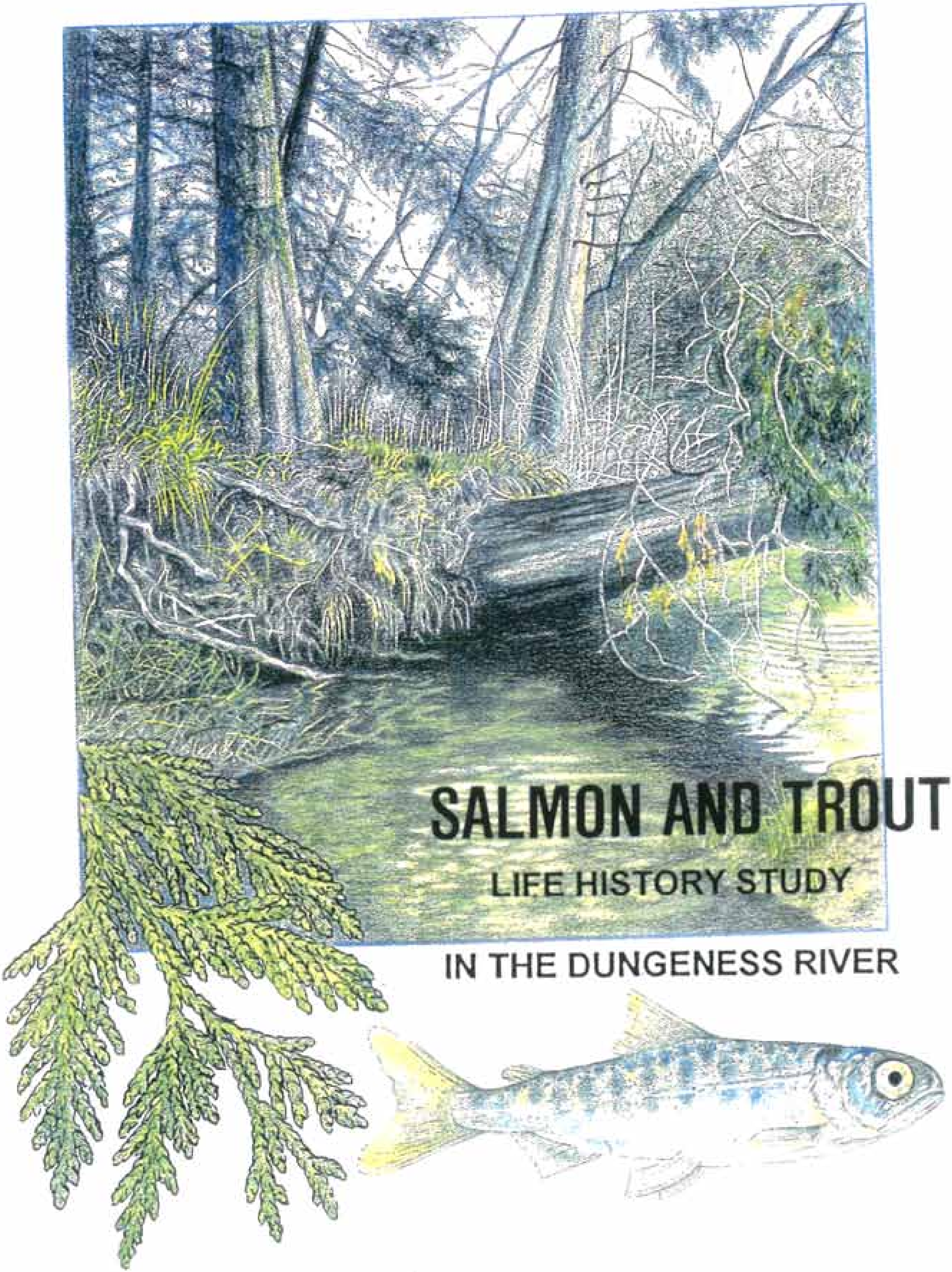


SALMON AND TROUT

LIFE HISTORY STUDY

IN THE DUNGENESS RIVER

SALMON AND TROUT

LIFE HISTORY STUDY

IN THE DUNGENESS RIVER

by

Ron Hirschi
Consulting Habitat Biologist
P.O. Box 899
Hadlock, Washington 98339

and

Mike Reed
Project Manager and Habitat Biologist
Jamestown S'Klallam Tribe
1033 Old Blyn Highway
Sequim, Washington 98382

1998

LIFE HISTORY STUDY IN THE DUNGENESS WATERSHED

Seasonal Life History (Distribution and Use) Of Native Salmonids in the Dungeness River, Washington

By Ron Hirschi
Consulting Habitat Biologist
P.O. Box 899
Hadlock, Washington 98339

and

Mike Reed
Project Manager and Habitat Biologist
Jamestown S'Klallam Tribe
1033 Old Blyn Highway
Sequim, Washington 98382

Prepared for The Jamestown S'Klallam Tribe

Under Contract No. X990696-01-0 from the EPA

The Tribe's Objectives:

1. To identify seasonal use patterns for salmon and trout within the Dungeness basin. Special emphasis on critical stocks of pink and chinook salmon.

2. Determine habitat types playing a role in survival from one life history stage to the next.

3. Use information to focus restoration efforts removing bottlenecks to survival so that the current chinook and pink stock recovery plans are successful. Of particular importance is the use of life history information to formulate a release strategy for captive broodstock progeny.

About the Cover Illustration

The illustration is of a juvenile chinook with an alcove pool along the river as background. The drawing is based on a photo of this alcove that is located at the tail end of Gagnon Side Channel at River Mile 3.25. The pool held chinook throughout the winter of 1997-98.

CONTENTS

DISCUSSION:

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The life history study began as a result of several concerns, including identification of production bottlenecks by Lichatowich (1993) and Orsborn and Ralph (1994). These authors have pointed out the needs for a study of juvenile salmon and their uses of freshwater habitats.

Additional interests focus on the ongoing and adaptive restoration projects in the watershed. These include the release in 1997 of 1,774,736 marked chinook fry from the broodstock program and an additional 2,419,521 marked and unmarked chinook in 1998. Reporting on the presence of these fish as well as wild chinook is a major aspect of our study. Sampling efforts are designed to identify habitat use and duration of juvenile chinook presence in the river.

Log structures are being placed in the river for several reasons, including fish habitat restoration. Our sampling includes investigation of juvenile fish use of these newly placed features. Additionally, we measured habitat features in our sample areas to help ongoing efforts aimed to restore river dynamics identified by the Dungeness River Restoration Group (Dungeness River Restoration Group 1997).

Depressed stocks of chinook and pink salmon were major concerns at the beginning of this study. While our efforts aim to report from a community perspective, including juvenile pink salmon, most of our efforts focused on salmonids with a longer river residence time. Coho and trout were sampled with interest in their populations and their potential interactions with broodstock release and wild emerging chinook. The overall hope is to better understand the life history of each species - information vital for successful watershed management (Mobrand et al 1997).

STUDY AREA

Sample sites were chosen at the beginning of the study in both the upper and lower watershed. Access was a consideration, but we were primarily interested in locating habitats that reflected, as much as possible, the diversity within mainstem, braided mainstem, and side channels in both the upper and lower river.

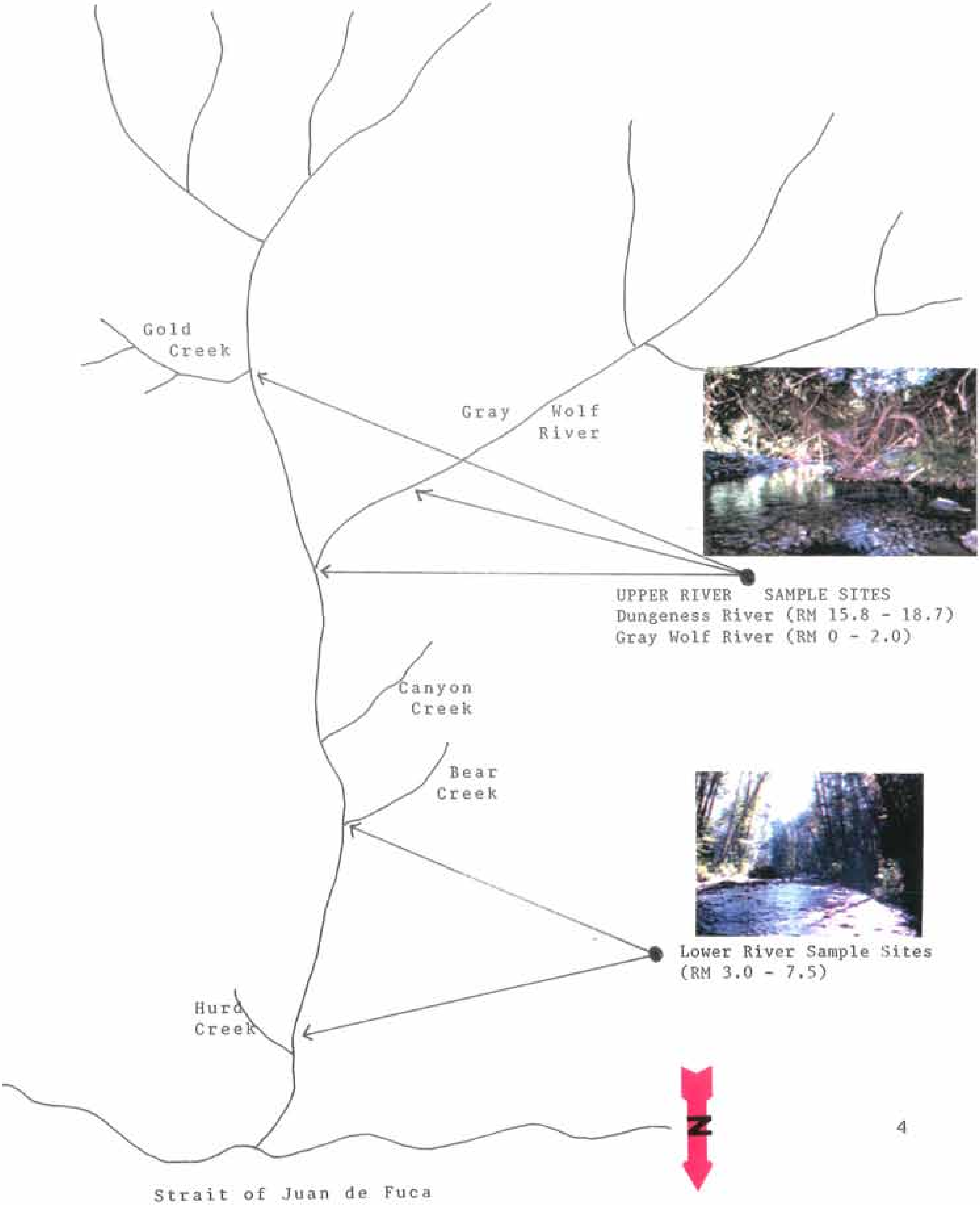
We were also interested in sampling above and below chinook broodstock releases. The upper limits of these plants were at the Gold Creek Bridge on the Dungeness (RM 18.7) and at an acclimation pond located just downstream from the Gray Wolf Bridge on the Gray Wolf River (RM 1.2).

Lower river sites were chosen in part because of generous permission on the part of property owners. Sites included river reaches with intact riparian woodlands surrounding both mainstem and off channel habitats. As the study progressed, we expanded our sampling efforts to include previously unknown off channel habitats.

The general locations of our sample areas are presented in Figure 1. Lower river sites are between RM 3.0 and RM 7.5, while upper watershed sites are between RM 15.8 and RM 18.7 on the Dungeness and RM 0 - 2 on the Gray Wolf. A few samples were taken above and below these points, but the majority of the information presented is within these boundaries.

FIGURE 1

DUNGENESS WATERSHED STUDY AREAS



SAMPLE AREAS

Four general areas in the lower river were chosen as sample sites. Each was centered around a side channel with relatively intact riparian habitat, but mainstem and braided channels within each area were also sampled. Figure 2 shows map locations of these sites that we have named to ease discussion:

1) GAGNON SIDE CHANNEL (RM 3.25 - 4.0)

2) WEST RAILROAD BRIDGE SIDE CHANNEL (RM 5.6 - 6.4)

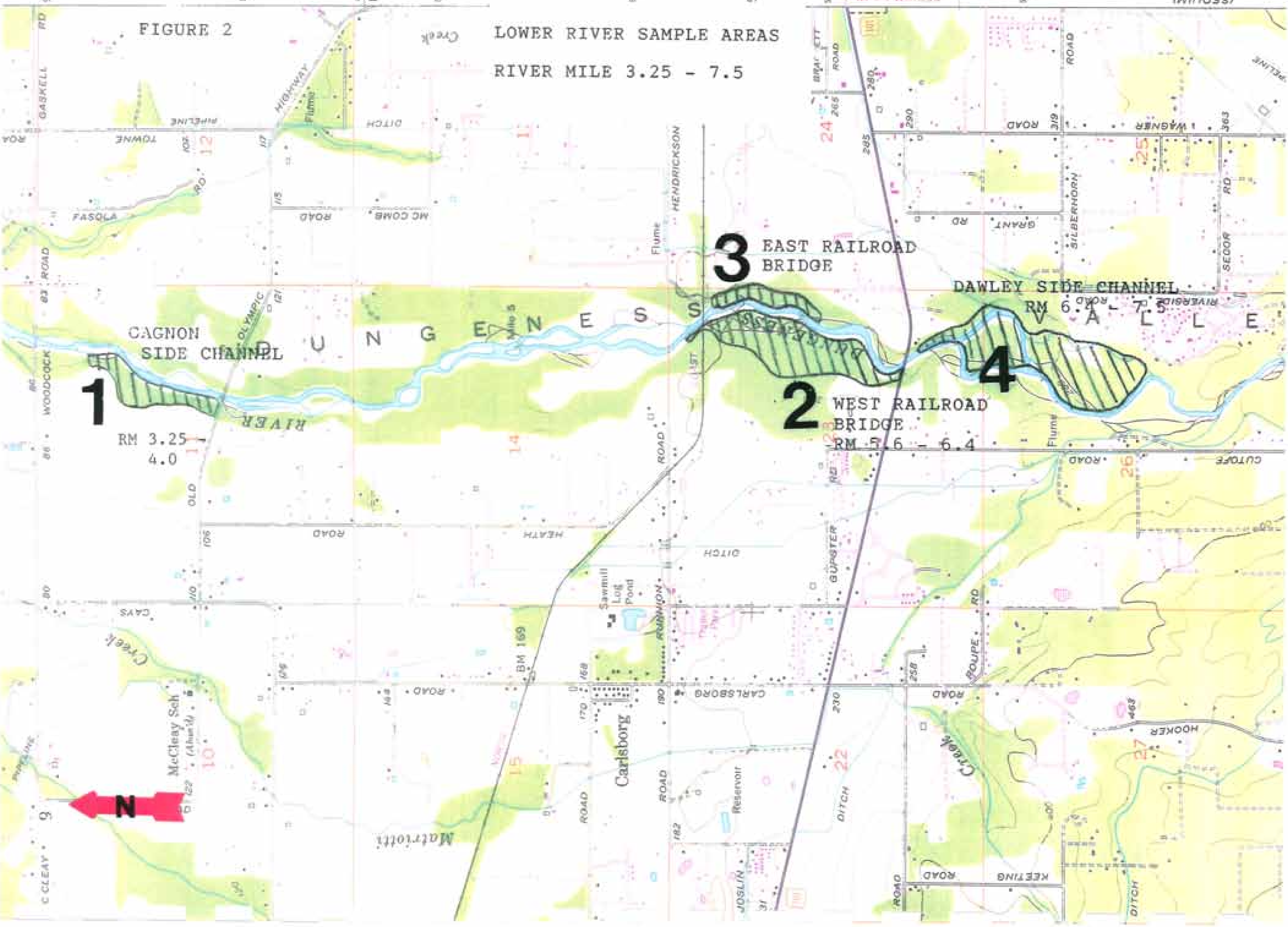
3) EAST RAILROAD BRIDGE SIDE CHANNEL (RM 5.65 - 6.4)

4) DAWLEY SIDE CHANNEL (RM 6.4 - 7.5)

FIGURE 2

LOWER RIVER SAMPLE AREAS

RIVER MILE 3.25 - 7.5



Two general areas in the upper watershed were chosen as sample sites and they include both the Dungeness and Gray Wolf Rivers. Initially, the mainstem of each was the focus of our study, but we soon discovered a number of side channels and included them as the year progressed. Figure 3 shows map locations of these sites that are also named to help in locating and discussing these features:

Gray Wolf River

1)THE FORKS SIDE CHANNEL (RM 0)

2)COHO SIDE CHANNEL (RM 0.25)

3)SNAG SIDE CHANNEL (RM 0.4)

4)MOSSY ROCK SIDE CHANNEL (RM 0.5)

5)DRY CHANNEL (RM 1.0)

6)UPPER GRAY WOLF SIDE CHANNEL (RM 1.25)

7)BEAVER POND SIDE CHANNEL (RM 1.5)

8)DEBRIS JAM SIDE CHANNEL (RM 2.0)

Dungeness River

9) EAST CROSSING SIDE CHANNEL (RM 17.5)

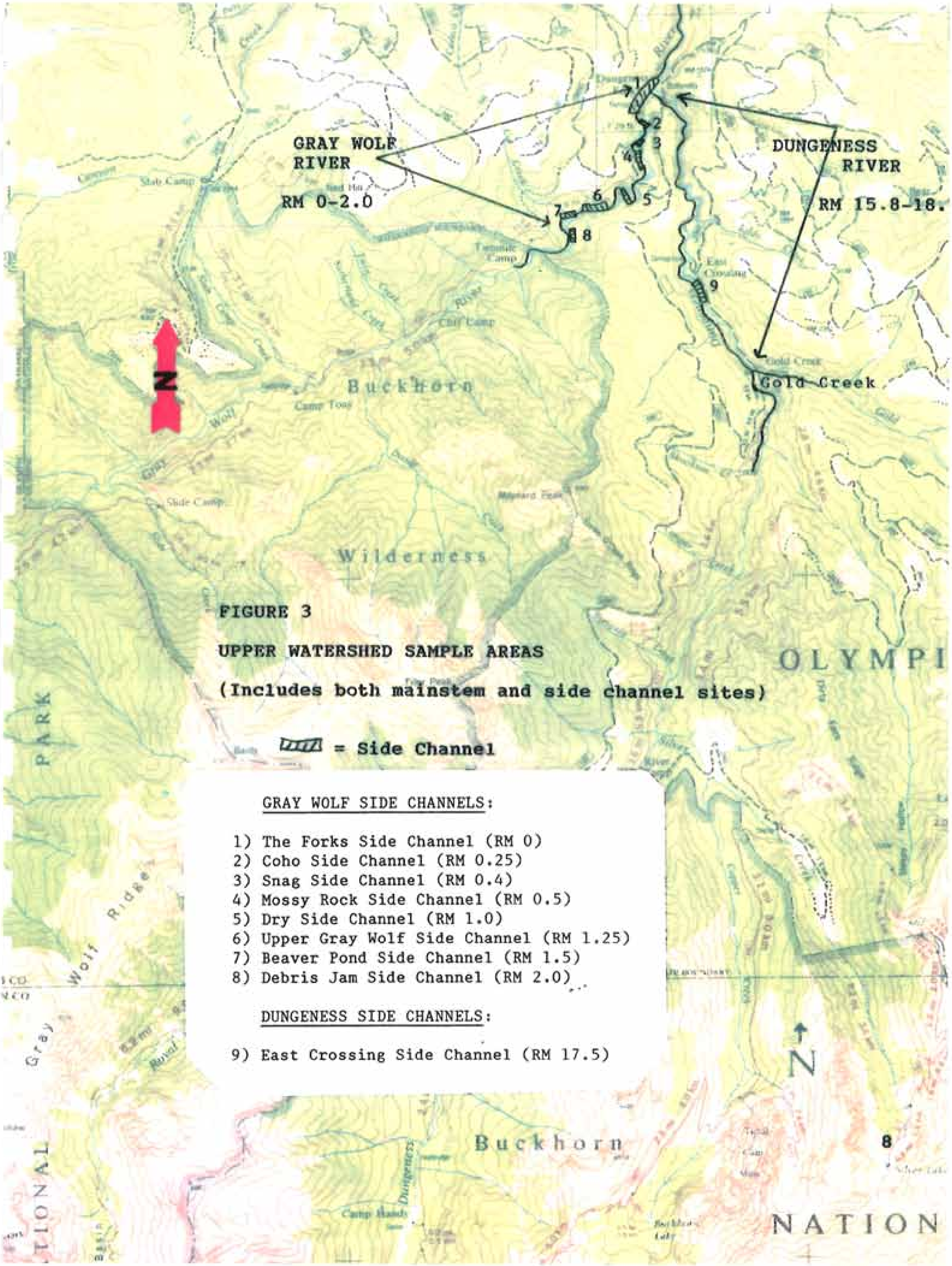


FIGURE 3

UPPER WATERSHED SAMPLE AREAS

(Includes both mainstem and side channel sites)

HABITAT

Methods

We measured habitat features along the total length of each side channel and adjacent mainstems in each of our primary sample areas in the lower river. We also measured habitat features in two upper watershed side channels to compare with those in the lower river.

The goal was to conduct quantitative surveys just after spring runoff dropped, allowing maximum coverage of side channels while assuring ability to identify features.

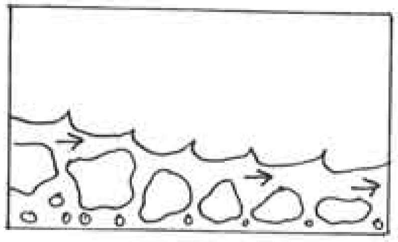
Habitat features identified are depicted in Figure 4. Length, width, and maximum depths were measured and recorded for each glide, riffle, and cascade. Pool type was identified and each pool was also measured to determine maximum depth, length, and average width so that pool surface area could be calculated from the field data.

Woody debris was also measured in each pool. Wood was identified as being IN the pool or OVER the surface of the pool and each piece was measured to determine diameter in 20cm increments. We then estimated the percentage of each diameter class, noting any special features.

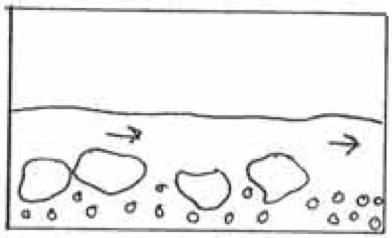
We also identified specific pools on our field forms, noting those where fish samples were frequently taken. Individual pool information could then be retrieved later, allowing us to calculate, for example, fish densities.

FIGURE 4

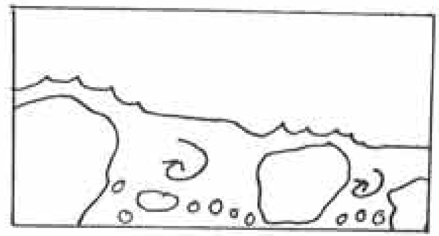
<u>HABITAT FEATURES</u> Identified and Measured in Side Channel and Mainstem Sample Sites.



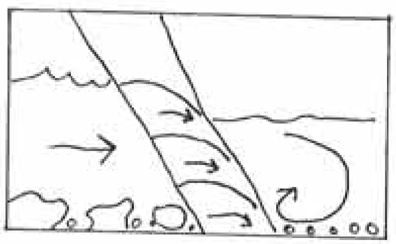
RIFFLES are defined by presence of a broken, splashing surface.



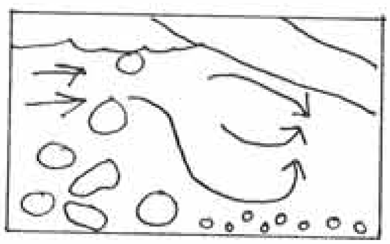
GLIDES form where surface water flattens and is not broken, but flow is steady.



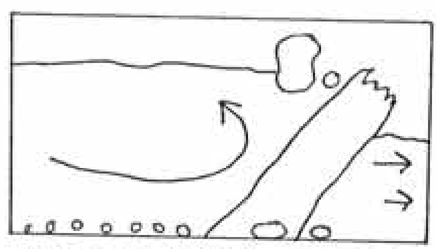
CASCADES occur where cobble and boulder habitat creates steps of alternating fast and quiet, pooled water.



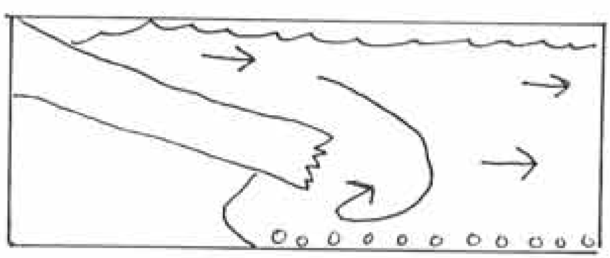
PLUNGE POOLS form where streamflow drops over logs or other obstructions to create deeper, quiet water on the downstream side.



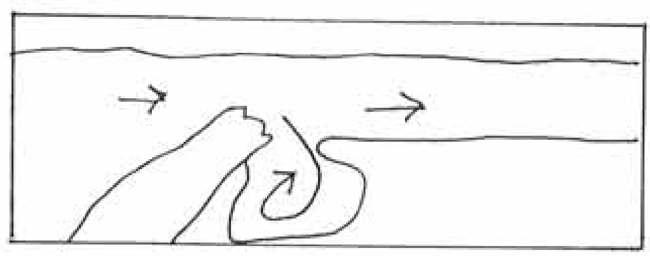
SCOUR POOLS form where streamflow is diverted by logs or other constrictions that direct flow to create the pool.



DAMMED POOLS form upstream of blocking logs or other features.



BACKWATER POOLS form where eddy or slack water conditions exist. Flow is relatively high compared to alcoves.



ALCOVE POOLS form where eddy or slack water conditions exist at channel margins or at junctions between two channels. Flow is low compared to that in backwaters. Common between mainstem and off channel habitats.

Modified from Bisson et al (1982) and Nickelson et al (1992)

Results

LOWER RIVER SAMPLE SITES (RM 3.25 - 7.5)

1) RM 3.25 - RM 4.0 (Gagnon Side Channel)

While we sampled as far downstream as sloughs in the estuary, Sample Area 1 was the lowest regularly visited site and is referred to as the Gagnon Side Channel. It lies within a mature, mixed second growth woodland along the west side of the river between Woodcock Bridge and Old Olympic Highway. Figure 5 presents an aerial view of the approximate location of the side channel, showing river connections as well as overflow channels. To help in understanding our definitions of some of these features, Figure 6 presents a generalized view of side channels in relationship to mainstems and braids.

Gagnon Side Channel begins in a wooded wetland at the base of Old Olympic Highway and flows for 951.1m before meeting the mainstem. During low flows, the tail end is cut off from the river, isolating an alcove pool at the mouth of the side channel. This break in the connection with the river occurred on 10 March when streamflows fell to 200cfs. As flow increased, the connection was again opened in April. By 8 May, flows had been at 1000cfs or higher for several days and the river backed into the alcove. Fish were present at all stages, even in late summer when the side channel became isolated for an extended period.

The upper reaches of the channel go dry during summer and wintertime intermittent flows were also noted.

Table 1 presents habitat features of this side channel that is characterized by its slow moving, protected nature. Gagnon had the greatest percentage (61%) of its length in pool, including one of the largest pools we found on the river. See Figure 6 for a comparison of channel length and pool percentage for other side channels and for

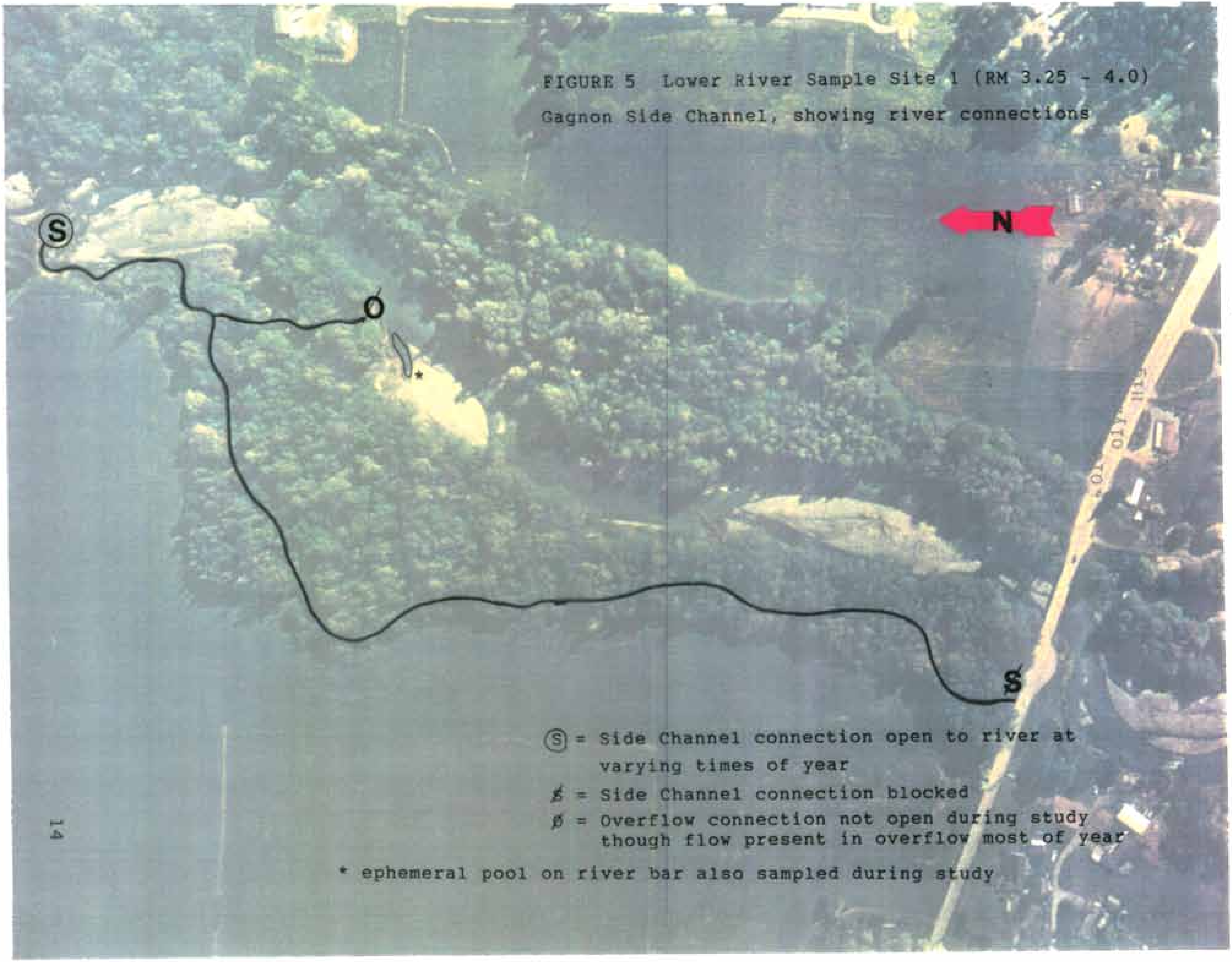
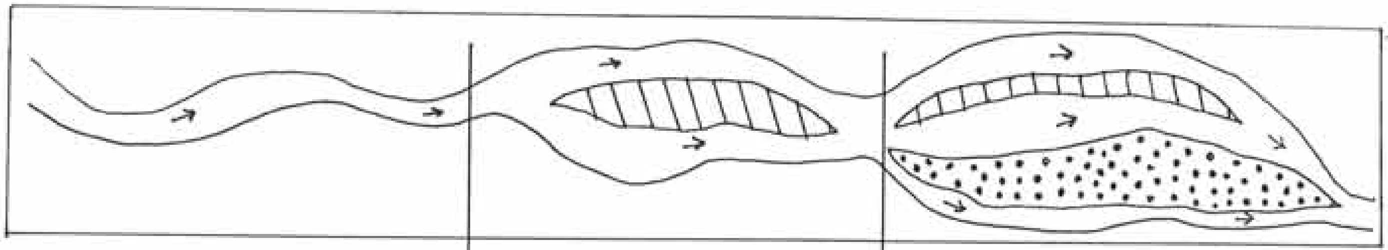


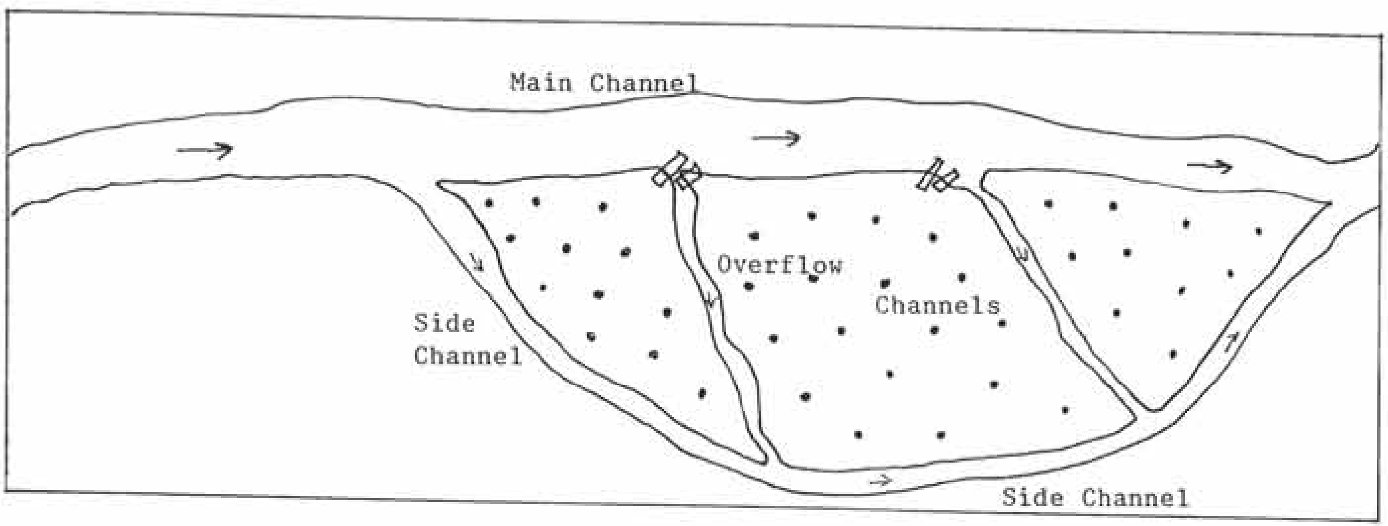
FIGURE 5 Lower River Sample Site 1 (RM 3.25 - 4.0)
Gagnon Side Channel, showing river connections



Main Channel (also referred to as Mainstem)

Braided Main Channel Separated by Bar or Bars that may be sparsely vegetated but with no mature trees, or few of them in small clusters

Braided Channel (Top) and Off channel, Side Channel Habitat that is separated from mainstem or braid by well vegetated riparian woodlands. Side Channels often appear to be streams, but they maintain river connections.



Off Channel habitats can include a number of inter-connected channels. The Side Channel is isolated from the main channel. A wide, wooded riparian area lies between the river and the main side channel. But, other small channels can connect it with the river. These Overflow Channels often form at debris jams. Alcove Pool habitat is typical at both ends of these overflows. The relatively deep Alcove Pools often hold water and fish, even when the rest of the overflow channel is dry.

FIGURE 6 Generalized View of Side Channels in Relationship to Mainstem and Braids.

TABLE 1 HABITAT FEATURES:

Site: GAGNON SIDE CHANNEL (River Miles 3.25 - 4.0)

Total Length: 951.1m

POOL HABITAT

Total Number of Pools: 32

Total Length in Pool: 582.6m (61% of total)

Pool Surface Area: 2468.96m^2

Pool Maximum Depth: 138cm

Average of Pool Maximum Depths: 55.97cm

Total Glides: 23

Total Length in Glide: 275.1m

Total Riffles: 12

Total Length in Riffle: 93.4m

Total Cascades: Not Present

Total Length in Cascade: 0

Presence of Wood in Pools

Diameter (cm)	(Area/% coverage of wood by size) Submerged (In)	Over Pool
0-20	226.85m^2 / 9%	63.89m^2 / 3%
20-40	111.02m^2 / 4%	72.8m^2 / 3%
40-60	162.72m^2 / 7%	36.65m^2 / 1%
60 +	186.00m^2 / 8%	167.4m^2 / 7%
Total Coverage by all sizes	686.59m^2 / 28%	340.74m^2 / 14%

Note: Much of the wood over 20cm in Gagnon Side Channel is imbedded, well anchored old logs -- many form structural features that create the many pools at this site.

mainstem sites adjacent to lower river side channels.

Much of the wood found in the Gagnon Side Channel is imbedded, well anchored in bank and bottom. Often forming structural features that create pools, wood is also larger, on average, than at any other site with 15% of the pool surface containing 40cm and larger diameter woody debris.

Beaver activity was also noted. Though no dams were attributed to their activity, they appear to help maintain pools and undercuts in at least two pools that held water throughout our study.

A number of overflow channels enter the side channel, but flows were too low to connect them directly with the river during our study. However, significant flow and fish use occurred along one overflow that received subsurface water in its upper reaches.

Mainstem habitat features adjacent to the Gagnon Side Channel are presented in Table 2. This area included sites that were frequently monitored during fish sampling due to their special features. These included an ephemeral alcove pool shown in Figure 5 Its position on the edge of an exposed river bar suggests that it was once an alcove at the tail end of a braided channel that has since migrated away from the present riverbank.

The greatest amount of large wood per pool surface area in any mainstem site was found in this reach. The deepest pool measured was also located at the top end of this mainstem area.

Even with substantial amounts of wood present, we observed a dramatic change at one pool frequently sampled for juvenile fish and one noted for its use by resting adults. When we measured this 184m scour pool on 3 September

TABLE 2 HABITAT FEATURES:

Site: MAINSTEM ADJACENT TO GAGNON SIDE CHANNEL (River Miles 3.25 - 4.0)

Total Length: 1008.3m

POOL HABITAT

Total Number of Pools: 19

Total Length in Pool: 207.3m (20% of total)

Pool Surface Area: 1348.72m^2

Pool Maximum Depth: 250 cm (Deepest of all sites)

Average of Pool Maximum Depths: 70.5cm

Total Glides: 10

Total Length in Glide: 352m

Total Riffles: 11

Total Length in Riffle: 436m

Total Cascades: 1

Total Length in Cascade: 13m

Presence of Wood in Pools

Diameter (cm)	(Area/% coverage of wood by size) Submerged (In)	Over Pool
0-20	42.45m^2 / 3%	21.33m^2 / 2%
20-40	57.26m^2 / 4%	37.38m^2 / 3%
40-60	5.46m^2 / $<$1%	27.01m^2 / 2%
60 +	253.44m^2 / 19%	395.79m^2 / 29%
Total Coverage by all sizes	358.61m^2 / 27%	481.51m^2 / 36%

1998, it was bordered by a large cottonwood and four additional trees with rootwads attached. One of the deepest pools measured, it was 143cm at its deepest point and seemed to be a relatively permanent feature.

As a follow-up to our main sampling effort, we revisited this area in early November 1998 just after high fall flows of 2600cfs. The large cottonwood was still present, but hung over the water surface where all of the four large trees it once anchored had vanished. The pool had filled in and was replaced by a riffle.

Still, some of the wood present does remain and at two locations large debris jams help create alcoves at the entrance to side channels. These alcove pools connect these off channel habitats to the mainstem opposite of, and just downstream from the Gagnon Side Channel. These additional side channels add to the diversity of the mainstem. And, each of these features appear to offer year-round refuge since they remained connected to the river throughout our study - this, in contrast to the Gagnon Side Channel.

2) RM 5.6 - RM 6.4 (West Railroad Bridge Side Channel)

Tables 3 and 4 present habitat features of the side channel and adjacent mainstem in this area. Actually, the majority of channel habitat in the "mainstem" is a long braid that branches away from the river just below Highway 101.

The major side channel in this area is referred to as the West Railroad Bridge Side Channel and has its upper end at a turn in the braid. See Figure 7 for an aerial view of the side channel and other features in this highly braided, complex area.

The West Railroad Bridge Side Channel is very streamlike, flowing for 1255.5m through mature second growth riparian forest before connecting with the mainstem just below Railroad Bridge. West Railroad Side Channel has fewer pools than Gagnon, but its lower reaches are very similar with quiet, leaf-littered pools providing significant coho habitat. An active, continuously connected overflow channel, adds significant diversity to this lower portion. Chinook were only found from the point at which it enters the side channel and in areas downstream. The upper end was never connected to the river during our study but did hold both coho and trout.

324m (26% of total length) of the channel is pool habitat and much of the remaining channel length is in quiet glides, often with undercut banks and brush or woody cover. Woody debris was smaller than at Gagnon, with only 2-3% of pool surfaces containing wood with a diameter of 60cm or larger. However, 20% of the pool surfaces contained

TABLE 3 HABITAT FEATURES:

Site: WEST RAILROAD BRIDGE SIDE CHANNEL (River Miles 5.6 - 6.4)

Total Length: 1255.5m

POOL HABITAT

Total Number of Pools: 34

Total Length in Pool: 324m (26% of Total)

Pool Surface Area: 1475.5m^2

Pool Maximum Depth: 170cm

Average of Pool Maximum Depths: 57.8cm

Total Glides: 26

Total Length in Glide: 410m

Total Riffles: 22

Total Length in Riffle: 192.25m

Total Cascades: 1

Total Length in Cascade: 159m

Presence of Wood in Pools

Diameter (cm)	(Area/% coverage of wood by size) Submerged (In)	Over Pool
0-20	153.1m^2 / 10%	86.11m^2 / 6%
20-40	76.15m^2 / 5%	108.7m^2 / 7%
40-60	47.61m^2 / 3%	30.75m^2 / 2%
60 +	36.6m^2 / 2%	39.7m^2 / 3%
Total Coverage by all sizes	313.46m^2 / 20%	265.26m^2 / 18%

TABLE 4 HABITAT FEATURES:

Site: MAINSTEM ADJACENT TO WEST RAILROAD BRIDGE SIDE CHANNEL (River Miles 5.6 - 6.4)

Total Length: 1517.4m

POOL HABITAT

Total Number of Pools: 25

Total Length in Pool: 414.5m (27% of total)

Pool Surface Area: 2191.67m^2

Pool Maximum Depth: 104cm

Average of Pool Maximum Depths: 52cm

Total Glides: 16

Total Length in Glide: 424.4m

Total Riffles: 21

Total Length in Riffle: 627.5m

Total Cascades: 2

Total Length in Cascade: 51m

Presence of Wood in Pools

Diameter (cm)	(Area/% coverage of wood by size) Submerged (In)	Over Pool
0-20	214.67m^2/ 10%	177m^2/ 8%
20-40	133.7m^2/ 6%	162.27m^2/ 7%
40-60	85.1m^2/ 4%	105.1m^2/ 5%
60 +	134.01m^2/ 6%	156.62m^2/ 7%
Total Coverage by all sizes	567.48m^2/ 26%	601.79m^2/ 27%

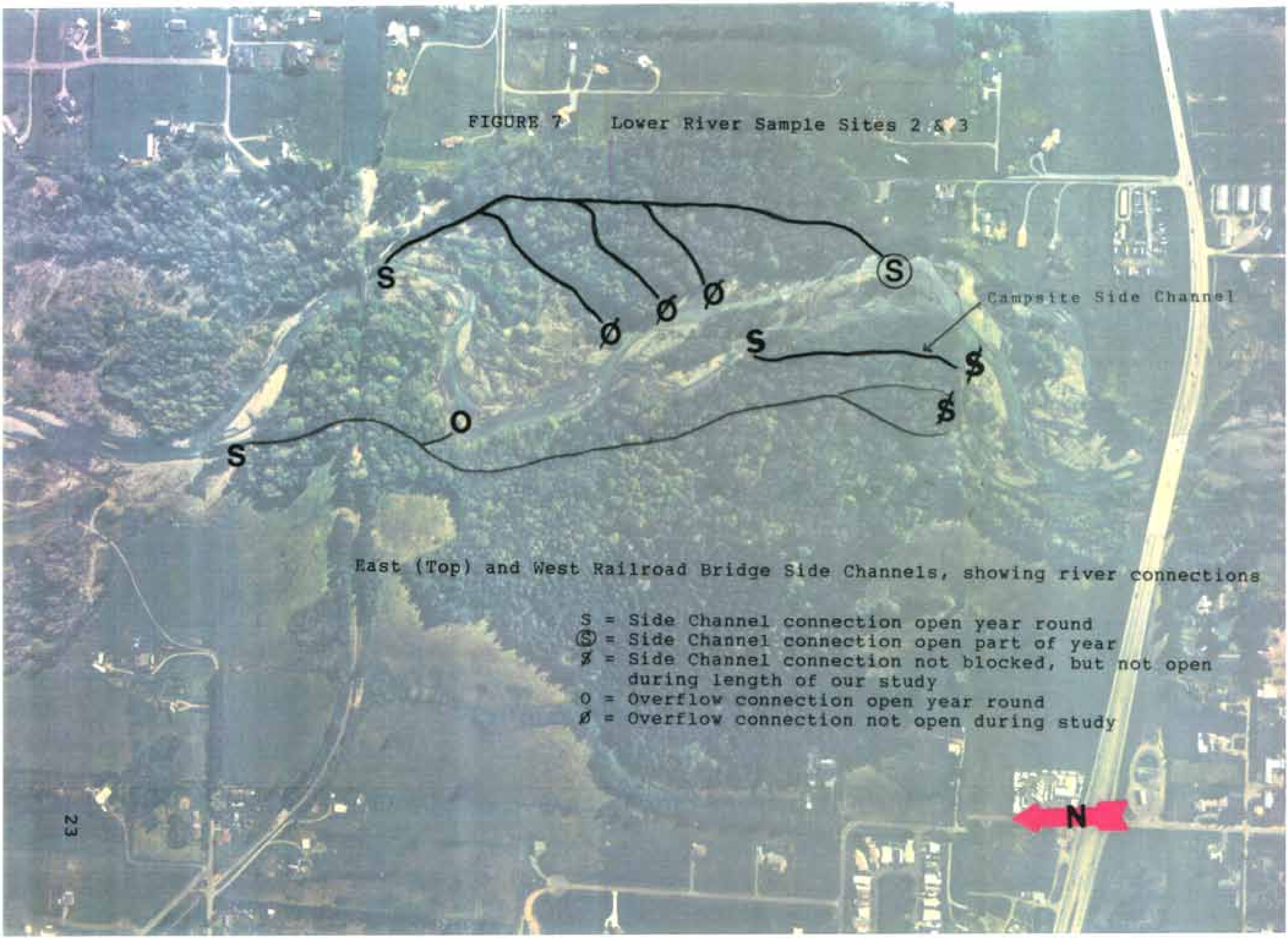


FIGURE 7 Lower River Sample Sites 2 & 3

woody debris, providing good cover for juvenile fish. The average pool depth was 57.8cm.

Numerous overflows weave through the areas between the braided mainstem below 101 and the side channel. Many of these were de-watered during our study, but one additional side channel was also present. We refer to this site as the Campsite Side Channel since there is a well used fire ring on a bar just below its junction with the river.

The Campsite Side Channel wasn't sampled as often as others, but it did support both chinook and coho. It also maintained flow throughout its length, holding water in its upper reaches despite no apparent above ground connection with the river. It is interesting to note that the alcove pool at its junction with the river was never cut off from the Dungeness. This, despite the fact that this side channel begins and ends with a connection to a braid, not the main channel.

Mainstem sample sites in the area adjacent to the West Railroad Bridge Side Channel were complex. As mentioned, this area is primarily braided mainstem as can be seen in Figure 7. The braids form on the broad river reach north of Highway 101. Some of these are gradually becoming more isolated from the river as alders spread onto the bars. This process may well create new side channel habitat as the river migrates and succession occurs.

At times, the braids, like side channels, are cut off from the river, but some deep pools hold water even when their channels go dry. Debris jams in these braids act to divert water into the side channels.

Significant pool habitat in this reach provides winter and late summer low flow refuge for chinook, coho, and trout. These include a large pool within a debris jam complex constructed in 1997. The pool's 175m surface area contains approximately 75% woody debris.

Other pools within this braided reach also contain a surprising amount of woody debris - more than in the adjacent side channel habitat. And pool surface area amounted to more than 2100m as compared to slightly over 1400m in the adjacent side channel. But the majority of the habitat along this braided reach is riffle and glide.

3) RM 5.65 - RM 6.4 (East Railroad Bridge Side Channel)

A side channel that is much shorter than that along the west side of the Railroad Bridge is the major feature in this reach. As seen in Figure 7, the top entrance of this off channel habitat is open at least part of the year. This wide, boulder dominated connection with the river goes dry as the river drops, leaving the side channel dry for half its length during both winter and summer low flow periods.

We refer to this area as East Railroad Bridge Side Channel. This active habitat is laced with overflow channels that were wetted during the entire length of the study. This, despite a lack of surface connections with the river in this time period. Large swaths of woody debris formed dense tangles in the upper reaches of these overflows where some deep scour pools formed pockets that were isolated for varying lengths of time..

Table 5 presents habitat features of this 595.5m long side channel. It contains 13 pools that occupy 28% of its total length. Approximately 75% of its length is in riffle and glide.

One large pool in this side channel is dominated by a

TABLE 5 HABITAT FEATURES:

Site: EAST RAILROAD BRIDGE SIDE CHANNEL (River Miles 5.65 - 6.4)

Total Length: 595.5m

POOL HABITAT

Total Number of Pools: 13

Total Length in Pool: 164.5m (28% of Total)

Pool Surface Area: 1230.15m^2

Pool Maximum Depth: 150cm

Average of Pool Maximum Depths: 70.7cm

Total Glides: 8

Total Length in Glide: 156.5m

Total Riffles: 9

Total Length in Riffle: 178.5m

Total Cascades: 7

Total Length in Cascade: 96m

Presence of Wood in Pools

Diameter (cm)	(Area/% coverage of wood by size) Submerged (In)	Over Pool
0-20	76.15m^2 / 6%	49.29m^2 / 4%
20-40	42.62m^2 / 3%	51.76m^2 / 4%
40-60	24.64m^2 / 2%	4.2m^2 / <1%
60 +	Not Present	3.0m^2 / <1%
Total Coverage by all sizes	143.41m^2 / 12%	108.25m^2 / 9%

significant debris jam that offers cover for both juvenile and adult salmon, including chum. Chum were observed spawning in the riffle above this pool and chum alevins were captured here.

Debris Jam at "The Chum Pool" along East Railroad Bridge Side Channel

The tail end of the side channel arches against rip rap on the eastbank of the Railroad Bridge. Quiet, alcove pools in this lower reach offer significant coho habitat during low flows. This lower end alcove is also a likely access for chinook that may use the pools as doorways into the refuge of the side channel.

East Railroad Bridge is the only side channel in which both coho and chinook were captured in main side channel habitats as well as in overflows.

Habitat features of the mainstem adjacent to the East Railroad Bridge Side Channel are presented in Table 6. This reach is noted for its low number of pools. Most of these are midchannel scours with little or no wood. One exception was a sample site at which large numbers of chinook were captured during late summer low flows. This pool was referred to as the Cutthroat Pool for the presence of adult cutthroat holding here in the Fall of 1997.

Although not directly tied to the side channel, the Cutthroat Pool is located just upstream of the entrance and may serve as a kind of doorway for fish that become swept into East Railroad Bridge Side Channel at high flows.

TABLE 6 HABITAT FEATURES:

Site: MAINSTEM ADJACENT TO EAST RAILROAD BRIDGE SIDE CHANNEL (River Miles 5.65-6.4)

Total Length: 830.9m

POOL HABITAT

Total Number of Pools: 6

Total Length in Pool: 55.5m (7% of Total)

Pool Surface Area: 446.5m^2

Pool Maximum Depth: 112cm

Average of Pool Maximum Depths: 84.5cm

Total Glides: 6

Total Length in Glide: 106.4m

Total Riffles: 6

Total Length in Riffle: 668.5m (80% of total)

Total Cascades: 1

Total Length in Cascade: 56m

Presence of Wood in Pools

Diameter (cm)	(Area/% coverage of wood by size) Submerged (In)	Over Pool
0-20	-	-
20-40	20m^2 / 4%	20m^2 / 4%
40-60	-	10m^2 / 2%
60 +	1.6m^2 / <1%	1.6m^2 / <1%
Total Coverage by all sizes	21.6 m^2 / 5%	31.6m^2 / 7%

Note: Most pools are in main channel as scours without woody debris.

4) RM 6.4 - 7.5 (Dawley Side Channel)

Sample Area 4 includes the most diverse side channel habitat in our study. It is part of a wooded area on the east side of the river, just south of Highway 101. We refer to the main channel of this 1151.9m long site as Dawley Side channel.

Samples reported in our study also include the lower reaches of Spring Creek as well as several overflow channels. Not a true stream, Spring Creek is actually a much longer side channel (See Figure 8) with a history of highly productive coho habitat (Randy Johnson, WDFW, personal communication). This is likely one of the longest side channels on the river. It begins near the Dungeness Meadows Dike, where it was cut off from the river in 1992 due to the

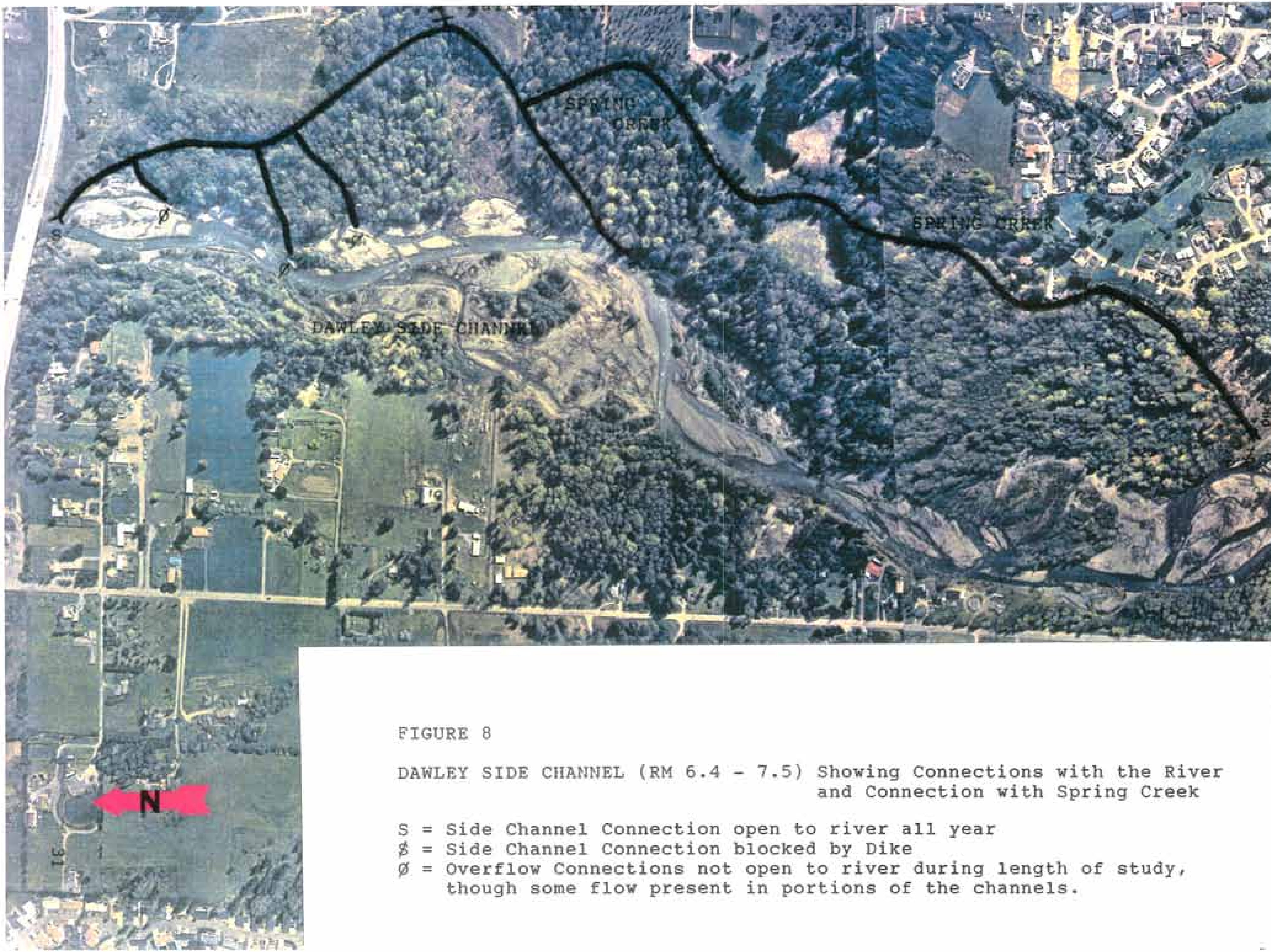


FIGURE 8

DAWLEY SIDE CHANNEL (RM 6.4 - 7.5) Showing Connections with the River and Connection with Spring Creek

S = Side Channel Connection open to river all year
$ = Side Channel Connection blocked by Dike
Ø = Overflow Connections not open to river during length of study, though some flow present in portions of the channels.

repair and lengthening of this structure (Randy Johnson, personal communication).

The only side channel with flow during all months of our study, the upper reaches of Dawley Side Channel are periodically opened by the Prairie Ditch Company. This effort maintains flow into the Prairie Ditch at a point about one half way up the channel.

Dawley Side Channel is predominantly riffle and glide (85% of total length) as can be seen in Table 7. It was the only side channel with known chinook and pink spawning. Chinook use was significant during most of the year. Even though pools were not as abundant as in other side channels, they were diverse in character. Alcove and backwater habitat was especially diverse, forming at junctions with overflows as well as at the permanent connection with the river at its lower end.

Spring Creek is intimately connected to the side channel, providing additional flow and habitat diversity. We routinely sampled its lower reaches, monitoring locations above and below a pool where juvenile chinook presence was noted in 1997. This streamlike side channel is very similar

TABLE 7 HABITAT FEATURES:

Site: DAWLEY SIDE CHANNEL (River Miles 6.4 - 7.5)

Total Length: 1151.9m

POOL HABITAT

Total Number of Pools: 21

Total Length in Pool: 176.9m (15% of total)

Pool Surface Area: 985.6m^2

Pool Maximum Depth: 144cm

Average of Pool Maximum Depths: 73.3cm

Total Glides: 13

Total Length in Glide: 407m

Total Riffles: 16

Total Length in Riffle: 568m

Total Cascades: Not Present

Total Length in Cascade: 0

Presence of Wood in Pools

(Area/% coverage of wood by size)

Diameter (cm)	Submerged (In)	Over Pool
0-20	131.3m^2 / 13%	110.43m^2 / 11%
20-40	47.3m^2 / 5%	46.3m^2 / 5%
40-60	12.8m^2 / 1%	19.2m^2 / 2%
60 +	-	7.2m^2 / 1%
Total Coverage by all sizes	191.4m^2 / 19%	183.13m^2 / 19%

to Gagnon Side Channel with its quiet, well shaded pools. Like Gagnon, the upper end is not connected to the river due to the blocking structure. This creates coho rearing habitat, but likely prevents chinook access.

Mainstem sites adjacent to the Dawley Side Channel include significant alcoves at the top ends of overflow channels. Each of these is characterized by the presence of large woody debris jams. Juvenile chinook, coho, and trout, including steelhead smolts, frequented these sites. Like the other alcoves along or at entrances to side channels, juveniles likely use them as doorways to the off channel refuges. As can be seen in Table 8, woody debris in pools within this reach is predominantly large - greater than 60cm.

We also sampled riffle edges at varying flows throughout the year, capturing juvenile salmon in this quiet, edge habitat. But pool habitat is the most notable feature in this reach. As can be seen in Figure 9, a greater percentage of the total length of this mainstem area is pool when compared to that of the Dawley Side Channel.

TABLE 8 HABITAT FEATURES:

Site: MAINSTEM ADJACENT TO DAWLEY SIDE CHANNEL (River Miles 6.4 - 7.5)

Total Length: 950.4m

POOL HABITAT

Total Number of Pools: 14

Total Length in Pool: 194.4m (20% of total)

Pool Surface Area: 864.88m^2

Pool Maximum Depth: 106cm

Average of Pool Maximum Depths: 73cm

Total Glides: 6

Total Length in Glide: 135m

Total Riffles: 15

Total Length in Riffle: 621m

Total Cascades: Not Present

Total Length in Cascade:

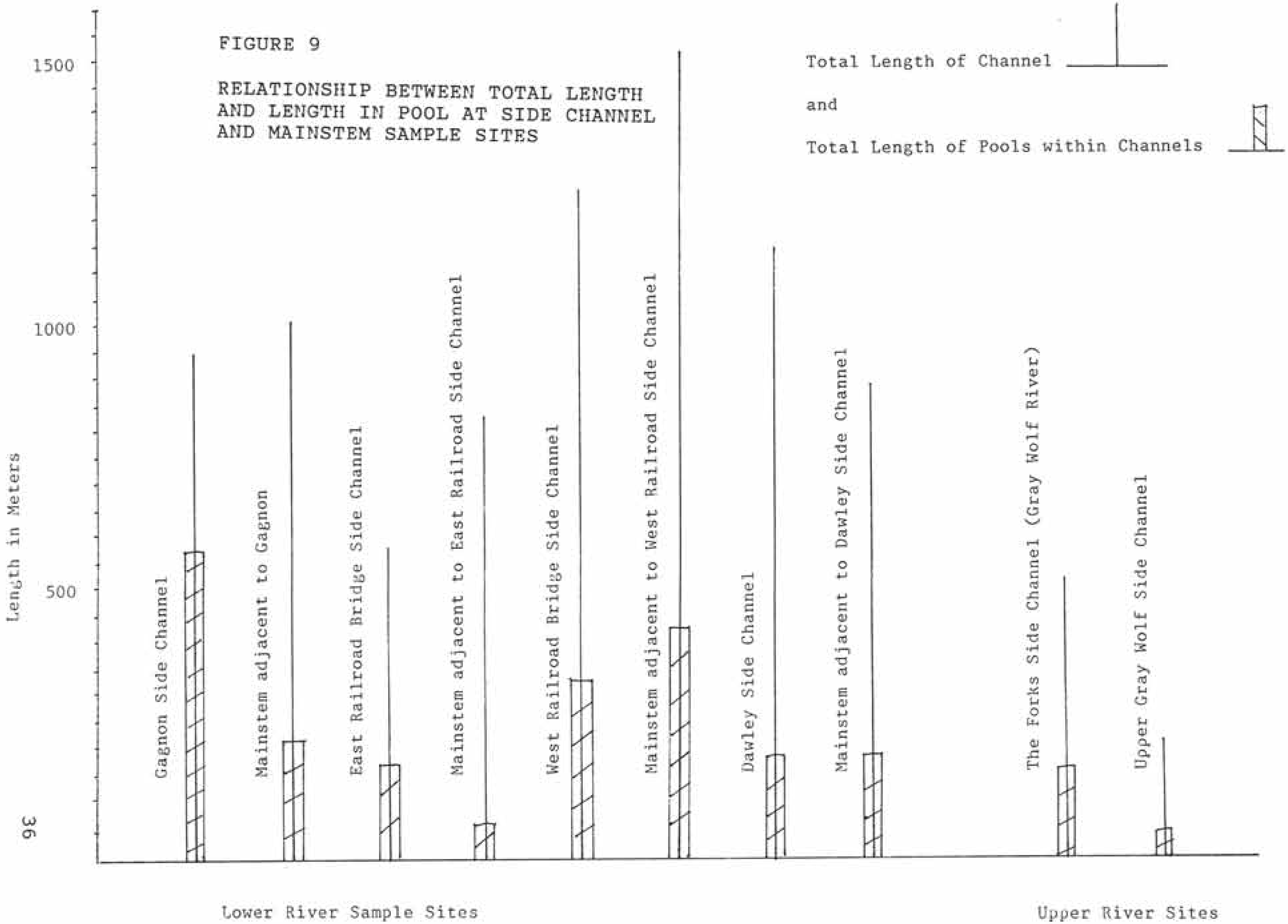
Presence of Wood in Pools

Diameter (cm)	(Area/% coverage of wood by size) Submerged (In)	Over Pool
0-20	32.96m^2 / 4%	36.3m^2 / 4%
20-40	1.29m^2 / < 1%	26.25m^2 / 3%
40-60	2.7m^2 / < 1%	7.86m^2 / 1%
60 +	174.07m^2 / 20%	79.29m^2 / 9%
Total Coverage by all sizes	211.02m^2 / 26%	149.7m^2 / 17%

Note: The large (60cm diameter) wood is predominantly found in alcove pools at top ends of overflow channels.

FIGURE 9

RELATIONSHIP BETWEEN TOTAL LENGTH AND LENGTH IN POOL AT SIDE CHANNEL AND MAINSTEM SAMPLE SITES



UPPER RIVER SAMPLE SITES

Both the Dungeness and Gray Wolf are included in upper river sample areas. Early sampling focused on braids and mainstem locations, but our hikes along the riverbanks soon revealed diverse side channel habitats above RM 15.8. This was surprising, since no earlier mention had been made of these off channel areas.

Gray Wolf River (RM 0 - 2)

Gray Wolf side channels are especially significant, including one with chinook use throughout its length. We refer to this site as The Forks Side Channel since it is located opposite The Forks Campground on the West side of the river (See Figure 10).

The top of this side channel takes off from the river just below a deep, rock walled glide at the tail of an even deeper mainstem scour pool. Its entry channel is similar to the boulder and cobble channel at the top end of the East Railroad Bridge Side Channel. However, the upper end maintains a more constant flow than that lower river site.

30% of the 514.55m channel is in pool habitat (See Table 9), some of which are beaver dammed. But one of the most interesting features is the top channel. It is dominated by boulders that form a series of cascade pools


GRAY WOLF SIDE CHANNELS
in the vicinity of
THE FORKS CAMPGROUND
FIGURE 10 RM 0
COHO SIDE CHANNEL
S
S
S
S
"The Forks"
The Confluence of the
Gray Wolf (Top) and the
Dungeness Rivers.
S = SIDE CHANNEL CONNECTION
WITH RIVER - OPEN ALL
YEAR. 1" = 250'
N

TABLE 9 HABITAT FEATURES:

Site: THE FORKS SIDE CHANNEL, GRAY WOLF RIVER (Gray Wolf River Mile 0 - 0.2)

Total Length: 514.5m

POOL HABITAT

Total Number of Pools: 18	Total Glides: 2
Total Length in Pool: 152.05m	Total Length in Glide: 18m
Pool Surface Area: $339m^2$	Total Riffles: 2
Pool Maximum Depth: 40cm	Total Length in Riffle: 4.5m
Average of Pool Maximum Depths: 18cm	Total Cascades: 2
	Total Length in Cascade: 58m

Presence of Wood in Pools

Diameter (cm)	(Area/% coverage of wood by size) Submerged (In)	Over Pool
0-20	$136.2m^2$ / 40%	$26.33m^2$ / 8%
20-40	$2.25m^2$ / < 1%	$11.5m^2$ / 3%
40-60	-	$1.6m^2$ / < 1%
60 +	$0.44m^2$ / < 1%	$5.4m^2$ / 2%
Total Coverage by all sizes	$138.89m^2$ / 41%	$44.83m^2$ / 14%

Note: Woody debris is predominantly salmonberry stems cut by beavers that cover pools for much of year.

Boulder dominated upper end of The Forks Side Channel

providing significant chinook habitat. Immediately below this cascade reach, a large pool is formed behind a debris jam.

A short overflow exits the side channel beneath the debris jam and the main side channel flows away, then parallel with the river at this same point. Much of the channel is within an alder flat, but it also borders a drier, coniferous forest at the base of a steep slope.

While there is not a great deal of large wood cover in pools in this side channel, much of the quiet surfaces are covered by salmonberry branches. Cut by beavers, these form a dense, floating mat during much of the year.

Another side channel near the Forks Campground was

Salmonberry trimmings in The Forks Side Channel

visited on a few trips late in the study. This channel forms at the edge of a deep pool along a steep rock face on the East side of the river.

We refer to this short and steep site as the Coho Side Channel (Figure 10). No flow was observed in its upper reaches on any of our visits. But gradient and presence of large boulders suggest that cascades predominate at higher flows. A small alcove at its tail end junction with the river offered habitat to both chinook and coho.

A short braid was also visited several times in the late summer, providing several of our mainstem samples. The main feature of the braid is deep scour pool sheltered by a leaning, live cedar. Large trout and dense schools of chinook were captured at this site.

While we did not measure habitat features at this site, a side channel immediately below the Chinook Acclimation Pond was also visited. Its entrance, or upper connection with the river is on the west side - directly across the stream from the channel outlet below the ponds. This river connection is very narrow and lacks a debris jam or alcove pool "doorway", possibly accounting for the lack of chinook in the side channel during our study. Additionally, newly released chinooks may also be swept along the East side of the river, well away from the entrance.

The remainder of the channel is characterized by boulder cascades and small pools. We refer to it as the Mossy Rock Side Channel due to the moss-covered rocks defining the channel. Large numbers of coho are present in

MOSSY ROCK
SIDE CHANNEL

GRAY WOLF RIVER

this habitat that lies in a young second growth woodland, bordered by larger conifers on the upper, steep slopes.

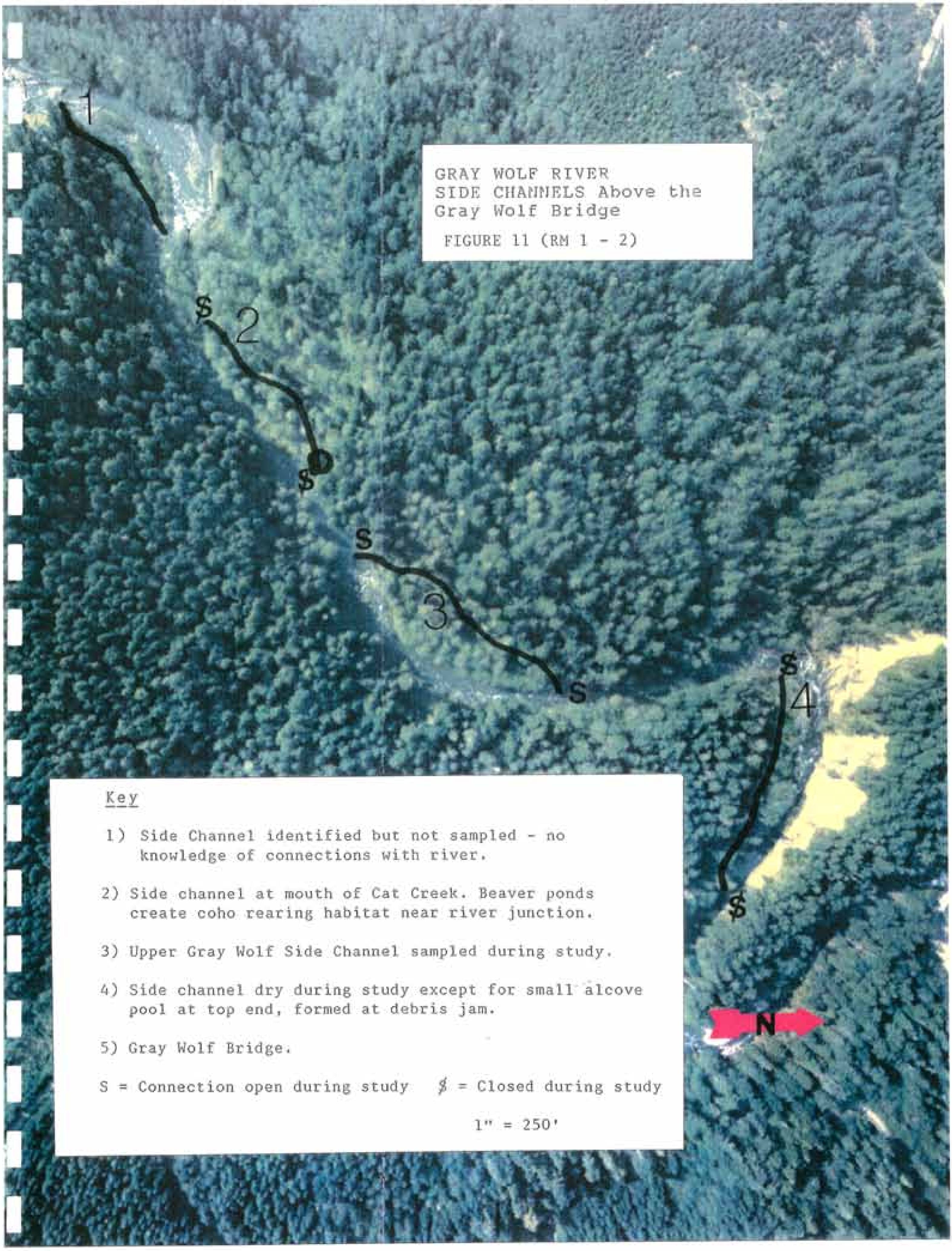
Though sampled less frequently, we visited and measured habitat features at two other Gray Wolf sites. One is referred to as the Upper Gray Wolf Side Channel and lies on the west side of the river approximately one mile above the Gray Wolf Bridge (Figure 11).

Like The Forks Side Channel, it lies at the base of a steep slope and its upstream channel leads directly from the river through a cascade reach. The surrounding woodlands include old growth conifers on the upper edges, many of which form root tangle walls for the small number of deep pools.

This is the only side channel sampled that lies above broodstock chinook releases. No chinook were captured during the study.

While shorter than all lower river side channel sample sites, this side channel is significant in that off channel habitats may be limiting in the upper watershed. Also, low flow refuges and low velocity refuges offer valuable juvenile habitat compared to the adjacent, steep gradient mainstem.

As seen in Table 10, pools occupied 20% of the total length of this 211.9m long side channel. Surprisingly, no woody debris with diameters greater than 40cm was found in this side channel. As in the Forks site, beaver trimmed salmonberry provided significant cover as floating debris in the Upper Gray Wolf Side Channel.



GRAY WOLF RIVER
SIDE CHANNELS Above the
Gray Wolf Bridge

FIGURE 11 (RM 1 - 2)

TABLE 10 HABITAT FEATURES:

Site: UPPER GRAY WOLF SIDE CHANNEL (Gray Wolf River Mile 0.2 - 1.8)

Total Length: 211.9m

POOL HABITAT

Total Number of Pools: 7

Total Length in Pool: 43m

Pool Surface Area: 120.93m^2

Pool Maximum Depth: 103cm

Average of Pool Maximum Depths: 30cm

Total Glides: Not Present

Total Length in Glide: 0

Total Riffles: 1

Total Length in Riffle: 22m

Total Cascades: 5

Total Length in Cascade: 65.9m

Presence of Wood in Pools

Diameter (cm)	(Area/% coverage of wood by size) Submerged (In)	Over Pool
0-20	9.9m^2/ 8%	4.34m^2/ 3.5%
20-40	-	0.99m^2/ 0.8%
40-60	-	-
60 +	-	-
Total Coverage by all sizes	9.9m^2/ 8%	5.33m^2/ 4.2%

Note: Woody debris is predominantly salmonberry stems cut by beavers that cover the pools for much of the year.

The Beaver Pond Side Channel is just above the former and was sampled on an infrequent basis. It forms at the mouth of Cat Creek and is notable for the presence of actively maintained beaver ponds in its lowest reaches. The lowest pool has a surface area of 156m and supported coho, rainbow, and dolly varden.

UPPER DUNGENESS RIVER

Upper Dungeness River sample sites are located between East Crossing Campground and the vicinity of Gold Creek. We did sample areas above The Cascades, a point reported to be an anadromous barrier. But, most samples were at points below Gold Creek.

This reach is primarily riffle and cascade with one very short side channel located along the east bank a short distance above the campground. This channel is referred to as The East Crossing Side Channel and is the only side channel in this reach as depicted in Figure 3.

It provided significant refuge habitat for chinooks newly released upriver at the Gold Creek Bridge. The lack of off channel habitat between these points appeared to concentrate fish in the East Crossing Side Channel.

Mainstem sites below Gold Creek included many eddy pools behind large boulders and quieter, peripheral areas similar to lower river riffle edges. These sites are most notable for their lack of fish, perhaps due to poor spawning habitat as well as the lack of refuge habitat diversity.

JUVENILE SALMONID COMMUNITIES

FISH SAMPLING METHODS

Minnow traps baited with coho eggs were used at each of our primary sample locations. The traps were successful in capturing juveniles ranging from fry to smolts (38 - 140mm). Smaller, newly emerged fry either did not enter our traps or slipped through the wire mesh. In locations where these younger fish were observed, we used seines to supplement the trapping effort.

Seines were also used in new areas or reaches where a brief, qualitative sample was sufficient.

We also used hand held nets on occasion. They were especially useful in sampling smaller, overflow channels where we occasionally netted fish in inch deep water. Both seines and the hand held nets allowed us to establish presence or absence over wide areas in a short amount of time.

We rotated sampling at regular sites for monthly visits, but we also maintained a larger, riverwide strategy. This included attempts to determine upper limits of chinook distribution and use of lower river habitats. The latter brought us into the estuarine sloughs where we captured chum and pink in marshy edges of the lower river in spring.

Results

We captured 1030 juvenile chinooks, 3147 juvenile coho, and 362 trout during from October 1997 to October 1998. We also captured smaller numbers of chum and pink salmon, as well as dolly varden, mottled sculpins, and brook lamprey. These total captures are presented in Table 11 and include all sample methods.

Upper river chinook captures totaled 465, while lower river totals were 565. The upper river captures may be inflated due to the ease of seining large numbers of newly released fish near the release sites. However, the goal of our study is not to present information on numbers of fish except as they relate to the habitats being used by those fish.

Upper river coho and lower river coho may be more

TOTAL CAPTURES BY SPECIES (October 1997 - October 1998)

TABLE 11

Totals include all sample methods at all sample sites

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
UPPER RIVER (RM 15.8 - RM 18.7) *													
CHINOOK		35			1	26	2	0	174	173	0	54	465
COHO		0			8	14	60	56	153	106	94	46	537
TROUT		10			18	80	13	3	6	2	10	5	147
D.VARDEN											5		5
LOWER RIVER (RM 3.0 - RM 7.5)													
CHINOOK	8	100		33	31	39	10	2	75	35	172	60	565
COHO	100	218		208	172	485	392	96	261	168	255	255	2610
CHUM						20							20
PINK						10							10
TROUT	14	27		42	14	61	20	3	1	3	14	16	215
D.VARDEN													present
SCULPIN						2							2
LAMPREY						3							3

* Note that upper river samples include both Dungeness and Gray Wolf Rivers

directly comparable since all captures were of wild fish. According to Washington Fish and Wildlife records (Dick Rogers, WDFW, personal comunication), all coho releases in the Dungeness during our study were adipose clipped 1.5 year old smolts. None of these fall releases appeared in our samples.

The 2610 coho captured in the lower river reflect highly productive habitats available to them in off channel areas sampled. Upper river totals of 537 coho were significantly lower than the lower watershed count and is striking when broken down further.

Tables 12 and 13 present total captures by individual sample sites within side channels and mainstem locations. As can be seen in totals for the upper watershed, the Gray Wolf mainstem and side channels accounted for the majority of coho captures. No coho were taken in the upper Dungeness side channel and only 29 coho were included in upper Dungeness mainstem samples. In contrast, 394 coho were captured in Gray Wolf Side Channels in a comparable length of river.

This difference in coho numbers may be a reflection of side channel habitat available as shown in Figure 3. We discovered eight side channels in the first two miles of the Gray Wolf above its confluence with the Dungeness. Only one side channel was located from the confluence (RM 15.8) to river mile 18.7 on the Dungeness.

Chinook were found in all sample areas in both the lower and upper river with the exception of Gray Wolf sites above the broodstock acclimation pond. Highest totals were recorded in the lower river at Dawley Side Channel (RM 6.4 to RM 7.5) and in combined samples within the mainstem. It should be noted that these latter numbers are from the entire lower mainstem (RM 3.25 - 7.5). They also included

TOTAL CAPTURES BY ALL METHODS (October 1997 - October 1998)

TABLE 12

Lower River Sites (RM 3.0 - 7.5)

Site	Species	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
GAGNON	CHINOOK		43		25	7	8	4	0	0		0	0	87
	COHO		102		66	42	92	128	15	2		30	84	561
	TROUT		8		6	8	3	7	0	0		0	5	37
W.RAILROAD	CHINOOK	7			0		4		0	0	0		1	12
	COHO	60			21		234		32	22	31		60	460
	TROUT	26			3		56		2	0	2		1	90
	LAMPREY						3							3
E.RAILROAD	CHINOOK	0	17		0		6	0	0	7		0	0	30
	COHO	8	28		0		24	29	8	11		13	72	193
	CHUM						20							20
	TROUT	2	10		4		28	4	0	0		3	3	54
	SCULPIN						1							1
DAWLEY	CHINOOK	1	39		3	24	15	6	0	29	35	98		250
	COHO	30	88		112	126	126	233	4	140	135	203		1197
	PINK	0	0		0	1	10	8	0	0	0	0		19
	TROUT	7	10		3	3	8	7	0	0	1	5		44
LOWER MAINSTEM	CHINOOK	0	1		5	0	6	0	2	39	0	74	59	186
	COHO	2	0		13	4	9	2	37	86	2	250	39	444
	CHUM								2					2
	PINK													
	TROUT	5	1		26	3	27	2	1	1	0	6	7	79

Note: Lower Mainstem includes all captures between RM 3.25-7.5

TOTAL CAPTURES BY SPECIES (October 1997 - October 1998) TABLE 13

Totals include all methods in all sample sites (RM 15.8 - RM 18.7) UPPER RIVER

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
GRAY WOLF SIDE CHANNELS													
CHINOOK					0	26	2	0	1	55	0	0	84
COHO					4	10	60	56	128	86	94	23	461
TROUT					1	68	13	3	0	1	9	0	95
UPPER DUNGENESS SIDE CHANNELS													
CHINOOK									132	15		1	148
COHO									0	0		0	0
TROUT									1	0		2	3
UPPER DUNGENESS MAINSTEM													
CHINOOK		35			1	0			41	73		8	158
COHO		0			4	2			25	1		3	35
TROUT		10			17	0			5	0		2	34
UPPER GRAY WOLF MAINSTEM													
CHINOOK						0				30	0	45	75
COHO						2				19	0	20	41
TROUT						12				1	1	1	15

large numbers of chinook within deep pools along the main channel and mainstem braids during late summer and early fall low flows.

The highest number of captures of chinook in the upper watershed were within the single Dungeness side channel near East Crossing Campground and within the upper Dungeness mainstem. Several of our captures included seines downstream of release sites. These may be among our only samples and sample sites at which released fish affected our sampling results. This is due to the nature of this area as much as being immediately below release sites. That is, fish released at Gold Creek have little refuge until they reach the East Crossing Side Channel and likely stack up in higher than normal numbers.

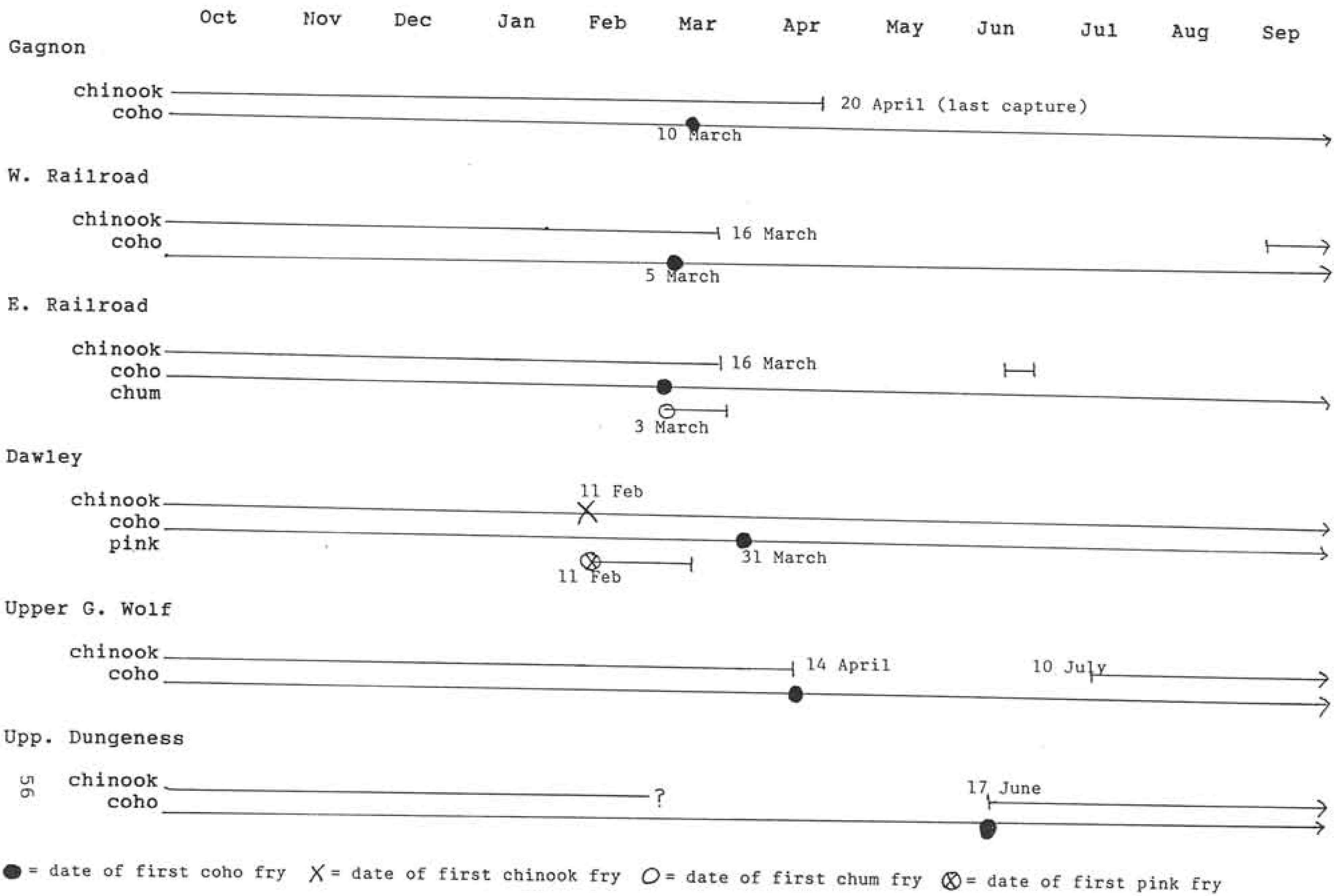
Coho were especially abundant in the Dawley Side Channel samples, but large numbers were also recorded in most other lower river side channels as well as in the mainstem during summer low flows.

It is interesting to note that the ratio of coho to chinook captures was far greater in lower river than upper river sites. Five times more chinook than coho appeared in our upper Dungeness samples than in lower river captures. Slightly more than twice as many coho were taken in lower river sites as compared with chinook in the same areas.

The first newly emerged, wild chinook fry appeared in our seine samples on 11 February 1998. These captures also included our first observation of juvenile pinks. Both were within Dawley Side Channel. See Figure 11 for dates of fry appearance for other species as well as dates of the presence of juveniles within each side channel.

PRESENCE OF JUVENILE SALMON IN SIDE CHANNELS
October 1997 - October 1998

FIGURE 12



CHINOOK AND COHO USE OF ALCOVES

While some alcoves were used exclusively by coho during our study, none of those frequented by chinook were restricted to a single species use. The differences between

the kinds of alcoves may shed light on chinook preferences, or movements in and out of side channels and other refuge habitats.

Coho alcoves - those in which we only found coho - were found off the mainstem, along the edges of side channels at the junction of smaller channels. We call these smaller braids overflow channels since their primary flow comes from the river during high water events. One exception is an alcove we sampled many times. It is a stranded pool along a side channel and is at the tail end of a dry braid of the side channel itself.

All of the coho alcoves were isolated/stranded at various times. Our samples included river stages at which time water levels were high enough to re-connect them to the side channel. All were within 10 meters or less of the side channel.

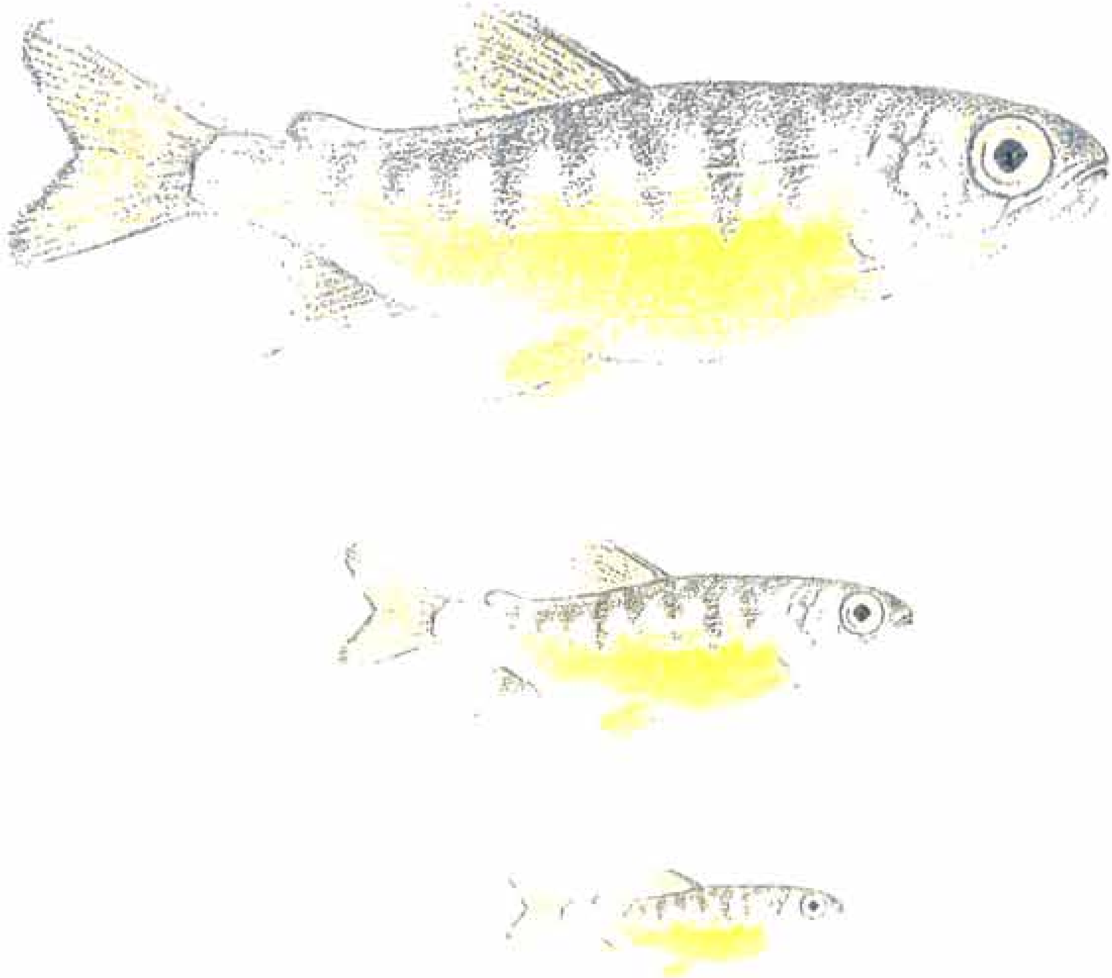
One of the most interesting coho alcoves is located next to a large pool in which chinook were frequently captured. It also had one of the most frequently connected outlets between it and the side channel. Yet, no chinook were observed using it during the length of our study.

Chinook alcove use was restricted to those more intimately associated with the river itself. This included alcoves at both top and bottom ends of side channels. One of the sites where chinook were taken most consistently during winter sampling was an alcove. Like coho alcoves, it became stranded at low river stages, being cut off from the mainstem at flows below about 400 cfs.

Alcove habitat is typical of the entry and exit feature of side channels, usually forming quite close to the mainstem and often associated with large debris jams. We call them "doorways" to the side channel refuges due to this intimate connection. There is good reason to suggest that they are optimal habitats, offering a degree of quiet refuge alongside the swifter river.

That coho use some alcoves exclusively might suggest preference on their part. But it doesn't support avoidance by chinook. It could be that chinook numbers in the Dungeness were not high enough during our study for us to see them in all optimal habitats.

An alcove-like habitat we sampled that was used by coho was also upstream from chinook release sites in the Gray Wolf. This beaver pond was at the tail end of a side channel and was also used by both dolly varden and rainbow trout. Chinook were not observed here or at any other site above release sites, suggesting no upriver movements during our study.



SIZE FREQUENCIES OF CHINOOK AND COHO

Graphic presentation of size frequencies of chinook and coho for all sample locations during our study is shown in Appendices I and II. The information is grouped according to season, from the winter of 1997-98 to summer 1998. Each of our primary sample sites are represented.

As discussed earlier, chinook were present in only one location during all months - Dawley Side Channel (RM 6.4-7.5). We believe this is due to two factors, one being its open connection with the river at both the top and bottom ends of its channel. This lower river side channel was also the only off channel habitat with known chinook spawning the previous year. It may also serve as a refuge for downstream migrants from both the upper mainstem and the Gray Wolf.

Overwintering chinook ranged in size from 60-90mm. In early spring, emerging fry contributed greatly to our samples. It should be pointed out that the large numbers in the spring are much lower than the actual population. This is due to our reluctance to seine fry and possible alevins. On each sample date, we only seined to obtain a general idea of presence and size. Each time we seined newly emerged chinooks (or pinks), we stopped sampling in that area to avoid potential mortality or disruption of the gravel refuges.

Regardless of numbers, spring months did reveal a distinct separation between Age 0 and Age 1 chinook at Dawley Side Channel. By summer those lines were blurred, but it is clear that some of the younger age class fish were still in the channel along with yearlings up to 90mm.

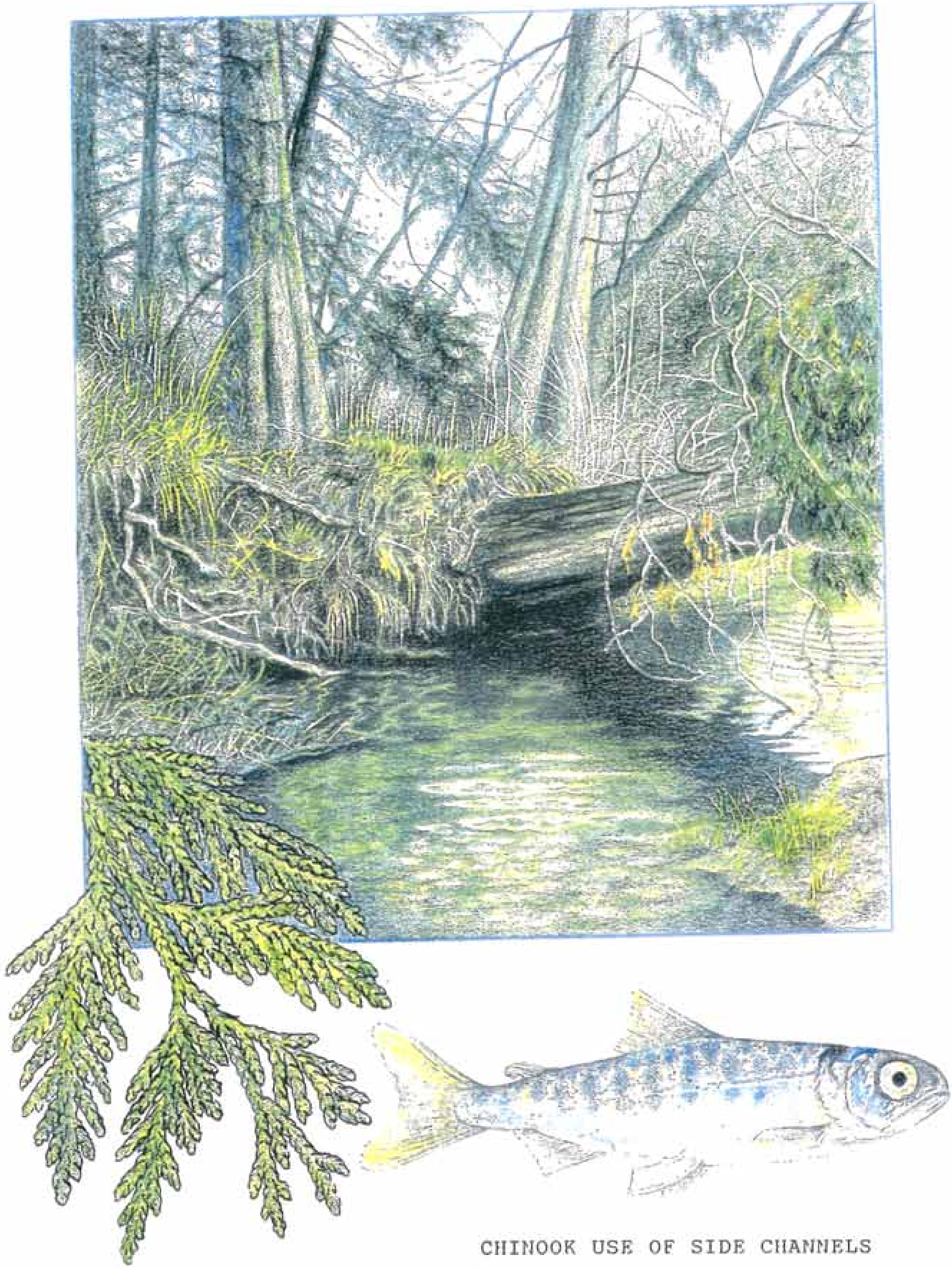
The samples at all other sites are assumed to reflect a predominance of, or exclusive representation by, broodstock release chinook. For example, East and West Railroad Bridge chinook are all in tight, even-sized groupings. Limited sampling for coded wire tags with a portable wand during the winter also indicated that most chinook were from the broodstock releases.

However, lower river samples include some of the smaller, very likely wild, chinook as observed at Dawley. For example, spring lower river chinook are predominantly clustered in two groups ranging in size from 30-60mm and 70-100mm. This suggests the presence of Age 0 and Age 1 chinook. The later samples in summer showed that younger fish remained in samples, along with much larger chinook up to about 110mm. These larger fish represent possible overwintering populations as well those migrating to sea as Age 1+ smolts.

In general, coho occur in each sample site in a broader range of size/age categories. Age 0, Age 1, and apparent Age 2 coho juveniles were captured at all lower river sites as well as in the Gray Wolf River Side Channels.

The Upper Dungeness sample sites were the only location without a broad representation of coho age classes. As can be seen in Appendix II - S and II - T, only larger (likely Age 1) coho were captured in Spring samples. Summer samples included Age 0 fry, exclusively.

Coho up to 140mm were captured in the quiet off channel habitats of the Gagnon Side Channel (RM 3.25 - 4.0). Additionally, large coho were taken in this area in each sample period as can be seen in Appendices II - A-C.



CHINOOK USE OF SIDE CHANNELS

We captured chinook in each lower river side channel, beginning in the fall of 1997. Additonal captures were recorded in the Upper Dungeness and in the Gray Wolf side channel near The Forks Campground. The majority of these fish were from broodstock releases the previous spring and summer. Of these 1,774,736 fish, 1,005,702 were adipose clipped. All releases were marked with an implanted coded wire tag.

As we handled fish, we noted presence or absence of the adipose fin and, on some occasions, we used a portable wand detector to note presence or absence of a coded tag.

Chinook remained in each side channel, showing up in samples throughout the winter of 97-98. Distribution within the side channels varied from site to site. In general, chinook use included the entire length of those side channels with open connections with the river at both top and bottom ends.

Side channels with modified connections with the river had reduced extent of use. For example, Gagnon Side Channel had a blocked upper connection at its junction with Old Olympic Highway (RM 4.0). Chinook were probably limited to the lower end due to a lack of access to that upper reach (See Figure 13). This is in contrast to distribution of chinook in the Dawley Side Channel (RM 6.4 - 7.5) where chinook occurred throughout its length.

While we did record over-wintering chinook, some of the 1997 broodstock fish left the river in the fall. Department of Fish and Wildlife smolt sampling resulted in captures of

FIGURE 13 DISTRIBUTION OF CHINOOK AND COHO IN GAGNON SIDE CHANNEL

approximately 380,000 chinooks, including an equal 21% from each released group of fish (Dave Seiler, WDFW, personal communication).

Our sampling indicates that the remainder of the 1997 broodstock release fish left the river as age 1 smolts during the early spring, possibly during a fairly short time period. As seen in Figure 12, lower river side channel habitats held chinooks until dates ranging from 16 March to 20 April. Upper river side channels held chinooks until 14 April.

Beginning in late winter 1997, we also began capturing newly emerged wild chinook in Dawley Side Channel. We were able to distinguish these fish from all others until May 1998 when new releases took place. Unlike the previous year, 1998 releases included unmarked fry, so we weren't able to tell wild from broodstock fish.

Dawley Side Channel was the only off channel habitat with known chinook spawning in 1997. Newly emerged fry were first captured in seine samples on 11 February 1998, the same day on which we also captured pink fry in the same area, often in the same seines. Yearling chinook were also present in the side channel at this time.

Chinook began appearing in other side channels in mid-summer. One of these locations is notable in that large numbers of fry showed up soon after upstream releases. This was in strong contrast to non-side channel sites sampled above that point but still below the releases.

Chinook releases in the upper watershed took place at the acclimation ponds along the Gray Wolf River just below the Gray Wolf Bridge and as far upstream as Gold Creek on the upper Dungeness (RM 18.7).

We sampled the Dungeness River following Gold Creek releases and found few fish until we reached a short side channel, approximately one mile below the release site, just above the East Crossing Campground. There are no other side channels in this steep reach of the river.

Chinook captures at the East Crossing Side Channel included our largest single seine samples. Scoops of more than 50 fry were recorded in June, shortly after release dates. On the same date, no more than three chinook were scooped in a single seine at locations along the mile of mainstem above the side channel. Chinook were present, though in lower numbers in each sample after June, through the end of September.

Upper Gray Wolf chinook were only captured below the acclimation ponds, but not in the first side channel downstream of that release site.

Unlike the upper Dungeness above the Forks, the Gray Wolf River includes several off channel habitats. Of those immediately below the acclimation ponds, the first to hold significant chinook is just opposite The Forks Campground. Two others that were regularly sampled were primarily coho habitats.

The Forks Campground Side Channel held chinook throughout its length. 1997 broodstock release fish were present until 14 April and 1998 release fish showed up in our July samples and were present through the end of our study in September. It is interesting to note that chinook occurred in lower reaches of the side channel during the summer of 1998, all in quiet pools occupied almost exclusively by coho the previous year.

Chinook use of the lower river side channels at West and East Railroad Bridge, as well as at Gagnon Side Channel reflects a lack of access into these refuge habitats.

Chinook could access each of these lower river side channels during the Fall of 1997 due to high flows. This was especially true at East Railroad Bridge, where fish could enter the side channel through the top channel and through overflows connecting along its length.

East Railroad Bridge Side Channel held chinook throughout the winter of 1997-98. Both chinook and coho were captured in pools within narrow overflows as well as in pools along the length of the side channel. Chinook from the 1997 Broodstock releases were last observed here in March.

1998 chinook juveniles were only captured once, near the mouth of the side channel in June. This is likely due to the low flows that have cut off the upper entrance from the river. Even though fish could swim up, and into the side channel from the mouth, no chinook have been captured in the lower end from July to the end of September.

At West Railroad Bridge Side Channel, water levels were not high enough to open the top channel at any time during our study. But, an overflow, located not far above Railroad Bridge, connected with the river. Chinook were found from this point, downstream, in the side channel until 16 March. Chinook were absent until 10 September and appear to be following a pattern similar to the previous year - that is, chinook use is restricted to the lower half of the side channel.

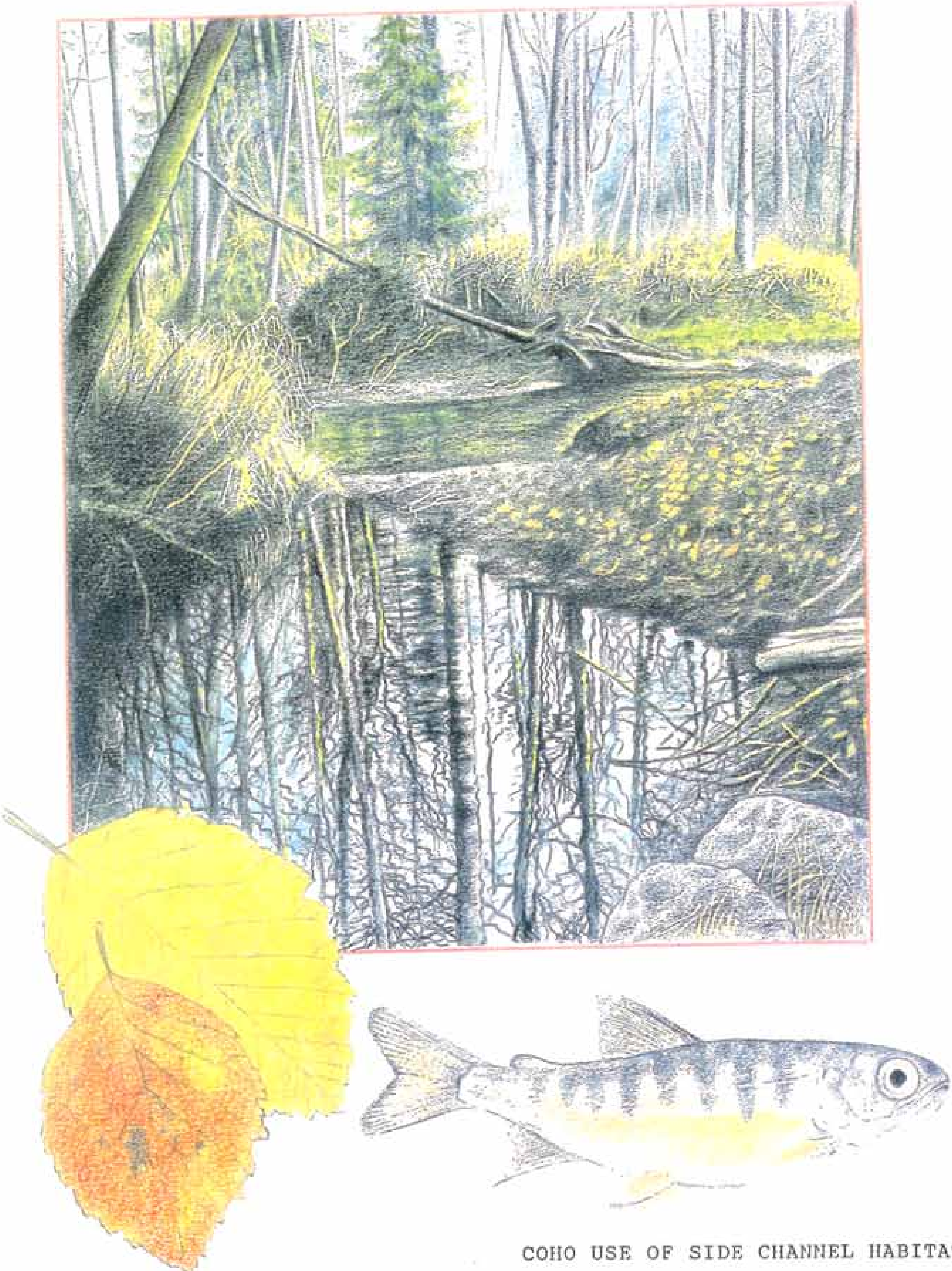
Gagnon Side Channel had no connection with the river during our study except the narrow channel at its lower end. Overflows connect at higher flows than recorded, but its top end has likely been cut off from the river since construction of the Old Olympic Highway.

Chinook were found consistently in a pool at the lower end of the channel not far from the river. Densities of chinook at this site were 0.5 fish/m^2. Small numbers of chinook were also captured a short distance up the channel.

Some chinook spent the entire winter and early spring at the lower end pool, but an increase in flow in early January backed the river into the side channel. This increase from 200cfs on 13 January to 1000cfs on the 14th covered the short, shallow channel connecting the pool with the river. Captures of chinook fell after this date, indicating densities of 0.2 fish/m^2.

Our last observation of chinook anywhere in this side channel was on 20 April 1998. We visited the site several times since that time. But, low flows dried the connection with the river over summer. Even though chinook were present in the mainstem adjacent to the side channel they could not enter until high fall flows.

We revisited this alcove pool on 24 November 1998 and found conditions similar to those in January. The river had backed into the side channel after peak flows of 2600cfs. This re-connect allowed juvenile fish to enter and we seined chinook here for the first time in seven months.



COHO USE OF SIDE CHANNEL HABITATS

Coho were present in all side channels, all year long and occupied each overflow channel as well as isolated pools, some separated from any flowing water for the length of the study. They also inhabited the highest reaches of each side channel, moving up and down with the wetted length of all but one site.

We captured coho along with other salmonids in minnow traps and in seines. But there were habitat types where coho were exclusively found. These observations may be an aid in determining fish movements.

Figure 12 presents information on the presence of coho in each of the main side channels sampled. As can be seen, coho fry began showing up in lower river samples in early March with later emergence indicated by captures as late as June in the upper Dungeness. It should be noted that captures of coho were much lower in the upper Dungeness than in other sites, including the upper Gray Wolf. For example, from 17 June to the end of September our total captures in the upper Dungeness included 234 chinook and 29 coho. During the same time period, we captured 162 chinook and 430 coho in Dawley Side Channel in a similar sampling effort.

Coho were more abundant in the upper Gray Wolf than Dungeness, likely due to the more diverse off channel habitats. See, for example, Figure 3 which shows locations of side channels in comparable lengths of the upper Dungeness and the Gray Wolf above The Forks. Eight side channels have been located in this area along the Gray Wolf, while only one side channel habitat was located along the Dungeness.

Several sites along the Gray Wolf held coho, exclusively. These included two side channels sampled above the acclimation ponds (upper limit of chinook releases). It also included a side channel immediately below the ponds.

Mossy Rock Side Channel was first sampled in April 1998. It is narrow and well vegetated with boulder rimmed pools. It is connected to the river at its top end by a trickle entrance leading away from the river through a foot wide channel. It slowly cascades into the river at its tail end across an equally narrow, and shallow channel.

Located just downstream from the acclimation pond outlet, and across the Gray Wolf on the west side of the river, no chinooks appeared to make their way into the small entrances in 1998. But coho were abundant. And, in April as well as in May, we measured coho ranging from 25 to 110mm.

Larger coho were also seen at this side channel in early Fall, suggesting multiple age groups in this upper river site. Age 0, Age 1, and possibly Age 1+ coho were present in the side channel.

Large coho were also present in beaver ponds along the upper Gray Wolf in late season captures. The beaver ponds were our uppermost sample site, located about 1 mile above the Gray Wolf Bridge. Coho as large as 117mm were captured in August, along with dolly varden and rainbow. The salmon were possibly stranded, due to the low water levels in late summer which kept spillway levels a foot or more above the pond.

No Age 0 coho were captured in the beaver pond, suggesting that fish access had been limited during the spring. Adult spawning in the channel immediately above the pond may have been limited as well.

Immediately downstream from the beaver pond, another side channel also held coho. It was connected freely to the river and also held larger coho. Age 0 fish were present in late summer samples, but densities were low (pools with approximately 0.2 coho/m).

The lower river contains some of the most productive coho habitats in the region. Spring Creek, a tributary entering Dawley Side Channel, is especially important (Washington Department of Fish and Wildlife, Unpublished).

Each of the lower river side channels held coho throughout our study. Unlike chinook, coho were also continuously present. As newly emerged fry appeared in Spring (dates of first appearance ranged from 3 to 31 March in the four lower river side channels), older, age 1 and possibly age 2 cohos remained. This may be an adaptation on the part of Dungeness/Gray Wolf coho to the unpredictable nature of side channel connection with the river.

Gagon side channel is lower than any others sampled. Coho were present in a pool frequently sampled for chinook on 20 April 1998. After that time, chinook departed the channel and, presumably, the river during relatively high spring flows. This pool and sites upstream continued to hold coho throughout the summer and early fall after the channel was completely cut off from the river. Size of coho in April and in September is shown in Figures 14 and 15.

A similar pattern of use by coho was seen at other side channels in the lower river, but each of these had open connections with the river in at least their lower end. Larger coho were not as abundant in these side channels. This is especially true at Dawley Side Channel with its open connections at both top and bottom. Sizes of coho captured during comparable periods as shown for Gagnon Side Channel are shown for Dawley in Figures 16 and 17.

FIGURE 14

Length Frequencies of Juvenile Coho captured at Gagnon Side Channel in the Lower River, April 20,1998.

Mean Length = 92.1mm

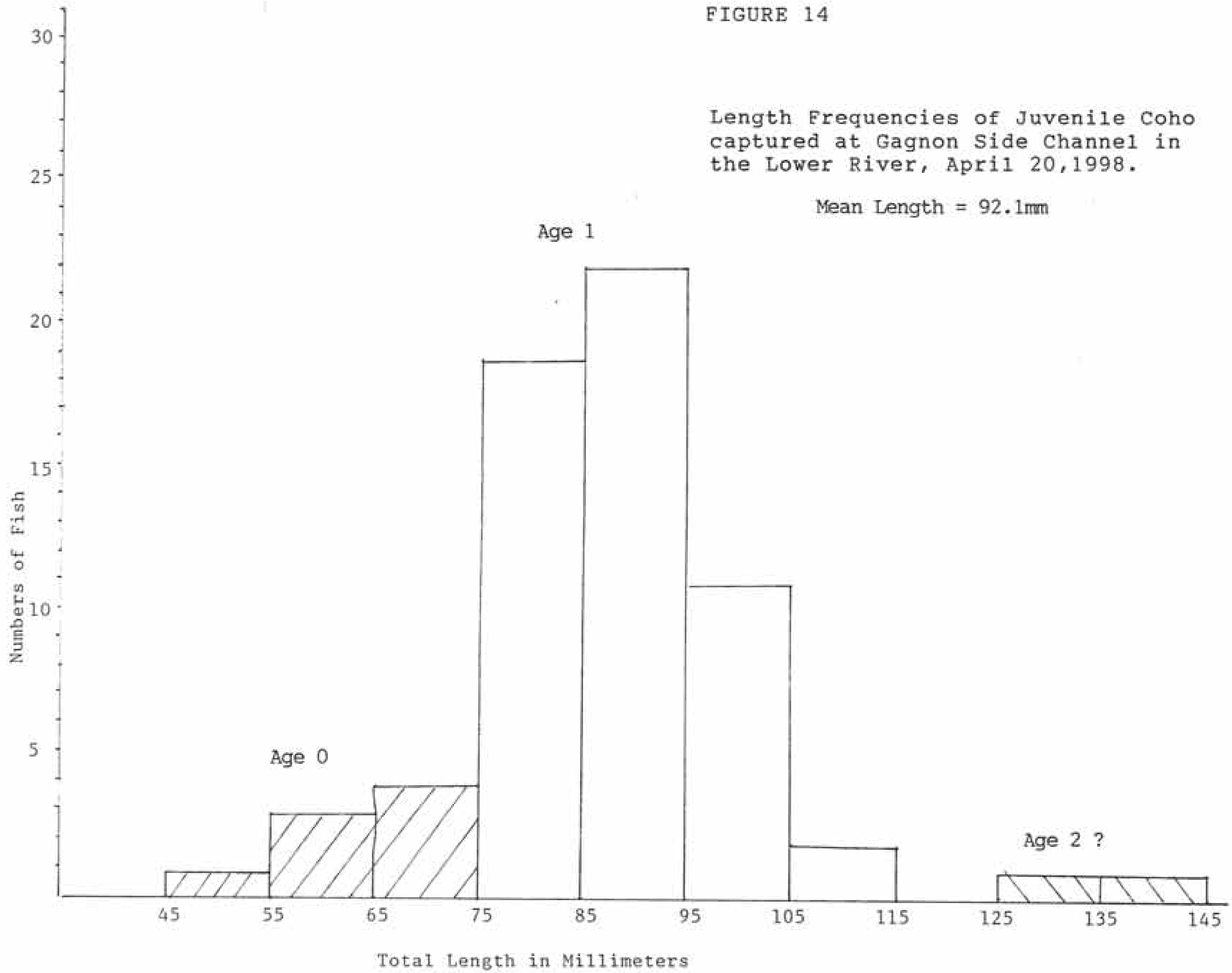


FIGURE 15

Length Frequencies of Juvenile Coho captured at Gagnon Side Channel in the Lower River, 24 September 1998.

Mean Length = 80.3mm

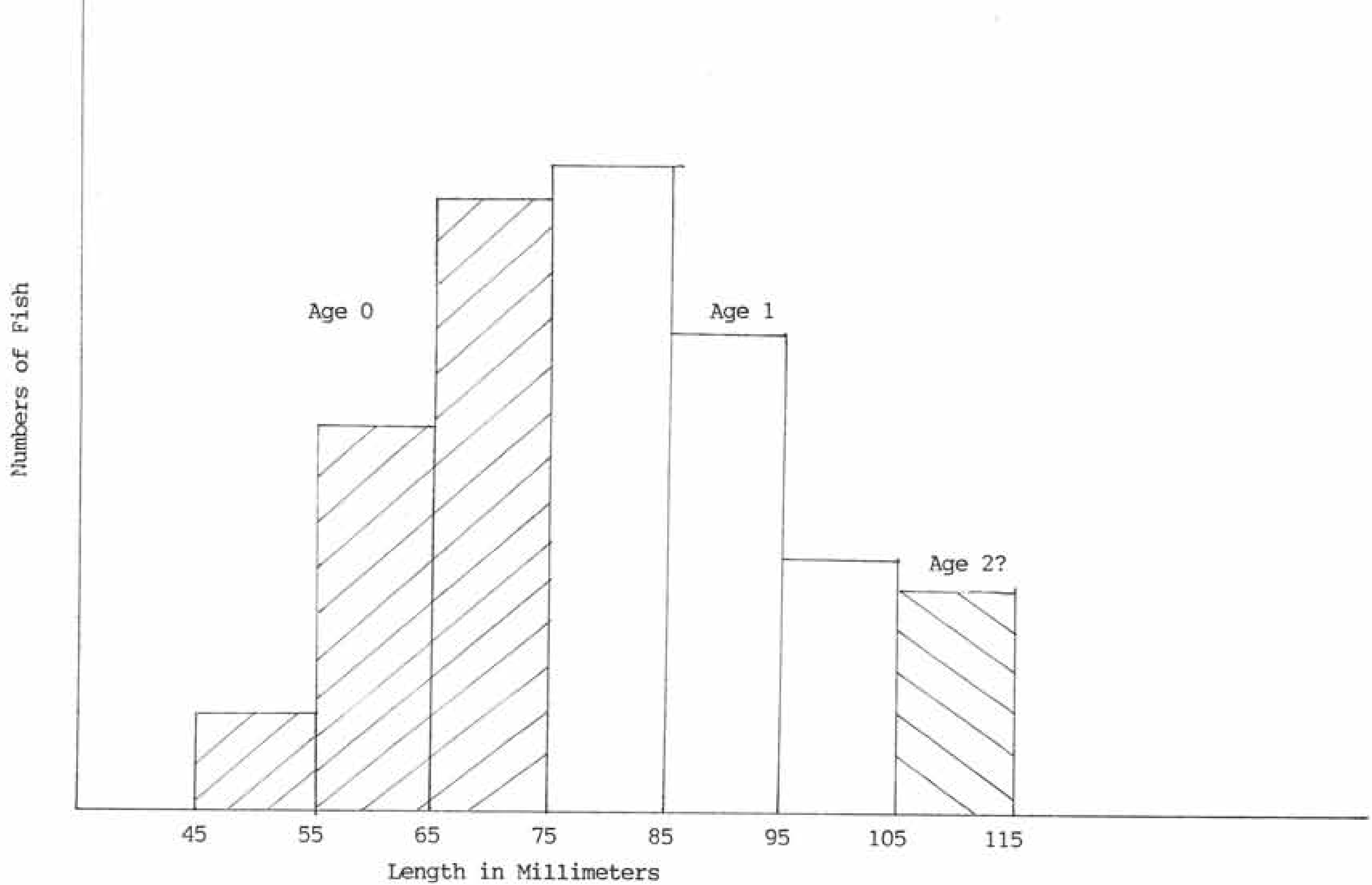
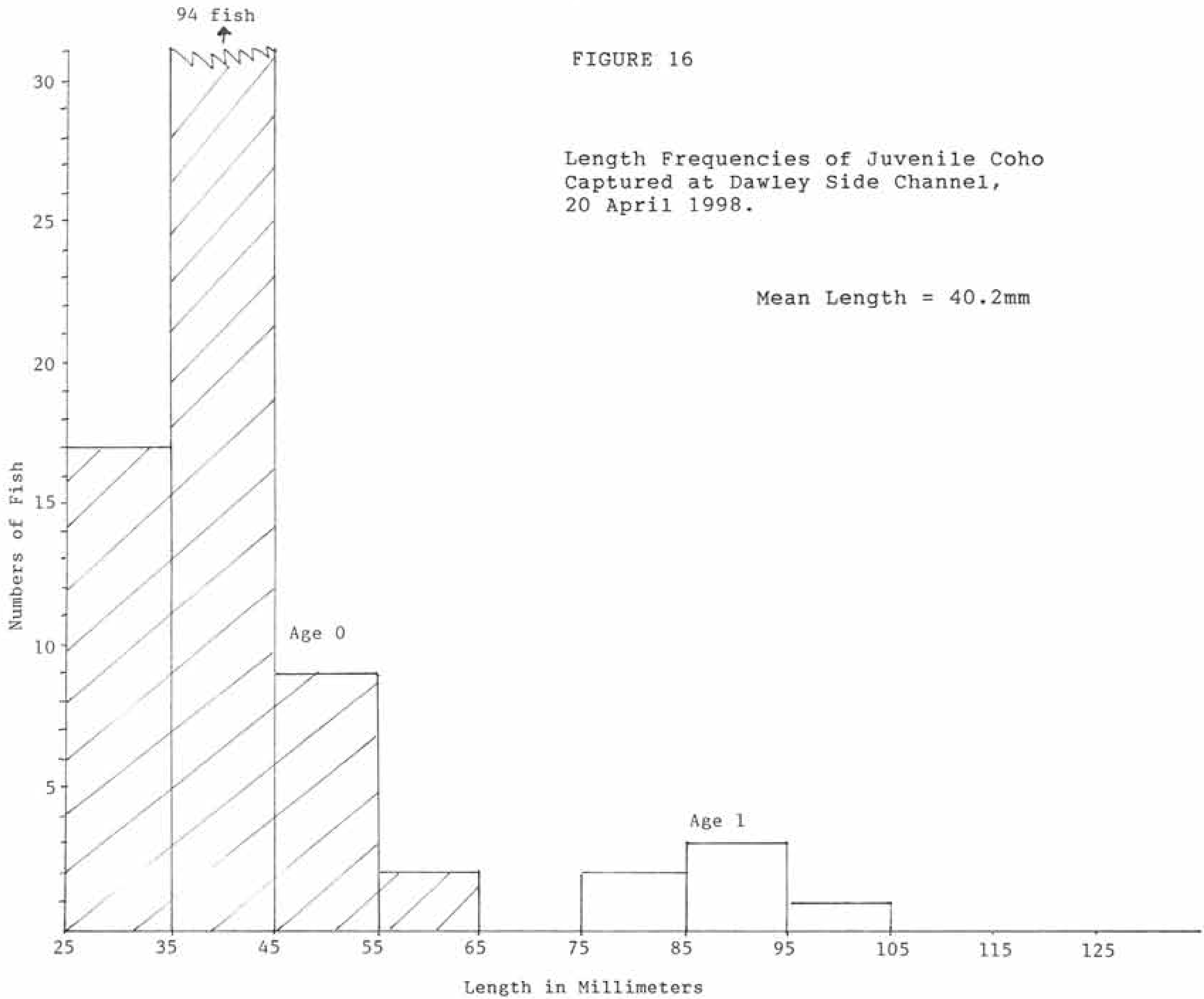


FIGURE 16

Length Frequencies of Juvenile Coho Captured at Dawley Side Channel, 20 April 1998.

Mean Length = 40.2mm



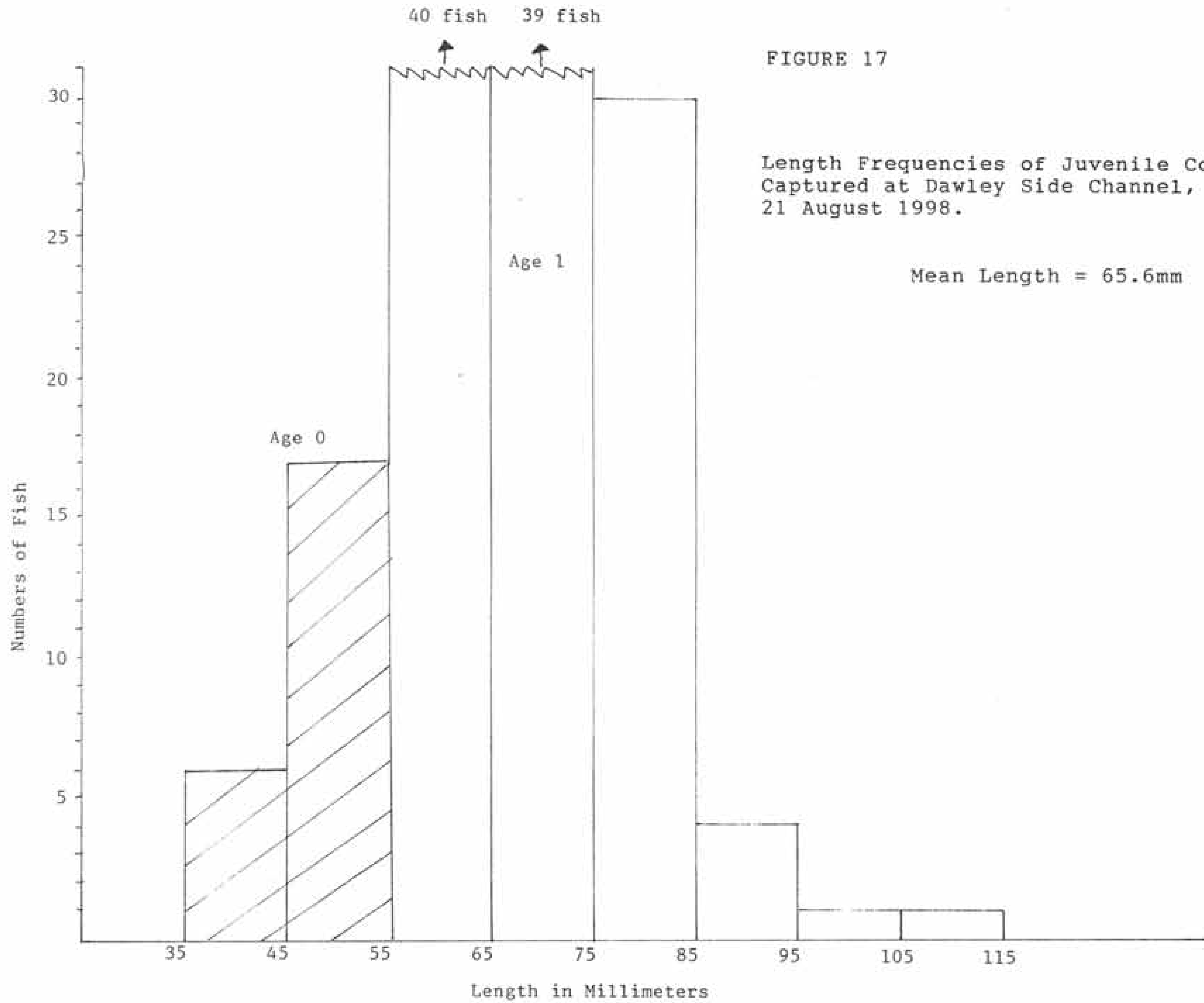


FIGURE 17

Length Frequencies of Juvenile Coho Captured at Dawley Side Channel, 21 August 1998.

Mean Length = 65.6mm

Coho captured here did not reach as large a size as at Gagnon and no coho presumed to be greater than age 1 were included in our samples. This may be due to older coho migration, both as smolts and pre-smolts. The latter may move into other side channels or seek refuge within pools in the mainstem. It is also tempting to suggest that older fish may move into Gagnon, since it is lower in the watershed. But, the side channel was cut off from the river during much of this period.

Coho were often captured or observed in small, isolated pools throughout the watershed. Some of these were monitored

Alcove Pool at Junction of Overflow and the Dawley Side Channel. (Used exclusively by Coho - 1997 - 1998)

closely and most were used exclusively by coho.

The pools are typically alcove scours formed at the tail end of overflow channels. Even though the overflow dries, most of these deeper pools held water the length of our study. All had shallow, often dry, channels connecting them with the main side channel.

Two stranded pools along Dawley Side Channel were sampled routinely. They were often connected to the side channel, but even when flows were high, they remained protected with very little flow. Leaf litter covered the bottoms and remained through the summer. Even though chinook were often found in the channel as near as one meter away, coho were the sole captures in each alcove.

Coho were present in each of the Dawley alcove "strand pools" during all samples. This was true in a similar pool along the Gagnon Side Channel until late summer low flows.

The tiny alcove (surface area varied from less than one to about nine square meters) formed along an overflow channel of the Gagnon channel and held coho throughout the winter and spring. As many as 29 coho were captured in November (3.4 fish/m^2), but only one was present in a June seine that followed a period of water high enough to connect the pool with the side channel. By September no fish were present and its size was reduced to its smallest dimensions.

As water levels dropped, other, larger pools took on characteristics of these smaller "strands". This included the pool at the tail end of Gagnon Side Channel where chinook were present from October 1997-April 1998.

An alcove formed at the junction with the river, this pool became isolated from the river and the upper side channel as water levels fell to historic lows in late summer and early fall. At one point in August, algae filled much of the pool and temperatures as high as 70F were recorded. But, coho were present throughout this period, including our last sample on 24 September when we trapped 51 coho (1.3 fish/m^2).

PINK SALMON USE OF SIDE CHANNELS

We were unable to sample pink salmon as effectively as coho and chinook. This is likely due to the small window of pink presence in the river and the unlikely chance of capture in minnow traps.

However, we did capture pinks when our chinook sampling began to focus on recently emerged fry that were also trap shy or smaller than the wire mesh in the traps. Use of seines in late winter 1998 helped in catching the young of the year.

Pink fry are the most distinctive of all juvenile salmon. Their silver sides are unmarked by any lines or parr marks. They almost glow and can be picked out in schools of other small fish, just as the coho's white anal fin line can often distinguish them from other salmon and trout.

Our first captures were on 11 February along Dawley Side Channel. This was the only non-estuarine site where we found pinks. Four were measured on this date, each with a total length of 35mm.

Ten pinks were seined on 13 March, ranging in size from 30-45mm (average length of 37.5mm).

One additional capture was recorded on 14 April in the estuary. A 40mm pink was seined in a tidal channel on that date.

JUVENILE SALMON AND TROUT USE OF THE MAINSTEM

Lower River (River Mile 3.25 - 7.5)

As seen in Table 12, captures of juvenile salmon were very low during winter months in the lower mainstem. In the same time period, both chinook and coho were present in much higher numbers in side channel samples. This likely reflects the importance of off channel refuges as seen in many other rivers. For example, Peterson (1982) noted the extensive movement of coho into riverine ponds on the Clearwater River as streamflows increased.

Winter captures of trout were much higher, accounting for 60% of fish in samples from October to February. This pattern carried over into early spring, when trout accounted for 59% of all captures until May.

After that time coho increased greatly in numbers, while trout captures fell markedly. For example, No more than 7 trout were included in monthly totals from April to September. At the same time, we recorded as many as 86 coho in June and 250 coho in August samples.

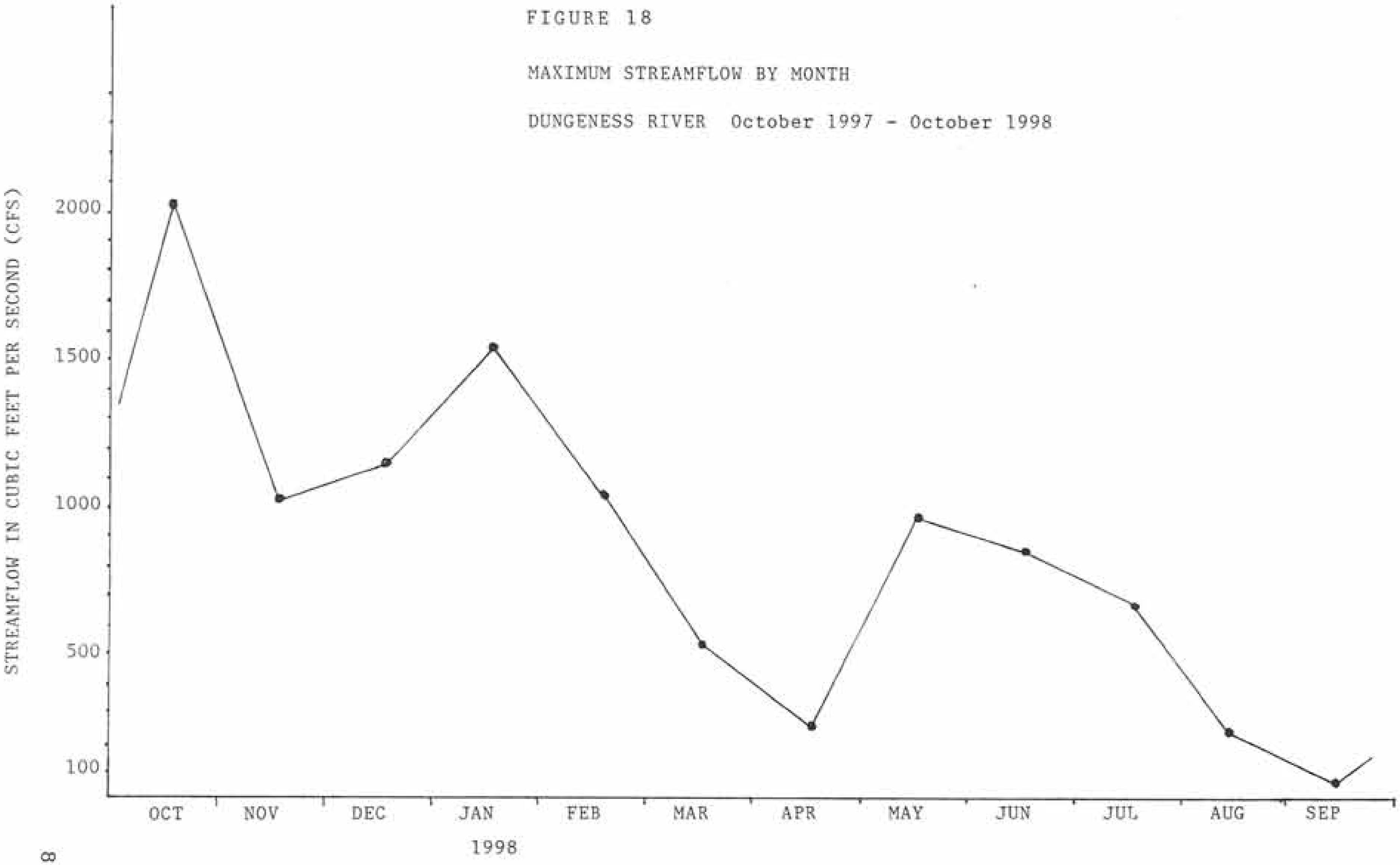
The large numbers of coho in summer were primarily in samples within wood dominated alcoves. Streamflows fell dramatically from May-September, as seen in Figure 18. Extreme low flows of less than 100cfs created conditions in the mainstem that approached those of off channel habitats.

Juvenile chinook were also found in larger numbers in the alcove pools and their numbers roughly parallel those of coho. Chinook were not as abundant as coho with the

FIGURE 18

MAXIMUM STREAMFLOW BY MONTH

DUNGENESS RIVER October 1997 - October 1998



exception of September, the only month when we captured more chinook than coho in the lower mainstem.

UPPER DUNGENESS (RM 15.8-18.7) and GRAY WOLF (RM 0-2)

We have limited samples from the upper watershed during the winter of 1997-98. However, both chinook and trout were present in the Dungeness mainstem. These samples are from a relatively protected braid near the East Crossing Campground.

In spring samples, trout were significantly higher in numbers within both the Gray Wolf and Dungeness mainstem, accounting for 76% of all captures. These included larger steelhead smolts to 130mm and rainbows to 180mm. At the same time we captured greater numbers of trout in adjacent side channels, but of much smaller size.

As can be seen in Table 13, chinook and coho numbers increased in summer with chinook accounting for 71% of all captures from June through September. Large numbers of chinook were concentrated in one pool within a braided channel of the Gray Wolf throughout this time. On revisiting the pool in November 1998, following high fall flows of 2600cfs, we found no chinook present.

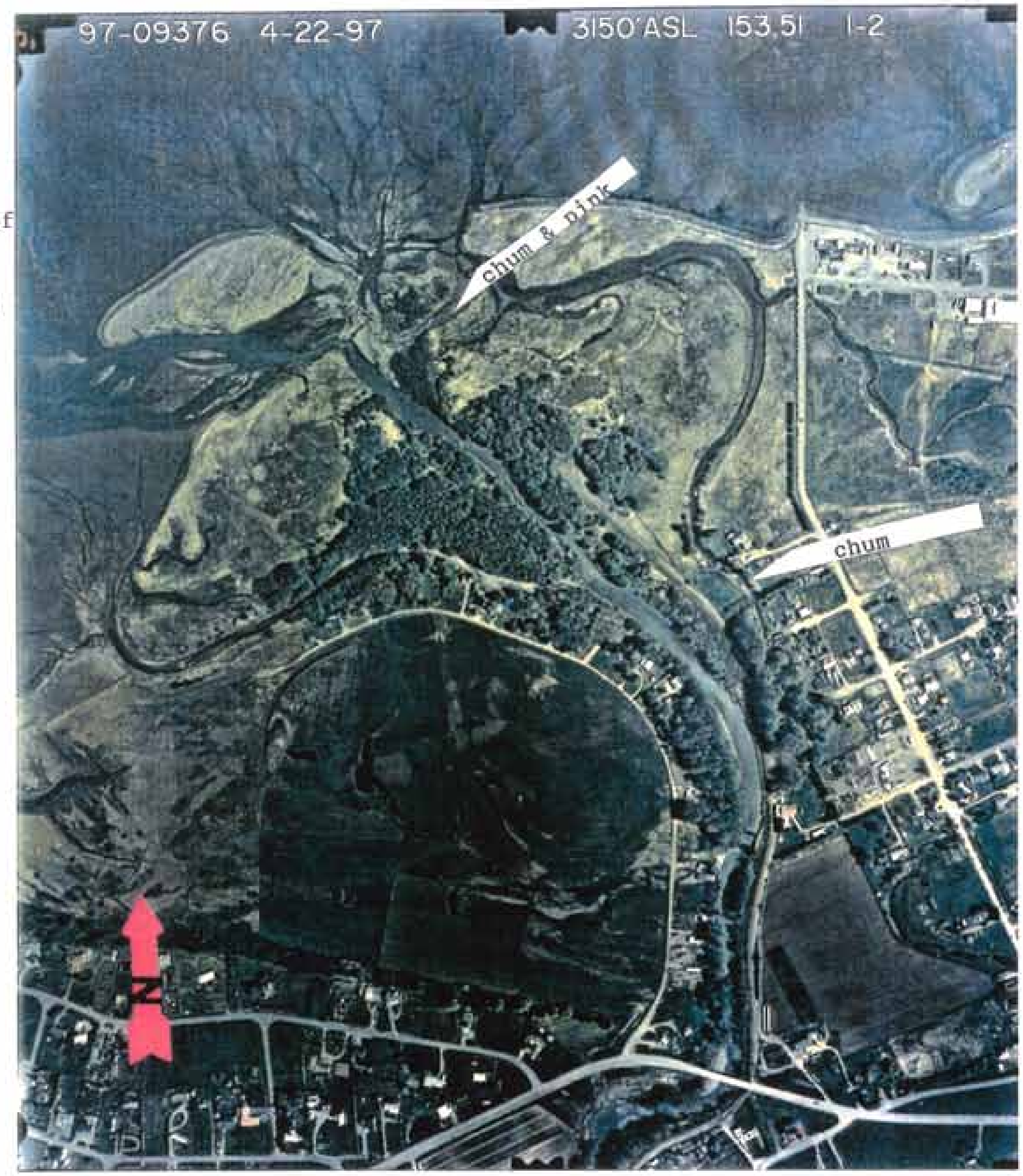
Coho numbers were much higher in Gray Wolf side channels than in the Gray Wolf mainstem. This is likely due to the presence of a large number of off channel habitats as pointed out earlier in this report.

It is of interest to note that coho were only captured in mainstem sites within the upper Dungeness. Even these numbers were low in comparison with other areas. For example, we captured 502 coho in the Gray Wolf from RM 0-2 and only 35 coho in all Dungeness samples from RM 15.8 - 18.7. This points to a need to investigate spawning habitat and other factors that may contribute to a lack of coho in the upper Dungeness.

Chinook were present in this pool within a braided channel of the Gray Wolf in Spring and Summer samples. Following high streamflows of 2600cfs in Fall 1998, no chinook were captured.

FIGURE 19

Locations of chum and pink captures in estuarine sloughs.



JUVENILE SALMON USE OF ESTUARINE SLOUGHS/SIDE CHANNELS

Although few samples were taken in the estuary, we did seine both chum and pink salmon in tidal sloughs. Figure 19 indicates locations of these captures.

Chum were seined near the river mouth on 14 April along with one pink. Small schools of chum were also seined along the upper reaches of a tidal slough to the east of the river mouth. Like Gagnon Side Channel, this slough is blocked by a dike at its upper end.

This dike blockage prevents access, likely limiting juvenile chinook use of valuable rearing habitat. In similar Skagit River sloughs, chinook fry were observed to grow to a larger size than those in the river (Congleton et al 1981). Slough habitat is also important for chum, coho, and chinook as a zone of transition from the river to the salt water environment (Macdonald et al 1987),

Even if chinook and other salmonids are unable to physically access all reaches of the sloughs, their importance is significant for early life history stages. Marsh vegetation supported by these tidal channels is the base of the detrital food chain supporting juvenile salmonids (Healey 1979).

DISCUSSION

LIFE HISTORY TACTICS OF DUNGENESS JUVENILE CHINOOK

On a broad geographic scale, two distinct life history strategies have been identified among chinook juveniles (Healey and Prince 1995). Ocean-type forms typically remain in freshwater for a short time, migrating to sea about 3 months after emerging from the gravel. Stream-type forms remain in freshwater much longer, residing in the river for one and even two years.

On a smaller scale, local populations of salmon often express variations within a given watershed. For example, Talman and Healey (1991) found that three populations of chum salmon spawned at different times in two small streams within one inlet on Vancouver Island, British Columbia. And yet, the fry from these staggered spawning groups all emerged at the same time.

Within the Dungeness watershed, Lichatowich (1993) suggests five probable life history strategies of chinook based on studies on the Sixes River, Oregon (Reimers 1973). This information is summarized in Table 14.

TABLE 14. Possible Life History strategies of Juvenile Chinook in the Dungeness River (Lichatowich 1993)

LIFE HISTORY	SPAWNING	REARING	MIGRATION TO SEA
1	Gray Wolf	Gray Wolf	Spring at Age 1+
2	Upper Dungeness	Upper Dungeness	Spring at Age 1+
3	Gray Wolf	Lower River and estuary	Summer or Fall at Age 0
4	Upper Dungeness	Lower River and estuary	Summer or Fall at Age 0
5	Lower Dungeness	Lower River, Side Channels and estuary	Summer or Fall at Age 0

Lichatowich (1993) suggests that strategies shown in his types 3, 4, and 5 were probably dominant in the Dungeness. He cites patterns from scales of Dungeness chinooks that show 0 age migration, with no scale circuli reflecting patterns of age 1 migration. He also cites other rivers with low frequencies of older smolts. For example, only 3.1% of Oregon's Sixes River chinook migrated to sea at age 1 or older (Reimers 1973).

Our study suggests that a relatively large number of chinook juveniles overwinter in the Dungeness watershed. Their rearing habitat includes side channels and overwintering fish may be dependent on those off channel habitats for critical refuge during high flows.

We have also shown that these off channel areas become partially dewatered as well as isolated from the mainstem for varying lengths of time. For example, the Gagnon Side Channel was cut off from the lower Dungeness for two months in the late summer of 1998 as well as during a short period in the previous winter.

As side channels are connected and isolated, fish are prevented from movements. This isolation can be a physical factor that affects outmigration. Also, at least one side channel in the upper river was blocked for the entire spring due to beaver dams. Over time, juvenile salmon may have adapted to these factors, expressing that adaptation in variable life history tactics.

At a minimum, juvenile chinook in the Dungeness and Gray Wolf appear to follow life histories 1, 3, 4, and 5. But within each of those strategies, rearing is very likely to include far more side channel use than suggested by Lichatowich (1993). Though difficult to assess, it is likely that mainstem rearing would be much higher if more large woody debris was present. This would create refuge habitat shown to be important in other studies (Heifetz et al 1986). These habitats include alcove pools found to be important in the Dungeness, as mentioned earlier in this report.

Life history strategy 1 is supported by our observations of chinook in the Gray Wolf River well into the spring of 1998. Juveniles released from the acclimation ponds (Gray Wolf River Mile 1) made their way into side channels and were last captured at Age 1 in April 1998 (see Figure 11). While no chinook were planted above the ponds, we found a number of side channels in the Gray Wolf that could support overwintering fish.

Life history strategy 2 is highly unlikely. We found only one side channel in this area in the vicinity of River Mile 15.8. A lack of rearing by coho was also evident, suggesting conditions affecting habitat in general. We did note cementing of sediments in the upper Dungeness, although extensive investigation was not conducted. If significant embeddedness is occurring, rearing habitat will be decreased as interstitial spaces between cobbles are filled, leaving no room for fish seeking cover (Hillman et al 1987).

Life histories 3 - 5 are supported by observations of juvenile outmigration during the fall of 1997. Washington Department of Fish and Wildlife smolt trapping recorded migration at this time. However, only 20% of the released chinook were captured in this effort (Dave Sieler, personal communication).

We suggest a more complex pattern of life history strategies in lower river populations. As our captures indicate, a large number of juveniles overwintered in the river and side channels in 1997-98. Juveniles did outmigrate in the fall, but each side channel held chinook until spring, at which time they left the river at Age 1+.

Without further marking of fish, it is not possible to say if upper river chinook also moved into the lower river for rearing. But, this is a likely strategy as well, especially during years with high flows. Fish are also likely to move downstream from the upper Dungeness (as opposed to Gray Wolf) due to the lack of refuge habitat as mentioned earlier.

Based on our findings Dungeness life histories likely follow patterns shown in Table 15. But this pattern should be viewed as a very simplified view as suggested by many authors. It is more likely that a variety of strategies are used in the river, varying with streamflow and other factors. In general, juvenile chinook may well use the watershed as a patch-dynamic system - with the upper river, side channels, lower mainstem, and estuary offering critical functions at varying times as suggested by Murphy et al (1997).

TABLE 15. POSSIBLE LIFE HISTORY STRATEGIES OF JUVENILE CHINOOK IN THE DUNGENESS WATERSHED

LIFE HISTORY	SPAWNING	REARING	MIGRATION TO SEA
1	Gray Wolf	Gray Wolf side channels	Fall Age 0 or Spring Age 1
2	Upper Dungeness	Lower River Mainstem and side channels	Fall Age 0 or Spring Age 1
3	Lower Dungeness	Lower River Mainstem and side channels	Fall Age 0 or Spring Age 1

Note that some rearing in the estuary is likely in each life history.

POTENTIAL INTERACTIONS BETWEEN COHO AND CHINOOK: OBSERVATIONS AND SUGGESTIONS FOR RELEASE STRATEGIES WITH BROODSTOCK CHINOOK

Coho and chinook juveniles were often captured in the same habitats within both mainstem and side channels during our study. There were differences in movement patterns within these habitat types and in size relationships between the two species. It may be useful to consider these and other interactions for future chinook broodstock release efforts in the Dungeness watershed.

There were specific differences in movement patterns of chinook and coho in some habitat types. Chinook appeared to use side channels differently by entering some side channels in their lower reaches without moving far upstream. They would continually occupy lower pool and alcove habitats in these lower reaches despite a lack of physical barriers that could have inhibited upstream movement.

Two sample sites where this occurred, Spring Creek and Gagnon Side Channel, had similar physical features. There were side channels where the top end connection with the river was blocked. The only entry into these side channels was at the mouth of these long refuge channels. In contrast, side channels with open access at their upper entrances from the river supported chinook throughout their length.

A possible explanation for this difference in distribution of the two species is that chinook are drawn to those side channels with open access at their upper ends because they contained more flow. In controlled environments, Taylor (1988) found that chinook selected slightly higher velocity areas, while coho were drawn to quieter areas with cover. However, chinook have been observed to enter stream channels connected to rivers only at their lower ends. For example, Murray and Rosenau (1989) reported that juvenile chinook entered nonnatal tributaries of the Fraser Rive, moving as far as 6.5km upstream.

Another explanation for the apparent differences in use may be the difference in size classes of the two species at the time of movement into side channels. During winter peak flows, refuge from higher velocities may be the dominant force driving juveniles of both species into refuge sites as reported elsewhere (Cederholm and Scarlett 1981, Nickelson et al 1992). Preferences for slightly higher velocity areas by chinook may not be as important as the need to seek shelter.

The two side channels with their upper ends closed supported large populations of coho. As shown in Figure 15, Gagnon coho included fish in two, possibly three age classes. The largest coho captured during our study was in this site. Spring Creek also held large coho and is known for its highly productive coho habitat (Randy Johnson, WDFW, personal communication). Side channels with open access at their upper entrances from the river appeared to support smaller coho, or coho of only two age groups. Perhaps different age and size classes of the two species separate themselves into distinct habitat types based on competition for resources.

In the Sixes River, Oregon, Stein et al (1972) observed overlap in timing of both spawning and emergence of coho and chinook. In their artificial trough experiments, they found that coho grew faster to larger size, assuming a competitive advantage over chinook for rearing and feeding sites.

In our study we found wild chinook emerging earlier than coho (Figure 12). Timing of spawning and emergence are genetically controlled strategies that occur within distinct time periods. Early emergence may give wild chinook a competitive advantage over coho for feeding and rearing sites in the Dungeness. It might be worthwhile to consider the significance of this observation and its significance for timing of chinook releases, taking into account the information on size ranges of coho and chinook as seen in Appendices I and II.

We also found an absence of chinook in upper Gray Wolf River sites above release points. While upstream movement apparently did not occur in 1997-98, we did observe significant rearing habitat such as the side channels shown in Figure 3.

Chinook did make use of side channels availabe to them in the upper Gray Wolf as shown earlier in this report. We also suggest that rearing to Age 1 is a likely strategy for the Gray Wolf (Table 15). Due to the extent of this habitat available, we suggest releases in the Gray Wolf River as far upstream as possible.

LOW FLOWS IN THE MAINSTEM AND ITS EFFECTS ON SIDE CHANNELS

A range of conditions for juvenile rearing were presented by diverse flow conditions during our study. These included winter low flows and extreme late summer low flows, as shown in Figure 18. Conditions varied within side channels as discussed below:

East Railroad Bridge Side Channel (RM 5.65 - RM 6.4)

Both the upper and lower entrances to this side channel were connected to the river during high and moderate flows throughout the study. As flows dropped during late summer and winter, the upper boulder dominated channel went dry for approximately half (225m) its 595m length.

During winter months, flows dropped in the mainstem to 225cfs on 13 January. There were very low intermittent flows in the upper portion of the side channel at this time. On 14 January, flows increased to 1000cfs and the channel was flowing again.

During early spring, flows dropped to 240cfs on 3 March and the upper 225m section of the channel went completely dry. On 16 March, flows increased to 350cfs in the mainstem, bringing only intermittent flow to the upper side channel.

On 10 September, flows in the mainstem dropped to 120cfs and the upper 225m went dry again. This upper portion remained dry until the flows picked up in the mainstem in November.

West Railroad Bridge Side Channel (RM 5.6 - RM 6.4)

The upper end of this side channel appears to have been cut off from the river for a long time. Overflow channels lace the upper end of this side channel, providing some connection to the river during high flow events. During summer low flows, the upper end of the channel goes dry.

A braid of the mainstem skirts the banks of the top entrance of this side channel and the Campsite Side Channel also winds through this complex area, as shown in Figure 7. Flow in this latter side channel was consistent during our study, despite no visible connection with the river.

Gagnon Side Channel (RM 3.25 - RM 4.0)

This side channel begins in a wooded wetland at the base of Old Olympic Highway and flows for 951.1m before meeting the mainstem. During low flows the lower end is cut off from the river, isolating an alcove pool at the mouth of the side channel. This alcove was monitored all year because of its consistent use by overwintering chinook.

On 10 March, the alcove was isolated from the river when flows dropped to 200cfs in the mainstem. Chinook were captured in this blocked alcove on that date. When the site was visited again on 8 May, flows had increased to 900cfs and the connection between the alcove and river was open again and chinook had departed.

A number of overflow channels enter the side channel, but flows were never high enough to funnel surface water from the mainstem to the side channel. However, one overflow channel received subsurface water in its upper reaches, allowing some flow into the side channel.

Dawley Side Channel (RM 6.4 - 7.5)

This is the only side channel in our study that contained flow throughout its length during the entire study. The Sequim Prairie Ditch Company (SPDC) maintains an open connection to the mainstem in order to provide irrigation water to its ditch system, bringing water into the side channel.

This unique situation creates a side channel with higher flows than those seen in the other side channels sampled, directly contributing to a higher diversity of habitat types (i.e., deep pools, alcoves, cut banks, long riffles, etc.). As a result, fish species, size and age class diversity is also high.

This active management also has some negative affects. On 21 August when flows in the mainstem had dropped to 171cfs for several days, SPDC took measures to increase water flow into its ditch system. A temporary dam diverted low flows into the ditch intake, blocking water in the upper portion of Dawley Side Channel. This dewatered a pool near the diversion, resulting in a fish kill of 71 juveniles (23 chinook, 27 coho, 5 trout, and 16 unidentifiable salmonids). When informed of the situation, SPDC immediately corrected the problem, allowing water into the side channel. Plans have been made to keep an eye on this situation during the next summer low flow period.

During winter and early spring, there are also times when high flows in the mainstem are directed into the side channel through the open connection maintained by SPDC. The amount of flows directed into the channel depend on the condition of the opening. For example, what could be described as artificial "freshets" occurred in March when the SPDC improved the upper connection with the river.

When increasing flows in the mainstem were directed into the side channel, flows increased rapidly and in such quantities that former refuges were eliminated, causing juveniles to move downstream. Our habitat surveys reveal a lack of wood of sufficient size in the Dawley Side Channel - wood that might otherwise create sufficient refuges in these high flow situations.

It is clear that without active management by SPDC to keep sufficient flow in the Dawley Side Channel for irrigation purposes that this site would not have the diversity of habitat and fish use we observed. During summer months, it would likely dry in its upper reaches in times of extreme low flows. To keep this channel ideal for juvenile rearing, management actions would need to allow sufficient flows into the side channel, even during these low flows - at a time when irrigation focuses on increases of flows into the ditch system.

Summer low flow needs in the side channel are, at a minimum, to keep pools watered. To provide refuge during high flow events, steps should be taken to create large woody debris jams throughout the Dawley Side Channel.

THE IMPORTANCE OF SIDE CHANNEL HABITAT IN THE DUNGENESS RIVER

In our study chinook were found in all sample areas in both the lower and upper river with the exception of Gray Wolf sites above the broodstock acclimation ponds. The highest numbers recorded occurred in the lower river at the Dawley Side Channel (RM 6.4 - 7.5) and in combined samples in the mainstem. These latter captures occurred over a longer time period and included large numbers of chinook within deep pools along the main channel and mainstem braids during late summer and early fall low flows. The highest number of captures of chinook in the upper watershed were within the single Dungeness side channel near East Crossing Campground and within the Dungeness mainstem.

While high captures were recorded in mainstem sites, those numbers were spread over a much longer time than within side channels. This is due to a greater effort sampling this reach adjacent to each individual side channel area. Also, the mainstem sample area is much larger. As a result, the lower mainstem captures reported in Table 12 (186 chinook) reflect the entire area between RM 3.0 and RM 7.5, or 0.025 chinook per meter. In Dawley Side Channel alone, we captured 250 chinook, or 0.28/m.

Habitat features we believe are necessary for optimum rearing for chinook occur in the side channels, especially during winter months. While optimal features do occur in the mainstem, they are far less abundant, as reflected by the lower capture rates.

Habitat measurements in lower river side channels reflect these conclusions. Those sites have a greater percentage of their length in pool with the exception of the reach between RM 6.4 - 7.5 (Figure 9).

Much of this difference has to do with a lack of stable, longterm debris jams in the mainstem. A habitat survey conducted by Orsborn and Ralph (1994) reported few stable pools and a limited number of large woody debris jams. This is not surprising. Active removal of large wood has been occurring for decades with the subsequent reduction of pools.

Observations made over the length of this study confirmed the importance of stable debris jams for the creation and maintenance of pool habitat in the mainstem. One example is a pool formed by several large trees with root wads attached in the mainstem at the tailend of the Gagnon Side Channel (RM 3.25).

One of the deepest pools measured in our study, it was used by both juveniles and adult salmon. In November 1998, a sudden high flow event (2600cfs) removed the debris jam and subsequent gravel movement filled the pool. This event dramatized concerns that the mainstem is not providing consistent, long term refuge habitat suitable for rearing juveniles. It also points out the importance of adjacent side channels where that critical refuge is available, especially in winter months.

Mainstem pools may often be serving as a kind of staging area for juvenile salmon, rather than as long term refuge habitat. Many of them are used for extended periods, such as during summer low flows when movement to side channels is difficult or not possible. Others may serve more as a kind of staging area, or doorway, linking the mainstem pool with side channel habitats .

This linkage is especially true in alcoves or other deep pools forming at the head end of overflow channels, at the top entrance to side channels, or at the outlet of the latter. Within the mainstem, these alcoves appear to be used by juveniles for brief periods. In side channels, the alcoves sampled in our study were the most consistently used habitats.

A restoration plan created by the Dungeness River Restoration work Group and approved by the Dungeness River Management Team has called for active placement of large woody debris (LWD) throughout the lower river (Dungeness River Restoration Work Group 1997). The Tribe has completed its second year placing LWD in several reaches of the lower river. Due to the enormous resources and time needed to replace stable debris jams in the river, it may be many years before this critical feature is in the abundance needed to provide refuge habitat for overwintering juveniles. The question that needs to be answered is: Do we have enough side channel habitat in both the upper and lower watershed to provide refuge conditions for this important freshwater life history stage?

RECOMMENDATIONS FOR FURTHER STUDY

We suggest a second year of study to maintain ongoing observations of juvenile chinook overwintering in the Dungeness. This would allow a more effective characterization of movements and definition of critical refuge habitats in the watershed.

Since our first study was during an unusual flow year, this second season of sampling would allow comparison as well as follow-up observations. As we have already seen in limited observations in November of this year, chinook movement into side channels has occurred along with debris jam shifts in the mainstem. The latter changes are of interest for ongoing habitat monitoring.

LITERATURE CITED

Bisson, Peter, Jennifer L. Nielsen, Ray A. Palmason, and Larry E. Grove. 1982. A system of naming habitat types in small streams, with examples of habitat utilization by salmonids during low stream flow. p. 62-73. In: N.B. Armantrout (ed) Acquisition and utilization of aquatic habitat inventory information. American Fisheries Society, Bethesda, MD. 376p.

Cederholm, C.J. and W.J. Scarlett. 1981. Seasonal immigrations of juvenile salmonids into four small tributaries of the Clearwater River, Washington, 1977-1981. In: Salmon and trout migratory behavior symposium, E.L. Brannon and E.O. Salo (eds). School of Fisheries, University of Washington 98195.

Congleton, James L., Steven K. Davis, and Steven R. Foley. 1987. Distribution, abundance and outmigration timing of chum and chinook salmon fry in the Skagit salt marsh. p. 153-162. In: E.L. Brannon and E.O. Salo (eds) Salmon and Trout Migratory Behavior Symposium. School of Fisheries, University of Washington, Seattle, 98195.

Dungeness River Restoration Work Group. 1997. Recommended Restoration Projects for the Dungeness River. (Contributors include: Jamestown S'Klallam Tribe, Washington Dept Fish and Wildlife, Clallam County, USFWS, USFS, Natural Resource Conservation Service, Clallam County Conservation District, Private Landowners). Jamestown S'Klallam Tribe, Blyn, Washington.

Healey, M.C. 1979. Detritus and juvenile salmon production in the Nanaimo estuary. I: Production and feeding rates of juvenile chum salmon (Oncorhyhnchus keta). J. Fish. Res. Board Can. 36: 488-496.

Healey, M.C. and Angela Prince. 1995. Scales of variation in life history tactics of Pacific salmon and the conservation of phenotype and genotype. Am. Fish. Soc. Symposium 17: 176-184.

Heifetz, J., M.L. Murphy, and K.V. Koski. 1986. Effects of logging on winter habitat of juvenile salmonids in Alaskan streams. North Am. Jrnl. of Fish. Mgmt. 6: 52-58.

Hilman, T.W., J.S. Griffith, and W.S. Platts. 1987. Summer and winter habitat selection by juvenile chinook salmon in a highly sedimented Idaho stream. Trans. Am. Fish. Society 116: 185-195.

Lichatowich, J. 1993. Dungeness River pink and chinook salmon historical abundance, current status, and restoration. Report prepared by Alder Fork Consulting for the Jamestown S'Klallam Tribe, Sequim, Washington.

MacDonald, J. Stevenson, I.K. Birtwell, and G.M. Kruzynski. 1987. Food and habitat utilization by juvenile salmonids in the Campbell river estuary. Can. J. Fish. Aquat. Sci. 44: 1233-1246.

Murphy, Michael L., K.V. Koski, J. Mitchel Lorenz, and John F. Thedinga. Downstream migrations of juvenile Pacific salmon (Oncorhynchus spp.) in a glacial transboundary river. Can. J. Fish. Aquat. Sci. 54: 2837-2846.

Murray, C.B. and M.L. Rosenau. 1989. Rearing of juvenile chinook salmon in nonnatal tributaries of the lower Fraser River, British Columbia. Trans. Am. Fish. Soc. 118: 284-289.

Nickelson, Thomas E., Jeffrey D. Rodgers, Steven L. Johnson, and Mario F. Solazzi. 1992. Seasonal changes in habitat use by juvenile coho salmon (Oncorhynchus kisutch) in Oregon coastal streams. Can. J. Fish. Aquat. Sci. 49: 783-789.

Orsborn, John F. and Stephen C. Ralph. 1994. An Aquatic Resource Assessment of the Dungeness River System. Prepared for the Jamestown S'Klallam Tribe and The Quilcene Ranger District, Olympic National Forest.

Peterson, N.P. 1982. Immigration of juvenile coho salmon (Oncorhynchus kisutch) into riverine ponds. Can. J. Fish. Aquat. Sci. 39: 1308-1310.

Reimers, P.E. 1973. The length of residence of juvenile fall chinook salmon in Sixes River, Oregon. Research Rpt. Fish Comm. of Oregon 4.

Stein, Roy A., Paul E. Reimers, and James D. Hall. 1972. Social interaction between juvenile coho (Oncorhynchus kisutch) and fall chinook salmon (O. tsawytscha) in Sixes River, Oregon. J. Fish. Res. Bd. Canada 29: 1737-1748.

Talman, R.F. and M.C. Healey. 1991. Phenotypic differentiation in seasonal ecotypes of chum salmon, Oncorhynchus keta. Can.J. Fish. Aquat. Sci. 48: 661-671.

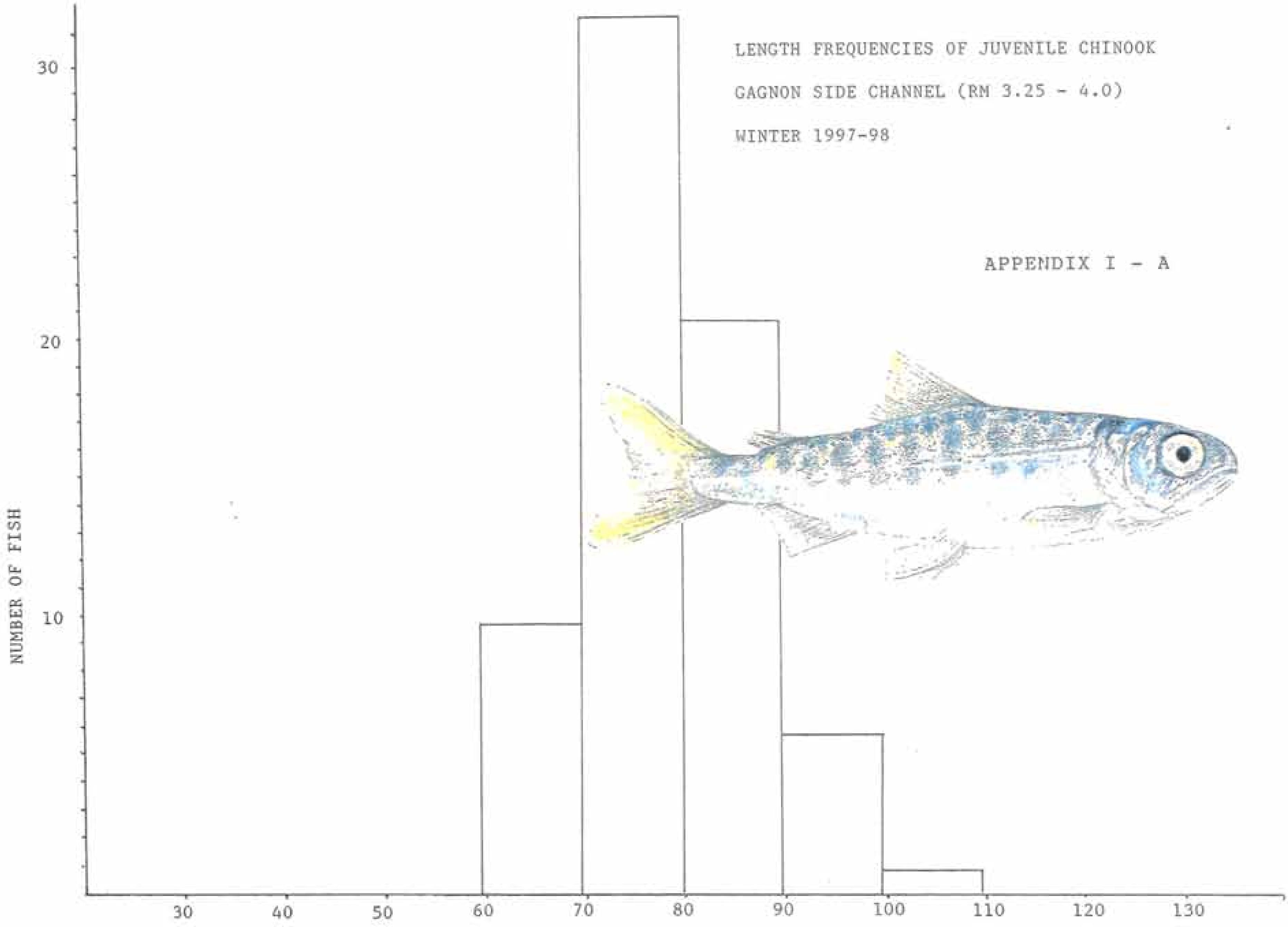
Taylor, Eric B. Water temperature and velocity as determinants of microhabitats of juvenile chinook and coho salmon in a laboratory stream channel. Tans. Am. Fish. Society 117: 22-28.

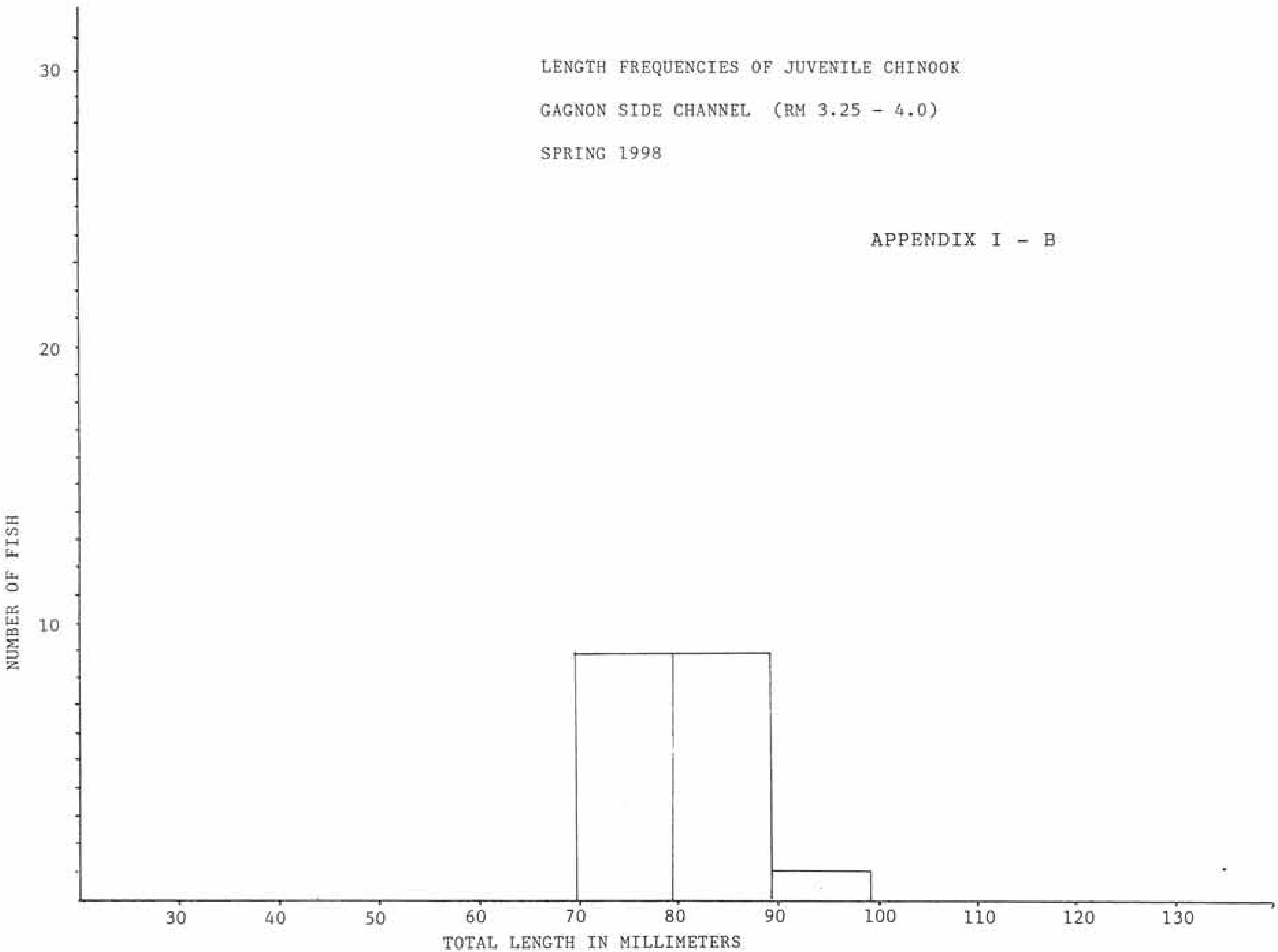
Large Woody Debris Jam Created in 1997 in a Mainstem Braid. Wood protected pools provided refuge habitat for chinook, coho, and trout through the winter of 1997-98.

APPENDICES

Length Frequencies of Juvenile Chinook I - A-T

Length Frequencies of Juvenile Coho II - A-S


LENGTH FREQUENCIES OF JUVENILE CHINOOK
GAGNON SIDE CHANNEL (RM 3.25 - 4.0)
WINTER 1997-98
APPENDIX I - A
NUMBER OF FISH
30
20
10
30
40
50
60
70
80
90
100
110
120
130

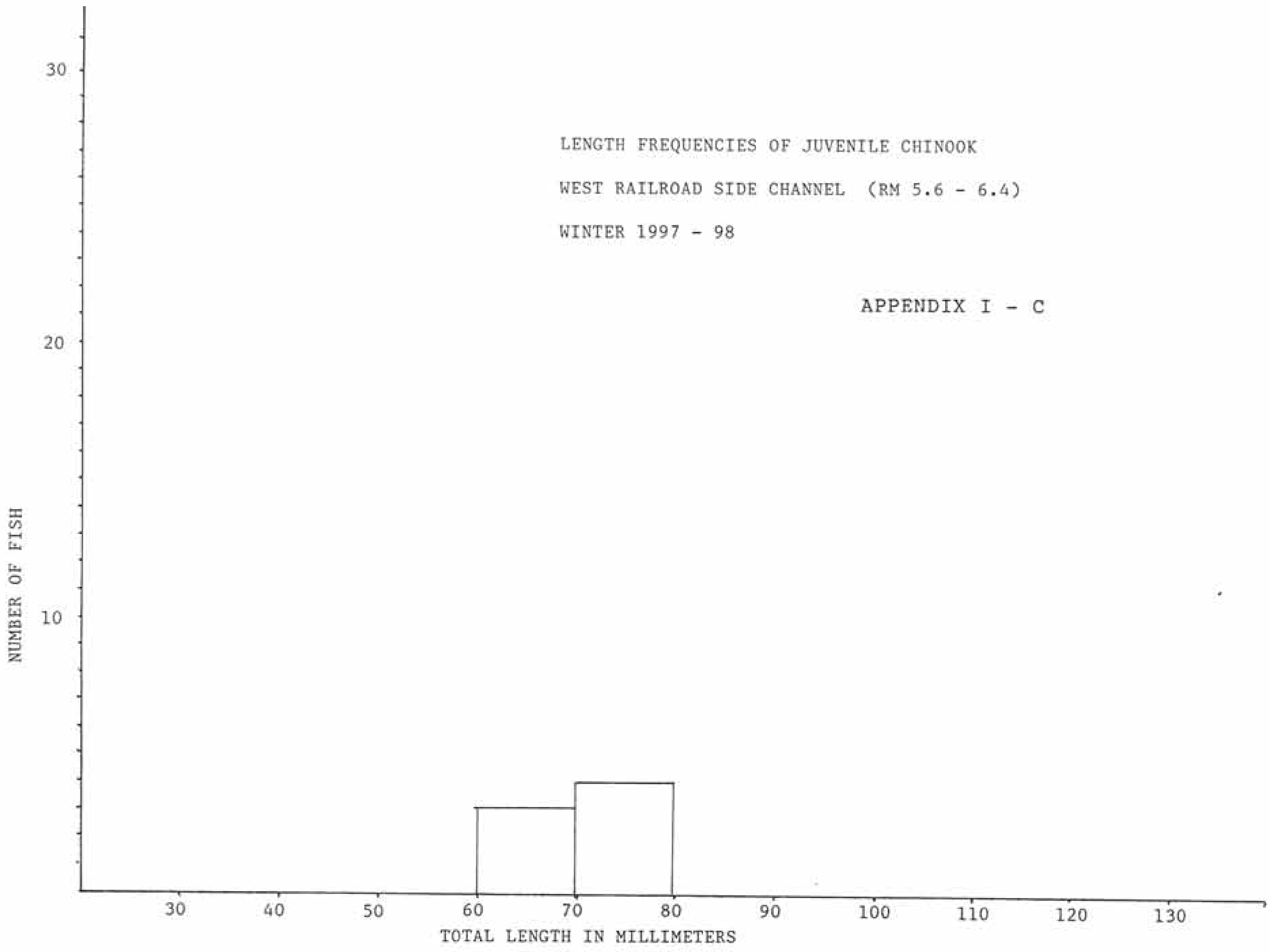

LENGTH FREQUENCIES OF JUVENILE CHINOOK
GAGNON SIDE CHANNEL (RM 3.25 - 4.0)
SPRING 1998
APPENDIX I - B
NUMBER OF FISH
10
20
30
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

APPENDIX I - C

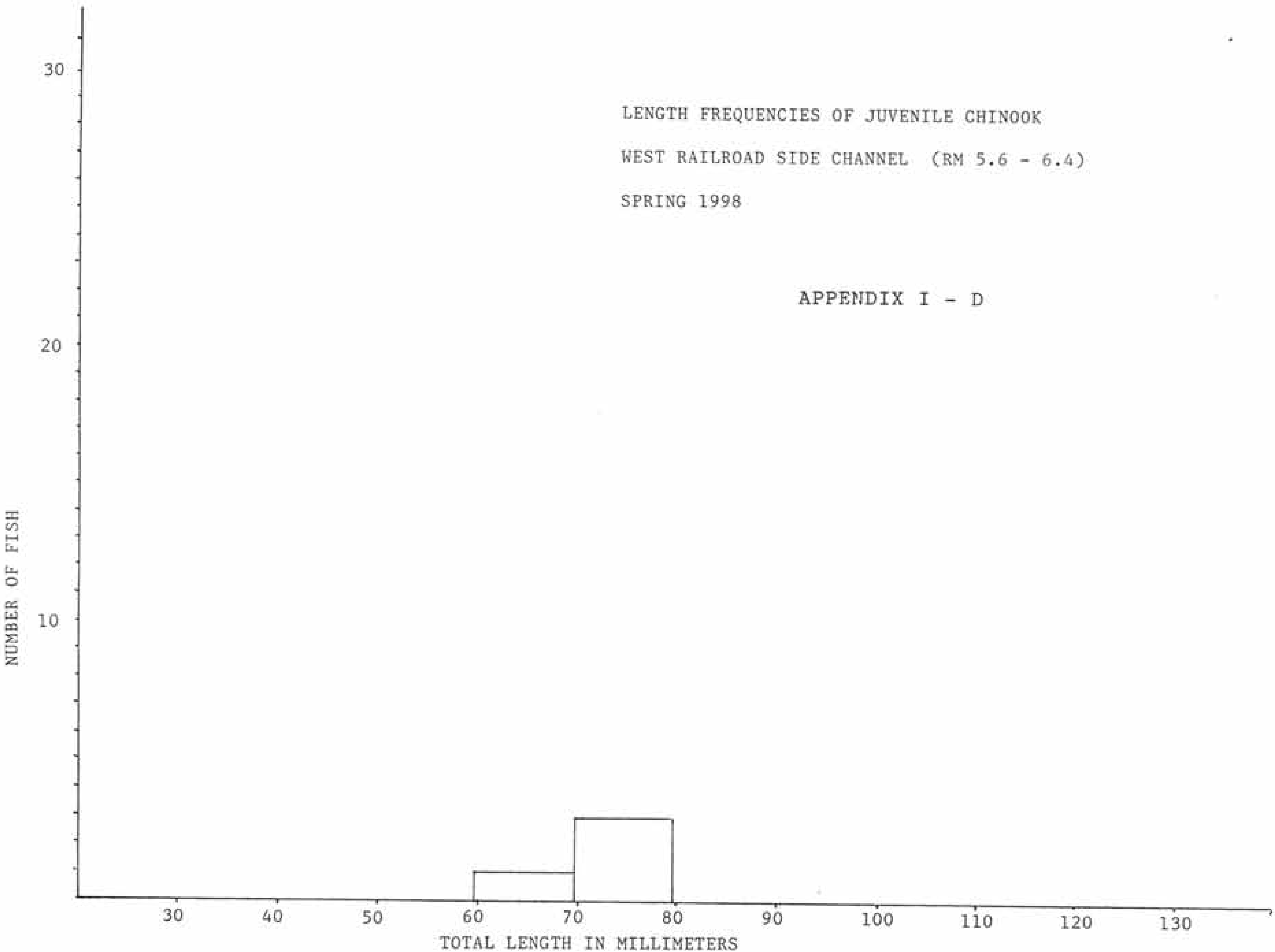
LENGTH FREQUENCIES OF JUVENILE CHINOOK

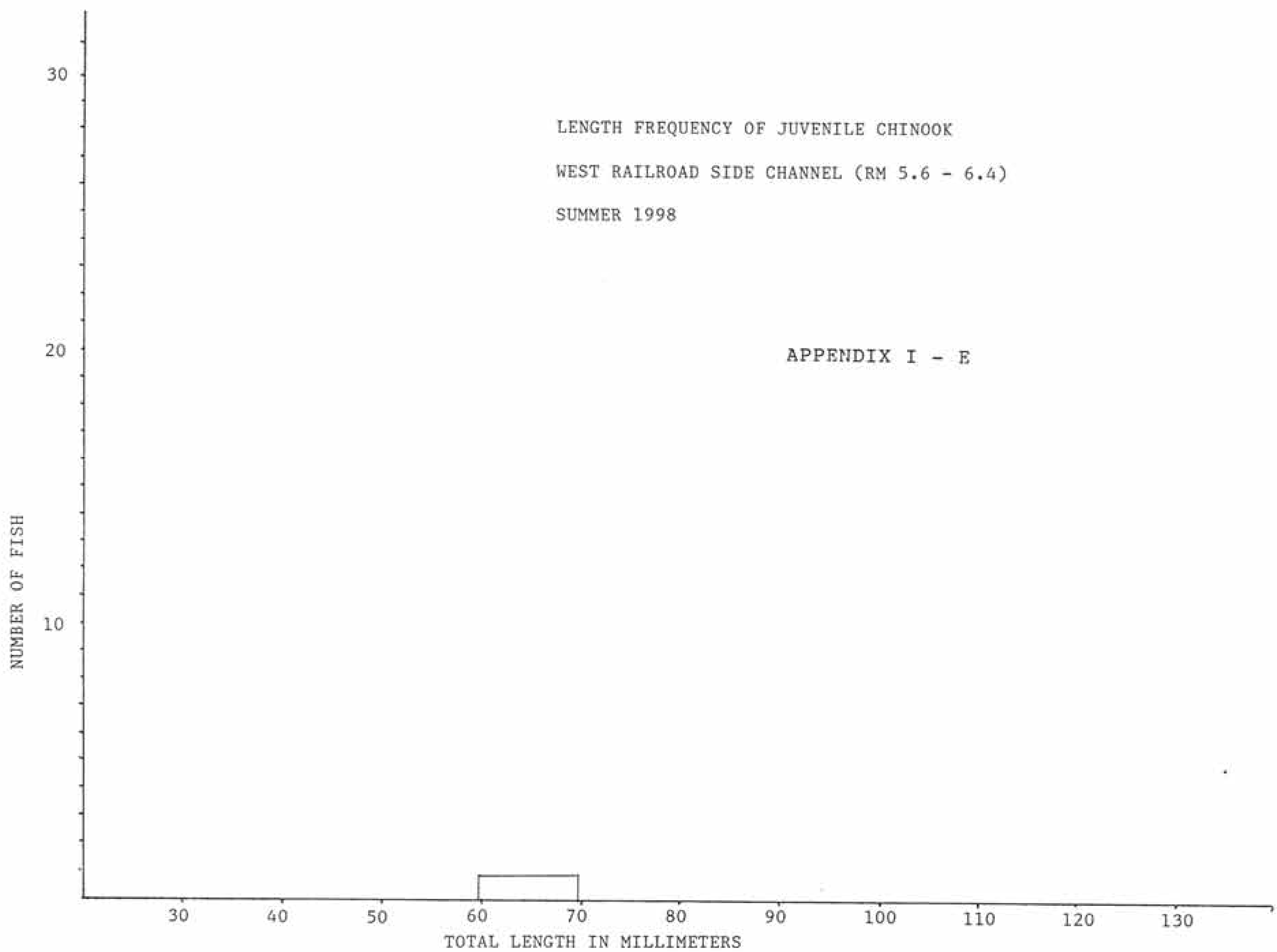
WEST RAILROAD SIDE CHANNEL (RM 5.6 - 6.4)

WINTER 1997 - 98

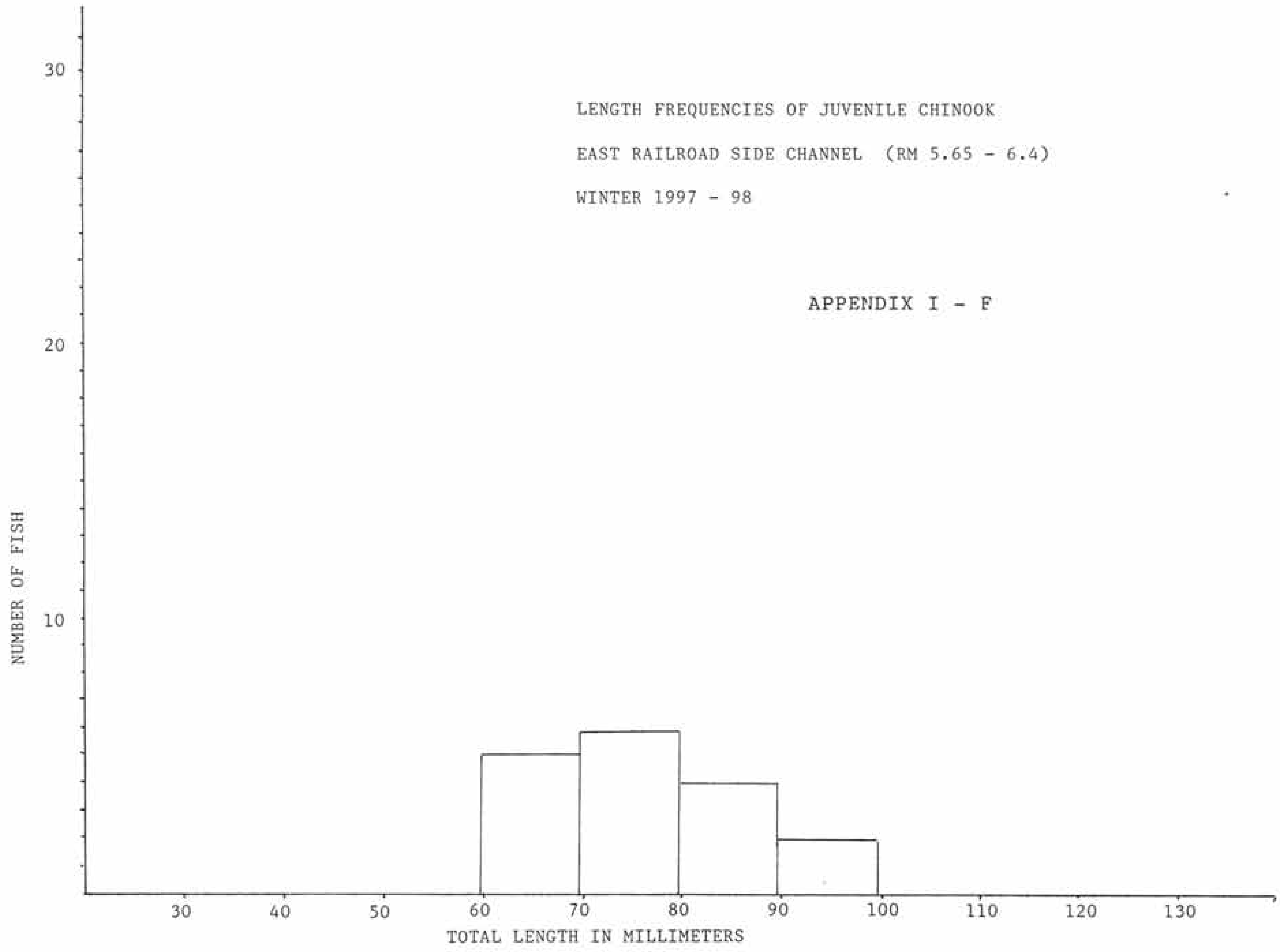


APPENDIX I - D

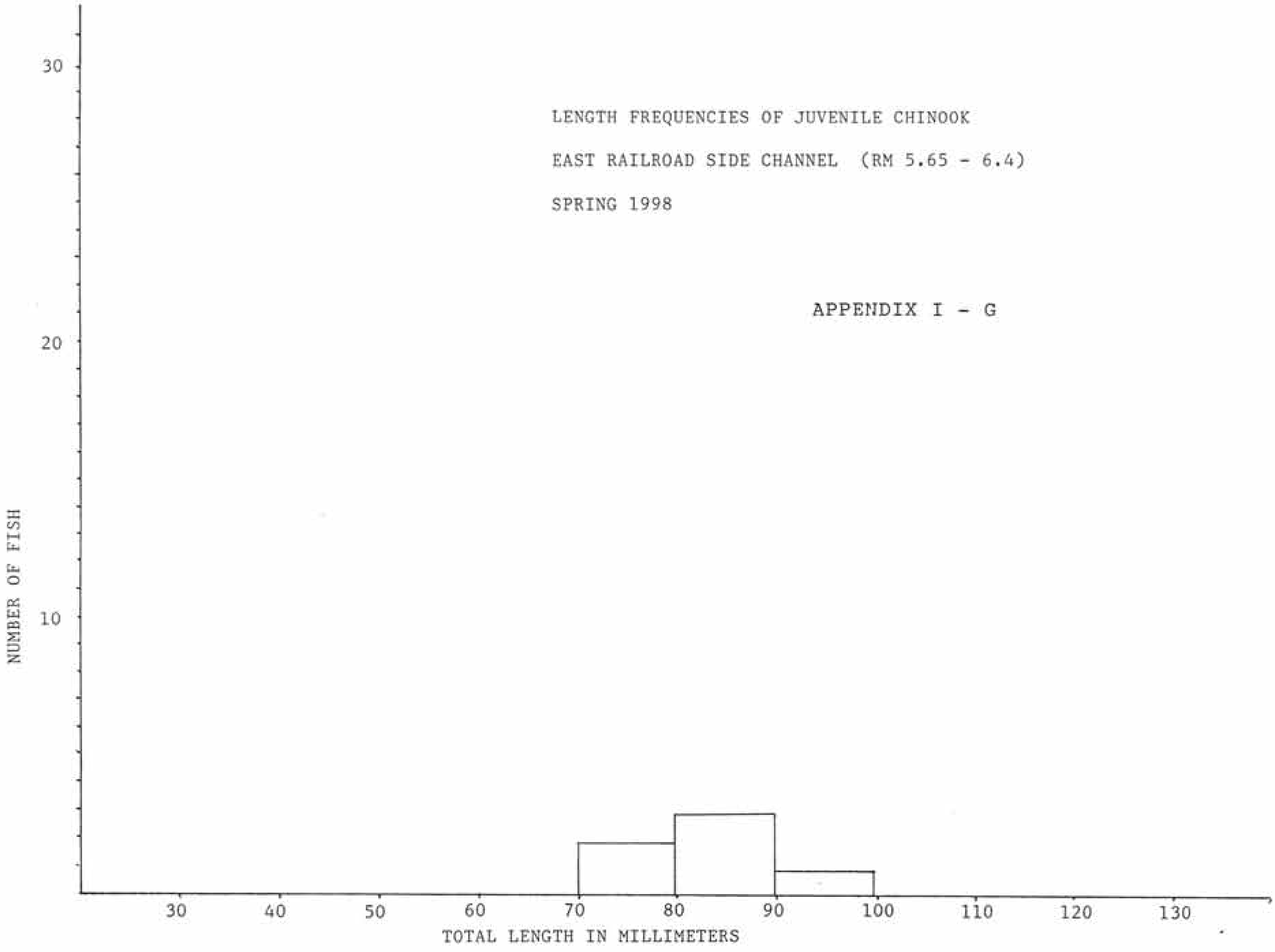

LENGTH FREQUENCIES OF JUVENILE CHINOOK
WEST RAILROAD SIDE CHANNEL (RM 5.6 - 6.4)
SPRING 1998
NUMBER OF FISH
10
20
30
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

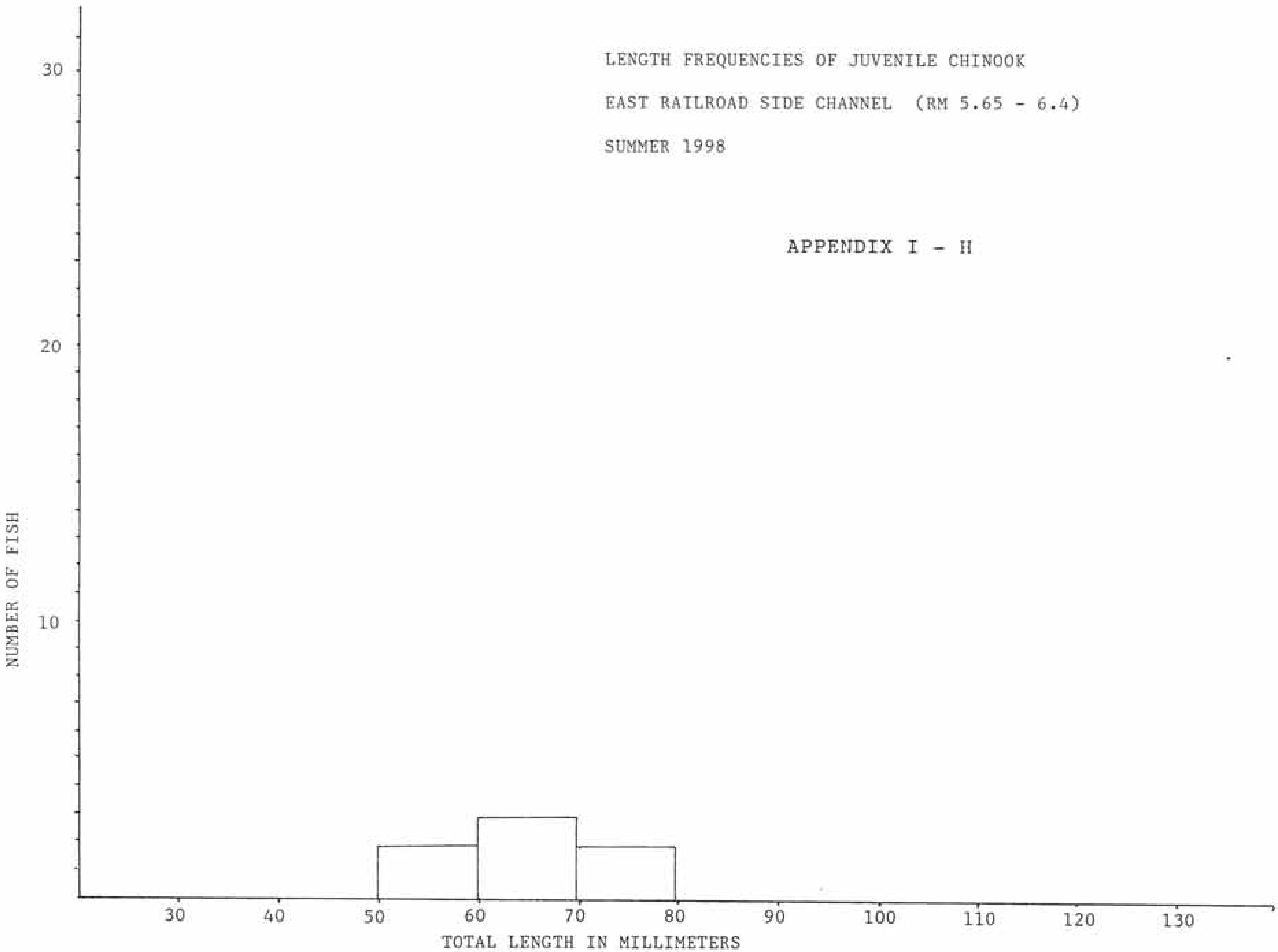

LENGTH FREQUENCY OF JUVENILE CHINOOK
WEST RAILROAD SIDE CHANNEL (RM 5.6 - 6.4)
SUMMER 1998
APPENDIX I - E
NUMBER OF FISH
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

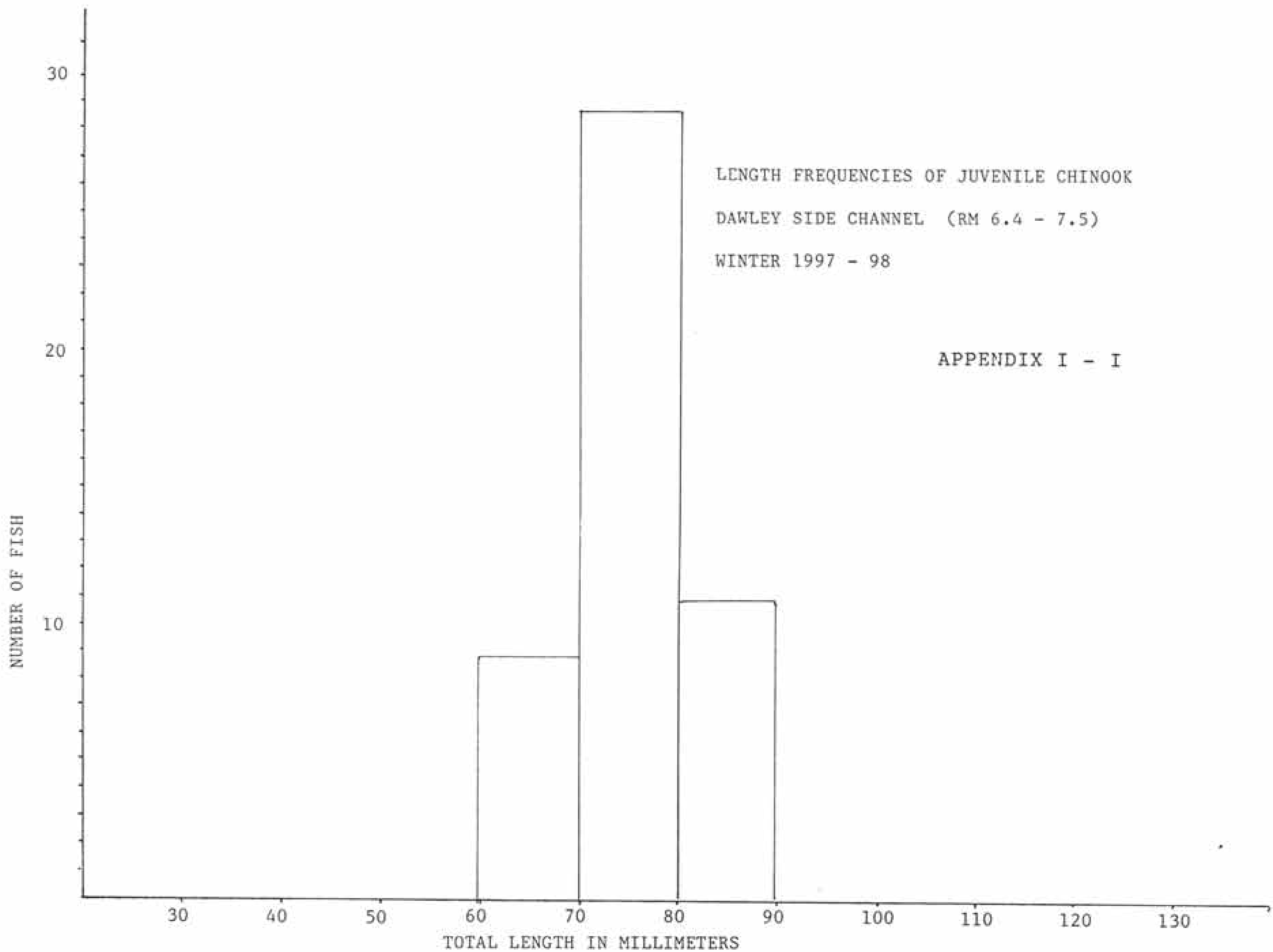
APPENDIX I - F



LENGTH FREQUENCIES OF JUVENILE CHINOOK
EAST RAILROAD SIDE CHANNEL (RM 5.65 - 6.4)
WINTER 1997 - 98
NUMBER OF FISH
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS


LENGTH FREQUENCIES OF JUVENILE CHINOOK
EAST RAILROAD SIDE CHANNEL (RM 5.65 - 6.4)
SPRING 1998
APPENDIX I - G
NUMBER OF FISH
10
20
30
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS


LENGTH FREQUENCIES OF JUVENILE CHINOOK
EAST RAILROAD SIDE CHANNEL (RM 5.65 - 6.4)
SUMMER 1998
APPENDIX I - H
30
20
10
NUMBER OF FISH
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

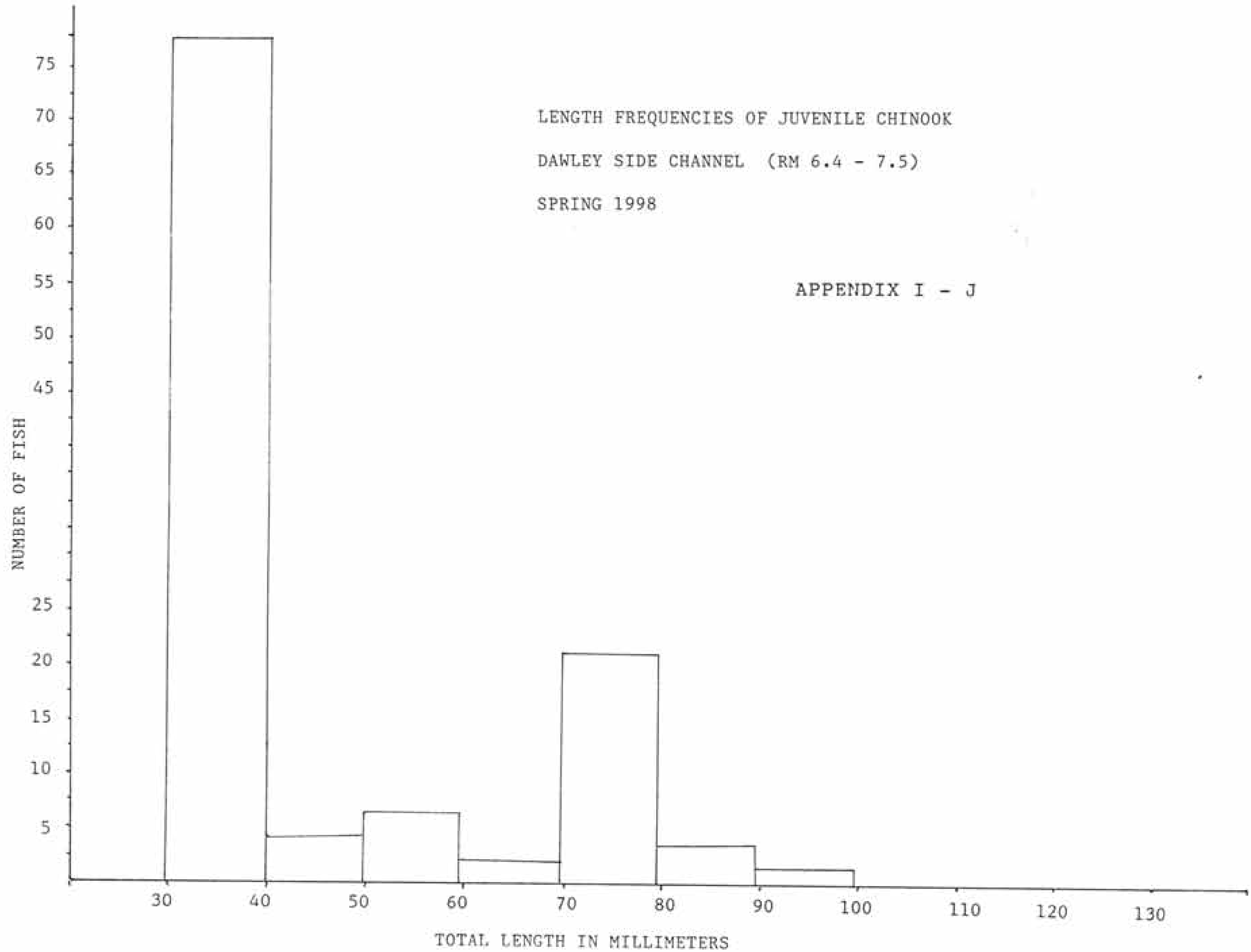

LENGTH FREQUENCIES OF JUVENILE CHINOOK
DAWLEY SIDE CHANNEL (RM 6.4 - 7.5)
WINTER 1997 - 98
APPENDIX I - I
30
20
10
NUMBER OF FISH
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

LENGTH FREQUENCIES OF JUVENILE CHINOOK

DAWLEY SIDE CHANNEL (RM 6.4 - 7.5)

SPRING 1998

APPENDIX I - J

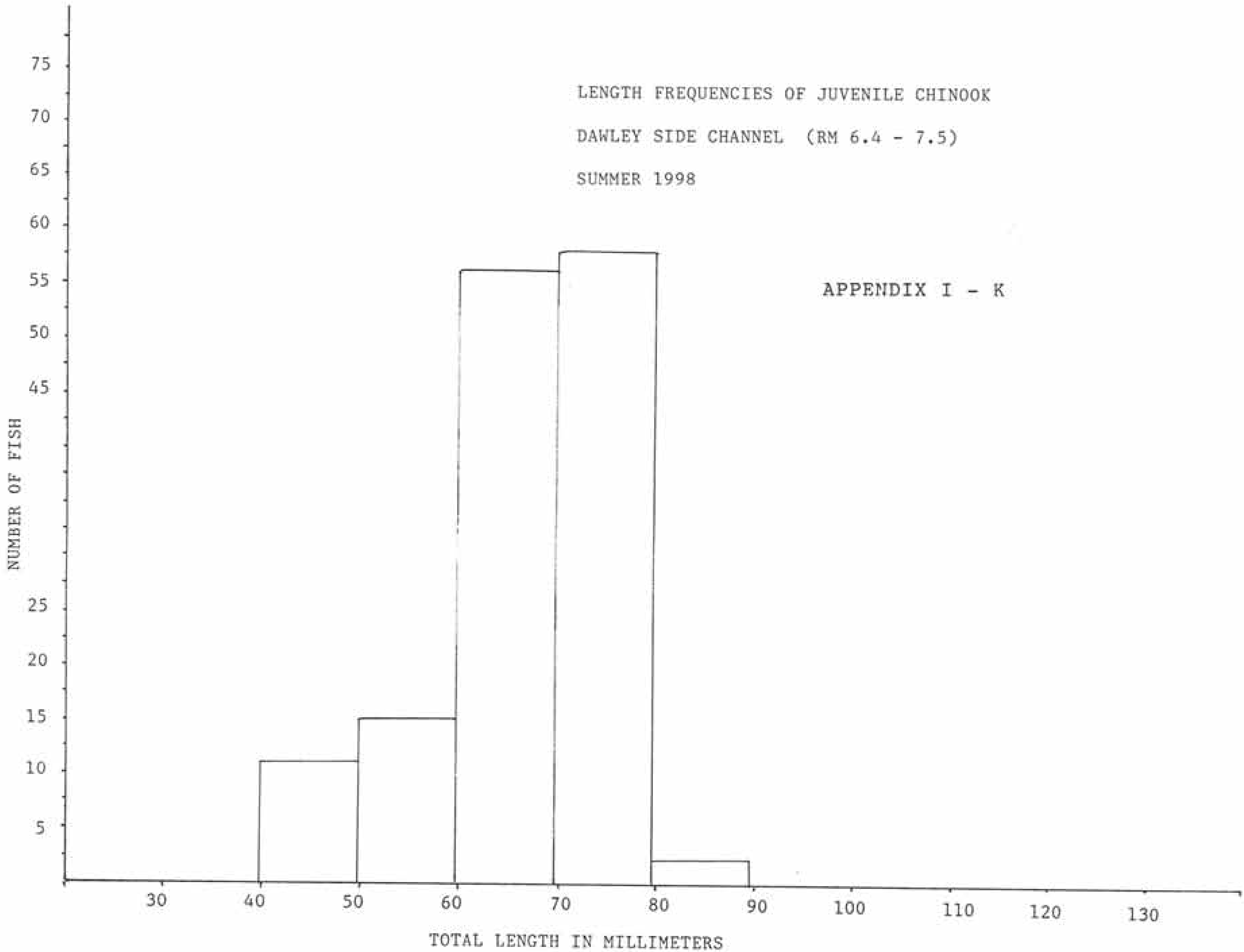


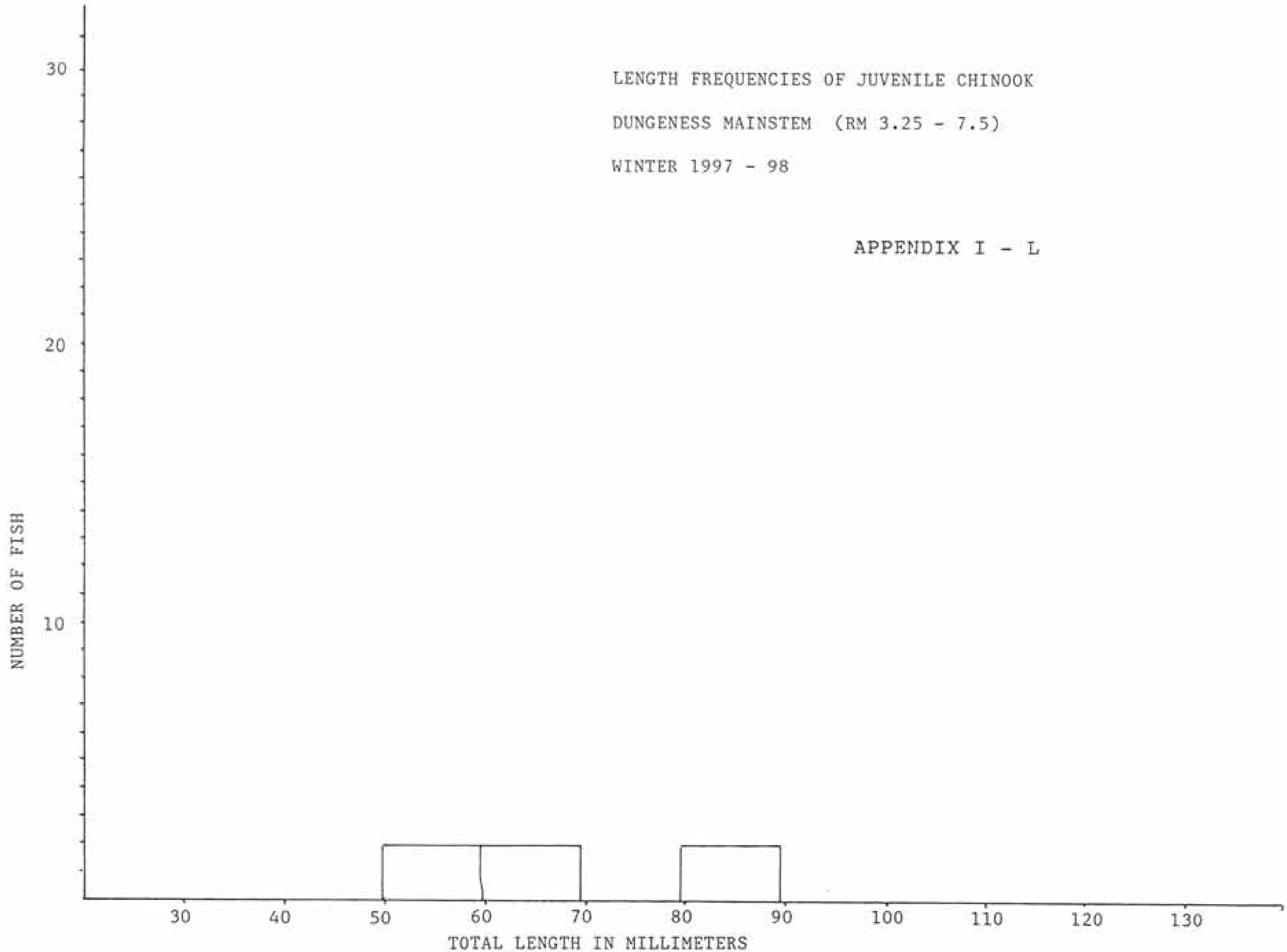
LENGTH FREQUENCIES OF JUVENILE CHINOOK

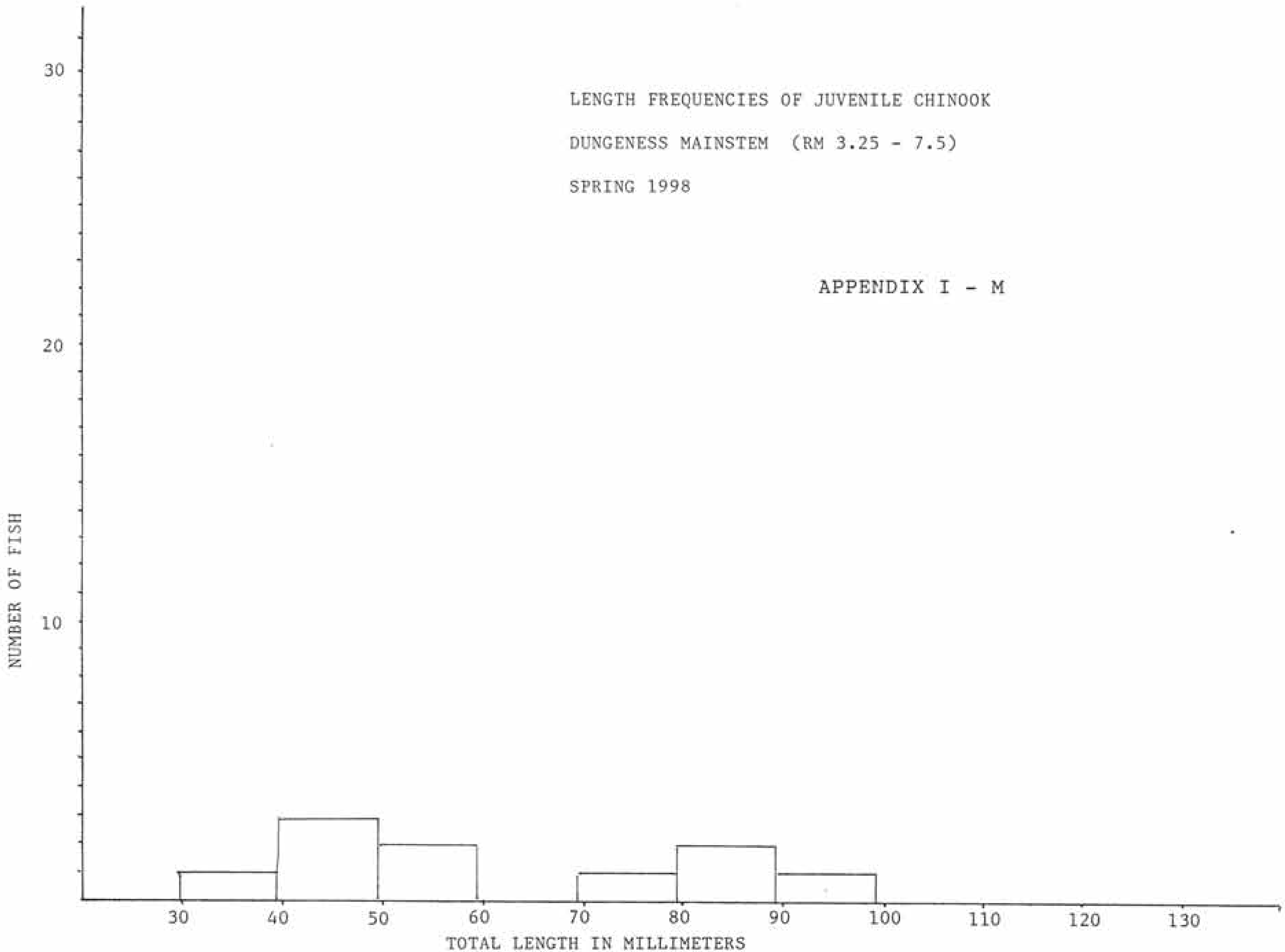
DAWLEY SIDE CHANNEL (RM 6.4 - 7.5)

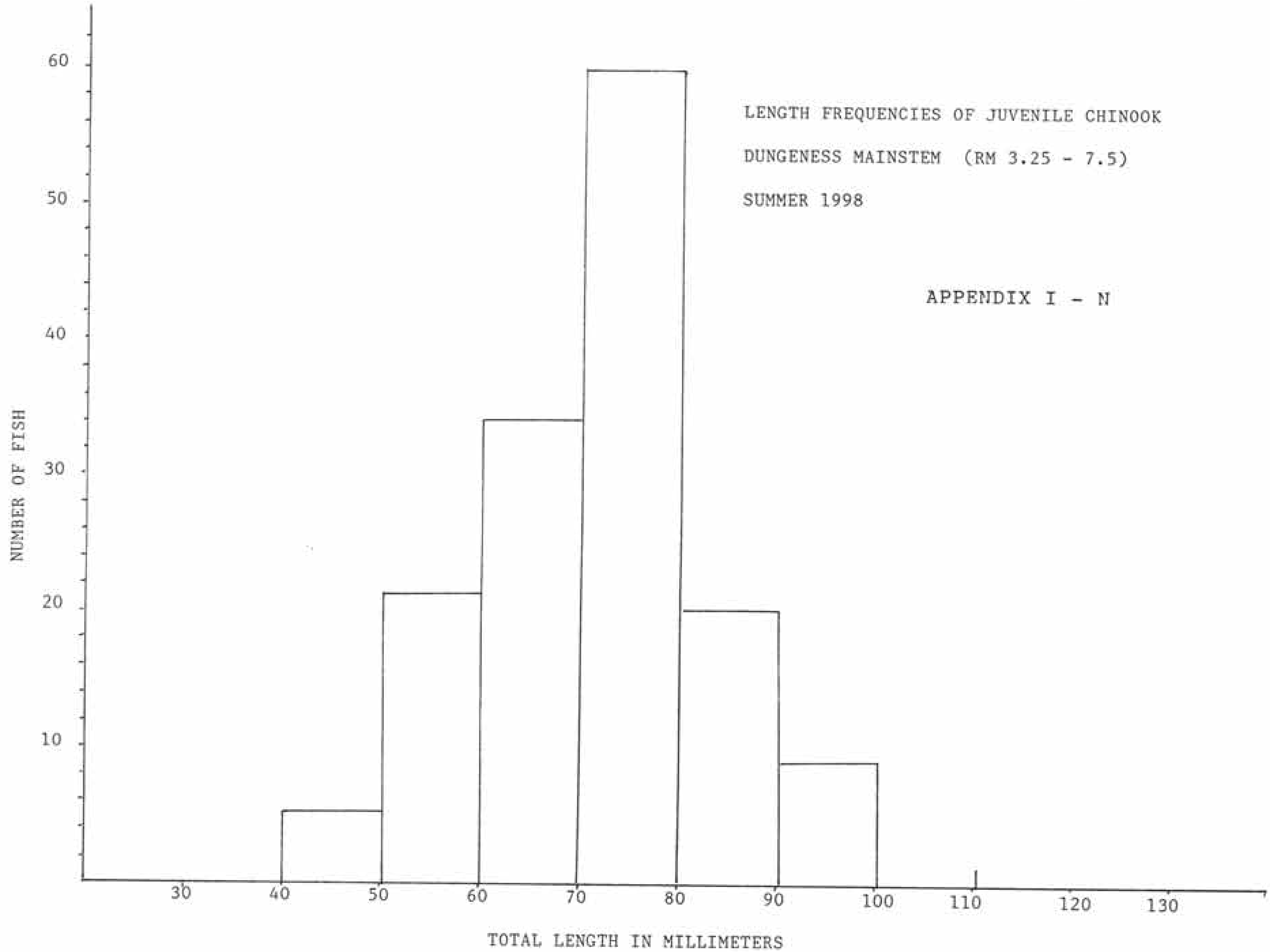
SUMMER 1998

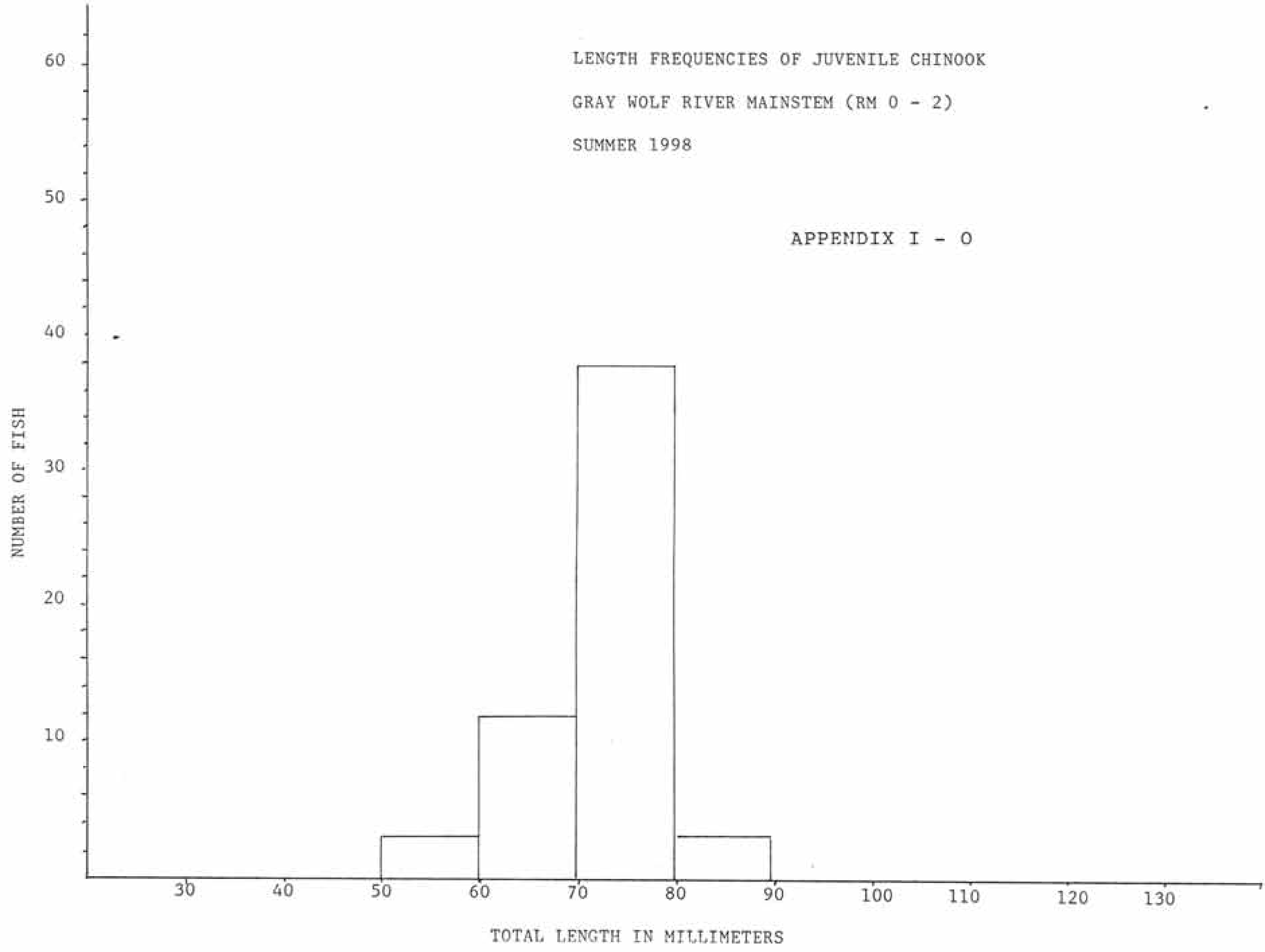
APPENDIX I - K




LENGTH FREQUENCIES OF JUVENILE CHINOOK
DUNGENESS MAINSTEM (RM 3.25 - 7.5)
WINTER 1997 - 98
APPENDIX I - L
NUMBER OF FISH
10
20
30
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS


LENGTH FREQUENCIES OF JUVENILE CHINOOK
DUNGENESS MAINSTEM (RM 3.25 - 7.5)
SPRING 1998
APPENDIX I - M
NUMBER OF FISH
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS


LENGTH FREQUENCIES OF JUVENILE CHINOOK
DUNGENESS MAINSTEM (RM 3.25 - 7.5)
SUMMER 1998
APPENDIX I - N
NUMBER OF FISH
60
50
40
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

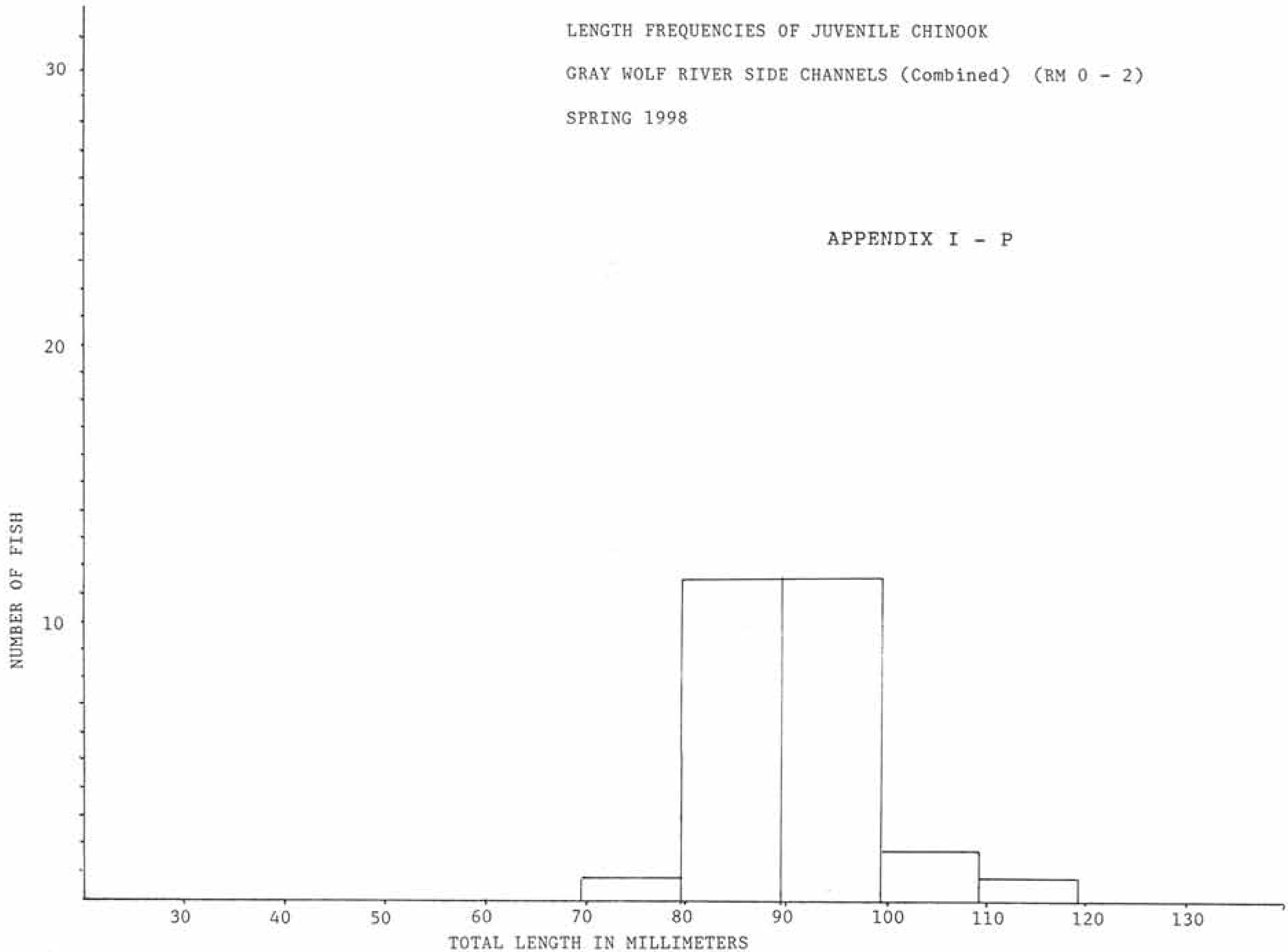

LENGTH FREQUENCIES OF JUVENILE CHINOOK
GRAY WOLF RIVER MAINSTEM (RM 0 - 2)
SUMMER 1998
APPENDIX I - O
60
50
40
30
20
10
NUMBER OF FISH
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

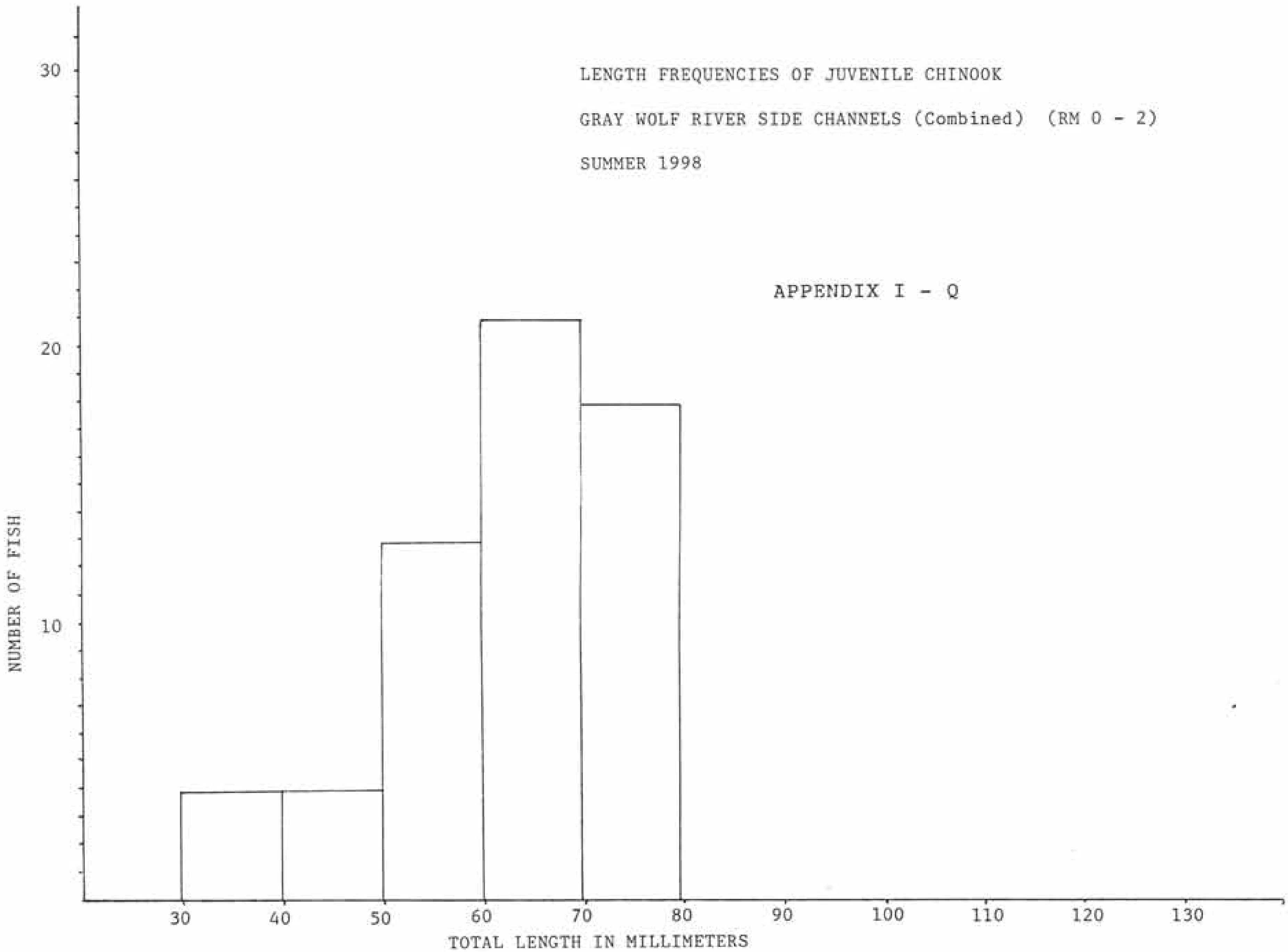
LENGTH FREQUENCIES OF JUVENILE CHINOOK

GRAY WOLF RIVER SIDE CHANNELS (Combined) (RM 0 - 2)

SPRING 1998

APPENDIX I - P





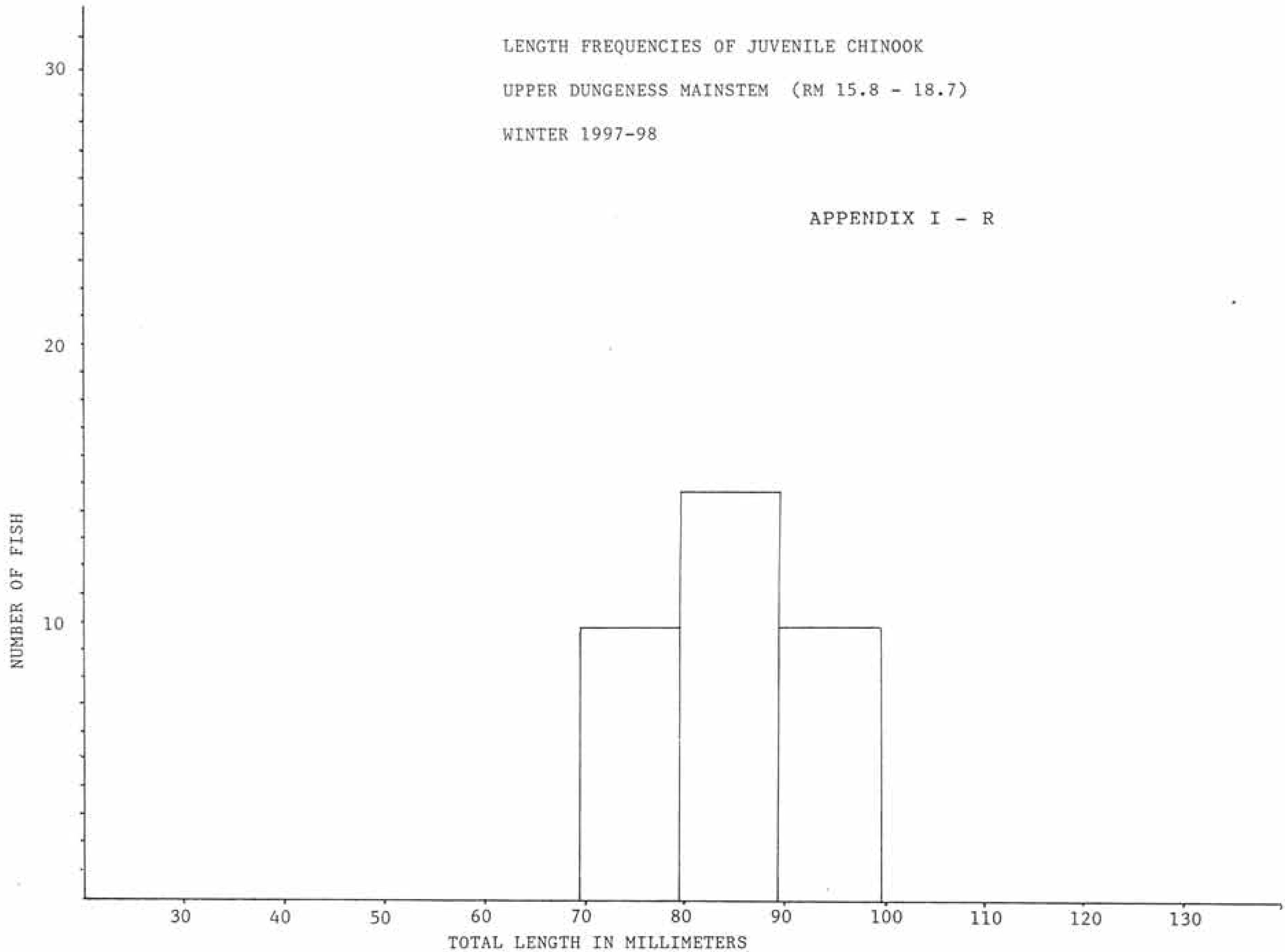
LENGTH FREQUENCIES OF JUVENILE CHINOOK
GRAY WOLF RIVER SIDE CHANNELS (Combined) (RM 0 - 2)
SUMMER 1998
APPENDIX I - Q
NUMBER OF FISH
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

APPENDIX I - R

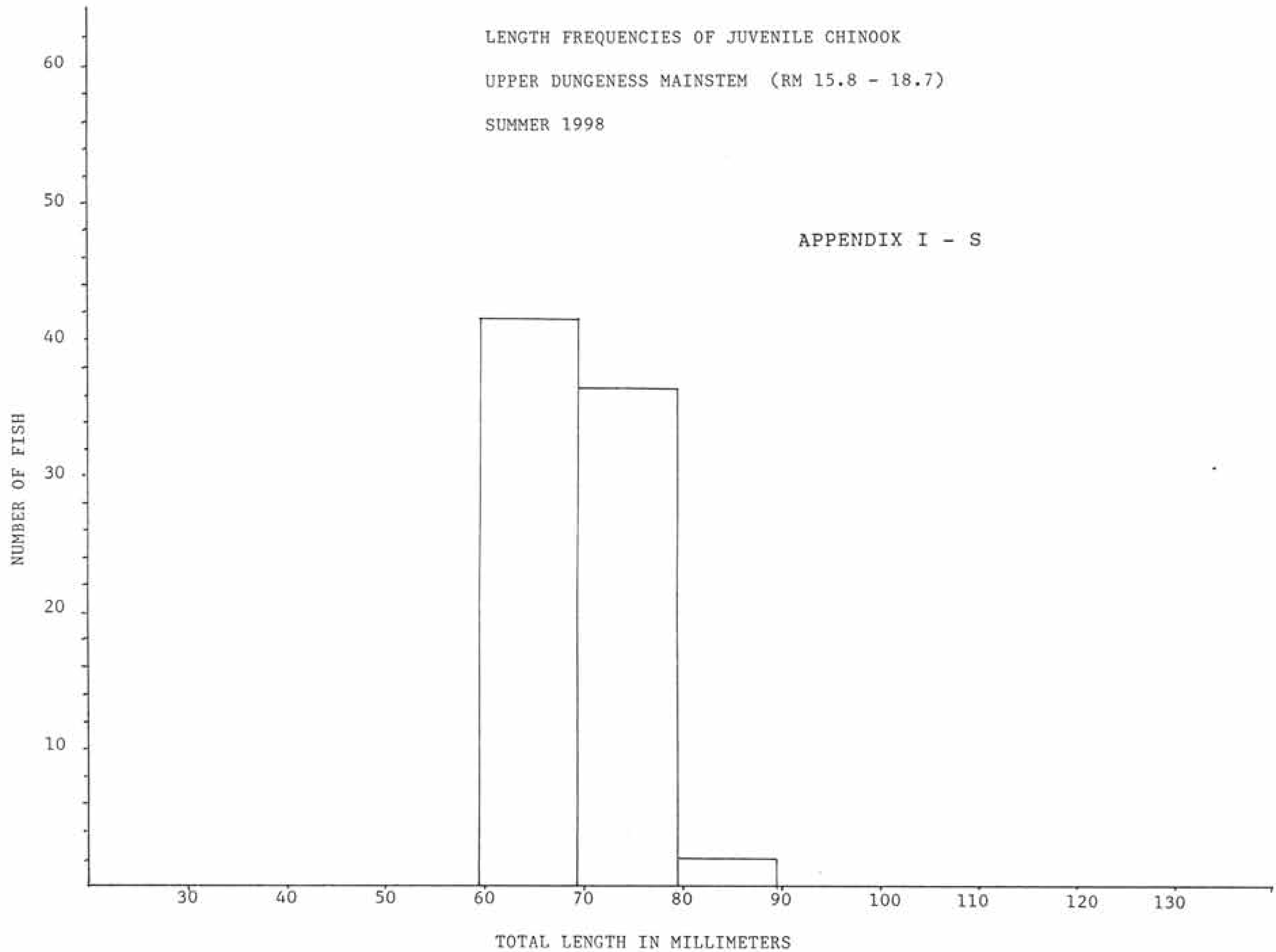
LENGTH FREQUENCIES OF JUVENILE CHINOOK

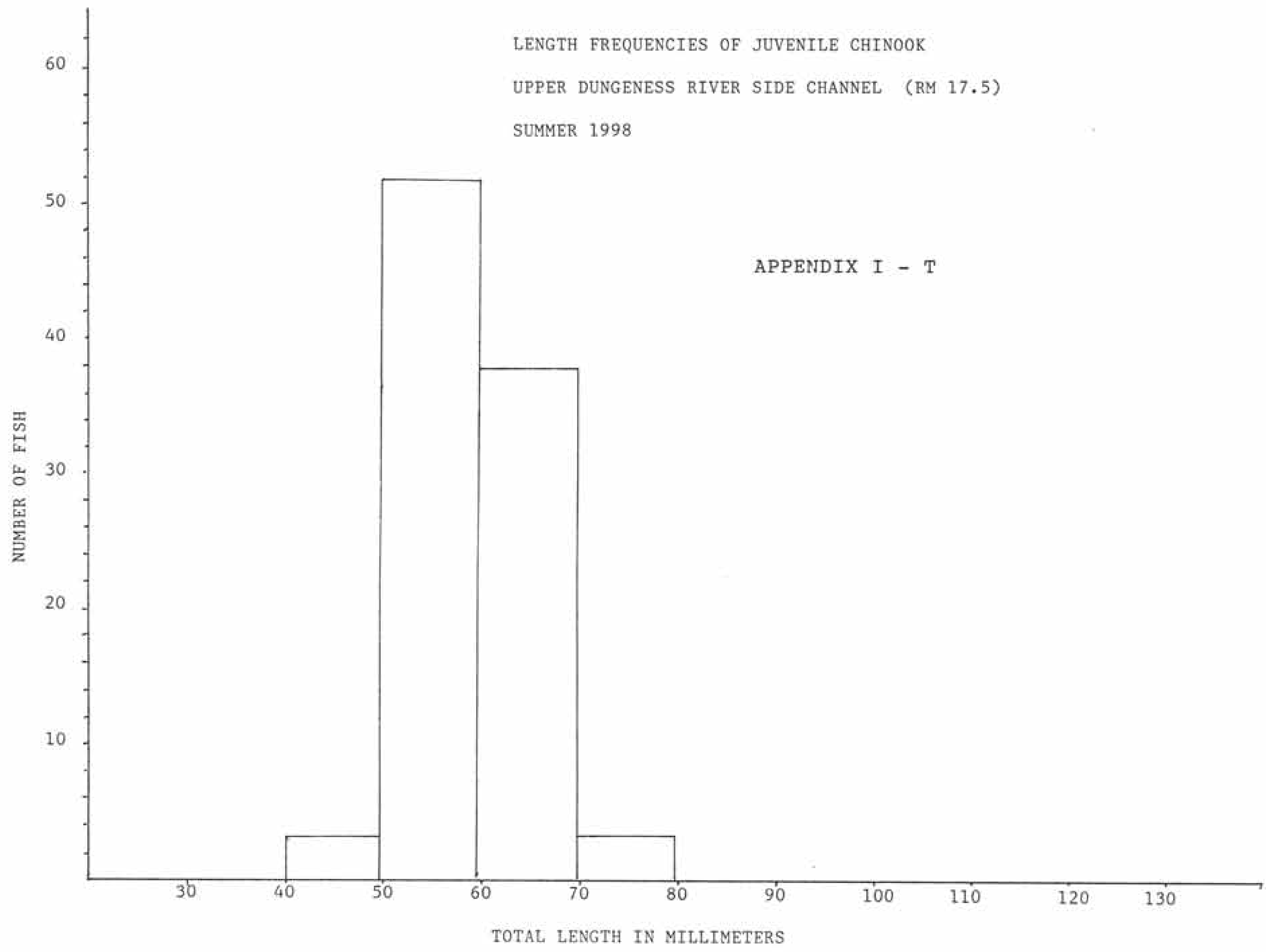
UPPER DUNGENESS MAINSTEM (RM 15.8 - 18.7)

WINTER 1997-98



APPENDIX I - S


LENGTH FREQUENCIES OF JUVENILE CHINOOK
UPPER DUNGENESS MAINSTEM (RM 15.8 - 18.7)
SUMMER 1998
NUMBER OF FISH
60
50
40
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

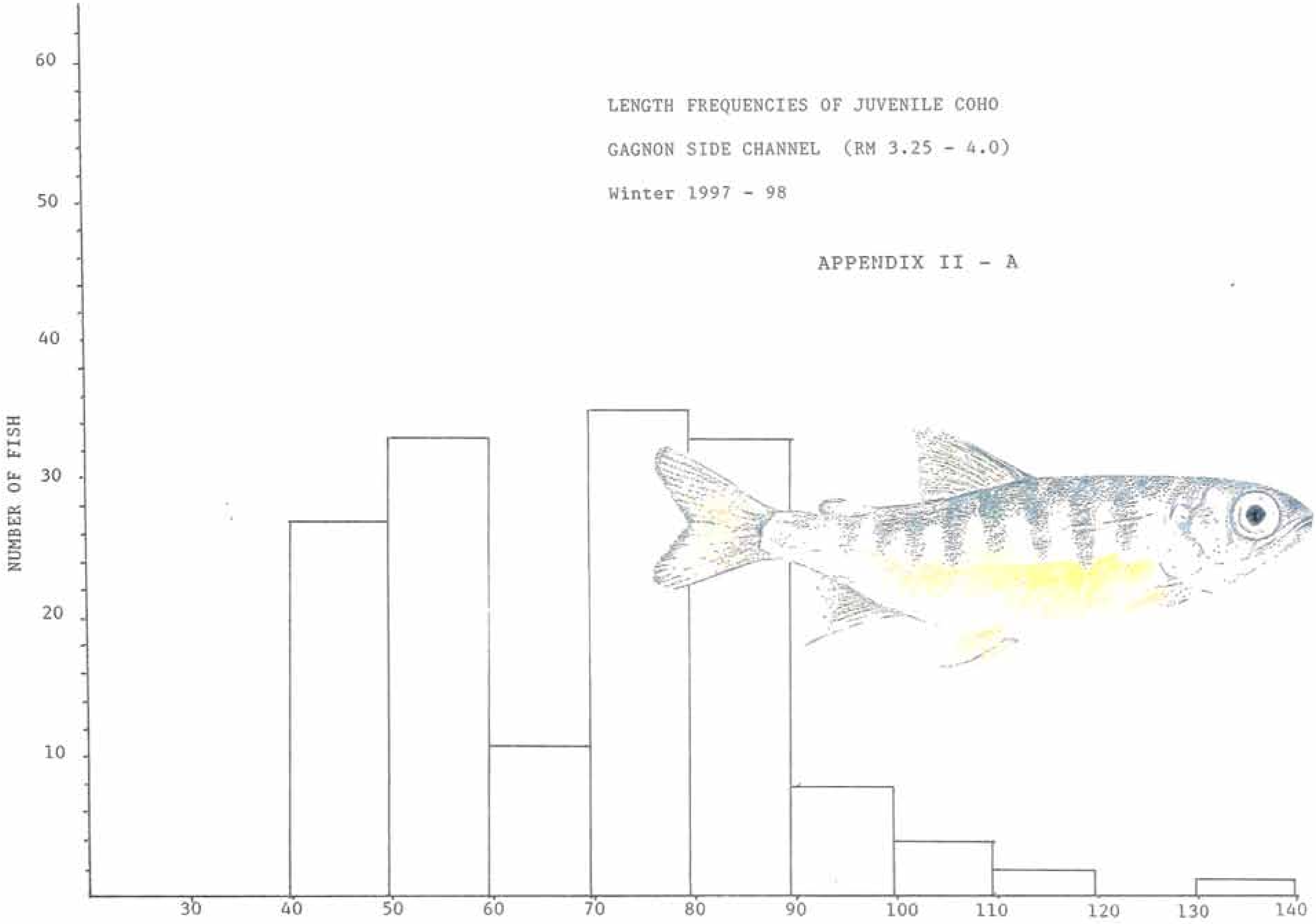

LENGTH FREQUENCIES OF JUVENILE CHINOOK
UPPER DUNGENESS RIVER SIDE CHANNEL (RM 17.5)
SUMMER 1998
APPENDIX I - T
NUMBER OF FISH
60
50
40
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

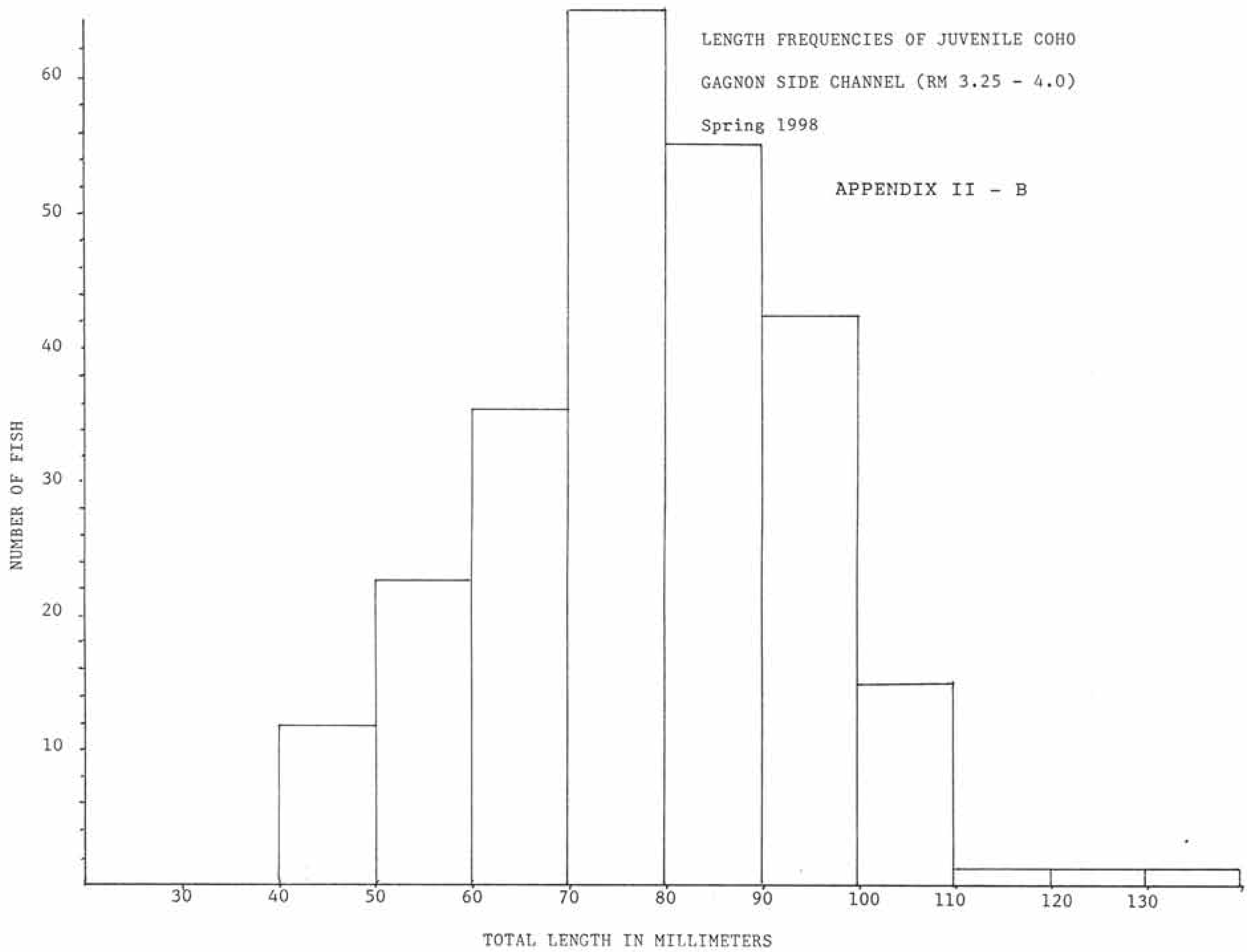
LENGTH FREQUENCIES OF JUVENILE COHO

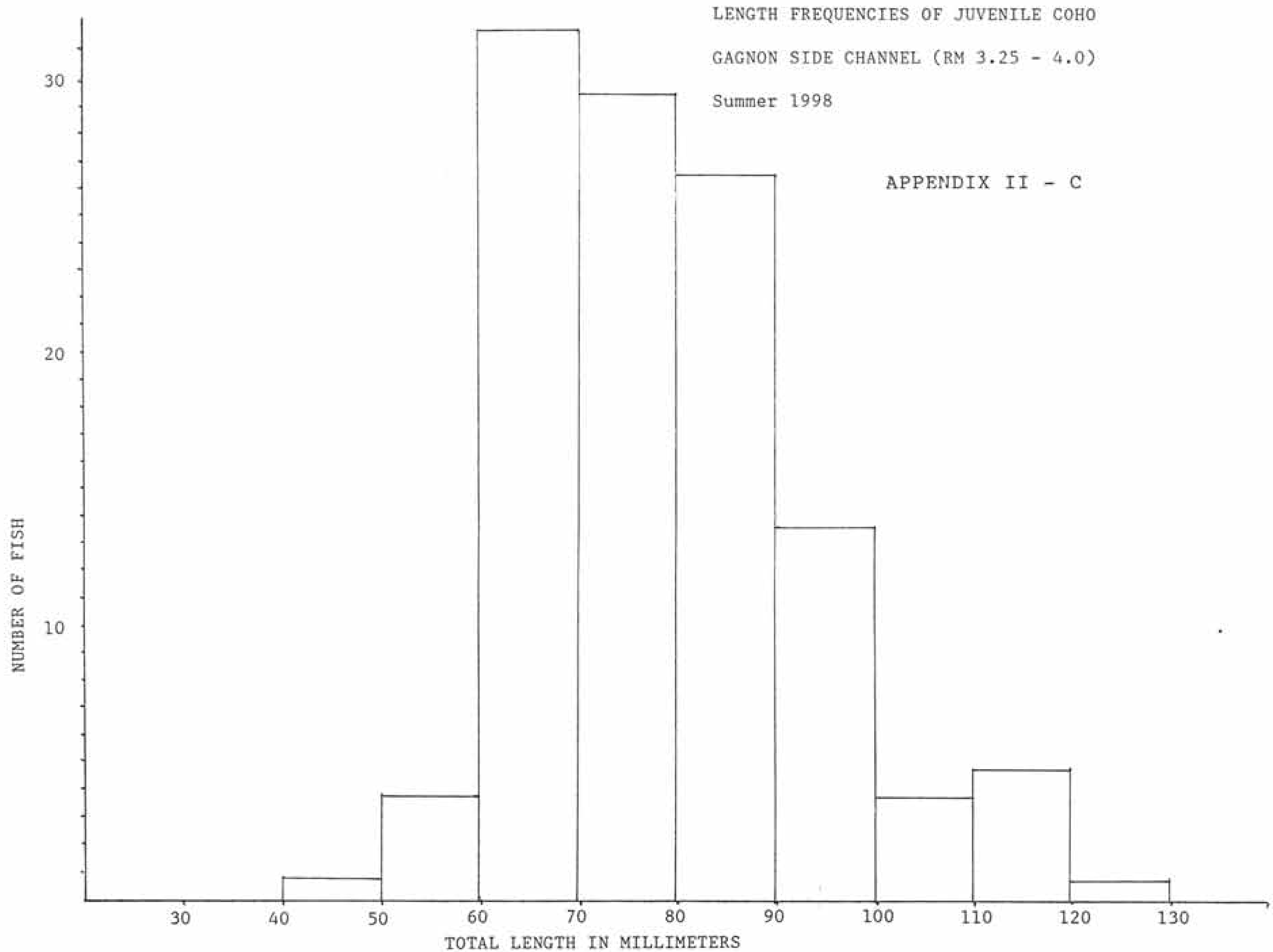
GAGNON SIDE CHANNEL (RM 3.25 - 4.0)

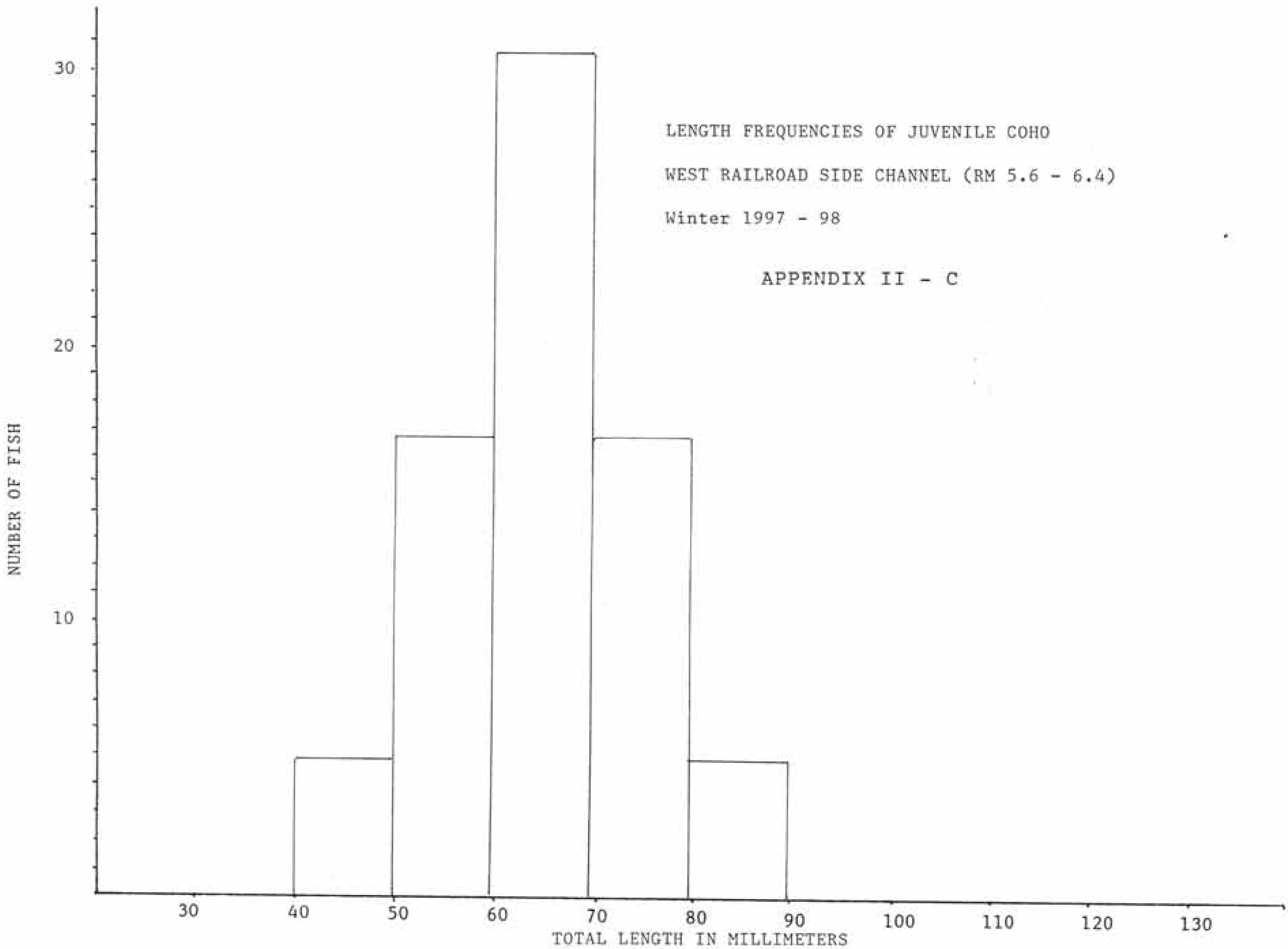
Winter 1997 - 98

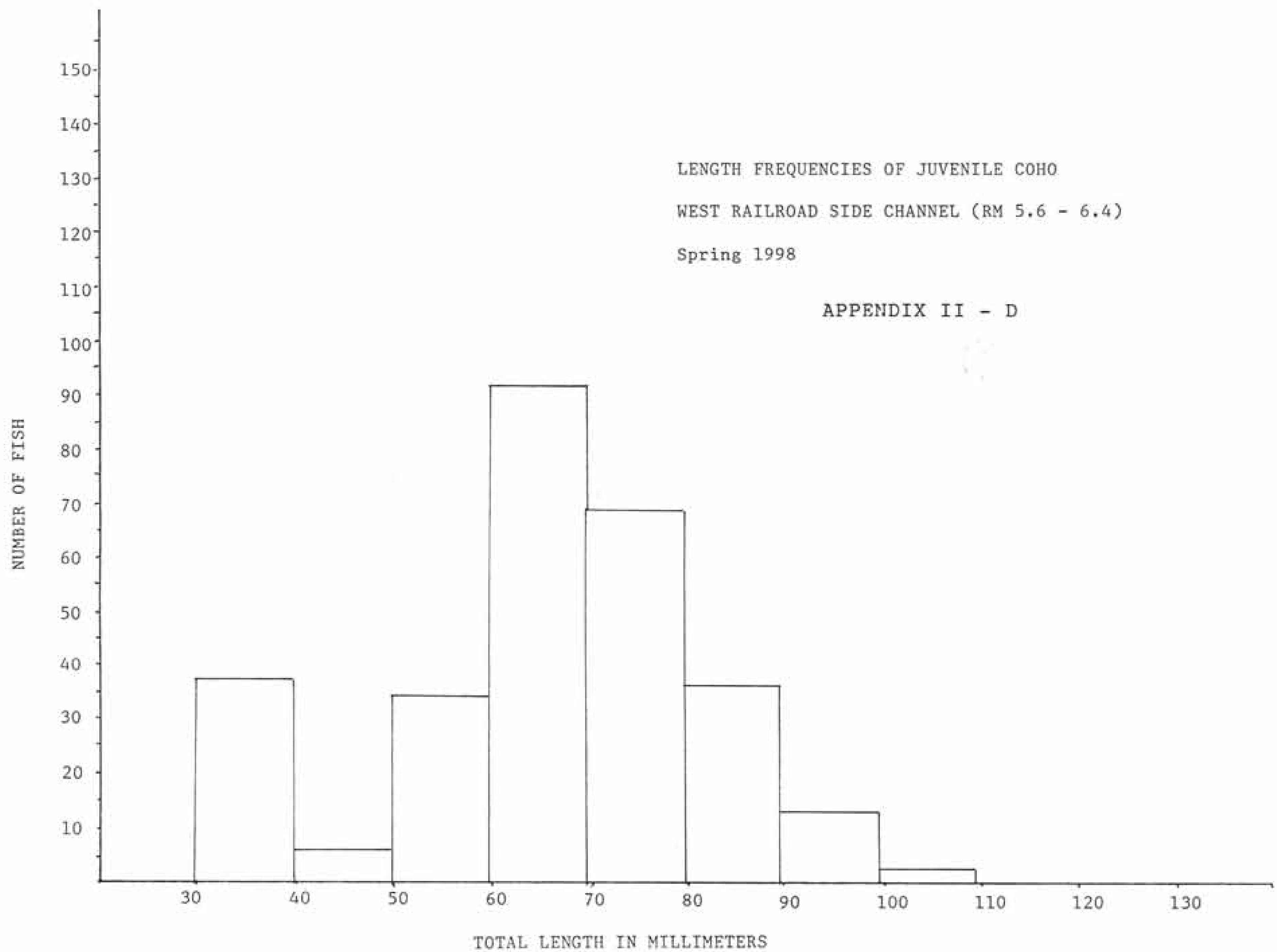
APPENDIX II - A




LENGTH FREQUENCIES OF JUVENILE COHO
GAGNON SIDE CHANNEL (RM 3.25 - 4.0)
Spring 1998
APPENDIX II - B
NUMBER OF FISH
10
20
30
40
50
60
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS


LENGTH FREQUENCIES OF JUVENILE COHO
GAGNON SIDE CHANNEL (RM 3.25 - 4.0)
Summer 1998
APPENDIX II - C
NUMBER OF FISH
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS


LENGTH FREQUENCIES OF JUVENILE COHO
WEST RAILROAD SIDE CHANNEL (RM 5.6 - 6.4)
Winter 1997 - 98
APPENDIX II - C
NUMBER OF FISH
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

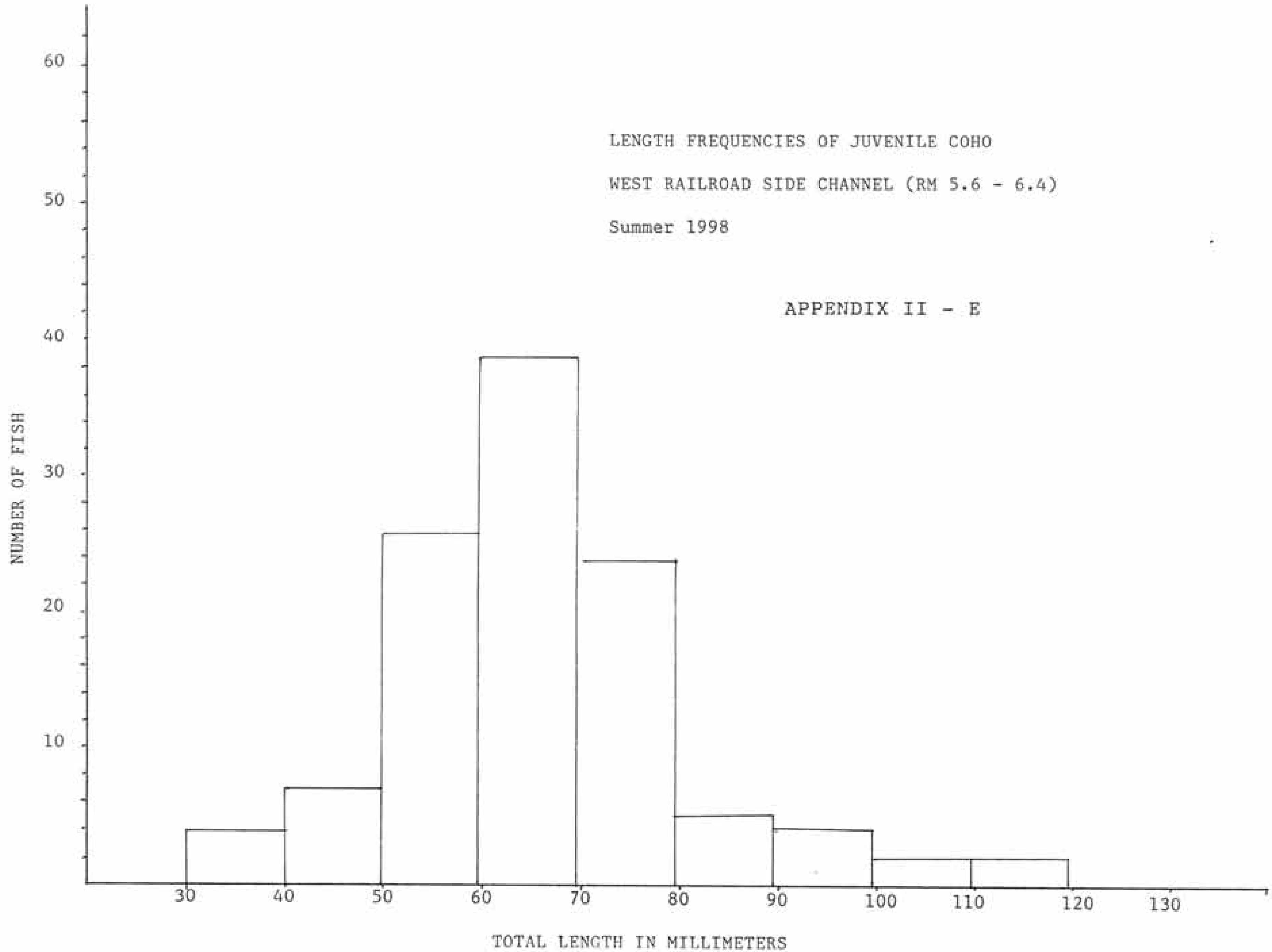

LENGTH FREQUENCIES OF JUVENILE COHO
WEST RAILROAD SIDE CHANNEL (RM 5.6 - 6.4)
Spring 1998
APPENDIX II - D
NUMBER OF FISH
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

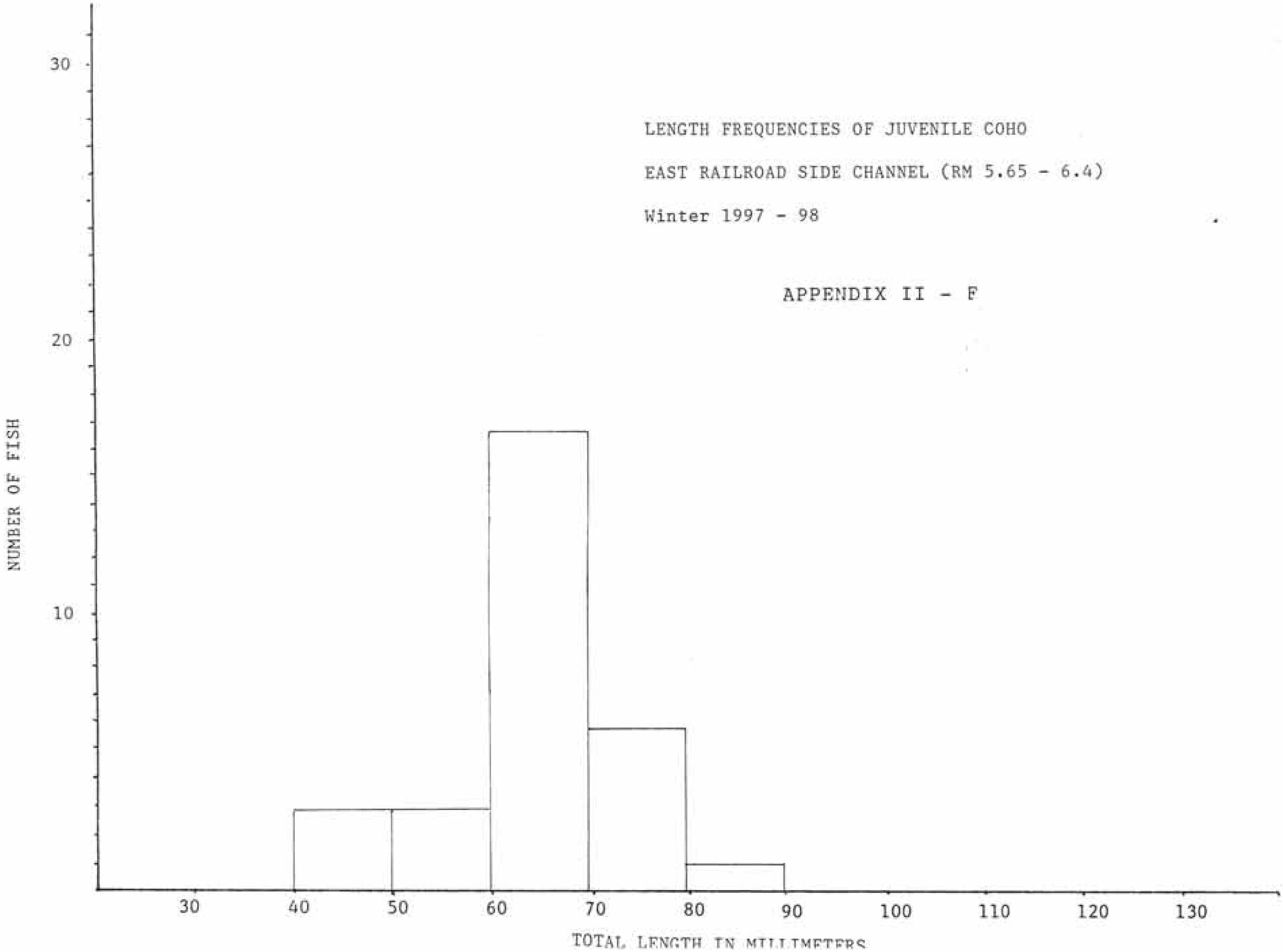
APPENDIX II - E

LENGTH FREQUENCIES OF JUVENILE COHO

WEST RAILROAD SIDE CHANNEL (RM 5.6 - 6.4)

Summer 1998





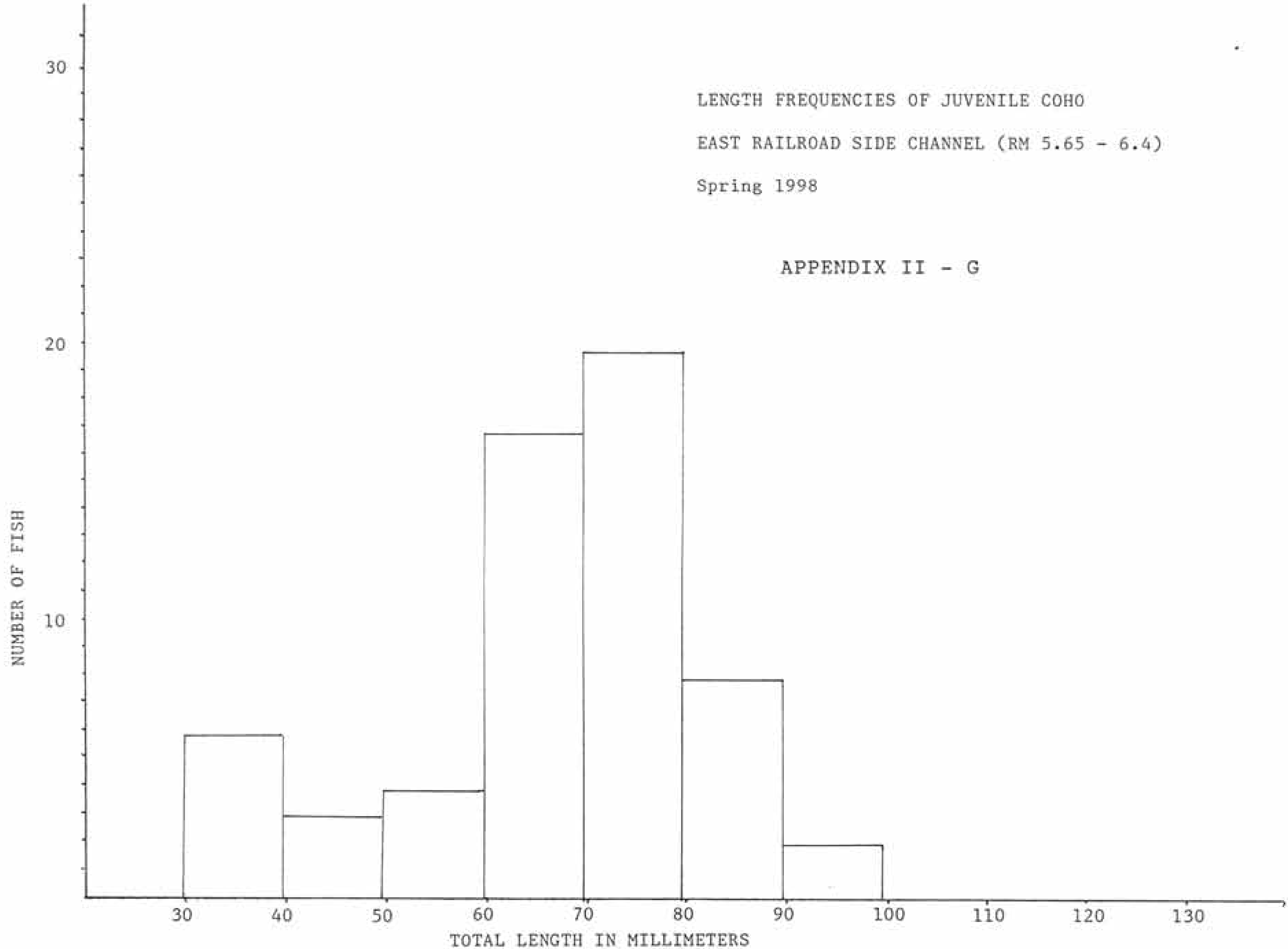
LENGTH FREQUENCIES OF JUVENILE COHO
EAST RAILROAD SIDE CHANNEL (RM 5.65 - 6.4)
Winter 1997 - 98
APPENDIX II - F
NUMBER OF FISH
10
20
30
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

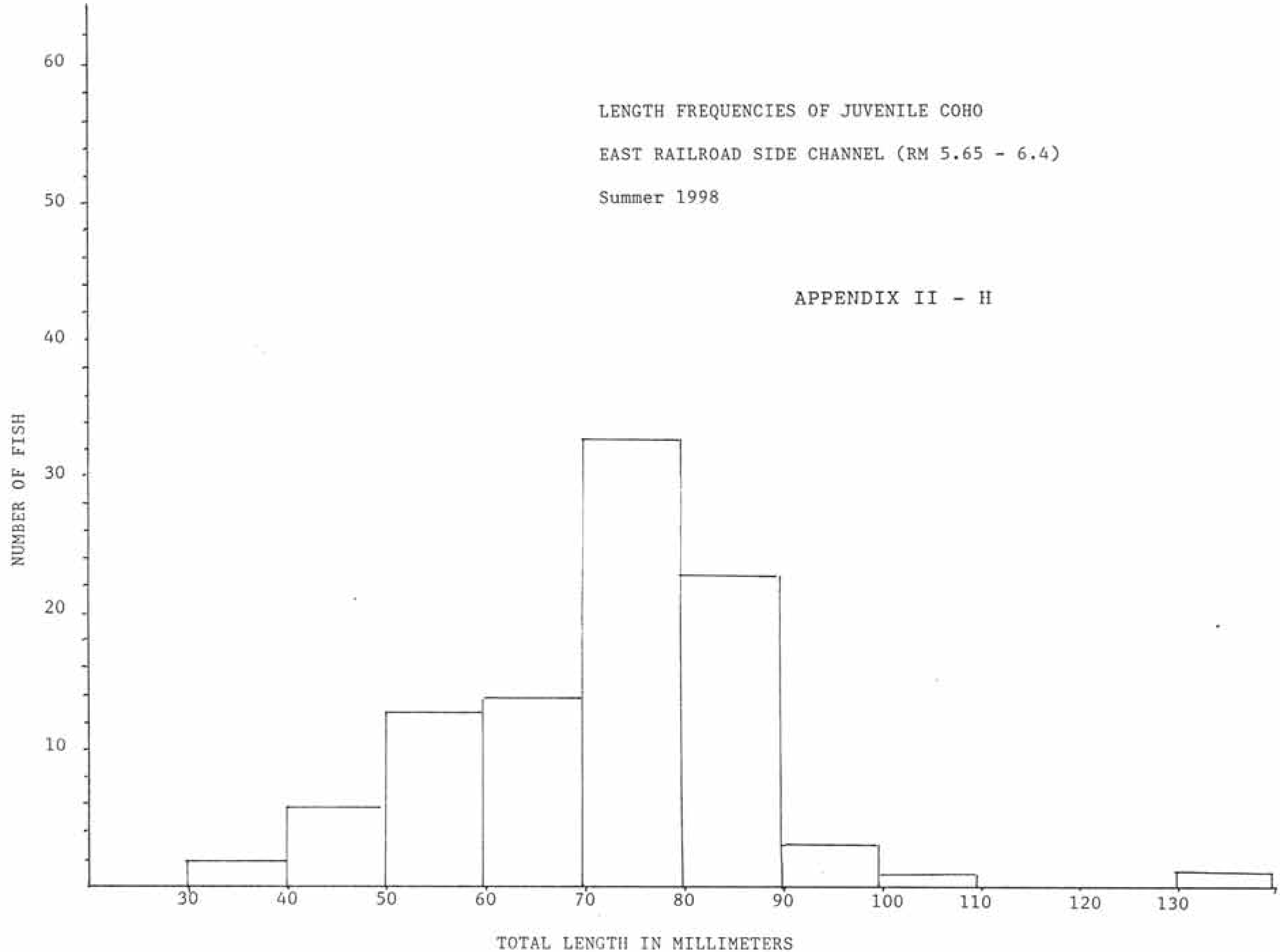
APPENDIX II - G

LENGTH FREQUENCIES OF JUVENILE COHO

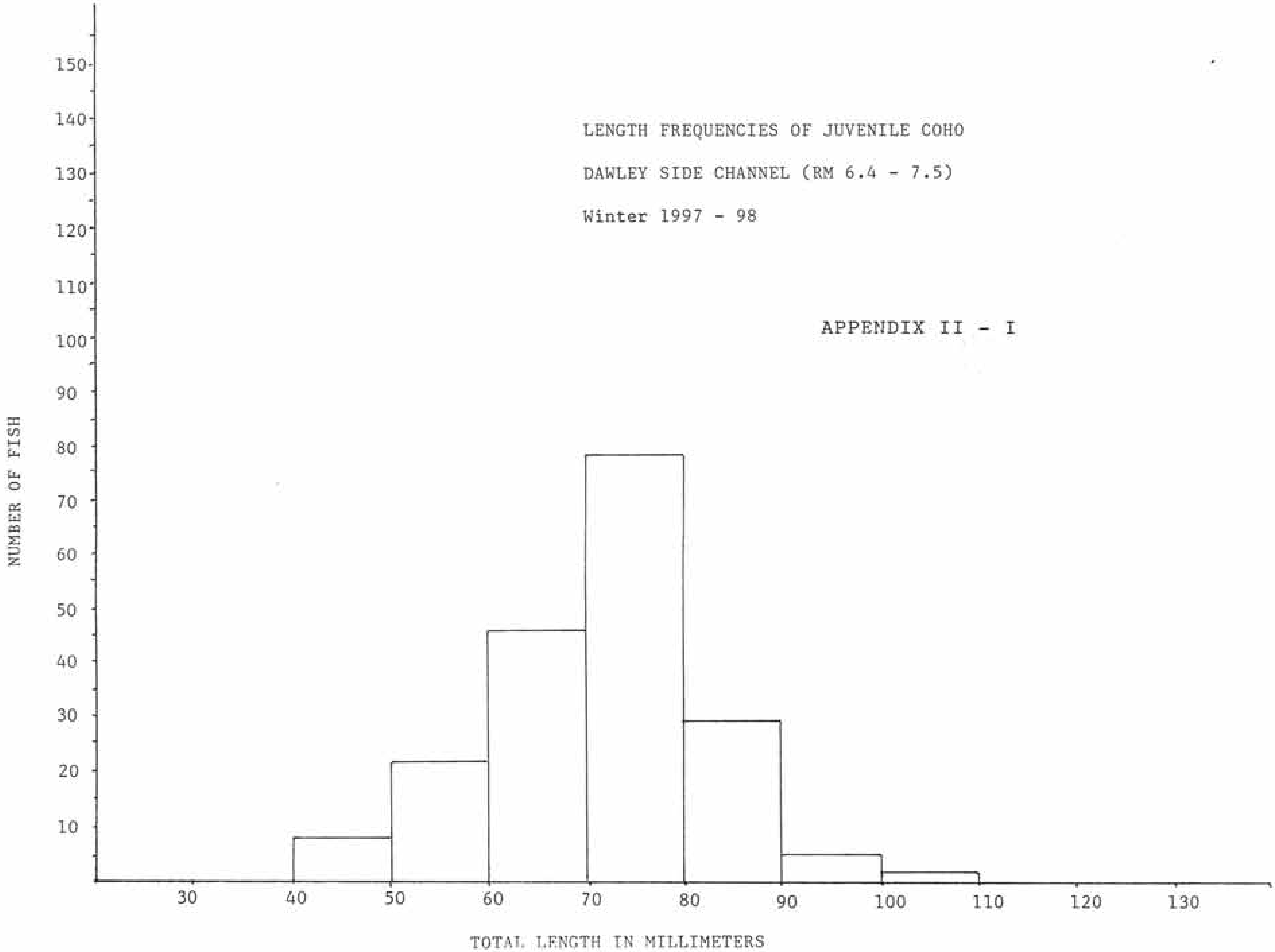
EAST RAILROAD SIDE CHANNEL (RM 5.65 - 6.4)

Spring 1998

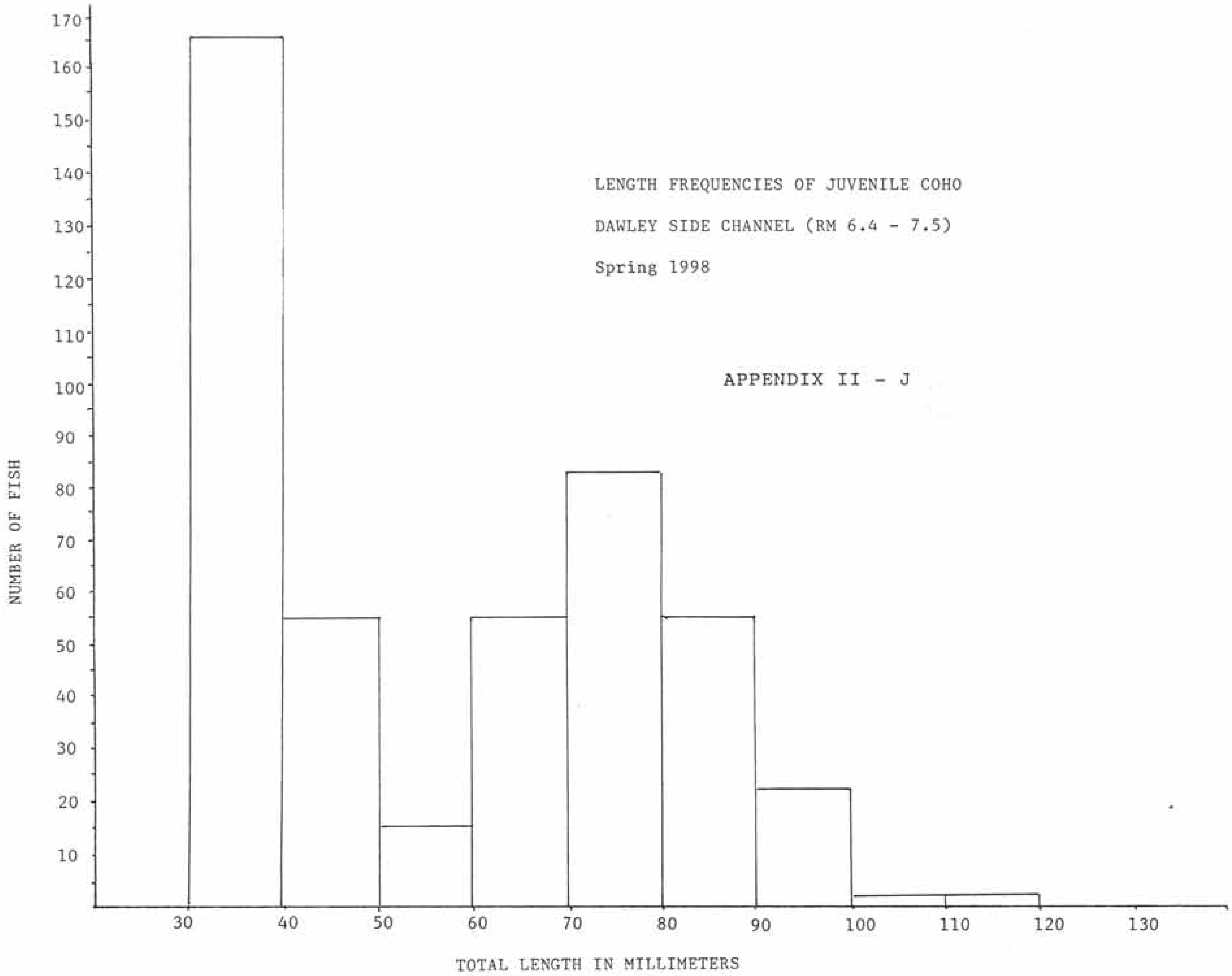



LENGTH FREQUENCIES OF JUVENILE COHO
EAST RAILROAD SIDE CHANNEL (RM 5.65 - 6.4)
Summer 1998
APPENDIX II - H
NUMBER OF FISH
60
50
40
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

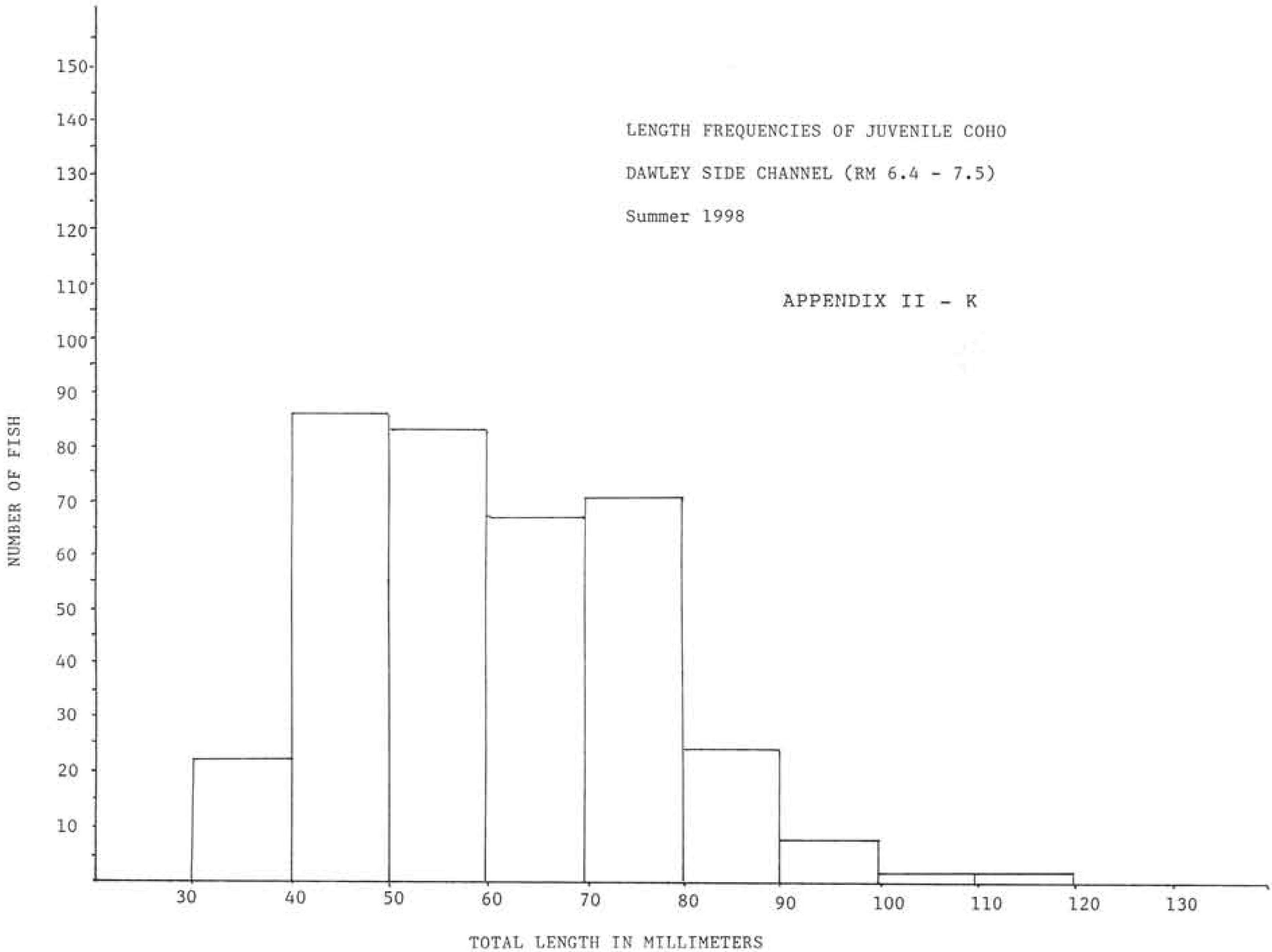
APPENDIX II - I

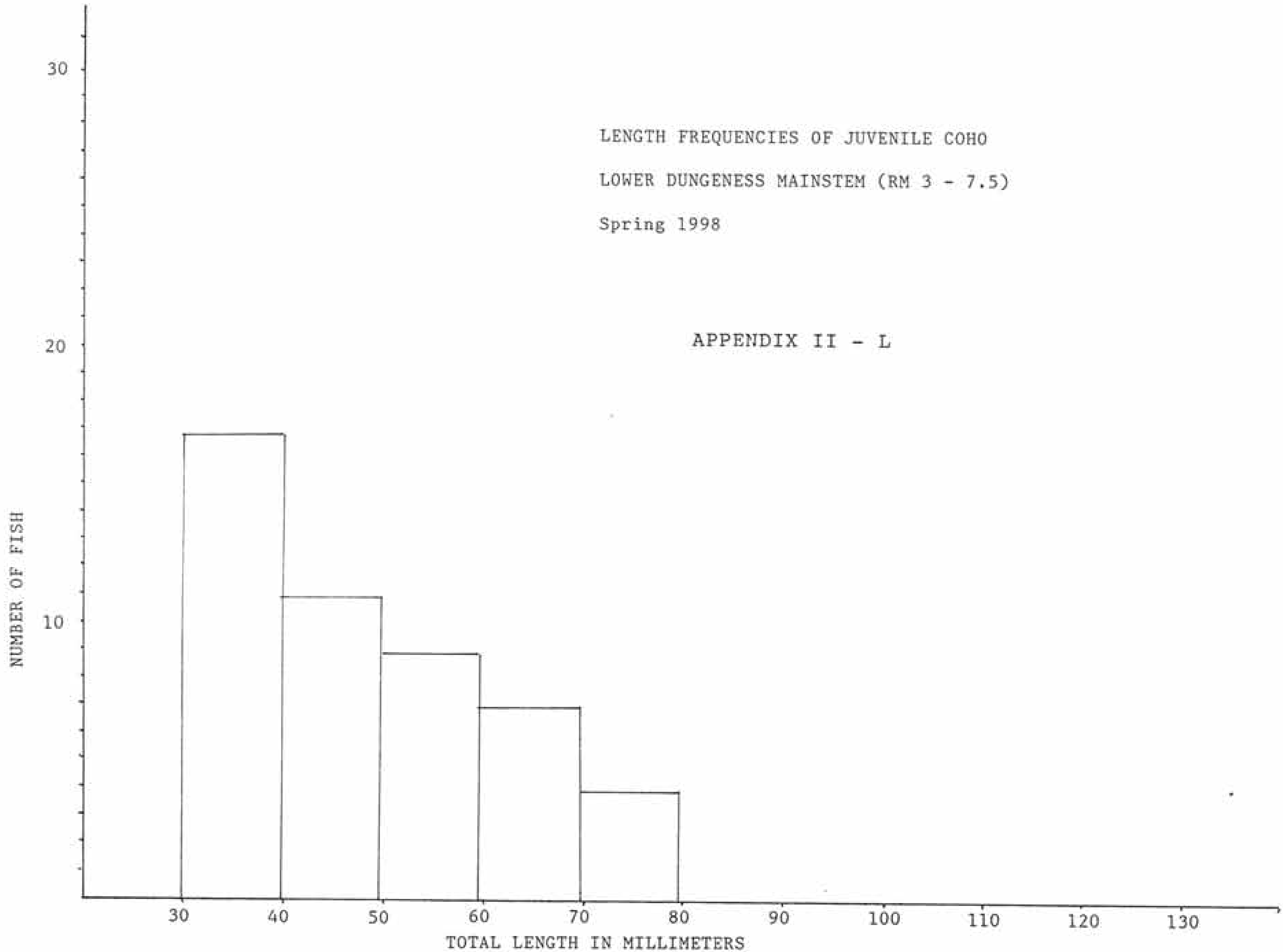


APPENDIX II - J



APPENDIX II - K



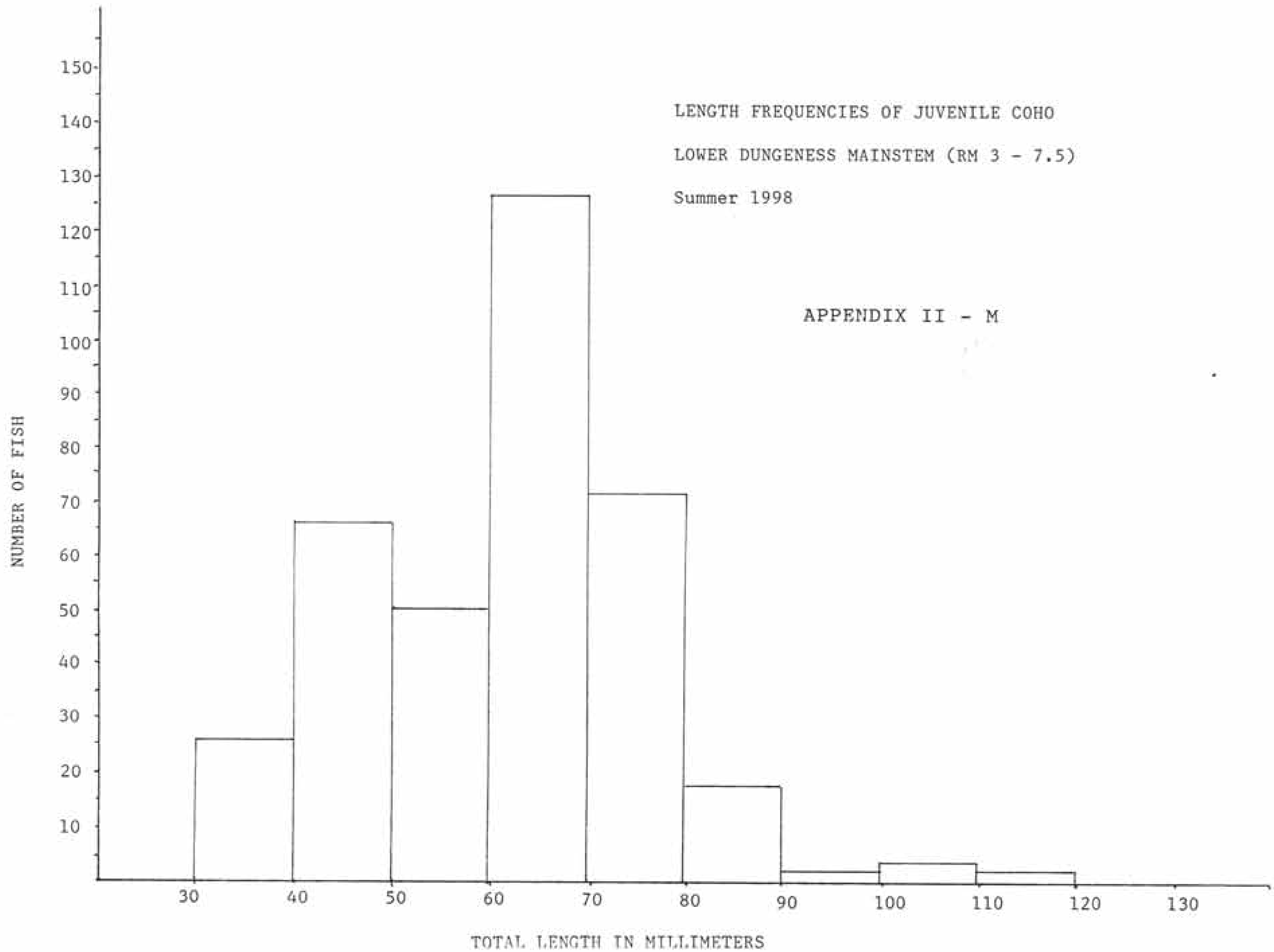

LENGTH FREQUENCIES OF JUVENILE COHO
LOWER DUNGENESS MAINSTEM (RM 3 - 7.5)
Spring 1998
APPENDIX II - L
NUMBER OF FISH
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

LENGTH FREQUENCIES OF JUVENILE COHO

LOWER DUNGENESS MAINSTEM (RM 3 - 7.5)

Summer 1998

APPENDIX II - M

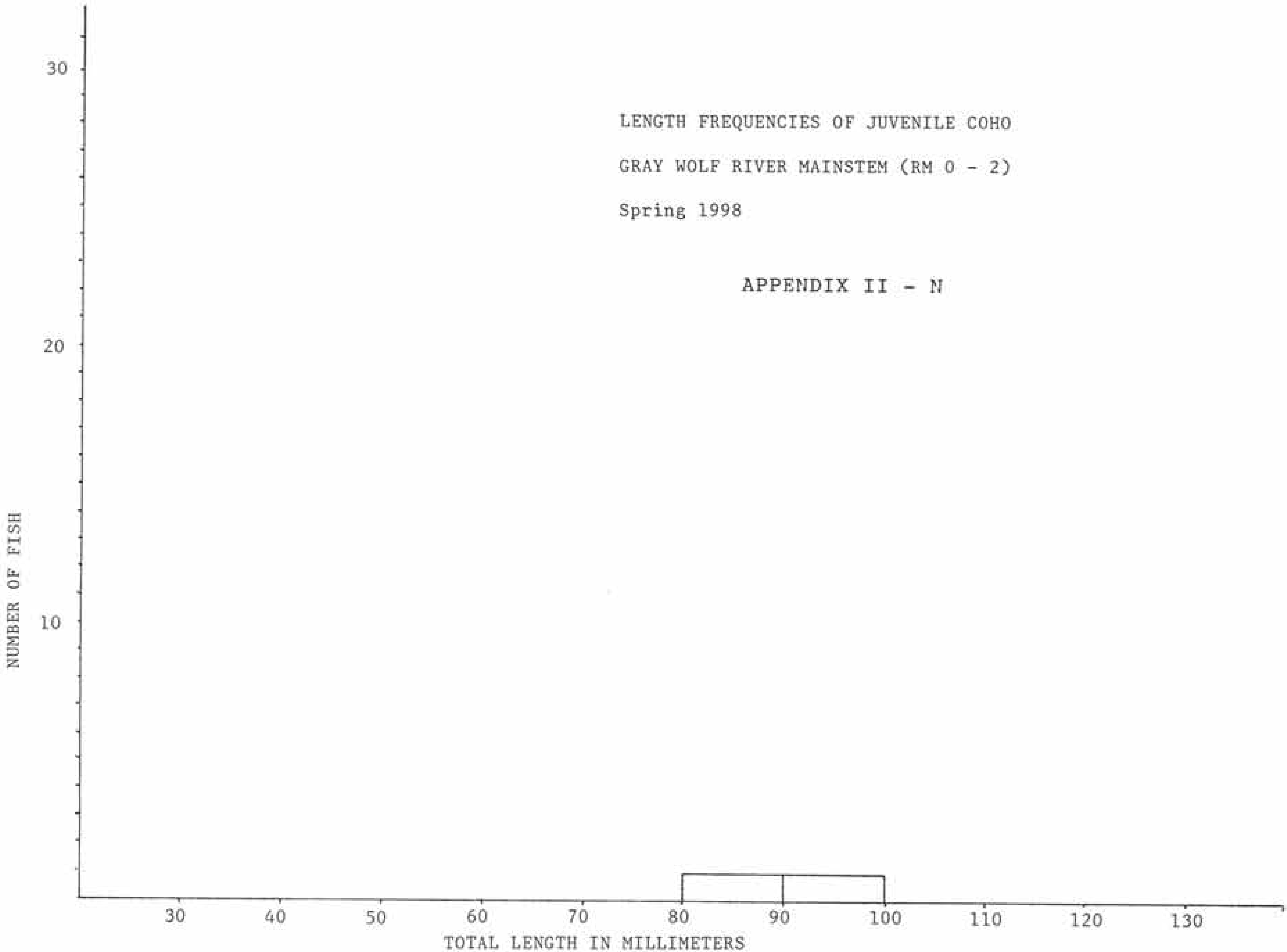


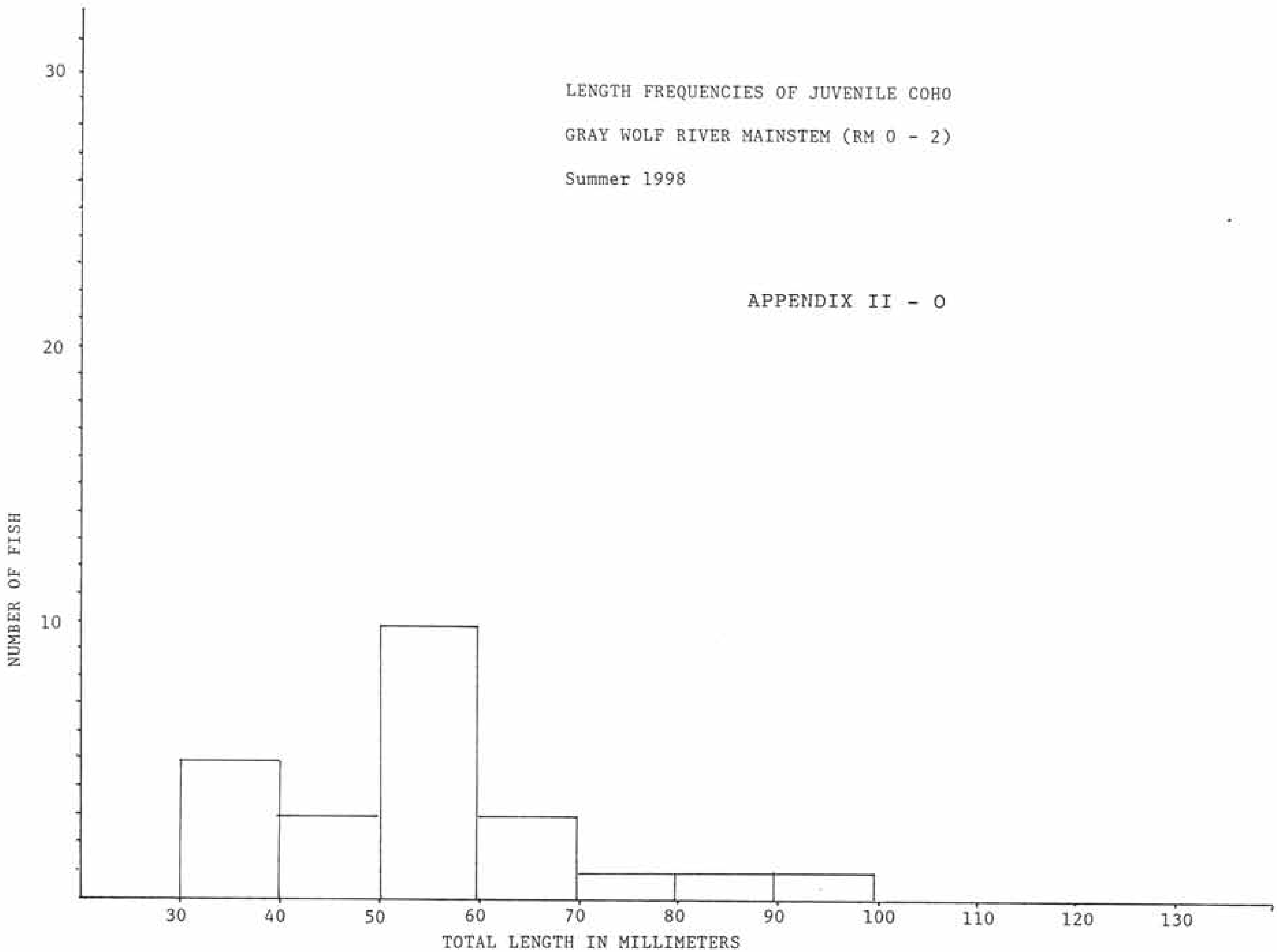
LENGTH FREQUENCIES OF JUVENILE COHO

GRAY WOLF RIVER MAINSTEM (RM 0 - 2)

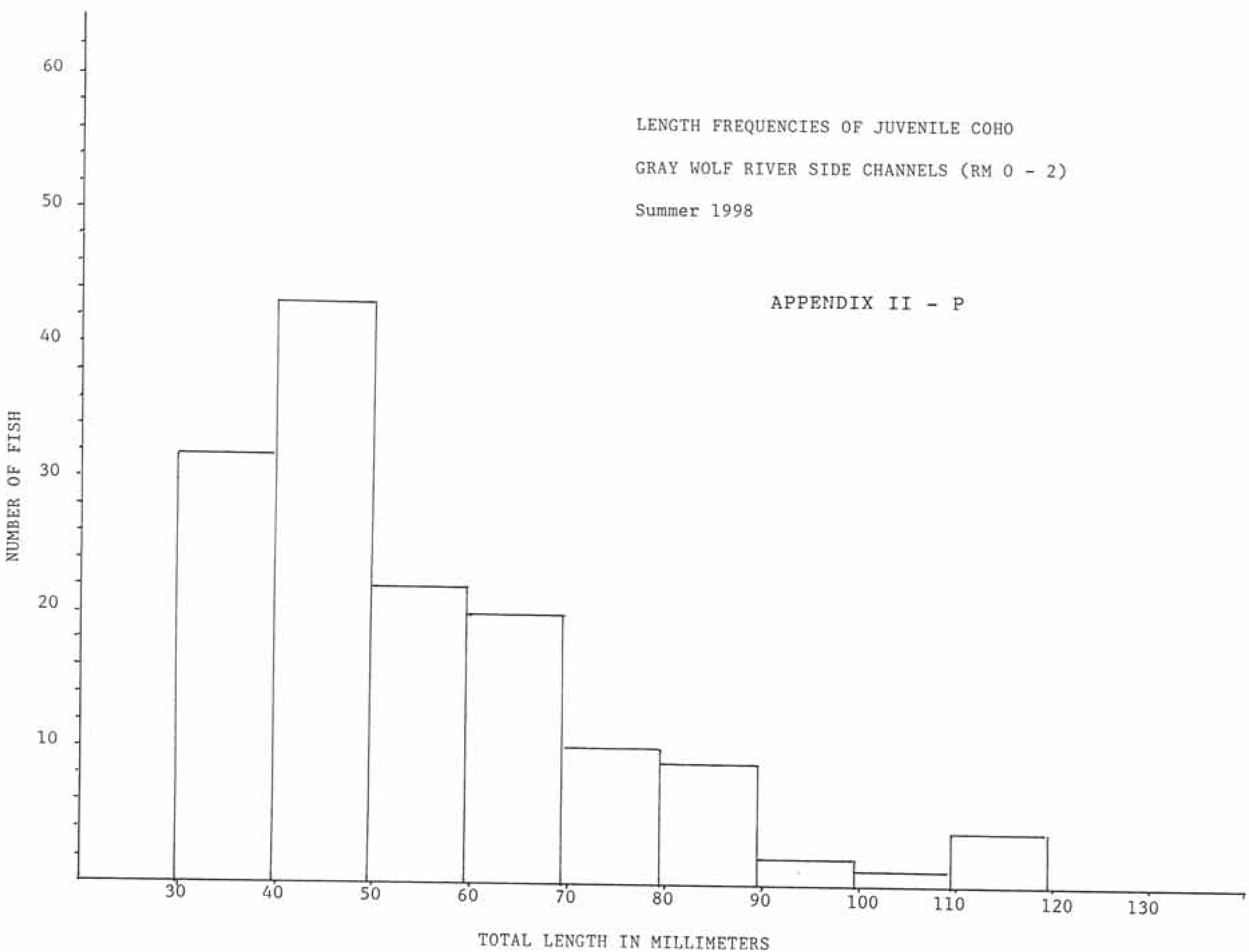
Spring 1998

APPENDIX II - N



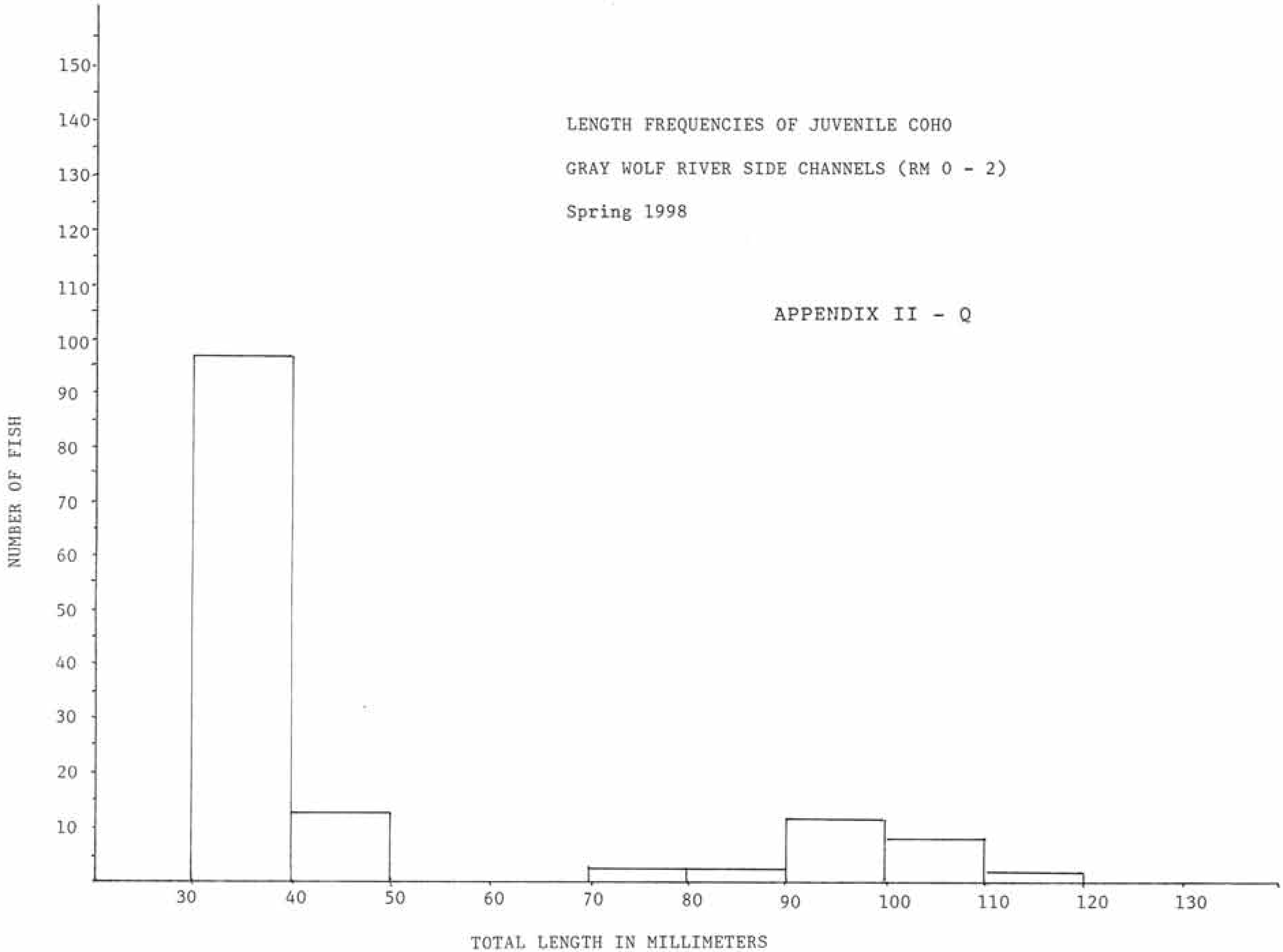


APPENDIX II - O



LENGTH FREQUENCIES OF JUVENILE COHO
GRAY WOLF RIVER SIDE CHANNELS (RM 0 - 2)
Summer 1998
APPENDIX II - P
NUMBER OF FISH
60
50
40
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS

APPENDIX II - Q

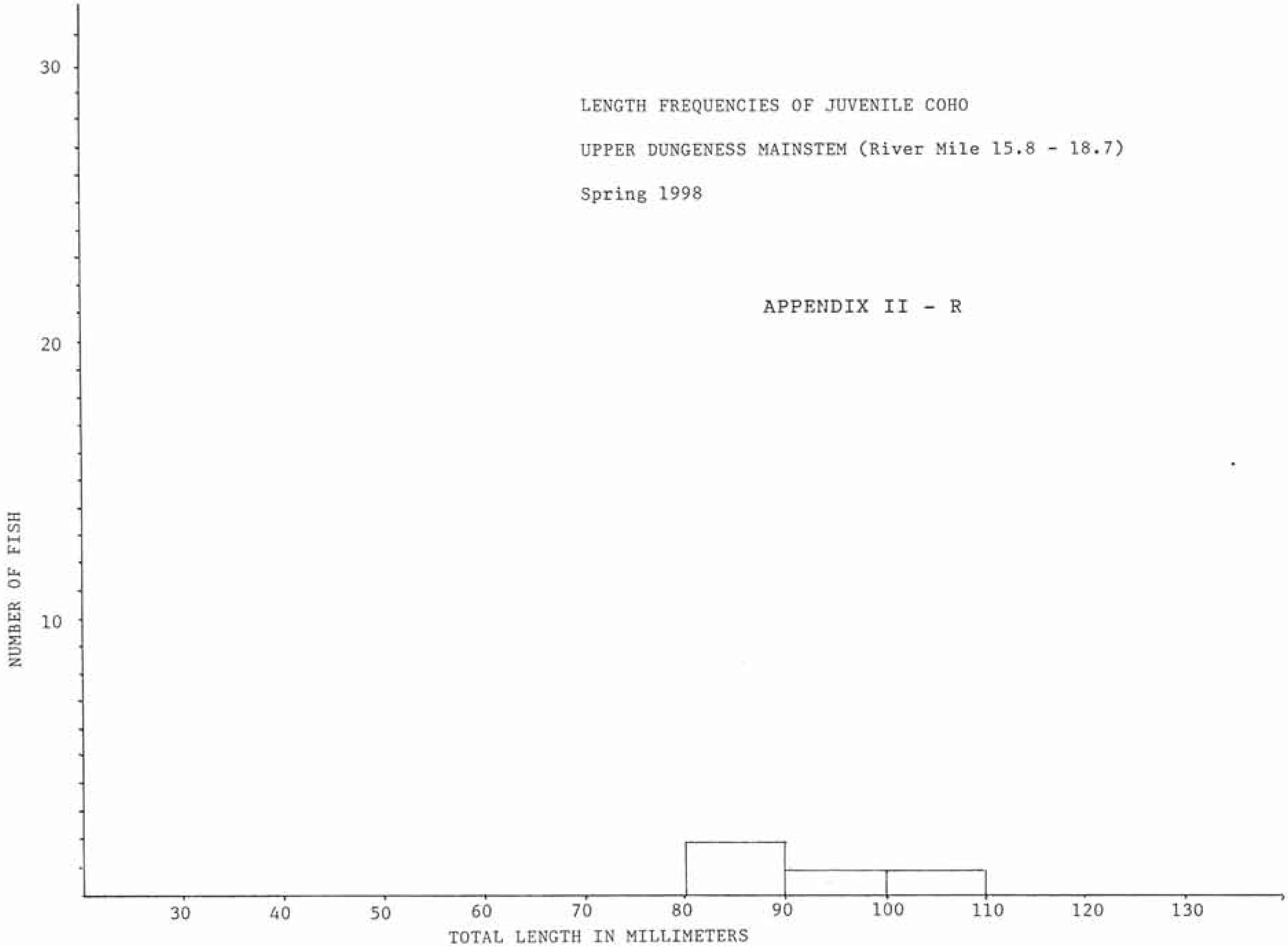


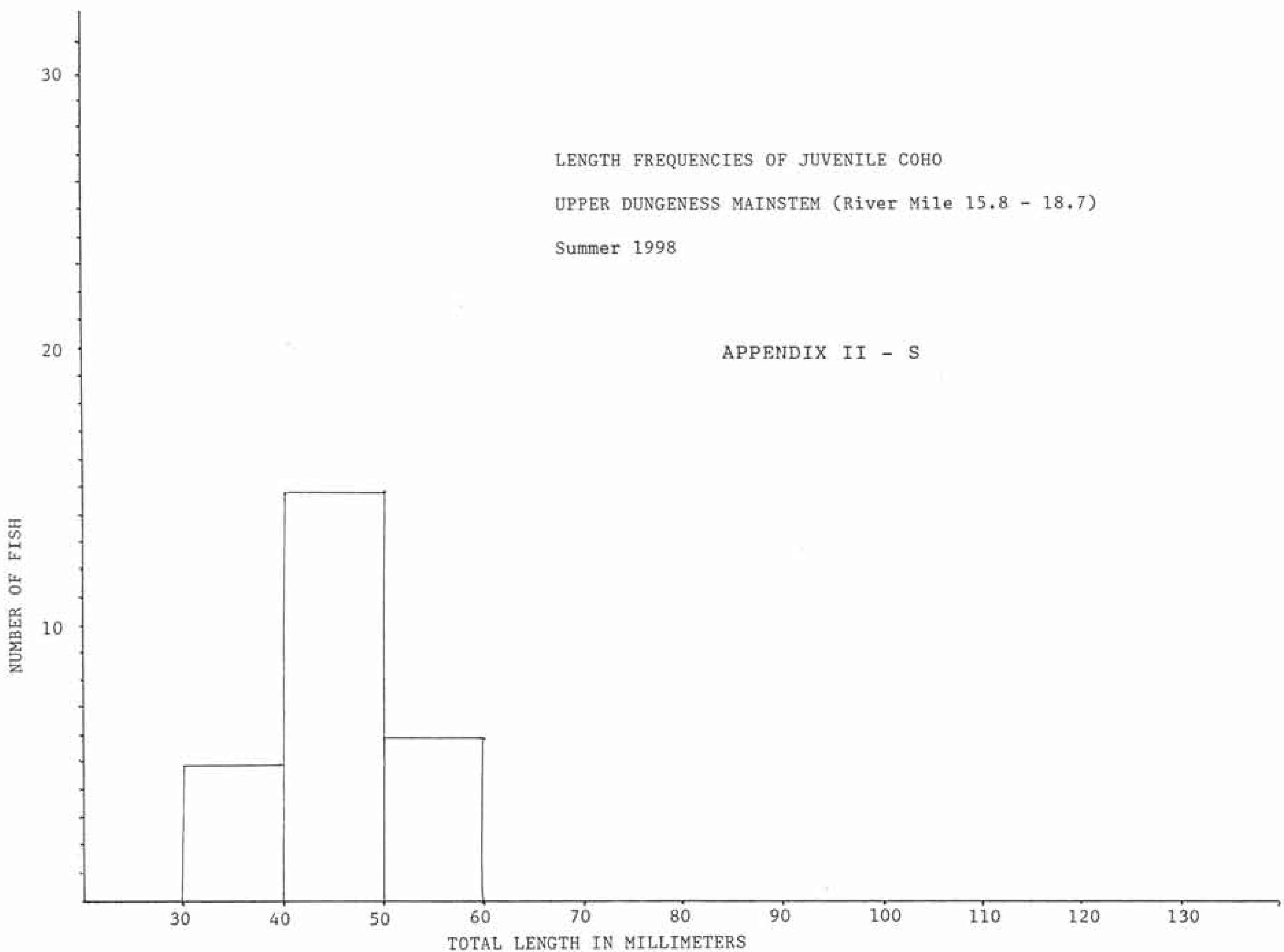
LENGTH FREQUENCIES OF JUVENILE COHO

UPPER DUNGENESS MAINSTEM (River Mile 15.8 - 18.7)

Spring 1998

APPENDIX II - R




LENGTH FREQUENCIES OF JUVENILE COHO
UPPER DUNGENESS MAINSTEM (River Mile 15.8 - 18.7)
Summer 1998
APPENDIX II - S
NUMBER OF FISH
30
20
10
30
40
50
60
70
80
90
100
110
120
130
TOTAL LENGTH IN MILLIMETERS