Parasites of Salmonid Fishes from Southcentral Alaska

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PARASITES OF SALMONID FISHES FROM
SOUTHCENTRAL ALASKA

BY
JAMES CARL RIIS

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A thesis submitted in partial fulfillment of the requirements for the degree Master of Science, Major in Zoology, South Dakota State University

1974
PARASITES OF SALMONID FISHES FROM
SOUTHCENTRAL ALASKA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser

Head, Entomology-Zoology Department

Date
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JCR
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>REVIEW OF LITERATURE</td>
<td>3</td>
</tr>
<tr>
<td>METHODS</td>
<td>8</td>
</tr>
<tr>
<td>RESULTS AND DISCUSSION</td>
<td>13</td>
</tr>
<tr>
<td>Salmonid Fishes</td>
<td>13</td>
</tr>
<tr>
<td>Parasites of Salmonids</td>
<td>14</td>
</tr>
<tr>
<td>TREMATODA</td>
<td>14</td>
</tr>
<tr>
<td>CESTODA</td>
<td>16</td>
</tr>
<tr>
<td>NEMATODA</td>
<td>23</td>
</tr>
<tr>
<td>Family Heterocheilidae</td>
<td>23</td>
</tr>
<tr>
<td>Family Cucullanidae</td>
<td>25</td>
</tr>
<tr>
<td>Family Philometridae</td>
<td>26</td>
</tr>
<tr>
<td>ACANTHOCEPHALA</td>
<td>27</td>
</tr>
<tr>
<td>COPEPODA</td>
<td>28</td>
</tr>
<tr>
<td>SUMMARY AND CONCLUSIONS</td>
<td>36</td>
</tr>
<tr>
<td>LITERATURE CITED</td>
<td>42</td>
</tr>
<tr>
<td>APPENDIX</td>
<td>48</td>
</tr>
</tbody>
</table>
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>FISHES EXAMINED FOR PARASITES, SOUTHCENTRAL ALASKA, SUMMER, 1973</td>
<td>31</td>
</tr>
<tr>
<td>2.</td>
<td>PARASITES FOUND IN FISHES, SOUTHCENTRAL ALASKA, SUMMER, 1973</td>
<td>33</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Brachyphallus crenatus</em> to show telescopic tail.</td>
<td>38</td>
</tr>
<tr>
<td>2.</td>
<td>Enlargement of <em>B. crenatus</em> to show preacetabular pit.</td>
<td>38</td>
</tr>
<tr>
<td>3.</td>
<td><em>Cyathocephalus truncatus</em>.</td>
<td>38</td>
</tr>
<tr>
<td>4.</td>
<td>Immature <em>Eubothrium</em>.</td>
<td>38</td>
</tr>
<tr>
<td>5.</td>
<td>Mature <em>Eubothrium</em>.</td>
<td>39</td>
</tr>
<tr>
<td>6.</td>
<td><em>Eubothrium</em> proglottids.</td>
<td>39</td>
</tr>
<tr>
<td>7.</td>
<td>Scolex of <em>Proteocephalus</em>.</td>
<td>39</td>
</tr>
<tr>
<td>8.</td>
<td><em>Proteocephalus</em> proglottids.</td>
<td>39</td>
</tr>
<tr>
<td>9.</td>
<td>Scolex of <em>Phyllobothrium</em>.</td>
<td>40</td>
</tr>
<tr>
<td>10.</td>
<td>Mouth parts and pharynx of <em>Cucullanus</em>.</td>
<td>40</td>
</tr>
<tr>
<td>11.</td>
<td>Mouth parts of <em>Cucullanus</em>.</td>
<td>40</td>
</tr>
<tr>
<td>12.</td>
<td>Preanal sucker of <em>Cucullanus</em>.</td>
<td>40</td>
</tr>
<tr>
<td>13.</td>
<td>Gross appearance of <em>Philonema oncorhynchi</em>.</td>
<td>41</td>
</tr>
<tr>
<td>14.</td>
<td>Posterior end of male <em>P. oncorhynchi</em>.</td>
<td>41</td>
</tr>
<tr>
<td>15.</td>
<td>Larvae expressed from female <em>P. oncorhynchi</em>.</td>
<td>41</td>
</tr>
<tr>
<td>16.</td>
<td>Posterior end of <em>Raphidascaris</em>.</td>
<td>41</td>
</tr>
<tr>
<td>17.</td>
<td>Posterior end of <em>Porrocaecum</em>.</td>
<td>42</td>
</tr>
<tr>
<td>18.</td>
<td>Proboscis of <em>Neoechinorhynchus rutili</em>.</td>
<td>42</td>
</tr>
<tr>
<td>19.</td>
<td>Enlargement of <em>N. rutili</em> proboscis to show hooks.</td>
<td>42</td>
</tr>
<tr>
<td>20.</td>
<td><em>Salmincola</em> showing pair of egg sacs.</td>
<td>42</td>
</tr>
<tr>
<td>Map</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>1. Approximate boundary of study area is indicated by block.</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>
INTRODUCTION

The importance of fish parasites is directly related to the value of the fish they affect. Alaskan salmonids are extremely important and are constantly increasing in value to the United States. Other countries, such as Japan and Russia, are also finding Alaskan salmonids important as a foodstuff. If human populations continue growing at present rates, in only a few years there could be twice as many people eating fish. As a recreational asset in Alaska, salmonids rank at or near the top, both for sportfishing and as a natural attraction. It is thus important from an economic point of view that we have a knowledge of the parasites of our freshwater and marine fishes.

Parasites are always present in natural populations of animals. Normally, the parasites are in a complex dynamic equilibrium with their hosts. In any natural aquatic environment fishes are the apex of the predator-prey pyramid, which is a complex web of food chains. Fish are exposed to a considerable range of parasites, which may occur in large numbers.

If some unusual event occurs in the environment, the equilibrium between parasite and host may be upset and an epizootic of parasites may occur. Regulating mechanisms in the environment eventually will restore this balance, but before a new equilibrium is established there may be a serious fish loss. Once sound background knowledge is attained, it may be possible to avoid undesirable interference in
natural waters. To control the more harmful parasites, an understanding of the biology of the parasites is required.

Hoffman (1967) stated that before treatment or control of fish parasitic diseases can be best achieved, the study of fish parasites should follow a logical pattern:

1. Identifying the parasite.
2. Obtaining a thorough knowledge of its life history, which may be simple or very complicated.
3. Learning the ecological requirements of the parasite, such as host specificity, optimum temperature, pH, nutrition, and other metabolic requirements.
4. Mapping the geographic range of the parasite.
5. Determining the effect of immunologic mechanisms of the host on the parasite or vice versa.
6. Studying control and treatment methods.

The primary objectives of my research were:

1. To determine the incidence and identity of parasites found in salmonid fishes in southcentral Alaska.
2. To assist in mapping the geographic range of the parasites.
McGregor (1963) has shown that diseases of fish were recognized centuries ago in his partial bibliography on fish parasites and diseases from 330 B.C. to A.D., 1923. Mawdesley-Thomas (1972) found in the Egyptian collection of the British Museum a tomb painting of a fish with a swollen abdomen which was dated approximately 1450 B.C.

The parasite fauna of the freshwater fishes of eastern and central United States are fairly well known as the result of several regional surveys. The first comprehensive study on parasites of freshwater fishes in the United States was conducted by Mueller and Van Cleave (1932). The chief aim of this survey was to present a comprehensive treatment of the biology and ecology of the parasites of fishes in a single lake, Oneida Lake in New York. Many new species of parasites were described and many new host records were established during this study.

Other early studies in the eastern United States on fish parasites were done in New York by Hunter and Hunter (1930, 1931). A comparative study on the parasites of northern pike and pickerel of Lake Pactopaug in Connecticut with parasites of the same two species of fish from other localities was conducted by Hunter and Rankin (1940).

Meyer (1954), another important investigator in the eastern United States, examined fish from many different lakes in Maine. The species of parasites found were reported and their life cycles were described.
Investigators in the midwest have also contributed to the knowledge of fish parasites. Fischthal (1947, 1950, 1952, and 1953) did extensive studies on the parasites of fishes from various lakes, ponds, streams, and rivers in northwestern Wisconsin. Anthony (1963) examined fishes from 17 different lakes throughout Wisconsin.

Lawler and Watson (1958) studied parasites of fishes from three lakes in Michigan. In northern Minnesota, new distribution records were determined for parasites of fish from Basswood Lake by Odlaug, Arseneau, and Brownell (1962).

Wilson (1957) conducted two surveys on Leavenworth County State Lake in Kansas. In these surveys, 66 percent of the fish were infected with at least one species of parasite. Harms (1959, 1960) also conducted two surveys in Kansas on the parasites of catfish. The author discussed the importance of the ecological habitat on the degree of parasitism.

Meyer (1958) conducted a detailed study of parasites of fish that were collected during the summers of 1954 and 1955 in Clay County, Iowa.

The first survey in North Dakota was by Hoffman (1953). Collections were made during the summers of 1951 and 1952 from the Turtle River near Arvilla. Examination of 195 fish of nine different species showed 92 percent to be infected with at least one species of parasite.
Huggins (1959) conducted the first extensive investigation of parasites of fishes in South Dakota. A total of 589 fish of 28 different species were examined from 33 different bodies of water. Of the fishes examined, 449 or 76 percent were parasitized by at least one of the 35 different species of parasites found.

In the western part of the North American Continent, isolated records give a very incomplete picture of parasitism. Wardle (1932a, 1933a, 1933b), Smedley (1933), Kuitunen-Ekbaum, (1933a, 1933b), Lynch (1936), Shaw (1947), Gustafson (1949), and Van Cleave and Lynch (1950) are some of those who have contributed to the western records of fish parasitism. Bangham (1951) conducted a study on the parasites of fish in the upper Snake River drainage and in Yellowstone Lake in Wyoming. Haderlie (1953) published a fairly extensive study on the parasites of freshwater fishes in northern California.

Bangham and Adams (1954) surveyed the parasites of freshwater fishes from the mainland of British Columbia. This was the first attempt to give a comprehensive picture of the geographic distribution and of the degree of parasitism in freshwater fishes of this area. Examination of 5,456 fish of 36 different species collected in 1951 and 1952 showed 90 percent to be infected with at least one species of parasite. The authors concluded that the parasite fauna of fishes in this area appeared to be less varied than that of eastern and southern parts of the continent.
Perhaps the most noteworthy contribution of parasitology to an understanding of the life of Pacific salmon has been in the use of parasites to determine the ocean distribution of some stocks of sockeye salmon (Margolis, 1963). To fulfill the role of a "biological tag" a parasite must have a relatively long life span, preferably as long as that of the fish, and, of course, the geographical areas in which infection takes place must be limited. Two parasites of freshwater origin have been found in sockeye salmon which satisfy these requirements. Others of potential value are presently under study (Margolis, 1965). The two freshwater parasites are the plerocercoid larva of *Triacanthoborus crassus* Forel (Cestoda), which is found only in stocks originating in western Alaska, and *Dacnitis truttae* Fabricius (Nematoda), which is known to occur only in some sockeye salmon from Kamchatka.

Margolis has been a very important contributor to the understanding of the parasites of fishes of the Northwest. He showed how data about parasites could provide supplementary information about the biology of the Pacific salmons (*Oncorhynchus* spp.).

Soviet investigators (Dogiel et al., 1958) have given a great deal of attention to the ecological approach of parasitic fish diseases. Concerning their work, Kabata (1971) said:

"This book represents the first attempt at a comprehensive summing up of the problems of fish parasitology, both marine and freshwater. It is based on a prodigious effort of
scientists of a country which offers within its frontiers an almost full range of habitats existing on earth. This wide range of experience has allowed them to postulate, though often only tentatively, some general principles governing the most important phenomena occurring within the field of fish parasitology."

One of the most important reference sources on parasites of North American freshwater fishes was published by Hoffman (1967). In the introduction of this book, the author states that very little work had been reported from Alaska.

Rausch (personal communication), an eminent parasitologist with the Arctic Health Research Center in Fairbanks, Alaska, stated that to his knowledge, "very little has been done concerning parasites of fishes in Alaska."

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1Based on personal correspondence with Dr. Robert L. Rausch, Chief, Infectious Disease Section, Arctic Health Research Center.
METHODS

The fishes used for this study were collected from May 15, 1973, to August 15, 1973. The approximate boundary of the study area is shown in Map 1, and specific location of collections are in the Appendix. The majority of the fishes used for this study were caught in experimental monofilament gill nets. To sample completely the species composition and different age classes in a lake, two nets were stationed on the surface and two were stationed on the bottom.

Other methods used to obtain fish were as follows:

1. A weir to trap out-going smolts.
2. A fishwheel and trap to collect adult salmon that were moving upstream to spawn.
3. A backpack electrical fish shocker to capture fish from creeks and rivers.
4. Sportfishing with rod and reel.

Each fish was assigned a collection number and location, date, species, sex, total length, weight, and location of parasite within the host were recorded. The fish were examined as soon as possible after death. The entire external surface was carefully searched for ectoparasites, with special attention given to the oral region, gills, opercula, and the fins. Parasitic copepods were placed in 70 percent ethyl alcohol and stored in vials.
Map 1. Approximate boundary of study area is indicated by block.
Following the external examination, the body cavity was opened from the anus to the isthmus. The viscera and body cavity were examined for endoparasites. Next, the gastrointestinal tract was removed and thoroughly examined.

Cestodes, trematodes, nematodes, and acanthocephalans were stored in 70 percent ethyl alcohol. Plastic bags and vials were used for storage until clearing and mounting for identification. A label which contained the host number, name of the fish, sex, total length, weight, date, and location from which the fish was taken was included in each vial along with the parasites found.

Semichon's acetic-carmine was used in staining the parasites. The specimens were transferred from the 70 percent alcohol used for storage directly to the stain and left overnight in the stain. They were then rinsed with 70 percent alcohol to remove excess stain from the dish. Destaining was accomplished by adding a mixture of HCL and 70 percent alcohol until the cortical layer was nearly free of stain and the reproductive organs were a light pink.

Next, the specimens were run through two washes of fresh 70 percent alcohol to stop destaining. Complete dehydration was then accomplished by running the specimens through single baths of 80 and 90 percent ethyl alcohol, and at least two changes of absolute ethyl alcohol. Time required in the alcohols for dehydration depended on the size of the specimen and the permeability of its integument.
With all traces of water removed, the specimens were ready for clearing. First, they were transferred to a solution of one-half xylol and one-half absolute ethyl alcohol, to avoid the formation of violent diffusion currents which may distort specimens. The final step in clearing was with pure xylol. So that the specimens would not absorb moisture from the atmosphere, they were quickly transferred from xylol to a few drops of mounting medium on a glass slide and a glass cover slip was applied. The mounting medium was Harleco \textregistered synthetic resin. The host number was etched onto each slide and the slides were put in a drying oven.

All of the cestodes, trematodes, acanthocephalans, and a few nematodes were permanently mounted in the manner just described. Un-mounted nematodes were transferred from 70 percent ethyl alcohol and cleaner in a mixture of 90 parts 70 percent ethyl alcohol and 10 parts glycerine. The vials were left open so that the alcohol would evaporate, and glycerine was slowly added until the nematodes were in pure glycerine. The mounted parasites and the nematodes in glycerine could then be studied, identified, and photographed.

Photomicrographs of the parasites were taken with a Wild (Heerbrugg) M 20 \textregistered microscope equipped with H-tube and Photoautomat MKa4 \textregistered camera with 35 mm film. Photographs were taken at various magnifications and degrees of lighting. Photomicrographs of larger specimens were taken with a Wild (Heerbrugg) M 5 \textregistered stereomicroscope. The photoautomat MKa4 \textregistered camera was used again with 35 mm film and a
light-field background setting and reflected lighting from two high intensity spot lights.

Photomacrophotographs of copepods were taken with a Canon® FT/QL camera, Canon® bellows, and Canon® macro lens.

Kodachrome® II film with an ASA rating of 25 was used for all photographs.
RESULTS AND DISCUSSION

Salmonid Fishes

The Family Salmonidae contains the salmon, trout, whitefishes, and grayling. These fish are characterized by an adipose fin and an axillary process at the base of each pelvic fin. This family is divided into the salmon-trout subfamily, Salmoninae, the whitefish subfamily, Coregoninae, and the grayling subfamily, Thymallinae.

The members of the subfamily Salmoninae possess fine scales, coarse stubby gill rakers, and well developed teeth. This subfamily includes the Pacific salmon, (Oncorhynchus spp.); the trout, (Salmo spp.); and the charrs, (Salvelinus spp.). These fish thrive best in water not warmer than 70°F and were originally confined to the colder waters of the northern hemisphere. The Pacific salmon are anadromous, living in the sea and spawning in freshwater. Most trout live in streams and lakes.

The members of the subfamily Coregoninae are found only in the northern part of the Northern Hemisphere. They have poorly developed teeth, weak jaws, and filamentous gill rakers. Most of the whitefishes live in lakes.

The subfamily Thymallinae is represented by several species of grayling which are found in northern Europe, Asia, and North America. They are easily recognized by their large sail-like dorsal fin.
The various members of the Family Salmonidae have a wide range of feeding habits and thus are susceptible to a variety of different parasites.

Examination of 92 fish of nine different species showed 83.5 percent to be infected with at least one species of parasite. The fishes examined and the parasites found are listed in Tables 1 and 2.

Parasites of Salmonids

TREMATODA

The flukes represent the Class Trematoda in the Phylum Platyhelminthes. This phylum contains all of the so-called flatworms which are characterized as having a body that is flattened dorso-ventrally; an excretory or osmoregulatory system composed of flame cells, tubules and excretory vesicle; and internal organs embedded in a parenchymatous tissue which develops from mesoderm and resembles the mesenchyme of embryos of more advanced animals (Schell, 1970).

The trematodes are all parasitic, usually in or on vertebrates. There are two orders of trematodes, Monogenea and Digenea. The monogenetic flukes are essentially ectoparasites on the gills and skin of many different fishes and have direct life cycles involving no intermediate hosts. There were no monogenetic flukes observed on fishes in this study. It is possible that some of these flukes were present and were overlooked because of their extremely small size.
The digenetic flukes are endoparasites and have indirect life cycles involving one or more intermediate hosts, the first of which is always a mollusk. Only three specimens of a digenetic fluke, *Brachyphallus crenatus* (Rudolphi), were found in this study. All were obtained from the stomachs of king salmon, *Oncorhynchus tschawytscha* (Walbaum). This fluke is in the Family Hemiuridae and has a distinct "telescoping tail," an elongated body, and often a pit between the ventral sucker and genital pore. The tail and the pit are illustrated in Figures 1 and 2. Lloyd (1938) pointed out that this genus combines the characters of two subfamilies, Hemiurinae and Sterrhurinae, having the ringed cuticle of the former, but the presomatic pit and vesicular parenchyma of the latter. Lloyd found it impossible to assign the genus *Brachyphallus* to either the Hemiurinae or Sterrhurinae and stated that it is best to consider it as an isolated genus intermediate between the two subfamilies.

Yamaguti (1934) reported *B. crenatus* from *O. milktschitsch* (Walbaum). Lloyd (1938), Miller (1941), and Shaw (1947) found this species in the stomachs of *O. tschawytscha*. Bangham and Adams (1954) found this species in dolly varden charr, *Salvelinus alpinus malma* (Walbaum). Additional hosts for *B. crenatus* were listed by Linton (1940) and Dawes (1946).

Schell (1970) stated that in the few life cycles known for the Family Hemiuridae, cystophorous cercariae develop in rediae in snails.
The cercariae are thought to be eaten by copepods in which they develop in the hemocoel.

In discussing how parasites might be an auxiliary source of information about the food and feeding habits of Pacific salmon, Margolis (1965) said that the presence of *B. crenatus* is indicative of the consumption of crustacean plankters during their marine life.

**Cestoda**

The tapeworms are in the Phylum Platyhelminthes, Class Cestoidea. All of the members of this class are obligate parasites. The tapeworms have no digestive system and must absorb their food through their body wall. The scolex, or head, is an organ of attachment only; no food is absorbed through the scolex. The body usually consists of a chain of segments called proglottids, each of which contains both female and male reproductive organs. A few primitive tapeworms have an elongated body that is nonsegmented with only one set of reproductive organs. Two life-cycle stages of tapeworms are represented in fish. Adults inhabit the pyloric ceca and intestine and the second stage larvae, the plerocercoids, are found in the musculature and in the visceral organs. First stage larvae, called procercoïds, are found in aquatic copepods, amphipods, and isopods.

*Cyathocephalus truncatus* is common in northern Europe in species of whitefish (*Coregonus*) and trout (*Salmo*). Neiland (1952) listed the cut-throat trout, *Salmo clarkii* Richardson as a host of *Cyathocephalus*
in Washington. Hoffman (1967) listed the following additional genera as hosts to *C. truncatus*: *Thymallus*, *Salvelinus*, and *Oncorhynchus*.

I found two specimens of *C. truncatus* (Pallas) in separate silver salmon, *Oncorhynchus kisutch* (Walbaum). The strobila appear to have no external segmentation, but segmentation is present internally. The adhesive organ is funnel-like, a character of the Family Cyathocephalidae. The family is in the Order Spathebothrioidea which was established by Hart and Guberlet (1936) for certain genera formerly included in the Order Pseudophyllidea. Wardle and McLeod (1952) found no evidence that the organs of adherence in *C. truncatus* are derived from bothria. They classified the order upon the genus *Spathebothrium* because they regarded the lack of a differentiated holdfast end in that genus as a more primitive character than the differentiated holdfast end of the other genera. Cooper (1918), while studying material from Lakes Huron and Michigan, believed that the American parasites differed from European material because of the absence of a sphincter muscle around the vagino-uterine aperture. He described these specimens as *C. americanus* Cooper. However, Wardle (1932b) showed that there is such a muscle, and *C. americanus* and *C. truncatus* appear to be identical. *C. truncatus* is shown in Figure 3.

Cooper described two gammarids as being vectors in the life history. The eggs develop in fish excreta and are eaten by a gammarid. The salmon becomes infected by swallowing infected gammarids.

I found *Eubothrium* spp. in seven king salmon, three silver salmon, 11 rainbow trout, *Salmo gairdneri* Richardson, and three dolly
varden. In many of the hosts, this cestode was confined to the pyloric caeca. Occasionally, a specimen was found in the intestine. The scolex of this tapeworm is elongated with simple bothria, an apical disk, and two grooves, which place it in Order Pseudophyllidea; no hooks or suckers are present. Cooper (1918) described the occurrence of a deformed holdfast which may be found at the same stage of development as tapeworms that have normal holdfast organs in the same fish. The deformity consists of a hypertrophy of the apical disk and anterior half of the holdfast to form a pyramid-shaped pad which is embedded in the walls of the pyloric caecum of the fish. Consequently, I damaged many specimens when trying to remove them from the pyloric caeca because of the manner in which they become embedded.

Figures 4, 5, and 6 show Eubothrium characters.

Eubothrium oncorhynchi Wardle is the common tapeworm of the Pacific salmon, (Oncorhynchus spp.). This parasite is very close in its features to E. crassum (Block), the common tapeworm of the genus Salmo, and therefore should be regarded as species inquirendae (Wardle and McLeod, 1952).

Wardle (1932a) listed the king salmon as a host of Eubothrium. Shaw (1947) found Eubothrium in dolly varden from Oregon. Haderlie (1953) found Eubothrium in the intestine of six large king salmon from a tributary of the Klamath River in California. Griffith (1953) reported Eubothrium in rainbow trout from Washington. DeRoth (1953) reported Eubothrium in salmonid fishes from Maine. Bangham and Adams
(1954) found *Eubothrium* in both *Oncorhynchus* spp. and *Salmo* spp. Dombroski (1955) stated that 35 percent of one-year old red salmon smolts, *Oncorhynchus nerka* (Walbaum), migrating from Babine Lake in British Columbia in 1952 and 1953, were infected with *Eubothrium*. Fish infected by cestodes only or cestodes and nematodes were significantly smaller than uninfected fish or those with nematodes only, which indicates that this cestode retards growth.

Smith and Margolis (1970) also conducted a study on Babine Lake. From the lake 20 and 50 million red salmon yearlings migrate seaward annually between May 1 and June 15. These fish were sampled daily for certain vital statistics. Twenty percent were found to be infected with the cestode *E. salvelini* (Schrank). The authors initiated studies to measure the effects of this parasite on individual fish and on total sockeye production of Babine Lake. Infected smolts averaged about 1 g lighter and 5 mm shorter than noninfected ones. Smolts carrying parasites were also shown to fatigue much faster in an experimental swimming tunnel. These studies not only suggested that small infected smolts suffer higher postlacustrine mortality, but also that they were inclined to stay at sea more years than larger ones. Smolt runs that have a high percentage of infected fish can be expected to have poor survival rates.

In the life cycle of *Eubothrium* spp. there is no intermediate fish host. The procercoids occur in copepods and the adults are found in
salmon. Adult salmon excrete the egg which hatches into a ciliated, free-swimming coracidium. The coracidium contains a six-hooked embryo, called an onchosphere. The coracidia are ingested by microcrustaceans and the onchosphere develops into a procercoid. These tiny crustaceans are an important food item of salmonid fishes. When the copepod is eaten, the tapeworm matures in the intestine of the fish and begins laying eggs. Control of this parasite at some stage in its life cycle could be a very significant management tool in a program ultimately designed to increase the numbers of adult salmon returning to spawn.

I found Proteocephalus spp. in the intestines of one red salmon, five silver salmon, nine rainbow trout, three dolly varden, and one whitefish, Prosopium cylindraceum Pallas. These tapeworms have no spines, hooks, or folds of tissue on the holdfast. The scolex has four concave suckers and sometimes a fifth sucker or apical organ at the anterior tip. This genus is in the Order Proteocephaloidea and is extremely large and difficult to treat taxonomically. Many of the most noted experts have difficulty identifying species of this genus. The recognition of species-groups has been suggested in the past, but the distinctions between such species-groups are not clean-cut and some species fall into more than one group. Figures 7 and 8 show a scolex and proglottids of Proteocephalus.

LaRue (1914) found Proteocephalus in whitefish, Coregonus sp., and published a revision of the Family Proteocephalidae. Faust (1920)
discovered a new species of Proteocephalus in whitefish, Prosopium williamsoni (Girard) from Montana. Wardle (1932a, 1933a) found Proteocephalus in red salmon and whitefish from Canada. Alexander (1951) found a new species of Proteocephalus in rainbow trout from Oregon. Wagner (1953) initiated a study on the diseases of trout in California and discovered a proteocephalid tapeworm that was not previously described. Haderlie (1953) likewise reported Proteocephalus in California trout. Wagner (1954) worked out the life history of P. tumidocollus Weinland in rainbow trout. Meyer (1954) listed the lake whitefish, Coregonus clupeaformis (Mitchill), as a host of Proteocephalus. In British Columbia, Bangham and Adams (1954) found Proteocephalus in red salmon and rainbow trout. Freeman (1964) stated that species of Proteocephalus occur in many freshwater teleosts throughout most of the world and that few life cycles of proteocephalids have been studied in detail. Freeman studied the life cycles of P. parallacticus MacLulich in Algonquin Park, Canada. This species of cestode grows in lake trout, Salvelinus namaycush (Walbaum), which thrive in cold water. In contrast, most other proteocephalids are found in warm water fishes. Plerocercoids of P. parallacticus were observed throughout the year in the gut of most of the trout examined. Worms showing early segmentation were found shortly after the ice left the lakes and until freeze-up. Gravid worms first appeared in late May or early June. Eggs from gravid P. parallacticus were observed to be eaten by most, if not all planktonic copepods. Two basic routes were
suggested to complete its life cycle after obligatory development in the copepod. The first route is direct—the copepod is eaten by the trout and segmentation and egg production proceed in the gut. The second route is indirect—the infected copepod is eaten by a fish other than the trout, in which case the plerocercoid remains in its gut until it is eaten by a trout, in which the worm will mature.

Becker and Brunson (1968) discussed a problem with the bass tapeworm, *Proteocephalus ambloplitis* (Leidy), in the management of rainbow trout in western Washington. Concentrations of larvae of this tapeworm in the reproductive organs of bass cause the formation of connective tissue that often results in parasitic castration (Moore, 1926; Hunter, 1928; Bangham, 1927a and 1927b). *P. ambloplitis* is widely distributed in the eastern and central United States due to the stocking of infected fish (Hunter, 1928). In the Pacific Northwest, *P. ambloplitis* remains relatively unknown and has not been associated with populations of salmonids. In Washington, larvae of the bass tapeworm apparently infected salmonids only in waters shared with bass. Copepods eat the eggs that are released from the bass into the water and yearling trout acquire the plerocercoids by ingestion of the crustacea which harbor the infective proceroids. In the yearling trout, the plerocercoids were encapsulated under the surface of the visceral organs and in the mesenteries and liver. Becker and Brunson suggested modifications of lake rehabilitation and stocking procedures as a means of eliminating the parasite.
I found *Phyllobothrium* spp. in all five species of Pacific salmon that occur in Alaska. The following number of fishes were infected with *Phyllobothrium*: seven king salmon, four red salmon, two silver salmon, five pink salmon, *O. gorbuscha* (Walbaum), and eight chum salmon, *O. keta* (Walbaum).

The genus *Phyllobothrium* is in the Order Tetraphyllidea. The bothridia are folded and curled like leaves of lettuce, giving this tapeworm an unmistakable appearance. In some fish there were so many phyllobothroid tapeworms in the alimentary canal that they appeared to cause intestinal blockage. Dogiel *et al.* (1958) pointed out that these parasites exert influences of two kinds: obstruction of the lumen of the gut and damage to its walls.

Wardle and McLeod (1952) stated that the true identity of any species of *Phyllobothrium* can only be surmised after the material has been compared fully and carefully with both the original and later descriptions of the whole anatomy of the worm. Differences in the bothridia are used as the main distinctions in the key to species. Since the bothridia are mobile and vary greatly in shape at any moment, even between individuals of the same species, I did not attempt to assign specimens to species. Figure 9 shows a scolex of *Phyllobothrium*.

*Phyllobothrium* spp. are marine parasites and provide evidence that the hosts are migratory. Canavan (1928) reported a new species of *Phyllobothrium* from chum salmon in Alaska. Shaw (1947) found *Phyllobothrium* in steelhead. Bangham and Adams (1954) found *Phyllobothrium*
in red salmon. Hoffman (1967) also lists the king salmon as a host of Phyllobothrium.

NEMATODA

The nematodes, commonly called roundworms, are in the Class Nematoda, Phylum Aschelminthes. Members of this class have an elongated, cylindrical shape and lack segmentation. The sexes are separate and the female is usually somewhat larger than the male. Roundworms have a complete alimentary tract with a mouth and anus present. The Class Nematoda is very large and comprises both non-parasitic and parasitic forms with the majority being tiny free-living forms. Parasitic nematodes show a great variety in their life cycles which indicates they are not a closely unified group like the trematodes and cestodes. Features from various nematodes are illustrated in Figures 10 through 17.

Family Heterocheilidae

Contracaecum spiculigerum (Rudolphi) was recovered from the mesenteries of one rainbow trout. This worm is recognized by the stout white body usually about an inch long, and by the intestinal caecum which lies beside the esophagus. Other features are a tiny caudal spine at the posterior tip and a tiny boring tooth at the anterior tip.

Thomas (1937a) worked out the life cycle of C. spiculigerum. The adult worms live in the stomach of fish-eating birds, and the worm
eggs are excreted in the feces of the bird. Larvae hatch in the water and are eaten by small fish in which the worms encyst on the liver or mesenteries. The parasite may be transferred to larger fish that feed on the smaller ones. Birds acquire the parasites by eating infected fish. This nematode has no fish host specificity; it has been reported from many different species of fish from areas throughout North America.

A large larva of Porrocaecum sp. was found in a king salmon. This is a marine parasite that can also be recognized by the intestinal caecum that is present. Meyer (1954) reported a Porrocaecum sp. in anadromous fishes from Maine.

An Anisakis sp. was found in three red salmon, one king salmon, one silver salmon, and four chum salmon. The large larva of this marine parasite were coiled on the surface of the liver. The intestinal caecum is absent in this worm.

A Raphidascaris sp. was recovered from one king salmon. This genus is recognized by the presence of an esophageal appendix and the absence of an intestinal caecum.

Thomas (1937b) experimented with the life cycle of R. canadensis Smedley. The eggs pass out in the feces and become embryonated within eight hours. After one molt in the egg, they are infective to small bottom feeding fish. In these fish they are walled off in the mesenteries and liver and continue to grow until eaten by the definitive host which completes the cycle.
Shaw (1947) reported both *Anisakis* spp. and *Raphidascaris* spp. in king salmon from Oregon. Yamaguti (1961) listed *Thymallus, Salmo,* and *Salvelinus* as hosts of *Raphidascaris.*

Family Cucullanidae

A *Cucullanus* sp. was found in the intestine of 10 rainbow trout, one king salmon, and one grayling, *Thymallus arcticus* (Pallas). The anterior extremity of this worm is bent dorsally and the esophagus is dilated to form a pseudocapsule. The buccal capsule, which looks like unarmed "jaws", and the presence of a precloacal sucker in the male are good recognition features of this genus.

The genus *Bulbodacnitis* Lane has been differentiated from *Cucullanus* Mueller only by the possession of a tubercle on the dorsal aspect of the head (Yorke and Maplestone, 1926), but Yamaguti (1961) and Hoffman (1967) apparently felt there is no justification for separating them and listed *Bulbodacnitis* and *Dacnitis* Dujardin as synonyms of *Cucullanus.*

The life cycle of this genus is unknown. *Cucullanus* has been reported in rainbow trout from British Columbia by Smedley (1933). Shaw (1947) found *Cucullanus* in rainbow trout and king salmon from Oregon. Yamaguti (1961) listed over 50 species of *Cucullanus* that are found in many different species of fishes, most of which are not salmonids.
Family Philometridae

I found *Philonema oncorhynchi* Kuitunen-Ekbaum in the body cavity of three red salmon, two silver salmon, and three rainbow trout. The posterior extremity of this worm is curled and pointed. The tiny larvae are found in the gravid female which may be up to one foot long.

*Philonema* spp. cause adhesions of the viscera of trout and salmon; in severe cases the entire viscera is bound into a solid mass of adhesions preventing normal functions including reproduction (Meyer, 1960; Richardson, 1937).

Shaw (1947) found *P. oncorhynchi* in the peritoneum of rainbow trout. Haederlie (1953) also recovered *P. oncorhynchi* from rainbow trout from California. Dombroski (1955) reported that smolts of red salmon from Babine Lake in British Columbia were infected with *P. oncorhynchi*.

Margolis (1965) in discussing parasites as an auxiliary source of information about the biology of salmon, stated the freshwater parasite, *P. oncorhynchi* occurs commonly in red salmon. This parasite utilizes cyclopoid and diaptomid copepods as hosts of the larval stages which reflects the importance of planktonic copepods in the diet of young red salmon during their lake residence. The absence of this parasite in pink salmon and chum salmon also tells something about their food and feeding habits. The fry of these two species of fish begin their downstream migration immediately after emerging from the gravel and are in saltwater before they pick up the infective stage of *Philonema*. 
ACANTHOCEPHALA

Members of the Phylum Acanthocephala are commonly called thorny-headed or spiny-headed worms because of the proboscis which bears chitinoid hooks which become embedded in the intestinal wall of the fish. Thorny-headed worms are characterized as having an elongated, unsegmented, flat body. The sexes are separate and the males are usually smaller than the females. The adult acanthocephalan is restricted to the intestinal tract of the final host because, like the tapeworms, the worm has no vestige of a digestive system.

I found Neoechinorhynchus rutili (Cueller) in five red salmon, 10 silver salmon, and 11 rainbow trout. Neoechinorhynchus tumidus Van Cleave et al. was recovered from one whitefish, one rainbow trout, and one silver salmon, which also contained N. rutili. The Family Neoechinorhynchidae is easily recognized by the short, globose proboscis which has 18 hooks in six spiral rows of three each (Yamaguti, 1963). The proboscis and hooks are shown in Figures 18 and 19.

Recognition of N. rutili in America has come about gradually following a long period of confusion and indecision about the taxonomic status of some of the early collections. Van Cleave and Lynch (1950) reported that N. rutili has a circumpolar distribution. Information was published in detail for the first time giving proof of a wide dispersal of this species in freshwater fishes of the northern Holarctic region. Migratory hosts, such as salmonids, have introduced N. rutili into new localities during their wanderings.
The life history of *N. rutili* was demonstrated experimentally by Merritt and Pratt (1964). The adult worms release shelled embryos into the lumen of the digestive tract of the fish and are passed out in the feces. An ostracod ingests the eggs. The acanthor hatches out in the intestine of the ostracod and penetrates the wall of the intestine. In six to 12 days the acanthella is found free in the hemocoel where it gradually metamorphoses to the juvenile stage which is infective in fish.

Schmidt (1965) examined specimens from George Lake, Alaska. He found both *N. rutili* and *N. tumidus* in various whitefish, *Coregonus* spp.

**COPEPODA**

Parasitic copepods belong to the Phylum Arthropoda, Class Crustacea, subclass Copepoda. The crustaceans are a large group, including amphipods and the familiar crayfish which are non-parasitic. Copepods are undoubtedly the largest group of Crustacea that is parasitic on fishes.

I found *Salmincola californiensis* (Dana) on eight rainbow trout, and two silver salmon. *S. thymalli* (Kessler) was found on one grayling, and one whitefish. Most of these copepods were found on the gills and were obviously damaging the gill filaments. In the more heavily infected fish, the gill filaments were much shorter than normal and were pale in appearance. The large amount of space occupied
by these parasites in the gill cavity probably has an adverse effect on the proper functioning of the gills. *Salmincola* is illustrated in Figure 20.

Wilson (1908) published a list of North American parasitic copepods found on the fishes of the Pacific coast and described new genera and species. Wilson (1915) revised the Family Lernaeopodidae, of which *Salmincola* is a member. He listed the red salmon, brook trout, *S. fontinalis* (Mitchill), dolly varden, whitefish, *C. nelsoni* Bean, and king salmon as hosts of various species of *Salmincola*.

Savage (1935) discovered the life cycle of *S. edwardsi* (Olsson). The copepod eggs hatch into small free-swimming larvae which must find a suitable host within two days. The mouth parts bear a peculiar filament that the larva uses to attach itself permanently by forcing the filament into the tissue of the fish. The parasite then undergoes degeneration, becoming grublike. Sexual dimorphism is universally present with the male being much smaller than the female. Copulation occurs two and one-half to three weeks after attachment and after fertilization the male dies. The female also dies after she gives rise to two batches of embryonated eggs. The entire life cycle takes about two and one-half months.

Haderlie (1953) found *S. edwardsi* on several large rainbow trout in California. DeRoth (1953) and Meyer (1954) found the same species on brook trout in Maine. Bangham and Adams (1954) reported
S. edwardsi on dolly varden, lake trout, and rainbow trout in British Columbia.

Kabata (1969) published a revision of the genus *Salmincola*. Until this time the taxonomy of *Salmincola* was in deplorable condition. The taxonomy is now based mainly on the details of the appendages which are reliable criteria. Kabata (1970) stated that most of the species in the Family Lernaeopodidae are marine, though the genus *Salmincola* has infiltrated and become established in the fresh waters of the northern hemisphere. Kabata stated that S. *californiensis* is the common parasite of all species of *Salmo* and *Oncorhynchus* along the Pacific rim. He also stated that the circumpolar species, S. *thymalli*, although most common on *Thymallus*, also has been recorded from *Prosopium* sp. and *Salvelinus* sp.
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Number Examined</th>
<th>Number Infected</th>
<th>Parasites Found</th>
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<td>----------------</td>
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</table>
| Silver salmon| Oncorhynchus kisutch          | 24             | 20             | Plerocercoid of Pseudophyllidea  
Cyathocephalus truncatus  
Eubothrium sp.  
Proteocephalus sp.  
Phyllobothrium sp.  
Neoechinorhynchus rutili  
Neoechinorhynchus tumidus  
Philonema oncorhynchi  
Anisakis sp.  
Salmincola californiensis |
| King salmon  | Oncorhynchus tschawytscha     | 11             | 8              | Brachyphallus crenatus  
Eubothrium sp.  
Phyllobothrium sp.  
Cucullanus sp.  
Anisakis sp.  
Raphidascaris sp.  
Porrocaecum sp.  |
| Chum salmon  | Oncorhynchus keta             | 9              | 9              | Phyllobothrium sp.  
Anisakis sp.  |
| Pink salmon  | Oncorhynchus gorbuscha        | 4              | 4              | Phyllobothrium sp.  |
### TABLE 2

PARASITES FOUND IN FISHES, SOUTHCENTRAL ALASKA, SUMMER, 1973

<table>
<thead>
<tr>
<th>Kind of Parasite</th>
<th>Name of Parasite</th>
<th>Fish Host</th>
<th>Site in Fish</th>
<th>Number Examined</th>
<th>Number Infected</th>
<th>Percent</th>
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<td>Chum salmon</td>
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<td>Proteocephala</td>
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## TABLE 2 (continued)

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<th>Kind of Parasite</th>
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<th>Site in Fish</th>
<th>Number Examined</th>
<th>Number Infected</th>
<th>Percent</th>
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SUMMARY AND CONCLUSIONS

The objectives of this study were to determine the incidence and identity of parasites in salmonid fishes in southcentral Alaska and to assist in mapping the geographic range of parasites. The fishes examined for parasites are listed in Table 1. The incidence and identity of the parasites found are listed in Table 2. No previous work had been reported on parasites of fishes in this specific area of Alaska; therefore, all of these findings are range extensions. The locations of collections are listed in the Appendix.

A total of 92 fish of nine different species were examined for parasites. At least one species of parasite was found in 83.5 percent of the total number of fish examined.

Silver salmon and rainbow trout were the most heavily parasitized species of fish, each harboring 10 different species of parasites.

Nematodes and cestodes comprised the majority of parasites found. Six different genera of nematodes and four different genera of cestodes were represented. There were two species of acanthocephalans, two species of copepods, and one species of trematode.

Every parasite discussed in this study could be of pathological importance. Modern concepts of fishery management should encompass the control of parasitic diseases so that great losses of fish may be prevented. For effective control, the fullest possible details of the biology of parasites are required. These details can be acquired only through future research.
Figure 1. *Brachyphallus crenatus* to show telescopic tail.

Figure 2. Enlargement of *B. crenatus* to show preacetabular pit.

Figure 3. *Cyathocephalus truncatus*.

Figure 4. Immature *Eubothrium*. 
Figure 5. Mature *Eubothrium*.

Figure 6. *Eubothrium* proglottids.

Figure 7. Scolex of *Proteocephalus*.

Figure 8. *Proteocephalus* proglottids.
Figure 9. Scolex of *Phyllobothrium*.

Figure 10. Mouth parts and pharynx of *Cucullanus*.

Figure 11. Mouth parts of *Cucullanus*.

Figure 12. Preanal sucker of *Cucullanus*.
Figure 13. Gross appearance of *Philonema oncorhynchi*.

Figure 14. Posterior end of male *P. oncorhynchi*.

Figure 15. Larvae expressed from female *P. oncorhynchi*.

Figure 16. Posterior end of *Raphidascaris*. 
Figure 17. Posterior end of *Porrocaecum*.

Figure 18. Proboscis of *Neoechinorhynchus rutili*.

Figure 19. Enlargement of *N. rutili* proboscis to show hooks.

Figure 20. *Salmincola* showing pair of egg sacs.
LITERATURE CITED


Dawes, B. 1946. The Trematoda with Special Reference to British and other European forms. Cambridge Univ. Press. 644 pp.


1937b. Life cycle of Raphidascaris canadensis Smedley, 1933, a nematode from the pike, Esox lucius. J. Parasitol.,


APPENDIX
<table>
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<th><strong>Lake Name:</strong></th>
<th>Big</th>
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<td><strong>Location:</strong></td>
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<td><strong>Date:</strong></td>
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**Fish Species and Parasite Species:**

- **Red salmon, Oncorhynchus nerka**
  - Plerocercoid of Protecephala
  - Plerocercoid of Pseudophyllidea
  - Philonema oncorhynchi
  - *Neoechinorhynchus rutili*

- **Silver salmon, Oncorhynchus kisutch**
  - *Cathocephalus truncatus*
  - *Neoechinorhynchus rutili*

- **Dolly varden, Salvelinus malma**
  - *Eubothrium* sp.
  - *Proteocephalus* sp.
TABLE II

Lake Name: Congahbuna

Location: T 11 N; R 12 W; S 5, 4, 8, 9

Date: June 11, 1973

Fish Species and Parasite Species:

Rainbow trout, *Salmo gairdneri*

- Plerocercoid of Pseudophyllidea
- Plerocercoid of Proteocephalus
- *Eubothrium* sp.
- *Proteocephalus* sp.
- *Philonema oncorhynchi*
- *Cucullanus* sp.
- *Neoechinorhynchus rutili*
- *Salmincola californiensis*

Silver salmon, *Oncorhynchus kisutch*

- Plerocercoid of Pseudophyllidea
- *Neoechinorhynchus rutili*
- *Salmincola californiensis*

Chemical Characteristics of Surface Waters:

- Temperature: 60°F
- Dissolved Oxygen: 10.5 mg./l
- pH: 7.0
- Total Alkalinity: 34.0 mg./l
- Secchi Depth: 2.0 m
- Thermocline: 4.0 m
TABLE III

Lake Name: Judd
Location: T 17 N; R 13 W; S 12, 13
Date: June 20, 1973

Fish Species and Parasite Species:
- Rainbow trout, *Salmo gairdneri*
  - Eubothrium sp.
  - Cucullanus sp.
  - Neoechinothynchus rutili
  - Salmincola californiensis
- Arctic grayling, *Thymallus arcticus*
  - Salmincola thymallii
- Dolly varden, *Salvelinus malma*
  - Eubothrium sp.
  - Proteocephalus sp.
- Round whitefish, *Prosopium cylindraceum*
  - Salmincola thymallii

Chemical Characteristics of Surface Waters:
- Temperature: 47.5°F
- Dissolved Oxygen: 12.0 mg./l
- pH: 7.0
- Total Alkalinity: 34.0 mg./l
- Total Hardness: 34.0 mg./l
**TABLE IV**

Lake Name: Coal Creek  
Location: T 16 N; R 13 W; S 10, 11  
Date: July 11, 1973

Fish Species and Parasite Species:
- Rainbow trout, *Salmo gairdneri*
  - *Eubothrium* sp.  
  - *Proteocephalus* sp.  
  - *Cucullanus* sp.  
  - *Neoechinorhynchus rutili*
- Silver salmon, *Oncorhynchus kisutch*
  - *Proteocephalus* sp.  
  - *Philonema oncorhynchi*  
  - *Neoechinorhynchus rutili*  
  - *N. tumidus*  
  - *Salmincola californiensis*

Chemical Characteristics of Surface Waters:
- Temperature: 64°F  
- Dissolved Oxygen: 10.0 mg./l  
- pH: 7.0  
- Total Alkalinity: 34.0 mg./l  
- Total Hardness: 34.0 mg./l  
- Secchi Depth: 5.4 m  
- Thermocline: 5.0 m
TABLE V

Lake Name: Lockwood
Location: T 19 N; R 7 W; S 8
Date: July 25, 1973

Fish Species and Parasite Species:

- Rainbow trout, *Salmo gairdneri*
- Eubothrium sp.
- Proteocephalus sp.
- Contracaecum spiculigerum
- Cucullanus sp.
- Neoechinorhynchus rutili
- Salmincola californiensis

Chemical Characteristics of Surface Waters:

- Temperature: 69°F
- Dissolved Oxygen: 9.0 mg./l
- pH: 8.0
- Total Alkalinity: 68.0 mg./l
- Total Hardness: 68.0 mg./l
- Secchi Depth: 3.0 m
- Thermocline Depth: 3.0 m
TABLE VI

Lake Un-named no. 6694.

Location: T 19 N; R 7 W; S 22

Date: July 25, 1973

Fish Species and Parasite Species:

Round whitefish, *Prosoptium cylindraceum*

*Proteocephalus* sp.

*Neochinorhynchus tumidus*

Rainbow trout, *Salmo gairdneri*

*Eubothrium* sp.

*Neochinorhynchus rutili*

*Neochinorhynchus tumidus*

*Salmincola californiensis*

Silver salmon, *Oncorhynchus kisutch*

Chemical Characteristics of Surface Waters:

Temperature: 70°F

pH: 8.0

Total Alkalinity: 68 mg./l

Total Hardness: 51 mg./l
TABLE VII

Lake Name: Seven-Mile
Location: T 20 N; R 11 W; S 14
Date: August 14, 1973

Fish Species and Parasite Species:
- Silver salmon, *Oncorhynchus kisutch*
- *Porteoccephalus* sp.
- *Neoechinorhynchus rutili*

Chemical Characteristics of Surface Waters:
- Temperature: 57°F
- Dissolved Oxygen: 9.0 mg./l
- pH: 7.0
- Total Alkalinity: 34.0 mg./l
- Total Hardness: 51.0 mg./l
- Secchi Depth: 3.2 m
- Thermocline Depth: 6.0 m
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Lake Name: Eight-Mile  
Location: T 20 N; R 11 W  
Date: August 14, 1973  

Fish Species and Parasite Species:  

- Silver salmon, *Oncorhynchus kisutch*  
  - *Eubothrium* sp.  
  - *Proteocephalus* sp.  
  - *Cyathocephalus truncatus*  
  - *Neoechinorhynchus rutili*  

Chemical Characteristics of Surface Waters:  

- Temperature: 57°F  
- pH: 7.0  
- Total Alkalinity: 68.0 mg./l  
- Total Hardness: 103.0 mg./l
**TABLE IX**

Name: Talachulitna River  
Location: From Judd Lake to Skwentna River  
Date: August 4-6, 1973

**Fish Species and Parasite Species:**

- **Rainbow trout, *Salmo gairdneri***  
  - *Eubothrium* sp.  
  - *Proteocephalus* sp.  
  - *Cucullanus* sp.  
  - *Neoechinorhynchus rutili*

- **Arctic grayling, *Thymallus arcticus***  
  - *Cucullanus* sp.

- **Red salmon, *Oncorhynchus nerka***  
  - *Phyllobothrium* sp.  
  - *Philonema oncorhynchi*  
  - *Anisakis* sp.

- **Pink salmon, *Oncorhynchus gorbuscha***  
  - *Phyllobothrium* sp.

- **Chum salmon, *Oncorhynchus keta***  
  - *Phyllobothrium* sp.  
  - *Anisakis* sp.
TABLE X

Name: Ship Creek
Location: Anchorage
Date: July 18-August 11, 1973

Fish Species and Parasite Species:

King salmon, *Oncorhynchus tschawytscha*

- *Brachyphallus crenatus*
- *Eubothrium* sp.
- *Phyllobothrium* sp.
- *Cucullanus* sp.
- *Anisakis* sp.
- *Raphidascaris* sp.
- *Porrocaecum* sp.

Silver salmon, *Oncorhynchus kisutch*

- *Phyllobothrium* sp.

Pink salmon, *Oncorhynchus gorbuscha*

- *Phyllobothrium* sp.

Chum salmon, *Oncorhynchus keta*

- *Phyllobothrium* sp.
- *Anisakis* sp.