INTERNATIONAL PACIFIC SALMON
FISHERIES COMMISSION

# PROGRESS REPORT

No. 18

# LAMPREY PARASITISM ON FRASER RIVER SOCKEYE AND PINK SALMON DURING 1967

BY

I. V. WILLIAMS and P. GILHOUSEN



NEW WESTMINSTER, B. C.
CANADA
1968

INTERNATIONAL PACIFIC SALMON
FISHERIES COMMISSION

Appointed under a Convention
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the Sockeye and Pink Salmon Fisheries
in the Fraser River System

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ABSTRACT

The 1967 late season runs of sockeye salmon (Oncorhynchus nerka) to the Fraser River, of which the great majority were bound for Adams River, showed a high incidence of lamprey parasitism. When first examined in the lower Fraser River, 67 per cent of Adams sockeye had been attacked by lampreys (Entosphenus tridentatus) and 6 per cent bore wounds classed as severe. However, blood samples indicated no significant difference in packed blood cell volume between wound severity classes. Later, on the Adams River spawning grounds, many wounds showed signs of healing and comparable percentages for wounded fish were 57 per cent overall, and 5 per cent severe. Mortality of the Adams River run during up-river migration was calculated at less than 2 per cent. Other races of sockeye entering the lower Fraser at the same time as the Adams fish showed a 65 per cent overall incidence of lamprey wounds and a 3 per cent incidence of severely wounded fish. Among pink salmon (O. gorbuscha) examined in the lower Fraser, the incidence of wounded fish was only 20 per cent, and less than 2 per cent carried moderate or severe wounds. Although mortality of sockeye and pink salmon was considered to be negligible during up-river migration, some evidence suggested a possibly greater mortality of fish in Georgia Strait, prior to river entry.

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# LAMPREY PARASITISM ON FRASER RIVER SOCKEYE AND PINK SALMON DURING 1967

## INTRODUCTION

During the latter portion of the 1967 fishing season, the International Pacific Salmon Fisheries Commission received reports from fishermen of severe lamprey parasitism on Fraser River sockeye (Oncorhynchus nerka) and pink (O. gorbuscha) salmon. The salmon catches displaying the highest incidence of lamprey wounds were those taken off the mouth of the Fraser River in Georgia Strait (FIGURE 1). Lamprey attacks on sockeye salmon in varying degrees of intensity have apparently been observed by fishermen in past fishing seasons. However, 1967 was the first year that significant lamprey parasitism on Fraser River sockeye and pink salmon was reported to and observed by the Commission.

Although there have been numerous reports of lamprey parasitism on salmonids on the Atlantic coast (Davis, R.M., 1967), and especially on the Great Lakes trout (Hubbs and Pope, 1937; Berst and Wainio, 1967), there have been very few published reports of lamprey parasitism on Pacific salmon of the genus Oncorhynchus. Birman (1950) reported lamprey (Lampetra japonica) attacks on pink and chum (O. keta) salmon in the Amur estuary during 1948 and 1949. Clemens and Wilby (1961) noted that two species of lamprey, Entosphenus tridentatus and Lampetra ayresii, are present in British Columbia coastal waters. E. tridentatus is reported to attack various fishes, especially salmon and steelhead trout. Little is known of the life history of L. ayresii, but specimens have been captured attached to coho (O. kisutch) salmon.

A preliminary investigation undertaken by the Commission on September 12, 1967, substantiated the reports of a high incidence of lamprey parasitism on salmon caught in Georgia Strait (Davis, W., 1967). Approximately two thirds of the sockeye and one third of the pink salmon examined carried lamprey wounds.

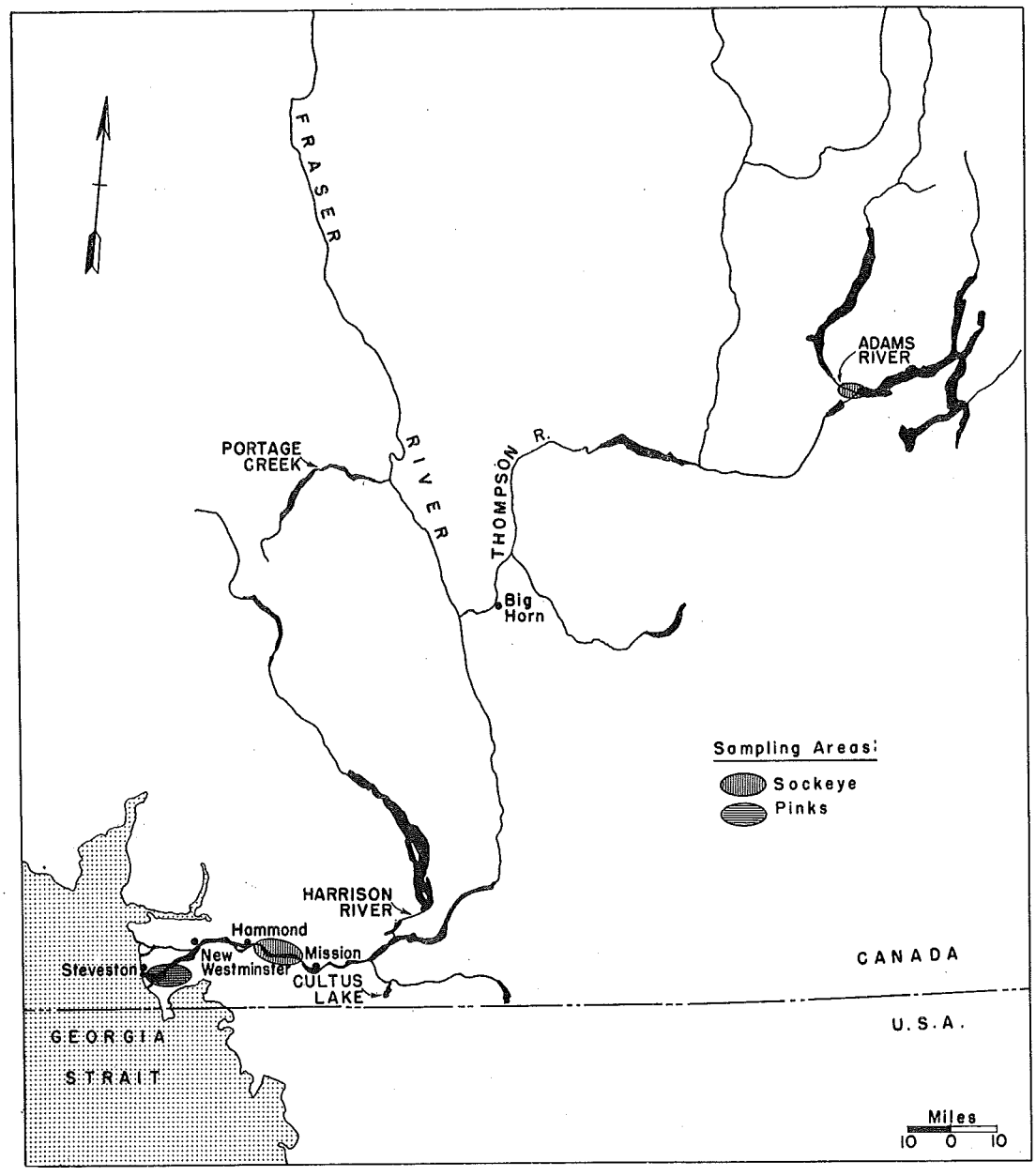


FIGURE 1 - Fraser River watershed showing the areas where sockeye and pink salmon were sampled for lamprey wounds.

Scale samples taken from the commercial fishery during this period were analysed according to the method outlined by Henry (1961) and indicated the predominant race of sockeye present to be the Adams River run. At this time the Adams sockeye were delaying off the mouth of the Fraser River, a behavior exhibited each year by this run. Since this was one of the major sockeye runs for 1967, it was deemed necessary to investigate the level and degree of parasitism on both the lower Fraser fishing grounds and the Adams River spawning grounds, in an attempt to evaluate the effect of lamprey wounds on survival during migration. Other late season sockeye runs and pink salmon caught in the lower Fraser River at this time were also examined for lamprey parasitism.

## MATERIALS AND METHODS

A total of 2,828 adult sockeye salmon were examined for lamprey parasitism during this survey. On September 22nd, 988 sockeye migrating upstream were sampled from the lower Fraser River commercial catch. Half of this sample (490 fish) was taken in the vicinity of the river mouth, near Steveston; the remainder was sampled from the catch farther up river between Hammond and Mission. An additional 250 sockeye were sampled during test fishing near Steveston from September 23 to 29, inclusive. A scale sample was taken from each sockeye sampled on the Fraser River in order to separate the Adams River fish from sockeye of other, smaller runs migrating at the same time. Following this, on October 7, 10 and 12, three samples totalling 1,590 sockeye were examined for lamprey parasitism during tagging operations at the Adams River spawning grounds.

A total of 189 pink salmon captured in the lower Fraser on September 22 and 25 were also examined for lamprey parasitism, and tagging crews at the pink salmon spawning grounds were alerted to watch for and record any evidence of lamprey markings.

The number, position and severity of lamprey wounds were recorded for each fish. The position of each wound on the body was designated as either anterior dorsal (AD), anterior ventral (AV), posterior dorsal (PD) or posterior ventral (PV), as shown in FIGURE 2.

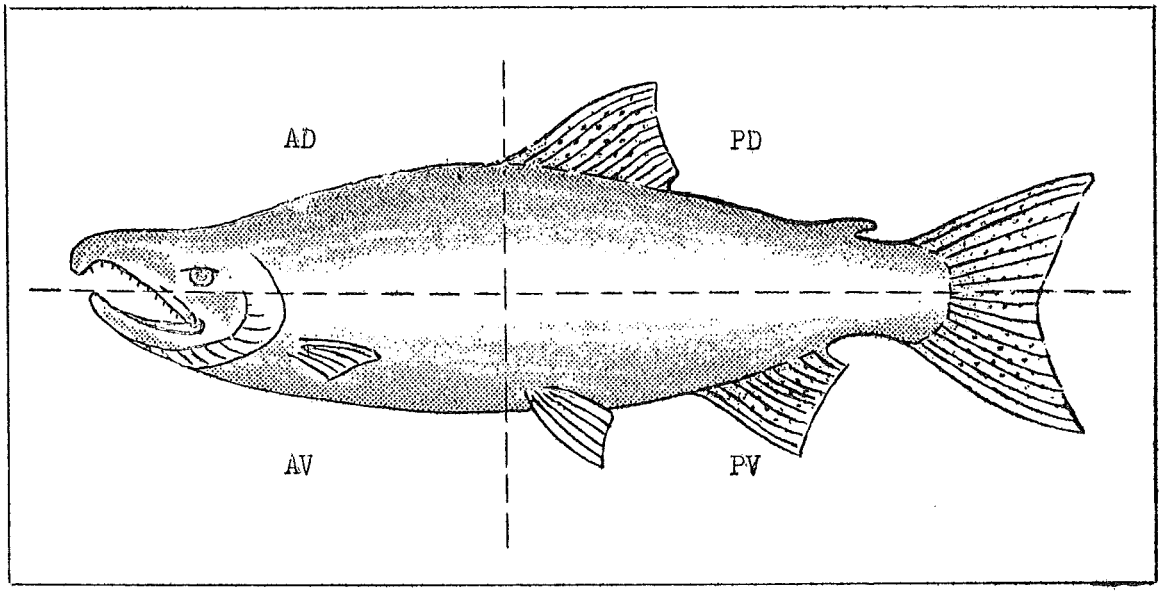


FIGURE 2 - Diagram of salmon showing the four different wound locations.

The severity of a wound was designated as either superficial, moderate or severe. A wound which marked the epidermis but did not penetrate the dermis was classed as superficial (FIGURE 3). A small wound which penetrated the dermis but did not penetrate into the muscle to any extent was classed as moderate (FIGURE 4). Large wounds penetrating deep into the muscle were classed as severe (FIGURE 5).

Along with wound classification, a blood sample was taken from the sockeye caught during test fishing as an aid in assessing wound severity. Blood samples were taken with heparinized microcapillary tubes from freshly caught, live sockeye. The hematocrit readings obtained, expressed as per cent packed cell volume (PCV), were used as a measure of the extent of changes in blood composition.

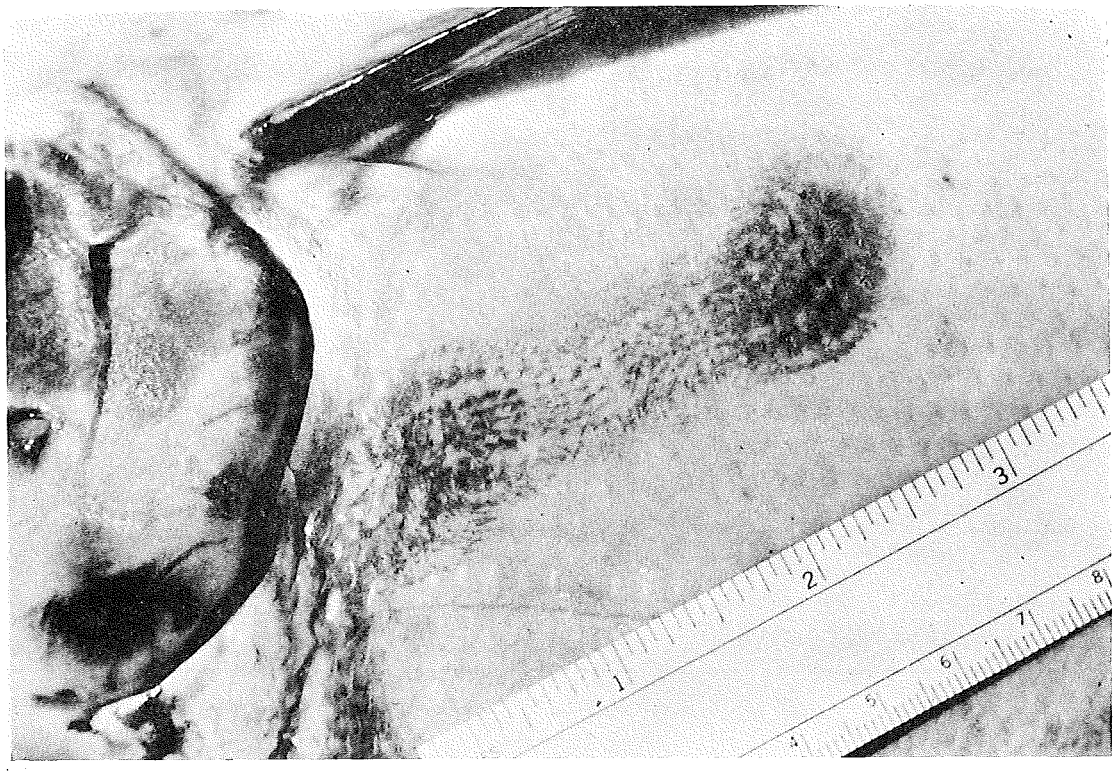

FIGURE 3 - Superficial wounds probably made by one lamprey.

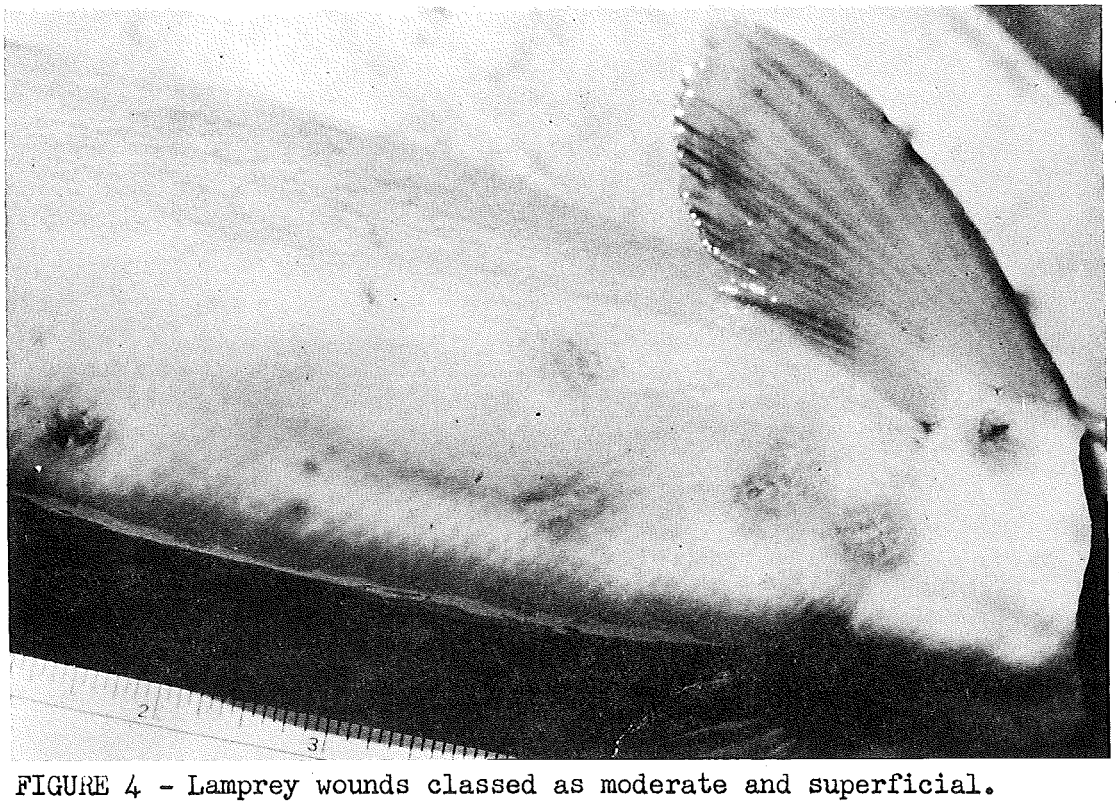

FIGURE 4 - Lamprey wounds classed as moderate and superficial.

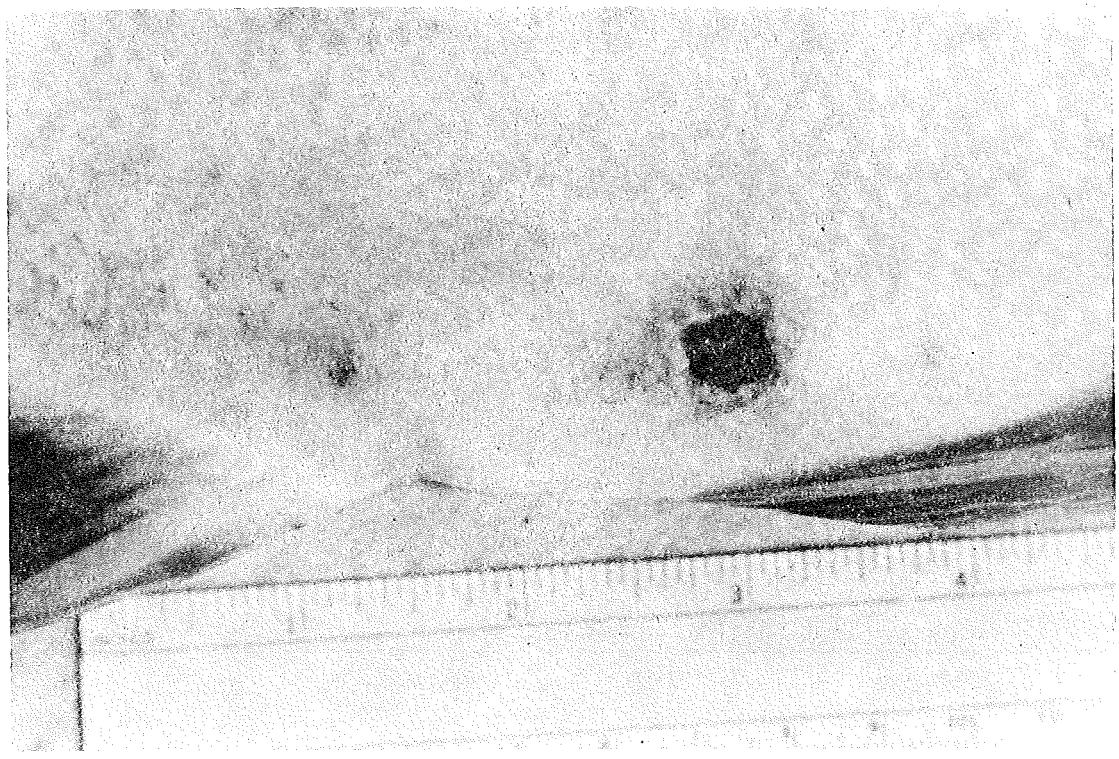

FIGURE 5 - A severe lamprey wound located in the posterior ventral position.

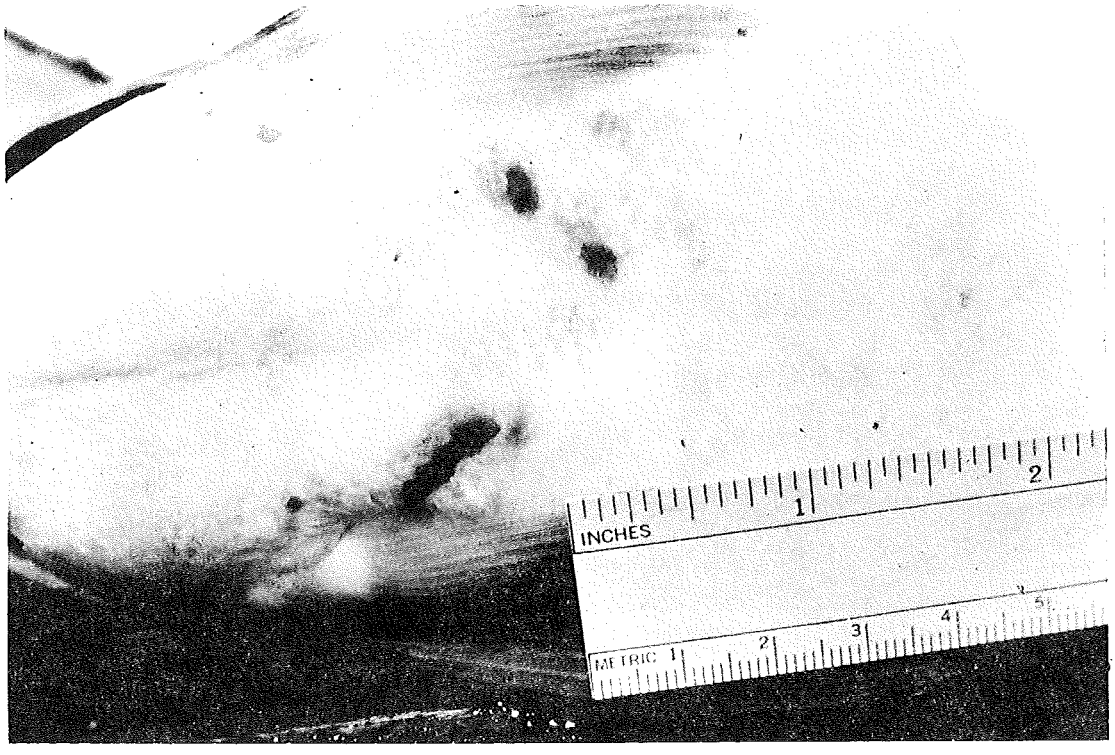


FIGURE 6 - The anterior ventral location of a sockeye salmon showing the area most susceptible to lamprey attack.

## RESULTS

Based on scale samples obtained later in the season at the Adams River spawning grounds, all sockeye captured in the lower Fraser bearing scales with freshwater ring counts (without spring growth) of 13 or less were considered to be Adams fish. Those with 16 or more rings were designated as non-Adams sockeye, which at the time were a composite of Cultus, Weaver, Harrison and Portage races. Those with ring counts in the area of overlap (14-15) or with unreadable scales were omitted from the analysis. With these omissions, 830 of the 1,238 sockeye examined on the lower Fraser River were identified as Adams River fish and 155 were identified as non-Adams sockeye.

The Adams sockeye were sampled from the latter portion of the migration both on the lower Fraser River and at the mouth of the Adams River (FIGURE 7). The migration pattern in the lower Fraser, based on an index of abundance obtained from test fishing, indicates an 11-day migration to the counting site at Big Horn on the Thompson River. The arrival curve at the mouth of Adams River is not necessarily accurate to the specific day as it is a projection of the tower counts made at Big Horn (FIGURE 1). It does, however, show the general segments of the migration that were sampled.

The incidence and degree of lamprey parasitism on late season Fraser River sockeye is summarized in TABLES 1 to 3, where the "severe" column represents the percentage of fish with severe wounds in any combination with moderate and superficial wounds. Percentages in the "moderate" column represent fish with moderate wounds which may be in combination with superficial wounds. Percentages of fish without lamprey wounds or classed as "superficial" are exclusive.

Approximately 67 per cent of the Adams population migrating through the lower Fraser showed some degree of lamprey attack, but overall only 6 per cent showed signs of severe wounding (TABLE 1). Although the percentage of fish with wounds, particularly severe wounds, showed a considerable increase in the test gill net sampling period (September 23 to 29), the percentage of severe wounds fluctuated widely from day to day (0 to 25 per cent) and gave no evidence of a progressive increase in percentage of severe wounds during sampling in the lower Fraser River.

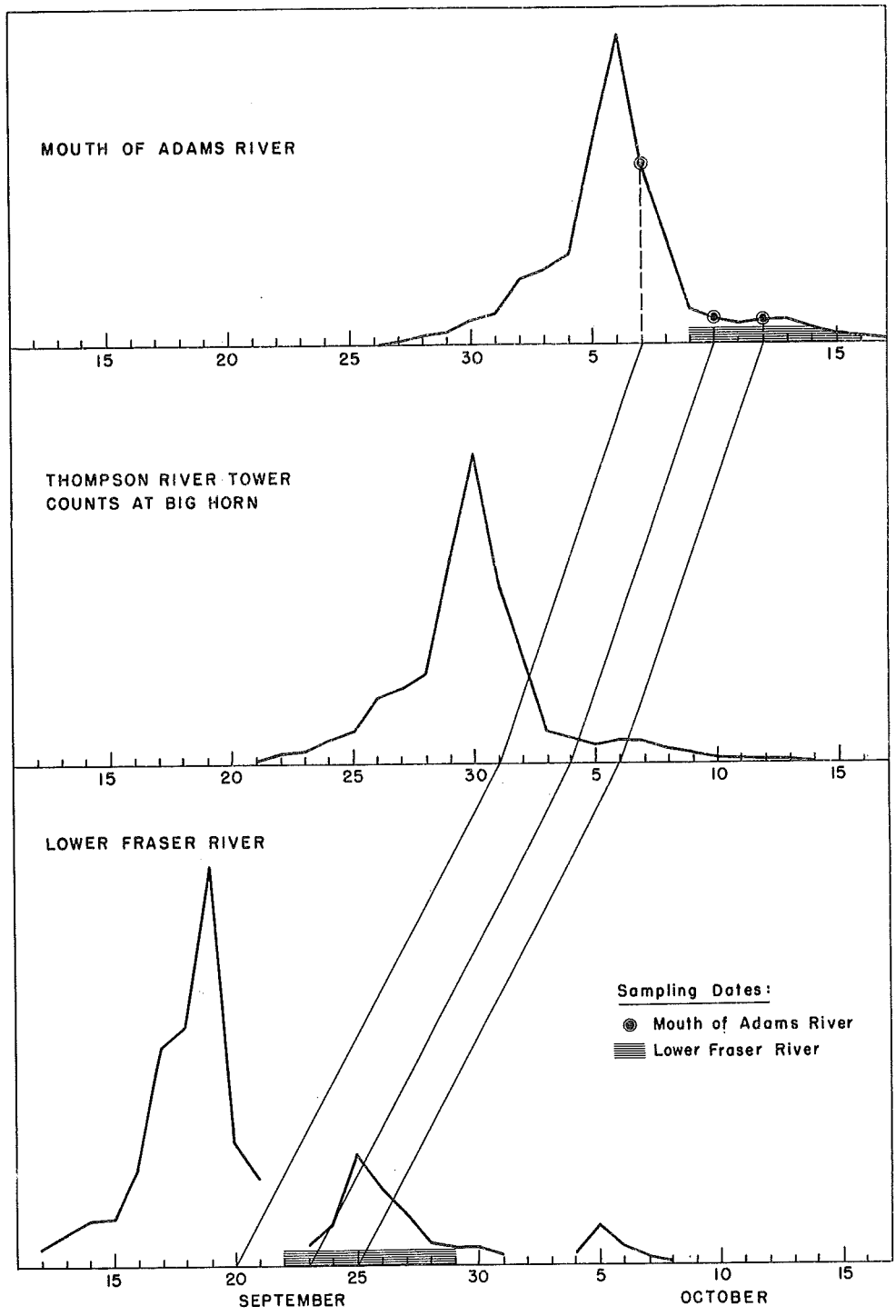


FIGURE 7 - Adams River sockeye migration showing segment of population sampled on the lower Fraser and at the mouth of Adams River. Diagonal lines indicate sampling dates at Adams River projected back to dates of passage through the lower Fraser.

TABLE 1 - Per cent of Adams sockeye with lamprey wounds, lower Fraser River.

| LOCATION | DATE CAUGHT | % WITHOUT LAMPREY WOUNDS | % WITH LAMPREY WOUNDS | | | TOTAL EXAMINED |
|---|---|---|---|---|---|---|
| | | | Superficial | Moderate | Severe | |
| Hammond - Mission Area | Sept.22 | 35.7 | 30.9 | 29.1 | 4.3 | 350 |
| Steveston - New Westminster | Sept.22 | 37.8 | 22.9 | 36.0 | 3.3 | 328 |
| Test Fishing Near Steveston | Sept. 23-29 | 19.1 | 38.2 | 26.3 | 16.4 | 152 |
| MEAN | | 33.5 (278) | 29.0 (241) | 31.3 (260) | 6.1 (51) | 830 |

TABLE 2 - Per cent of Adams sockeye with lamprey wounds, mouth of Adams River.

| LOCATION | DATE CAUGHT | % WITHOUT LAMPREY WOUNDS | % WITH LAMPREY WOUNDS | | | TOTAL EXAMINED |
|---|---|---|---|---|---|---|
| | | | Superficial | Moderate | Severe | |
| Adams River | Oct. 7 | 38.9 | 35.9 | 17.2 | 8.0 | 488 |
| | Oct.10 | 44.3 | 36.4 | 14.5 | 4.8 | 600 |
| | Oct.12 | 45.6 | 48.4 | 4.8 | 1.2 | 502 |
| MEAN | | 43.1 (685) | 40.0 (636) | 12.3 (195) | 4.6 (74) | 1590 |

TABLE 3 - Per cent of non-Adams sockeye with lamprey wounds, lower Fraser River.

| LOCATION | DATE CAUGHT | % WITHOUT LAMPREY WOUNDS | % WITH LAMPREY WOUNDS | | | TOTAL EXAMINED |
|---|---|---|---|---|---|---|
| | | | Superficial | Moderate | Severe | |
| Hammond - Mission Area | Sept.22 | 39.2 | 31.4 | 27.4 | 2.0 | 51 |
| Steveston - New Westminster | Sept.22 | 41.0 | 26.2 | 32.8 | 0 | 61 |
| Test Fishing Near Steveston | Sept. 23-29 | 23.3 | 27.9 | 39.5 | 9.3 | 43 |
| MEAN | | 35.5 (55) | 28.4 (44) | 32.9 (51) | 3.2 (5) | 155 |

On the Adams River spawning grounds, approximately 57 per cent of the spawning population displayed some degree of lamprey attack and about 5 per cent still showed signs of severe wounds (TABLE 2). However, considerable healing of wounds was observed when fish were examined at Adams River. This healing process evidently obscured many of the wounds classed as moderate in the lower Fraser, to the extent that on the spawning grounds they were classed as superficial. Similarly, many superficial wounds were no longer evident, and a larger percentage of the spawning ground population was classed as being without definite lamprey wounds. In contrast to the data obtained from the lower Fraser, the percentage of moderate and severe wounds observed on the spawning grounds decreased throughout the sampling period.

The non-Adams sockeye sampled in the lower Fraser had an incidence and severity of lamprey wounds similar to the Adams fish (TABLE 3). The greatest difference occurred in the severe wound class with 3.2 per cent of non-Adams compared with 6.1 per cent of the Adams fish carrying severe wounds.

The average number of lamprey wounds for sockeye which were attacked was 2.5 per fish. This was relatively constant for the Fraser River and Adams River samples. The average number of severe wounds for sockeye in this category was 1.6 per fish for the Fraser River samples and 1.3 per fish for the Adams River samples. The highest number of wounds recorded for one fish was 13, but 10 of these were superficial. The largest number of severe wounds recorded for one fish was six, all of which were located in the anterior ventral (AV) area. Of the more than 1,200 sockeye examined on the Fraser River, only two, one from the Hammond-Mission sample and one from the Steveston sample, displayed severe lamprey wounds penetrating through the muscle into the coelom.

The sockeye body area most susceptible to lamprey attack was the AV area, and approximately 80 to 90 per cent of the AV lesions were in the restricted area shown in FIGURE 6 (page 10). Many of the severe wounds were located directly posterior to the base of the pectoral fin. The anterior body areas, AV and AD, were also the locations where the most successful lamprey attacks took place (FIGURE 8). Superficial wounds were somewhat more widely distributed over the body surface and very few severe wounds were located on the posterior body areas.

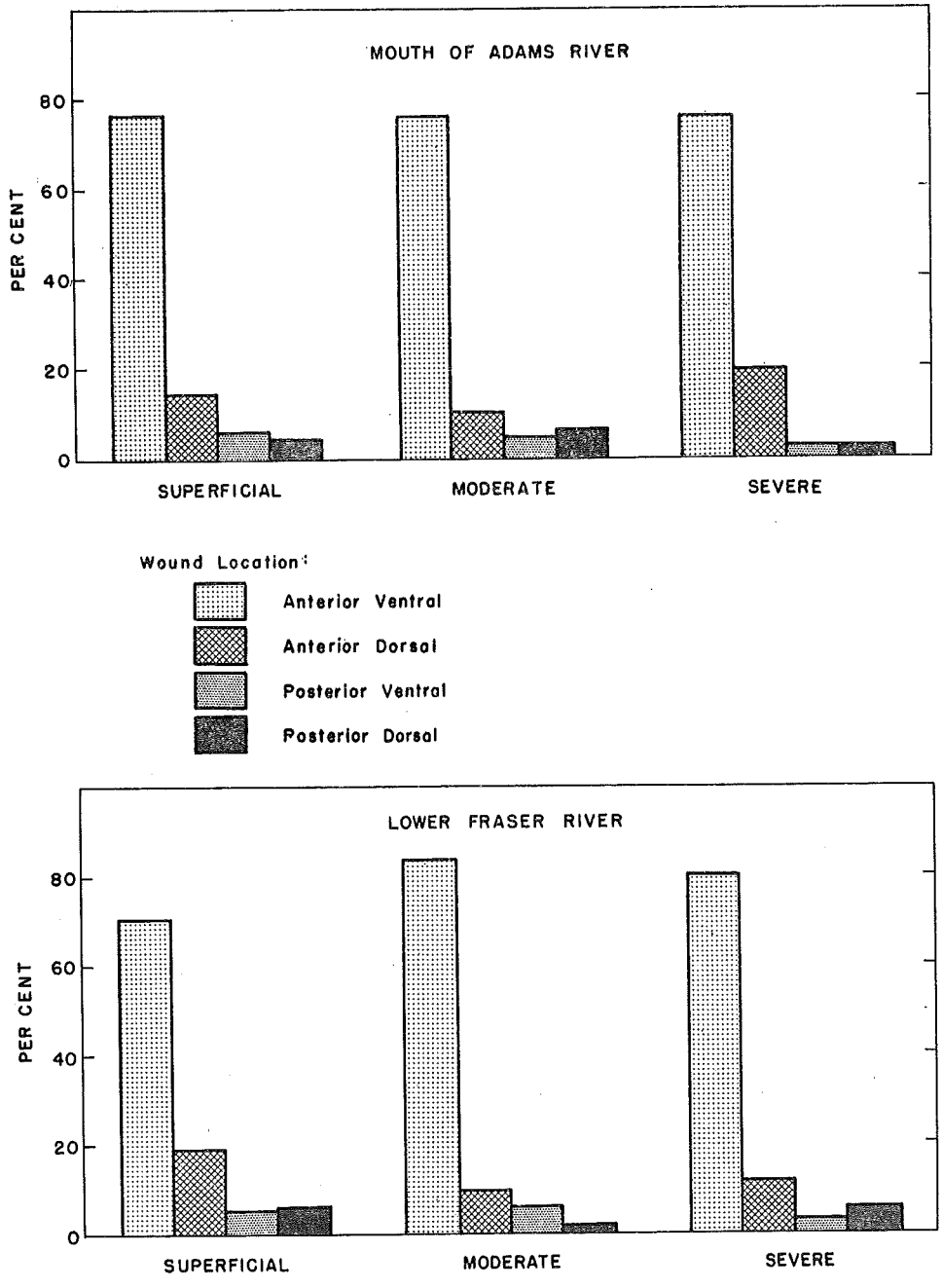


FIGURE 8 - Body location and severity of lamprey attacks on Adams River sockeye examined in the lower Fraser and at the mouth of Adams River.

A total of 189 pink salmon were also examined on the lower Fraser. Of these, approximately 20 per cent (37 fish) showed some sign of lamprey attack but less than 2 per cent displayed wounds in the moderate or severe class. This was substantiated by an examination of pink salmon during tagging on the Fraser spawning grounds where a very low incidence of lamprey parasitism was found.

Hematocrit data from the total of 216 sockeye blood samples taken during test fishing are presented in TABLE 4. Although the mean hematocrit value was slightly lower for severely wounded fish than unwounded fish, measurements varied widely within each wound class and no significant correlation was found between lamprey wound severity and number compared with hematocrits.

TABLE 4 - Comparison of wound severity with hematocrits of sockeye sampled in the lower Fraser River, September 23 to 29.

| WOUND CLASSIFICATION | NUMBER SAMPLED | HEMATOCRIT (PCV) | |
|---|---|---|---|
| | | Mean | Range |
| Unwounded + Superficial | 121 | 52.8 | 31.5 - 65.0 |
| Moderate | 59 | 50.7 | 30.5 - 63.5 |
| Severe | 36 | 48.5 | 36.0 - 63.5 |
| TOTAL | 216 | 51.5 | 30.5 - 65.0 |

Several lampreys were caught during test fishing, still clinging to the salmon when brought on board. These were identified according to their tooth pattern as Entosphenus tridentatus (Clemens and Wilby, 1961). Similar tooth patterns were also observed as superficial wounds on sockeye and pink salmon examined in the lower Fraser River. A second species of lamprey, Lampetra ayresii, is also reported to be present in Georgia Strait but the 1967 investigation provided no evidence of parasitism on sockeye and pink salmon by this species.

# DISCUSSION

In view of the reported heavy parasitism, a major concern was whether lampreys were causing any significant mortality among the Fraser River sockeye and pink salmon populations. The extent of sockeye mortality occurring in Georgia Strait from lamprey parasitism is unknown. In the preliminary investigation, an attempt was made to examine sockeye caught exclusively in Georgia Strait. It was stated that many of the lamprey wounds extended through the body wall into the coelomic cavity (Davis, W., 1967). As there were only two such wounds found on sockeye in the lower Fraser, a significant mortality could have occurred from the time the fish were holding in Georgia Strait to the time they entered the lower Fraser River. However, to substantiate this, a more detailed examination of sockeye caught in the Georgia Strait fishery would have to be made concurrently with an examination of fish migrating through the lower Fraser River.

The mortality occurring from the time the Adams sockeye pass through the lower Fraser River to their arrival on the spawning grounds can be calculated from the data collected. In order to determine any intervening mortality, only the severe class of lamprey wounds was considered, in view of the various degrees of healing taking place during the river migration. Severe wounds, however, were still recognizable as such on the Adams River, either because the wounds were still large, or were small wounds with relatively large areas of new tissue surrounding them.

If, then, only the severe wounds are compared, 6.1 per cent of the Adams population migrating through the lower Fraser at the time of sampling were carrying severe wounds, whereas on the Adams River 4.6 per cent of the population were carrying severe wounds, all Adams samples combined. Based on these figures, there was a small intervening mortality during migration, which was calculated as follows:

Let: a = sockeye with severe wounds which die en route

b = sockeye with severe wounds which survive en route

c = sockeye without severe wounds

Then $\frac{a + b}{a + b + c} = 0.061 = 6.1\%$ in the lower Fraser River samples (1)

$\frac{b}{b + c} = 0.046 = 4.6\%$ in the spawning ground samples (2)

Since $a + b + c = 1.000 = 100\%$, $a + b = 0.061$ and

$c = 1.000 - 0.061 = 0.939$

From equation (2)

$$\frac{b}{b + 0.939} = 0.046 \text{ and } b = 0.045 = 4.5\%$$

From equation (1)

$a + b = 0.061$ and $a = 0.061 - 0.045 = 0.016 = 1.6\%$

That is, an estimated 1.6 per cent of the Adams population died en route to the spawning grounds due to the severe wounds received from lampreys. Mortality among sockeye with severe wounds was 1.6/6.1 = 26 per cent, approximately.

The foregoing estimate of 1.6 per cent is based on percentages of severe wounds in the total sample of Adams fish examined in the lower Fraser (September 22 to 29) compared with the total number of fish examined on the spawning grounds (October 7 to 12). However, based on the rate of migration shown in FIGURE 7, a more accurate estimate of mortality would be obtained by deleting the late Fraser River samples (September 26 to 29) and the first Adams River sample (October 7) from the analysis. The resulting mortality is then calculated as 1.8 per cent of the population or 37 per cent of the severely wounded fish.

The estimates of either 1.6 or 1.8 per cent mortality suggest that lamprey attacks caused no significant loss of the 1967 Adams sockeye run during their river migration. In fact, the estimates are probably too large because the healing process may have prevented some originally severe wounds from being recognized as such in the spawning ground sampling.

Lamprey parasitism on non-Adams sockeye was very similar in degree to the Adams fish sampled in the lower Fraser with the exception of the severe wound class. Approximately 3 per cent of the non-Adams fish were in the severe wound class while 6 per cent of the Adams fish carried severe wounds. The significance of this is not entirely clear as the non-Adams sample was comparatively small (only 155 fish), and the difference may not be real. Because representative samples of the smaller non-Adams sockeye runs could not be obtained from the lower Fraser, no further examinations were carried out at the various spawning grounds.

Lamprey parasitism on pink salmon examined within the lower Fraser River was for all purposes negligible, in that less than 2 per cent of the fish carried moderate or severe wounds. Nevertheless, there is some evidence to suggest a possible mortality of pink salmon between Georgia Strait and the lower Fraser. Although wound severity was not recorded, the percentage of attacked pink salmon was considerably higher in the Georgia Strait sample (38 per cent; from Davis, W., 1967) than among fish from the lower Fraser (20 per cent). Although the two sets of samples may have been from different sections of the run, the data suggest a possible high mortality of wounded pink salmon prior to entering the Fraser River.

There is evidence which indicates that lampreys parasitize pink salmon to a considerable degree in other areas. Birman (1950) examined samples of pink salmon from the Ozerpakh Fish Combine in the Amur estuary. Approximately 20 per cent of 275 pinks examined in 1948 and 44 per cent of 234 pinks examined in 1949 were attacked by lampreys. Although wounds were not classified as to severity, in many cases a perforation of the skin was observed.

The data gathered on the Fraser River do not isolate the reason for the marked difference between the percentages of lamprey-wounded fish in the sockeye and pink salmon populations. However, there are several possible reasons for this difference:

1. A higher initial mortality of pink salmon in Georgia Strait due to lamprey attack.

2. A preference for sockeye by these parasitic lampreys.

3. A behavior difference between sockeye and pink salmon rendering sockeye more vulnerable to lamprey attack during a similar period of exposure to these parasites.

4. The incidence of attack being correlated with the period of delay off the Fraser River mouth.

Whether the prolonged delaying behavior of Adams River sockeye makes them particularly vulnerable to lamprey attack is questionable. Pink salmon and non-Adams sockeye also delay to some extent off the Fraser River mouth and it is not possible to quantify the exact delay period of the particular sockeye and pink salmon examined in the present investigation.

The blood analysis indicated a slight difference in the hematocrits from sockeye with differing wound severity, ranging from an average of 48.5 for severely wounded fish to 52.8 for fish in which the skin had not been broken. However, in view of the wide range of hematocrit measurements within each group, the differences do not appear great enough to be biologically significant. Many other factors could affect the hematocrit within these ranges. The mean values indicate that sockeye were healthy at the time of sampling and hematocrit measurements were very similar to the mean value of 47.5 determined for unmarked green sockeye captured previously in the lower Fraser River (Colgrove, 1964). If lamprey attachment does have serious effects, these effects disappear rapidly in the majority of cases once the lamprey is gone.

## SUMMARY AND CONCLUSIONS

1. Late season runs of Fraser River sockeye and pink salmon in 1967 were observed to have a high incidence of lamprey wounds. Although some lamprey attacks had been noted by fishermen in the past, this was the first time a high incidence of lamprey parasitism had been reported to the Commission. An investigation was made of the frequency and severity of lamprey wounds, mainly in the latter portion of the large Adams River sockeye run.

2. A total of 2,828 adult sockeye salmon were examined for lamprey wounds in September, in the lower Fraser River, and in October at the spawning grounds of Adams River sockeye. Approximately 200 pink salmon were also examined. Wounds were classified as superficial, moderate, or severe and recorded for four different body areas. In addition, over 200 live sockeye were tested for percentage packed blood cell volume.

3. Approximately 66 per cent of the sockeye and 20 per cent of the pink salmon sampled in the lower Fraser had marks of lamprey attacks. Slightly over half of the Adams River sockeye at the spawning grounds bore detectable lamprey wounds and healing of many wounds was evident. Severe wounds were carried by about 6 per cent of the identifiable Adams sockeye in the lower Fraser and about 5 per cent at the spawning grounds. Moderate and severe wounds were recorded in less than 2 per cent of pink salmon.

4. Estimated loss of Adams sockeye during river migration was calculated to range from 1.6 to 1.8 per cent of the total run entering the Fraser, and was considered to be of minor significance. However, mortality of sockeye and pink salmon between the site of lamprey attack and the lower Fraser River is a question which is not resolved by this investigation. Possible reasons for the difference in frequency of lamprey attacks on sockeye and pink salmon are discussed.

5. Hematocrit measurements (percentage packed blood cell volume) in tested sockeye had a wide range and revealed no significant differences between sockeye with wounds of differing severity, or without wounds.

6. Although two species of lampreys are present in Georgia Strait, Lampetra ayresii and Entosphenus tridentatus, only E. tridentatus was positively identified as an ectoparasite of salmon in the 1967 investigation.

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