EVALUATION OF METHOD OF
ESTIMATING MEAN FISH WEIGHT IN THE JAPANESE MOTHERSHIP SALMON FISHERY

by

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INTRODUCTION

The number of salmon taken in the Japanese mothership salmon fishery operating in the U.S. Fishery Conservation Zone (U.S. FCZ) conventionally has been estimated for each species and mothership by dividing the daily catch in weight by the mean weight for the day. The daily mean weight is obtained by the Japan Fishery Agency (JFA) agent who takes a 30-fish sample of each species from the catch of five different catcherboats. No randomization procedures have been specified for the selection of the catcherboats to be sampled or for the sampling of their delivered catch. In fish that vary in size, such as chinook, the mean weights obtained and the subsequent estimate of numbers caught could be subject to significant errors.

During the 1981 season, the U.S. observers aboard the four motherships were instructed to obtain independent estimates of mean fish size. These estimates were obtained by having the observer arbitrarily choose a previously weighed sling of fish and count its contents; one of these estimates for each species was obtained daily for most of the season. Since the observer has no prior knowledge of the contents (other than species) or origin of the sling and since the entire contents is weighed and counted, these estimates should be considered to be less subject to nonrandom variation. Thus, these estimates are used as a basis to evaluate the present method of sampling used by the JFA.
RESULTS

Each day, the number of fish of each species caught per mothership was estimated using the JFA-obtained mean \( \hat{N}_{JFA} = \text{Catch in weight} ÷ \hat{W}_{JFA} \) and the mean obtained by the observers \( \hat{N}_{OBS} = \text{Catch in weight} ÷ \hat{W}_{OBS} \). These daily estimates plotted against each other show a tendency for the \( \hat{N}_{JFA} \) to be exceeded by the \( \hat{N}_{OBS} \) (Figures 1-5). This tendency is consistent for all species, with the tendency strongest for chinook where the slope \( \left( \hat{N}_{JFA} / \hat{N}_{OBS} \right) \) for the regression is estimated to be 0.876 (Figure 5). Only 1 of 20 comparisons (4 motherships X 5 species) had \( \hat{N}_{JFA} \) exceed \( \hat{N}_{OBS} \) (Table 1), and chinook had the greatest proportional difference with \( \hat{N}_{OBS} \) exceeding \( \hat{N}_{JFA} \) from 5.6% to 13.8% (Table 2). Comparable ranges for other species were 2.5-5.6% (sockeye), 0.1-3.4% (chums), and 0.6-3.1% (pinks). For coho, the value ranged as high as 5.8%, although on one mothership, the \( \hat{N}_{JFA} \) exceeded \( \hat{N}_{OBS} \).

DISCUSSION

Under the JFA system, catcherboats to be sampled are designated ahead of time; thus, it is a possibility that the crew somehow strives to decrease landings of small salmon. Chinook data were used to evaluate this possibility. This was achieved by comparing CPUE of the sampled catch in a particular 1° X 1° area and 10-day period with the CPUE as a whole in that same time-area. No significant difference was found (Figure 6). Thus, it appears that the prior selection of boats to sample did not cause the bias found in the average weight determinations.
More than likely, it is impossible to obtain a random subsample from such large accumulations of fish as encountered on the motherships. Because fish tend to segregate by size when dumped (Pope 1963; May and Hodden 1966), the sampler should not take the most readily available fish, nor should he compensate for any perceived over-sampling of large or small fish. The method of taking the 30 fish samples by JFA varies within the fishery. In one case, the sampler attempted to take "average" fish; at other times, fish to be sampled were spilled out of the bag for the samplers; and at still other times, fish were taken from the top of a bin (Dahlberg and Harris 1981). An experiment in 1980 showed that the 30 fish samples taken by the JFA agent are not random samples of the catch (Fujioka and Dahlberg 1980). Dealing with pink salmon of relatively uniform size, the 1980 study did not detect a bias in average weight estimation. For chinook salmon, a random sample would be necessary to minimize bias because the chinook salmon are more variable in size.

The lack of randomness in the taking of the 30-fish sample is a likely cause of bias. Whereas there is no easy way to obtain a proper sample from a large catch of fish widely ranging in size, methods used in trawl-catch sampling may prove useful. Hughes (1976) describes how the catch is initially divided in half by spilling the contents symmetrically over a bin divider. This procedure could be used on randomly selected large slings of fish during the weighing process on the motherships. Hughes (1976) also describes how dominant species are further subsampled from one of the divided halves of the catch by using a group of baskets (e.g. 3 or 4), which are filled simultaneously in a rotating order. When these baskets are filled, another group of the same number of baskets is filled in the same manner. This is repeated until all fish are removed from the initial 50% subsample. One or
more baskets from each group are selected at random. The number of baskets per group and the number of baskets sampled are chosen to provide an appropriate number of fish for sampling.

These procedures could be used aboard a mothership to sample the catch from randomly selected catcherboats. The initial halving would reduce the catch to a size that could be further subsampled by the rotated placement of fish into baskets. Either subsampling stage could be skipped if, alone, the other results in a reasonable sample size. Whenever the catch of a species is small, the method is not necessary as the entire catch should be sampled. If necessary, several catches should be accumulated to attain adequate sample size. If the accumulation exceeds a workable sample size, the subsampling procedures could be used as prescribed for a single large catch.

The need for a random sample procedure applies to the taking of biological observations as well as for average weight determination. Any variable that might be size-related could be affected by size-biased sampling. Even if the sampling is not biased by size, Fujioka and Dahlberg (1980) reported the 30-fish samples are still not a random sample of the catch. Any variable that is not randomly distributed in the catch could be biased by the present procedure.
LITERATURE CITED


Table 1.--Estimated numbers of salmon caught using the Japan Fishery Agency (JFA) mean weights and using observer-obtained (OBS) mean weights. Only days when both types of mean weights are available are used in this table.

<table>
<thead>
<tr>
<th>Salmon species</th>
<th>Mothership 1</th>
<th>Mothership 2</th>
<th>Mothership 3</th>
<th>Mothership 4</th>
<th>Motherships combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>JFA</td>
<td>OBS</td>
<td>JFA</td>
<td>OBS</td>
<td>JFA</td>
</tr>
<tr>
<td>Sockeye</td>
<td>413,707</td>
<td>436,987</td>
<td>387,225</td>
<td>408,533</td>
<td>496,677</td>
</tr>
<tr>
<td>Chum</td>
<td>302,716</td>
<td>309,862</td>
<td>313,007</td>
<td>313,202</td>
<td>355,666</td>
</tr>
<tr>
<td>Pink</td>
<td>611,197</td>
<td>626,013</td>
<td>510,896</td>
<td>515,004</td>
<td>847,769</td>
</tr>
<tr>
<td>Coho</td>
<td>104,162</td>
<td>110,276</td>
<td>148,110</td>
<td>154,251</td>
<td>96,040</td>
</tr>
<tr>
<td>Chinook</td>
<td>17,011</td>
<td>18,950</td>
<td>15,755</td>
<td>16,632</td>
<td>12,063</td>
</tr>
</tbody>
</table>
Table 2.--Ratio of number of salmon caught estimated from observer mean weight/number caught estimated from Japan Fishery Agency mean weights.

<table>
<thead>
<tr>
<th>Salmon species</th>
<th>MOTHERSHIP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Sockeye</td>
<td>1.056</td>
</tr>
<tr>
<td>Chum</td>
<td>1.024</td>
</tr>
<tr>
<td>Pink</td>
<td>1.024</td>
</tr>
<tr>
<td>Coho</td>
<td>1.058</td>
</tr>
<tr>
<td>Chinook</td>
<td>1.114</td>
</tr>
</tbody>
</table>
Figure 1.-- Number of sockeye salmon caught per day per mothership estimated using JFA-obtained mean fish weight plotted against estimate using observer-obtained mean weight.
Figure 2.--Number of chum salmon caught per day per mothership estimated using JFA-obtained mean fish weight plotted against estimate using observer-obtained mean weight.
Figure 3.—Number of pink salmon caught per day per mothership estimated using JFA-obtained mean fish weight plotted against estimate using observer-obtained mean weight.
Figure 4.--Number of coho salmon caught per day per mothership estimated using JFA-obtained mean fish weight plotted against estimate using observer-obtained mean weight.
Figure 5.--Number of chinook salmon caught per day per mothership estimated using JFA-obtained mean fish weight plotted against estimate using observer-obtained mean weight.
Figure 6.--Average chinook catch/day of sampled boats compared with the average chinook catch/day of all boats fishing the same 1° X 1° area during the same 10-day period.