A Time and Size at Release Study on Chum Salmon. Details of Releases from Conuma Hatchery in the Spring of 1985

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A TIME AND SIZE AT RELEASE STUDY ON CHUM SALMON. DETAILS OF RELEASES FROM CONUMA HATCHERY IN THE SPRING OF 1985

by

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ABSTRACT

Morley, R. B., and D. Brouwer. 1986. A time and size at release study on chum salmon. Details of releases from Conuma Hatchery in the spring of 1985. Can. MS Rep. Fish. Aquat. Sci. 1901: 20 p.

A study is currently in progress at Conuma River hatchery, west coast of Vancouver Island, B.C., to measure the effects of time and size at release of juvenile chum salmon on their subsequent survival, growth, distribution, and age at maturity. In the spring of 1985 four releases (March 25, April 16, May 6, and May 27) of juveniles were made from the hatchery, the first consisting of two size categories, each of the remainder of three. An estimated total of 362,216 marked, validly tagged fry were released. Samples were obtained just prior to each release to provide information on long term tag retention, lengths and weights, sex ratios, health, and ability to adapt to seawater. This report provides a detailed description of the study and results of sampling up to and including release; final results are dependent upon recovery of adults.

Key words: Conuma, chum, release size, release time, tag retention

RESUME

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Une étude en cours à la piscifacture de la rivière Conuma située sur la côte ouest de l'Île Vancouver (C.-B.) vise la quantification des incidences du moment et de la taille au lâcher de saumons kétas juvéniles sur la survie, la croissance, la répartition et l'âge à maturité. Au printemps 1985, (25 mars, 16 avril, 6 et 27 mai) on a effectué quatre lâchers dont le premier était composé de juvéniles de deux classes de longueur et les autres, de trois classes. Ces lâchers ont totalisé environ 362 216 alevins marqués et étiquetés. Avant chaque lâcher, on a prélevé des échantillons pour obtenir des données sur la rétention des étiquettes à long terme, la longueur, le poids, la proportion des sexes, l'état de santé et la capacité d'adaptation aux eaux salées. Le présent rapport fournit une description détaillée de l'étude et les résultats de l'échantillonnage jusqu'au lâcher inclus. Les résutats finals dépendent de la récupération d'adultes.

Mots-clés: Conuma, kéta, taille au lâcher, moment du lâcher, rétention d'étiquette

INTRODUCTION

A study was begun in 1984 at Conuma hatchery (west coast Vancouver Island, B.C.) to examine the effects of time and size at release of juvenile chum on their subsequent survival, growth, and age at maturity. Conuma was selected as a desirable location for such a study on the bases of three criteria - availability of sufficient small rearing units to handle experimental groups of fish, good potential for adult recovery, and availability of both surface and well (ground) water. The latter was required to allow regulation of growth through temperature control, in order to achieve size differences in the fry. This report summarizes details of the study up to and including release.

MATERIALS AND METHODS

EXPERIMENTAL DESIGN

The initial design was for four releases of coded wire tagged fry, the first release to be made on March 25, 1985 with subsequent releases at 3-week intervals, i.e. April 15, May 6, and May 27. These release dates were selected to encompass normal dates for release of hatchery produced Conuma chum fry, which are normally released over the period early April to mid-May. Peak wild fry migration is about mid to late April. Each release was to consist of fry of three distinct sizes, each tagged in three replicates of 15,000 to give a total release of 540,000 fry (4 dates x 3 sizes x 3 replicates x 15,000).

In practice it was not possible to conform entirely to this design. Size differences did not develop as rapidly as planned and consequently only two sizes of fry were used in the first release. Other changes were a reduction in numbers of medium sized fry in the fourth release and delay of the second release by 1 day.

PARENT STOCK AND REARING

The required eggs were collected from Conuma River stock in a single egg-take on October 2, 1984. Females were obtained by seineboat in the estuary while males were obtained by beach-seine in the river (standard hatchery procedure). An estimate of the age composition of the parent stock was obtained from scale samples taken from fish used in the egg take.[1] A total of 720,000 eggs was collected.

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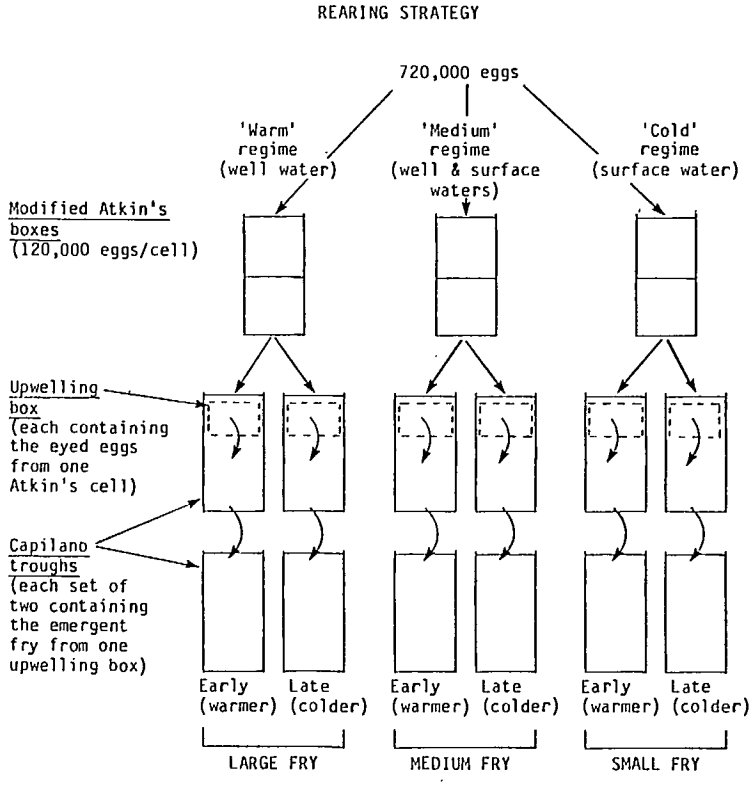
[1]This information was provided by T. Beacham and W. Barner of the Pacific Biological Station, who collected and analyzed the scales as part of a separate study.

In order to obtain fry of various sizes, temperature differences between well and surface (Leagh Ck) water were used to establish various temperature regimes, with corresponding differences in developmental rate. At the time of egg collection the surface water temperature was about 10°C and beginning to decline. Well water temperature was 8.2°C at this time and fluctuated very little throughout the study, ranging from 7.8 to 8.2. Surface water temperature reached a low of 1.6°C on December 31 and had warmed to 8.5°C by the time of the last release on May 27. Eggs and fry were incubated and reared within these extremes, mixing or alternating water sources to control rate of development. During the final stages of rearing some adjustments to growth were made using ration restriction but this technique was used to a very limited degree. The rearing strategy as planned is shown schematically below.



Initial incubation was in modified Atkin's boxes with the eggs distributed evenly among 6 cells (120,000/cell). Three temperature regimes were set up, each containing two cells - a "cold" regime (mainly surface water) to provide small fry, a "warm" regime (mainly well water) to provide large fry, and a "medium" regime (using both surface and well water) to provide medium sized fry. Eggs were picked at the eyed stage and shortly before hatch the eggs from each Atkin's cell were transferred to one of six aluminum upwelling boxes with 1" plastic intalox saddles[2] as a substrate.

[2]Norton Co.; Akron, Ohio, U.S.A.

Each of these boxes was positioned at the inlet end of a separate set of Capilano troughs, each set consisting of two troughs arranged in series. Fry emerged directly into the first trough of each set and were distributed evenly between the two troughs in the set for rearing. In some groups of larger fry it was later necessary to further divide the fish using additional troughs to avoid overcrowding as fish grew.

Once in the upwelling boxes, additional temperature regimes were established and maintained throughout emergence and rearing. Within the warm regime (large category fish, now contained in two sets of troughs) two sub-regimes of warmer or colder water were established, one set of troughs on each. The same was done for the cold (small fish) regime and medium (medium fish) regime. The purpose of this was to divide fry of each size category into 'early' and 'late' groups to be used for the first two and last two releases respectively. This was done to help alleivate the problem of fish in later releases being so large as to preclude comparison with those of earlier releases. The rearing strategy outlined above was in general adhered to; however, some alterations to it were required and are discussed in the results section.

Fry were fed Oregon moist pellet (OMP), the standard hatchery diet. Feeding was initiated on #2 semi-moist, which has more plankton and a lower moisture content than regular OMP; it is a floating diet and therefore remains available to the fish for a long period. Regular OMP was gradually incorporated into the diet and completely replaced the #2 semi-moist when fish reached about 0.6 g. Feeding was done by hand six times a day, generally at chart rates plus 20 percent (approximate).

TAGGING

Fry tagging began Feb. 19 on the largest fry available, which by this time had been feeding for about 2 weeks. Fish were anaesthetized with 2-phenoxyethanol, the adipose fin removed, and a full length coded wire tag (CWT) applied. Three and occasionally four tagging machines were used with two crew members per machine, one clipping adipose fins, the other applying tags. Normally only one group of fry was handled at any one time, each machine applying one of the three replicate tag-codes for that group. Tagging continued over most of the period of the releases, the last fry being tagged 11 days before the final May 27 release. Marking and tagging of hatchery production fish was interspersed with that of time and size study fry.

The length of time between completion of tagging and release varied for the different groups. Since this could conceivably influence fitness at release, the order of tagging for the various size categories was varied between releases to avoid consistent bias. This was not always feasible, however, since tagging order was determined somewhat by time of emergence and fry size (tagging of very small fry was avoided as much as possible).

TAG LOSS ESTIMATES

Live samples of tagged fry of each size category were taken at the time of each release and retained in small tanks of freshwater. These retained groups were checked approximately weekly for tag loss, which was considered complete (stability achieved) when no further loss was observed for a 2 week period. Final tag loss estimates obtained from these retained samples were used to adjust release figures, on the assumption that the losses observed in the samples were representative of what occurred in the released fry. For the first two releases a single sample of 200 fry was taken from each size category, for the third and fourth releases two replicate samples of 200 each were taken.

FRY RELEASES

Experimental groups were reared using varying combinations of well and surface water, raising the possibility of imprinting differences which might influence rates of return. To circumvent this all groups were switched to full surface water 3 to 4 days before release, if not already on it. Feeding was discontinued for approximately 24 hr before release to reduce stress during handling. For the first, third, and fourth releases approximately 80,000 to 100,000 untagged chum fry were released in conjunction with the tagged experimental groups to serve as buffers against predation. These were mainly production fry but included some surplus experimental fry. This was not done for the second release because of chum fry lingering in the release channel from a production release of approximately 1 million made two nights previous; it was roughly estimated that 100,000 fry still remained in the channel and would serve as a buffer group. This abundance of production fry was the reason for postponement of the second release by one day (to April 16), their numbers having been so high on the 15th it was felt they might unduly bias the experiment.

Releases were made over a 2 to 3 hr period beginning at late dusk. Fry were dipnetted from the Capilano rearing troughs into an 1100 L truck-mounted fiberglass tank and immediately transported approximately 200 m to the lower end of the hatchery release channel, just above its confluence with Conuma River. They were then discharged directly into the channel through the tank outlet. Numerous trips were required, depending on the numbers and size of the fry being released.

SAMPLES

On the day of each release samples of 300 tagged fry of each size category were taken from the fry to be released that night. These were frozen and retained for later determination of length, weight, and presence or

absence of a tag. Further samples of 36-50 live tagged fry of each size were taken and tested by J. Blackburn and C. Clarke of the Pacific Biological Station for their ability to adapt to seawater, as measured by blood sodium levels after 24 hr exposure to seawater (Clarke and Blackburn 1977). Five days before each release 40-50 tagged fry of each size were killed and their state of health determined by the Diagnostic Services Unit of the Pacific Biological Station.

As previously mentioned, 200 to 400 live tagged fry of each size category were retained at the time of each release and monitored for continued tag loss. These were eventually killed and a sample of 80 tagged fish from each group examined histologically to determine sex ratios.

All tags present in the sampled fish were extracted and decoded and release figures adjusted accordingly.

RESULTS

AGE COMPOSITION OF PARENT STOCK

The estimated age composition of the parent stock is shown below, based on analysis of scales taken from a sample of 100 fish used in the egg take. This information was provided by T. Beacham and W. Barner of the Pacific Biological Station, who collected and analysed the scales as part of a separate study.

	Total age (years)				
Sex	3	4	5	6	Number of fish
Male	26	25	0	0	51
Female	24	23	1	1	49
Combined	50	48	1	1	100

REARING AND EXPERIMENTAL DESIGN

Fry intended for use as medium category fish for the first two releases were late in emerging and were not available for marking in sufficient time for use in the first release. This release therefore consisted of only small and large category fry. A major problem occurred in

the group of fry intended for use as small category fish for the last two releases. Fry of this group had a very high incidence of fin erosion (roughly estimated at 7-10%) and showed quite high mortality.[3] Because of their poor condition they were not used in the experiment.

The rearing strategy outlined in Materials and Methods was changed (by adjusting temperatures) to allow for the problems encountered during incubation and rearing as follows:

- the group intended for use as small fry for the first two releases was used as small fry for the last two releases instead.
- the group intended for use as medium fry for the last two releases was used as small fry for the first two releases.
- the group intended for use as medium fry for the first two releases was used as medium fry for the second and third releases; the surplus of this group was used as medium fry for the fourth release (with reduced numbers in each replicate).

TAG LOSSES OBSERVED IN RETAINED SAMPLES

Table 1 shows the tag losses observed in the samples of fry retained at the time of each release and monitored until losses had stabilized. Each sample represents a random mix of fry tagged with one of the three replicate tag codes for that release and size category. The losses observed in these samples were used to adjust release figures.

Fry in the retained groups were killed when losses had stabilized and the remaining tags extracted and read. Examination of the proportions of the three codes present in each of the groups at this time indicated possible differences in tag loss among replicates, which appeared to be associated with different markers.[4] This was not consistent among groups, however, and it was decided that the loss as observed in the mixed sample for each group was probably the best estimate for each of the three replicates within the group.

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[3]Fin erosion was observed in other groups as well, but at very much lower levels of occurrence, as indicated in the following report by Diagnostic Services. Suspected causes include "hot-spots" (areas of poor circulation) in the upwelling boxes and possibly periods of high flow, also while in the boxes.

[4]Initial representation of the three tag codes in each sample (i.e. at the time the sample was taken) could not be determined since this would have required killing the fish.

NUMBERS MARKED AND TAGGED, NUMBERS RELEASED, AND SIZE AT RELEASE

Table 2 shows the numbers of fry marked and tagged and the numbers released, both with and without adjustment for tag loss; release weights are also shown. Detailed observations on lengths, weights, and condition factors at time of release are given in Tables 3-6.

During processing of the length-weight samples taken at the time of each release, six fry bearing second release small tag code 08-23-23 were found in the sample of 311 taken from the trough containing first release small fry. Since marking for the second release began before the first release was made, it appears a few second release fry were placed in the wrong trough at some time, possibly during tag retention checks. These fry would have been released along with fry of the first release. The number involved was estimated from their representation in the sample and is given in Table 2. One other second release tag (code 08-23-22) was observed in the first release small sample, but since only one tag of this code was found its occurrence was discounted as a possible processing error.

SEX RATIOS OF RELEASED FRY

The numbers of males and females observed in samples of fry of each size category from each of the four releases are shown in Table 7. Also shown are results of a heterogeneity G-test (Sokal and Rohlf 1981) to examine both deviations from a 50:50 male to female ratio and differences in sex ratio between groups.

In summary, there was a highly significant predominance of males overall. While this could be statistically confirmed in only one individual group, it appears likely to have existed in all groups; larger samples would be required to confirm this. Differences in sex ratio between groups were not significant and the pooled estimate of 0.55 male is probably the best estimate for all groups.

HEALTH OF RELEASED FISH

This section was provided by the Diagnostic Services Section of the Pacific Biological Station and summarizes methods and results of health checks on fry just prior to release.

Summary of procedures employed

Random samples

1. Shortly before each release 40 fish were selected randomly from each size category.

2. Fish were checked externally and internally for gross signs of pathology and infectious disease.

3. Kidney tissue from each fish was streaked aseptically onto Tryptic Soy Agar (TSA) for the detection of bacterial pathogens.

4. Gram stained kidney tissue was examined for bacterial and parasitic agents.

5. Gram stains of gill smears were checked for bacteria.

6. Liver, gill, kidney, pancreas, and intestine tissues of 6 to 10 fish from each sample were collected for histological evaluation.

7. Hematocrit values were measured in fish large enough to yield a sufficient volume of blood.

Moribund samples

If available, moribund or fresh dead fish (to a maximum of 10) were sampled from each size category.

The sampling procedure was the same as for random fish, but omitting histological evaluation.

In random samples a very low incidence of infectious disease is often not detected. Examination of moribund and/or fresh dead fish may show the presence of bacterial pathogens more readily.

Samples collected

Release date		25/03/85	16/04/85	06/05/85	27/05/85
Date sampled		20/03/85	11/04/85	01/05/85	22/05/85
Case no.		85065	85086	85118	85152
Random samples					
(No. of fish)	Large	40	40	42	40
	Medium	n/a[a]	40	46	44
	Small	40	40	46	48
Moribund samples					
(No. of fish)	Large	10	n/a	7	10
	Medium	n/a	10	5	5
	Small	10	10	4	2

[a]Not available.

Results

Random samples

1. Hematocrit values (HCT). Averages and ranges are shown.

Size category	Release date			
	25/03/85	16/04/85	06/05/85	27/05/85
Large	n/a[a]	50.5 (24-63%)	48.5 (35-61%)	44.8 (35-54%)
Medium	n/a	n/a	46.7 (34-63%)	46.6 (25-55%)
Small	n/a	n/a	n/a	43.1 (21-54%)

[a]Not available. Except for the medium group of 25/03/85 this is due to fish being too small to yield sufficient blood.

2. Tissue examination. Liver, gill, kidney, pancreas and intestine.

All tissues were relatively normal with the exception of the gills, with some fish in every sample showing some indication of gill irritation (hypertrophy). Although sample sizes were small and gill tissue was missing in some cases, the results suggest most small and medium fish in the first and second releases probably had a slight degree of irritation, with the occasional small fish having acute or chronic irritation. Most small and medium fish of the third and fourth releases probably had a slight to moderate degree of irritation.

The gills of large category fish showed less evidence of irritation. The results indicate that approximately one half the fish of this size category in the first release had a slight degree of irritation, gill tissue was present in the tissue samples of only one large fish of the second release and also showed a slight irritation. Roughly 20% of the large fish of the third and fourth releases had a slight irritation.

3. Other observations (number observed with condition/sample size).

Size category	Release date			
	25/03/85	16/04/85	06/05/85	27/05/85
Large	Coagulated yolk (3/40)	Coagulated yolk (1/40)	No abnormalities found	Bacterial gill disease (4/40)
Medium	n/a	Coagulated yolk (2/40) Eroded fins (2/40)	Coagulated yolk (3/46)	Coagulated yolk (5/44) Bacterial gill disease (2/44)
Small	Coagulated yolk (14/40)	Coagulated yolk (7/40) Eroded fins (1/40)	Coagulated yolk (7/42)	Coagulated yolk (3/48) Bacterial gill disease (3/48)

Moribund samples (number observed with condition/sample size)[5]

Size category	Release date 25/03/85	16/04/85	06/05/85	27/05/85
Large	Coagulated yolk (1/10)	n/a	Coagulated yolk (1/7) bacterial gill disease (4/7)	empty stomach (9/10) bacterial gill disease (9/10) ext. myxo-bacterial lesions (4/10) (4)
Medium	n/a	fin erosion (4/10) (3) coagulated yolk (6/10) myxobacteria on gills (3/10)	coagulated yolk (1/5)	bacterial gill disease (3/6)
Small	Coagulated yolk (6/10) hyperplastic pectoral fins (7/10)	fin erosion (8/10) (2) coagulated yolk (8/10) myxobacteria on gills (3/10)	bacterial gill disease (2/4)	bacterial gill disease (2/2)

[5]A second value in parentheses indicates the condition resulted in loss of the tail. For the April 16 release this was attributed to fin erosion associated with coagulated yolk (see below). For the May 27 release it was attributed to bacterial infection of the adipose clip site.

Fish with missing tails, as observed in release samples.[6]

	Release date 25/03/85		16/04/85		06/05/85		27/05/85	
Size category	Missing tail	Sample size	Missing tail	Sample size	Missing tail	Sample size	Missing tail	Sample size
Large	4	280	0	314	2	298	2	300
Medium	-	-	0	305	2	300	5	300
Small	11	319	7	300	7	300	9	300

[6]These observations were made during processing of the length-weight samples collected at the time of each release, and are distinct from the samples examined by the Diagnostics Services Section.

Conclusions

Coagulated yolk

This protein precipitation of the yolk is often associated with rough handling of the eggs or yolksac fry during a critical stage of their development. The coagulated yolk condition is often followed by fin erosion, particularly of the pectoral and tail fins. Fish fail to thrive and frequently develop bacterial gill disease.

The coagulated yolk condition probably accounted for most of the moribund and fresh dead fish examined from the four release groups.

Hematocrit values

Normal hematocrit values for salmonids range from 35-45%. Average values in these groups of fish are high in comparison to those limits. This is probably an artifact due to sampling procedures in these very small fish. Where values are missing, sample taking was not possible because the fish were too small. Some values of individual fish were below the normal range. In many cases the low hematocrit values were found in fish which had bacterial gill disease.

Infectious agents

No bacteria or parasites were found in the kidney (by Gram stain of kidney smear or on TSA). Myxobacteria and other bacteria causing bacterial gill disease were found on the gills where indicated on the tables.

Prognosis

Most of the health problems observed appear to have been associated with coagulated yolk. As stated earlier, fish with coagulated yolk in the body cavity fail to thrive, tend to be small, and often suffer from eroded fins and bacterial gill disease.

Fin erosion is a common problem in hatchery reared fish. Pectoral fin erosion is especially frequent but does not appear to reduce the survival chances. If other fins, such as the tail, are severely eroded swimming disability will make the fish less able to avoid predators. In cases where bacterial involvement of the fin erosion has progressed to a systemic infection survival changes are reduced, especially with myxobacterial infection. Myxobacterial infections resulting from infection of the adipose clip site would have the same effect and fish with definite external lesions could not be expected to survive. Fish with obvious bacterial gill disease are also not likely to survive.

Gill irritation would probably not significantly affect survival following release, but was most likely a factor in development of the bacterial gill disease observed in some groups.

SEAWATER CHALLENGE TESTS

This information was provided by C. Clarke and J. Blackburn of the Pacific Biological Station. Results of blood plasma sodium analysis on samples of fry subjected to 24 hr exposure to seawater are summarized in Table 8. Seawater adaptability was very high from late March til mid May, as indicated by the low sodium levels in the first three tests, but decreased somewhat at the beginning of June. There were no mortalities during the first three tests, but in the fourth test there was one mortality in each of the small and medium groups. The medium size group tended to have greater seawater adaptability than either the small or large release groups.

OTHER OBSERVATIONS AT THE TIME OF RELEASE

River levels were moderate and differed only slightly at the time of each release. Fry of the first release were slow to leave and substantial numbers remained in the release channel for several days following release. The majority of the fry of the middle two releases had left the release channel by morning of the day following release. Virtually all fry of the fourth release left on the night of release. Some indications of smolting were observed in large category fry of the third release. During completion of marking the week before release it was noted that many of these fry had completely lost their parr marks and some minor descaling was noted. Fry of this group were also exhibiting strange behaviour by the time of release, forming schools and showing a high level of activity.

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Table 1. Tag losses observed in samples of fry of each time-size category retained at time of release and checked approximately weekly for continued loss. (Tag loss was considered stable when no further loss was observed for a period of 2 weeks.)[a]

Release date	Size category	Period of tagging for group	Approx. wt. at time of tagging (g)	Replicate	Tag loss at time of release (%)	Days required for loss to stabilize (from completion of tagging)	Final tag loss at stability (%)
March 25	Small	Mar. 12-16	0.42	-	10.00	86	49.22
March 25	Large	Feb. 19-26	0.47	-	25.00	105	42.86
April 16	Small	Mar. 16-20	0.44	-	8.50	90	34.00
April 16	Medium	Mar. 25-28	0.48	-	23.00	132	53.03
April 16	Large	Mar. 4-7	0.85	-	19.00	62	22.11
May 6	Small	Apr. 17-24	0.47	1	2.50	75	14.72
				2	3.50	75	13.13
				Avg.	3.00	75	13.93
May 6	Medium	Apr. 13-17	0.78	1	12.50	42	20.00
				2	10.55	55	18.97
				Avg.	11.53	49	19.49
May 6	Large	Apr. 24-May 1	2.04	1	1.01	22	2.01
				2	0.50	6	0.50
				Avg.	0.76	14	1.26
May 27	Small	May 13-17	0.91	1	2.01	31	6.53
				2	3.52	32	6.09
				Avg.	2.77	32	6.31
May 27	Medium	May 10-13	1.83	1	2.51	15	2.51
				2	3.00	15	3.00
				Avg.	2.76	15	2.76
May 27	Large	Apr. 29-May 10	2.60	1	2.00	45	4.00
				2	2.50	32	3.00
				Avg.	2.25	39	3.50

[a]For the first two releases a single sample of 200 fry was taken from each size category, each composed of a random mixture of the three tag codes used for that size. For the last two releases two replicate samples of 200 were taken from each size category.

Table 2. Numbers of chum fry tagged and released at Coruma hatchery in 1985 for time and size at release study.

Release date	Size category	Tag code[a]	Mean wt. at release (g)[b]	Estimated tag loss at stability (%)[c]	No. of fry marked and tagged	No. of fry marked, tagged and released[d]	Est. no. of marked, validly tagged fry released[e]
March 25	Small	08-23-15	0.473	49.22	16,376	16,233	8,243
"	"	08-23-16	0.458	"	14,849	14,522	7,374
"	"	08-23-17	0.452	"	14,516	14,303	7,263
"	Large	08-23-18	1.280	42.86	15,539	15,303	8,744
"	"	08-23-19	1.332	"	16,233	16,036	9,163
"	"	08-23-20	1.326	"	15,478	15,282	8,732
April 16	Small	08-23-21	0.511	34.00	16,993	16,802	11,089
"	"	08-23-22	0.530	"	15,735	15,464	10,206
"	"	08-23-23*	0.513	"	15,752	15,468	10,209*
"	Medium	08-23-24	0.951	53.03	17,310	17,230	8,093
"	"	08-23-25	0.964	"	14,734	14,589	6,852
"	"	08-23-26	0.899	"	15,501	15,320	7,196
"	Large	08-23-27	2.139	22.11	15,705	15,559	12,119
"	"	08-23-28	2.287	"	15,783	15,663	12,200
"	"	08-23-29	2.313	"	15,913	15,788	12,297
May 6	Small	08-23-30	0.733	13.93	16,649	16,343	14,066
"	"	08-23-31	0.783	"	14,602	14,272	12,284
"	"	08-23-32	0.748	"	16,330	15,954	13,732
"	Medium	08-23-33	1.385	19.49	15,699	15,054	12,120
"	"	08-23-34	1.447	"	15,245	15,013	12,087
"	"	08-23-35	1.464	"	15,946	15,728	12,663
"	Large	08-23-36	2.242	1.26	15,969	15,776	15,577
"	"	08-23-37	2.267	"	16,361	16,165	15,961
"	"	08-23-38	2.244	"	15,591	15,446	15,251
May 27	Small	08-23-40	1.222	6.31	13,944	13,793	12,923
"	"	08-23-41	1.193	"	14,038	13,909	13,031
"	"	08-23-42	1.229	"	14,312	14,035	13,149
"	Medium	08-24-03	2.499	2.76	4,170	4,028	3,917
"	"	08-24-04	2.435	"	4,476	4,341	4,221
"	"	08-24-05	2.510	"	5,705	5,482	5,331
"	Large	08-23-46	3.642	3.50	15,976	15,814	15,261
"	"	08-23-47	3.606	"	16,214	16,028	15,467
"	"	08-23-48	3.552	"	16,184	15,953	15,395
Totals					483,828	476,696	362,216

[a]Agency - Data 1 - Data 2.

[b]Detailed length, weight, and condition factor statistics are given in Tables 3-6.

[c]From observations on samples retained at time of release and monitored for continued tag loss (see Table 1).

[d]Number marked and tagged minus mortalities and samples, without correction for tag loss.

[e]Number marked, tagged and released, adjusted for estimated tag loss at stability.

*An estimated 971 marked, validly tagged fry of this tag code were accidentally released on March 25 (95% confidence limits 359 and 1,752). The remaining 9,238 (i.e. 10,209-971) were released April 16.

Table 3. Lengths, weights, and condition factors for groups of chum fry released from Conuma hatchery on March 25, 1985; from samples taken on day of release.

Tag code[a]	Size category	$\bar{X}$	S.D.	n	95% Confidence limits	Median	Direction[b] of skewness	Coefficient of variation (%)
					a) Length (mm)			
08-23-15	Small	39.73	1.52	99	39.42-40.03	40.00	+	3.82
08-23-16	Small	39.39	1.40	95	39.10-39.67	39.00	-	3.56
08-23-17	Small	39.39	1.58	82	39.04-39.74	39.00	+	4.00
08-23-18	Large	52.87	3.65	70	52.00-53.74	53.00	+	6.90
08-23-19	Large	53.09	4.06	67	52.10-54.08	53.00	-	7.64
08-23-20	Large	53.42	3.03	98	52.81-54.03	53.00	+	5.67
					b) Weight (g)			
08-23-15	Small	0.473	0.073	99	0.458-0.487	0.470	+	15.51
08-23-16	Small	0.458	0.076	95	0.442-0.473	0.450	+	16.60
08-23-17	Small	0.452	0.061	82	0.439-0.466	0.450	+	13.40
08-23-18	Large	1.280	0.256	70	1.219-1.341	1.255	+*	19.99
08-23-19	Large	1.332	0.301	67	1.258-1.405	1.300	+	22.64
08-23-20	Large	1.326	0.217	98	1.282-1.369	1.300	+	16.39
					c) Condition Factor[c]			
08-23-15	Small	0.749	0.072	99	0.735-0.764	0.750	+	9.63
08-23-16	Small	0.746	0.090	95	0.728-0.764	0.750	+	12.04
08-23-17	Small	0.738	0.067	82	0.723-0.753	0.735	+	9.08
08-23-18	Large	0.859	0.074	70	0.841-0.876	0.855	+	8.58
08-23-19	Large	0.877	0.072	67	0.860-0.895	0.880	-	8.23
08-23-20	Large	0.865	0.06	98	0.851-0.879	0.870	+	8.03

[a]Numbers indicate agency, data 1, and data 2 respectively.

[b]+ = skewed right; - = skewed left. *,**,*** indicate significance at the 0.05, 0.01 and 0.001 levels, respectively.

[c]$C.F. = \frac{\text{Weight (g)}}{[\text{Length (mm)}]^3} \times 10^5$

Table 4. Lengths, weights, and condition factors for groups of chum fry released from Conuma hatchery on April 16, 1985; from samples taken on day of release.

Tag code[a]	Size category	$\bar{X}$	S.D.	n	95% Confidence limits	Median	Direction[b] of skewness	Coefficient of variation (%)
					a) Length (mm)			
08-23-21	Small	40.74	2.32	94	40.27-41.22	41.00	+	5.70
08-23-22	Small	41.24	2.37	84	40.72-41.75	41.00	+	5.75
08-23-23	Small	40.89	2.27	91	40.42-41.36	41.00	+	5.56
08-23-24	Medium	48.21	3.92	82	47.35-49.07	48.00	+**	8.13
08-23-25	Medium	48.88	3.50	72	48.05-49.70	48.50	+	7.17
08-23-26	Medium	47.54	4.03	87	46.68-48.40	48.00	+	8.48
08-23-27	Large	62.73	4.85	81	61.66-63.80	63.00	-*	7.72
08-23-28	Large	63.99	4.59	76	62.94-65.04	63.50	+	7.18
08-23-29	Large	64.41	3.86	92	63.61-65.21	64.00	-	5.99
					b) Weight (g)			
08-23-21	Small	0.511	0.118	94	0.487-0.536	0.500	+**	23.16
08-23-22	Small	0.530	0.112	84	0.505-0.554	0.520	+	21.12
08-23-23	Small	0.513	0.113	91	0.490-0.536	0.510	+	21.94
08-23-24	Medium	0.951	0.250	82	0.896-1.005	0.900	+***	26.27
08-23-25	Medium	0.964	0.205	72	0.916-1.012	0.935	+*	21.30
08-23-26	Medium	0.899	0.223	87	0.852-0.947	0.870	+*	24.75
08-23-27	Large	2.139	0.482	81	2.032-2.246	2.140	-	22.55
08-23-28	Large	2.287	0.488	76	2.176-2.399	2.220	+*	21.33
08-23-29	Large	2.313	0.404	92	2.229-2.396	2.315	-	17.46
					c) Condition Factor[c]			
08-23-21	Small	0.746	0.094	94	0.726-0.765	0.730	-	12.55
08-23-22	Small	0.747	0.086	84	0.728-0.765	0.755	-	11.54
08-23-23	Small	0.743	0.108	91	0.720-0.765	0.730	+	14.53
08-23-24	Medium	0.835	0.050	82	0.824-0.846	0.825	+	6.04
08-23-25	Medium	0.816	0.079	72	0.798-0.835	0.820	+	9.65
08-23-26	Medium	0.823	0.059	87	0.810-0.835	0.810	-	7.13
08-23-27	Large	0.853	0.061	81	0.839-0.866	0.860	-	7.13
08-23-28	Large	0.862	0.056	76	0.849-0.875	0.860	-	6.57
08-23-29	Large	0.857	0.061	92	0.845-0.870	0.860	+**	7.13

[a]Numbers indicate agency, data 1, and data 2, respectively.

[b]+ = skewed right; - = skewed left. *,**,*** indicate significance at the 0.05, 0.01 and 0.001 levels, respectively.

[c]$C.F. = \frac{\text{Weight (g)}}{[\text{Length (mm)}]^3} \times 10^5$

Table 5. Lengths, weights, and condition factors for groups of chum fry released from Conuma hatchery on May 6, 1985; from samples taken on day of release.

Tag code[a]	Size category	$\bar{X}$	S.D.	n	95% Confidence limits	Median	Direction[b] of skewness	Coefficient of variation (%)
					a) Length (mm)			
08-23-30	Small	44.52	2.60	99	44.00-45.03	44.00	-	5.85
08-23-31	Small	45.41	2.42	91	44.90-45.91	45.00	+	5.33
08-23-32	Small	44.73	3.16	93	44.08-45.38	44.00	+***	7.06
08-23-33	Medium	54.65	4.61	97	53.72-55.58	55.00	-	8.44
08-23-34	Medium	55.76	3.54	70	54.91-56.60	56.00	-	6.34
08-23-35	Medium	55.88	4.03	97	55.06-56.69	56.00	-	7.21
08-23-36	Large	63.84	4.13	97	63.00-64.67	64.00	-	6.47
08-23-37	Large	64.53	4.08	110	63.76-65.30	65.00	+	6.32
08-23-38	Large	63.95	3.98	80	63.06-64.84	64.00	-	6.22
					b) Weight (g)			
08-23-30	Small	0.733	0.138	99	0.706-0.761	0.740	-	18.86
08-23-31	Small	0.783	0.124	91	0.757-0.808	0.770	+	15.85
08-23-32	Small	0.748	0.181	93	0.711-0.785	0.730	+***	24.18
08-23-33	Medium	1.385	0.343	97	1.316-1.454	1.410	+	24.79
08-23-34	Medium	1.447	0.268	70	1.383-1.511	1.455	-	18.49
08-23-35	Medium	1.464	0.302	97	1.404-1.525	1.440	+	20.60
08-23-36	Large	2.242	0.438	97	2.154-2.330	2.280	-	19.52
08-23-37	Large	2.267	0.437	110	2.184-2.350	2.205	+*	19.30
08-23-38	Large	2.244	0.429	80	2.148-2.339	2.210	+	19.14
					c) Condition Factor[c]			
08-23-30	Small	0.823	0.072	99	0.808-0.837	0.820	-	8.77
08-23-31	Small	0.831	0.059	91	0.819-0.843	0.830	+	7.06
08-23-32	Small	0.823	0.055	93	0.812-0.835	0.830	-*	6.71
08-23-33	Medium	0.832	0.057	97	0.821-0.844	0.840	-	6.89
08-23-34	Medium	0.826	0.051	70	0.814-0.839	0.815	+	6.21
08-23-35	Medium	0.830	0.063	97	0.818-0.843	0.840	-	7.56
08-23-36	Large	0.851	0.060	97	0.839-0.864	0.840	+	7.09
08-23-37	Large	0.836	0.063	110	0.824-0.848	0.835	+	7.53
08-23-38	Large	0.849	0.060	80	0.836-0.863	0.840	-	7.07

[a]Numbers indicate agency, data 1, and data 2, respectively.

[b]+ = skewed right; - = skewed left. *,**,*** indicate significance at the 0.05, 0.01 and 0.001 levels, respectively.

[c]$C.F. = \frac{\text{Weight (g)}}{[\text{Length (mm)}]^3} \times 10^5$

Table 6. Lengths, weights, and condition factors for groups of chum fry released from Conuma hatchery on May 27, 1985; from samples taken on day of release.

Tag code[a]	Size category	$\bar{X}$	S.D.	n	95% Confidence limits	Median	Direction[b] of skewness	Coefficient of variation (%)
					a) Length (mm)			
08-23-40	Small	52.36	3.89	86	51.53-53.19	53.00	-*	7.43
08-23-41	Small	52.15	3.43	92	51.44-52.86	53.00	-**	6.58
08-23-42	Small	52.53	3.85	94	51.74-53.32	53.00	-	7.32
08-24-03	Medium	66.33	4.39	89	65.40-67.25	66.00	-*	6.62
08-24-04	Medium	65.58	4.65	91	64.61-66.55	65.00	+*	7.09
08-24-05	Medium	66.33	3.62	107	65.63-67.02	66.00	-	5.45
08-23-46	Large	74.36	4.50	105	73.49-75.23	74.00	-	6.05
08-23-47	Large	74.18	5.04	88	73.11-75.25	75.00	-**	6.79
08-23-48	Large	73.89	5.12	89	72.81-74.97	74.00	-	6.94
					b) Weight (g)			
08-23-40	Small	1.222	0.276	86	1.163-1.281	1.235	-	22.56
08-23-41	Small	1.193	0.244	92	1.142-1.243	1.210	-	20.46
08-23-42	Small	1.229	0.274	94	1.173-1.285	1.240	-	22.27
08-24-03	Medium	2.499	0.497	89	2.394-2.604	2.430	-	19.90
08-24-04	Medium	2.435	0.575	91	2.315-2.555	2.340	+*	23.62
08-24-05	Medium	2.510	0.443	107	2.425-2.595	2.520	+	17.63
08-23-46	Large	3.642	0.697	105	3.507-3.777	3.620	+	19.15
08-23-47	Large	3.606	0.749	88	3.447-3.764	3.660	-*	20.78
08-23-48	Large	3.552	0.771	89	3.390-3.714	3.580	-	21.70
					c) Condition Factor[c]			
08-23-40	Small	0.836	0.058	86	0.824-0.848	0.840	-	6.88
08-23-41	Small	0.829	0.058	92	0.817-0.841	0.830	+	7.01
08-23-42	Small	0.834	0.057	94	0.822-0.846	0.835	+	6.81
08-24-03	Medium	0.845	0.054	89	0.834-0.857	0.850	+	6.36
08-24-04	Medium	0.850	0.083	91	0.832-0.867	0.850	+***	9.81
08-24-05	Medium	0.852	0.054	107	0.841-0.862	0.860	-	6.38
08-23-46	Large	0.876	0.063	105	0.864-0.889	0.870	+*	7.16
08-23-47	Large	0.869	0.068	88	0.855-0.884	0.870	-**	7.87
08-23-48	Large	0.867	0.063	89	0.854-0.880	0.870	-	7.28

[a]Numbers indicate agency, data 1, and data 2 respectively.

[b]+ = skewed right; - = skewed left. *,**,*** indicate significance at the 0.05, 0.01 and 0.001 levels, respectively.

[c]$C.F. = \frac{\text{Weight (g)}}{[\text{Length (mm)}]^3} \times 10^5$

Table 7. Numbers of males and females and mean weights for samples of fry of each size category for each of the four releases. Tests on sex ratios using the heterogeneity G-test of Sokal and Rohlf are shown; see text for interpretation.[a]

Release date	Size category	Mean[b] weight (g)	No. of males	No. of females	Total	Proportion male	Test	df	G[c]	P
March 25	Small	3.01	57	26	83	0.687	Individual	1	11.864***	0.001
March 25	Large	4.85	40	36	76	0.526	Individual	1	0.211	0.646
April 16	Small	2.46	48	37	85	0.565	Individual	1	1.428	0.232
April 16	Medium	5.78	42	35	77	0.546	Individual	1	0.637	0.425
April 16	Large	5.04	48	33	81	0.593	Individual	1	2.794	0.095
May 6	Small	2.94	38	43	81	0.469	Individual	1	0.309	0.578
May 6	Medium	2.77	47	37	84	0.560	Individual	1	1.193	0.275
May 6	Large	3.59	47	42	89	0.528	Individual	1	0.281	0.596
May 27	Small	2.10	40	44	84	0.476	Individual	1	0.191	0.663
May 27	Medium	3.05	48	43	91	0.528	Individual	1	0.275	0.600
May 27	Large	4.75	45	31	76	0.592	Individual	1	2.594	0.107
							Total	11	21.775*	0.026
Sum			500	407	907	0.551	Pooled	1	9.553**	0.002
							Heterogeneity	10	12.223	0.270

[a]Samples were taken from retained groups (held to monitor tag loss) when tag losses had stabilized. Sex was determined by histological examination of the gonads.

[b]Weight of fry when sampled for sex ratio. Determined from a separate sample of 50 live fish taken on the same day and returned to the tank prior to taking the sex ratio sample.

[c]*,**,*** indicate significance at the 0.05, 0.01, and 0.001 levels, respectively.

Table 8. Blood plasma sodium levels after 24-hr exposure to sea water for each size category of chum fry in each of four releases from Conuma hatchery in 1985.

Date of release and sample collection	Date tested	Size category	Blood sodium			Other observations (after exposure)						
						Length (cm)			Weight (g)		Condition factor	
			n	$\bar{x}$	S.E.	n	$\bar{x}$	S.E.	$\bar{x}$	S.E.	$\bar{x}$	S.E.
March 25	March 29	Small	8	155.3	3.3	27	4.13	0.02	0.41	0.01	0.60	0.01
		Large	12	151.6	0.5	21	5.61	0.08	1.19	0.06	0.66	0.01
		Pooled	20	153.04	1.4	48	4.78	0.11	0.75	0.06	0.62	0.01
April 16	April 21	Small	8	155.9	4.4	34	4.47	0.04	0.55	0.02	0.61	0.01
		Medium	12	151.9	2.1	25	4.88	0.06	0.75	0.03	0.64	0.01
		Large	13	154.3	1.5	13	6.54	0.08	1.98	0.09	0.71	0.01
		Pooled	33	153.8	1.4	72	4.99	0.10	0.88	0.07	0.64	0.01
May 6	May 14	Small	12	157.5	1.2	24	4.83	0.06	0.72	0.03	0.63	0.01
		Medium	18	154.3	2.6	18	5.74	0.07	1.26	0.05	0.66	0.01
		Large	18	159.8	1.2	18	6.83	0.09	2.27	0.10	0.71	0.01
		Pooled	48	157.2	1.2	60	5.70	0.12	1.35	0.09	0.66	0.01
May 27	June 3	Small	24	162.7	2.7	26	5.57	0.08	1.25	0.05	0.71	0.01
		Medium	23	159.4	1.6	26	7.04	0.12	2.64	0.13	0.74	0.01
		Large	24	166.8	4.5	26	7.86	0.12	3.59	0.16	0.73	0.01
		Pooled	71	163.0	1.8	78	6.82	0.12	2.49	0.13	0.73	0.01

Notes: In many cases individual fish were too small to provide sufficient blood for sodium analysis. In these instances pooled blood from several fish was used.

There were no mortalities during the first three tests. In the fourth test there was one mortality in each of the small and medium groups.