

**Time and Size at Release Experiment:
Four Releases of Three Size
Categories of Juvenile Chinook
Salmon from the Quinsam Hatchery
in the Spring of 1982**

H. T. Bilton, A. S. Coburn, and R. B. Morley

Department of Fisheries and Oceans
Fisheries Research Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

May 1983

**Canadian Data Report of
Fisheries and Aquatic Sciences
No. 397**



Government of Canada
Fisheries and Oceans

Gouvernement du Canada
Pêches et Océans

Canadian Data Report of Fisheries and Aquatic Sciences

These reports provide a medium for filing and archiving data compilations where little or no analysis is included. Such compilations commonly will have been prepared in support of other journal publications or reports. The subject matter of Data Reports reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries management, technology and development, ocean sciences, and aquatic environments relevant to Canada.

Numbers 1-25 in this series were issued as Fisheries and Marine Service Data Records. Numbers 26-160 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Data Reports. The current series name was changed with report number 161.

Data Reports are not intended for general distribution and the contents must not be referred to in other publications without prior written clearance from the issuing establishment. The correct citation appears above the abstract of each report.

Rapport statistique canadien des sciences halieutiques et aquatiques

Ces rapports servent de base à la compilation des données de classement et d'archives pour lesquelles il y a peu ou point d'analyse. Cette compilation aura d'ordinaire été préparée pour appuyer d'autres publications ou rapports. Les sujets des Rapports statistiques reflètent la vaste gamme des intérêts et politiques du Ministère des Pêches et des Océans, notamment gestion des pêches, techniques et développement, sciences océaniques et environnements aquatiques, au Canada.

Les numéros 1 à 25 de cette série ont été publiés à titre de Records statistiques, Service des pêches et de la mer. Les numéros 26-160 ont été publiés à titre de Rapports statistiques du Service des pêches et de la mer, Ministère des Pêches et de l'Environnement. Le nom de la série a été modifié à partir du numéro 161.

Les Rapports statistiques ne sont pas préparés pour une vaste distribution et leur contenu ne doit pas être mentionné dans une publication sans autorisation écrite préalable de l'établissement auteur. Le titre exact paraît au haut du résumé de chaque rapport.

Canadian Data Report of
Fisheries and Aquatic Science No. 397

May 1983

TIME AND SIZE AT RELEASE EXPERIMENT: FOUR RELEASES OF
THREE SIZE CATEGORIES OF JUVENILE CHINOOK SALMON FROM
THE QUINSAM HATCHERY IN THE SPRING OF 1982

by

H. T. Bilton, A. S. Coburn, and R. B. Morley

Department of Fisheries and Oceans
Fisheries Research Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

(c) Minister of Supply and Services Canada 1983

Cat. No. Fs 97-13/397

ISSN 0706-6465

ABSTRACT

Bilton, H. T., A. S. Coburn, and R. B. Morley. 1983. Time and size at release experiment: four releases of three size groups of juvenile chinook salmon from the Quinsam Hatchery in the Spring of 1982. Can. Data Rep. Fish. Aquat. Sci. No. 397: iv + 18 p.

This report provides, in readily accessible form, background information required to assess the results of an experiment in progress at the Quinsam River production hatchery, Campbell River, B.C. The experiment is designed to measure the effects of time and size at release of juvenile Chinook salmon (Oncorhynchus tshawytscha) on their subsequent survival, growth, distribution, and age at maturity. In the spring of 1982 four releases (May 5, May 26, June 16, and July 7) of juvenile chinook salmon, each comprised of three size groups, were released from the Quinsam River hatchery, representing a combined total of 315,986 marked and tagged fish. Prior to each release, samples of smolts were obtained for examination for disease, proximate analysis, and sea water challenge tests. Specific information on lengths, weights, sex composition, health, and ability of released fish to adapt to sea water is given.

Key words: Quinsam, chinook, data, release size, release time.

RÉSUMÉ

Bilton, H. T., A. S. Coburn, and R. B. Morley. 1983. Time and size at release experiment: four releases of three size groups of juvenile chinook salmon from the Quinsam Hatchery in the Spring of 1982. Can. Data Rep. Fish. Aquat. Sci. No. 397: iv + 18 p.

Le présent rapport fournit, dans une forme facilement accessible, les données fondamentales nécessaires à l'évaluation des résultats d'une expérience présentement en cours à la piscifaculture de la rivière Quinsam, à Campbell River (C.-B.). Cette expérience vise à quantifier l'incidence de la taille des saumons quinnats (Oncorhynchus tshawytscha) juvéniles mis en liberté, et du moment choisi pour ce faire, sur leur survie ultérieure, leur croissance, leur répartition et leur âge à la maturité. Au printemps de 1982, quatre lâchers (5 mai, 26 mai, 16 juin et 7 juillet) de saumons quinnats juvéniles, chacun comprenant trois classes de longueur, ont été effectués à la piscifaculture de la rivière Quinsam. Au total, 315 986 poissons étiquetés et marqués ont été mis en liberté. Avant chaque lâcher, des échantillons de saumoneaux ont été obtenus pour l'examen pathologique, l'analyse immédiate et des tests d'acclimatation à l'eau de mer. Le rapport contient des données précises sur la longueur, le poids, la répartition des sexes, l'état de santé des poissons relâchés et leur capacité à s'acclimater à l'eau de mer.

Mots-clés: Quinsam, quinnat, données, taille au lâcher, moment du lâcher.

INTRODUCTION

The purpose of this report is to provide, in readily accessible form, background information required in a current experiment on the effects of time and size at release of juvenile Quinsam River chinook salmon (Oncorhynchus tshawytscha) on their subsequent survival, growth, distribution and age at maturity. The report has been divided into four major sections: the first deals with the smolt releases; the second with disease; the third with sea-water challenge tests; and the fourth with number of tagged juveniles recovered by the Coastal Habitat group in a study of the Campbell River estuary and adjacent waters.

SECTION 1. SMOLT RELEASES

MATERIALS AND METHODS

A. Donor stock and rearing

A part of the production stock of 1981 brood Quinsam hatchery juvenile chinook were used for the experiment. Fish assigned to the experiment were reared separately from the production fish using normal hatchery water supply, in 2 Burrow's ponds at production densities. Fish were fed Oregon moist pellets (OMP) according to hatchery feeding schedule. It should be noted there were insufficient fish in the two ponds for the last release. Hence, some fish from a production pond were used in addition to what remained of the experimental groups.

B. Experimental Design

The object of the experiment was to release three sizes of juvenile chinooks on each of four dates. Size groups were achieved by grading the population of fish in each pond into small, medium, and large size length categories. Each size group was replicated three times. Thus there were nine groups planned for each release, making a total of 36 groups for all four releases. The design was as shown below.

Release date and number of fish

| Size Category | May 5 | May 26 | June 16 | July 7 |
|---------------|--------|--------|---------|--------|
| Small | 10,000 | 10,000 | 10,000 | 10,000 |
| | 10,000 | 10,000 | 10,000 | 10,000 |
| | 10,000 | 10,000 | 10,000 | 10,000 |
| Total | 30,000 | 30,000 | 30,000 | 30,000 |
| Medium | 10,000 | 10,000 | 10,000 | 10,000 |
| | 10,000 | 10,000 | 10,000 | 10,000 |
| | 10,000 | 10,000 | 10,000 | 10,000 |
| Total | 30,000 | 30,000 | 30,000 | 30,000 |
| Large | 10,000 | 10,000 | 10,000 | 10,000 |
| | 10,000 | 10,000 | 10,000 | 10,000 |
| | 10,000 | 10,000 | 10,000 | 10,000 |
| Total | 30,000 | 30,000 | 30,000 | 30,000 |
| Grand Total | 90,000 | 90,000 | 90,000 | 90,000 |

C. Nose-Tagging and Marking

All fish were tagged and marked during the period mid-April to mid-June, 1982. On an alternating basis for each release, a portion of the fish from one of the two stock ponds were removed, tagged, and transferred into a release pond: e.g., for release 1 fish from pond A were used; for release 2 fish from pond B were used, and so on. Just prior to each tagging session, a sample of 1,000 fish was taken from the stock pond. These were anesthetized, measured for length, and returned to the pond. Length-frequency curves derived from these data were used to determine the size categories for marking. Arbitrarily, it was decided that fish with lengths falling within the 5% tails of the curve would be rejected to remove out-riders and that the remaining 90% would be divided into three equal proportions, classified as small, medium and large.

Once size categories were determined, marking and tagging of the fish was initiated. Fish were first anesthetized and graded to size category. The adipose fin was then removed and the appropriately coded binary magnetic wire nose tag applied. Tagged fish were then transferred to the release pond. It should be noted that because of the rapid growth of the

fish at this time of the year, the limits delineating each size category had to be moved upwards several millimeters every two to three days throughout each of the four tagging sessions (a session lasted 10-12 days).

Due to a shortage of fish, only 2 replicates of each size category were tagged for the final release (as opposed to 3 replicates for all other releases).

D. Release

Approximately 900 tagged fish were randomly removed from the release pond on the day of each release. These fish were killed and retained for subsequent examination for tag code, length, weight, and sex. A further 90 fish (30 small, 30 medium, and 30 large) were killed and frozen for subsequent proximate analysis by D. Higgs (results of proximate analysis are not reported here). Before each release a sample of 100 fish were examined for disease by the Diagnostic Services section (G. Hoskins). In addition, samples of approximately 36 live fish (12 small, 12 medium, 12 large) were removed just prior to release and tested by C. Clarke for their ability to adapt to sea water as measured by blood sodium levels after 24 h exposure to sea water (Clarke and Blackburn 1977).

Each release of fish began at approximately 1800 hours by removal of stop logs from the end of the pond leading directly to a channel to the river. Fish were released on May 5, May 26, June 16, and July 7, 1982.

RESULTS

The numbers of tagged fish released on each date are given by tag-code in Tables 1 - 4. Also given in Tables 1 - 4 are estimates (based on release samples) of mean lengths and weights of fish by sex in each of the groups. An estimated total of 327,058 marked fish were released, of which 315,986 were estimated to have a tag (based on incidence of marked fish without tags in the release samples). Estimated tag loss by release and size category is given in Table 5. In three of the four releases there were highly significant negative correlations between percent tag loss and mean length at release, e.g., second release, $r = -0.91$, $n = 9$, $P = <0.001$; third release, $r = -0.94$, $n = 9$, $p < .001$; fourth release, $r = -0.97$, $n = 6$, $P < .001$. Among fish of the first release there was a positive but non significant correlation, $r = 0.44$, $n = 9$, $P > .05$. When the groups from all releases are combined a significant negative correlation resulted, $r = -0.37$, $n = 33$, $p < .05$. Comparison of the percent tag loss with the standard deviation at release indicated significant positive correlations between these two variables for all but one release, e.g., second release, $r = 0.89$, $n = 9$, $P < .001$; third release, $r = 0.77$, $n = 9$, $P < .02$; fourth release, $r = 0.87$, $n = 6$, $P < .01$. Among fish of the first release there was a positive but non significant correlation, $r = 0.31$, $n = 9$, $P > .05$. When the groups from all releases are combined and compared a highly significant positive correlation

results, $r = .65$, $n=33$, $P<.001$. These data indicate that within three of the release groups, size of fish and tag loss are inversely related, with the tag loss decreasing with increased size of fish. Since this occurred in three of the releases even though the fish had grown over time it does not seem to be an effect of size alone. For example, the first group of small category fish from release one, averaged 56.92 mm and tag loss of 6.5%; for release two 77.37 mm and 6.98%; for release three 89.70 mm and 6.5%; and for release four 95.51 mm and 7.40% (Table 5). The positive correlation between tag loss and standard deviation suggests the problem may result from variability in size of the group being tagged. Variability was greatest for small category fish; among fish of each release there was a negative correlation between the mean and the standard deviation (release one, $r = -0.69$, $n = 9$; release two, $r = -0.69$, $n = 9$; release three, $r = -0.66$, $n = 9$; and release four, $r = -0.73$, $n = 6$). The correlations were significant at the 5% level among fish from the first three releases and of borderline significance among those of the fourth release ($P>.05$). It is possible the head molds used for tagging the small fish were not adequate to cover the range of sizes encountered, resulting in improper implantation of the tags and greater tag loss for fish of this size category.

Deviations from a 50:50 sex ratio in the samples from each release group were tested using the 50% probability test (Langley 1979). In eight of the 33 groups there were significantly more males than females ($P<0.05$). These groups were: May 5 release, tag-codes 8-21-19, 8-21-21, 8-21-23, 8-21-25, 8-21-26, 8-21-27; July 7 release, tag-codes 8-21-52, 8-21-53.

Examination of the sex ratios of fish in the total samples from each release (all groups combined) indicates that for each release there were significantly more males than females ($P<0.05$).

Comparison of the sex ratios of fish in samples from the three size categories from each release (replicates combined) using chi-square (Langley 1979) indicated no differences ($P>0.05$) in the proportions of males and females between size categories for the first three releases. However, for samples from the fourth release, a borderline significant difference was observed ($\chi^2 = 6.00$, d.f. 2, $P<0.05$) with a higher proportion of males in the large category than in the other categories.

SECTION 2. DISEASE

This section was provided by the Diagnostic Services and summarizes the methods and results of disease examination of fish from each of the four releases.

The following samples of tagged chinook smolts were randomly selected from the release ponds on dates indicated.

| Case No. | Release Date | Collection Date | Number examined | |
|----------|--------------|-----------------|-----------------|----------|
| | | | Random | Moribund |
| 82-149 | May 5/82 | May 5/82 | 100 | 10 |
| 82-183 | May 26/82 | May 25/82 | 100 | 10 |
| 82-224 | June 16/82 | June 15/82 | 100 | 10 |
| 82-254 | July 7/82 | July 6/82 | 100 | 5 |

METHODS

A. Random Samples

- (1) 100 fish were randomly selected by dip net from different areas in each pond.
- (2) Fish were examined internally and externally for gross signs of pathology and infectious disease.
- (3) Kidney tissue was streaked aseptically onto Tryptic Soy Agar (TSA) for the detection of bacterial pathogens.
- (4) Gram stained kidney tissue was examined for the detection of bacterial and parasitic agents.
- (5) As a general indicator of health, microhematocrit values were collected on the first 25 fish in each sample.
- (6) Liver and kidney tissue was collected for histological examination of the first 25 fish in each sample.

B. Moribund Samples

- (1) If available, moribund or fresh dead fish (to a maximum of 10) were sampled from each pond.
- (2) The sampling procedure was the same as for random fish, but omitting the collection of microhematocrit values and histological samples.
- (3) In random samples a very low incidence of infectious disease can often not be detected, while examinations of moribund and/or fresh dead fish may show the presence of a bacterial pathogen more readily.

RESULTS

No abnormalities or pathogens were found in any of these fish with the exception of 2 fish from the first sample (May 5/82) which showed external fungus. The microhematocrit values were: 5 May - average 36.8%, range 31 - 42%; 26 May - average 40.6%, range 33 - 47%; 16 June - average 40.1%, range 17 - 47%; 7 July - average 41.2%, range 30 - 49%.

Histology: Liver and anterior kidney were examined from the first 25 fish in each group. All kidney sections were normal. Liver sections in 25% of the chinook showed some slight to moderate vacuolation.

CONCLUSIONS

- (1) Many fish had pale livers. However this, as well as the degree of liver vacuolation seen in histology, can be considered to be within the normal range for hatchery-raised fish.
- (2) In comparison to the normal range of microhematocrit values which lies between 35 - 45%, some of the observed values were low (e.g., 17%). However the average values were in the normal range.
- (3) No eye damage or opacity was seen in any of these fish.

SECTION 3. SEAWATER CHALLENGE TESTS

This section was provided by C. Clarke. Tests were performed on tagged fish from May 6 to July 8 (Table 6). At the time of the first release in early May, the medium and large size groups showed good seawater adaptability as evidenced by relatively low blood sodiums after 24 h exposure to seawater. However, by late May and early June all groups showed only mediocre adaptability. Overall adaptability was poorest June 7 but by the time of the third release was much improved for all size groups and remained so for the last sampling July 8.

SECTION 4. RECOVERIES IN ESTUARY SAMPLING

This section was provided by the Coastal Habitat Group (C. D. Levings). The following table lists by tag code, the numbers of chinook juveniles from the various size and time groups released in the spring of 1982 that were subsequently recovered in the Campbell River estuary and adjacent waters up until November 10, 1982. Sampling is still being conducted, hence there may be additional recoveries.

| Tag code | Number recovered | | Total |
|----------|-------------------|-----------------------------|-------|
| | May 10-June 17/82 | Period June 19-Nov 10/82 | |
| 8-21-19 | 22 | 18 | 40 |
| 8-21-20 | 22 | 22 | 44 |
| 9-21-21 | 29 | 11 | 40 |
| 8-21-22 | 33 | 12 | 45 |
| 8-21-23 | 36 | 19 | 55 |
| 8-21-24 | 36 | 14 | 50 |
| 8-21-25 | 46 | 7 | 53 |
| 8-21-26 | 51 | 6 | 57 |
| 8-21-27 | 51 | 2 | 53 |
| 8-21-28 | 20 | 15 | 35 |
| 8-21-29 | 21 | 16 | 37 |
| 8-21-30 | 13 | 18 | 31 |
| 8-21-31 | 23 | 11 | 34 |
| 8-21-32 | 23 | 14 | 37 |
| 8-21-33 | 31 | 15 | 46 |
| 8-21-34 | 13 | 5 | 18 |
| 8-21-35 | 22 | 8 | 30 |
| 8-21-36 | 18 | 9 | 27 |
| 8-21-37 | 9 | 35 | 44 |
| 8-21-38 | 7 | 36 | 43 |
| 8-21-39 | 17 | 25 | 42 |
| 8-21-40 | 4 | 15 | 19 |
| 8-21-41 | 7 | 20 | 27 |
| 8-21-42 | 10 | 22 | 32 |
| 8-21-43 | 11 | 16 | 27 |
| 8-21-44 | 5 | 22 | 27 |
| 8-21-45 | 4 | 16 | 20 |
| 8-21-46 | - | 66 | 66 |
| 8-21-47 | - | 61 | 61 |
| 8-21-49 | - | 65 | 65 |
| 8-21-50 | - | 43 | 43 |
| 8-21-52 | - | 59 | 59 |
| 8-21-53 | - | 46 | 46 |
| Total | 584 | 769 | 1,353 |

ACKNOWLEDGMENTS

The authors would like to thank Messrs. J. Van Tyne, R. Reinhardt, and the Quinsam River hatchery staff for their help and cooperation in the carrying out of this work and C. Clarke and G. Hoskins of the Pacific Biological Station for their participation.

REFERENCES

- Clarke, W. C., and J. Blackburn. 1977. A seawater challenge to measure smolting of juvenile salmon. Fish. Mar. Serv. Res. Div. Tech. Dept. 705: 11 p.
- Langley, R. 1979. Practical statistics, simply explained. Pan Books Ltd., Cavaye Place, London SW10 9 PG, 400 p.

Table 1. Numbers of tagged chinook smolts in the nine groups released at Quinsam hatchery on May 5, 1982. Mean lengths and weights by sex, of smolts sampled at release are given.

| Tag b code | Number tagged fish released | Size group | Length (mm) | | | | | | | | | | | | Skewness ^a | Median | |
|---------------|--------------------------------------|---------------|-------------|------|-----|-----------|------|-----|-----------------|------|-----|-----------------------------|-----------------------------|---|-----------------------|--------|---------------------|
| | | | Male | | | Female | | | Male and Female | | | 95% confidence limits | | | | | Coeff. variation |
| | | | \bar{x} | SD | N | \bar{x} | SD | N | \bar{x} | SD | N | 95% confidence limits | 95% confidence limits | | | | |
| 8-21-19 | 6,740 | small | 56.96 | 4.53 | 28 | 56.85 | 2.91 | 13 | 56.92 | 4.05 | 41 | 55.65-58.20 | 7.12 | + | 56.00 | | |
| 8-21-20 | 9,215 | small | 59.56 | 3.48 | 52 | 58.76 | 3.49 | 33 | 59.25 | 3.48 | 85 | 58.49-59.99 | 5.88 | - | 60.00 | | |
| 8-21-21 | 8,782 | small | 58.04 | 3.63 | 53 | 58.37 | 3.01 | 27 | 58.15 | 3.42 | 80 | 57.39-58.91 | 5.87 | - | 58.00 | | |
| 8-21-22 | 9,761 | medium | 60.82 | 2.82 | 44 | 62.03 | 3.20 | 30 | 61.31 | 3.02 | 74 | 60.61-62.01 | 4.92 | - | 62.00 | | |
| 8-21-23 | 10,070 | medium | 63.38 | 2.88 | 69 | 63.30 | 2.73 | 43 | 63.35 | 2.81 | 112 | 62.82-63.87 | 4.44 | - | 63.00 | | |
| 8-21-24 | 10,108 | medium | 65.67 | 2.44 | 72 | 65.58 | 2.64 | 50 | 65.63 | 2.51 | 122 | 65.18-66.08 | 3.83 | - | 65.50 | | |
| 8-21-25 | 9,539 | large | 68.17 | 3.11 | 76 | 67.41 | 3.52 | 32 | 67.94 | 3.24 | 108 | 67.33-68.56 | 4.77 | - | 68.00 | | |
| 8-21-26 | 9,754 | large | 67.40 | 2.99 | 68 | 67.52 | 2.59 | 46 | 67.45 | 2.82 | 114 | 66.92-67.97 | 4.18 | + | 67.00 | | |
| 8-21-27 | 9,622 | large | 69.65 | 3.16 | 71 | 69.45 | 2.75 | 42 | 69.57 | 3.00 | 113 | 69.01-70.13 | 4.32 | - | 70.00 | | |
| Total | 83,591 | | | | 533 | | | 316 | | | 849 | | | | | | |

Table 1 (cont'd)

| Tag ^b code | Number tagged fish released | Size group | Weight (g) | | | | | | | | | | | | 95% confidence limits | Coeff. variation | Skewness ^a | Median |
|--------------------------|--------------------------------------|---------------|------------|------|-----|-----------|------|-----|-----------------|------|-----|-----------|-------|----|-----------------------------|---------------------|-----------------------|--------|
| | | | Male | | | Female | | | Male and Female | | | | | | | | | |
| | | | \bar{x} | SD | N | \bar{x} | SD | N | \bar{x} | SD | N | | | | | | | |
| 8-21-19 | 6,740 | small | 2.17 | 0.63 | 28 | 2.13 | 0.33 | 13 | 2.16 | 0.55 | 41 | 1.98-2.33 | 25.56 | ++ | 2.13 | | | |
| 8-21-20 | 9,215 | small | 2.43 | 0.43 | 52 | 2.35 | 0.37 | 33 | 2.39 | 0.41 | 85 | 2.31-2.48 | 16.98 | - | 2.41 | | | |
| 8-21-21 | 8,782 | small | 2.17 | 0.45 | 53 | 2.20 | 0.30 | 27 | 2.18 | 0.40 | 80 | 2.09-2.27 | 18.53 | + | 2.24 | | | |
| 8-21-22 | 9,761 | medium | 2.65 | 0.41 | 44 | 2.78 | 0.39 | 30 | 2.70 | 0.40 | 74 | 2.61-2.80 | 14.97 | - | 2.65 | | | |
| 8-21-23 | 10,070 | medium | 2.94 | 0.40 | 69 | 2.90 | 0.43 | 43 | 2.92 | 0.41 | 112 | 2.85-3.00 | 13.98 | ++ | 2.91 | | | |
| 8-21-24 | 10,108 | medium | 3.19 | 0.37 | 72 | 3.18 | 0.39 | 50 | 3.18 | 0.38 | 122 | 3.12-3.25 | 11.86 | + | 3.19 | | | |
| 8-21-25 | 9,539 | large | 3.74 | 0.54 | 76 | 3.64 | 0.53 | 32 | 3.71 | 0.54 | 108 | 3.61-3.81 | 14.53 | + | 3.67 | | | |
| 8-21-26 | 9,754 | large | 3.69 | 0.53 | 68 | 3.63 | 0.46 | 46 | 3.67 | 0.50 | 114 | 3.57-3.76 | 13.65 | ++ | 3.58 | | | |
| 8-21-27 | 9,622 | large | 3.85 | 0.50 | 71 | 3.85 | 0.59 | 42 | 3.85 | 0.54 | 113 | 3.75-3.95 | 13.91 | + | 3.83 | | | |
| Total | 83,591 | | | | 533 | | | 316 | | | 849 | | | | | | | |

^aNote: Skewed right = +; skewed left = -; *significant at .05 level.

^bthe first number indicates agency, the second data 1, the third data 2.

Table 2. Number of tagged chinook smolts in the nine groups released at Quinsam hatchery on May 26, 1982. Mean lengths and weights by sex, of smolts sampled at release are given.

| Tag ^t code | Number tagged fish released | Size group | Length (mm) | | | | | | | | | | | | 95% confidence limits | Coeff. variation | Skewness ^a | Median |
|--------------------------|--------------------------------------|---------------|-------------|------|------------|-----------|------|------------|-----------------|------|------------|-------------|------|----|-----------------------------|---------------------|-----------------------|--------|
| | | | Male | | | Female | | | Male and Female | | | | | | | | | |
| | | | \bar{x} | SD | N | \bar{x} | SD | N | \bar{x} | SD | N | | | | | | | |
| 8-21-28 | 9,434 | small | 76.92 | 4.41 | 37 | 77.80 | 4.71 | 40 | 77.37 | 4.56 | 77 | 76.34-78.41 | 5.89 | + | 78.00 | | | |
| 8-21-29 | 9,590 | small | 76.62 | 4.77 | 55 | 77.49 | 3.52 | 43 | 77.00 | 4.27 | 98 | 76.14-77.86 | 5.55 | -* | 78.00 | | | |
| 8-21-30 | 9,072 | small | 78.88 | 6.44 | 33 | 78.61 | 5.45 | 28 | 78.75 | 5.96 | 61 | 77.23-80.28 | 7.57 | - | 79.00 | | | |
| 8-21-31 | 10,184 | medium | 84.67 | 2.89 | 61 | 84.31 | 3.79 | 48 | 84.51 | 3.31 | 109 | 83.88-85.14 | 3.91 | + | 85.00 | | | |
| 8-21-32 | 10,302 | medium | 84.40 | 2.81 | 69 | 84.72 | 2.97 | 58 | 84.55 | 2.87 | 127 | 84.05-85.06 | 3.40 | - | 85.00 | | | |
| 8-21-33 | 9,776 | medium | 84.79 | 2.77 | 44 | 84.43 | 1.88 | 46 | 84.61 | 2.35 | 90 | 84.12-85.10 | 2.78 | - | 85.00 | | | |
| 8-21-34 | 10,205 | large | 89.73 | 3.04 | 56 | 90.32 | 3.40 | 44 | 89.99 | 3.20 | 100 | 89.35-90.62 | 3.56 | + | 90.00 | | | |
| 8-21-35 | 10,394 | large | 89.27 | 2.98 | 52 | 89.02 | 3.33 | 44 | 89.16 | 3.13 | 96 | 88.52-89.79 | 3.51 | - | 89.00 | | | |
| 8-21-36 | 10,169 | large | 90.54 | 2.83 | 66 | 89.37 | 3.75 | 46 | 90.06 | 3.28 | 112 | 89.45-90.68 | 3.64 | -* | 90.00 | | | |
| Total | 89,126 | | | | 473 | | | 397 | | | 870 | | | | | | | |

Table 2 (cont'd)

| Tag ^b code | Number tagged fish released | Size group | Weight (g) | | | | | | | | | | | | 95% confidence limits | Coeff. variation | Skewness ^a | Median |
|--------------------------|--------------------------------------|---------------|------------|------|-----|-----------|------|-----|-----------------|------|-----|-----------|-------|----|-----------------------------|---------------------|-----------------------|--------|
| | | | Male | | | Female | | | Male and Female | | | | | | | | | |
| | | | \bar{x} | SD | N | \bar{x} | SD | N | \bar{x} | SD | N | | | | | | | |
| 8-21-28 | 9,434 | small | 5.19 | 0.85 | 37 | 5.44 | 0.89 | 40 | 5.32 | 0.88 | 77 | 5.12-5.52 | 16.51 | + | 5.35 | | | |
| 8-21-29 | 9,590 | small | 5.13 | 0.94 | 55 | 5.26 | 0.73 | 43 | 5.18 | 0.85 | 98 | 5.01-5.36 | 16.49 | -* | 5.26 | | | |
| 8-21-30 | 9,072 | small | 5.52 | 1.49 | 33 | 5.39 | 1.07 | 28 | 5.46 | 1.30 | 61 | 5.12-5.79 | 23.85 | + | 5.45 | | | |
| 8-21-31 | 10,184 | medium | 6.97 | 0.76 | 61 | 6.83 | 0.91 | 48 | 6.91 | 0.83 | 109 | 6.75-7.07 | 12.00 | + | 6.89 | | | |
| 8-21-32 | 10,302 | medium | 6.82 | 0.69 | 69 | 6.95 | 0.78 | 58 | 6.88 | 0.74 | 127 | 6.75-7.01 | 10.72 | + | 6.78 | | | |
| 8-21-33 | 9,776 | medium | 6.79 | 0.61 | 44 | 6.60 | 0.57 | 46 | 6.70 | 0.59 | 90 | 6.57-6.82 | 8.84 | + | 6.68 | | | |
| 8-21-34 | 10,205 | large | 8.42 | 1.03 | 56 | 8.39 | 1.03 | 44 | 8.41 | 1.02 | 100 | 8.20-8.61 | 12.18 | + | 8.26 | | | |
| 8-21-35 | 10,394 | large | 8.03 | 0.76 | 52 | 8.17 | 0.86 | 44 | 8.09 | 0.81 | 96 | 7.93-8.25 | 9.96 | + | 8.01 | | | |
| 8-21-36 | 10,169 | large | 8.23 | 0.81 | 66 | 8.08 | 0.96 | 46 | 8.17 | 0.87 | 112 | 8.01-7.88 | 10.70 | -* | 8.08 | | | |
| Total | 89,126 | | | | 473 | | | 397 | | | 870 | | | | | | | |

^aNote: Skewed right = +; skewed left = -; *Significant at .05 level.

^bthe first number indicates agency, the second data 1, the third data 2.

Table 3. Numbers of tagged chinook smolts in the nine groups released at Quinsam hatchery on June 16, 1982. Mean lengths and weights by sex, of smolts sampled at release are given.

| Tag ^b code | Number tagged fish released | Size group | Length (mm) | | | | | | | | | | | | 95% confidence limits | Coeff. variation | Skewness ^a | Median |
|--------------------------|--------------------------------------|---------------|-------------|------|-----|-----------|------|-----|-----------------|------|-----|---------------|------|----|-----------------------------|---------------------|-----------------------|--------|
| | | | Male | | | Female | | | Male and Female | | | | | | | | | |
| | | | \bar{x} | SD | N | \bar{x} | SD | N | \bar{x} | SD | N | | | | | | | |
| 8-21-37 | 9,478 | small | 88.98 | 4.89 | 48 | 90.76 | 3.39 | 33 | 89.70 | 4.41 | 81 | 88.73-90.68 | 4.91 | + | 90.00 | | | |
| 8-21-38 | 9,763 | small | 87.42 | 3.65 | 47 | 87.52 | 3.58 | 42 | 87.47 | 3.60 | 89 | 86.71-88.23 | 4.11 | + | 87.00 | | | |
| 8-21-39 | 9,400 | small | 86.12 | 4.05 | 50 | 87.85 | 4.74 | 41 | 86.90 | 4.43 | 91 | 85.98-87.82 | 5.10 | +* | 87.00 | | | |
| 8-21-40 | 10,022 | medium | 96.24 | 3.38 | 53 | 96.26 | 2.65 | 38 | 96.25 | 3.08 | 91 | 95.61-96.89 | 3.20 | - | 96.00 | | | |
| 8-21-41 | 10,417 | medium | 94.46 | 3.37 | 58 | 94.36 | 3.37 | 52 | 94.42 | 3.35 | 110 | 93.78-95.05 | 3.55 | + | 95.00 | | | |
| 8-21-42 | 9,739 | medium | 92.93 | 3.08 | 44 | 92.17 | 2.38 | 36 | 92.59 | 2.80 | 80 | 91.96-93.21 | 3.02 | +* | 92.00 | | | |
| 8-21-43 | 10,602 | large | 99.37 | 3.43 | 58 | 98.66 | 3.50 | 50 | 99.05 | 3.46 | 108 | 98.38-99.71 | 3.50 | -* | 99.00 | | | |
| 8-21-44 | 10,119 | large | 102.07 | 2.66 | 45 | 100.96 | 3.45 | 45 | 101.51 | 3.11 | 90 | 100.86-102.16 | 3.07 | -* | 102.00 | | | |
| 8-21-45 | 10,059 | large | 97.95 | 3.32 | 56 | 97.65 | 2.55 | 49 | 97.81 | 2.97 | 105 | 97.23-98.38 | 3.04 | + | 97.00 | | | |
| Total | 89,599 | | | | 459 | | | 386 | | | 845 | | | | | | | |

Table 3 (cont'd)

| Tag ^b code | Number tagged fish released | Size group | Weight (g) | | | | | | | | | | | | 95% confidence limits | Coeff. variation | Skewness ^a | Median |
|--------------------------|--------------------------------------|---------------|------------|------|-----|-----------|------|-----|-----------------|------|-----|-------------|-------|----|-----------------------------|---------------------|-----------------------|--------|
| | | | Male | | | Female | | | Male and Female | | | | | | | | | |
| | | | \bar{x} | SD | N | \bar{x} | SD | N | \bar{x} | SD | N | | | | | | | |
| 8-21-37 | 9,478 | small | 8.21 | 1.48 | 48 | 8.74 | 1.19 | 33 | 8.43 | 1.39 | 81 | 8.12-8.73 | 16.45 | + | 8.48 | | | |
| 8-21-38 | 9,763 | small | 7.76 | 1.04 | 47 | 7.75 | 1.08 | 42 | 7.76 | 1.05 | 89 | 7.54-7.98 | 13.55 | + | 7.67 | | | |
| 8-21-39 | 9,400 | small | 7.17 | 1.01 | 50 | 7.51 | 1.30 | 41 | 7.32 | 1.15 | 91 | 7.08-7.56 | 15.78 | + | 7.24 | | | |
| 8-21-40 | 10,022 | medium | 10.43 | 1.00 | 53 | 10.27 | 0.87 | 38 | 10.36 | 0.94 | 91 | 10.17-10.56 | 9.12 | - | 10.42 | | | |
| 8-21-41 | 10,417 | medium | 9.56 | 0.89 | 58 | 9.67 | 1.13 | 52 | 9.61 | 1.01 | 110 | 9.42-9.80 | 10.47 | - | 9.62 | | | |
| 8-21-42 | 9,739 | medium | 9.06 | 0.98 | 44 | 8.63 | 0.65 | 36 | 8.87 | 0.87 | 80 | 8.68-9.06 | 9.79 | + | 8.84 | | | |
| 8-21-43 | 10,602 | large | 11.24 | 1.18 | 58 | 11.12 | 1.30 | 50 | 11.19 | 1.23 | 108 | 10.95-11.42 | 11.01 | - | 11.13 | | | |
| 8-21-44 | 10,119 | large | 12.42 | 1.16 | 45 | 12.10 | 1.33 | 45 | 12.26 | 1.25 | 90 | 12.00-12.52 | 10.20 | -* | 12.27 | | | |
| 8-21-45 | 10,059 | large | 10.58 | 1.14 | 56 | 10.45 | 0.83 | 49 | 10.52 | 1.01 | 105 | 10.33-10.72 | 9.58 | + | 10.33 | | | |
| Total | 89,599 | | | | 459 | | | 386 | | | 845 | | | | | | | |

^aNote: Skewed right = +; skewed left = -; *significant at .05 level

^bthe first number indicates agency, the second data 1, the third data 2.

Table 4. Numbers of tagged chinook smolts in the six groups released at Quinsam hatchery on July 7, 1982. Mean lengths and weights by sex, of smolts sampled at release are given.

| Tag ^b code | Number tagged fish released | Size group | Length (mm) | | | | | | | | | | | | 95% confidence limits | Coeff. variation | Skewness ^a | Median |
|--------------------------|--------------------------------------|---------------|-------------|------|------------|-----------|------|------------|-----------------|------|------------|---------------|------|----|-----------------------------|---------------------|-----------------------|--------|
| | | | Male | | | Female | | | Male and Female | | | | | | | | | |
| | | | \bar{x} | SD | N | \bar{x} | SD | N | \bar{x} | SD | N | | | | | | | |
| 8-21-46 | 9,074 | small | 95.36 | 5.10 | 53 | 95.69 | 4.94 | 45 | 95.51 | 5.00 | 98 | 94.51-96.51 | 5.24 | -* | 96.00 | | | |
| 8-21-47 | 9,249 | small | 94.28 | 6.38 | 39 | 94.35 | 5.04 | 45 | 94.32 | 5.67 | 84 | 93.09-95.55 | 6.01 | - | 95.00 | | | |
| 8-21-49 | 9,578 | medium | 104.25 | 3.30 | 84 | 104.01 | 2.86 | 82 | 104.31 | 3.09 | 166 | 103.66-104.60 | 2.96 | + | 105.00 | | | |
| 8-21-50 | 6,859 | medium | 102.55 | 3.69 | 58 | 102.76 | 3.14 | 47 | 102.65 | 3.44 | 105 | 101.98-103.31 | 3.35 | - | 103.00 | | | |
| 8-21-52 | 9,704 | large | 111.00 | 4.03 | 119 | 110.43 | 4.41 | 72 | 110.78 | 4.17 | 191 | 110.19-111.38 | 3.77 | + | 111.00 | | | |
| 8-21-53 | 9,206 | large | 109.59 | 2.75 | 76 | 109.45 | 3.76 | 51 | 109.53 | 3.18 | 127 | 108.98-110.09 | 3.26 | -* | 110.00 | | | |
| Total | 53,670 | | | | 429 | | | 342 | | | 771 | | | | | | | |

Table 4 (cont'd)

| Tag ^b code | Number tagged fish released | Size group | Weight (g) | | | | | | | | | | | | | | |
|--------------------------|--------------------------------------|---------------|------------|------|-----|-----------|------|-----|-----------------|------|-----|-----------------------------|-------|-------|---------------------|-----------------------|--------|
| | | | Male | | | Female | | | Male and Female | | | 95% confidence limits | | | Coeff. variation | Skewness ^a | Median |
| | | | \bar{x} | SD | N | \bar{x} | SD | N | \bar{x} | SD | N | lower | upper | lower | | | |
| 8-21-46 | 9,074 | small | 10.23 | 1.68 | 53 | 10.23 | 1.62 | 45 | 10.23 | 1.65 | 98 | 9.90-10.56 | 16.11 | - | 10.36 | | |
| 8-21-47 | 9,249 | small | 9.67 | 1.77 | 39 | 9.87 | 1.48 | 45 | 9.78 | 1.62 | 84 | 9.43-10.13 | 16.55 | - | 9.99 | | |
| 8-21-49 | 9,578 | medium | 13.33 | 1.26 | 84 | 13.44 | 1.29 | 82 | 13.38 | 1.27 | 166 | 13.19-13.57 | 9.50 | + | 13.32 | | |
| 8-21-50 | 6,859 | medium | 12.78 | 1.47 | 58 | 12.78 | 1.34 | 47 | 12.78 | 1.41 | 105 | 12.50-13.05 | 11.03 | - | 12.70 | | |
| 8-21-52 | 9,704 | large | 16.49 | 2.15 | 119 | 16.31 | 2.02 | 72 | 16.42 | 2.10 | 191 | 16.13-16.72 | 12.78 | +* | 16.39 | | |
| 8-21-53 | 9,206 | large | 15.81 | 1.23 | 76 | 15.55 | 1.72 | 51 | 15.71 | 1.44 | 127 | 15.45-15.96 | 9.20 | - | 15.74 | | |
| Total | 53,670 | | | | 429 | | | 342 | | | 771 | | | | | | |

^aNote: skewed right = +; skewed left = -; *significant at .05 level

^bthe first number indicates Agency, the second data 1, the third data 2.

Table 5. Percent tag loss among tagged chinook smolts released from Quinsam hatchery at different sizes and times in 1982.

| Release date | Tag code | Size group | Percent tag loss | Length (mm) | |
|--------------|----------|------------|------------------|-------------|------|
| | | | | \bar{x} | SD |
| May 5 | 8-21-19 | small | 6.52 | 56.92 | 4.05 |
| | 8-21-20 | small | 2.25 | 59.25 | 3.48 |
| | 8-21-21 | small | 2.44 | 58.15 | 3.42 |
| | 8-21-22 | medium | 2.56 | 61.31 | 3.02 |
| | 8-21-23 | medium | 1.74 | 63.35 | 2.81 |
| | 8-21-24 | medium | 1.60 | 65.63 | 2.51 |
| | 8-21-25 | large | 8.33 | 67.94 | 3.24 |
| | 8-21-26 | large | 6.40 | 67.45 | 2.82 |
| | 8-21-27 | large | 6.56 | 69.57 | 3.00 |
| May 26 | 8-21-28 | small | 6.98 | 77.37 | 4.56 |
| | 8-21-29 | small | 5.71 | 77.00 | 4.27 |
| | 8-21-30 | small | 8.70 | 78.75 | 5.96 |
| | 8-21-31 | medium | 1.79 | 84.51 | 3.31 |
| | 8-21-32 | medium | 1.53 | 84.55 | 2.87 |
| | 8-21-33 | medium | 2.13 | 84.61 | 2.35 |
| | 8-21-34 | large | 0.97 | 89.99 | 3.20 |
| | 8-21-35 | large | 1.01 | 89.16 | 3.13 |
| | 8-21-36 | large | 0.00 | 90.06 | 3.28 |
| June 16 | 8-21-37 | small | 6.45 | 89.70 | 4.41 |
| | 8-21-38 | small | 5.88 | 87.47 | 3.60 |
| | 8-21-39 | small | 5.61 | 86.90 | 4.43 |
| | 8-21-40 | medium | 2.02 | 96.25 | 3.08 |
| | 8-21-41 | medium | 1.71 | 94.42 | 3.35 |
| | 8-21-42 | medium | 2.30 | 92.59 | 2.80 |
| | 8-21-43 | large | 0.00 | 99.05 | 3.46 |
| | 8-21-44 | large | 0.00 | 101.51 | 3.11 |
| | 8-21-45 | large | 0.89 | 97.81 | 2.97 |
| July 7 | 8-21-46 | small | 7.40 | 95.51 | 5.00 |
| | 8-21-47 | small | 8.70 | 94.32 | 5.67 |
| | 8-21-49 | medium | 1.75 | 104.31 | 3.09 |
| | 8-21-50 | medium | 1.84 | 102.05 | 3.44 |
| | 8-21-52 | large | 0.00 | 110.78 | 4.17 |
| | 8-21-53 | large | 0.00 | 109.53 | 3.18 |

Table 6. Blood sodium levels after 24 h exposure to sea water for three size groups of chinook smolts in each of four releases from Quinsam Hatchery in 1982.

| Date released | Date tested | Size group | Observations after challenge | | | | | | | | |
|----------------------------------|-------------|------------|------------------------------|-------------------------------|------|-------------------------|------|---------------|------|------------------|------|
| | | | N | Length ($\frac{cm}{mm}$) | | Blood Sodium (meq/L) | | Weight (g) | | Condition factor | |
| | | | | \bar{x} | S.E. | \bar{x} | S.E. | \bar{x} | S.E. | \bar{x} | S.E. |
| May 5 | May 6 | Small | 8 | 5.89 | .07 | 176.6 | 3.7 | 1.80 | .09 | .87 | .02 |
| | | Medium | 11 | 6.54 | .08 | 163.9 | 0.9 | 2.52 | .02 | .90 | .02 |
| | | Large | 15 | 7.23 | .08 | 163.5 | 1.6 | 3.54 | .14 | .93 | .02 |
| | | ALL | 36 | 6.69 | .10 | 166.3 | 1.4 | 2.80 | .13 | .91 | .01 |
| May 26 | May 29 | Small | 9 | 8.03 | .22 | 174.4 | 2.3 | 4.71 | .33 | .91 | .01 |
| | | Medium | 11 | 8.59 | .08 | 175.8 | 2.2 | 5.74 | .23 | .90 | .01 |
| | | Large | 11 | 9.04 | .15 | 172.8 | 1.7 | 7.22 | .38 | .96 | .01 |
| | | ALL | 32 | 8.58 | .11 | 174.2 | 1.1 | 5.95 | .25 | .92 | .01 |
| June 18 ¹⁶ | June 7 | Small | 6 | 8.78 | .11 | 173.6 | 2.5 | 6.35 | .29 | .94 | .02 |
| | | Medium | 20 | 9.43 | .04 | 177.6 | 2.2 | 7.74 | .11 | .92 | .01 |
| | | Large | 10 | 9.95 | .06 | 183.4 | 5.3 | 9.23 | .27 | .94 | .02 |
| | | ALL | 36 | 9.47 | .07 | 178.5 | 2.0 | 7.92 | .19 | .93 | .01 |
| June 18 ¹⁶ | June 18 | Small | 13 | 9.04 | .11 | 165.7 | 1.2 | 7.05 | .25 | .95 | .01 |
| | | Medium | 8 | 9.94 | .13 | 166.1 | 1.7 | 9.56 | .50 | .97 | .02 |
| | | Large | 13 | 10.15 | .06 | 167.6 | 3.4 | 10.10 | .33 | .96 | .02 |
| | | ALL | 36 | 9.65 | .10 | 167.0 | 1.4 | 8.79 | .30 | .96 | .01 |
| July 7 | June 29 | Small | 7 | 9.30 | .28 | 164.0 | 2.1 | 7.70 | .71 | .94 | .01 |
| | | Medium | 6 | 10.37 | .08 | 163.9 | 1.6 | 10.68 | .33 | .96 | .01 |
| | | Large | 17 | 10.99 | .10 | 162.1 | 0.8 | 12.99 | .42 | .98 | .01 |
| | | ALL | 36 | 10.42 | .14 | 162.9 | 0.6 | 11.07 | .48 | .97 | .01 |
| July 7 | July 8 | Small | 15 | 9.74 | .14 | 161.5 | 0.7 | 9.03 | .38 | .97 | .01 |
| | | Medium | 11 | 10.92 | .09 | 162.7 | 0.7 | 13.00 | .47 | 1.00 | .02 |
| | | Large | 9 | 11.29 | .09 | 164.7 | 1.1 | 15.10 | .46 | 1.04 | .01 |
| | | ALL | 36 | 10.53 | .13 | 162.7 | 0.5 | 11.84 | .50 | 1.00 | .01 |

Notes: No mortality resulted from seawater exposure.
 Size groups determined by coded wire tag reading.
 Samples taken from release pond 3-5 days before release.
 Weight and condition factor may have been affected by dehydration.