OBSERVATIONS ON THE FATE OF EXPERIMENTALLY INDUCED SCARS AND MARKS ON CHINOOK SALMON: AN INTERIM REPORT
Observations on the Fate of Experimentally Induced Scars and Marks on Chinook Salmon: An Interim Report

by

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The finding by troll fishermen and processors in Alaska of apparent non-troll gear marks on chinook and coho salmon before the occurrence of these marks could be accounted for by the operation of domestic net fisheries led to a plan for a field investigation of these marks and scars in the Northeast Alaska commercial troll fishery (Anonymous 1982). In this report marks and scars were arbitrarily divided into the following 6 categories:

<table>
<thead>
<tr>
<th>Category</th>
<th>General Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>One or more fairly well delineated linear marks between the head and dorsal fin, approximately perpendicular to the longitudinal body axis and encircling or partially encircling the body.</td>
</tr>
<tr>
<td>2</td>
<td>A series of approximately parallel mark or scrape lines over a substantial portion of the body; two or more series of such marks occurring at different angles may give the appearance of cross hatching marks.</td>
</tr>
<tr>
<td>3</td>
<td>A fairly well delineated scrape band generally occurring between the head and the dorsal fin approximately perpendicular to the longitudinal body axis or angled slightly backward from the top to the bottom of the body and containing an approximately oval shaped open wound normally in the upper portion of the body.</td>
</tr>
<tr>
<td>4</td>
<td>Extensive descaling of at least 25 percent or more of one or both sides of the body, but with no well delineated marks or wounds.</td>
</tr>
<tr>
<td>5</td>
<td>Open, gaping wounds or puncture marks located anywhere on the body either with no other marks and scrapes or with adjacent irregular &quot;scratch&quot; or &quot;claw&quot; marks but no marks as described in Categories 1-4.</td>
</tr>
<tr>
<td>6</td>
<td>Any scars/marks not fitting the descriptions in Categories 1-5.</td>
</tr>
</tbody>
</table>

Knowledge of the duration of the categories of scars and marks would be of considerable value in determining the source(s) of the afflicted fish. The purpose of the investigation reported here was to provide a basis for estimating how long some of the categories of injuries observed in the field might have persisted. It is recognized, of course, that the experimental conditions differ from the natural conditions but whether or not these differences lead to significant errors in estimation remains to be seen.

**Methods**

In July 1983 21 chinook salmon (2-3 lb) were taken from seapens and placed in an 8 ft diameter, 4 ft deep fiberglass tank supplied with sand-filtered sea water of 28% salinity. The fish were fed daily to satiation with Oregon Moist Pellets, except on the days before and after sampling.
After a period of adaptation the fish were anesthetized with MS-222 and cold branded for individual identification. A length of 1/8 inch cotton twine, or a scalpel was then used to scarify each fish in accordance with the description of the particular category chosen. (Categories 1-4 only were chosen for this study because Categories 5 and 6 were considered too indefinite.) Fish were then photographed to record the "0" time or initial condition.

At various times post-scarification fish were captured, anesthetized and photographed to show the experimentally affected area. The sampling schedule, days since the marks and scars were inflicted, and water temperatures are shown in Table 1.

Table 1. Sampling schedule of fish marked and scarred according to each of the four categories tested.

<table>
<thead>
<tr>
<th>Date (1983)</th>
<th>Days post-scarifying</th>
<th>No. of fish in category</th>
<th>T (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fish 1-7</td>
<td>Fish 8-21</td>
<td>1</td>
</tr>
<tr>
<td>July 29</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Aug. 4</td>
<td>0</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Aug. 19</td>
<td>21</td>
<td>15</td>
<td>12.0</td>
</tr>
<tr>
<td>Sept. 9</td>
<td>42</td>
<td>36</td>
<td>11.7</td>
</tr>
<tr>
<td>Oct. 7*</td>
<td>70</td>
<td>64</td>
<td>11.3</td>
</tr>
</tbody>
</table>

*Date of last observation.

Results and Discussion

There were no mortalities associated with the scarification and handling of the fish but one specimen was lost when it jumped from the tank.

Complete sets of photographs of each category of injury from time of infliction to last observation (64 or 70 days) were not available at time of writing so only typical examples are presented to illustrate specific points. Visual observations of the condition of the scars or marks at the date of last observation are described below.

1. Gross observations

Category 1

At 70 days most simulated gill net marks were still clearly visible but in some cases were becoming less definite, possibly because of mild descaling associated with handling. This type of mark appeared to be one of the most persistent, as evidenced by Figure 1.
Category 2

The characteristics of this category are difficult to reproduce experimentally making assessment of the recovery process somewhat unsatisfactory.

The results of descaling were substantially evident at the last sampling (Figure 2) but again the observations were somewhat confounded by the handling procedures. The diffuse nature of the scarification described in this category makes more subtle changes less apparent than with Categories 1 or 3.

Category 3

The open wounds inflicted showed a definite healing trend that at 64 days had almost obliterated the original deep cut into the musculature. Typical progression of this type of wound repair is shown in Figures 3 and 4, and the histology is described below.

Category 4

No obvious areas of scale regeneration were visible but the generalized and superficial nature of the damage inflicted, coupled with further descaling associated with handling makes definitive observation difficult.

2. Histological observations

In this aspect of the report observations have been restricted to those on the open wound feature of Category 3 because this is the most profound type of injury. Descriptions of the healing process are given for 3, 15, 21, and 42 days post-scarification, and the area examined is illustrated diagrammatically in Figure 5. Photomicrographs illustrating this healing process are presented in Figures 6-10, and a key to the symbols can be found on Page 6.

3 Days

The surface of the wound showed a pale eosinophilic substance, probably congealed tissue exudate (T), overlying the cut ends of damaged muscle bundles (M).

A vigorous proliferation of inflammatory cells (I) was seen infiltrating the area and macrophages appeared to be active around areas of necrotic tissue (N).

No organized blood clot was found at the surface and no epithelial proliferation appeared to have been initiated from the marginal areas. See Figure 6.
15 Days

During the intervening 12 days intense cellular activity had taken place and the formation of granulation tissue (G) had commenced. However, the sub-dermal areas consisted of a rather chaotic mixture of endothelial cells, fibroblasts, macrophages and erythrocytes, with partially autolysed muscle cells and collagen (C).

A multi-layered sheet of primitive epithelium (E) had formed sealing off the surface and extending down in some areas into the damaged underlying tissues. The basement membrane did not appear to be continuous, as would normally be the case in well developed epithelium. See Figure 7.

21 Days

Deep into the damaged area, the process of cleaning up the debris was well advanced and the formation of new muscle fibers and connective tissue elements had commenced.

Toward the surface, the granulation tissue (G) was still in evidence as was the primitive non-structured type of epithelium. However, the granulation tissue was already less vascularized and a more organized regime of fibrous connective tissue and primitive muscle fibres (P) was emerging. See Figure 8.

42 Days

In the central sub-dermal region, the granulation tissue had all but disappeared and strong fibrous elements (F) could be seen filling the gaps between developing muscle and epithelium, and containing well-formed blood vessels.

The newly formed epidermis (E) was now much more structured showing the basal columnar cells, fusiform layer with mucus secreting goblet cells and the external layer of squamous epithelial cells.

The marginal areas of both areolar (A) and dense fibrous connective (D) tissue in the uninjured, adjoining tissues appeared to be forming anastomoses (J) and becoming continuous with the newly formed tissues of the repairing areas. See Figures 9 and 10.

The process of repair and healing of these wounds is still not complete at the time of this interim report, however, the continuing process will be monitored and reported on later.

Summary

Repair of Category 1 marks was slow and the initial injury was still readily visible after 70 days. It was more difficult to follow changes in descaled areas as described in Categories 2 and 4 because this
was a less definite form of injury and was probably masked by the effects of handling. Scale regeneration would better be seen in sections of the skin, and these will be prepared later. Finally, the deep wounds characteristic of Category 3 healed most dramatically. From raw, bleeding lesions deep into the musculature they became almost completely repaired within 64-70 days at temperatures of 11-12°C.

Later reports will deal in greater detail with the histological aspects of the repair process, as well as showing stages of visible changes in marks or scars.

Reference

Captions to Figures

Fig. 1. Category 1, 64 days post injury.
   (Identity card 2 cm²)

Fig. 2. Category 2, 64 days post injury.

Fig. 3. Category 3, 21 days post injury.

Fig. 4. Category 3, 64 days post injury.

Fig. 5. Diagram of Category 3 wound showing granulation and relative orientation of tissues.

Fig. 6. Photomicrograph of Category 3 wound, 3 days post injury
   H + E X 100.

Fig. 7. Photomicrograph of Category 3 wound, 15 days post injury
   H + E X 32.

Fig. 8. Photomicrograph of Category 3 wound, 21 days post injury
   H + E X 32.

Figs. 9 + 10. Photomicrograph of Category 3 wound, 42 days post injury
   H + E X 32.

Symbols on photomicrographs

CONGEALED TISSUE EXUDATE-----------------------------------------------T
MUSCLE------------------------------------------------------------------M
INFLAMMATORY CELLS------------------------------------------------------I
NECROTIC TISSUE----------------------------------------------------------N
GRANULATION TISSUE-------------------------------------------------------G
EPITHELIUM/EPIDERMIS------------------------------------------------------E
PARTIALLY AUTOLYSED MUSCLE AND COLLAGEN--------------------------------C
PRIMITIVE MUSCLE FIBRES-----------------------------------------------P
STRONG FIBROUS ELEMENTS---------------------------------------------F
AREOLAR TISSUE----------------------------------------------------------A
DENSE FIBROUS CONNECTIVE TISSUE----------------------------------------D
ANASTOMOSING AREA------------------------------------------------------J