REFERENCES

California State Water Resources Control Board. 1972. Water quality control plan for ocean waters of California. California State Water Resources Control Board. Sacramento, Ca., 13 p.

Carlisle, J. G., Jr. 1969. Results of a six-year trawl study in an area of heavy waste discharge: Santa Monica Bay, Ca. Calif. Fish and Game, 55(1): 26–46.

Day, D. S., and W. G. Pearcy. 1968. Species associations of benthic fishes on the continental shelf and slope off Oregon. Can., Fish Res. Bd., Jour., 25(12): 2665–2675.

Johnson, M. G., and R. O. Brinkhurst. 1971. Associations and species diversity in benthic marco-invertebrates of the Bay of Quinte and Lake Ontario. Can., Fish Res. Bd., Jour., 28: 1683–1697.

Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Calif. Dept. Fish and Game, Fish Bull., (157): 1–235.

Southern California Coastal Water Research Project. 1973. The ecology of the southern California bight: implications for water quality management. So. Calif. Coast. Wat. Res. Proj. El Segundo, California, 521 p.

Stephens, J. S., Jr., D. Gardiner, and C. Terry. 1973. Marine studies of San Pedro Bay. Part II, Biological Investigations, June 1973. The demersal fish populations of San Pedro Bay. In manuscript, Occidental College, Los Angeles.

Tillman, D. C., and R. D. Bargman. 1973. Report on waste discharges to the ocean, Part I. Dept. Pub. Works, City of Los Angeles, 336 p.

Ulrey, A. B., and P. O. Greeley. 1928. A list of the marine fishes (Teleosti) of southern California with their distribution. So. Cal. Acad. Sci., Bull., 27: 1–53.

Calif. Fish and Game 64(2): 117–120. 1978.

PARASITES OF SILVER (COHO) SALMON AND KING (CHINOOK) SALMON FROM THE PACIFIC OCEAN OFF OREGON[1]

ROBERT E. OLSON
Department of Zoology
Oregon State University
Marine Science Center
Newport, Oregon 97365

During the summer of 1972, 80 silver salmon *(Oncorhynchus kisutch)* and 15 king salmon *(O. tshawytscha)* caught in the Pacific Ocean off Newport, Oregon, were examined for parasites. A total of 16 parasite species (11 of marine origin) were found in silver salmon and seven species (six of marine origin) in king salmon. Larval *Anisakis* sp were found commonly in both host species. These nematodes are of potential public health importance since larval anisakids have been implicated elsewhere as human pathogens. Data on the prevalence of *Nanophyetus salmincola* and *Salvelinema walkeri* in silver salmon indicates that these species have potential value as biological tags.

INTRODUCTION

A survey of the protozoan and metazoan parasites of silver *(Oncorhynchus kisutch)* and king *(O. tshawytscha)* salmon caught in the Pacific Ocean was conducted during the summer of 1972. Salmon were caught between 1 and 30 km (0.6–19 miles) off Newport, Oregon, before their return to fresh water. The purpose of the investigation was to provide information on the parasite faunas of these species during the oceanic phase of their life cycle, to obtain data on the longevity of parasites of freshwater origin, to explore the possibility that parasites might be used as biological tags to indicate geographical areas of salmonid origin, and to obtain information on the prevalence of parasites that are of potential public health importance.

MATERIALS AND METHODS

Salmonids were collected by trolling with commercial salmon gear that was raised and lowered with a hand winch. On shipboard, the fish were measured to the nearest cm (FL), a blood smear made from blood obtained by heart puncture, the viscera removed and both viscera and carcass placed on ice until returned to the laboratory.

After weighing the carcass and viscera the following areas were examined for parasites the day following collection: skin, fins, eyes, musculature, gills, heart, liver, gall bladder, stomach, intestine, mesenteries, swim bladder and kidneys. Blood smears were fixed in methanol and stained with Giemsa. Myxosporidians were studied in wet mounts before preparing smears fixed in methanol and stained with Giemsa. Whole mounts of trematodes, cestodes, and acanthocephalans were prepared after fixation in AFA and staining in Semichon's acetocarmine. Nematodes were fixed in 70% ethyl alcohol containing 5% glycerine and cleared in lactophenol for study. Copepods were preserved in 70% ethyl alcohol.

[1] Accepted for publication June 1977.

RESULTS AND DISCUSSION

The 80 silver salmon examined ranged from 47.0 to 77.5 cm (18.5–30.5 inches) FL and from 1.1 to 6.1 kg (2.4–13.4 lb) in weight and harbored 16 species of parasites (Table 1). Based upon length, these fish were all determined to be 3 years old and to have been at sea for 2 years (Robert McQueen, Oregon Department of Fish and Wildlife, Pers. commun.). Fifteen king salmon ranged from 41.0 to 87.0 cm (16.2–34.3 inches) FL and from 0.9 to 7.9 kg (2.0–17.4 lb) in weight. King salmon age could not be determined from data on fish length.

No blood parasites were found and myxosporidians were uncommon. Of the 3 species of myxosporidians found in silver salmon, *Myxosoma squamalis* and *Myxidium minteri* are known to be acquired by hosts in fresh water (Iverson 1954; Sanders and Fryer 1970; Yasutake and Wood 1957). It is probable that spores are released when the salmon die after spawning and that the parasites are capable of living for the life of the host. *Henneguya salmonicola* has been reported from adult salmonids (Fish 1939) and has apparently not been observed in salmonids prior to their entry into salt water; this argues that the infections are of marine origin.

The hemiurid trematodes *Brachyphallus crenatus* and *Tubulovesicula lindbergi* are acquired by salmon in marine waters where these parasites are found in a wide variety of hosts (Pratt and McCauley 1961; Yamaguti 1971). Though the marine trematode *Syncoelium katuwo* has previously been reported from pink salmon (*O. gorbuscha*) and sockeye salmon (*O. nerka*) (Lloyd and Guberlet 1936; Margolis 1963) this is the first report of this parasite in silver salmon. Intestinal trematodes were absent in king salmon and uncommon in silver salmon. Two species were observed: *Plagioporus shawi*, a parasite acquired in fresh water (Margolis 1970) and therefore with a life span of at least 2 years; and *Podocotyle* sp, probably of marine origin.

The prevalence of *Nanophyetus salmincola* metacercariae (as determined by microscopic examination of kidney tissue) was low when compared with that reported by Milleman, Gebhart and Knapp (1964) from salmon collected in the same area. They found *N. salmincola* in 24 of 43 silver and three of four king salmon. The low prevalence observed in this study (4/80 silver salmon and 2/15 king salmon) could indicate that the bulk of the fish sampled were not from the endemic area for this parasite (southwestern Washington to northern California) or that they were from endemic areas where the parasite was not common. Unfortunately, data on the prevalence of *N. salmincola* in streams of high silver salmon production, such as the Columbia River system, are not available.

Both silver salmon and king salmon were commonly parasitized by the larval cestodes *Phyllobothrium* sp. and *Bothriocephalus* sp, the larval nematodes *Anisakis* sp. and the adult nematode *Thynascaris* sp. These parasites are of marine origin and are found in many species of marine fishes. Larval *Anisakis* sp are of potential public health importance since it has been shown that members of this group can infect man and cause pathology when improperly prepared or uncooked fish containing them is ingested (Asami et. al. 1965; Van Thiel, Kuipers and Roskam 1960).

Salvelinema walkeri, a freshwater nematode that locates in the swim bladder (Margolis 1967) was found in silver salmon, but not king salmon. This parasite occurred more commonly in fish collected in May and June (14/40) than in fish

Table 1. Prevalence and Intensity of Parasitic Infections in Silver and King Salmon (Ranges in parentheses)

Parasite	Silver salmon (N = 80) Prevalence	Intensity/infected fish	Location	King salmon (N = 15) Prevalence	Intensity/infected fish	Location
PROTOZOA:						
Henneguya salmonicola	2.5%	**	Musculature	0		
Myxosoma squamalis	2.5%	**	Scales	0		
Myxidium minteri	1.3%	**	Gall bladder	0		
TREMATODA:						
Brachyphallus crenatus	11.3%	4.9 (1–19)	Stomach	13.3%	1.0	Stomach
Tubulovesicula lindbergi	8.8%	2.3 (1– 4)	Stomach	0		
Plagioporus shawi	2.5%	2.5 (1– 4)	Intestine	0		
Podocotyle sp.	1.3%	1.0	Intestine	0		
*Syncoelium katuwo**	20.0%	1.4 (1– 4)	Gills	0		
Nanophyetus salmincola (metacercaria)	5.0%	**	Kidney	13.3%	**	Kidney
CESTODA:						
Phyllobothrium sp. (larval)	78.8%	5.3 (1–17)	Intestine	73.3%	6.2 (1–15)	Intestine
Bothriocephalus sp. (larval)	11.3%	2.9 (1– 8)	Intestine	13.3%	4.0 (2– 6)	Intestine
NEMATODA:						
Salvelinema walkeri	21.3%	10.6 (1–30)	Swim bladder	0	0	
Thynascaris sp.	45.0%	5.2 (1–54)	Intestine	60.0%	5.0 (1–15)	Intestine
Anisakis sp. (larval)	73.8%	3.6 (1–16)	Body cavity	80.0%	4.2 (1– 8)	Body cavity
ACANTHOCEPHALA:						
*Nipporhynchus trachuri**	12.5%	1.0	Intestine	0	0	
COPEPODA:						
Lepeophtheirus salmonis	80.0%	3.2 (1–10)	Skin	73.3%	3.4 (1–10)	Skin

* New host record.
** Intensity of infection not calculated.

collected in July and August (3/40). The known geographic distribution of *S. walkeri* indicates that British Columbia is the primary source of infected fish although a single record exists from northern California (Margolis 1967). Based upon the preponderance of reports of this parasite from British Columbia and on the low numbers of California silver salmon that are known to occur in the Oregon salmon troll catch (Robert McQueen, pers. commun.), it is likely that fish infected with this nematode were destined for British Columbian streams. In this regard, it is interesting to note that none of the four fish infected with *N. salmincola* carried *S. walkeri* infections.

The acanthocephalan *Nipporhynchus trachuri* was found in silver salmon. This constitutes a new host record. The only other report of this parasite from the northeastern Pacific is that of Margolis (1963) who found it in sockeye salmon.

Lepeophtheirus salmonis was the only copepod found. It occurred commonly on both silver salmon and king salmon where it located on the body surface, usually just above the anal fin.

ACKNOWLEDGEMENTS

Appreciation is extended to Eugene Burreson and Richard Miller who assisted in the collection and examination of specimens, to Warren Groberg and Guy Tebbit who aided in specimen collection and to Robert McQueen of the Oregon Department of Fish and Wildlife who gave valuable advice. This investigation was supported by Research Grant 04-3-158-4 from the Oregon State University Sea Grant College Program, National Oceanic and Atmospheric Administration Office of Sea Grant, Dept. of Commerce.

REFERENCES

Asami, K., T. Watanuki, H. Sakai, H. Imano, and R. Okamoto. 1965. Two cases of stomach granuloma caused by *Anisakis*-like larval nematodes in Japan. Am. J. Trop. Med. Hyg., 14:119-123.

Fish, F. F. 1939. Observations on *Henneguya salmonicola* Ward, a myxosporidian parasite in Pacific salmon. J. Parasit., 25:169-172.

Iverson, E. S. 1954. A new myxosporidian, *Myxosoma squamalis*, parasite of salmonid fishes. J. Parasit., 40: 397-404.

Lloyd, L. C. and J. E. Guberlet. 1936. *Syncoelium filiferum* (Sars) from the Pacific salmon. Tran. Am. Micro. Soc., 55:44-48.

Margolis, L. 1963. Parasites as indicators of the geographical origin of sockeye salmon, *Oncorhynchus nerka* (Walbaum) occurring in the North Pacific Ocean and adjacent seas. Int. North Pac. Fish. Comm., Bull., (11):101-156.

——— 1967. The swimbladder nematodes (Cystidicolinae) of Pacific salmons (genus *Oncorhynchus*). Can. J. Zool., 45:1183-1199.

———1970. The trematode *Plagioporus shawi* (McIntosh, 1939) n. comb. (Opercoelidae: Plagioporinae) from the North Pacific sockeye salmon, *Oncorhynchus nerka*. An. Inst. Biol. Univ. Nal. Auton. Mexico 41, Ser. Zoologia, Num. Unico: 99-108.

Milleman, R. E., G. E. Gebhardt, and S. E. Knapp. 1964. "Salmon poisoning" disease. 1. Infection in a dog from marine salmonids. J. Parasit., 50:588-589.

Pratt, I. and J. E. McCauley. 1961. Trematodes of the Pacific Northwest an annotated catalog. Oregon State Monogr., Studies Zool., (11), 118 p.

Sanders, J. E. and J. L. Fryer. 1970. Occurrence of the myxosporidan parasite *Myxidium minteri* in salmonid fish. J. Protozool., 17:354-357.

Van Thiel, P. H., F. C. Kuipers and R. Th. Roskam. 1960. A nematode parasitic to herring causing acute abdominal syndromes in man. Trop. Geogr. Med., 2:97-113.

Yamaguti, S. 1971. Synopsis of digenetic trematodes of vertebrates. Vol. 1. Keigaku Publishing Co. Tokyo.

Yasutake, W. T. and E. M. Wood. 1957. Some myxosporidia found in Pacific Northwest salmonids. J. Parasit., 43:633-642.

Calif. Fish and Game 64(2): 121–132 1978.

NOTES

Comparison of Floy Internal Anchor and Disk Dangler Tags on Largemouth Bass (*Micropterus salmoides*) at Merle Collins Reservoir

As part of an evaluation of mortality and survival rates of largemouth bass before and after a 305-mm (12.0-inch) size limit went into effect at Merle Collins Reservoir, Yuba County, we initiated a tagging study of bass greater than legal length. This study compared the Floy internal anchor tag [1], described by Thorson (1967) and Dell (1968), and the disk dangler tag.

Stobo (1972) showed that the Floy tag Model FD-67 was suitable for field use on yellow perch (*Perca flavescens*). Results of the senior author's work with FD-67 on several salmonids were excellent (Rawstron 1973). However, subsequent use of this tag on rainbow trout (*Salmo gairdneri*) resulted in an 85% separation of the tubing from the nylon "T" bar. This experience was shared by Wilbur and Duchrow (1973) in their work with largemouth bass. They reported losses of up to 78% for FD-67 and 53% for FD-67C, a similar tag, from fish held in small hatchery ponds. The FD-68B, a stronger Floy tag, was the most satisfactory internal anchor tag tested by these workers. Largemouth bass retained 88% of the tags after 97 days in a 0.28 ha (0.70 acre) pond.

The main difference between these internal anchor tags is the amount of surface available for gluing between the nylon shaft and the vinyl tubing. In the FD-67 and FD-67C tags only about 0.3 to 0.6 cm (0.13 to 0.25 inch) of nylon contacts the vinyl irrespective of tube length, whereas in the FD-68B the nylon shaft is inserted about 3.8 to 5.1 cm (1.5-2.0 inches). In addition, the distal end of the vinyl tube has a nylon monofilament insert which contacts the nylon shaft. This bonding of similar materials further strengthens the FD-68B and overcomes the inherent weakness at the base of the other models. Therefore, because of the speed with which it can be applied and its commercial availability, we chose this tag to compare with a tag proven to be effective, the disk dangler. The latter has been widely and successfully used on a variety of fish species in California, including striped bass (*Morone saxatilis*) (Chadwick 1963); channel catfish (*Ictalurus punctatus*) (McCammon and La Faunce 1961); white catfish (*I. caust*) and brown bullheads (*I. nebulosus*) (McCammon and Seeley 1961); bluegill (*Lepomis macrochirus*) (Rawstron 1967); largemouth bass (Rawstron 1967; Rawstron and Hashagen 1972).

All bass were caught by electrofishing during April 1974, held in live cages, tagged, and released along the sections of shoreline from which they were captured. Totals of 239 and 145 fish were tagged with disk dangler and FD-68B internal anchor tags, respectively. All tags advertised a $5 reward, and were attached below the dorsal fin, approximately a third to a half the distance from the base of the longest spine to the lateral line. Chadwick (1963) described the application technique for the disk dangler tag. Rawstron (1973) enlarged on the application technique for the internal anchor tag on salmonids provided by Thorson (1967) and Dell (1968).

[1] Tags and specifications obtainable from: Floy Tag and Manufacturing, Inc., 2909 Northeast Blakeley Street, Seattle, Washington 98105.