Investigations of the Distribution, Detection, and Biology of *Henneguya salminicola* (Protozoa, Myxozoa), a Parasite of the Flesh of Pacific Salmon

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ABSTRACT

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Cysts caused by the myxosporean (Protozoa) *Henneguya salminicola* (or *H. zschokkei*), and measuring up to 15 mm in diameter, occur in the flesh of the five species of Pacific salmon common to the North American and Asian coasts. Although *Henneguya* is not of public health significance, the presence of the cysts adversely affects the marketability of some fresh, frozen, or smoked products. In canned products, the cysts are not readily evident.

Recent studies in British Columbia have demonstrated marked differences in infection prevalence among salmon species and stocks, the order of decreasing prevalence by species being coho, sockeye, chinook, chum, and pink salmon. Major variations occur among stocks of a single species, even from localities in close proximity. In general, stocks from the middle and upper reaches of large river systems (e.g. Fraser, Skeena, Nass) and apparently from mainland coastal streams in the southern half of British Columbia (although sampling in the latter area was limited) are free or have very low prevalences of infection.

Although the mechanism of transmission of the parasite remains a mystery, infection was shown to take place in fresh water as juvenile salmon become infected before seaward migration. This largely explains the inter-species differences in infection prevalence, the species with the shortest freshwater life, pink salmon, being exposed to infection for the shortest time, and coho and sockeye salmon, with the longest freshwater life, being exposed for the longest time. The parasite and the cysts are slow to develop, rarely being macroscopically evident in seaward migrants. In spawning adults, cysts reach their largest size in species with the longest average ocean life, e.g., chinook and chum salmon, and are smallest in pink salmon, the species with the shortest life span.

Henneguya cysts can be detected in whole fish with ultrasonic equipment used in medical diagnostics, offering some promise that a means for routine culling of infected fish can be developed. At present, the best approach to reducing economic loss due to *Henneguya* seems to lie with selection of fish from uninfected stocks for the fresh, frozen, and smoked markets.

RESUME

Boyce, N. P., Z. Kabata, and L. Margolis. 1985. Investigations of the distribution, detection, and biology of Henneguya salminicola (Protozoa, Myxozoa), a parasite of the flesh of Pacific salmon. Can. Tech. Rep. Fish. Aquat. Sci. 1405: 55 p.

On trouve dans la chair de cinq espèces de saumon du Pacifique répandues près des côtes de l'Asie et de l'Amérique du Nord des kystes mesurant jusqu'à 15 mm de diamètre produits par la myxosporidie (protozoaire) Henneguya salmonicola (ou H. zschokkei). Bien que Henneguya ne présente pas de danger pour la santé, la présence de ces kystes nuit à la mise en marché de certains produits frais, congelés ou fumés. Dans les produits mis en conserve, les kystes ne se voient pas facilement.

Des études réalisées récemment en Colombie-Britannique ont montré qu'il y avait des différences notables dans le nombre de cas d'infection entre les espèces et les stocks de saumon, les espèces les plus touchées par ordre décroissant étant le saumon coho, le saumon rouge, le saumon quinnat, le saumon kéta et le saumon rose. Il y a des fluctuations importantes entre les stocks à l'intérieur d'une même espèce, même entre ceux provenant d'endroits très rapprochés. De façon générale, les stocks provenant des tronçons moyen et supérieur des bassins de grands cours d'eau (par ex. Fleuve Fraser, rivières Skeena et Nass) et, semble-t-il, des cours d'eau côtiers situés sur le continent dans la moitié sud de la Colombie-Britannique (bien que l'échantillonnage ait été limité dans ce secteur) ne sont pas contaminés ou très peu.

Bien que le mode de transmission du parasite demeure un mystère, on a démontré que l'infection se produit en eau douce, car les jeunes saumons sont touchés avant d'entreprendre leur migration vers la mer. Cela explique en grande partie les différences observées entre les espèces pour ce qui est du nombre d'individus contaminés, l'espèce passant le moins de temps en eau douce, le saumon rose, étant exposée le moins longtemps à l'infection et celles passant le plus de temps en eau douce (saumons coho et rouge) y étant exposées le plus longtemps. Le parasite et les kystes se développent lentement et sont rarement visibles à l'oeil nu chez les poissons qui s'acheminent vers la mer. Chez les adultes qui frayent, les kystes atteignent leur dimension maximale chez les espèces qui passent en moyenne le plus de temps en mer, par ex. les saumons kéta et quinnat. Les kystes les plus petits se trouvent chez le saumon rose, espèce dont l'espérance de vie est la plus courte.

Les kystes de Henneguya peuvent être décelés chez les poissons entiers en utilisant des appareils à ultrasons dont on se sert en médecine pour établir un diagnostic, ce que permet d'espérer la mise au point d'une méthode d'élimination sélective et systématique des poissons contaminés. Pour le moment, la meilleure approche permettant de réduire les pertes commerciales attribuables à Henneguya semble être de choisir des poissons provenant de stocks non contaminés pour les mettre sur le marché des produits frais, congelés et fumés.

INTRODUCTION

The value of the Pacific salmon industry is related not only to the volume of catch, but to its quality as well. Anything that reduces this quality is economically detrimental. The quality of Pacific salmon is sometimes adversely affected by a parasite that produces small, fluid-filled, creamy-white cysts in the flesh. Usually invisible externally, these cysts stand out in striking contrast to the pink or reddish background when the cut surfaces of the flesh are exposed, e.g., by filleting (Fig. 1). Fillets blemished by these cysts are not readily acceptable, either fresh or smoked, in the market place.

The organism responsible for the formation of these cysts in salmon flesh is a parasite known only by its scientific Latin name *Henneguya salminicola*, discovered and described by Ward (1919) from Alaskan salmon. The parasite is microscopic and only development of a cyst containing huge numbers of the parasite makes its presence visible to the naked eye in the flesh of salmon.

Margolis (1982) briefly summarized the literature dealing with the impact of this microscopic organism on the quality of salmon. He pointed out that because of the presence of cysts, portions of catches of salmon, particularly chum and coho, are on occasion rendered unsuitable for smoking or marketing as whole fish. Reports of such occurrences come from several European countries (e.g., Denmark) and from Japan. The salmon industry of British Columbia, as well as that of the U.S.A., has long been concerned about recurring losses suffered because of the presence of *Henneguya* in the salmon they catch and process. The Far-eastern Asian stocks of Pacific salmon are not immune, the presence of *Henneguya* being well-known in salmon from the U.S.S.R. The natives of Kamchatka shun salmon infected by this parasite, in the mistaken belief that by eating it one can contract leprosy. Although such beliefs have no basis in fact and can be consigned to the already rich collection of anecdotal fish lore, the more real economic impacts of *Henneguya* cannot be ignored.

It should be stressed that *Henneguya*, economically deleterious though it is, is harmless from the point of view of public health. It is strictly a fish parasite that cannot live in or affect warm-blooded animals, including man.

The need for information on an organism that exerts such an undesirable effect on the salmon industry is quite clear. In response to this need, we mounted an investigation of *Henneguya*. It was clear from the outset that the chances of controlling *Henneguya* were remote, because the control of parasites of wild stocks of fish is rarely possible. The investigation had four objectives: (a) to determine the distribution of the parasite in stocks of salmon in British Columbia, to enable processors to select stocks free of the parasite or with very low prevalence of infection for use in the fresh, frozen, or smoked salmon market; (b) to develop, if possible, a method for detecting the parasite within the flesh in a non-destructive way, e.g., without filleting, to permit culling of salmon with cysts; (c) to find out whether its economic impact can be reduced or avoided after capture of the salmon; and (d) to learn more about the biology and transmission of the parasite to assess the possibility for its control.

This report is intended to present our current state of knowledge on the parasite and the results of our investigations to date.

The Parasite

Henneguya salminicola belongs to a large group of parasitic animals, the true identity of which continues to perplex scientists. The members of this group had been classified for many years as Protozoa, i.e. one-celled animals. More recent discoveries revealed that their one-celled structure is replaced at a certain stage of life by a spore that consists of six or more cells. Possession of several cells would disqualify them from membership in Protozoa. However, there seems to be no other suitable group to accommodate them. Hence, Henneguya and its numerous relatives, collectively known as Myxosporea, continue to hang on as a half-tolerated appendage to Protozoa within a group labelled Myxozoa.

As mentioned above, Henneguya changes its structure in the course of its life, probably passing through several developmental stages. The best-known stage is the spore, shown in Figure 2 and 3. It is a small chamber consisting of two valves that could be compared to spoons with very fine, tail-like handles. Stuck together with their concave surfaces towards each other, they enclose a small space and trail the slender tails. Inside the cavity of the spore, in its anterior part, there are two oval vesicles, each containing a long, coiled, and hollow thread. The thread is known as the polar filament and the vesicle itself as the polar capsule. The posterior part of the cavity is occupied by an amoeba-like blob of substance, the sporoplasm. It is the sporoplasm that is the infective agent, destined to transfer Henneguya to the next host fish. The elaborately structured spore is a kind of space capsule intended to transport the parasite from one host to another through the water. The length of the spores (tails included) varies from 33 to 54 micrometers (μm).

The details of the mechanism of transmission and its development within the fish are largely unknown. As will be noted later, salmon become infected as juveniles in fresh water. When the parasite reaches the muscle, presumably via the circulatory system, it undergoes a complex process of multiplication culminating in the development of spores that are enclosed in a visible cyst formed of host tissue. When post-spawned salmon decompose, the cysts rupture, releasing myriads of spores to start the cycle all over again.

Henneguya salminicola infects several species of salmon and their close relatives, over a wide geographic area. The full host and distribution range is a little difficult to define because of a difference of opinion between experts. Russian specialists believe that H. salminicola is simply another name for Henneguya zschokkei, a species originally reported from freshwater whitefish in Europe (Gurley 1894). The latter species is known in the Soviet Union not only from various species of salmon and whitefish, but also from several species of non-salmonid freshwater fishes. It is found in the Far-eastern USSR, as well as in European Russia and parts in between. Records come also from western Europe. Whatever the merit of the suggestion that H. salminicola and H. zschokkei are identical, the species that we call by the former of these two names is widespread in Pacific salmon. Fish (1939), who made a preliminary study of this parasite, found it in coho, pink, and chinook salmon. He also quoted unconfirmed reports of its occurrence in chum salmon. He thought that pink salmon might be the primary host for H. salminicola, while coho, chum, and chinook salmon are only accidentally infected. We know now that Henneguya is quite common in all species of British Columbia salmon, as well as in steelhead trout. It occurs throughout the distribution range of these Pacific salmon species (if we assume that the two species of Henneguya are identical), but its distribution does not appear to be uniform. More will be said about this in the section reporting on the results of the partial survey carried out in British Columbia.

Pathogenicity

As mentioned above, Henneguya produces cysts in the flesh of the infected fish. The cysts create subspherical cavities in the flesh and are filled with masses of spores, earlier stages in the development of the parasite, and debris of destroyed muscle. They vary from 4 to 15 mm in diameter. The largest sizes observed during our studies (up to 15 mm) occur mainly in chum and chinook salmon. In sockeye, pink, and coho salmon the cysts tend to be somewhat smaller (up to 9 mm in diameter). Each cyst has a thin wall, deposited by the connective tissue of the fish in an attempt to isolate the invading parasite. The cysts are noticeable externally as rounded swellings only when located in superficial layers of musculature, close to the skin. Otherwise they cannot be seen until the infected flesh is exposed, e.g., by filleting. The size and appearance of the cysts prompted the name of "tapioca disease" for the infection with Henneguya.

In all Pacific salmon species, the cysts are found in the musculature mainly in the posterior part of the fish (dorsal fin to caudal peduncle); they tend to occur along the membranes separating muscle blocks from one another. In rare instances they are found also along the lower jaw and spine, behind the eyes, and in the kidneys.

Several observers have suggested that the infection of Henneguya is associated with softening of the flesh of salmon, referred to as "milkiness." This topic will be discussed below.

RESULTS OF RESEARCH ON HENNEGUYA CONDUCTED AT THE PACIFIC BIOLOGICAL STATION

The biology of Henneguya

The main objective of this aspect of our investigations was to learn when, where, and how salmon become infected with Henneguya. As an ancillary activity, a preliminary study was conducted into the development of Henneguya in sockeye salmon.

The first of these questions (when) has been answered by studying (a) hatchery fry of coho salmon before their transfer to semi-natural rearing channels, (b) fingerlings after six months of residence in these channels, (c) juveniles from the channels at the pre-smolt stage, and (d) smolts during seaward migration from the channels. Live samples of coho salmon at these various life history stages were transported from the hatchery to the Pacific Biological Station, maintained live in Henneguya-free water, and killed and examined at various times ranging from four to 22 months after capture. These observations have shown that the coho became infected during their first 6 months of residence in the rearing channels and that the infection increased in prevalence and intensity over the entire rearing period. Infections were not evident when the coho were removed from the hatchery but developed to the macroscopically visible stage during captivity.

The answer to the second question (where) is obviously linked with that to the first one. Wild coho fry captured in different locations in the same stream were maintained as separate groups in tanks at the Pacific Biological Station. Later examinations revealed the presence of cysts in some groups, but not in others. Although the study was not comprehensive enough to allow definitive conclusions to be drawn, some preliminary ones are possible. As noted above, fish contract the infection during the first few months of their freshwater residence. It appears, however, that not all localities are equally conducive to the process of infection. Infected coho fry were captured in places where carcasses of spawned coho salmon accumulated in the absence of rapid currents, but not in areas of rapid flow where carcasses did not accumulate. It can be speculated that spores released by decomposing fish remain in the neighbourhood long enough to be picked up by the fry. Vigorous flushing makes contact between fry and spores less likely. (These apparent associations between the type of environment and infection provide clues as to a possible method of reducing the prevalence of Henneguya, namely, by removal of carcasses of spawned our salmon from areas where they are known to be heavily infected.)

The third question (how) concentrated on the mode of infection, i.e., on the way in which fish become infected. There are at least two ways in which it can be accomplished: the spore can be swallowed directly from the water, or it can be ingested by another organism (e.g., some small invertebrate) in which a stage infective for fish develops. Within the large group of parasites to which Henneguya belongs, information is scanty on the mode of infection of the fish hosts. For some species, direct transmission via ingestion of spores has been demonstrated. For one species it has been recently proposed that transmission of infection requires development within an invertebrate in which a stage of the parasite infective to fish is produced. Our experiments, which included a) direct introduction of spores into the stomachs of fry, b) exposure of fry to dense concentrations of spores, and c) exposure of small crustaceans and aquatic larvae of certain insects to spores, did not succeed in clarifying how juvenile salmon become infected with Henneguya, although both fry and invertebrates ingested spores.

The study of the development of Henneguya in sockeye salmon between the smolt and the adult stage showed that some smolts already carried barely visible cysts. This indicates that Henneguya within them had enough time to move from the intestine to the musculature and to build up in it a large enough mass to be recognizable under low magnification. The earliest (and smallest) cyst found was 73 μm in diameter and did not contain spores. It was located in the membrane separating adjacent blocks of muscle. Spores were found in cysts only after the smolts had been kept a whole year in captivity in sea water. The smallest cyst containing spores was 300 μm in diameter, although some cysts were free of spores even at a size of 1.7 mm. The largest cyst, found in a sockeye salmon after 15 months of captivity, was 4 mm. All these cysts were much smaller than the spore-filled cysts found in returning adult salmon. It can be deduced, therefore, that the parasite continues its development within the fish throughout the entire period of its host's sea life.

The most important findings of this part of the investigation were the determination of the fact that Henneguya infects salmon very early in the latter's life, that infection takes place in fresh water (some scientists previously believed that salmon became infected in the ocean), and that different types of environment might differ in their potential for infection.

Investigation of the suspected "milkiness" of salmon flesh allegedly caused by *Henneguya*

The phenomenon of "milkiness," reported by some observers, was assumed to be due to the liquefaction of salmon flesh in the vicinity of the cysts of Henneguya. Studies of sockeye salmon infected with this parasite yielded no evidence of this condition nor clues as to its possible cause. They included examination of salmon treated in various ways, under different storage temperatures and duration. The fish were smoked (including artificial liquid smoke) and salted. The contents of cysts were applied directly to the muscle in an attempt to ascertain the effects of such contacts. Observations suggest that reports of "milkiness" may have been based on erroneous interpretation of large, ruptured cysts as areas of liquefaction. Most of these reports have referred to chum salmon, a species that characteristically has large (10 mm) cysts. Such single large cysts, or closely grouped aggregates of cysts, were observed to exude large volumes of milky material when cut, e.g., in the process of filleting. The resulting appearance could be construed by the casual observer as liquefaction of the flesh, since the released cyst contents could cover a considerable area and tend to obscure the outline of the cyst wall.

It was clearly important to determine the chemical composition of the cyst contents, if its impact on the flesh were to be understood. The results of this work have been published recently (Bilinski et al. 1984). The cysts were found to contain one or several proteases, i.e., enzymes capable of breaking down the protein of salmon muscle. This result was not unexpected. It seemed obvious that Henneguya derived its energy from the absorption of the products of breakdown of these tissues. The protease was heat-labile and soluble. It hydrolyzed blood cells most efficiently at pH 3.0 and muscle protein at pH 4.5. It could be inhibited by metal ions and by sulfhydryl group binding reagents. No preliminary activation was required for the enzyme to become active. The hydrolysis of muscle depended strongly on the temperature. Although proteolysis occurred most readily at 30-40°C, the enzyme remained active in iced flesh. Freezing arrested proteolytic activity but a prolonged frozen storage (-28°C) had only slight inhibiting influence. The presence of the parasite had no marked effect on the texture of raw or cooked flesh.

Heavily infected Henderson Lake sockeye were canned commercially to examine the effect of the processing on the cysts. Some cysts could be later detected in the canned product by a trained observer but only with considerable difficulty. The cysts were soft, reduced in size, and of irregular shape. They appeared as traces of fatty material or curd, not unlike what would be expected in normal canned salmon.

Development of a non-destructive method for detection of *Henneguya* cysts

Since the presence and abundance of *Henneguya* cysts can determine the commercial acceptability of salmon and the way in which the product will be used, the ability to detect cysts in whole fish is a matter of some importance. An investigation was launched, therefore, with the aim of developing a non-invasive method for detection of these cysts. The current use in medicine of ultrasound techniques for the examination of internal structures suggested that these techniques could be adapted for examination of whole salmon. The experimental approach was to try the medical ultrasonic scanning device for examining whole sockeye salmon. The scanning frequencies were 3.5, 7.5, and 10 megahertz. The first of these was not effective, but at the higher frequencies the cysts of *Henneguya* embedded in the flesh were seen quite satisfactorily in fresh fish. Visual observation confirmed the accuracy of the ultrasonic scanning search (Boyce 1985). This technique, however, proved to be unsatisfactory with fish that had been previously frozen.

In principle, therefore, a method for non-destructive detection of *Henneguya* cysts has been found. Its practical application will ultimately depend on its cost and on the feasibility of developing a system that can be used in a fish processing line. The cost, in turn, will depend on the scale on which such scanning units will be used in the fish or food industry generally.

SURVEY OF DISTRIBUTION OF *HENNEGUYA* IN BRITISH COLUMBIA

To determine the prevalence of *Henneguya salminicola* in various stocks of the five salmon species in British Columbia, a survey was conducted, spanning the entire area of the province. Given the size of the territory in question and the multitude of stocks involved, the coverage could not be complete. Nonetheless, between July 1977 and October 1983 samples were collected from 97 locations. In all, 323 samples were examined, consisting in total of 16,257 fish. The results of the survey are presented in five maps (Figs. 4-8), one for each species of salmon, and in corresponding five tables that give details of the infection for each locality sampled. A composite table for all species combined, grouped by geographic area, is also included (Table 6). A narrative below summarizes these results separately for each salmon species.

Sockeye salmon (Fig. 4)

Sockeye salmon were sampled in 52 localities and proved to be infected with H. salminicola in 21 of them. A total of 172 samples was taken, ranging from a single fish to 190. Some localities were sampled more than once and three were sampled quite frequently (Great Central Lake 46 times, Sproat Lake 46 times, and Henderson Lake 17 times, in relation to other biological studies.) In all, 10,414 sockeye were examined for infection with Henneguya; 1,464 (14%) carried the parasite.

In addition to the localities shown in the map (Fig. 4), sockeye salmon were sampled in another four, situated on Canada-USA transboundary rivers to the North of the area shown (Klukshu River, Little Trapper Lake, Tahltan Lake, and Stikine River). Only the last-named of these four yielded infected sockeye salmon (0.7%), the others being free of Henneguya. The southern most localities sampled were Cultus Lake and Weaver Creek on the Fraser River system and San Juan River on Vancouver Island.

The distribution of infected sockeye salmon stocks did not show any clear geographic trends. Highly infected and uninfected stocks occurred in juxtaposition in several parts of British Columbia. For example, sockeye salmon in Henderson Lake (where 1,575 fish were examined over a period of 6 years) was 67% infected, the infected fish carrying from one to 200 cysts. On the other hand, neighbouring Sproat Lake (2,701 fish examined) had no infected sockeye salmon. (It is worth noting that coho salmon in Sproat Lake were 28% infected.)

Perhaps the only recognizable, albeit tentative, trend in distribution of the parasite is its apparent scarcity in the upper reaches of rivers. In the Fraser River system, from which samples were taken from 10 localities, those from the lower reaches (Cultus Lake, Weaver Creek, Pitt Lake, and Birkenhead River) contained infected sockeye salmon, whereas those from further upstream (Gates Creek, Chilko Lake, Adams River, Horsefly River, Stellako River, and Gluske Creek) were negative for Henneguya. Of the samples taken in the Skeena River system, only those taken at the Babine River fence and in Fulton River (Babine Lake) were free of the parasite. The samples taken downstream from these localities all contained infected fish.

The highest prevalences of infection in sockeye salmon were found in southern Vancouver Island (San Juan River - 73%, Henderson Lake - average 67%, and Hobiton Lake - 50%) and in two localities sampled in the Skeena River system (Schulbuckhand Creek - 71%, Williams Creek - 55%). The Conuma River 100% infection is a sampling artifact (the sample consisted of only one fish).

The details of distribution, prevalence, and intensity of infection of sockeye salmon with Henneguya are shown in Tables 1 and 6.

Coho salmon (Fig. 5)

Samples of coho salmon were collected in 30 localities and infected fish were found in 23. The total number of samples taken was 54, with parasitized fish occurring in 44. Most localities were sampled only once, but several were sampled two or more times (Big Qualicum River - 4, Capilano River

- 4, Great Central Lake - 4, Quinsam River - 3, Robertson River - 3, San Juan River - 4, Little Qualicum River - 2, Mesachie Creek - 2, Robertson Creek - 2, Salwein Creek - 2, Sooke River - 3, and Sproat Lake - 4). Sample size varied from 2 to 150 fish. The intensity of infection varied from one to 150 cysts per fish. In all, 2,192 coho salmon were examined for Henneguya; 603 (27.5%) were infected.

One northern locality, Iskut River, from which coho salmon were collected does not appear on the map. The sample from this locality was uninfected. The southernmost localities sampled on the mainland are Hopedale and Salwein creeks in the Fraser River system and Goldstream River and Sooke River on Vancouver Island. The island was sampled much more intensively than other parts of the province, providing 17 of 30 (57%) sampling localities.

Infection prevalence in 13 samples was more than 30%. Three of them consisted of five or fewer fish and the prevalence figures could not be considered necessarily representative of the situation in the total population. Of the remaining 10, only two are from mainland localities (Bella Coola River - 38.5% and Salwein Creek - 34.4%); all others are from Vancouver Island. The highest prevalence of infection in coho salmon was observed in Little Qualicum River (51.5%). Big Qualicum River (43.6%), Mesachie Creek (45.0%), Robertson River (43.7%), and San Juan River (41.3%) were among the localities with the highest prevalences of infection. The uneven distribution of samples does not permit speculation on any possible geographic trends in the distribution of infection in coho salmon stocks.

It should be noted that although the mean prevalence of infection in coho salmon samples was much higher than that of other salmon species, the prevalences among individual samples were generally lower than those in infected sockeye salmon samples (see above). Indeed, the infection in coho salmon was much more widespread (80% of samples infected) than that in sockeye salmon (52% of samples infected).

The details of distribution of Henneguya infection in coho salmon are presented in Tables 2 and 6.

Chinook salmon (Fig. 6)

Samples of this species were taken in 25 localities, nine of which contained infected fish. A total of 38 samples was taken, the sample size varying from one to 117 fish. In all, 1,503 fish were examined, of which 197 (13%) were infected. The intensity of infection varied from one to 58 cysts per fish.

Only two samples were collected from rivers draining to the sea further north than the northern tip of Vancouver Island (Kitimat River and Babine River fence) whereas 17 samples from seven localities were taken on the island itself. The southernmost samples were obtained from Salmon River, Weaver Creek, and San Juan River. At least ten samples can be regarded as being taken from localities situated well inland (Babine River fence, Finn Creek, Nechako River, Bowron River, Slim Creek, Quesnel River, Horsefly River, Bonaparte River, Salmon River, Nicola River, and Birkenhead River).

Inasmuch as the size and the distribution of the samples allow, it could be argued that the infection of chinook salmon with Henneguya has a coastal character. Of the 10 inland localities, only two (Bowron River and Birkenhead River) were found to contain Henneguya (2.2 and 6.1%, respectively).

The prevalence of Henneguya in chinook salmon from the nine infected localities varied from 2.2 to 39.9%. In five of them (Birkenhead River, Bowron River, Chemainus River, Nitinat River, and San Juan River) chinook salmon were less than 10% infected, in two (Quinsam River and Weaver Creek) they were less than 20% infected, and in two (Big Qualicum River and Cowichan River) they were less than 40% (39.9 and 33.0%, respectively) infected.

Details of the distribution of chinook salmon infected with Henneguya are shown in Tables 3 and 6.

Chum salmon (Fig. 7)

Samples of chum salmon were collected from 22 localities, 11 of which yielded fish infected with Henneguya. Thirty-five samples were examined, 17 of them being infected. Individual samples consisted of one to 107 fish. The intensity of infection varied from 3 to 123 cysts per fish. Several localities were sampled more than once, but only three (Nanaimo River, Big Qualicum River, and Weaver Creek) provided as many as three samples. In all, 1,260 chum salmon were examined, 89 of which were infected (7%) with Henneguya.

The southernmost samples came from Vedder River on the mainland and Sooke River on Vancouver Island. The samples taken furthest north were from Kitimat River on the mainland and Pallant Creek on the Queen Charlotte Islands. These two samples were the only ones collected north of the northern tip of Vancouver Island. Of the 35 samples, 19 were taken on Vancouver Island.

Obvious gaps in the survey coverage to date do not allow us to draw any firm conclusions about the pattern of distribution of Henneguya in British Columbia chum salmon.

Details of the distribution of chum salmon infected with Henneguya are shown in Tables 4 and 6.

Pink salmon (Fig. 8)

This species appears to be least subject to infection with Henneguya. Infected pink salmon were found in only 2 of the 16 localities sampled. A total of 20 samples was taken (three of them infected) varying in size from one to 100 fish. The intensity of infection varied from 1 to 400 cysts per fish, its prevalence in the two infected localities being 6.4% and 7.7%.

The difficulties in obtaining pink salmon samples contributed to the incompleteness of the distribution picture. Samples were collected from Weaver Creek in the south to a creek associated with Mathers Lake (Queen Charlotte Islands) in the north, but large areas were not sampled.

The picture emerging from the survey suggests that pink salmon stocks generally are not highly infected with Henneguya. Anecdotal reports obtained from industry subsequent to the survey, however, suggest that higher prevalences than observed in the survey may occur in some pink salmon stocks.

The generally low prevalence of infection in pink salmon might be in large part due to the life cycle of this species (short duration of stay in fresh water before seaward migration).

Details of infection of pink salmon with Henneguya are shown in Tables 5 and 6.

CONCLUDING REMARKS

This study has demonstrated that some stocks of all five species of Pacific salmon in British Columbia are infected with Henneguya. However, only a fraction of the total number of salmon stocks have been examined. Best coverage was achieved with sockeye salmon and least with pink salmon. Although the five species have not been equally sampled, it is evident that marked differences in prevalence of infection occur among species. Highest prevalences of infection were found in those species with the longest average freshwater life prior to seaward migration, i.e., sockeye and coho salmon. Coho salmon seem to be more frequently infected than sockeye salmon and in some watersheds, e.g., Sproat Lake and Great Central Lake on the west coast of Vancouver Island, where sockeye were free or almost free of Henneguya infection, coho had a prevalence of infection of approximately 25%. These differences presumably reflect the different freshwater life styles of the two species. Other salmon species with shorter freshwater lives prior to seawater migration show much lower prevalences of infection, with the prevalence on the average declining as the affinity with fresh water decreases. Thus, chinook, chum, and pink salmon show progressively lower prevalences of infection.

Among the stocks of any one of the salmon species, there are marked variations in infection prevalence, even among stocks from rivers only a few kilometers apart. Areas in which all species appear to be free of Henneguya or have very low prevalences of infection include the middle and upper reaches of large river systems (Fraser, Babine, Nass, Stikine) and possibly the mainland coastal streams in the southern half of British Columbia. However, coho salmon, the most frequently infected species, were sampled from only a few streams in the latter area. This information on geographic distribution might be useful for selecting uninfected stocks for use in the fresh, frozen, and smoked fish market. The cysts pose no marketing problem when salmon are canned because they are virtually unrecognizable after canning.

We established, for the first time, that *Henneguya* infection of salmon clearly takes place in fresh water before the juvenile salmon migrate to sea. The longer the early freshwater life, the greater the chance of infection. This explains the high prevalence of infection in salmon with the longest freshwater life prior to seaward migration. The familiar *Henneguya* cysts are not evident in the flesh of seaward migrating juvenile salmon, developing slowly and increasing their size over the life of the salmon. Species that have on the average the longest ocean life, e.g., chinook and chum salmon, tend to have the largest cysts; pink salmon, with the shortest life span of all salmon, have the smallest cysts. Upon decomposition of spawned out salmon, spores of *Henneguya* are released from the cysts and in an as yet unknown manner infect juvenile salmon. The possibility of breaking this cycle and preventing infection seems remote, particularly in large river systems with large salmon populations. Nevertheless, it might be worthwhile to attempt to break the cycle in a small stream where it is feasible to remove post-spawned fish before decomposition and release of *Henneguya* spores to test the potential for this method of control. However, the cost/benefit ratio of such an experiment and the consequences of losing nutrients to the stream through carcass removal would have to be weighed carefully. Nutrient loss could be compensated for by artificial fertilization.

Because of the apparent impossibility of eliminating *Henneguya* from most infected stocks, culling in processing plants may be the only way, apart from stock selection, to prevent *Henneguya*-infected salmon from reaching the market and producing economic losses. Ultrasonic techniques for this purpose have been shown to have promise, but it remains to be explored whether equipment that can be used in a plant assembly line can be developed at an acceptable cost. Immuno-diagnosis using fish mucus may also have some promise, but a long-term research project would be required to assess the prospects of this approach. The objective of this research would be to determine if *Henneguya* produces species-specific antibodies that can be detected in the mucus by a simple, inexpensive test that can be applied routinely and quickly in a processing plant. The applicability of such a test could be complicated by the transfer of mucus between infected and uninfected fish during contact after capture, for example, in the hold of fishing vessels or packers.

At the present time, the best prospect for obtaining *Henneguya*-free salmon seems to be through selection of fish from stocks known to be uninfected or having a very low frequency of infection. Even this approach is complicated by the fact that most fisheries are conducted on mixed stocks. To be certain of obtaining uninfected salmon, one would have to resort to terminal fisheries, although this could pose other quality problems.

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Table 1. Infection of sockeye salmon with <u>Henneguya</u>.

Locality	Drainage system or coastal area	No. fish examined	Prevalence* (%)	Intensity**
Adams River	Fraser River	140	0.0	-
Alastair Lake	Skeena River	50	20.0	NC***
Ashlulm Creek	Mainland Coast	12	0.0	-
Awun Lake Creek	Queen Charlotte Is.	50	0.0	-
Babine River	Skeena River	160	0.0	-
Birkenhead River	Fraser River	68	4.4	49(18-100)
Bonilla Lake	Mainland Coast	129	24.8	NC
Bowser Lake	Nass River	41	0.0	-
Canoe Creek	Mainland Coast	52	44.2	NC
Chilko Lake	Fraser River	65	0.0	-
Conuma River	Vancouver Is.	1	100.0	NC
Copper River	Queen Charlotte Is.	28	42.9	NC
Cultus Lake	Fraser River	135	4.4	31(2-89)
Damdochax Lake	Nass River	50	0.0	-
Delta Creek	Queen Charlotte Is.	50	0.0	-
Devereux Creek	Mainland Coast	4	0.0	-
Docee River	Mainland Coast	4	0.0	-
Fred Wright Lake	Nass River	53	0.0	-
Fulton River	Skeena River	50	0.0	-
Gates Creek	Fraser River	50	0.0	-
Gluske Creek	Fraser River	105	0.0	-
Great Central Lake	Vancouver Is.	2,698	0.5	NC
Henderson Lake	Vancouver Is.	1,575	66.5	32(1-200)
Hobiton Lake	Vancouver Is.	54	50.0	NC
Horsefly River	Fraser River	92	0.0	-
Iskut River	Stikine River	110	0.0	-
Kennedy Lake	Vancouver Is.	229	17.0	49(1-317)
Kitlope Lake	Mainland Coast	190	0.0	-
Klukshu River	Alsek River	50	0.0	-
Lakelse River	Skeena River	32	9.4	NC
Little Trapper Lake	Taku River	52	0.0	-
Lowe Lake	Mainland Coast	104	0.0	-
Mathers Lake	Queen Charlotte Is.	50	0.0	-
Mercer Lake	Queen Charlotte Is.	50	0.0	-
Meziadin Lake	Nass River	50	0.0	-
Naden River	Queen Charlotte Is.	50	36.0	NC
Neechanz River	Mainland Coast	100	0.0	-
Nimpkish River	Vancouver Is.	56	0.0	-
Pitt Lake	Fraser River	54	22.2	6(2-11)
Sakinaw Lake	Mainland Coast	59	0.0	-
San Juan River	Vancouver Is.	139	72.7	15(1-62)
Schulbuckhand Creek	Skeena River	42	71.4	NC
Smokehouse Creek	Mainland Coast	48	37.5	NC
Sproat Lake	Vancouver Is.	2,701	0.0	-
Stellako River	Fraser River	25	0.0	-
Stikine River	Stikine River	168	1.2	NC

Table 1 (cont'd)

Locality	Drainage system or coastal area	No. fish examined	Prevalence* (%)	Intensity**
Tahltan Lake	Stikine River	50	0.0	-
Weaver Creek	Fraser River	215	19.5	17(1-52)
Williams Creek	Skeena River	42	54.8	NC
Woss Lake	Vancouver Is.	10	0.0	-
Woss River	Vancouver Is.	10	0.0	-
Yakoun River	Queen Charlotte Is.	12	16.7	NC

*Percent of examined fish infected.

**Average (and range in parentheses) number of cysts per infected fish.

***Not counted.

Table 2. Infection of coho salmon with Henneguya.

Locality	Drainage system or coastal area	No. fish examined	Prevalence* (%)	Intensity**
Babine River	Skeena River	4	0.0	-
Bella Coola River	Mainland Coast	52	38.5	23(2-112)
Big Qualicum River	Vancouver Is.	310	43.6	9(1-70)
Black Creek	Vancouver Is.	21	33.3	6(1-30)
Bonsall Creek	Vancouver Is.	13	30.8	5(2-12)
Capilano River	Mainland Coast	200	0.5	NC***
Chemainus River	Vancouver Is.	16	18.8	26(2-70)
Conuma River	Vancouver Is.	36	0.0	-
Devereux Creek	Mainland Coast	3	0.0	-
Goldstream River	Vancouver Is.	18	0.0	-
Great Central Lake	Vancouver Is.	195	21.0	40(1-100)
Hopedale Creek	Fraser River	41	0.0	-
Iskut River	Stikine River	11	0.0	-
Kincolith (hatchery)	Nass River	4	0.0	-
Lakelse River	Skeena River	32	9.4	NC
Little Qualicum River	Vancouver Is.	68	51.5	21(4-92)
Mesachie Creek	Vancouver Is.	40	45.0	17(1-63)
Millard Creek	Queen Charlotte Is.	5	40.0	NC
Pallant Creek	Queen Charlotte Is.	70	14.3	NC
Puntledge River	Vancouver Is.	83	9.6	13(1-50)
Quinsam River	Vancouver Is.	143	34.3	5(1-22)
Robertson Creek	Vancouver Is.	125	8.0	42(2-158)
Robertson River	Vancouver Is.	174	43.7	14(1-102)
Salwein Creek	Fraser River	61	34.4	12(1-69)
San Juan River	Vancouver Is.	201	41.3	22(1-150)
Sooke River	Vancouver Is.	129	29.5	32(3-140)
Sproat Lake	Vancouver Is.	118	28.0	10(2-20)
Tsolum River	Vancouver Is.	2	50.0	NC
Weaver Creek	Fraser River	5	60.0	NC
Yakoun River	Queen Charlotte Is.	12	16.7	NC

*Percent of examined fish infected.

**Average (and range in parentheses) number of cysts per infected fish.

***Not counted.

Table 3. Infection of chinook salmon with Henneguya.

Locality	Drainage system or coastal area	No. fish examined	Prevalence* (%)	Intensity**
Babine River	Skeena River	60	0.0	-
Big Qualicum River	Vancouver Is.	323	39.9	4(1-13)
Birkenhead River	Fraser River	33	6.1	36(29-43)
Bonaparte River	Fraser River	21	0.0	-
Bowron River	Fraser River	46	2.2	NC***
Capilano River	Mainland Coast	90	0.0	-
Chemainus River	Vancouver Is.	14	7.1	NC
Cowichan River	Vancouver Is.	118	33.0	7(1-37)
Devereux Creek	Mainland Coast	24	0.0	-
Finn Creek	Fraser River	25	0.0	-
Horsefly River	Fraser River	9	0.0	-
Kitimat River	Mainland Coast	60	0.0	-
Nanaimo River	Vancouver Is.	82	0.0	-
Nechako River	Fraser River	14	0.0	-
Nicola River	Fraser River	11	0.0	-
Nitinat River	Vancouver Is.	90	8.9	2(1-5)
Puntledge River	Vancouver Is.	53	0.0	-
Quesnel River	Fraser River	73	0.0	-
Quinsam River	Vancouver Is.	103	14.6	8(1-58)
Robertson Creek	Vancouver Is.	100	0.0	-
Salmon River	Fraser River	21	0.0	-
San Juan River	Vancouver Is.	75	1.3	(18)
Slim Creek	Fraser River	45	0.0	-
Squamish River	Mainland Coast	7	0.0	-
Weaver Creek	Fraser River	6	16.7	NC

*Percent of examined fish infected.

**Average (and range in parentheses) number of cysts per infected fish.

***Not counted.

Table 4. Infection of chum salmon with Henneguya.

Locality	Drainage system or coastal area	No. fish examined	Prevalence*1 (%)	Intensity**
Big Qualicum River	Vancouver Is.	197	11.2	24(3-66)
Blaney Creek	Fraser River	42	7.1	30(11-50)
Bonsall Creek	Vancouver Is.	3	33.3	NC***
Cheakamus River	Mainland Coast	7	0.0	-
Chemainus River	Vancouver Is.	72	0.0	-
Conuma River	Vancouver Is.	78	0.0	-
Cowichan River	Vancouver Is.	22	9.1	NC
Devereux Creek	Mainland Coast	4	0.0	-
Inches Creek	Fraser River	107	14.9	41(8-123)
Kitimat River	Mainland Coast	36	0.0	-
Little Qualicum River	Vancouver Is.	70	2.9	20(6-34)
Nanaimo River	Vancouver Is.	69	0.0	-
Nitinat River	Vancouver Is.	55	7.3	6(1-15)
Orford River	Mainland Coast	7	0.0	-
Pallant Creek	Queen Charlotte Is.	101	1.0	NC
Rosewall Creek	Vancouver Is.	34	0.0	-
San Juan River	Vancouver Is.	6	0.0	-
Sliammon River	Mainland Coast	74	0.0	-
Sooke River	Vancouver Is.	33	30.3	NC
Squamish River	Mainland Coast	8	0.0	-
Vedder River	Fraser River	101	2.0	NC
Weaver Creek	Fraser River	134	19.4	34(8-72)

*Percent of examined fish infected.

**Average (and range in parentheses) number of cysts per infected fish.

***Not counted.

Table 5. Infection of pink salmon with *Henneguya*.

Locality	Drainage system or coastal area	No. fish examined	Prevalence* (%)	Intensity**
Amor de Cosmos River	Vancouver Is.	50	0.0	-
Ashlulm Creek	Mainland Coast	12	0.0	-
Babine River	Skeena River	98	0.0	-
Devereux Creek	Mainland Coast	1	0.0	-
Glendale River	Mainland Coast	25	0.0	-
Indian River	Mainland Coast	50	0.0	-
Kakweiken River	Mainland Coast	25	0.0	-
Kincolith (hatchery)	Nass River	4	0.0	-
Kispiox River	Skeena River	9	0.0	-
Kitimat River	Mainland Coast	102	0.0	-
Mathers Lake	Queen Charlotte Is.	62	0.0	-
Pallant Creek	Queen Charlotte Is.	126	6.4	240(2-400)
Quinsam River	Vancouver Is.	160	0.0	-
San Juan River	Vancouver Is.	26	0.0	-
Squamish River	Mainland Coast	8	0.0	-
Weaver Creek	Fraser River	130	7.7	17(1-50)

*Percent of examined fish infected.

**Average (and range in parentheses) number of cysts per infected fish.

***Not counted.

Table 6. Summary of pacific salmon stocks examined for <u>Henneguya</u>.

Locality by drainage system or coastal area	Species	Date collected	No. of fish		Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
			Examined	Infected		
EAST COAST VANCOUVER ISLAND						
1) GOLDSTREAM RIVER	COHO	5-16 Nov. 1980	18	0	0	-
2) COWICHAN R. SYSTEM						
In River near outlet	CHUM	5 Dec. 1977	5	1	20	NC*
In River near outlet	CHUM	11 Dec. 1979	17	1	6	NC
In River near lake	CHINOOK	26 Oct. 1978	40	6	15	NC
In River near lake	CHINOOK	15-23 Nov. 1979	78	33	42	7(1-37)
Robertson River	COHO	12 Dec. 1979	90	45	50	14(1-63)
Robertson River	COHO	26 Nov. 1980	75	29	39	14(2-102)
Robertson River	COHO	2-7 Dec. 1981	9	2	22	NC
Mesachie Creek	COHO	24 Nov. 1977	15	8	53	NC
Mesachie Creek	COHO	11 Dec. 1979	25	10	40	17(1-63)
3) CHEMAINUS RIVER	CHUM	27 Oct. 1978	25	0	0	-
	CHUM	6 Nov. 1979	47	0	0	-
	COHO	11-23 Jan. 1980	16	3	19	26(2-70)
	CHINOOK	27 Oct. 1978	13	1	8	NC
	CHINOOK	6 Nov. 1979	1	0	0	-

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish Examined	No. of fish Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
EAST COAST VANCOUVER IS. (cont'd)						
4) BONSALL CREEK	CHUM	11 Jan. 1980	3	1	33	NC
	COHO	11 Jan. 1980	13	4	31	5(2-12)
5) NANAIMO RIVER	CHUM	7 Nov. 1979	34	0	0	-
	CHUM	13 Nov. 1979	20	0	0	-
	CHUM	7 Dec. 1979	15	0	0	-
	CHINOOK	4-5 Oct. 1979	34	0	0	-
	CHINOOK	20-21 Oct. 1980	48	0	0	-
6) LITTLE QUALICUM RIVER (Spawning Channels)	COHO	7 Dec. 1979	6	2	33	16(5-7)
	COHO	5 Dec. 1980	62	33	53	21(4-92)
	CHUM	7 Dec. 1979	70	2	3	20(6-34)
7) BIG QUALICUM RIVER (Hatchery & Spawning Channel)	CHUM	4 Dec. 1979	96	10	10	24(3-66)
	CHUM	4 Nov. 1981	51	8	16	NC
	CHUM	25 Nov. 1981	50	4	8	NC

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish: Examined	No. of fish: Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
EAST COAST VANCOUVER IS. (cont'd)						
7) BIG QUALICUM RIVER						
(Hatchery & Spawning Channel)	COHO	28 Nov. 1978	25	2	8	NC
(cont'd)	COHO	27 Nov.-12 Dec. 1979	150	61	41	9(1-70)
	COHO	24 Nov. 1980	75	45	60	NC
	COHO	24 Nov. 1981	60	27	45	NC
	CHINOOK	16 Oct. 1978	25	3	12	NC
	CHINOOK	18 Oct. 1979	100	57	57	4(1-13)
	CHINOOK	29 Oct. 1980	81	30	37	NC
	CHINOOK	20,27 Oct. 1981	117	39	33	NC
8) ROSEWALL CREEK	CHUM	21 Dec. 1979	34	0	0	-
9) PUNTLEDGE R. SYSTEM						
Puntledge River (at Hatchery)	COHO	12 Nov. 1980	83	8	10	13(1-50)
	CHINOOK	17 Oct. 1977	15	0	0	-
	CHINOOK	9 Oct. 1979	38	0	0	-
Black Creek	COHO	12 Nov. 1980	21	7	33	6(1-30)
Tsolum River	COHO	18 Nov. 1981	2	1	50	NC

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish Examined	Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
EAST COAST VANCOUVER IS. (cont'd)						
10) QUINSAM RIVER	PINK	18-19 Sept. 1978	60	0	0	-
(at Hatchery)	PINK	8 Oct. 1980	100	0	0	-
	COHO	26 Oct. 1977	15	0	0	-
	COHO	9 Nov. 1978	25	2	8	NC
	COHO	13 Nov. 1979	103	47	46	5(1-22)
	CHINOOK	24 Oct. 1979	103	15	15	8(1-58)
11) AMOR DE COSMOS RIVER (also known as Bear River)	PINK	17 Oct. 1980	50	0	0	-
12) NIMPKISH R. SYSTEM						
Nimpkish River	SOCKEYE	29 Oct. 1979	56	0	0	-
Woss River	SOCKEYE	20 Nov. 1979	10	0	0	-
Woss Lake	SOCKEYE	20 Nov. 1979	10	0	0	-
WEST COAST VANCOUVER ISLAND						
1) SOOKE RIVER	CHUM	11 Dec. 1979	20	6	30	NC
	CHUM	12 Dec. 1979	13	4	31	29(17-39)

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish Examined	No. of fish Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
WEST COAST VANCOUVER IS. (cont'd)						
1) SOOKE RIVER (cont'd)	COHO	11 Dec. 1979	45	12	27	NC
	COHO	12 Dec. 1979	30	10	33	32(3-140)
	COHO	2 Dec. 1980	54	16	30	NC
2) SAN JUAN RIVER	SOCKEYE	5,6,13 Nov. 1979	10	6	60	18(2-62)
	SOCKEYE	21 Nov. 1980	52	28	54	14(1-62)
	SOCKEYE	9 Dec. 1981	77	67	87	NC
	PINK	14 Oct. 1980	26	0	0	-
	CHUM	5,6,13 Nov. 1979	6	0	0	-
	COHO	12 Dec. 1978	20	3	15	NC
	COHO	5,6,13 Nov. 1979	63	34	54	29(1-100)
	COHO	21 Nov.,18 Dec. 1980	84	32	38	23(4-150)
	COHO	Nov. 1980	34	14	41	8(2-18)
	CHINOOK	16 Oct. 1980	75	1	1	18
3) NITINAT RIVER	CHUM	28 Oct. 1980	55	4	7	6(1-15)
	CHINOOK	10 Oct. 1979	90	8	9	2(1-5)

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish		Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
			Examined	Infected		
WEST COAST VANCOUVER IS. (cont'd)						
4) HOBITON LAKE	SOCKEYE	24-25 June 1980	23	11	48	NC
	SOCKEYE	3 July 1980	31	16	52	NC
5) HENDERSON LAKE (Clemens Creek)	SOCKEYE	5 Oct. 1978	89	50	56	NC
	SOCKEYE	18 Oct. 1978	99	53	53	NC
	SOCKEYE	3 Oct. 1979	107	79	74	33(1-136)
	SOCKEYE	16 Oct. 1979	104	81	78	31(1-200)
	SOCKEYE	22 Oct. 1980	100	73	73	NC
	SOCKEYE	29 Oct. 1980	100	70	70	NC
	SOCKEYE	14 Oct. 1981	100	68	68	NC
	SOCKEYE	22 Oct. 1981	100	75	75	NC
	SOCKEYE	22 Oct. 1981	50	39	78	51(1-533)
	SOCKEYE	5 Nov. 1981	100	75	75	NC
	SOCKEYE	5 Nov. 1981	27	20	74	NC
	SOCKEYE	5 Oct. 1982	100	56	56	NC
	SOCKEYE	12 Oct. 1982	100	62	62	NC
	SOCKEYE	19 Oct. 1982	100	72	72	NC
	SOCKEYE	6 Oct. 1983	99	51	52	NC
	SOCKEYE	11 Oct. 1983	100	71	71	NC
	SOCKEYE	19 Oct. 1983	100	53	53	NC

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish		Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
			Examined	Infected		
WEST COAST VANCOUVER IS. (cont'd)						
6) SPROAT LAKE (at Fishway)	COHO	3 Sept. 1980	20	1	5	NC
	COHO	12 Sept. 1980	8	3	38	10(2-20)
	COHO	18 Sept. 1980	8	1	12.5	NC
	COHO	15,22 Sept. 1981	82	28	34	NC
	SOCKEYE	13 July 1977	15	0	0	-
	SOCKEYE	21 June 1979	10	0	0	-
	SOCKEYE	28 June 1979	15	0	0	-
	SOCKEYE	5 July 1979	15	0	0	-
	SOCKEYE	13 July 1979	15	0	0	-
	SOCKEYE	19 July 1979	15	0	0	-
	SOCKEYE	25 July 1979	15	0	0	-
	SOCKEYE	1 Aug. 1979	15	0	0	-
	SOCKEYE	9 Aug. 1979	15	0	0	-
	SOCKEYE	16 Aug. 1979	15	0	0	-
	SOCKEYE	24 Aug. 1979	15	0	0	-
	SOCKEYE	29 Aug. 1979	15	0	0	-
	SOCKEYE	6 Sept. 1979	15	0	0	-
	SOCKEYE	29 May 1980	1	0	0	-
	SOCKEYE	5 June 1980	75	0	0	-
	SOCKEYE	11 June 1980	62	0	0	-
	SOCKEYE	19 June 1980	81	0	0	-
	SOCKEYE	25 June 1980	80	0	0	-

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish		Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
			Examined	Infected		
WEST COAST VANCOUVER IS. (cont'd)						
6) SPROAT LAKE	SOCKEYE	2 July 1980	98	0	0	-
(at Fishway) (cont'd)	SOCKEYE	9 July 1980	100	0	0	-
	SOCKEYE	16 July 1980	100	0	0	-
	SOCKEYE	22 July 1980	75	0	0	-
	SOCKEYE	30 July 1980	50	0	0	-
	SOCKEYE	6 Aug. 1980	99	0	0	-
	SOCKEYE	12 Aug. 1980	100	0	0	-
	SOCKEYE	20 Aug. 1980	100	0	0	-
	SOCKEYE	26 Aug. 1980	100	0	0	-
	SOCKEYE	3 Sept. 1980	100	0	0	-
	SOCKEYE	9 Sept. 1980	94	0	0	-
	SOCKEYE	16 Sept. 1980	15	0	0	-
	SOCKEYE	2 June 1981	4	0	0	-
	SOCKEYE	9 June 1981	54	0	0	-
	SOCKEYE	16 June 1981	34	0	0	-
	SOCKEYE	23 June 1981	100	0	0	-
	SOCKEYE	30 June 1981	100	0	0	-
	SOCKEYE	7 July 1981	100	0	0	-
	SOCKEYE	14 July 1981	100	0	0	-
	SOCKEYE	21 July 1981	100	0	0	-
	SOCKEYE	28-29 July 1981	47	0	0	-
	SOCKEYE	4 Aug. 1981	99	0	0	-
	SOCKEYE	18&20 Aug. 1981	100	0	0	-

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish Examined	No. of fish Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
WEST COAST VANCOUVER IS. (cont'd)						
6) SPROAT LAKE (at Fishway) (cont'd)	SOCKEYE	25 Aug. 1981	100	0	0	-
	SOCKEYE	1 Sept. 1981	100	0	0	-
	SOCKEYE	9 Sept. 1981	29	0	0	-
	SOCKEYE	15 Sept. 1981	14	0	0	-
	SOCKEYE	22 Sept. 1981	100	0	0	-
7) GREAT CENTRAL LAKE (at Fishway)	COHO	20 Aug. 1980	10	4	40	NC
	COHO	3 Sept. 1980	73	9	12	11(3-62)
	COHO	16 Sept. 1980	41	6	15	NC
	COHO	9,15,21 Sept. 1981	71	22	31	52(1-100)
	SOCKEYE	13 July 1977	15	0	0	-
	SOCKEYE	19 June 1979	10	0	0	-
	SOCKEYE	27 June 1979	14	0	0	-
	SOCKEYE	3 July 1979	15	0	0	-
	SOCKEYE	10 July 1979	15	0	0	-
	SOCKEYE	17 July 1979	15	0	0	-
	SOCKEYE	24 July 1979	15	0	0	-
	SOCKEYE	31 July 1979	15	1	7	NC
	SOCKEYE	7 Aug. 1979	15	0	0	-
	SOCKEYE	14 Aug. 1979	15	0	0	-
	SOCKEYE	22 Aug. 1979	15	0	0	-

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish Examined	No. of fish Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
WEST COAST VANCOUVER IS. (cont'd)						
7) GREAT CENTRAL LAKE (at Fishway) (cont'd)	SOCKEYE	28 Aug. 1979	15	0	0	-
	SOCKEYE	5 Sept. 1979	15	0	0	-
	SOCKEYE	5 June 1980	4	0	0	-
	SOCKEYE	11 June 1980	38	0	0	-
	SOCKEYE	18 June 1980	55	0	0	-
	SOCKEYE	25 June 1980	93	0	0	-
	SOCKEYE	2 July 1980	100	1	1	NC
	SOCKEYE	9 July 1980	98	0	0	-
	SOCKEYE	16 July 1980	81	0	0	-
	SOCKEYE	22 July 1980	47	0	0	-
	SOCKEYE	30 July 1980	41	1	2	NC
	SOCKEYE	6 Aug. 1980	85	1	1	NC
	SOCKEYE	12 Aug. 1980	80	0	0	-
	SOCKEYE	20 Aug. 1980	100	1	1	NC
	SOCKEYE	26 Aug. 1980	99	1	1	NC
	SOCKEYE	3 Sept. 1980	100	2	2	NC
	SOCKEYE	9 Sept. 1980	100	0	0	-
	SOCKEYE	16 Sept. 1980	52	0	0	-
	SOCKEYE	2 June 1981	6	0	0	-
	SOCKEYE	9 June 1981	19	0	0	-
	SOCKEYE	16 June 1981	100	0	0	-
	SOCKEYE	23 June 1981	100	0	0	-

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish		Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
			Examined	Infected		
WEST COAST VANCOUVER IS. (cont'd)						
7) GREAT CENTRAL LAKE (at Fishway) (cont'd)	SOCKEYE	30 June 1981	100	0	0	-
	SOCKEYE	7 July 1981	100	0	0	-
	SOCKEYE	14 July 1981	100	0	0	-
	SOCKEYE	21 July 1981	100	0	0	-
	SOCKEYE	28-29 July 1981	55	0	0	-
	SOCKEYE	4 Aug. 1981	100	1	1	NC
	SOCKEYE	11 Aug. 1981	20	1	5	NC
	SOCKEYE	18&20 Aug. 1981	120	1	1	NC
	SOCKEYE	25 Aug. 1981	100	0	0	-
	SOCKEYE	1 Sept. 1981	132	0	0	-
	SOCKEYE	9 Sept. 1981	74	2	3	NC
	SOCKEYE	15 Sept. 1981	43	0	0	-
	SOCKEYE	22 Sept. 1981	67	1	1.5	NC
8) ROBERTSON CREEK HATCHERY	COHO	14 Nov. 1978	25	2	8	NC
	COHO	29 Nov. 1979	100	8	8	42(2-158)
	CHINOOK	25 Oct. 1978	25	0	0	-
	CHINOOK	29 Oct. 1979	75	0	0	-

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish		Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
			Examined	Infected		
WEST COAST VANCOUVER IS. (cont'd)						
9) KENNEDY LAKE						
Clayoquot Arm	SOCKEYE	28 Nov. 1979	79	16	20	47(1-317)
	SOCKEYE	12 Nov. 1980	100	17	17	NC
Main Arm	SOCKEYE	12 Nov. 1980	50	6	12	54(10-152)
10) CONUMA RIVER (at Tlupana Hatchery)	CHUM	26 Oct. 1979	77	0	0	-
	CHUM	30 Sept. 1981	1	0	0	-
	COHO	2,16 Nov. 1981	36	0	0	-
	SOCKEYE	30 Sept. 1981	1	1	100	NC
11) COLONY LAKE CREEK (Quatsino Sound)	KOKANEE	6 Feb. 1980	4	0	0	-
LOWER FRASER RIVER						
1) PITT LAKE (Cypress Creek)	SOCKEYE	12 Sept. 1980	54	12	22	6(2-11)
2) BLANEY CREEK (N. Alouette R.)	CHUM	8 Nov. 1979	42	3	7	30(11-50)
3) CULTUS LAKE	SOCKEYE	24 Nov. 1978	25	0	0	-
	SOCKEYE	3 Dec. 1979	110	6	5	31(2-89)

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish: Examined	No. of fish: Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
<u>LOWER FRASER RIVER</u> (cont'd)						
4) VEDDER-CHILLIWACK SYSTEM						
Salwein Creek	COHO	21 Jan. 1980	22	5	23	NC
	COHO	19 Jan. 1982	39	16	41	12(1-69)
Hopedale Creek	COHO	21 Jan. 1980	41	0	0	-
Vedder River	CHUM	23 Nov. 1978	25	1	4	NC
	CHUM	7 Dec. 1979	76	1	1	6
Chilliwack Lake	KOKANEE	30 June 1978	4	0	0	-
5) INCHES CREEK	CHUM	4 Dec. 1979	107	16	15	41(8-123)
6) WEAVER CREEK	SOCKEYE	23 Oct. 1979	75	15	20	17(1-52)
	SOCKEYE	5 Nov. 1980	85	17	20	NC
	SOCKEYE	29 Oct. 1981	55	10	18	NC
	PINK	23 Oct. 1979	22	6	27	21(1-50)
	PINK	29 Oct. 1981	108	4	4	6.5(1-11)
	CHUM	5 Nov. 1980	24	7	29	34(8-72)
	CHUM	29 Oct. 1981	10	4	40	NC
	CHUM	10 Dec. 1981	100	15	15	NC

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish: Examined	No. of fish: Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
LOWER FRASER RIVER (cont'd)						
6) WEAVER CREEK (cont'd)	COHO	11 Dec. 1981	5	3	60	NC
	CHINOOK	10 Dec. 1981	6	1	17	NC
7) BIRKENHEAD RIVER	SOCKEYE	2-3 Oct. 1979	68	3	4	49(18-100)
	CHINOOK	19-25 Sept. 1979	33	2	6	36(29-43)
CENTRAL FRASER RIVER						
1) BONAPARTE RIVER	CHINOOK	1-7 Sept. 1981	21	0	0	-
2) NICOLA RIVER	CHINOOK	1-7 Sept. 1981	11	0	0	-
3) SOUTH THOMPSON SYSTEM						
Gates Creek of Shuswap R.	SOCKEYE	18 Sept. 1979	50	0	0	-
Adams River	SOCKEYE	19 Oct. 1981	90	0	0	-
	SOCKEYE	20 Oct. 1982	50	0	0	-
Salmon River	CHINOOK	14 Sept. 1981	21	0	0	-

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish: Examined	No. of fish: Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
CENTRAL FRASER RIVER (cont'd)						
4) NORTH THOMPSON SYSTEM Finn Creek of Blue River	CHINOOK	22 Aug. 1981	25	0	0	-
5) CHILKO LAKE	SOCKEYE	6&7 Oct. 1980	65	0	0	-
NORTHERN FRASER RIVER						
1) QUESNEL RIVER	CHINOOK	1 Nov. 1979	13	0	0	-
	CHINOOK	1-2 Oct. 1980	60	0	0	-
2) HORSEFLY RIVER	SOCKEYE	3 Sept. 1981	92	0	0	-
	CHINOOK	1 Nov. 1979	9	0	0	-
3) NECHAKO RIVER	CHINOOK	1 Nov. 1979	14	0	0	-
4) STELLAKO RIVER (Francois Lake System)	SOCKEYE	16 Oct. 1980	25	0	0	-
5) MIDDLE RIVER (Gluske Cr.)	SOCKEYE	7 Aug. 1980	25	0	0	-
(Upper Stuart System)	SOCKEYE	5 Aug. 1981	80	0	0	-

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish: Examined	No. of fish: Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
NORTHERN FRASER RIVER (cont'd)						
6) BOWRON RIVER SYSTEM						
Bowron River	CHINOOK	31 Aug. 1980	25	1	4	NC
	CHINOOK	11-14 Sept. 1980	21	0	0	
Slim Creek	CHINOOK	30 Aug. 1980	20	0	0	-
	CHINOOK	5-6 Sept. 1981	25	0	0	-
MAINLAND COASTAL STREAMS						
1) CAPILANO RIVER HATCHERY	COHO	22 Nov. 1978	25	0	0	-
	COHO	22 Oct. 1979	52	0	0	-
	COHO	23 Oct. 1979	53	1	2	NC
	COHO	9 Nov. 1979	70	0	0	-
	CHINOOK	27 Oct. 1977	15	0	0	-
	CHINOOK	23 Oct. 1979	75	0	0	-
2) INDIAN RIVER (Burrard Inlet)	PINK	27 Sept. 1979	50	0	0	-
3) HOWE SOUND						
Squamish River	PINK	8 Dec. 1977	8	0	0	-
	CHUM	8 Dec. 1977	8	0	0	-

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish Examined	No. of fish Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
MAINLAND COASTAL STREAMS (cont'd)						
3) HOWE SOUND (cont'd) Squamish River (cont'd)	CHINOOK	8 Dec. 1977	7	0	0	-
Cheakamus River	CHUM	8 Dec. 1977	7	0	0	-
4) SAKINAW LAKE (near Sechelt)	SOCKEYE	25 Nov. 1980	59	0	0	-
5) SLIAMMON RIVER (near Powell River)	CHUM	16 Nov. 1979	74	0	0	-
6) ORFORD RIVER (Bute Inlet)	CHUM	2 Oct. 1981	7	0	0	-
7) KNIGHT INLET Devereux Creek	CHINOOK	13 Oct. 1981	13	0	0	-
(also known as Mussel Creek)	CHINOOK	14 Oct. 1981	11	0	0	-
	SOCKEYE	13 Oct. 1981	4	0	0	-
	COHO	13 Oct. 1981	3	0	0	-
	PINK	13 Oct. 1981	1	0	0	-

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish Examined	No. of fish Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
MAINLAND COASTAL STREAMS (cont'd)						
7) KNIGHT INLET (cont'd) Devereux Creek (cont'd)	CHUM	13 Oct. 1981	4	0	0	-
	KOKANEE	13 Oct. 1981	31	0	0	-
Kakweiken River	PINK	28 Sept. 1978	25	0	0	-
Glendale River	PINK	27 Sept. 1978	25	0	0	-
8) KITLOPE LAKE (Dean Channel)	SOCKEYE	10-12 Sept. 1980	190	0	0	-
9) KITIMAT RIVER (Douglas Channel)	PINK	19 Sept. 1977	12	0	0	-
	PINK	24 Aug. 1978	90	0	0	-
	CHUM	19 Sept. 1977	2	0	0	-
	CHUM	24 Aug. 1978	34	0	0	-
	CHINOOK	23-24 Aug. 1978	60	0	0	-
10) LOWE LAKE (Lowe Inlet)	SOCKEYE	Sept. 1980	104	0	0	-

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish: Examined	No. of fish: Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
MAINLAND COASTAL STREAMS (cont'd)						
11) BELLA COOLA RIVER (Hagensborg Slough)	COHO	17 Nov. 1980	52	20	39	23(2-112)
12) OWIKENO LAKE SYSTEM (Rivers Inlet)						
Ashlulum Creek	PINK	26 Sept. 1979	12	0	0	-
	SOCKEYE	26 Sept. 1979	12	0	0	-
Neechanz River	SOCKEYE	17 Sept. 1981	100	0	0	-
13) LONG LAKE SYSTEM (Smith Inlet)						
Canoe Creek	SOCKEYE	26 Sept. 1980	2	1	50	NC
	SOCKEYE	14 Oct. 1981	50	22	44	NC
Docee River	SOCKEYE	29 July 1981	4	0	0	-
Smokehouse Creek	SOCKEYE	14 Oct. 1981	48	18	38	NC
14) BONILLA LAKE	SOCKEYE	21 Sept. 1980	14	5	36	NC
(Banks Island - head of	SOCKEYE	22 Sept. 1980	65	18	28	NC
Kingkown Inlet)	SOCKEYE	3 Aug. 1983	50	9	18	NC

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish: Examined	No. of fish: Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
SKEENA RIVER SYSTEM						
1) ALASTAIR LAKE (Southend Creek)	SOCKEYE	8 Sept. 1982	50	10	20	NC
2) LAKELSE LAKE SYSTEM						
Lakelse R. near Herman Cr.	COHO	27 Oct. 1981	32	3	9	NC
Lakelse R. near Terrace	SOCKEYE	27 Oct. 1981	32	3	9	NC
Williams Creek	SOCKEYE	16 Aug. 1982	42	23	55	NC
Schulbuckhand Creek (also known as Scully Creek)	SOCKEYE	16 Aug. 1982	42	30	71	NC
3) BABINE LAKE SYSTEM						
Babine River Fence	CHINOOK	18-19 Sept. 1979	60	0	0	-
	COHO	18-19 Sept. 1979	4	0	0	-
	PINK	18-19 Sept. 1979	98	0	0	-
	SOCKEYE	18-19 Sept. 1979	100	0	0	-
	SOCKEYE	27 July-30 Aug. 1982	60	0	0	-
Fulton River	SOCKEYE	9 Sept. 1982	50	0	0	-
4) KISPIOX RIVER (near Hazelton)	PINK	4 Sept. 1980	9	0	0	-

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish: Examined	No. of fish: Infected	Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
NASS RIVER SYSTEM						
Meziadin Lake Fishway	SOCKEYE	24-25 July 1982	50	0	0	-
Bowser Lake	SOCKEYE	14 Sept. 1982	41	0	0	-
Damdochax Lake	SOCKEYE	14 Sept. 1982	50	0	0	-
Fred Wright Lake (Bonney Creek)	SOCKEYE	13 Sept. 1982	53	0	0	-
Kincolith Hatchery	PINK	7 Sept. 1979	4	0	0	-
	COHO	7 Sept. 1979	4	0	0	-
STIKINE RIVER SYSTEM						
River Mouth (from fishery)	SOCKEYE	6 July-4 Aug. 1982	50	2	4	NC
Stikine River	SOCKEYE	13 Sept. 1983	118	0	0	-
Iskut River	SOCKEYE	13 Sept. 1983	110	0	0	-
	COHO	13 Sept. 1983	11	0	0	-
Tahltan Lake weir	SOCKEYE	9-10 Aug. 1982	50	0	0	-
TAKU RIVER SYSTEM						
Little Trapper Lake	SOCKEYE	20 Sept. 1982	52	0	0	-

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish		Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
			Examined	Infected		
ALSEK RIVER SYSTEM, YUKON TERR.						
Klukshu River	SOCKEYE	21 July 1983	50	0	0	-
QUEEN CHARLOTTE ISLANDS						
1) MATHERS LAKE (Upper Creek)	SOCKEYE	24 Sept. 1982	50	0	0	-
	PINK	17 Oct. 1980	62	0	0	-
2) COPPER RIVER	SOCKEYE	mid-Oct. 1982	28	12	43	NC
3) PALLANT CREEK	CHUM	18-19 Oct. 1978	25	1	4	NC
	CHUM	15-16 Oct. 1980	76	0	0	NC
	PINK	18-19 Oct. 1978	26	0	0	-
	PINK	15-16 Oct. 1980	100	8	8	240(2-400)
	COHO	10 Dec. 1980	70	10	14	NC
4) MILLARD CREEK (Masset Inlet)	COHO	10 Nov. 1981	5	2	40	NC

Table 6 (cont'd)

Locality by drainage system or coastal area	Species	Date collected	No. of fish		Prevalence (%)	Intensity (Average (and range) of no. of cysts per infected fish)
			Examined	Infected		
QUEEN CHARLOTTE ISLANDS						
5) YAKOUN RIVER SYSTEM						
In River	COHO	10 Nov. 1981	12	2	17	NC
Delta Creek, Yakoun Lake	SOCKEYE	28 Sept. 1982	50	0	0	-
6) AWUN LAKE CREEK	SOCKEYE	28 Sept. 1982	50	0	0	-
7) UPPER NADEN RIVER	SOCKEYE	27 Sept. 1982	50	18	36	NC
8) MERCER LAKE CREEK	SOCKEYE	25 Sept. 1982	50	0	0	-
COLUMBIA RIVER DRAINAGE						
Okanagan Lake	KOKANEE	28 Sept. 1979	17	0	0	-

*Not counted.

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Figure 1. Cysts of Henneguya in the flesh of a sockeye salmon.

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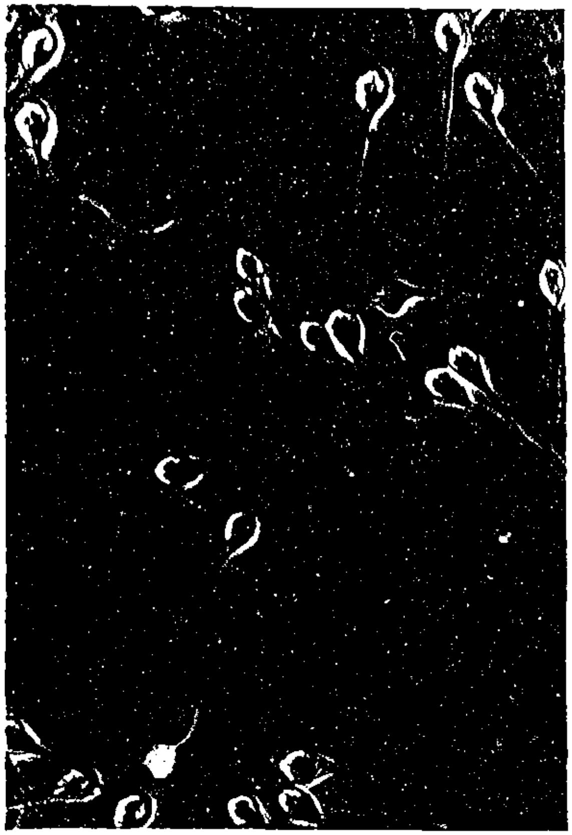

Figure 2. Spores of Henneguya salminicola released from a cyst. Magnified approximately 600X.

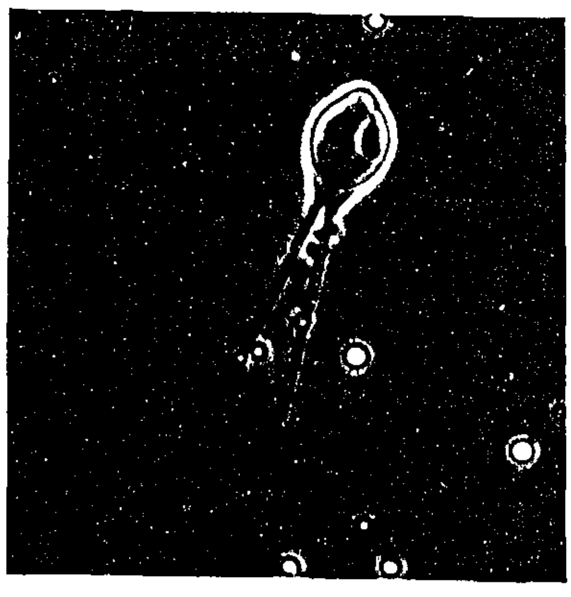

Figure 3. Single spore of Henneguya magnified approximately 1300X.

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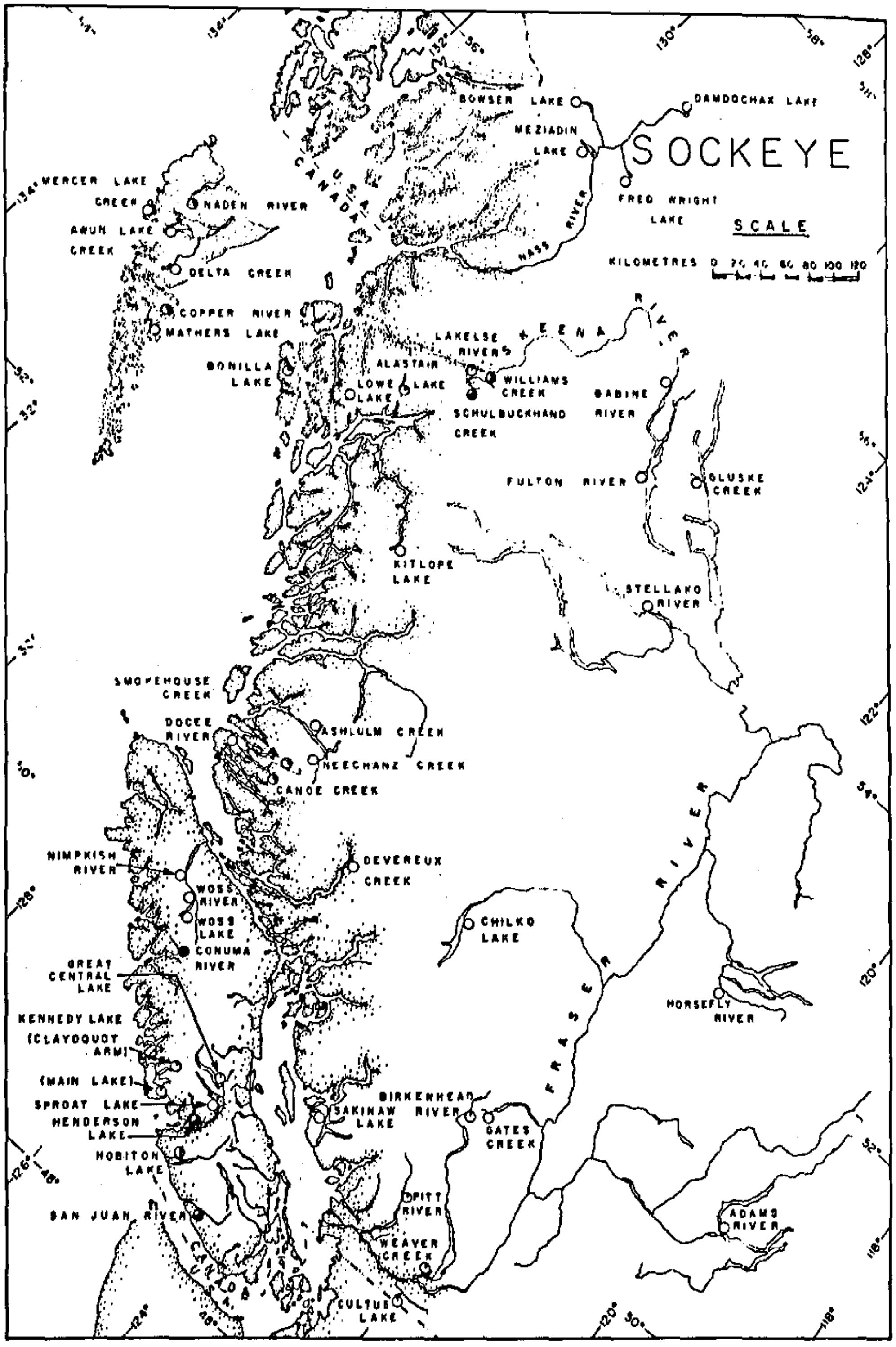

Figure 4. Prevalence of Henneguya in sockeye salmon samples. Circles represent sampling localities, and prevalence (%) is indicated by the proportion of the circle shaded black.

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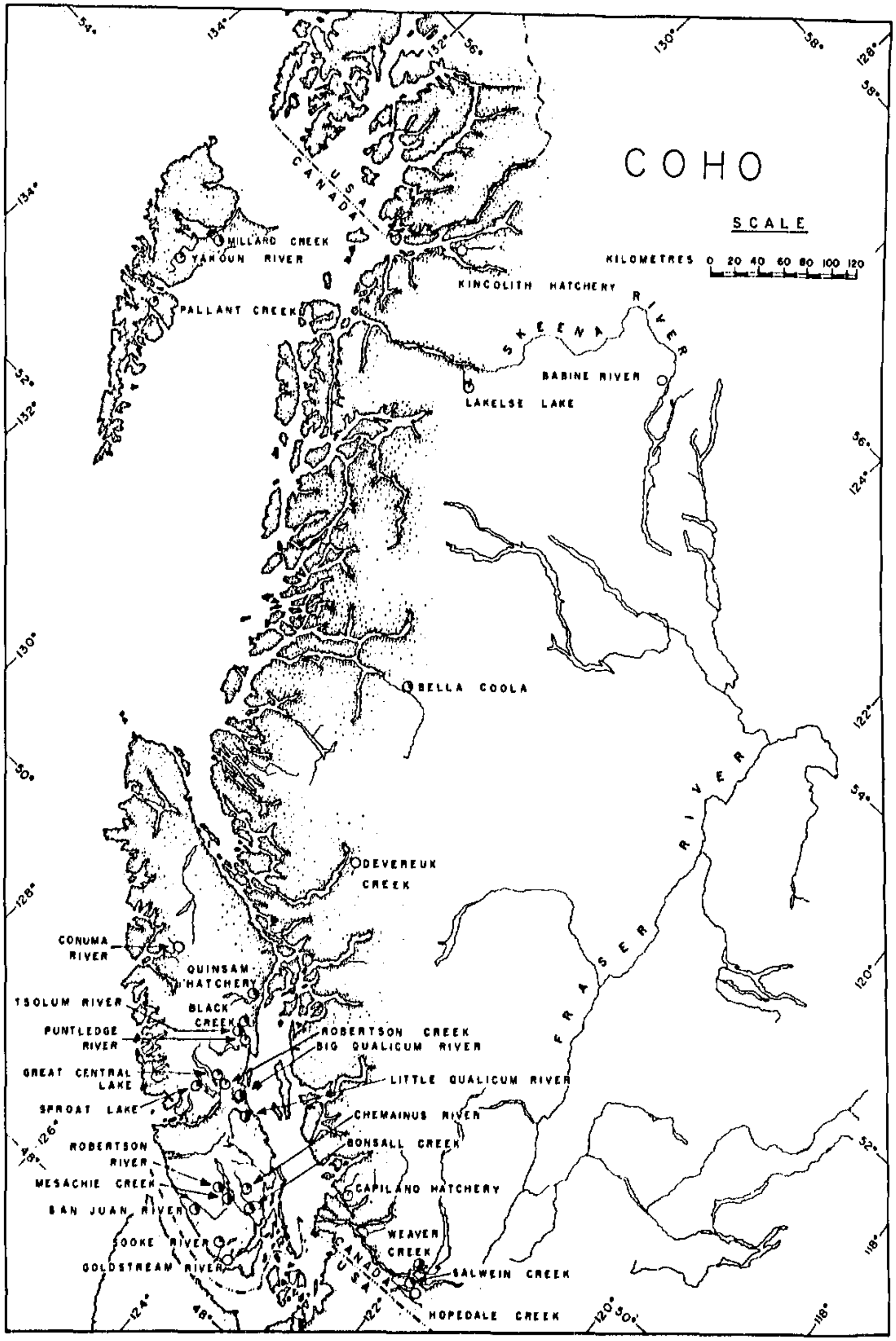

Figure 5. Prevalence of <u>Henneguya</u> in coho salmon samples. Circles represent sampling localities, and prevalence (%) is indicated by the proportion of the circle shaded black.

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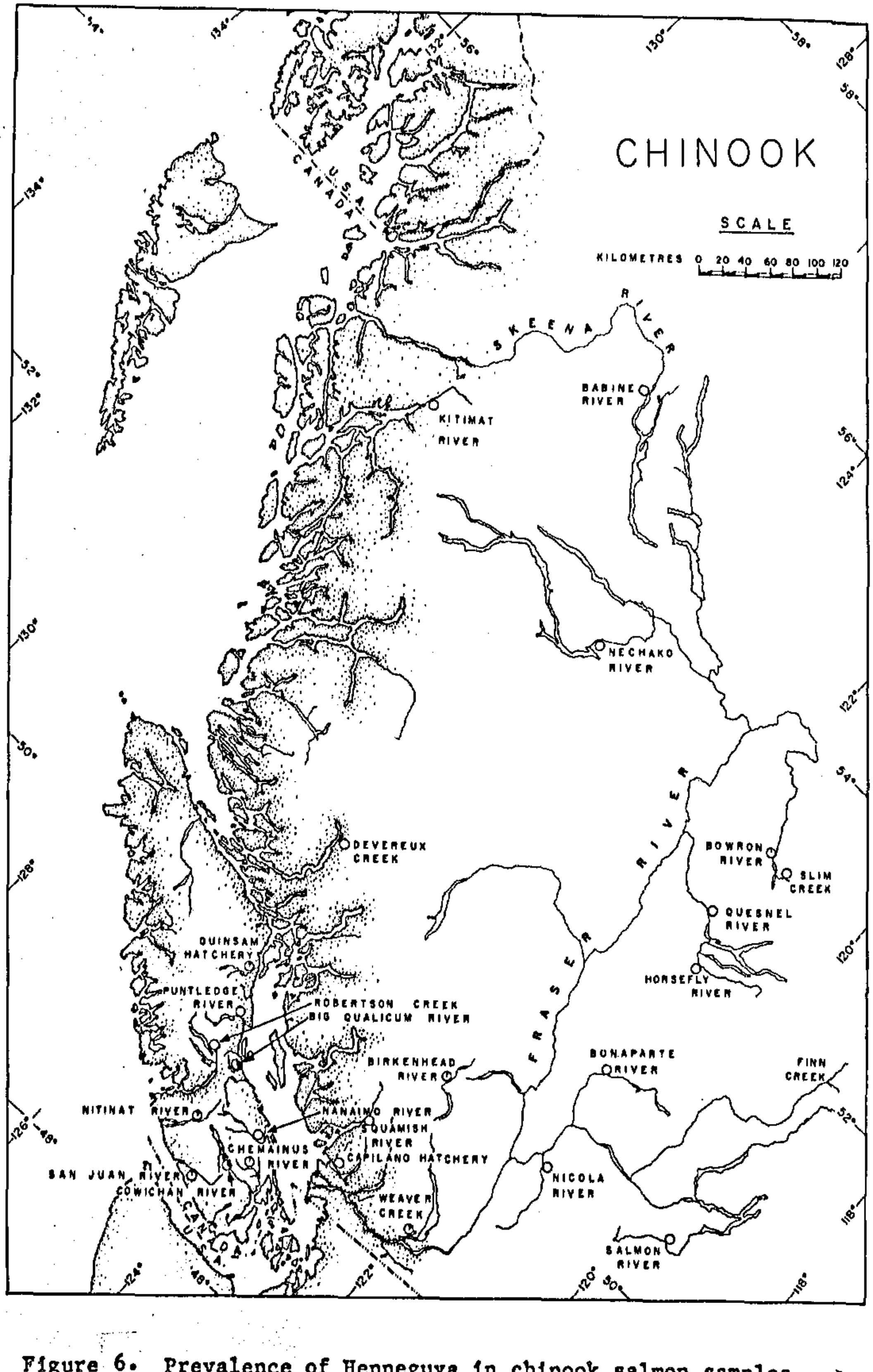

Figure 6. Prevalence of Henneguya in chinook salmon samples. Circles represent sampling localities, and prevalence (%) is indicated by the proportion of the circle shaded black.

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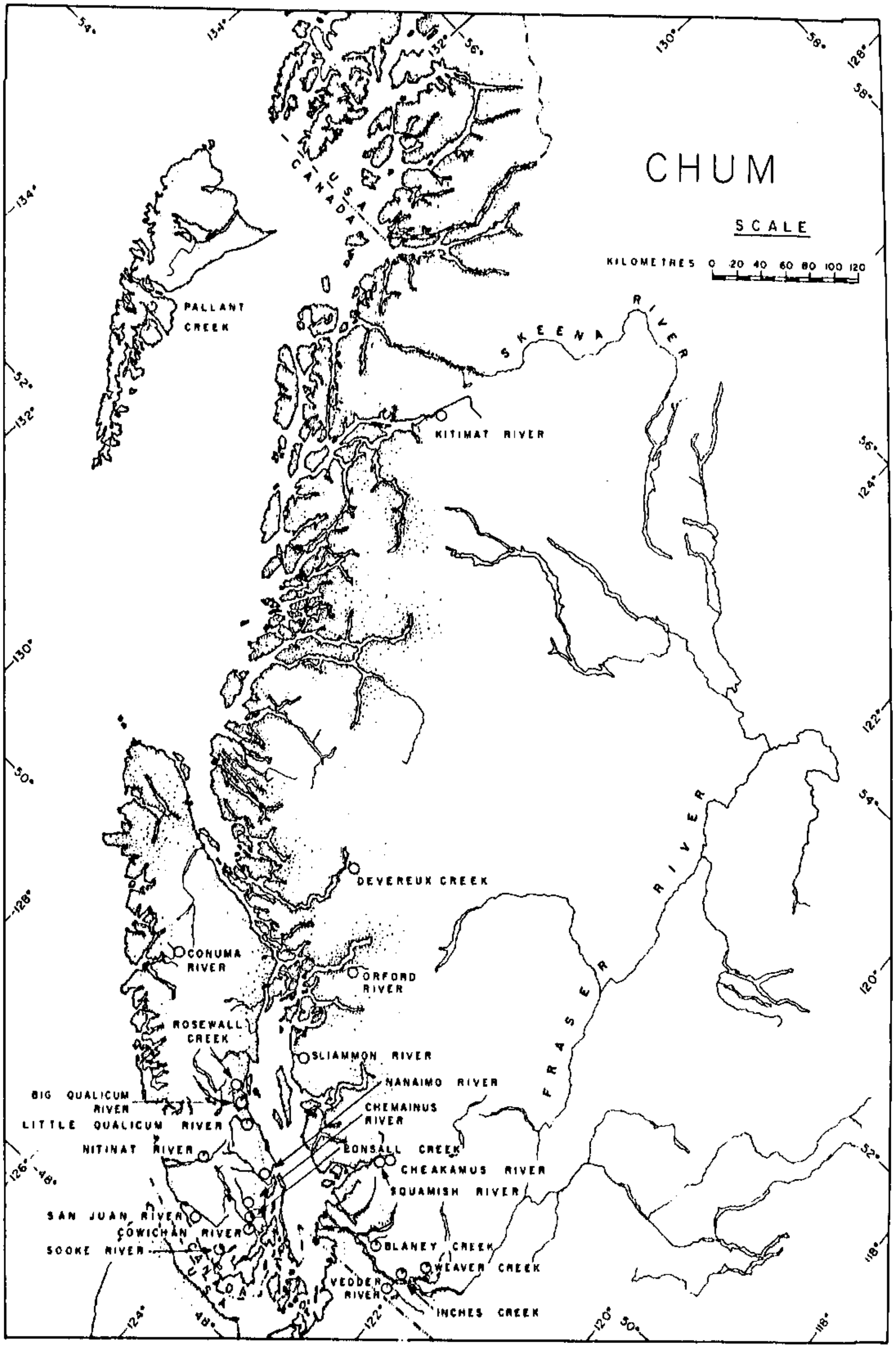

Figure 7. Prevalence of Henneguya in chum salmon samples. Circles represent sampling localities, and prevalence (%) is indicated by the proportion of the circle shaded black.

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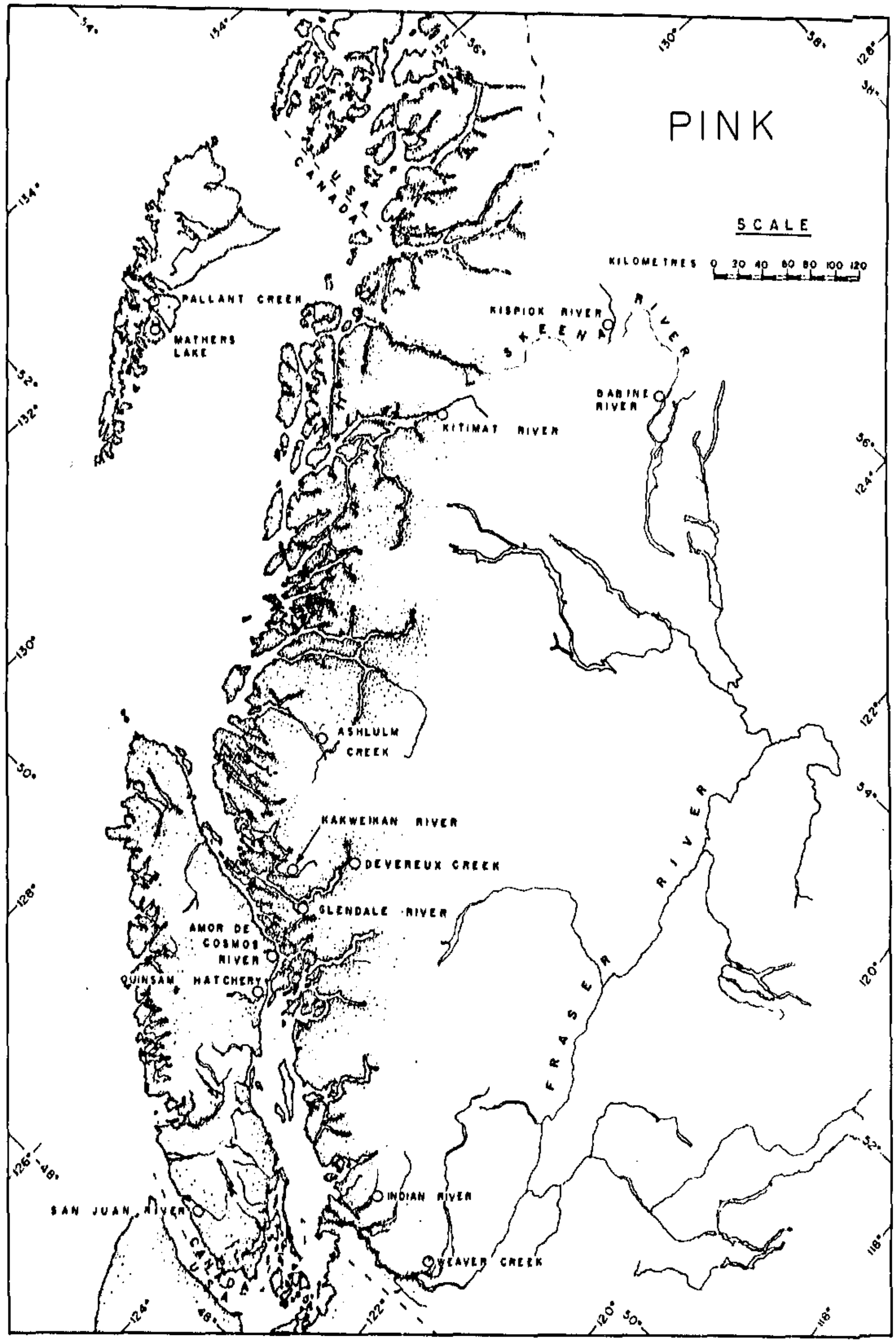

Figure 8. Prevalence of Henneguya in pink salmon samples. Circles represent sampling localities, and prevalence (%) is indicated by the proportion of the circle shaded black.