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Coho Salmon (*Oncorhynchus kisutch*) Spawning Enumeration and Related Studies at Chase River and Beck Creek, Vancouver Island

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COHO SALMON (*Oncorhynchus kisutch*) SPAWNING
ENUMERATION AND RELATED STUDIES AT CHASE RIVER
AND BECK CREEK, VANCOUVER ISLAND

by

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ABSTRACT

Irvine, J. R., R. E. Bailey, D. Imhof, F. C. Dalziel, W. Pennell, and C. Chestnut. 1994. Coho salmon (*Oncorhynchus kisutch*) spawning enumeration and related studies at Chase River and Beck Creek, Vancouver Island. Can. Manuscr. Rep. Fish. Aquat. Sci. 2264: 31 p.

Results of coho salmon spawning escapement studies from 1988-1993 in two streams near Nanaimo are provided with details on the 1993 surveys. Escapements were estimated using two techniques; mark-recapture, and area-under-the-curve with visual survey data. Approximately 900 adult coho and 127 jack coho returned to Chase River in 1993, and 99 adult coho and 16 jacks returned to nearby Beck Creek. The fishery exploitation on these fish was about 80% with recreational and commercial fisheries in the Strait of Georgia accounting for most of the catch.

RÉSUMÉ

Irvine, J. R., R. E. Bailey, D. Imhof, F. C. Dalziel, W. Pennell, and C. Chestnut. 1994. Coho salmon (*Oncorhynchus kisutch*) spawning enumeration and related studies at Chase River and Beck Creek, Vancouver Island. Can. Manuscr. Rep. Fish. Aquat. Sci. 2264: 31 p.

Nous présentons les résultats des études concernant les échappées de saumon coho, de 1988 à 1993, dans deux cours d'eau proches de Nanaimo, ainsi que des détails sur les relevés de 1993. Deux méthodes ont été employées pour calculer les échappées : le marquage avec recapture, et l'aire délimitée par la courbe établie avec les données du dénombrement visuel. En 1993, environ 900 cohos adultes et 127 «jacks» sont revenus dans la rivière Chase, tandis que 99 cohos adultes et 16 «jacks» remontaient le crique Beck, tout proche. L'exploitation de ces saumons par les pêches était de l'ordre de 80%, la plus grande part étant attribuable aux pêches commerciales et sportives dans le détroit de Géorgie.

INTRODUCTION

Escapement is the number of mature salmon that avoid marine fisheries and return to freshwater to spawn. Accurate escapement estimates are necessary for proper management of the fishery resource and they also allow us to monitor effects of habitat change. Generating reliable estimates of escapement is not an easy task however, especially for coho salmon (*Oncorhynchus kisutch*), because coho tend not to occur in high densities, and their cryptic coloration makes them difficult to see. We have been conducting research on the use of capture-recapture (Schwarz et al. 1993) and area-under-the-curve (AUC) (Irvine et al. 1992) methods to estimate the numbers of coho salmon returning to several streams near Nanaimo, including the Chase River.

The Chase River, its main tributary Catstream, and Beck (Hong Kong) Creek (Figure 1) are in urban and semi-urban areas of Nanaimo, and have experienced and continue to experience many changes. The primary purpose of this report is to provide details from our 1993 coho salmon escapement estimation studies in these systems and to summarize our results from previous years. Because the Chase River has played an important hydrological role for Nanaimo, a synopsis of other relevant historical information is also given.

STUDY AREA

Chase River

The Chase River is approximately 11 kilometres long, although only the lower 4.5 km are accessible to anadromous fish. The river flows northeast out of the Colliery Park Dams in south Nanaimo, entering the Nanaimo River estuary in the Strait of Georgia. Catstream, Chase River's main tributary, flows into the river approximately 2.8 kilometres upstream of the ocean (Figure 1).

The river and its tributary (Catstream) were divided according to habitat and accessibility into five strata (A-E) (Figure 1; Table 1). Longitudinal profiles (Figure 2) were drawn using a digital curvi-meter and 1:5,000 scale topographic maps. Elevations were determined by the intersection of the river with one and two metre contour lines. From the profiles, the mean gradient for each stratum was calculated.

Mean gradients ranged from 0.56% to 1.70%. Gradients were steepest in strata D and A, and shallowest in stratum B (Table 1).

Chase River discharge ranges from an estimated $35 \text{ m}^3\text{s}^{-1}$ in winter to approximately $0.2 \text{ m}^3\text{s}^{-1}$ in summer. The river bed is composed mostly of cobbles. Spawning gravels are distributed throughout the system, although the bulk of the available spawning habitat is in strata A, B, and lower C below the Catstream. Gravels in Catstream are of marginal quality due to siltation, however, spawning does occur in at least four discrete 100 m reaches.

Historical Perspective

The origin of the name of the Chase River is of interest. On 5 November 1852, Peter Brown, a Hudson's Bay herder, was murdered near Saanich, south of Nanaimo. An investigation revealed that two Cowichan tribe natives were responsible. On 7 January 1853, Governor Douglas and his troop arrived in Nanaimo to apprehend one suspect who had fled. Sergeant Battineau gave "chase" in the vicinity of the Chase River. The suspect was later captured and hung (Paterson 1993, and unpublished information, Nanaimo Archives).

Four reservoirs exist on the Chase River: two reservoirs created by the upper and lower Colliery Park dams, the No. 1 Reservoir, and the Old No. 1 City Reservoir (Figure 1). Apparently the Canadian Western Fuel Company built the dams at Colliery Park around the beginning of this century. In 1901, the city purchased the waterworks system including the Old No. 1 City Reservoir from the Nanaimo Waterworks Company. The source of supply was the Chase River. In 1907 and 1908 the city had water supply problems; therefore, a wooden dam 25.7 km away on the south fork of the Nanaimo River was constructed to supplement the Chase River water supply. This water was diverted to the Old No. 1 City Reservoir. In 1912, the city constructed the new No. 1 Reservoir and the water was diverted to this reservoir. In 1930, logging and development in the Chase River watershed posed a risk of contamination of the water, and water flow during summer was reduced to a mere trickle. Therefore, the south fork of the Nanaimo River was further developed as a water source, and Chase River water was no longer used as a domestic water supply for the city of Nanaimo. Nanaimo River water continues to be diverted to the new No. 1 Reservoir.

It is not clear how significant a problem water abstraction was to the fisheries resource in the early years when the Chase River was a domestic water supply. Nor is it clear how much water of Nanaimo River origin has spilled down the Chase River. In recent years, at least until 1992, approximately $60 \text{ L}\cdot\text{s}^{-1}$ of Nanaimo River water (2 cfs) has been discharged over the ledge of the No. 1 Reservoir into the Chase River during winter and spring, although water was not usually discharged in summer.

During 1992 and 1993, apparently no Nanaimo River water spilled into the Chase River (unpublished data, Nanaimo Archives and Wayne Hanson and Richie Fulla, Public Works Office City of Nanaimo, pers. comm.).

In 1985, the Malaspina College Hatchery was built adjacent to the new No. 1 Reservoir. In 1987, the first hatchery-raised coho smolts were released into the Chase, and the first coded-wire-tagged smolts were released in 1989. We initiated a mark-recapture program in the Chase River in 1988 and in 1990 this was supplemented with AUC surveys to provide a second estimate of escapement.

Beck Creek

Beck Creek enters into the Nanaimo River Estuary south of the Chase River (Figure 1). Richard Creek, its main tributary, enters approximately 1.1 kilometres upstream of the estuary mudflat. It appears from fry distribution surveys that only the lower 600 m of Richard Creek is accessible to anadromous fish. The upstream limit for fish migration on Beck Creek varies: In some years, an impassable beaver dam in a small canyon, 900 m above the Island Highway culvert is the upper limit, however, this blockage is occasionally washed away by flooding, as it was during early December, 1993. When this occurs, fish may be able to migrate up the entire length of Beck Creek to Beck Lake.

We first generated mark-recapture estimates of coho escapement to Beck Creek in 1991. At that time, only the lower sections of Beck Creek, below the beaver dam site were accessible to anadromous fish. Lower Beck Creek was divided into three strata (L, M, U), again according to habitat and accessibility (Table 3). Following methods described earlier, longitudinal profiles were drawn (Figure 2). From these profiles, mean gradient was calculated for each stratum. Stratum L has the steepest gradient (1.96%); the gradients in the other strata are flatter (M, 0.41%; U, 0.24%). Discharge ranges from approximately $5 \text{ m}^3\text{s}^{-1}$ in winter to $0.01 \text{ m}^3\text{s}^{-1}$ in summer. The channel is mainly cobble in stratum L, but is composed of fine gravels and sand in the upper two strata. All strata are characterized by the presence of much large woody debris. Coho spawning occurs in all three strata, however, most occurs in the lower 300 m of M stratum, between Cedar Road and the Richard Creek confluence pool, and the lower 300 m of L stratum.

METHODS

Chase River Physical Data

Stage and temperature data were recorded at the Chase River using a Unidata 6003 datalogger, equipped with a Unidata 6508a hydrostatic depth and temperature probe. The datalogger was installed approximately 250 m above the tidal influence, in lower 'A' stratum. Stage and temperature were recorded every 3 hr.

The Chase River discharge was estimated on six occasions during 1993. Water depths and velocities were recorded at 0.5 m intervals, and wherever sufficient depth existed, water velocities were determined at 0.2 and 0.8 times the depth from the water surface. The stage discharge relationship was determined as:

$$\ln(Q) = 3.41 + 3.034x(\ln(stage))$$

The stage-discharge regression had an r^2 value of 0.96, however, it should be noted that the estimates only represent discharges over the range of 0.18 to 2.14 m³sec⁻¹.

No physical data were recorded at Beck Creek.

1993 Population Estimates

Mark-Recapture

Fish were captured throughout the escapement period, either by tangle netting or electrofishing. An attempt was made to sample the entire length of the Chase River and Beck Creek accessible to fish every week. Early in the run to the Chase River, and prior to the first freshet, coho were captured using tangle-nets (25 m x 3 m x 3 cm mesh gill nets) before they dispersed to spawning grounds. The net tangled both adult and jack (precocious male) coho. Later in the run, and particularly after freshet events, the fish moved into shallower water and electroshocking was used instead of tangle netting. On Beck Creek, all fish capture was done using

electrofishing apparatus. An electrofishing crew consisted of at least three people, one person operating the electroshocker (Smith Root Mk. 11A and 12A shockers, operating at 200-300 V pulsed DC at 30 Hz), and the others using large-frame (1.25 m hoop), fine-meshed (1 cm) landing nets to catch the fish. Electrofishing surveys were conducted in a downstream direction.

Once captured, coho were examined to determine age (adult or jack), sex, degree of sexual maturity, and whether or not they had been adipose fin-clipped. The capture location and date were also recorded, all new captures were tagged with a uniquely numbered Ketchum No. 1 operculum tag (Ketchum Manufacturing Sales Ltd., 396 Berkley Ave., Ottawa, Ont. Canada K2A 2G6), and the number recorded. Untagged carcasses were recorded and used in the mark-recapture estimate. All dead fish were cut in half to prevent re-counting. Escapement estimates were generated using the modified Jolly-Seber approach described by Schwarz et al. (1993).

Area-Under-The Curve

Fish counts

AUC is a method used to convert periodic counts of mature salmon into an escapement estimate (English et al. 1992). In addition to fish counts, the method requires an estimate of observer efficiency and residence time in the stream.

The stratified index sampling (SIS) system (Irvine et al. 1992) was used to estimate adult escapement. The study sites for the SIS design were chosen for easy access or where fish congregate, and to be representative of the habitat as a whole within that stratum. Every week, an attempt was made to survey fifteen 100 m index sites along the Chase River, Catstream, and Beck Creek (Table 2). At each site, two observers walked upstream, displacing salmon with 2-m-long poles from underneath the cutbanks and rocks. Counts were only performed if there was good visibility and safe wading. In the few instances when weather conditions prevented us from conducting surveys at all sites in each strata, fish numbers in unsampled sites were derived from a linear interpolation between the abundances observed on the previous and following surveys when these sites were sampled. Fish were counted and categorized as not tagged or floy tagged (different colours), and as jack or adult. A best estimate for the observers was recorded for each category for each 100 m site. AUC data were analyzed using the AUC software described by Irvine et al. (1993).

Observer Efficiency

Observer efficiency was estimated by comparing visual counts to

electroshocking estimates using the methods and software of Irvine et. al. (1993). No observer efficiency data were collected in 1993, therefore, the 30 tests performed on adults between 1989 and 1992 were used to estimate observer efficiency. The observer efficiency for jacks was assumed to be the same as for adult coho salmon.

Residence Time

Residence time is the average time fish spend alive and are visible to surveyors within the survey area. Tangle-netting and electroshocking were used during 1993 to capture adult fish in lower stratum A on the Chase River. Fish were tagged with a Floy FD-68B anchor tag on each side of the dorsal surface of the fish, immediately ventral to the origin of the dorsal fin. Two groups of adult fish were floy tagged; one group of 35 fish was tagged on 3 November with red floy tags, and another of 29 fish was tagged on 28 November with green tags. Residence times calculated for Chase River fish were also used for the Beck Creek AUC analyses, in lieu of system specific values.

Coded-wire Tag Returns

In order to obtain coded-wire tags, heads of all adipose fin-clipped carcasses were taken, labelled and stored individually in plastic bags, and frozen. Heads were later dissected by employees of J.O. Thomas and Assoc. Ltd. (Vancouver) to recover and read coded-wire-tags.

Coded-wire tagged coho reared at, and released from the Chase River hatchery are caught in ocean fisheries and during escapement sampling. In 1993, recoveries occurred from tagged releases in 1992 and 1993. Tag recoveries, expanded for sampling rates (estimated - Kuhn et al. 1988) were determined by examination of the Mark Recovery Program (MRP) database (Kuhn 1988). Survival rates by tagcode were determined as $\text{Survival}(\%) = 100 * (\text{Catch} + \text{Escapement}) / \text{No. released}$, and exploitation rates were determined as $\text{Exploitation}(\%) = 100 * \text{Catch} / (\text{Catch} + \text{Escapement})$.

RESULTS

Chase River Physical Data

Estimated discharges were low for most of the study period, remaining below $1.0 \text{ m}^3\text{sec}^{-1}$ during the fall of 1993 except between Dec. 08 - Dec. 17. The peak estimated discharge was approximately $30 \text{ m}^3\text{sec}^{-1}$ on Dec. 09. Water temperatures declined steadily from approximately $12 \text{ }^\circ\text{C}$ in mid-October to less than $2 \text{ }^\circ\text{C}$ in late November, then ranged between $4.5 \text{ }^\circ\text{C}$ and $7.9 \text{ }^\circ\text{C}$ for the remainder of the study (Figure 3).

Population Estimates

Mark Recapture

Four hundred and forty two fish were handled during the 1993 mark-recapture surveys on the Chase River and Catstream. Of these, 403 were classified as adults, and 39 as jacks. There were insufficient jacks captured and recaptured to estimate the jack escapement using the modified Jolly-Seber approach of Schwarz et al. (1993). Similarly, we were unable to generate estimates of adult or jack coho escapements to Beck Creek using the modified Jolly-Seber method, again due to the limited numbers of fish handled (56 adults; 10 jacks).

On the Chase River, the first fish was captured on Oct. 20 and the last fish was handled on Dec. 24. The run was later than observed in previous years, and peaked in the first week of December, the time of the first major peak discharge event (Figure 3). Capture-recapture data were initially stratified into 10 'weekly' timing periods; (1) \leq Oct. 24; (2) Oct. 25 - Nov. 01.; (3) Nov. 02 - Nov 08; (4) Nov. 09 - Nov. 15; (5) Nov. 16 - Nov. 22; (6) Nov. 23 - Nov. 29; (7) Nov. 30 - Dec. 06; (8) Dec. 07 - Dec. 13; (9) Dec. 14 - Dec. 20; and (10) Dec. 21 on. However, we were unable to sample at all during period 8, and in weeks 2, 4, 5 and 6, the numbers of previously marked animals recaptured were low, leading to problems in the analyses (Table 3a). To overcome these problems, we pooled data from weeks 1 and 2, 3 and 4, 5 and 6, and 8 and 9. The resultant time periods were as follows: (1+2) \leq Nov. 01; (3+4) Nov. 02 -

Nov. 15; (5+6) Nov. 16 - Nov. 29; (7) Nov. 30 - Dec. 06; (8+9) Dec. 07 - Dec. 20; (10) Dec. 21 on (Table 3b). Recaptures of previously marked fish remained less than 10 for periods (5+6) and (7), however, the resulting mark-recapture estimates weren't confounded. Using the modified Jolly-Seber approach, the mark-recapture estimate of the adult coho return to the Chase River was 900 +/- 146 (2 SD).

Area-Under-the-Curve

The relationship between the number of fish observed by surveyors and the number of fish present (seen during electrofishing surveys) (Figure 4) was reasonably well described by a linear regression ($r^2 = 0.88$). The regression parameters calculated from these data were used to expand the visual survey fish count data.

Because only one red floy tagged fish was seen after tagging, these results were not used to generate an estimate of residence time. For the green floy tagged fish, the residence time estimate using the observed tag curve was 8.9 d while the estimate using the total tag curve was 10.4 d. The former was used because it was recognized that coho in the Chase River typically hold in pools for a period of time before moving onto the spawning sites where they are more frequently observed by stream walkers.

Figures 5 and 6 illustrate the results of the visual surveys conducted for adult coho and jack coho respectively in the Chase River. The AUC escapement estimates were 731 adults and 127 jacks (Table 4).

At Beck Creek, reasonable numbers of adult coho were seen (Figure 7) and the resulting AUC estimate was 99 fish. Unfortunately, only two jack coho were seen by the AUC survey crews in Beck Creek and it was not possible to generate a credible escapement estimate based on such limited data. Therefore we decided to use the results from electrofishing surveys and generate AUC estimates with these data. During the mark recapture electrofishing censuses, a crew electrofished virtually all the area of Beck Creek that coho were found. We assumed that only 75% of the fish present were seen (i.e. observer efficiency was 0.75) and the residence time was the same as calculated for Chase River fish (i.e. 8.9 d) and generated an AUC estimate using data collected for adults and jacks. The estimate for adults (106 fish) was close to the AUC estimate of 99 fish generated using the visual survey data. The AUC estimate for jacks using electrofishing data was 16 (Table 4).

Age and Sex Composition

Assuming the mark recapture estimate of 900 adult coho to be the most accurate for 1993, we estimate that approximately 493 (54.8%) were males and 407 (45.2%) were females. Adult males significantly outnumbered adult females (G Test; $P < .05$; $n=403$). Of the 99 adult coho returning to Beck Creek approximately 51 (52%) were male and 47 (48%) were female. When Beck Creek adult and jack males were combined, males still did not significantly outnumber females (G Test; $P > .05$; $n=66$).

Coded-Wire Tag Returns

Of the estimated 900 adults and 127 jacks that returned to the Chase River in 1993, an estimated 222 (27.9%) of the adults were adipose-clipped, and 45 (20.5%) of the jacks. In 1993, recoveries of marked smolts from the 1992 release occurred in both ocean fisheries and in escapement samples; recoveries from smolts released in spring 1993 occurred in escapement samples only. Of the estimated contribution of 908 adult fish from the 1992 coded-wire tagged smolt release, 630 occurred in the Strait of Georgia recreational and commercial fisheries. There were 77 recoveries estimated in the west coast troll fishery, another 16 recoveries in the north and central coast regions, and one recovery in Washington (Table 5).

Escapement of the marked group was estimated to be 184 fish. There were three fish in the sampled escapement containing coded-wire tags of non-Chase River origin. When expanded for sampling rate, these were estimated to account for 38 fish (4.2%) of the adult escapement. Two of these were of Nanaimo River origin and the other was from the Chemainus River. Survival for the 1992 release was estimated at 6.7% for adults, and the exploitation rate (excluding jacks), 79.8%.

DISCUSSION

Coho escapements to Chase River have been estimated by us since 1988 and to Beck Creek since 1991 (Table 6). Adult escapements to the Chase River have ranged from a low of 281 in 1988 to a high of 1851 in 1991 (mark-recapture estimates). AUC and mark-recapture estimates of adult escapement to the Chase River have generally been similar, although AUC estimates appear to be biased low. This may be due to overestimating residence time and/or observer efficiency, or unrepresentative index sites. We suspect that the main cause is overestimating residence time, since recruitment to the escapement continues over an extended period, and obtaining sufficient 'new' fish for externally visible tagging for streamlife estimation is only feasible prior to the peak of migration.

Reliable estimates of adult escapements to Beck Creek have been obtained by the AUC method only, and have varied from a low of 48 in 1992 to a high of 410 in 1991. Estimates of jack escapements to both systems are less reliable. For the Chase River, jack escapements have been estimated to range from 180 to 629 (mark-recapture). Beck Creek jack escapements ranged between 16 and 52 (AUC).

Escapements to Chase River and Beck Creek were delayed in 1993 by extended low water conditions; escapements began approximately 1 month later than had occurred in the previous three years. Exploitation rates for Georgia Strait 1990 brood coho were generally high and Chase River fish followed that trend. Many of the fish that were captured occurred in the Strait of Georgia recreational fishery, and Chase River origin salmon were not nearly as commonly caught in the southwest and northwest Vancouver Island troll fisheries as they were in 1991 and 1992.

This study has shown that mark-recapture and AUC can be used to generate reasonable escapement estimates. Staff with relatively little training and supervision were able to gather appropriate data in the field. Mark-recapture estimates required more labour in the field than AUC because of the requirement of handling individual fish more than once. However when this was possible, escapement estimates were considered most reliable.

It is not possible to reach conclusions on the status of the population of coho in the Chase River because of variable hatchery influences. Nevertheless, results obtained are gratifying because they demonstrate that urban streams around Nanaimo are still significant producers of anadromous salmon.

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Table 1. Locations, lengths, and gradients of the four strata on the Chase River (A-D), one stratum on Catstream (E), and three strata on Beck Creek (L,M, and U) (see also Figure 1).

Stratum	Location	Length (m)	Gradient (%)
A	Above the tidal mudflat to railway tunnel	1,050	1.69
B	Railway tunnel to Park Avenue	1,250	0.56
C	Park Avenue to Bruce Avenue	850	0.94
D	Bruce Avenue to Wakesiah Avenue	1,000	1.70
E	Park Avenue Bridge to Wakesiah Avenue	3,000	0.92
L	Tidal mudflat to Cedar Road	750	1.96
M	Cedar Road to Island Highway	450	0.41
U	Island Highway to beaver dam	925	0.24

Table 2. Index sites for stratified index sampling in Chase River and Beck Creek watersheds (see also Figure 1).

System	Stratum	Location
Chase River	A	100-200 metres
Chase River	A	500-600 metres
Chase River	B	50-150 metres
Chase River	B	1150-1250 metres
Chase River	C	50-150 metres
Chase River	C	400-500 metres
Chase River	D	0-100 metres
Chase River	D	500-600 metres
Catstream	E	50-150 metres
Catstream	E	700-800 metres
Catstream	E	2450-2550 metres
Beck Creek	L	200-300 metres
Beck Creek	L	500-600 metres
Beck Creek	M	100-200 metres
Beck Creek	U	0-100 metres

Table 3. Mark-recapture statistics for adult coho before (a) and after pooling (b).

(a)

Week	$n_{(i)}$	$m_{(i)}$	$l_{(i)}$	$R_{(i)}$	$r_{(i)}$	$z_{(i)}$
1	6	0	0	6	4	0
2	46	2	3	43	17	2
3	55	12	11	44	8	7
4	14	4	8	6	0	11
5	11	2	1	10	3	9
6	58	7	18	40	19	5
7	188	21	35	153	23	3
8	0	0	0	0	0	0
9	76	22	17	59	13	4
10	36	17	14	22	0	0

(b)

Week	$n_{(i)}$	$m_{(i)}$	$l_{(i)}$	$R_{(i)}$	$r_{(i)}$	$z_{(i)}$
1+2	50	0	3	47	19	0
3+4	66	13	19	47	5	6
5+6	67	7	19	48	20	4
7	188	21	35	153	23	3
8+9	76	22	17	59	13	4
10	36	17	14	22	0	0

Where: $n_{(i)}$ is the number of captures in the i th sample, $i=1, \dots, s$

$m_{(i)}$ is the number of captures in the i th sample, $i=1, \dots, s$

$l_{(i)}$ is the number of animals lost on capture in the i th sample, $i=1, \dots, s$

$R_{(i)}$ is the number released after the i th sample, $i=1, \dots, s-1$

$r_{(i)}$ is the number of $R_{(i)}$ released that are subsequently recaptured, $i=1, \dots, s-1$

$z_{(i)}$ is the number of animals captured before i , not captured at i , and subsequently recaptured, $i=1, \dots, s-1$

Table 4. Summary of 1993 coho escapement estimates. Numbers underlined are considered to be our best annual estimate.

System	Cohort	Method	Escapement
Chase River	Adults	AUC-visual survey data	731
Chase River	Adults	M/R	<u>900+/-153</u>
Chase River	Jacks	AUC-visual survey data	<u>127</u>
Beck Creek	Adults	AUC-visual survey data	<u>99</u>
Beck Creek	Adults	AUC-electrofishing data	106
Beck Creek	Jacks	AUC-electrofishing data	<u>16</u>

Table 5. Expanded (for sampling rate only) coded-wire tag recovery information for 1990 brood year Chase River coho smolts, released May 4 1992.

Region	Gear Type	Recovery Age	
		2	3
West Coast of Vancouver Island	Troll	0	77
	Net	0	0
	Sport	0	0
Central and North Coast	Troll	0	3
	Net	0	9
	Sport	0	4
Strait of Georgia, Entrances	Troll	0	146
	Net	0	20
	Sport	0	464
Washington and Oregon	All	0	1
Escapement		116	184
Total		116	908
Survival (%)		0.9	6.7

Table 6. Summary of coho escapement estimates for the Chase River and Beck Creek (excluding any fish taken for brood stock). Numbers underlined are considered to be our best annual estimate. N/A means no estimate available.

Creek	Cohort	Year	AUC	Mark-Recapture
Chase River	Adults	1988	N/A	<u>281</u>
Chase River	Adults	1989	N/A	<u>546</u>
Chase River	Adults	1990	1061	<u>1586</u>
Chase River	Adults	1991	1892	<u>1851</u>
Chase River	Adults	1992	360	<u>481</u>
Chase River	Adults	1993	731	<u>900</u>
Beck Creek	Adults	1991	<u>410</u>	N/A
Beck Creek	Adults	1992	<u>48</u>	N/A
Beck Creek	Adults	1993	<u>99</u>	N/A
Chase River	Jacks	1989	N/A	<u>248</u>
Chase River	Jacks	1990	N/A	<u>629</u>
Chase River	Jacks	1991	N/A	<u>180</u>
Chase River	Jacks	1992	478	<u>627</u>
Chase River	Jacks	1993	<u>127</u>	N/A
Beck Creek	Jacks	1991	<u>41</u>	N/A
Beck Creek	Jacks	1992	<u>52</u>	N/A
Beck Creek	Jacks	1993	<u>16</u>	N/A

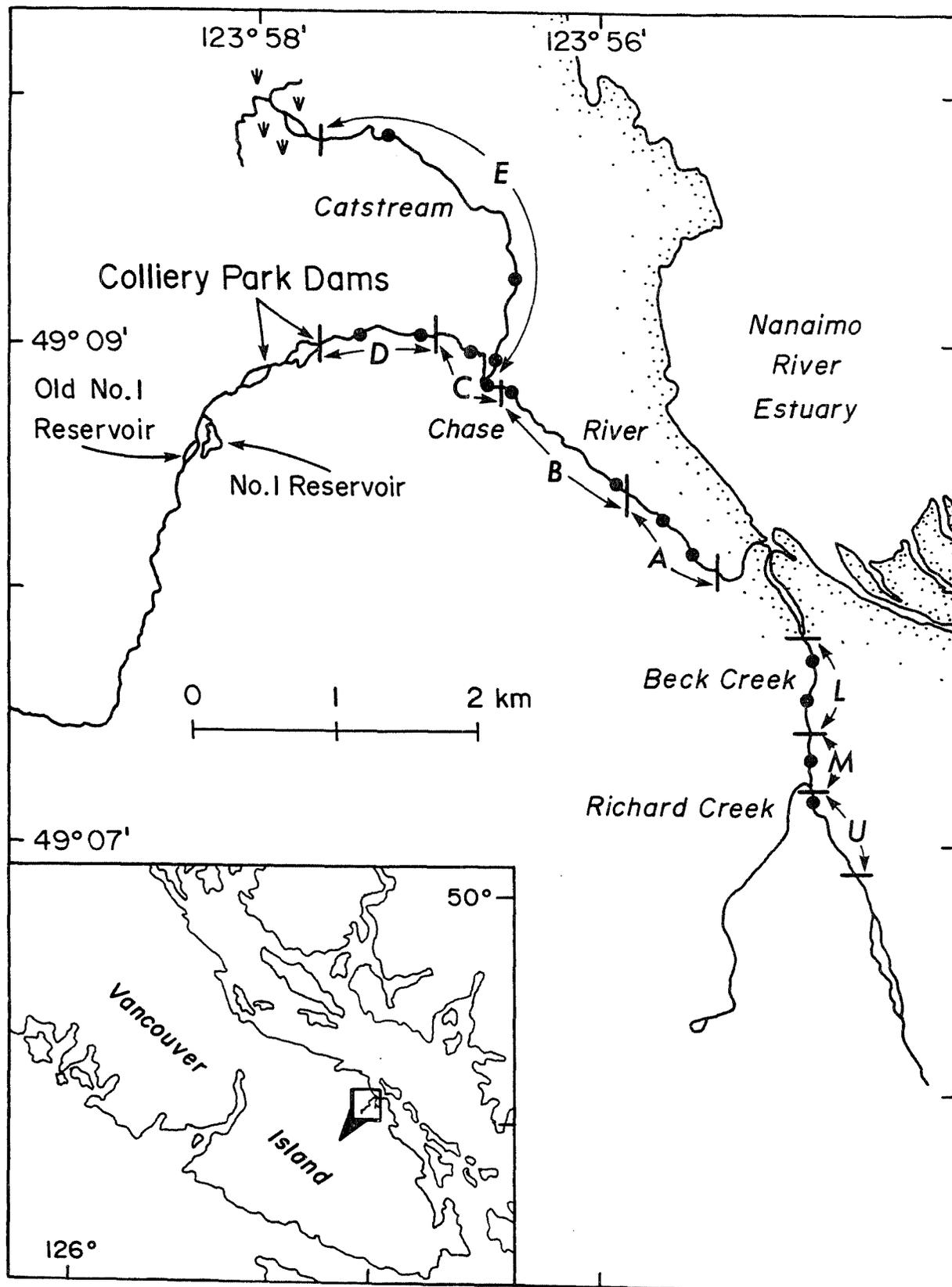


Figure 1. Locations of the Chase River and Beck Creek watersheds showing the strata and index sites for area-under-the-curve (AUC) sampling (latter identified by black dots). Inset shows location of study area on Vancouver Island.

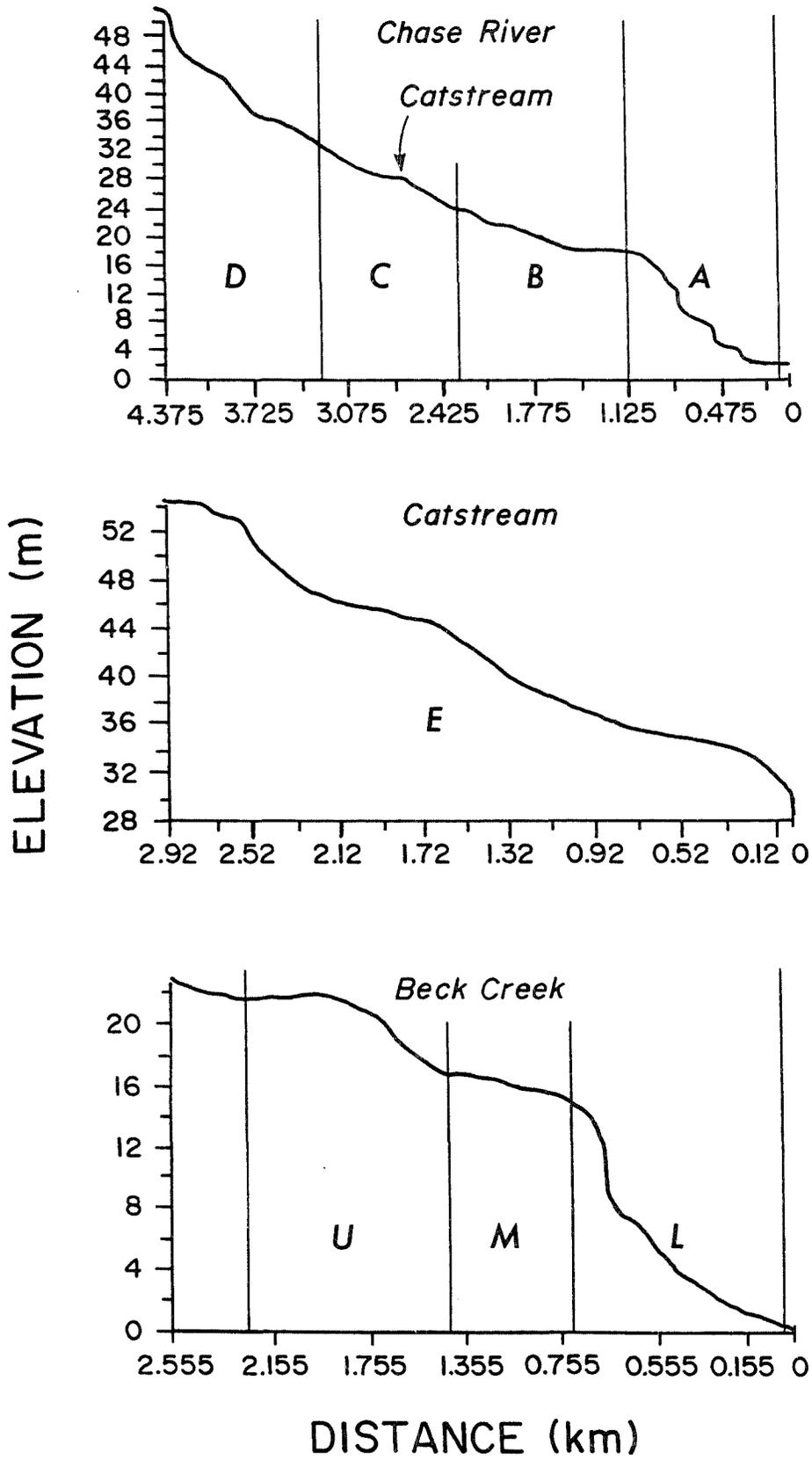


Figure 2. Stream gradient profiles for Chase River, Catstream, and Beck Creek.

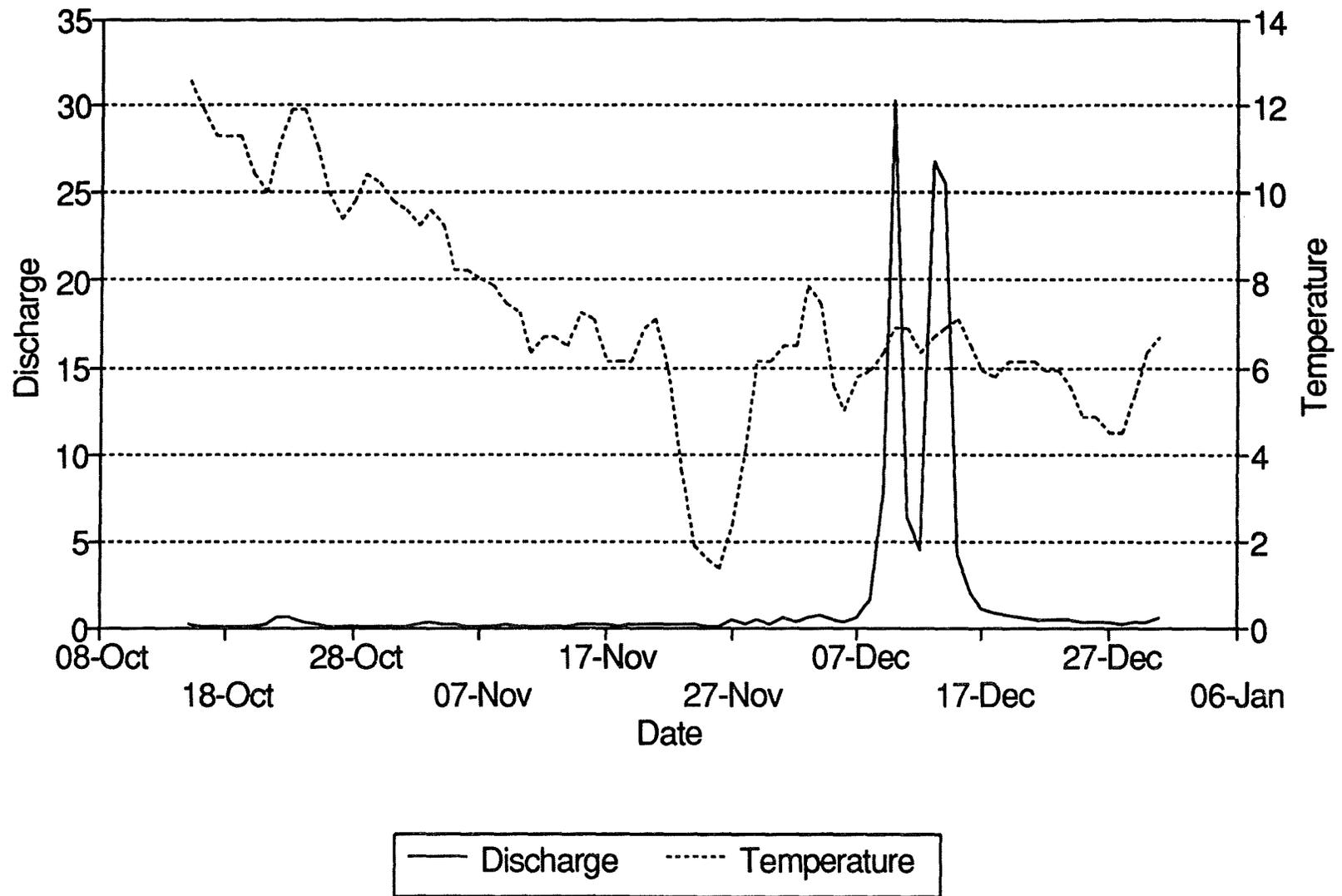
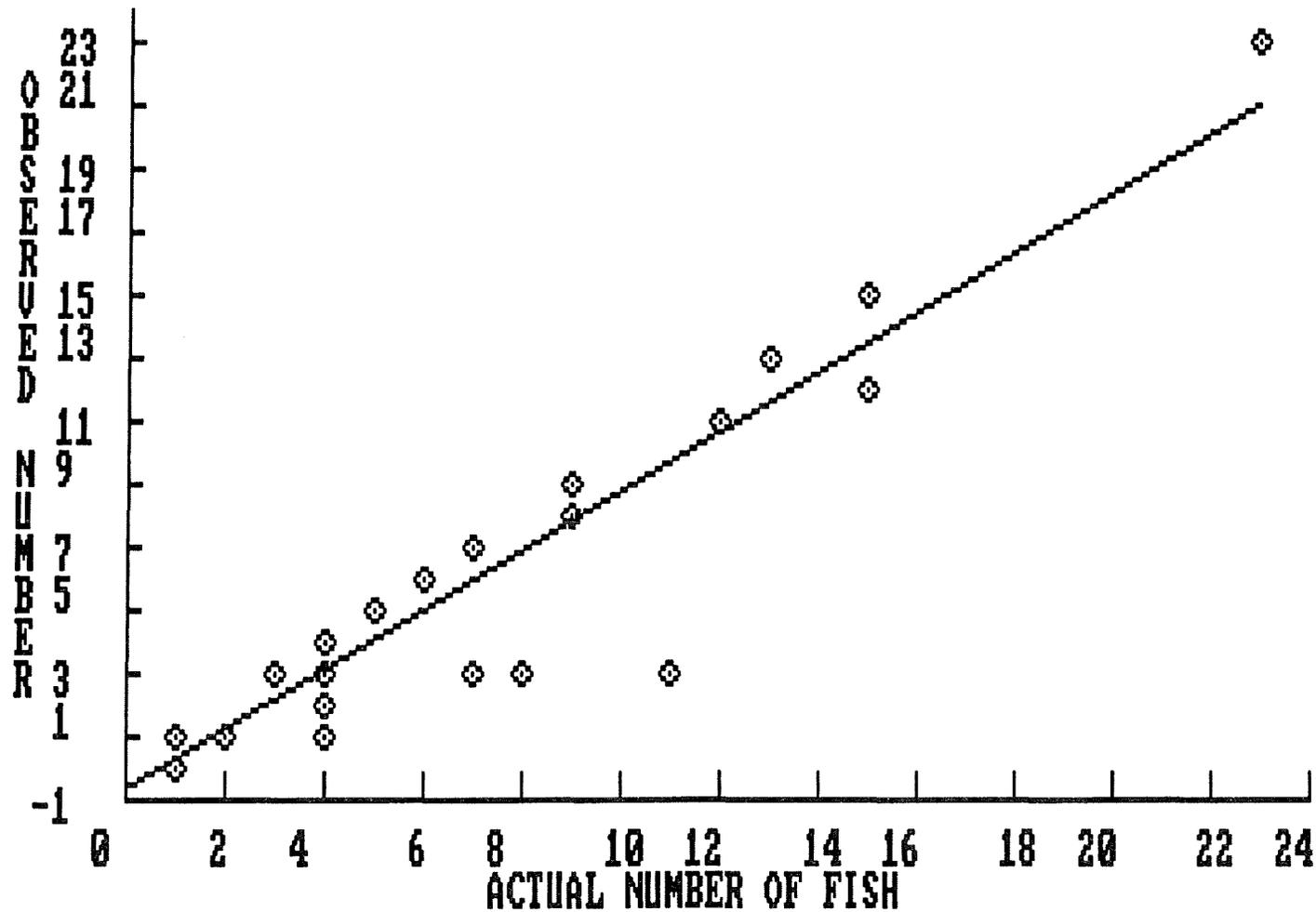


Figure 3. Discharge (m^3s^{-1}) and temperature (C°) data for the Chase River, Oct. 15 to Dec. 31, 1993.

OBSERVER EFFICIENCY

GRAPH INFO



TRANS TYPE:
NONE

FISH TYPE:
ADULT COHO

INTERCEPT:
-0.7418

SLOPE:
0.9428

Figure 4. Plot of numbers of adult coho observed during visual surveys in the Chase River versus actual numbers of fish present, with line of best fit.

ESCAPEMENT CURVE

GRAPH INFO

FISH TYPE:
ADULT COHO

SIS METHOD

AUC:
6505

ESCAPEMENT
ESTIMATE:
731

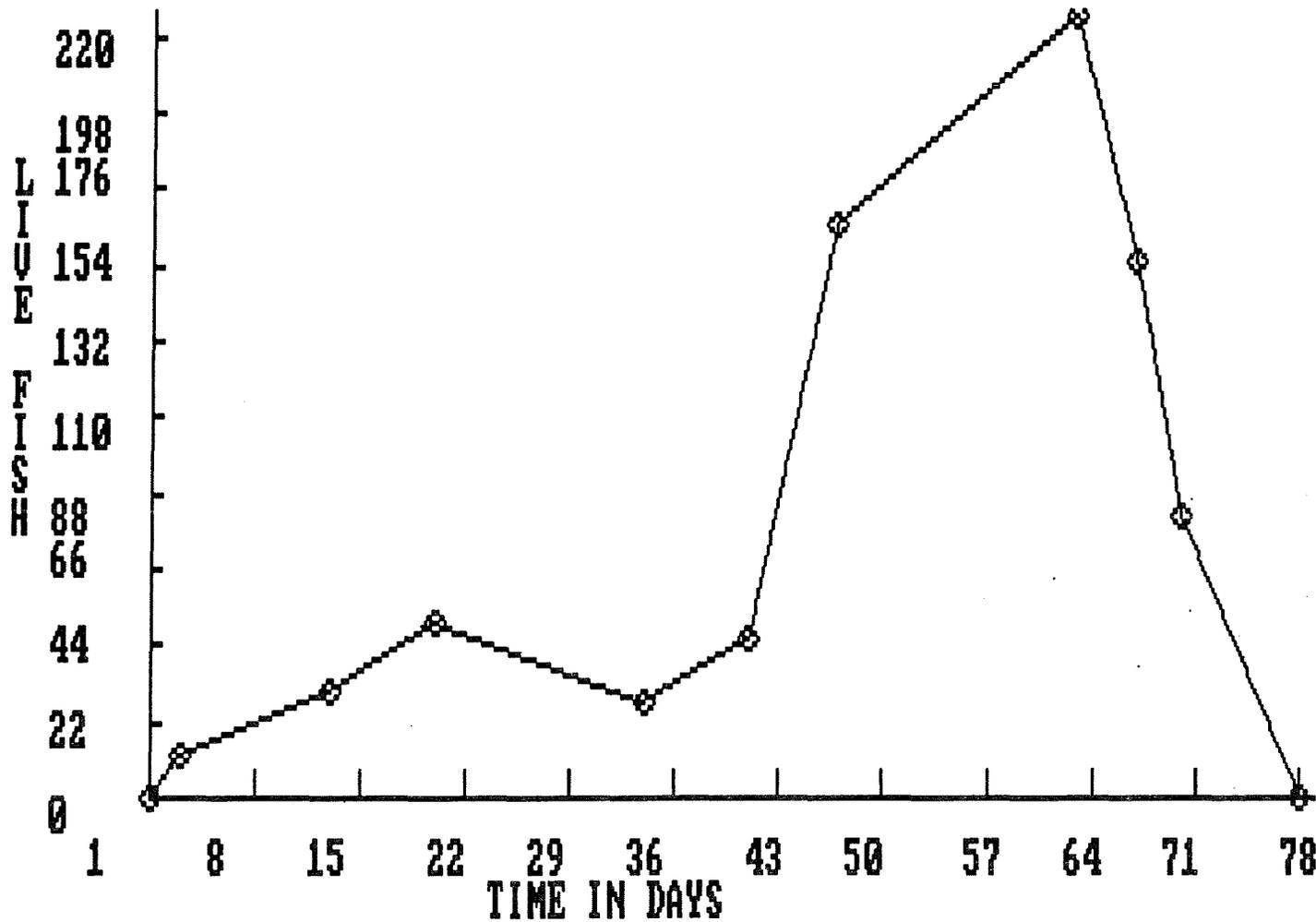


Figure 5. Graph of results from AUC surveys at Chase River, 1993 (numbers of adult coho salmon versus time). Day 0 was 15 October 1993.

ESCAPEMENT CURVE

GRAPH INFO

FISH TYPE:
JACK COHO

SIS METHOD

AUC:
1129

ESCAPEMENT
ESTIMATE:
127

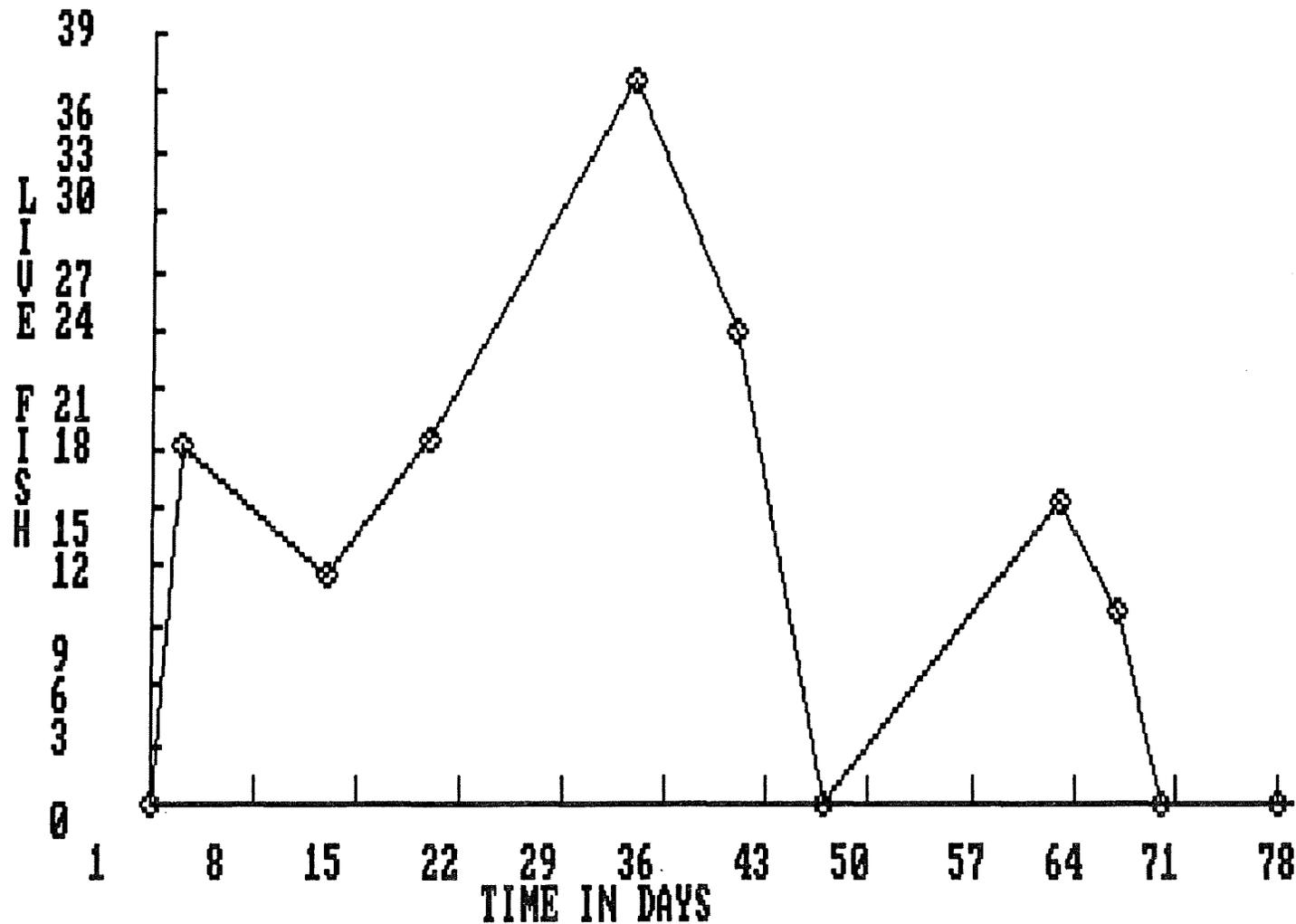


Figure 6. Graph of results from AUC surveys at Chase River, 1993 (numbers of jack coho salmon versus time). Day 0 was 15 October 1993.

ESCAPEMENT CURVE

GRAPH INFO

FISH TYPE:
ADULT COHO

SIS METHOD

AUC:
880

ESCAPEMENT
ESTIMATE:
99

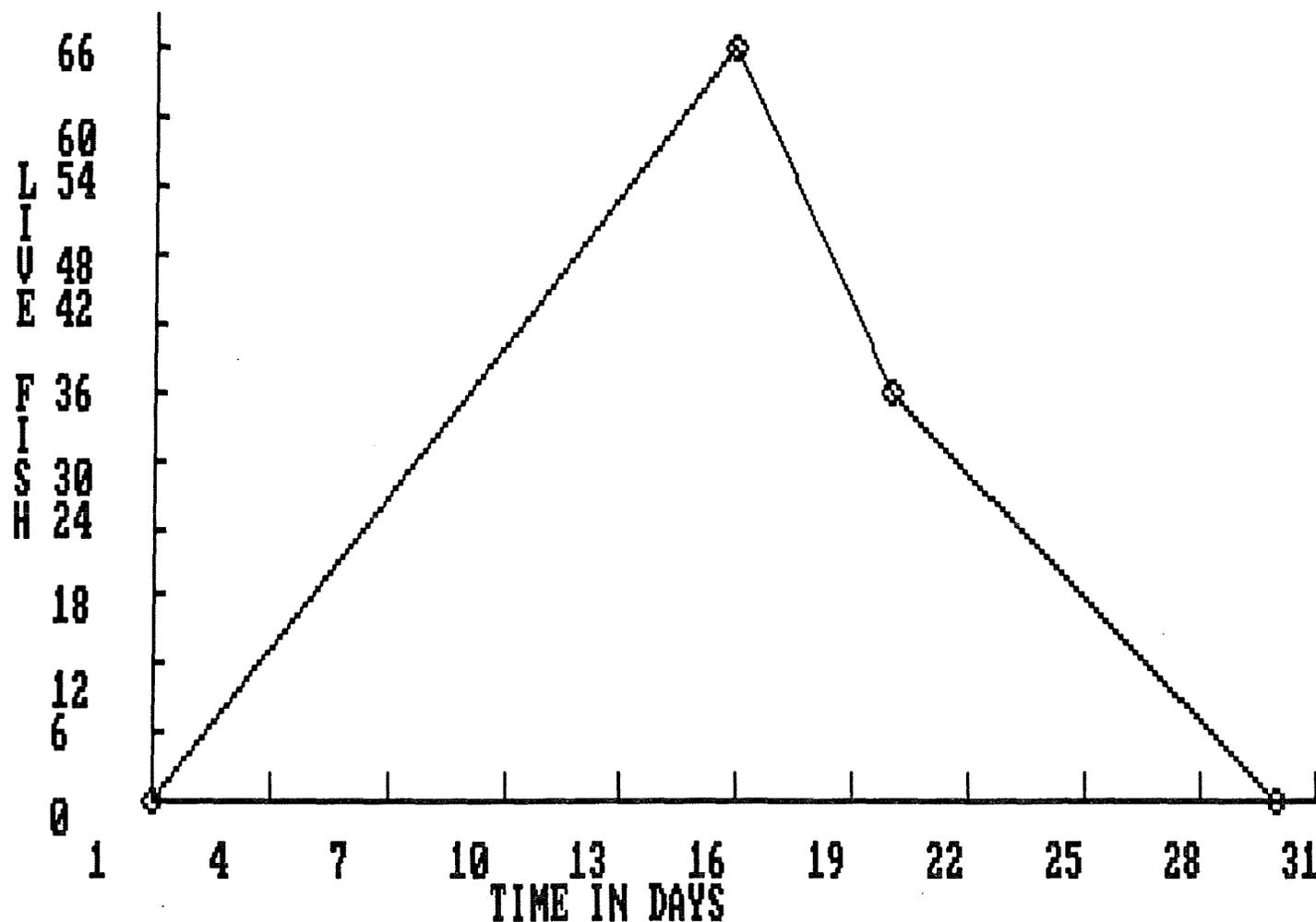


Figure 7. Graph of results from AUC surveys at Beck Creek, 1993 (numbers of adult coho salmon versus time). Day 0 was 2 December 1993.