

**REGIONAL ANALYSIS OF FISHERIES FLOW
REQUIREMENTS FOR THE EAST COAST
OF VANCOUVER ISLAND**

Prepared for
WATER USE UNIT
HABITAT MANAGEMENT DIVISION
DEPT. OF FISHERIES & OCEANS,
PACIFIC REGION

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FEBAP Project #578

March 31, 1983

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Any questions arising from this report should be directed to him.

Gita Kapahi,
Project Manager
FEBAP Project #578

74484

INTRODUCTION

General

The information contained in this report is intended to serve as an aid to those individuals and agencies concerned with water management and the maintenance of instream habitats vital to the support of anadromous fish stocks. Hydrometric data for the period of record has been analysed to obtain minimum flow values for the period May 1 through November 30 for unregulated, gauged streams in the East Coast Vancouver Island Region. This information, combined with field observations and the measurement of various watershed characteristics from topographic maps, has formed the base for an initial estimate of minimum flow requirements for spawning and rearing salmon.

Limited field work was performed during the summer and fall of 1982 to acquire data on stream channel characteristics and flows for each study stream. Information on instream habitat and escapement timing and numbers has been gathered from fishery officer reports. Stream inventory data of general nature has been obtained from Department of Fisheries and Oceans technical reports.

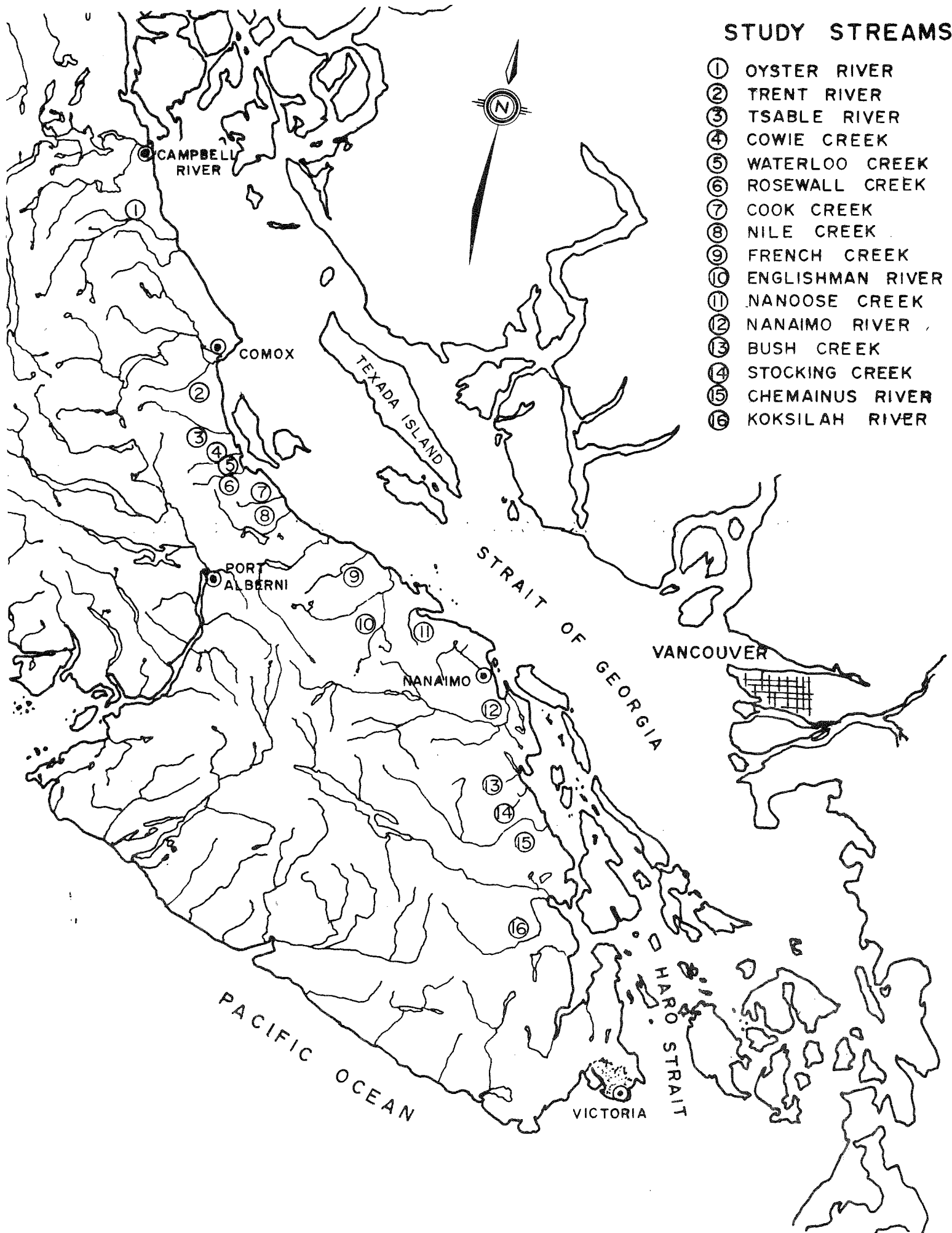
All of the study streams listed on the following page are represented within this report (with the exception of (7) Cook Creek, (10) Englishman River and (12) Nanaimo River) and follow in numerical order through the body of the report. Study Stream (1), the Oyster River being the northernmost and working progressively south to Study Stream (16), the Koksilah River. Both the Englishman and Nanaimo Rivers have been extensively studied in

INTRODUCTION cont'd

the past (refer to Fisheries & Aquatic Sciences Manuscript Report #1676; Hamilton & Kosakoski, Sept. 1982 and R. Hamilton, April 1973 (unpub.), respectively).

STUDY STREAMS

- ① OYSTER RIVER
- ② TRENT RIVER
- ③ TSABLE RIVER
- ④ COWIE CREEK
- ⑤ WATERLOO CREEK
- ⑥ ROSEWALL CREEK
- ⑦ COOK CREEK
- ⑧ NILE CREEK
- ⑨ FRENCH CREEK
- ⑩ ENGLISHMAN RIVER
- ⑪ NANOOSE CREEK
- ⑫ NANAIMO RIVER
- ⑬ BUSH CREEK
- ⑭ STOCKING CREEK
- ⑮ CHEMAINUS RIVER
- ⑯ KOKSILAH RIVER



COMMENTS

The object of this series of reports is to present a summary of the available watershed data and provide approximations of spawning and rearing flows necessary to maintain salmon populations. In order to predict these flows a number of assumptions have been made with regard to the physical characteristics of the watersheds involved. The following results, therefore, are meant to be first approximations only.

This study had combined the methods of Collings (1974), Orsborn (1976) and Hamilton (1978), to predict spawning and rearing flows in both gauged and ungauged streams. Collings (1974) developed multiple regression equations for spawning and rearing flows, in terms of basin and stream characteristics. His study involved a number of streams in western Washington.

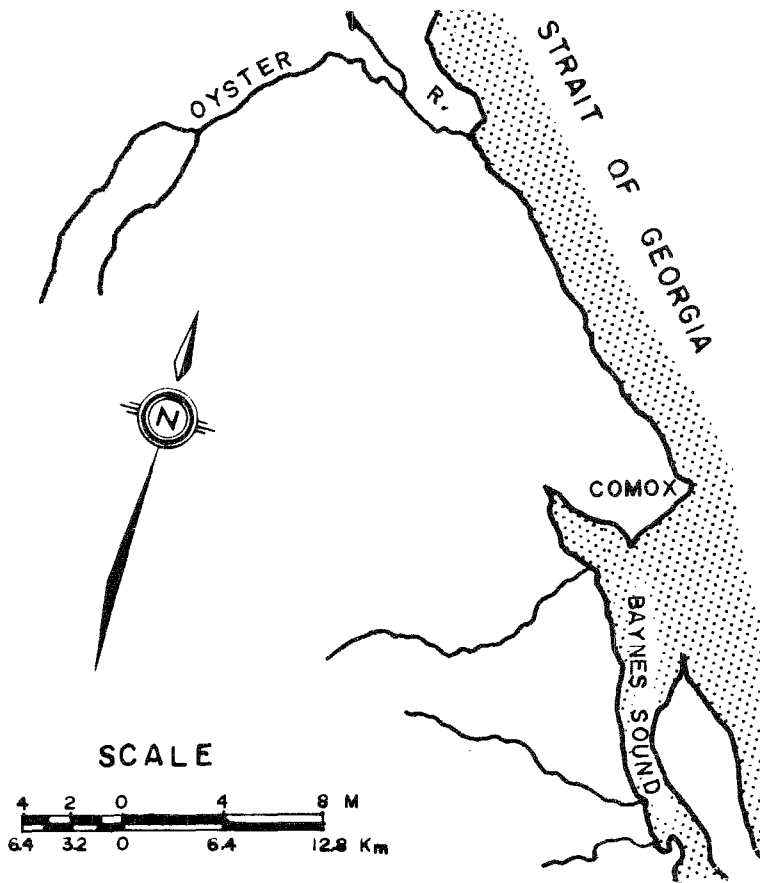
Hamilton (1978) has developed a computer program ("Stream Flow") based on stream hydraulics at individual transects using velocity, depth and substrate criteria. The output of this program provides estimates of velocities, depths and other parameters for specified flows and a prediction of spawning area.

Orsborn makes use of a number of watershed parameters to predict recurrence intervals of low flows for ungauged streams.

Complete descriptions and summaries of the preceeding methods are in the Appendix.

Oyster River

General Description

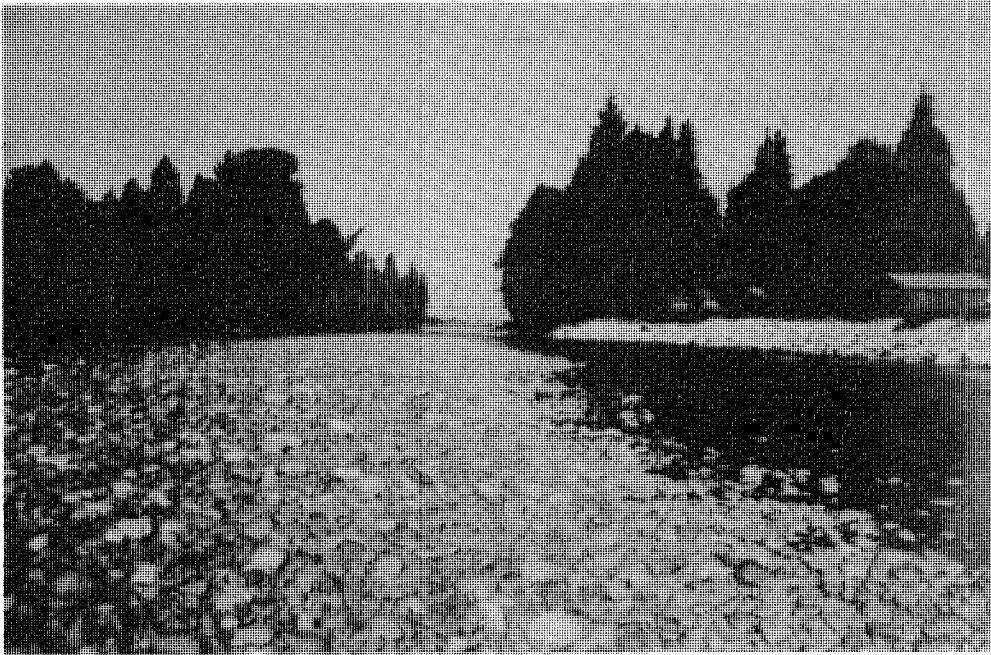


The Oyster River is located on the east coast of Vancouver Island, its mouth situated approximately 25 kilometers north-west of Comox. Fifty-two kilometers from the strait of Georgia, headwaters flow from 1900 meter high ridges to Pearl Lake. Downstream for the next 31 kilometers the river courses generally eastward through reaches

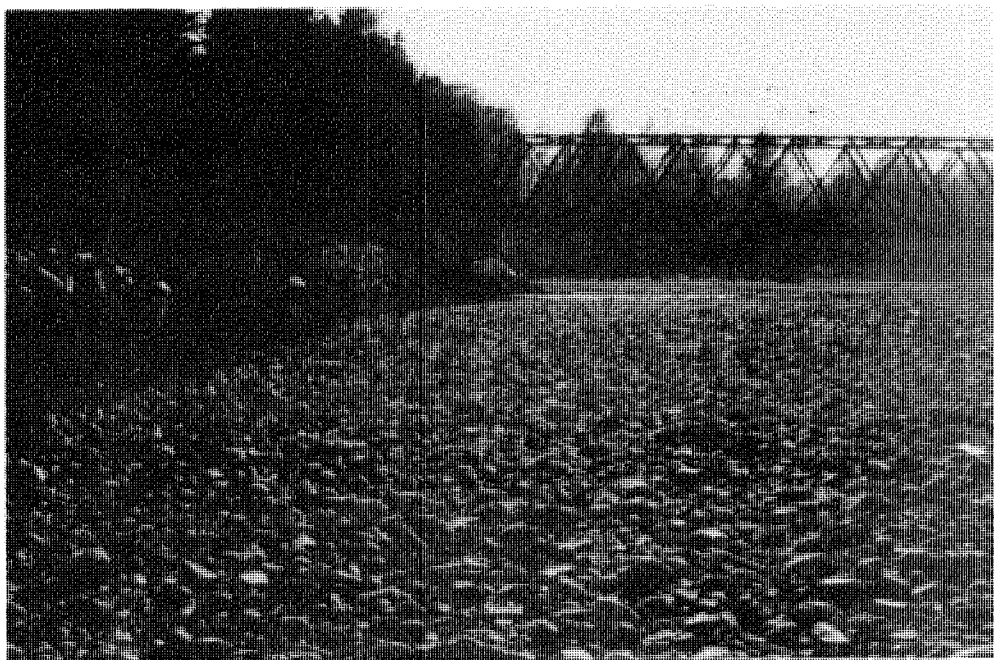
characterized by steep gradients and a narrow confined channel. Forest cover is predominated by Coastal Douglas Fir and Western Hemlock, supported by Podzolic soils typical to coniferous forests. Twenty-one kilometers from tidewater a series of chutes and falls presents an impassible barrier to the upstream migration of spawning salmon. From this point to the mouth of the stream gradients average an 8.5 meter drop per kilometer and much of the lower portion of the Oyster and its main tributary the Little Oyster provide potential spawning and rearing environments. However scouring due to high wintertime flows has substantially depleted the extent of spawning ground in the lower reaches. Reports for recent years indicate a decline in escapements for the major species present, Coho and Pinks.

(N.B.- Watershed map is located in a pocket at the back of this report,)

The same reports point to extensive logging activity as being a prime factor contributing to excessive flows and resulting damage to spawning and rearing habitat.

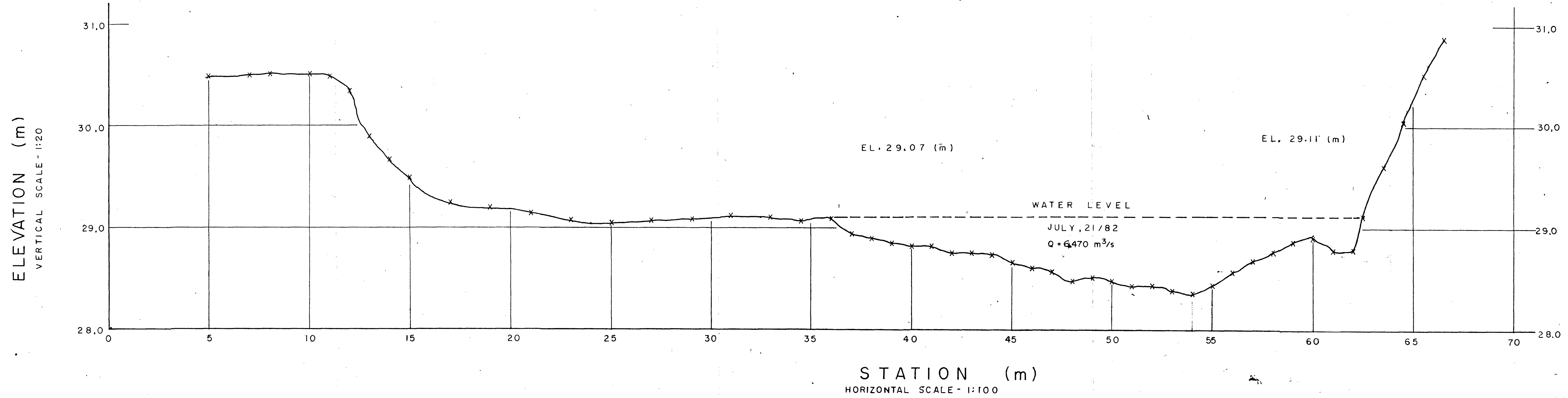


Downstream view 500 meters above the mouth.



Upstream view 500 meters above the mouth.

OYSTER RIVER - CROSS SECTION



Watershed Data

Hydrometric Station # 03HD011 Oyster River

Watershed Area	(A)	363.0 km ²
Mean Elevation	(H)	1000 m
First Order Length	(L ₁)	179.7 km
All Orders	(L _T)	503.0 km
Average Precipitation	(AP)	2500 mm/year
Average Annual Flow	(QAA)	15.1 m ³ /sec

For The Period June 1 - Nov. 30:

Average Flow of Lowest Month (September)	6.15 m ³ /sec
7 Day Low Flow, 2 year recurrence (Q7L2)	1.93 m ³ /sec
7 Day Low Flow, 20 year recurrence (Q7L20)	0.83 m ³ /sec
Variability (Q7L20/Q7L2)	0.43
Yield (Q7L2/A)	0.0053 m ³ sec ⁻¹ /km ²

SUMMARY

Estimated Fishery Flow Requirements

A. Spawning Flow

	m ³ /sec
"Streamflow" (Hamilton) Optimum Flow (Coho)	No data
Collings Method Preferred Flow (All Species)	14.30
Sustained Flow (All Species)	11.67
Actual Average Flow At Peak Spawning Time	
Chum	5.58
Coho	25.37
Pink	26.73

B. Rearing Flow

	m ³ /sec
"Streamflow" (Hamilton) Optimum Flow (Based on Surface Width)	5.5
Collings Method Optimum Flow (All Species)	4.33
Average Flow of Lowest Month (Jan. 1-Dec. 31)	6.15
Average Flow of Lowest Month (June 1-Nov. 30)	6.15

Historical Streamflow Data

OYSTER RIVER BELOW WOODHUS CREEK STATION NO. 08HD011													
MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD													
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1974	19.8	10.6	16.8	21.1	24.6	34.7	22.6	8.95	3.87	2.36	15.7	20.8	16.8
1975	6.23	5.18	7.68	13.3	10.4	24.6	10.6	5.90	3.25	21.8	55.9	20.2	17.1
1976	14.5	7.23	5.66	11.6	21.3	19.3	14.2	7.02	4.08	3.85	10.0	15.9	11.4
1977	7.35	16.4	8.44	14.9	12.8	12.7	4.39	2.27	5.05	---	---	---	---
1978	---	---	15.0	14.8	16.5	20.4	9.04	9.99	14.5	5.62	12.5	---	---
1979	---	9.02	---	---	---	---	---	---	---	---	---	---	---
MEAN	12.0	9.69	10.7	15.1	21.5	22.3	12.2	6.83	6.15	8.41	23.5	19.0	15.1
LOCATION - LAT 49 53 38 N DRAINAGE AREA, 248 km ²													
LONG 125 14 18 W NATURAL FLOW													

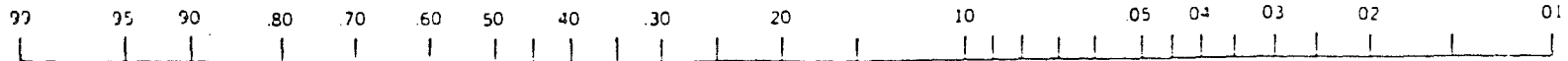
OYSTER RIVER BELOW WOODHUS CREEK - STATION NO. 08HD011				
ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD				
YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m ³ /s)	MAXIMUM DAILY DISCHARGE (m ³ /s)	MINIMUM DAILY DISCHARGE (m ³ /s)	TOTAL DISCHARGE (dam ³)
1974	235 E AT 19:00 PST ON NOV 24	131 E ON JAN 15	1.12 ON NOV 4 *	531 000
1975	348 AT 14:45 PST ON NOV 13 *	260 ON NOV 13 *	1.47 ON OCT 2	540 000
1976	83.3 AT 06:42 PST ON DEC 26	63.4 ON DEC 26	2.18 ON OCT 23	361 000
1977	---	---	1.68 ON SEP 14	---
1978	---	---	2.74 ON OCT 22	---
1979	---	---	---	---
E - ESTIMATED * - EXTREME RECORDED FOR THE PERIOD OF RECORD				477 000

After; Historical Streamflow Summary, British Columbia to 1979.

Inland Waters Directorate
Water Resources Branch
Water Survey of Canada
Ottawa, Canada, 1980

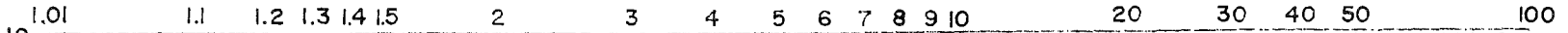
OYSTER RIVER BELOW WOODHUS CREEK STATION #08HD011

PROBABILITY

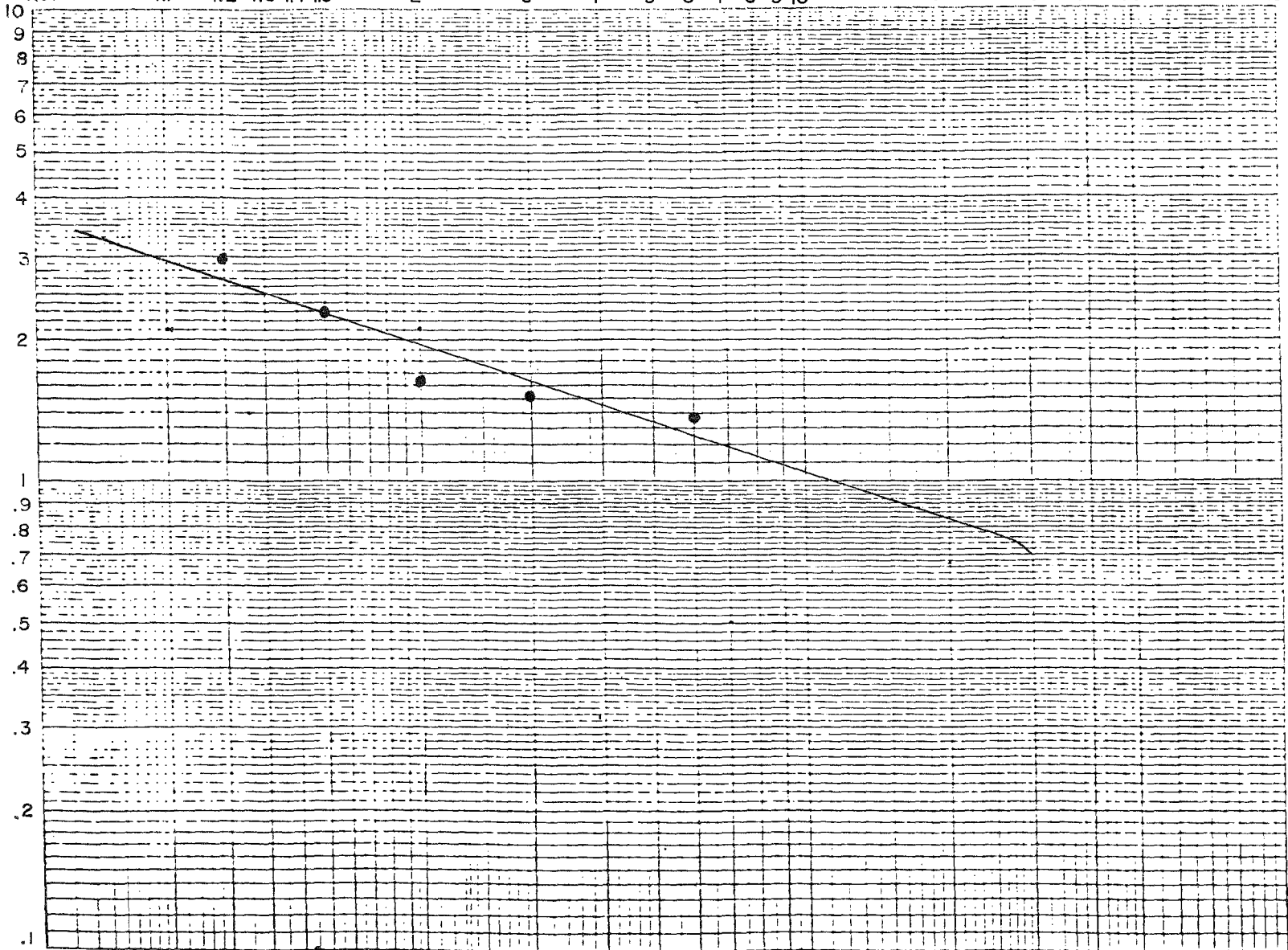


Lowest 7 Day Summer and Fall Flows (June 1 - Nov. 30)

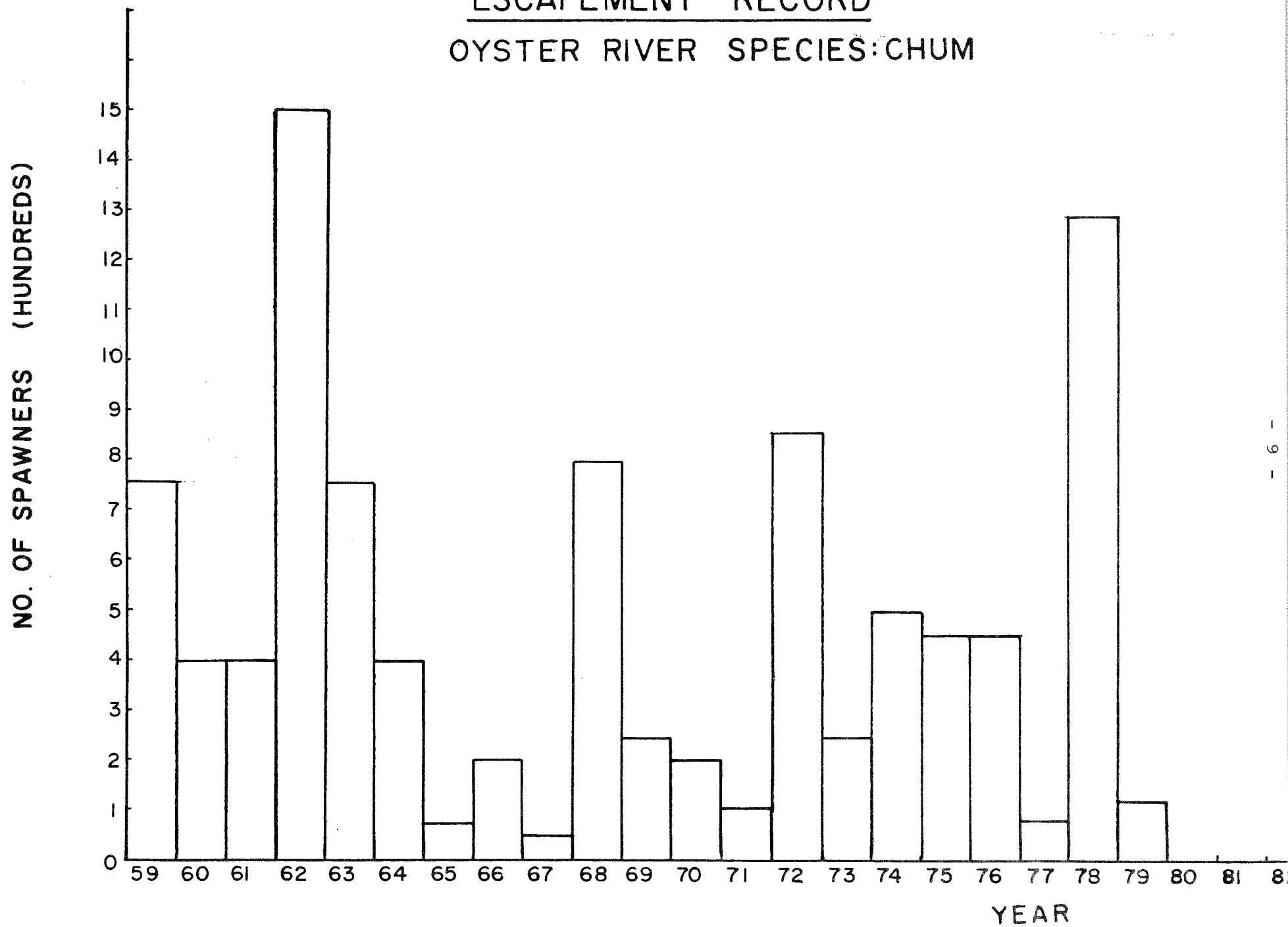
RECURRENCE INTERVAL IN YEARS



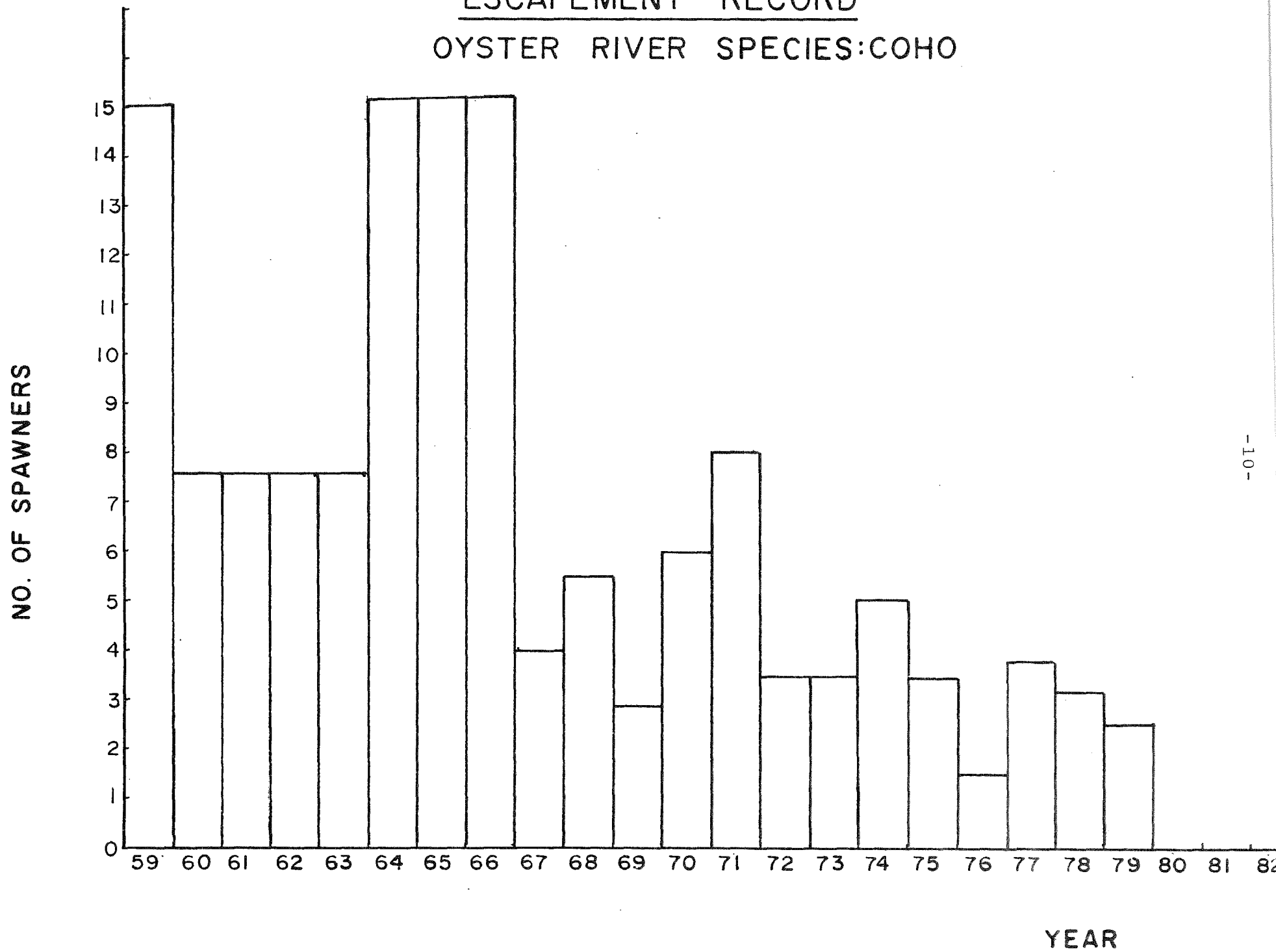
M³/SEC



ESCAPEMENT RECORD
OYSTER RIVER SPECIES: CHUM

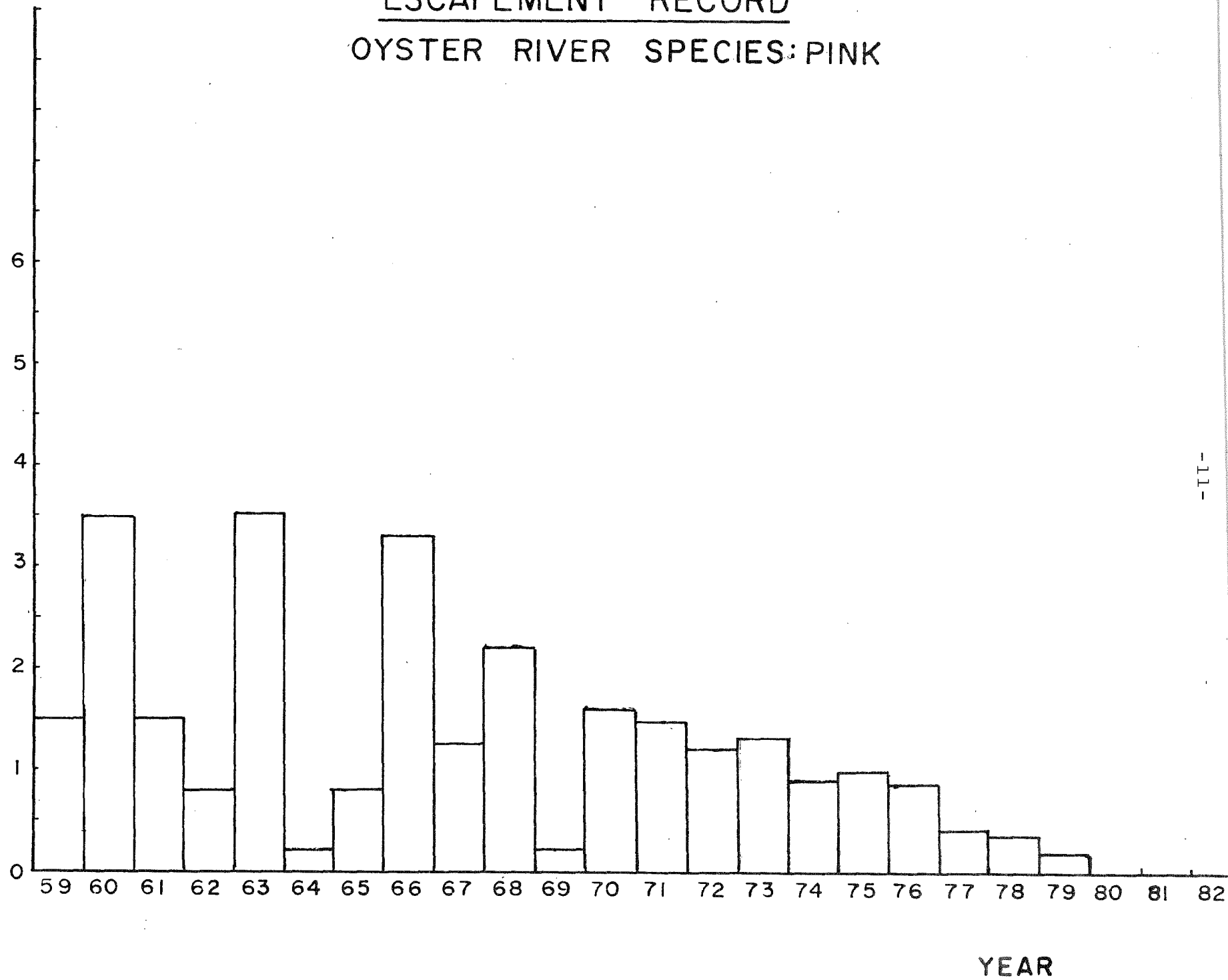


ESCAPEMENT RECORD
OYSTER RIVER SPECIES: COHO



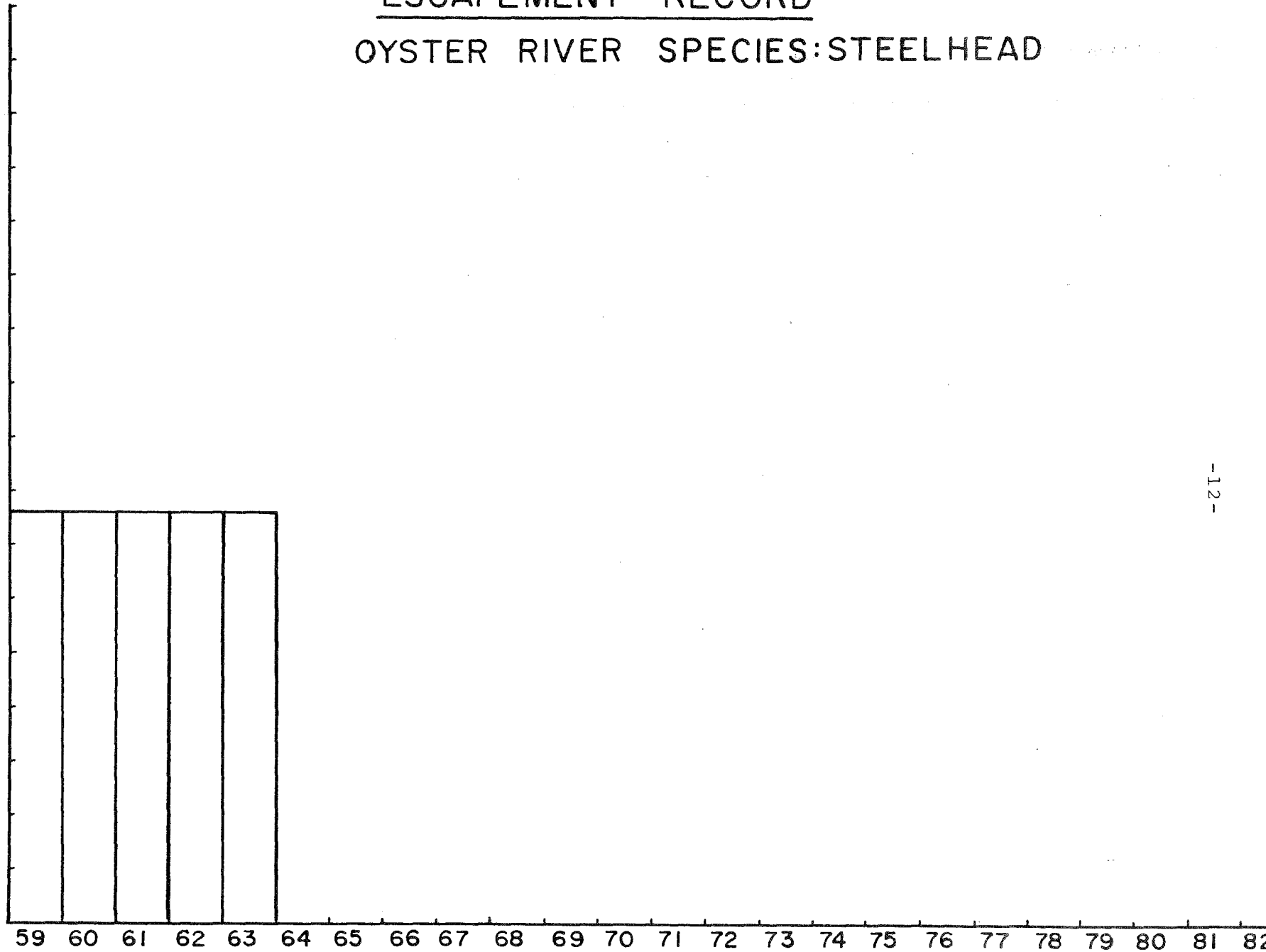
ESCAPEMENT RECORD
OYSTER RIVER SPECIES: PINK

NO. OF SPAWNERS (THOUSANDS)

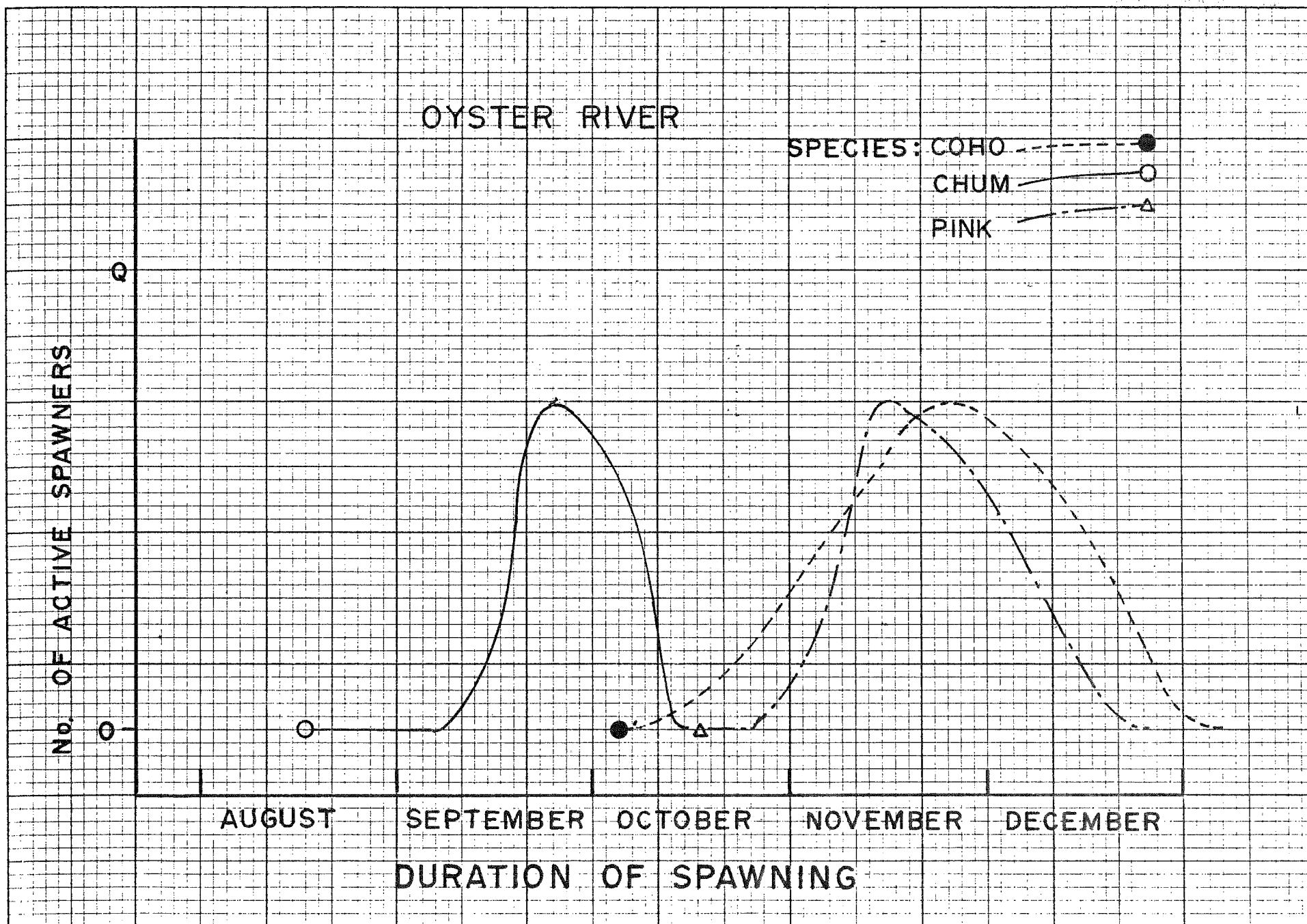


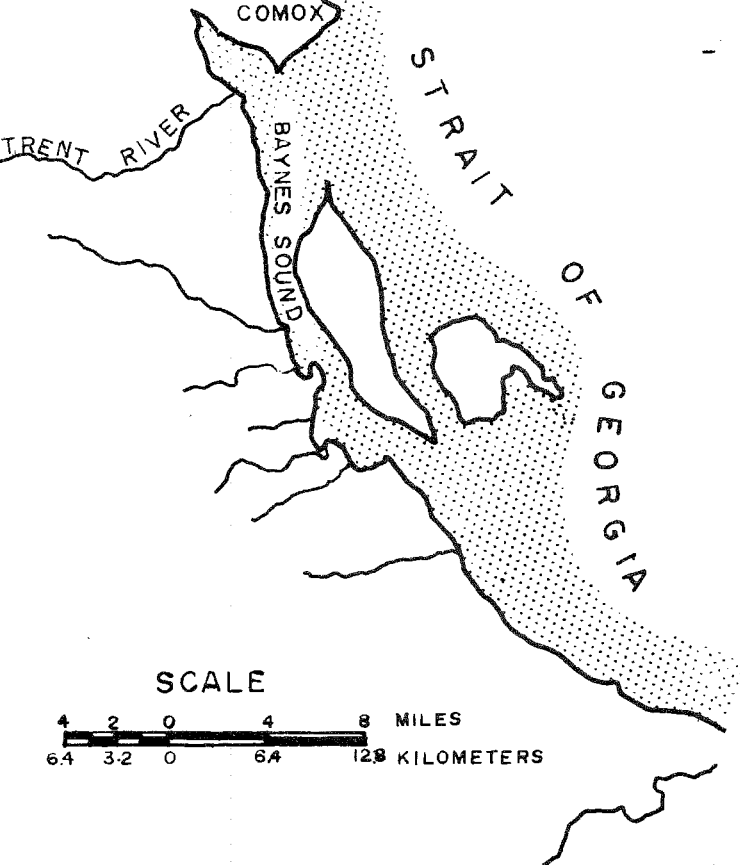
ESCAPEMENT RECORD
OYSTER RIVER SPECIES: STEELHEAD

NO. OF SPAWNERS (HUNDREDS)



YEAR



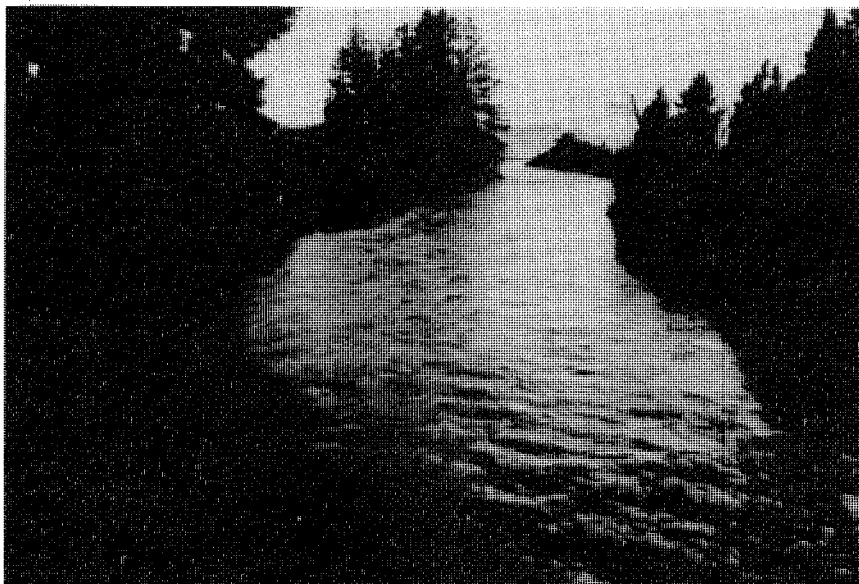


Trent River

General Description

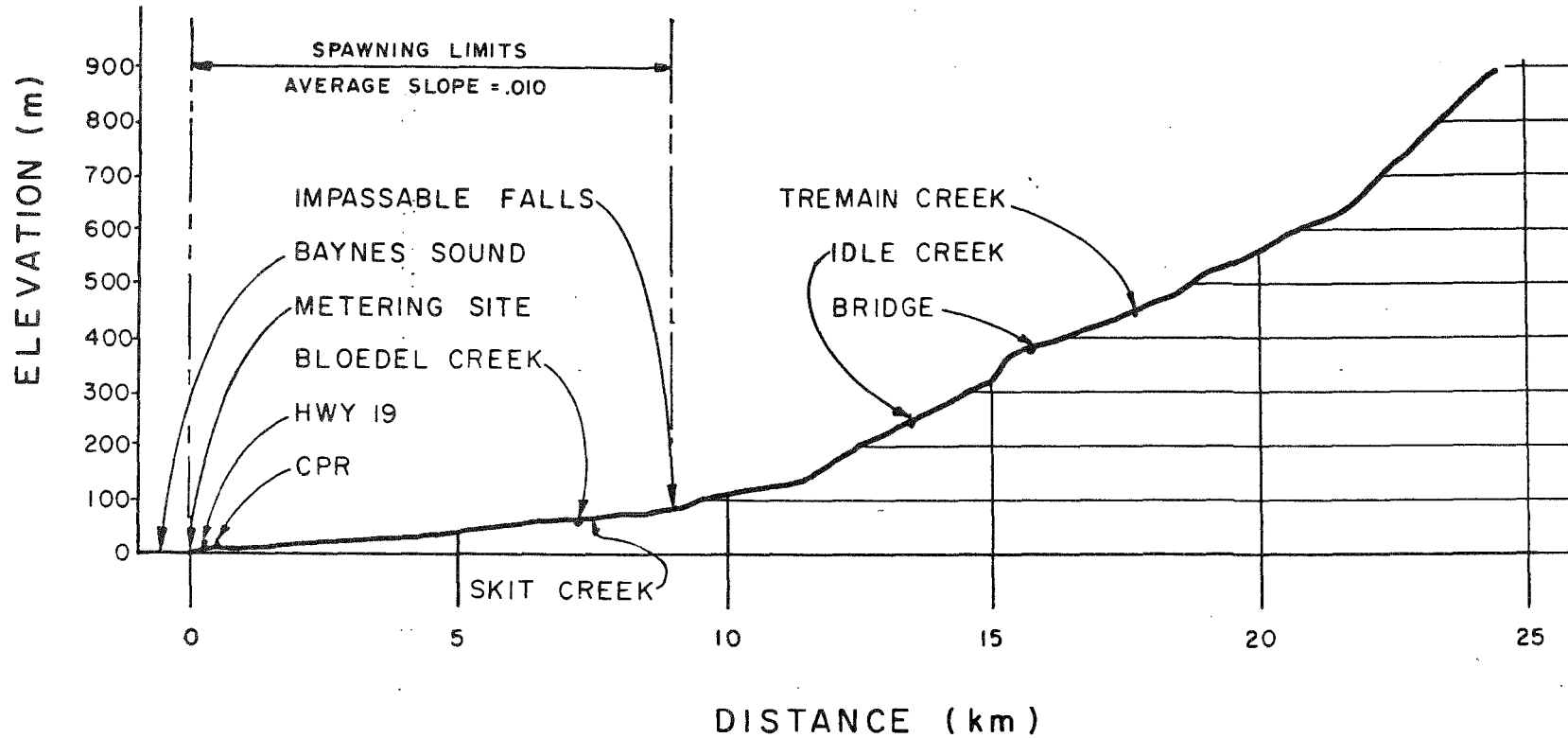
The Trent River flows north-east into Comox Harbour just north of Gartley Point. Nine kilometers upstream there is an impassable drop of 20 m. The Trent has a fairly extensive network of tributaries of which two, the Skit and Bloedel, are known to be accessible.

According to a Fisheries Stream Report in 1962, the Trent was "poisoned by coal mine effluent which either wiped out or greatly decimated the fish runs". Now Coho are distributed throughout the creek below the falls and the Chum are found mainly in the lower reaches. For 8 kilometers above the falls the creek has possible potential for rearing juvenile salmon. Escapement for both Chum and Coho has been variable over the past 20 years.



View downstream of highway bridge.

TRENT RIVER ELEVATION PROFILE



Watershed Data

Hydrometric Station # 08HB044 Trent River

Watershed Area	(A)	72.0 km ²
Mean Elevation	(H)	1000 m
First Order Length	(L ₁)	33.5 km
All Orders	(L _T)	82.5 km
Average Precipitation	(AP)	2300 mm/year
Average Annual Flow	(QAA)	Not Available

For The Period June 1 - Nov. 30:

Average Flow of Lowest Month (August)	0.199 m ³ /sec
7 Day Low Flow, 2 year recurrence (Q7L2)	0.31 m ³ /sec
7 Day Low Flow, 20 year recurrence (Q7L20)	0.14 m ³ /sec
Variability (Q7L20/Q7L2)	0.45
Yield (Q7L2/A)	0.0043 m ³ sec ⁻¹ /km ²

SUMMARY

Estimated Fishery Flow Requirements

A. Spawning Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Coho)	No data
Collings Method	
Preferred Flow (All Species)	
Sustained Flow (All Species)	
Actual Average Flow At	
Peak Spawning Time	
Chum	No data
Coho	No data

B. Rearing Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Based on Surface Width)	No data
Collings Method	
Optimum Flow (All Species)	
Average Flow of Lowest Month	
(Jan. 1-Dec. 31)	0.199
Average Flow of Lowest Month	
(June 1-Nov. 30)	0.199

Historical Streamflow Data

TRENT RIVER NEAR ROYSTON - STATION NO. 08HB044													
MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD													
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1971	---	---	---	---	5.44	2.05	0.481	0.063	0.569	---	---	---	---
1972	---	---	---	---	3.16	1.04	0.277	0.040	0.680	---	---	---	---
1973	---	---	---	2.01	2.33	0.860	0.148	0.024	0.077	---	---	---	---
1974	---	---	---	---	3.31	1.96	1.07	0.053	0.018	---	---	---	---
1975	---	---	---	4.05	5.10	0.955	0.061	0.784	0.288	---	---	---	---
1976	---	---	---	4.37	3.02	1.57	0.484	0.231	0.311	---	---	---	---
MEAN	---	---	---	3.48	3.73	1.41	0.420	0.199	0.324	---	---	---	---

LOCATION - LAT 49 38 22 N DRAINAGE AREA, 72.0 km²
LONG 124 55 50 W NATURAL FLOW

TRENT RIVER NEAR ROYSTON - STATION NO. 08HB044				
ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD				
YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m ³ /s)	MAXIMUM DAILY DISCHARGE (m ³ /s)	MINIMUM DAILY DISCHARGE (m ³ /s)	TOTAL DISCHARGE (dam ³)
1971	---	11.9 ON APR 8 *	0.014 ON AUG 12	---
1972	---	---	0.006 ON AUG 14	---
1973	---	---	---	---
1974	---	8.89E ON MAY 25	0 ON SEP 4 *	---
1975	---	---	---	---
1976	---	---	---	---

E - ESTIMATED

* - EXTREME RECORDED FOR THE PERIOD OF RECORD

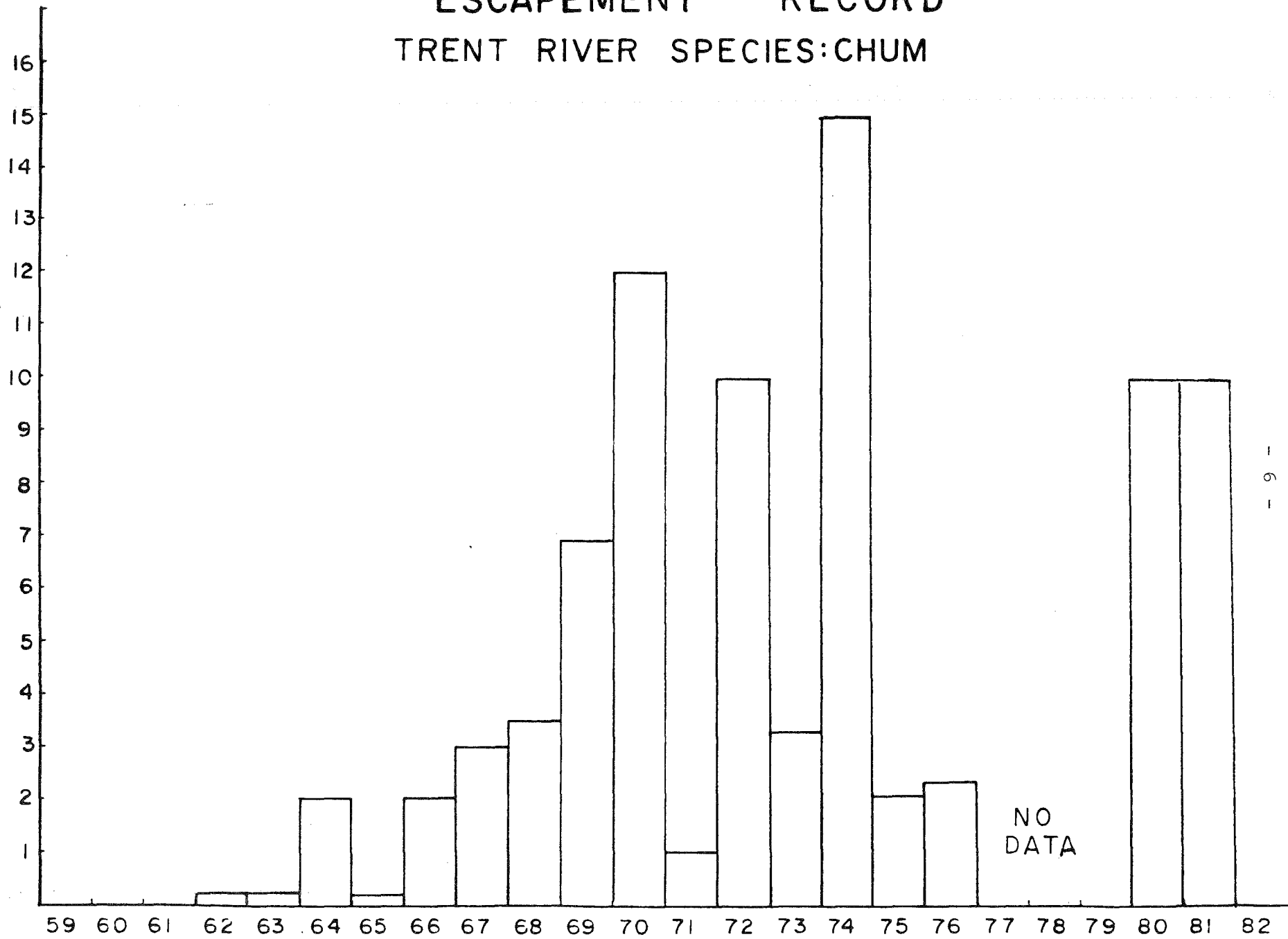
After; Historical Streamflow Summary, British Columbia to 1979.

Inland Waters Directorate
Water Resources Branch
Water Survey of Canada
Ottawa, Canada, 1980

ESCAPEMENT RECORD

TRENT RIVER SPECIES:CHUM

NO. OF SPAWNERS (HUNDREDS)

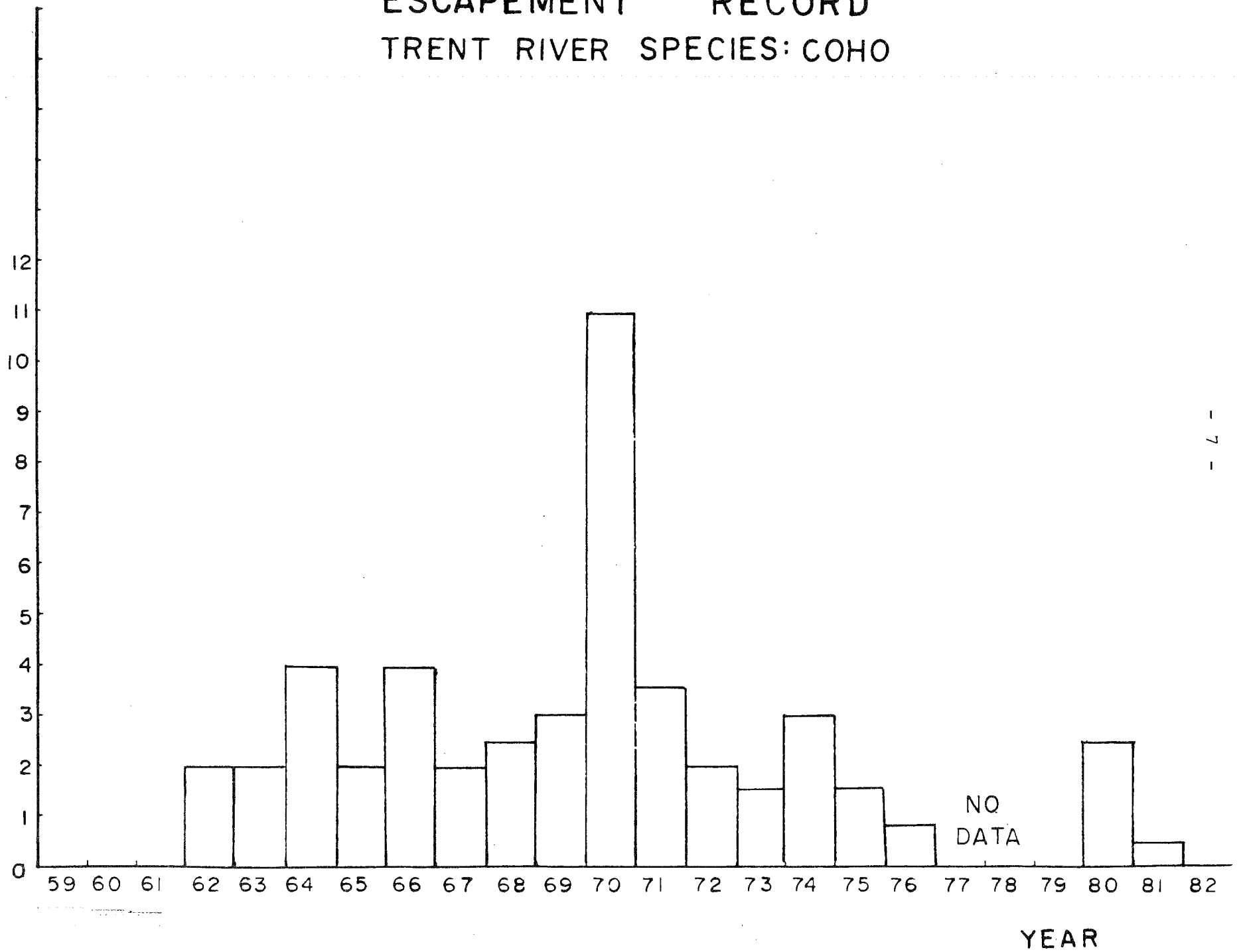


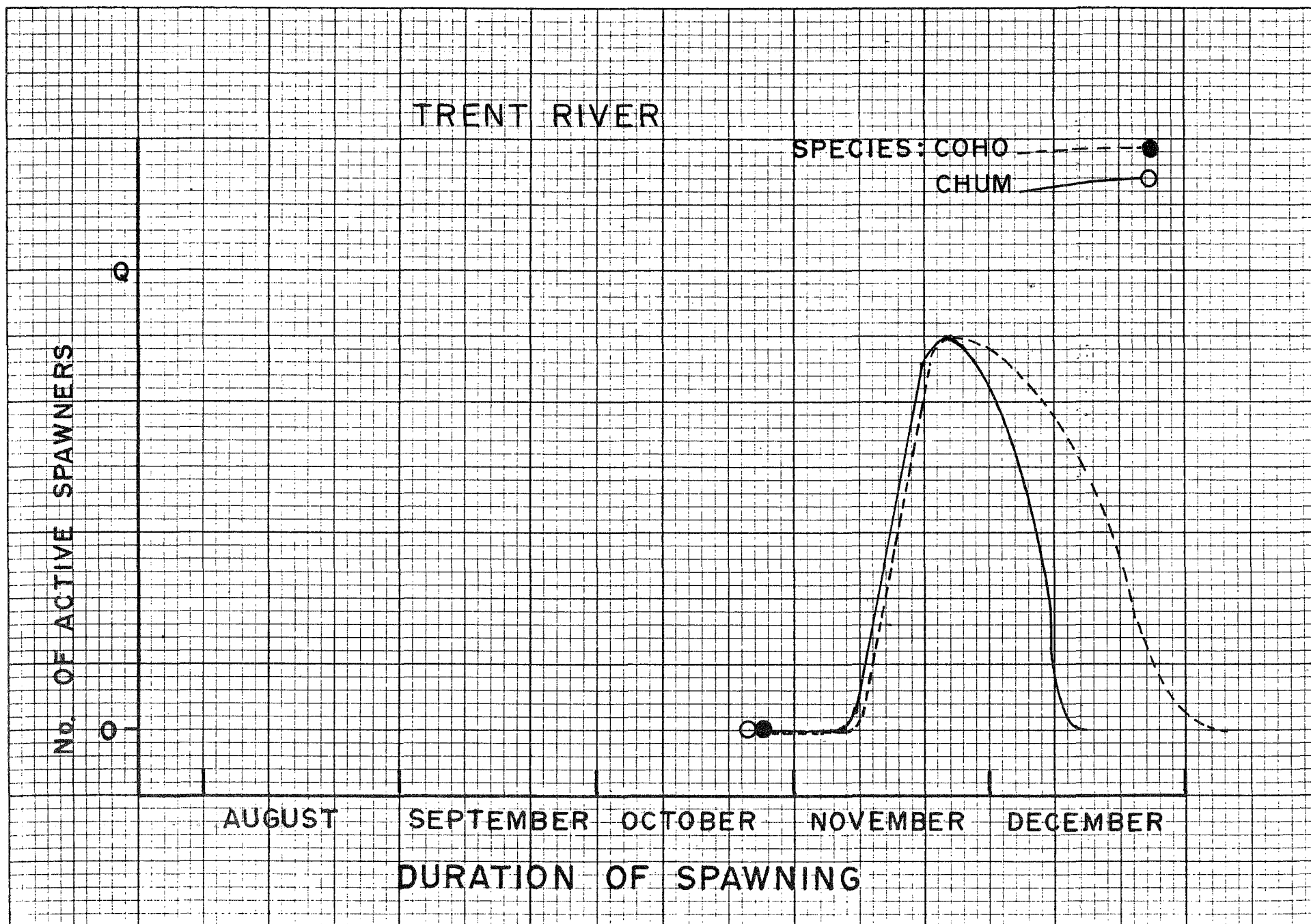
YEAR

ESCAPEMENT RECORD

TRENT RIVER SPECIES: COHO

NO. OF SPAWNERS (HUNDREDS)





125° 35'



COMOX
HARBOUR
GARTLEY
POINT

ROYSTON

STATION
08HB044

CUMBERLAND

RIVER

IMPASSABLE
FALLS
BOUNDARY
RIVER

TRENT
CREEK

WATERSHED
TRENT

CREEK

IDLE

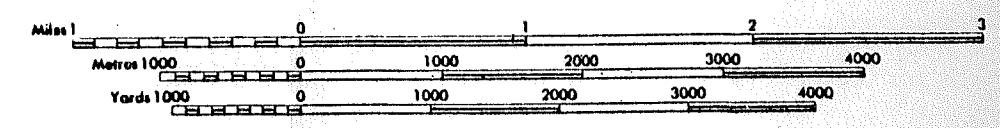
BLOEDEL

BRADLEY
LAKE

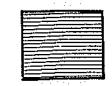
TREMAIN

FISHERIES Canada
TRENT RIVER WATERSHED

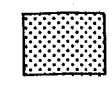
AREA = 72.0Km²



LEGEND



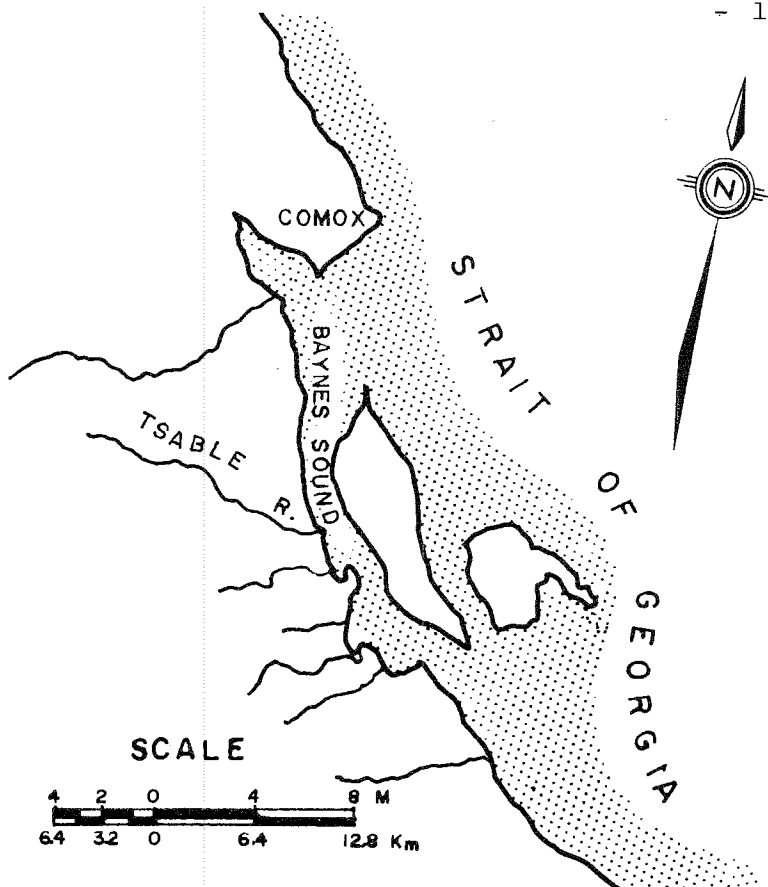
CHUM SPAWNING AREA (0 - 0.3 km)



COHO SPAWNING AREA (0 - 0.6 km)

BASE MAP NTS 92 F/11 FORBIDDEN PLATEAU
RAB No. 92 - 2900

49° 05'



Tsable River

General Description

This system supports a significant population of Chum, Coho and Pink salmon. Spawning ground is available throughout the lower reaches of the stream below a falls located 5 kilometers from tidewater. Migrating adult Coho use this entire section, whereas Chum spawn mainly in the lower two to three kilometers.

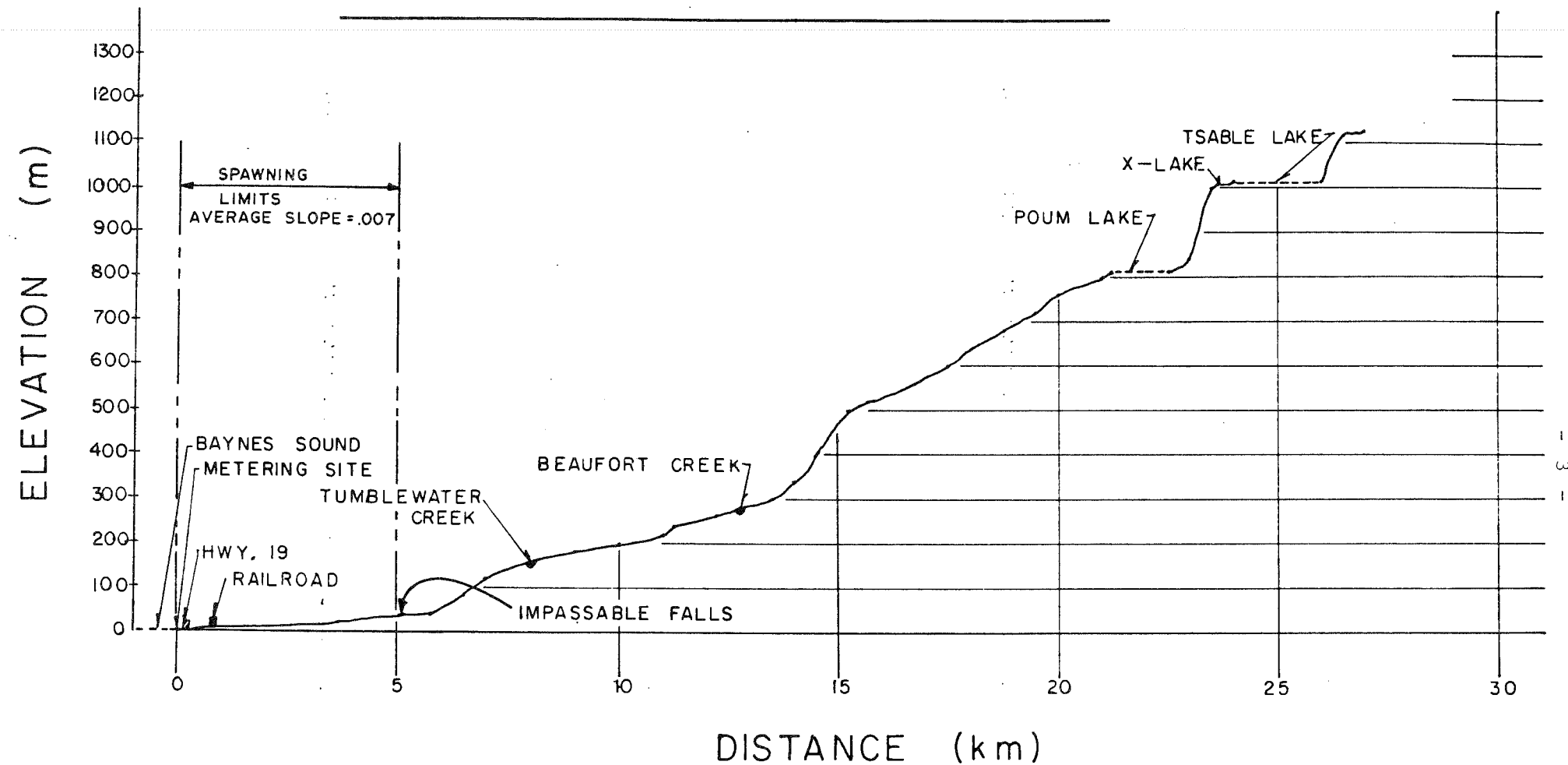
Fishery officer reports indicate that natural stream processes have sustained an adequate supply of gravel relatively free of siltation and scouring. Drought flow analysis suggests that discharges during summer and fall dry periods are moderately stable (variability 0.42), and for the period of record, the system generates adequate flow for the maintenance of instream fishery habitat (estimated optimum rearing flow $2.51 \text{ m}^3/\text{sec.}$, minimum monthly average daily flow $1.61 \text{ m}^3/\text{sec.}$).

Escapements for Coho and Chum have remained relatively stable for the past decade, reflecting the stability of the spawning and rearing environment.



View upstream of highway bridge.

TSABLE RIVER ELEVATION PROFILE



Watershed Data

Hydrometric Station # 08HB024 Tsable River

Watershed Area	(A)	107.2 km ²
Mean Elevation	(H)	1120 m
First Order Length	(L ₁)	36.0 km
All Orders	(L _T)	108.5 km
Average Precipitation	(AP)	2500 mm/year
Average Annual Flow	(QAA)	8.07 m ³ /sec

For The Period June 1 - Nov. 30:

Average Flow of Lowest Month (August)	1.61 m ³ /sec
7 Day Low Flow, 2 year recurrence (Q7L2)	0.38 m ³ /sec
7 Day Low Flow, 20 year recurrence (Q7L20)	0.16 m ³ /sec
Variability (Q7L20/Q7L2)	0.42
Yield (Q7L2/A)	0.0035 m ³ sec ⁻¹ /km ²

SUMMARY

Estimated Fishery Flow Requirements

A. Spawning Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Coho)	No data
Collings Method	
Preferred Flow (All Species)	6.52
Sustained Flow (All Species)	5.17
Actual Average Flow At Peak Spawning Time	
Chum	8.23
Coho	9.85
Pink	9.85

B. Rearing Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Based on Surface Width)	No data
Collings Method	
Optimum Flow (All Species)	2.51
Average Flow of Lowest Month (Jan. 1-Dec. 31)	1.61
Average Flow of Lowest Month (June 1-Nov. 30)	1.61

Historical Streamflow Data

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TSABLE RIVER NEAR FANNY BAY - STATION NO. 08HB024

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1960	---	---	---	---	---	---	---	0.801	0.890	10.9	14.0	17.6	---
1961	29.2	17.4	11.7	10.6	13.4	7.62	2.47	0.474	1.14	5.65	9.33	12.0	10.0
1962	8.95	8.34	2.78	10.9	8.04	6.91	1.80	3.43	3.25	11.9	17.8	24.0	9.01
1963	7.19	18.8	8.56	7.50	8.36	3.81	2.60	0.473	0.453	17.9	14.4	15.0	8.69
1964	9.63	6.23	4.87	5.97	8.10	11.1	5.90	1.25	2.29	4.15	8.96	7.66	6.33
1965	6.44	8.91	4.62	8.32	6.42	4.15	1.26	0.713	0.384	11.8	17.9	15.5	7.18
1966	15.0	7.28	10.5	8.18	8.55	10.2	5.71	1.22	1.56	8.99	14.6	23.5	9.63
1967	15.0	7.58	8.28	3.49	11.8	10.7	2.57	0.468	0.472	21.1	7.82	15.0	8.73
1968	23.4	11.7	10.9	4.21	9.57	6.42	2.84	1.68	1.75	20.9	18.8	11.0	10.3
1969	3.65	8.20	7.27	12.3	19.7	13.4	3.33	1.75	6.75	5.65	15.3	12.5	9.13
1970	5.03	7.78	6.56	8.16	7.14	6.03	2.03	0.734	0.958	4.63	6.58	7.37	5.23
1971	10.0	9.31	4.92	8.08	16.2	13.2	6.58	2.70	2.56	5.19	17.4	2.49	8.19
1972	2.93	7.00	16.5	9.86	13.4	9.47	5.39	1.10	3.03	0.711	8.16	15.7	7.77
1973	16.3	6.45	5.50	4.32	11.7	7.04	2.97	0.717	0.874	6.37	7.00	19.7	7.44
1974	17.6	8.76	14.7	8.78	10.2	13.2	8.39	2.88	1.16	0.673	12.6	13.7	9.40
1975	4.30	2.58	4.28	4.73	12.0	8.41	2.83	3.61	1.03	13.9	31.4	17.5	8.91
1976	7.60	4.74	4.45	6.29	10.8	8.55	6.83	2.73	1.33	2.79	5.74	5.60	5.63
1977	---	---	---	8.77	5.95	5.33	1.10	0.497	2.27	11.6	11.8	---	---
1978	9.08	10.1	11.6	5.97	6.21	5.33	1.47	4.30	6.66	2.27	6.76	2.90	6.02
1979	2.35	11.5	9.95	5.23	9.81	3.95	2.81	0.607	6.80	9.02	5.35	24.9	7.69
MEAN	10.8	9.04	8.22	7.46	10.4	8.15	3.63	1.61	2.28	8.80	12.6	13.8	8.07

LOCATION - LAT 49 31 03 N LONG 124 50 30 W DRAINAGE AREA, 113 km². NATURAL FLOW

TSABLE RIVER NEAR FANNY BAY - STATION NO. 08HB024

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m ³ /s)	MAXIMUM DAILY DISCHARGE (m ³ /s)	MINIMUM DAILY DISCHARGE (m ³ /s)	TOTAL DISCHARGE (dam ³)
1960	---	229 E ON DEC 12	0.340 ON SEP 14	---
1961	---	229 E ON JAN 11	0.241 ON AUG 29	317 000
1962	---	118 ON NOV 24	0.354 ON SEP 17	284 000
1963	---	159 ON OCT 21	0.241 ON SEP 4	274 000
1964	---	92.3 ON NOV 30	0.283 ON SEP 13	200 000
1965	---	62.9 ON NOV 18	0.340 ON SEP 26	226 000
1966	---	96.3 E ON NOV 28	0.524 ON SEP 8	304 000
1967	---	98.5 ON DEC 10	0.159 ON SEP 19	275 000
1968	---	227 E ON OCT 29	0.181 ON AUG 18	325 000
1969	---	66.5 ON NOV 22	0.549 ON SEP 12	288 000
1970	---	62.9 ON APR 9	0.218 ON SEP 16	165 000
1971	---	105 ON NOV 9	0.762 ON SEP 25	258 000
1972	---	109 ON APR 5	0.269 ON AUG 31	246 000
1973	---	135 ON JAN 15	0.249 ON SEP 19	235 000
1974	---	261 E ON JAN 15 *	0.294 ON OCT 25	296 000
1975	---	198 E ON NOV 13	0.128 ON SEP 27	281 000
1976	---	38.5 ON OCT 31	0.357 ON OCT 23	178 000
1977	---	106 ON OCT 28	0.139 ON AUG 20 *	---
1978	---	106 ON MAR 7	0.303 ON AUG 11	190 000
1979	---	198 E ON DEC 17	0.351 ON AUG 16	242 000

E - ESTIMATED

* - EXTREME RECORDED FOR THE PERIOD OF RECORD

255 000

After; Historical Streamflow Summary, British Columbia to 1979.

Inland Waters Directorate
Water Resources Branch
Water Survey of Canada
Ottawa, Canada, 1980

STREAM : TSABLE RIVER NEAR FANNY BAY Station #08HB024

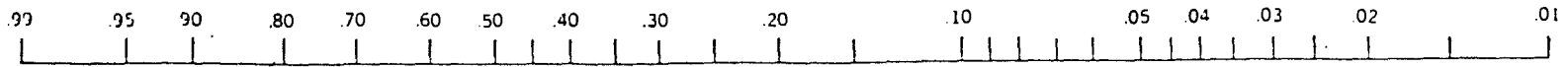
REMARKS :

Year	Date	Min Av	Rank (M)	Recurrence (T)	Year	Date
		M ³ /SEC		Years		
1979	Aug 10	0.412	1) 0.193	20.0	1967	Sep 23
1978	Aug 5	0.360	2) 0.206	10.0	1977	Aug 16
1977	Aug 16	0.206	3) 0.247	6.67	1970	Sep 11
1976	Oct 17	0.408	4) 0.249	5.00	1961	Aug 24
1975	Sep 24	0.372	5) 0.253	4.00	1963	Sep 4
1974	Oct 20	0.346	6) 0.273	3.33	1973	Sep 13
1973	Sep 13	0.273	7) 0.316	2.86	1972	Aug 31
1972	Aug 31	0.316	8) 0.345	2.50	1965	Sep 25
1971	Sep 22	0.866	9) 0.346	2.22	1974	Oct 20
1970	Sep 11	0.247	10) 0.356	2.00	1964	Sep 9
1969	Sep 6	0.781	11) 0.360	1.82	1978	Aug 5
1968	Aug 7	0.432	12) 0.370	1.67	1962	Sep 20
1967	Sep 23	0.193	13) 0.372	1.54	1975	Sep 24
1966	Sep 2	0.578	14) 0.408	1.43	1976	Oct 17
1965	Sep 25	0.345	15) 0.412	1.33	1979	Aug 10
1964	Sep 9	0.356	16) 0.432	1.25	1968	Aug 7
1963	Sep 4	0.253	17) 0.578	1.18	1966	Sep 2
1962	Sep 20	0.370	18) 0.781	1.11	1969	Sep 6
1961	Aug 24	0.249	19) 0.866	1.05	1971	Sep 22

$$\text{Recurrence Period (T)} = \frac{\text{Total No. of Years} + 1}{\text{Rank (M)}}$$

TSAGLE RIVER NEAR FANNY BAY STATION # 08HB024

PROBABILITY

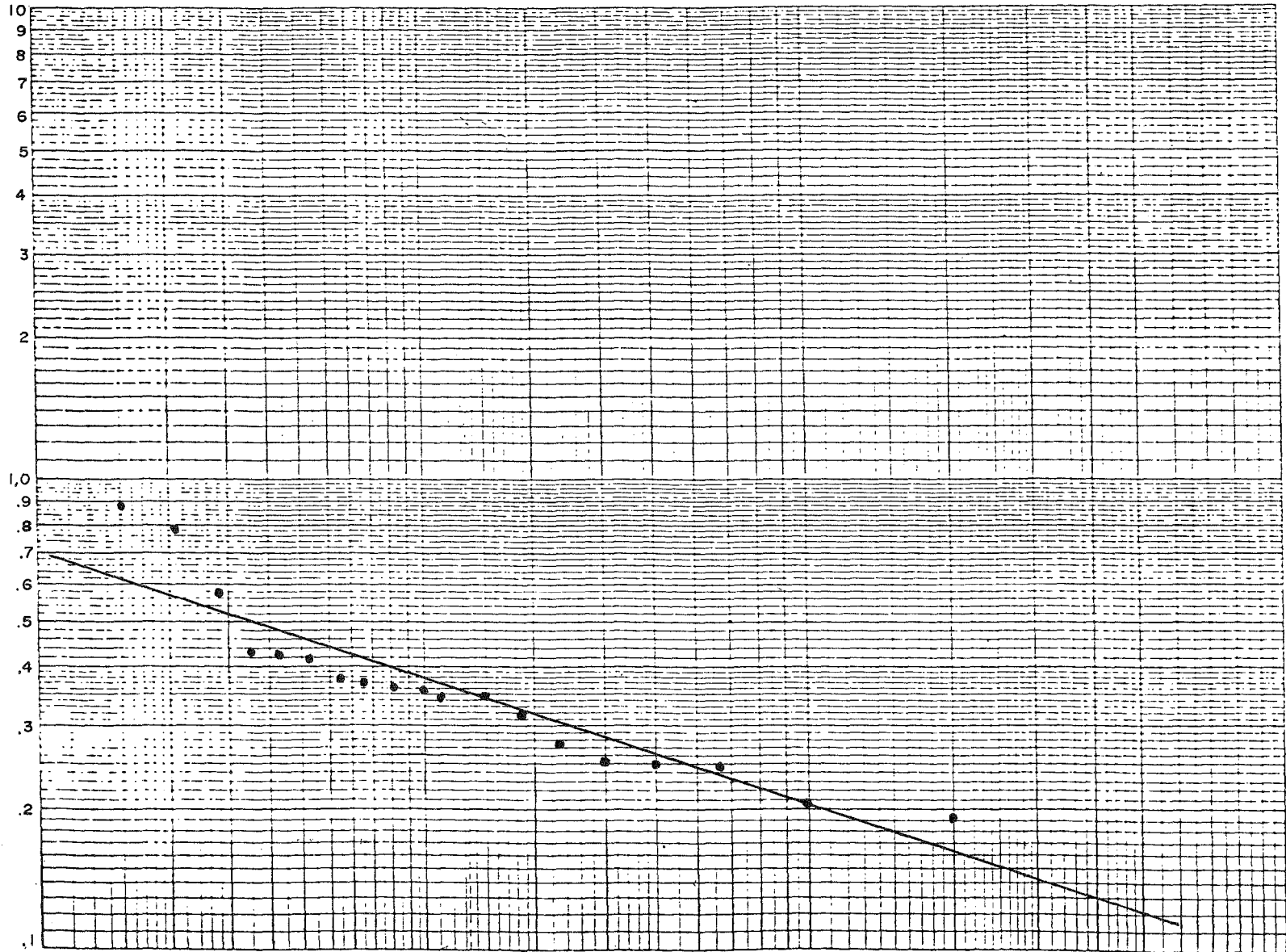


Lowest 7 Day Summer & Fall Flows (June 1 - Nov. 30)

RECURRENCE INTERVAL IN YEARS



M^3/SEC

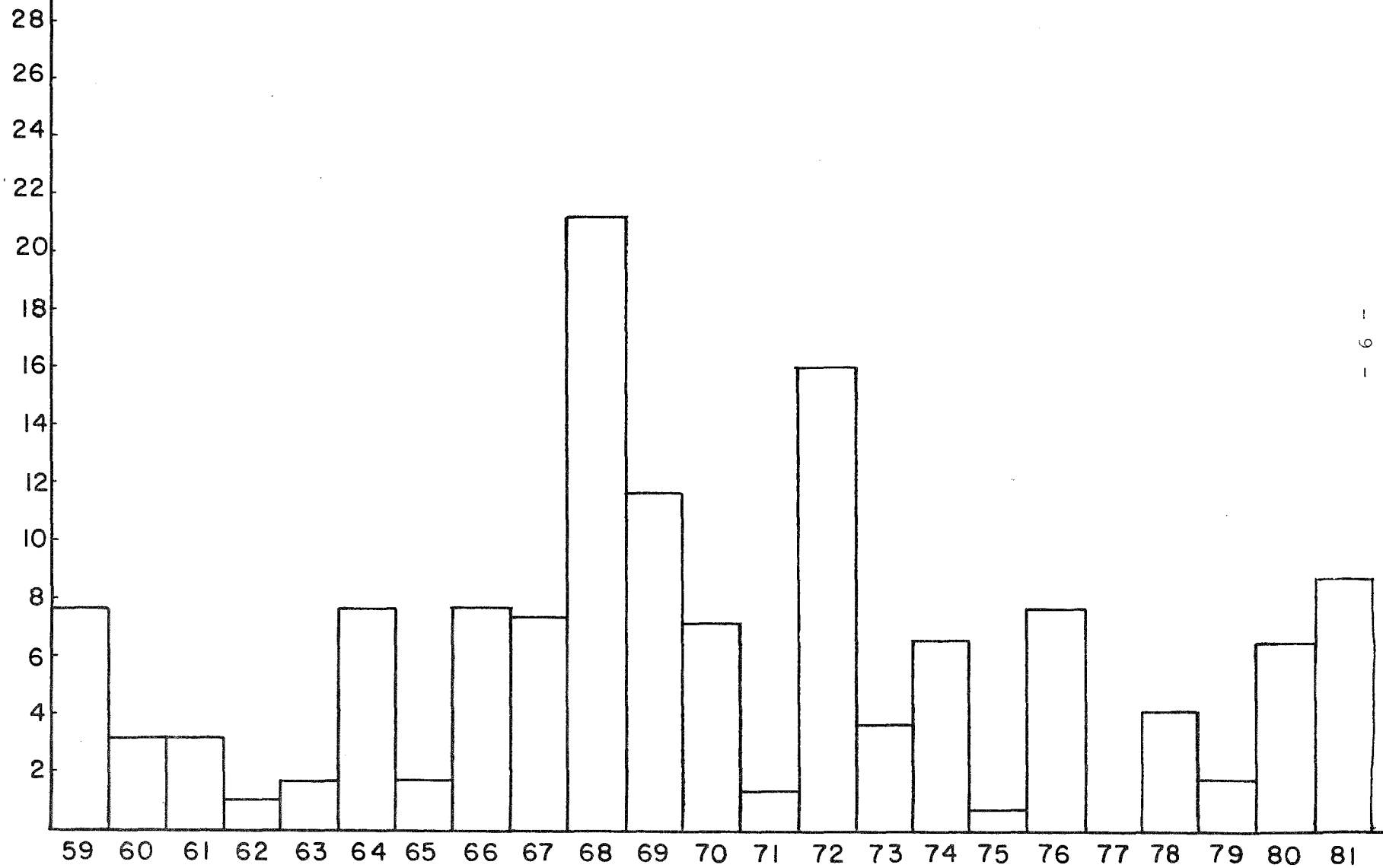


ESCAPEMENT RECORD

TSABLE RIVER

SPECIES: CHUM

NO. OF SPAWNERS (THOUSANDS)



YEAR

ESCAPEMENT RECORD

TSABLE RIVER

SPECIES: COHO

NO. OF SPAWNERS

600

500

400

300

200

100

59

60

61

62

63

64

65

66

67

68

69

70

71

72

73

74

75

76

77

78

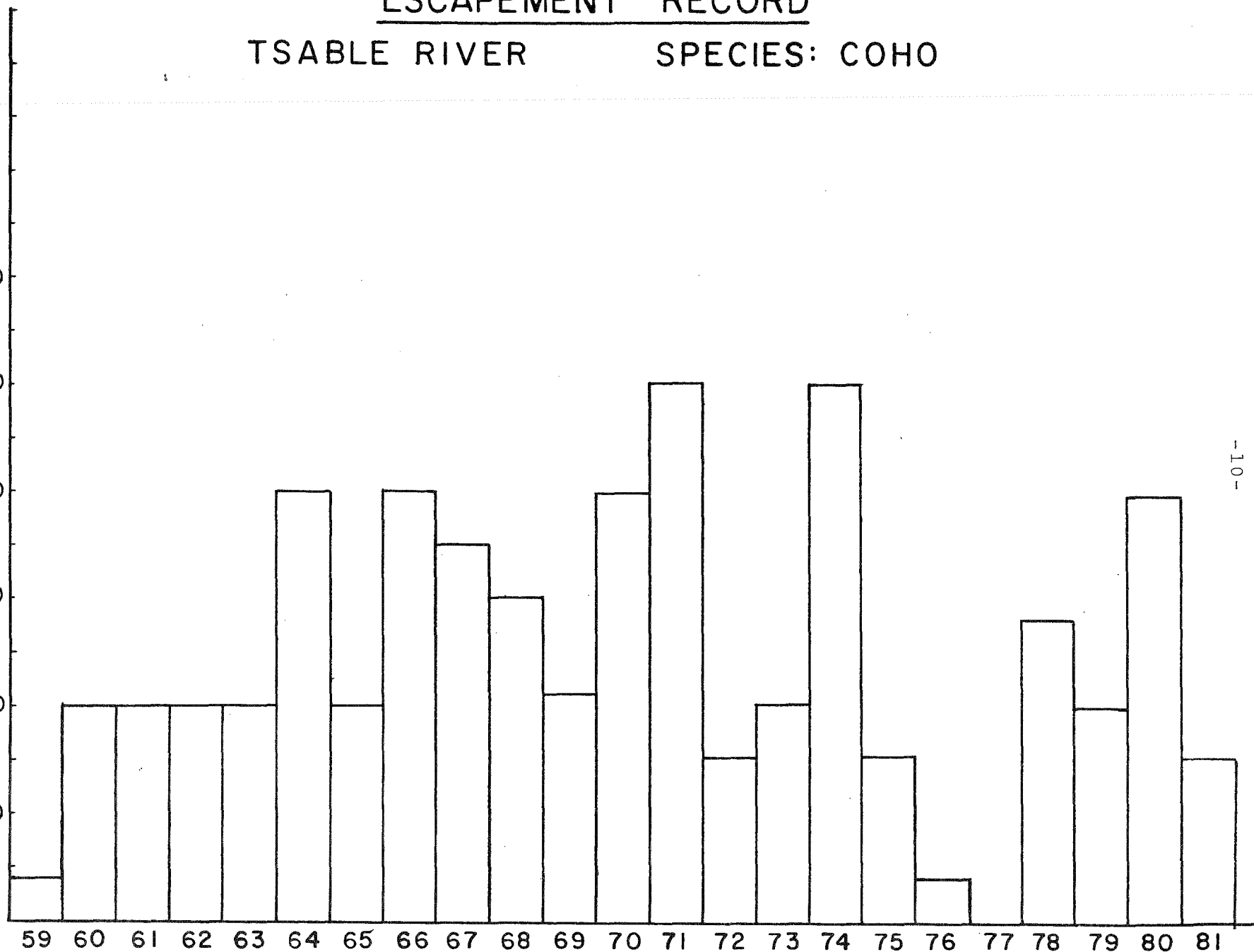
79

80

81

YEAR

-10-



ESCAPEMENT RECORD

TSABLE RIVER

SPECIES: PINK

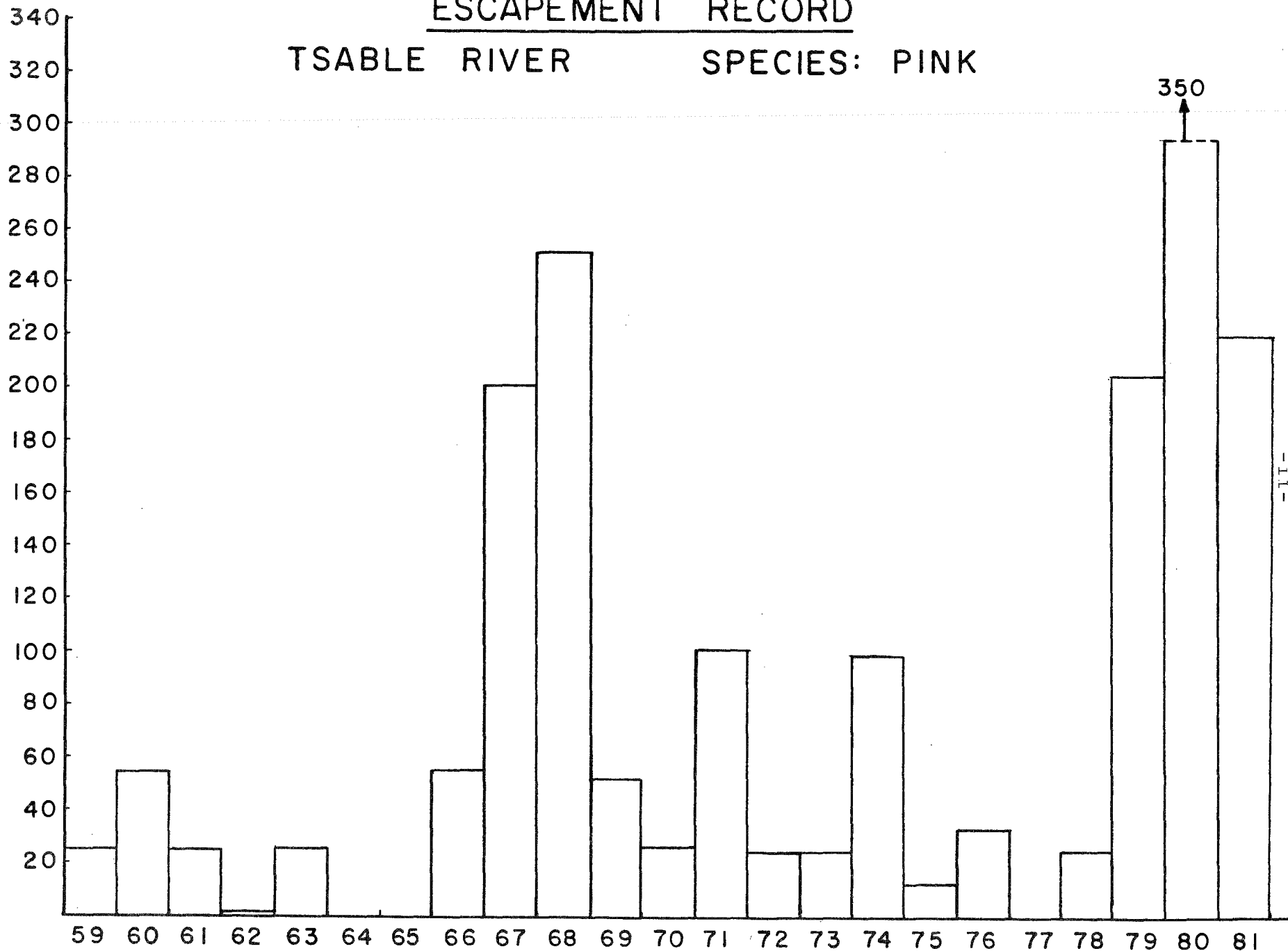
NO. OF SPAWNERS

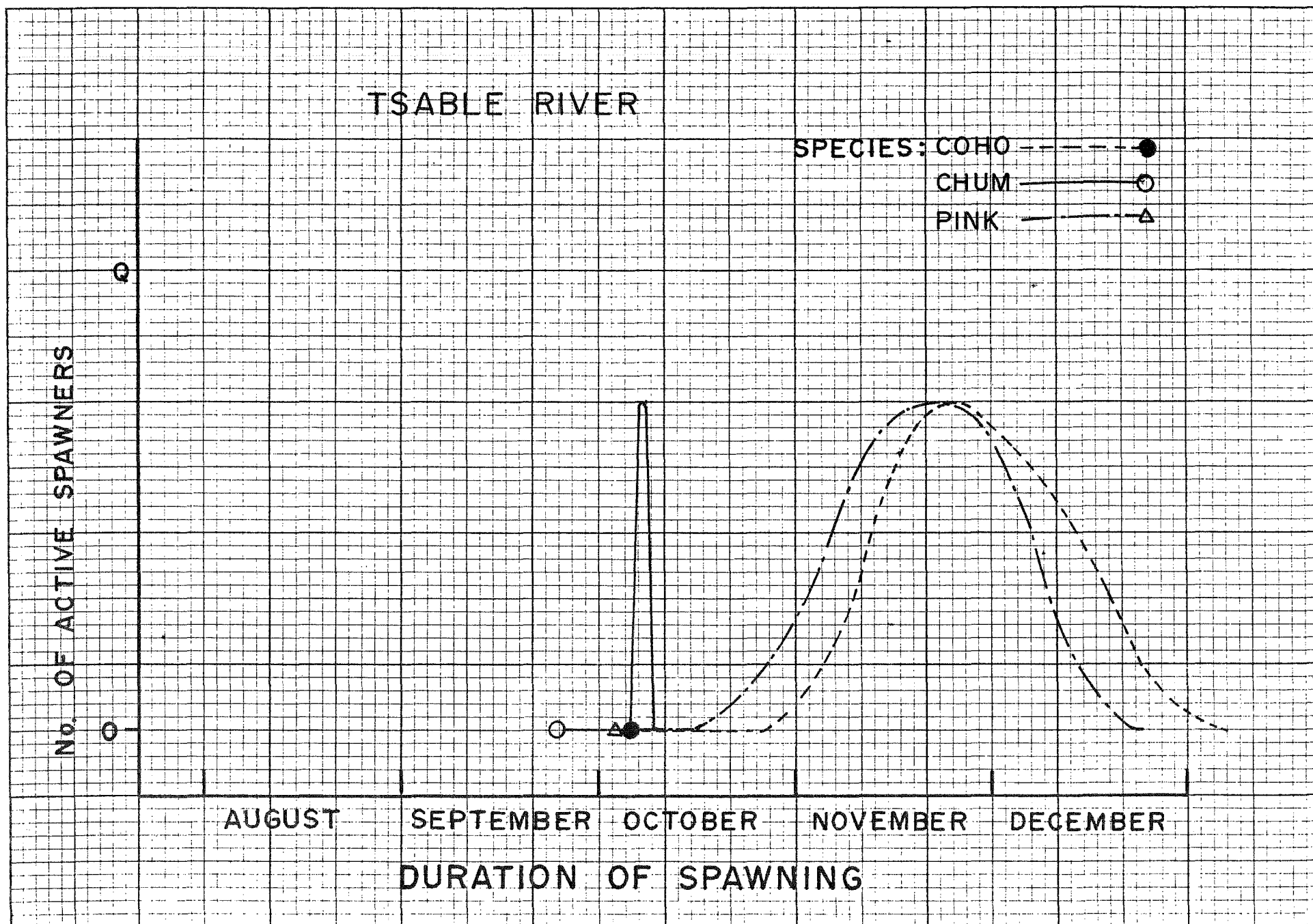
350

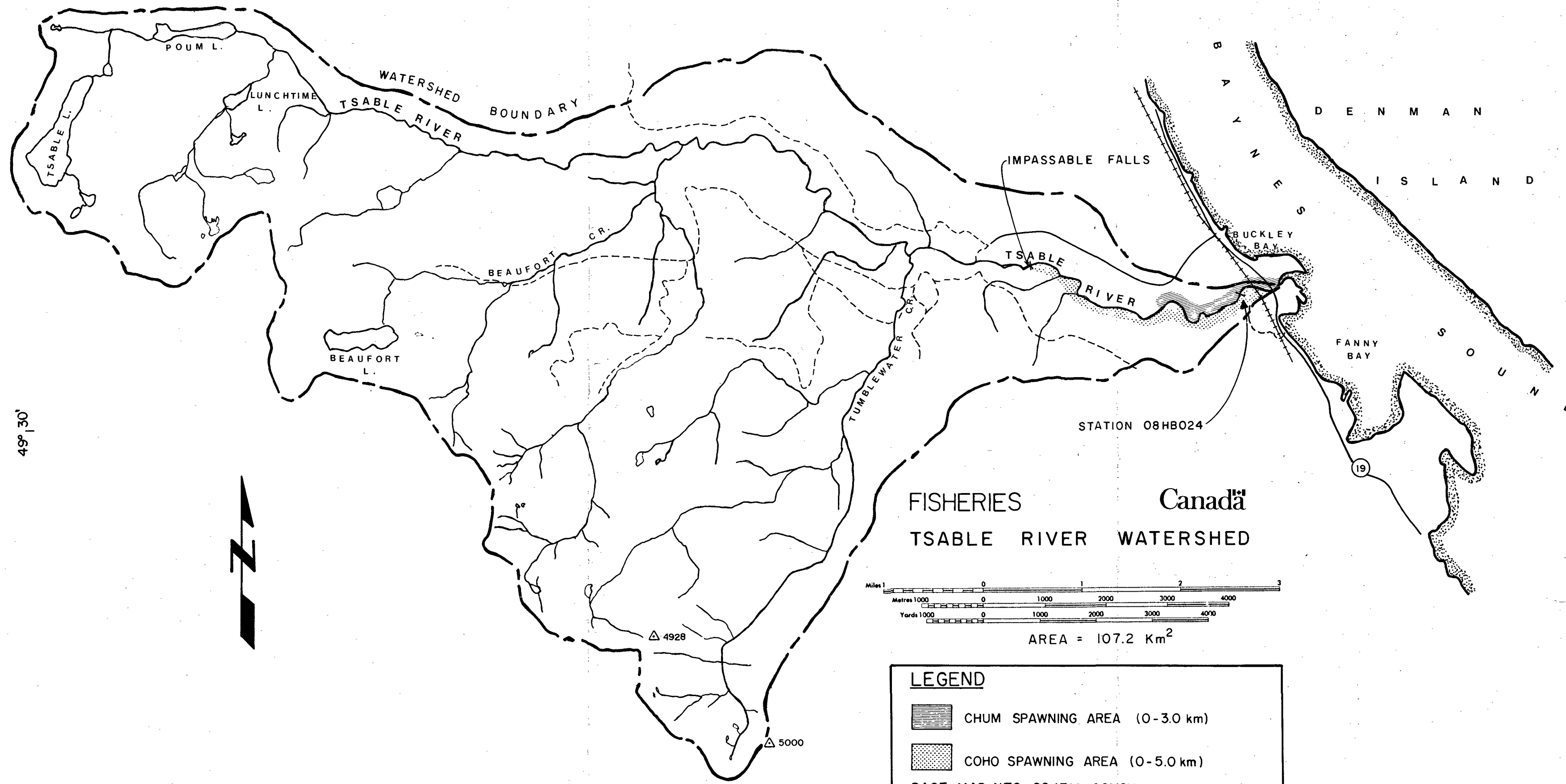
-11-

59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81

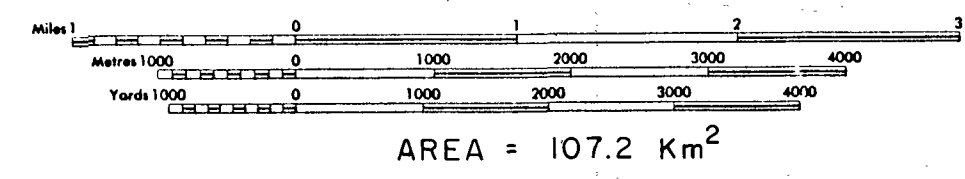
YEAR







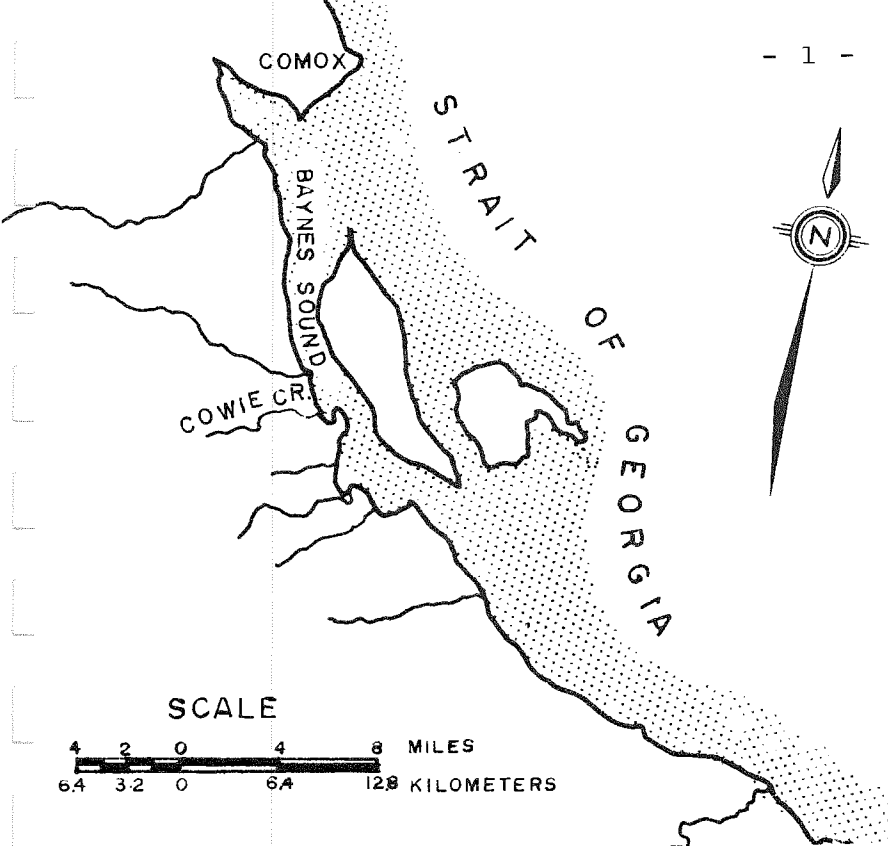
FISHERIES
TSABLE RIVER WATERSHED



LEGEND

-  CHUM SPAWNING AREA (0-3.0 km)
-  COHO SPAWNING AREA (0-5.0 km)

BASE MAP NTS 92/FIO COMOX
RAB No. 92-3000

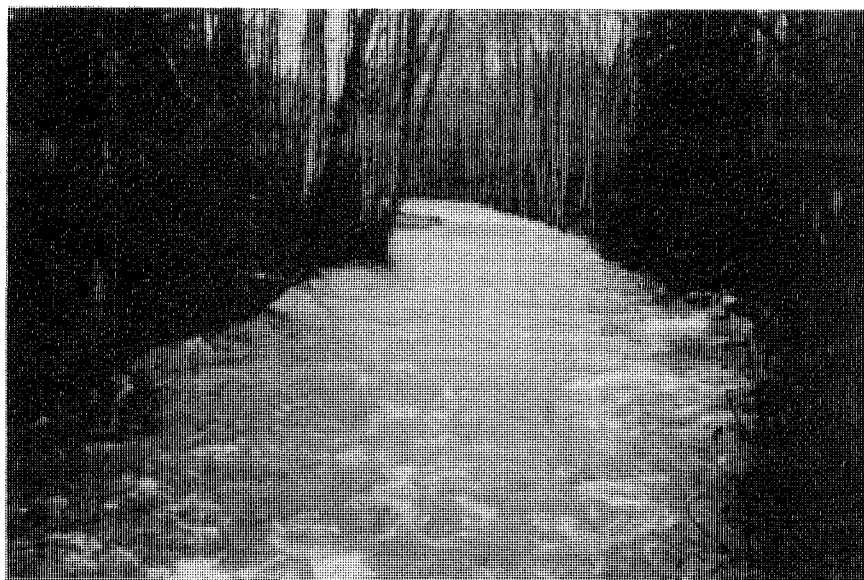


Cowie Creek (Cougar Creek)

General Description

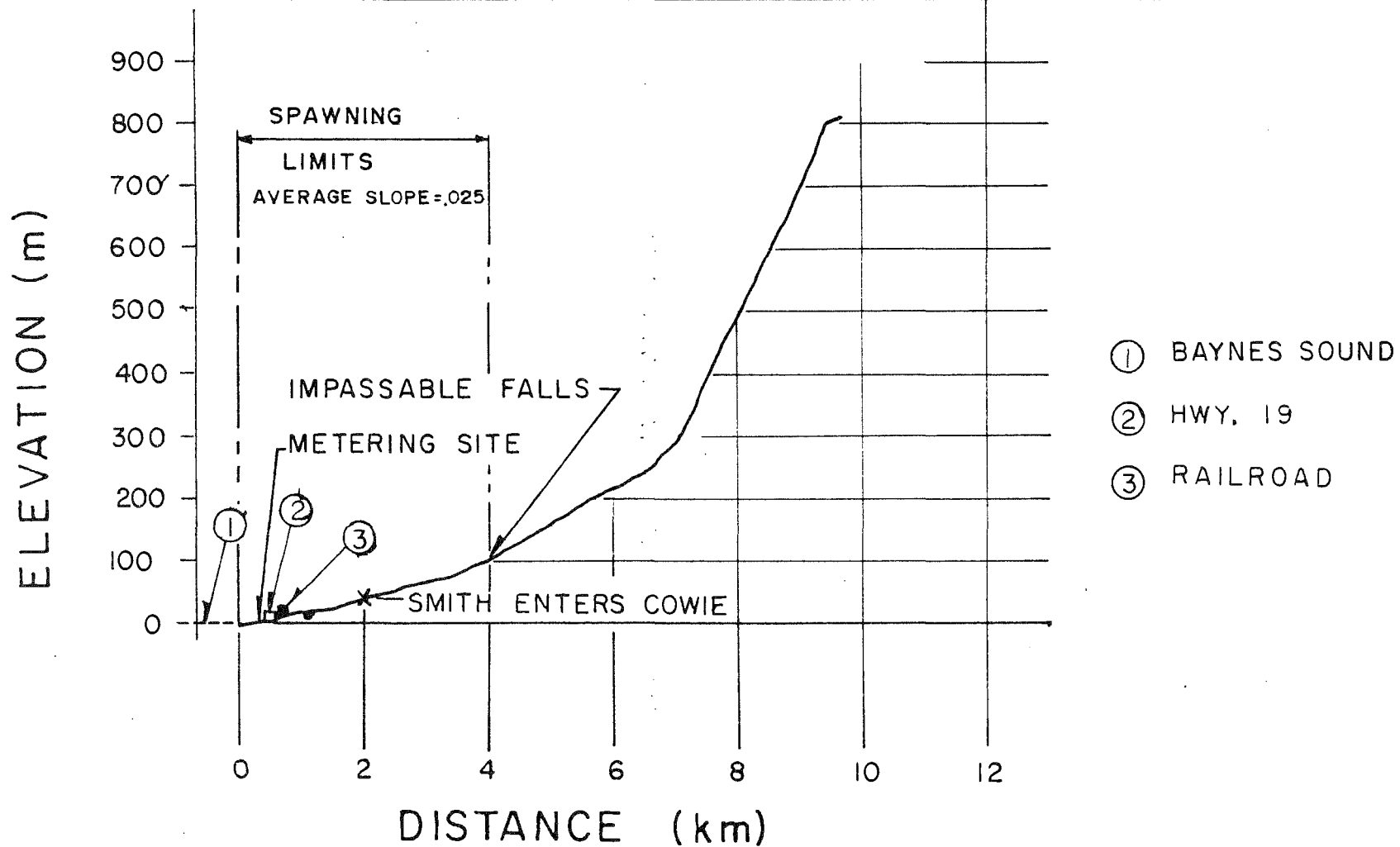
Cowie Creek is situated on the east coast of Vancouver Island and flows 4.8 kilometers north-east into Fanny Bay. Cougar-Smith, a tributary of Cowie, has a total accessible length of 1.6 kilometers, ending with impassable falls. Cowie Creek has two falls. The first is

a passable 1.5 meter drop situated below the forks, while the second, formed about 4 kilometers upstream, has a 10 meter drop and is impassable. Most of the area between the 2 falls is comprised of large boulders and coarse gravel. Coho are thinly distributed in the middle to upper reaches while the Chum are found below the Island Highway bridge. Escapement for both Chum and Coho has been variable over the past 20 years (see graphs).



View upstream of highway bridge.

COWIE CREEK ELEVATION PROFILE



Watershed Data

Hydrometric Station # Ungauged. Cowie Creek

Watershed Area	(A)	23.8 km ²
Mean Elevation	(H)	800 m
First Order Length	(L ₁)	4.3 km
All Orders	(L _T)	22.5 km
Average Precipitation	(AP)	2300 mm/year
Average Annual Flow	(QAA)	Not Available

For The Period June 1 - Nov. 30:

Average Flow of Lowest Month	Not Available
7 Day Low Flow, 2 year recurrence (Q7L2)	0.086 m ³ /sec
7 Day Low Flow, 20 year recurrence (Q7L20)	0.030 m ³ /sec
Variability (Q7L20/Q7L2)	0.35
Yield (Q7L2/A)	0.0036 m ³ sec ⁻¹ /km ²

SUMMARY

Estimated Fishery Flow Requirements

A. Spawning Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Coho)	1.70
Collings Method	
Preferred Flow (All Species)	2.57
Sustained Flow (All Species)	1.99
Actual Average Flow At Peak Spawning Time	
Chum	No data
Coho	No data

B. Rearing Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Based on Surface Width)	1.70
Collings Method	
Optimum Flow (All Species)	0.67
Average Flow of Lowest Month (Jan. 1-Dec. 31)	No data
Average Flow of Lowest Month (June 1-Nov. 30)	No data

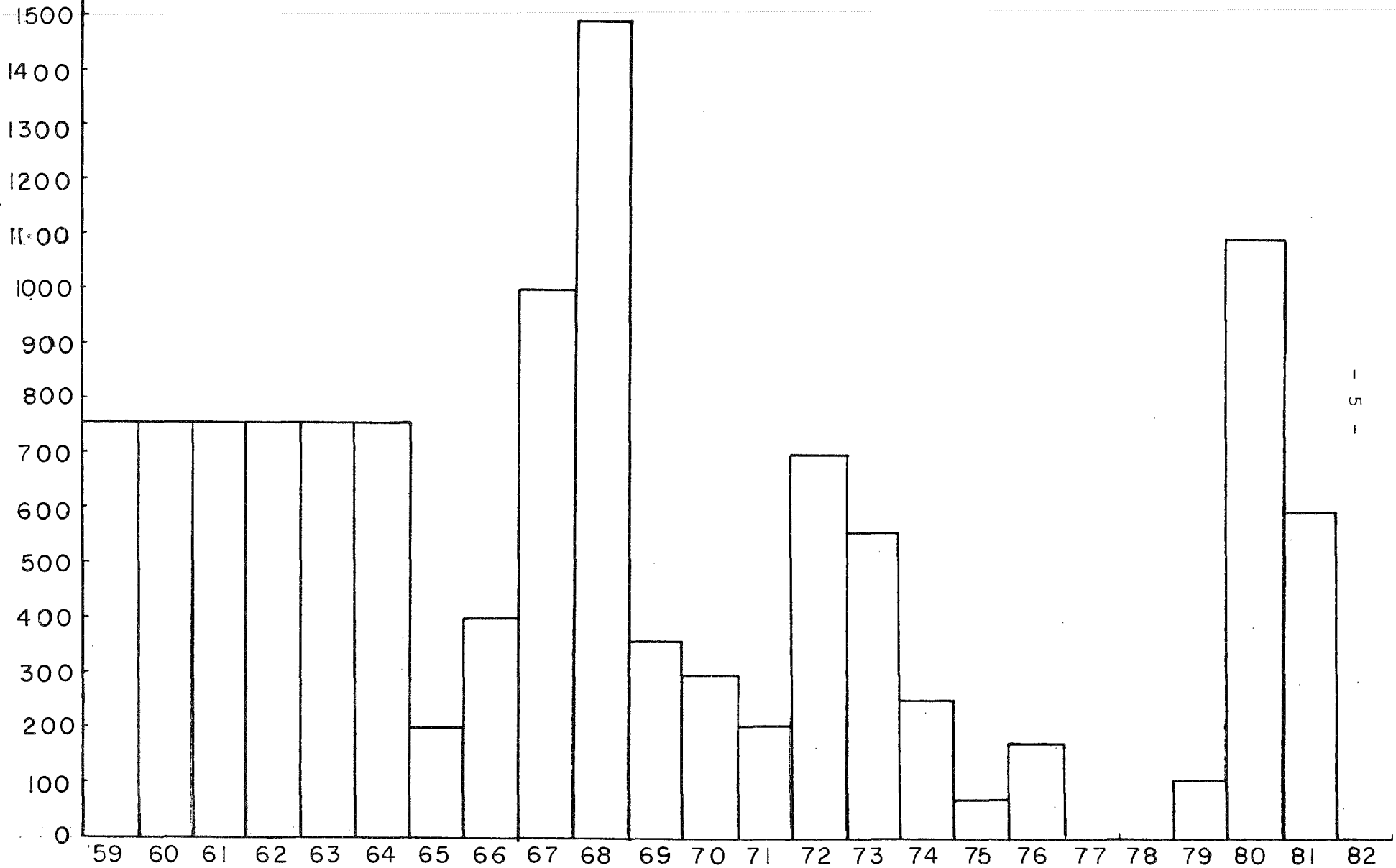
ESCAPEMENT RECORD

COUGAR CREEK

SPECIES:

CHUM

NO. OF SPAWNERS



YEAR

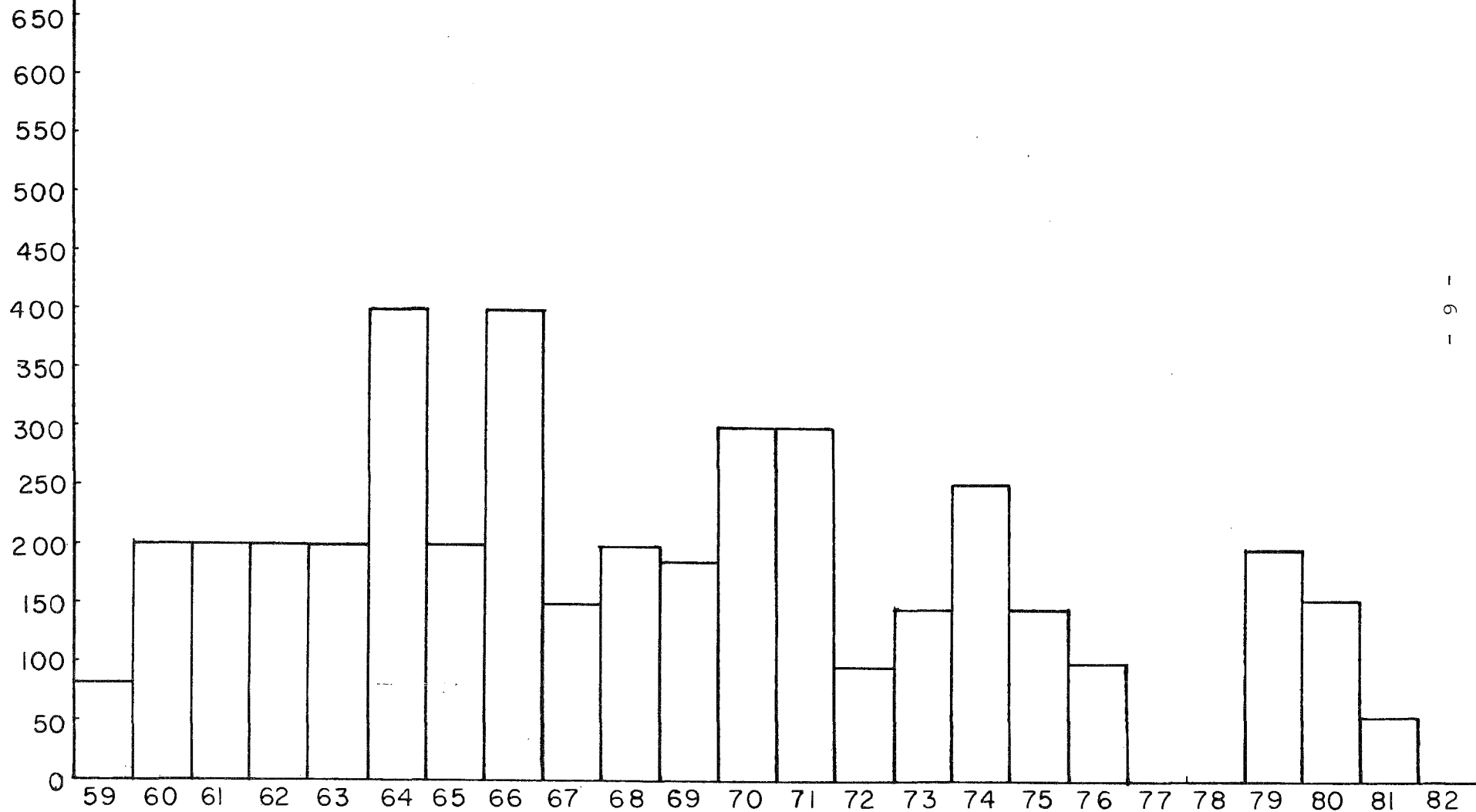
ESCAPEMENT RECORD

COUGAR CREEK

SPECIES:

COHO

NO. OF SPAWNERS



YEAR

ESCAPEMENT RECORD

COUGAR CREEK

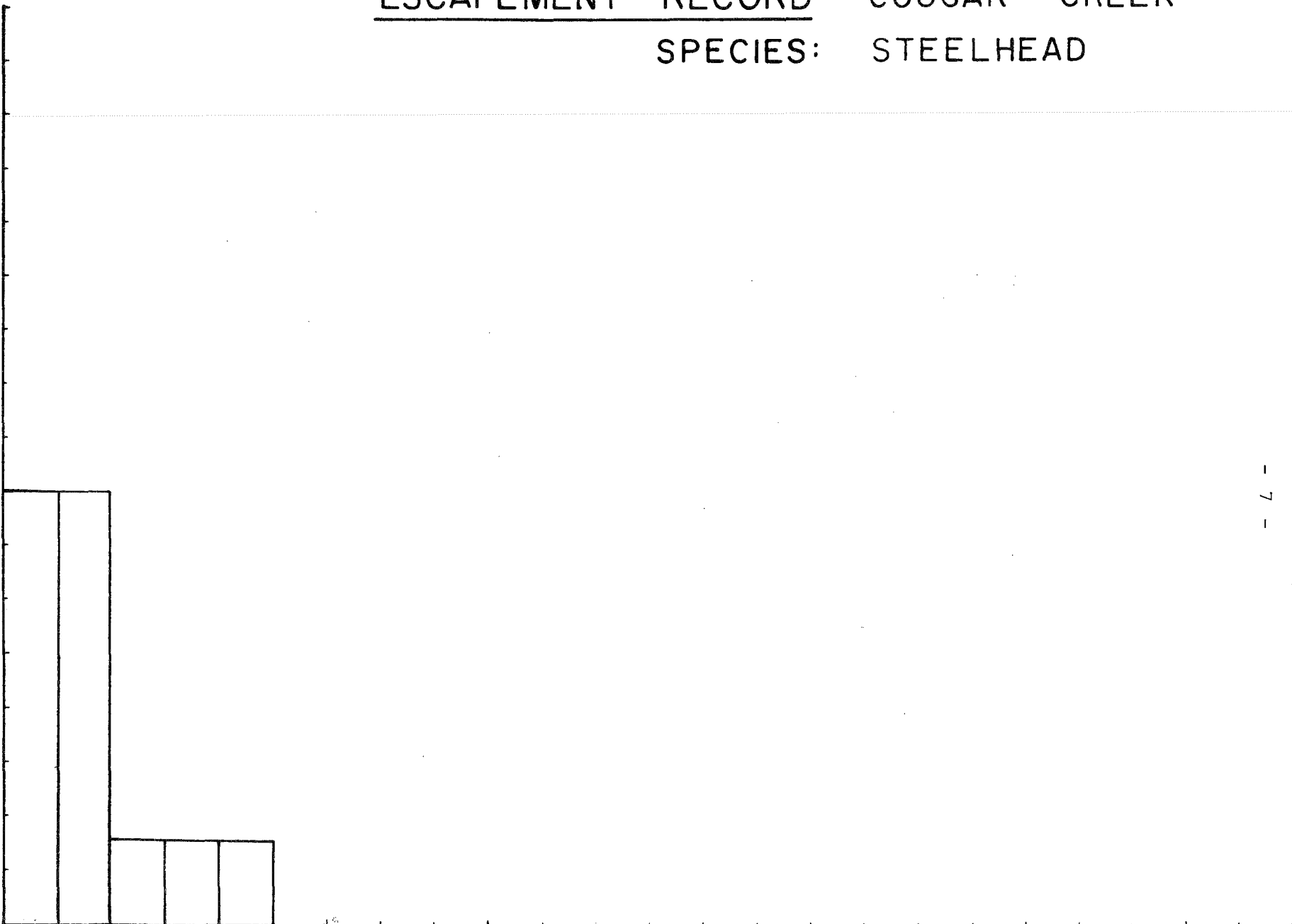
SPECIES: STEELHEAD

NO. OF SPAWNERS

500
450
400
350
300
250
200
150
100
50
0

59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82

YEAR



COWIE CREEK

SPECIES: COHO
CHUM

NO. OF ACTIVE SPAWNERS

Q

0

AUGUST

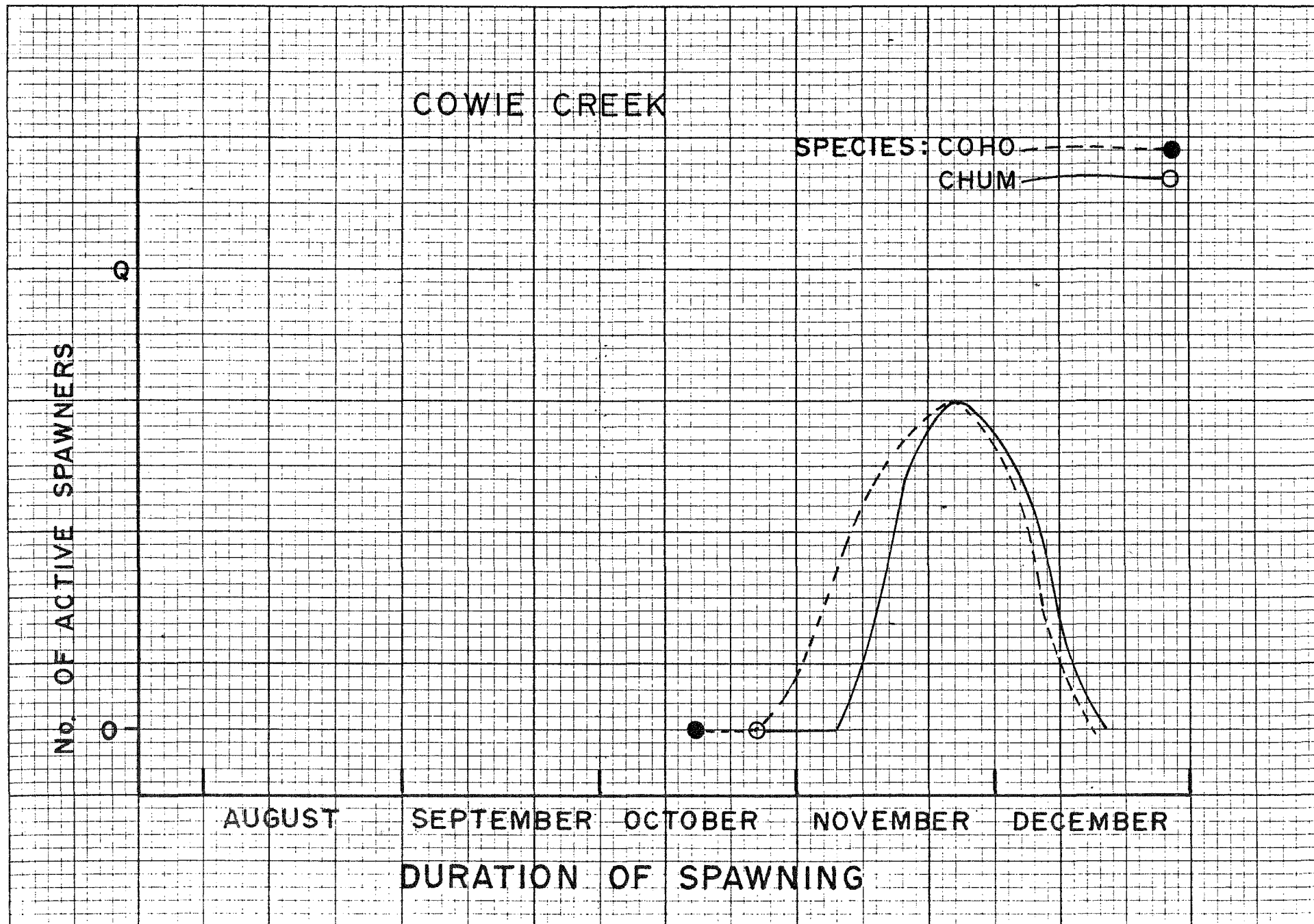
SEPTEMBER

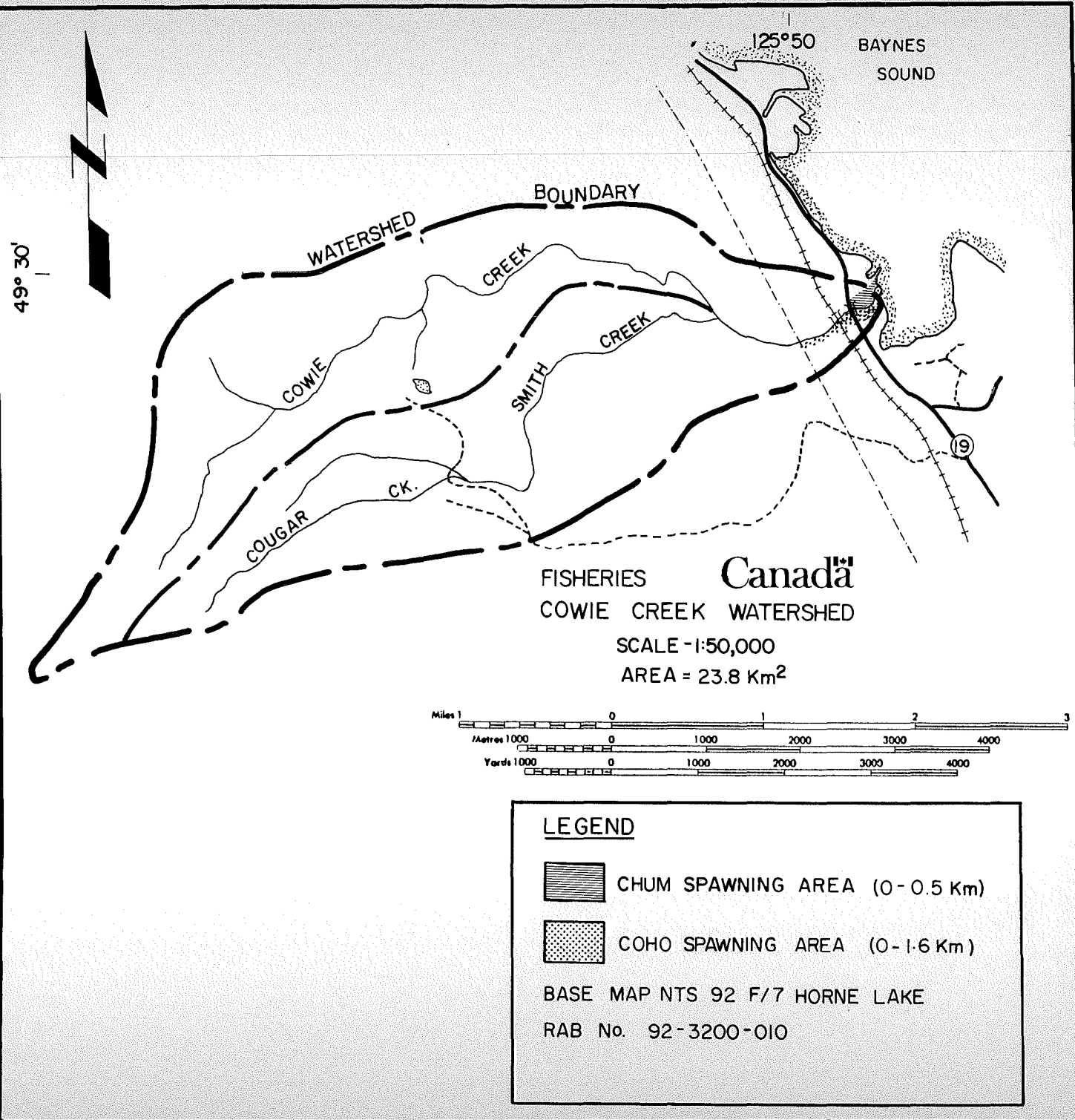
OCTOBER

NOVEMBER

DECEMBER

DURATION OF SPAWNING

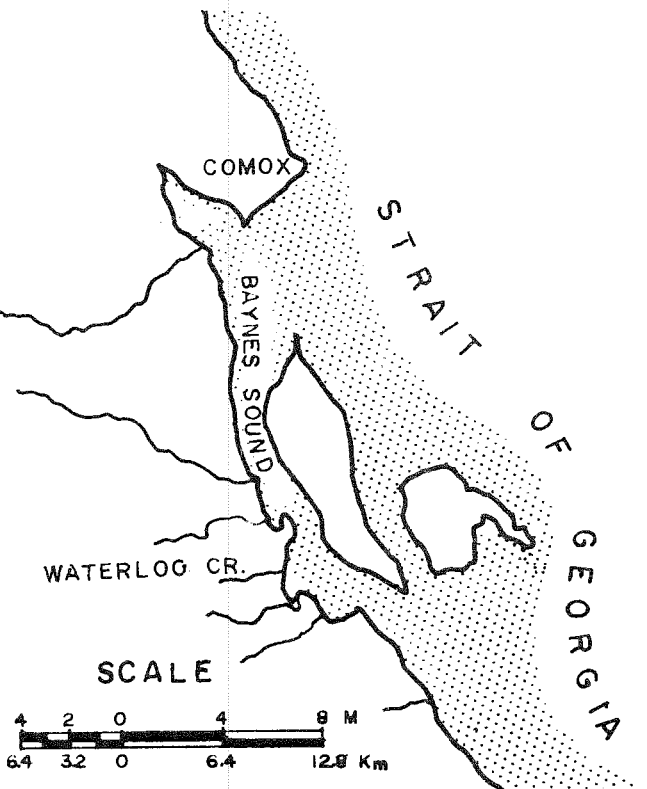




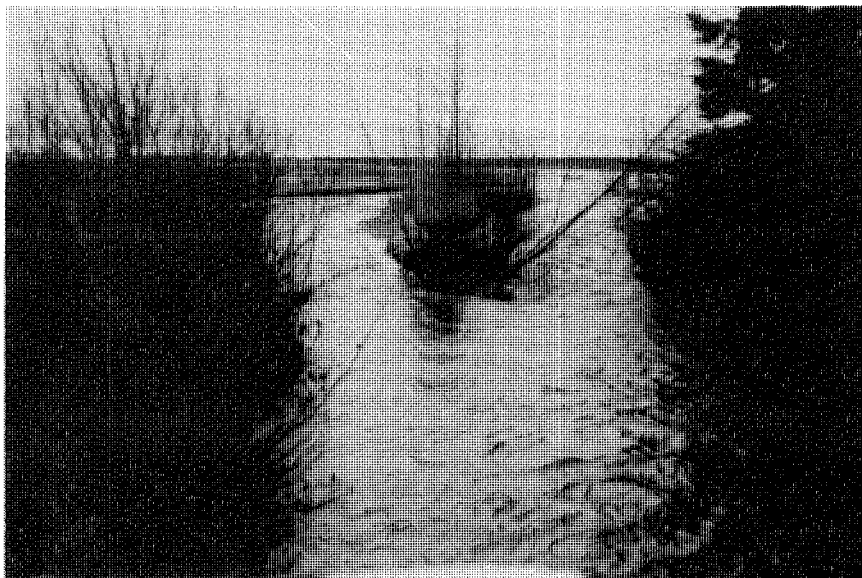
Waterloo Creek

General Description

Waterloo Creek flows east for 3.2 kilometers into Baynes Sound, north of Mud Bay. 75% of the streambed is made up of boulders with steep gradient. Coho spawn throughout the system while the Chums utilize the .8 kilometers below the railroad bridge.

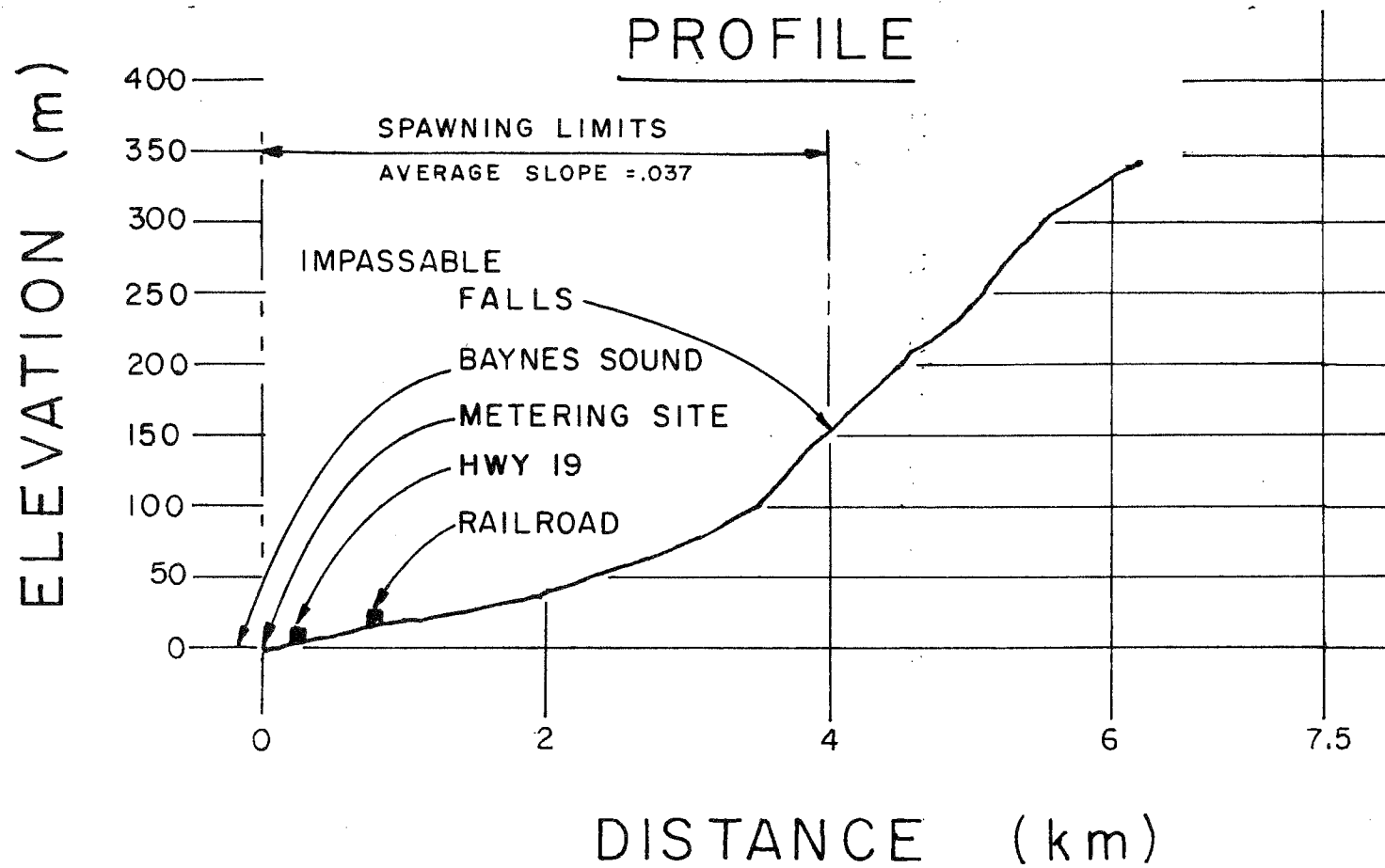


The mouth of the stream is usually dry from summer until late October. Logging in the upper reaches has produced an unstable watershed which results in a short severe flood period in mid-December. The extent of erosion is slight and there is some scouring at the lower end. Escapement of Chum and Coho has been variable in the past 20 years (see graphs)

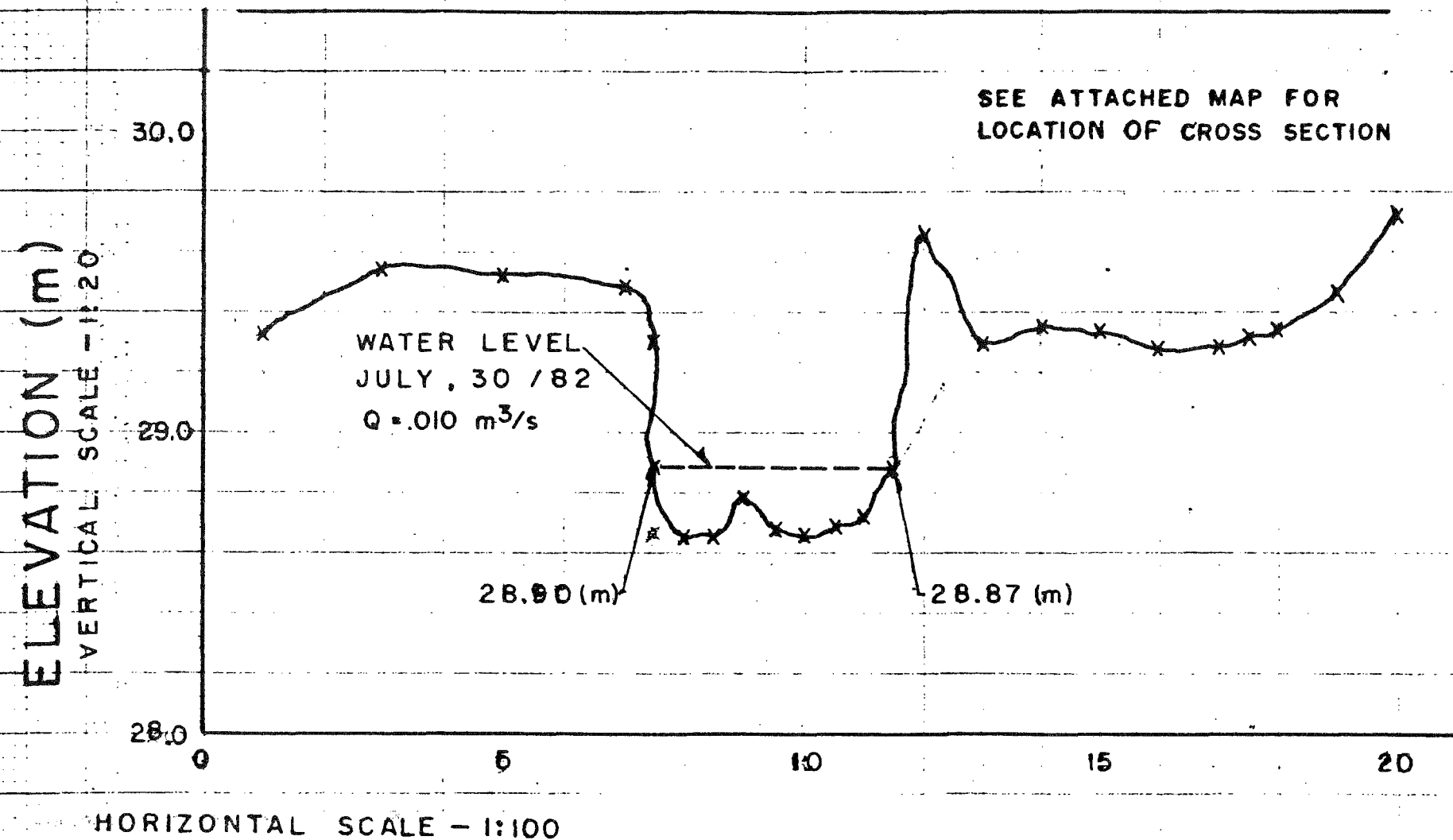


View downstream of highway bridge.

WATERLOO CREEK PROFILE



WATERLOO CREEK - CROSS SECTION



Watershed Data

Hydrometric Station # Ungauged. Waterloo Creek

Watershed Area	(A)	11.2 km ²
Mean Elevation	(H)	320 m
First Order Length	(L ₁)	4.8 km
All Orders	(L _T)	12.5 km
Average Precipitation	(AP)	2300 mm/year
Average Annual Flow	(QAA)	Not Available

For The Period June 1 - Nov. 30:

Average Flow of Lowest Month	Not Available
7 Day Low Flow, 2 year recurrence (Q7L2)	0.44 m ³ /sec
7 Day Low Flow, 20 year recurrence (Q7L20)	0.0082 m ³ /sec
Variability (Q7L20/Q7L2)	0.19
Yield (Q7L2/A)	0.0039 m ³ sec ⁻¹ /km ²

SUMMARY

Estimated Fishery Flow Requirements

A. Spawning Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Coho)	No data
Collings Method	
Preferred Flow (All Species)	0.78
Sustained Flow (All Species)	0.65
Actual Average Flow At Peak Spawning Time	
Chum	No data
Coho	No data

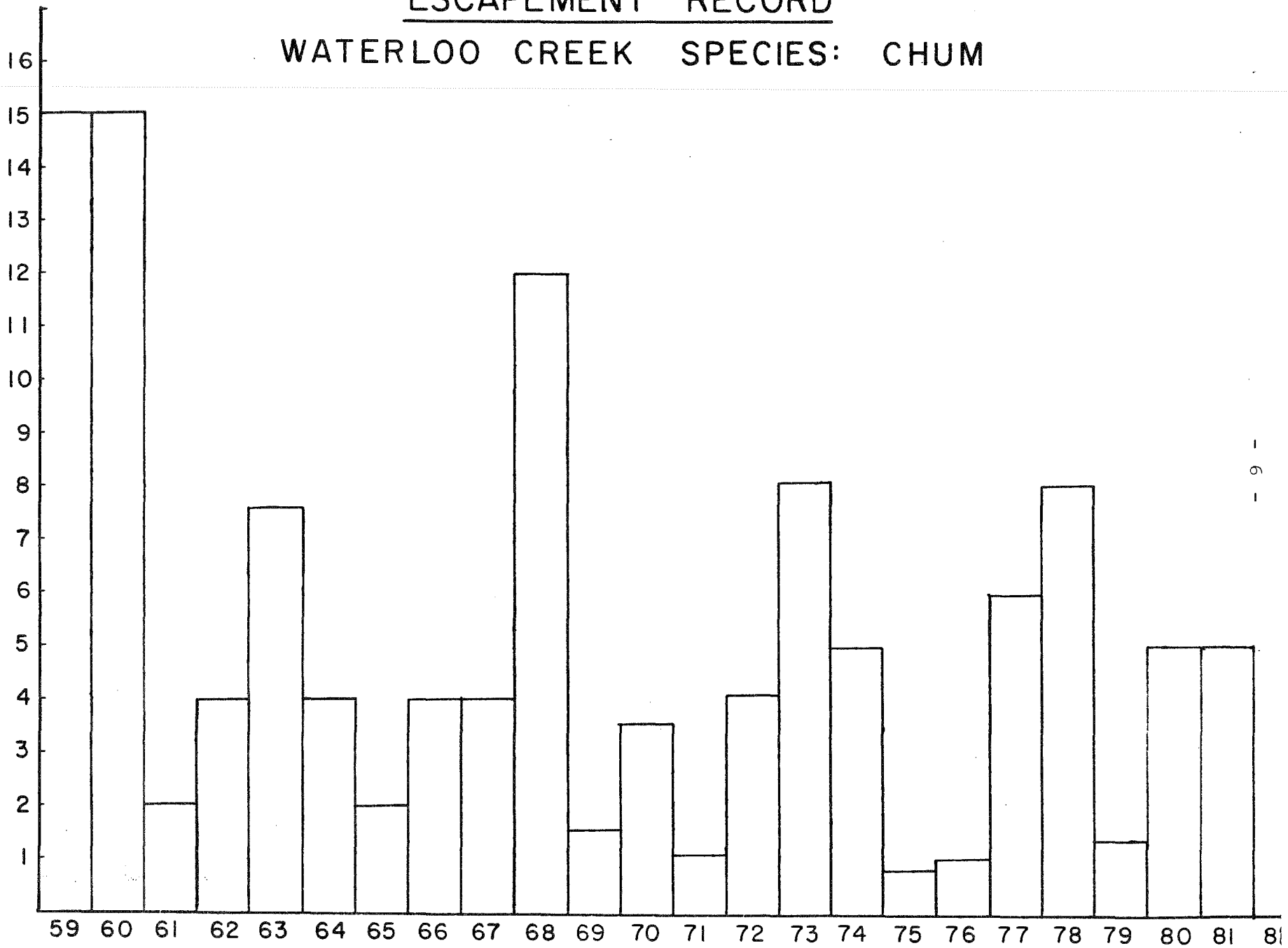
B. Rearing Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Based on Surface Width)	No data
Collings Method	
Optimum Flow (All Species)	0.38
Average Flow of Lowest Month (Jan. 1-Dec. 31)	No data
Average Flow of Lowest Month (June 1-Nov. 30)	No data

ESCAPEMENT RECORD

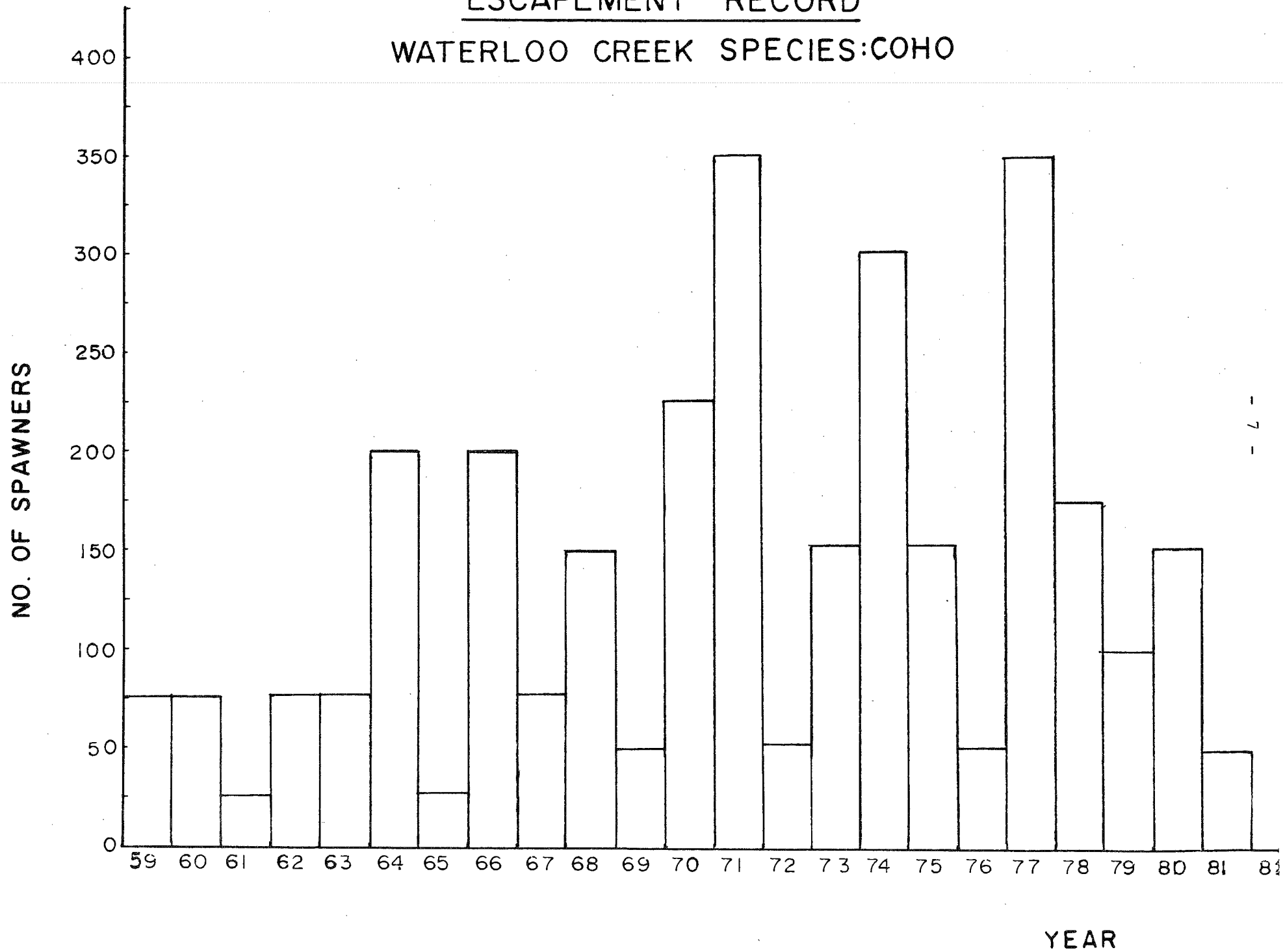
WATERLOO CREEK SPECIES: CHUM

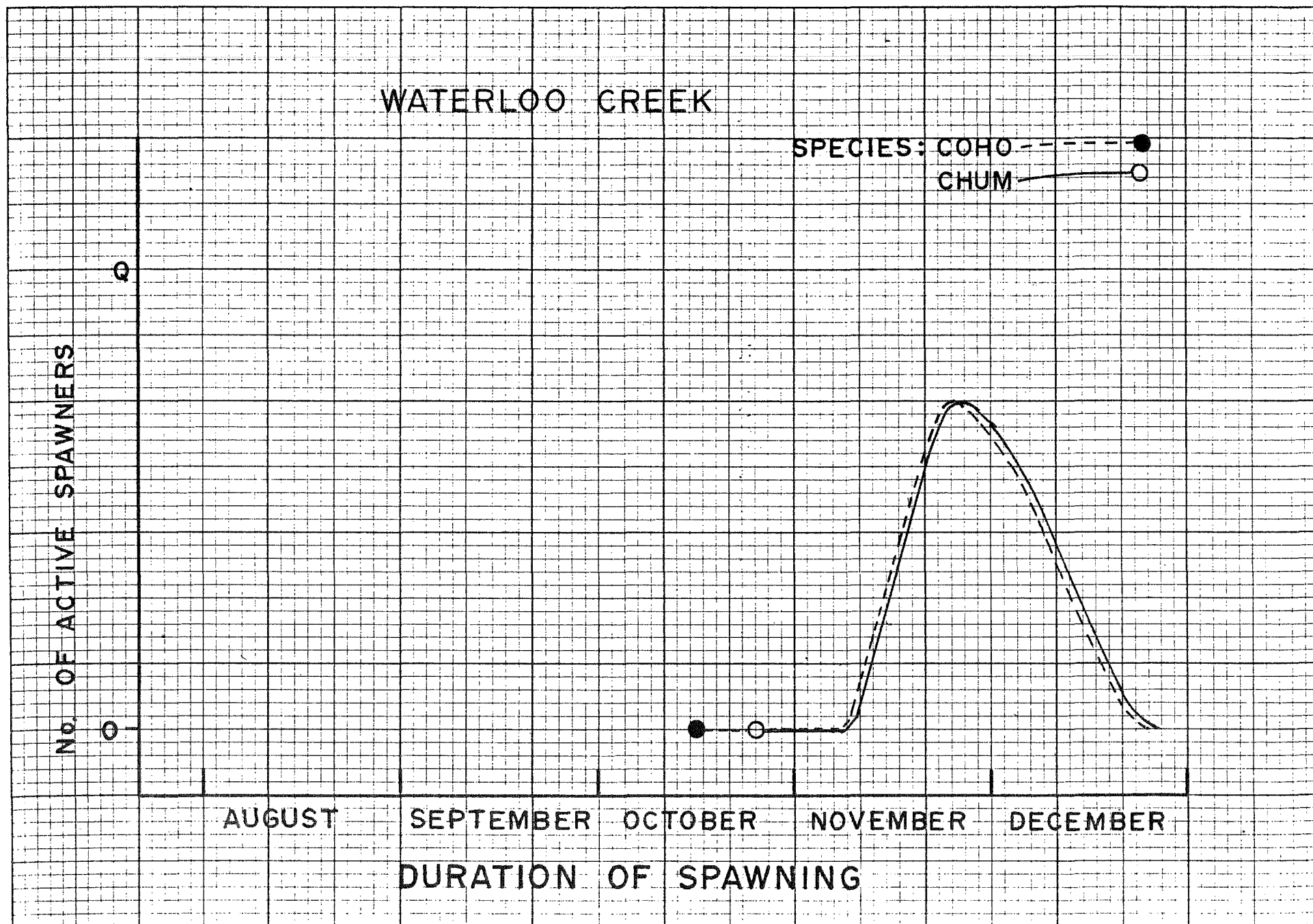
NO. OF SPAWNERS (HUNDREDS)



YEAR

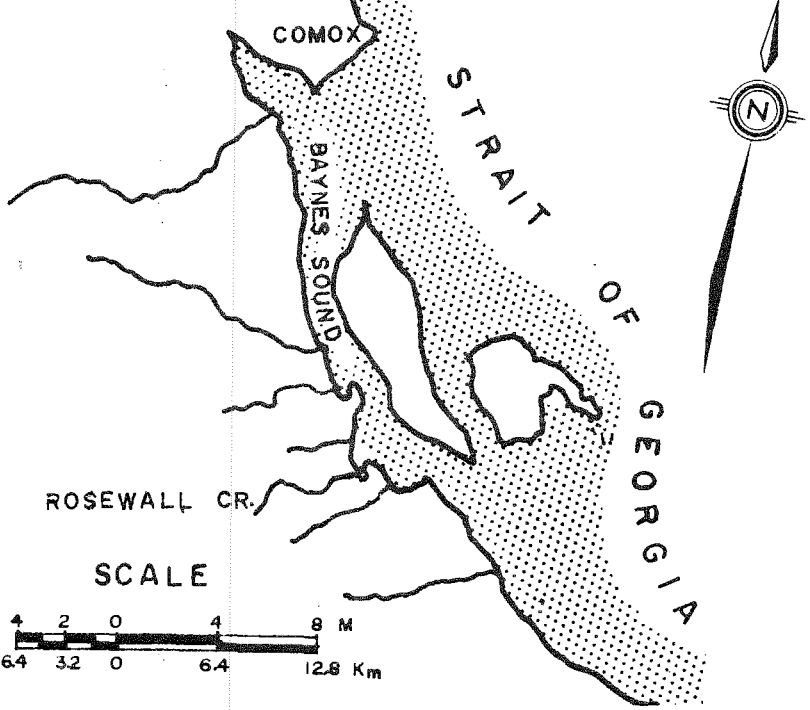
ESCAPEMENT RECORD
WATERLOO CREEK SPECIES: COHO





Rosewall Creek
General Description

Within this stream system, both the nature of seasonal discharges and human manipulation of anadromous fish stocks severely impact upon the fishery resource and environment.



Frequently during summer

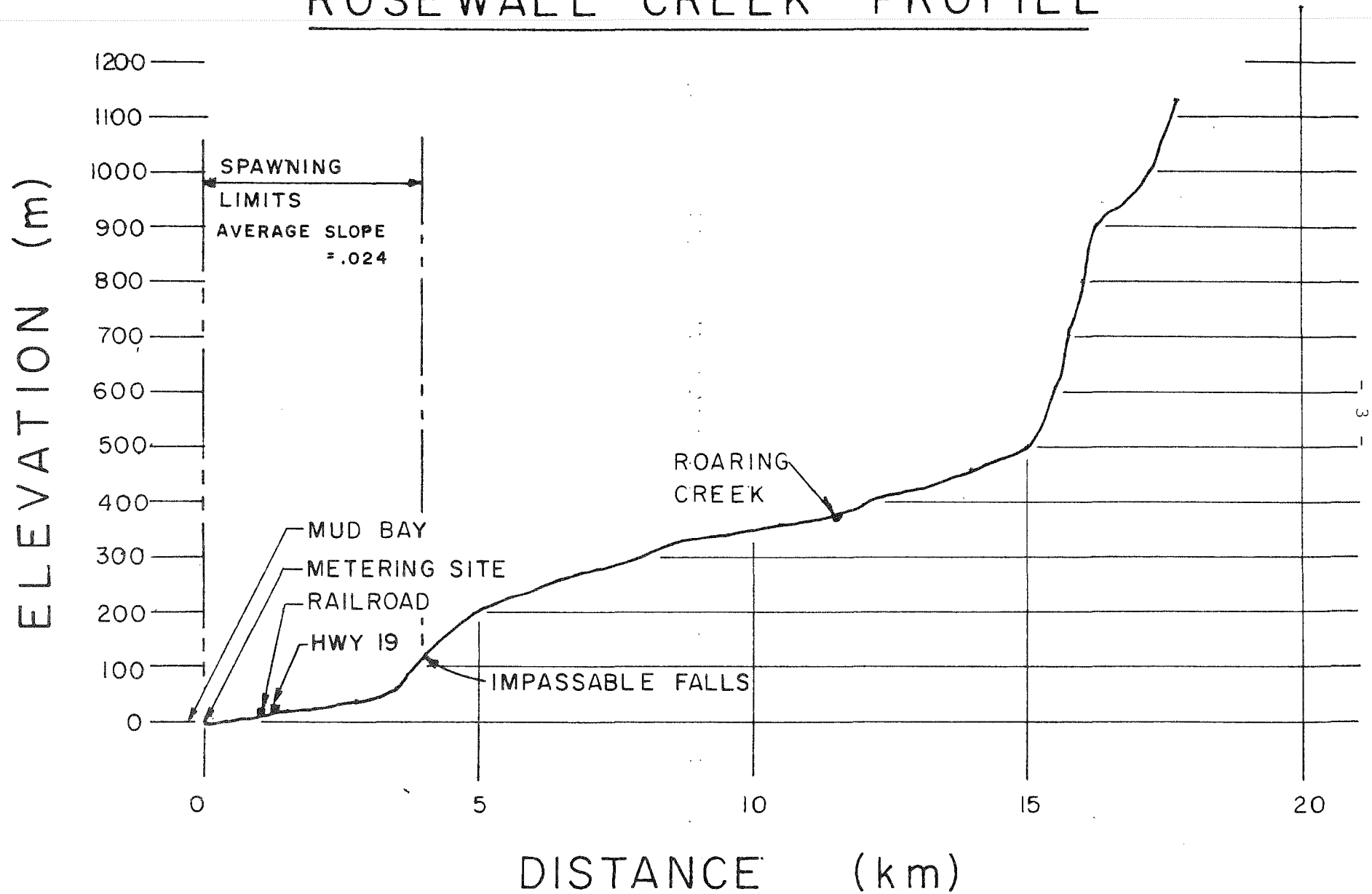
and fall droughts the stream dries completely in the lower reaches. Under natural conditons this situation may impose definitive limits on the capacity of the system to support rearing Coho populations. However, artificial stocks of Coho and Chum have been introduced in recent years by way of a Fisheries Research Board hatchery installation. As a result of this program escapements for these species have increased markedly. For the year 1979 local fishery officers have reported an over-escapement of Coho and 1980 reports indicate that approximately one-half of the spawners sighted below the hatchery fence were hatchery fish.

Erosion and shifting of abundant pea-size gravel has been repeatedly noted by Fisheries staff. This could be due, in part, to extensive logging activity in the upper reaches. Migrating Coho encounter an impassable falls 4 kilometers from the tidal boundary. A majority of Chums utilize the lower 1.5 kilometers of spawnable ground. The hatchery fence controls access to spawning ground above the hatchery.

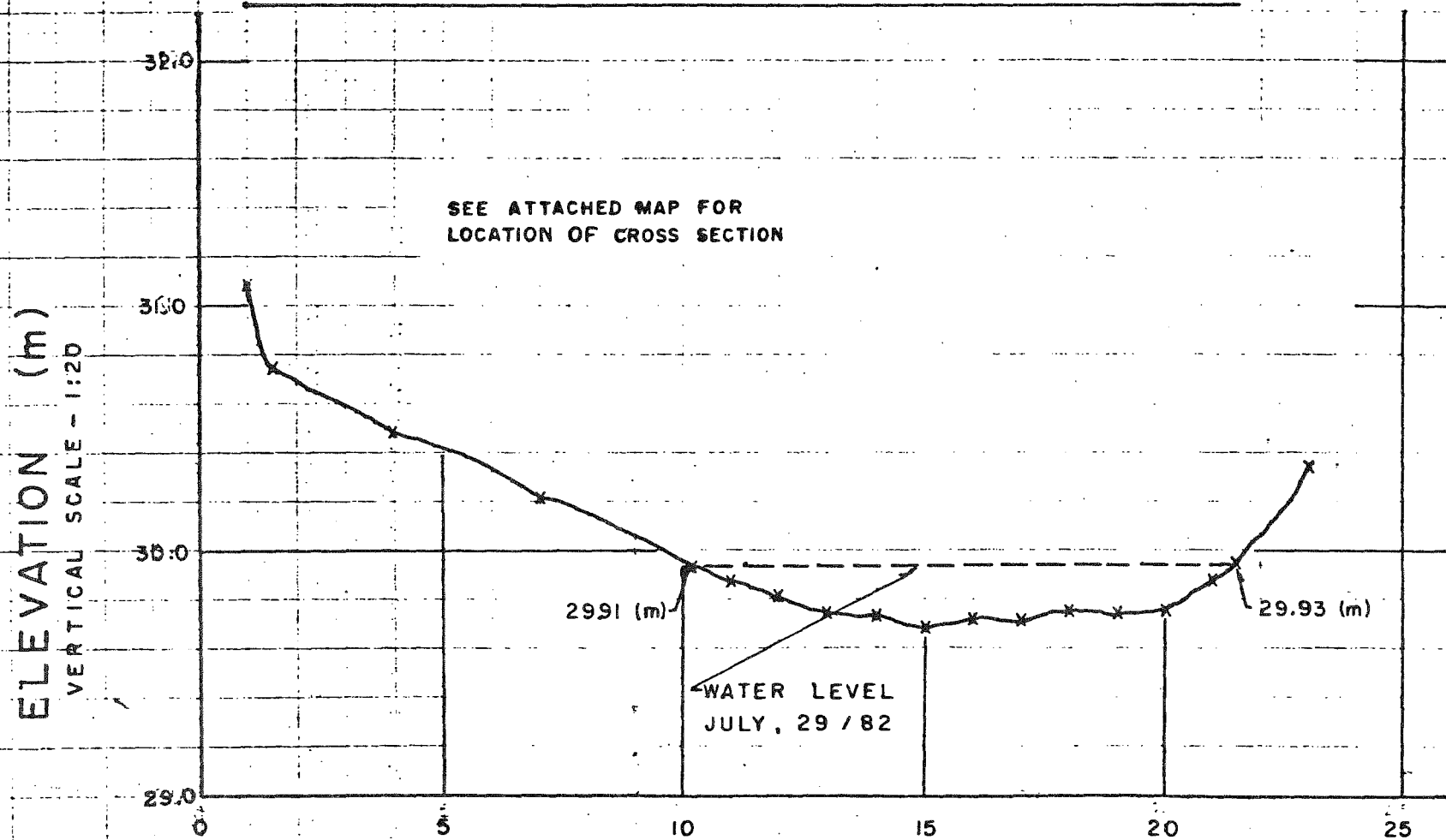


View downstream of highway bridge.

ROSEWALL CREEK PROFILE



ROSEWALL CREEK - CROSS SECTION



HORIZONTAL SCALE - 1:100

Watershed Data

Hydrometric Station # 08HB037 Rosewall Creek

Watershed Area	(A)	45.0 km ²
Mean Elevation	(H)	440 m
First Order Length	(L ₁)	25.8 km
All Orders	(L _T)	75.0 km
Average Precipitation	(AP)	2500 mm/year
Average Annual Flow	(QAA)	2.62 m ³ /sec

For The Period June 1 - Nov. 30:

Average Flow of Lowest Month (August)	0.419 m ³ /sec
7 Day Low Flow, 2 year recurrence (Q7L2)	0.00 m ³ /sec
7 Day Low Flow, 20 year recurrence (Q7L20)	0.00 m ³ /sec
Variability (Q7L20/Q7L2)	None
Yield (Q7L2/A)	0.00 m ³ sec ⁻¹ /km ²

SUMMARY

Estimated Fishery Flow Requirements

A. Spawning Flow

	m ³ /sec
"Streamflow" (Hamilton) Optimum Flow (Coho)	No data
Collings Method Preferred Flow (All Species)	2.51
Sustained Flow (All Species)	2.08
Actual Average Flow At Peak Spawning Time	
Chum	2.23
Coho	2.23

B. Rearing Flow

	m ³ /sec
"Streamflow" (Hamilton) Optimum Flow (Based on Surface Width)	No data
Collings Method Optimum Flow (All Species)	0.88
Average Flow of Lowest Month (Jan. 1-Dec. 31)	0.42
Average Flow of Lowest Month (June 1-Nov. 30)	0.42

Historical Streamflow Data

ROSEWALL CREEK AT THE MOUTH - STATION NO. 08HB037

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
1968	---	---	---	---	---	---	0.555	0.113	0.330	10.1	6.79	8.13	---	1968
1969	---	---	---	5.03	7.50	4.28	0.673	0.204	1.92	1.93	4.41	4.36	---	1969
1970	2.38	2.94	2.25	3.09	2.29	1.70	0.305	0.020	0.156	1.47	3.04	3.00	1.88	1970
1971	4.21	4.86	2.48	3.09	6.02	3.65	2.00	0.477	0.818	1.74	6.56	0.944	3.05	1971
1972	1.05	2.98	7.72	3.48	3.96	2.78	1.47	0.074	0.738	0.109	2.39	6.91	2.81	1972
1974	---	---	---	---	3.63	4.30	2.91	0.747	0.152	0.088	---	---	---	1974
1975	1.81	1.18	2.17	1.85	3.89	2.76	0.835	1.01	0.291	---	---	---	---	1975
1976	3.25	2.31	2.03	2.63	3.78	3.02	2.31	0.872	0.433	1.07	1.74	3.75	2.27	1976
1977	1.56	5.30	3.34	3.40	2.10	1.71	0.221	0.045	0.698	5.69	5.64	4.91	2.86	1977
1978	8.56	3.78	5.80	2.44	2.28	1.95	0.301	0.631	4.24	1.04	1.69	1.50	2.85	1978
MEAN	3.26	3.34	3.68	3.13	3.94	2.91	1.16	0.419	0.978	2.58	4.03	4.19	2.62	MEAN

LOCATION - LAT 49 27 46 N DRAINAGE AREA, 43.3 km²
LONG 124 46 22 W NATURAL FLOW

ROSEWALL CREEK AT THE MOUTH - STATION NO. 08HB037

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m ³ /s)	MAXIMUM DAILY DISCHARGE (m ³ /s)	MINIMUM DAILY DISCHARGE (m ³ /s)	TOTAL DISCHARGE (dam ³)	YEAR
1968	---	71.9 ON DEC 15	0	---	1968
1969	---	21.1 ON MAY 29	0 ON AUG 17	---	1969
1970	---	29.4 ON APR 9	0 ON AUG 14	59 100	1970
1971	---	47.0 ON NOV 9	0.004 ON AUG 30	96 300	1971
1972	---	43.6 ON DEC 19	0 ON AUG 14	88 800	1972
1974	---	---	0 ON SEP 19	---	1974
1975	---	---	0 ON AUG 6	---	1975
1976	---	33.4E ON DEC 26	0 ON OCT 8	71 700	1976
1977	---	47.3 ON OCT 28	0 ON JUL 25	90 200	1977
1978	---	72.8 ON JAN 16 *	0 ON JUL 24	89 700	1978
				82 600	MEAN

E - ESTIMATED

* - EXTREME RECORDED FOR THE PERIOD OF RECORD

After; Historical Streamflow Summary, British Columbia to 1979.

Inland Waters Directorate
Water Resources Branch
Water Survey of Canada
Ottawa, Canada, 1980

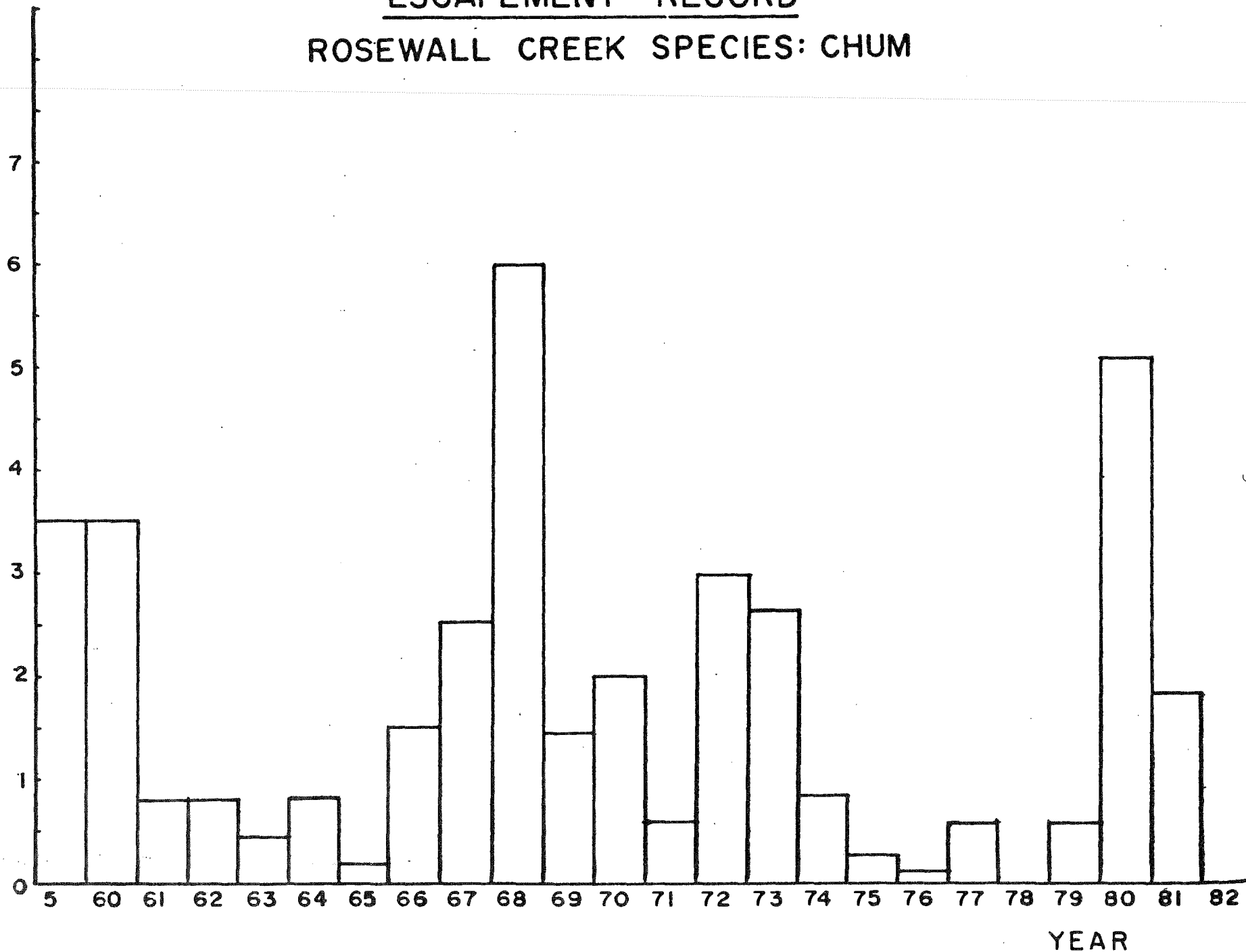
REMARKS :

[illegible]

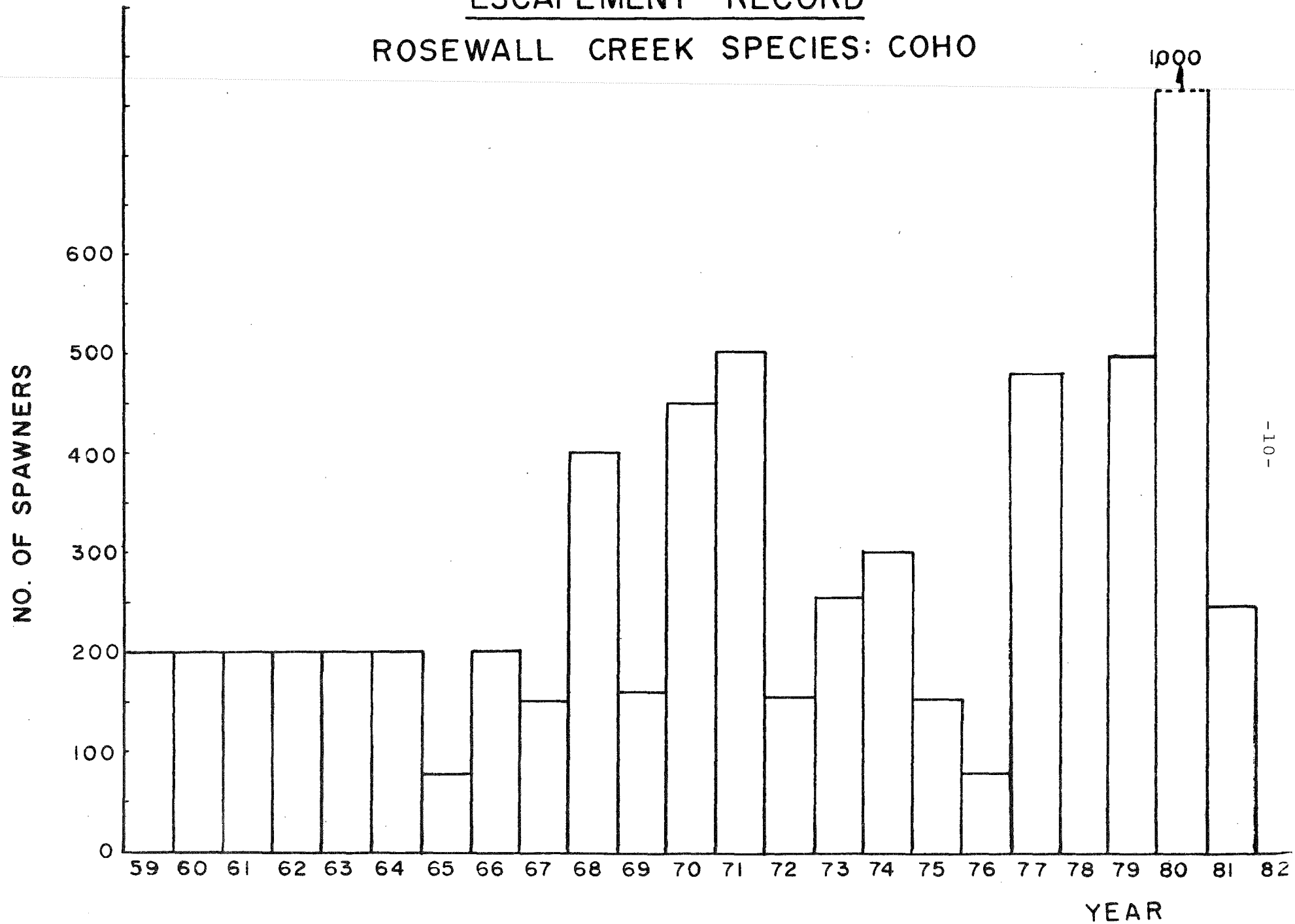
$$\text{Recurrence Period (T)} = \frac{\text{Total No. of Years} + 1}{\text{Rank (M)}}$$

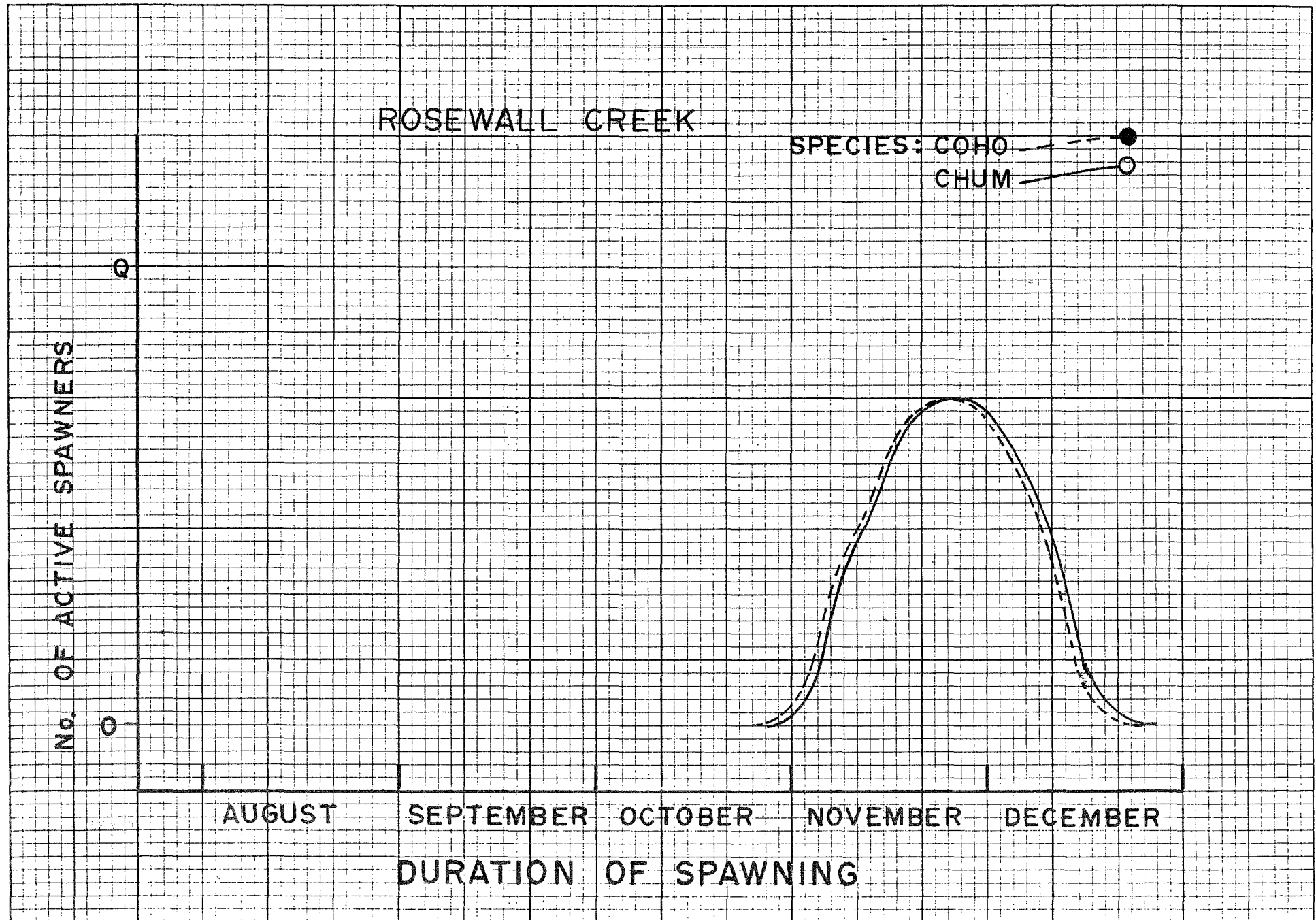
ESCAPEMENT RECORD
ROSEWALL CREEK SPECIES: CHUM

NO. OF SPAWNERS (THOUSANDS)



ESCAPEMENT RECORD
ROSEWALL CREEK SPECIES: COHO

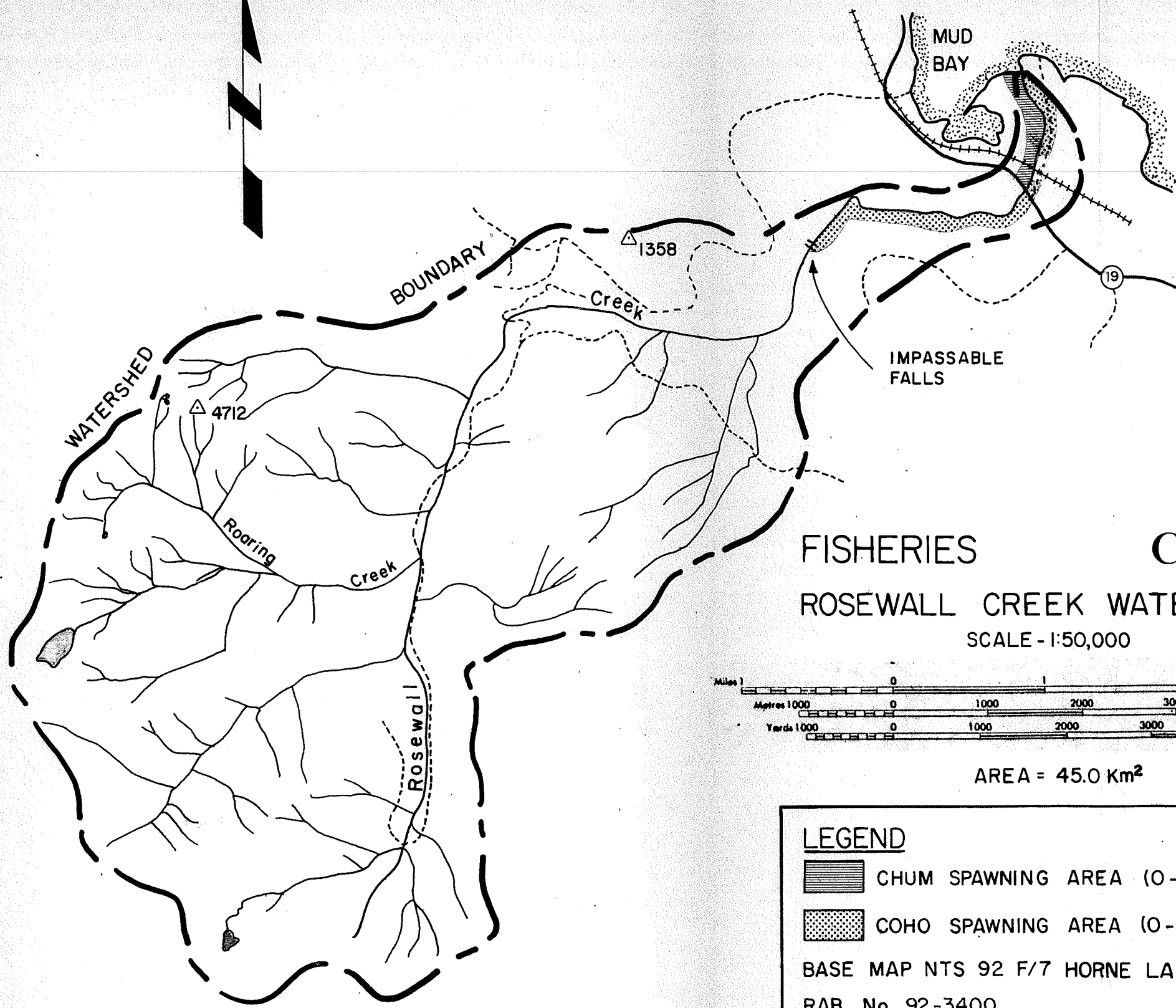




125° 55'



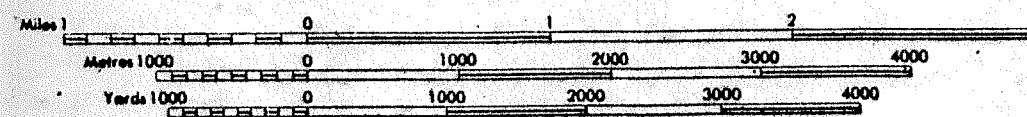
49° 25'



FISHERIES Canada

ROSEWALL CREEK WATERSHED

SCALE - 1:50,000



AREA = 45.0 Km²

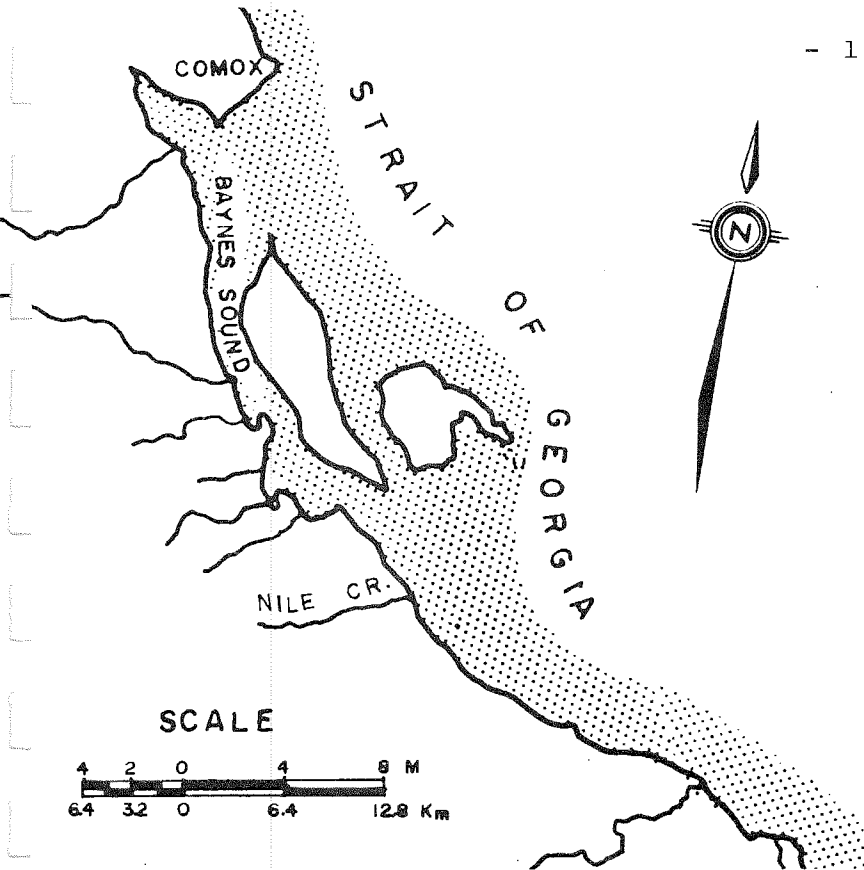
LEGEND

- CHUM SPAWNING AREA (0-1.5 KM)
- COHO SPAWNING AREA (0-4.0 KM)

BASE MAP NTS 92 F/7 HORNE LAKE

RAB No. 92-3400

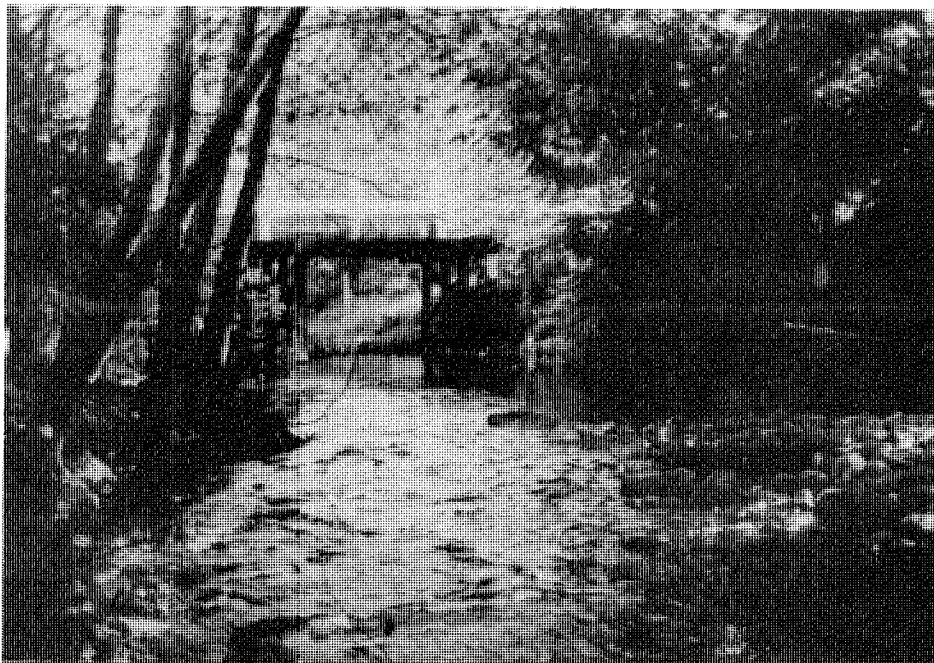
COOK CREEK
(not included
in this report)



Nile Creek General Description

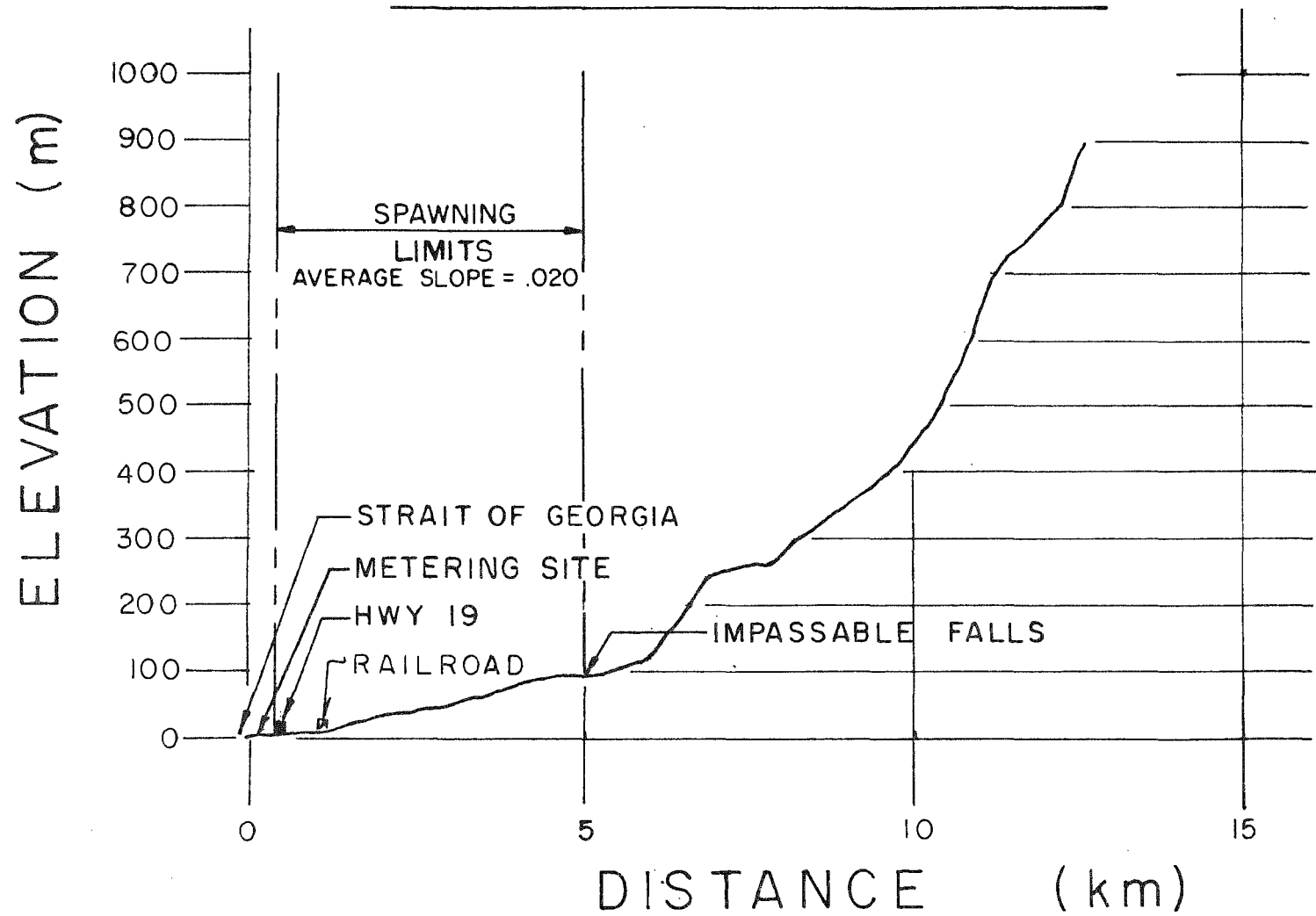
Nile Creek drains an area of 19.3 square kilometers, flowing 14 kilometers eastward into Qualicum Bay. A falls impassable to all species occurs 5 kilometers from tidewater. Coho spawn throughout this lower portion while Chum utilize only the lower 1.2 kilometers. Escapements for both Coho

and Chum have fallen to low levels in recent years. Very low summer flows combined with flash floods in winter may contribute to this decline. Domestic water licences regulate Nile Creek's flow throughout the year.



Nile Creek. 100 meters upstream of tidewater.

NILE CREEK PROFILE



Watershed Data *

Hydrometric Station # 08HB022 Nile Creek

Watershed Area	(A)	15.0 km ²
Mean Elevation	(H)	450 m
First Order Length	(L ₁)	5.3 km
All Orders	(L _T)	17.0 km
Average Precipitation	(AP)	1800 mm/year
Average Annual Flow	(QAA)	1.01 m ³ /sec

For The Period June 1 - Nov. 30:

Average Flow of Lowest Month (August)	0.214 m ³ /sec
7 Day Low Flow, 2 year recurrence (Q7L2)	0.16 m ³ /sec
7 Day Low Flow, 20 year recurrence (Q7L20)	0.10 m ³ /sec
Variability (Q7L20/Q7L2)	0.63
Yield (Q7L2/A)	0.011 m ³ sec ⁻¹ /km ²

* See Appendix

SUMMARY

Estimated Fishery Flow Requirements

A. Spawning Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Coho)	1.83
Collings Method	
Preferred Flow (All Species)	2.43
Sustained Flow (All Species)	1.90
Actual Average Flow At Peak Spawning Time	
Chum	1.38
Coho	1.38

B. Rearing Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Based on Surface Width)	0.13
Collings Method	
Optimum Flow (All Species)	0.82
Average Flow of Lowest Month (Jan. 1-Dec. 31)	0.214
Average Flow of Lowest Month (June 1-Nov. 30)	0.214

Historical Streamflow Data

NILE CREEK NEAR BOWSER - STATION NO. 08HB022													
MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD													
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1959	---	---	---	---	---	0.298	0.231	0.198	0.263	0.442	1.10	1.78	---
1960	1.10	1.32	0.888	1.42	0.827	0.325	0.165	0.170	0.214	0.911	1.19	1.09	0.799
1961	2.84	2.95	1.67	1.20	0.741	0.240	0.178	0.084	0.265	0.752	1.11	2.14	1.17
1962	1.60	0.783	0.667	1.19	0.681	0.393	0.226	0.407	0.298	1.03	2.62	3.38	1.11
1963	0.909	2.66	1.40	1.07	0.482	0.198	0.231	0.198	0.198	1.99	1.85	2.23	1.11
1964	2.35	1.36	1.25	1.08	0.911	0.418	0.358	0.208	0.345	0.491	0.963	0.935	0.888
1965	1.30	1.85	0.833	1.16	0.596	0.224	0.168	0.150	0.146	1.82	1.78	2.72	1.06
1966	2.69	1.27	1.59	1.04	0.603	0.392	0.276	0.201	0.236	1.07	1.80	2.98	1.18
1967	2.02	1.32	1.21	0.685	0.848	0.248	0.185	0.164	0.173	1.72	0.898	2.08	0.965
1968	3.45	1.93	1.47	0.848	0.652	0.337	0.285	0.260	0.423	1.89	2.11	1.66	1.28
1969	0.712	0.989	1.36	1.73	1.72	0.475	0.243	0.216	0.820	0.716	1.31	1.40	0.974
1970	1.09	1.10	0.779	1.27	0.429	0.239	0.193	0.181	0.212	0.503	1.01	1.39	0.697
1971	1.95	1.54	1.18	1.13	1.51	0.652	0.296	0.231	0.349	0.703	1.77	0.506	0.981
1972	0.877	1.67	2.83	1.20	1.01	0.342	0.353	0.232	0.434	0.244	0.831	2.76	1.07
1973	3.31	1.49	0.829	0.534	0.560	0.242	0.148	0.129	0.145	0.834	1.22	3.34	1.07
1974	4.26	1.83	2.80	1.44	1.16	0.585	0.513	0.196	0.199	0.209	1.81	2.29	1.44
1975	1.01	0.827	1.25	0.860	1.26	0.372	0.201	0.429	0.214	1.64	3.88	2.13	1.17
1976	1.55	1.19	0.986	1.21	1.09	0.455	0.268	0.297	0.295	0.517	0.734	1.13	0.810
1977	0.631	1.55	1.15	0.875	0.308	0.215	0.146	0.142	0.228	0.911	1.58	1.72	0.782
1978	1.30	1.29	1.42	0.666	0.341	0.224	0.170	0.240	0.588	0.356	0.729	0.871	0.679
1979	0.423	2.12	1.49	0.773	0.462	0.193	0.215	0.166	0.536	0.807	0.719	3.88	0.977
MEAN	1.77	1.55	1.35	1.07	0.810	0.337	0.240	0.214	0.313	0.931	1.48	2.02	1.01
LOCATION - LAT. 49 25 08 N DRAINAGE AREA, 15.0 km ²													
LONG 124 38 32 W REGULATED SINCE 1969													

NILE CREEK NEAR BOWSER - STATION NO. 08HB022				
ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD				
YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m ³ /s)	MAXIMUM DAILY DISCHARGE (m ³ /s)	MINIMUM DAILY DISCHARGE (m ³ /s)	TOTAL DISCHARGE (dam ³)
1959	---	---	0.190 ON AUG 20	---
1960	---	11.6 ON DEC 12	0.142 ON DEC 29	25 300
1961	---	17.4 ON JAN 15	0.065 ON JUL 31 *	36 900
1962	---	14.5 ON NOV 24	0.142 ON SEP 21	34 900
1963	---	18.7 ON FEB 3	0.142 ON OCT 6	34 900
1964	---	10.6 ON NOV 30	0.176 ON SEP 12	28 100
1965	---	15.4 ON OCT 20	0.110 ON AUG 2	33 400
1966	---	13.1 ON JAN 13	0.187 ON AUG 20	37 300
1967	---	11.8 ON DEC 10	0.161 ON AUG 13	30 400
1968	---	17.7 ON JAN 19	0.204 ON AUG 18	40 400
1969	---	6.74 ON NOV 23	0.193 ON JUL 24	30 700
1970	---	11.8 ON APR 9	0.173 ON AUG 22	22 000
1971	---	9.17 ON NOV 9	0.218 ON AUG 10	30 900
1972	---	16.8 ON DEC 25	0.218 ON AUG 29	31 700
1973	---	22.6 ON JAN 14	0.125 ON AUG 2	33 700
1974	---	11.4 E ON JAN 15 *	0.173 ON SEP 30	45 500
1975	---	14.3 ON NOV 11	0.173 ON AUG 1	37 100
1976	---	8.58 ON DEC 26	0.184 ON OCT 19	25 600
1977	---	11.7 ON DEC 11	0.119 ON AUG 3	24 700
1978	---	10.1 ON MAR 7	0.142 ON AUG 6	21 400
1979	---	30.0 ON DEC 17	0.144 ON AUG 9	30 800
* - EXTREME RECORDED FOR THE PERIOD OF RECORD				31 900
E - ESTIMATED				

After; Historical Streamflow Summary, British Columbia to 1979.

Inland Waters Directorate
Water Resources Branch
Water Survey of Canada
Ottawa, Canada, 1980

- 6 -
 LOWEST 7 DAY SUMMER AND FALL FLOWS
 (June 1 - Nov. 30)

STREAM : NILE CREEK NEAR BOWSER Station #08HB022

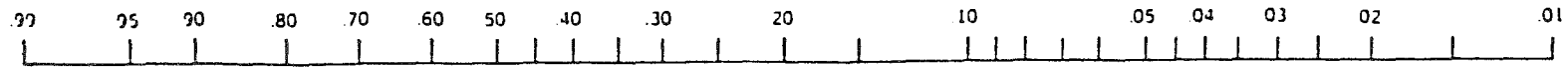
REMARKS :

Year	Date	Min Av	Rank (M)	Recurrence (T)	Year	Date
		M ³ /SEC		Years		
1959	Aug 19	0.193	1) 0.065	24	1961	Jul 31
1960	Jul 10	0.159	2) 0.121	12	1965	Jul 31
1961	Jul 31	0.065	3) 0.125	8	1973	Aug 2
1962	Sep 20	0.143	4) 0.125	6	1977	Aug 14
1963	Oct 1	0.149	5) 0.143	4.8	1962	Sep 20
1964	Sep 8	0.182	6) 0.144	4.0	1979	Aug 9
1965	Jul 31	0.121	7) 0.149	3.43	1963	Oct 1
1966	Aug 20	0.187	8) 0.149	3.0	1978	Aug 4
1967	Aug 13	0.161	9) 0.154	2.67	1980	Aug 11
1968	Aug 1	0.227	10) 0.159	2.4	1960	Jul 10
1969	Jul 24	0.193	11) 0.161	2.18	1967	Aug 13
1970	Aug 21	0.174	12) 0.161	2.0	1981	Aug 17
1971	Aug 8	0.223	13) 0.174	1.85	1970	Aug 21
1972	Aug 29	0.218	14) 0.174	1.71	1975	Jul 31
1973	Aug 2	0.125	15) 0.179	1.6	1974	Sep 24
1974	Sep 24	0.179	16) 0.182	1.5	1964	Sep 8
1975	Jul 31	0.174	17) 0.185	1.41	1976	Oct 17
1976	Oct 17	0.185	18) 0.187	1.33	1966	Aug 20
1977	Aug 14	0.125	19) 0.193	1.26	1959	Aug 19
1978	Aug 4	0.149	20) 0.193	1.2	1969	Jul 24
1979	Aug 9	0.144	21) 0.218	1.14	1972	Aug 29
1980	Aug 11	0.154	22) 0.223	1.09	1971	Aug 8
1981	Aug 17	0.161	23) 0.227	1.04	1968	Aug 1

$$\text{Recurrence Period (T)} = \frac{\text{Total No. of Years} + 1}{\text{Rank (M)}}$$

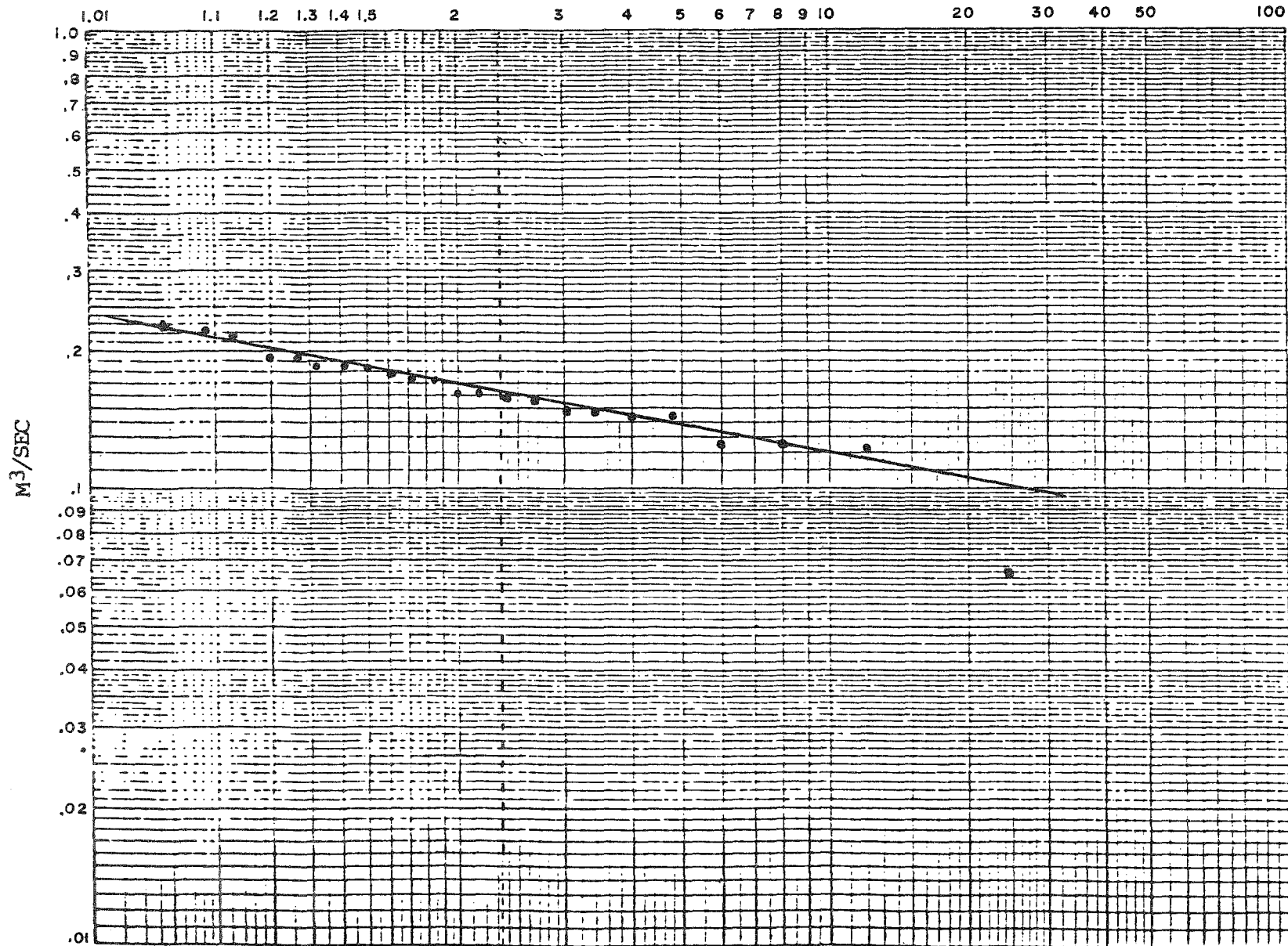
NILE CREEK NEAR BOWSER STATION # 08HB022

PROBABILITY



Lowest 7 Day Summer and Fall Flows (June 1 - Nov. 30)

RECURRENCE INTERVAL IN YEARS

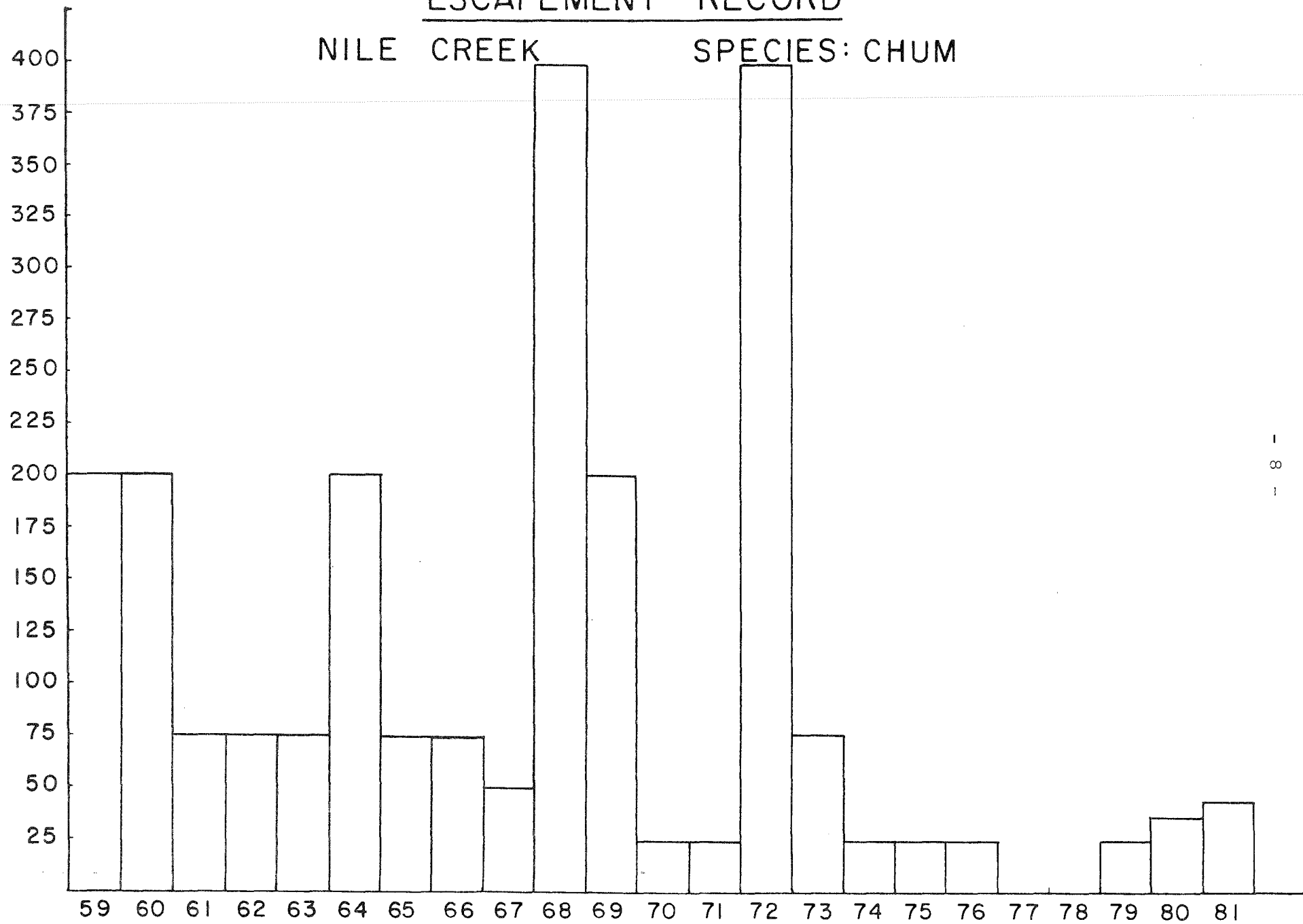


ESCAPEMENT RECORD

NILE CREEK

SPECIES: CHUM

NO. OF SPAWNERS



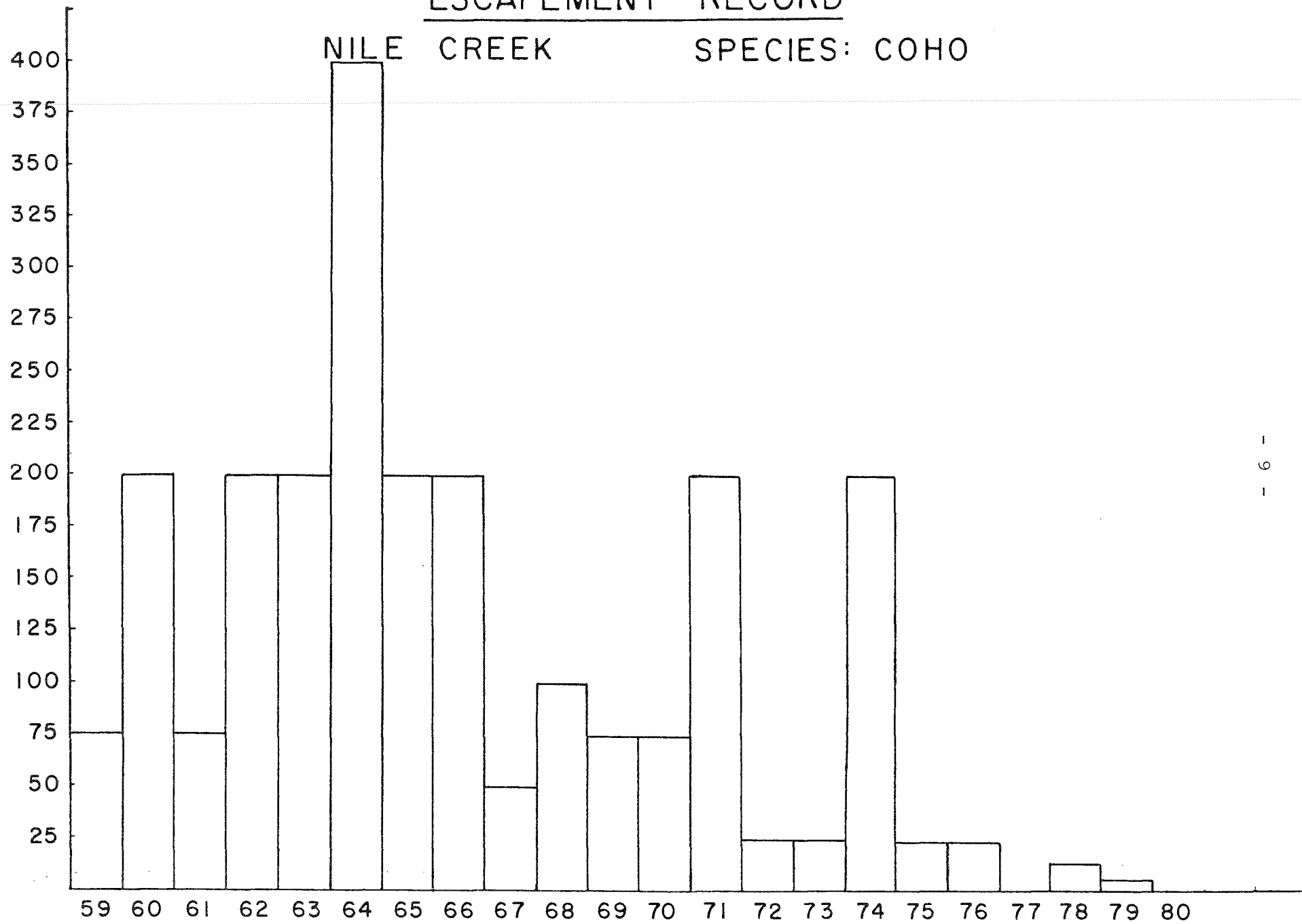
YEAR

ESCAPEMENT RECORD

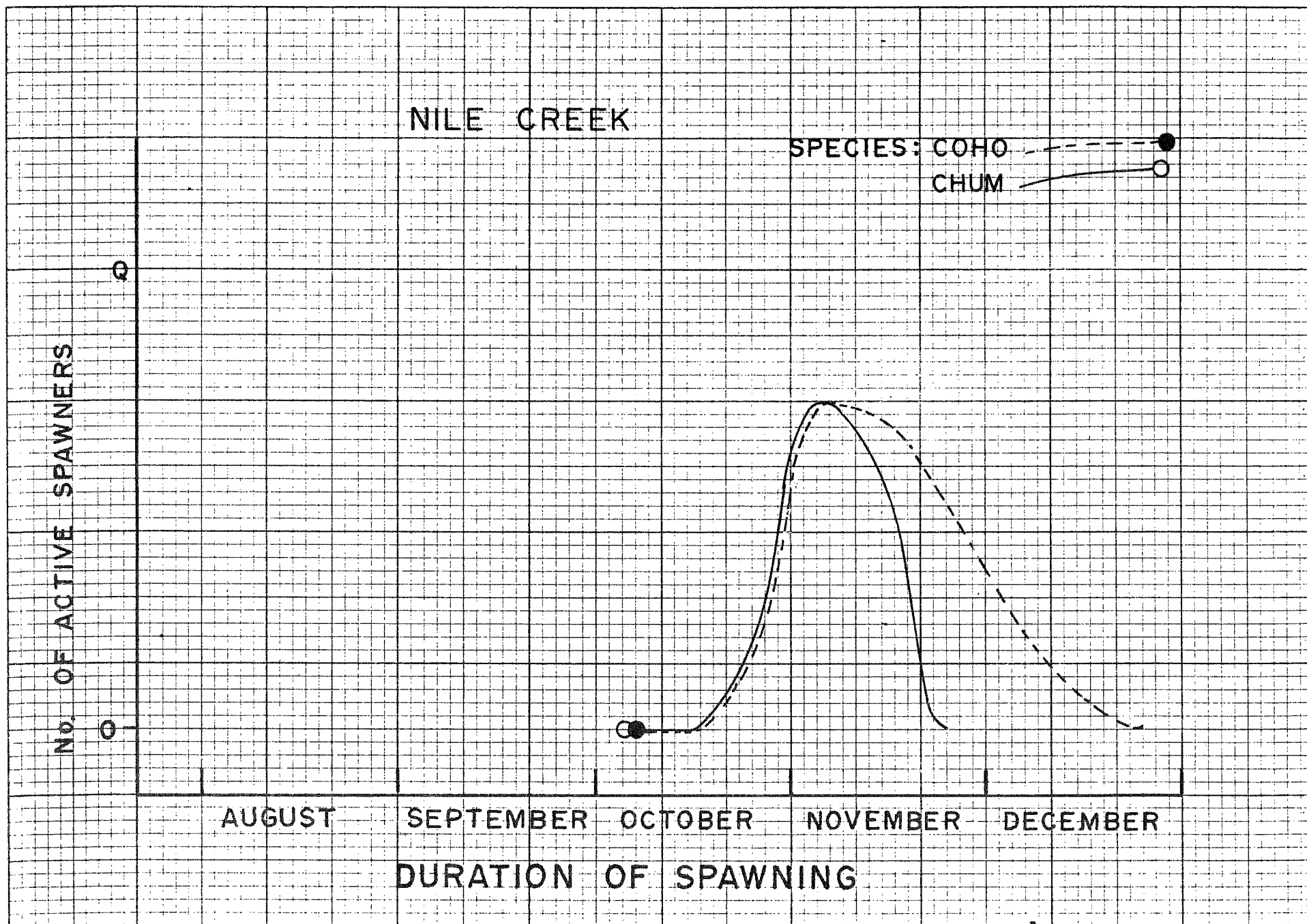
NILE CREEK

SPECIES: COHO

NO. OF SPAWNERS



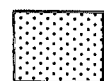
YEAR



LEGEND



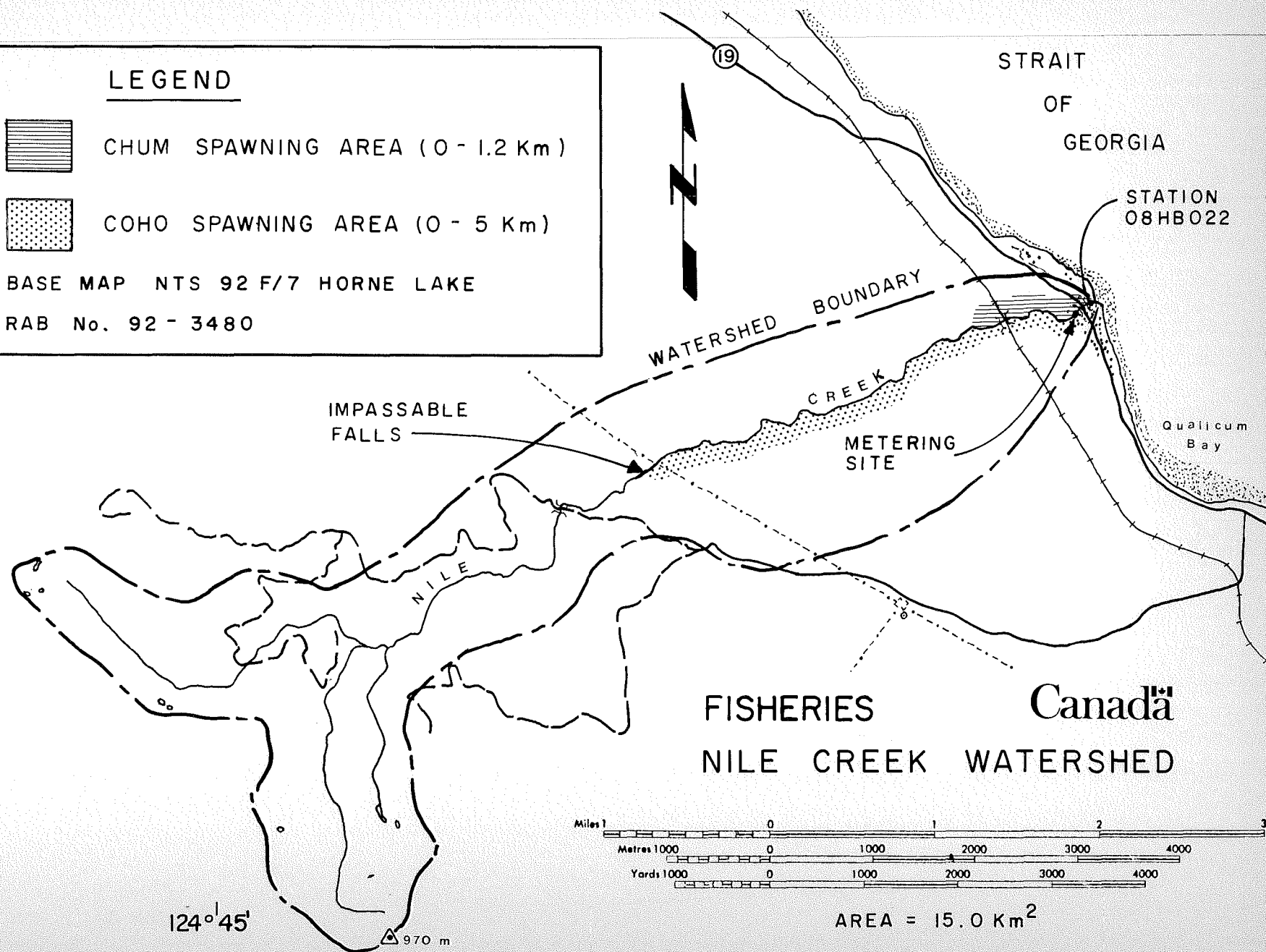
CHUM SPAWNING AREA (0 - 1.2 Km)



COHO SPAWNING AREA (0 - 5 Km)

BASE MAP NTS 92 F/7 HORNE LAKE

RAB No. 92 - 3480



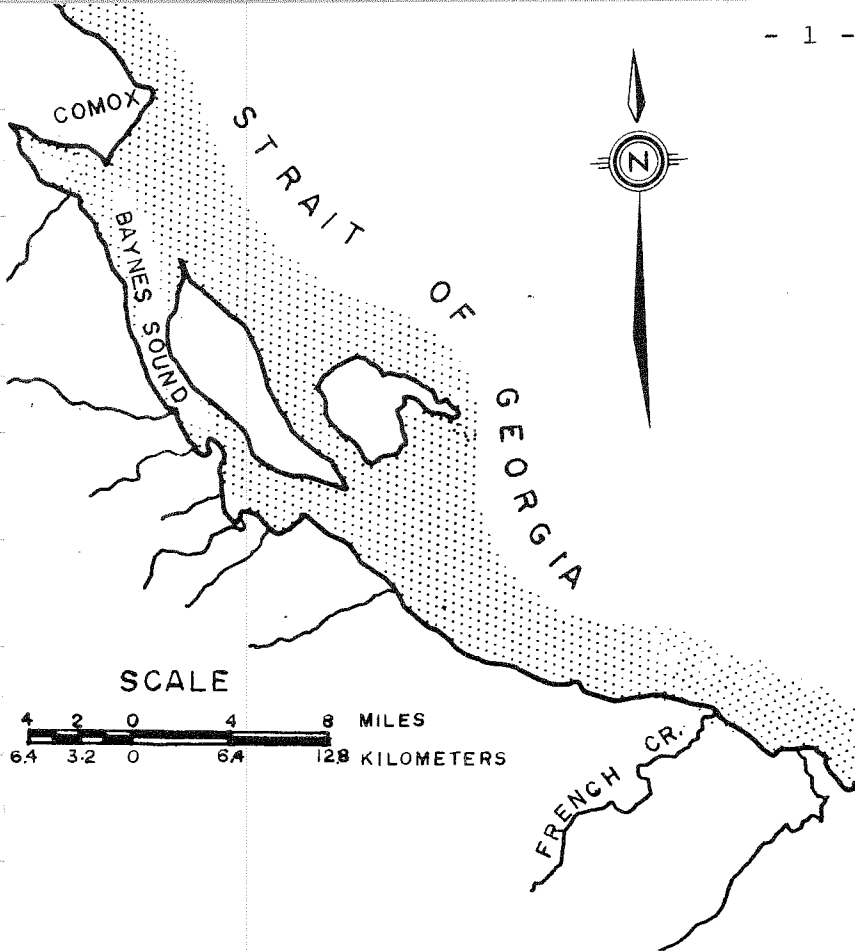
French Creek

General Description

French Creek is an important Coho producer located on the east coast of Vancouver Island, flowing into the Strait of Georgia approximately 4 kilometers north-west of Parksville. The watershed drains an area of 62 square kilometers bounded on the west by 950 meter high ridges and to the north and south by low hills and lowlands that characterize most of the basin.

From headwater elevations of over 500 meters the stream descends 300 meters in five kilometers. Gradients average a 26 meter per kilometer drop through the next 8 kilometers. In the lower reaches, running 10 kilometers to tidewater, gradients average a 7 meter drop per kilometer.

Coho frequent feeder streams and upper reaches of the mainstream, while Chum spawn mainly in the lower reaches. All species encounter an impassable falls on the west fork of French Creek, 400 meters from its confluence with the mainstream and 11 kilometers from tidewater. Seasonal extremes of discharge have had deleterious effects upon spawning and rearing habitat. Flash floods in winter have caused extensive gravel movement in the lower reaches, while very low summertime flows limit rearing capacity for Coho.



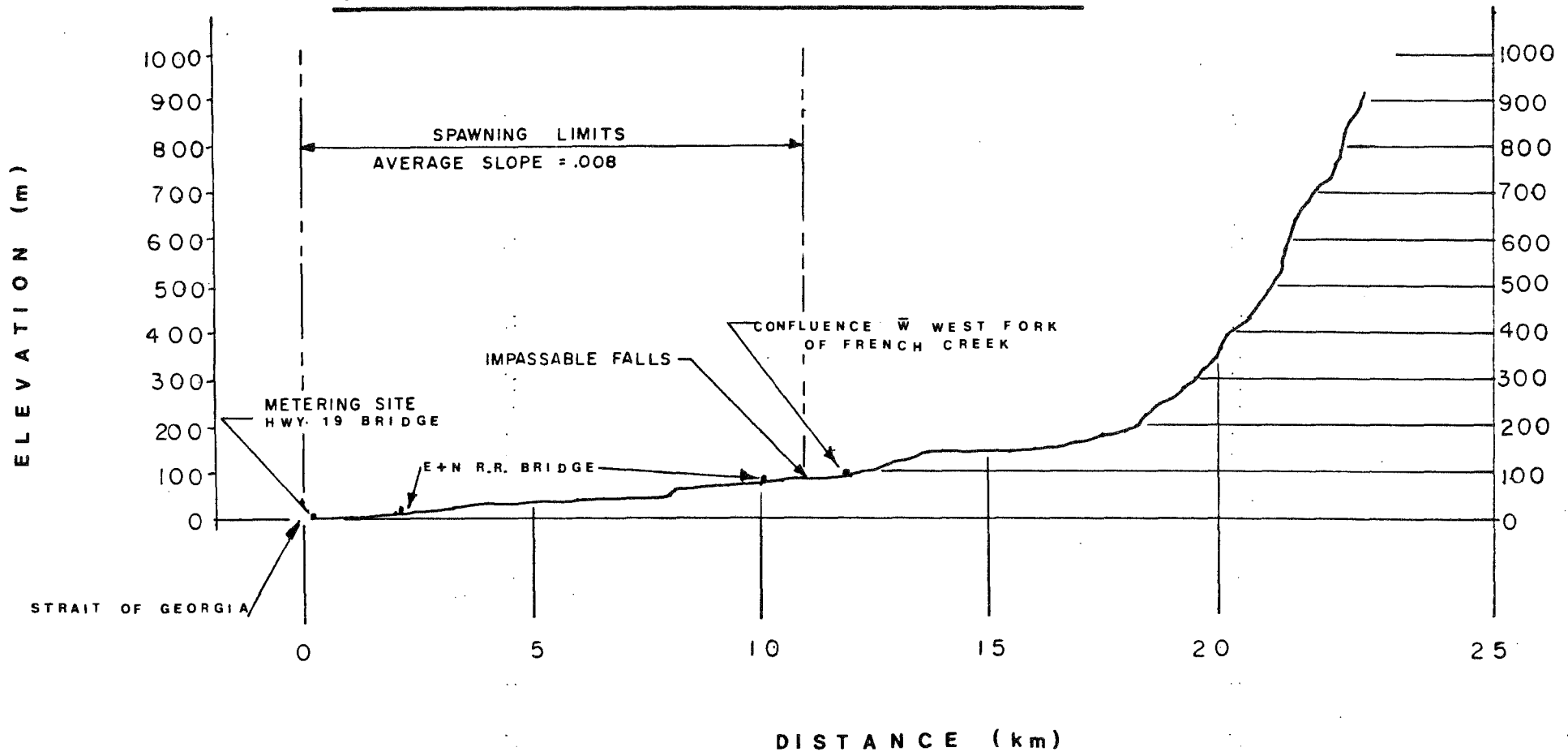
Low flows will continue to be a problem in the future as increasing by heavy demands are placed upon the system by residential and agricultural subscribers.



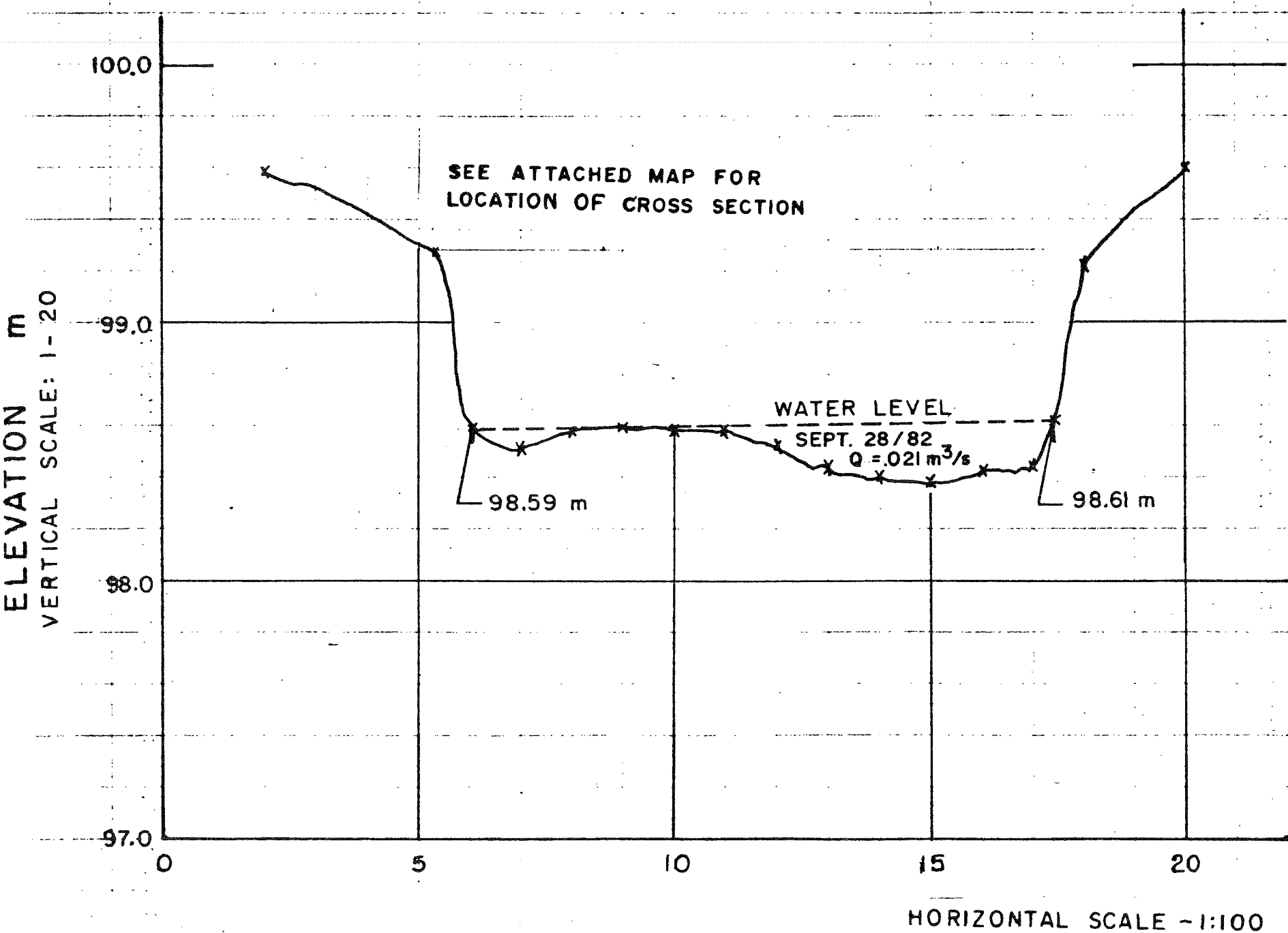
Sections of good gravel 150 meters above highway bridge.



FRENCH CREEK ELEVATION PROFILE



FRENCH CREEK CROSS - SECTION



Watershed Data

Hydrometric Station #08HB038 French Creek

Watershed Area	(A)	61.8 km ²
Mean Elevation	(H)	140 m
First Order Length	(L ₁)	16.9 km
All Orders	(L _T)	40.2 km
Average Precipitation	(AP)	1500 mm/year
Average Annual Flow	(QAA)	Not Available

For The Period June 1 - Nov. 30:

Average Flow of Lowest Month (August)	0.009 m ³ /sec
7 Day Low Flow, 2 year recurrence (Q7L2)	0.042 m ³ /sec
7 Day Low Flow, 20 year recurrence (Q7L20)	0.0074 m ³ /sec
Variability (Q7L20/Q7L2)	0.18
Yield (Q7L2/A)	0.00068 m ³ sec ⁻¹ /km ²

SUMMARY

Estimated Fishery Flow Requirements

A. Spawning Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Coho)	No data
Collings Method	
Preferred Flow (All Species)	2.55
Sustained Flow (All Species)	2.13
Actual Average Flow At Peak Spawning Time	
Chum	No data
Coho	No data

B. Rearing Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Based on Surface Width)	No data
Collings Method	
Optimum Flow (All Species)	0.71
Average Flow of Lowest Month (Jan. 1-Dec. 31)	0.01
Average Flow of Lowest Month (June 1-Nov. 30)	0.01

Historical Streamflow Data

FRENCH CREEK AT COOMBS - STATION NO. 08HB038													
MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD													
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1969	---	---	---	2.48	1.96	0.432	0.103	0.012	0.361	---	---	---	---
1970	---	---	---	1.58	0.487	0.074	0.012	0.008	0.006	---	---	---	---
1971	---	---	---	1.85	1.68	0.565	0.089	0.006	0.017	---	---	---	---
MEAN	---	---	---	1.97	1.38	0.357	0.068	0.009	0.128	---	---	---	---
LOCATION - LAT 49 18 17 N DRAINAGE AREA, 58.3 km ²													
LONG 124 25 30 W NATURAL FLOW													
FRENCH CREEK AT COOMBS - STATION NO. 08HB038													
ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD													
YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m ³ /s)			MAXIMUM DAILY DISCHARGE (m ³ /s)			MINIMUM DAILY DISCHARGE (m ³ /s)			TOTAL DISCHARGE (dam ³)			
1969	---			---			0 ON AUG 10 *			---			
1970	---			---			0 ON JUL 20			---			
1971	---			---			0.001 ON SEP 22			---			
* - EXTREME RECORDED FOR THE PERIOD OF RECORD													

After; Historical Streamflow Summary, British Columbia to 1979.

Inland Waters Directorate
Water Resources Branch
Water Survey of Canada
Ottawa, Canada, 1980

ESCAPEMENT RECORD

FRENCH CREEK

SPECIES:

CHUM

NO. OF SPAWNERS

4000

3500

3000

2500

2000

1500

1100

550

0

59

60

61

62

63

64

65

66

67

68

69

70

71

72

73

74

75

76

77

78

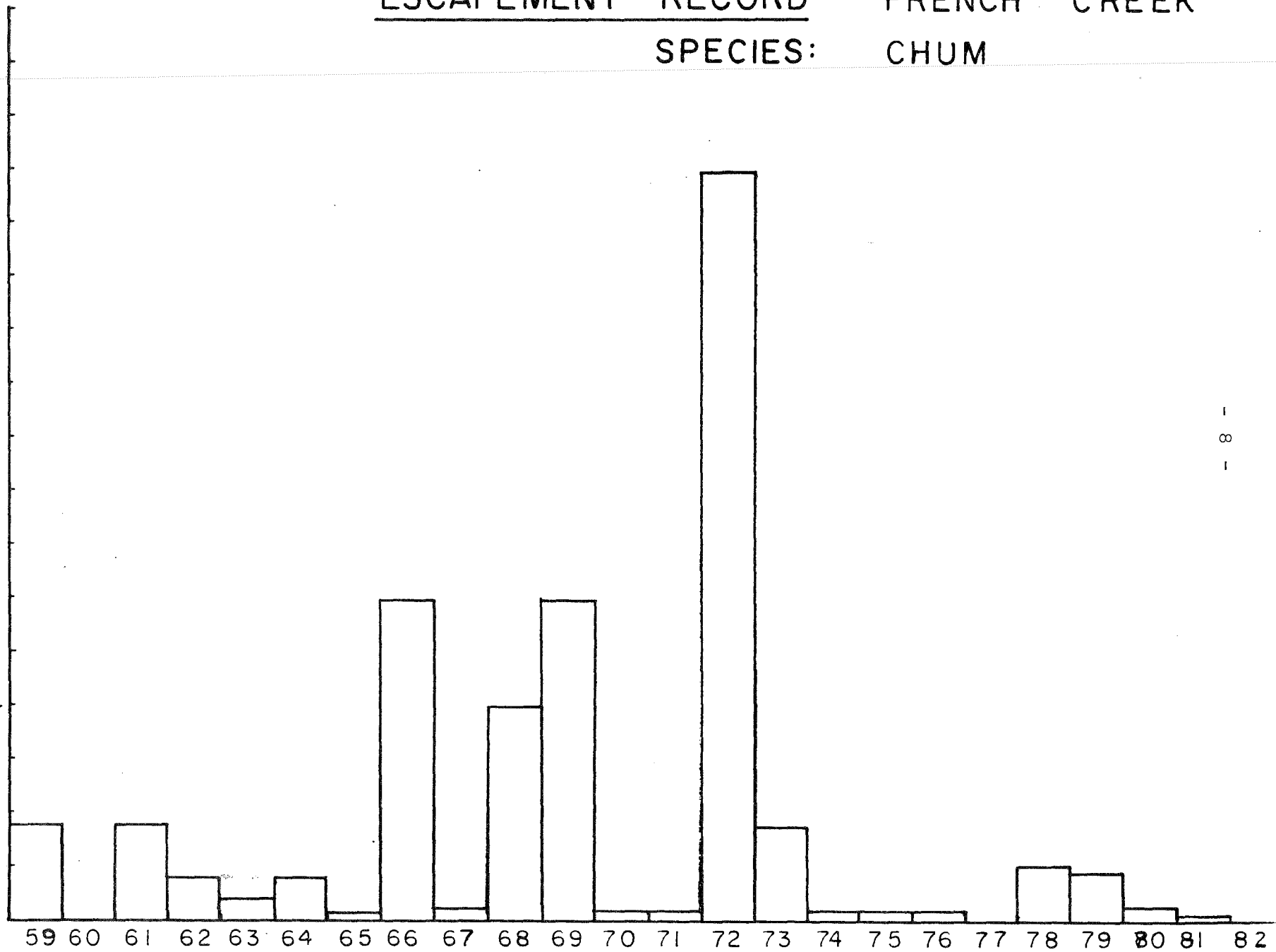
79

80

81

82

1
8
1

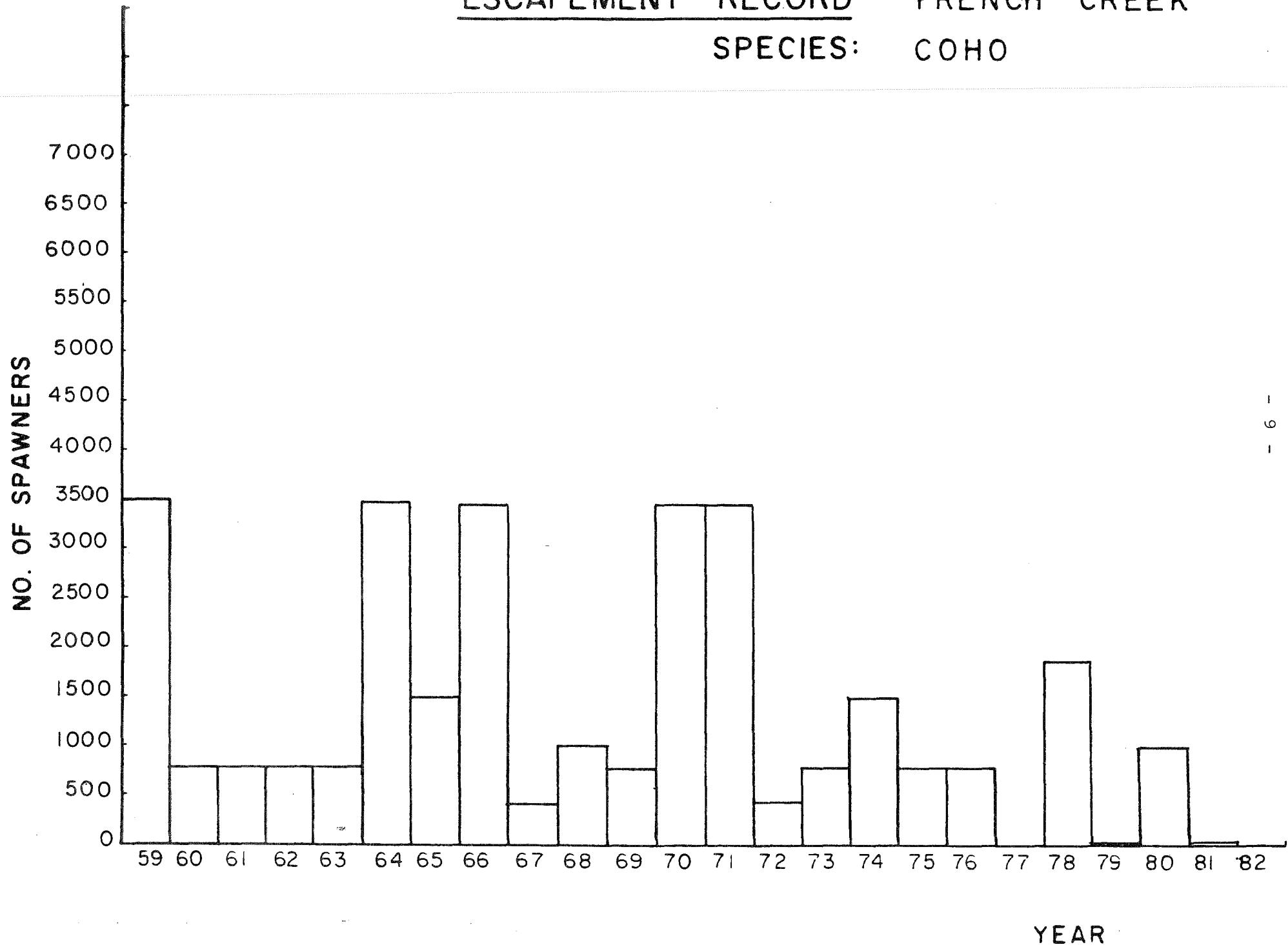


ESCAPEMENT RECORD

FRENCH CREEK

SPECIES:

COHO



FRENCH CREEK

SPECIES: COHO

CHUM

NO. OF ACTIVE SPAWNERS

Q

0

AUGUST

SEPTEMBER

OCTOBER

NOVEMBER

DECEMBER

DURATION OF SPAWNING

124° 25'

STRAIT OF
GEORGIA

TRANSECT SITE

WATERSHED
BOUNDARY

IMPASSABLE
FALLS

LEGEND

 CHUM SPAWNING AREA (0 - 0.5 km)

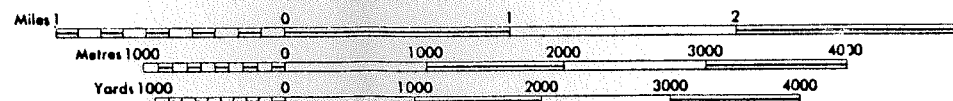
 COHO SPAWNING AREA (0 - 11.0 km)

BASE MAP NTS 92/F8 PARKSVILLE

RAB No. 92-3200

FISHERIES
FRENCH CREEK WATERSHED

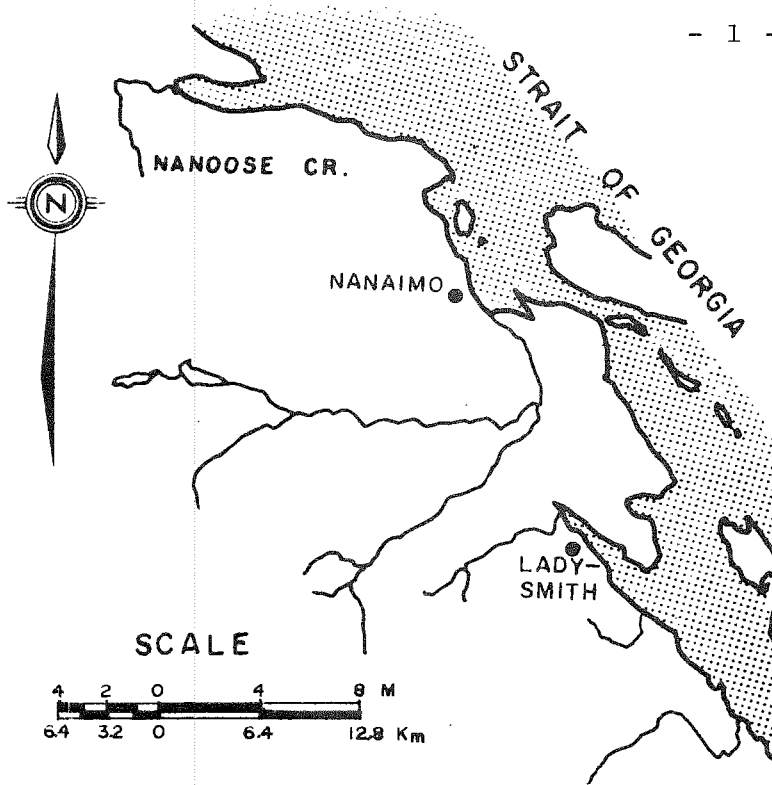
Canada



AREA = 61.8 Km²

49° 15'

FRENCH
CREEK



Nanoose Creek

General Description

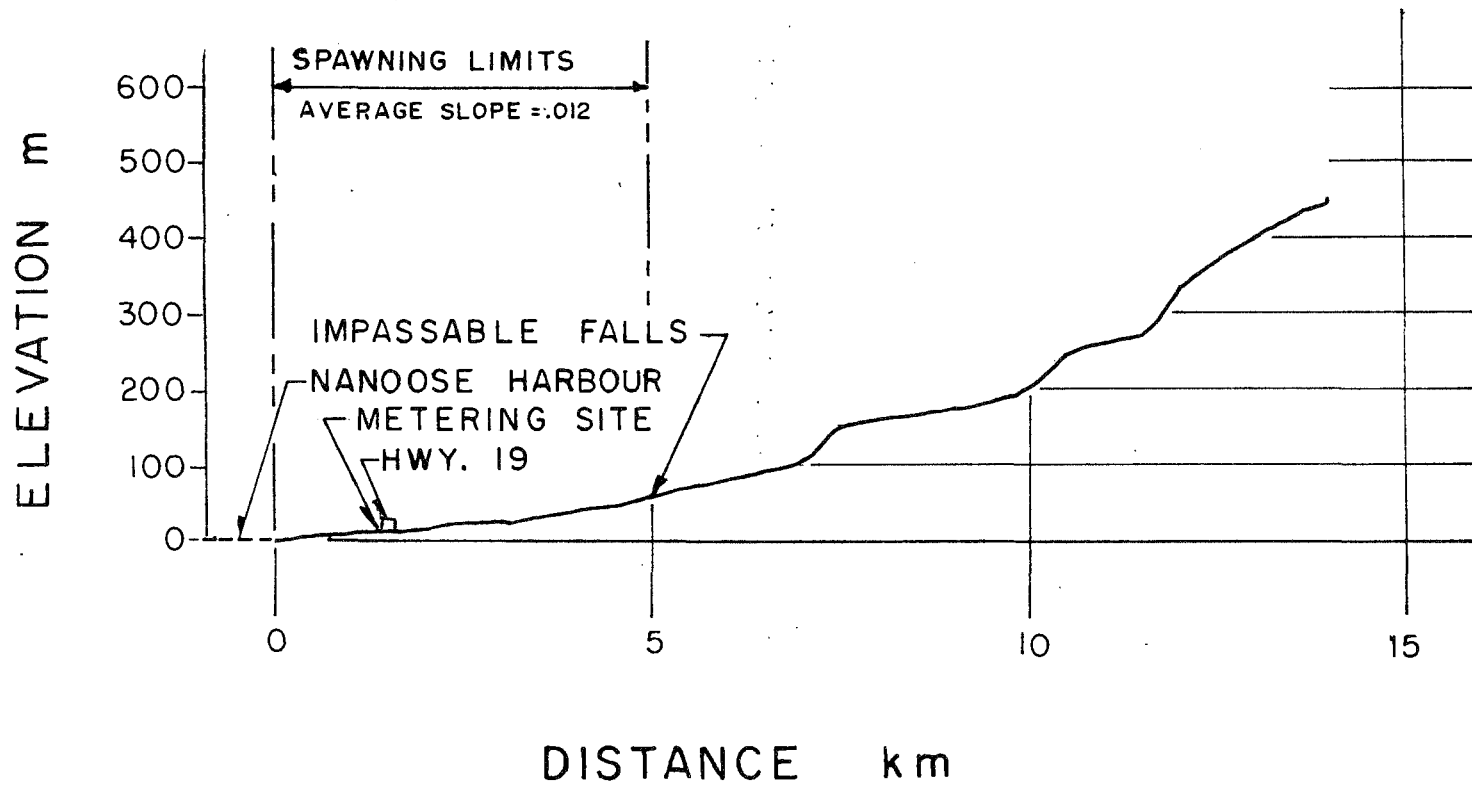
Nanoose Creek flows north and east into Nanoose Harbour. A natural rock falls situated 5 kilometers from the mouth is impassable. The stream is very productive with excellent cover throughout for adult spawners.

Spawning Coho are found between 1 - 5 km upstream and Chum to 4 km upstream. Modest erosion occurs in lower 3 km of stream and minor scouring of spawning beds. Escapement of both Chum and Coho has been variable in the last 20 years (see graphs).



View upstream of highway bridge.

NANOOSE CREEK ELEVATION PROFILE



Watershed Data

Hydrometric Station # 08HB039 Nanoose Creek

Watershed Area	(A)	33.9 km ²
Mean Elevation	(H)	425 m
First Order Length	(L ₁)	6.5 km
All Orders	(L _T)	20.5 km
Average Precipitation	(AP)	2000 mm/year
Average Annual Flow	(QAA)	Not Available

For The Period June 1 - Nov. 30:

Average Flow of Lowest Month (August)	0.01 m ³ /sec
7 Day Low Flow, 2 year recurrence (Q7L2)	0.051 m ³ /sec
7 Day Low Flow, 20 year recurrence (Q7L20)	0.012 m ³ /sec
Variability (Q7L20/Q7L2)	0.24
Yield (Q7L2/A)	0.0015 m ³ sec ⁻¹ /km ²

SUMMARY

Estimated Fishery Flow Requirements

A. Spawning Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Coho)	No data
Collings Method	
Preferred Flow (All Species)	1.74
Sustained Flow (All Species)	1.43
Actual Average Flow At Peak Spawning Time	
Chum	No data
Coho	No data

B. Rearing Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Based on Surface Width)	No data
Collings Method	
Optimum Flow (All Species)	0.49
Average Flow of Lowest Month (Jan. 1-Dec. 31)	0.01
Average Flow of Lowest Month (June 1-Nov. 30)	0.01

Historical Streamflow Data

NANOOSE CREEK AT THE MOUTH - STATION NO. 08HB039

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1970	---	---	---	0.353	0.083	0.017	0.010	0.010	0.012	---	---	---	---
1971	---	---	---	0.797	0.170	0.076	0.041	0.014	0.024	---	---	---	---
1972	---	---	---	0.663	0.122	0.048	0.015	0.006	0.013	---	---	---	---
MEAN	---	---	---	0.604	0.125	0.047	0.022	0.010	0.016	---	---	---	---

LOCATION - LAT 49 15 54 N
LONG 124 12 13 W NATURAL FLOW

NANOOSE CREEK AT THE MOUTH - STATION NO. 08HB039

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

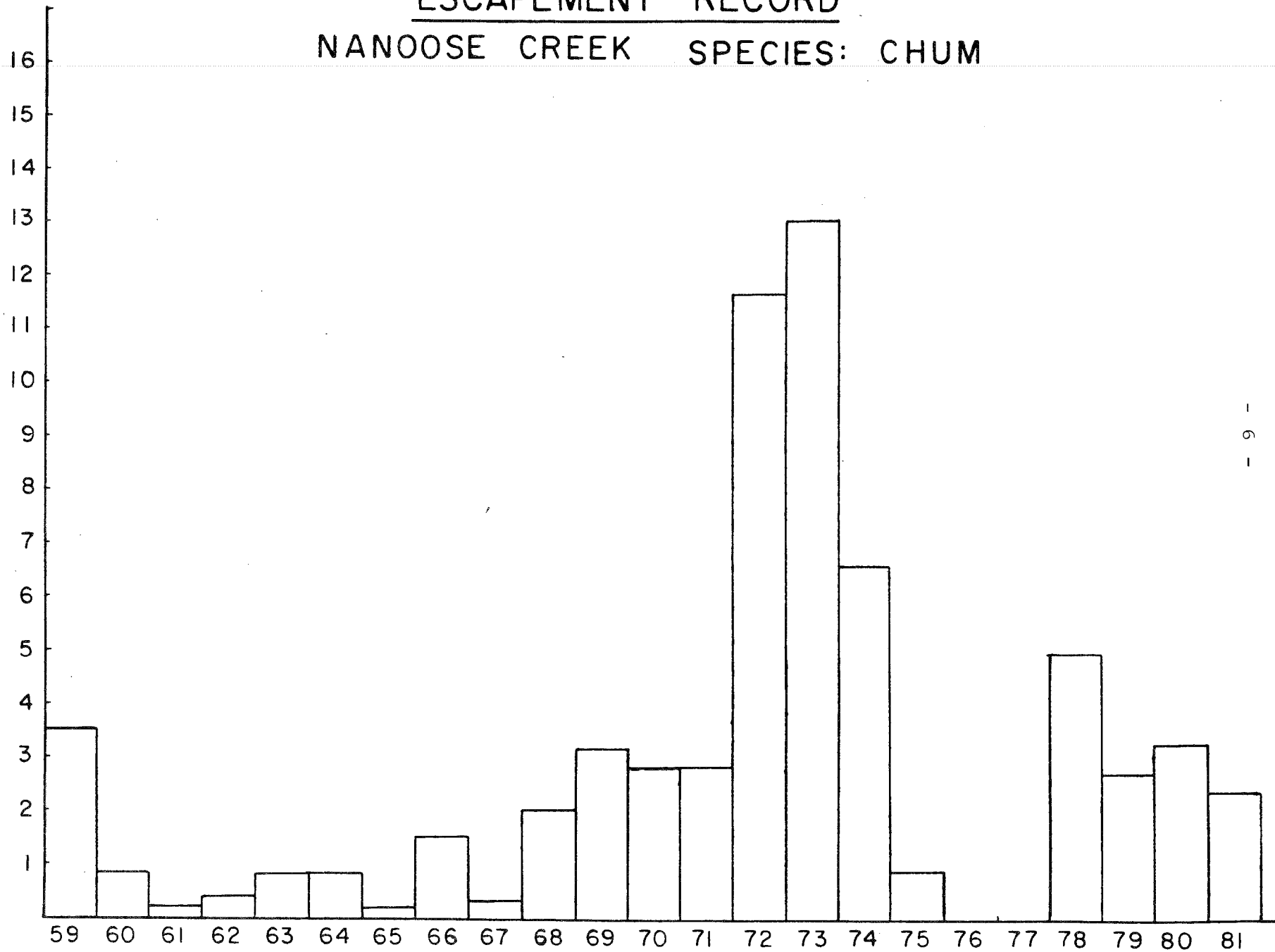
YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m ³ /s)	MAXIMUM DAILY DISCHARGE (m ³ /s)	MINIMUM DAILY DISCHARGE (m ³ /s)	TOTAL DISCHARGE (dam ³)
1970	---	---	0.008 ON JUL 22	---
1971	---	---	0.008 ON AUG 10	---
1972	---	5.15 ON MAR 13 *	0.005 ON AUG 3 *	---
* - EXTREME RECORDED FOR THE PERIOD OF RECORD				---

After; Historical Streamflow Summary, British Columbia to 1979.

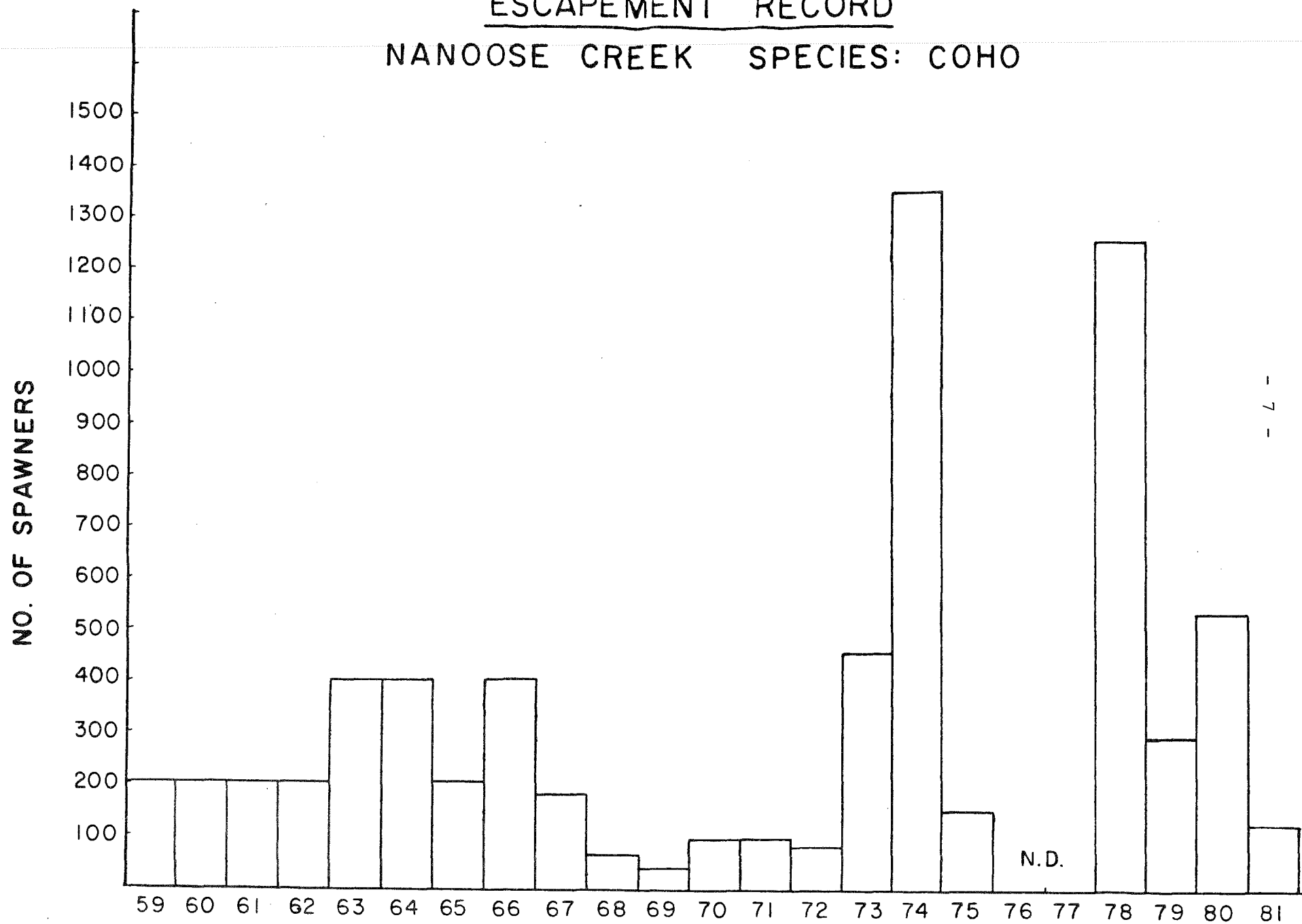
Inland Waters Directorate
Water Resources Branch
Water Survey of Canada
Ottawa, Canada, 1980

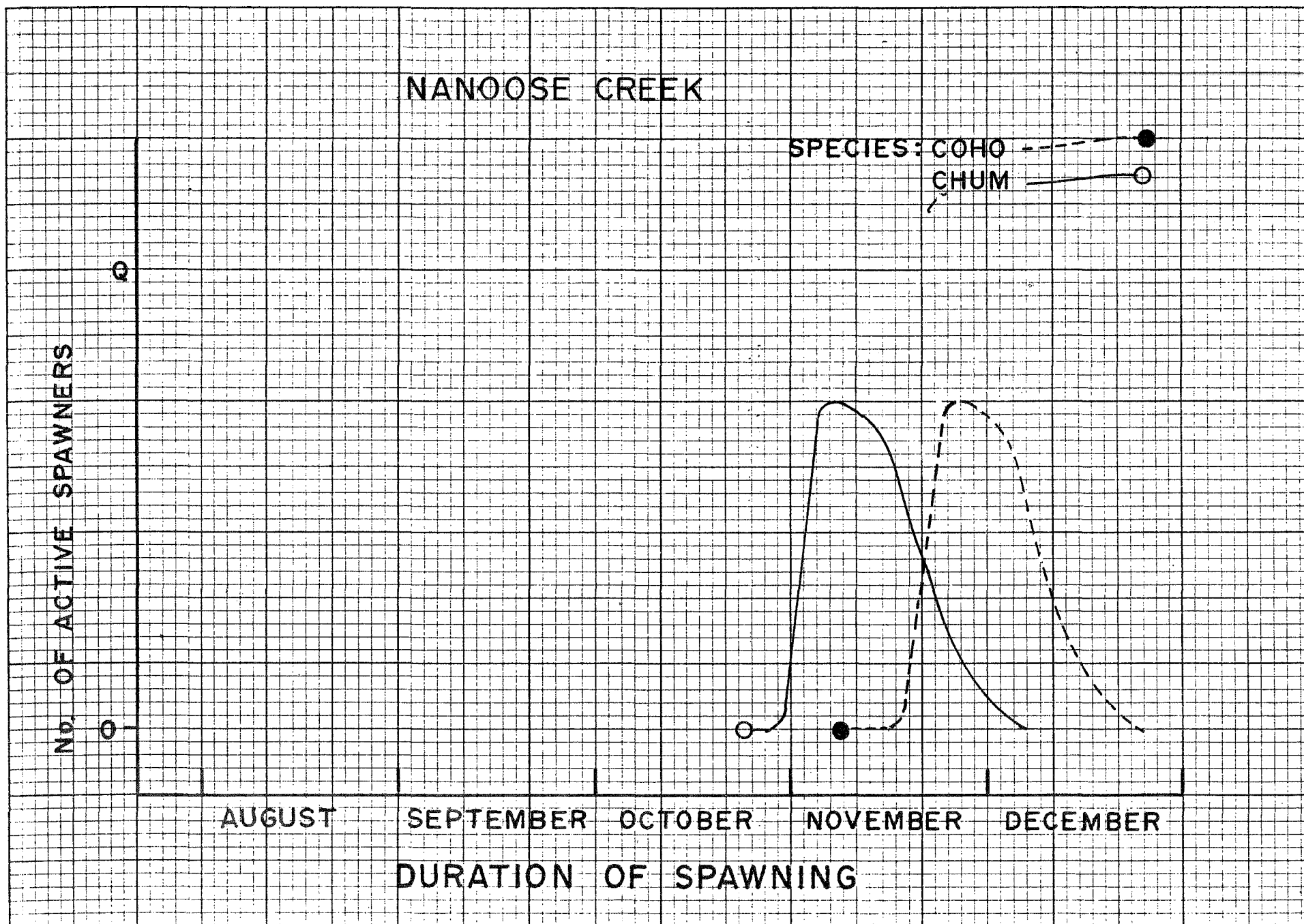
ESCAPEMENT RECORD
NANOOSE CREEK SPECIES: CHUM

NO. OF SPAWNERS (THOUSANDS)



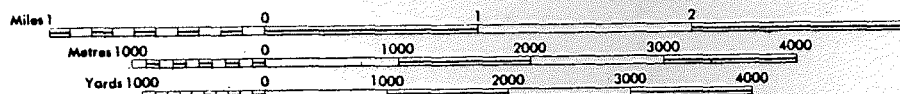
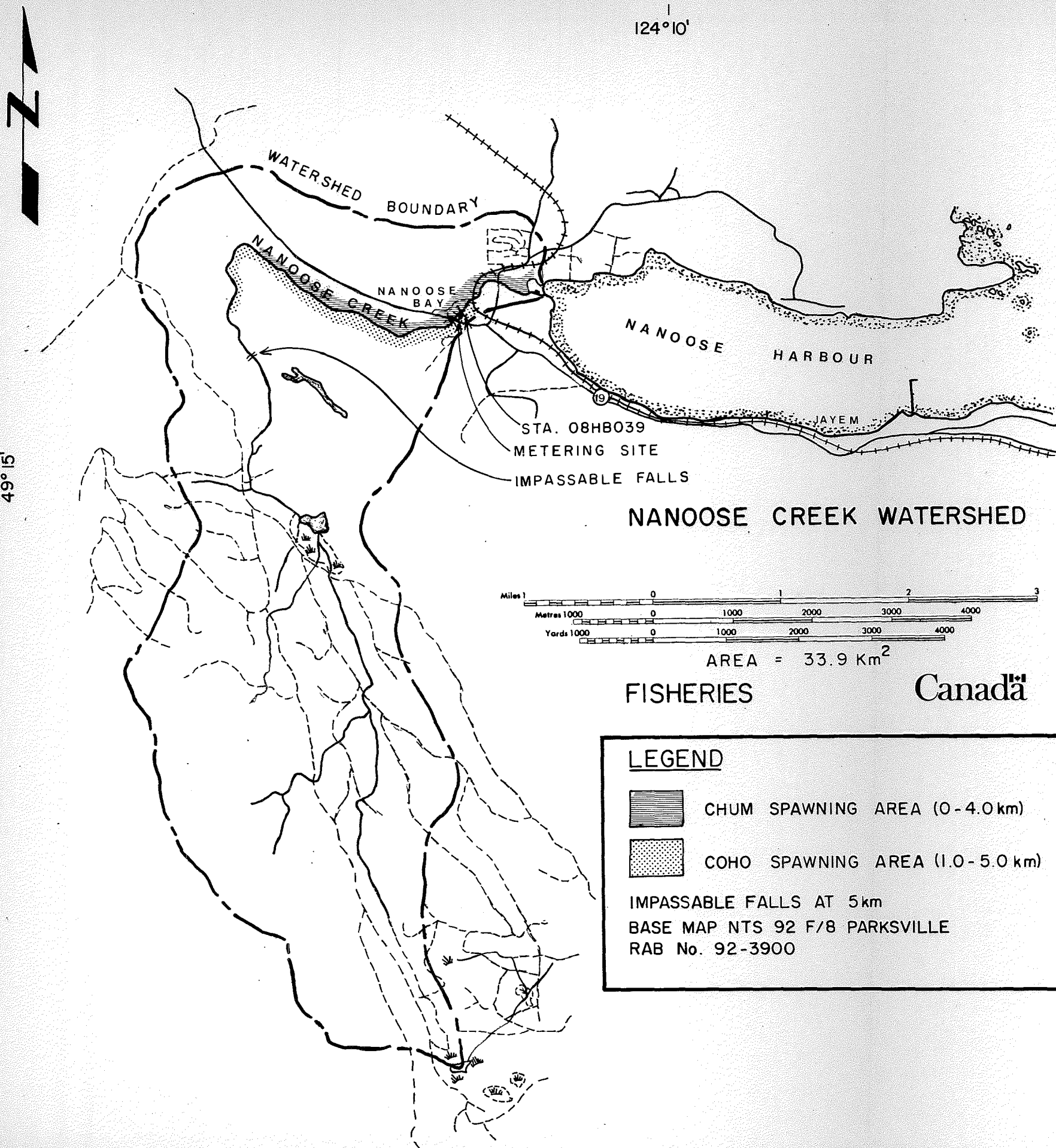
ESCAPEMENT RECORD
NANOOSE CREEK SPECIES: COHO





124°10'

49°15'



AREA = 33.9 km²

FISHERIES

Canada

LEGEND



CHUM SPAWNING AREA (0 - 4.0 km)

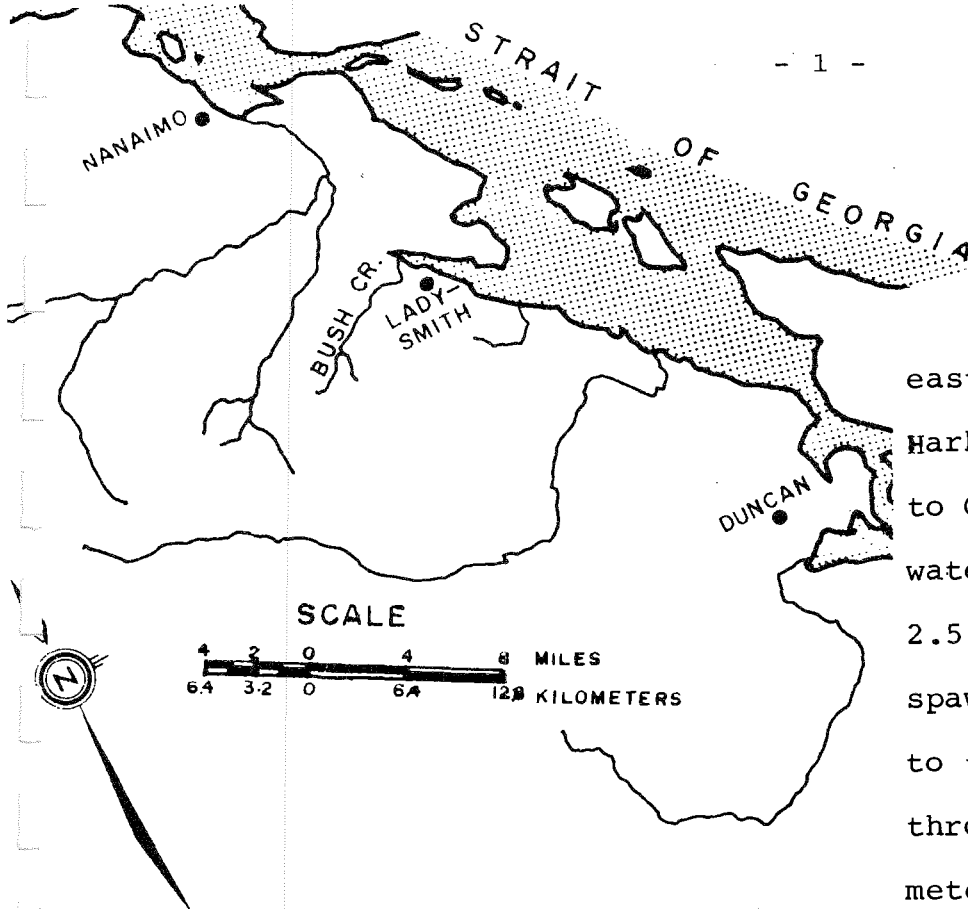


COHO SPAWNING AREA (1.0 - 5.0 km)

IMPASSABLE FALLS AT 5 km

BASE MAP NTS 92 F/8 PARKSVILLE

RAB No. 92-3900



Bush Creek

General Description

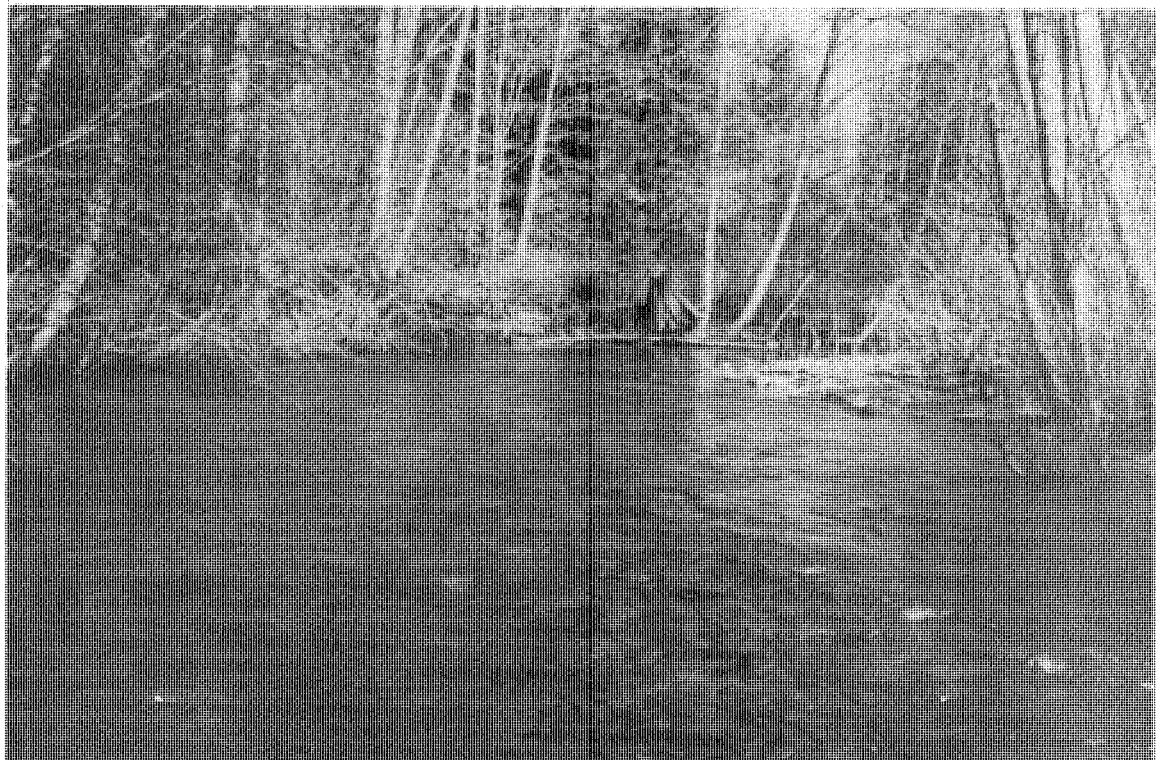
Flowing from Coronation Lake eastward 13 kilometers to Ladysmith Harbour, this system is accessible to Coho and Chum salmon from tide-water to an impassable waterfall 2.5 kilometers upstream. Coho spawn from 0.8 kilometers upstream to the falls, Chum from tidewater throughout the initial 1.5 kilometers.

Escapements for Chums in recent years have numbered near 1,000 , down from peak year records of over 6,000 . Escapements for Coho have remained relatively constant for the past 20 years, returns averaging 150 adults.

Between the Island Highway and the mouth, the stream runs through Evergreen Provincial Park, providing good natural cover for rearing and spawning salmon. However, due to ready access to the stream these populations are exposed to molestation from park visitors and juveniles (fishery officer reports). Severe drought flows may be encountered during August and September; adequate flows are present during spawning season, early October through December, for both species present.

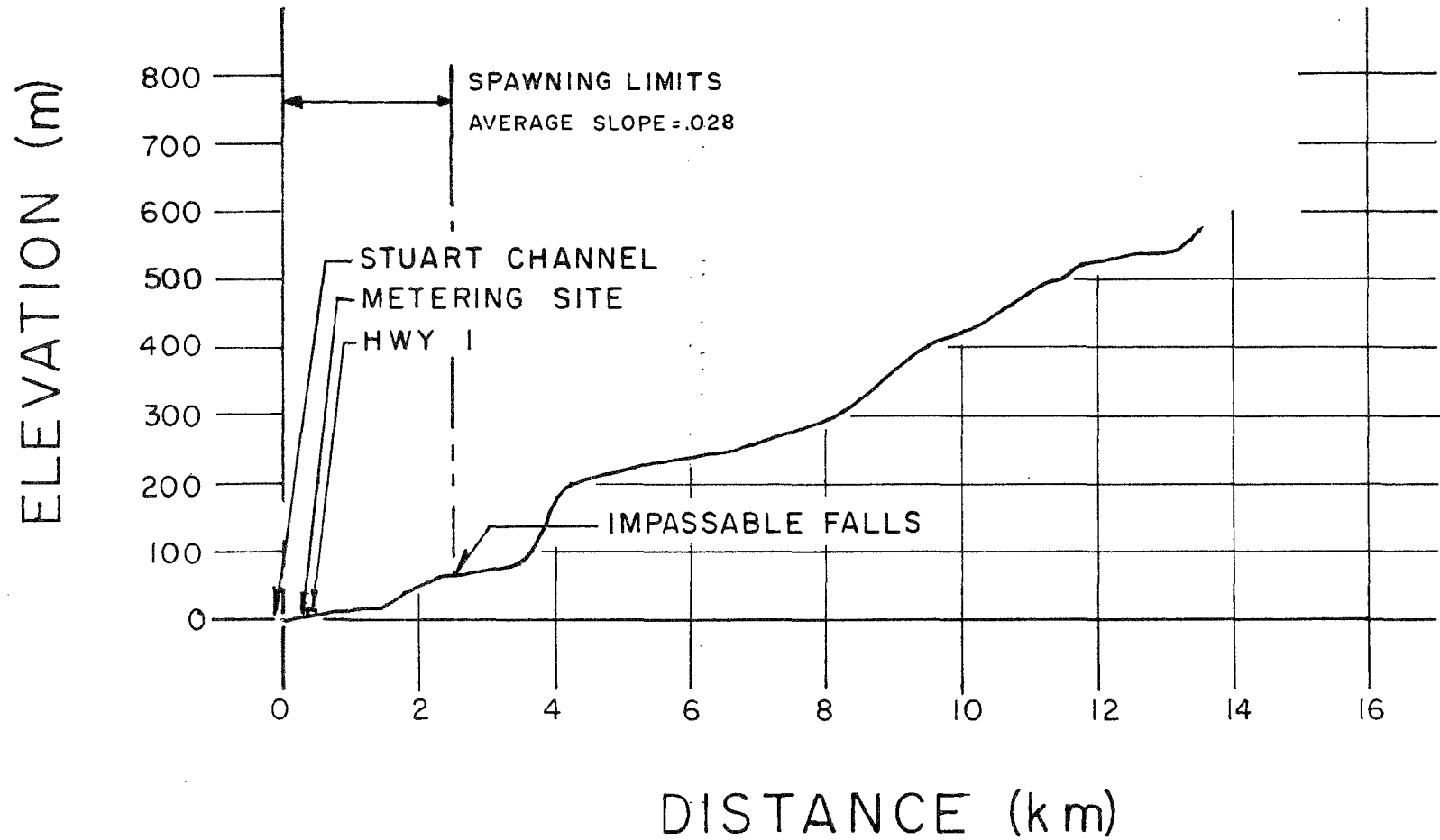


Upstream view above highway



Downstream view below highway

BUSH CREEK PROFILE



BUSH CREEK - CROSS SECTION

ELEVATION meters

VERTICAL SCALE - 1:20

31.0

30.0

29.0

28.0

SEE ATTACHED MAP FOR
LOCATION OF CROSS SECTION

WATER LEVEL

28.77 (m)

JULY, 28/82

28.76 (m)

$Q = .060 \text{ m}^3/\text{s}$

meters

HORIZONTAL SCALE - 1:100

Watershed Data

Hydrometric Station # Ungauged. Bush Creek

Watershed Area	(A)	24.5 km ²
Mean Elevation	(H)	565 m
First Order Length	(L ₁)	1.2 km
All Orders	(L _T)	13.2 km
Average Precipitation	(AP)	2300 mm/year
Average Annual Flow	(QAA)	Not Available

For The Period June 1 - Nov. 30:

Average Flow of Lowest Month	Not Available
7 Day Low Flow, 2 year recurrence (Q7L2)	0.053 m ³ /sec
7 Day Low Flow, 20 year recurrence (Q7L20)	0.013 m ³ /sec
Variability (Q7L20/Q7L2)	0.25
Yield (Q7L2/A)	0.0022 m ³ sec ⁻¹ /km ²

SUMMARY

Estimated Fishery Flow Requirements

A. Spawning Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Coho)	No data
Collings Method	
Preferred Flow (All Species)	2.05
Sustained Flow (All Species)	1.65
Actual Average Flow At	
Peak Spawning Time	
Chum	No data
Coho	No data

B. Rearing Flow

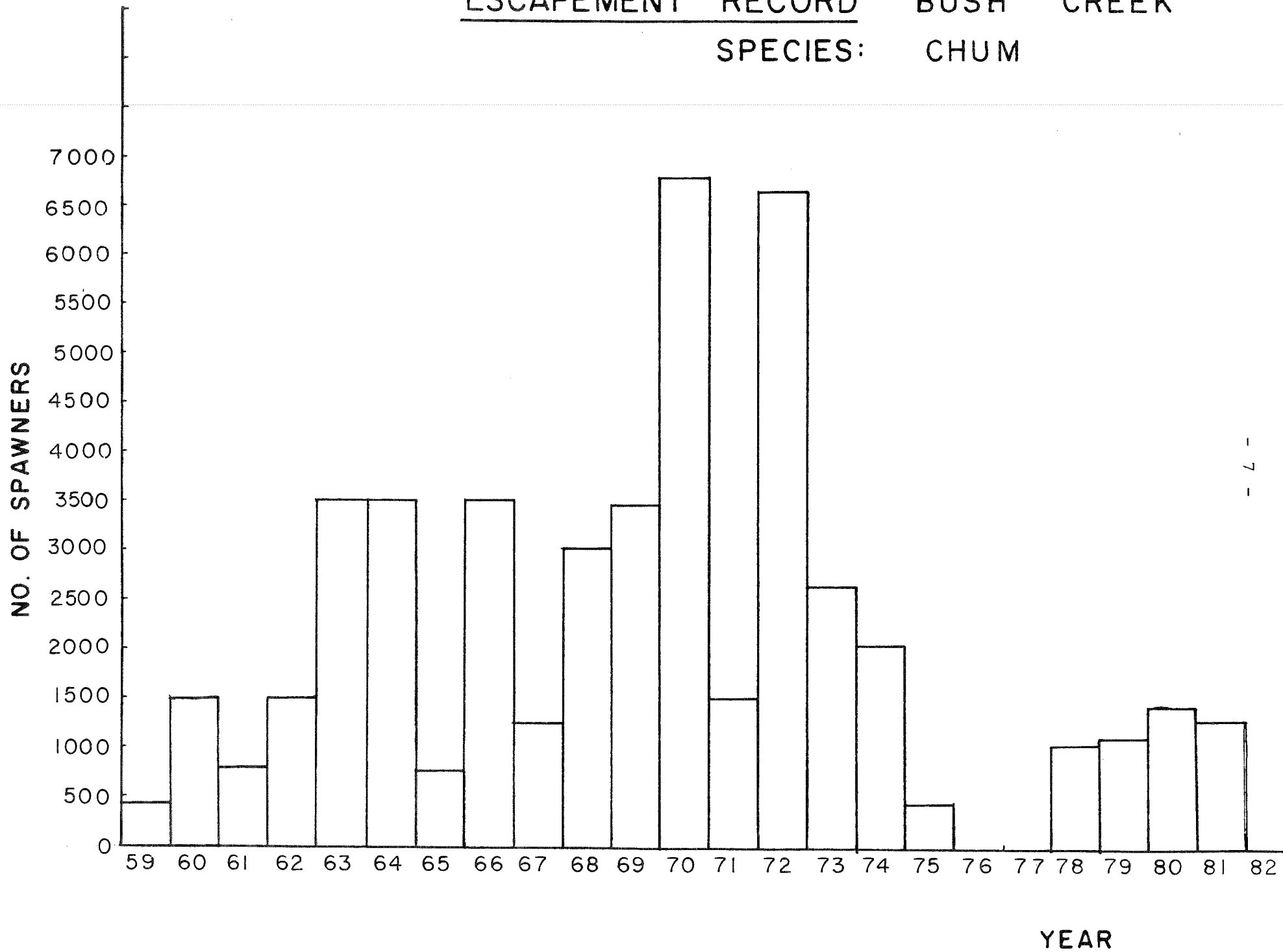
	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Based on Surface Width)	No data
Collings Method	
Optimum Flow (All Species)	0.74
Average Flow of Lowest Month	
(Jan. 1-Dec. 31)	No data
Average Flow of Lowest Month	
(June 1-Nov. 30)	No data

ESCAPEMENT RECORD

BUSH CREEK

SPECIES:

CHUM

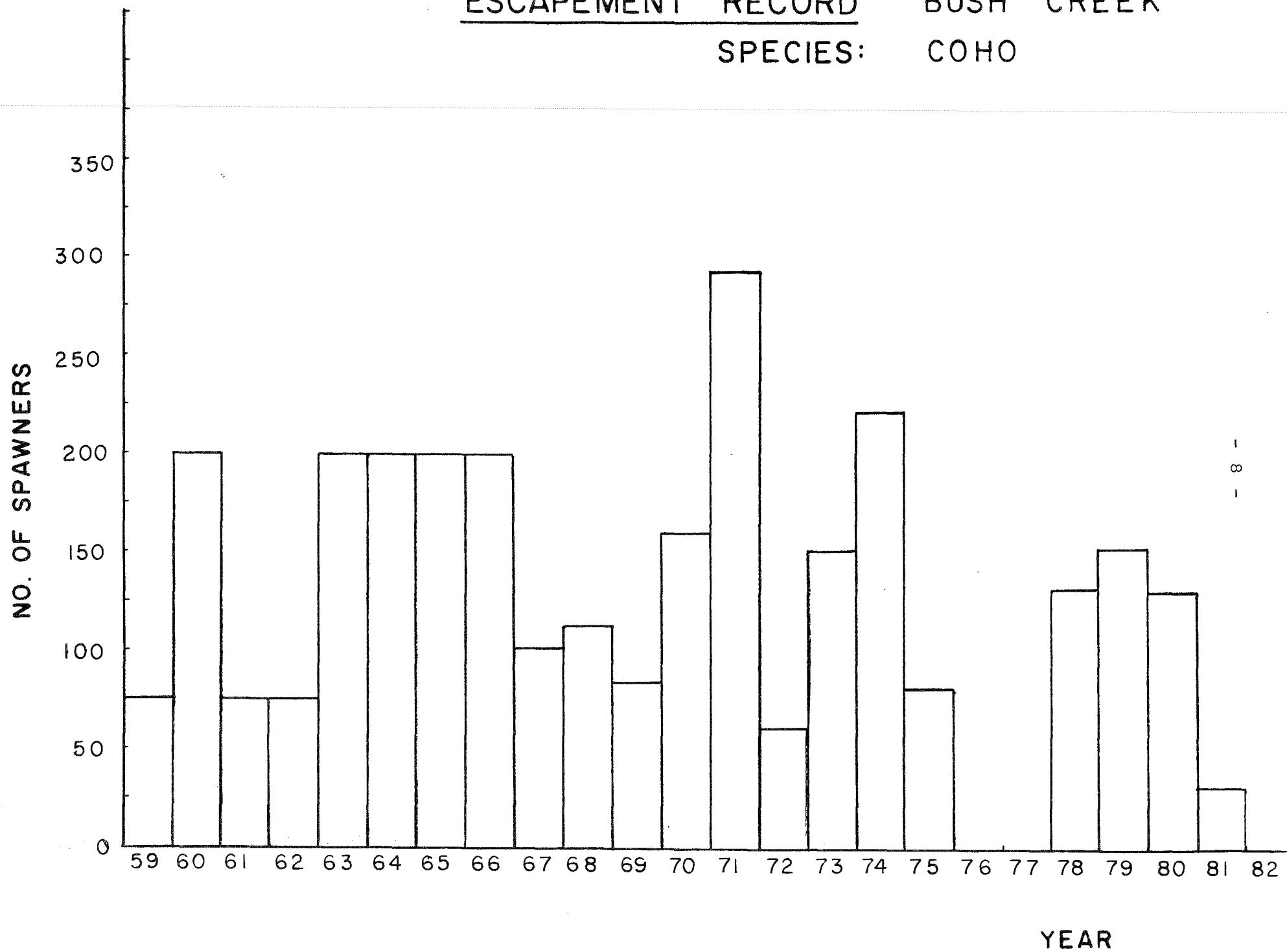


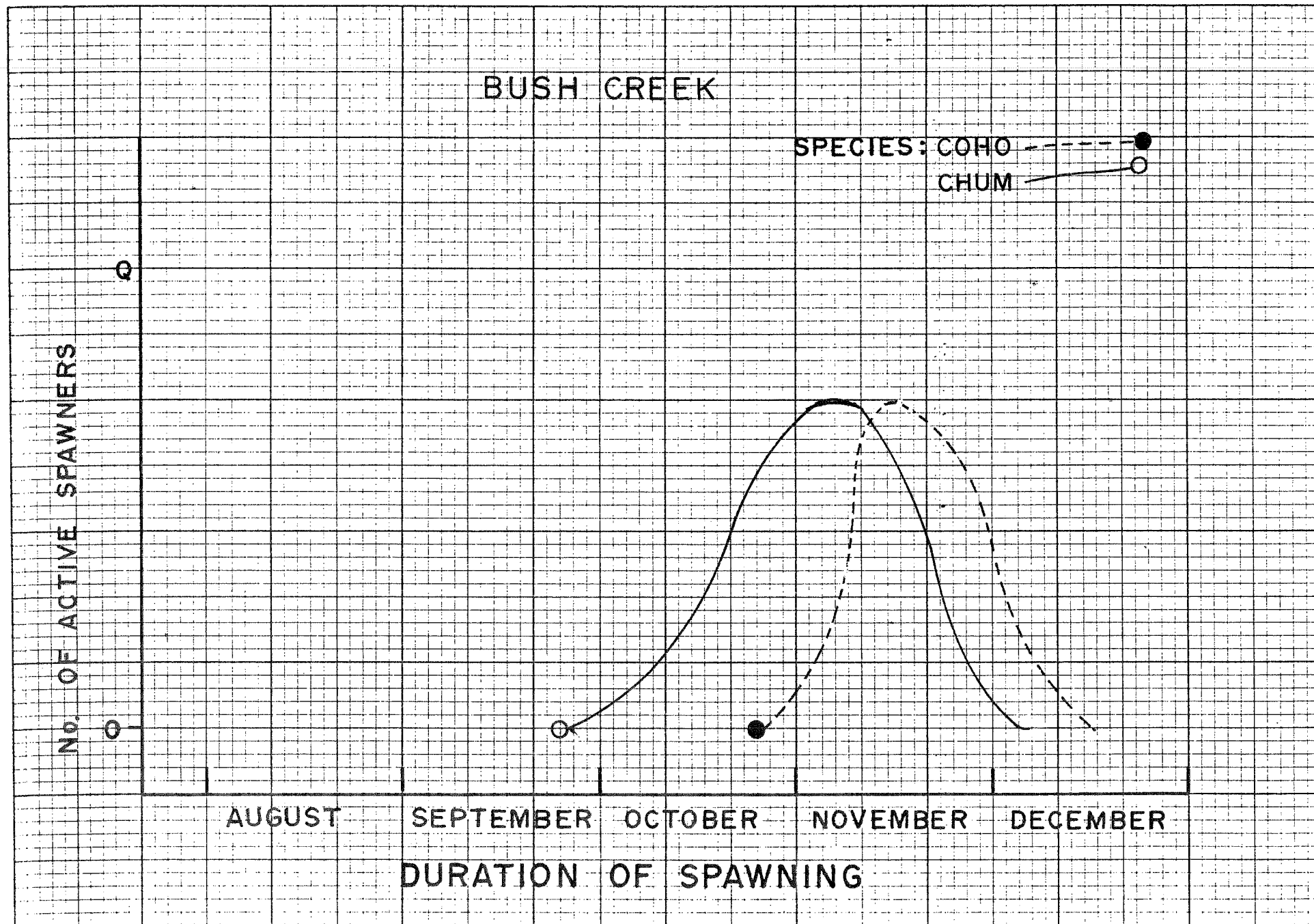
ESCAPEMENT RECORD

BUSH CREEK

SPECIES:

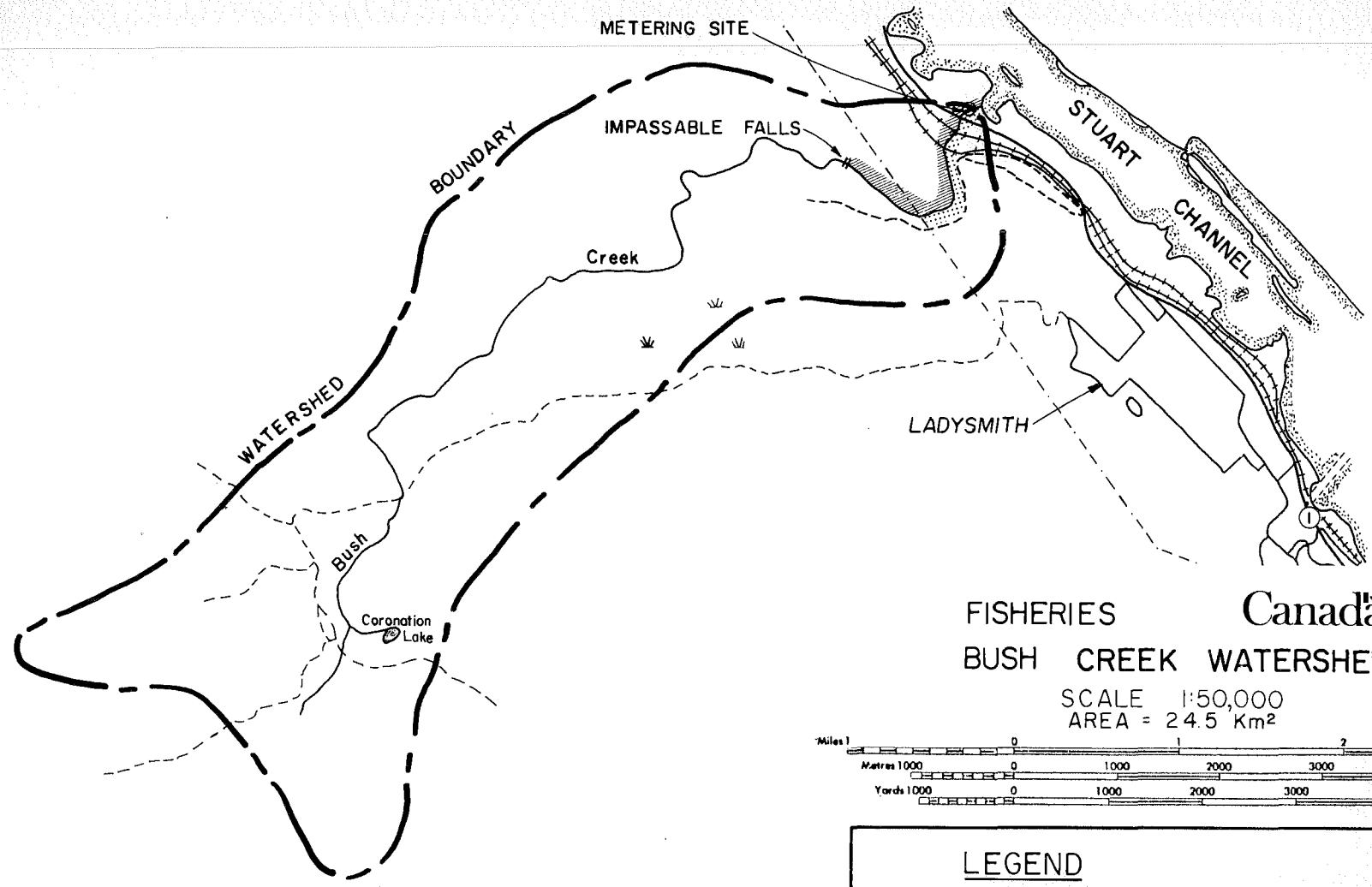
COHO





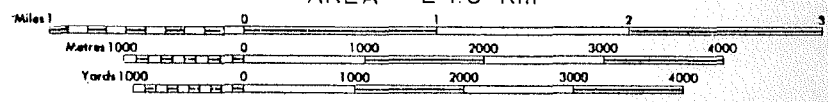
49° 00'

124° 50'



FISHERIES Canada
BUSH CREEK WATERSHED

SCALE 1:50,000
AREA = 24.5 Km²



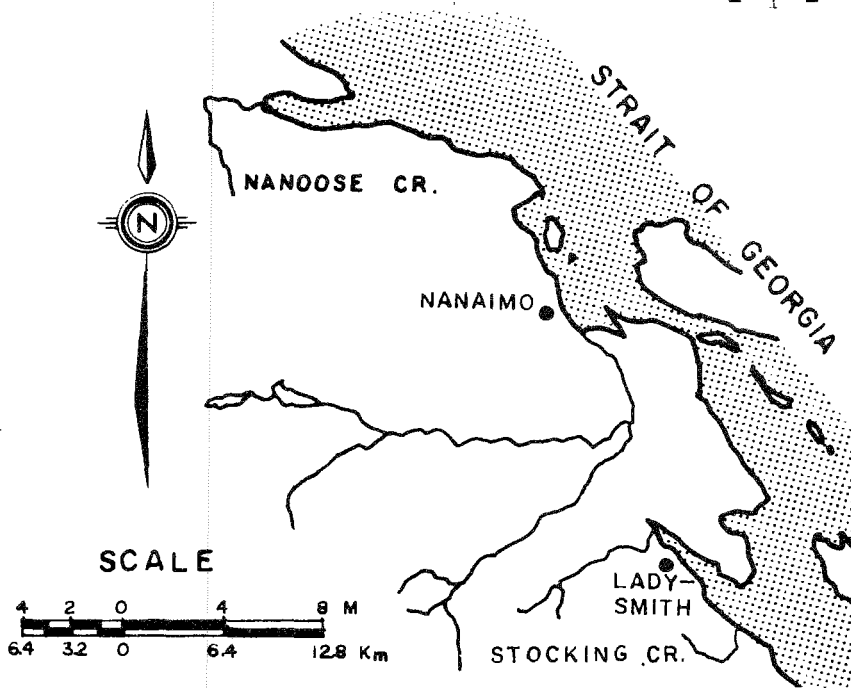
LEGEND

- CHUM SPAWNING AREA (0 - 1.5 km)
- COHO SPAWNING AREA (0 - 0.8 km)

BASE MAP NTS 92 B/13 DUNCAN
RAB No. 92 - 4600

Stocking Creek

General Description



Flowing into Stuart Channel south of the village of Ladysmith, this small system supports a significant run of Chum and a small number of Coho salmon. Spawning area is limited by an impassable falls 0.7 kilometers from tide-water, good ground is found

throughout this lower portion of the stream and returns of up to 7000 adult Chum have been reported. Escapements of up to 4000 Chum have been common in recent years and fishery officers have noted conditions of injurious over-crowding and spoiling of previously spawned ground in peak years.

Stocking Creek is used as a domestic water supply for the villages of Ladysmith and Saltair. As a result, during summer months discharges below Stocking Lake can be very low, however, during fall migration periods a four inch valve on the main water line is opened to allow additional flow into the natural channel (1970).

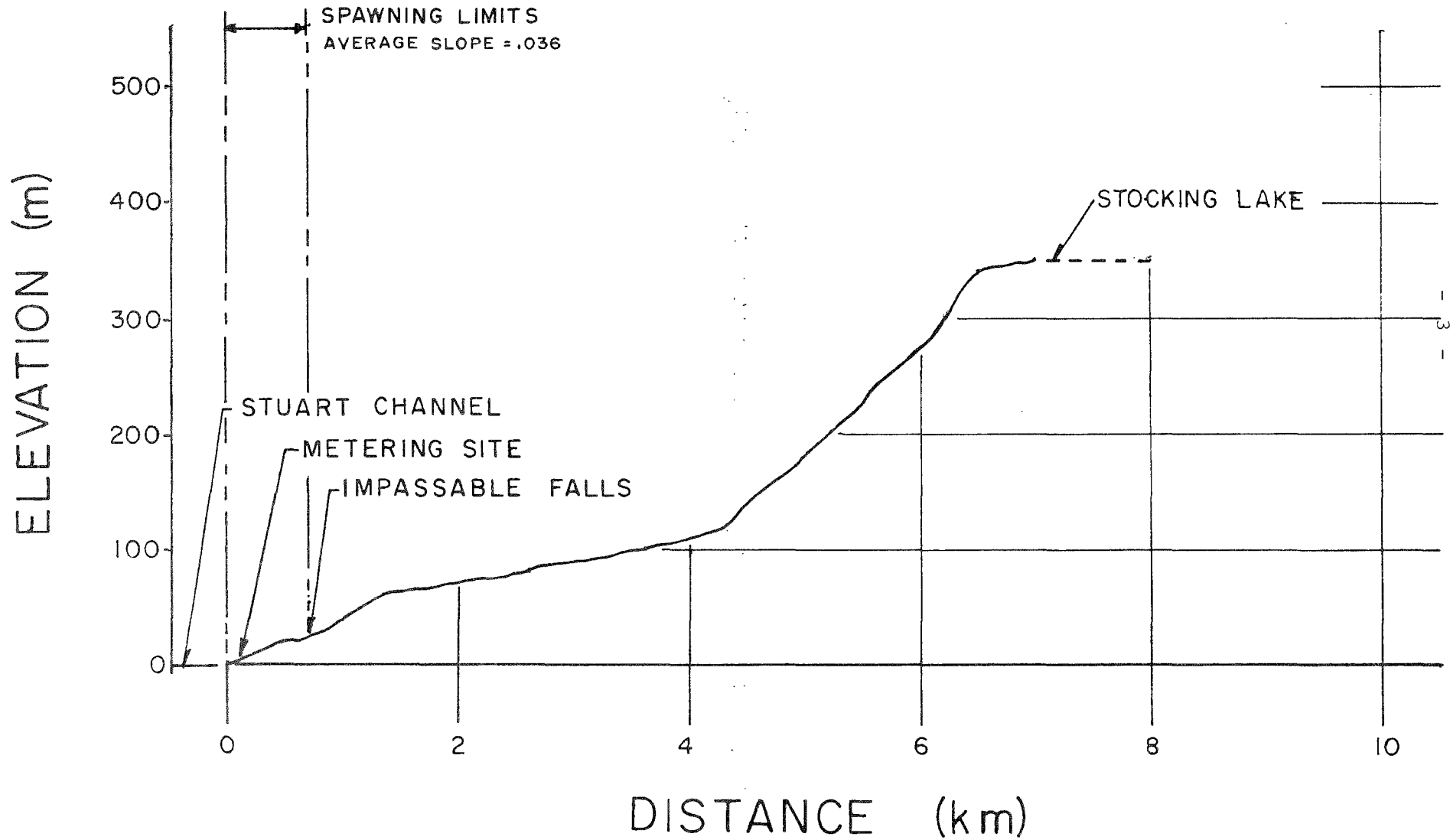


Mouth of Stocking Creek (Davis Lagoon).



Downstream view below highway.

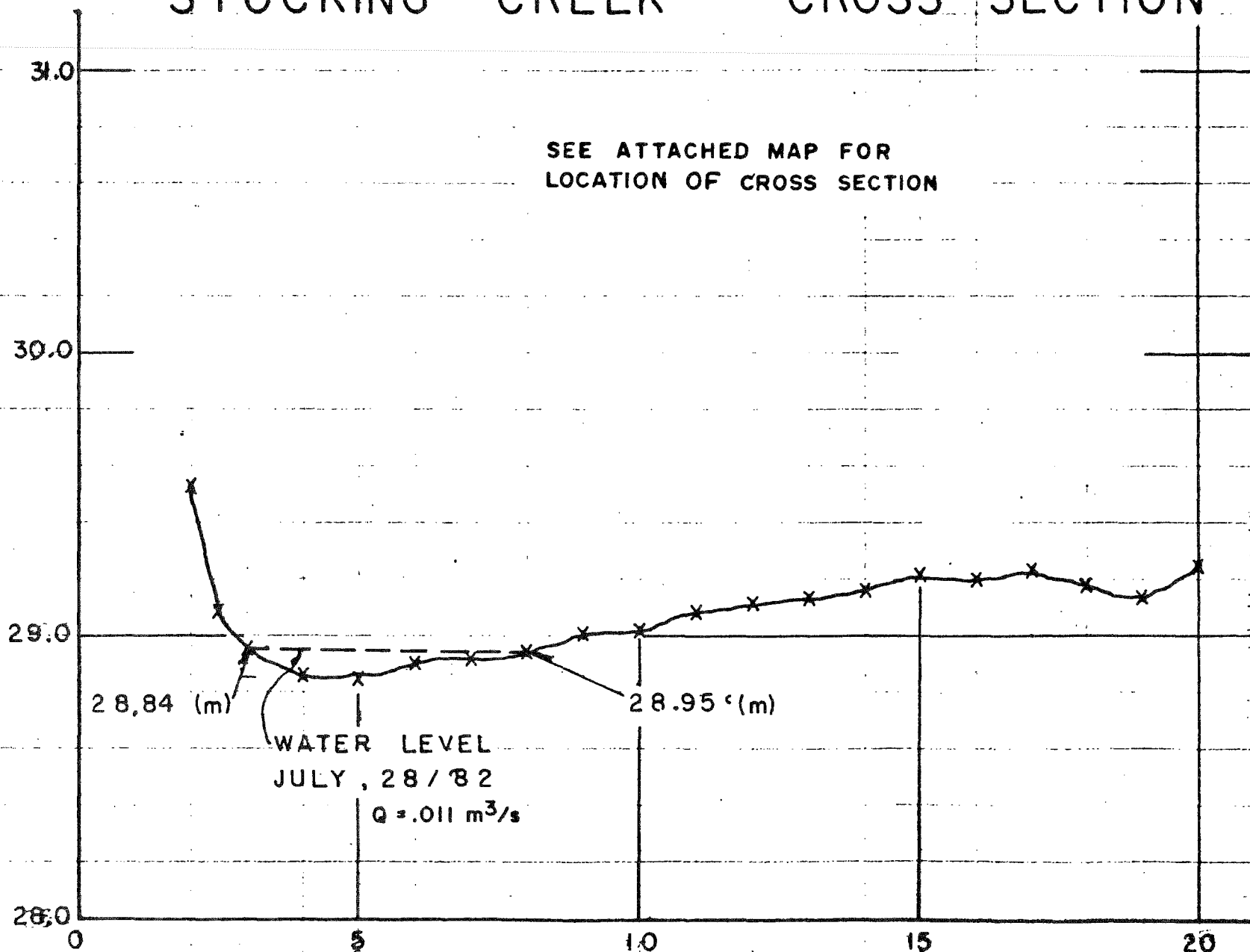
STOCKING CREEK PROFILE



STOCKING CREEK - CROSS SECTION

SEE ATTACHED MAP FOR
LOCATION OF CROSS SECTION

ELEVATION (m)
VERTICAL SCALE 1:20



HORIZONTAL SCALE 1:100

Watershed Data

Hydrometric Station # Ungauged. Stocking Creek

Watershed Area	(A)	13.6 km ²
Mean Elevation	(H)	360 m
First Order Length	(L ₁)	0.5 km
All Orders	(L _T)	9.5 km
Average Precipitation	(AP)	2300 mm/year
Average Annual Flow	(QAA)	Not Available

For The Period June 1 - Nov. 30:

Average Flow of Lowest Month	Not Available
7 Day Low Flow, 2 year recurrence (Q7L2)	0.044 m ³ /sec
7 Day Low Flow, 20 year recurrence (Q7L20)	0.0081 m ³ /sec
Variability (Q7L20/Q7L2)	0.18
Yield (Q7L2/A)	0.0032 m ³ sec ⁻¹ /km ²

SUMMARY

Estimated Fishery Flow Requirements

A. Spawning Flow

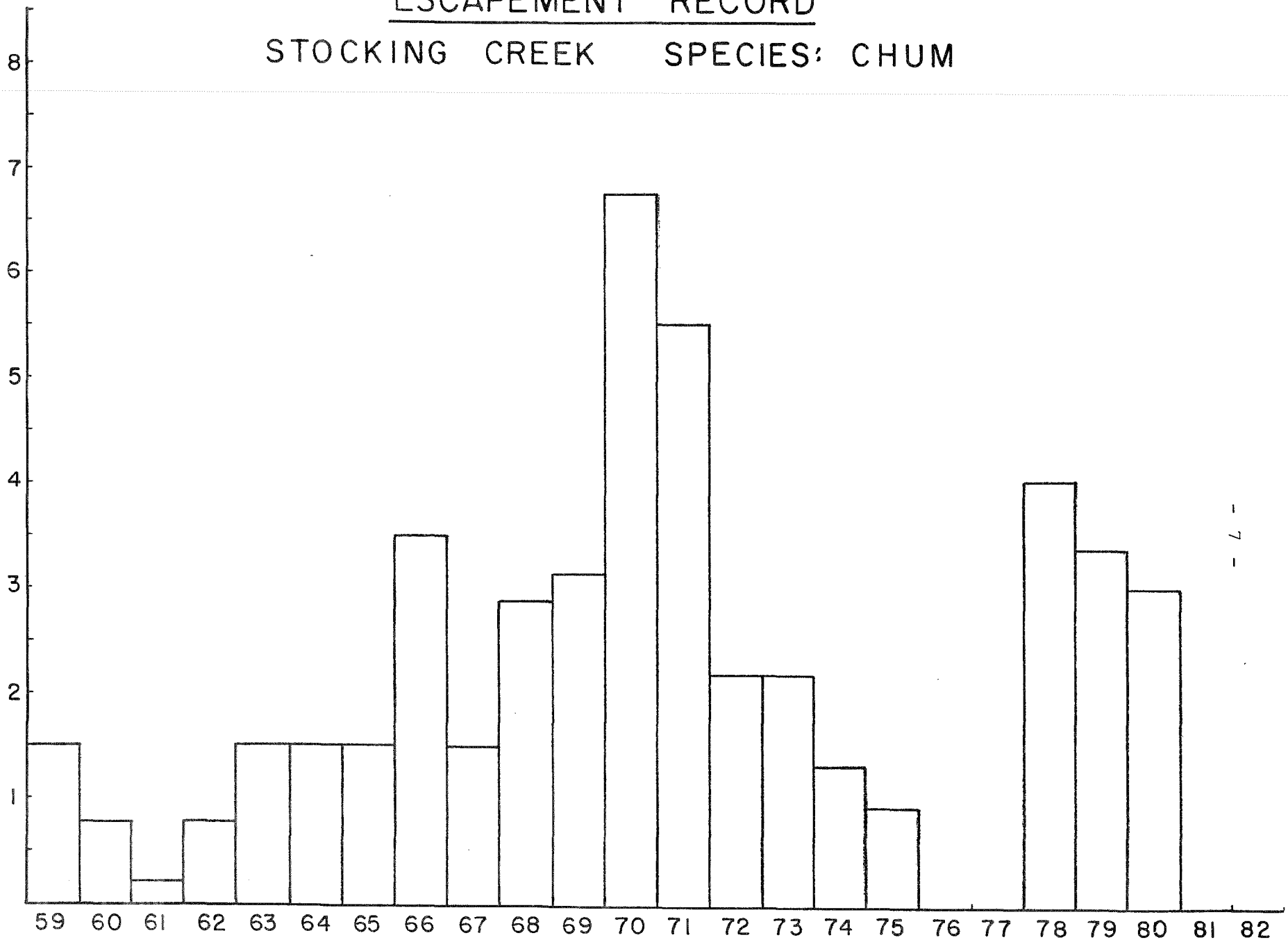
	m ³ /sec
"Streamflow" (Hamilton) Optimum Flow (Coho)	No data
Collings Method Preferred Flow (All Species)	1.44
Sustained Flow (All Species)	1.15
Actual Average Flow At Peak Spawning Time	
Chum	No data
Coho	No data

B. Rearing Flow

	m ³ /sec
"Streamflow" (Hamilton) Optimum Flow (Based on Surface Width)	No data
Collings Method Optimum Flow (All Species)	0.42
Average Flow of Lowest Month (Jan. 1-Dec. 31)	No data
Average Flow of Lowest Month (June 1-Nov. 30)	No data

ESCAPEMENT RECORD
STOCKING CREEK SPECIES: CHUM

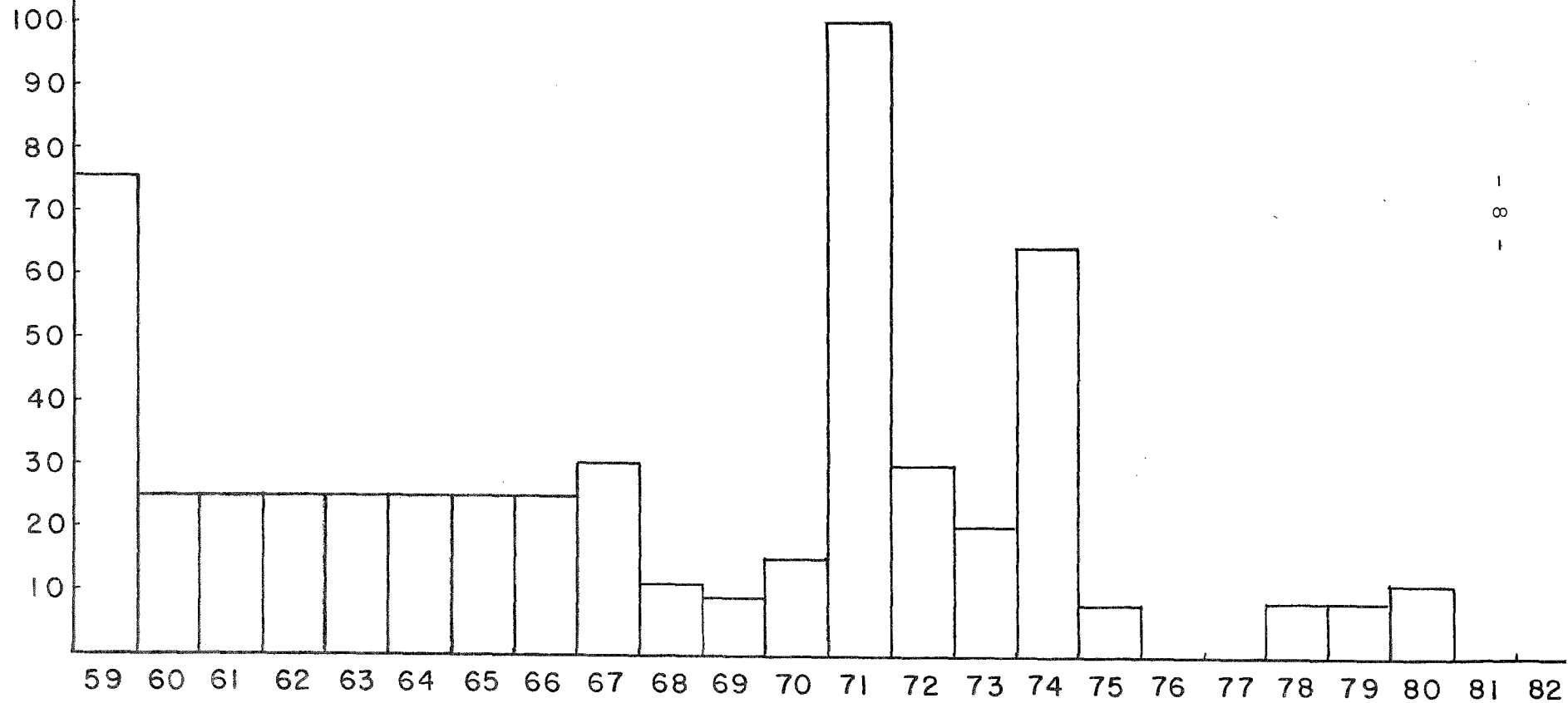
NO. OF SPAWNERS (THOUSANDS)



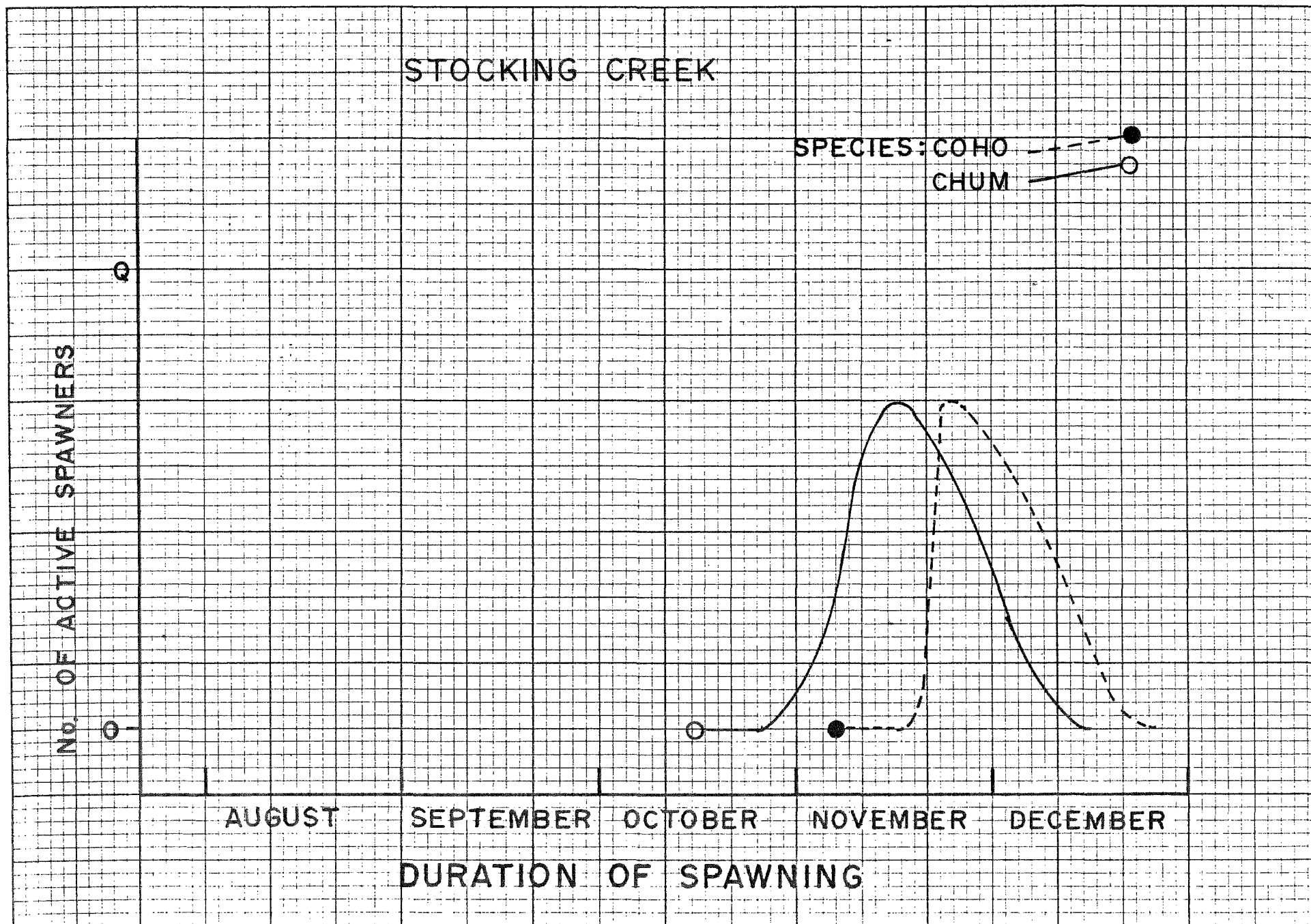
YEAR

ESCAPEMENT RECORD
STOCKING CREEK SPECIES: COHO

NO. OF SPAWNERS

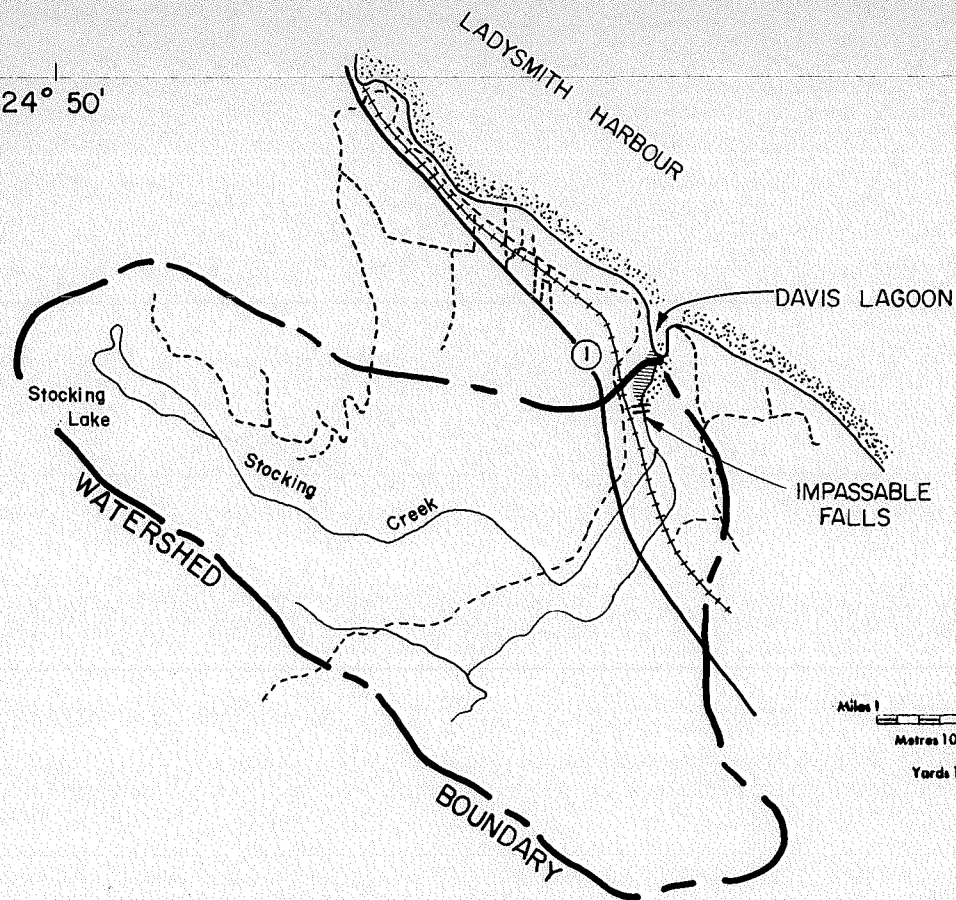


YEAR



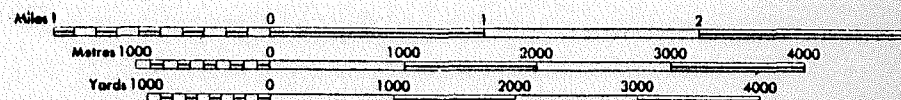
124° 50'

48° 58'



FISHERIES
STOCKING CREEK WATERSHED

Canada



AREA = 13.6 Km²

LEGEND



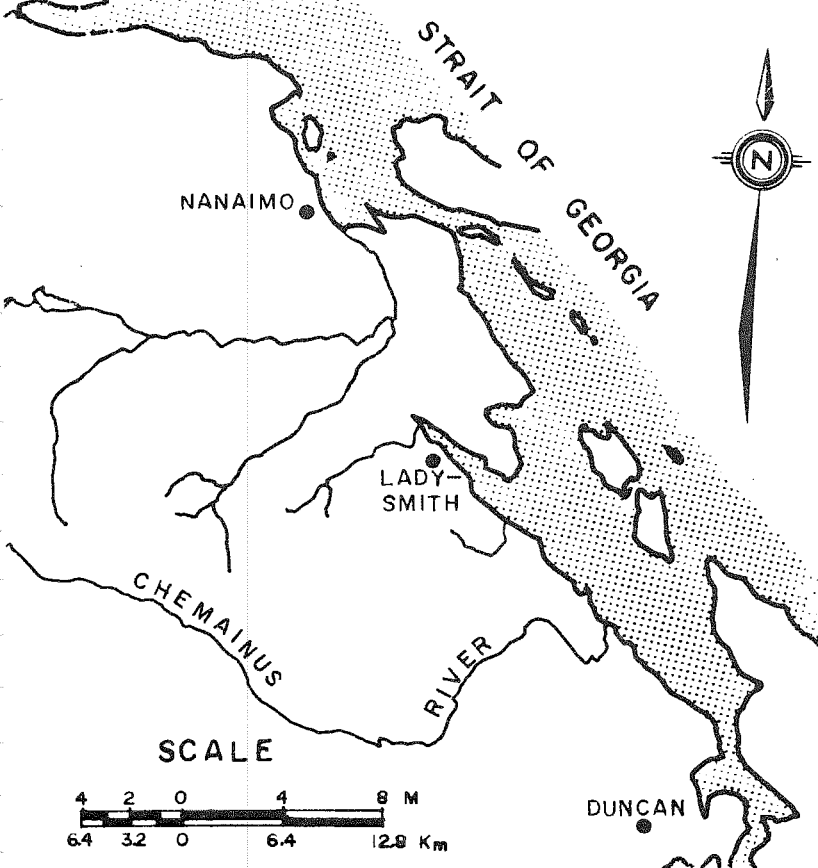
CHUM SPAWNING AREA (0-0.7Km)



COHO SPAWNING AREA (0-0.7Km)

BASE MAP NTS 92 B/13 DUNCAN

RAB No. 92-4650



Chemainus River

General Description

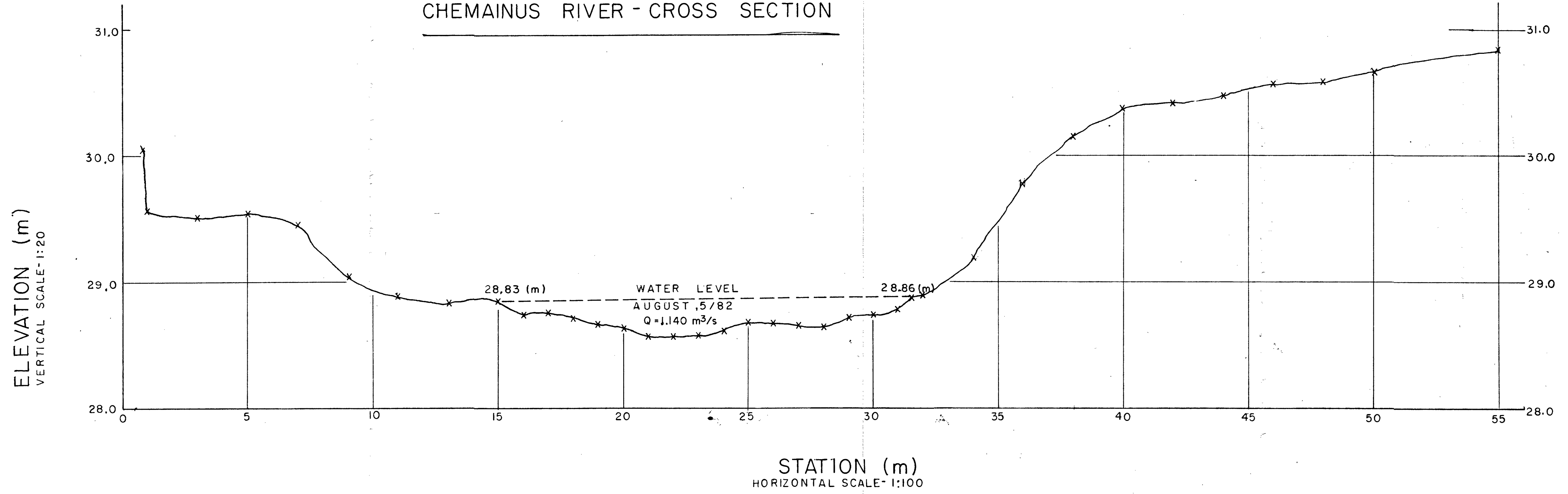
The Chemainus River, located on the east coast of Vancouver Island, flows eastward 53 kilometers from its headwaters into Stuart Channel, just south of Chemainus. Extensive logging in the upper drainage area causes extreme fluctuation in temperature and flow.

The lower river is bordered by farm land and second growth forest. 12 kilometers from the mouth, Copper Canyon presents a total barrier to Chum salmon. Good gravel begins 2 kilometers above the Island Highway bridge and extends to tide water. The 3 kilometers below the bridge contain extensive gravel suitable for spawning and rearing.



Downstream view below highway bridge.

CHEMAINUS RIVER - CROSS SECTION



Watershed Data

Hydrometric Station # 08HA001 Chemainus River

Watershed Area	(A)	357.2 km ²
Mean Elevation	(H)	680 m
First Order Length	(L ₁)	101.5 km
All Orders	(L _T)	255.8 km
Average Precipitation	(AP)	2300 mm/year
Average Annual Flow	(QAA)	18.9 m ³ /sec

For The Period June 1 - Nov. 30:

Average Flow of Lowest Month (August)	1.24 m ³ /sec
7 Day Low Flow, 2 year recurrence (Q7L2)	0.49 m ³ /sec
7 Day Low Flow, 20 year recurrence (Q7L20)	0.16 m ³ /sec
Variability (Q7L20/Q7L2)	0.33
Yield (Q7L2/A)	0.0014 m ³ sec ⁻¹ /km ²

SUMMARY

Estimated Fishery Flow Requirements

A. Spawning Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Coho)	5.00
Collings Method	
Preferred Flow (All Species)	8.54
Sustained Flow (All Species)	7.20
Actual Average Flow At	
Peak Spawning Time	
Chinook	4.26
Chum	25.27
Coho	43.31

B. Rearing Flow

	m ³ /sec
"Streamflow" (Hamilton)	
Optimum Flow (Based on Surface Width)	No data
Collings Method	
Optimum Flow (All Species)	2.98
Average Flow of Lowest Month	
(Jan. 1-Dec. 31)	1.24
Average Flow of Lowest Month	
(June 1-Nov. 30)	1.24

Historical Streamflow Data

CHEMAINUS RIVER NEAR WESTHOLME - STATION NO. 08HA001													
MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD													
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1914	---	---	---	---	---	5.74	2.17	0.705	3.07	37.6	62.2	12.3	---
1915	25.9	20.2	23.8	26.4	7.17	4.18	1.63	0.680	0.425	22.5	25.4	51.3	17.5
1916	7.84	38.8	39.6	36.7	33.5	27.5	9.70	1.54	0.569	1.74	13.5	12.2	18.5
1917	19.1	17.1	9.18	---	---	---	---	---	---	---	---	---	---
1952	---	---	---	---	---	---	---	---	---	---	---	28.0	---
1953	73.9	31.7	16.1	18.5	16.9	6.60	2.34	0.785	3.41	14.9	46.9	50.2	23.5
1954	39.9	76.2	35.2	---	---	---	9.56	1.74	6.50	11.6	57.6	38.7	---
1955	20.2	14.7	10.5	24.9	18.9	11.0	4.83	2.71	0.705	18.1	33.2	23.3	15.2
1956	24.3	5.57	20.4	30.0	31.2	21.2	4.13	0.636	1.79	20.7	18.0	39.7	17.9
1957	19.9	23.6	36.4	19.3	9.08	2.43	2.80	4.22	2.58	5.14	6.32	25.4	13.1
1958	42.8	36.6	17.5	23.8	7.40	2.80	0.664	0.344	1.89	12.3	26.5	70.2	20.2
1959	53.3	13.7	18.6	38.4	17.2	5.77	2.29	1.38	3.38	9.78	29.5	30.1	18.6
1960	24.6	37.4	17.5	31.1	16.4	6.43	1.38	0.760	0.869	10.1	26.8	31.2	17.0
1961	61.4	65.6	35.1	17.7	16.4	4.20	1.22	0.410	1.09	13.8	25.6	41.0	23.4
1962	36.4	14.7	10.7	26.9	15.7	6.90	1.69	2.18	1.30	19.2	63.1	63.2	21.8
1963	18.5	37.9	21.3	19.2	11.5	1.84	1.48	0.678	0.367	24.4	34.9	36.4	17.2
1964	41.1	24.3	19.0	19.4	15.8	11.9	4.03	1.61	2.19	7.39	13.8	18.5	14.9
1965	19.7	38.9	14.9	15.6	10.6	2.67	0.698	0.469	0.381	18.8	31.8	45.7	16.6
1966	41.7	25.0	34.5	28.2	15.0	6.18	2.71	0.682	0.792	9.81	33.5	72.5	22.6
1967	54.3	29.8	28.8	16.0	18.8	7.13	1.11	0.351	0.393	22.5	23.2	46.3	20.7
1968	99.2	50.3	33.8	13.6	10.3	4.93	1.41	1.29	4.55	27.0	31.9	26.4	25.4
1969	12.9	12.0	23.5	39.7	28.1	8.04	1.68	1.08	5.24	6.93	18.2	44.6	16.9
1970	25.9	26.6	23.4	23.3	8.80	2.80	0.759	0.222	0.816	8.66	18.0	42.1	15.1
1971	49.3	50.4	29.0	33.1	42.5	15.4	5.59	1.31	1.46	8.74	24.9	17.5	23.1
1972	---	---	---	---	---	---	---	---	---	---	---	74.0	---
1973	44.1	17.7	12.8	7.89	8.68	5.47	1.92	0.531	0.631	6.92	---	---	---
1974	---	32.8	67.1	32.7	25.9	16.2	7.75	1.27	0.692	0.867	---	---	---
1975	22.5	13.6	24.7	21.0	29.3	9.64	2.17	3.52	2.32	36.8	74.4	65.1	25.5
1976	46.1	24.0	19.8	31.5	24.9	12.5	3.90	3.02	2.39	2.73	11.6	30.3	17.7
1977	12.3	25.0	23.1	18.2	7.09	3.21	0.945	0.303	1.83	8.73	77.1	25.2	16.8
1978	18.3	22.7	25.8	11.6	7.22	1.76	0.751	1.13	8.29	4.09	10.6	15.6	10.7
1979	5.43	30.3	42.3	16.6	12.8	2.56	0.986	0.407	4.75	16.0	10.4	125	22.4
MEAN	34.3	29.6	25.3	23.8	17.3	7.82	2.84	1.24	2.23	14.1	31.3	41.5	18.9
LOCATION - LAT 48 52 51 N DRAINAGE AREA 355 km ²													
LONG 123 41 10 W NATURAL FLOW													

CHEMAINUS RIVER NEAR WESTHOLME - STATION NO. 08HA001				
ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD				
YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m ³ /s)	MAXIMUM DAILY DISCHARGE (m ³ /s)	MINIMUM DAILY DISCHARGE (m ³ /s)	TOTAL DISCHARGE (dam ³)
1914	---	---	0.396 ON SEP 3	---
1915	---	174 ON DEC 8	0.311 ON SEP 3	---
1916	---	172 ON FEB 15	0.396 ON SEP 23	551 000
1917	---	---	---	584 000
1952	---	---	---	---
1953	---	198 ON JAN 9	0.365 ON SEP 21	741 000
1954	---	194 ON NOV 19	0.917 ON AUG 17	---
1955	---	320 E ON NOV 3	0.227 ON SEP 12	480 000
1956	---	175 ON DEC 9	0.071 ON DEC 2	565 000
1957	---	170 ON FEB 24	0.838 ON OCT 8	412 000
1958	---	153 ON DEC 1	0.227 ON AUG 25	616 000
1959	---	160 ON DEC 17	1.08 ON SEP 3	588 000
1960	---	258 ON JAN 29	0.510 ON AUG 12	536 000
1961	---	275 E ON JAN 15	0.207 ON AUG 29	718 000
1962	---	242 ON NOV 19	0.227 ON AUG 2	688 000
1963	---	241 E ON OCT 21	0.227 ON SEP 12	544 000
1964	---	169 ON NOV 10	0.892 ON SEP 13	471 000
1965	---	188 ON FEB 4	0.283 ON SEP 12	521 000
1966	---	224 E ON DEC 13	0.408 ON AUG 23	712 000
1967	---	189 ON JAN 28	0.227 ON AUG 28	655 000
1968	---	456 ON JAN 19	0.561 ON AUG 7	804 000
1969	---	104 ON DEC 17	1.02 ON AUG 22	532 000
1970	---	202 ON APR 9	0.127 ON AUG 25	475 000
1971	---	241 ON FEB 14	0.963 ON AUG 15	729 000
1972	---	---	---	---
1973	---	---	0.368 ON SEP 16	---
1974	---	---	0.481 ON SEP 26	---
1975	---	---	---	---
1976	---	106 ON DEC 27	0.524 ON AUG 13	804 000
1977	---	140 ON DEC 26	1.13 ON OCT 23	560 000
1978	---	240 ON NOV 1	0.091 ON JAN 9	529 000
1979	---	86.4 ON MAR 7	0.592 ON AUG 10	339 000
---	---	452 ON DEC 14	0.365 ON AUG 12	705 000
E ESTIMATED * EXTREME RECORDED FOR THE PERIOD OF RECORD				596 000

After; Historical Streamflow Summary, British Columbia to 1979.

Inland Waters Directorate
Water Resources Branch
Water Survey of Canada
Ottawa, Canada, 1980

- 6 -

LOWEST 7 Day SUMMER AND FALL FLOWS
(June 1 - Nov. 30)

STREAM : CHEMAINUS RIVER NEAR WESTHOME Station #08HA001

REMARKS :

Year	Date	Min Av	Rank (M)	Recurrence (T)	Year	Date
		M ³ /SEC		Years		
1914	Sep 3	0.41	(1) 0.14	32	1970	Aug 26
1915	Sep 4	0.33	(2) 0.18	16	1956	Sep 5
1916	Sep 24	0.43	(3) 0.22	10.7	1977	Aug 19
1917	N/A	N/A	(4) 0.24	8	1967	Aug 31
1952	N/A	N/A	(5) 0.25	6.4	1961	Aug 26
1953	Sep 22	0.40	(6) 0.27	5.3	1958	Aug 25
1954	Aug 14	1.09	(7) 0.30	4.6	1963	Sep 30
1955	Sep 9	0.31	(8) 0.31	4	1955	Sep 9
1956	Sep 5	0.18	(9) 0.32	3.6	1965	Sep 29
1957	Oct 1	0.99	(10) 0.33	3.2	1915	Sep 4
1958	Aug 25	0.27	(11) 0.38	2.9	1979	Aug 14
1959	Aug 31	1.13	(12) 0.39	2.7	1973	Sep 15
1960	Aug 14	0.56	(13) 0.40	2.5	1953	Sep 22
1961	Aug 26	0.25	(14) 0.41	2.3	1914	Sep 3
1962	Jul 31	0.46	(15) 0.43	2.1	1916	Sep 24
1963	Sep 30	0.31	(16) 0.44	2.0	1966	Aug 27
1964	Sep 12	0.94	(17) 0.46	1.9	1962	Jul 3
1965	Sep 29	0.32	(18) 0.49	1.8	1974	Sep 27
1966	Aug 23	0.44	(19) 0.56	1.7	1960	Aug 14
1967	Aug 31	0.24	(20) 0.57	1.6	1975	Aug 16
1968	Aug 9	0.58	(21) 0.58	1.5	1968	Aug 9
1969	Aug 22	1.03	(22) 0.60	1.5	1978	Aug 8
1970	Aug 26	0.14	(23) 0.66	1.4	1980	Aug 25
1971	Aug 14	1.08	(24) 0.68	1.3	1981	Aug 28

$$\text{Recurrence Period (T)} = \frac{\text{Total No. of Years} + 1}{\text{Rank (M)}}$$

STREAM :

CHEMAINUS RIVER NEAR WESTHOME

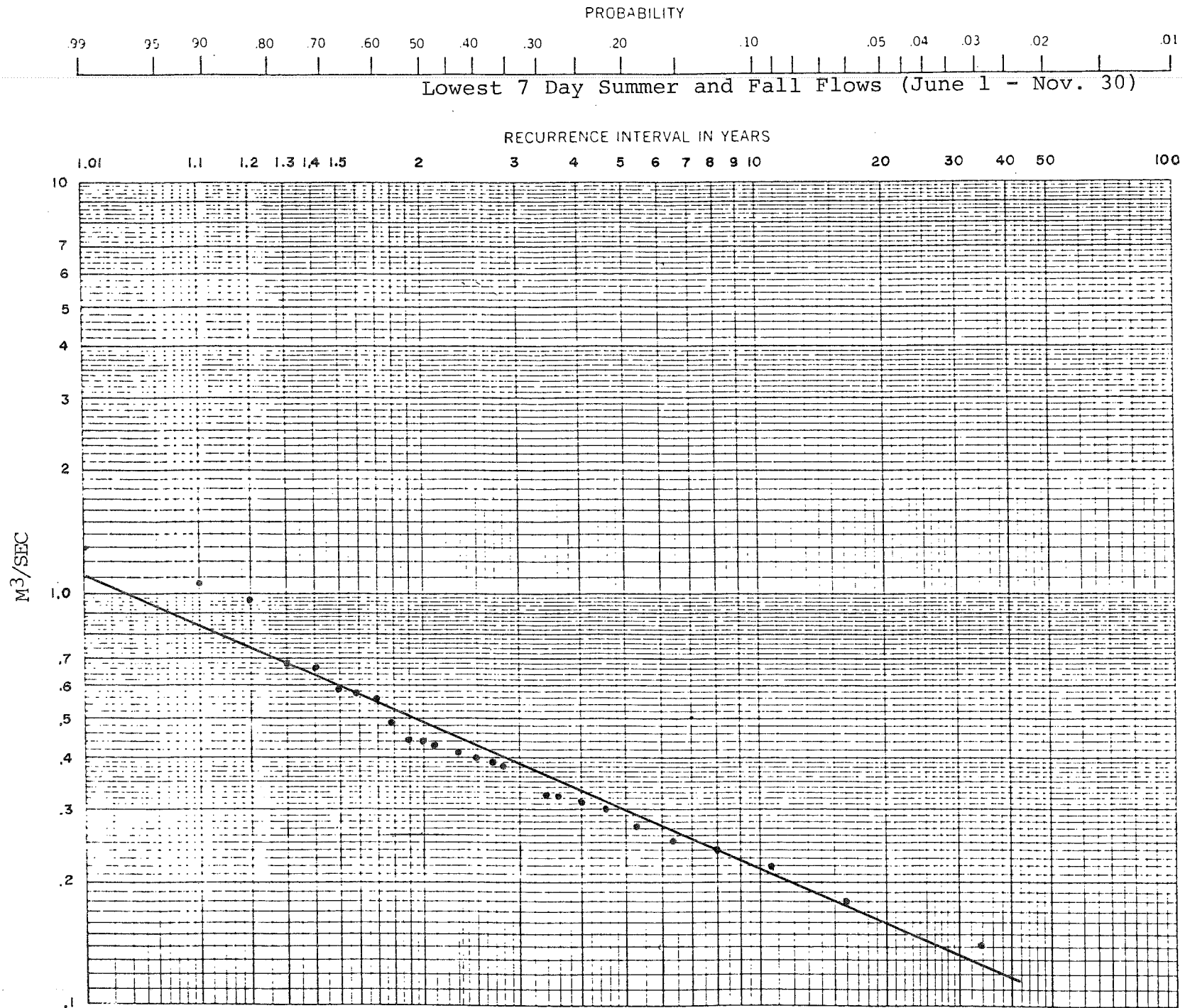
Station #08HA001

REMARKS :

[illegible]

$$\text{Recurrence Period (T)} = \frac{\text{Total No. of Years} + 1}{\text{Rank (M)}}$$

CHEMAINUS RIVER NEAR WESTHOLME STATION #03HA001

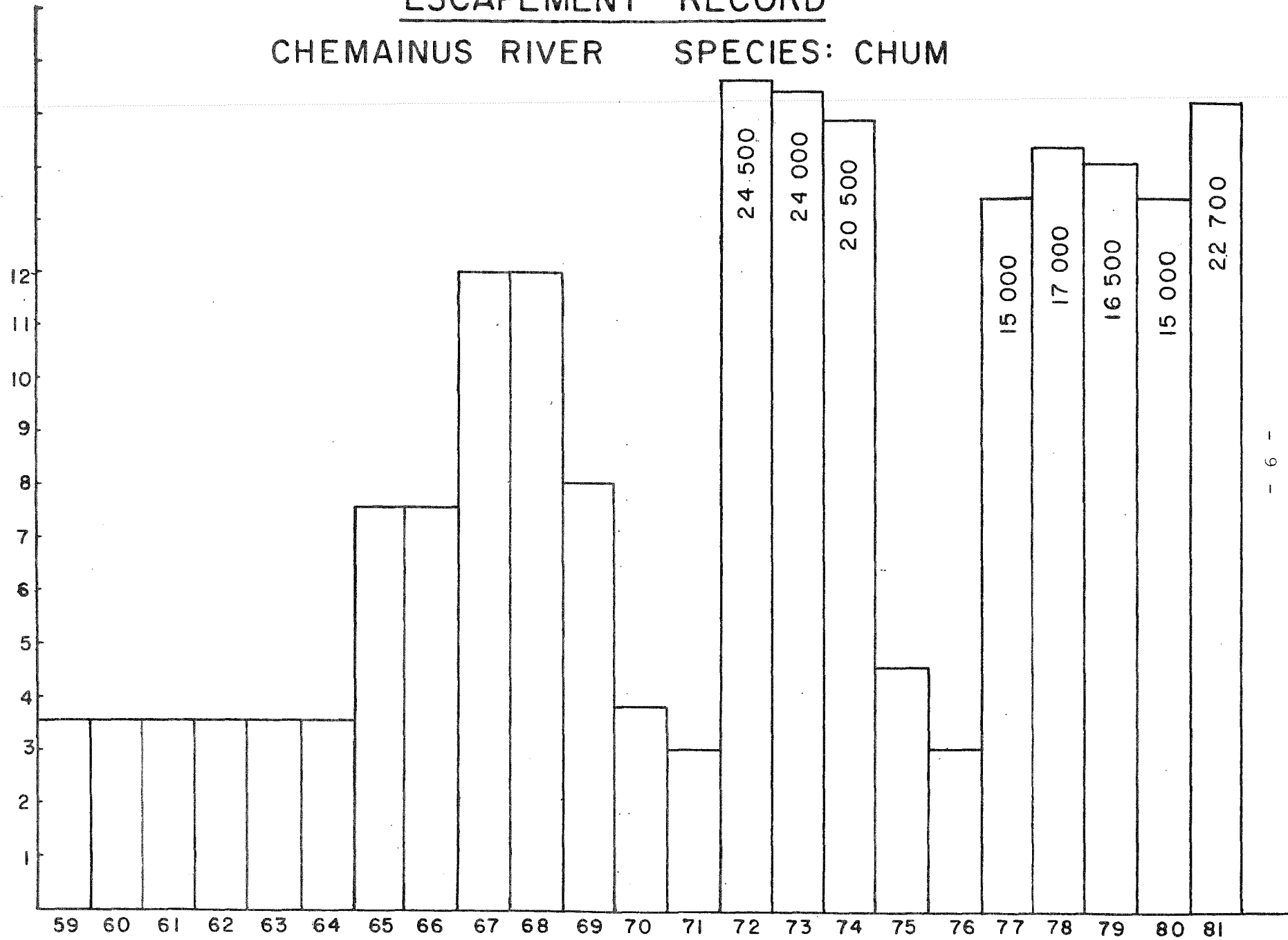


ESCAPEMENT RECORD

CHEMAINUS RIVER

SPECIES: CHUM

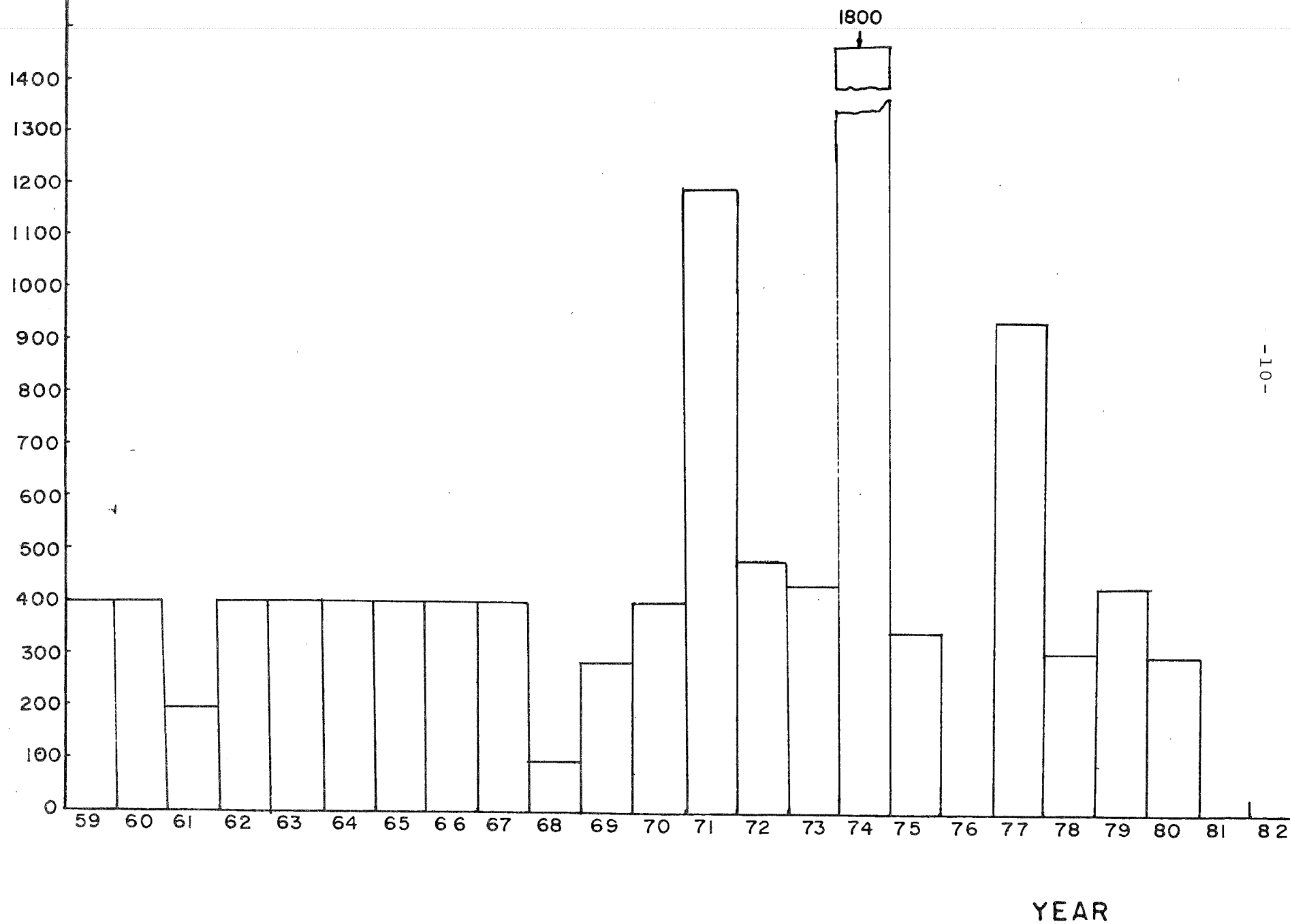
NO. OF SPAWNERS (THOUSANDS)



YEAR

ESCAPEMENT RECORD CHEMAINUS RIVER
SPECIES: COHO

NO. OF SPAWNERS

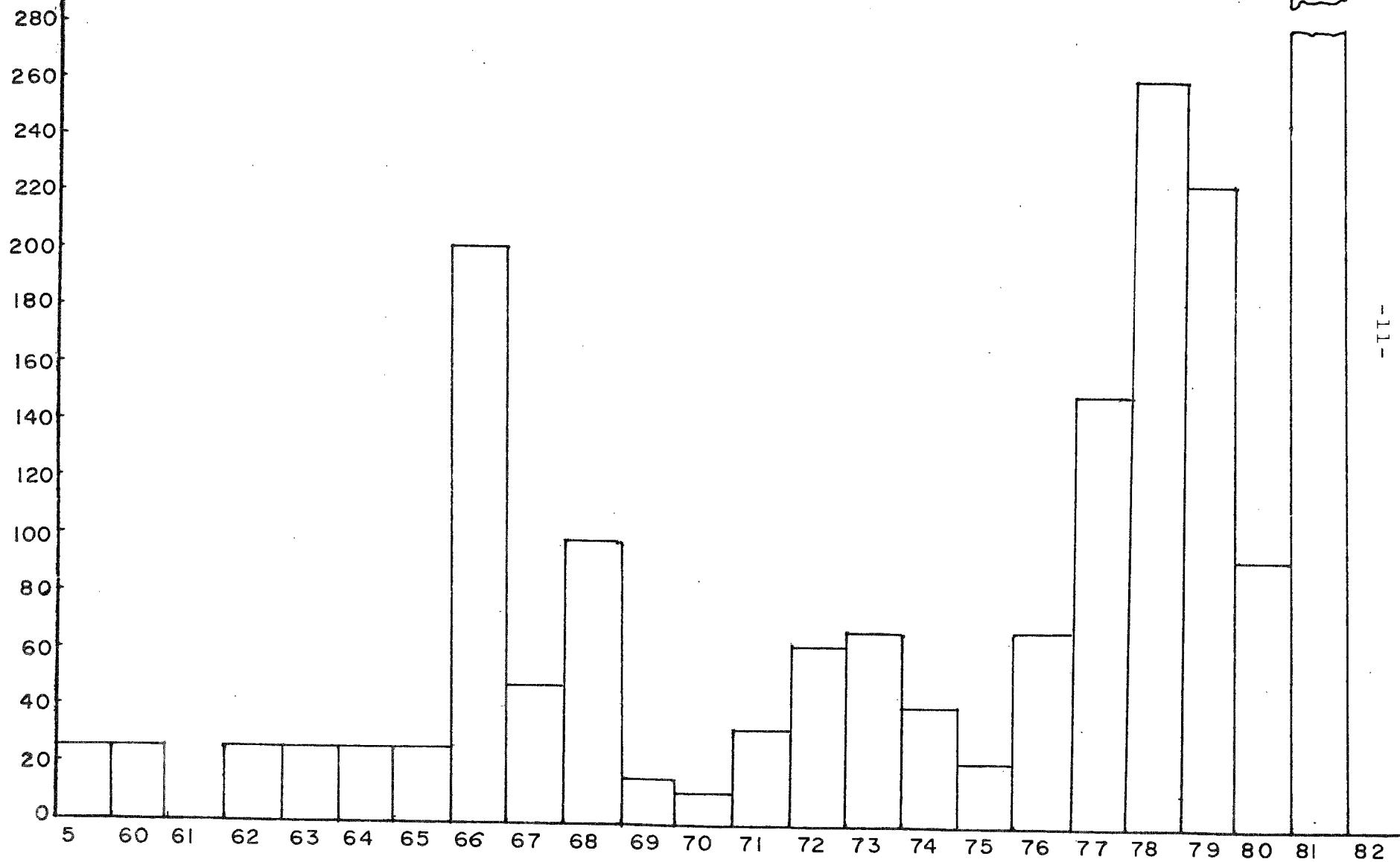


ESCAPEMENT RECORD CHEMAINUS RIVER

SPECIES: CHINOOK

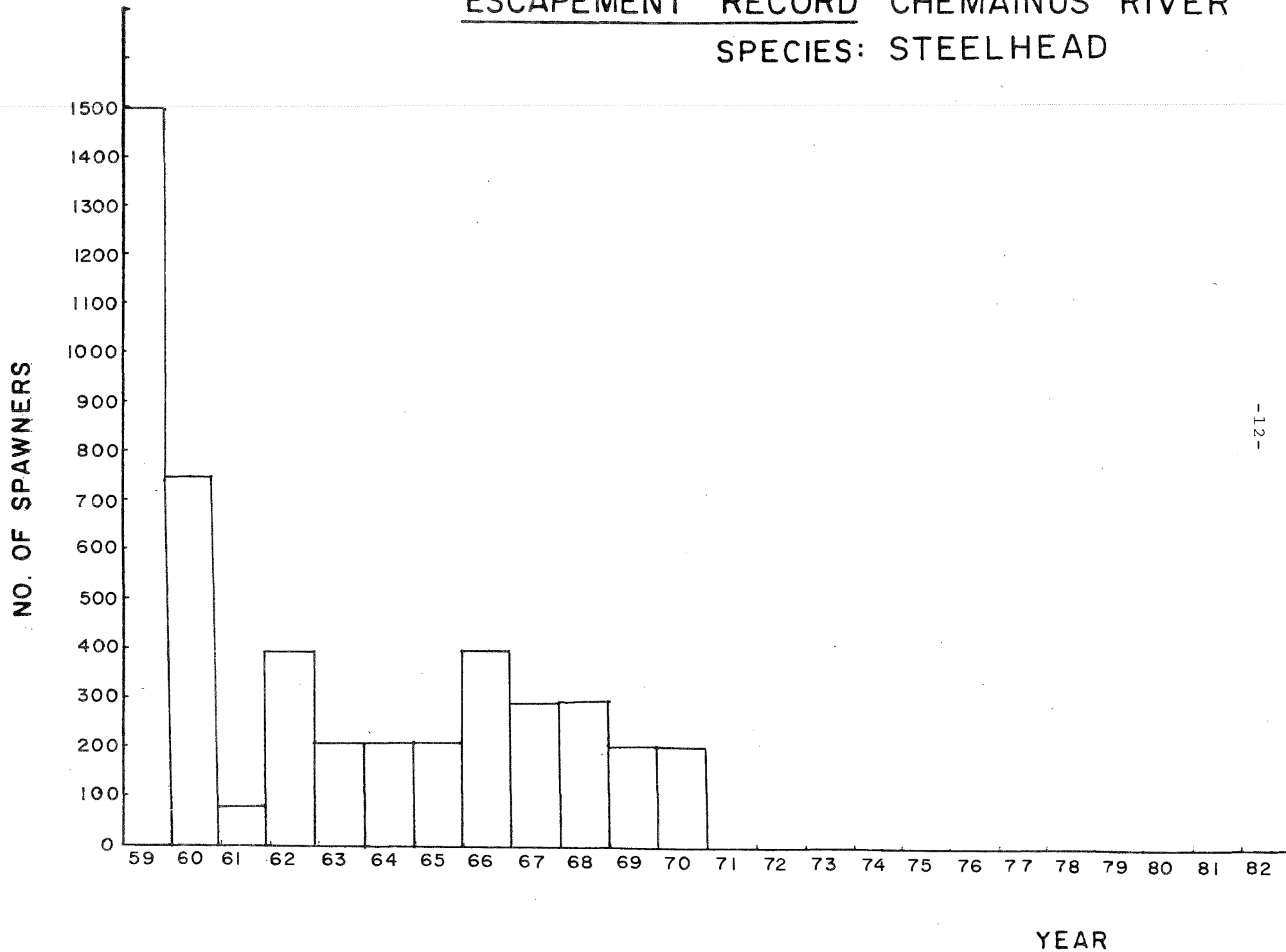
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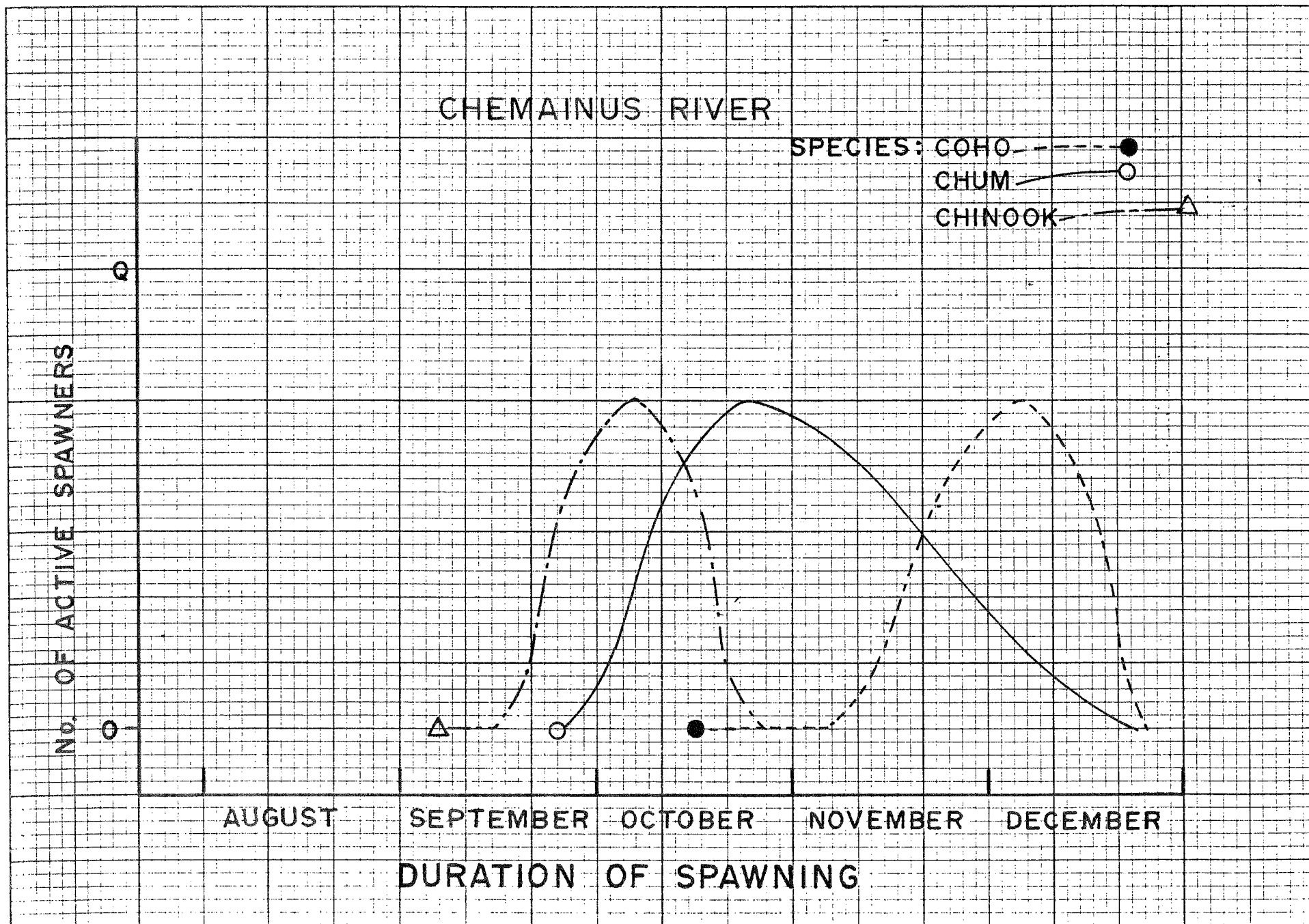
NO. OF SPAWNERS

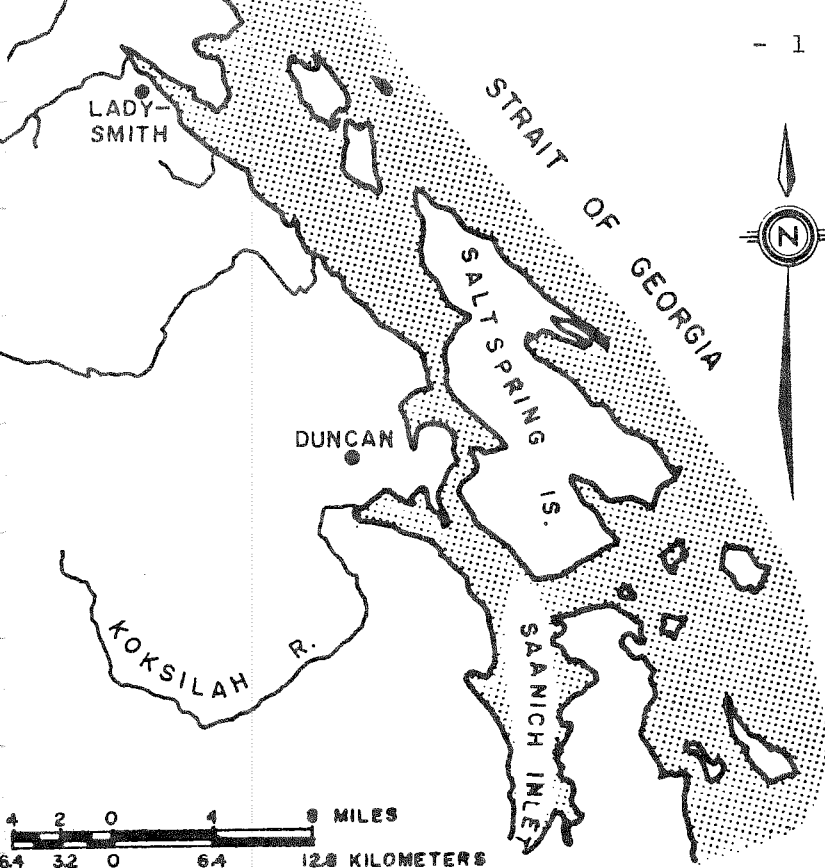


YEAR

ESCAPEMENT RECORD CHEMAINUS RIVER
SPECIES: STEELHEAD







Koksilah River

General Description

This extensive stream system (209 km²) is limited in its natural potential as a salmon producer due to the impact of extremes of gradient. A falls at 20 kilometers from the Cowichan Estuary is impassable to all species except Steelhead. The canyon that extends approximately 3 kilometers below the falls is unusable to spawners,

however, deep pools may provide adequate rearing habitat. The lower reaches of the river are characterized by low gradients resulting in poor gravel size and channel shifting. Chum spawn in the first eight kilometers while spawning Coho range throughout the usable portion of the system. Good rearing habitat occurs from the highway bridge to tidewater. This reach has abundant natural cover provided by dense vegetation, debris jams and deep pools.

The inaccessible upper reaches of the system may provide extensive rearing territory for artificial Coho stocks. Escapements for all species have been relatively stable for the past ten years and down significantly from peak years in the early 60's.

The Koksilah River and the neighbouring Chemainus River exhibit similar characteristics of relatively low summer and fall yields (discharge per unit of area) and relatively moderate variability (stability) under extreme low flow conditions.

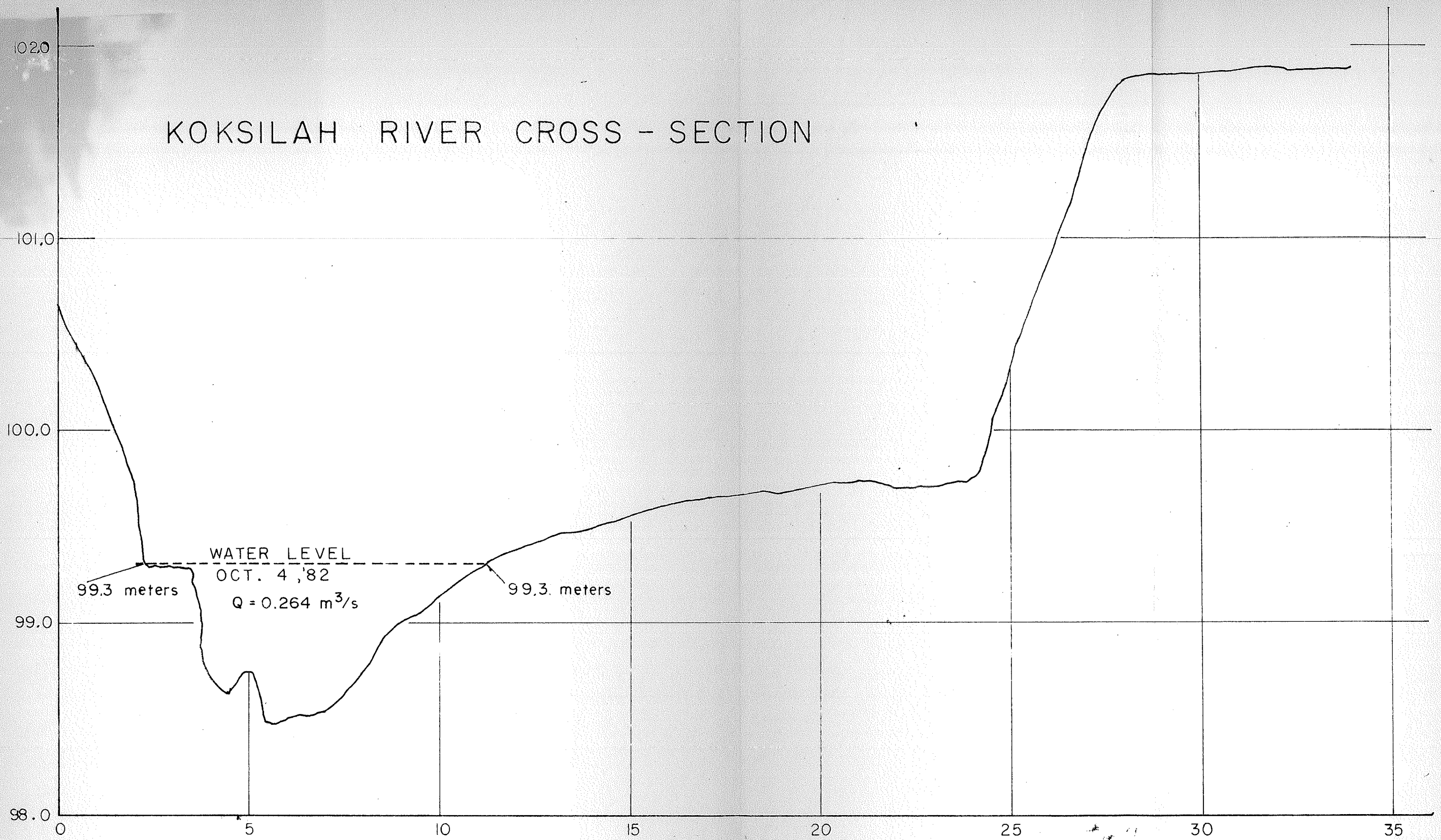


Metering site 1 kilometer above Cowichan Station.



As above.

ELEVATION (m)
VERTICAL SCALE - 1:20



STATION (m)
HORIZONTAL SCALE - 1:100

Watershed Data

Hydrometric Station # 08HA003 Koksilah River

Watershed Area	(A)	209.0 km ²
Mean Elevation	(H)	200 m
First Order Length	(L ₁)	78.0 km
All Orders	(L _T)	246.5 km
Average Precipitation	(AP)	1500 mm/year
Average Annual Flow	(QAA)	9.8 m ³ /sec

For The Period June 1 - Nov. 30:

Average Flow of Lowest Month (August)	0.451 m ³ /sec
7 Day Low Flow, 2 year recurrence (Q7L2)	0.30 m ³ /sec
7 Day Low Flow, 20 year recurrence (Q7L20)	0.13 m ³ /sec
Variability (Q7L20/Q7L2)	0.43
Yield (Q7L2/A)	0.0014 m ³ sec ⁻¹ /km ²

SUMMARY

Estimated Fishery Flow Requirements

A. Spawning Flow

	m ³ /sec
"Streamflow" (Hamilton)	No data
Optimum Flow (Coho)	
Collings Method	
Preferred Flow (All Species)	5.29
Sustained Flow (All Species)	4.56
Actual Average Flow At	
Peak Spawning Time	
Chinook	9.89
Chum	9.81
Coho	9.81

B. Rearing Flow

	m ³ /sec
"Streamflow" (Hamilton)	No data
Optimum Flow (Based on Surface Width)	
Collings Method	
Optimum Flow (All Species)	1.25
Average Flow of Lowest Month	
(Jan. 1-Dec. 31)	0.45
Average Flow of Lowest Month	
(June 1-Nov. 30)	0.45

Historical Streamflow Data

KOKSILAH RIVER AT COMICHAN STATION - STATION NO. 08HA003

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1914	---	---	---	---	---	1.47	0.665	0.397	1.01	10.3	21.7	7.37	---
1915	15.6	10.2	13.6	12.4	3.24	1.19	0.619	0.413	0.224	11.1	26.2	39.2	11.2
1916	12.1	21.4	28.0	21.7	13.3	5.14	4.11	0.535	0.264	2.72	14.7	12.3	11.3
1917	18.0	20.5	11.3	---	---	---	---	---	---	---	---	---	---
1954	---	---	---	---	---	---	---	---	0.602	---	---	---	---
1955	---	---	---	---	5.72	2.35	1.14	0.842	0.636	---	---	---	---
1956	---	---	---	---	11.3	7.67	0.986	0.673	1.06	---	---	---	---
1957	---	---	---	---	---	1.06	0.821	0.805	0.654	---	---	---	---
1958	---	---	---	---	2.83	1.13	0.368	0.227	0.393	---	---	---	---
1959	---	---	---	---	7.34	1.98	0.497	0.267	1.75	---	---	---	---
1960	16.5	22.6	11.5	16.0	4.31	1.63	0.597	0.441	0.494	4.03	15.6	16.5	9.12
1961	34.6	37.4	23.6	6.70	5.34	1.23	0.484	0.249	0.409	4.58	10.8	24.4	12.4
1962	15.6	5.93	7.58	9.04	7.19	2.17	0.837	0.594	0.448	7.01	28.8	31.2	9.73
1963	14.5	19.0	7.18	8.32	4.55	0.758	0.879	0.425	0.303	12.7	28.5	26.7	10.3
1964	30.7	16.7	15.4	8.39	3.59	1.73	0.836	0.528	0.751	2.79	6.57	8.34	8.03
1965	13.9	27.8	8.06	8.01	4.54	1.17	0.501	0.367	0.448	5.90	13.7	20.2	8.59
1966	26.0	13.2	17.2	10.6	3.47	1.12	0.948	0.386	0.449	4.76	13.5	46.2	11.5
1967	35.0	18.4	18.3	6.17	3.61	0.876	0.335	0.217	0.311	20.2	13.1	30.6	12.3
1968	38.8	23.8	17.6	6.65	2.46	1.29	0.618	0.531	1.95	10.2	17.6	22.6	12.0
1969	9.64	10.9	19.9	20.4	6.02	1.44	0.671	0.500	1.89	3.06	6.11	23.5	8.66
1970	18.1	14.0	8.92	12.1	2.49	0.816	0.332	0.222	0.446	2.11	9.80	22.1	7.59
1971	29.9	22.0	20.6	15.5	8.76	2.30	1.08	0.395	0.641	3.75	15.3	11.8	10.9
1972	23.7	29.4	27.2	10.4	4.10	0.983	1.40	0.473	1.40	0.996	6.98	35.0	11.8
1973	21.4	7.66	7.03	2.94	2.42	1.43	0.573	0.257	0.319	3.19	19.5	32.5	8.30
1974	30.3	24.8	24.9	11.2	4.67	3.35	1.20	0.509	0.441	0.484	14.6	21.7	11.4
1975	16.0	11.0	13.8	10.2	6.26	1.01	0.357	0.969	0.824	19.8	33.1	28.5	11.8
1976	24.4	17.4	14.0	13.1	5.61	2.01	0.708	0.534	0.493	0.726	2.82	7.91	7.45
1977	7.77	11.2	17.0	5.88	1.77	0.916	0.348	0.229	0.550	3.20	24.6	21.6	7.90
1978	13.5	11.0	8.50	4.24	3.07	1.20	0.418	1.50	1.50	1.16	4.04	8.89	4.79
1979	3.24	26.5	15.1	5.12	2.22	0.724	0.463	0.305	0.985	5.71	3.18	39.2	8.48
MEAN	20.4	18.4	15.5	10.2	5.01	1.79	0.814	0.451	0.746	6.11	15.3	23.4	9.80

LOCATION - LAT 48 43 39 N LONG 123 40 11 W DRAINAGE AREA, 209 km²
NATURAL FLOW

KOKSILAH RIVER AT COMICHAN STATION - STATION NO. 08HA003

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m ³ /s)	MAXIMUM DAILY DISCHARGE (m ³ /s)	MINIMUM DAILY DISCHARGE (m ³ /s)	TOTAL DISCHARGE (dam ³)
1914	---	---	---	---
1915	---	157 ON DEC 7	0.198 ON SEP 19	353 000
1916	---	56.1 ON MAR 8	0.057 ON OCT 10 *	358 000
1917	---	---	---	---
1954	---	---	---	---
1955	---	---	---	---
1956	---	---	---	---
1957	---	---	0.481 ON AUG 20	---
1958	---	---	0.481 ON SEP 3	---
1959	---	---	0.142 ON JUL 9	---
1960	---	---	0.255 ON AUG 2	---
1961	---	157 ON JAN 29	0.289 ON SEP 13	288 000
1962	---	190 ON JAN 15	0.227 ON AUG 29	390 000
1963	---	108 ON NOV 19	0.278 ON SEP 12	307 000
1964	---	134 ON DEC 23	0.266 ON SEP 13	323 000
1965	---	95.7 ON JAN 16	0.385 ON SEP 11	254 000
1966	---	76.7 ON JAN 30	0.283 ON AUG 19	271 000
1967	---	148 ON DEC 13	0.323 ON AUG 26	364 000
1968	---	130 ON DEC 10	0.204 ON AUG 6	387 000
1969	---	182 ON JAN 19	0.396 ON AUG 12	379 000
1970	---	104 ON DEC 13	0.425 ON SEP 11	273 000
1971	---	100 ON JAN 23	0.167 ON SEP 2	239 000
1972	---	108 ON JAN 19	0.317 ON AUG 19	345 000
1973	---	183 ON DEC 25	0.306 ON SEP 4	374 000
1974	---	166 ON NOV 28	0.210 ON SEP 14	262 000
1975	---	183 E ON JAN 14	0.408 ON SEP 3	361 000
1976	---	124 ON DEC 26	0.255 ON AUG 13	374 000
1977	---	77.6 ON JAN 15	0.340 ON AUG 8	235 000
1978	---	125 ON NOV 1	0.119 ON AUG 17	249 000
1979	---	43.9 ON JAN 8	0.201 ON AUG 11	151 000
	---	212 ON DEC 14 *	0.247 ON AUG 8	267 000

E - ESTIMATED

* - EXTREME RECORDED FOR THE PERIOD OF RECORD

309 000

After; Historical Streamflow Summary, British Columbia to 1979.

Inland Waters Directorate
Water Resources Branch
Water Survey of Canada
Ottawa, Canada, 1980

LOWEST 7 DAY

SUMMER AND FALL FLOWS

(June 1 - Nov. 30)

STREAM : KOKSILAH RIVER AT COWICHAN STATION Station #08HA003

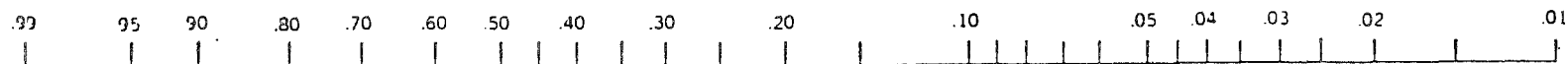
REMARKS :

Year	Date	Min Av	Rank (M)	Recurrence (T)	Year	Date
		M ³ /SEC		Years		
1914	Aug 16	0.340	1) 0.061	26	1916	Oct 8
1915	Sep 19	0.198	2) 0.133	13	1977	Aug 14
1916	Oct 8	0.061	3) 0.183	8.7	1970	Aug 27
1960	Sep 12	0.313	4) 0.198	6.5	1915	Sep 19
1961	Aug 25	0.233	5) 0.212	5.2	1967	Aug 11
1962	Sep 6	0.296	6) 0.216	4.3	1978	Aug 6
1963	Sep 8	0.274	7) 0.220	3.7	1973	Sep 11
1964	Sep 9	0.389	8) 0.233	3.25	1961	Aug 25
1965	Jul 28	0.310	9) 0.252	2.9	1979	Aug 6
1966	Aug 20	0.338	10) 0.267	2.6	1975	Aug 10
1967	Aug 11	0.212	11) 0.274	2.36	1963	Sep 8
1968	Aug 6	0.417	12) 0.296	2.17	1962	Sep 6
1969	Sep 8	0.459	13) 0.310	2.0	1965	Jul 28
1970	Aug 27	0.183	14) 0.313	1.86	1960	Sep 12
1971	Aug 14	0.355	15) 0.319	1.73	1972	Aug 31
1972	Aug 31	0.319	16) 0.338	1.63	1966	Aug 20
1973	Sep 11	0.220	17) 0.340	1.53	1914	Aug 16
1974	Sep 19	0.416	18) 0.343	1.44	1976	Aug 6
1975	Aug 10	0.267	19) 0.355	1.37	1972	Aug 31
1976	Aug 6	0.343	20) 0.389	1.3	1964	Sep 9
1977	Aug 14	0.133	21) 0.416	1.24	1974	Sep 19
1978	Aug 6	0.216	22) 0.417	1.18	1968	Aug 6
1979	Aug 6	0.252	23) 0.428	1.13	1981	Sep 11
1980	Aug 13	0.463	24) 0.459	1.08	1969	Sep 8
1981	Sep 11	0.428	25) 0.463	1.04	1980	Aug 13

$$\text{Recurrence Period (T)} = \frac{\text{Total No. of Years} + 1}{\text{Rank (M)}}$$

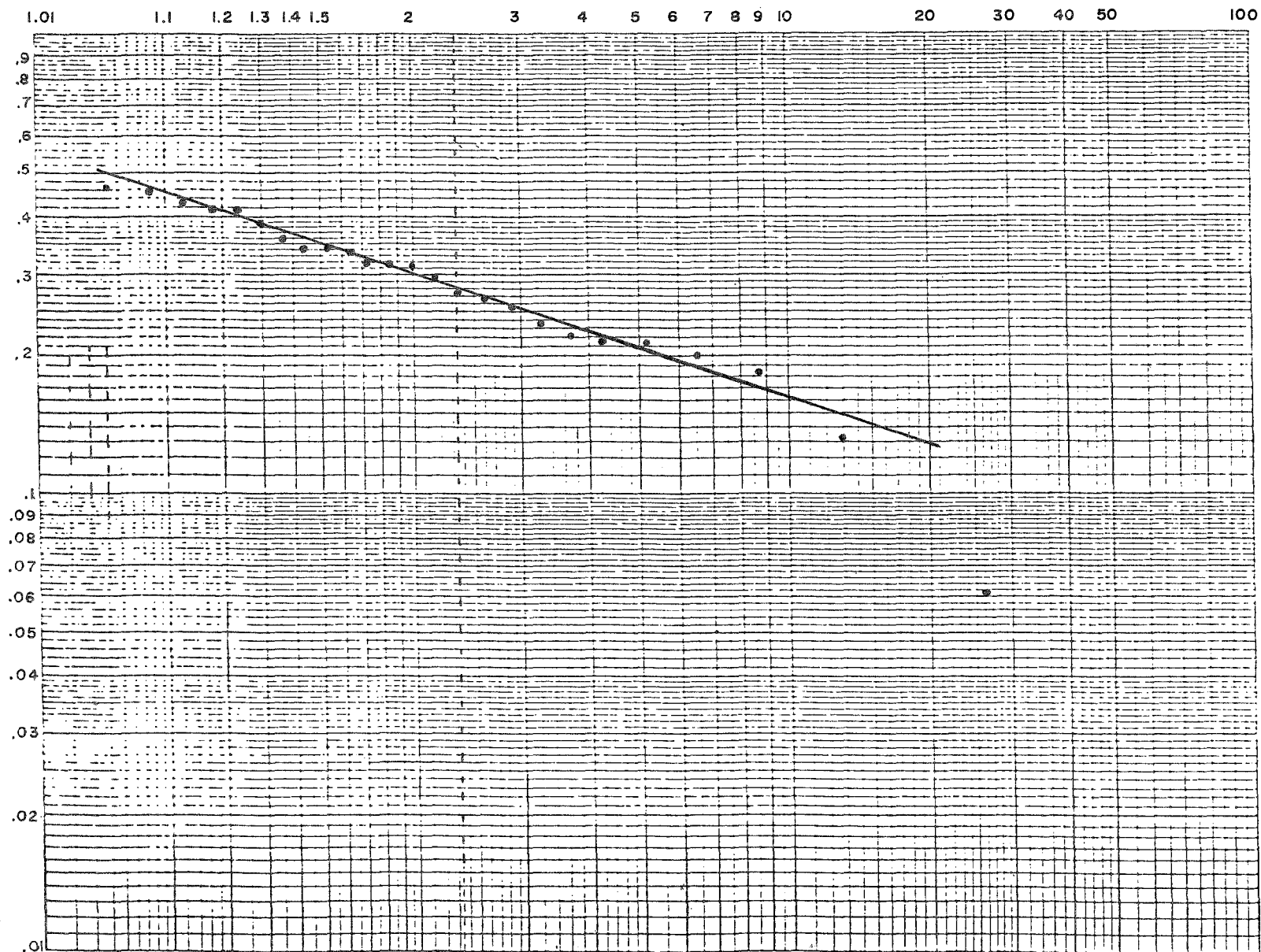
KOKSILAH RIVER AT COWICHAN STATION STATION # 08HA003

PROBABILITY



Lowest 7 Day Summer and Fall Flows (June 1 - Nov. 30)

RECURRENCE INTERVAL IN YEARS

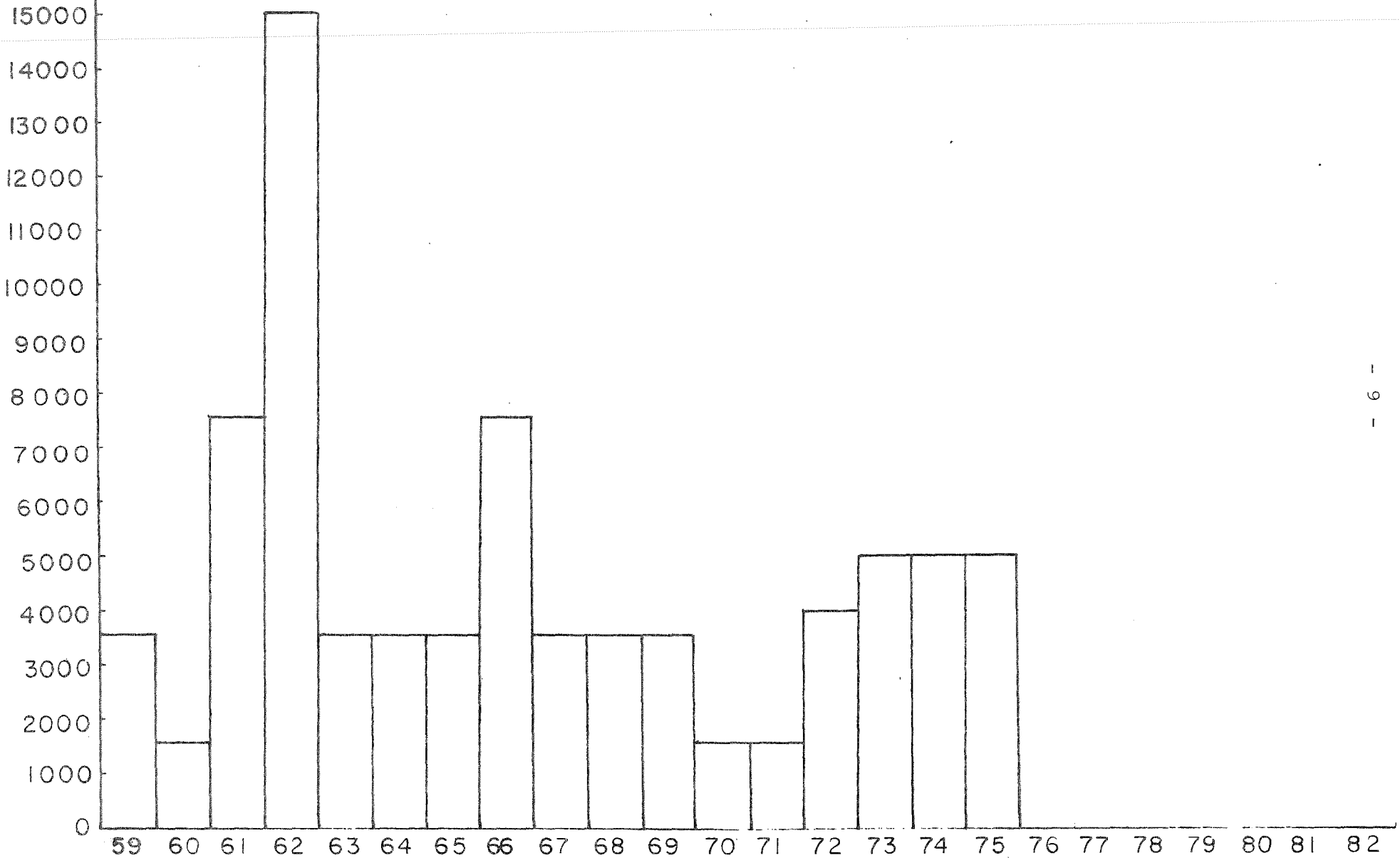


ESCAPEMENT RECORD

KOKSILAH RIVER

SPECIES: CHUM

NO. OF SPAWNERS



YEAR

ESCAPEMENT RECORD

KOKSILAH RIVER

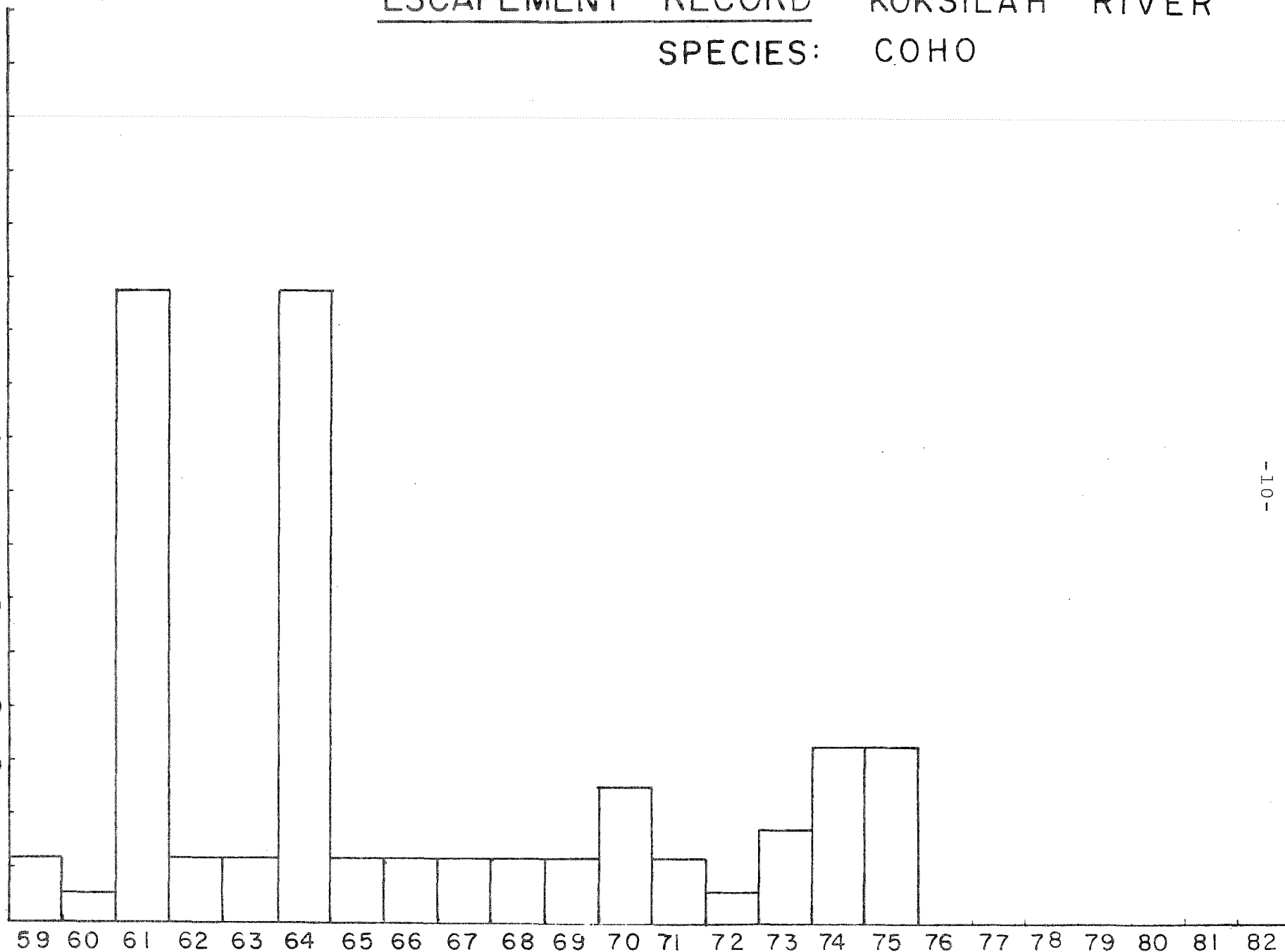
SPECIES: COHO

NO. OF SPAWNERS

39000
36000
33000
30000
27000
24000
21000
18000
15000
12000
9000
6000
3000
0

59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82

YEAR



ESCAPEMENT RECORD KOKSILAH RIVER

SPECIES: CHINOOK

NO. OF SPAWNERS

700
600
500
400
300
200
100
0

59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82

YEAR

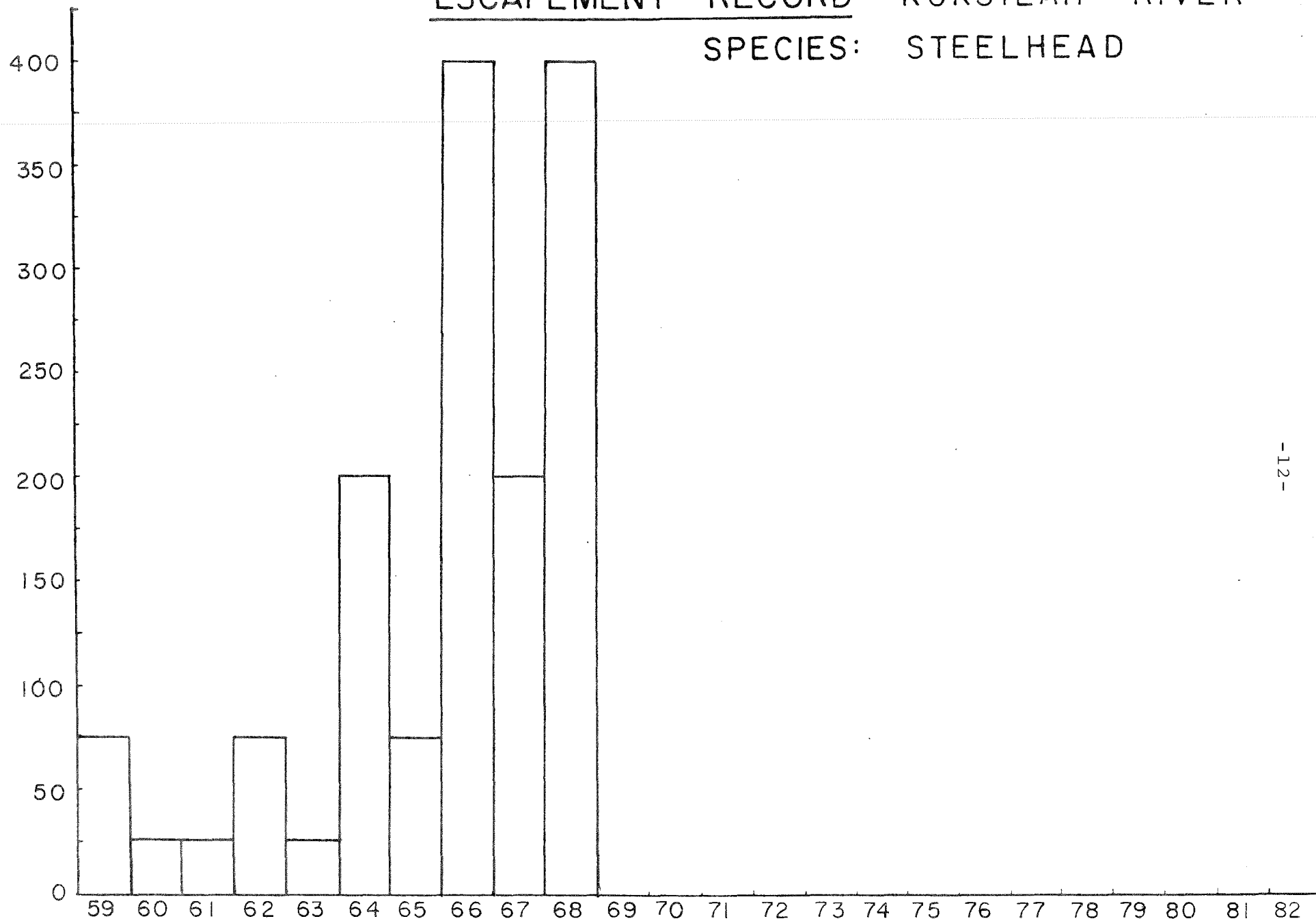


ESCAPEMENT RECORD

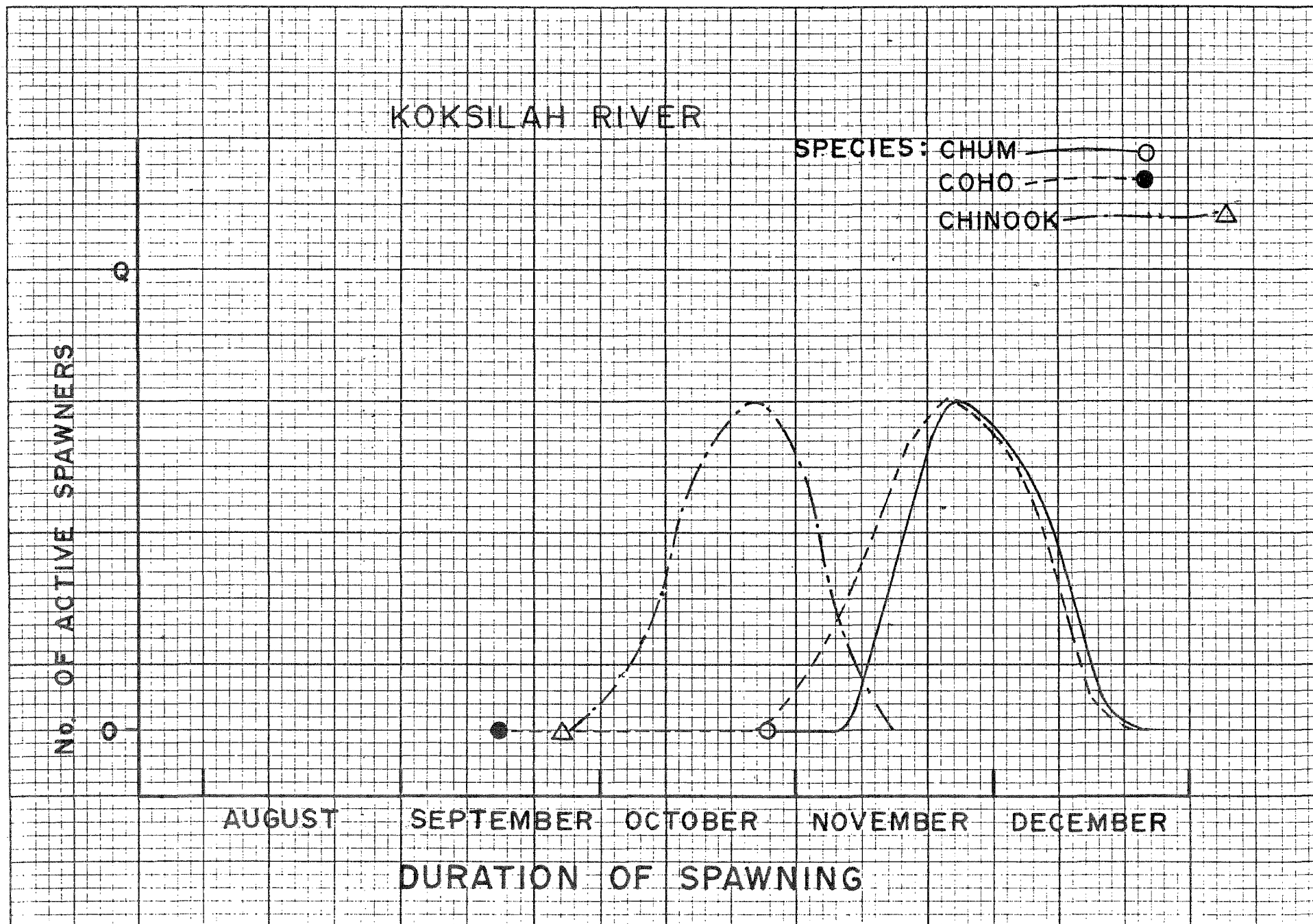
KOKSILAH RIVER

SPECIES: STEELHEAD

NO. OF SPAWNERS



YEAR



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REGIONAL ANALYSIS

Sixteen watersheds on the east coast of Vancouver Island, between Cowichan Bay, near Duncan and Oyster Bay, near Campbell River, were chosen for this study. Watersheds within this region exhibit similar characteristics of topography, climate and surficial geology. Although the range of variation among the factors, both natural and human, which may influence minimum flows within a watershed is broad, statistical analysis of the relationship between watershed parameters and known minimum flows for gauged streams yield correlations strong enough to enable these relationships to be applied to watershed data gathered for ungauged streams. A discussion of analytical methodology follows this section.

In general, headwaters for the study streams originate at elevations of 1,000 meters or more in the ridges of east-central Vancouver Island, fifteen to thirty kilometers west of the Strait of Georgia. Study streams are characterized by steep gradients in the upper reaches, so that the majority of the spawnable grounds are distributed through the lower reaches which course through a narrow coastal plain. The coastal plain varies in width from approximately 3 kilometers in the south to nearly 25 kilometers near Campbell River. For most of the streams, extremes of discharge are not buffered by significant retention areas, such as lakes or marshlands.

Average annual precipitation in the region varies with elevation. The coastal plain, averaging 150 meters in elevation, receives between 1,000 m.m. and 1,500 m.m. yearly, while sub-alpine regions of the larger watersheds may receive up to 4,000 m.m. Some of this accumulates as snow, which produces spring run-off in some of the systems.

Forestry is the predominant industry in the East Coast Vancouver Island region. Although practices and regulation of logging activity have changed since the original alienation of Crown forest lands on Vancouver Island during the latter half of the nineteenth century, various land uses, including logging, continue to affect the retention capacity of the soil mantle throughout the region. Any analyses of spawning and rearing flow requirements for salmon are subject to the influences of the surrounding land use and should be viewed accordingly.

All five species of Pacific salmon are found in Vancouver Island streams, but Chum and Coho are the dominant specie utilizing the streams of the study region. Approximately 92 percent of Chum escapement, and 75 percent of the Coho and Chinook escapement for Vancouver Island return to the streams of the east coastal plain (Fraser et al, 1974). Escapement figures for recent years show an overall decline in the salmon stock. Water use practices in the region may have contributed, in part, to this decline.

ORSBORN ANALYSIS

Table D is a summary of seven day low flow values derived for ungauged streams in the region. The technique used was developed by J. F. Orsborn of Washington State University. Essentially, surface water data from historical records, for gauged streams, are analysed to obtain minimum flow values for specified recurrence intervals. These values are then related to measured watershed parameters to establish regression equations. Watershed parameter values for ungauged streams are then input to the regression equations displaying the best correlations. The resulting values are an approximation of minimum flow values for ungauged streams.

Six of the eight gauged streams in the study region provided sufficient historical streamflow data (10 or more years of complete annual record) to be used in the regression analysis. The watershed characteristics measured were; basin area, mean altitude, stream length and mean annual precipitation. Topographic data was measured at a map scale of 1:50000. Averaging the characteristics of both gauged and ungauged streams, the following results are obtained:

	Gauged	Ungauged
Basin Area	258 km ²	34 km ²
Altitude	740 meters	515 meters
Length (L ₁)	104 km	9.7 km

Transferring the minimum flow relationships from the gauged streams to the ungauged may introduce a considerable degree of error as, with the exception of Nile Creek and Rosewall Creek, the measured characteristics of the gauged watersheds are of a different order of magnitude than those of the ungauged. Further studies are required to determine the validity of such comparisons. Relatively lower water retention capacity in the smaller watersheds due to steeper average grades, fewer tributaries and fewer lakes may effect a different set of relationships between watershed parameters and minimum flow values.

Analysis of the surface water data for gauged streams involved scrutiny of the historical record for periods of natural flows only. As a result, predicted minimum flows for ungauged streams may vary significantly from actual flows due to withdrawals by licensed subscribers and the nature and extent of land use within the watershed.

The following pages are an excerpt from the text of R. Hamilton's 'Fisheries Resource Maintenance Flows for Pacific Salmon'. This analytical routine was followed in order to generate low flow values for ungauged streams in the East Coast Vancouver Island region. All measurements used for the purpose of this report have been converted to S.I. (metric) units.

APPENDIX C

APPLICATION OF LOW FLOW ANALYSIS
TO THE UNGAGED TSULQUATE RIVER

The seven day low flow, two year recurrence interval, Q7L2, was calculated for the Tsulquate River as follows:

1. Using a few flow measurements of the Tsulquate River and comparing them with data on the Zeballos River of the same period.
2. Using a method developed by Orsborn (1976) using various watershed parameters and analyzing the nearest gaged rivers (Kokish, Benson and Zeballos). I have summarized his procedure in step form below; not only is the Q7L2 value determined, but also the values of a number of other parameters:
 - A. Do the following for all the gaged streams in the region:
 1. Plot Q7L2 and Q7L20 against the basin parameters: $LT(H)^{\frac{1}{2}}$, $3/2LI(H)$, $LT(H)$, $LI(DD)^{\frac{1}{2}}$. Select the best basin parameter.
 2. Plot Q7L2 and Q7L20 on log-log paper against recurrence interval (Figure C1). Determine slope, p and intercept, Q7L1P from the graphs. Calculate the average ratios Q7L1P/Q7L2 and Q7L20/Q7L2 for the region.

3. Calculate $\frac{(AH)^{\frac{1}{2}}(Q7L1P)}{300p} = \chi$ for each station.
 4. Plot Q7L2 against χ on log-log paper (Figure C2). From the regression line determine the coefficients for the equation $Q7L2 = k(\chi)^m$.
- B. Do the following for the ungaged stream under study:
1. Calculate basin parameters $LT(H)^{\frac{1}{2}}$ etc., and using the graphs prepared in step A1, estimate Q7L2 and Q7L20.
 2. Plot Q7L2 and Q7L20 on log-log paper to determine the slope p.
 3. Calculate Q7L1P from the ratio determined in step A2, or read off graph plotted in B2.
 4. Calculate Q7L2 from the equation determined in step A4. If it does not correspond satisfactorily with the estimated Q7L2, another iteration of the calculations is necessary.

The variables used in the analysis are described below:

- A = Watershed area above gage, in sq. mi.
- H = Elevation difference between gage elevation and highest average continuous contour in the watershed, in feet.
- L_1 = Total length of first order stream in miles.
- L_T = Total length of streams (all orders) in miles.

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DD = Drainage density = L_T/A

$X = \frac{(AH)^{\frac{1}{2}} Q7LIP}{300p}$, a watershed parameter.

k = A coefficient

Q7L2 = Seven day low flow, 2 year recurrence interval

Q7L20 = Seven day low flow, 20 year recurrence interval

Q7LIP = Hypothetical value obtained by projecting the
log-log graph (Figure C1) to the one year line.

p = Slope of seven day low flow curve on the log-
log graph.

QAA = Average annual flow.

Flow records were obtained on the Tsulquate River for a three month period in 1975. Two 7 day low flow periods were extracted from this data and compared with 7 day low flow data of the same period obtained for the Zeballos River:

Zeballos River 8HE6

	Date	7 day low flow	Recurrence Interval
A.	July 27 - August 2/75	300 cfs	1.1 years
B.	Sept 26 - Oct. 2/75	208 cfs	1.4 years
		185 cfs	2.0 years

Tsulquate River

A.	July 26 - August 1/75	5.0 cfs
B.	Sept 21 - 27/75	7.2 cfs

or the Tsulquate:

$$A \text{ data, } Q7L2 = \frac{185}{300} \times 5 = 3.1 \text{ cfs}$$

$$B \text{ data, } Q7L2 = \frac{185}{208} \times 7.2 = 6.4 \text{ cfs}$$

A tentative value of 5.0 cfs was taken as Q7L2 for the Tsulquate River. This tentative value of Q7L2 can be used instead of going through steps A1 and B1 of the Orsborn procedure.

The results of steps A2 to A4 are shown in Table CI and Figures C1 and C2. As there were records for two gages on the Kokish which had quite different 7 day low flow values a double set of values was calculated for the Tsulquate based on these two Kokish gages. Ratios of Q7L1P to Q7L2 and Q7L20 to Q7L2, as indicated in step A2 were used to calculate Q7L1P and Q7L20 for the Tsulquate, using a tentative value of 7 cfs for the Tsulquate (obtained by a trial run). Table CI shows that the Q7L2 values of 6.7 and 5.1 obtained check reasonably well with those calculated by comparison with the Zeballos records. Average values of 6.0 for Q7L2 and 2.0 for Q7L20 are about as close as would ever be needed to analyze low flows for fisheries.

The average annual flow, QAA, for the Tsulquate was also calculated, using the coefficient, C, obtained by averaging the values for the Kokish. See last entries in Table CI. Precipitation data, P, was taken from Figure 27.

TABLE CI
BASIN PARAMETERS AND 7-DAY LOW FLOWS
FOR SEVERAL RIVERS ON VANCOUVER ISLAND

BASIN PARAMETER	KOKISH RIVER 8HF3	ZEBALLOS RIVER ZEBALLOS	BENSON RIVER BENSON	TSULQUATE RIVER TSULQUATE	KOKISH RIVER 8HF1
A	104	69.8	81	23	120
H	0.89	0.85	0.68	0.284	1.03
L ₁	111	120.9	101.3	22.5	121
3/2L ₁ H	148.2	154.1	103.3	9.58	187.3
L _T	275	211.8	189.7	61.8	290
L _T H	244.8	180	129	17.6	299.3
L _T H ^{1/2}	259.0	195.3	156.4	32.9	294.6
DD	2.64	3.03	2.34	2.69	2.42
$\sqrt{DD(L_1)}$	180	210.4	155	36.9	188.2
X	5.1	51.4	6.8	.18 .14	2.67
k	18.8	17.4	15.2		16.6
Q7L2	50	185	48±	6.7 5.1	30
Q7L20	19	148	30±	2.6 1.6	7
Q7L1P	65	200	55	9.1 10.7	46
P	.41	.10	.20	.43 .65	.64
QAA	639	1110	702	103	635
P	130	200+	180	100	130
$C = \frac{QAA}{PA}$	.047	.07±	.048	.045	.041

7-DAY LOW FLOW RECURRENCE INTERVAL CURVES FOR THE BENSON RIVER AND KOKISH RIVER

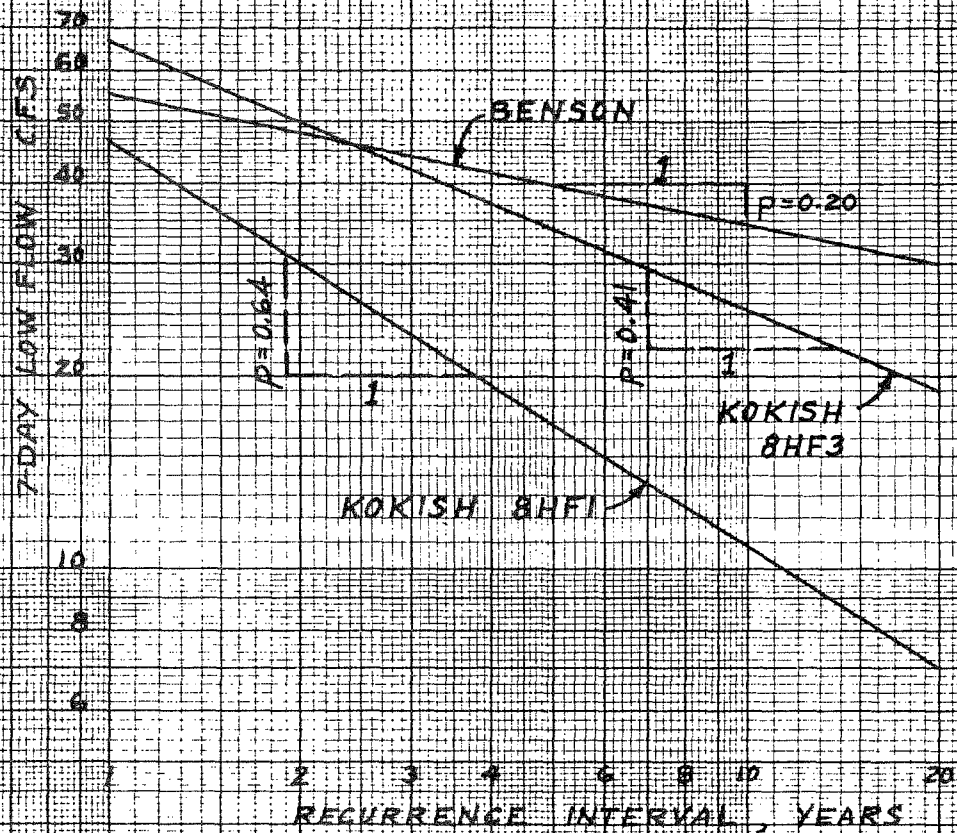


FIGURE 01

RELATIONSHIP OF THE 7-DAY LOW FLOW
TO THE WATERSHED PARAMETER X

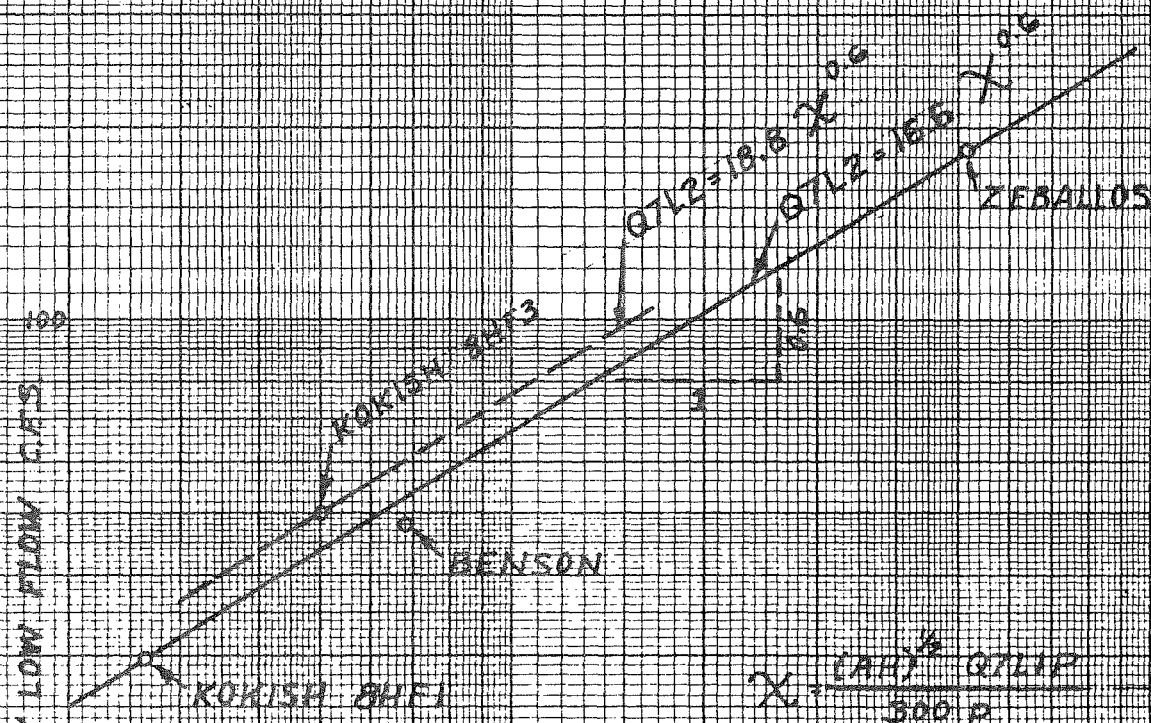


FIGURE C2

AVERAGE ANNUAL FLOW (QAA) vs PRECIPITATION x AREA (PA)

Fig. 1

$r=0.95$
 $b/a=1.98$

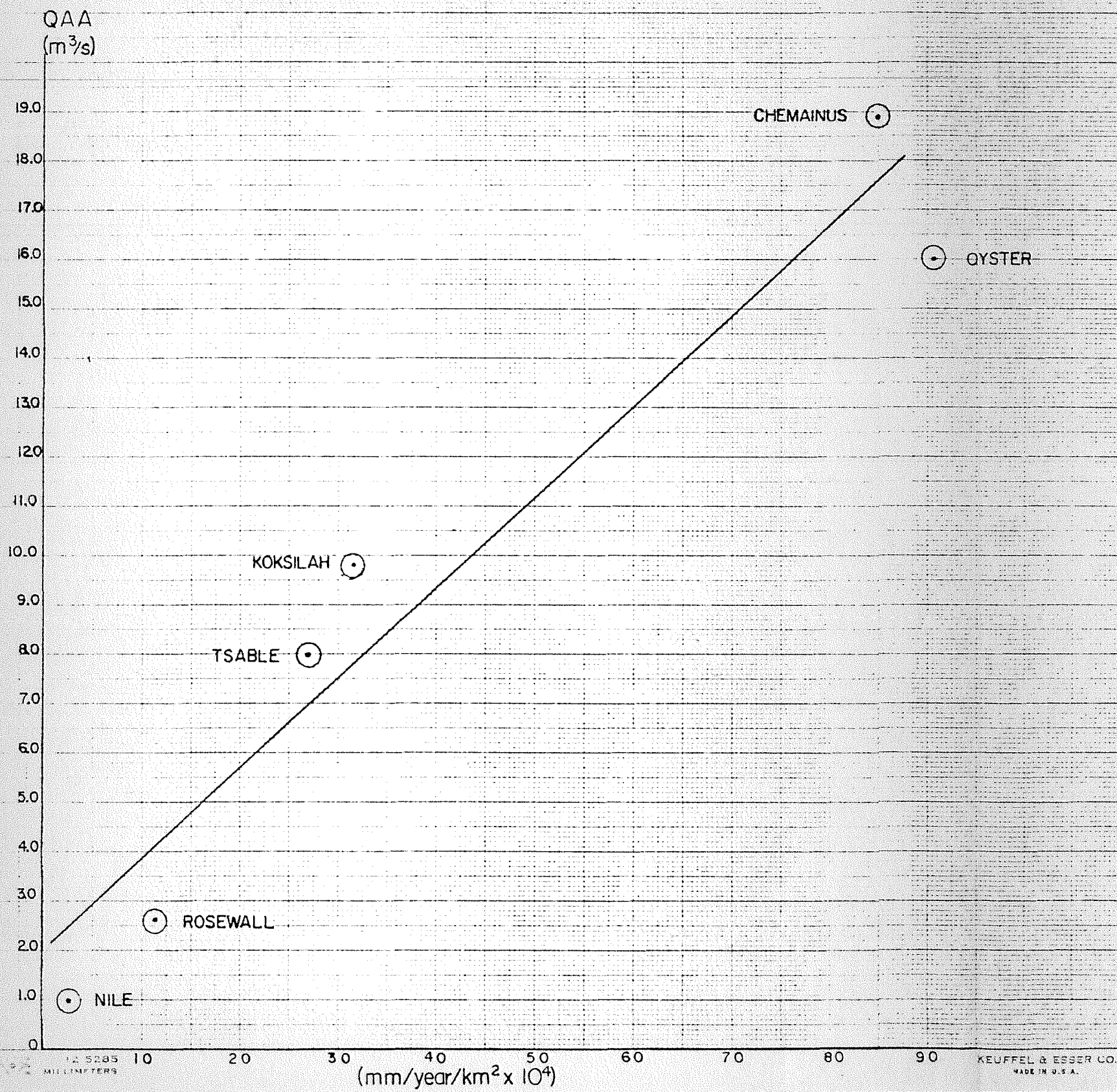


Fig. 2

AVERAGE ANNUAL FLOW (QAA) vs WATERSHED AREA (A)

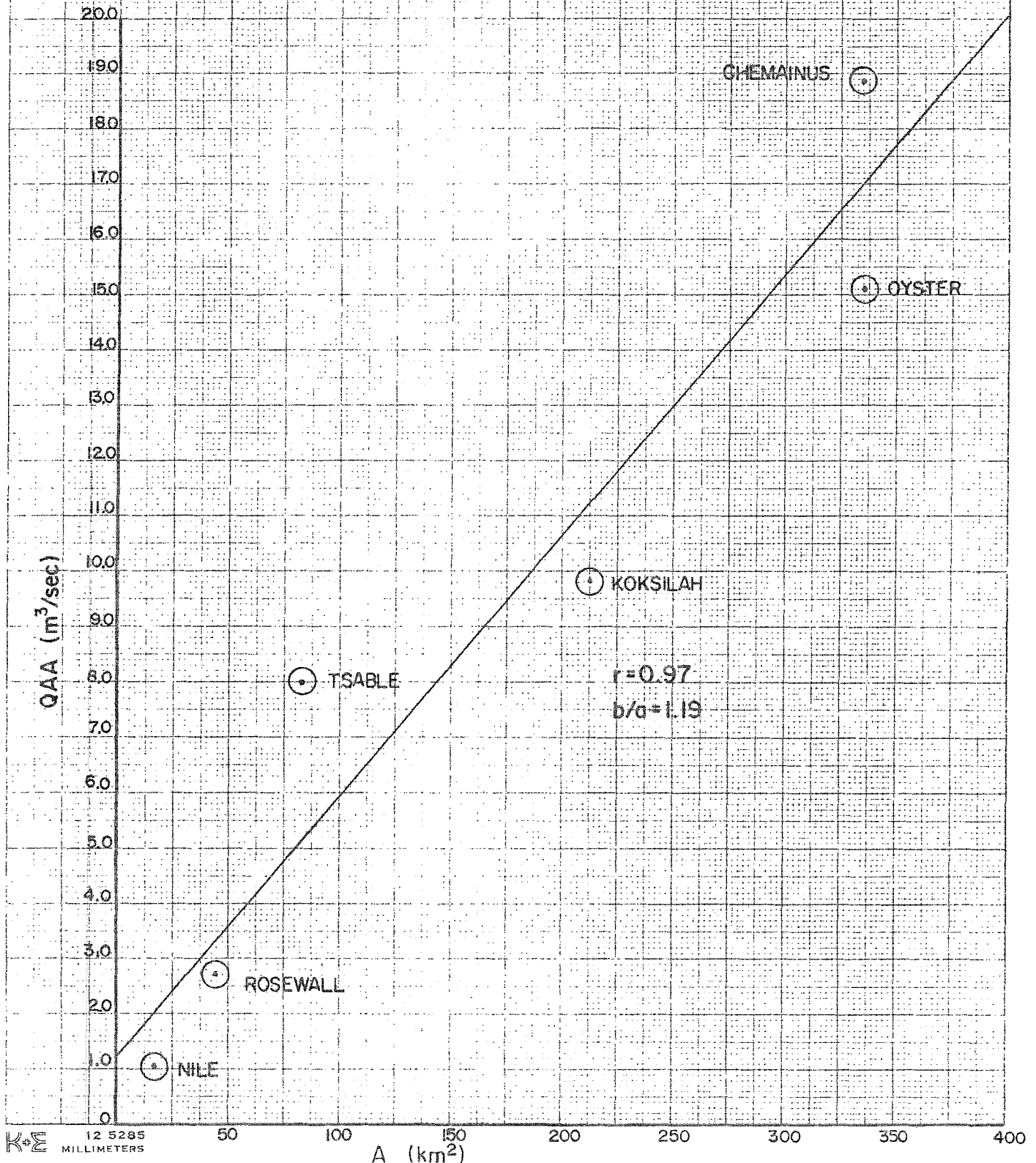
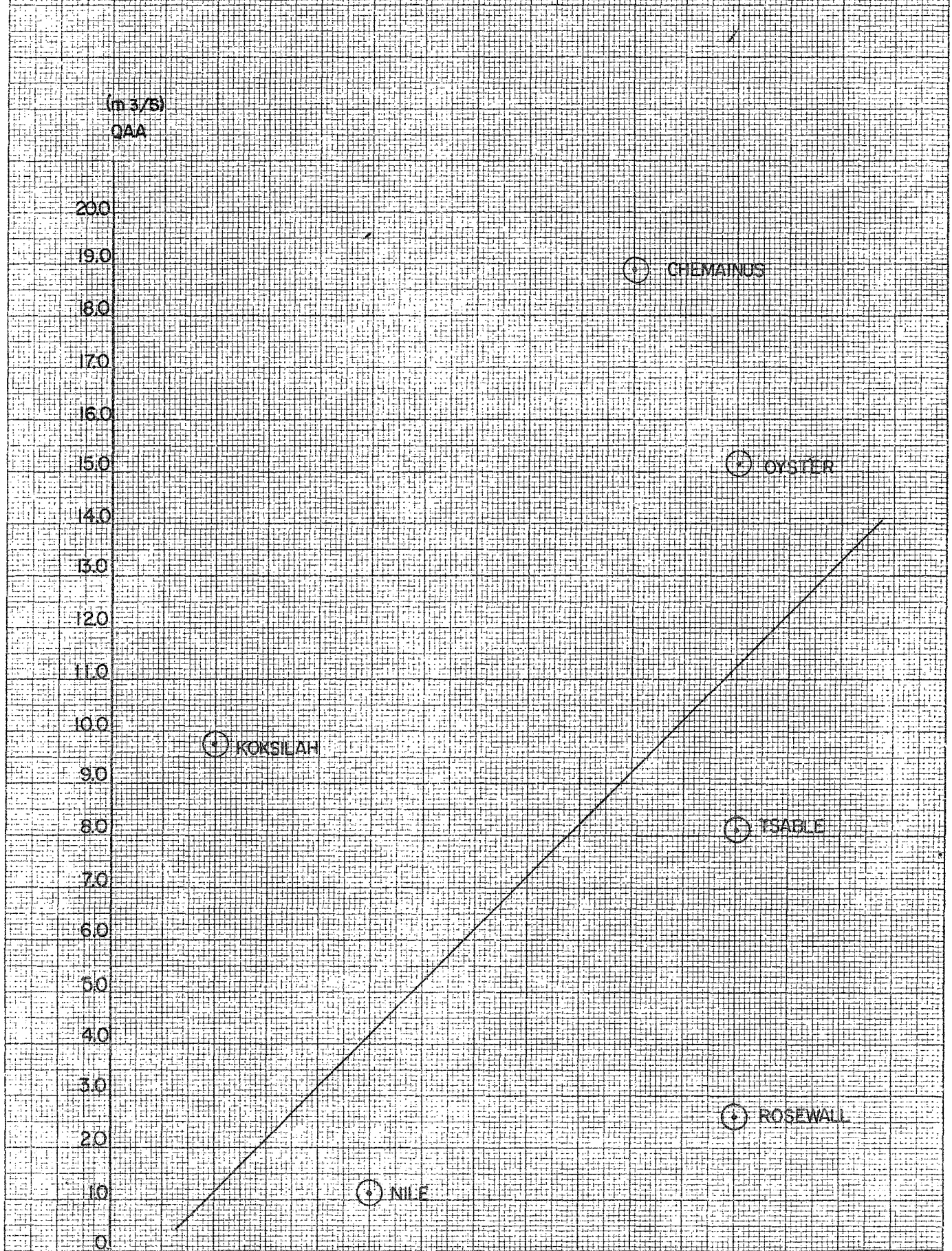
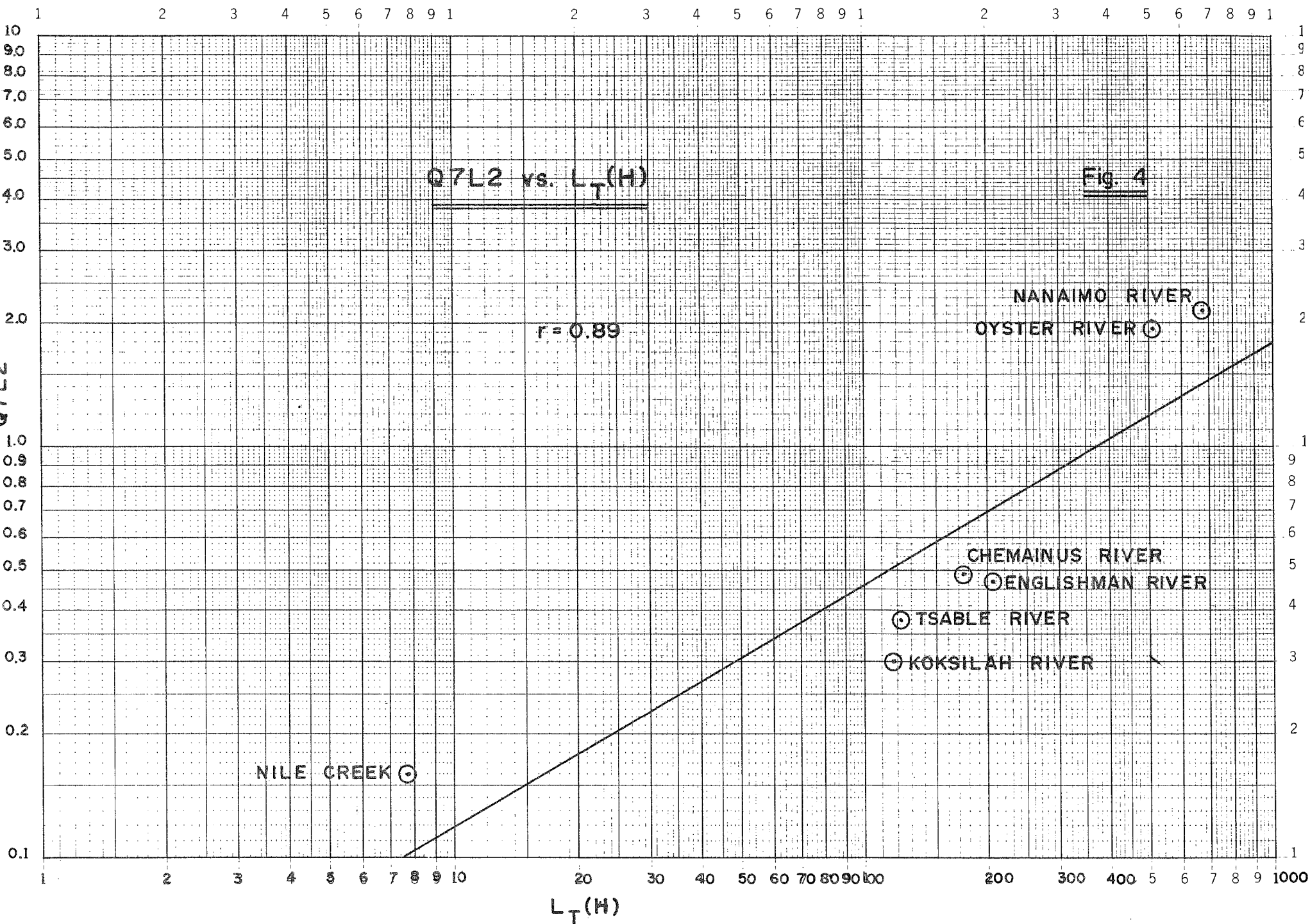
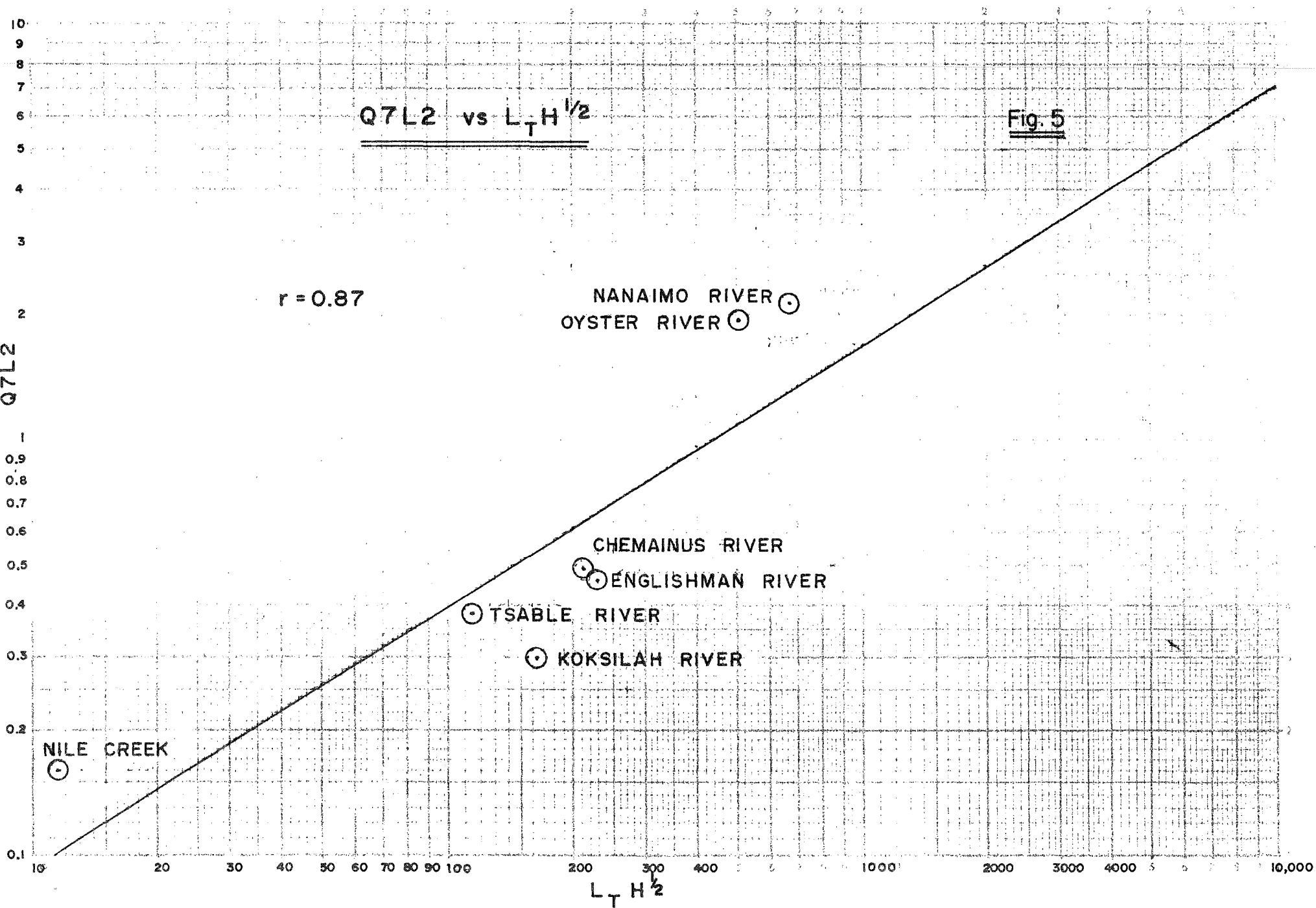


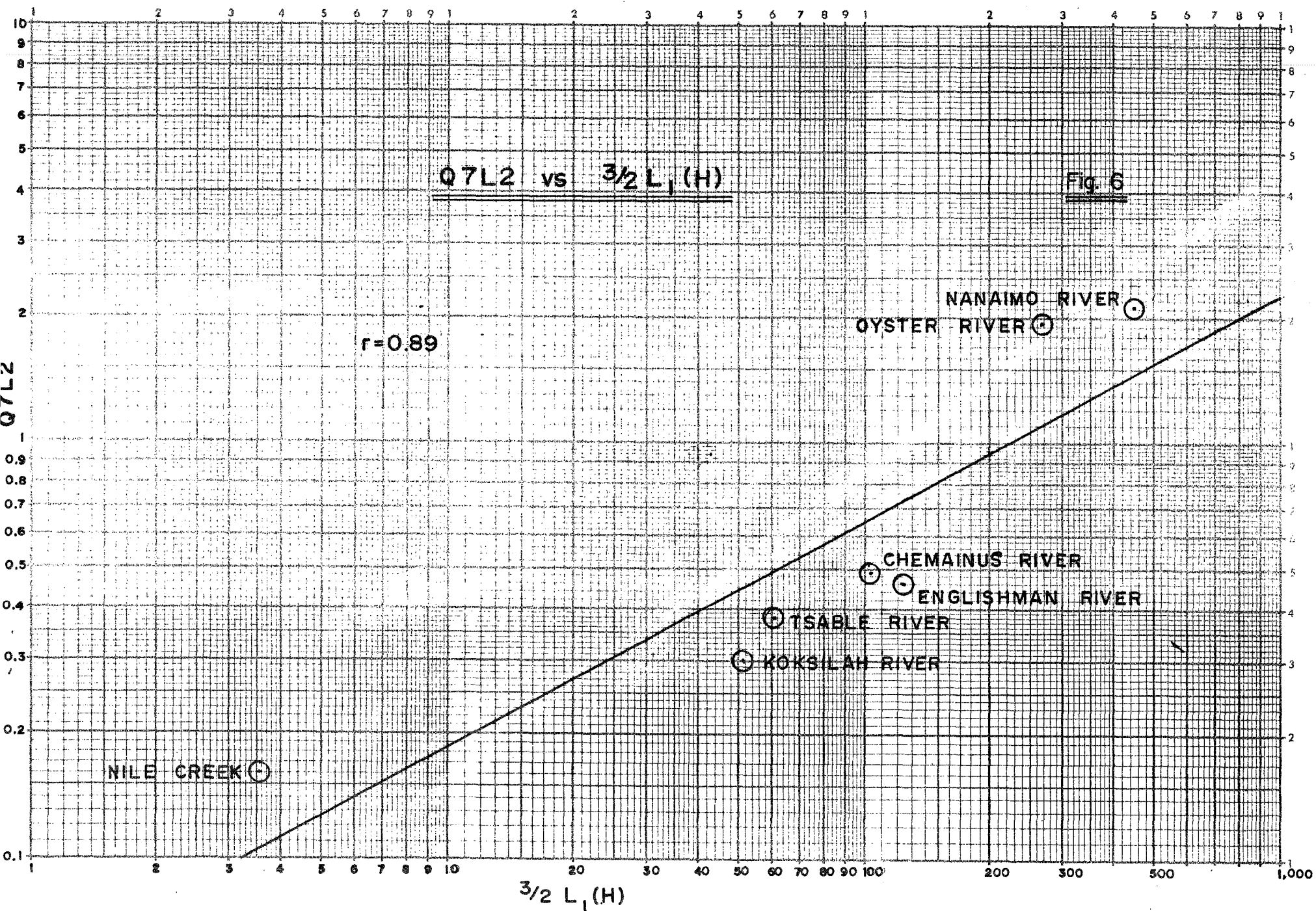
Fig. 3

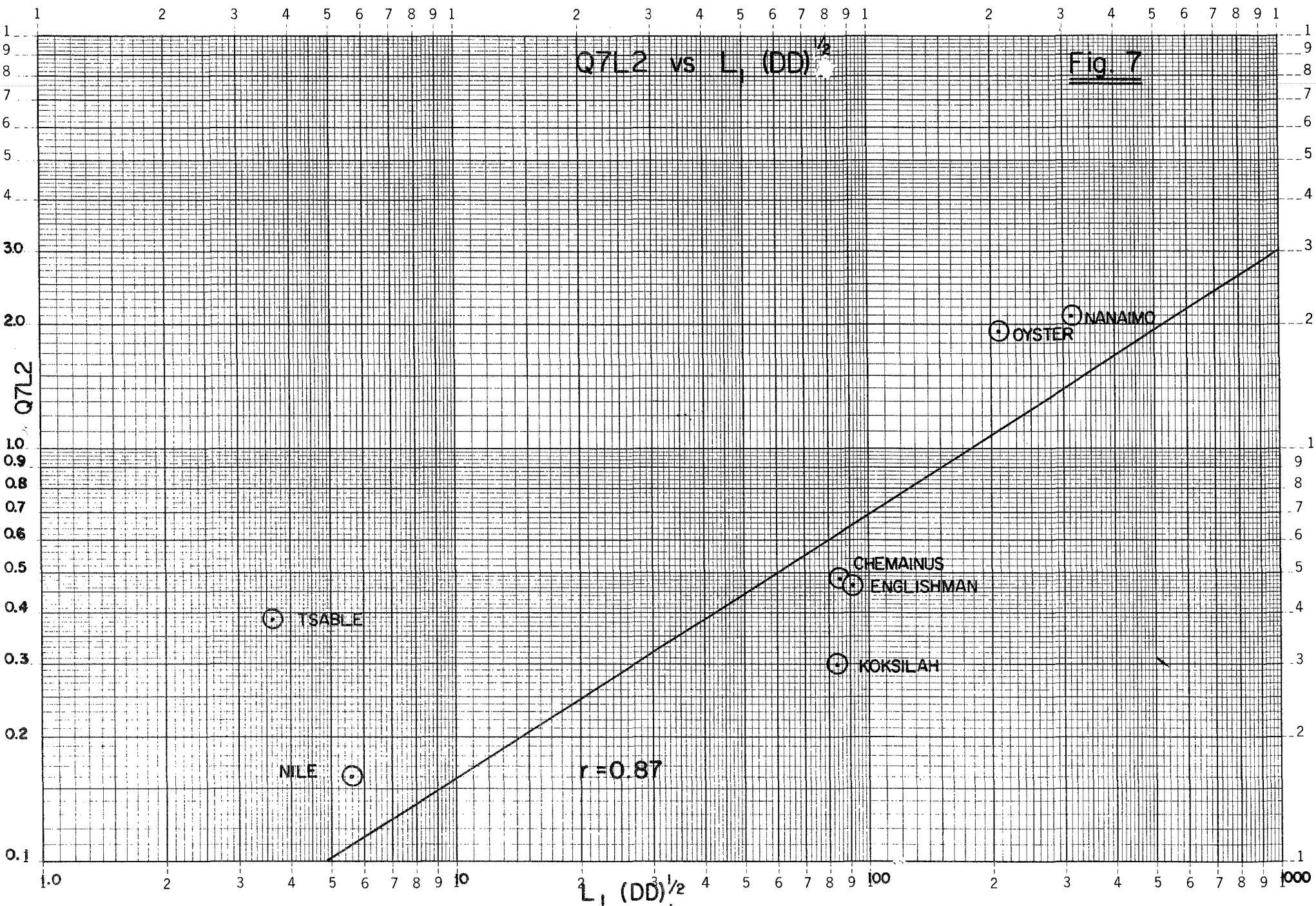
AVERAGE ANNUAL FLOW (QAA) vs AVERAGE ANNUAL PRECIPITATION (P)

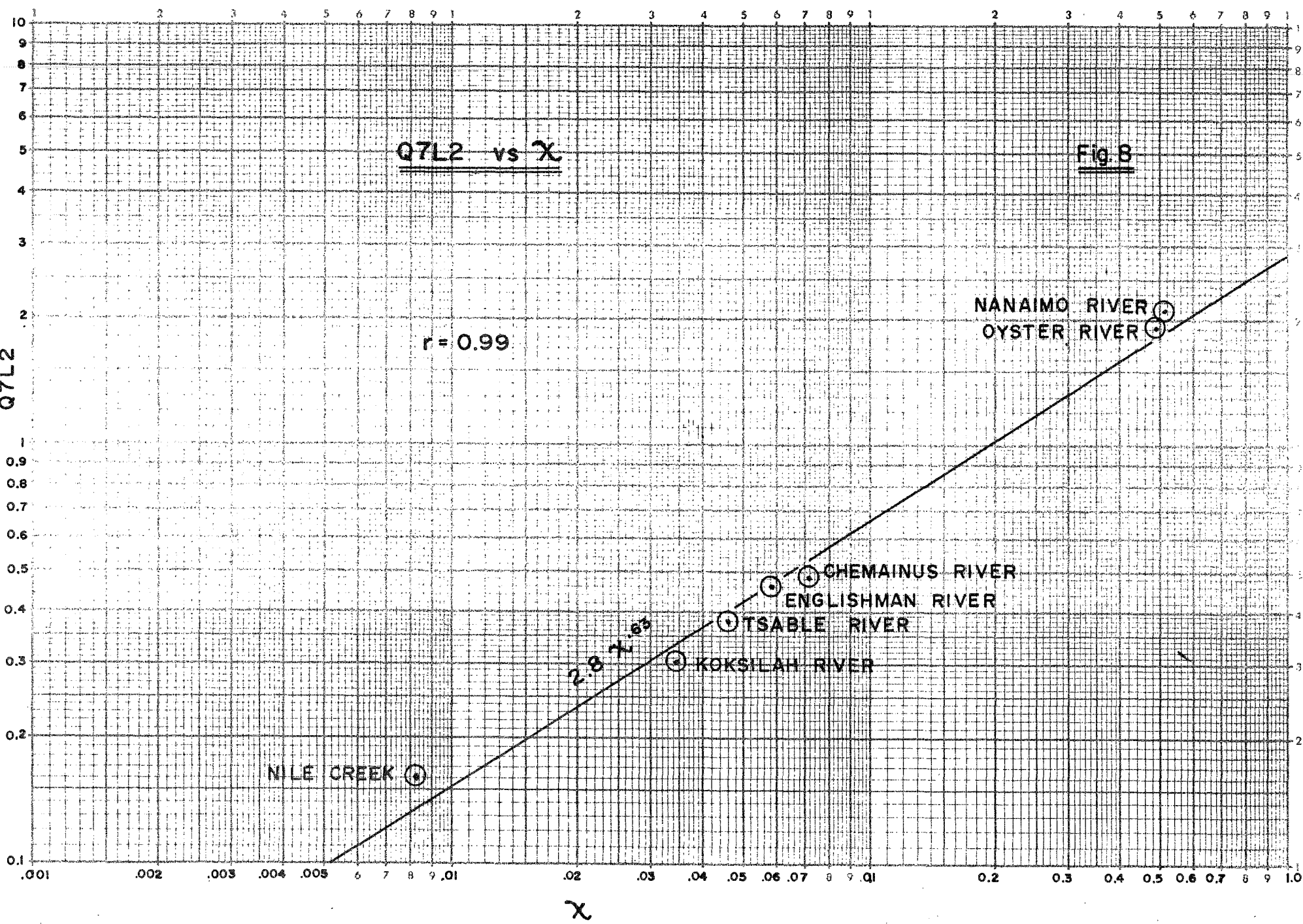


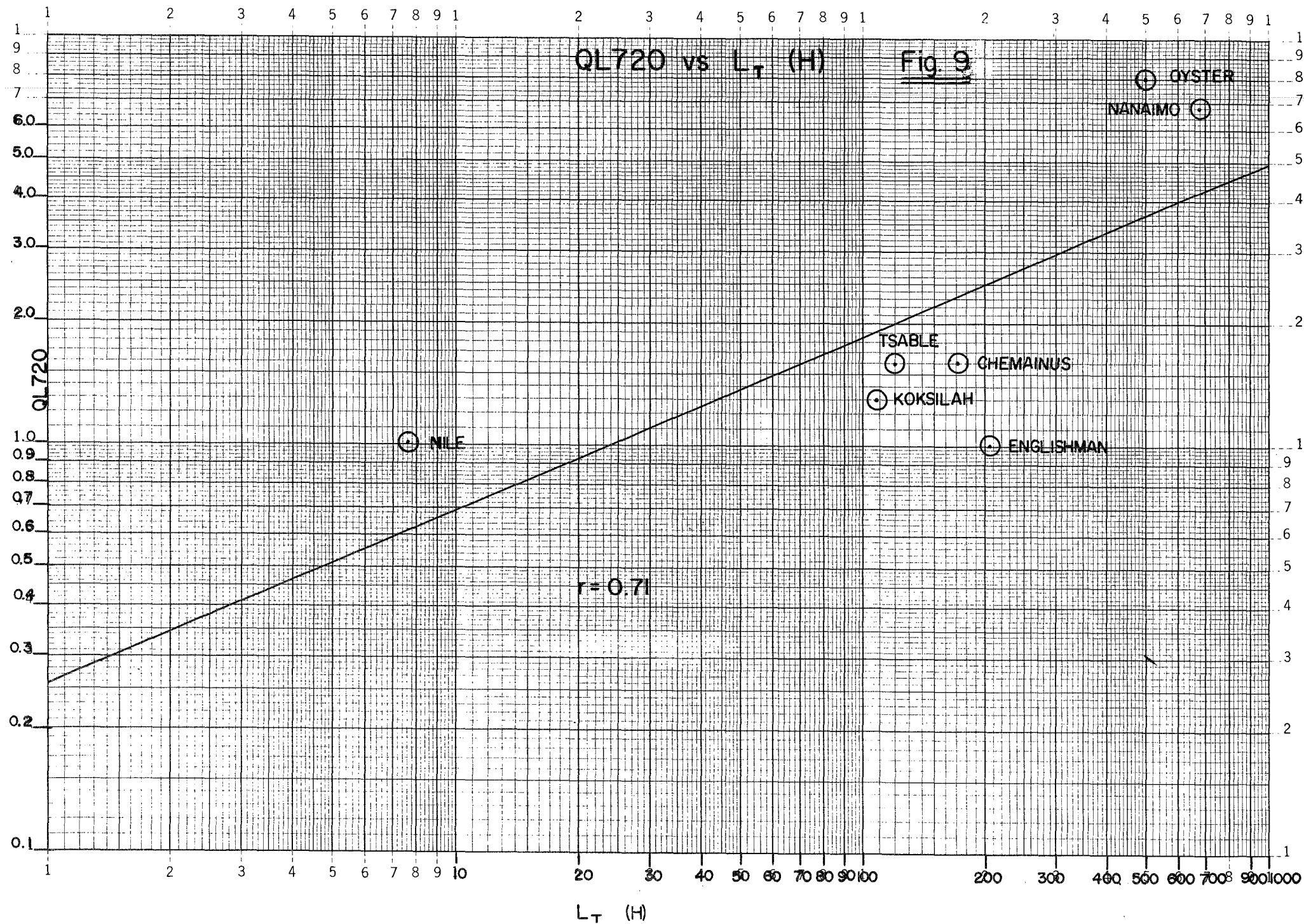












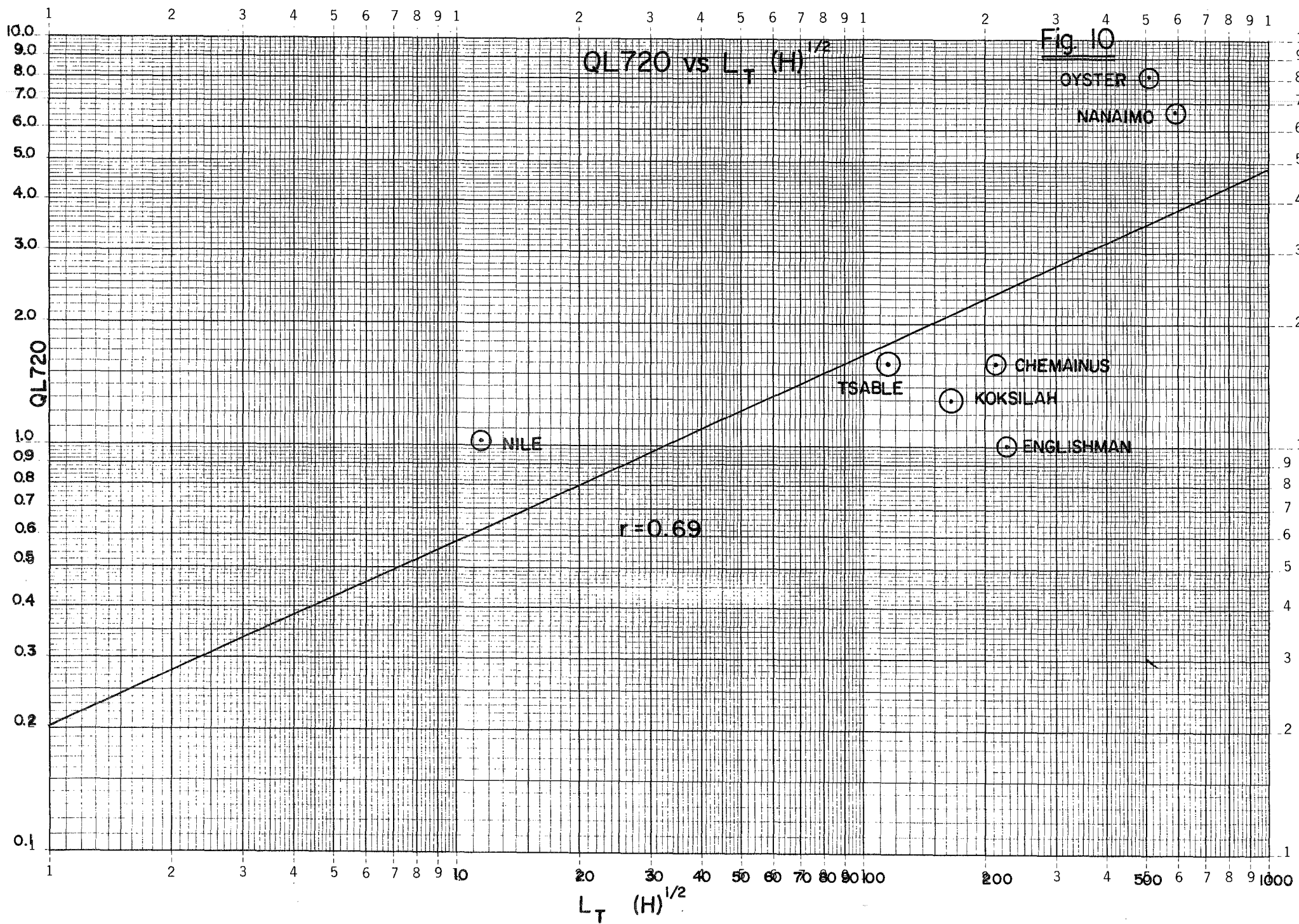
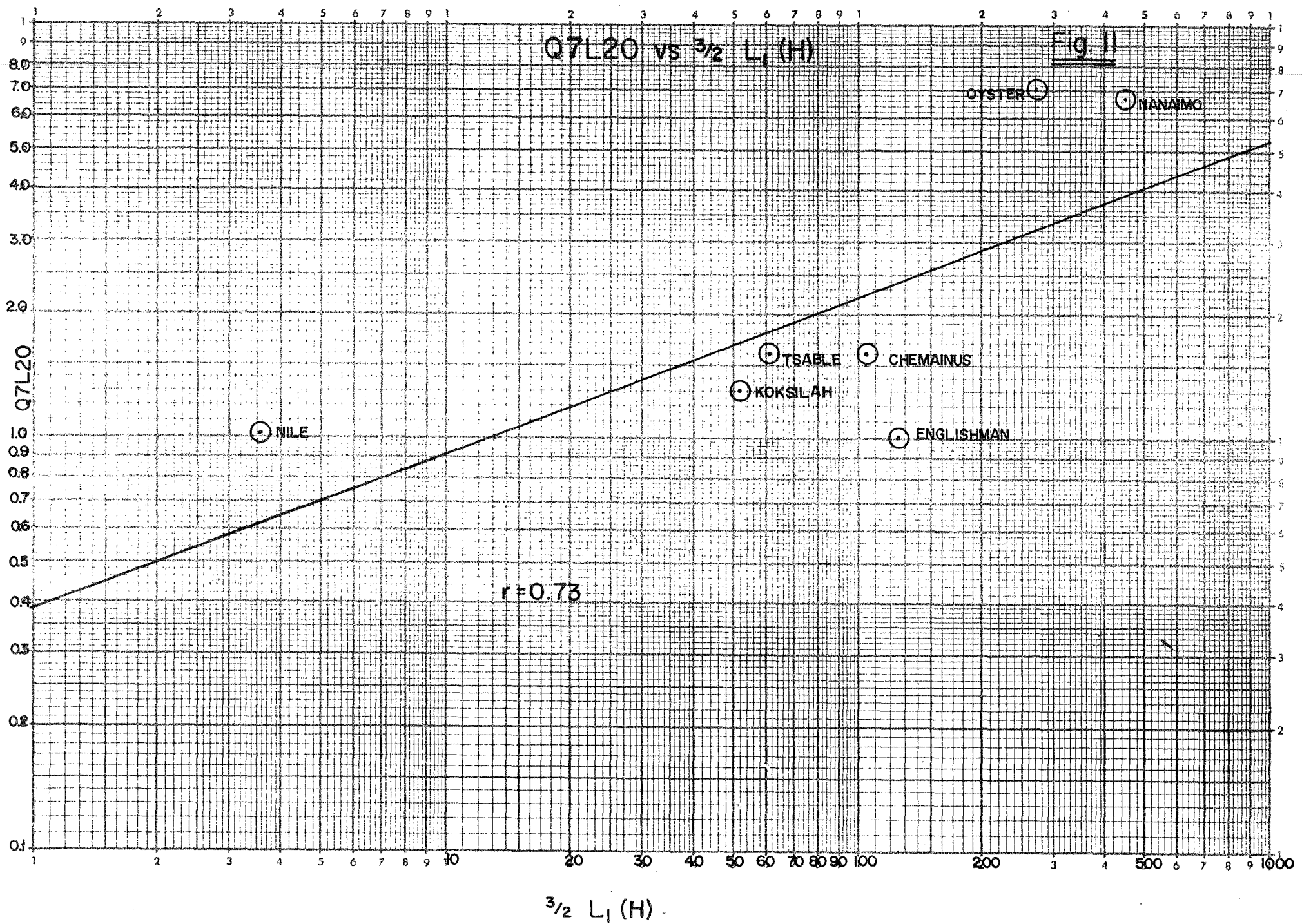
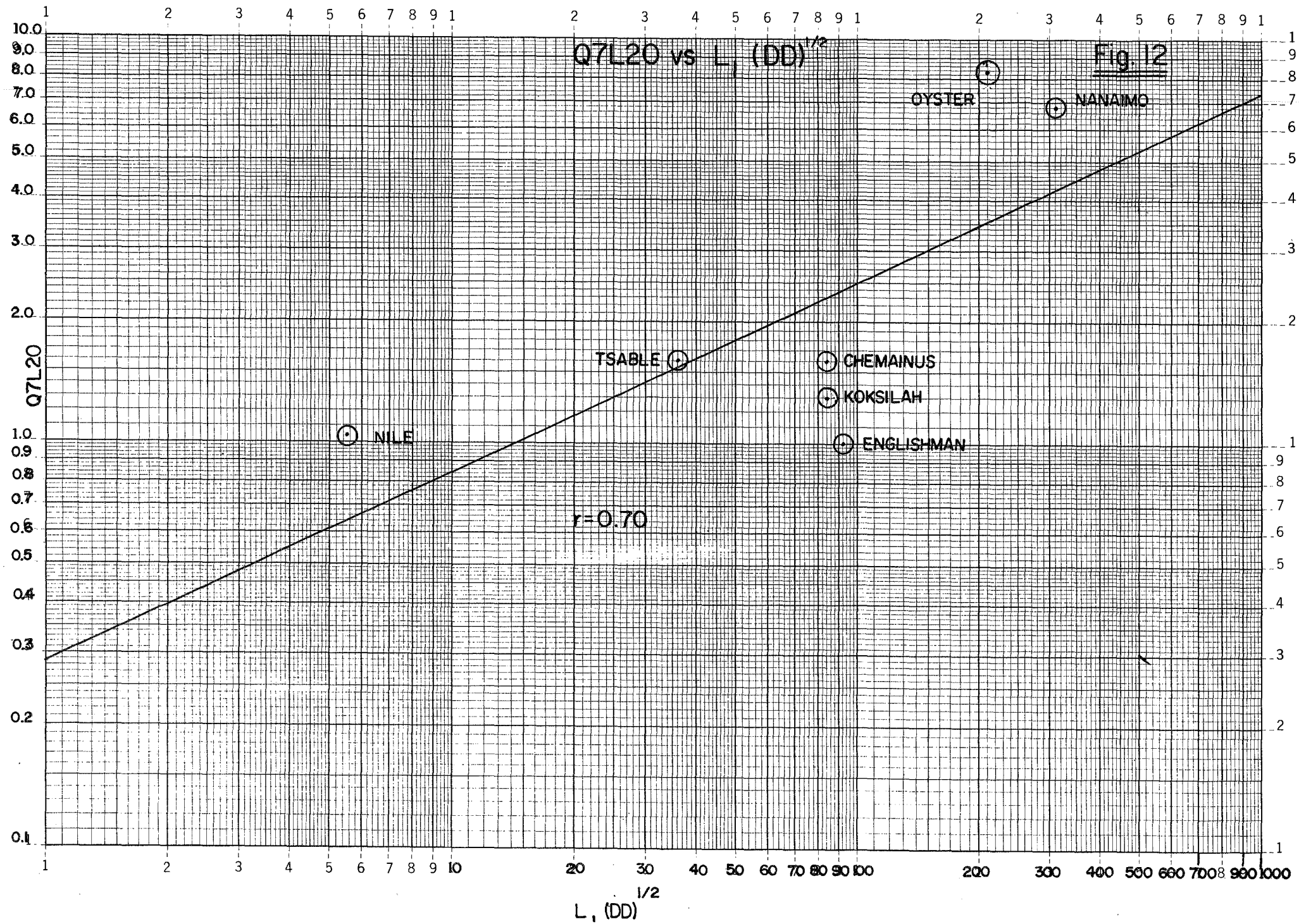


FIG 11





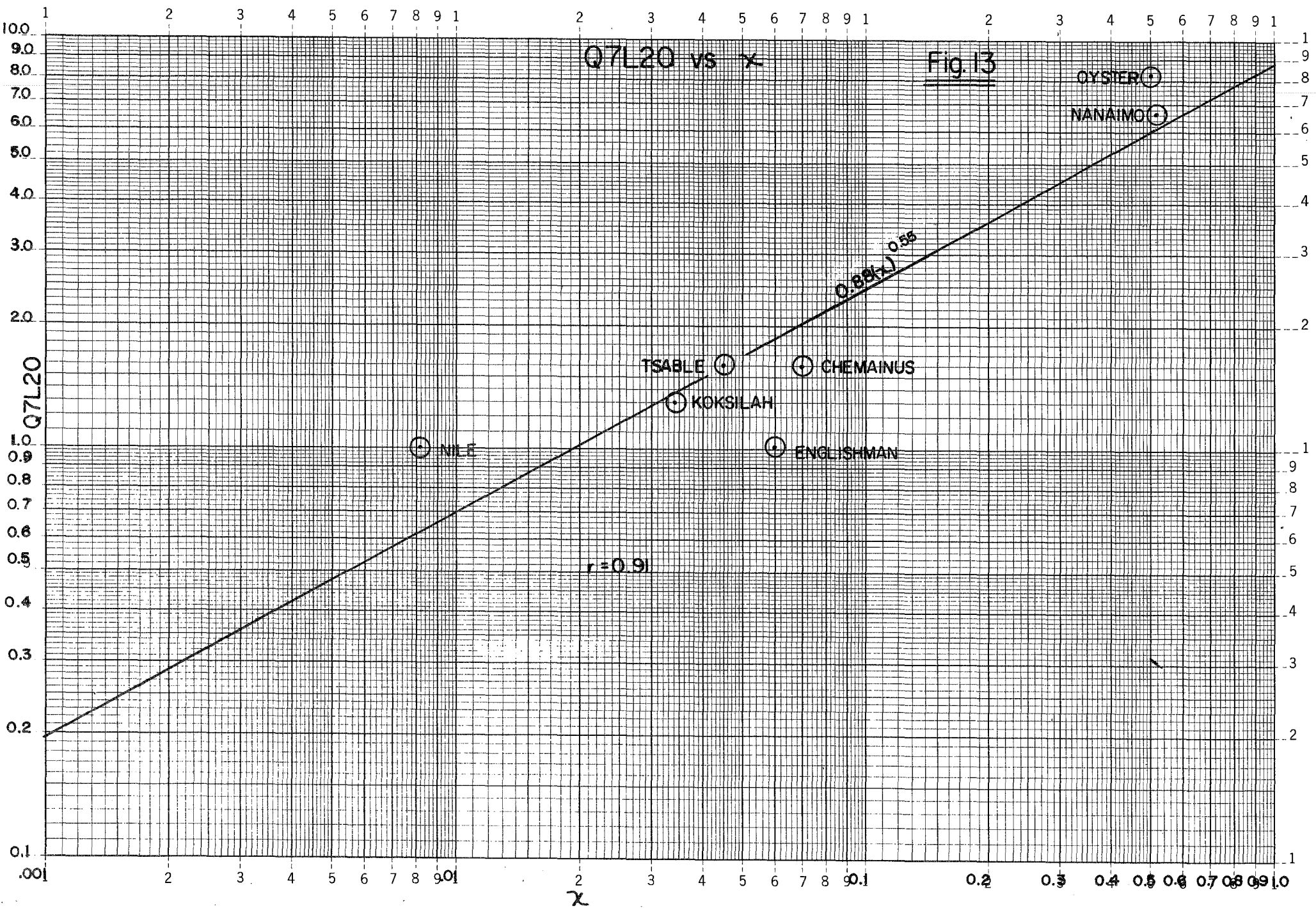


Fig. 14

RECURRENCE INTERVAL vs 7 DAY LOW FLOW - GAUGED STREAMS

Fig. 14

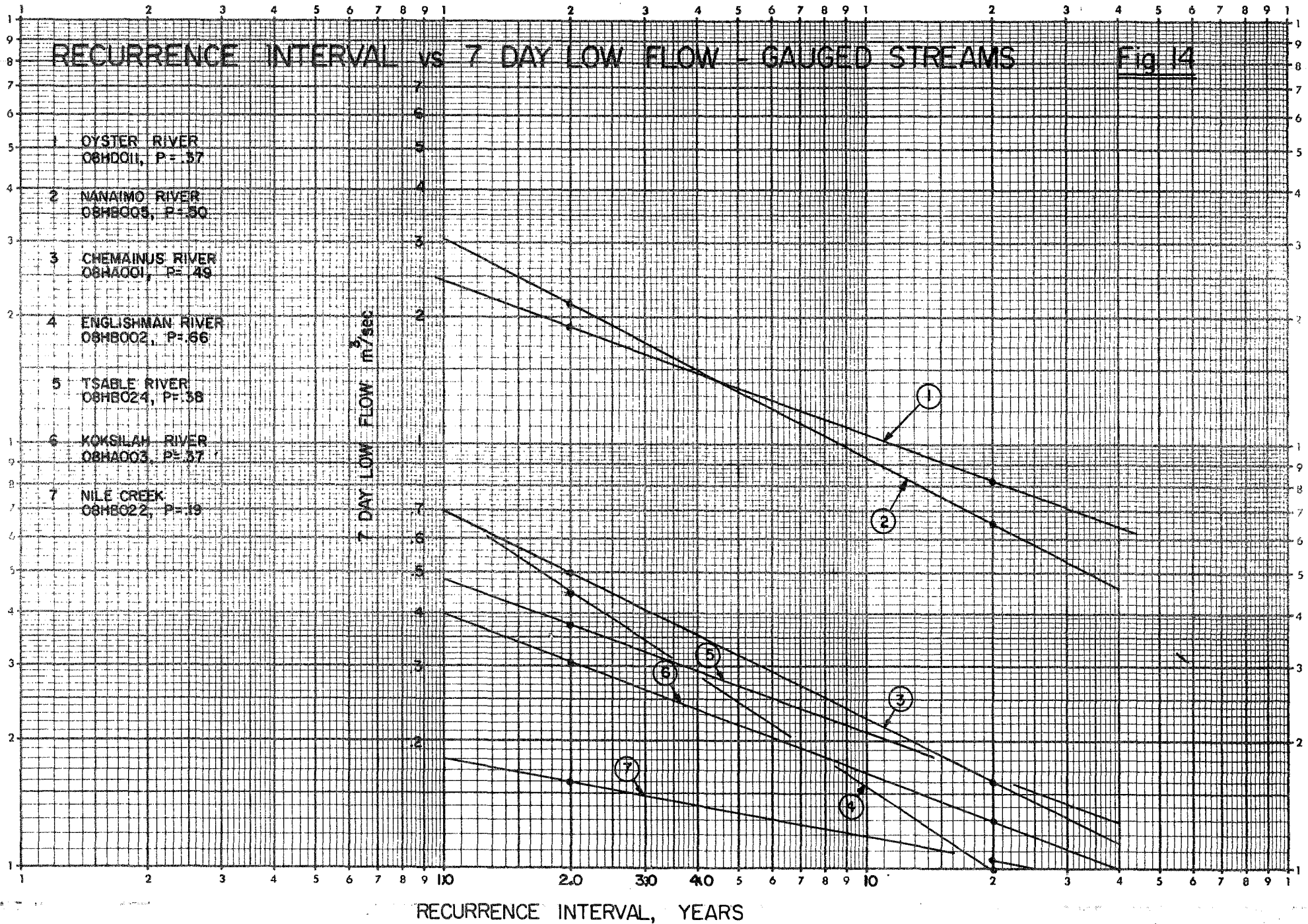


Fig. 15

UNGAUGED STREAMS 7 DAY LOW FLOW vs RECURRENCE INTERVAL

7 DAY LOW FLOW m^3/sec

TRENT RIVER

COWIE CREEK

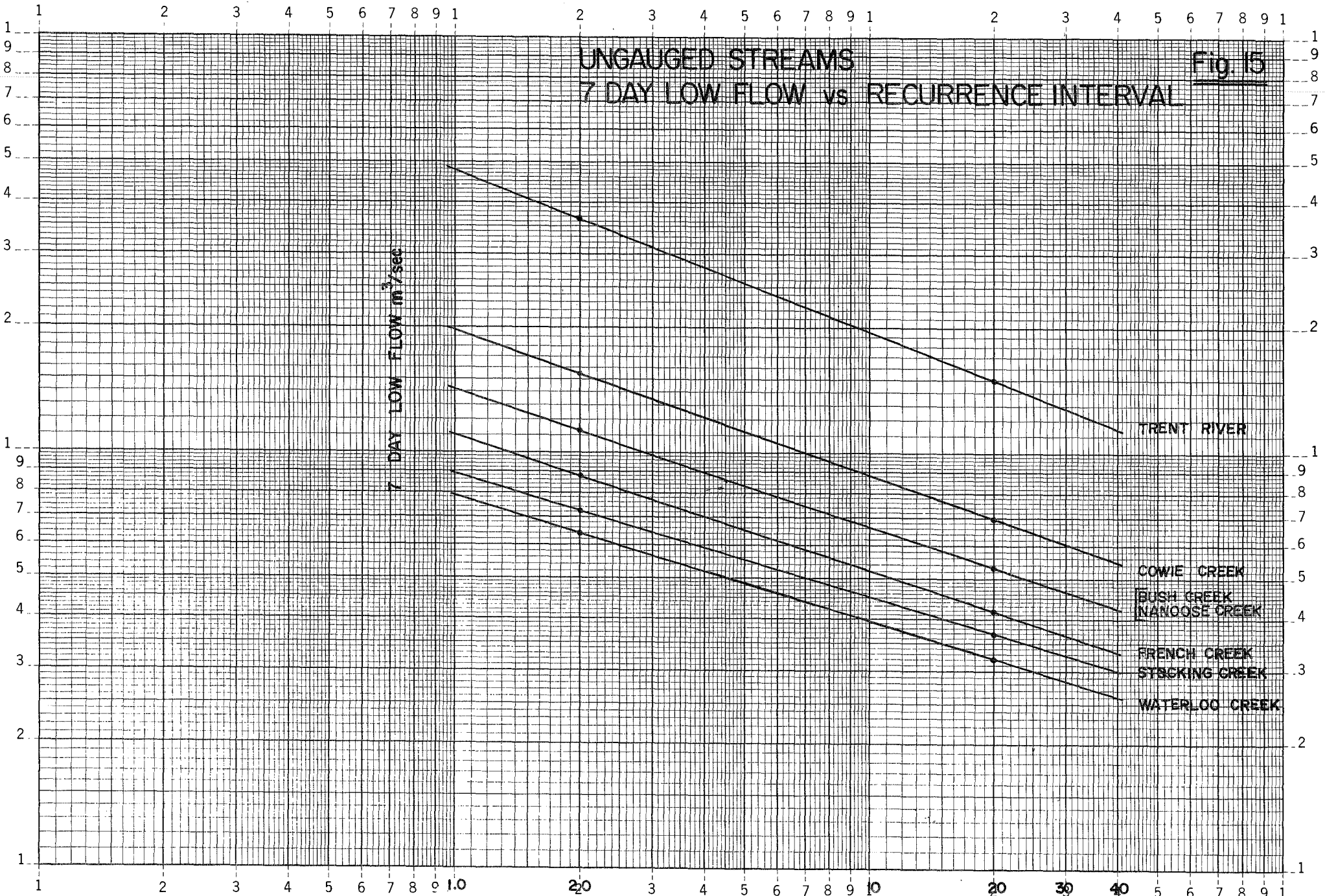
BUSH CREEK
NANOOSE CREEK

FRENCH CREEK

STOCKING CREEK

WATERLOO CREEK

RECURRENCE INTERVAL



REGION EAST COAST VAN. IS.....
Gaured Streams

* For explanation of symbols see 'Hamilton' p.p. 138-139.

✱

REGION EAST COAST VAN. IS.
Ungauged Streams

[illegible]

* For explanation of symbols see 'Hamilton' p.p. 138-139.

REGION

Gauged Streams

[illegible]*DISCHARGE IN m^3/sec

YIELD - Q7L2 / BASIN AREA

VARIABILITY - Q7L20/Q7L2

QAA ETC., SEE HAMILTON P.P. 138-139

East Coast Van. Is.
Ungauged Streams

[illegible]*DISCHARGE IN m^3/sec

YIELD = Q7L2 / BASIN AREA

VARIABILITY - Q7L20 / Q7L2

QAA ETC., SEE HAMILTON P.P. 138-139

COLLINGS METHOD

Collings derives values for preferred and sustaining spawning flows and optimum rearing flows from several key stream channel and watershed characteristics including:

- drainage area
- mean basin altitude
- reach altitude
- reach width
- gravel size
- reach slope
- shape factor
- hydraulic radius

The scope of this analysis is limited by climatic and geographic factors common to the area of original research. (See Figure 1). In reviewing the Collings values submitted in this report the reader should be aware that the regression equations used are unadjusted for the climate and topography of the East Coast Vancouver Island region. It was assumed, however, that the East Coast of Vancouver Island is similar to the area of original research.

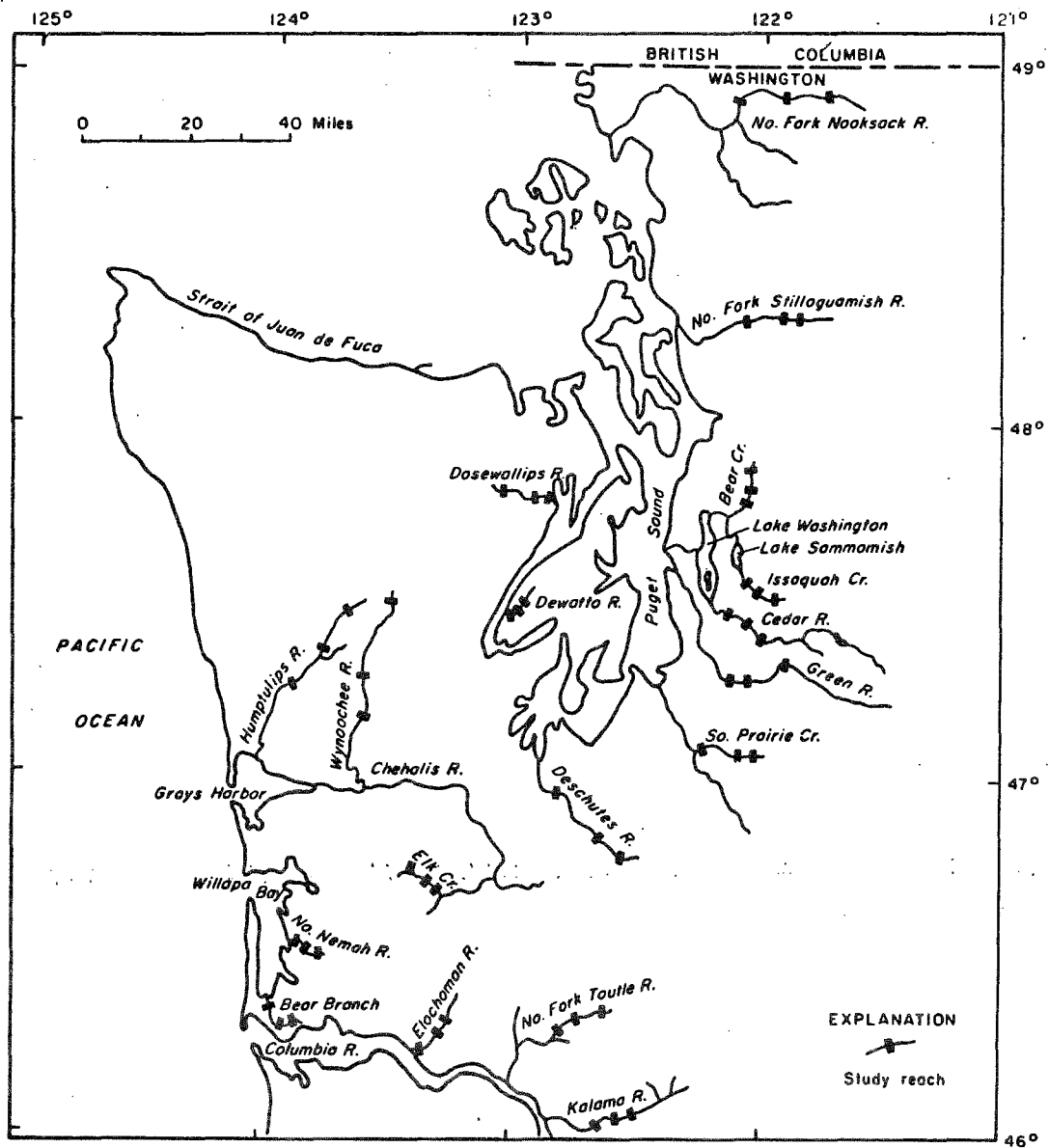


FIGURE 1.--Location of streams studied in western Washington. Small bars across streams indicate study reaches.

From: Collings, M.R. "Generalization of Spawning and Rearing Discharges for Several Pacific Salmon Species in Western Washington".

ESTIMATED FISHERY FLOW REQUIREMENTS

Sample Calculation (Nile Creek)

Preferred Spawning Flow (YP)

$$\begin{aligned} YP &= 1.17 (A^{.419}) (RA^{-.10}) (W^{.632}) (GS^{.153}) (RS^{.143}) \\ &\quad (SF^{-.224}) \\ &= 2.43 \text{ m}^3/\text{sec} \end{aligned}$$

Sustained Spawning Flow (YS)

$$\begin{aligned} YS &= 1.05 (A^{.456}) (RA^{-.087}) (W^{.587}) (GS^{.131}) (RS^{.143}) \\ &\quad (SF^{-.199}) \\ &= 1.90 \text{ m}^3/\text{sec} \end{aligned}$$

Optimum Rearing Flow (YR)

$$\begin{aligned} YR &= 0.026 (A^{.301}) (MA^{.638}) (RA^{-.124}) (W^{.564}) \\ &= 0.82 \text{ m}^3/\text{sec} \end{aligned}$$

Where;

A = Drainage Area (mi²)
 MA = Mean Altitude (ft)
 RA = Reach Altitude (ft)
 W = Bankfull Width (ft)
 GS = % 1" to 3" Gravel
 RS = Reach Slope (ft/mi)
 SF = Shape Factor

After; Collings, M.R. "Generalization Of Spawning And Discharges For Several Pacific Salmon Species In Western Washington".

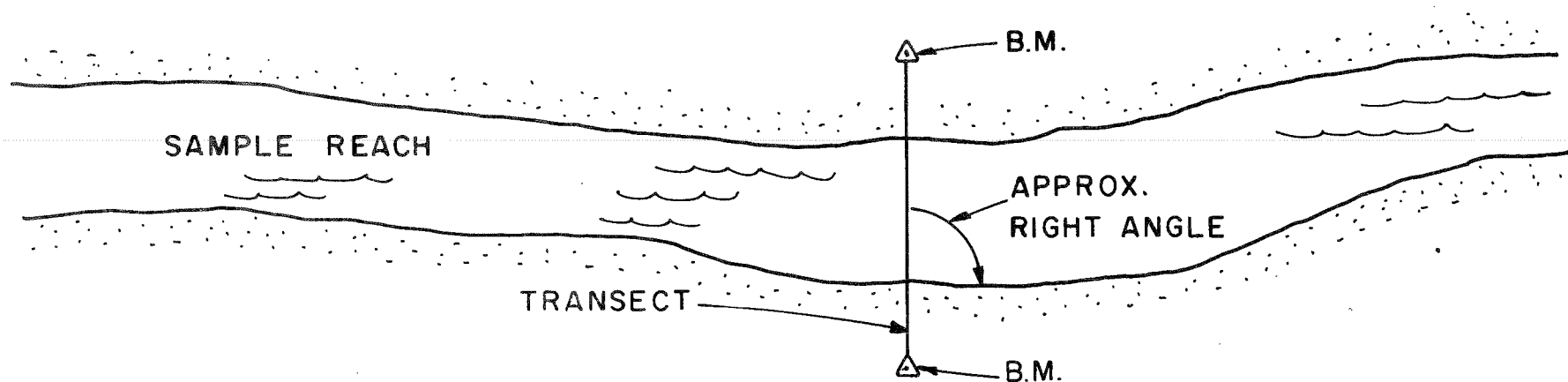


FIG. A

PLAN VIEW OF SAMPLE REACH

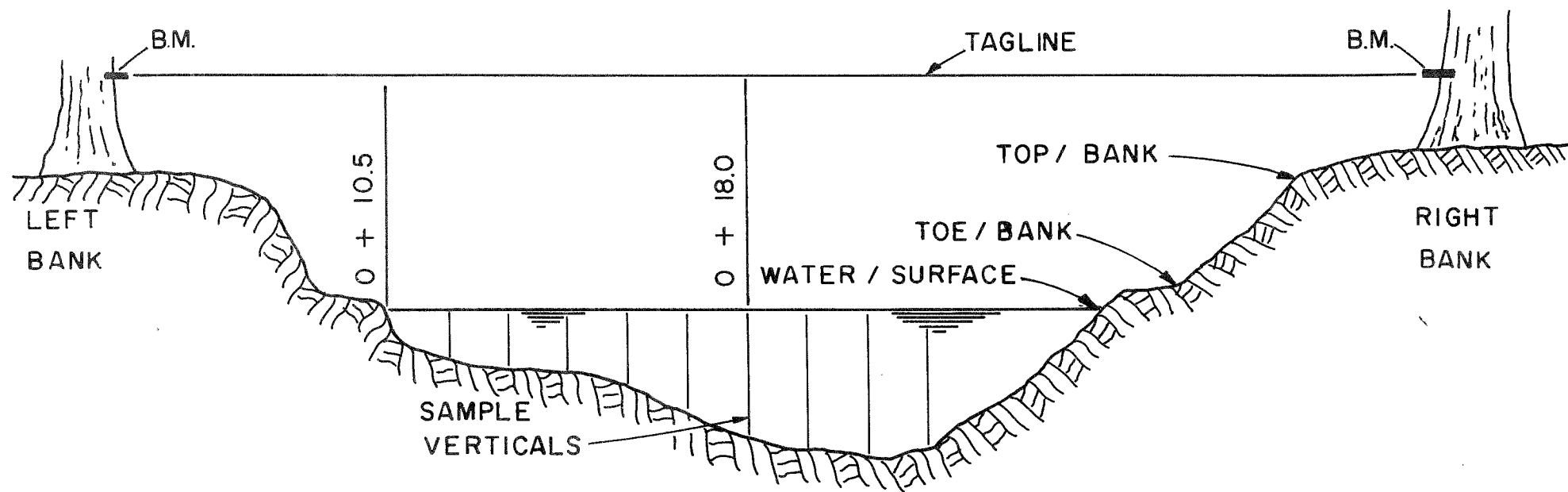
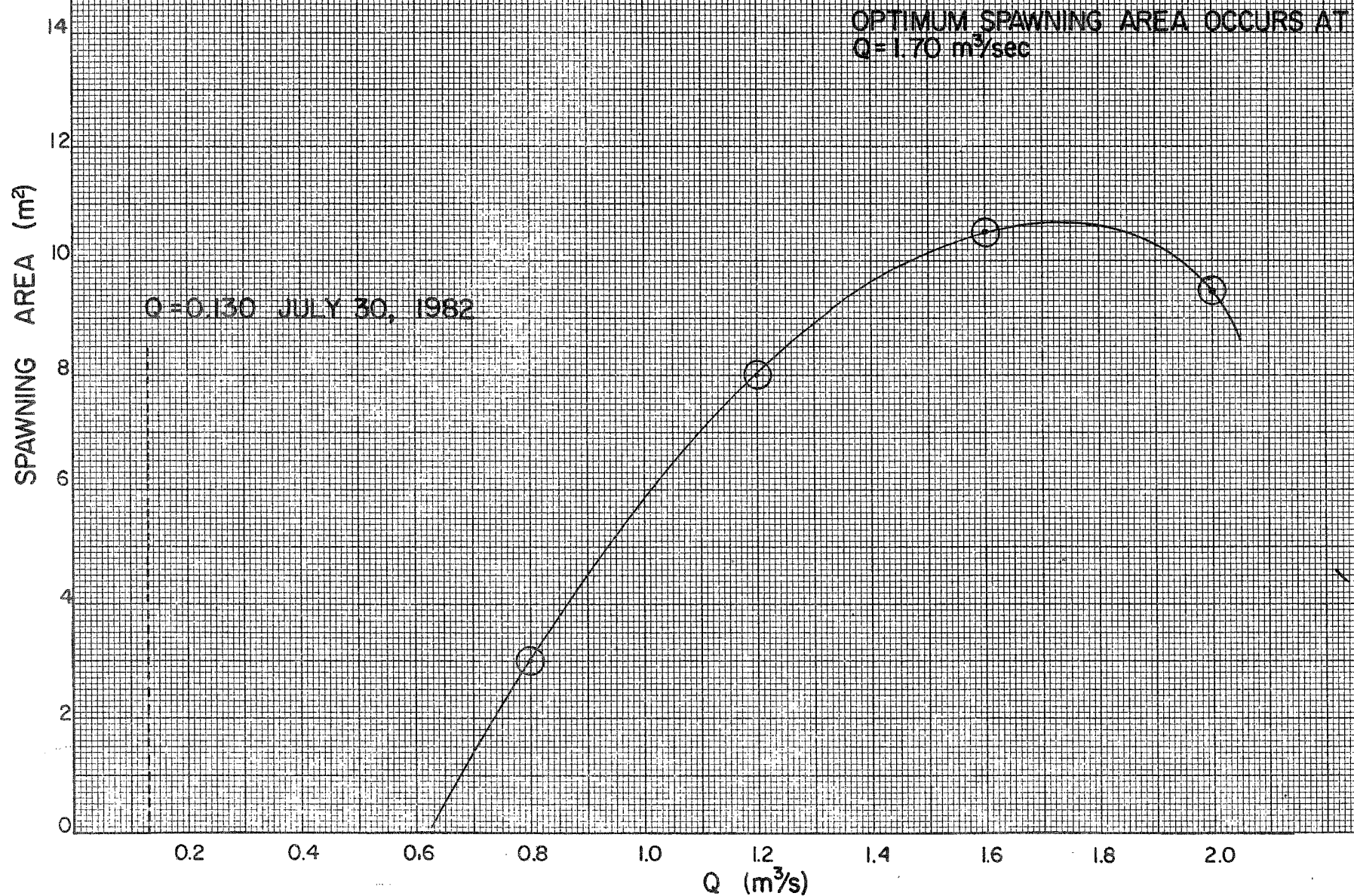


FIG. B

SEGMENTED CROSS SECTION

COWIE CREEK
SPAWNING AREA vs DISCHARGE

Fig 17



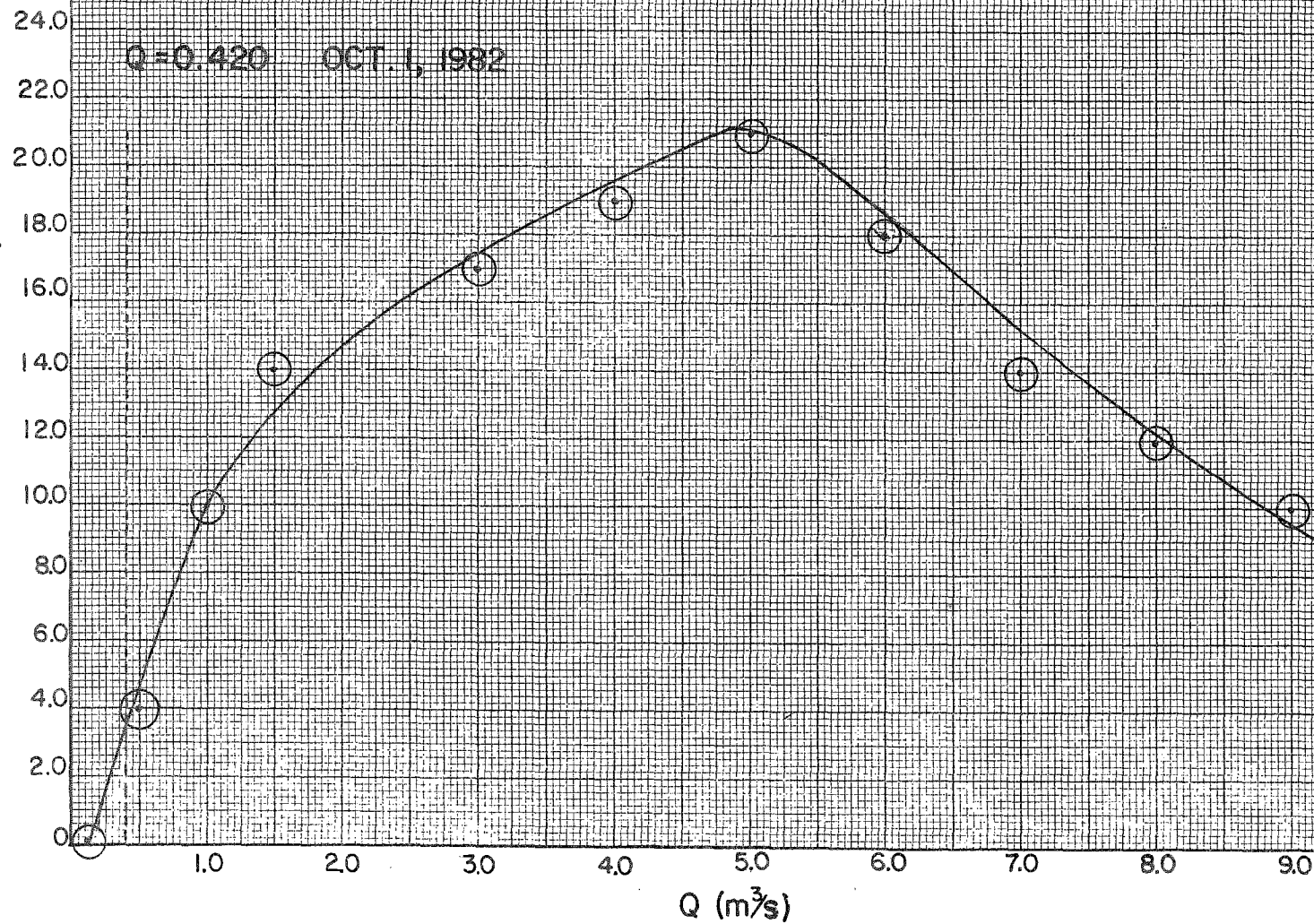
CHEMAINUS RIVER
SPAWNING AREA vs DISCHARGE

Fig 18

OPTIMUM SPAWNING AREA OCCURS AT
 $Q = 5.00 \text{ m}^3/\text{s}$

$Q = 0.420$ OCT. 1, 1982

SPAWNING AREA (m^2)



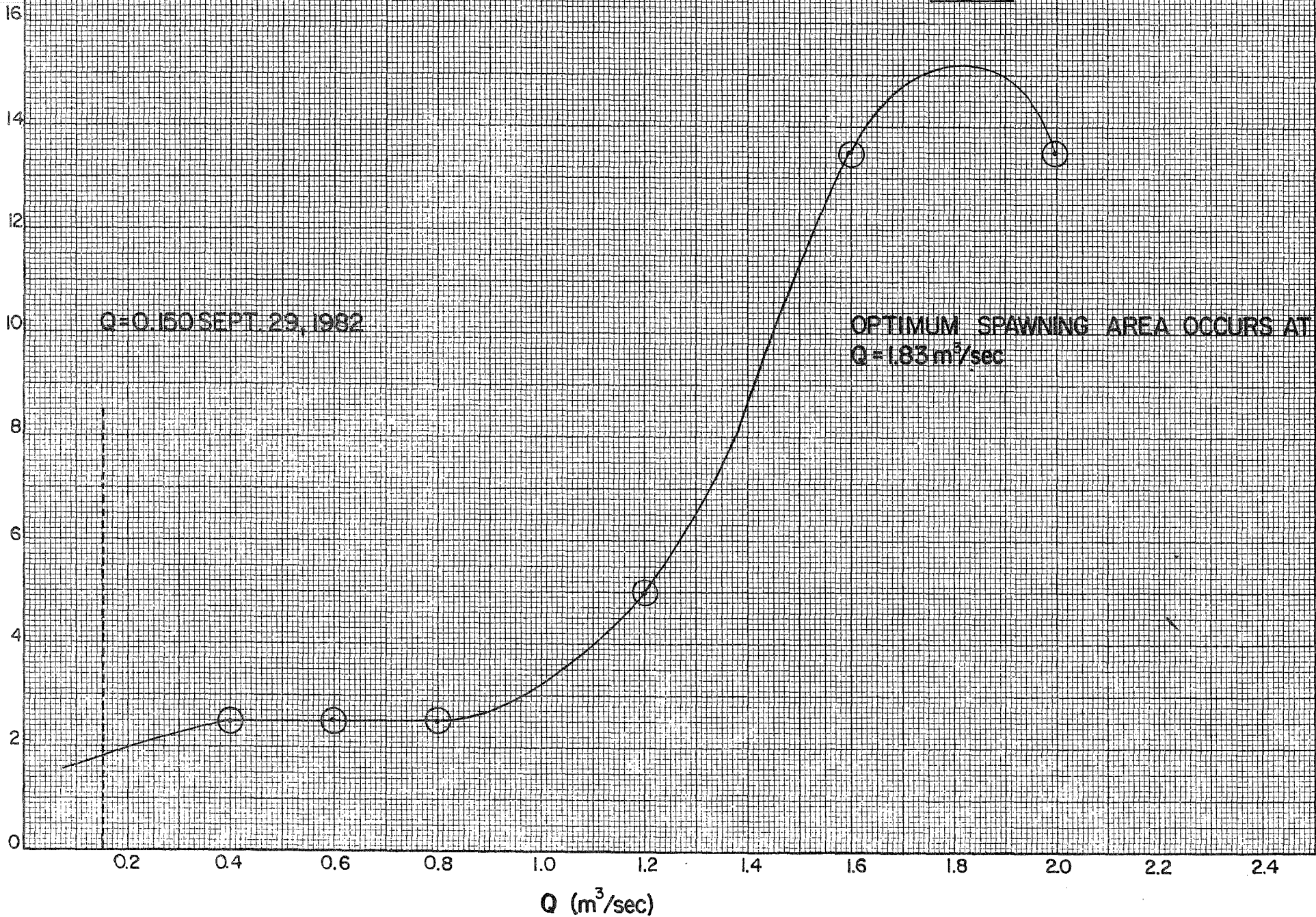
NILE CREEK
SPAWNING AREA vs DISCHARGE

Fig. 19

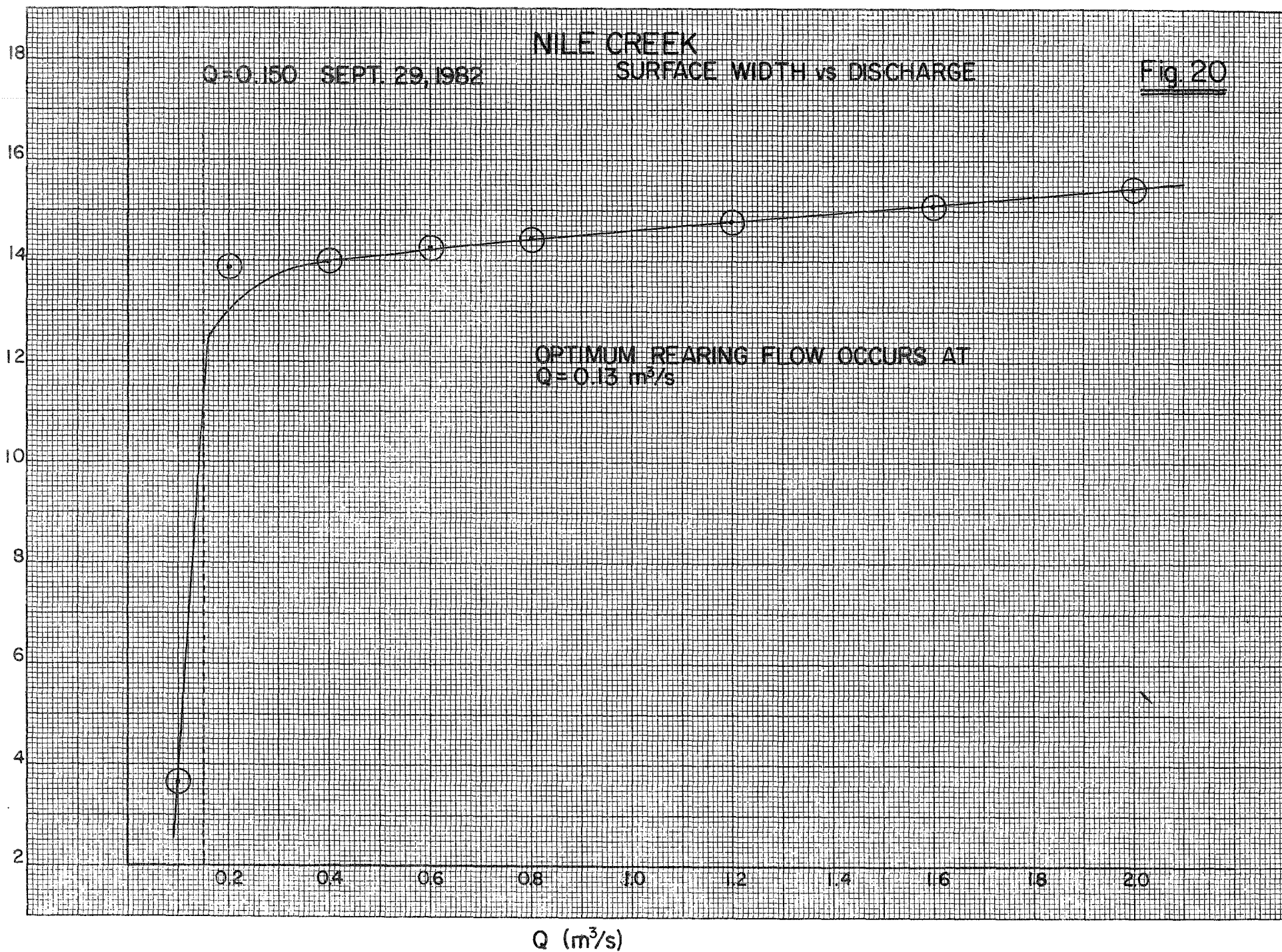
SPAWNING AREA (m^3)

Q=0.150 SEPT. 29, 1982

OPTIMUM SPAWNING AREA OCCURS AT
Q=1.83 m^3/sec



SURFACE WIDTH (m)



OYSTER RIVER
SURFACE WIDTH vs DISCHARGE

Fig 21

$Q=6.47$ JULY 21, 1982

OPTIMUM REARING FLOW
OCCURS AT $Q=6.4 \text{ m}^3/\text{sec}$

SURFACE WIDTH (m)

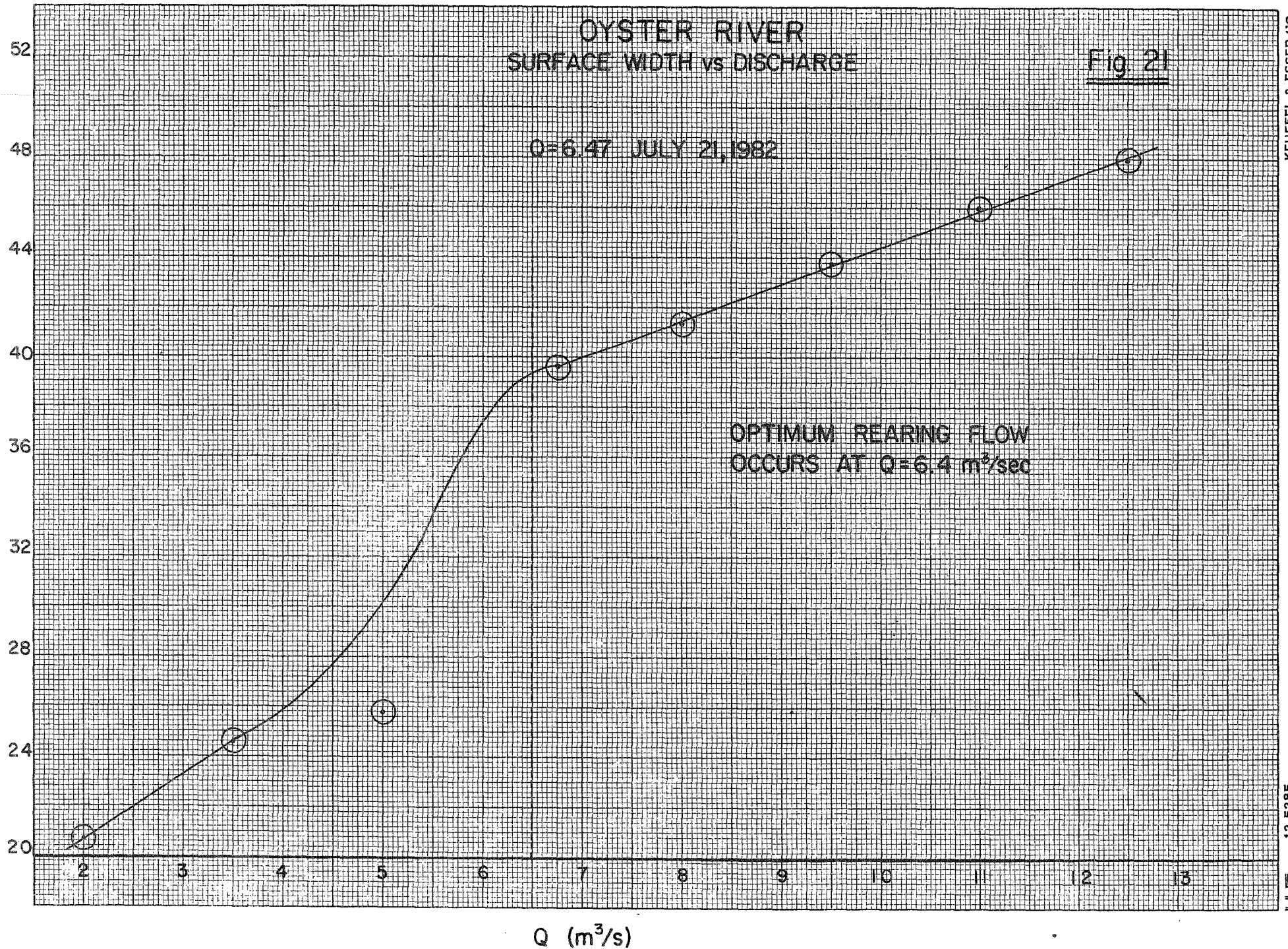


TABLE E

ESTIMATED FISHERY FLOW REQUIREMENTS *

STREAM	COLLINGS			'STREAMFLOW' (HAMILTON)		ACTUAL FLOW (SPAWNING)			
	YP	YS	YR	OPT. SPAWNING	OPT. REARING	COHO	CHUM	CHINOOK	PINK
Bush Cr.	2.6	2.0	0.8			No Data	No Data	No Data	No Data
Chemainus R.	8.54	7.20	2.98	5.00		43.31	25.27	4.26	
Cowie Cr.	2.5	2.0	0.67	1.70		No Data	No Data	No Data	No Data
French Cr.	3.1	2.7	1.0			No Data	No Data	No Data	No Data
Koksilah R.	5.29	4.56	1.25			9.81	9.81	9.89	
Nanoose Cr.	2.7	2.1	0.9			No Data	No Data	No Data	No Data
Nile Ck.	2.43	1.90	0.82	1.83	0.13	1.38	1.38		
Oyster R.	14.30	11.67	4.33		0.4	25.37	5.58		26.73
Rosewall Cr.	2.51	2.08	0.88			2.23	2.23		
Stocking Cr.	2.2	1.7	0.7			No Data	No Data	No Data	No Data
Trent R.	4.1	3.3	1.3			No Data	No Data	No Data	No Data
Isable R.	6.52	5.17	2.51			9.85	8.23		9.85
Waterloo Cr.	2.1	1.7	0.7			No Data	No Data	No Data	No Data

YP=PREFERRED SPAWNING FLOW (ALL SPECIES)

YS=SUSTAINED SPAWNING FLOW (ALL SPECIES)

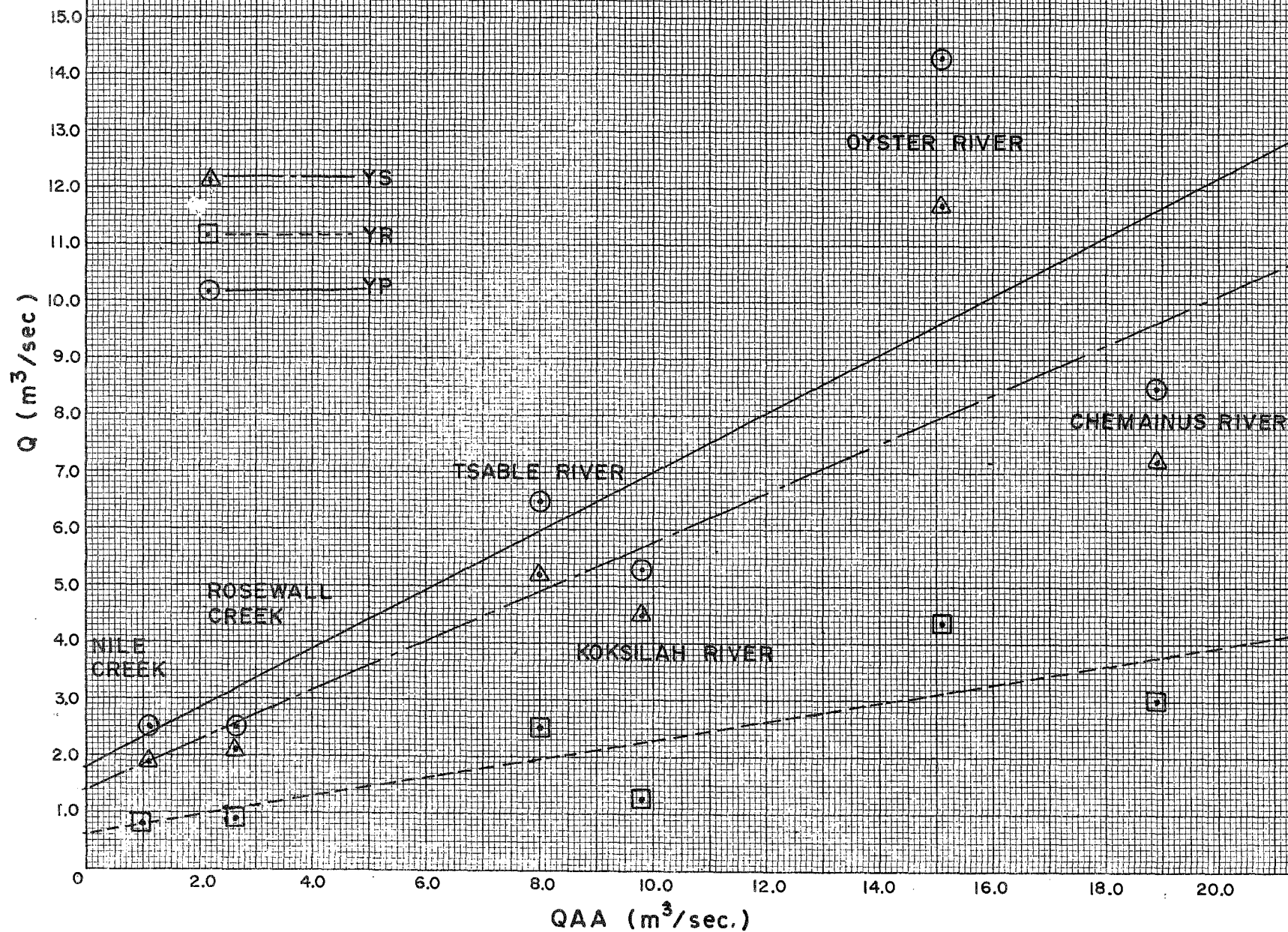
YR=OPTIMUM REARING FLOW (ALL SPECIES)

ACTUAL FLOW SPAWNING=AVERAGE DAILY DISCHARGE AT PEAK SPAWNING PERIOD

* DISCHARGE IN m^3/sec

ESTIMATED FISHERY FLOW REQUIREMENTS (COLLINGS)

Fig. 16



"STREAM FLOW" (HAMILTON, 1976)

Hamilton's computer program, "Stream Flow" is based on Stream hydraulics at individual transects using velocity, depth and substrate criteria. The output of this program provides estimates of velocities, depths and other parameters for specified flows and a prediction of spawnable area.

Transects are laid out as indicated in Fig. A and Fig. B. Hamilton suggests four transects be grouped together 20 to 50 feet apart and metered at three or more flow levels, to provide a sufficient data base. Suitable spawning gravel is also input on a presence/absence basis.

The "Stream Flow" program output generates the optimum spawning flow based on the parameters mentioned above. The optimum flow occurs when spawning area reaches a maximum (see Fig. 17-19). Rearing flows may also be predicted using the surface width/discharge (Q) relationship. Optimum rearing flows occur at the point of maximum curvature on the surface width vs. discharge graph (see Fig. 20-21).

APPLICATION TO THIS STUDY:

The Stream Flow program was run using data from 13 Vancouver Island streams, both gauged and ungauged. The final results however, are somewhat tentative due to the minimal amount of

data collected. The input for the program for these Vancouver Island streams consisted of one transect and one metering, with the exception of the Oyster and Chemainus Rivers, which were metered twice. No data were collected with regard to substrate at the transect site. Instead, areas where the slope of the cross section was greater than 20% were considered unsuitable for spawning. Because of the minimal amount of data input the program had to extrapolate more than was desirable. The end result was that only three of the thirteen streams had optimum spawning flows predicted by "Stream Flow" and only two had optimum rearing flows predicted by the program.

In conclusion, it is recommended that more than one transect be used and that discharges be measured at several stages. To further enhance the final results Hamilton suggests that substrate be input on a scale of 1-10 rather than presence/absence as it has been. The results of this type of input could then be evaluated alongside Collings (1974) and the actual flows on gauged streams.

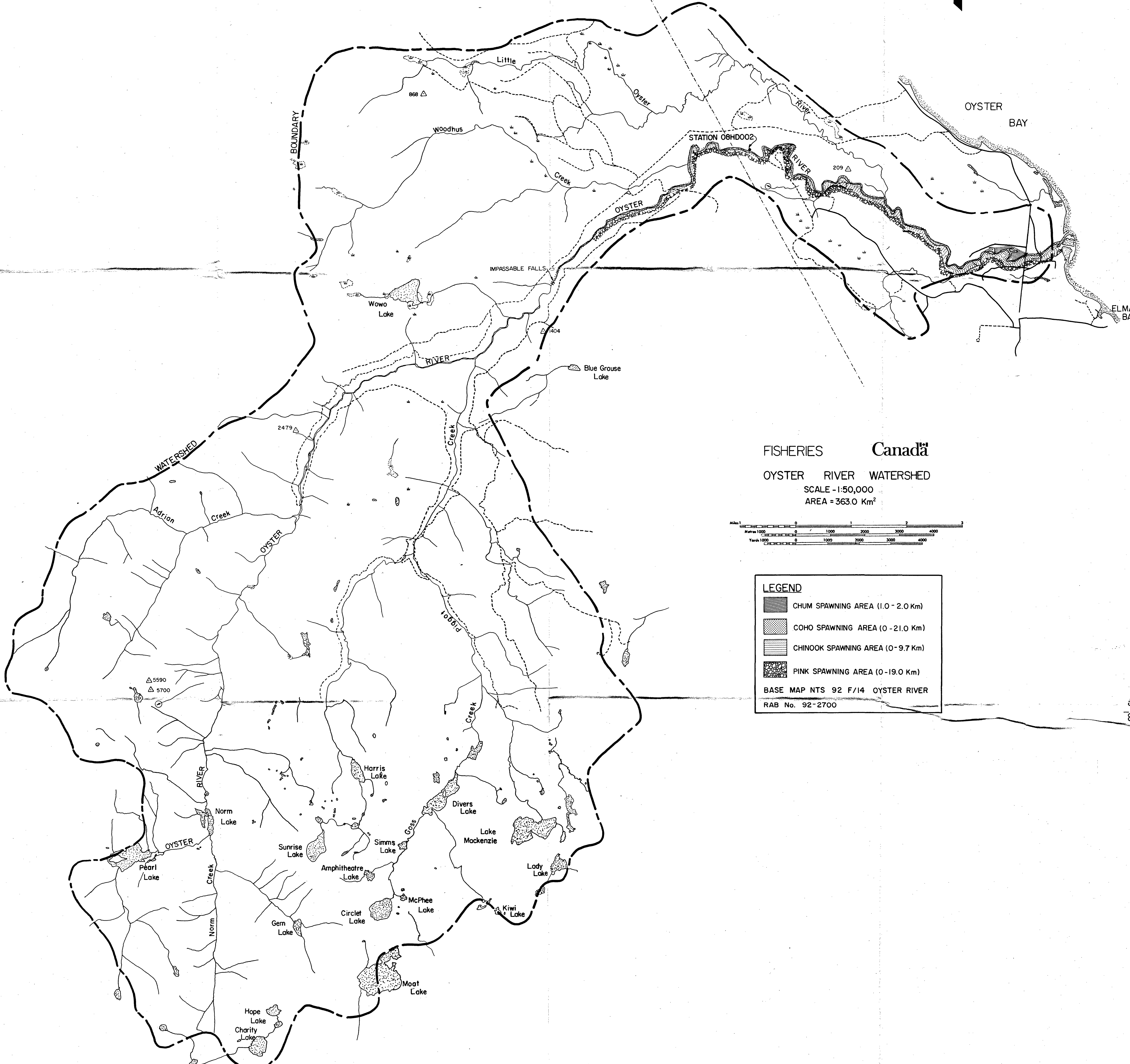
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Branch, RAB Technical Paper 3, Victoria, B.C., 1980.

University of Michigan, 'Drought Flow of Michigan Streams',
Department of Environmental Health, School of Public Health,
University of Michigan, 1960.

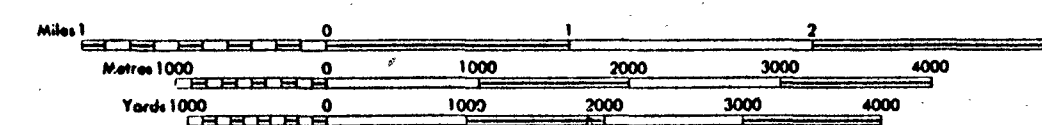
125° 15'



FISHERIES Canada

OYSTER RIVER WATERSHED

SCALE - 1:50,000
AREA = 363.0 Km²



LEGEND

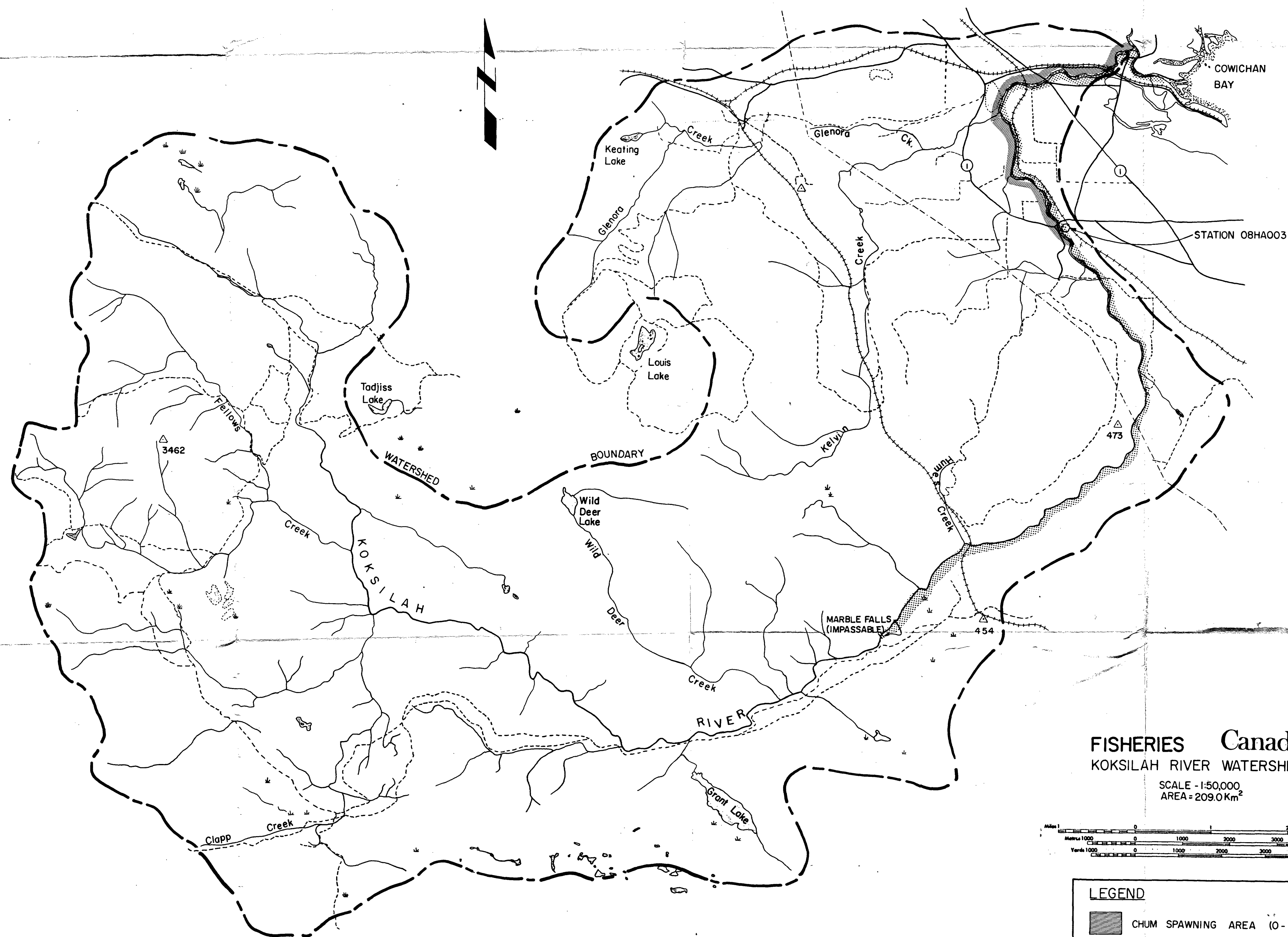
- CHUM SPAWNING AREA (1.0 - 2.0 Km)
- COHO SPAWNING AREA (0 - 21.0 Km)
- CHINOOK SPAWNING AREA (0 - 9.7 Km)
- PINK SPAWNING AREA (0 - 19.0 Km)

BASE MAP NTS 92 F/14 OYSTER RIVER
RAB No. 92-2700

49° 05'

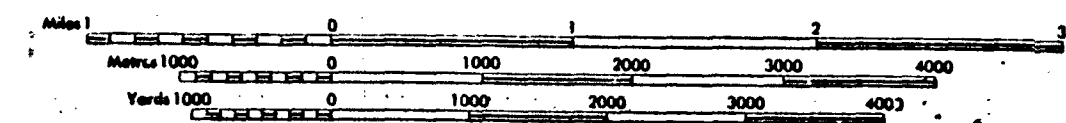
123° 40'

48° 45'

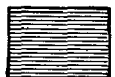
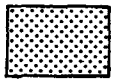


FISHERIES Canada
KOKSILAH RIVER WATERSHED

SCALE - 1:50,000
AREA = 209.0 Km²



LEGEND

-  CHUM SPAWNING AREA (0 - 8.0 km)
-  COHO SPAWNING AREA (0 - 20.0 km)
- FALLS IMPASSABLE AT 20 KM
- BASE MAP NTS 92/F12 BUTTLE LAKE
- RAB No. 92-4900

