was recognized by at least one of these commissions around the turn of the century (Wood, 1953). Around 1903, both of these commissions became part of the Department of Commerce and Labor and in 1912, the name of that Department was changed to the Department of Commerce, which contained the Bureau of Fisheries.[8]

In 1939 the Department of Interior took over the responsibilities of the Bureau of Fisheries, and in 1940 that bureau merged with another agency and became the U.S. Fish and Wildlife Service (USFWS) (Anonymous, 1940). In 1934, just prior to that merger, the Department of Commerce established a disease diagnostic service with H.S. Davis and F.F. Fish (Fish, 1935; Higgins, 1935). This service established the foundation for the development of the USFWS research laboratories at Leetown, WV and Seattle, WA that would become world leaders in fish health work. Although these became part of the USFWS, the Department of Commerce still retained interest in fish diseases and managed some marine laboratories that did research on the health of salt water fish. The Department of Agriculture had only minimal involvement with aquaculture and fish health prior to 1970.

[8] Information obtained from title pages of the Bulletin of the United States Fish Commission and the United States Commission of Fish and Fisheries from 1900 through 1915.

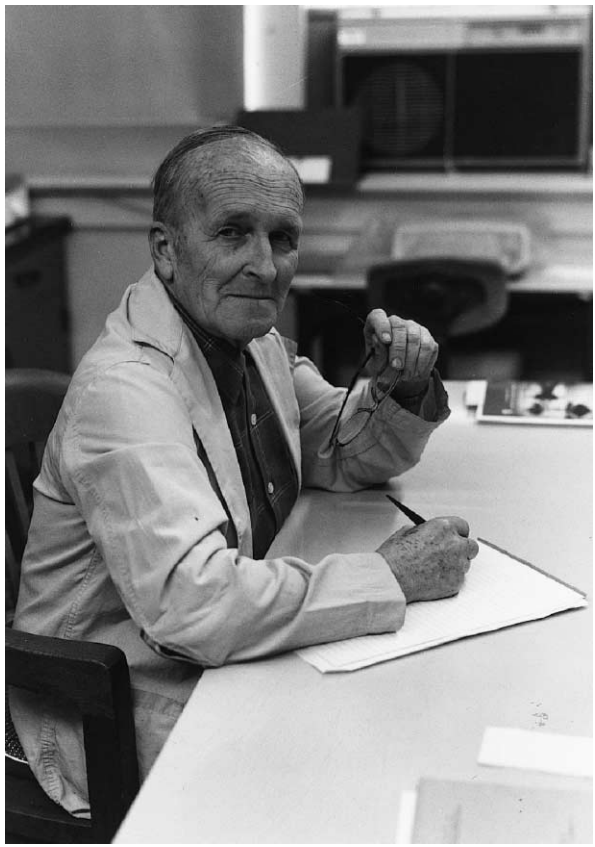

Fig. 15. Stanislas F. Snieszko (1902–1984). Snieszko was a major force in furthering the cause of modern fish health research, education and management in the U.S. Snieszko's picture was obtained for publication from the Technical Information Services, Leetown Science Center, Leetown, WV.

The foremost figure in the modern era of fish health was unquestionably Stanislas F. Snieszko[9] (Fig. 15). Snieszko became head of the Leetown laboratory in 1946 shortly after H.S. Davis retired in 1945. This laboratory became known as the Microbiology Laboratory (Abt and Bullock, 1996) and was the first federal laboratory in the U.S. devoted primarily to fish parasite and disease studies (Glenn L. Hoffman, Leetown, WV, personal communication). Before this, most federal fish health work was performed at laboratories such as the Marine Biological Laboratory at Woods Hole, MA and the United States Fisheries Biological Station, Fairport, IA; however, these sites had many missions of which fish health was only one. In 1958, the U.S. Fish and Wildlife Service changed the name of the Microbiology Laboratory to the Eastern Fish Disease Laboratory (currently the National Fish Health Research Laboratory). Snieszko remained the

[9] He did fish health work in the 1930s in Poland (Snieszko, 1937).

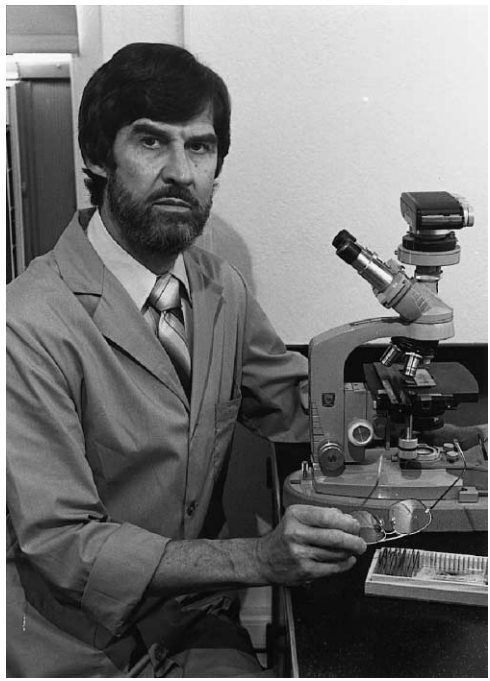

Fig. 16. Ken Wolf. Ken Wolf developed cell lines for the culture of fish viruses, pioneered research efforts in the study of fish viruses, and unraveled the mystery of the cycle of the sporozoan causing whirling disease in trout. His picture was obtained for publication from the Technical Information Services, Leetown Science Center, Leetown, WV.

director of that laboratory until his retirement in 1972, but continued as a senior scientist in that laboratory until shortly before his death in 1984 (Becker, 1979). He was a prolific writer and produced over 200 papers on various aspects of fish health as it related to the production of fish (Wolf, 1980). Snieszko was best known for his work with bacterial pathogens of fish and for promoting an understanding of the interaction of the host, pathogen, and environment in the disease process. He also was the key editor of a popular six book set entitled *Diseases of Fishes* that was published from 1970 to 1980 by T.F.H. Publications, Neptune City, NJ. This series dealt with crustacean, bacterial, warmwater fish, and fungal diseases as well as fish immunology and environmental stressors associated with fish diseases (Anderson, 1974; Bullock et al., 1971; Kabata, 1971; Neish and Hughes, 1980; Sarig, 1971; Wedemeyer et al., 1976).

Snieszko added a number of prominent fish health professionals to his staff including Ken Wolf, Glenn L. Hoffman, Graham L. Bullock, Phillip J. Griffin, C. Edward Dunbar, Roger L. Herman, Douglas P. Anderson and Robert E. Putz. Ken Wolf (Fig. 16) was the leading fish health virologist of his time and published over 200 papers[10] from 1956 to

[10] The number of publications for all Eastern Fish Disease Laboratory employees was supplied by the library of the National Fishery Center, Leetown.

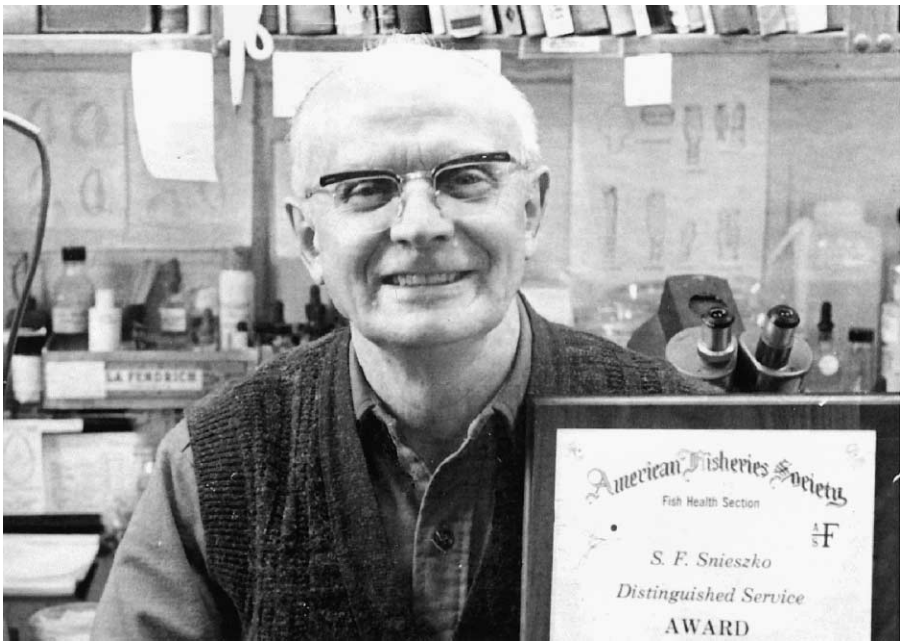

Fig. 17. Glenn L. Hoffman. Glenn Hoffman organized the work of scores of parasitologists and produced a textbook on fish parasites that has remained unparalleled for more than 30 years. His picture was obtained from the photographic collection at the Stuttgart National Aquaculture Research Center, Stuttgart, AR.

1989. His development of the first fish cell line opened the field of virology to fish health professionals (Wolf and Quimby, 1962). He produced the first text book on fish viruses called *Fish Viruses and Fish Viral Diseases* (Wolf, 1988) and along with Maria E. Markiw solved the life cycle of the sporozoan causing whirling disease in trout. This was a breakthrough that led to an understanding of the life cycle of many other sporozoan diseases of fish (Wolf and Markiw, 1984).

Glenn L. Hoffman (Fig. 17), an internationally recognized fish parasitologist, published over 175 papers from 1949 to the present. He described and identified fish parasites from all over the U.S. and around the world. Hoffman also compiled and organized the work of parasitologists from North America to author *Parasites of North American Freshwater Fishes*[11] and *Parasites of Freshwater Fishes* (Hoffman, 1967; Hoffman and Meyer, 1974). He tested chemicals for the control of fish parasites and developed detection methods for the whirling disease organism (Hoffman, 1976).

Graham L. (Pete) Bullock (Fig. 18), was a world-leading bacteriologist who published about 150 papers from 1957 to 1993. He developed diagnostic and control methods for many of the bacterial diseases of salmonids (Snieszko and Bullock, 1957). Bullock published the book *Bacterial Diseases of Fishes and Identification of Fish Pathogenic Bacteria* in 1971 (Bullock et al., 1971).

[11] Revised and expanded edition in 1999.

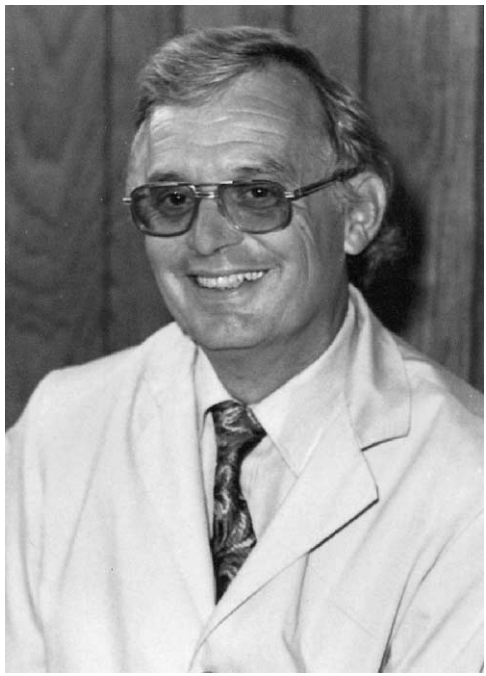

Fig. 18. Graham L. (Pete) Bullock. Pete Bullock is one of the leading fish bacteriologist in the United States and has done extensive work on diagnostic and control measures for bacterial infections in fish. Bullock's picture was obtained for publication from the Technical Information Services, Leetown Science Center, Leetown, WV.

Phillip J. Griffin, a bacteriologist, published 15 papers from 1950 to 1955 and was best known for his work characterizing the causative agents of ulcer disease and Furunculosis in trout (Griffin, 1953). C. Edward Dunbar along with Edward M. Wood (to be discussed later) were among the first to make histopathological analysis of tissues a major part of their fish health research. Dunbar published 26 papers from 1957 to 1971 on viral, bacterial, and parasitic diseases of cultured fish and also was involved with some testing of chemicals and drugs against fish diseases.

Roger L. Herman first worked with therapeutants for fish diseases in 1967 (Herman and Degurse, 1967), but soon developed an interest in histopathology and was trained as a histopathologist. During his career at Leetown he described the pathology associated with many different infectious and non-infectious disease problems of fish and published over 100 papers through 1994. Douglas P. Anderson began his career in fish health with the U.S. Fish and Wildlife Service at Seattle but moved to Leetown in 1974. He worked as a fish immunologist and developed techniques and biologics for rapid identification of infectious organisms. During his career, Anderson (1974) published the book *Fish Immunology* and about 175 papers from 1968 to 1995. Robert E. Putz was hired as an assistant to Glenn L. Hoffman and published about 25 papers, mostly on sporozoa and trematodes, from 1963 to 1973. The research and extensive publication records of these men made Leetown one of the world's leading fish disease research laboratories.

Snieszko saw the need for more than just research and in 1953, he initiated fish health training courses at Leetown (Abt and Bullock, 1996). These courses were offered through the 1980s and biologists from across the nation and the world were trained to carry out fish health inspections and fish disease diagnoses, and offer management and treatment advice. The first courses he initiated were short courses lasting about 2 weeks. In 1956 or 1957, he initiated a longer course that became known as the Fish Disease Long Course, that lasted 6 to 9 months (Glenn L. Hoffman, personal communication) (Abt and Bullock, 1996). Many graduates of these long courses became the principal fish health practitioners in the U.S. throughout the 1960s and 1970s (John A. Plumb, Auburn, AL, personal communication). Jimmy Camper and Lyle Pettijohn trained at the long course in 1958 and through their efforts, along with those of Stan Snieszko, the U.S. Fish and Wildlife Service's Hatchery Biologist System was established. This system has served as a model for fish disease diagnostic and certification programs and mainly due to this system, diagnostic services were established in strategic places nationwide (Glenn L. Hoffman, personal communication).

James S. Gutsell, who worked part of his career with the U.S. Fish and Wildlife Service at Leetown, WV, produced about 10 papers from 1940 to 1951 related to fish health in hatchery situations (Beckman, 1955; Bullock et al., 1971; Davis, 1953; Gutsell and Snieszko, 1947). Gutsell is best known for the introduction of modern drugs for the treatment of systemic bacterial diseases of fish. Most of his work involved establishing rates for the treatment of Furunculosis with sulfonamides and observing the effects of the treatments on fish (Gutsell, 1946; Gutsell and Snieszko, 1947).

Robert R. Rucker (Fig. 19) is also a prominent figure in the field of fish health among those starting in the 1940 to 1969 period. He published at least 40 papers from 1943 to 1976 (Anonymous, 1996). He established, staffed and directed the Seattle-based U.S. Fish and Wildlife Service Laboratory known as the Western Fish Disease Laboratory (now called the National Fisheries Research Center, Seattle) from 1950[12] to 1973 and led many research projects in fish health (Anonymous; Fox and Smith, 1986; Rucker, 1993). Rucker was considered a leading authority on salmonid diseases. He, along with Erling J. Ordal, (see Table 12) made significant strides in the identification and culture of the bacterium responsible for Columnaris Disease (Ordal and Rucker, 1944). Rucker's laboratory, like the Leetown laboratory, had a worldwide reputation for its work. Several leading fish health specialists worked at this laboratory, including William T. Yasutake, A. John Ross, Thomas J. Parisot, J.R. Uzmann, Donald F. Amend and Gary A. Wedemeyer. George W. Klontz (discussed in another section) and Douglas P. Anderson (discussed earlier) both initiated their fish health careers at this laboratory.

William Tosh Yasutake (Fig. 20) published over 60 papers from 1954 to 1989 and was renowned for his fish histopathology work and an atlas he produced with Joseph H. Wales, entitled *Microscopic Anatomy of Salmonids* (Anonymous, 1996; Yasutake and

[12] Some consider that this laboratory was originally established by F.F. Fish in 1934 when he set up research and diagnostic services at Montlake Laboratory, Seattle, WA, in space provided by the University of Washington, as a field unit of the Leetown, WV laboratory. It was subsequently moved to Corvallis, OR in 1948 and then back to Seattle in 1950. Its last move to the Sand Point Naval Air Station in Seattle occurred in 1959 (Anonymous; Rucker, 1993).

Fig. 19. Robert R. Rucker (1912–1998). Robert Rucker was a leading authority on salmonid diseases and helped establish the Western Fish Disease Laboratory with a worldwide reputation for its fish health work. His picture was obtained for publication from the Northwest Biological Science Center, Seattle, WA.

Wales, 1983). Two researchers, A. John Ross (published about 40 papers from 1958 to 1978) and Thomas J. Parisot (published more than 10 papers from 1958 to 1970) were known for their work on the bacterial and viral diseases of salmonids (Anonymous, 1996). In 1954 to 1966, J.R. Uzmann, published 17 papers on the parasites of fish (Anonymous, 1996). Donald F. Amend was well known for his work on the toxicity and efficacy of chemicals and his research on Infectious Hematopoietic Necrosis of trout. He wrote more than 75 fish health papers from 1965 to 1995 (Anonymous, 1996; Fish and Fisheries Worldwide, 1999). Gary A. Wedemeyer (Fig. 21), known by his contemporaries as "Dr. Stress", published over 60 papers from 1963 to 1992 and he is credited with bringing about an understanding of the aquatic environment and its effect on the initiation of diseases in fish. Wedemeyer was the senior author of the book *Environmental Stress and Fish Disease*, which was hailed for evaluating the disease process and placing an emphasis on the stressor, not just the disease organism (Anonymous, 1996; Wedemeyer et al., 1976).

John E. Halver, a well-known fish nutritionist, was stationed at a sister laboratory to the Western Fish Disease Laboratory, called the Salmon Nutrition Laboratory (later called the Western Fish Nutrition Laboratory) located at Cook, WA. He published over 20 papers relating nutrition to fish diseases from 1953 to 1989. In 1953, he wrote about nutrition and fish diseases and from 1962 to 1969 he published 16 papers associating

Fig. 20. William T. Yasutake. Yasutake works with salmonid diseases and is an expert in the histopathology of fish diseases. Yasutake's picture is a courtesy Diane G. Elliot of the Western Fisheries Research Center, Seattle, WA.

aflatoxins with hematoma production in salmonids. Halver also studied the effect of aflatoxins on channel catfish and vitamin C on other fish species (Ashley, 1970; Fish and Fisheries Worldwide, 1999; Wales, 1970). Edward M. Wood (17 fish health papers from 1954 to 1957) and Laurence M. Ashley (at least 16 fish health related papers from 1960 to 1975), both also stationed at the Salmon Nutrition Laboratory, published a broad range of fish health problems (Ashley, 1970; Anonymous, 1996; Wales, 1970; Wood et al., 1957). Wood produced seven histopathology papers on various disease problems of salmonids from 1955 to 1957 (Anonymous, 1996).

In 1958, the Fish Farming Experimental Station, a USFWS laboratory, was established in Stuttgart, AR. This laboratory offered fish health assistance and disease research to the fledgling warmwater aquacultural industry in the Mississippi Delta region. The first field trials on the use of chemotherapeutants for fish disease problems in large aquaculture facilities (multi-acre ponds) were performed by researchers at this laboratory (Meyer, 1964). At Stuttgart, disease research, diagnostic services, and fish health training were initiated by Fred P. Meyer (Fig. 22), a parasitologist. In 1962, he established the first short course for warmwater fish diseases that became known as the Diagnosis and Treatment of Warmwater Fish Diseases (Fred P. Meyer, La Crescent, MN, personal communication). The course moved to Starkville, MS in the 1970s and Tom Wellborn (discussed later) assumed leadership of the course in the late 1970s when it became known as the Warmwater Fish Disease Short Course. This course helped train

Fig. 21. Gary A. Wedemeyer. Wedemeyer is renowned for his work on the role of stress in fish diseases. His picture was obtained for publication as a courtesy of William T. Yasutake of the Western Fisheries Research Center, Seattle, WA.

many fish producers, fishery extension workers, and hatchery biologists how to recognize and control fish diseases. Fred Meyer directed the Fish Farming Experimental Station and then the Fish Control Laboratory and the National Fisheries Research Center at LaCrosse, WI. He published over 125 papers through 1991 on many aspects of fish health including parasites, disease treatments and bacterial diseases (Fish and Fisheries Worldwide, 1999). In 1974, Glenn L. Hoffman, the parasitologist from Leetown, WV, replaced Meyer at the Stuttgart lab where he conducted research until 1985.

There were other U.S. Fish and Wildlife Service research facilities and personnel that did fish health work prior to 1970. From 1964 to 1993, Joseph B. Hunn, Fish Pesticide Laboratory, Columbia, MO, published about 40 research articles on the effects of agricultural pesticides and other potential toxins on fish health (Fish and Fisheries Worldwide, 1999; Hunn, 1964, 1982). Robert (Bob) G. Piper of the USFWS, LaCrosse, WI then later Bozeman, MT, worked with a broad range of fish cultural systems and was an authority on the health of hatchery reared fish, although he published only about 10 fish health papers (the first one in 1956). These publications dealt mostly with bacterial diseases of salmonids and the effects of treatments and water quality on salmonid health (Fish and Fisheries Worldwide, 1999; Vi Catrow of the National Fisheries Center, Leetown, WV supplied list of publications for Piper). Leif L. Marking, Fish Control Laboratory, LaCrosse, WI, (1967 to 1995) produced over 80 papers on the toxicity of numerous chemicals including therapeutants to various cultured fish species (Fish and Fisheries Worldwide, 1999; Marking and Hogan, 1967). Charlie E. Smith,

Fig. 22. Fred P. Meyer. Fred Meyer worked as a diagnostician and disease researcher with the fledgling catfish industry and helped developed the first large scale pond treatments. His picture was obtained from the photographic collection of the Stuttgart National Aquaculture Research Center, Stuttgart, AR.

U.S. Fish and Wildlife Service, Bozemen, MT, was a nationally recognized fish histopathologist. His first fish health publication was in 1968 and by 1994 he had more than 80 papers to his credit (Fish and Fisheries Worldwide, 1999; Smith et al., 1974).

Lamprey control studies were also done by the Fish and Wildlife Service. Vernon C. Applegate of the Hammond Bay Biological Station, Millersburg, MI, is considered the pioneer in the studies of lamprey and their control. He published about 25 papers on the subject from 1947 to 1967 (information and a publication list provided by William Swink of the Hammond Bay Biological Station, MI). At the same laboratory, John H. Howell produced more than 20 papers on lamprey control from 1957 to 1981.

The Department of Commerce, National Marine Fisheries Service, had a few laboratories that did fish health work after the 1930s. The most notable of these laboratories was the Northeast Fishery Center, Sandy Hook, NJ under the direction of Carl J. Sindermann (Fig. 23). From 1953 to 1992 Sindermann published at least 60 papers on various aspects of salt and brackish water finfish disease problems (Fish and Fisheries Worldwide, 1999; Hoffman, 1967; Sindermann, 1966, 1974, 1977). He authored two books, *Diseases of Marine Fishes* (Sindermann, 1966) and a two-volume book *Principal Diseases of Marine Fish and Shellfish* (Sindermann, 1990a,b). He edited at least two handbooks, *Diagnosis and Control of Mariculture Diseases in the United States* (Sindermann, 1974) and *Disease Diagnosis and Control in North American Marine Aquaculture* (Sindermann, 1977). Two other Department of Commerce laborato-

Fig. 23. Carl J. Sindermann. Sindermann is a leading authority on the diseases of marine fish. His picture was obtained for use in this publication from the Library of the Cooperative Oxford Laboratory.

ries, the Northeast Fishery Center at Oxford, MD and the Northwest Fishery Center at Seattle, WA were also involved with research related to the health of marine species prior to 1970 (Fish and Fisheries Worldwide, 1999; Sindermann, 1977). Much of their work was concerned with shellfish disease problems that are not covered in this review.

As previously stated, the Department of Agriculture (USDA) gave little attention to the health of fish prior to 1970. The hesitancy of the USDA to become involved with fish revolved around the issue of whether or not aquaculture was agriculture. During the last 30 years, aquaculture has gradually become accepted as a form of agriculture. It is interesting to note that as early as 1878 Eber-Bauditten gave a reading entitled *On Carp Culture, Chiefly in its Relation to Agriculture,* that was published in a United States Fish Commission Report (Brauditten, 1980).

Two USDA employees (previously discussed) who worked with fish parasites prior to 1940 were Charles W. Stiles, who published in 1893, and Emmett W. Price, who first published in 1929. They were both employed by the U.S. Bureau of Animal Industry, a Bureau that was part of the Department of Agriculture. It is highly probable that there were other USDA employees who did some fish disease or parasite related research; however, there were no apparent efforts by the USDA to become actively involved with diseases of cultured fish until the late 1960s. In 1966 Tommy B. Taylor, County Extension Agent in Humphries County, MS, began assisting catfish farmers in his county who were experiencing losses due to disease (Wellborn, 1983). Because of

Taylor's influence, the USDA-funded Mississippi Cooperative Extension Service decided to establish a position for an extension specialist who would work on fish disease problems. As a result, Thomas Wellborn (discussed later) was hired in 1969. Through the 1980s the USDA showed interest in aquaculture and supported fish health research and offered fish disease extension assistance at universities. In 1992, the USDA officially established their own fish disease laboratory in Auburn, AL by converting an existing, large animal, parasite laboratory to a fish disease laboratory.

6.2. The modern era: the efforts of researchers at academic institutions

Researchers studying fish health have been associated with colleges and universities since the 1820s. Thomas Say was a professor at the University of Pennsylvania from 1822 to 1828, James Dana became a professor at Yale College in 1856, and Addison E. Verrill was a professor of zoology at Yale College from 1864–1907 (Encyclopaedia Britannica, 1983). Edwin Linton, who focused his career on parasites of fishes, was a professor at the Washington and Jefferson College, Washington, PA from 1882 to 1920 (Moore, 1939).

Several other colleges and universities were staffed with researchers studying some aspects of fish health prior to the 1930s (Table 11). Fish health work at these institutions was apparently the result of interest by individual researchers, because prior to the 1930s none of these institutions had a fish health program (although several had fisheries programs).

Table 11
Colleges and universities staffed with researchers studying fish health problems prior to 1930

College or University	Fish health researcher
Boston College in Boston, MA	David L. Belding
Brown University in Providence, RI	Frederick P. Gorham and David Kellicott
Cornell University in Ithaca, NY	George C. Embody
Oregon State Agricultural College in Corvallis, OR	B.T. Simms
Pennsylvania State University in University Park, PA	H.A. Surface
State Normal School in Westfield, MA	Charles B. Wilson
University of Florida in Gainesville, FL	Herbert S. Davis
University of Illinois at Champaign in Champaign, IL	Stephen A. Forbes
University of Illinois at Urbana in Urbana, IL	Richard R. Kudo, George R. LaRue, and Henry B. Ward
University of Indiana	David S. Jordan
University of Pennsylvania in Philadelphia, PA	Edward D. Cope, Ferdinand V. Hayden, Joseph P. Leidy, and Thomas Say
University of Rochester in Rochester, NY	C.W. Dodge
University of Wisconsin in Madison, WI	William Trelease
Washington and Jefferson College in Washington, PA	Edwin Linton
Wesleyan University in Middletown, CT	George Hunter, III
Wooster College in Wooster, OH	Ralph V. Bangham
Yale College in New Haven, CT	Addison E. Verrill and James Dana

The establishment of an actual program of fish health at an institution of higher learning was first initiated at Oregon State Agricultural College in 1932. Three hundred dollars per annum was allocated to this college by the Oregon State Game Commission to study parasites and diseases of fish (Shaw et al., 1934). J.N. Shaw directed this program and several previously mentioned individuals, Frederic F. Fish (late 1930s to early 1940s), Robert R. Rucker (short time in the 1940s), and Phillip J. Griffin (early 1940s) worked at this college that is now called Oregon State University (John L. Fryer, Corvalis, OR, personal communication).

In 1958, John L. Fryer (Fig. 24) began his illustrious career at Oregon State University. During his tenure at this institution he became head of the Department of

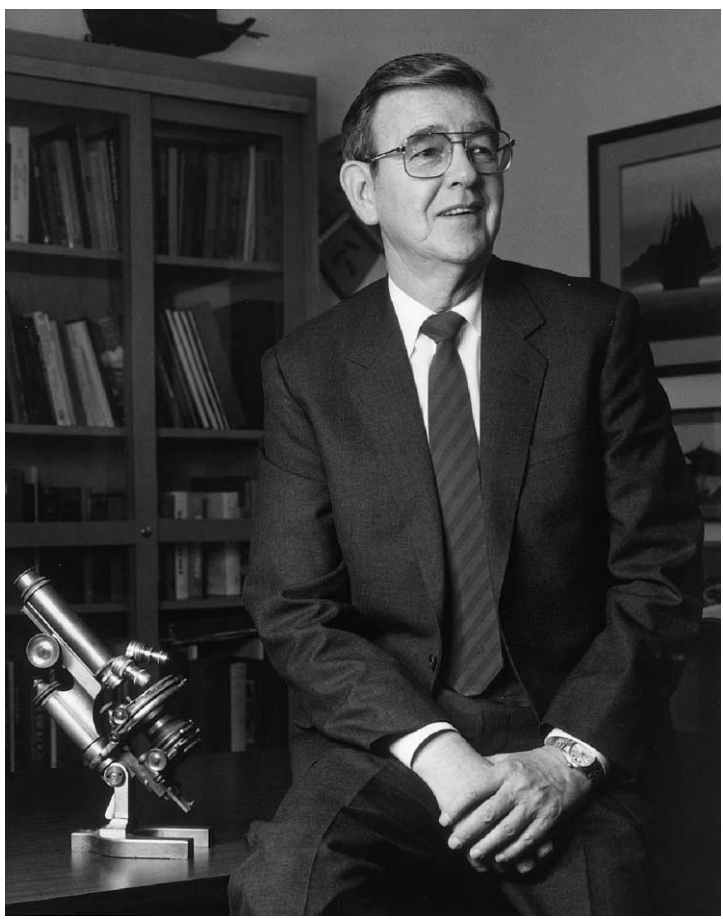

Fig. 24. John L. Fryer. Through the leadership of John Fryer, Oregon State University has become the leading institution for studies on salmonid fish health, including bacterial, viral, immunological, and parasitological studies. This picture was obtained for use in this publication as a courtesy of John Fryer, Oregon Sea Grant, Corvallis, OR.

Microbiology and through his leadership, the institution became renowned for its research on salmonid diseases. Researchers at Oregon State had many accomplishments including the development of cell lines for the detection of viral pathogens and the development of the *Vibrio* vaccine for fish reared in salt water. They worked with bacterial diseases including the characterization and nomenclature of the bacterial kidney disease organism. They also did pioneering work on rickettsia-like diseases associated with fish and studies defining the life cycle of the salmonid sporozoan, *Ceratomyxa shasta* (John L. Fryer, personal communication). Many of John Fryer's graduate students now hold key positions in fish health across the country.

K. Steve Pilcher, an associate of Fryer at Oregon State University worked extensively with viral diseases of salmonids, most particularly infectious hematopoietic necrosis, and had about 40 publications in the fish health field from 1965 to 1980 (Fish and Fisheries Worldwide, 1999; Pilcher and Fryer, 1980). R.E. Pacha, a bacteriologist, also worked at Oregon State University as well as at the University of Washington. He characterized bacteria, specializing in myxobacteria, and published from 1961 to 1970 (Austin and Austin, 1987; Pacha and Ordal, 1970).

Fish health studies at the University of Maine began in 1940 with a then little known visiting scientist from Poland, Stanislas F. Snieszko. Since he could not return to his native Poland because of World War II, he took a position at Maine. However, he was there for only a short time because the need for microbiologists in the war effort got him transferred to Fort Detrick, Frederick, MD (Snieszko et al., 1941; Wolf, 1980). The same year (1940) Marvin C. Meyer, also of the University of Maine, started publishing on various parasites of fish. His main emphasis was leeches and he published about 15 papers until 1965 (Hoffman, 1967). A fish health program was established at the University of Maine in 1969 by Bruce Nicholson. He published over 30 papers on the viruses of fresh and salt water species and pioneered the production and use of monoclonal antibodies in the antigenic analysis of aquatic Birnaviruses (Fish and Fisheries Worldwide, 1999). Through his efforts and those of his colleagues, the University of Maine gained a reputation for work on fish viruses and the development of viral and bacterial diagnostic techniques. A fish health diagnostic laboratory was also set up at the University of Maine.

At Auburn University, some fish health work was initiated in the late 1950s. It wasn't until 1964, when the Southeastern Cooperative Fish Disease Project was organized by H.S. Swingle, that Auburn University established itself in the field of fish health. Fish health research and fish disease diagnostic assistance for the southeastern state game and fish agencies and fish producers were the two major components of this project. Swingle established the project with Ray Allison, a parasitologist; George E. Krantz, a bacteriologist (immunologist); and Wilmer A. (Bill) Rogers (Fig. 25) and Heino Beckert as instructors. All these men were, or became, well known in the field of fish health. In 1964, George Krantz demonstrated a protective response in fish subjected to *Aeromonas salmonicida* antigens (Krantz et al., 1964).

In 1968, Rogers became the project leader and with his leadership Auburn University took a leading role in the area of warmwater fish health. Bill Rogers become a leading warmwater fish parasitologist and published about 70 papers on freshwater fish parasites and other areas of fish health (Fish and Fisheries Worldwide, 1999). He hired John A.

Fig. 25. Wilmer A. Rogers. Rogers' headed the prestigious Parasite and Disease section of the Department of Fisheries and Allied Aquacultures at Auburn University, AL, and is a leading fish parasitologist. This picture was obtained for use in this publication as a courtesy of John Plumb.

Plumb (Fig. 26) who produced more than 130 publications from 1969 to the present. Through Plumb's efforts the University also gained national and international recognition for its work with viral and bacterial diseases of warmwater fish. John A. Plumb wrote the book *Health Maintenance and Principal Microbial Diseases of Cultured Fishes* (Plumb, 1994).

A fish pathology lab was set up at Southern Illinois University, Carbondale, IL, in about 1963 (Lewis and Lewis, 1963). The husband and wife team, William M. Lewis and Susan D. Lewis, worked in this lab and aided the Arkansas bait minnow industry with their efforts in fish health (mostly from 1960 to 1972) (Fish and Fisheries Worldwide, 1999). They worked with parasites, toxins, environmental factors affecting fish health, and disease treatments.

George (Bill) W. Klontz, one of the early veterinarians in fish health, along with Donald H. Lewis, a bacteriologist, established a fish health program at Texas A&M University in the late 1960s (Sterling K. Johnson, College Station, TX, personal communication). This program was most noted for its work on bacterial fish pathogens. Bill Klontz published about 35 papers from 1965 to 1995 on various aspects of fish health. Don Lewis published about 40 papers, mostly on the characterization of fish bacterial isolates, the treatment of bacterial disease and the immune response in fish

Fig. 26. John A. Plumb. John Plumb is regarded by many as the authority on bacterial and viral diseases of warmwater fish in the U.S. His picture was obtained for publication from the Department of Fisheries and Allied Aquacultures, Auburn University, AL.

(Fish and Fisheries Worldwide, 1999). In the early 1970s, Klontz moved to the University of Idaho where he started a program that emphasized fish health issues associated with salmonid culture and also trained many graduate students in the field of fish health.

Thomas L. Wellborn, Jr. (Fig. 27) was hired by the Mississippi State University, Cooperative Extension Service (MSU CES) in 1969 as a State Extension Specialist. His mission was to help the aquaculture industry in fish health management and other areas of fish farming. He later established the MSU (CES) fish disease laboratories at Stoneville and Belzoni in Mississippi in the 1980s. Through the training efforts of Wellborn and others, the catfish industry grew tremendously in Mississippi.

After the 1970s, many universities and colleges began to offer fish disease diagnostics and assistance and perform fish disease research. Veterinary schools including those at Auburn University, Louisiana State University, Oregon State University, Washington State University and Mississippi State University also started to offer courses on fish diseases.

Several key individuals (Fig. 28), who began their fish health careers between 1940 and 1969 but who did not work at Universities with fish health programs established before 1970, are included in Table 12.

Fig. 27. Thomas L. Wellborn Jr. (1932–1998). Wellborn was a fish health diagnostician and teacher who did much to build the catfish industry in Mississippi. Wellborn's picture was obtained for publication as a courtesy of Rachael Josey of the Department of Wildlife and Fisheries, Mississippi State University.

6.3. The modern era: the efforts of fish health workers employed by state agencies[13]

Several states had employees working in fish health prior to 1970. Although it is not practical to cover all these employees, several are highlighted. These fish pathologists usually had diagnostic and extension duties that limited their production of scientific papers. As previously mentioned, Emmeline Moore was a fish pathologist for the New York Department of Conservation in the 1920s and was followed by Louis E. Wolf in the 1930s. Also in the 1930s, Joseph H. Wales worked for the California Fish and Game.

Following Emmeline Moore and Louis Wolf, New York's Department of Conservation had two more pathologists that started prior to 1970. In about 1955, Richard

[13] Most of the information in this section was provided by fish health or fisheries workers from the various states mentioned in this section. These include: Julia Beyerle for Michigan; Thurston Dotson for Montana; Keith A. Johnson for Idaho; Susan Macquenski for Wisconsin; Joseph W. Marcino for Minnesota; John C. Modin for California, Oregon, and Washington; Joe O'Grodnick for Pennsylvania; George Post for Colorado, Utah, and Wyoming; John H. Schachte for New York; Charles V. Suppes for Missouri; Peter G. Walker for Maine, and Mike Wood for Louisiana. The author has received written permission from each of the above mentioned persons to use the information included in this section.

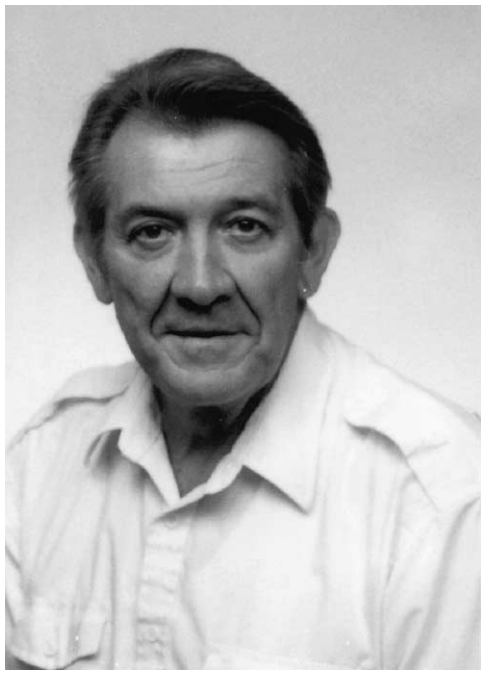

Fig. 28. L. William Clem. Clem is regarded as one of the leading fish immunologist in the world. This picture was obtained for use in this publication as a courtesy of L.W. Clem of the University of Mississippi Medical Center.

Stevens took over for Wolf and 5 years later, Neil F. Ehlinger replaced Stevens. Ehlinger continued Wolf's work on selecting Furunculosis-resistant strains of trout.

Other eastern states with fish pathologist positions set up prior to the 1970s included Pennsylvania and Maine. Arthur D. Bradford (about 1958 to 1972) and Courtney C. Gustafson (about 1963 to 1980) of the Pennsylvania Fish Commission did fish pathology work primarily with whirling disease in trout. David O. Locke of the Maine Department of Inland Fisheries and Wildlife isolated infectious pancreatic necrosis virus from hatchery fish in the early 1960s and successfully eliminated the virus from Maine by using a fish depopulation program.

California had one of the strongest contingencies of fish pathologists who began their careers between 1940 and 1969. Harold Wolf followed Joseph Wales and worked from 1949 to 1981. He was the first designated Parasitologist–Pathologist in the California Department of Fish and Game and in 1956 he initiated a fish importation inspection program that was probably the first large scale program of its kind in the U.S. Harold Wolf had about 10 publications on subjects relating to trout hematomas, fish health inspection programs, and fish parasites (Fish and Fisheries Worldwide, 1999; Wales, 1970; Wales and Wolf, 1955; Wolf, 1970; Yasutake and Wolf, 1970). His reputation came from his expertise in the diagnosis, treatment, and prevention of salmonid hatchery disease problems. Other fish pathologists working for the California Game and Fish

Table 12
Some university fish health specialists starting their careers after 1940 but before 1970

Researcher	Dates[a]	Affiliation	Number of papers and area of expertise	References
Omar M. Amin	1969–1996	University of Wisconsin-Parkside, Kenosha, WI	Wrote about 50 papers on acanthocephalans of fish.	(Fish and Fisheries Worldwide, 1999; Hargis, 1985; Mitchum, 1995)
C. Dale Becker	1960–1992	Pacific Northwest Laboratories, Richland, WA	About 30 papers on the cestode, protozoan and sporozoan parasites of fish and environmental issues affecting the health of fish. His key work was the monograph *The bacterial pathogen Flexibacter columnaris and its epizootiology among Columbia River Fish*.	(Becker, 1977; Becker and Fujihara, 1978; Fish and Fisheries Worldwide, 1999)
L. William Clem (Fig. 28)	1961–date	University of Mississippi Medical Center, Jackson MS	World renowned immunologist who published about 200 papers with more than 125 papers in the field of fish immunology. Originally worked with tissue culture and fish viruses	Curriculum vitae supplied by L. William Clem
John E. Cushing	1942–1956	California Institute of Technology	First fish immunology study in the U.S. (effect of temperature on antibody production). Also did study on the serology of tuna.	(Anderson, 1974)
Danzel E. Ferguson	1964–1970	Mississippi State College, State College, MS	Produced about 20 papers on the effects of agricultural pesticides on fishes.	(Ferguson, 1967a,b, 1968; Ferguson and Goodyear, 1967; Fergusson et al., 1966; Fish and Fisheries Worldwide, 1999)
Jacob H. Fischthal	1940–1957	Triple CitiesCollege of Syracuse University, Endicott, NY	Twenty-five papers, mostly on trematodes and cestodes of feral fish	(Fischthal, 1949; Hoffman, 1967; Yamaguti, 1959, 1963)

William J. Hargis	1952–1992	College of William and Mary, Gloucester Point, VA	Over 45 papers on the monogenetic trematodes of fishes	(Fish and Fisheries Worldwide, 1999; Hargis, 1985; Hoffman, 1967; Price and McMahon, 1967)
John S. Mackiewicz	1959–1982	State University of New York at Albany	Leading authority on the caryophyllaid tapeworms and published about 35 papers.	(Fish and Fisheries Worldwide, 1999; Hoffman, 1967; Mackiewicz, 1972; Mitchum, 1995)
Erling J. Ordal	1944–1970	University of Washington	Published about 15 papers on myxobacteria and *Vibrio sp*. but is best known for his work with the causative agent of columnaris.	(Fish and Fisheries Worldwide, 1999; Ordal and Rucker, 1944; Pacha and Ordal, 1970)
Robin M. Overstreet	1968–date	Gulf Coast Research Laboratory, Ocean Springs, MS, part of the university system in Mississippi	Produced well over 100 papers on many aspects of the health of marine aquaculture species. Much of his work has been on parasitic problems of marine species. He is one of only a few authorities on fish parasites still working in the U.S. today.	(Fish and Fisheries Worldwide, 1999; Overstreet, 1978)
D.C. Saunders	1954–1966	Unknown	Produced 10 papers on the blood protozoa of marine fishes	(Becker, 1970; Lom and Dykova', 1992)
M. Michael Sigel	1961–1986	University of Miami, Miami, FL	Published about 30 papers, early research involved fish virus and tissue culture work, but later research was mostly in the area of fish immunology.	(Anderson, 1974; Fish and Fisheries Worldwide, 1999; Wolf, 1988)
Roland Walker	1947–1985	Rensselaer Polytechnic Institute	About 15 papers, mostly on lymphocystis virus and piscine erythrocytic necrosis virus of fish	(Fish and Fisheries Worldwide, 1999;Walker and Sherburne, 1977; Wolf, 1988)

[a]Range of dates when fish health publications were found.

included William (Bill) H. Wingfield (1967 to 1998), who studied salmonid viruses; Robert J. Toth (1960 to 1992) who worked mainly with metazoan parasites; Mel J. Willis (1965 to date) who effectively purged broodstock of bacterial kidney disease; William E. Schafer (about 1958 to 1969) who studied the epizootiology of *Ceratomyxa shasta*; John C. Modin (1964 to date) who studied several sporozoans of trout; and Donald Manzer (1964 to 1993) who worked with protozoan and bacterial problems of salmonids (Fig. 29 includes five of the above mentioned California fish pathologists).

From 1950 to 1960, James W. Wood was the head fish pathologist for the Oregon Department of Fisheries and Wildlife. He studied various fish health issues including bacterial and noninfectious problems of pacific salmon (Fish and Fisheries Worldwide, 1999). John Fryer (discussed earlier) followed James W. Wood as the Oregon Fish Pathologist for a short time and then John F. Conrad took over in the mid-1960s. Conrad and Mark G. DeCew are credited with the first report of *Ceratomyxa* in juvenile salmonids (Conrad and DeCew, 1966). Mark DeCew also worked as a pathologist for Oregon from about 1962 to 1968.

Bryan Earp, a bacteriologist, was the fish pathologist for the State of Washington from 1950 to 1960. Most of his work centered on bacterial kidney disease of salmonids.

Fig. 29. Mel J. Willis, Donald Manzer, Robert J. Toth, Harold Wolf, and John C. Modin (given in order as they appear in the picture from left to right). These pathologists formed one of the most impressive state fish pathology units in the U.S. This picture was obtained for use in this publication as a courtesy of John Modin of the Department of Fish and Game, Rancho Cordova, CA.

James W. Wood was hired as the Washington State Fish Pathologist in 1960 and remained there until his retirement in 1986. Harlan "Red" Johnson also worked for the State of Washington as a fish pathologist during this period.

George Post (Fig. 30) worked with a broad spectrum of fish health problems associated with fish production and published more than 35 papers on fish health problems from 1955 to 1993 (Fish and Fisheries Worldwide, 1999). He first worked with the Wyoming Game and Fish Commission from 1948 to 1960, then for the Utah Department of Fish and Game until 1963. George Post was the first to demonstrate a protective response in fish when subjecting them to bacterial antigens (Post, 1962). In 1965, he began working for Colorado State University where he taught a course in fish health and was chairman of the Fish Disease Technology Curriculum in the Department of Microbiology for about two decades. His efforts culminated in his 1983 *Textbook of Fish Health* and subsequent revision of that book in 1987 (Post, 1987). His successors at the Wyoming Department of Game and Fish were William G. Hepworth and Douglas L. Mitchum. Mitchum, who started his career at the Wyoming Department of Game and Fish in 1960, worked on treatments, diagnosis, and descriptions of diseases (primarily parasites), and produced a book entitled *Parasites of Fishes of Wyoming* along with about 15 other scientific publications (Mitchum, 1995). George Post's successors at Utah were Gar D. Workman from 1963 to 1966 and Ronald Goede from 1966 to present.

Ron Goede was a major force in the Colorado River Wildlife Council. The Council was a cooperative seven-state effort responsible for legislation that resulted in some of the first regional fish health regulations. He also became known for his emphasis on

Fig. 30. George Post. Post was a fish health researcher and teacher who produced a much needed textbook on fish health and was the first to show a protective response from a fish vaccine. This picture was obtained for use in this publication as a courtesy of George Post, Rio Rico, AZ.

inspection work and fish health assessment surveys. Goede's career actually started as a state fish pathologist for the Missouri Department of Conservation in 1963. Two other fish pathologists, Gary W. Camenish and Charles V. Suppes, started working for Missouri in 1966.

Two other western states, three north central states and one southern state had fish pathologists prior to 1970. From 1969 to 1971 Robert L. Dent worked for the Montana Department of Fish Wildlife and Parks and from the mid-1960s to 1987 Harold Ramsey worked for the Idaho Department of Fish and Game. Leonard N. Allison was a pathologist for the Michigan Department of Natural Resources from 1948 to 1971 and Phil Economon for Minnesota Department of Natural Resources 1954 to 1986. Five fisheries employees with a work emphasis in fish pathology, Lowell H. Woodbury (1938 to 1943), George B. Deane (1949 to 1952), Kenneth Flakas (1953 to 1954), Richard Stevens (1952 to 1956), and Paul Degurse (1950 to 1980), worked for the Wisconsin Department of Natural Resources. Janice S. Hughes (1961 to 1995) of the Louisiana Department of Wildlife and Fisheries concentrated her early efforts on fish health work, particularly the toxicity of pesticides and other chemicals to fish.

7. Where do we go from here?

Through the 19th century and into the early 20th century the Europeans clearly led the world in fish health research and management. Since its start in 1797, the field of fish health in the U.S. has experienced tremendous growth and expansion. In most areas the U.S. has caught up with the rest of the world and has taken a leading role in many areas. Since the 1970s, fish vaccination programs have been established, herd health management practices initiated and pathogen detection and identification methods using immunodiagnostic and molecular techniques developed and used on fish pathogens.

It was not until the 1980s that the veterinary profession began to show a serious interest in fish health. Constraints such as the small size of the aquaculture industry and the lack of fish health training in veterinary schools may have kept veterinarians from becoming involved in aquaculture. Fish health programs for diagnosis, inspection and certification work were set up without much input from veterinarians.

The American Fisheries Society (AFS) established the Fish Health Section (FHS) in the mid-1970s. The FHS developed two programs to certify competent fish health professionals. The first certification of Fish Health Inspectors gave credibility mainly to fishery and hatchery biologists who did inspection work on salmonids. The second certification of the professional Fish Pathologist was a more demanding certification that provided credibility to a broader range of fish health professionals. Both of these programs came at a time when foreign countries began to require that imported fish receive a fish health certification from a veterinarian. Even though there were very few veterinarians involved in fish health, the programs were useful and gave the fisheries professional the needed credibility to carry out inspection and diagnostic procedures for requesting countries. By the early 1990s, there was more pressure to use veterinarians and questions arose concerning the validity of the certified inspectors and pathologists. This pressure came from foreign countries and from federal and state officials in the

U.S. For the last 15 years, veterinarians, mostly from the Department of Agriculture, have taken steps to become involved in aquaculture. They are now seeking an active role in diagnostic work and fish health regulation issues. Their continued involvement should be welcomed and the training of veterinarians in fish health is one of the last major hurdles that the U.S. fish health community must clear to come of age.

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Appendix A. Annotated bibliography

The following bibliography has been annotated. Most references, particularly those prior to 1900, have been briefly annotated for their fish health content. With others, the annotation simply reflects the specific reason that reference was used in this manuscript. The number of publications was an important factor in deciding whether or not to include many fish health scientists in this historical review. I looked through the literature cited sections of many papers and books to determine that number. Therefore, several books and papers are cited to show that their references or literature cited sections were used as a source for determining the number of publications by a given author. As an example, the annotation may read: the literature cited serves as a source for the publications of (author's name). To include references to all these publications would add thousands of citations to this bibliography and would be beyond the scope of this review.

Several references in this bibliography are cited solely because they give some biographical information on a given author. That information may be the first name of the author, the institution employing the author, or something of historical interest. In this case, the annotation usually states that the report gives biographical information (the specific information is usually not mentioned) on a given author. Books published or edited by given authors are usually annotated as important achievements of the authors rather than for their content.

Many of the early bulletins, commissioner reports and transactions contain reports that were written 1 to 3 years prior to the official publication date. Therefore, it is not uncommon to see a bulletin published in 1900 containing reports from 1898. In this case the citation may read "Report for the Commissioner for 1898" but carry a publication date of 1900.

Twenty-two papers for which I was unable to obtain a copy are sub-referenced in brackets to a publication containing information from them. All but one of these sub-references are fully cited in the bibliography for another purpose, therefore only author and date are given, e.g., [taken from McGregor, 1963]. The one exception is fully cited in the brackets. Lastly, following several citations are page numbers given in parentheses. This is done to help the reader locate the cited information.

References

Abt, D.A., Bullock, G.L., 1996. Two pathways—same destination: development of educational programs in fish health. Annu. Rev. Fish Dis. 6, 93–105.
Information is given on early fish health training programs including the first that was established by Herbert S. Davis in 1941. Also some historical information is given on the U.S. Fish and Wildlife Service's laboratory at Leetown, WV.

Adams, A.L., 1868. Death of fishes in the bay of fundy. Am. Nat. 2 (7), 337–342.
This paper describes an 1867 wild fish kill involving mostly American herring (*Clupea elongata*), in the Bay of Fundy, off the northern coast of Maine.

Agassiz, A., 1865. Illustrated catalogue of the Museum of Comparative Zoology, Harvard College: No. II. North American Acalephae, p. 87.
In this publication there is a description of a crustacean (*Pennella orthagorisci*) on an ocean sunfish.

Anderson, D.P., 1974. In: Snieszko, S.F., Axelrod, H.R. (Eds.), Fish Immunology: Diseases of Fishes (Book 4). T.F.H. Publications, Neptune City, NJ, 239 pp.
This was the first major text in the U.S. on fish immunology, and was a major publication for Douglas P. Anderson. It also is one of six books co-edited by Stanislas F. Snieszko. The literature cited in this book serves as a source for publications of John E. Cushing and M. Michael Sigel.

Anonymous, 1883. Poisoned water in the Gulf of Mexico—from the Sunland Tribune. Bull. U. S. Fish Comm. for 1882, 2, 104.
This paper gives a description of the death of many fish species in the Gulf of Mexico off the coast of Florida.

Anonymous, 1884. Report of the Commissioner. U. S. Comm. Fish and Fisheries: Part X. Report of the Commissioner for 1882. Government Printing Office, Washington, pp. XVII–XCI (LII).
This report discusses a massive tile fish (*Lopholatilus chameleonticeps*) kill off the coast of Maryland, Delaware and New Jersey.

Anonymous, 1886. Report of the Commissioner. U. S. Comm. Fish and Fisheries: Part XII. Report of the Commissioner for 1884. Government Printing Office, Washington, pp. XIII–LXX (XLIII).
This paper gives a report of multi-fish species mortalities from the Gulf of Mexico and Wisconsin Lakes.

Anonymous, 1891. Report of the Commissioner. U. S. Comm. Fish and Fisheries: Part XV. Report of the

Commissioner for 1887. Government Printing Office, Washington, pp. I–LXIII (LVI).
This report gives biographical information on David S. Jordan.

Anonymous, 1892. Report of the Commissioner. U. S. Comm. Fish and Fisheries: Part XVI. Report of the Commissioner for 1888. Government Printing Office, Washington, pp. IX–XXXIX (XVI).
This report gives biographical information on John A. Ryder and C.M. Blackford.

Anonymous, 1893. Report of the Commissioner. U. S. Comm. Fish and Fisheries: Part XVII. Report of the Commissioner for 1889–1891. Government Printing Office, Washington, pp. 1–96 (17, 27 and 45).
This report discusses egg and fry diseases in cod and Atlantic salmon and coagulated yolk (white spot) in black bass.

Anonymous, 1894. Report of the Commissioner. U. S. Comm. Fish and Fisheries: Part XVIII. Report of the Commissioner for 1893. Government Printing Office, Washington, pp. VII–LXXXVII (LV–LVI).
This paper gives reports on brook trout fry and egg diseases and the treatment of fry with salt and earth.

Anonymous, 1896. Report of the Commissioner. U. S. Comm. Fish and Fisheries: Part XX. Report of the Commissioner for 1894. Government Printing Office, Washington, pp. 1–19 (7).
This report gives an account of fungus and a protozoan (probably Ich) affecting several species of fish held in aquaria.

Anonymous, 1899. Report of the Commissioner. U. S. Comm. Fish and Fisheries: Part XXIV. Report of the Commissioner for 1898. Government Printing Office, Washington, pp. VII–XXIX (XVI).
This is a report of mill and factory pollution killing fish and fish eggs in a stream.

Anonymous, 1940. Notes and News: introducing the Fish and Wildlife Service. Prog. Fish-Cult. 51, 42–44.
This note gives information on the establishment of the U.S. Fish and Wildlife Service.

Anonymous, 1992. The White House 1792 to 1992: Image in Architecture. The American Architectural Foundation and the White House Historical Society, McGraw Hill, 67 pp.
This report gives biographical information on Benjamin H. Latrobe.

Anonymous, 1996. Northwest Biological Science Center–Publications list, Seattle, WA, 58 pp.
This publication list serves as a source for the publications of several personnel from the U.S. Fish and Wildlife Service, who worked in association with Western Fish Disease Laboratory, Seattle, WA.

Anonymous. Western Fish Disease Laboratory (background information from an in house memo supplied by William T. Yasutake), p. 14.
This report gives biographical information on Robert R. Rucker and some historical information on the Western Fish Disease Laboratory.

Ashley, L.M., 1970. Pathology of fish fed aflatoxins and other antimetabolites. In: Snieszko, F. (Ed.), A Symposium on Diseases of Fishes and Shellfishes. Special Publication No. 5, American Fisheries Society, Washington, DC, pp. 366–379.
The literature cited in this paper serves as a source for the publications of Laurence Ashley, John Halver and Edward M. Wood.

Atkins, C.G., 1872. The salmon breeding enterprise in Maine (comment). Trans. Am. Fish Cult. Assoc. 1, 16–18.
This paper gives a report of a fungal disease on Atlantic salmon cultured in Maine.

Atkins, C.G., 1880. XLIII. Cheap fixtures for the hatching of salmon. U. S. Comm. Fish and Fisheries: Part IV. Report of the Commissioner for 1878. Government Printing Office, Washington, pp. 945–965 (963).
This is a report on salmon eggs infected with fungi in a hatchery.

Atkins, C.G., 1884. XXIII. Report of the propagation of Penobscot salmon in 1881–1882. U. S. Comm. Fish and Fisheries: Part IX. Report of the Commissioner for 1881. Government Printing Office, Washington, pp. 1085–1089 (1085).
This report discusses an eye disease in cultured Penobscot salmon.

Atkins, C.G., 1885. XXVII. Report of the propagation of Schoodic salmon in 1883–1884. U. S. Comm. Fish and Fisheries: Part XI. Report of the Commissioner for 1883. Government Printing Office, Washington, pp. 1011–1015 (1013).
This report mentions coagulated yolk in propagated Schoodic salmon fry.

Atkins, C.G., 1898. The atlantic salmon—a manual of fish-culture based on the methods of the United States Commission of Fish and Fisheries. Prepared under the direction of John J. Brice. U. S. Comm. Fish and Fisheries: Part XXIII. Report of the Commissioner for 1897. Government Printing Office, Washington, pp. 1–340 (27–66).

Information is presented in this report concerning fungi on Atlantic salmon eggs and adults, coagulated yolk in Atlantic salmon fry, and treatments against egg diseases using salt and mud.

Austin, B., Austin, D.A., 1987. Bacterial Fish Pathogens; Disease in Farmed and Wild Fish. Wiley, New York, NY, 364 pp.
The reference sections in this book serve as sources for the publications of R.E. Pacha.

Bangham, R.V., 1941. Parasites of fresh-water fish of southern Florida. Proc. Fla. Acad. Sci. 289–307.
The literature cited in this publication serves as a source for the publications of R.V. Bangham and L.J. Thomas.

Bangham, R.V., 1972. A resurvey of the fish parasites of western Lake Erie. Bull. Ohio Biol. Survey.
The literature cited in this publication serves as a reference for the publications of Ralph V. Bangham, George W. Hunter III and L.J. Thomas.

Bean, T.H., 1892. Observations upon fishes and fish culture. Bull. U. S. Fish Comm. for 1890, vol. 10, Government Printing Office, Washington, pp. 49–61 (54).
This bulletin gives a report on fry diseases of cultured landlock salmon and Swiss lake trout.

Bean, T.H., 1896a. Report on the propagation and distribution of food fish. U. S. Comm. Fish and Fisheries: Part XX. Report of the Commissioner for 1894. Government Printing Office, Washington, pp. 20–80 (41, 60 and 61).
Information is given on a mortality of propagated brook trout fry and adults and another mortality of trout investigated by R.R. Gurley, and a trout and bass mortality caused by lightning. A letter entitled "On fish epidemic—May 30, 1894", was sent to T.H. Bean from E.M. Robinson and published in this paper. In that letter (pp. 60–61) Robinson reports that fungi and probably *Ichthyophthirius* infections were on salmon fry. Salt treatments for fungi and parasites are also discussed.

Bean, T.H., 1896b. 1. Report of the representative of the United States Fish Commission at the World's Columbian Exposition. U. S. Comm. Fish and Fisheries: Part XX. Report of the Commissioner for 1894. Government Printing Office, Washington, pp. 177–196 (177).
This report gives biographical information on Stephen A. Forbes and W. de C. Ravenel.

Bean, T.H., 1910. A plea for the systematic study of fish diseases. Trans. Am. Fish. Soc., 39, 65–78, Government Printing Office, Washington 6, 194–195.
This paper is a reference source for fish parasitology and fish disease literature prior to 1900 and a source for historical information on the origin of fish culture in the U.S.

Becker, C.D., 1970. Hematozoa of fishes, with emphasis on North American Records. In: Snieszko, S.F. (Ed.), A Symposium on Diseases of Fishes and Shellfishes, Special Publication No. 5. American Fisheries Society, Washington, DC, pp. 82–100.
The literature cited in this publication serves as a reference for the publications of D.C. Saunders.

Becker, C.D., 1977. Flagellate parasites of fish. Chapter in Parasitic Protozoa, vol. 1, Academic Press, New York, pp. 357–415.
The reference section of this chapter serves as a source for the publications of C. Dale Becker and the chapter also contains some biographical information on Becker.

Becker, C.D., 1979. National Fish Health Research Laboratory, Lab Series 6. Fisheries 4 (6), 20–22.
This article gives biographical information on Stanislas F. Snieszko.

Becker, C.D., Fujihara, M.P., 1978. The bacterial pathogen *Flexibacter columnaris* and its epizootiology among Columbia River fish. A review and synthesis. American Fisheries Society, Washington, DC, Monograph No. 2, 92 pp.
This monograph on *Flexibacter columnaris* is referenced as a key publication for C. Dale Becker.

Beckman, W.C., 1955. Index to Transactions of the American Fisheries Society. Volumes 59 to 82 (1929–1952). Ann Arbor, MI, 112 pp.
The Authors Index (Part II, pp. 88–112) of this publication serves as a reference source for publications of Louis E. Wolf, Roger E. Burrows, James S. Gutsell, George C. Embody, David L. Belding and Emmeline Moore.

Belding, D.L., 1921. Discussion on furunculosis. Trans. Am. Fish. Soc. 51, 101–106.
This paper contains a discussion on the Furunculosis Disease of trout.

Belding, D.L., Merrill, A., Kitson, J., 1924. Fisheries investigations in Massachusetts. Trans. Am. Fish. Soc. 54, 29–47.
This paper contains a discussion on the effects of water-borne toxins to fish.

Bowen, J.T., 1970. A history of fish culture as related to the development of fishery programs. In: Benson, N.G. (Ed.), A Century of Fisheries in North America, Special Publication No. 7. American Fisheries Society, Washington, DC, pp. 71–93 (87–88).
This history contains information on the appointments, as fish pathologists, of Millard C. Marsh and Herbert S. Davis. It also mentions a major trout epidemic reported by Mather in 1890 (original report not found) and serves as a source for biographical information on Livingston Stone.

Bradley, F.N., 1872. *Dibothrium cordiceps* in trout. Report on Montana, Idaho, and Utah, p. 234. [taken from McGregor, 1923].
This paper reports the presence of a tapeworm (*Dibothrium cordiceps)* in trout.

Brauditten, E., 1980. On carp culture, chiefly in its relation to agriculture. Report of the Commission for 1878. U. S. Comm. Fish and Fisheries. Government Printing Office, Washington, pp. 667–670.
This 1880s reference in a U.S. government publication indicated that fish culture was agriculture, an issue debated in the 1980s, some 100 years later.

Bullock, G.L., Conroy, D.A., Snieszko, S.F., 1971. In: Snieszko, S.F., Axelrod, H.R. (Eds.), Bacterial Diseases of Fishes: Diseases of Fishes (Book 2A). T.F.H. Publications, Neptune City, NJ, 151 pp.
The literature cited in this book serves as a source for publications by James S. Gutsell. This citation also serves as the source of one of six books co-edited by Stanislas F. Snieszko and as a key book on bacterial fish pathogens written by Bullock and others.

Bullock, W.L., 1970. The zoogeography and host relations of the acanthocephalan parasites of fishes. In: Snieszko, F. (Ed.), A Symposium on Diseases of Fishes and Shellfishes, Special Publication No. 5. American Fisheries Society, Washington, DC, pp. 161–173.
The literature cited in this paper serves as a source for publications of Harold W. Manter.

Calkins, G.N., 1899. Report upon the recent epidemic among brook trout *Salvelinus fontinalis* on Long Island. Fourth Annual Report of NY Fish, Forestry and Game Commission for 1898, pp. 175–190.
In this report, Calkin discusses fungi, nematodes, crustacean (gill copepods) and an internal spore-like organism (probably *Ichthyophonus)* infecting propagated brook trout. His findings also include some information about the histological analysis of diseased tissues.

Chapin, M.K., 1929. Index to Transactions of the American Fisheries Society. Volumes I to LVIII, (1872–1928). Baltimore, MD, 99 pp.
The Authors Index (Part II, pp. 73–99) provided a reference source for publications of Millard C. Marsh, George C. Embody, David L. Belding and Emmeline Moore.

Clark, F.N., 1884a. XIV. Report of experiments for determining the smallest amount of water in which young shad and eggs can be kept. U. S. Comm. Fish and Fisheries: Part IX. Report of the Commissioner for 1881. Government Printing Office, Washington, pp. 783–786 (783).
Clark observed and reported fungi on American shad eggs held in hatching cones in his experiments.

Clark, F.N., 1884b. XX. Report of work at the United States Hatchery, Northville, MI, 1881–1882. U. S. Comm. Fish and Fisheries: Part IX. Report of the Commissioner for 1881. Government Printing Office, Washington, pp. 1037–1062 (1044).
This is a report of fungi covering dead salmonid eggs in hatching jars.

Clark, F.N., 1889. Report of the operations at the Michigan stations of the U. S. Fish Commission for the year. U. S. Comm. Fish and Fisheries. Part XIV. Report of the Commissioner for 1886. Government Printing Office, Washington, pp. 729–736 (735).
Clark mentions the presence of blue-sac disease in brown trout fry.

Clark, F.N., 1898a. The brook trout—a manual of fish-culture based on the methods of the United States Commission of Fish and Fisheries. Prepared under the direction of John J. Brice. U. S. Comm. Fish and Fisheries: Part XXIII. Report of the Commissioner for 1897. Government Printing Office, Washington, pp. 1–340 (91–101).
This report includes information on the use of a salt treatment for brook trout fry.

Clark, F.N., 1898b. The lake trout—a manual of fish-culture based on the methods of the United States Commission of Fish and Fisheries. Prepared under the direction of John J. Brice. U. S. Comm. Fish and Fisheries: Part XXIII. Report of the Commissioner for 1897. Government Printing Office, Washington, pp. 1–340 (103–117).
This publication discusses the presence of fungi on eggs and blue-sac in fry of lake trout. It also reports that salt and swamp earth treatments were used on lake trout fry.

Clark, F.W., 1874. Reproduction of a fish's tail. Am. Nat. 8, 363–364.
Clark reports fungi (*Achlya prolifera*) on the tail of a goldfish held in an aquarium, followed by the regeneration of the tail tissues.

Clinton, G.P., 1894. Observations and experiments on *Saprolegnia* infesting fish. Bull. U. S. Fish Comm. for 1893, 13, 163–172.
This paper reports fungi on several fish species and the use of salt treatments to control the fungi.

Collins, J.W., 1884. XI. History of the tile-fish. U. S. Comm. Fish and Fisheries: Part X. Report of the Commissioner for 1882. Government Printing Office, Washington, pp. 237–294 (253–283).
This is a detailed report of a massive fish kill, mostly tile fish (*Lopholatilus chameleonticeps*), off the coast of Maryland, Delaware and New Jersey.

Conrad, J., DeCew, M., 1966. First report of *Ceratomyxa* in juvenile salmonids in Oregon. Prog. Fish-Cult. 28 (4), 238.
This is the first report of the salmonid sporozoan disease caused by *Ceratomyxa* in juvenile salmonids.

Cope, E.D., 1871. Remarks on the fauna of the Wyandotte Cave. Proc. Acad. Nat. Sci. Philadelphia 23, 297.
Cope's paper mentions the copepod (*Cauloxenus stygius*) found on a blind cave fish (*Amblyopsis spelaeus*).

Cope, E.D., 1872. On Wyandotte Cave and its fauna. Am. Nat. 6 (8), 406–444 (420).
This paper also discusses the copepod (*Cauloxenus stygius)* on cave fish.

Cushing, J.E., 1942. An effect of temperature upon antibody production in fish. J. Immunol. 45, 123–126.
This is probably the earliest report by a U.S. researcher on an aspect of fish immunology.

Dana, J.D., 1852. Synopsis of characters of the crustacea obtained during the cruise of the vessels of the United States Exploring Expedition. (in paper by Carolo Wilkes, entitled Conspectus crustaceorum in Orbis Terrarum circumnavigatione) Proc. Am. Acad. Arts Sci. 2, 9–61.
In this report Dana describes a salt water crustacean (*Caligus* spp.) on fish.

Dana, J.D., 1853. United States exploring expedition during the years 1838–1842 under the command of Charles Wilkes, U.S.N. Crustacea 13 (2), 686–1618 (1351) [taken from Hoffman, 1967 and Wilson, C.B. (1903). North American parasitic copepods of the family Argulidae, with a bibliography of the group and a systematic review of all known species. Proc. U. S. Natl. Mus. 25: 635–742].
This is a report of two crustacea (*Argulus pugettensis* and *Salmincola californiensis*) found on fish.

Dana, J.D., Herrick, E.C., 1836. 8. New species of *Argulus*. Am. J. Sci. Arts 30, 388–389.
This is a report of a crustacean (*Argulus catostomi*) on suckers.

Dana, J.D., Herrick, E.C., 1837. Description of *Argulus catostomi*, a new parasitic crustaceous animal. Am. J. Sci. Arts 31 (2), 297–308.
This is the second report by Dana and Herrick of the same Crustacean (*Argulus catostomi*) on suckers.

Davidson, S.G., Merwin Jr., J.G., Capper, J., Power, G., Shivers Jr., F.R., 1997. Chesapeake Waters: Four Centuries of Controversy, Concern, and Legislation. 2nd edn. Tidewater Publishers, Centreville, MD, 272 pp. (52, 233).
This is a document that provides information on large fish kills associated with whale processing in the Chesapeake River a little more than 300 years ago. The information was obtained from the Council Papers of Virginia in 1698.

Davis, H.S., 1916. The structure and development of a Myxosporidian parasite of the squeteague, *Cynoscion regalis*. J. Morphol. 27, 333–377.
This was Herbert S. Davis' first paper on an aspect of fish health.

Davis, H.S., 1922. A new bacterial disease of fresh-water fishes. Bull. U. S. Bureau Fish. for 1921–1922, 38, 261–280.
This informative paper, full of photographs, was the first description of Columnaris Disease.

Davis, H.S., 1947a. Care and diseases of trout. revised edition, 1946. Research report 12. United States Fish and Wildlife Service. United States Government Printing Office, Washington, DC, 98 pp.
The reference section in this booklet serves as a source for the publications of Herbert S. Davis, David Marine, David L. Belding, Emmeline Moore and George C. Embody.

Davis, H.S., 1947b. Studies of the protozoan parasites of fresh-water fishes. Fishery Bulletin 41. United States Fish and Wildlife Service, USDI. Washington, Government Printing Office, 29 pp.
The reference section in this booklet serves as a source for the publications of Herbert S. Davis.

Davis, H.S., 1953. Culture and Diseases of Game Fishes. University of California Press, Berkeley, CA, 332 pp.
This classic work by Davis was for years the standard text of fish culture and fish disease information. Its reference section also serves as a source for the publications of Herbert S. Davis, Louis E. Wolf and James S. Gutsell.

Davis, H.S., James, M.C., 1924. Some experiments on the addition of vitamins to trout feed. Trans. Am. Fish. Soc. 54, 77–91.
This early report details some nutritional factors that affect fish health.

DeKay, J.E., 1822. Art. VIII. Observation on the *Pennatule fleche* (*P. sagitta* of La Marck) in the cabinet of Dr. Mitchill. Am. J. Sci. Arts 4, 87–88.
DeKay reports a crustacean (*Pennatule fleche*, probably a *Caligus* sp.) that was parasitizing a porcupine fish (*Diodon pilosus*).

DeKay, J.E., 1844. Zoology of New York, or the New York Fauna: Part VI. Crustacea. Albany, NY, Carroll and Cook, pp. 46–50, 57–59.
This report mentions crustacea [*Argulus catostomi, A. alosae, Lernaea (Lernaeenicus) cruciata L. radiata* and *Lironeca (Cymothoa) ovalis*] as parasites of fish.

Dexter, E., 1870. A fish farm. Am. Nat. 3, 202–207 (206).
This includes a note about fungi on hatchery held Atlantic salmon eggs.

Dodge, C.W., 1895. Fish fungus at Caledonia. Trans. Am. Fish. Soc. 24, 109–112.
This paper reports fungi on trout and the treatment of fungi with electrozone.

Donham, C.R., Simms, B.T., Miller, F.W., 1926. So-called salmon poisoning in dogs (Progress Report). J. Am. Vet. Med. Assoc. 68, 701–715.
Simms, one of the authors of this paper, was a veterinarian. He may be the first veterinarian in the U.S. to have worked with fish health (digenetic trematode in salmon).

Dunning, P., 1884. Two hundred tons of dead fish, mostly perch, at Lake Mendota, WI. Bull. U. S. Fish Comm. for 1884, vol. 4, Government Printing Office, Washington, pp. 439–443.
This paper reports a large fish kill of many fish species, mainly the yellow perch in a Wisconsin Lake. Dead birds found around the shore indicate that a toxin may have been in the water. It also reports that other mortalities occurred including one in about 1844 where massive numbers of white fish died in same lake.

Edwards, 1873. III. Testimony in regard to the present condition of the fisheries, taken in 1871. U. S. Comm. Fish and Fisheries: Part I. Report of the Condition of the Sea Fisheries of the South Coast of New England in 1871 and 1872, pp. 7–72 (56–57).
This report gives some information on a wild fish kill of Tautog. The fish apparently succumbed to extremely cold waters.

Ellis, J.Esq., 1763. Of the sea pen or *Pennatula phosphorea* of Linnaeus; also a description of a new species of sea pen found on the coast of South Carolina, with observation on sea pens in general. Philos. Trans. 53, 419–428.
The sea pen described in this paper is a free living organism related to the corals and not a fish parasite.

Embody, G.C., Gorden, M., 1924. A comparative study of natural and artificial foods of brook trout. Trans. Am. Fish. Soc. 54, 185–200.
This paper reports that improperly balanced rations contribute to the loss of hatchery trout.

Embody, G.C., Hayford, C.O., 1925. The advantage of rearing brook trout fingerlings from selected breeders. Trans. Am. Fish. Soc. 55, 135–142.
This is probably the first U.S. paper concerning the selection of disease resistant broodstock. Brook trout were selected for resistance to furunculosis.

Embody, G.C., Laird, J., 1931. Controlling the trout gill worm. Trans. Am. Fish. Soc. 61, 189–192.
Embody reported the use of zonite (chlorine and salt solution) to control the gill fluke *Discocotyle salmonis*.

Encyclopaedia Britannica, 1983. The New Encyclopaedia Britannica, vols. 1–10, Micropaedia, Chicago.
This encyclopedia serves as a source for some biographical information on the following people: Alexander Agassiz (vol. 1, page 132); Edward D. Cope (vol. 3, page 132); James D. Dana (vol. 3, page 365); Augustus A. Gould (vol. 4, page 652); Ferdinand V. Hayden (vol. 4, page 965); Joseph P. Leidy (vol. 6, page 129); Thomas Say (vol. 8, page 937); and Addison E. Verrill (vol. 10, page 405).

Endlich, F.M., 1882a. An analysis of water destructive to fish in the Gulf of Mexico. Proc. U. S. Natl. Mus. for 1881, 4, 124.
This paper describes parameters of the water taken from the Gulf of Mexico following a fish mortality. Parasitic algae is mentioned as a possible cause for the fish kill.

Endlich, F.M., 1882b. An analysis of water destructive to fish in the Gulf of Mexico. Smithson. Misc. Coll., Washington 22, 124.
This paper also describes parameters of the water taken from the Gulf of Mexico following a fish mortality. Parasitic algae is mentioned as a possible cause for the fish kill.

Farlow, W.G., 1882. Report on the contents of two bottles of water from the Gulf of Mexico, forwarded by the Smithsonian Institution. Proc. U. S. Natl. Mus. for 1881, 4, 234.
This is a report of a water analysis from the Gulf of Mexico following a fish kill in 1881.

Farlow, W.G., 1887. Vegetable parasites of codfish. Bull. U. S. Fish Comm. for 1886, vol. 6, Government Printing Office, Washington, pp. 1–4.
This paper contains information on the bacterial contamination of stored fish, not a parasitic or disease condition of a live fish.

Ferguson, D.E., 1967a. Insecticide-resistant fishes: a potential hazard to consumers. J. Miss. Acad. Sci. 13, 138–140.
This paper contains some biographical information on Danzel E. Ferguson and lists some of Ferguson's publications in the literature cited.

Ferguson, D.E., 1967b. The ecological consequences of pesticide resistance in fishes. Proceedings of the Thirty-second North American Wildlife and Natural Resources Conference, March 13–15, 1967. Wildlife Management Institute, Washington, DC, pp. 103–107.
The literature cited in this publication serves as a source for the publications of Danzel E. Ferguson.

Ferguson, D.E., 1968. Characteristics and significance of resistance to insecticides in fishes. Reservoir Fishery Resources Symposium, Athens, GA, April 5–7, pp. 531–536.
The literature cited in this publication serves as a source for the publications of Danzel E. Ferguson.

Ferguson, D.E., Goodyear, C.E., 1967. The pathway of endrin entry in black bullheads, *Ictalurus melas*. Copeia 2, 467–468.
The literature cited in this publication serves as a source for the publications of Danzel E. Ferguson.

Ferguson, D.E., Ludke, J.L., Murphy, G.G., 1966. Dynamics of endrin uptake and release by resistant and susceptible strains of mosquito fish. Trans. Am. Fish. Soc. 95 (4), 335–346.
The literature cited in this publication serves as a source for the publications of Danzel E. Ferguson.

Fischthal, J.H., 1949. The over-wintering of black grubs and yellow grubs in fish. J. Parasitol. 35 (2), 191–192.
This paper contains some biographical information on Jacob H. Fischthal and the literature cited serves as a source for some of his publications.

Fish, F.F., 1935. The Bureau of Fisheries' disease service. Prog. Fish-Cult. 8, 9–12.
This paper reports that an early fish diagnostic service was available to fish producers.

Fish, F.F., 1940. Formalin for external protozoan parasites. Prog. Fish-Cult. 48, 1–10.
Frederic Fish reports some of the fish treatments he tested including formalin, copper sulfate, salt, and boric acid.

Fish and Fisheries Worldwide, 1999. CD Rom Disc, 1971–January 1999. National Information Services, Baltimore, MD.
This database serves as a reference source for publications of several fish health specialists.

Forbes, S.A., 1890. Preliminary report upon the invertebrate animals inhabiting Lakes Geneva and Mendota, WI, with an account of the fish epidemic in Lake Mendota in 1884. Bull. U. S. Fish Comm. for 1888, vol. 8, Government Printing Office, Washington, pp. 473–487.
This paper reports a large fish kill mostly of yellow perch in Lake Mendota, WI. Forbes analyzed the fish using histological techniques and bacteriological staining. This was probably the first use of these techniques on diseased fish in the U.S.

Forbes, S.A., 1894. The aquarium of the United States Fish Commission at the World's Columbian Exposition. Report of the Director. Bull. U. S. Fish Comm. for 1893, vol. 13, Government Printing Office, Washington, pp. 143–158.

Forbes reported finding fungi on several species of fish held in aquaria. He treated the fungal infestations with salt and carbolic acid. He also used carbolic acid as a disinfectant. He found *Ichthyophthirius*, a protozoan parasite, on channel catfish and found that salt was not a very effective treatment against Ich.

Fore, P.L., 1966. Cumulative subject and author index to The Progressive Fish Culturist. Nos. 1–56 (1934 to 1955). Resource publication 24. USDI. Washington, DC, 21 pp.
This publication serves as a reference source for publications of Louis E. Wolf.

Fox, A.C., Smith, S.D., 1986. Laboratory series 40: National Fishery Research Center. Fisheries 11 (2), 43–45.
This publication gives some historical information on the Western Fish Disease Laboratory and some biographical information on Robert R. Rucker.

Gage, S.H., 1893. The lake and brook lampreys of New York, especially those of Cayuga and Seneca Lakes. Wilder Quarter-Century Book, Ithaca, NY, pp. 421–493.
Gage was one of the first in the U.S. to recognize that lamprey were a problem to other fish species and that there was a need for their control.

Gardener, A.P., 1883. Experiments in the pond culture of trout, suckers, and catfish. Bull. U. S. Fish Comm. for 1883, vol. 3, Government Printing Office, Washington, pp. 417–420 (418).
Gardener mentions a trout mortality that occurred in a pond.

Garlick, T., 1858. A treatise on the artificial propagation of fish with the description and habits of such kinds as are the most suitable for pisciculture. In: Moore, A.O. (Ed.), Agricultural Book Publisher, New York, 142 pp.
This treatise contains a mention of fungi (byssus) on salmonid eggs in a hatchery and that attacked eggs should be thrown away.

Gaylord, H.R., Marsh, M.C., Busch, F.C., Simpson, B.T., 1914. Carcinoma of the thyroid in the salmonoid fishes. Bull. U. S. Bur. Fish. for 1912, 32, 367–525.
This paper gives a pathological evaluation of thyroid tumors in trout, including a comprehensive histological examination of the tumors. The references in this paper serve as a source for the publications of Harvey R. Gaylord, David Marine and Millard C. Marsh.

Gerard, W.R., 1879. The *Saprolegnia ferax* (an account of an epidemic among fish of the Passaic River, NJ). Proc. Poughk Soc. Nat. Sci. 25 [taken from McGregor, 1923].
According to McGregor Gerard gives an account of a fungi on diseased fish from the Passaic River, NJ.

Gillispie, C.C. (Ed.), 1971. Dictionary of Scientific Biography, vol. 3, Charles Scribner's Sons, New York, pp. 549–554.
This dictionary provided biographical information on James D. Dana.

Gillispie, C.C. (Ed.), 1973. Dictionary of Scientific Biography, vol. 7, Charles Scribner's Sons, New York, pp. 169–170.
This dictionary provided biographical information on David S. Jordan.

Gillispie, C.C. (Ed.), 1974. Dictionary of Scientific Biography, vol. 10, Charles Scribner's Sons, New York, pp. 272–274.
This dictionary provided biographical information on Alpheus S. Packard.

Gillispie, C.C. (Ed.), 1975. Dictionary of Scientific Biography, vol. 12, Charles Scribner's Sons, New York, pp. 479–480.
This dictionary provided biographical information on Sidney I. Smith.

Gillispie, C.C. (Ed.), 1976. Dictionary of Scientific Biography, vol. 13, Charles Scribner's Sons, New York, pp. 63–64, 456.
This dictionary provided biographical information on Charles W. Stiles and William Trelease.

Gillispie, C.C. (Ed.), 1977. Dictionary of Scientific Biography, vol. 14, Charles Scribner's Sons, New York, pp. 1–2.
This dictionary provided biographical information on Addison E. Verrill.

Girard, C., 1851. On a new generic type in the class of worms. Proc. Am. Assoc. Adv. Sci. for 1850, 4, 124–125.
This publication is a report of a salt water leech found on a skate.

Gissler, C.F., 1883. A new parasitic copepod crustacean. Am. Nat. 17 (2), 885–887.
This paper discusses a crustacean (*Caligus*) found on Pacific Salmon.

Glazier, W.C.W., 1882a. Assistant surgeon, M.H.S. On the destruction of fish by polluted water in the Gulf of Mexico. Proc. U. S. Natl. Mus. for 1881, 4, 126–127.
Glazier reported fish kills associated with discolored waters in Gulf of Mexico in 1865, 1878, and 1881.

Glazier, W.C.W., 1882b. On the destruction of fish by polluted water in the Gulf of Mexico. Smithson. Misc. Coll., Washington 22, 126–127.
Glazier also reported fish kills associated with discolored waters in Gulf of Mexico in 1865, 1878, and 1881.

Glennan, A.H., 1887. Fish killed by poisonous water. Bull. U. S. Fish Comm. for 1886 6, 10–11.
This paper reports a large mortality (1885) of several fish species in the Gulf of Mexico (Florida) that is probably due to the red tide (reddish waters were observed).

Goode, G.B., 1879. The natural and economic history of the American menhaden. U. S. Comm. Fish and Fisheries: Part V. Report for the year 1876–77. Government Printing Office, Washington, pp. 1–529 (101–104).
This publication reports a mortality of menhaden in Merrimac River in 1876 and reports another kill 40 years earlier (about 1836). Leeches and a crustacean (*Lerneonema radiata*) are also reported from menhaden.

Goode, G.B., 1883. Materials for a history of the sword-fish. U. S. Comm. Fish and Fisheries: Part VIII. Report for the year 1880. Government Printing Office, Washington, pp. 289–387 (342–346).
Goode mentions that leeches and crustacea are parasites of swordfish. Within this publication F.W. True gives an account of seven cestodes, nematodes, and trematodes, and five crustacea found in the swordfish.

Goode, G.B., 1884. The fisheries and fishing industries of the United States: Section I. Natural history of useful aquatic animals. U. S. Comm. Fish and Fisheries. Government Printing Office, Washington, 895 pp. [taken from Smith, 1995].
The paper states that lampreys were considered semi-parasitic by some and suspected as being destructive of food fish that enter estuaries and rivers.

Gorham, F.P., 1898. Some physiological effects of reduced pressure on fish. J. Boston Soc. Med. Sci. 3, 250.
This is the first report of gas-bubble disease in fish. Possible causes, including the effects of reduced pressure on the fish and the possibility of a bacterial infection were studied.

Gorham, F.P., 1901. The gas-bubble disease of fish and its cause. Bull. U. S. Fish Comm. for 1899, 19, 33–37.
This publication is of an early report of gas-bubble disease in several fish species.

Gould, A.A., 1841. Report on the invertebrata of Massachusetts comprising the mollusca, crustacea, annelida, and radiata. Folsom, Wells and Thurston, Cambridge, 373 pp (338, 340–341, 343).
Gould apparently made the first record of fish leech (*Phylline hippoglossi*) in the U.S. He also reports crustacea (*Argulus alosae*, *Caligus* spp., *Anthosoma*, and an isopod species) from several species of fish.

Green, L.W., 1885. On a disease affecting the rainbow trout at McCloud River Station. Bull. U. S. Fish Comm. for 1885, 5, 472.
This paper contains a discussion by L.W. Green on mortalities of rainbow trout in the wild and among propagated fish.

Green, L.W., 1887. Salmon in the McCloud River during the season of 1886. Bull. U. S. Fish Comm. for 1886, 6, 334–336.
Green made mention in this paper of salmon with a fungus infection.

Green, S., 1878. Methods of fish culture. Trans. Am. Fish Cult. Assoc. 7, 14.
This paper has a comment on treating sick fish with salt.

Griffin, P.J., 1953. The nature of bacteria pathogenic to fish. Trans. Am. Fish. Soc. 83, 241–253.
This paper characterizes bacteria that cause some trout diseases. The literature cited in this paper is used as reference source for some of the publications of Philip J. Griffin.

Guido, L., Little, C.L., 1959. The Association of Research Libraries; A catalog of books represented by the Library of the Congress printed cards. Issued July 1942, vol. 88, Pageant Books, New York, pp. 491–493.
This references in this publication serve as a source for the papers of Edwin Linton.

Gurley, R.R., 1893. On the classification of Myxosporidia, a group of protozoan parasites infesting fishes. Bull. U. S. Fish Comm. for 1891, 11, 407–420.
This paper is an early report of sporozoa in fish by a U.S. author.

Gurley, R.R., 1894. The Myxosporidia, or psorosperms of fishes, and the epidemics produced by them. U. S.

Comm. Fish and Fisheries: Part XVIII. Report of the Commissioner for 1892. Government Printing Office, Washington, pp. 65–304.
This is an extensive publication on the sporozoan parasites of fish.

Gutsell, J.S., 1946. Sulfa drugs and the treatment of furunculosis in trout. Science 104, 85–86.
This is apparently the first publication on the use of antibiotics against bacteria in fish in the U.S.

Gutsell, J.S., Snieszko, S.F., 1947. Response of brook, rainbow and brown trout to various dosages of sulfamerazine. Trans. Am. Fish. Soc. 77, 93–101.
This publication provides information on the early use of antibiotics on fish and serves as a reference source for some biographic information and the publications by James S. Gutsell.

Harger, O., 1879. Notes on New England isopoda. Proc. U. S. Natl. Mus. 2, 157–163 (161–162).
Harger reports on crustacea (Livoneca, Nerocila, and Aega) from several marine fish species.

Harger, O., 1880. XIV. Report on the marine isopoda of New England and adjacent waters. U. S. Comm. Fish and Fisheries for 1878: Part VI. Report of the Commissioner for 1878. Government Printing Office, Washington, pp. 297–462 (392–396).
This report describes five species of crustacea (isopods), including the genera *Cirolana*, *Aega*, *Aegathoa*, *Livoneca* and *Nerocila*, that parasitize marine fish.

Hargis, W.J., 1985. Quantitative effects of marine diseases on fish and shellfish populations. Transactions of the North American Wildlife and Natural Resource Conference, Number 50, pp. 608–640.
This paper gives biographical information on William J. Hargis and the literature cited serves as a source for the publications of Hargis and Omar V. Amin.

Harkness, Moore, 1880. Pacific Coast Fungi, p. 32 [taken from Clinton, 1894].
This paper gives information on a fungus infecting salmon.

Harris, T.W., 1839. New species of Argulus. Am. J. Sci. Arts I, 36, 393.
This research note reports a crustacea (*Argulus*) found in the gills of herring.

Harshbarger, J.C., Clark, J.B., 1990. Epizootiology of neoplasms in bony fish of North America. Sci. Total Environ. 94, 1–3.
These researchers report finding brown bullhead melanomas identical to and in the same location as Henry D. Thoreau's 1850s descriptions.

Hayden, F.V., 1872. V. The Grand Canon-Falls-Hot Springs-Yellowstone Lake. Preliminary Report on U.S. Geological Survey of Montana and Portions of Adjacent Territories; being a Fifth Annual Report of Progress. Government Printing Office, Washington, pp. 81–101 (97–98).
This survey reports the presence of the tapeworm (*Dibothrium cordiceps*) in trout from Yellowstone Lake.

Hedgpeth, J.W., 1941. Founders of fish culture. Prog. Fish-Cult. 55, 11–14.
This report contains biographical information on Livingston Stone.

Herman, R.L., Degurse, P.E., 1967. Sulfamerazine residues in trout tissues. Ichthyologica 39, 73–79.
This is a report of Roger L. Herman's early work on testing fishery chemicals.

Hess, W.N., 1935. Reduction of islets of Langerhans in the pancreas of fish by means of diet, overeating and lack of exercise. J. Exp. Zool. 70 (2), 187–195.
Hess reports a histopathological evaluation of fish with nutritional problems.

Higgins, E., 1935. Important announcement—hatchery disease service established. Prog. Fish-Cult. 8, 8.
Information on the establishment of a diagnostic service for sick fish.

Hine, L., 1878. Spore-formation of Mesocarpeae. Am. Q. Microsc. J. 1, 20.
This is a report of fungi on perch and sunfish held in an aquarium.

Hoffman, G.L., 1960. Synopsis of strigeoidea (trematoda) of fishes and their life cycles. Fishery Bulletin, vol. 175, United States Fish and Wildlife Service, Government Printing Office, Washington, DC, pp. 439–469.
The references cited in this synopsis serves as a source for the publications of R. Chester Hughes.

Hoffman, G.L., 1967. Parasites of North American freshwater fishes. Bibliography (pp. 407–468). University of California Press, Berkeley, CA, 486 pp.
This book by Hoffman is the major fish parasitology text used by researchers and students in North America. The bibliography in this book serves as a source for the publications, including books, of a number of researchers working with fish parasites.

Hoffman, G.L., 1976. Whirling disease of trout; Fish Disease Leaflet, U.S. Fish and Wildlife Service, 10 pp.
This leaflet on Whirling Disease gives general information on the disease including detection methods for the causative agent.

Hoffman, G.L., Meyer, F.P., 1974. Parasites of Freshwater Fishes. T.F.H. Publications, Neptune City, NJ, 224 pp.
This book, a key publication by Glenn Hoffman and Fred Meyer, is known for its colorful pictures of parasites and information on parasite treatments.

Hopkins, S.H., 1956. Two new trematodes from Louisiana, and the excretory system of Bucephalidae. Trans. Am. Microsc. Soc. LXXV (1), 129–135.
This papers offers some biographical data on Sewell H. Hopkins and provides a source for some of his publications.

Hunn, J.B., 1964. Some patho-physiological effects of bacterial kidney disease in brook trout. Proc. Soc. Exp. Biol. Med. 117, 383–385.
The literature cited in this paper serves as a reference source for publications of Joseph B. Hunn. The paper also gives some biographical information on Hunn.

Hunn, J.B., 1982. Urine flow rates in freshwater salmonids: a review. Prog. Fish-Cult. 44 (3), 119–124.
The literature cited in this paper serves as a source for the publications of Joseph B. Hunn.

Hunter, G.W., 1942. Studies on the parasites of fresh-water fishes of Connecticut. A Fishery Survey of Important Connecticut Lakes, State Geological and Natural History Survey. Bulletin No. 63, pp. 228–288.
The literature cited in this paper serves as a source for the publications of George W. Hunter III and Justus F. Mueller.

Hunter, G.W., Dalton, H.C., 1939. Studies on Clinostomum: V. The cyst of the yellow grub of fish (*Clinostomum marginatum*). Proc. Helminthol. Soc. Wash. 6 (2), 73–76.
The literature cited in this paper serves as a source for the publications of George W. Hunter III.

Hunter, G.W., Rankin, J.S., 1939. Parasites of northern pike and pickerel. Trans. Am. Fish. Soc. 69, 268–272.
The literature cited in this paper serves as a source for a publication of Justus F. Mueller.

Ingersoll, E., 1882a. On the fish mortality in the Gulf of Mexico. Proc. U. S. Natl. Mus. for 1881, 4, 74–80.
Ingersoll reported fish kills in the Gulf of Mexico, off the coast of Florida, in 1844, 1854, 1878, 1879 and 1880. He reported that the greatest fish kill episode occurred in 1878.

Ingersoll, E., 1882b. On the fish mortality in the Gulf of Mexico. Smithson. Misc. Coll., Washington for 1881, 22, 74–80.
This paper describes a fish mortality in the Gulf of Mexico and is identical to the Ingersoll (1882a) reference.

Jefferson, J.P., 1879. On the mortality of fishes in the Gulf of Mexico in 1878. Proc. U. S. Natl. Mus. for 1878, 1, 363–364.
This is a report of a large mortality of fishes in the Gulf of Mexico in 1878. The cause was given as heavy rainfalls.

Jefferson, J.P., Porter, J.Y., Moore, T., 1879. On the destruction of fish in the vicinity of the Tortugas during the months of September and October, 1878. Proc. U. S. Natl. Mus. for 1878, 1, 245–344.
This publication gives information on fish mortalities from the Gulf of Mexico in 1856 or 1857 and 1878. Poisoned discolored water streaks were reported in the Gulf.

Johnson, S.H., 1882. Notes on the mortality among fishes of the Gulf of Mexico. Proc. U. S. Natl. Mus. for 1881, 4, 205.
Johnson reported on an 1880 Gulf of Mexico fish kill that he thought resulted from salt water fish being trapped in fresh water flowing from inland streams.

Jones, R.O., 1950. Propagation of fresh-water mussels. Prog. Fish-Cult. 12 (1), 13–26.
The literature cited in this paper serves as a source for A.D. Howard's publications.

Jones, W.A., 1873. Report on Northwestern Wyoming (Yellowstone National Park), p. 22. [taken from McGregor, 1923].
This is a report of tapeworms in trout from the Yellowstone National Park.

Jordan, D.S., Gilbert, C.H., 1881. Observations on the salmon of the Pacific. Am. Nat. 15, 177–186 (180).
This publication reported fungi on body and parasitic worms on gills of wild spawning Pacific salmon.

Kabata, Z., 1971. In: Snieszko, S.F., Axelrod, H.R. (Eds.), Crustacea as Enemies of Fishes: Diseases of Fishes (Book 1). T.F.H. Publications, Neptune City, NJ, 171 pp.
This book on the crustacea of fish is one of a series of six that was co-edited by Stanislas F. Snieszko.

Kabata, Z., 1979. Parasitic Copepods of British Fishes. The Ray Society, London, 468 pp.

This book on European copepods provides a more recent name (*Lernaeenicus radiatus*) for a crustacean that LeSueur described (*Lerneocera radiata*), which in turn is an updated name for Benjamin Latrobe's parasitic crustacean (*Oniscus praegustator*) described in 1797.

Kellicott, D.S., 1877. Description of a new species of Argulus. Bull. Buffalo Soc. Nat. Sci. 3, 214–216.
This paper describes a crustacean (*Argulus lepidostei*) found on a gar (*Lepidosteus osseus*).

Kellicott, D.S., 1878. Description of a new species of Argulus. Am. J. Microsc. Pop. Sci. 3 (1), 1–3.
This paper also describes a crustacean found on a gar.

Kellicott, D.S., 1879a. *Argulus lepidostei*. Am. J. Microsc. Pop. Sci. 4, 153–155.
This paper also describes a crustacean found on a gar.

Kellicott, D.S., 1879b. On certain Crustacea, parasitic on fish from the Great Lakes. Am. J. Microsc. Pop. Sci. 4 (10/12), 208–210.
Kellicott describes a crustacean called *Lernaea* on rock bass and an herring.

Kellicott, D.S., 1880a. *Argulus stizostethii*, n.s. Am. J. Microsc. Pop. Sci. 5 (3), 53–58.
In this publication a parasitic crustacean (*Argulus stizostethii*) is described from blue pike.

Kellicott, D.S., 1880b. On certain crustacea parasitic on fishes from the Great Lakes. Proc. Am. Soc. Microscopists 1, 53–57.
This paper reports a crustacean (*Achtheres*) that is found on rock bass and that possibly the same genera of crustacean is found on a whitefish *Coregonus artedi*.

Kellicott, D.S., 1880c. Observations on *Lernaeocera cruciata*. Proc. Am. Soc. Microscopists 1, 64–68.
This paper reports the observation of the parasitic crustacean (*Lernaea cruciata*) on rock bass.

Kellicott, D.S., 1880d. A larval *Argulus*. North Am. Entomol. 1, 57–60.
This paper reports on a larval crustacean (*Argulus*) parasite of fish.

Kellicott, D.S., 1881. *Lernaeocera tortua* n. sp. Proc. Am. Soc. Microscopists 2, 41–43.
This publication gives information on *Lernaeocera tortua*, a parasitic crustacean of fish.

Kellicott, D.S., 1882. On certain crustacea parasites of freshwater fishes. Proc. Am. Soc. Microscopists 4, 75–78.
This publication contains information on three parasitic crustacea of fish; *Achtheres corpulentus* on white fish, *Achtheres ambloplitis* on rock bass, and *Lerneocera pectoralis* on red-finned shiner.

Kellicott, D.S., 1886. A note on *Argulus catostomi*. Proc. Am. Soc. Microscopists 7, 144.
Kellicott makes a note on a fish parasitic crustacean called *Lernaeocera tortua*.

Kneeland, S., 1858. On the parasites of a sunfish. Proc. Boston Soc. Nat. Hist. 6, 396 [taken from McGregor, 1923 and Wilson, 1917].
Kneeland reports a crustacean parasite (*Lernaea* sp.) found on sunfish.

Knowles, H.M., 1887. Dead fish on the coast of Rhode Island. Bull. U. S. Fish Comm. for 1886, vol. 6, Government Printing Office, Washington, pp. 194–195.
This is a report of a wild fish kill of a small herring-like fish at Point Judith, RI.

Krantz, G.E., Reddecliff, J.M., Heist, C.E., 1964. Immune response of trout to *Aeromonas salmonicida*: Part 1. Development of agglutinating antibodies and protective immunity. Prog. Fish-Cult. 26, 3–10.
This is apparently the first U.S. report of protection in fish against a bacteria by using an injection of a killed bacterial antigen.

Kudo, R.R., 1954. Protozoology. 4th edn. Charles B. Thomas, Springfield, IL, 966 pp.
This text book was for years the key text on protozoa. The reference section serves as a source for other publications by Richard R. Kudo.

Lankford, J., 1967. Captain John Smith's America. Harper Torchbooks, Harper & Row, New York, 195 pp. (64).
Included in this text is "The General History of Virginia, New England and the Summer Isles" (1607 to 1609) by Captain John Smith in which he describes what appears to be the first fish kill record on the American continent. He reported that there were numbers of small fish with their heads out of the water, swimming near the surface, and some dead on the shores.

Latrobe, B.H., 1802. A drawing and description of the *Clupea tyrannus* and *Oniscus praegustator*. Trans. Am. Philos. Soc. held at Philadelphia for Promoting Useful Knowledge 5, 77–81.
This paper is probably the first record of a fish parasite in the U.S. Latrobe found a crustacean, *Oniscus praegustator*, in the mouth of menhaden.

Lea, I., 1860. Art. III. Descriptions of the embryonic forms of 38 species of Unionidae. J. Acad. Nat. Sci. Phila. (Second Series) 4, 43–50.
Lea described parasitic mollusks (glochidia) in clam gills, but not in fish gills.

Lefevre, G., Curtis, W.C., 1912. Studies on the reproduction and artificial propagation of fresh-water mussels. Bull. Bureau Fish., vol. 30, Government Printing Office, Washington, pp. 105–197.
The literature cited in this paper serves as a source for other publications of George Lefevre.

Leidy, J.P., 1852a. Descriptions of new species of Entozoa. Proc. Acad. Nat. Sci. Philadelphia for 1850–1851, 5 (7), 155–156.
Leidy described a nematode in winter flounder that is probably the first record of nematodes in fish in the U.S.

Leidy, J.P., 1852b. Contributions to helminthology. Proc. Acad. Nat. Sci. Philadelphia for 1850–1851, 5, 205–210.
This contribution describes trematodes in pike (*Esox*) species and an acanthocephalan (*Echinorhynchus*) in brook trout. It is apparently the first record of acanthocephala and digenetic trematodes in fish in the U.S.

Leidy, J.P., 1854a. On nodular bodies in the tails and fins of fishes, a parasitic worm of the genus *Distoma*. Proc. Acad. Nat. Sci. Philadelphia for 1852–1853, 6, 241.
This paper reports that trematodes were found in tails and fins of fishes.

Leidy, J.P., 1854b. Some observations on *Nematoidea imperfecta* and descriptions of three parasitic infusoriae. Trans. Am. Philos. Soc. for 1852–1853, 10, 241–244.
Leidy observed parasitic protozoa of frogs well before they were first recorded in fish in the U.S.

Leidy, J.P., 1856. Contributions toward the knowledge of the marine invertebrate fauna of the coasts of Rhode Island and New Jersey. J. Acad. Nat. Sci. Phila. for 1854–1855, 3, 135–152.
This publication reports a crustacean (*Caligus*) found on shark fins off the Atlantic coast of New Jersey.

Leidy, J.P., 1857. A synopsis of entozoa and some of their ecto-congeners, observed by the author. Proc. Acad. Nat. Sci. Philadelphia for 1856, 8, 42–58.
This paper reports observations of trematodes, nematodes and acanthocephalans that parasitize fishes.

Leidy, J.P., 1859a. Remarks on disease of the scales of minnows and on fungus on goldfish. Proc. Acad. Nat. Sci. Philadelphia for 1858, 10, 12–13.
Leidy reported the presence of carcinomatous cells on the scales of wild fish. He also made the first observation that stress (weakness) predisposes fish (goldfish) to a disease (fungi). Additionally, this is one of the earliest mentions of fungi on fish in the U.S.

Leidy, J.P., 1859b. Contributions to helminthology. Proc. Acad. Nat. Sci. Philadelphia for 1859, 10 (2), 110–112.
This contribution gives information on trematodes, nematodes, cestodes, and acanthocephalans that are found in fishes. It is apparently the first record of cestodes in fish in the U.S.

Leidy, J.P., 1871. Notice of some worms (*Dibothrium cordiceps*, *Hirudo*, *Gordius*). Proc. Acad. Nat. Sci. Philadelphia for 1871, 23, 305–307.
This is a description of a cestode (*Dibothrium cordiceps*) in brook trout.

Leidy, J.P., 1872. Notice of some parasitic worms collected during Professor Hayden's expedition to the Yellowstone River in the summer of 1871. Fifth Annual Preliminary Report U.S. Geological Survey Montana and Portions of Adjacent Territories. Washington, pp. 381–382. [taken from Osborn, 1913].
This note discusses a cestode (*Dibothrium cordiceps*) found in salmonids.

Leidy, J.P., 1875. On psorosperms in a mallard duck. Proc. Acad. Nat. Sci. Philadelphia for 1875, 30, 171.
Leidy found sporozoans in a duck and thought that they probably came from a fish.

Leidy, J.P., 1879. On the parasitic worms in shad (*Filaria capsularia*). Proc. Acad. Nat. Sci. Philadelphia for 1878, 30, 171.
This is a report of a nematode from shad.

Leidy, J.P., 1883. Filaria of the black bass. Proc. Acad. Nat. Sci. Philadelphia for 1882, 34, 69.
This is a report of a nematode in black bass.

Leidy, J.P., 1886a. Bothriocephalus in trout. Proc. Acad. Nat. Sci. Philadelphia for 1885, 37, 122–123.
This paper describes a cestode (*Bothriocephalus cestus*) from trout.

Leidy, J.P., 1886b. On Amia and its probable taenia. Proc. Acad. Nat. Sci. Philadelphia for 1886, 38, 62–63.
This publication is a discussion on a cestode found in bowfin (*Amia calva*).

Leidy, J.P., 1886c. Notices of nematoid worms. Proc. Acad. Nat. Sci. Philadelphia for 1886, 38, 308–313.
This paper discusses a nematode (*Filaria stigmatura*) found in lake trout.

Leidy, J.P., 1888a. Notice on some parasitic worms. Proc. Acad. Nat. Sci. Philadelphia for 1887, 39, 20–24.
This observation contains information on trematodes, cestodes, acanthocephalans and leeches that were found in fishes.

Leidy, J.P., 1888b. Parasites of the shad and herring. J. Comp. Med. Surg. 9 (3), 211–215.
This paper describes nematodes and a cestode found in the American shad and common herring.

Leidy, J.P., 1889a. Parasites of the striped bass. Proc. Acad. Nat. Sci. Philadelphia for 1888, 40, 125.
This note describes two parasites found in striped bass, a crustacean (*Ergasilus labricis*) and an acanthocephalan (*Echinorhynchus proteus*).

Leidy, J.P., 1889b. A crustacean parasite of the red snapper. Proc. Acad. Nat. Sci. Philadelphia for 1888, 40, 138–139.
Leidy describes a crustacean (*Anchorella*) from the red snapper.

Leidy, J.P., 1889c. Parasitic crustacea. Proc. Acad. Nat. Sci. Philadelphia for 1888, 40, 165.
This is a note on a crustacean (*Lerneonema*) found in shark. Leidy also mentions that Alexander Agassiz described a crustacean from a fish.

Leidy, J.P., 1889d. Parasites of the rock fish. Proc. Acad. Nat. Sci. Philadelphia for 1888, 40, 166–167.
This is a report of trematodes, nematodes, acanthocephalans and crustaceans that parasitize striped bass.

Leidy, J.P., 1889e. Parasites of the pickerel. Proc. Acad. Nat. Sci. Philadelphia for 1888, 40, 169.
Leidy reports the finding of a cestode from the pickerel (*Esox reticulatus*).

Leidy, J.P., 1890. A parasitic copepod (*Chalimus tenuis*). Proc. Acad. Nat. Sci. Philadelphia for 1889, 41, 95.
This discussion describes a crustacean (*Chalimus tenuis*) from the surface of a transparent fish (*Leptocephalus* sp.).

Leidy, J.P., 1891. Parasites of *Mola rotunda*. Proc. Acad. Nat. Sci. Philadelphia for 1890, 42, 281–282.
Leidy reports the presence of trematodes, cestodes and crustaceans from the ocean sunfish.

Leidy, J.P., 1904. Researches in helminthology and parasitology. (arranged and edited by J. Leidy, Jr.) Smithson. Misc. Coll., Washington 46 (3), 1–281 [taken from McGregor, 1963].
This is a posthumous paper by Joseph Leidy and in it he reports on mollusks that infect fish.

Leslie, C.C., 1883. Scarcity of blackfish—Mortality of codfish. Bull. U. S. Fish Comm. for 1882, vol. 2, Government Printing Office, Washington, p. 132.
In this paper, Leslie reports that codfish were floating belly up and struggling off shore between Hatteras and Cape Henry.

LeSueur, C.A., 1818. Description of several species of chondropterigious fishes, of North America, with their varieties. Trans. Am. Philos. Soc. held at Philadelphia for Promoting Useful Knowledge (New Series), 1, 383–386.
This is an early description of a lamprey (Petromyzon) in the U.S. that was later found to be parasitic.

LeSueur, C.A., 1824. On three new species of parasitic vermes, belonging to the Linnaean genus *Lernaea*. J. Acad. Nat. Sci. Phila. 3 (2), 286–292.
LeSueur described a crustacean (*Lernaea*) found on rock bass and two other similar parasites with one described from menhaden. He renamed Benjamin Latrobe's crustacean (*Oniscus praegustator*), found in 1797, as *Lerneocera radiata*.

Lewis, W.M., Lewis, S.D., 1963. Control of Epizootics of *Gyrodactylus elegans* in golden shiner populations. Trans. Am. Fish. Soc. 92 (1), 60–62.
This is a source of information for a fish pathology lab that was set up at Southern Illinois University, Carbondale, IL.

Lillie, F.R., 1895. The embryology of the Unionidae. A study in cell-lineage. J. Morphol. 10 (1), 1–100.
This is probably the first report of Glochidia in the gills of fish.

Linnaeus, C., 1746. Fauna Suecica Sistens Animalia Sueciae Regni: Quadrupedia, Aves, Amphibia, Pisces, Insecta, Vermes, Distributa per Classes et Ordines, Genera et Species. Stockholmiae, 411 pp. [taken from Hoffman, 1967].
Linnaeus did a detailed descriptive work on fish parasites in Europe about 50 years before the Latrobe's parasite description in 1797.

Linton, E., 1887. Notes on two forms of cestoid embryos. Am. Nat. 21, 195–201.
This is a record of cestodes (*Rhynchobothrium*) in bluefish.

Linton, E., 1889a. IV. Notes on entozoa of marine fishes of New England, with descriptions of several new species. U. S. Comm. Fish and Fisheries: Part XIV. Report of the Commissioner for 1886. Government Printing Office, Washington, pp. 453–512.
This publication gives a detailed description of cestodes and acanthocephalans found in fishes.

Linton, E., 1889b. Notes on Cestoid entozoa of marine fishes. Am. J. Sci. Third Series 37, 239–240.
This note concerns cestodes that parasitize fish.

Linton, E., 1891a. Notes on entozoa of marine fishes of New England, with descriptions of several new species (Part II). U. S. Comm. Fish and Fisheries: Part XV. Report of the Commissioner for 1887. Government Printing Office, Washington, pp. 719–899.
In this lengthy 181 page publication, Linton reports on several cestodes found in marine fishes.

Linton, E., 1891b. On two species of larval *Dibothria* from the Yellowstone National Park. Bull. U. S. Fish Comm. for 1889, 9, 65–76.
This paper reports on two cestodes found in trout (*Salmo mykiss*) in the Yellowstone National Park.

Linton, E., 1891c. On certain wart-like excrescences, occurring on the short minnow, *Cyprinodon variegatus* due to psorosperms. Bull. U. S. Fish Comm. for 1889, 9, 99–102.
Linton was the first to report sporozoa in fish in the United States. These sporozoa were found in the short minnow (*Cyprinodon variegatus*).

Linton, E., 1891d. A contribution to the life history of *Dibothrium cordiceps* Leidy, a parasite infesting the trout of Yellowstone Lake. Bull. U. S. Fish Comm. for 1889, 9, 337–358.
This contribution reports the cestode (*Dibothrium cordiceps*) from trout (*Salmo mykiss*).

Linton, E., 1891e. Notice of the occurrence of protozoan parasites (Psorosperms) on cyprinoid fishes of Ohio. Bull. U. S. Fish Comm. for 1889, 9, 359–361.
This is a paper on sporozoa in the minnow (*Notropis megalops*).

Linton, E., 1892a. Notes on the entozoa of marine fishes, with descriptions of new species (Part III). U. S. Comm. Fish and Fisheries: Part XVI. Report of the Commissioner for 1888. Government Printing Office, Washington, pp. 523–542.
Descriptions of acanthocephala from fishes are reported in this paper.

Linton, E., 1892b. On the anatomy of *Thysanocephalum crispum*, Linton, a parasite of the tiger shark. U. S. Comm. Fish and Fisheries: Part XVI. Report of the Commissioner for 1888. Government Printing Office, Washington, pp. 543–555.
This is a report of a cestode (*Thysanocephalum crispum*) in the tiger shark.

Linton, E., 1893. On fish entozoa from Yellowstone National Park. U. S. Comm. Fish and Fisheries: Part XVII. Report of the Commissioner for 1889 to 1891. Government Printing Office, Washington, pp. 545–564.
Linton reported on cestodes, trematodes, nematodes and acanthocephala found in fishes.

Linton, E., 1894. Some observations concerning fish parasites. Bull. U. S. Fish Comm. for 1893, 13, 101–112.
Linton discusses not only the cestode, trematode, and nematode parasites of fish but also the parasite's effect on the health of the fish.

Linton, E., 1897. Notes on larval cestode parasites of fishes—No. 1123. Proc. U. S. Natl. Mus. 19, 787–824.
This is a publication on the cestodes of fishes.

Linton, E., 1898a. Notes on larval cestode parasites of fishes—No. 1123. Zool. Zentralbl. 5 (2), 46–47.
This is an abstract of Linton's 1897 paper on the cestodes of fishes.

Linton, E., 1898b. Notes on cestode parasites of fishes—No. 1125. Proc. U. S. Natl. Mus. 20, 423–456.
This paper describes cestodes parasitizing fishes.

Linton, E., 1898c. Notes on trematode parasites of fishes—No. 1133. Proc. U. S. Natl. Mus. 20, 507–548.
Information on the trematodes of fishes is found in this paper.

Linton, E., 1898d. An economical consideration of fish parasites. Bull. U. S. Fish Comm. for 1897, 17, 193–199.
This paper discusses some economic issues associated with the presence of sporozoa, trematodes, cestodes, nematodes and acanthocephala in fishes.

Linton, E., 1901a. Fish parasites collected at Woods Hole in 1898. Bull. U. S. Fish Comm. for 1899, 19, 267–304.
This bulletin reports sporozoan, trematode, cestode, nematode, acanthocephalan, leech and crustacean parasites of fishes.

Linton, E., 1901b. Parasites of fishes of the Woods Hole region. Bull. U. S. Fish Comm. for 1899, 19, 407–492.
This publication describes trematodes, cestodes, nematodes, acanthocephala and crustacea found in fishes.
Lockwood, S., 1872. An entozoon from the eel. Am. Nat. 6 (8), 449–454.
Lockwood reports the finding of an acanthocephalan (Echinorhyncus) in an eel.
Lockwood, S., 1890. Fungi affecting fish—an aquarium study. J. N. Y. Microsc. Soc. 6 (3), 67–78.
This paper gives information on a fungal infection (*Saprolegnia*) found on several sunfish species held in aquarium.
Lom, J., Dykova', I., 1992. Protozoan Parasites of Fishes (References). Elsevier, Amsterdam, 315 pp.
The references (pp. 155 and 231) found in Lom and Dykova serve as a source for protozoologists including Richard R. Kudo, Elmer R. Noble and D.C. Saunders.
Mackiewicz, J.S., 1972. Parasitological review, caryophyllidea (Cestoidea): a review. Exp. Parasitol. 31, 417–512.
The review provides some biographical information and the references serve as a source for the publications of John S. Mackiewicz.
Marking, L.L., Hogan, J.W., 1967. Toxicity of Bayer 73 to fish. U.S. Bureau of Sport Fisheries and Wildlife. Investigations in Fish Control No. 19 and Resource Publication No. 36, 13 pp.
The literature cited in this paper provides information on the publications by Leif L. Marking.
Marsh, M.C., 1901a. *Bacterium truttae*, a new bacterium pathogenic to trout. Science 16, 706.
This paper gives the first biochemical description of a bacterial fish pathogen (*Aeromonas salmonicida*) from fish in the U.S.
Marsh, M.C., 1901b. The brook trout disease. Trans. Am. Fish. Soc. 30, 66–81.
This publication describes a disease (Furunculosis) of brook trout, discusses predisposing factors of the disease, and also discusses the first use of formalin as a bath for treatment.
Marsh, M.C., 1902. Hemoglobin estimations and blood counts in fishes. Washington Med. Ann. 1 (5), 397 [taken from Wood, 1953].
This is probably the first report of fish blood studies.
Marsh, M.C., 1903a. Epithelioma in trout. Washington Med. Ann. 2 (1), 59 [taken from Gaylord, et al., 1912].
This is a report of an epithelial tumor in trout.
Marsh, M.C., 1903b. A more complete description of *Bacterium truttae*. Bull. U. S. Fish Comm. for 1902, 22, 411–415.
This paper is a further description of the bacteria causing Furunculosis.
Marsh, M.C., 1904. Danger to fry from galvanized iron shipping cans. Trans. Am. Fish. Soc. 33, 53–54.
Marsh describes the toxicity of zinc (from galvanized cans) to fish.
Marsh, M.C., 1905. The Cold Spring Harbor epidemic among trout. Tenth Annual Report N.Y. Fish, Forestry and Game Comm. for 1904, pp. 125–139.
Marsh describes ulcer disease of trout (no bacteria isolated) and reports on several other factors affecting fish health, including supersaturation with oxygen and nitrogen, factors affecting the immune system, nutritional inadequacies of hatchery diets, affects of overcrowding on fish, and disinfection of fish ponds.
Marsh, M.C., 1914. The feeding of trout in relation to thyroid tumor. Trans. Am. Fish. Soc. 44, 13–19.
Nutritional components and their effect on thyroid tumor development in trout are discussed in this publication.
Marsh, M.C., Gorham, F.P., 1905. The gas disease in fishes. Rep. Bureau Fish. for 1904. Government Printing Office, Washington, pp. 343–376.
This is a thorough discussion of the causes, effects, and the prevention of gas bubble disease and the reference section also includes two other publications by Marsh on the gas bubble disease.
Marsh, M.C., Gorham, F.P., 1906. Hemoglobin and blood counts in fishes in health and disease: a review. Science. New Series 23, 666 [taken from Wood, 1953].
This paper gives information on the blood picture of healthy and sick fish.
Mather, F., 1878a. Feeding of fishes in confinement. Trans. Am. Fish Cult. Assoc. 7, 67–72.
Mather mentions that a nutritional deficiency can kill fish.
Mather, F., 1878b. XIII. Account of trip to Europe with eggs of Quinnat salmon. U. S. Comm. Fish and

Fisheries: Part III. Report for the year 1876–1877. Government Printing Office, Washington, pp. 811–816 (812).
This report gives some information on fungi infections on the eggs of Quinnat salmon.

Mather, F., 1884. XXXIII. Report upon the hatching and distribution of Penobscot and land-locked or schoodic salmon in the spring of 1882. U. S. Comm. Fish and Fisheries: Part X. Report for the year 1882. Government Printing Office, Washington, pp. 873–875 (874).
This report gives some information on coagulated yolk and blue-sac disease of Penobscot salmon.

Mawdesley-Thomas, L.E., 1972. Some tumors of fish. In: Mawdesley-Thomas, L.E. (Ed.), Diseases of Fish. Symposia of the Zoological Society of London, Number 30. Academic Press, London, pp. 191–283, 380 pp.
This publication shows a picture of Tilapia-like fish with an enlarged abdomen that was painted by an Egyptian in about 1450 BC. According to Thomas it may be a diseased fish.

McGregor, E.A., 1963. Publication on fish parasites and diseases, 330 BC–AD 1923. Special Scientific Report —Fisheries No. 474. Washington, DC. 84 pp.
This paper is a reference source for the publication of several 19th and early 20th century fish parasitologists and naturalists reporting on fish parasites or diseases. Information on Boccone's 1671 paper is provided.

Meyer, F.P., 1964. Field treatments of *Aeromonas liquefaciens* infections in golden shiners. Prog. Fish-Cult. 26 (1), 33–35.
This paper describes the first treatments used on a large scale (40 acre reservoir) to control bacterial diseases under natural conditions.

Millemann, R.E., Knapp, S.E., 1970. Pathogenicity of the "salmon poisoning" trematode *Nanophyetus salmonicola*, to fish. In: Snieszko, S.F. (Ed.), A Symposium on Diseases of Fishes and Shellfishes, Special Publication No. 5. American Fisheries Society, Washington, DC, pp. 209–217.
The literature cited in this paper provides a source for the publications of B.T. Simms.

Milner, J.W., 1874. I. Report on the fisheries of the Great Lakes; the result of inquiries prosecuted in 1871–1872. U. S. Comm. Fish and Fisheries. Report for 1872–73, pp. 1–78 (64, 67).
Milner mentions that the acanthocephalan (*Echinorhychus*), the leech (*Ichthyobdella punctata*), the cestode (*Bothriocephalus*), and the crustacea (*Lernaea*) parasitize the white fish (*Coregonus albus*).

Mitchill, S.L., 1815. The fishes of New York, described and arranged. Trans. Literary Philos. Soc. N. Y. 1, 355–492.
This may be the first description of lamprey (*Petromyzon marinus*) in the U.S. but no fish host is mentioned.

Mitchum, D.L., 1995. Parasites of Fishes of Wyoming. Wyoming Game and Fish Department, 304 pp.
This textbook is the culmination of the life work of Mitchum. Its references serve as a source for the publication of several parasitologists.

Mizelle, J.D., Kritsky, D.C., 1967. Studies on the monogenetic trematodes: XXXIII. New species of Gyrodactylus and a key to the North American species. Trans. Am. Microsc. Soc. 86 (4), 390–401.
Publications of John D. Mizelle are found in the literature cited section of this paper.

Moore, E., 1922. *Octomitus salmonis*, new intestinal parasite. Trans. Am. Fish. Soc. 52, 74–94.
Moore reports a protozoan (*Octomitus salmonis*) in trout which is the first fish disease report in the U.S. by a women.

Moore, E., 1924. The transmission of *Octomitus salmonis* in the egg of trout. Trans. Am. Fish. Soc. 54, 54–56.
This paper describes an internal protozoan fish parasite studied in the 1920s.

Moore, E., 1929. The aeration of hatchery water supplies and the incidence of disease. Trans. Am. Fish. Soc. 59, 195–196.
The effect of aeration on the incidence of disease is described in this publication.

Moore, J.P., 1898. The utility and methods of mackerel propagation. Bull. U. S. Fish Comm. for 1897, 17, 353–361 (355).
Moore mentions a great fatality among bluefish at the beginning of the century.

Moore, J.P., 1899. The Leeches of the U.S. National Museum. Proc. U. S. Natl. Mus. 21, 543–563.
This paper describes some leeches (*Piscicola*, *Trachelobdella* and *Pontobdella* species) that parasitize various fish.

Moore, J.P., 1939. In Memoriam: Edwin Linton 1855–1939. J. Parasitol. 25, 450–453.
This memoriam contains some biographical information on Edwin Linton.

Moore, M.A., 1882a. Fish mortality in the Gulf of Mexico. Proc. U. S. Natl. Mus. for 1881, 4, 125–126.
This paper is a description of an 1878 fish kill in the Gulf of Mexico attributed to volcanic activity.

Moore, M.A., 1882b. Fish mortality in the Gulf of Mexico. Smithson. Misc. Coll. for 1881, Washington 22, 125–126.
This paper is also a description of an 1878 fish kill in the Gulf of Mexico attributed to volcanic activity.

Mueller, J.F., 1932. *Trichodina renicola* (Mueller 1931) a ciliate parasite of the urinary tract of *Esox niger*. Roosevelt Wildl. Ann. 3, 139–154 [taken from Davis 1947b].
This is a report of a protozoan (*Trichodina*) found in a chain pickerel.

Neish, G.A., Hughes, G.C., 1980. In: Snieszko, S.F., Axelrod, H.R. (Eds.), Fungal Diseases of Fish: Diseases of Fishes (Book 6). T.F.H. Publications, Neptune City, NJ, 159 pp.
This book on the fungi of fish is one of a series of six books co-edited by Stanislas F. Snieszko.

Nigrelli, R.F., 1952. Virus and tumors in fish. Ann. N. Y. Acad. Sci. 54 (6), 1076–1092.
This paper is used as a source for biographical information on Ross F. Nigrelli and the bibliography provides a source for the publications of the same.

Nigrelli, R.F., Ruggieri, G.D., 1965. Studies on virus diseases of fishes. Spontaneous and experimentally induced cellular hypertrophy (Lymphocystis disease) in fishes of the New York Aquarium, with a report of new cases and an annotated bibliography (1874–1965). Zoologica (Scientific contributions of the New York Zoological Society) 50 (2), 83–96.
This publication contains historical information on Lymphocystis Disease including references for publications of scientists working on the disease.

Noble, E.R., Noble, G.L., 1961. Parasitology, the Biology of Animal Parasites. Lea and Febiger, Philadelphia, 767 pp.
The reference section of this book provides a source for the publications of Elmer R. Noble.

Norris, T., 1868. American Fish-Culture. Porter and Coates, Philadelphia, 304 pp.
This is a paper on fungi infecting eggs in a hatchery.

O'Brien, M.E., 1895. Epidemic among trout in Nebraska. Trans. Am. Fish. Soc. 24, 52–53.
This paper discusses a trout disease and gives information on a salt treatment.

Ohlmacher, A.P., 1898. Several examples illustrating the comparative pathology of tumors. Bull. Ohio Hosp. Epileptics 1, 223–239.
Ohlmacher gives a pathological description of a tumor (sarcoma) in the northern pike (*Esox lucius*).

Ordal, E.J., Rucker, R.R., 1944. Pathogenic myxobacteria. Proc. Soc. Exp. Biol. Med. 56, 15–18.
The literature cited in this paper serves as a source for publications of Erling J. Ordal and Robert R. Rucker.

Osborne, H.F., 1913. Biographical Memoir of Joseph Leidy. Biogr. Mem. (Natl. Acad. Sci. U. S. A.) 7, 335–396.
This memoir list about 600 publications that Leidy produced from 1845 to 1891.

Overstreet, R.M., 1978. Marine maladies? Worms, Germs, and Other Symbionts from the Northern Gulf of Mexico. Blossoman Printing, Ocean Springs, MS, 140 pp.
The literature cited in this paper serves as a source for the publications of Robin M. Overstreet and Ross F. Nigrelli.

Pacha, R.E., Ordal, E.J., 1970. Myxobacterial diseases of salmonids. In: Snieszko, S.F. (Ed.), A Symposium on Diseases of Fishes and Shellfishes, Special Publication No. 5. American Fisheries Society, Washington, DC, pp. 243–257.
The literature cited in this paper serves as a source for the publications of Erling J. Ordal and R.E. Pacha.

Packard, A.S., 1867. VIII. Observations on the glacial phenomena of Labrador and Maine, with a view of the recent invertebrate fauna of Labrador. Memoirs read before the Boston Society of Natural History, Boston 1 (2) 210–303 (295–296).
This paper presents some information on crustacea (*Lernaea* and *Aega* species) that were taken from cod fish.

Packard, A.S., 1873. On *Cauloxenus stygius*. Fifth Annual Report Peabody Academy of Science, Salem [taken from Smith, 1874].
This report mentions a crustacean parasite (*Cauloxenus stygius*) found on fish.

Packard, A.S., 1874. Description of a Lernaean crustacean (*Achtheres carpenteri*). Obtained by Lieut. W.L. Carpenter in 1873 in Colorado. Annual Report of the U.S. Geological Survey of the Territories (1873), p. 116.
Packard described a crustacean (*Achtheres carpenteri*) found on trout.

Packard, A.S., 1875a. *Achtheres carpenteri* sp. nov., East River, CO, on trout. Ann. Rep. U.S. Territory, p. 612. [taken from McGregor, 1923].
This note gives information on a new crustacean (*Achtheres carpenteri*) found on trout.

Packard, A.S., 1875b. Life-histories of the crustacea and insects. Am. Nat. 9, 583–622.
The life histories of crustacean parasites (*Lerneonema radiata* and *Achtheres carpenteri*) of fish are described in this paper.

Packard, A.S., 1875c. Biographies of some worms. Am. Nat. 9, 352–373.
Information on acanthocephala that parasitize fish is given in this paper.

Page, C.N., 1898. Fish diseases. Aquaria. A treatise on the food, breeding, and care of fancy goldfish, paradise fish, etc. DesMoines, IA, pp. 34–37.
Page discusses fungi and other diseases [consumption, parasite causing white spot (Ich), anoxia, bladder complaint, itch, and dropsy] of aquarium fish. He also discusses several treatments including salt, silver nitrate, bi-chloride of mercury and digitalis.

Parker, G.H., 1891. The compound eyes in crustaceans. Bull. Mus. Comp. Zool., Harvard 21, 77–85.
In this discussion Parker mentions a crustacean (*Argulus*) found on killifish.

Peck, C.H., 1886. Thirty-ninth Annual Report of the Trustees of the State Museum of Natural History for the year 1885. Weed, Parsons and Company, Albany, NY, p. 49.
In this paper information is given concerning fungi (*Saprolegnia ferax*) on aquarium fish and on fish held in artificial ponds in New York.

Pickering, Dana, J.D., 1838. Description of a crustaceous animal, belonging to the genus Caligus—*Caligus americanus*. Am. J. Sci. Arts 34, 29–266.
This paper is a lengthy description of a crustacean (*Caligus americanus*) found on the common cod.

Pierce, H.D., 1883. The spawning of the blue-fish. An opinion of the cause of mortality of fish in the Gulf of Mexico. Bull. U. S. Fish Comm. for 1883, 3, 332.
This paper describes a large mortality of blue-fish, rock fish and flying fish in the Gulf of Mexico off the coast of Florida. Cold water temperature is given as a reason for the fish kill.

Pierce, H.D., 1884. Notes on the blue-fish; mortality of Florida fishes. Bull. U. S. Fish Comm. for 1884, 4, 263–266.
This report gives information on fish kills in the Gulf of Mexico including an 1876 and 1880 kill. It examines potential causes including cold water.

Pilcher, K.S., Fryer, J.L., 1980. The viral diseases of fish: a review through 1978: Part I. Diseases of proven viral etiology. CRC Crit. Rev. Microbiol. 7 (4), 287–364.
The reference section of this review serves as a source for the publications of K.S. Pilcher.

Plumb, J.A., 1994. Health Maintenance and Principal Microbial Diseases of Cultured Fishes. Iowa State University Press, Ames, IA, 328 pp.
This important textbook represents the culmination of the life work of John A. Plumb. It was extensively revised in 1999.

Post, G., 1962. Immunization as a method of disease control in fish. U. S. Trout News (5), 14–17.
The paper describes the first experiment showing that protection was achieved using a bacterial antigen.

Post, G., 1987. Textbook of Fish Health. T.F.H. Publications, Neptune City, NJ, 288 pp. (p. 6).
This textbook is the culmination of the life work of George Post. It also serves as a source for the early history of fish disease worldwide.

Price, C.E., McMahon, T.E., 1967. The monogenetic trematodes of North American freshwater fishes. Riv. Parasitol. 28 (3), 177–220.
This reference supplied some biographical information on Emmett W. Price and the literature cited section serves as a source of publications for Harley V. VanCleave and William J. Hargis.

Rathbun, R., 1882. List of marine invertebrates, mainly from the New England coast, distributed by the United States National Museum. Series II. Proc. U. S. Natl. Mus. for 1881, 4, 298–303 (299).
This listing makes mention of a crustacean (an isopod, *Aega psora*) found on cod and halibut.

Rathbun, R., 1885. Annotated list of the described species of parasitic copepoda (Siphonostoma) from American waters contained in the United States National Museum. Proc. U. S. Natl. Mus. for 1884, 7, 483–492.
Rathbun lists several parasitic crustacea found mostly on marine fish.

Rathbun, R., 1887. Descriptions of parasitic copepoda belonging to the genera *Pandarus* and *Chondracanthus*. Proc. U. S. Natl. Mus. for 1886, 9, 310–324.
This publication describes parasitic crustacea of the genera of *Pandarus* and *Chondracanthus* found on fish.

Rathbun, R., 1888. Descriptions of new species of parasitic copepods, belonging to the genera *Trebius*, *Perissopus*, and *Lernanthropus*. Proc. U. S. Natl. Mus. for 1887, 10, 559–571.
Rathbun describes copepods of the genera of *Trebius*, *Perissopus* and *Lernanthropus* that parasitize marine fish.

Rathbun, R., 1893. Report upon the inquiry respecting food-fishes and the fishing-grounds. U. S. Comm. Fish and Fisheries: Part XVII. Report of the Commissioner for 1889 to 1891. Government Printing Office, Washington, pp. 97–171 (145–147, 139–140, 168–169).
In this report Rathbun mentions that Professor Forbes was investigating a fish kill in Lake Mendota, that Edwin Linton was studying trout with tapeworms from the Yellowstone National Park and that he was evaluating blind trout specimens from cultured systems, and that Revere R. Gurley was assigned to study fish disease problems.

Rathbun, R., 1895. Report upon the inquiry respecting food-fishes and the fishing-grounds. U. S. Comm. Fish and Fisheries: Part XIX. Report of the Commissioner for 1893. Government Printing Office, Washington, pp. 17–51 (49–50).
This publication reports on a fish mortality with associated fungus among alewives in Lake Ontario. The mortality was studied by Revere R. Gurley.

Rathbun, R., 1896. Report upon the inquiry respecting food-fishes and the fishing-grounds. U. S. Comm. Fish and Fisheries: Part XX. Report of the Commissioner for 1893. Government Printing Office, Washington, pp. 81–114 (96, 114).
This paper gives a report of an 1894 spring mortality among adult brook trout that was investigated by Revere R. Gurley. This report also contains some biographical information on David S. Kellicott.

Ravenel, W. de C., 1896. Report on the propagation and distribution of food-fishes. U. S. Comm. Fish and Fisheries: Part XXI. Report of the Commissioner for 1895. Government Printing Office, Washington, pp. 6–72 (10, 37, 40).
This report contains information on fungi infecting mostly salmonid fish and eggs. It also discusses a disease (black-gill fever) in brook trout and treatments with salt and muck (mud).

Ravenel, W. de C., 1898a. Report on the propagation and distribution of food-fishes. U. S. Comm. Fish and Fisheries: Part XXII. Report of the Commissioner for 1896. Government Printing Office, Washington, pp. 11–92 (23, 27–28, 43, 57).
Ravenel reports about several fish disease problems including a disease of propagated rainbow trout eggs called white spot, a codfish fungal disease, a largemouth bass disease associated with high temperature and muddy water, and a large kill of fish in the Mississippi and Illinois Rivers.

Ravenel, W. de C., 1898b. Report on the representative of the United States Fish Commission at the Cotton States and International Exposition at Atlanta, GA, in 1895. U. S. Comm. Fish and Fisheries: Part XXII. Report of the Commissioner for 1896. Government Printing Office, Washington, pp. 147–167 (157).
This is a report of fungus on recently collected fish held in aquaria.

Ravenel, W. de C., 1898c. Report on the propagation and distribution of food-fishes. U. S. Comm. Fish and Fisheries: Part XXIII. Report of the Commissioner for 1897. Government Printing Office, Washington, pp. XVIII–XC (XXIII–XXIV, XXXV, L, LVII–LVIII, LXIX–LXX, CXXI).
Ravenel reported the capture of a few tile fish in 1892, the first caught since the great mortality of 1882. He also reported that captured cod held in live-cars died of spreading sores (probably bacterial), that fungi was found on small mouth bass eggs and brood rainbow trout, that white spot (coagulated yolk) was seen in salmon fry, and a parasitic trematode (probably *Gyrodactylus*) was observed on lake trout.

Ravenel, W.de C., 1899. Report on the propagation and distribution of food-fishes. U. S. Comm. Fish and Fisheries: Part XXIV. Report of the Commissioner for 1898. Government Printing Office, Washington, pp. XXXI–CXXII (LXXVII).

In this report mention is made that pike-perch eggs were covered with protozoa (*Carchesium* and *Vorticella*).

Ravenel, W. de C., 1900. Report on the propagation and distribution of food-fishes. U. S. Comm. Fish and Fisheries: Part XXV. Report of the Commissioner for 1899. Government Printing Office, Washington, pp. XXXV–CXVIII (XLVII–XLVIII, LXVII–LXVIII, LXXX, XCVII, XCVIII).

This reports mentions several salmonid disease problems including: salmon egg with fungi; an unknown rainbow trout fingerling disease in which darting and spinning fish were observed; an unidentified Atlantic salmon disease; a mortality of wild salmon in the McCloud River, CA, reported to be caused by poison from a spring; and a disease that was probably coldwater or peduncle disease in steelheads and rainbow trout. There is also a report of an examination of poor quality white fish eggs by C. M. Blackford Jr. who was studying the diseases of brook trout.

Ravenel, W. de C., 1901. Report on the propagation and distribution of food-fishes (Report of 1899 hatchery disease). U. S. Comm. Fish and Fisheries: Part XXVI. Report of the Commissioner for 1900. Government Printing Office, Washington, pp. 25–118 (72–73).

This paper reports a brook trout disease that was probably Furunculosis.

Raveret-Wattel, M.C., 1883. XV. Report on the condition of pisciculture in foreign countries from documents collected at the International Fishery Exposition at Berlin, 1880. U. S. Comm. Fish and Fisheries: Part VIII. Report of the Commissioner for 1880. Government Printing Office, Washington, pp. 477–489 (478–480).

This report gives historical information on fish culture (places, people and dates) in the United States.

Rice, H.J., 1884. Salt used for the destruction of fish fungus. Trans. Am. Fish. Soc. 13, 15–21.

This publication discusses the use of salt treatments to control fungi on fish and fish eggs. It also mentions the use of asphalt, tar, and salicylic acid for fungi treatments.

Robins, C.R., Bailey, R.M., Bond, C.E., Brooker, J.R., Lachner, E.A., Lea, R.N., Scott, W.B., 1991. Common and Scientific Names of Fishes from the United States and Canada. 5th edn. American Fisheries Society, Bethesda, MD, Special Publication 20, 183 pp.

This publication contains the official common and scientific names of 2428 fish species from the U.S. and Canada.

Rucker, R.R., 1993. History of the Western Fish Disease Laboratory—1934 to 1974. In-house publication of the National Fishery Research Center, Seattle, WA, 11 pp.

This publication contains information on the Western Fish Disease Laboratory, includes biographic information on Robert R. Rucker.

Ryder, J.A., 1882. On the retardation of the development of the ova of the shad (*Alosa sapidissima*), with observations on the egg-fungus and bacteria. Bull. U. S. Fish Comm. for 1881, 1, 177–190.

Ryder discusses the presence of fungi on shad (*Alosa sapidissima*) eggs.

Ryder, J.A., 1883. Experiments with carbolic acid to kill the fungus on large fishes. Bull. U. S. Fish Comm. for 1882, 2, 190–191.

This paper give information on a treatment (carbolic acid) used against fungi on goldfish held in aquarium. It also mentions asphalt as a fungi treatment.

Ryder, J.A., 1884a. On a skin parasite of the cunner (*Ctenolabrus adspersus*). Bull. U. S. Fish Comm. for 1884, 4, 37–42.

This paper reports a trematode found on a cunner *Tautogolabrus adspersus*). It also discusses the presence of monogenetic trematodes (*Gyrodactylus*) on goldfish in aquarium.

Ryder, J.A., 1884b. XVI. On the retardation of the development of the ova of the shad (*Alosa sapidissima*), with observations on the egg-fungus and bacteria. U. S. Comm. Fish and Fisheries: Part IX. Report of the Commissioner for 1881. Government Printing Office, Washington, pp. 795–811 (797).

This paper reports the presence of fungi on shad (*Alosa sapidissima*) eggs.

Samuel, M., 1894. Goldfish maladies. The Amateur Aquarist—How to Equip and Maintain a Self-Sustaining Aquarium. Baker & Taylor, New York, pp. 42–46.

Aquarium goldfish diseases are discussed including fungi, itch, consumption, bladder complaint and dropsy. Information is given on treatments (salt and digitalis) and management options for disease control.

Sarig, S., 1971. The prevention and treatment of diseases of warmwater fishes under subtropical conditions, with special emphasis on intensive fish farming. In: Snieszko, S.F., Axelrod, H.R. (Eds.), Diseases of Fishes (Book 3). T.F.H. Publications, Neptune City, NJ, 127 pp.

This book on the prevention and treatment of diseases is one of a series of six books co-edited by Stanislas F. Snieszko.

Say, T., 1818a. An account of crustacea of the United States (July 7, 1818). J. Acad. Nat. Sci. Phila. 1 (2), 374–401 (394–400).

This is one of the earliest accounts of a crustacean [*Livoneca* (*Cymothoa*)] spp. parasitizing fish in the U.S.

Say, T., 1818b. An account of crustacea of the United States (September 22, 1818). J. Acad. Nat. Sci. Phila. 1 (2), 423–441 (436–437).

This early work in fish parasitology gives information on two crustacea, *Pandarus sinuatus* on dog fish and *Caligus piscinus* on codfish.

Scott, G.C., 1869. Fishing in American Waters. Harper & Brothers, New York, 484 pp. (437–438).

In this publication Scott states that Doctor Gunther of Europe holds the absurd idea that lamprey attach to other fish. This may be the first statement in the U.S. of the fact that a lamprey can be parasitic even though Scott thinks it absurd.

Seagle, G.A., 1897. The artificial propagation of the rainbow trout. Bull. U. S. Fish Comm. for 1896, 16, 239–256 (253).

This paper reports on blue-sac disease, fungi and other diseases (probably parasitic and bacterial diseases) of fry and adults of propagated rainbow trout. Information is given on treatments with salt.

Seagle, G.A., 1898. The rainbow trout—a manual of fish-culture based on the methods of the United States Commission of Fish and Fisheries. Prepared under the direction of John J. Brice. U. S. Comm. Fish and Fisheries: Part XXIII. Report of the Commissioner for 1897. Government Printing Office, Washington, pp. 1–340 (71–89).

In this manual information is given on fungi infecting the eggs and fungi infections and blue-sac disease of fry of rainbow trout. Also discussed is an undetermined mortality among adult trout.

Seal, W.P., 1889. The aquarium. A brief exposition of its principles and management. Bull. U. S. Fish Comm. for 1887, 7, 274–282 (281–282).

Seal gives an exposition of microscopic parasites (probably protozoa) and fungi on goldfish, carp and other fish held in aquarium. He also includes some information on treatments with carbolic acid and salt.

Seal, W.P., 1892. Observations on the aquaria of the U. S. Fish Commission at Central Station, WA. Bull. U. S. Fish Comm. for 1890, 10, 1–12 (6).

This paper reports that microscopic protozoa, fungi *Ichthyophthirius* (*Chromatophagus parasiticus*) were found on several fish species and that carbolic acid, washing soda and salt were attempted as treatments. This apparently is the first report of Ich on fish in the U.S.

Shaw, J.N., Simms, B.T., Muth, O.H., 1934. Some Diseases of Oregon Fish and Game and Identification of Parts of Game Animals. Agricultural Experiment Station, Oregon State Agricultural College, Corvallis, OR, 23 pp.

This contains a report of the establishment and funding of a fish disease program at a college in 1932 and indicates that B.T. Simms was a veterinarian.

Shul'man, S.S., 1966. Myxosporidia of the USSR (Bibliography, 531–605). Nauka Publishers, Moscow, Leningrad. Translated by USDI and NSF, Washington, DC, Amerind Publishing, New Delhi (1988), 631 pp.

The bibliography in this book serves as a source for publications of protozoologists including Richard R. Kudo, Paul A. Meglitsch, F. Bonds and Elmer R. Noble.

Simpson, C.T., 1899. The pearly fresh-water mussels of the United States; Their habits, enemies, and diseases, with suggestions for their protection. Bull. U. S. Fish Comm. for 1898, 18, 279–288 (282).

In this publication, Simpson mentions that glochidia (larval clams) attach to the scales and gills of fishes.

Sindermann, C.J., 1966. Diseases of Marine Fishes. T.F.H. Publications, Neptune City, NJ, 89 pp.

This was an early key publication of Carl Sindermann and its references serve as a source for some publications of Ross F. Nigrelli and Carl J. Sindermann.

Sindermann, C.J., 1974. Diagnosis and Control of Maricultural Diseases in the United States. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Technical Series No. 2, 306 pp.

This was an important publication on diagnosing and controlling the diseases of marine species that was edited by Carl J. Sindermann and the references in it serve as a source for other publications of Sindermann.

Sindermann, C.J., 1977. Disease Diagnosis and Control in North American Marine Aquaculture (Developments in aquaculture and fisheries science; Volume 6). Elsevier, Amsterdam, The Netherlands, 329 pp.
This also is a very important publication edited by Carl J. Sindermann and the references in it serve as a source for other publications of Sindermann. This book also gives information on fish health studies at Department of Commerce laboratories.

Sindermann, C.J., 1990a. 2nd edn. Principal Diseases of Marine Fish and Shellfish, Vol. 1, Academic Press, New York, 521 pp.

Sindermann, C.J., 1990b. 2nd edn. Principal Diseases of Marine Fish and Shellfish, Vol. 2, Academic Press, New York, 516 pp.
This two-volume textbook on marine fish and shellfish diseases is a crowning achievement for Carl Sindermann in his long career.

Slack, J.H., 1859. Comment by J.H. Slack on fungous growth on sides of fish. Proc. Acad. Nat. Sci. Phila. for 1858, 10, 13.
Slack comments that fungus was found on the sides of fish. This is one of the earliest mentions of fungi on fish in the U.S.

Smiley, C.W., 1886. XXXIII. Some results of carp culture in the United States. U. S. Comm. Fish and Fisheries. Report of the Commissioner for 1884, Part XII. Government Printing Office, Washington, pp. 657–890.
This publication contains several reports on diseases and treatments of common carp. These include: G.T. Agar in 1883, G. Finley in 1880, S.P. McFall in 1883, and J.F. Wilson in 1884 who mentioned that mortalities occurred in common carp but gave little explanation (p. 693, 779, 794 and 696); H.G. Ewart, H.J. Fenton, S. Green (pioneer fish culturist), B.E.B. Kennedy, S. McClelland, and W.H. Siems, who from 1883 to 1884 reported the finding of fungus on common carp with few additional details (pp. 780, 670, 765, 754, 753, and 672); S.F. Baird (U. S. Fish Commissioner) who in 1886 wrote that stress (handling and emaciation) caused fungus to develop in carp and that salt treatments were suggested (p. 754); E.H. Frantz who in 1883 described a carp mortality that probably occurred because of low dissolved oxygen (p. 733); R.H. Lodge who in 1883 reported that carp died when placed in a newly plastered fountain bowl (p. 794); C. Scudder who in 1884 revived carp with two treatments of 50:50 brandy–water mixture applied in the mouth with a dropper (p. 675) and R.O. Sweeny who in 1883 mentioned that common carp were dying with signs that suggested a bacterial problem (p. 739).

Smiley, C.W., 1887. Notes upon fish and the fisheries. Bull. U. S. Fish Comm. for 1886, 6, 401–416 (413–414).
This contains a description of a disease affecting cultured channel catfish and that menhaden were dying along the South Carolina coast.

Smith, C.E., Brin, M., Halver, J.E., 1974. Biochemical, physiological, and pathological changes in pyridoxine-deficient rainbow trout (*Salmo gairdneri*). J. Fish. Res. Board Can. 31, 1893–1898.
The literature cited in this paper serves as a source for the publications of Charlie E. Smith.

Smith, H.M., 1892. Report on an investigation of the fisheries of Lake Ontario. Bull. U. S. Fish Comm. for 1890, 10, 177–215 (189–192).
This is a report of a large kill of alewives in Lake Ontario. Fungi, the lack of food, storms, and temperature changes were given as possible causes.

Smith, H.M., 1898. Report of the Division of Statistics and Methods of the Fisheries. U. S. Comm. Fish and Fisheries. Report of the Commissioner for 1897, Part XXIII. Government Printing Office, Washington, pp. XCI–CXXIV (CXXIII–CXXIV).
Smith reports that white fish held in aquaria had nutritional deficiencies and other species including salmon and trout also held in aquaria were infected with *Ichthyophthirius*.

Smith, H.M., 1899. Report on inquiry respecting food-fishes and the fishing-grounds. U. S. Comm. Fish and Fisheries. Report of the Commissioner for 1898, Part XXIV. Government Printing Office, Washington, pp. CXXIII–CXLVI (CXLII–CXLV).
This report provides information on a brood-cod mortality that was caused by injuries following handling. The diagnostic work-up was described in pathological terms which indicated the probable use of histological techniques. In this report it was also stated that the U. S. Fish Commission was urged to provide a permanent expert in fish pathology.

Smith, H.M., 1900. Report on inquiry respecting food-fishes and the fishing-grounds. U. S. Comm. Fish and Fisheries. Report of the Commissioner for 1899, Part XXV. Government Printing Office, Washington, pp. CXIX–CXLVI (CXL, CXLIV–CXLV).
This report discusses a brook trout mortality caused by *Streptococcus* found in blood at a hatchery in Northville, MI. Bacterial cultures were done on wood debris in pond. Also reported was the fact that Frederic P. Gorham did not find bacteria in water and tissues of aquarium fish with gas bubble disease. This paper also contains some biographical information on C.M. Blackford Jr. that is referenced in the history.

Smith, H.M., 1902. Report on inquiry respecting food-fishes and the fishing-grounds. U. S. Comm. Fish and Fisheries. Report of the Commissioner for 1901, Part XXVII. Government Printing Office, Washington, pp. 111–140 (126).
Smith reported that over 20 bacterial species isolated from fish and water were exhibited by Millard C. Marsh.

Smith, S., 1995. Early changes in the fish community of Lake Ontario. Technical Report 60. Great Lakes Fishery Commission, Ann Arbor, MI, 38 pp.
This report is a source for early lamprey references and for historic information on the origination and movement of lamprey.

Smith, S.I., 1874. XXV. The crustacea of the fresh waters of the United States–B. The crustacean parasites of the fresh-water fishes of the United States. U. S. Comm. Fish and Fisheries: Part II. Report of the Commissioner for 1872 and 1873. Government Printing Office, Washington, pp. 661–665.
Smith reports crustaceans from several species of fish.

Smith, S.I., 1884. Review of the marine crustacea of Labrador. Proc. U. S. Natl. Mus. 6, 223–232.
This paper provides information on two crustacea, *Lernaea* and *Aega* species, that were found on codfish.

Snieszko, S.F., 1937. Wyniki badan' nad bakterjami tl zw. posocznicy karpi. (Results of investigations on the so-called septicemia of carp). Prezegl. Ryb. 10 (8), 309–311.
This is an early publication on fish disease (bacterial septicemia) by Stanislas F. Snieszko that was written before he came to the United States.

Snieszko, S.F., Bullock, G.L., 1957. Treatment of sulfonamide-resistant furunculosis in trout and determination of drug sensitivity. U. S. Fish Wildl. Serv. Bull. 125, 57, 555.
This paper discusses the treatment of drug resistant bacteria in trout.

Snieszko, S.F., Friddle, S.B., 1949. Prophylaxis of furunculosis in brood trout (*Salvelinus fontinalis*) by oral immunization and sulfamerazine. Prog. Fish-Cult. 113, 161–168.
This is probably the first report for the preparation of a fish vaccine in the U.S.

Snieszko, S.F., McAllister, J., Hitchner, E.R., 1941. On the biology of certain Myxobacteria. J. Bacteriol. 41, 26–27.
This is the first U.S. publication by Stanislas F. Snieszko.

Stiles, C.W., 1894a. Report on a parasitic protozoan observed on fish in the aquarium. Bull. U. S. Fish Comm. for 1893, 8, 173–190.
Stiles reported *Ichthyophthirius multifiliis* (Ich) from channel catfish and tested several treatments including salt, potassium permanganate, copper sulfate, and hydrogen peroxide. The testing of the last three treatments is apparently the first fisheries use of these chemicals in the U.S.

Stiles, C.W., 1894b. A preliminary catalog of the parasites contained in the collections of the United States Bureau of Animal Industry, United States Army Medical Museum, and Biological Department of the University of Pennsylvania (Leidy collection) and in collections of Stiles and Hassell. Vet. Mag. 1, 245–253.
This paper mentions several trematodes of fish from a specimen collection.

Stiles, C.W., 1898. Notes on parasites—an inventory of the genera and subgenera of the trematode family Fasciolidae (notes on parasites, 48). Arch. Parasitol. 1 (1), 81–99 (86).
This publication is a discussion on trematodes (*Clinostomus*) of fish.

Stone, L., 1872. Domesticated Trout. How to Breed and Grow Them. J.R. Osgood, Boston, 342 pp. (76–77, 114–120, 176–192, 257–261).
This is a very interesting book full of observations and opinions. This is the first fish culture book in the U.S. to include a section on fish diseases. Twenty-three diseases or conditions affecting the health of the fish are described including fungi on eggs and fry, Seth Green's dropsy (blue-sac disease), constitutional

weakness, emaciation, ulcers on head, animal parasites (probably *Trichodina*-drawings included), fin disease, black ophthalmia, inflammation of the gills, black gill disease, fatty degeneration of the vitals and spotted rash. Drawings of the parasites *Gyrodactylus* and *Trichodina* are included in the text making Stone's book the apparent first record of protozoa and monogenetic trematodes in fish in the U.S. Information on salt treatments, another first, is also given.

Stone, L., 1878. III. The salmon fisheries of the Columbia River. U. S. Comm. Fish and Fisheries: Part IV. Report of the Commissioner for 1875–1876. Government Printing Office, Washington, pp. 801–823 (811).
This report discusses the finding of crustacea (sea louse) on the fins of salmon from the Columbia River.

Stone, L., 1880. XXXIII. Report of operations at the United States salmon-hatching station on the McCloud River, CA, in 1878. U. S. Comm. Fish and Fisheries: Part VI. Report of the Commissioner for 1878. Government Printing Office, Washington, pp. 741–772 (756, 760).
Stone reports an egg disease (white mark on eggs) in salmon from the McCloud River, CA. This report also contains biographical information on Livingston Stone.

Stone, L., 1882a. Mortality of McCloud River salmon in 1881. Bull. U. S. Fish Comm. for 1881, 1, 134.
This paper reports a mortality in salmon from the McCloud River, CA.

Stone, L., 1882b. XVI. Report on overland trip to California with living fishes, 1879. U. S. Comm. Fish and Fisheries: Part VII. Report of the Commissioner for 1879. Government Printing Office, Washington, pp. 637–644 (640).
This is one of the first reports of propagated fish dying from the loss of aeration. This report also contains biographical information on Livingston Stone.

Stone, L., 1884a. XXI. The report of the operations of the United States salmon-breeding station on the McCloud River, CA, during the season of 1881. U. S. Comm. Fish and Fisheries: Part IX. Report of the Commissioner for 1881. Government Printing Office, Washington, pp. 1063–1078 (1069).
This report is a note on a salmon mortality in the McCloud River, CA.

Stone, L., 1884b. XXII. Report of operations at the United States Trout Ponds, McCloud River, CA, for the season of 1881. U. S. Comm. Fish and Fisheries: Part IX. Report of the Commissioner for 1881. Government Printing Office, Washington, pp. 1079–1083 (1081).
This publication reports a trout mortality initiated by muddy waters at the McCloud River, CA. This report also contains biographical information on Livingston Stone.

Stone, L., 1888. VIII. Report of operations at the U.S. salmon and trout stations on the McCloud River, CA, for the year 1885. U. S. Comm. Fish and Fisheries: Part XIII. Report of the Commissioner for 1885. Government Printing Office, Washington, pp. 131–140 (135–139).
The paper discussed a trout mortality and the use of salt and earth as a treatment. It is also reported that Stephen A. Forbes sent preserving fluid for fixing sick fish for later analysis. Additionally, this paper contains a discussion by L.W. Green on mortalities of rainbow trout in the wild and among propagated fish.

Stone, L., 1889. XIII. Report of operations at the U.S. salmon and trout station on the McCloud River, CA, for the years 1885–1887. U. S. Comm. Fish and Fisheries: Part XIV. Report of the Commissioner for 1886. Government Printing Office, Washington, pp. 737–740 (737–738).
Stone reported a trout mortality with some dying of earthy matter in their gills (possibly Columnaris Disease). Specimens were sent to Stephen Forbes and he reported that only the kidneys were affected and they were black and soft as mush with micrococci and numerous encysted parasites. Salt and earth treatments were tried.

Stone, L., 1897. The artificial propagation of salmon on the Pacific Coast of the United States, with notes on the natural history of the quinnat salmon. Bull. U. S. Fish Comm. for 1896, 16, 203–235 (232).
This paper reports a salmon mortality associated with a fungal infestation.

Storer, D.H., 1839. Report of fishes and reptiles of Massachusetts, Volume 1. (Page 172). Boston. [taken from McGregor (1923) and Wilson (1917)].
This paper reports a crustacean (*Pennella sagitta*) from a sunfish.

Stranahan, J.J., 1898. The whitefish–a manual of fish-culture based on the methods of the United States Commission of Fish and Fisheries. Prepared under the direction of John J. Brice. U. S. Comm. Fish and Fisheries: Part XXIII. Report of the Commissioner for 1897. Government Printing Office, Washington, pp. 1–340 (119–131).
This paper mentions the occurrence of fungi on whitefish eggs.

Sumner, F.B., Osburn, R.C., Cole, L.J., 1913. A biological survey of the waters of Woods Hole and vicinity: Section III. A catalogue of the marine fauna of Woods Hole and vicinity. Bull. Bureau Fish., 31, Government Printing Office, Washington DC, pp. 549–794.
The references listed at the end of the paper are a source for the publications of Charles B. Wilson.

Surface, H.A., 1899a. The lampreys of central New York. Bull. U. S. Fish Comm. for 1897, Vol. 17, Government Printing Office, Washington, pp. 209–215.
Surface reports that lampreys (*Petromyzon marinus*) are damaging and killing several species of fish in Cayuga Lake, NY. Included are pictures of parasitized fish.

Surface, H.A., 1899b. Removal of lampreys from the interior waters of New York. Fourth Annual Report New York Fish Forestry & Game Commission for 1898, pp. 191–245.
This paper reported that lampreys (*Petromyzon marinus unicolor*) were attaching black bullheads, white suckers, lake trout and many other fish species and the need for lamprey control was recognized. It was also mentioned that lamprey were infected with fungi.

Swett, S.B., 1883. Decrease of fish in Squamscot River, NH, on account of refuse matter from gas works. Bull. U. S. Fish Comm. for 1882, 2, Government Printing Office, Washington, p. 33.
Swett gives an account of a pollution kill of perch and other fishes in the Squamscot River, NH, that was from a gas works refuse.

Tanner, Z.L., 1884. I. Report on the work of the United States Fish Commission steamer Fish Hawk for the year ending December 31, 1882, and on the construction of the steamer Albatross. U. S. Comm. Fish and Fisheries: Part X. Report of the Commissioner for 1882. Government Printing Office, Washington, pp. 3–34 (6).
This paper gives a report of the presence of fungi on spawned shad.

Tarr, R.S., 1886. Parasitism among marine animals. Science (An Illustrated Journal, January–June 1886) 7, 17–18.
Tarr mentions the presence of a crustacea (Penella) on swordfish.

Thoreau, H.D., 1852. In: Torrey, B. (Ed.), The Writings of Henry David Thoreau, vol. 10 (4), Houghton Mifflin, Boston, pp. 210–216 (214).
In his writings, Thoreau clearly describes a melanoma in black bullheads.

Thoreau, H.D., 1858. In: Torrey, B. (Ed.), The Writings of Henry David Thoreau, vol. 17 (11), Houghton Mifflin, Boston, pp. 85–89 (87).
This is a second description by Thoreau of melanomas in black bullheads.

Trelease, W., 1884. Preliminary list of Wisconsin parasitic fungi. Trans. Wis. Acad. Sci. 6, 106–144.
Trelease mentions that fungi attack fish in the wild.

Underwood, L.M., 1886. List of the described species of fresh water crustacea from America north of Mexico. Bull. Illinois State Lab. Nat. Hist. 2, 323–386.
This publication gives information on crustacea of the genera of *Ergasilus*, *Lepeophtheirus*, *Argulus*, *Lernaea*, *Achtheres*, *Cauloxenus*, and *Lernaeopoda* that parasitize fish.

Verrill, A.E., 1870. On the parasitic habits of crustacea. Am. Nat. 3, 239–250 (241–242).
In this paper, Verrill mentions several crustacea parasitizing fish including; *Lernaea*, *Penella*, *Argulus*, *Caligus*, and *Livoneca*.

Verrill, A.E., 1872. XVII. Descriptions of North American fresh-water leeches. Am. J. Sci. Arts, Third Series 3, 126–159 (126–127).
This paper describes two fish leeches, *Cystobranchus* and *Ichthyobdella*.

Verrill, A.E., 1873. XVIII. Report upon the invertebrate animals of Vineyard Sound and the adjacent waters, with an account of the physical characters of the region. A. Habits and distribution of the invertebrate animals. U. S. Comm. Fish and Fisheries: Part I. Report on the Condition of the Sea Fisheries of the South Coast of New England in 1871 and 1872. Government Printing Office, Washington, pp. 295–513 (455–460).
This publication provides some information on crustacean, nematode, trematode, cestode, acanthocephalan, and leech parasites of fish.

Verrill, A.E., 1874. XXVI. Synopsis of the North American fresh-water leeches. U. S. Comm. Fish and Fisheries: Part II. Report of the Commissioner for 1872 and 1873. Government Printing Office, Washington, pp. 666–689 (666–669).
This paper discusses two parasitic leeches of fish, *Cystobranchus* and *Ichthyobdella*.

Verrill, A.E., Rathbun, R., 1879. List of marine invertebrata from the New England Coast, distributed by the U. S. Commission of Fish and Fisheries. Proc. U. S. Natl. Mus. 2, 227–232.
This listing mentions a crustacea (Aega) on cod-fish.

Verrill, A.E., Smith, S.I., Harger, O., 1873. Catalogue of the marine invertebrate animals of the southern coast of New England, and adjacent waters. U. S. Comm. Fish and Fisheries: Part I. Report on the Condition of the Sea Fisheries of the South Coast of New England in 1871 and 1872. Washington, Government Printing Office, pp. 537–747 (571–578, 624–625).
In this report Verrill discusses parasitic crustacea and leeches from several fish species.

Wales, J.H., 1970. Hepatoma in rainbow trout. In: Snieszko, S.F. (Ed.), A Symposium on Diseases of Fishes and Shellfishes, Special Publication No. 5. American Fisheries Society, Washington, DC, pp. 351–365.
The literature cited in Wale's paper serves as a source for some of the publications of Laurence M. Ashley, John E. Halver, Joseph H. Wales, Harold Wolf and Edward M. Wood.

Wales, J., Wolf, H., 1955. Three protozoan diseases of trout in California. Calif. Fish Game 41, 183–187.
The reference section in this paper serves as a source for some of the publications of Joseph H. Wales.

Walker, R., Sherburne, S.W., 1977. Piscine Erythrocytic Necrosis Virus in Atlantic cod, *Gadus morhua*, and other fish: ultrastructure and distribution. J. Fish. Res. Board Can. 34, 1188–1195.
The reference section serves as a source for some of the publications of Roland Walker and for some biographical information on Walker.

Walker, S.T., 1884. Fish mortality in the Gulf of Mexico. Proc. U. S. Natl. Mus. for 1883, 6, 105–109.
Walker reports a serious fish kill of many fish species in the Gulf of Mexico off the coast of Florida in 1880. Dead birds that had eaten the fish also were reported. He believed that eruptions of poisonous gases were responsible.

Ward, H.B., 1894a. On the parasites of lake fish: 1. Notes on the structure and life history of *Distoma opacum* n. sp. Proc. Am. Microsc. Soc. 15, 173–182 [taken from Hoffman, 1967].
This paper concerns the trematode, *Distoma opacum*, found in fish.

Ward, H.B., 1894b. Some notes on the biological relations of the fish parasites of the Great Lakes. Proc. Nebraska Acad. Sci. 4, 8–11.
This note has a table of 20 fish parasites (listed by Class) and their hosts. Trematodes, nematodes, acanthocephala and cestodes are included in the table.

Ward, H.B., Whipple, G.C., 1918. Fresh-Water Biology. Wiley, New York, 1111 pp.
This book by Ward and Whipple stood alone as the freshwater biology textbook for decades.

Webb, J.G., 1887. The mortality of fish in the Gulf of Mexico. Bull. U. S. Fish Comm. for 1886, 6, 11–13.
Webb reported on a fish kill from the Gulf of Mexico near Florida that he believed was caused by toxic water released from underground channels.

Wedemeyer, G.A., Meyer, F.P., Smith, L., 1976. In: Snieszko, S.F., Axelrod, H.R. (Eds.), Environmental Stress and Fish Diseases: Diseases of Fishes (Book 5). T.F.H. Publications, Neptune City, NJ, 192 pp.
This was the first book written on the role of stress in fish diseases and is still considered one of the best on the subject today. This also was one of a series of six books co-edited by Stanislas F. Snieszko.

Weissenberg, R., Nigrelli, R.F., Smith, G.M., 1937. Lymphocystis in the hogfish, *Lachnoaimus maximus*. Zoologica 22, 303–305.
This paper on the Lymphocystis Disease in hogfish probably was the first publication in the U.S. written with an understanding of fish disease with a viral etiology.

Wellborn Jr., T.L., 1983. The catfish story: Farmers, state services create new industry. In: Hayes, J. (Ed.), Using Our Natural Resources: 1983 Yearbook of Agriculture. United States Department of Agriculture, pp. 298–305.
In this paper some biographical information on Tommy B. Taylor is given.

White, J.C., 1859. On the parasites of *Orthagoriscus mola*. Proc. Boston Soc. Nat. Hist. 6, 404 [taken from McGregor, 1923 and Wilson, 1917].
This paper describes a crustacea (*Pennella filosa*) on *Orthagoriscus mola*.

Wilcox, W.A., 1889. The fisheries of Gloucester, MS, in May 1887, with notes on those of other localities. Bull. U. S. Fish Comm. for 1887, 7, 76–78 (77).
This paper reports a wild fish kill off the coast of Massachusetts.

Willcox, J., 1887. Fish killed by cold along the Gulf of Mexico and Coast of Florida. Bull. U. S. Fish Comm. for 1886, 6, 123.

Willcox reported many dead fish (salt and freshwater) in 1885 in the shallow waters of the bays and rivers and only a few dead at the rivers' inlets to the Gulf of Mexico (Florida). He thought cold water was to blame.

Wilmont, S., 1883. Appendix to salmon-hatching report, 1880. U. S. Comm. Fish and Fisheries: Part VIII. Report of the Commissioner for 1880. Government Printing Office, Washington, pp. 611–613 (613).
Wilmont discussed a black spotted condition of salmon that apparently caused some to die. It appears from his description that the black spots may have been digenetic trematodes.

Wilson, C.B., 1904. A new species of *Argulus*, with a more complete account of two species already described. Proc. U. S. Natl. Mus. Washington 27, 627–655.
Wilson's paper gives some information on an unpublished manuscript by Revere R. Gurley.

Wilson, C.B., 1915. North American parasitic copepods belonging to the Lernaeopodidae, with a revision of the entire family. Proc. U. S. Natl. Mus. Washington 47, 565–729.
The references in this paper serve as a source for the publications of Nathan Fasten.

Wilson, C.B., 1916. Copepod parasites of fresh-water fishes and their economic relations to mussel glochidia. Bull. U. S. Bureau Fish. for 1914, vol. 34, Government Printing Office, Washington, pp. 333–374.
The references in this paper serve as a source for the publications of Charles B. Wilson.

Wilson, C.B., 1917. North American parasitic copepods belonging to the Lernaeidae with a revision of the entire family. Proc. U. S. Natl. Mus. Washington 53 (2194), 1–150.
The references in this paper serve as a source for the publications of Charles B. Wilson, Samuel Kneeland, D.H. Storer, and J.C. White.

Wilson, C.B., 1944. Parasitic copepods of the United States National Museum. Proc. U. S. Natl. Mus. Washington 94 (3177), 529–582.
This major treatise of parasitic copepods brought together information on all the collected copepods held at the National Museum.

Wolf, H., 1970. Problems associated with the operation of fish inspection programs in California. In: Snieszko, S.F. (Ed.), A Symposium on Diseases of Fishes and Shellfishes, Special Publication No. 5. American Fisheries Society, Washington, DC, pp. 36–40.
The literature cited in this paper serves as a source for some of the publications of Harold Wolf.

Wolf, K., 1956. The cause and control of blue-sac disease. PhD dissertation. Utah State University, Logan. [taken from Wolf, 1988].
This is apparently the first report of the use of cell cultures to attempt to detect fish virus in the U.S.

Wolf, K., Snieszko, S.F., 1980. J. Fish Dis. 3, 451–453.
This paper gives biographical information on Stanislas F. Snieszko.

Wolf, K., 1988. Fish Viruses and Fish Viral Diseases. Cornell University Press, Ithaca, NY, 476 pp.
This is the first textbook on fish viruses and it contains some biographic information on Richard Weissenberg, Roland Walker and M. Michael Sigel. Its references serve as a source for publication of these three.

Wolf, K., Markiw, M.E., 1984. Biology contravenes taxonomy in the Myxozoa: new discoveries show alternation of invertebrate and vertebrate hosts. Science 225, 1449–1452.
This paper describes the life cycle of whirling disease, a breakthrough in the understanding of the life cycles of sporozoan parasites of fish.

Wolf, K., Quimby, M., 1962. Established eurythermic line of fish cells in vitro. Science 135 (6), 20–22.
Describes the establishment of cell lines for detection of fish viruses.

Wolf, K., Snieszko, S.F., Dunbar, C.E., 1959. Infectious pancreatic necrosis, a virus-caused disease of fish. Excerpta Med. Abstr. 13, 228 [taken from Wolf, 1988].
This is the first isolation of a virus disease from a fish (IPNV from trout).

Wood, E.M., 1953. A century of American fish culture. Prog. Fish-Cult. 15 (4), 147–162.
This publication includes information on early American culturists, information on the expression of the need for a fish pathologist in the late 1890s, information on the Congressionally approved appointment of a fish pathologist (Herbert S. Davis) as a regular working member of the Bureau of Fisheries, and a literature cited list that includes two publications of Millard C. Marsh on hematology.

Wood, E.M., Yasutake, W.T., Johnson, H.E., 1957. Acute sulfamethazine toxicity in young salmon. Prog. Fish-Cult. 19 (2), 64–67.

The literature cited in this paper serve as a source for the publications of Edward M. Wood and biographic information.

Wood, W.M., 1882. Letter to Professor Baird. Bull. U. S. Fish Comm. for 1881, 1, 274.

This is a note on a fish kill in the Connecticut River, MA that was attributed to pollution from a paper mill.

Woodward, J.J., 1859. Communication on fungous growth on the head of a killifish. Proc. Acad. Nat. Sci. Phila. for 1858, 10, 12–13.

This is one of the earliest mentions of fungi infecting fish in the U.S. Woodward describes fungi on killifish (*Fundulus fasciata*).

Worth, S.G., 1895. Report on the propagation and distribution of food-fishes. U. S. Comm. Fish and Fisheries: Part XIX. Report of the Commissioner for 1893. Government Printing Office, Washington, pp. 78–138 (85, 86, 98–99, 113).

This paper reports that a fry mortality was arrested with the use of salt and earth, that a horse-leech was observed to kill salmon, that a parasite most probably *Ichthyophthirius* was observed on lake trout fry, that salt treatments applied to fish with white spots lowered their death rate, and that Revere R. Gurley was dispatched to study egg losses at a hatchery.

Worth, S.G., 1898. The Shad—A manual of fish-culture based on the methods of the United States Commission of Fish and Fisheries. Prepared under the direction of John J. Brice. U. S. Comm. Fish and Fisheries: Part XXIII. Report of the Commissioner for 1897. Government Printing Office, Washington, pp. 1–340 (27–66).

In this manual the development of fungi on shad eggs is considered one of the greatest dangers to the eggs.

Yamaguti, S., 1958. Systema Helminthum: The digenetic Trematodes of Vertebrates, Part II, vol. I, Interscience Publishers, New York, pp. 981–1575.

Yamaguti's book serves as a source for the publications of several parasitologists who worked with fish.

Yamaguti, S., 1959. Systema Helminthum: The Cestodes of Vertebrates, Vol. II, Interscience Publishers, New York, pp. 1–860.

Yamaguti's book serves as a source for the publications of several parasitologists who worked with fish.

Yamaguti, S., 1961. Systema Helminthum: The Nematodes of Vertebrates, Part II, Vol. III, Interscience Publishers, New York, pp. 681–1261.

The references in this book serve as a source for the publications of Harold W. Manter.

Yamaguti, S., 1963. Systema Helminthum: The Monogenea and Aspidocotylea of Vertebrates, Vol. IV, Interscience Publishers, New York, pp. 1–699.

Yamaguti's book serves as a source for the publications of several parasitologists who worked with fish.

Yasutake, W.T., Wales, J.H., 1983. Microscopic Anatomy of Salmonids: An Atlas. U.S. Department of Interior, U.S. Fish and Wildlife, Washington, DC, Resource Publication 150, 189 pp.

This atlas of salmonid histology represented the culmination of a lifetime of work for Yasutake. The references in this publication serve as a source for the publications of Joseph H. Wales.

Yasutake, W.T., Wolf, H., 1970. Occurrence of whirling disease of trout in Western United States. J. Fish. Res. Board Can. 27 955–956.

The references in this publication serve as a source for the publications of Harold Wolf.