A Preliminary Report on Juvenile Chinook Production in the Cowichan River, 1995

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ABSTRACT

Nagtegaal, D. A., E. W. Carter and B. Riddell. 1996. A preliminary report on juvenile chinook production in the Cowichan River, 1995. Can. Manuscr. Rep. Fish. Aquat. Sci. 2360: 43 p.

In 1995, the Department of Fisheries and Oceans, Pacific Biological Station, conducted a study of juvenile chinook salmon (*Oncorhynchus tshawytscha*) productivity in the Cowichan River. This study has been conducted since 1991 and the key components of this ongoing project include: i) enumeration of juvenile outmigrants, ii) monitoring growth of hatchery and naturally-reared fry, iii) monitoring hatchery releases and interaction between hatchery and naturally-reared fry in the river. Rotary screw traps were used to estimate naturally-reared fry production. Bismarck Brown dyed hatchery juveniles were released above the trap and mark-recapture results were used to expand trap catches to estimate total production. Estimated production of naturally-reared juvenile chinook for 1994 brood year was 169,828. Total hatchery releases of chinook fry and smolts were approximately 1.6 million. The interaction between hatchery and naturally-reared juveniles was believed to be minimal since most of the hatchery fish moved out of the river in just a few days after release.

RÉSUMÉ

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En 1995, le ministère des Pêches et des Océans, Station biologique du Pacifique, a effectué une étude de la productivité du saumon quinnat juvénile (*Oncorhynchus tshawytscha*) dans la rivière Cowichan. Cette étude a lieu depuis 1991 et la campagne actuelle est principalement axée sur ce qui suit : 1) dénombrement des migrants juvéniles; 2) observation du taux de croissance des alevins issus d'écloserie et de ceux issus de frayères naturelles; 3) observation des spécimens d'écloserie mis en liberté et caractérisation de l'interaction entre des alevins issus d'écloserie et les alevins issus des frayères naturelles. Des pièges de comptage à vis sans fin ont été utilisés pour évaluer la productivité des alevins issus des frayères naturelles. Les juvéniles issus d'écloserie ont été marqués avec une teinture brune Bismarck et relâchés dans le milieu en amont des pièges de comptage; les taux de récupération des spécimens marqués ont servi à extrapoler les chiffres de capture enregistrés par les pièges de comptage afin d'obtenir une estimation du taux de recrutement total. Le taux de recrutement des quinnats issus des frayères naturelles pour l'année de reproduction de 1994 a été de 169 828. Le nombre total d'alevins et de smolts issus d'écloserie relâchés dans le milieu était d'environ 1,6 million. On croit qu'il y a eu très peu d'interaction entre les juvéniles issus d'écloserie et ceux issus des frayères naturelles du fait que la plupart des spécimens issus d'écloserie ont quitté la rivière en l'espace de quelques jours.

INTRODUCTION

Considerable interest has been focused on the chinook salmon (Oncorhynchus tshawytscha) stocks in the southern portion of the Strait of Georgia over the past several years due to the decline in these stocks and their importance to the local fisheries (Farlinger et. al. 1990). The Department of Fisheries and Oceans, Pacific Biological Station, initiated a study of chinook productivity to assess rebuilding strategies and to evaluate the effects of harvest management policies for these stocks. The objectives of this study included: i) quantitatively determining the optimum spawning requirement for chinook salmon in the Cowichan River (this involved investigations of the determinants of juvenile production, interactions between hatchery and wild chinook, and estimation of the spawning escapement and catch attributed to the hatchery and wild components of the total run), and ii) developing guidelines for establishing escapement targets for other B. C. chinook stocks (Nagtegaal et al., 1994a).

In the spring of 1991, the juvenile component of this study was implemented (Candy et al. 1995). The purpose of this project was to: i) examine the timing and abundance of juvenile chinook outmigrants, ii) monitor the growth of hatchery and naturally-reared juveniles, iii) monitor the hatchery releases and observe the interaction between hatchery and naturally-reared juveniles in the river and in the estuary. For the purposes of this study, we refer to hatchery fish as those that were spawned and reared in the hatchery environment regardless of parental origin, and naturally-reared fish as those that were spawned and reared in the river environment.

Hatchery production of chinook on the Cowichan River began in 1980 (Cross et al.,1991). Chinook fry releases have increased from 64,681 in 1980, to 1.6 million in 1995. Coded-wire tagged releases also began in 1980, and in 1995 approximately 13% of the total number of chinook released were tagged. Three main release strategies are employed by the hatchery. The early release, 3 g fry, are generally released in mid-April and have been placed either in the upper reaches of the river or just above the North and South forks in the lower river. The lake release, 5-6 g pre-smolts, are initially reared at the hatchery. They are then moved to lake net pens just above the weir at Cowichan Lake prior to being released into the upper reaches of the river just below the weir in late May. The late release, 5-6 g pre-smolts, are generally released in the upper reaches of the river during late May. Recently, smaller releases have occurred directly from the hatchery site and from net pens situated in Cowichan Bay.

The purpose of this report is to present the results of the juvenile component of the ongoing chinook productivity study conducted on the Cowichan River during the spring of 1995.

METHODS

STUDY AREA

The Cowichan River flows into Cowichan Bay on the east coast of Vancouver Island, British Columbia, approximately 40 km north of Victoria (Fig. 1). Skutz Falls, 18 km downstream from Cowichan Lake, presented a partial obstruction to salmon migration which was alleviated by fishways constructed in 1956. The Cowichan drainage area is 840 km^2 and carries a mean annual discharge of 55 m^3/sec (Inland Waters Directorate, 1977). Mean monthly discharges range from 117 m^3/sec in December to 8.3 m^3/sec in August. A low-level flow control dam at the outlet of Cowichan Lake, built in 1957, provides a minimum river discharge of 7 m^3/sec. A fishway in the dam permits fish passage to Cowichan Lake. The Cowichan River system supports chinook, coho and chum salmon populations (Neave 1949). Chinook salmon spawn in the main Cowichan River, principally upstream of Skutz Falls.

A Community Economic Development Program (CEDP) hatchery is situated alongside the Cowichan River approximately 3 km upstream from the Cowichan estuary. The hatchery is managed by the the Cowichan Tribes under the auspices of the Habitat and Enhancement Branch of the Dept. of Fisheries and Oceans. The facility began chinook production with adults from the 1979 brood year.

FISH CAPTURE

A rotary screw trap[1], 2.4 m in diameter, was used to trap salmonid juveniles migrating downstream to the estuary from Mar. 3 to June 6, 1995. The trap was situated approximately 5 km upstream of the estuary (Fig. 1). The trap was held in position by galvanized steel cables suspended across the river. For the first part of the study the trap was placed at the lower pumphouse site (7B), and when decreasing flows reduced the efficiency of the trap it was moved to the upper pumphouse site (7E). The trap was fished overnight from 1900 hours to 0700 hours on Monday, Wednesday and Friday evenings. On several occassions throughout the study period, trapping occurred for a 24 hour period to observe diel movement. In addition, when hatchery releases occurred, the trap was fished 24 hours a day for several days after the release in an attempt to closely monitor the movement of hatchery juveniles at the pumphouse site. When trapping occurred over a 24 hour period, the fish were collected after 12 hours either at 7 AM or 7 PM, to observe the differences in movement during the day and night.

All fish captured by the trap were enumerated by species and recorded by time period and capture date. Chinook juveniles were identified as being either hatchery or naturally-reared based on length and weight characteristics. The number of adipose-clipped hatchery fish were recorded and coho juveniles were recorded as either fry or one and two year old smolts. Water temperature, flow rate and weather conditions were also recorded for each sampling event.

ABUNDANCE ESTIMATES

Trap efficiency information was used to expand trap catch to the estimated total numbers of fish migrating past the trap site. Trap efficiency was estimated by marking 100-300 hatchery chinook juveniles using Bismarck Brown stain (Ward and VerHoeven 1963), releasing them approximately 500 m above the trap

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[1]Manufactured by E.G. Solutions, Corvallis, Oregon, USA

site, and recording the number of marked fish that were recaptured over the next 3-4 days. Mark-recapture efficiency tests were done on a weekly basis throughout the study. The proportion of marked fish recaptured was used to expand the unmarked catch and estimate the total number of fish.

Trap efficiency was estimated by:

$$E_{ij} = R_{ij} / M_{ij}$$

where:

E is the estimated trap efficiency at site i and sampling week j

R is the number of marked fish recaptured

M is the number of marked fish releases

Assumptions inherent in these efficiency tests were that i) marking did not affect short term survival after release, ii) all marked fish released above the trap site migrated downstream past the trap, iii) marked fish behaved the same as unmarked fish, and iv) all recaptured marked fish were counted.

The total number of fish was estimated by:

$$N_i = U_{ij} / E_{ij}$$

where:

N is the estimated number of fish

U is the catch of unmarked fish in the trap

Total fish numbers were estimated by summing the daily estimates generated by dividing the daily catch by the trap efficiency for that week. For those days the trap was not in operation, the number of fish that migrated past the trap site that day was assumed to be the mean of the number recorded for the previous and subsequent sampling days. The total abundance estimate was assumed to be the sum of the daily estimates for the duration of the study. Confidence limits were determined from the trap efficiency using the adjusted Petersen estimate (Ricker 1975). This is a minimum estimate of confidence limits since there is added uncertainty from using weekly trap efficiency estimates, interpolating for unsampled days, and extrapolating for unsampled parts of the day.

GROWTH

Observations on the growth of chinook juveniles was accomplished by simultaneously collecting samples on a weekly basis from both hatchery and naturally-reared fish. At the hatchery approximately 30 chinook juveniles were collected each week from each of the three main release strategies (early, late and lake pen). Fish were measured for overall length to the nearest mm and weight to the nearest one-hundredth of a gram. Random samples of 20-30 naturally-reared and hatchery chinook juveniles were measured for length and weight at the trap site for each sampling evening. A subsample of adipose-clipped chinook juveniles was collected and frozen for each sampling evening after a hatchery release and kept for coded-wire tag analysis to determine release group.

RESULTS

MIGRATION TIMING

At the pumphouse site, 1,762 naturally-reared and 20,696 hatchery chinook juveniles were captured in the rotary screw trap (Table 1). Downstream movement was observed from the beginning of March to the end of May (Fig. 2). Peak migration occurred in the beginning of April. Due to overlap in size it became more difficult to distinguish naturally-reared fish from hatchery fish near the end of May. However, we observed very few fish that were within the expected size range of the naturally-reared group and therefore we assumed all fish to be of hatchery origin after May 15. Water discharge was high in March and had declined dramatically by the middle of April while river temperature increased slowly over the duration of the sampling period.

The majority of chinook juveniles were caught at night (Table 2). The difference between night and day catches for both naturally-reared and hatchery fish was substantial; 95% of the naturally-reared and 98% of the hatchery fry were caught at night.

A total of 1,663,867 hatchery chinook was released into the Cowichan River of which 226,465 were coded-wire tagged (Table 3). The early release group (approx. 419,000) was released in the upper Cowichan R. on May 2; the late group (approx. 940,000) was released in the upper Cowichan R. on May 16; and the Lake pen group (102,000) was released from the lake pens above the Cowichan Lake weir on May 25. There was a substantial decrease in hatchery releases compared with previous years (Fig. 3).

ABUNDANCE ESTIMATES

Trap efficiency tests were conducted on a weekly basis for both the upper and lower trap site at the pumphouse location (Table 4). Efficiency at the lower site (mean: 2.97%) was significantly less ($P < .05$; chi-square) (Zar 1984) than at the upper site (mean: 10.15%). This was because the lower site was wide and shallow resulting in lower flow, while the water funnels through a much narrower deeper section of the river at the upper site. The trap was moved to the upper site on April 24 when water flow became too slow at the lower site for effective trapping. Trap efficiency was calculated weekly and there were significant differences between consecutive weeks ($P < 0.05$;chi-square test). Trap efficiency generally decreased as discharge and flow (measured at the trap) decreased (Fig. 4). Daily extrapolated abundance estimates are listed in Table 5 for both naturally-reared and hatchery juveniles. Based on these estimates the total number of naturally-reared chinook outmigrants was calculated to be 169,828 with 95% confidence limits of 153,643 and 184,382. The total number of hatchery juveniles was calculated to be 324,896 with confidence limits of 293,933 and 352,739. According to hatchery records, 1,459,800 hatchery chinook juveniles were released above the pumphouse site.

GROWTH

Mean daily length and weight of naturally-reared chinook was fairly constant from the beginning of March until the beginning of May (Figs 5 and 6). Mean length began at 40 mm and weight at approximately 0.5 g. By the end of the sampling period the mean length had increased to 65 mm and mean weight was 2.6 g.

Mean daily length and weight of hatchery chinook juveniles continued to increase from the first sampling period until these fish were released in the river (Table 3). Both mean length and mean weight of all hatchery release groups was substantially greater than for the naturally-reared fish at any given time. By the beginning of May, however, there was some overlap between the smallest hatchery fish and the largest naturally-reared fish (Fig 7).

DISCUSSION

The rotary auger trap performed well in capturing both naturally-reared and hatchery chinook juveniles. More effort was expended monitoring chinook migration than in previous years, both in terms of the number of days the trap was in operation as well as continuous trapping to monitor day and night movement. As a measure of the accuracy of estimating chinook juveniles based on trap efficiency expansions of daily trap catches, we compared our abundance estimates of the early hatchery release with known numbers released based on hatchery records. On May 2, 418,750 chinook fry (early release group) were released into the upper Cowichan River. Between May 3 and 31 we estimated 136,359 early release hatchery fry had passed the pumphouse site. This time frame should have encompassed the majority of the total outmigration of the early group since by the end of the May less than 50 hatchery fish from the early group were recorded each day, based on CWT recoveries at the pumphouse site. Based on this information, our abundance estimate of the early group was only 33% of the known numbers of fry that should have passed the trap site.

The greatest potential for any significant error in these estimates would be from the trap efficiency tests. No obvious problems were observed during these tests and all dyed fish used in the mark-recapture tests were in good condition at the time of release. If dyeing reduced fish health and as a result caused trap efficiency to be biased high, then abundance would be underestimated. If dyed fish that were released upstream were not properly distributed in the river when they moved past the trap site, this could also have caused the efficiency tests to incorrectly underestimate the true abundance. Roper and

Scarnecchia (1996) reported that under low flow conditions, larger hatchery fish could avoid being caught by a Rotary Screw trap more likely than smaller naturally-reared fish. When such trap efficiency data were the basis for expansion to total abundance, it was emphasized that the results could be misleading if trap efficiencies were not measured independently for hatchery and naturally-reared fish. We were convinced that neither of these problems occurred in this study because we maintained the trap in higher flow conditions, but were unable to confirm that.

Frith et. al. (1995) reported that using trap efficiency values to expand daily trap catch for coho and steelhead smolts overestimated outmigration by 24% to 96%. The loss of dyed fish to mortality or residualization (defined as remaining in freshwater rather than emigrating to the marine environment) was hypothesized to explain the overestimates of emigrant smolts, and trap catch efficiencies were adjusted using a correction factor to compensate for this. Since chinook do not residualize in the Cowichan system, only disease and predation remain as likely explanations for the underestimate of hatchery fish.

Substantial populations of trout exist in the upper Cowichan river (Rimmer, pers comm.) that could negatively impact juvenile chinook survival. During the snorkel survey conducted on May 31, 1995, by the Ministry of Environment to assess trout stocks, considerable numbers of dead hatchery chinook juveniles were observed. There were large numbers of dead chinook on the riverbed for several kilometres below the Road Pool area (see Fig. 1). According to hatchery records, fish from the Late Release group were released the previous week.

Wetherall (1970) has suggested that fry quality in conjunction with streamflow may be a key determinate factor for survival of downstream migrants. According to the study, highest survival rates were observed with larger fish and higher flows while the lowest survival occurred with fingerlings and stream flows less than 20 cu m/sec.

Regardless of the reason, we have consistently underestimated the number of hatchery juveniles (Candy et al. 1995a) during the four years of this study. Our estimates have ranged between 20% and 40% less than the known number of hatchery chinook released above the trap site.

EGG TO FRY SURVIVAL

Nagtegaal et. al (1995) reported that escapement of chinook in 1994 was estimated to be 4,936 of which 55% were females. According to hatchery broodstock records (Millerd, pers comm), average fecundity of chinook was calculated to be 3,484 per female. Based on these data, we estimated egg deposition to be a little less than 9.5 million. Lister et al. (1971) divided chinook migrants in the Cowichan system into an early group and a late group based on size. The early group, comprising the majority of migrants, consisted primarily of emergent fry. The late migrants, trapped during June, were defined as fingerlings averaging over 55 mm in length and referred to by Healey as '90-day smolts' (Healey 1991). Based on Lister's data approximately 16% of the population in the Cowichan River could be considered as 'late migrants' (Lister et al. 1971, Argue et al. 1979). Since we did not monitor this late group, our naturally-reared fry estimates were expanded by 16% to estimate the total fry production. Based on these data, egg to fry survival for the 1994 brood was estimated to be 1.79%.

Two contributing factors that may have affected survival were environmental conditions and spawner distribution. Discharge from January to March, 1995, was considerably higher than the 30 year average monthly discharge in the Cowichan River (Fig. 8). Spawner distribution was considered in terms of the proportion of spawners in the upper river section above Skutz Falls. Depending on the water levels in the fall, chinook will move into the upper or middle river sections to spawn (Nagtegaal et al., 1994b). It has been suggested that spawning success is poorer in the lower and middle river partially due to overriding chum spawning in this area. Mean discharge from November to February and the proportion of spawners in the upper river section were compared to fry survival (Fig. 9). Although there was an increase in fry survival in 1995, there has been a decreasing trend since the 1991 brood year (Fig. 9).

GROWTH

Since the mean size of naturally-reared outmigrant fry did not increase until May, followed by a considerable increase during May, we assumed that we were likely not monitoring growth.

During the early part of the migration we were likely trapping only juveniles that had emerged and moved downstream to the estuary. By May, fish caught in the trap were likely a combination of fry that immediately move downstream and those that remained in the river above the trap for some weeks prior to migrating downstream (Candy et al.,1995). Similar patterns were also observed in other studies (Taylor and Bradford 1993; Duff et al. 1992).

Hatchery juveniles generally grew faster and were considerably larger than naturally-reared fry at the time of the hatchery releases.

INTERACTION

Preliminary information indicated that the majority of hatchery juveniles released in the river moved to the estuary within the first few days after release (Fig. 10). These results compared favourably with previous results (Candy et al., 1995) and other studies (Taylor and Bradford 1993; Healey 1991). Seelbach (1985) concluded that since hatchery fish move out of the river to the estuary fairly quickly, interaction with naturally-reared juveniles was minimal. This also seemed to be the case in the Cowichan system. Interaction also seems to be limited in the river environment because the bulk of hatchery releases occurred when the majority of naturally-reared juveniles had already emigrated to the estuary.

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Table 1. Rotary screw trap catch data at the pumphouse site, Cowichan River, 1995.

Date	Site	Sampling Time		CNW	CNH	CNC	CM	COF	CO1	CO2
280295	7B	1930							3	
280295	7B	2200							3	
280295	7B	0000					1			
010395	7B	1900		18	0	0	16	4	21	0
020395	7B	0800		1	0	0	0	1	5	1
030395	7B	0800		0	1	1	7	5	8	1
030395	7B	1900		15	0	0	14	15	50	0
050395	7B	2000		21	0	0	45	7	42	2
060395	7B	1900		04			30	28	27	
060395	7B	0800		01			07	07	17	
070395	7B	1930		13			34	06	53	
080395	7B	1900		41	0	0	22	0	23	0
140395	7B	1700		22	0	0	74	0	0	0
150395	7B	1900		22			90	02	06	
160395	7B	0800		5			25	5		
170395	7B	1700		66	0	0	296	6	3	1
200395	7B	1800		20	0	0	88	2	1	0
210395	7B	1800		96			236	20	2	
210395	7B	1800			5					
230395	7B	0800		04	0	0	36	0	0	0
240395	7B	1800		24	0	0	46	1	7	1
280395	7B	1700		81	0	0	631	43	22	0
290395	7B	1800		89	0	0	753	56	22	0
290395	7B	1800		0	7	0	0	0	0	0
300395	7B	0800		4	0	0	25	1	1	0
310395	7B	1800		43	0	0	281	41	13	0
030495	7B	2000		52	0	0	1773	39	6	0
040495	7B	1800	1	00	0	0	3123	102	3	0
050495	7B	1800			7					
050495	7B	1800	1	11		0	3972	140	4	0
060495	7B	0900			2					
060495	7B	1800		2	7	0	0	0	0	0
060495	7B	0900		2		0	72	1	0	0
070495	7B	1800		84	0	0	5096	126	2	0
100495	7B	1730	1	86	0	0	4412	173	7	0
110495	7B	1800		43	0	0	2621	40	1	0
120495	7B	1730	1	12	2	0	4883	130	2	0
120495	7B	1730		1	2	0	0	0	0	0
130495	7B	0930		7	0	0	324	7	0	0
140495	7B	1730		10	0	0	2078	11	2	0
170495	7B	1730		66	0	0	5564	76	2	0
190495	7B				0	0				
190495	7B	1700		35	0	0	2862	128	1	0
200495	7B	0900		2	0	0	486	2		0
210495	7B	1800	1	02	0	0	3947	448	2	0
240495	7E	1600	1	08	0	0	8732	448	160	16
280495	7E	1830		24	0	0	7854	106	57	5
010595	7E	1700		11	0	0	5390	30	53	11
030595	7E	1830		26	2782			33	124	0
030595	7E	1830			4					

Table 1 (cont.)

Date	Site	Sampling Time	CNW	CNH	CNC	CM	COF	CO1	CO2
030595	7E	0830	0	16	4	155	1	1	0
040595	7E	0900	2	8	0	43	3	0	0
040595	7E	1800		1					
040595	7E	1800	33	1929		200	109	150	0
050595	7E	1900	28	683		920	132	154	0
050595	7E	0930	0	2	0	15	1	1	0
260495	7E	1900	28		0	9312	86	35	0
260495	7E	1900		11					
270495	7E	0830	7	0	0	3415	3	2	0
060595	7E	0900	0	2	0	37	1	0	0
080595	7E	1730	6	131		823	45	92	0
100595	7E	1700	10	194		453	31	137	0
100595	7E	1700		24					
110595	7E	0930	1	2		501	0	1	0
120595	7E	1630	11	177		113	14	118	0
150595	7E	2200	01	69	09	508	25	19	0
150595	7E	2000	0	62	07	48	0	15	0
150595	7E	0800	0	07	0	15	01	07	0
150595	7E	2400	0	108	17	49	7	36	0
160595	7E	0800		46	5	23	1	12	
160595	7E	2200	1	156	12	14	3	70	
160595	7E	2000		372	29	666	48	83	0
160595	7E	0200		6		14		1	
170595	7E	2000		2788	207	251	46	348	
180595	7E	2000		30					
180595	7E	0800		167	5	91	4	36	
180595	7E	2200		2885	142	227	181	274	0
180595	7E	2000		292	19	31	3	26	
190595	7E	0800		60	2	7	2	10	0
190595	7E	2000	19	1846	104	254	142	166	0
220595	7E	2000	0	1115	57	192	235	95	0
230595	7E	2000	9	1019	58	283	283	82	0
240595	7E	2000	60	839	60	206	347	63	0
240595	7E	2000		18					
250595	7E	2000	45	1403	30	203	319	29	0
260595	7E	2000	4	538	19	157	302	35	0
290595	7E	2030	20	714	22	196	401	3	
310595	7E	2000	7	278	7	95	134	2	

Codes:

Site: see Fig. 1
Sampling Time: universal time
CNW: naturally-reared chinook
CNH: hatchery chinook
CNC: adipose-clipped hatchery chinook
CM: chum fry
COF: coho fry
CO1: 1 yr. coho smolt
CO2: 2 yr. coho smolt

Table 2. Diel migration pattern observed for chinook fry, Cowichan River, 1995.

Date	Day		Night	
	Wild	Hatchery	Wild	Hatchery
Mar. 1	1		18	
3	0		15	
6	1		4	
15	5		22	
22	4		96	
29	4		89	
Apr. 6	2		111	
12	7		112	
19	2		35	
26	7		28	
May 3	0	16	26	2782
5	0	2	28	683
10	1	2	10	194
15		46		245
18		167		3177
19		60		1846
Total:	34	293	594	5752
Mean:	5%	2%	95%	98%

Table 3. Juvenile chinook release data for the Cowichan hatchery, 1995.

Release code[1]	Number released	Tag code	Release date	Length (mm) Mean	Length (mm) Min	Length (mm) Max	Weight (g) Mean	Weight (g) Min	Weight (g) Max
Early	418,750	18-14-37	May 2	72	60	80	4.0	3.2	6.3
Late	939,287	18-14-38	May 16	85	67	94	6.4	2.7	9.6
Lake Pen	101,763	18-14-39	May 25	87	67	89	6.5	2.9	8.5
Hatchery	100,252	18-14-36	May 30	78			5.4		
Seapen	103,815	18-13-29	May 31	84			6.1		

Total: 1,663,867

[1]Release sites:

Early - upper Cowichan R. (Road Pool)
Late - upper Cowichan R. (Road Pool)
Lake Pen - Lake pen site above Cowichan Lake weir
Hatchery - released directly from the hatchery
Seapen - released from seapens located in Cowichan Bay

Table 4. Trap efficiency data for the rotary screw trap, 1995.

Bismarck Brown Rotary Screw Trap Efficiency Tests				
Test Site	Date released	Number released	Number recovered	Efficiency
Lower site	March 22	176	5	2.8%
	March 29	169	7	4.1%
	April 4	334	11	3.3%
	April 12	189	3	1.6%
	April 19	200	0	-
	MEAN:			2.4%
Upper site	April 26	157	11	7.0%
	May 3	55	4	7.3%
	May 10	136	24	17.6%
	May 17	294	30	10.0%
	May 24	209	18	8.6%
	MEAN:			10.2%

Table 5. Daily trap catch data at the pumphouse site, Cowichan River, 1995.

Preliminary naturally-reared chinook fry migration estimates, 1995					
		Missing cells	24-hour	Extrapolated	Cumulative
Date	Observed	Interpolated[1]	Estimates[2]	Estimates[3]	Total
01-Mar	18		21	729	729
02-Mar		17	20	688	1417
03-Mar	15		17	607	2025
04-Mar		18	21	729	2754
05-Mar	21		24	850	3604
06-Mar	4		5	162	3766
07-Mar	13		15	526	4292
08-Mar	41		47	1660	5952
09-Mar		30	35	1215	7167
10-Mar		30	35	1215	8382
11-Mar		30	35	1215	9597
12-Mar		30	35	1215	10812
13-Mar		30	35	1215	12026
14-Mar	22		25	891	12917
15-Mar	22		25	891	13808
16-Mar		40	46	1620	15428
17-Mar	66		76	2673	18100
18-Mar		40	46	1620	19720
19-Mar		40	46	1620	21340
20-Mar	20		23	810	22149
21-Mar		70	81	2834	24984
22-Mar	96		110	3887	28871
23-Mar		40	46	1620	30491
24-Mar	24		28	972	31463
25-Mar		50	58	2025	33487
26-Mar		50	58	2025	35512
27-Mar		50	58	2025	37537
28-Mar	81		93	3280	40817
29-Mar	89		102	2472	43289
30-Mar		60	69	1667	44955
31-Mar	43		49	1194	46150
01-Apr		45	52	1250	47400
02-Apr		45	52	1250	48650
03-Apr	52		60	1444	50094
04-Apr	100		115	3495	53590
05-Apr	111		128	3880	57469

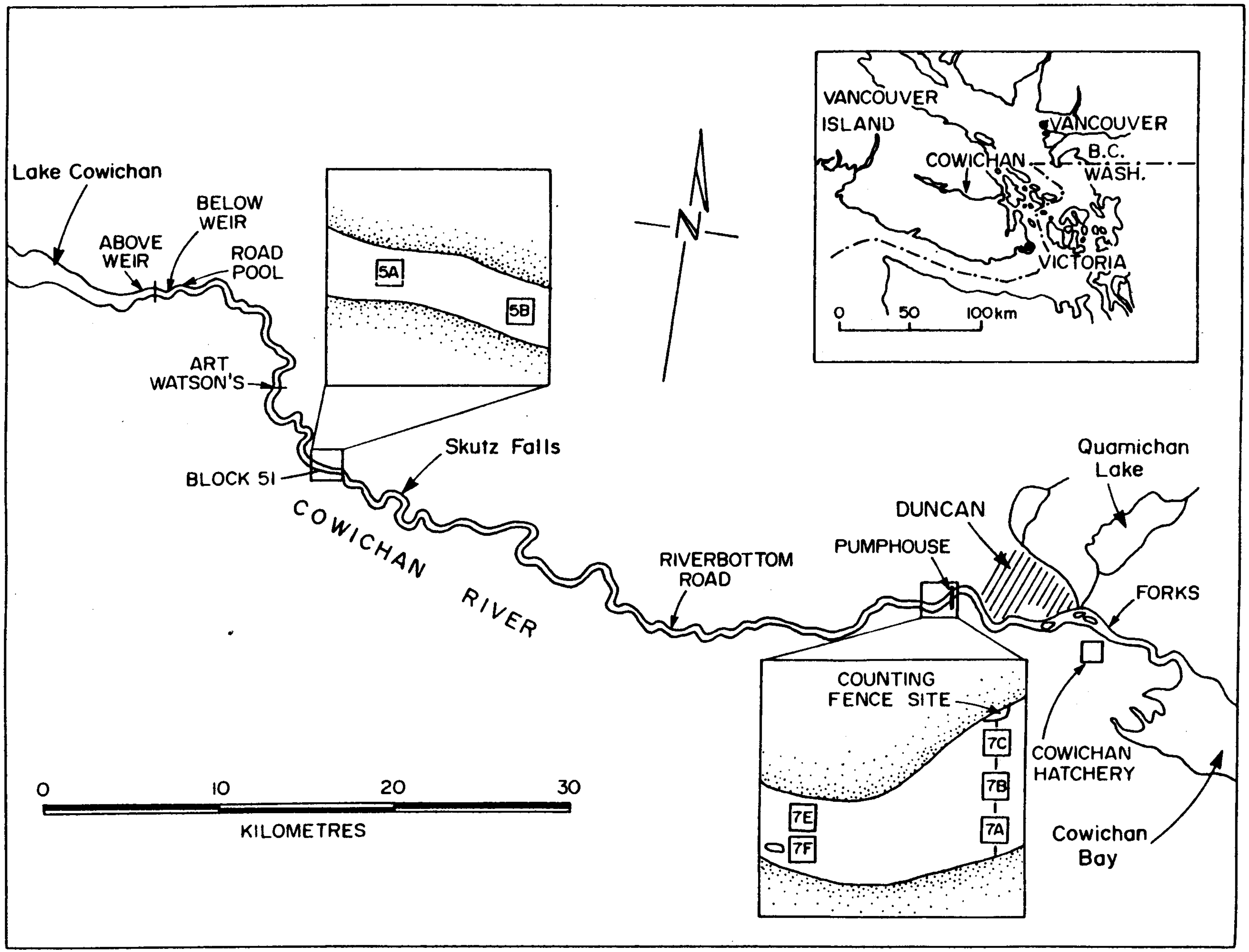
06-Apr		90	104	3146	60615
07-Apr	84		97	2936	63552
08-Apr		135	155	4719	68270
09-Apr		135	155	4719	72989
10-Apr	186		214	6501	79491
11-Apr	43		49	1503	80994
12-Apr	112		129	8101	89094
13-Apr		70	81	5063	94157
14-Apr	10		12	723	94880
15-Apr		60	69	4340	99220
16-Apr		60	69	4340	103560
17-Apr	66		76	4774	108333
18-Apr		40	46	2893	111226
19-Apr	35		40	4025	115251
20-Apr		80	92	9200	124451
21-Apr	102		117	11730	136181
22-Apr		100	115	11500	147681
23-Apr		100	115	11500	159181
24-Apr	108		124	1772	160953
25-Apr		50	58	820	161773
26-Apr	28		32	459	162233
27-Apr		26	30	427	162659
28-Apr	24		28	394	163053
29-Apr		18	21	295	163348
30-Apr		18	21	295	163643
01-May	11		13	180	163824
02-May		18	21	295	164119
03-May	26		30	411	164530
04-May	33		38	522	165052
05-May	28		32	443	165495
06-May		15	17	237	165733
07-May		10	12	158	165891
08-May	6		7	95	165986
09-May		12	14	190	166176
10-May	10		12	65	166241
11-May		10	12	65	166306
12-May	11		13	72	166378
13-May		6	7	39	166417
14-May	1		1	7	166423
TOTAL:	1762				166423

Preliminary hatchery chinook fry migration estimates, 1995					
		Missing cells	24-hour	Extrapolated	Cumulative
Date	Observed	Interpolated	Estimates	Estimates	Total
03-May	2798		3218	44259	44259
04-May	1937		2228	30640	74899
05-May	685		788	10836	85735
06-May	2		2	32	85767
07-May	131		151	2072	87839
08-May		160	184	2531	90370
09-May		160	184	2531	92901
10-May	194		223	1264	94164
11-May	2		2	13	94177
12-May		185	213	1205	95383
13-May	177		204	1153	96536
14-May		215	247	1401	97936
15-May	246		283	1603	99539
16-May	580		667	3779	103318
17-May	2788		3206	31430	134748
18-May	3344		3846	37698	172446
19-May	1906		2192	21487	193934
20-May		1500	1725	16910	210844
21-May		1500	1725	16910	227754
22-May	1115		1282	12570	240324
23-May	1019		1172	11488	251812
24-May	839		965	11206	263017
25-May	1403		1613	18739	281756
26-May	538		619	7186	288942
27-May		600	690	8014	296955
28-May		600	690	8014	304969
29-May	714		821	9536	314505
30-May		500	575	6678	321183
31-May	278		320	3713	324896
TOTAL:	20696				324896

[1] missing cells were interpolated as being the mean of the two adjacent sampling periods
[2] based on 12 hour sampling periods the data was expanded to 24 hr. estimates
[3] based on efficiency data trap catch was expanded to estimate abundance for total river for that day

FIGURES

Figure 1 - Map showing fry trap location for 1995 (counting fence site; 7A-7F). Previous years sampling site at Block 51 (site 5A and 5B).



Lake Cowichan
ABOVE WEIR
BELOW WEIR
ROAD POOL
ART WATSON'S
BLOCK 51
5A
5B
Skutz Falls
COWICHAN RIVER
RIVERBOTTOM ROAD
PUMPHOUSE
DUNCAN
Quamichan Lake
FORKS
COUNTING FENCE SITE
7C
7B
7A
7E
7F
COWICHAN HATCHERY
Cowichan Bay
VANCOUVER ISLAND
VANCOUVER
B.C.
WASH.
COWICHAN
VICTORIA
0
50
100km
0
10
20
30
KILOMETRES

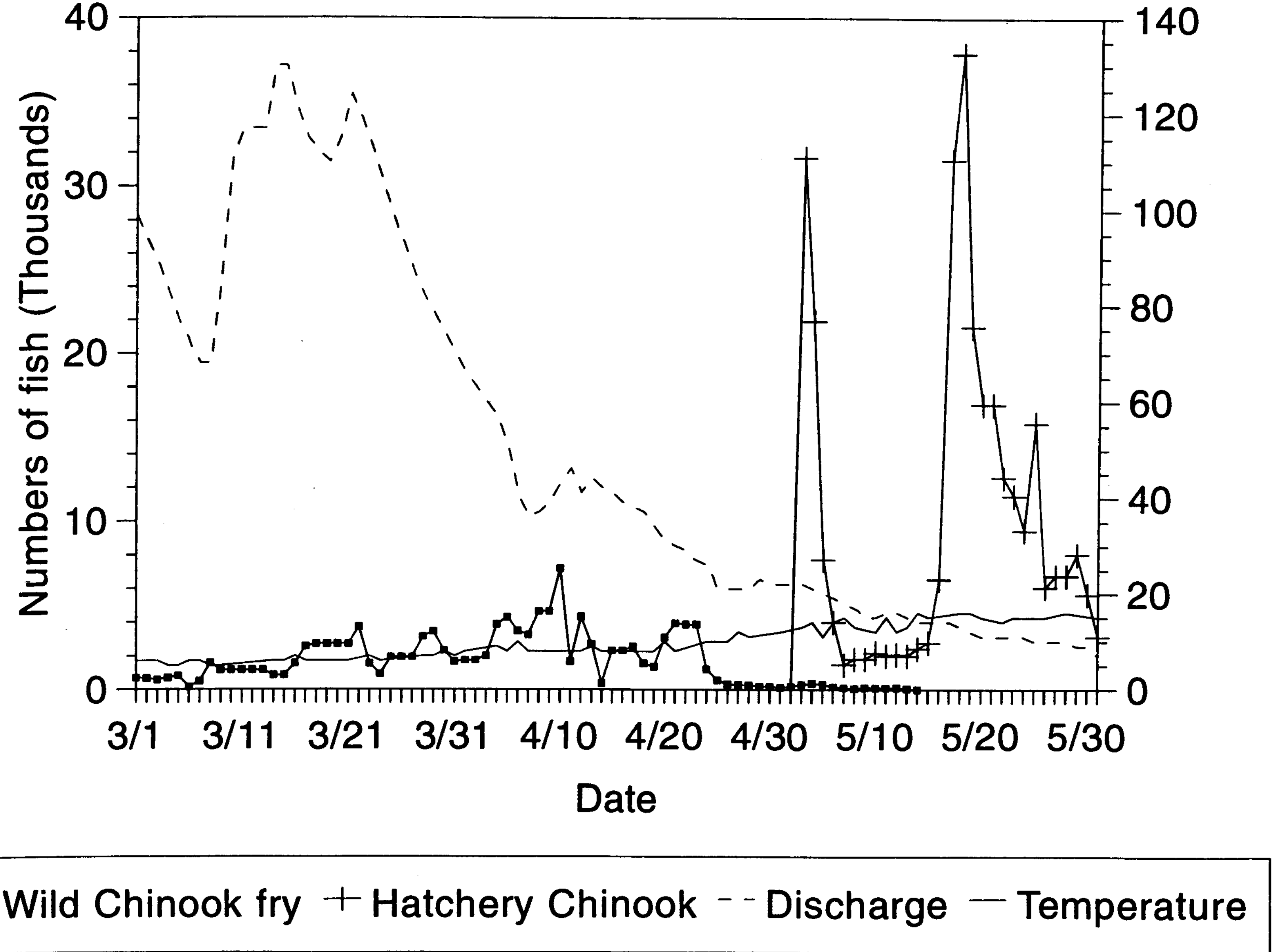


Fig. 2. Expanded estimate of chinook fry migration by day at the pumphouse site, 1995.

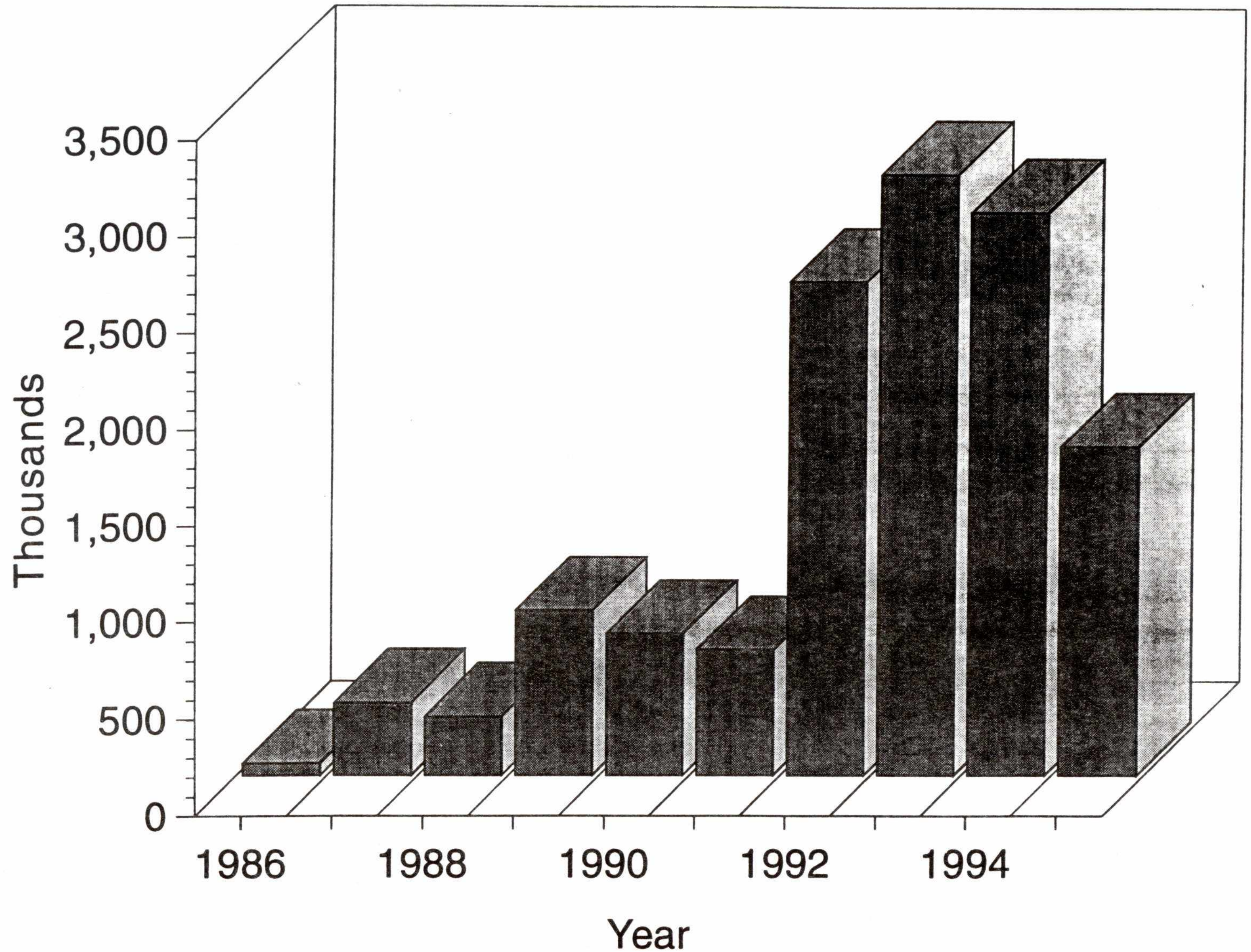
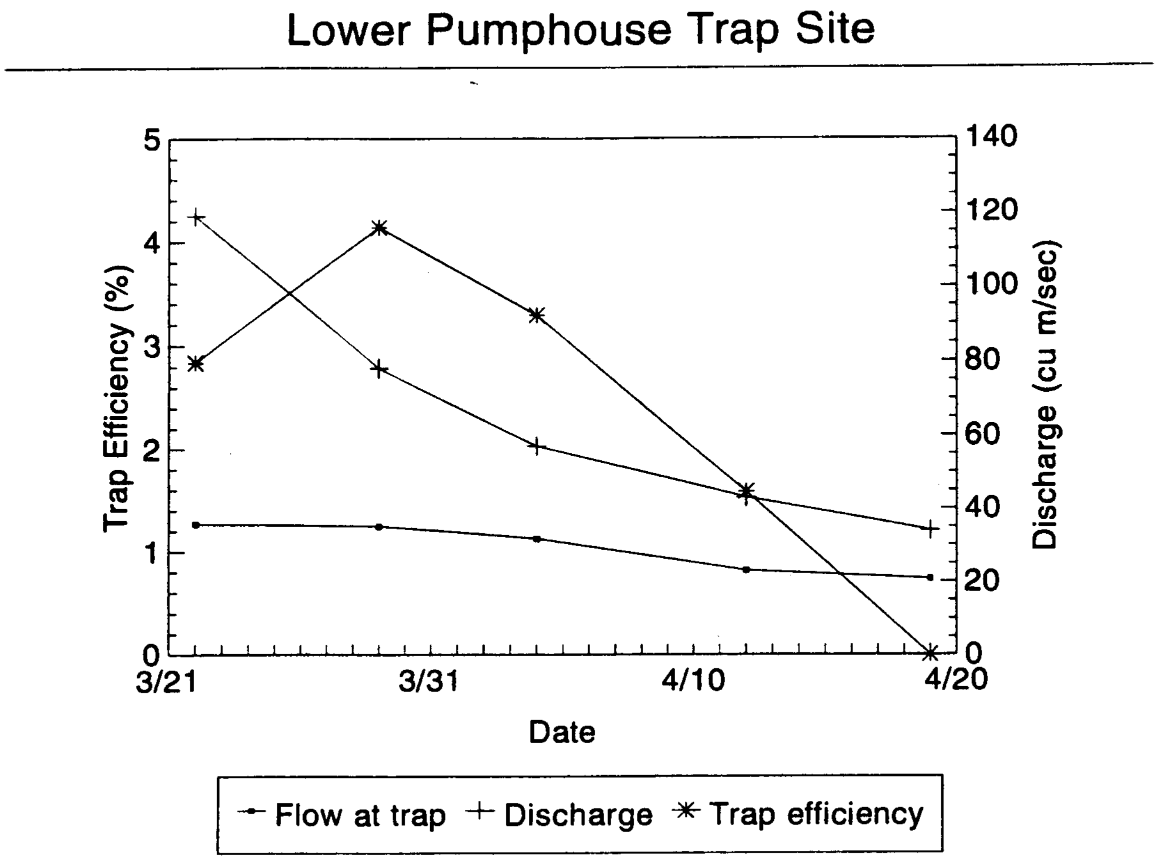


Fig. 3. Hatchery chinook released into the Cowichan system as fry (3 gm) and as pre-smolts (6 gm).



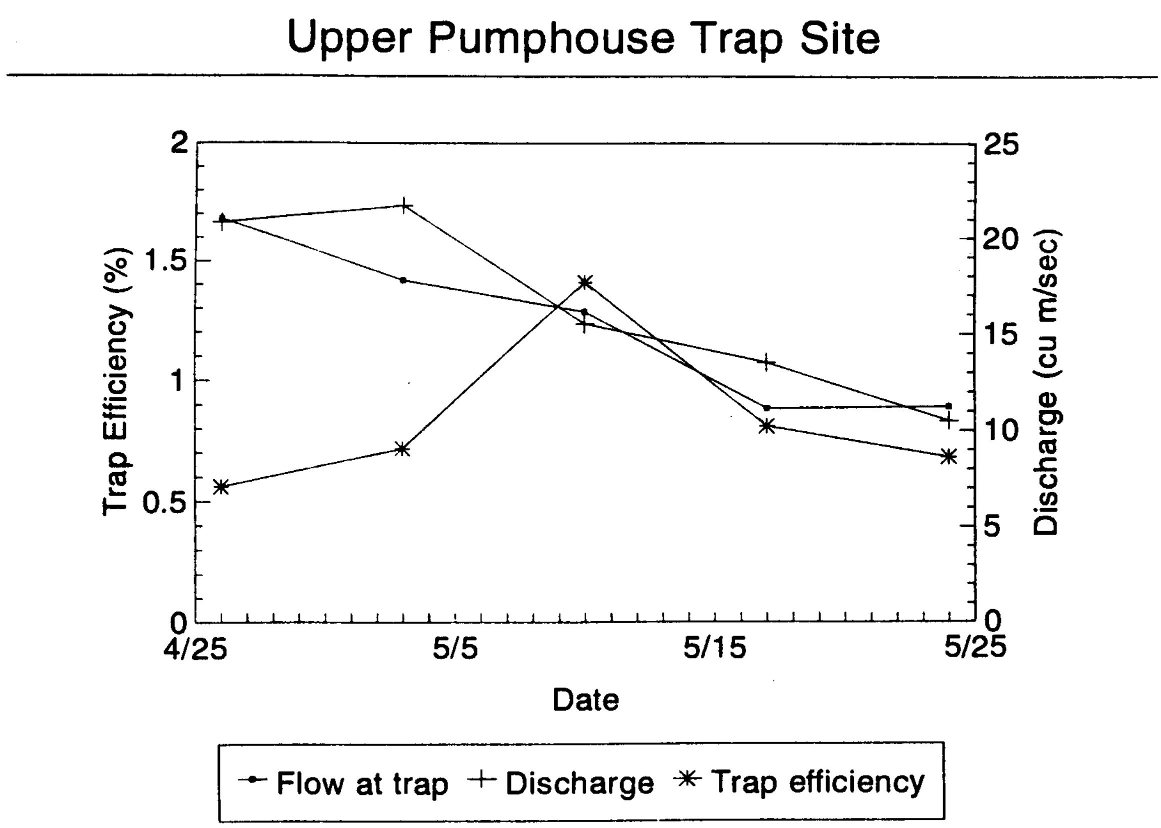


Fig. 4. Trap efficiency comparison between upper and lower sampling sites.

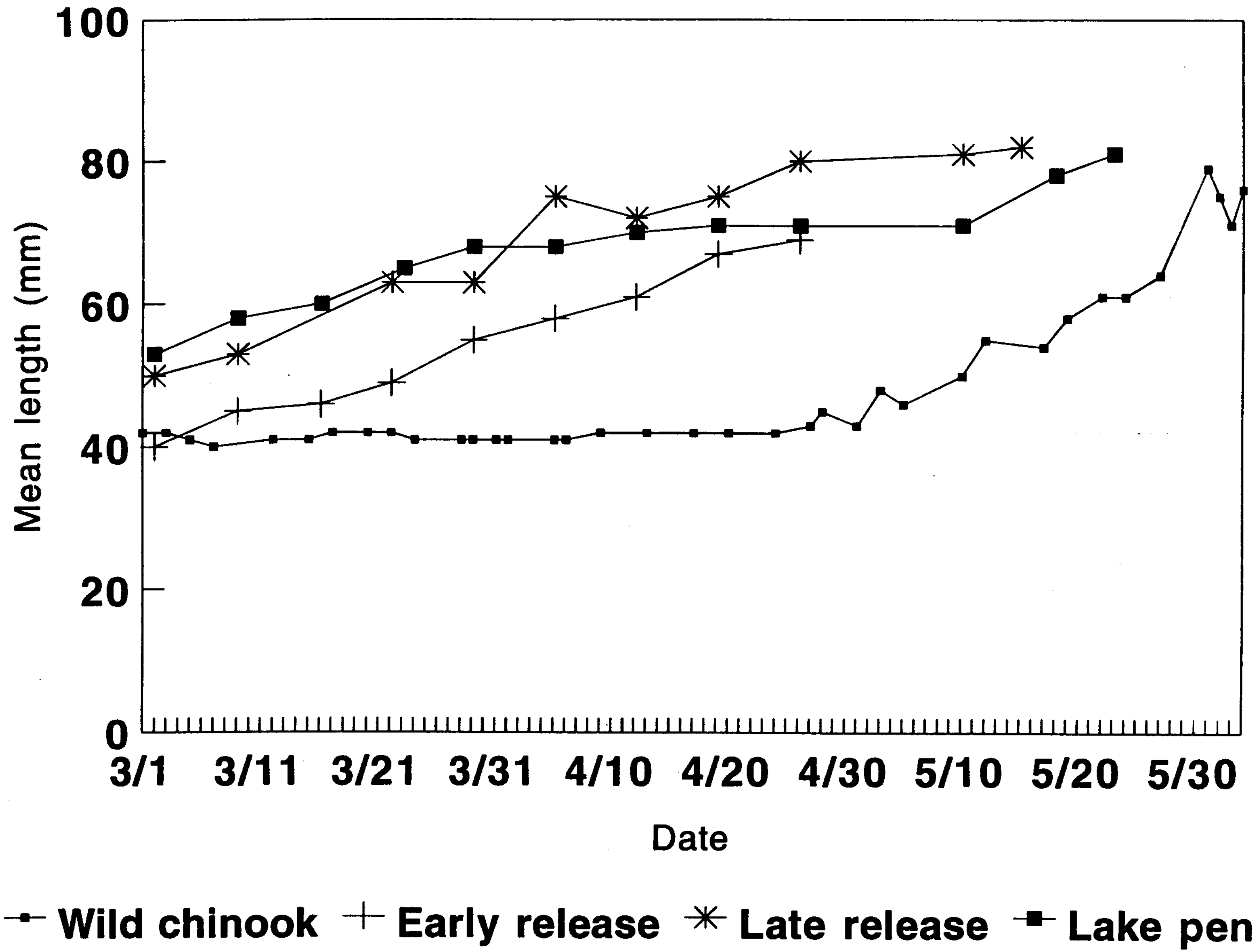


Fig. 5. Growth rate of chinook fry, Cowichan R., 1995
Early release; May 2. Late release; May 15/16/17. Lake pen release; May 23.

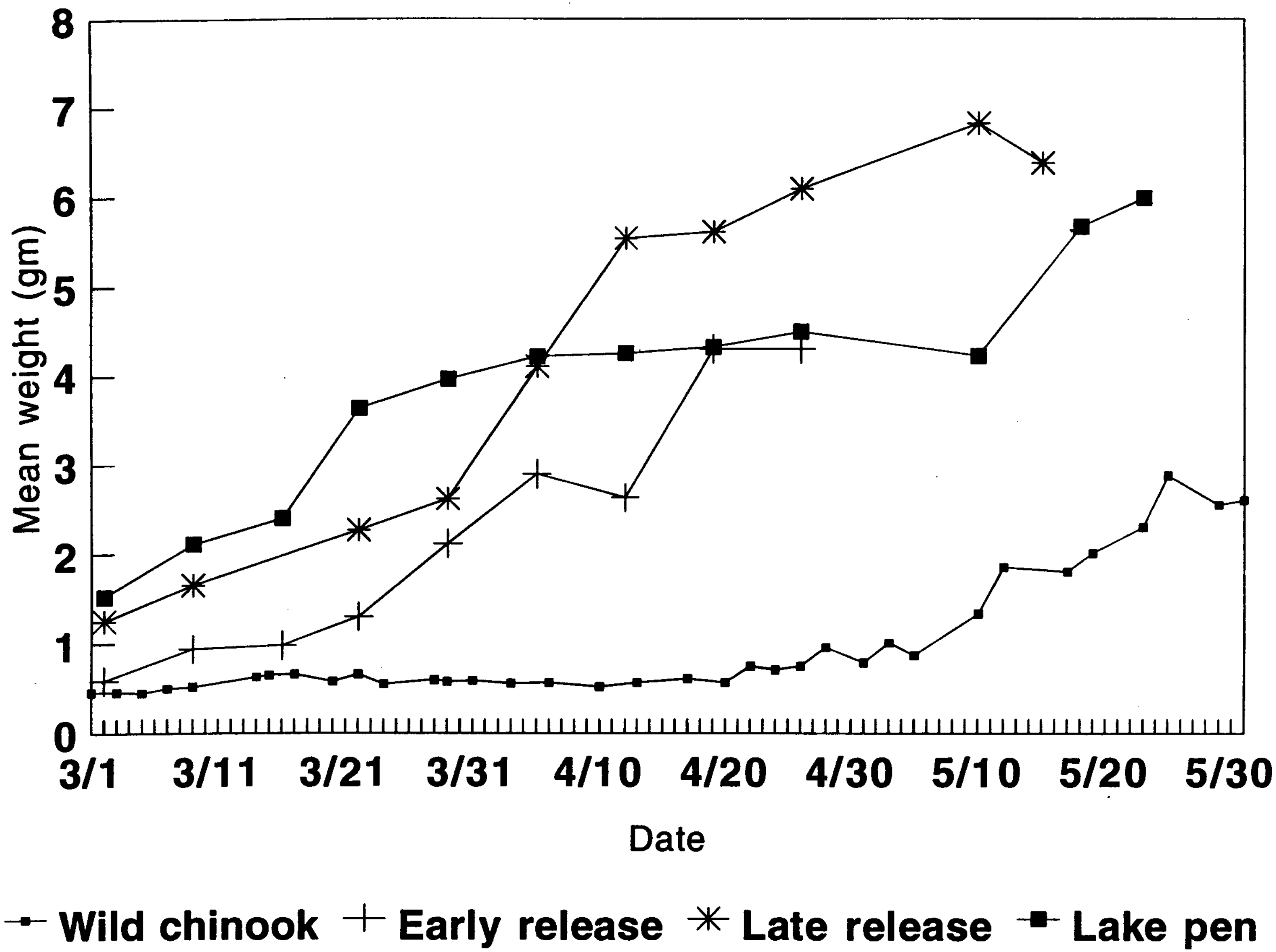


Fig 6. Growth rate of chinook fry, Cowichan R., 1995.
Early release; May 2. Late release; May 15/16/17. Lake pen release; May 23.

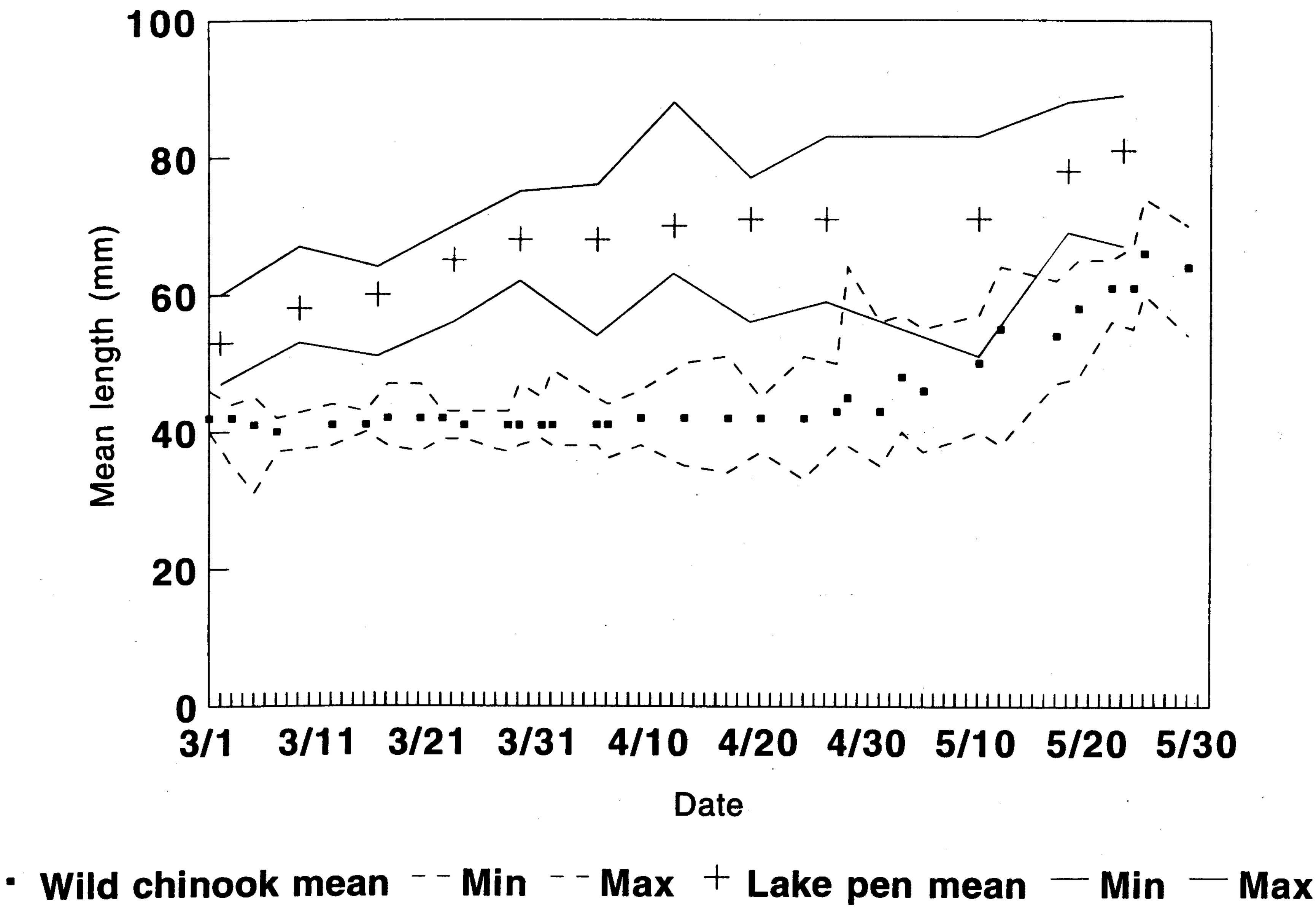


Fig. 7. Growth rate comparison of hatchery and naturally-reared chinook fry.

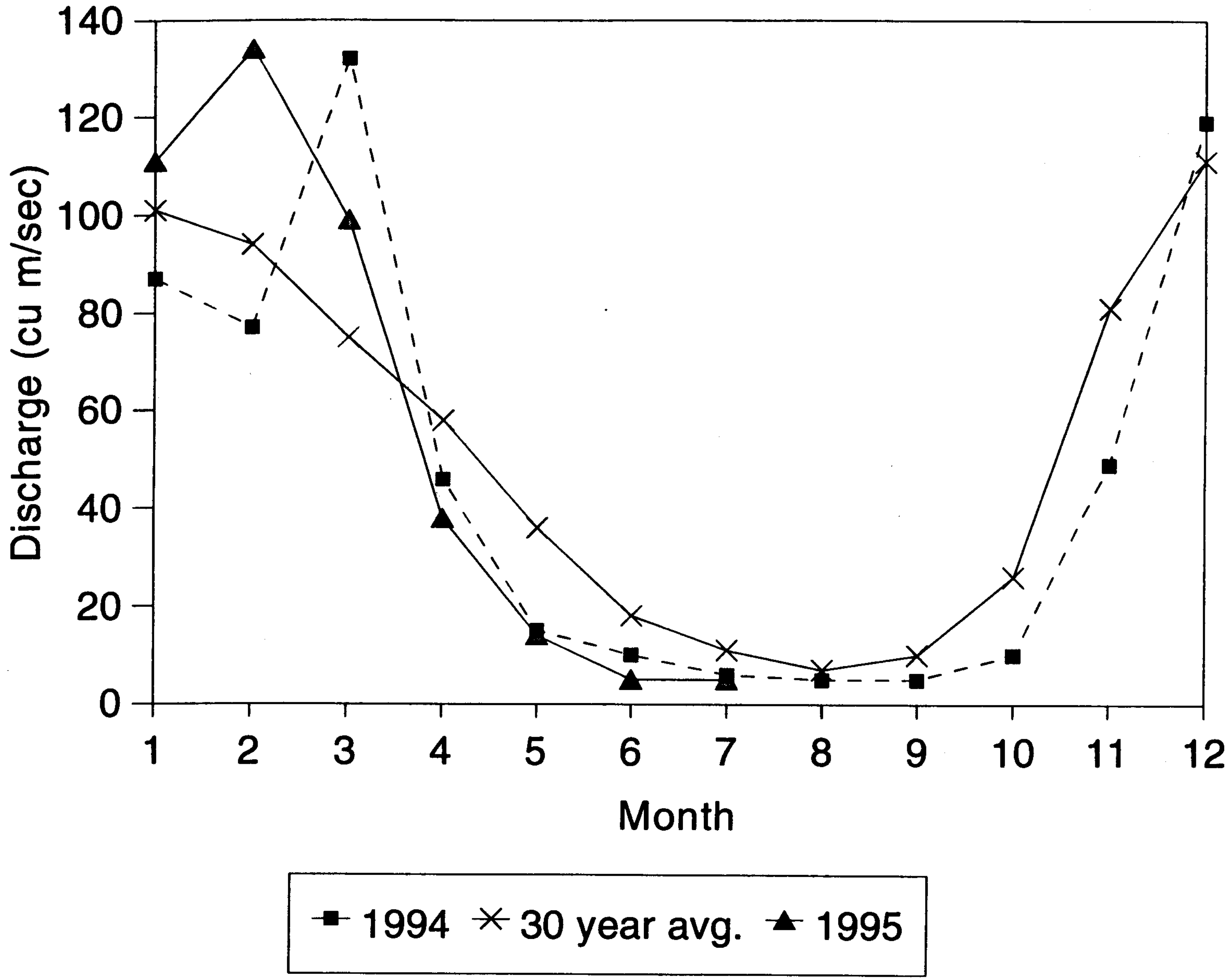


Fig. 8. Monthly discharge at Island Highway bridge in Duncan.

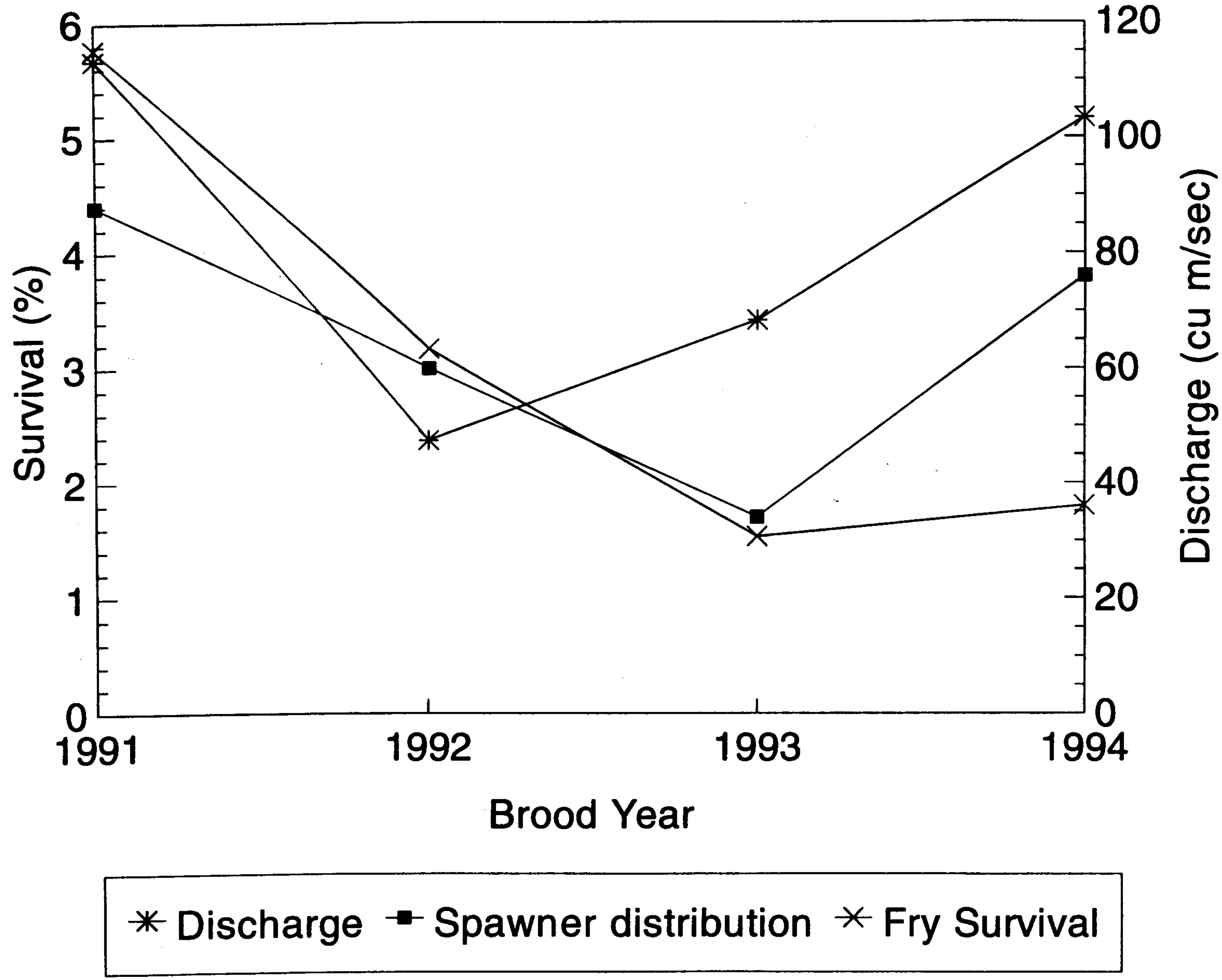


Fig. 9. Chinook fry survival compared with discharge and spawner distrbution.

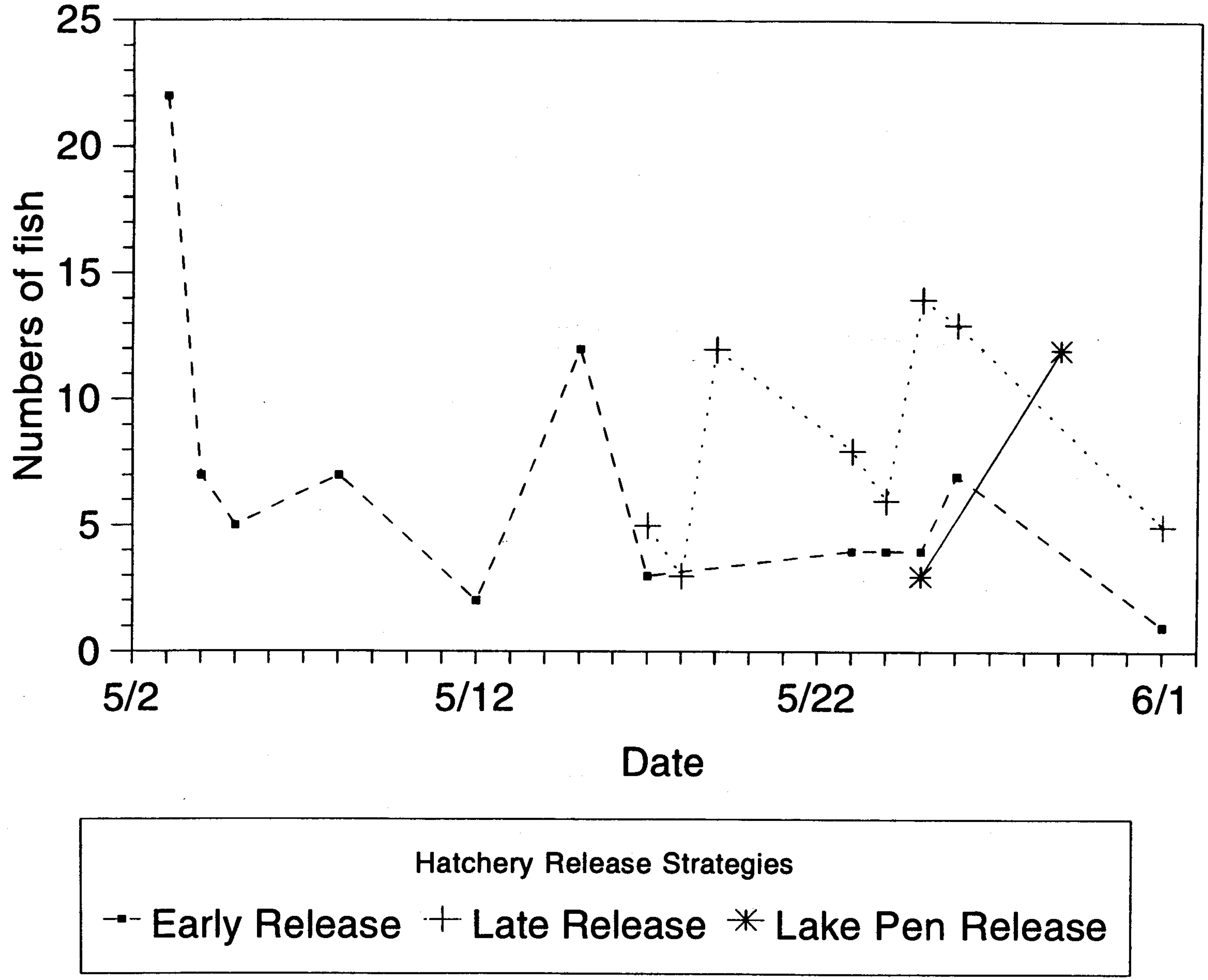


Fig. 10. Coded-wire tag recoveries at the pumphouse site, 1995