RESEARCH AND DEVELOPMENT SECTION

Oregon Department of Fish and Wildlife
Fish Division

Comparison of T-bar and Petersen Disc Tag loss from Chinook Salmon (*Oncorhynchus tshawytscha*) in the Rogue River, Oregon
Comparison of T-Bar and Petersen Disc Tag Loss from Chinook Salmon (Oncorhynchus tshawytscha) in the Rogue River, Oregon

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ABSTRACT

Loss of Floy T-Bar tags and Petersen disc tags was studied in the Rogue River on spring and fall chinook salmon tagged during their upstream migration. Petersen tags were lost throughout migration and spawning, but chinook lost T-bar tags primarily during spawning and/or after death. Adult spring chinook lost both types of tags at about the same rate (20-21%). However, fall chinook adults lost T-bar tags at a greater rate (39%) than Petersen tags (10%). Jacks of both races lost Petersen tags at higher rates (33-50%) than T-bar tags (9-25%). Males of both races lost T-bar tags at higher rates (41-53%) than females (9-32%) or jacks (9-25%). Jacks lost Petersen tags at higher rates (33-50%) than adults (0-29%). The adipose fin clip was a longer lasting secondary mark than opercular punches. Evaluation of tag loss, stratified by fish size, tagging site, recovery site, and possibly other strata is recommended. T-bar tags are recommended over Petersen tags in most situations.

INTRODUCTION

We tagged spring and fall chinook salmon for 3 yr in the Rogue River to estimate population size and migration rate, and to relate time of capture to time and place of spawning. Due to a high loss of T-bar tags the first year, we needed to determine 1) which type of tag the fish retained longer, and 2) how much loss occurred with both types of tags among different segments of the populations. Ricker (1975) stressed the importance of permanent marks for making population estimates. Tag loss can bias the results of tagging studies if segments of the population (e.g. jacks) lose tags at a different rate than other segments (e.g. adults).

Tagging is a widely used technique in salmonid research. Tag loss should be evaluated in any study using this technique since it can significantly affect
the results. Lister and Harvey (1969) found Petersen tag loss of 8-31% on
spawning chum salmon (*O. keta*). Coho (*O. kisutch*) and chinook in the ocean
lost Floy T-bar tags at rates of 9.8% and 25.0%, respectively, over a 3 yr
period (Butler and Loeffel 1972). Kruse (1964) reported only a 3% loss of
Petersen tags from steelhead (*Salmo gairdneri*) tagged in freshwater before
spawning and recovered afterward.

**METHODS**

We captured spring and fall chinook by beach seining and electrofishing
near the mouth of the Rogue River (km 5-48) and by trapping at Gold Ray Dam
(km 202). The fish were anesthetized, measured, tagged, and sampled for scales.
We tagged 496 fish near the river mouth and 449 fish at the dam during the 3 yr
period.

In 1975 and 1977 Floy T-bar tags, 7 cm long, were inserted on the left
size of the fish at the anterior base of the dorsal fin (Dell 1968) (Fig. 1).
The tags were passed through the pterygiophore bones, and we checked to insure
that the tags were securely attached before the fish were released. We used
single colored tags: yellow, red, white, or green on spring chinook and green
or blue on fall chinook. A circular hole (0.6 cm in diameter in 1975 and 0.8 cm
in 1977) was punched in an operculum of each tagged fish with a paper punch to
serve as a secondary mark for assessing tag loss. The right or left operculum
was punched to indicate the race of fish and tagging location.

In 1976 we tagged fish with Petersen disc tags, 1.4 cm in diameter (Fig.
2). Yellow or green tags were used on spring chinook and pink tags on fall
chinook. To assess tag loss, we removed the adipose fin from each tagged fish.

Live chinook were examined for tag loss at Gold Ray Dam and Cole Rivers
Hatchery (km 253), and carcasses were checked in spawning areas. Spring
chinook carcasses were examined on 48 km of the Rogue River immediately below
Fig. 1. Adult chinook salmon with a T-bar tag attached at the base of the dorsal fin.
Fig. 2. Adult chinook salmon with a Petersen disc tag attached at the base of the dorsal fin.
Lost Creek Dam (km 256) and 2 km of Big Butte Creek which enters the Rogue at km 250. Fall chinook carcasses were examined in the Rogue River below km 199 and in eight tributaries. Fish in all areas were checked first for a secondary mark and then for tags to reduce bias from examining tagged fish more closely for secondary marks than untagged fish.

We used the following equations to estimate tag loss for each group of fish:

\[
N_Q = N_S \div \frac{N_V-N_R}{N_V}
\]

\[
P_C = \frac{N_Q}{N_Q + N_T} (100\%)
\]

where:

- \(N_Q\) = number of fish recovered with secondary mark only (no tag) corrected for secondary mark loss
- \(N_R\) = number of fish recovered with tag only (no secondary mark)
- \(N_S\) = number of fish recovered with a secondary mark only (no tag)
- \(N_T\) = number of tagged fish recovered
- \(N_V\) = number of tagged fish examined for secondary mark loss
- \(P_C\) = percentage corrected tag loss

If secondary mark condition on all recoveries of tagged fish is recorded, \(N_T\) can be substituted for \(N_V\) in the first equation. We only had to use \(N_V\) in the first year. Percentages were rounded to the nearest whole number. Statistical comparisons of tag loss between tags, races, and sex were made using chi-square tests of null hypotheses after correction for continuity. All data were stratified into jacks (<60 cm, primarily precocial males) and adults (>60 cm).
RESULTS

Timing of Tag Loss

Recapture of tagged spring chinook at different points in their upstream migration indicated that the timing of tag loss differed between T-bar and Petersen tags (Table 1). Fish were tagged in April through September and recovered in May through November. Losses of T-bar tags mainly occurred during spawning and/or after death, but more Petersen tags were lost prior to spawning. Data on loss of T-bar tags in May and June are lacking, but the loss was assumed to be very low because no loss was observed in July and August when fish entered Cole Rivers Hatchery. The loss then jumped to 30% on spawned carcasses in September and October. In contrast, Petersen tag loss had already reached 27% in May and June at Gold Ray Dam.

Table 1. Percentage T-bar and Petersen tag loss from spring chinook tagged in the lower Rogue River and recovered upriver in 1976 and 1977, respectively.

<table>
<thead>
<tr>
<th>Observation site</th>
<th>Adults</th>
<th>Jack (&lt;60 cm)</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold Ray Dam (km 202) May, June</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>combined n = 19(^a)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cole Rivers Hatchery (km 253) July, Aug.</td>
<td>0</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>(combined n = 14, 63)</td>
<td>53</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Spawning area (km 206-253) Sept., Oct.</td>
<td>30</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>(combined n = 8, 70)</td>
<td>50</td>
<td>30</td>
<td>19</td>
</tr>
</tbody>
</table>

\(^a\) Total fish recaptured by type of tag.

Loss of Petersen tags may have increased after June, but the results were obscured because samples at the hatchery and in the spawning area contained fish tagged at Gold Ray Dam in addition to those tagged near the river mouth. The fish tagged at the dam probably lost fewer tags since they traveled
shorter distances and took less time to reach the hatchery and spawning areas than the fish tagged at the mouth of the river. However, the difference in tag loss could not be assessed because both groups had the same secondary mark (adipose clip).

Calculated tag loss increased from 43% in the spring to 53% in the summer for jacks, but decreased from 24% to 8% for adults and from 27% to 24% for combined size groups (Table 1). Tag loss for adults increased from 8% in the summer to 20% in the fall but remained similar for jacks (53% and 50%). Combined loss of Petersen tags by adults and jacks appeared to decrease from summer (24% at the hatchery) to fall (19% on the spawning grounds), but this was due to the greater tag loss from jacks and the greater ratios of jacks to adults in the hatchery sample than in the spawning ground sample.

Loss by Type of Tag

Our best comparisons between the two tag types are given in Table 2 where data from 1975 and 1977 for T-bar tags were combined. Adult fall chinook examined after spawning had lost T-bar tags at a significantly ($p<0.05$) greater rate than Petersen tags (39% and 10%, respectively), but adult spring chinook had lost both types about equally (21% and 20%, respectively). Spring and fall chinook jacks lost the T-bar tags at lower rates (9% and 25%, respectively) than Petersen tags (50% and 33%, respectively).

Table 2. Losses of T-bar and Petersen tags from spring and fall chinook after spawning, 1975-77.

<table>
<thead>
<tr>
<th>Race</th>
<th>Percentage tag loss and no. of recoveries (n)</th>
<th>Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>M</td>
</tr>
<tr>
<td>Spring chinook</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T-bar</td>
<td>9 (62)</td>
<td>41 (34)</td>
</tr>
<tr>
<td>Petersen</td>
<td>13 (46)</td>
<td>29 (38)</td>
</tr>
<tr>
<td>Fall chinook</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T-bar</td>
<td>32 (42)</td>
<td>53 (20)</td>
</tr>
<tr>
<td>Petersen</td>
<td>16 (19)</td>
<td>0 (11)</td>
</tr>
</tbody>
</table>
Loss by Race and Sex

Fall chinook lost T-bar tags at a significantly greater rate than spring chinook (37% and 19%, respectively). However, the difference may be exaggerated because in 1975 and 1977, 72% and 37% of the spring chinook were tagged at Gold Ray and Savage Rapids dams (km 172). Less than 10% of the fall chinook were tagged at Gold Ray Dam. The addition of fish tagged at the two dams to the group tagged at river entry undoubtedly reduced the apparent tag loss of spring chinook on their spawning grounds above Gold Ray Dam. An attempt to examine this by application of different secondary marks at each tagging location in 1977 failed due to inadequate sample sizes recovered from each tagging location.

Petersen tags applied at river entry were lost to a significantly greater extent from spring chinook than from fall chinook. Spring chinook had lost 27% of their tags when they reached Gold Ray Dam (Table 1), while fall chinook had only lost 15% on their spawning grounds below Gold Ray Dam (Table 2). Comparisons between races after spawning (Table 2) suggest that loss from spring chinook (19%) was not significantly different from fall chinook, but the comparison was biased due to the addition of freshly tagged spring chinook at Gold Ray Dam, as explained above.

Examination of spawning carcasses indicated that adult males of spring chinook lost T-bar tags at a higher rate (41%) than females (9%) or jacks (9%) (Table 2). With Petersen tags, jacks of both races lost tags at significantly higher rates (33-50%) than adults (0-29%).

Secondary Mark Loss

Secondary marks were lost primarily from tissue regeneration and the loss of the operculum and adipose area after death due to decomposition, scavengers, and predators. Differences between spring and fall chinook (Table 3) were not significant for loss of opercular punch marks (35% and 30%, respectively) or
adipose clips (1% and 6%, respectively). These data also show that opercular punch marks were lost at similar rates among sexes, but jacks lost adipose clips at a higher rate than adults among spring and fall races (33% versus 0% and 25% versus 0%, respectively).

Table 3. Losses of secondary marks from spring and fall chinook after spawning, 1975-77.

<table>
<thead>
<tr>
<th>Race</th>
<th>Percentage mark loss and no. of recoveries (n)</th>
<th>Adults</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>M</td>
<td>Total</td>
<td>Jacks (&lt;60 cm)</td>
<td>Combined</td>
</tr>
<tr>
<td>Spring chinook</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opercular punch</td>
<td>32 (25)</td>
<td>40 (10)</td>
<td>34</td>
<td>40 (5)</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Adipose clip</td>
<td>0 (40)</td>
<td>0 (27)</td>
<td>0</td>
<td>33 (3)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Fall chinook</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opercular punch</td>
<td>32 (31)</td>
<td>27 (11)</td>
<td>31</td>
<td>25 (8)</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Adipose clip</td>
<td>0 (16)</td>
<td>0 (11)</td>
<td>0</td>
<td>25 (8)</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

DISCUSSION

Timing of Tag Loss

The timing of tag loss was different between T-bar and disc tags, apparently because the mechanism of loss was different for each tag type. The loss of T-bar tags was low until the fish spawned. Since the Petersen disc tags are less streamlined than the T-bar tags, the much higher loss of disc tags prior to spawning may have been due to their greater resistance to water current. This resistance probably increased as the salmon shrunk in girth, allowing water current under the discs. The force of the water current may have led to failure of the wire or disc since we found only one fish with a wound where the wire had pulled through the flesh and dossal fin. However, such wounds may have caused mortality and reduced our chances of finding fish which lost disc tags by this mechanism. We found no direct evidence of wire or disc failure, such as cracked or broken discs described by Lister and Harvey (1969).
The loss of Petersen tags increased with time after tagging for spring chinook, but the greater loss from spring chinook than fall chinook can only be partially attributed to this greater time span of about 2 mo. Spring chinook were tagged primarily in April through June and fall chinook in August and September. Tag recovery was completed by November for spring chinook and by January for fall chinook. The results could have been due to the greater pull on the discs exerted by the greater number of severe rapids ascended by spring chinook. The distance traveled by fall chinook ranged from 15 to 200 km while spring chinook traveled 200-255 km. Gradients are steepest from km 80-104 and km 160-255 (Everest 1973). Our conclusion that travel distance and gradient affected loss rate was supported by the finding that Petersen tag loss from fall chinook ascending short distances (40 km) in a low gradient coastal watershed (Elk River, Oregon) was only 5-10% (discussion with Paul Reimers, Oregon Department of Fish and Wildlife, Charleston, Oregon).

Some T-bar tags may have been lost during spawning due to aggressive biting, particularly between males. This hypothesis is supported by Lister and Harvey (1969) who observed only 8.4-10% tag loss from spawning chum salmon females but 29.4-31.1% loss from males. However, only Petersen tags were used in their study. Removal of Petersen tags by nipping would have been much more difficult than for T-bar tags, and we found no significant difference between males and females in loss of Petersen tags. Although the effects of tag color could not be evaluated because we had no secondary mark for each color, color may have influenced the rate of biting (German and LeFaunce 1954). Additional T-bar loss probably occurred after spawning due to friction on the tags as the carcasses skidded along the stream bottom, degradation of the tissue holding the tag, and loss of anatomy containing the tag to decomposition and scavengers.
Tag Loss by Jacks

The greater loss of Petersen tags from jacks compared to adults may have been underestimated. The ratios of tagged to censused fish at recovery sites (R/C ratios) were corrected for tag loss, and we found that the ratios for jacks were less than half of those for adults. This difference in ratios could have occurred because 1) tag loss on jacks was underestimated due to mortality of fish which lost tags, 2) differential mortality between tagged and untagged fish was higher for jacks than adults, or 3) a lower percentage of the jack run was tagged than of the adult run. The third possibility was rejected since 44% of the fish tagged at river entry were jacks, while jacks comprised 27% of the fish counted at Gold Ray, and 16% of the carcasses examined on spawning surveys. It therefore seems that the first and/or second possibility must have occurred. The first possibility is the only one that would cause an underestimation of tag loss. It seems likely that it occurred because the one fish we found with a large wound from tag loss was a jack. The thinner skin and smaller bones and muscles of jacks are probably less able to hold the Petersen tag against water currents. Discs smaller than we used (1.4 cm diameter) might reduce the effects of water currents and improve tag retention on jacks.

Secondary Mark Loss

Although adipose clips were not lost from adults, their utility as a secondary mark is limited because of the higher loss from jacks and prior use of this mark at hatcheries on many streams. The usefulness of opercular punch marks is limited mainly by the regeneration of tissue without scarring in a period of several months.
CONCLUSIONS

1. Fall chinook adults lost T-bar tags at a greater rate (39%) than Petersen tags (10%), but spring chinook lost both types of tags equally (20-21%).

2. Jacks of both races lost Petersen tags at greater rates (33-50%) than T-bar tags (9-25%).

3. Adult males lost T-bar tags at greater rates (41-53%) than females (9-32%) or jacks (9-25%).

4. Jacks lost Petersen tags at greater rates (33-50%) than adults (0-29%).

5. Most of the T-bar tag loss occurred during spawning and/or after death.

6. Petersen tags were lost throughout migration and spawning.

7. Adipose fin clips lasted longer than opercular punches for secondary marks.

RECOMMENDATIONS

Population estimates made using tag recaptures should incorporate an evaluation of tag loss. Loss of secondary marks must be assessed to accurately assess tag loss. If tagging is done at widely separated sites or times, tag loss must be assessed for each site or time period by using different tags and secondary marks for each site or time period. Secondary marks should also be specific for each type, size, and color of tag. Tag loss data should be initially stratified since differential tag loss between sizes of fish, recovery sites, or recovery time (or other strata) can bias the tag return results.

For adult salmon tagged in rivers, we recommend T-bar tags over Petersen disc tags with some exceptions. T-bar tags can be applied much faster than disc tags, improving efficiency and possibly reducing stress and post-tagging mortality. Fish bearing disc tags are more vulnerable to capture by seine, gillnet, or other net because the tags may become snagged in the net. Petersen tags of 1.4 cm diameter appear to be unsuitable where fish must ascend steep
rapids and long distances similar to the Rogue basin. However, if fish are not
to be examined for tags until after spawning mortality occurs, Petersen tags
have the advantage of better retention with less differential loss between
sexes. Large disc tags and their numbers are also easier to see than the
T-bar tags.

Adipose clips are recommended instead of opercular punches for use as
secondary marks because retention is better, application is easier, and risk
of injury to the sensitive gills is avoided. However, adipose clips cannot be
used if the population contains a similar mark from hatcheries. Also, adipose
clip data must be stratified by fish size since loss rate is related to size.
One advantage of opercular punch marks is that different marks can be given
to different groups of fish. If adipose clips can be used and group distinctions
are needed, opercular punch marks could be used in addition.

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LITERATURE CITED


