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ESCAPEMENT ENUMERATION STUDIES OF ADULT COHO SALMON AT ZOLZAP CREEK, B.C., 1992

prepared by

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ABSTRACT

Nass, B. L. 1996. Escapement enumeration studies of adult coho salmon at Zolzap Creek, B.C., 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2374: viii + 30 p.

Adult coho escapement to Zolzap Creek, British Columbia, was monitored as part of the 1992-1993 Nisga'a Interim Measures Program. An aluminum conduit fence was used to enumerate and mark coho and upstream mark-recapture surveys were conducted to produce escapement estimates. The counting fence was operational between 8 September and 9 October. Mark-recapture surveys were conducted on 1 and 15 November. Estimated coho escapement was 1,561 adults and 270 jacks using the adjusted Petersen model. Age and length characteristics of adult males, females, and jacks were described.

RÉSUMÉ

Nass, B. L. 1996. Escapement enumeration studies of adult coho salmon at Zolzap Creek, B.C., 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2374: viii + 30 p.

Les taux d'échappement des saumons cohos adultes dans la rivière Zolzap Creek, en Colombie-Britannique, ont été observés dans le cadre du Programme de mesures provisoires 1992-1993 des Nisga'a. Une barrière de comptage en aluminium a été utilisée pour recenser et marquer les spécimens de cohos, et des opérations de récupération des spécimens marqués ont été effectuées en amont pour établir les taux d'échappement. La barrière de comptage a été fonctionnelle du 8 septembre au 9 octobre. La récupération des spécimens marqués s'est faite le 1er et le 15 novembre. Les chiffres d'échappement établis à l'aide du modèle de Peterson modifié sont de 1 561 pour les adultes et de 270 pour les jeunes mâles précoces. Le rapport d'étude décrit les caractéristiques d'âge et de taille pour les adultes mâles et femelles et pour les jeunes mâles précoces.

INTRODUCTION

As part of an agreement between the Nisga'a Tribal Council and the Canadian Government, an Interim Measures Program (IMP) was established in 1992 for fisheries research in the Nisga'a Land Claim Area, British Columbia. One component of this large research initiative focused on the assessment of adult coho (*Oncorhynchus kisutch*) escapement in Zolzap Creek, a tributary to the Nass River.

Estimation of escapement levels, harvest levels, and stock recruitment relationships of salmon are essential for establishing proper management plans. This has been a difficult task for coho salmon since there are approximately 1,000 discrete wild stocks in B.C. (Aro and Shephard 1967) and it is impractical to monitor each population. To circumvent this problem, it has been suggested that coho populations of a few streams be intensively studied to determine if one coho stock in a defined geographical area can be used as an indicator stock for nearby stream populations (Symons and Waldichuk 1984; Walters 1984). These indicator streams could then be monitored for escapement levels, smolt production, harvest contributions, and more reliable stock-recruitment relationships would be developed.

Accurate escapement estimates of coho do not exist for any tributary of the Nass River. Estimates of escapement to Zolzap Creek have been recorded (L. Jantz, Dept. of Fisheries and Oceans, Prince Rupert, B.C., unpubl. data); however, the accuracy of the data is limited by the estimation methodologies (Cousens et al. 1982). Foot surveys have been conducted on Zolzap Creek by McDame (1985) and Bustard (1992), but they present observed spawners rather than total system escapement estimates.

In the spring of 1992, juvenile coho smolts leaving Zolzap Creek were enumerated and coded-wire tagged (Nass 1996). The 1992 escapement of jack returns was monitored for adipose clips which would indicate the presence of a coded-wire tag (CWT).

The objectives of this research were to:

1. Estimate the escapement of coho to Zolzap Creek;

2. Document the timing, size, sex, maturation, and age distribution of the escapement; and

3. Monitor the escapement for marked (CWT) jack coho.

Achievement of these objectives involved the construction and operation of an aluminum panel fence located approximately 0.5 km upstream of the mouth of Zolzap Creek and conducting mark-recapture surveys at known spawning locations. Further details are presented in the methods section.

STUDY STREAM

Zolzap Creek is a tributary to the Nass River, located in northwestern British Columbia, Canada (Fig. 1 and 2). Zolzap Creek flows for 6 km in a northwesterly direction between Nisga'a Lava Beds Memorial Park and the Kitimat Range, to its confluence with the Nass River, 5 km downstream of Gitwinksihlkw. The lower 0.5 km of the creek regularly becomes inundated when water levels on the Nass River are high. Zolzap Creek supports many species of salmonids including coho, pink (*Oncorhynchus gorbuscha*), chum (*O. keta*), sockeye (*O. nerka*), steelhead (*O. mykiss*), cutthroat (*O. clarki*), and Dolly Varden (*Salvelinus malma*). Mean adult escapement estimates of coho, pink, and chum for the period 1980-1988 are 581, 483, 209, respectively (L. Jantz, Dept. of Fisheries and Oceans, Prince Rupert, B.C., unpubl. data).

METHODS

PHYSICAL OBSERVATIONS

Crews monitored water temperatures, water levels, and weather conditions daily. A maximum-minimum thermometer ($\pm$ 0.25° C) was used to measure fluctuations in temperature over 24 h. Water levels were monitored using staff gauges calibrated to the nearest 0.5 in. (subsequently converted to metric). Gauges were located within 50 m of the trapping site. Weather (rain index) was recorded on a scale of 0 to 5 with 0 representing no precipitation and 5 being heavy precipitation.

POPULATION ESTIMATES

Fence Enumerations

A semi-permanent aluminum conduit fence anchored to a sill was constructed at Zolzap Creek (Figure A-1 to A-4). Spacing between conduit measured 0.5" and was designed to stop adults. The panels were supported by A-frame type towers anchored to the sill. Two trap boxes, each 4' x 6' x 6', were installed over 16' chutes built into the sill. The fence spanned 90' between abutments. All salmonids caught at the fence were counted. Coho were classified by sex as males, females, or jacks. Sex was distinguished on the basis of length and body morphology. Crews were instructed to use 35 cm to distinguish male coho from jacks (all male coho less than 35 cm were classified as jacks). Coded-wire tag analysis for coho at Black Creek and French Creek, Vancouver Island, suggested 35 cm to be the most appropriate length to differentiate between adult and jack coho (Bocking et al. 1992; Nass et al. 1993). Each coho was hole punched on the operculum and examined for an adipose fin clip or tags that would be associated with coded-wire tagging or mark-recapture studies taking place on the Nass River, respectively. All coho were released upstream of the fence. During regular fence cleaning operations, crews also recorded the number of fish dead-pitched, by species.

Mark-recapture Estimates

Coho were recovered in upstream surveys by electrofishing and netting. Survey sites (Fig. 3) were chosen based on spawner distribution determined from independent visual foot surveys (Bustard 1992) and knowledge of local Nisga'a staff. We generated a mark-recapture estimate of the spawning population using the adjusted Petersen model (Ricker 1975). Biases in the estimate can occur when the assumptions of the model are violated (Cousens et al. 1982, Labelle 1990). The relevant assumptions of the model are:

1. Marked fish suffer the same natural and fishing mortality as the unmarked fish. Increased mortality of marked fish due to marking and handling would cause an overestimate of the population;

2. Marked fish do not lose their mark and marks are recognized and recorded upon recovery. The loss of marks from a population or not observing marks upon recapture would cause an overestimate of the population; and

3. Marks are applied randomly over the entire run and recovery effort is applied to the same population that was marked (i.e., there is a negligible influx of fish into the capture population after the conclusion of marking), and/or marked fish become randomly mixed with unmarked fish and each have equal probability of capture. Nonproportional marking or lack of mixing of marked and unmarked fish could bias the population estimate.

We assess our marking program relative to these assumptions in the Discussion.

AGE, LENGTH, AND SEX COMPOSITION

All live coho captured at the fence were measured for postorbital-hypural length and examined for sex and maturity. Maturity of each coho was also noted according to the following scale: 1 = silver bright, 2 = secondary spawning characteristics beginning to form, 3 = secondary characteristics well formed, 4 = ripe (full bellies), 5 = spawning, 6 = spent, and 7 = carcass. Crews attempted to sample at least 25 coho a day for scales (2 scales per fish). The actual number of samples was more or less depending migrations and logistics. Scale samples were interpreted by the Canada Department of Fisheries and Oceans Scale Lab, Vancouver, B.C. Secondary quality control checks were performed to ensure reliability of the age designations. Scale ages are reported in Gilbert-Rich notation where freshwater age 2 coho (having survived two winters from egg deposition) have a single freshwater annulus. Sex ratios were calculated from total fence captures. Mean lengths were calculated for adult males, adult females, and jacks.

CODED-WIRE TAG RECOVERIES

Coho smolts at Zolzap Creek were coded-wire tagged in the spring of 1992 during their migration (Nass 1996). Coded-wire tagged smolts were adipose fin clipped (AFC) prior to release for future identification. Only CWT recoveries for jack coho were anticipated.

RESULTS

PHYSICAL OBSERVATIONS

Water level was steady from early September to mid-September until heavy rainfall caused intermittent flooding into early October (Fig. 4). Zolzap Creek rose at least 1.2 m from its minimum level and topped the fence panels by at least 0.2 m. The water level gauge became inaccessible on 30 September. Water velocity decreased to a negligible rate as it rose above the fence and applied little pressure to the fence structure. Water temperatures ranged from a maximum of 10.0° C on 10 September to a minimum of 5.0° C on 7 October.

POPULATION ESTIMATES

Fence Enumerations

The fence at Zolzap Creek was operated from 8 September to 9 October. Operation was interrupted on 30 September due to flooding and on 8 October due to a large hole in the sill caused by erosion. Finally, continued erosion to the sill caused unrepairable damage on 10 October and the fence structure was removed. An unknown number of coho moved past the fence during these times. Hence, it was not possible to obtain a complete count for adult or jack coho.

A total of 691 adult and 80 jack coho were counted at the fence (Table 1). Of these, 666 adults and 80 jacks were operculum punched and released upstream. Adult fish migrated upstream past the fence in 2 major pulses (Fig. 5). Maximum migration past the fence reached 130 adults and 23 jacks on September 22, the second day of recorded coho catch.

For non-coho species captured at the fence, pink salmon had the greatest abundance (115), followed by chum (30), and sockeye (4). Cutthroat trout (17), Dolly Varden (9), and steelhead (5) were also captured. Pink and chum salmon were caught in their greatest numbers between 8 September and 12 September (the first 5 d of fence operation) and observed passing the fence site prior to complete installation. All other species were caught primarily in the last week of September and the first week in October. An unknown number of fish migrated upstream after the fence was removed.

Mark-recapture Estimates

A total of 123 adult coho and 19 jack coho were examined in upstream mark-recapture surveys conducted at four different sites on the creek (Table 2). Of these, there were 52 punched adults and 5 punched jacks. An estimated 1,561 adults and 270 jacks escaped to Zolzap Creek in 1992 (Table 3).

AGE, LENGTH, AND SEX COMPOSITION

A total of 239 coho were sampled for scales, of which 128 were successfully aged (Table 4). Unaged samples included 87 freshwater regenerates, 21 marine regenerates, and 3 that were unreadable. Adult coho had a similar freshwater age composition (79.0% age 2 and 21.0% age 3) with jack coho (77.8% age 2 and 22.2% age 3). All successfully aged samples were marine age 1.

Mean lengths of adult males, females and jacks were 48.6 cm (n=257, SD=8.9), 54.4 cm (n=230, SD=6.4), and 29.8 cm (n=35, SD=3.4), respectively. Female coho were significantly larger than adult male coho (t-test, $p < 0.001$).

Adult male coho were widely distributed over the range of 35 cm to 69 cm with the highest representation in the 42 cm and 56 cm size classes (Fig. 6). Jack coho were most abundant in the 32 cm size class. Female coho were uniformly distributed around 56 cm with a range of 33 cm to 72 cm.

Adult males captured at the fence (n=391) were significantly more abundant than females (n=300) (χ^2 test, $p < 0.001$). Jack coho (n=80) increased the ratio of male to female spawners from 1.3 to 1.6.

CODED-WIRE TAG RECOVERIES

Coho smolts at Zolzap Creek were coded-wire tagged in the spring of 1992 during their migration (Nass 1996) and, therefore, the only anticipated CWT recoveries were for jack coho. Crews did not observe any adipose clipped coho during this study; however, the total sample size of jacks (n=80) was relatively small. Based on this information, we assume that the contribution of 1992 CWT smolts to the Zolzap coho salmon escapement was nil.

DISCUSSION

POPULATION ESTIMATES

Adult coho accounted for 85.3% of the estimated total escapement of coho to Zolzap Creek. Jack coho were represented by the remaining 14.7%. The observed contribution of jack coho to total escapement observed at Zolzap Creek was substantially lower than that observed at some Vancouver Island streams (Table 5). However, as discussed later in the text, our estimate of jack coho escapement is unreliable.

Adult coho enumerated at the counting fence accounted for 44.2% of the Petersen population estimate. Therefore, 870 adults (55.8%) entered Zolzap Creek on 30 September and/or after 9 October. The fence count of jack coho was 29.6% of the Petersen estimate. The low percentage of jack captures could indicate that: 1) jack coho can slip through the fence panels and trap boxes, or 2) a significant migration of jack coho occurred after the fence was removed.

Mark-recapture estimates were derived using data from surveys conducted after the enumeration fence became inoperable (Table 2). We assess the reliability of our escapement estimates below by examining the potential for violation of the assumptions of the Petersen model.

1. Marked fish suffer the same natural and fishing mortality as the unmarked fish.

Fish handling procedures were developed to ensure minimal stress to passing fish. However, on occasion, vigorously moving fish would be mishandled and dropped unintentionally onto the fence decking causing possible injury and at least temporary shock. The degree to which this situation occurred was not quantified although crews indicate it was minimal (e.g., 10 times).

Sport fishing pressure and food fish harvesting is perceived to be minimal on Zolzap Creek and we see no reason why marked fish would be any more or less susceptible to any form of fishing pressure. The marks (operculum punches) are relatively conspicuous and should not effect the physiological condition of the fish.

2. Marked fish do not lose their mark and marks are recognized and recorded upon recovery.

Operculum punches are a form of marking which can be lost only through the degradation, or otherwise, removal of the operculum plate. There was no evidence of operculum loss during upstream surveys in which 142 coho were examined.

Stream surveys were conducted by at least three technicians and one experienced supervisor. Coho captured during surveys were examined carefully for the operculum punch and recorded simultaneously. Misidentification of marked and unmarked coho is unlikely given the relatively low number of fish examined and the conditions under which observations were made.

3. Marks are applied randomly over the entire run and recovery effort is applied to the same population that was marked (there is a negligible influx of fish into the capture population after the conclusion of marking), and/or marked fish become randomly mixed with unmarked fish and each have equal probability of capture.

Operculum punching of coho concluded on 9 October and upstream surveys were conducted on 1 and 15 November. The time period between tagging and recovery operations is long enough to provide for mixing of marked and unmarked fish and field observations suggest that the mix ratio observed was representative of the population. First, all coho examined in upstream surveys were healthy, vigorous, and actively spawning. There was no indication that marked and unmarked fish were at different stages of maturity (i.e., no carcasses were found). Secondly, crews surveyed four geographically separate sites during upstream surveys and found the composition of adult marked to unmarked fish to be consistent; unmarked fish ranged between 50% and 69% those examined (Table 2). Finally, a relatively high incidence of marked fish (adults) in the upstream surveys (52 marked out of 123 examined) was observed.

Procedures used during operations were designed to minimize the degree of violation of the Petersen model assumptions. However, since Petersen estimates tend to overestimate escapement (Cousens et al. 1982, Labelle 1990), we believe that the true escapement of adults to Zolzap Creek lies between the lower 95% confidence interval (1,195) and the Petersen estimate (1,561). According to procedures summarized in Ricker (1975), the number of jacks punched and the number of jacks recovered are too small to allow for the calculation of a population estimate that will deviate no more than 25% from the true value. The low number of jack recaptures is, in part, due to the relatively low number of marks applied and the low capture efficiency of electroshocking on jacks. Under these circumstances, our estimate of returning jacks is likely unreliable. The upper 95% confidence estimate of 623 jacks is likely more accurate than the Petersen estimate.

Our total escapement estimate of 1,831 coho to Zolzap Creek is substantially higher than any estimate by the Department of Fisheries and Oceans since it began recording in 1961. For the period 1980 to 1987, DFO estimates ranged between 150 and 1,000. Fishery officers generally conduct foot surveys to estimate escapement. This methodology, without a statistically valid sampling design, tends to be inaccurate and underestimate the total population. Low visibility of coho and limited creek access are often the major problems of the foot survey method (Cousens et al. 1982). Coho, in particular, can be especially hard to count because of their in-stream behaviour (cover orientated) and their migrations are often associated with fall freshets (Bocking et al. 1988, Irvine et al. 1992). Low sampling effort and unstandardized methods tend to make these DFO estimates more an index of abundance rather than estimates of escapement.

Fence operations at Zolzap Creek were terminated early in the migration period (9 October) due to severe erosion and damage to the fence structure. Typically, fence design focuses upon conditions at high water which may breach the top of a fence or destroy its structure with fast moving water. Water levels at Zolzap Creek varied dramatically during operation and allowed for evaluation of the fence structure under a wide variety of conditions. It was found that high water levels at Zolzap Creek were not a major problem to the fence structure or regular operations. High water topped the vertical panels for only one day during operations with no damage to the structure. However, low to medium water levels, coupled with organic debris, was the cause of substantial erosion and the eventual undermining of the sill.

AGE, LENGTH, AND SEX COMPOSITION

The freshwater age distribution of coho returning to Zolzap Creek in 1992 was substantially different from the age distribution observed in the migrating smolt population in 1992. Although the adult population age structure is not directly comparable, we expected the jack age structure to be similar. However, jack coho were 77.8% age 2 and 22.2% age 3 compared with the 1992 smolts which were 54.3% age 2 and 45.7% age 3 (Nass 1996). I consulted with the DFO Scale Lab in Vancouver (Camille Gosselin, pers. comm.) to assess potential reasons for the apparent discrepancy. The Scale Lab has found that the regeneracy rate of scales is approximately two times higher in freshwater age 3 coho compared to age 2. This observation is based on: 1) the high incidence of large scale growth in the freshwater area in a majority of regenerate coho scales, and 2) the high incidence of freshwater regenerate scales from coho known to be age 3 through coded-wire tag recoveries. Gosselin suggested using the 2 to 1 regenerate ratio to estimate an adjusted age composition. When this ratio is applied to the 108 regenerate samples, an additional 36 age 2 samples and 72 age 3 samples are obtained. The combined total of freshwater age 2 and 3 coho (using Table 4) is then 137 and 99, respectively. This results in an age composition for returning adult and jack coho of 58.1% age 2 and 41.9% age 3 which is more consistent to those observed in the 1992 smolt migration at Zolzap Creek. This issue requires further examination (analysis of 1993 juvenile and adult studies) and sampling procedures should be modified accordingly in future studies.

The observation that female coho were significantly larger than adult male coho at Zolzap Creek is consistent with observations at other systems (Table 6). Zolzap coho were similar in length to coho from some Vancouver Island streams.

Crews used a postorbital-hypural length of 35 cm to differentiate between adult males and jack coho. Coded-wire tag analysis for coho at Black and French creeks, Vancouver Island, supported previous findings which suggested 35 cm to be the most appropriate length to differentiate between adult and jack coho (Nass et al. 1993). Given ample recoveries, analysis of coded-wire tag data for the 1993 escapement should allow for testing the validity of applying this procedure to Zolzap Creek coho.

RECOMMENDATIONS

We propose the following recommendations for future operation of the Zolzap Creek adult enumeration fence.

1. Fence panels should be anchored to a crib type sill and large rock placed in the vicinity of the fence to alleviate erosion problems and allow for a complete season of operation;

2. Increase the rigidity of the trap box aluminum conduit by adding cross braces to decrease the potential for coho passing undetected. Assess need for wire jack panels;

3. Use numbered operculum tags for estimating spawner in-stream residence times from upstream surveys;

4. Increase the number of upstream surveys conducted and locations visited in anticipation of coded-wire tag recoveries and to better examine changes in opercular mark rates over time;

5. Increase the number of scales sampled from each fish (e.g., five) and collect scales from both sides of the fish to decrease the occurrence of regenerate scale samples; and

6. Collect otolith samples in conjunction with scale samples and coded-wire tag recoveries from carcasses during upstream surveys to examine the relationship between freshwater age and scale regeneration.

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TABLES

Table 1. Zolzap Creek fence counts of adult and jack coho, 1992.

	Adults		Jacks	
Date	No. examined	No. punched	No. examined	No. punched
21 Sep	30	27	0	0
22 Sep	130	108	23	23
23 Sep	107	107	13	13
24 Sep	72	72	13	13
25 Sep	55	55	3	3
26 Sep	51	51	6	6
27 Sep	20	20	2	2
28 Sep	24	24	0	0
29 Sep	23	23	6	6
30 Sep	-	-	-	-
01 Oct	14	14	4	4
02 Oct	5	5	0	0
03 Oct	9	9	0	0
04 Oct	26	26	5	5
05 Oct	36	36	1	1
06 Oct	48	48	1	1
07 Oct	10	10	0	0
08 Oct	-	-	-	-
09 Oct	31	31	3	3
Total	691	666	80	80

Table 2. Upstream mark-recapture effort and catch of adult and jack coho, Zolzap Creek, 1992.

		Adults					Jacks				
		punched		no punch			punched		no punch		
Date	Location a	No.	%	No.	%	total	No.	%	No.	%	total
1-Nov	3 (S2)	5	31	11	69	16	0	0	2	100	2
15-Nov	1 (D1)	2	50	2	50	4	0	0	2	100	2
	2 (S1)	28	41	41	59	69	5	50	5	50	10
	4 (S5)	17	50	17	50	34	0	0	5	100	5
	Total	52	42	71	58	123	5	26	14	74	19

[a] see Fig. 3; locations in parenthesis are observed spawning areas described in Bustard (1992).

Table 3. Petersen population estimates, confidence limits, and mark-recapture data for adult and jack coho escapement at Zolzap Creek, 1992.

Item	Adults	Jacks	Total
Number coho operculum punched	666	80	746
Number coho recovered	123	19	142
Number of punched coho recovered	52	5	57
Petersen estimate	1561	270	1831
Upper 95% CL	2035	623	2658
Lower 95% CL	1195	128	1323

Table 4. Freshwater age distribution of adult and jack coho at Zolzap Creek, 1992.

Sex	Age 2		Age 3		Total aged	Total unaged	Total sampled
	No.	%	No.	%			
Jacks	7	77.8	2	22.2	9	11	20
Adult males	33	80.5	8	19.5	41	36	77
Adult females	61	78.2	17	21.8	78	64	142
Total adults	94	79.0	25	21.0	119	100	219

Table 5. Escapement composition of returning adult and jack coho for Zolzap Creek and other west coast streams (based on population estimates).

System	% Adults	% Jacks
Zolzap Creek	85	15
Black Creek, 1990 [a]	38	62
French Creek, 1990 [a]	48	52
Trent River, 1990 [a]	90	10
Lachmach River, 1990 [b]	71	29

[a] Nass et al. 1993

[b] Davies 1991

Table 6. Mean length of returning adult and jack coho for Zolzap Creek and other west coast streams.

System	Mean post-orbital hypural length (cm)		
	Males	Females	Jacks
Zolzap Creek	48.6	54.4	29.8
Black Creek, 1990 [a]	47.5	51.6	28.6
French Creek, 1990 [a]	44.1	46.7	26.2
Trent River, 1990 [a]	47.6	49.8	28.7

[a] Nass et al. 1993

FIGURES

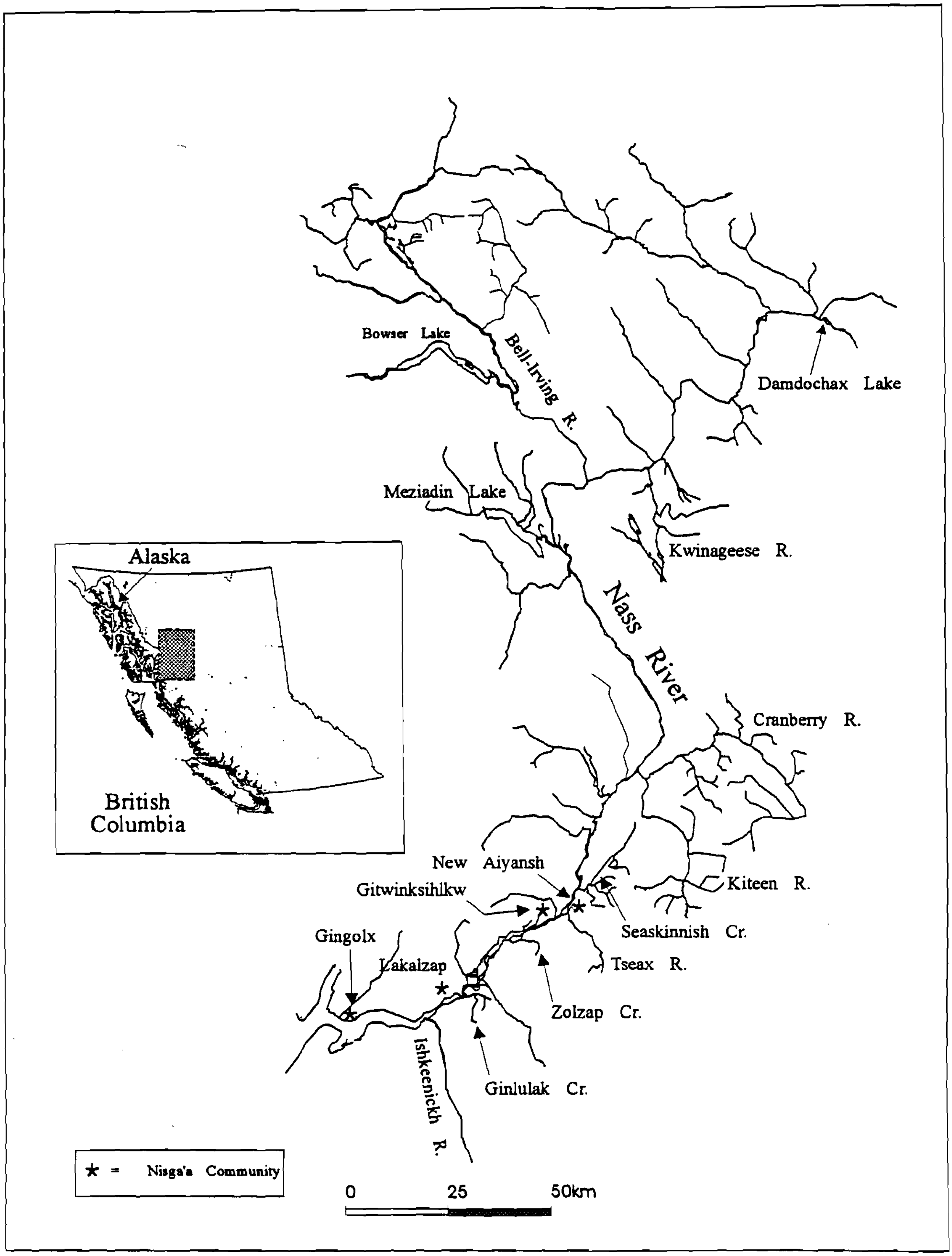


Figure 1. The Nass River watershed, British Columbia.

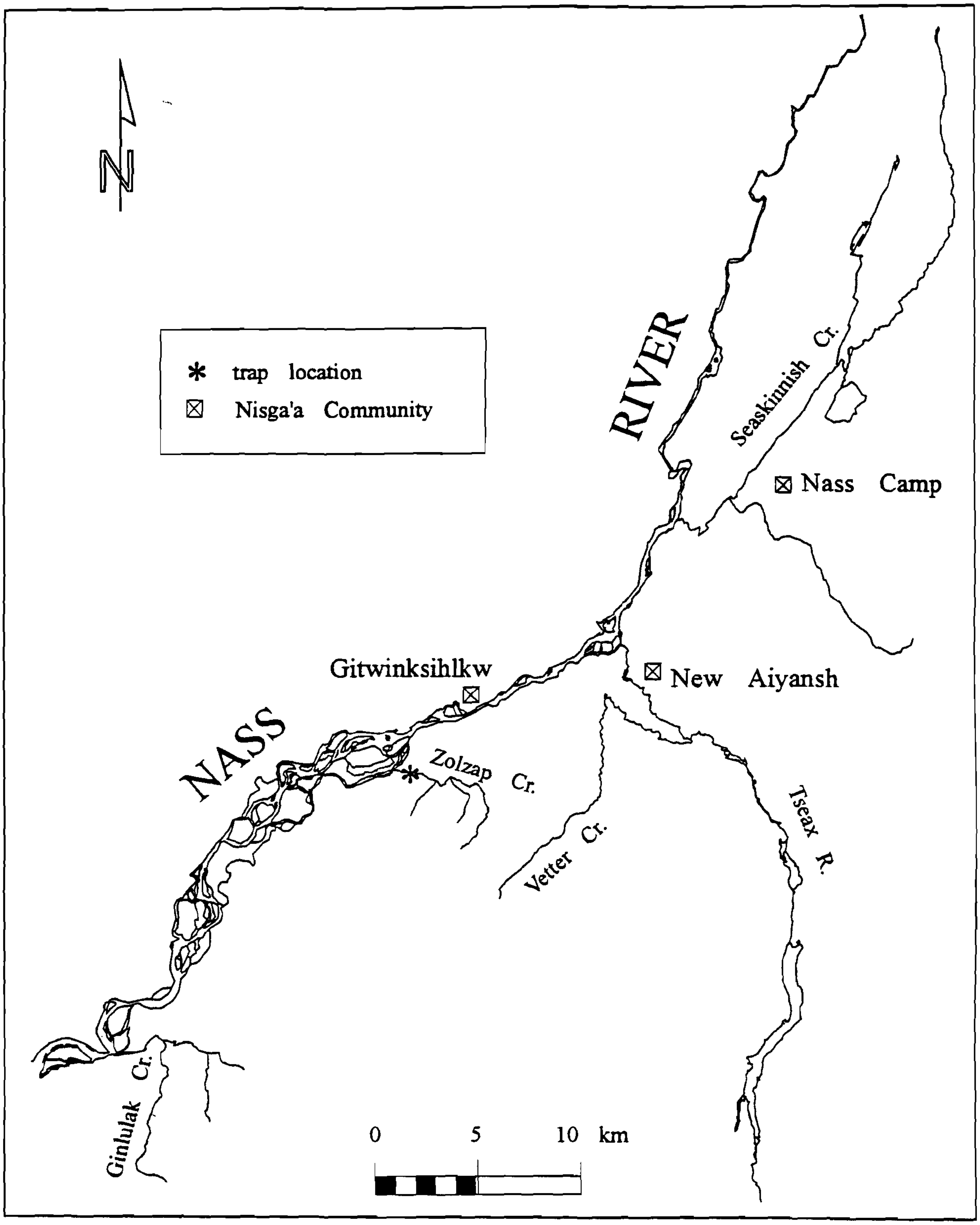


Figure 2. Zolzap Creek and location of adult enumeration fence.

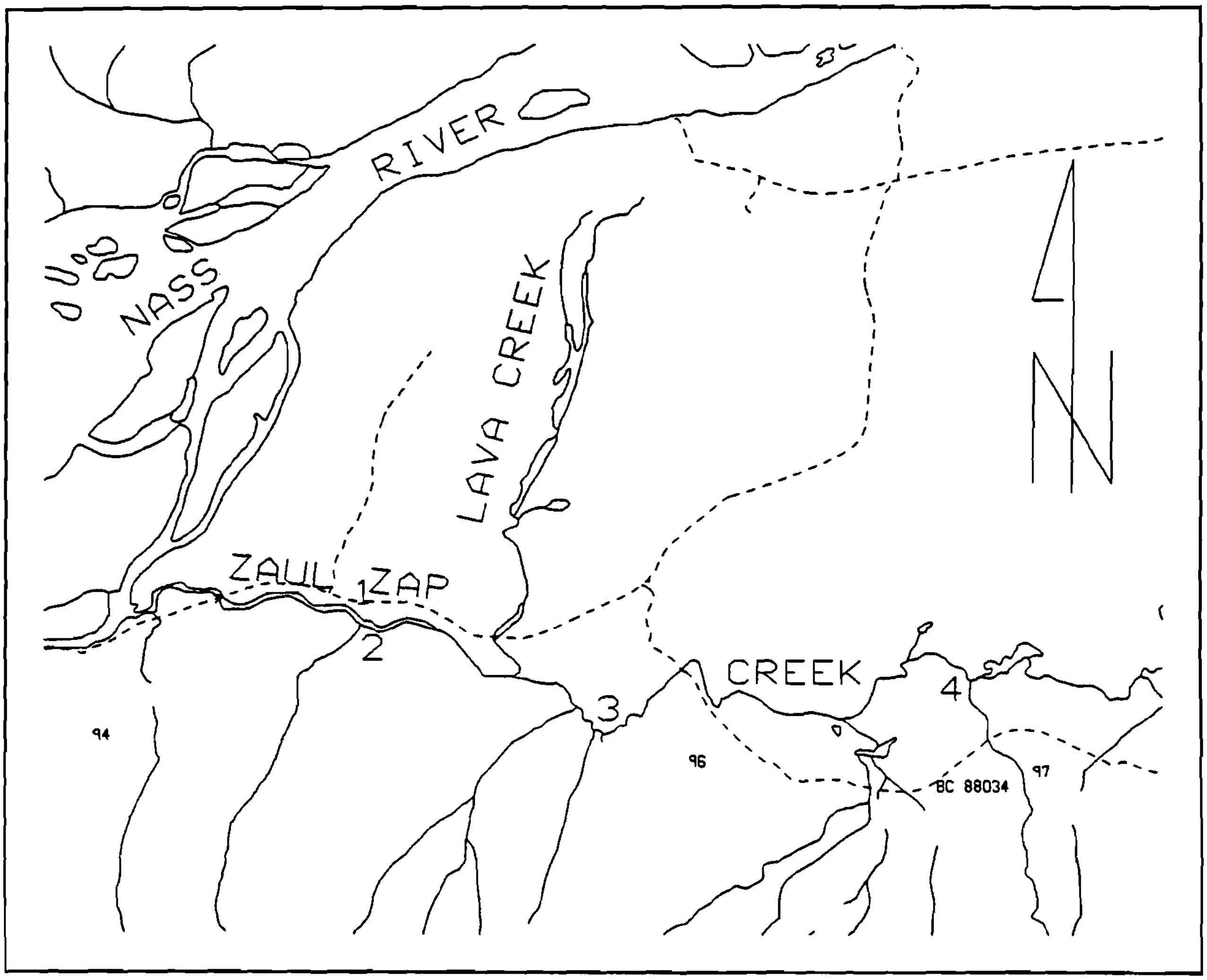


Figure 3. Zolzap Creek and upstream mark-recapture survey sites.

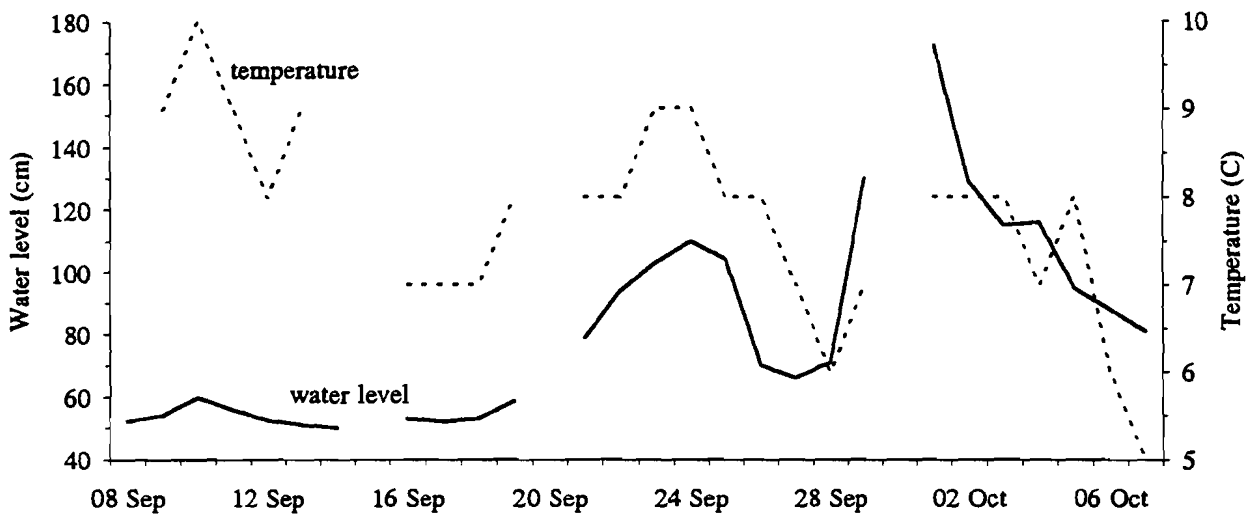


Figure 4. Water level and temperature for Zolzap Creek, 8 September to 7 October, 1992.

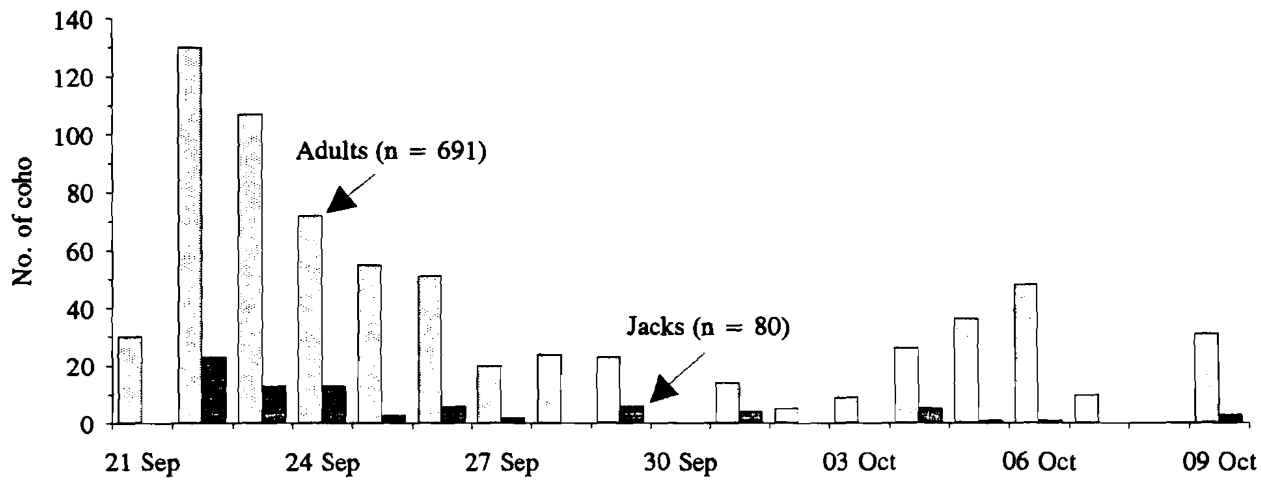
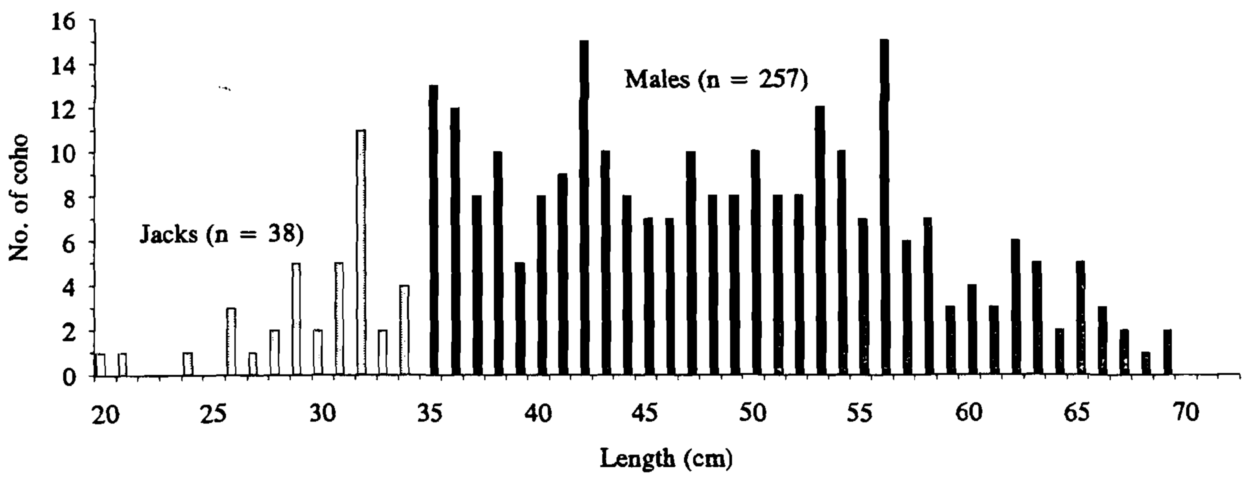


Figure 5. Daily fence counts of adult and jack coho at Zolzap Creek, 1992.



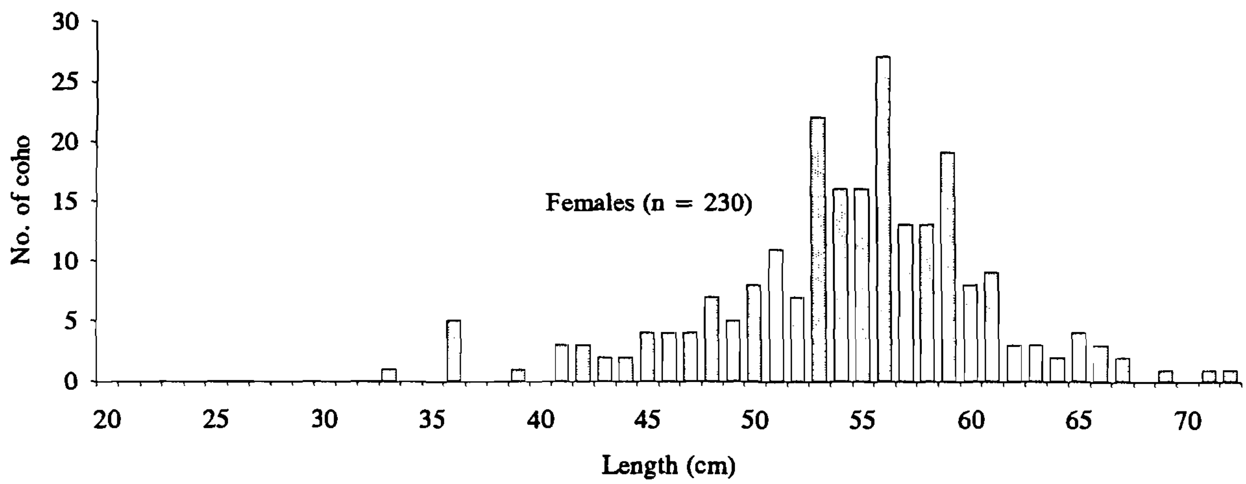


Figure 6. Length-frequency for adult and jack coho at Zolzap Creek, 1992.

APPENDICES

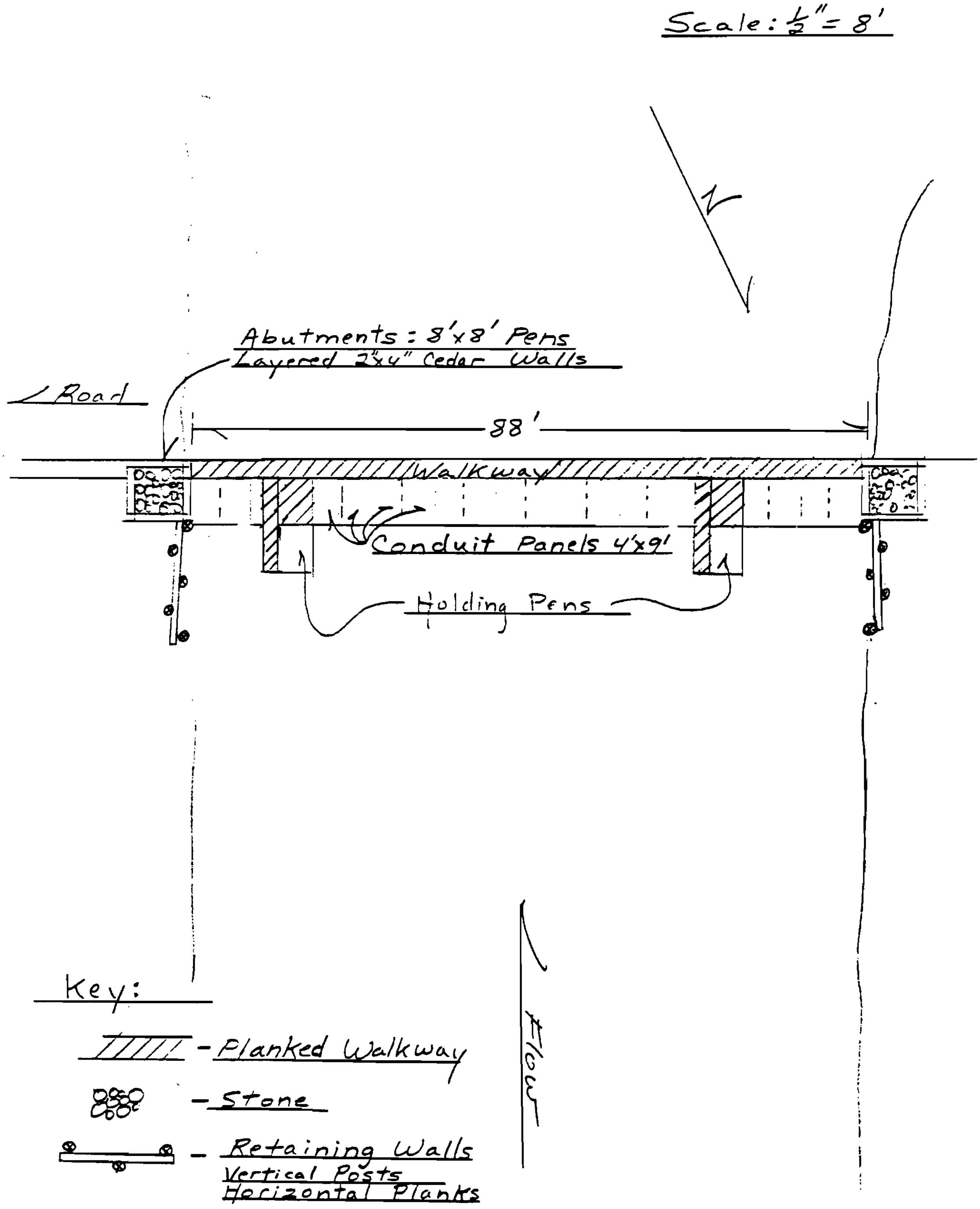


Figure A-1. Zolzap Creek fence layout.

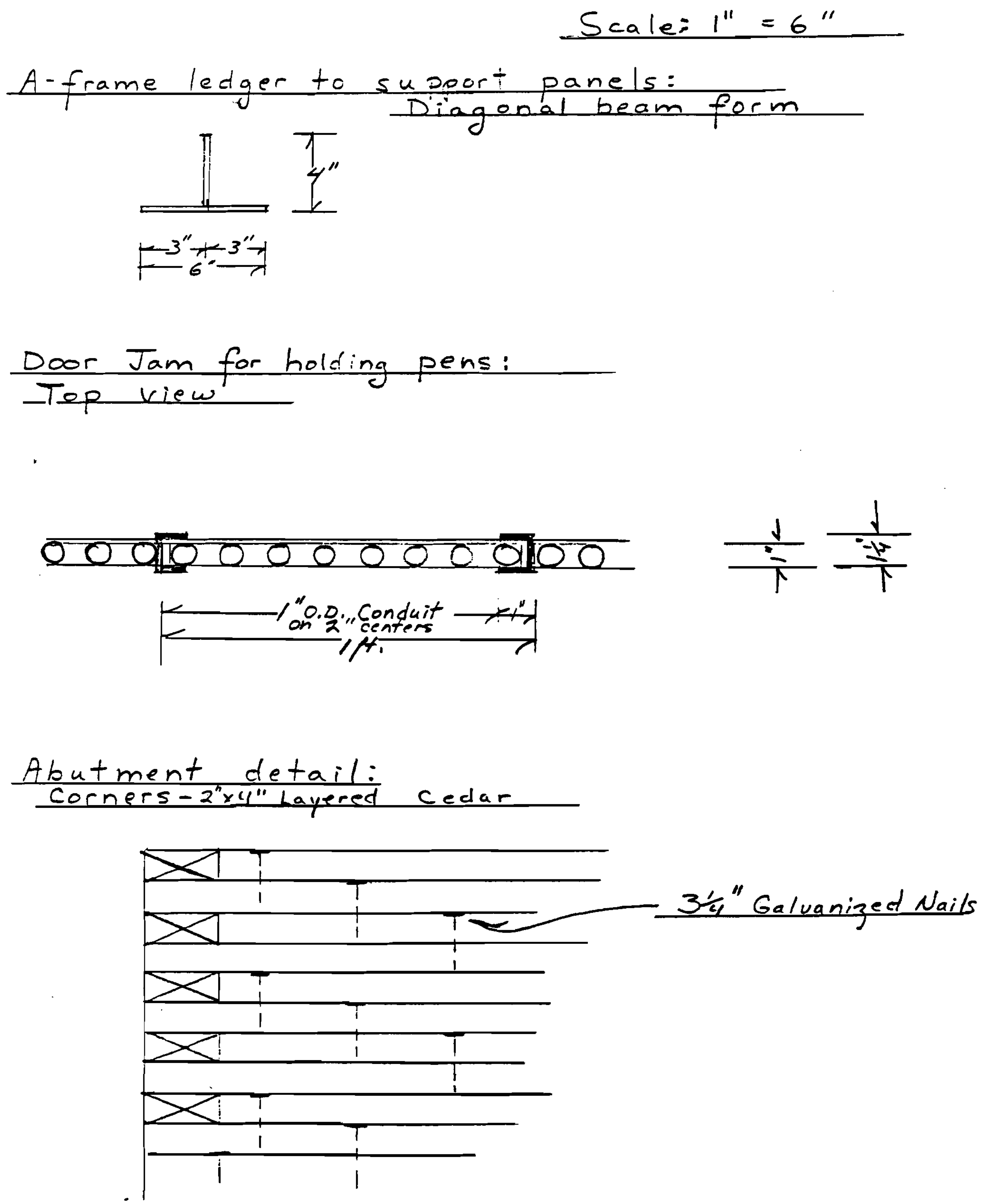


Figure A-2. Zolzap Creek fence construction details.

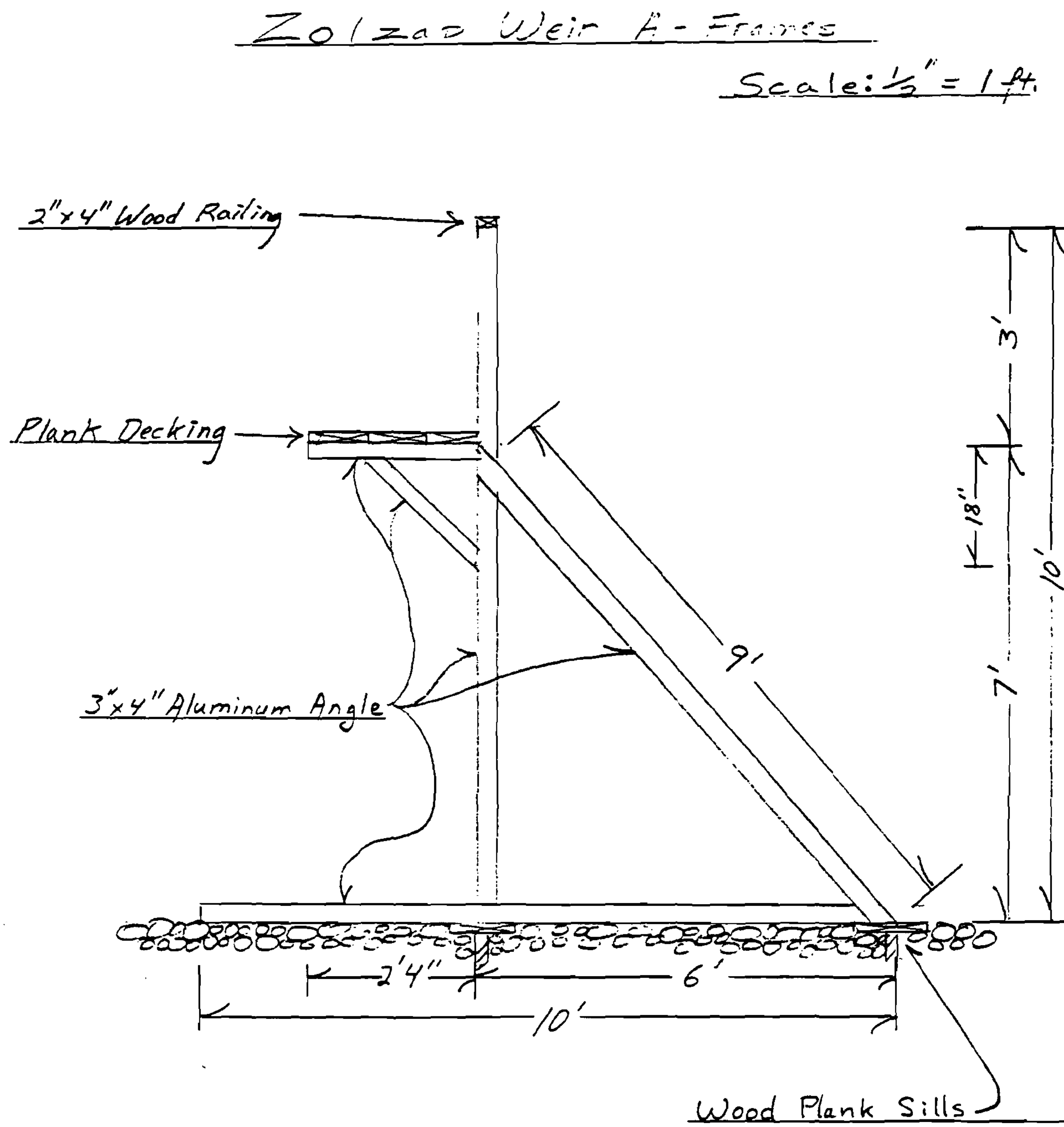


Figure A-3. Zolzap Creek fence A-frames.

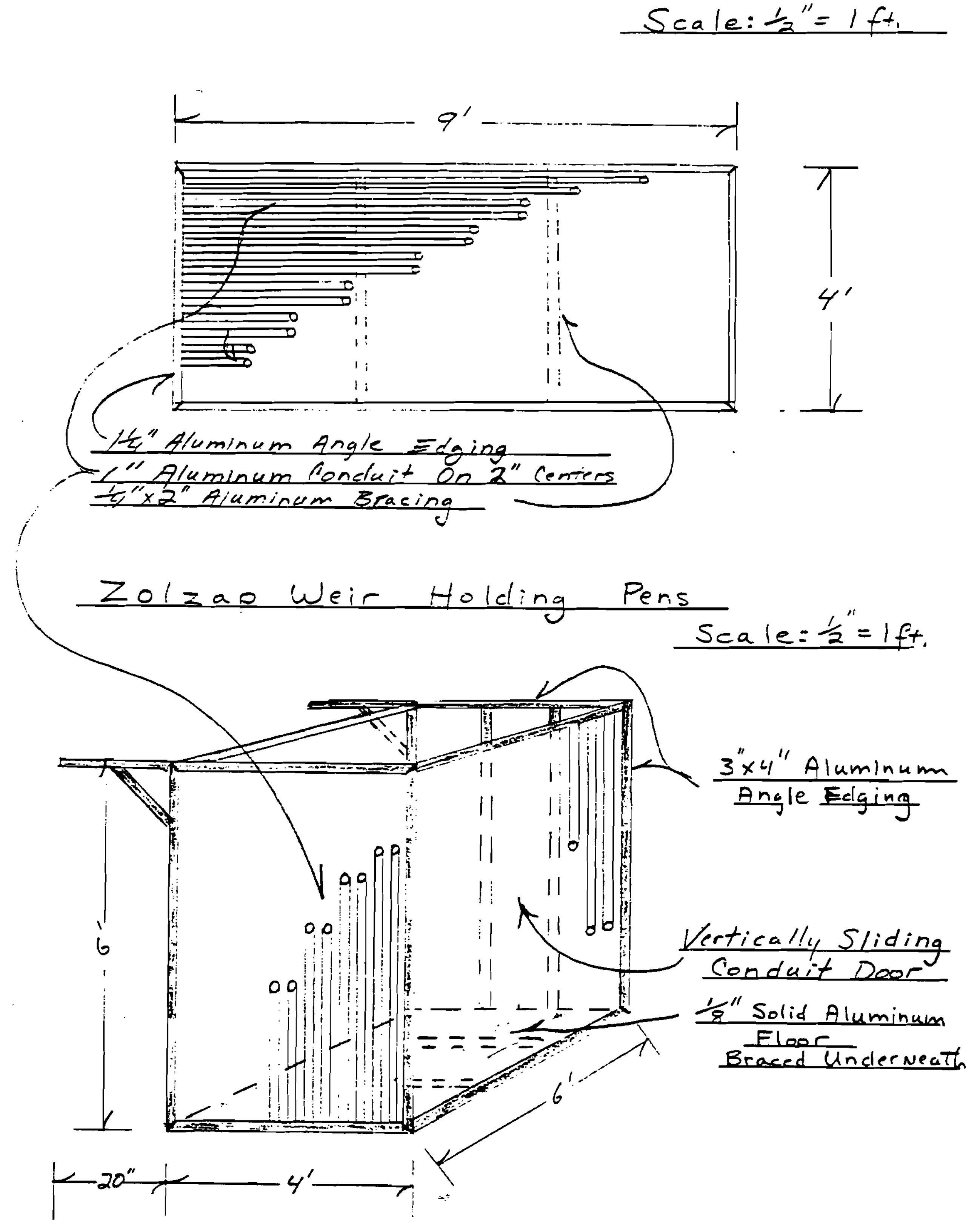


Figure A-4. Zolzap Creek interchangeable panels.