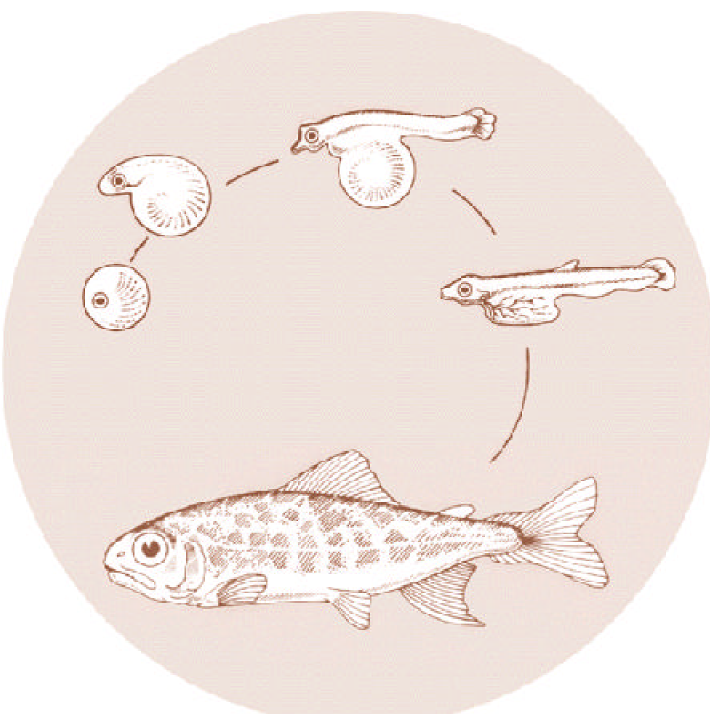
January 1981

INSTREAM FLOW STUDY OF THE UMATILLA RIVER



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#UNITED STATES DEPARTMENT OF THE INTERIOR

Fisheries Assistance Office
U.S. Fish and Wildlife Service
Vancouver, Washington

INSTREAM FLOW STUDY

OF THE UMATILLA RIVER

A Cooperative Study By:

U.S. Fish and Wildlife Service

and

Columbia River Inter-Tribal Fish Commission

JANUARY, 1981

(Funded by the Bonneville Power Administration)

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INTRODUCTION

Historically, the Umatilla River supported runs of spring and fall runs of chinook salmon, summer run steelhead trout and possibly coho salmon (Figure 1). These fish played an extremely important role in the culture and livelihood of The Confederated Tribes and Bands of the Umatilla Indian Reservation.

The advent of irrigation withdrawals reduced summer flows in the system and created a reduction in available habitat. Diversion dams also aggrevate the low flow conditions by hindering passage of salmonids and creating backwaters which trap sediment and slow velocities. Under, all these circumstances, salmonid runs have decreased dramatically. At the present time, the Umatilla River does not support runs of chinook and coho salmon. Steelhead runs are reduced, and some tributaries which once supported steelhead no longer do so.

The Confederated Tribes and Bands of the Umatilla Indian Reservation have long been aware of the declining health of anadromous fish runs in the Umatilla River system. In 1978, they requested the Fisheries Assistance Office-Vancouver (FAO) and the Columbia River Inter-Tribal Fish Commission (CRITFC) to determine the relationship between instream flow in the Umatilla River system and anadromous salmonid habitat. The CRITFC and FAO submitted a joint study proposal to the Bonneville Power Administration for funding in Fiscal Year 1978. The study was approved and funding received in March 1978.

To analyze available habitat under varying instream flow regimes, the incremental methodology developed by the U.S. Fish and Wildlife Service's Instream Flow Group (IFG), Fort Collins, Colorado was utilized because of its ability to self calibrate, and to evaluate both optimum and marginal habitat.

The IFG methodology allows the use of several hydraulic simulation techniques, of which FAO elected to use the rating curve method. This method is recommended by IFG for streams with complex channels and assumes that a linear logrithmic relationship exists between river stage and discharge.

The U.S. Geological Survey (USGS) was contracted to obtain the necessary flow measurements for input into the IFG model.

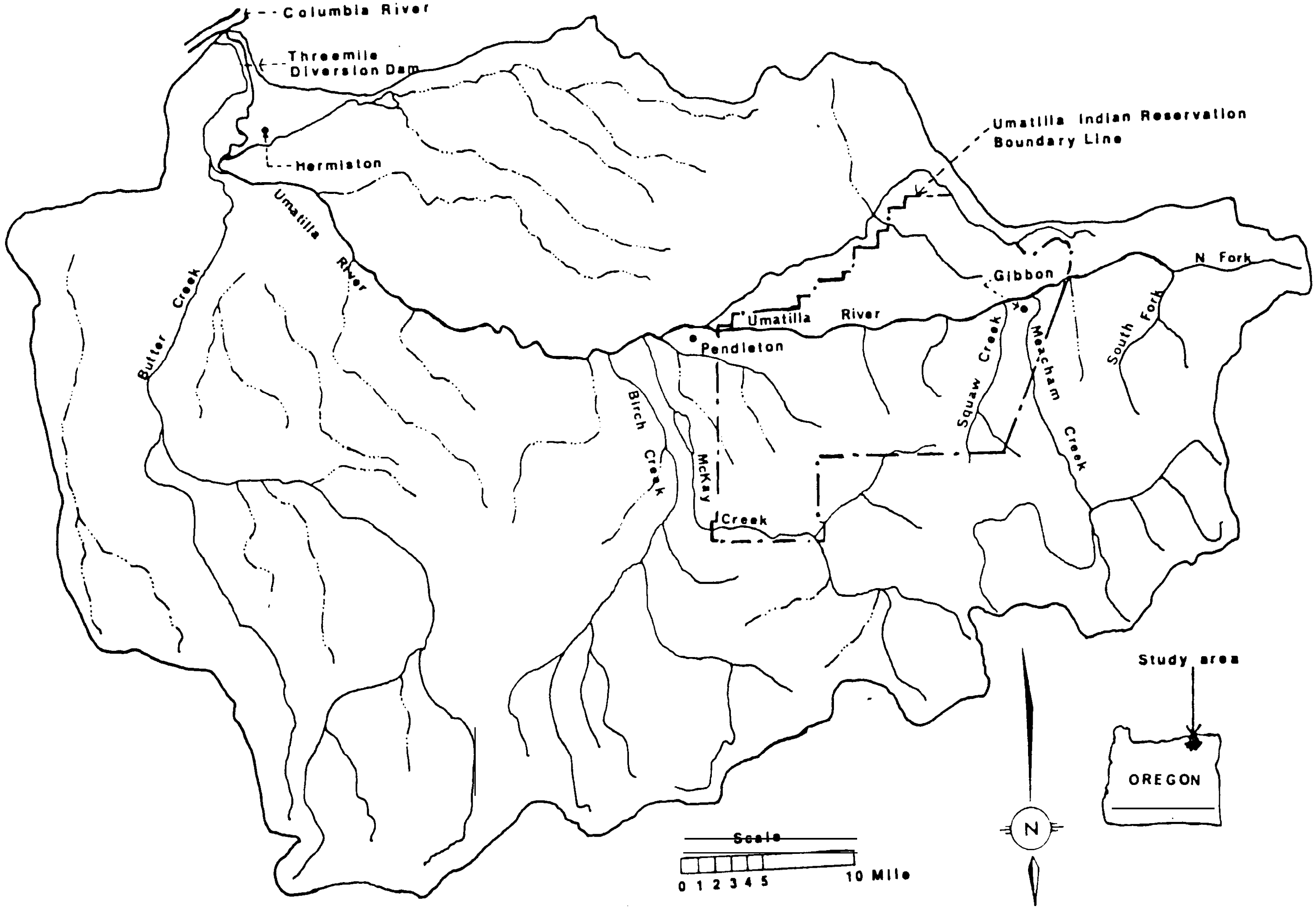


Figure 1: Location Map.

SITE SELECTION

The first task in the assessment of the instream flow requirements of anadromous salmonids in the Umatilla River was the division of the study area into sections providing relatively homogeneous habitat throughout their length. Factors considered in defining these sections included topography, geology, gradient, stream flow,and biological communities (Bovee and Milhous, 1978). The Oregon Department of Fish and Wildlife's District Fishery Biologist for the Umatilla Basin was consulted and in cooperation with him, the mainstem river was divided into eight sections.

During the process of segmenting the mainstem, study areas on tributary streams which contribute to, or which exhibited the greatest potential for contributing to the Basin's anadromous fishery resource were also established. The tributaries selected, based on present contribution, were the North and South Fork of the Umatilla River, Meacham Creek, Squaw Creek and Birch Creek. The tributaries offering the best potential for restoration were McKay Creek and Butter Creek. One study section was selected on each tributary. This section usually represented the longest section of uniform habitat within the tributary.

Following the identification of the river sections, representative study reaches from each section were established. A typical study reach contained two riffle-pool, or meander crossing meander-pool sequences. The length of the study reaches averaged ten to fourteen times the average channel width, as recommended by IFG (Bovee and Milhous, 1978).

In selecting the study reaches, each river section was toured to obtain a feeling for all habitat types and every area offering suitable access to field crews was visited. Lastly a concensus opinion of the area which best represented the river section was obtained. One representative study reach was selected in each of the eight river sections, with the exception of the second section upstream of the river's mouth. Due to the length of this section and the frequent change in stage caused by irrigation withdrawals, two study reaches were selected. Table 1 defines the representative river sections and locates the study reaches; Figure 2 shows the location of study reaches within the Umatilla River system. Study reaches are denoted with a "U" or "T"; the "U" signifies a mainstem Umatilla River reach and the "T" a tributary reach of the mainstem Umatilla River.

Four to six transects were established within each study reach. The number of transects used was based upon the complexity of the study reach. With the assistance of the USGS, transects were positioned to define a specific habitat type within the reach. The downstream transect, as specified by the IFG methodology, was placed whenever possible on a hydraulic control. On the reaches in the lower river, water depth and turbidity were such that hydraulic controls, if present, were not discernable.

Table 1. Representative Section Boundaries, and Study Reach Locations

Representative Section Boundaries	Study Reach Location	Stream Characteristics
Mouth of the Umatilla River R.M. 0. to Three Mile Dam R.M. 3.75; length 3.75 miles.	Ul Near USGS Gaging Station R.M. 2.1	Low stream gradient; a few long meanders in broad valley.
Three Mile Dam, R.M. 3.75, to Feed Canal Diversion Dam, R.M. 28.8 (approximately 1.8 miles upstream from Echo); length 25 miles.	u2 Near Hwy 207 bridge. R.M. 15.7. u3 Near Hwy Bridge at Echo R.M. 26.6	Low stream gradient; long meanders in broad valley.
Feed Canal Diversion Dam R.M. 28.8, to Birch Creek R.M. 46.5; length 17.7 miles.	u4 Near USGS Gaging Station and Hwy Bridge, R.M. 37.6.	Low stream gradient; moderate meanders in a valley approximately .25 miles wide.
Mouth of Birch Creek R.M. 46.5, to McKay Creek R.M. 48.9, length 2.4 miles.	u5 Near Hwy Bridge at Rieth R.M. 46.7.	Low stream gradient; moderate meanders in approximately .25 mile wide vallev-
From Mouth of McKay Creek R.M. 48.9, to bend in river at R.M. 54.9; length 6 miles.	U6 Near Main St. Bridge in Pendleton, R.M. 52.25.	Low stream gradient; moderate meanders through .25 to .5 mile wide valley.
Bend in river at R.M. 54.9, to Squaw Creek R.M. 74.9; length 20 miles.	u7 Near Hwy Bridge at Cayuse, R.M. 65.7.	Moderate stream gradient; moderate meanders .25 to 1 mile wide valley.
Squaw Creek R.M. 74.9, to Meacham Creek R.M. 77.1; length 2.2 miles.	U8 Near USGS Gaging Station 1.2 miles downstream from Gibbon R.M. 75.6.	Moderate stream gradient; moderate meanders through .2 mile wide valley.
Meacham Creek R.M. 77.1, to North and South Fork Junction R.M. 87.9; length 10.8 miles.	u9 .2 miles below Umatilla Reservation Boundary R.M. 79.35.	Moderate to high stream gradient in canyon bottom.

Table 1 (continued):

Representative Section Boundaries	Study Reach Location	Stream Characteristics
	T1	
North Fork of the Umatilla River from confluence with South Fork (R.M. 87.9 on Umatilla River main-stem), to 6.1 miles upstream; length 6.1 miles.	North Fork of Umatilla River .5 miles from the confluence with the South Fork of the Umatilla River.	High stream gradient in steep canyon.
	T2	
South Fork of Umatilla River from confluence with North Fork (R.M. 87.9 on mainstem of Umatilla River), to Thomas Creek; length 3.4 miles.	South Fork of Umatilla 2.2 miles from con-fluence with North Fork of Umatilla River.	High stream gradient in steep canyon.
	T3	
Meacham Creek from mouth (R.M.77.1 on Umatilla River) to confluence of North and South Forks of Meacham Creek; length 15 miles.	Meacham Creek .4 miles above Bonifer, 2.9 miles from the stream's mouth.	Moderate to high stream gradient in .2 mile wide steep canyon.
	T4	
Squaw Creek from its mouth at R.M. 74.9 on the Umatilla River, to 6.2 miles upstream; length 6.2 miles.	Squaw Creek 3.5 miles from mouth; .3 miles downstream from Bachelor Canyon.	Moderate stream grad-ient in .l mile wide canyon.
	T5	
McKay Creek from the south end of McKay Reservoir to the confluence of the North and South Forks of McKay Creek, length 12.5 miles.	McKay Creek near road bridge approximately 18.3 miles from the mouth of McKay Creek on Umatilla River. 8.3 miles from McKay Reservoir.	Low to moderate stream gradient in .l to .25 mile wide canyon.
	T6	
Birch Creek from its mouth at R.M. 46.5 on the Umatilla River, to the confluence of the West and East Forks of Birch Creek near Pilot Rock; length 16.2 miles.	Birch Creek, .2 miles below confluence of the East and West Forks of Birch Creek, approximately 16 miles from the stream's mouth.	Moderate stream grad-ient in a canyon that is .2 to .5 miles wide.
	T7	
Butter Creek from confluence of Butter Creek and Little Butter Creek, 19.5 miles from the mouth of Butter Creek, to the confluence with the East Fork of Butter Creek; length 31 miles.	Butter Creek, near USGS Gaging Station approximately 1 mile upstream from Vey Ranch, 28.5 miles from the stream's mouth.	Moderate stream grad-ient in a canyon .2 to .5 miles wide.

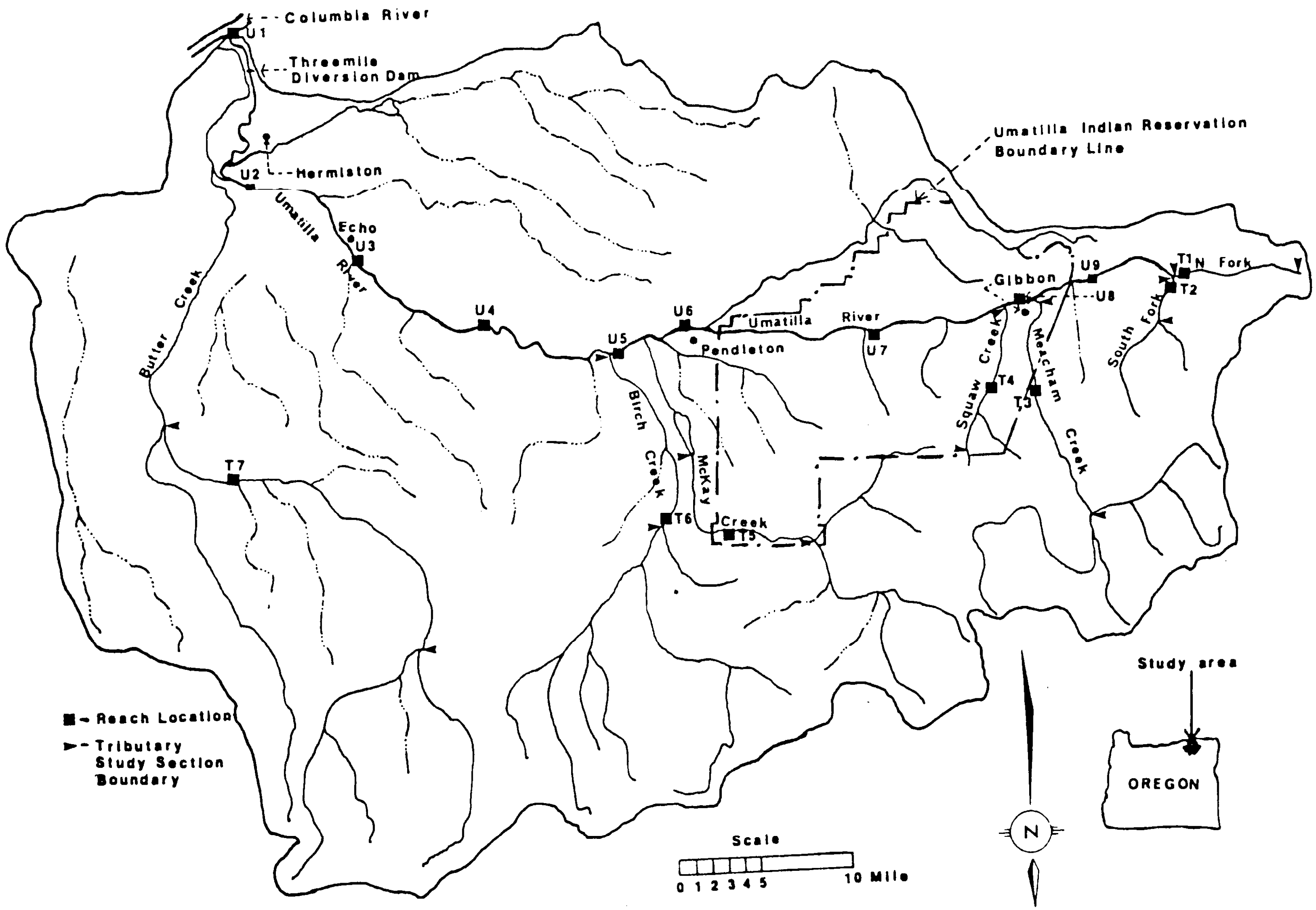


Figure 2: Reach Location and Tributary Study Sections.

DATA COLLECTION

As specified by IFG for a two-point rating curve, two sets of flow data (separated in discharge by approximately I50 percent) were collected from each study reach. The stage of zero flow, which is the water surface elevation at which stream flow ceases, was used as the third set of data. Given the time constraints placed on project completion, data at the higher flow were collected first (May 23-June 1).

The elevation of the headstakes marking the transect ends and the distance between transects was obtained prior to collection of flow measurements. For each flow studied, the water surface elevation was determined by obtaining the difference in elevation between the headstake and the water surface. A tagline was stretched across the stream at the transect location to measure the distance from the right bank headstake to data collection points along the transect. As specified by the IFG's Information Paper Number Five (Bovee and Milhous, 1978), a minimum of twenty data points were spaced along the transect. Care was taken to insure that no more than five percent of the stream discharge was represented by any one data point. At each collection point, measurements of depth, substrate, and velocity were obtained. To determine stream bed elevation, water depth was measured and the value obtained subtracted from the water surface elevation.

Substrate was examined and quantified, based on a modified Wentworth scale. This scale, based on particle size, assigns a numerical rating between one and eight to substrate type (Table 2).

Table 2. Substrate Classification Based upon Modified Wentworth Scale.

Substrate Index	Material	Size Range (mm)
8	Bedrock	--
7	Boulder	>305
6	Cobble	75 - 305
5	Gravel	5 - 75
4	Sand	.125 - 5
3	Silt	.062 - .125
2	Clay	<.062
1	Plant Detritus	--

Velocity at each point was measured by either a Price or Pigmy current meter. The former was used for depths greater than 1.5 feet and the latter for lesser depths. For depths of less than 2.5 feet one measurement of velocity, taken at six tenths of the depth from the surface, was used to determine the mean column velocity. For depths greater than 2.5 feet, two measurements of velocity were taken, one at two tenths and one at eight tenths of the depth from the surface. The two velocity measurements were then averaged to obtain the mean column velocity. This procedure was repeated at each transect for the flows studied. Table 3 is an example of a set of data collected at one transect.

Low flow data were collected between June 27 and June 29, and between September 12 and September 15. The dual collection period was necessary since flows dropped more quickly in some river sections than in others. Flows at the time periods selected were generally low enough to fall near the 150 percent guidelines set by IFG. Since headstake and bed elevations were static, these measurements were not repeated. One study reach, Umatilla River at Umatilla, Oregon, required additional flow data which was collected during the spring of 1979.

Table 3.

SOUTH FORK UMATILLA RIVER

5/31/78 SURVEY 1 DISCHARGE = 31.6 CFS

LENGTH l-2=46, 2-3=193, 3-4=35, 4-5=68

STAKE ELEVATIONS 1A=l2.42, 2A=11.81, 34=7.85, 4A=7.69, 5A=8.91
lB=12.08, 28=11.59, 3B=7.83, 4B=8.93, 58=9.39

TRANSECT 1

WATER SURFACE ELEVATION= 31.25 PZF= 9.9

STATION	DISTANCE	DEPTH	BED ELEV	VELOCITY	SUBSTRAIT
1A	0				
	11.6	.7	10.5	.l	6.5
	13.5	.6	10.6	2.39	6.5
	15.0	1.0	10.2	1.47	6.5
	16.0	.8	10.4	1.30	6.5
	17.0	1.1	10.1	2.55	6.5
	18.0	1.0	10.2	3.89	6.5
	18.8	1.0	10.2	2.99	6.5
	19.6	1.1	10.1	2.74	6.5
	20.4	1.5	9.8	3.06	6.5
	21.2	1.3	9.9	3.28	6.5
	22.0	1.2	10.0	2.15	6.5
	23.2	.9	10.3	3.43	6.5
	24.4	1.6	9.6	4.05	6.5
	25.0	1.3	9.9	5.04	6.5
	25.6	1.6	9.6	5.55	6.5
	26.2	1.6	9.6	3.31	6.5
	26.8	1.2	10.0	5.20	6.5
	27.4	1.4	9.0	4.05	6.5
	28.0	1.5	9.0	1.92	6.5
	28.6	1.3	9.9	1.65	6.5
	29.2	1.5	9.8	3.28	6.5
	29.8	1.3	9.9	3.28	6.5
	30.8	.2	11.0	3.57	6.5
	33.0	.4	10.8	4.26	6.5
	35.2	0.0	11.3	0	6.5
1B	39.9				

COMPUTER ANALYSIS

The IFG process for evaluation of instream flow requirements for any species of fish is composed of two segments: hydraulic simulation, and habitat evaluation. Hydraulic simulation estimates the relationship of one or more sets of measured flow related parameters, to stream discharge. Habitat evaluation estimates the total available habitat, by species and life history stage, based on the results of hydraulic simulation.

Fisheries Assistance Office staff, with the assistance of IFG personnel, modeled twelve discharges for each river reach, using the IFG's rating curve hydraulic simulation model (IFG4). The U.S. Bureau of Reclamation's Denver Computer facilities were used for this purpose.

Discharges from .77 times the minimum discharge to 1.7 times the maximum discharge were generally considered to be within the useful range of extrapolation for the two-point rating curve; however, a wider set of discharges (.4 times the minimum to 2.5 times the maximum discharges) was examined to determine the behavior of the rating curve outside the initial range. Based on the recommendations of IFG staff, results generated within the broader range (.4-2.5) were utilized for further analysis, as long as velocity adjustment factors stayed within the 10% acceptable limit.

After completion of hydraulic simulation, the resultant prediction of hydraulic conditions were interfaced with the Habitat (IFG3) program to obtain estimates of available habitat at various stream discharges. Probability of use curves for depth, velocity, substrate and temperature make up the core of the IFG's Habitat model (Figure 3).

The probability of use curves were developed by IFG, based on the best available information for each species. Frequency of occurrence was related to increments of depth, velocity, and substrate. Probability of use was then equated with frequency of occurrence. The point with the greatest frequency of occurrence was assigned 1.0 probability of use. Where frequency of occurrence equaled zero, probability of use was assigned zero. Intermediate values were assigned on a linear scale basis.

In order to estimate the composite probability of use, the IFG3 program cross-multiplies the individual probabilities drawn from the depth, velocity and substrate curves. The program applies this process to data collected from each point across all transects. The next step expands the habitat rating given to the individual data points to the total habitat contained within the study reach. Transects are divided into segments centered about a data point. For the transects forming the upper and lower boundries of a reach, the length of the segments extend from the transect to a line one-half the distance to the next transect. Segments of the inside transects extend one-half the distance from the transect in each direction. The entire area of each segment is given a habitat value the same as its central data point located on this transect (Figure 4).

FALL CHINOOK

SPAWNING

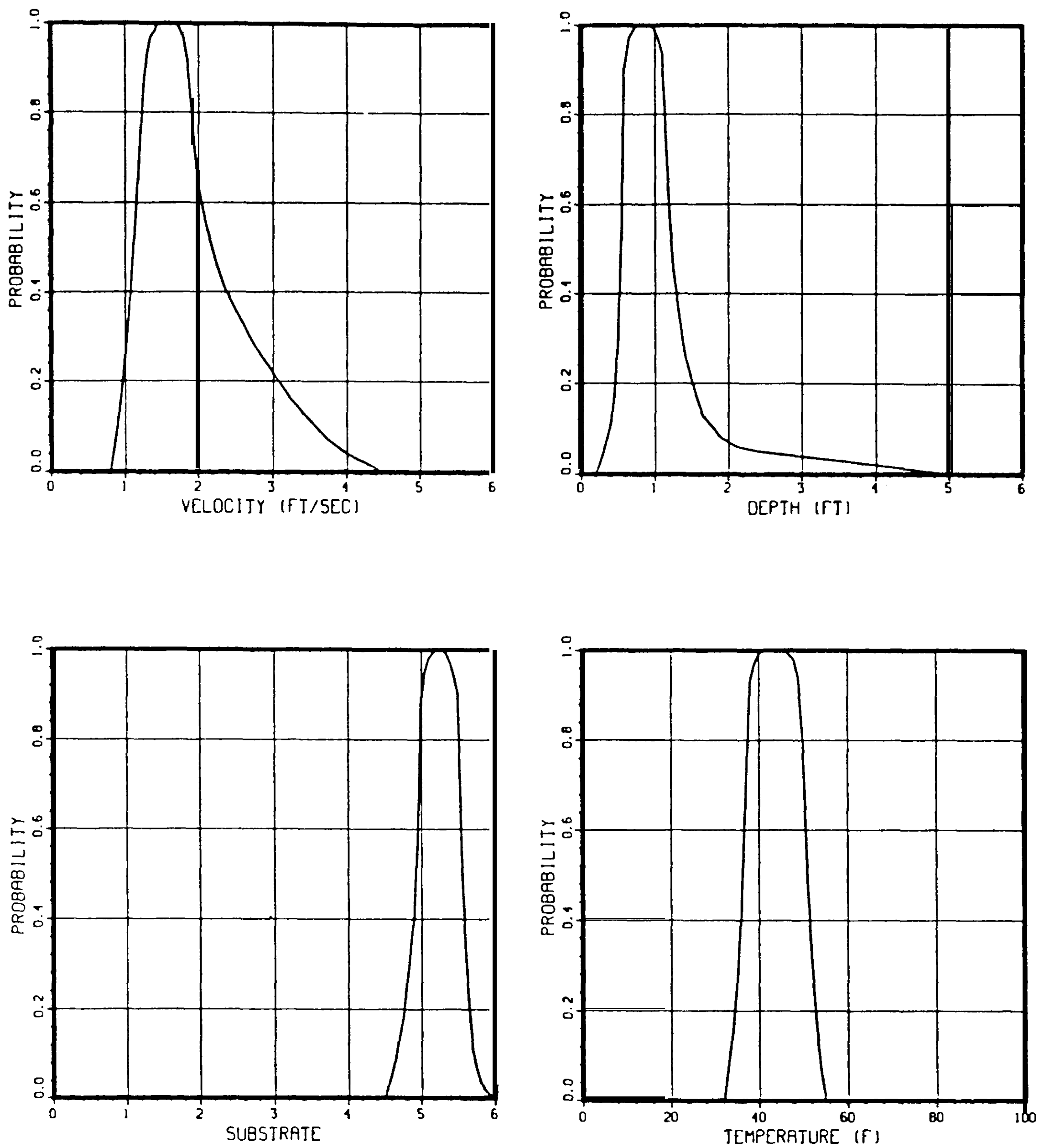


Figure 3: Probability of Use Curves.

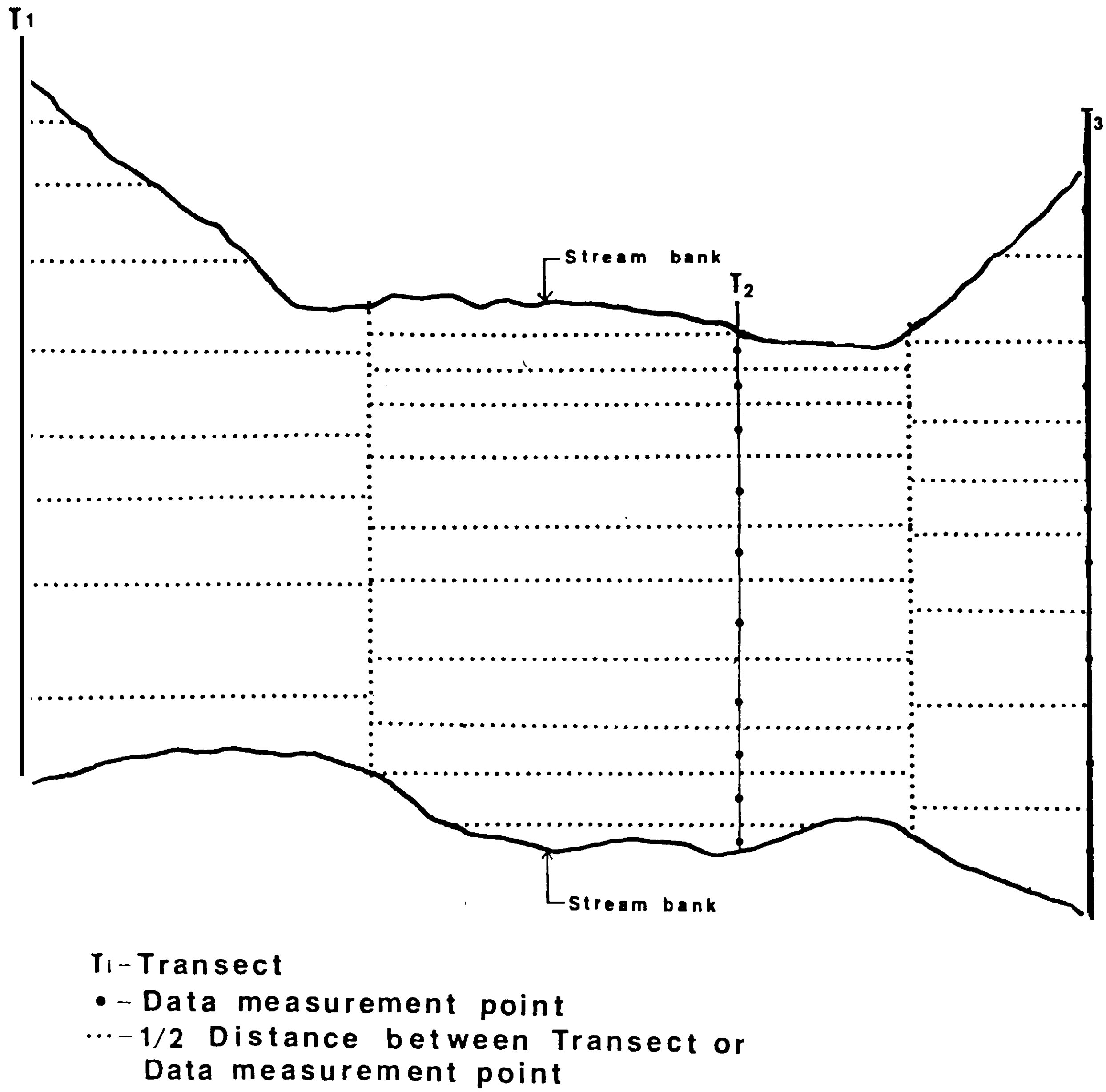


Figure 4: Example of the Division of a Study Reach into Segments to Estimate Habitat Value.

To compute available habitat, the area of the segment containing the data point is multiplied by the composite probability of use. This results in an estimate of available habitat expressed as weighted usable area. One unit of weighted usable area is equivalent to a unit of optimum habitat. The IFG3 program standardizes the measure of available habitat by expressing it in square feet of weighted usable area per 500 lineal feet of stream.

Additional analysis methods were utilized on the Umatilla River at the Umatilla, Oregon reach. This extremely short (3.75 miles) reach provides little or no habitat or potential habitat for anadromous salmonids due to water temperatures, flow patterns and bedrock substrate encountered throughout the section. The reach is, however, critical for passage of adult and juvenile salmonids.

Problems associated with passage of salmonids in the Umatilla River are directly related to water depth, since sustained swimming speeds of 13.5 ft. per second in steelhead and 11.0 ft. per second in chinook (Bell, 1973) are well above the velocities encountered in any mainstem simulations.

The IFG hydraulic simulation model was used to obtain passage data based upon discharge. The model provides at each transect, the width of the single widest channel and the total cumulative stream width which is of at least a selected passage depth. This technique determines the amount of channel that meets passage criteria, but does not evaluate other factors such as attractant flows and temperatures which are necessary to promote movement of fish into or through the system. FAO modeled a wide series of discharges for each transect. At each discharge the transect which provided the narrowest total width of channel which met the minimum passage standard was identified. The relationship of the narrowest or "critical" channel to discharge was examined through the use of graphics. Since this relationship is not linear, changes in discharge which yielded large increases in width of passable channel were identified. The discharge associated with this reach which, in the opinion of FAO staff, would allow for the minimum unrestricted salmonid passage was identified as minimum passage flow.

In utilizing this option for estimating passage conditions, we considered .8 feet to be the minimum passage depth for adult chinook; .6 to be the minimum passage depth for adult steelhead and coho; and .1 feet to be the minimum depth for passage of all juveniles (Smith, 1973), (Burley, 1974). .

FACTORS EFFECTING PREDICTION OF HABITAT

Water temperature is foremost among the factors influencing anadromous fish production that is not directly included in the computer analysis. The importance of temperature to Umatilla River anadromous salmonid production can be seen from the following example. The temperature curve developed by IFG (Figure 5) indicates that at temperatures higher than 24.4°C (76°F) the probability of use for juvenile rearing of steelhead trout drops to zero. A check of temperature information obtained by this office within some of the stream sections, and records available from the USGS's gaging station at Gibbon, show summer temperatures in some sections of the river routinely exceed this critical temperature. Even when maximum critical temperature is not exceeded, high summer water temperatures severely reduce probability of use values for available rearing habitat. For example, summer temperatures of the Umatilla River near Gibbon, often average 22°C (71.6°F) for several weeks. While this temperature is within the tolerance range for juvenile steelhead, it reduces the probability of use of available habitat over 82 percent. Flows identified in this report that produce maximum habitat may well be lower than flows required to maintain water temperatures at a desirable level.

Another important factor which is not evaluated by the model is passage of salmonids past man made obstacles. Passage of adult migrants is hindered by Three Mile Dam and several other diversions in the lower half of the river and on several tributaries. Downstream migration of juvenile salmonids is also complicated by unscreened irrigation diversions.

A third factor not included in this analysis is cover. Both instream and overhead cover are important in defining the actual amount of habitat available in a particular stream section. A separate analysis of cover, although it would provide a better estimate of available habitat, is not critical in the current assessment. It is our opinion that for the sections of the Umatilla River studied, cover is not a factor which affects salmonid rearing habitat to the degree the variables analyzed do.

When reviewing the actual results of the flow analysis presented in this report, it should be noted that IFG developed the probability of use curves, and based the hydraulic prediction on mean column velocity. At high flows, the mean column velocities can be significantly higher than velocities actually occurring near the stream bed where juvenile salmonids would be expected to occur. This undoubtedly results in the model underestimating actual available habitat at the higher flows, expecially if the mean water column velocities exceed the tolerance range identified in the probability of use curves.

A less serious problem presented by the velocity model is the tapering of all velocity curves so as to end at the origin. It is amply demonstrated that anadromous salmonids do utilize (to some degree) areas with zero velocity; consequently, available rearing habitat will be slightly underestimated. The Umatilla system is directly affected by this situation. On small tributaries such as Squaw Creek, minor spring inflow into pools maintains water temperatures and quality within tolerance

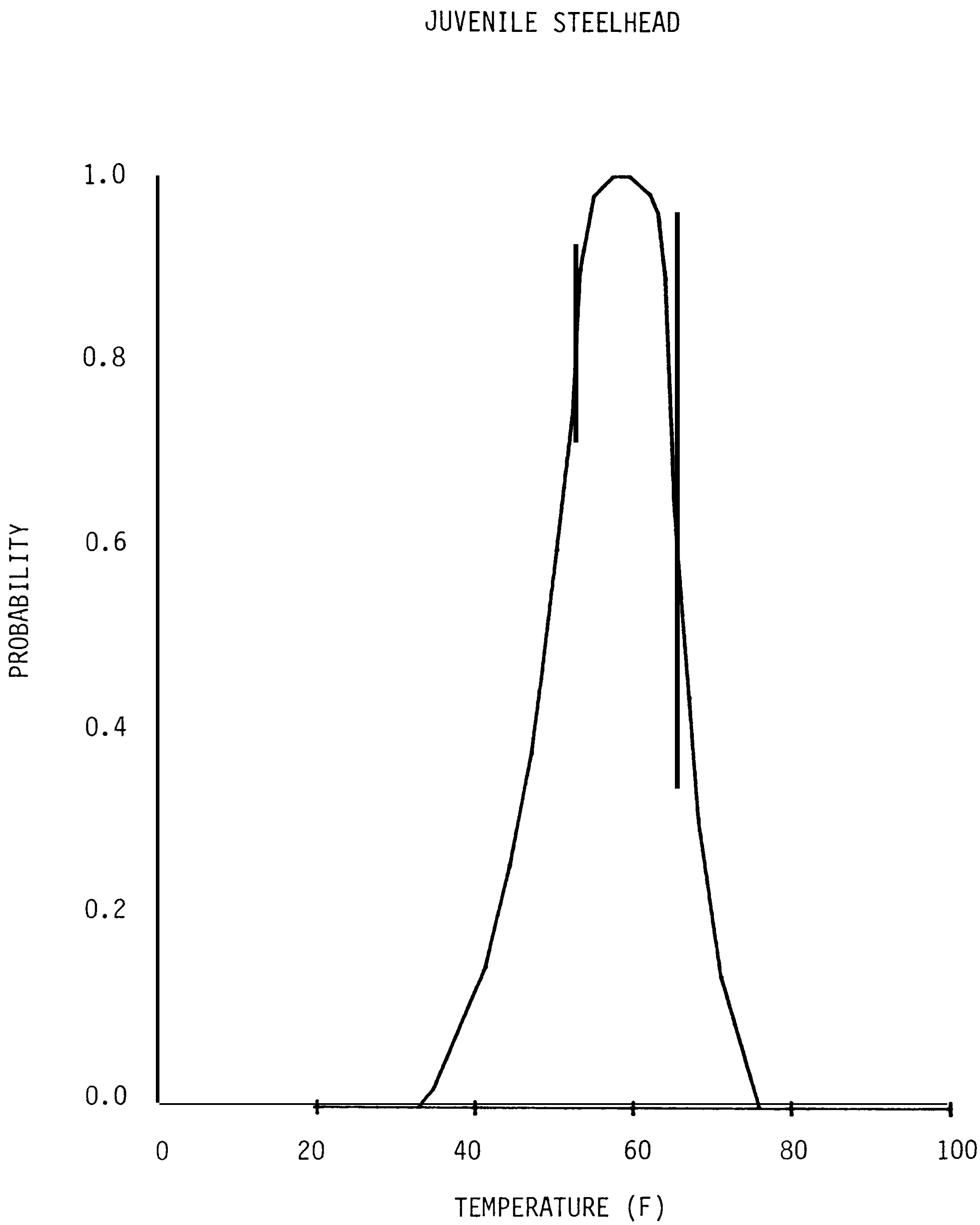


Figure 5: Probability of Use Curve for Temperature.

limits. Mid-summer surveys conducted by FAO personnel on Squaw Creek have located significant numbers of juvenile rainbow or steelhead trout in pools where velocities were at or very close to zero. This situation appears to be localized to short reaches of only a few tributaries and the overall effect is probably minimal. In most pools as velocities approach zero, water quality, (including temperature) deteriorates so as to reduce available habitat to a minimum.

Evidence, acknowledged by IFG (Bovee, 1978), indicates that depth probability of use curves do not tail off for fry and juvenile steelhead at depths greater than 1.5 feet (juvenile curve) or 0.5 feet (fry curve) utilized in the present model. FAO believes this same lack of tailing off would also occur in other anadromous salmonid fry and juveniles. Fish and Wildlife Service personnel in the Arcata Fisheries Assistance Office evaluated several stream sections with and without the tailing effect of the probability of use curves. The tests showed insignificant differences in prediction of available habitat throughout the ranges tested (personal communications, T. Chatto, FAO Arcata 1979). Consequently, although the curves used in this study for juvenile and fry may not reflect true behavior at these life stages, we do not feel their use significantly affected the results of the study.

OUTPUT

For each study section, the amount of available habitat for the range of flows modeled is provided in graphic and tabular form by species and life history stage.

Mean monthly discharges which would provide maximum habitat for steelhead are compared with presently occurring mean monthly discharges. Also provided for steelhead is a comparison of the amount of habitat available under presently occurring mean monthly discharges, and the amount of habitat that would be available under optimum discharges. These additional flow comparisons were made for steelhead since this specie is the most numerous of the anadromous salmonids presently using the Umatilla system. Actual mean monthly discharges for the Echo (U2) reach are not included in the data because of the large number of water withdrawals and absence of a U.S. Geological gaging station.

When two or more life history stages of a species are concurrently using the river, the life history stage requiring the greater discharge was utilized to identify the flow.

By comparing the figures and tables in each section, the user of this report can determine the extent or degree of impact an altered flow regime would have on anadromous fish habitat. Since there are undoubtedly several water management alternatives for the Umatilla River that would benefit anadromous fish, the decision maker will be able to determine the most cost effective alternative.

In several instances, available habitat was increasing at the end of the range of discharges that could be modeled. Optimum discharge in these instances was selected as the last discharge modeled.

The following section provides data by each study reach.

UMATILLA RIVER AT UMATILLA, OREGON (U 1)

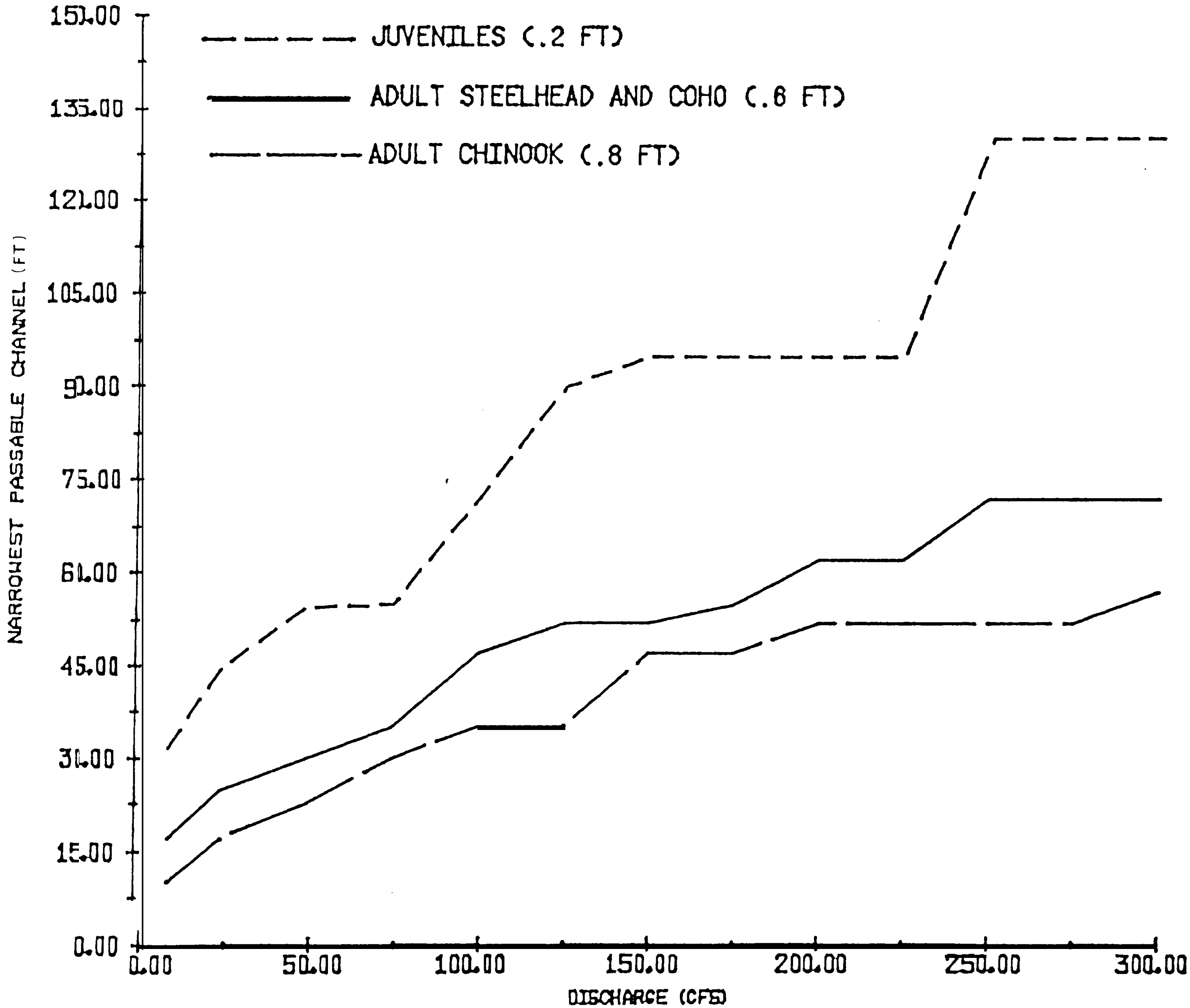
Umatilla River At Umatilla. Oregon

River reach analysis of passage in relation to discharge indicates that increases in discharge up to 50 cfs yield large increases in total width of passable channel for juvenile salmonids (.2-foot minimum passable depth); from 50 cfs to over 75 cfs little increase was noted in passable channel width; from 75 cfs to 125 cfs good increases are again noted, while little gain was noted between 125 cfs and 225 cfs. From 225 cfs to 250 cfs an increase in maximum width within the range of modeled flows occurs.

With regard to passage criteria for adult steelhead and coho (.6-foot minimum), and adult chinook (.8-foot minimum), a similar pattern of discharge v. passable width of channel was found. For steelhead and coho, discharges up to 100 cfs provide rapid increases in passable channel width. Above 100 cfs increases were small until 225 cfs was reached. In the interval between 225 and 250 cfs a significant increase in passable channel width was noted. Above that discharge no significant increase occurred.

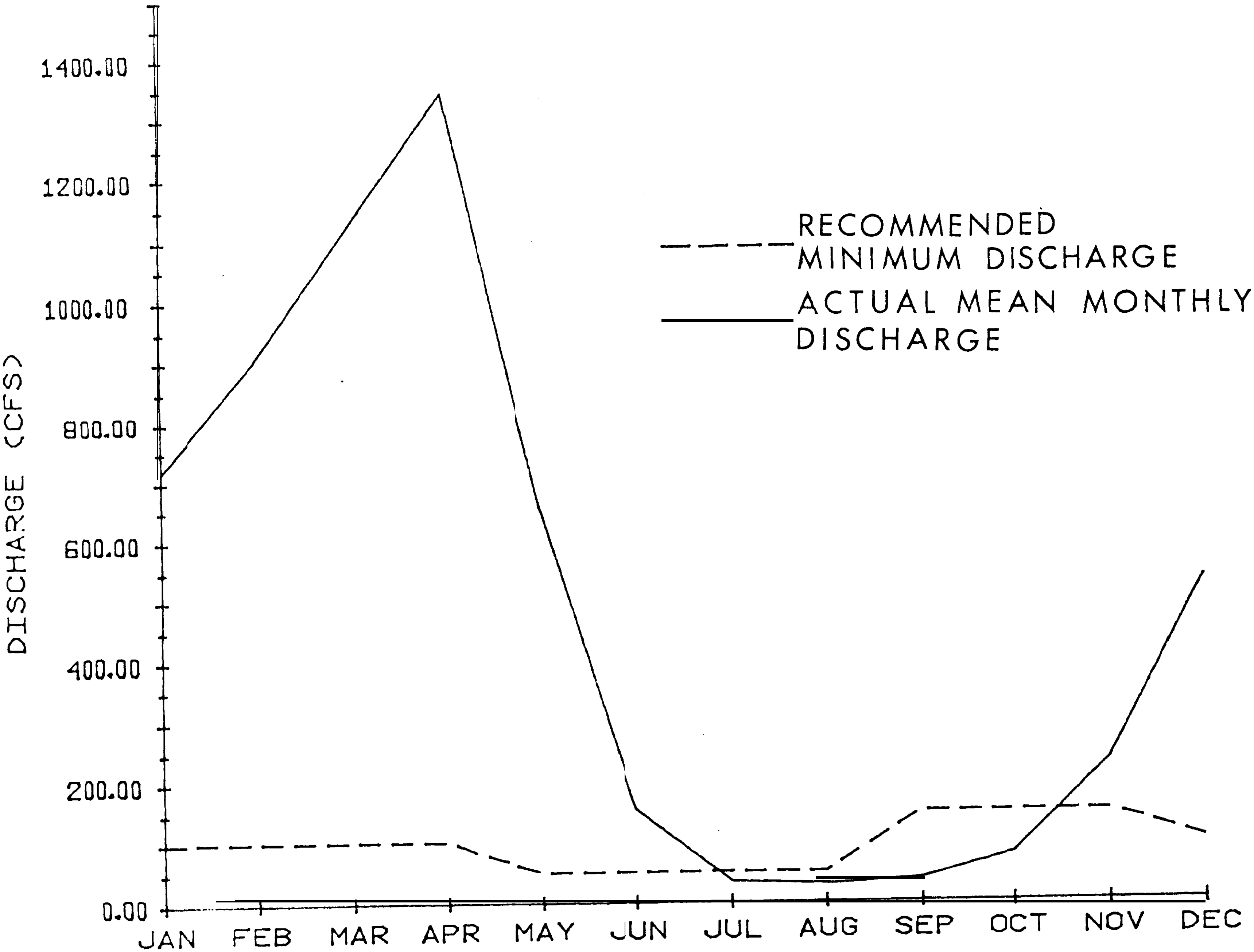
The pattern of increased passage area for adult chinook is gradual. Good increase is available up to 100 cfs, and again from 125 to 150 cfs. Increases are also available from 175-200 cfs, and 275-300 cfs. The single change yielding the greatest increase is that from 175-200 cfs.

Data for discharge (cfs) vs. available habitat area (sq.ft.) are provided in tabular form only because of the limited amount of habitat available for coho, chinook and steelhead.



ANADROMOUS SALMONID PASSAGE

UMATILLA RIVER AT UMATILLA, OREGON



ANADROMOUS SALMONID PASSAGE

UMATILLA RIVER AT UMATILLA, OREGON

UMATILLA RIVER AT UMATILLA OREGON
Discharge in cubic feet per second.

Period of record
1904 - 1977

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	717	902	1126	1345	656	154	32.8	29.4	39.2	80.8	233	530
(Standard Deviation)	(573)	(650)	(742)	(938)	(775)	(271)	(40.6)	(26.8)	(33.7)	(7.70)	(213)	(452)
Highest Average Flow	2402	3121	3678	4388	4673	1688	220	117	129	331	1302	1948
(Year)	(1918)	(1907)	(1972)	(1904)	(1917)	(1906)	(1913)	(1913)	(1912)	(1960)	(1928)	(1974)
Lowest Average Flow	89.3	80.7	154	4.56	1.55	2.22	0.42	0.00	0.17	9.35	39.6	31.2
(Year)	(1930)	(1911)	(1977)	(1968)	(1977)	(1977)	(1907)	(*)	(1909)	(1937)	(1923)	(1919)

(*) many years of record
(Source: U.S.G.S.)

Normal Annual Mean = 476

UMATILLA RIVER AT UMATILLA, OREGON

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

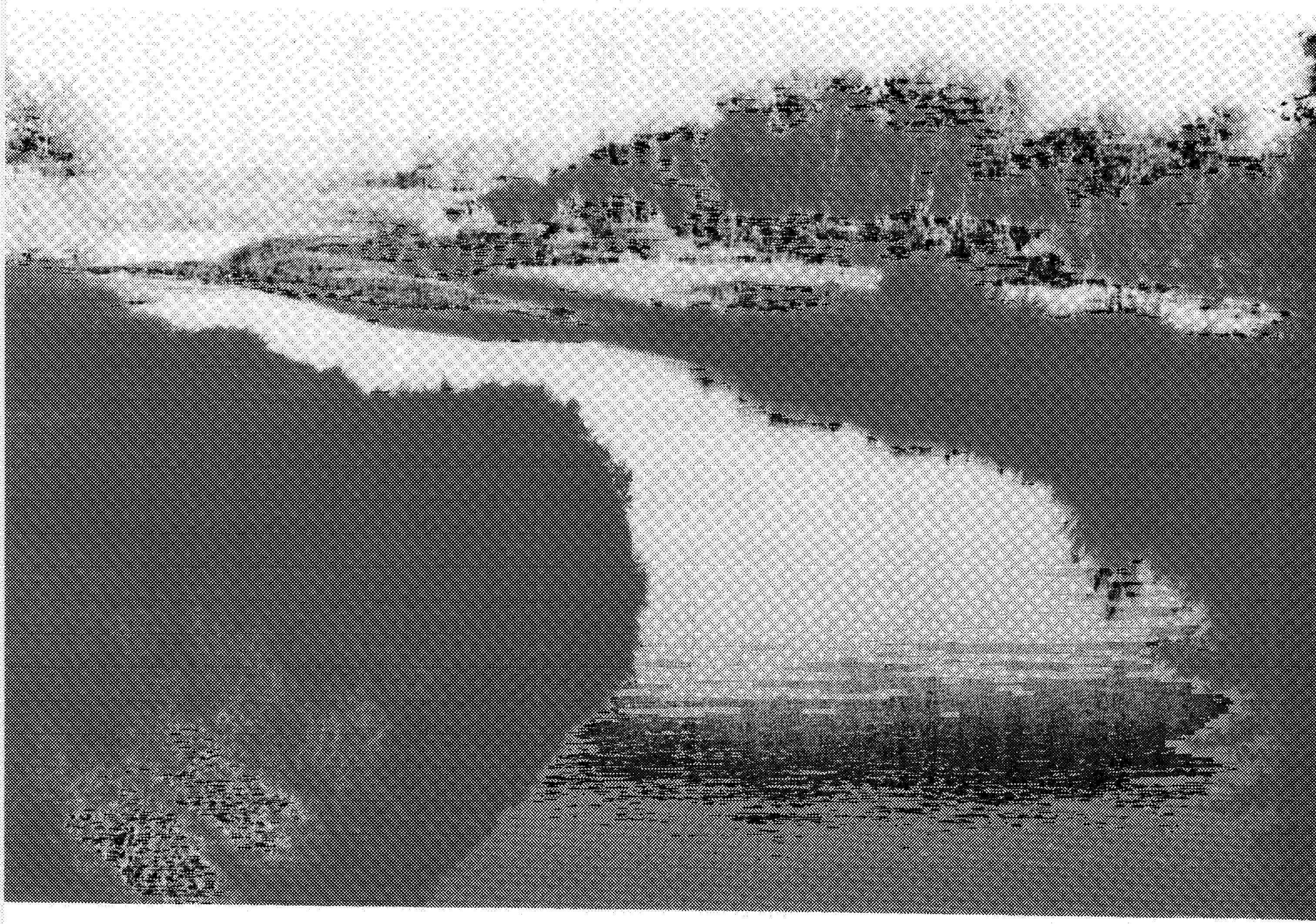
DISCHARGE	FRY	SPAWNING	INCUBATION
7.	246.	0.	0.
10.	368.	0.	0.
30.	723.	0.	0.
50.	695.	0.	13.
70.	642.	0.	49.
90.	581.	0.	90.
110.	594.	0.	147.
130.	609.	0.	206.
150.	635.	1.	285.
175.	653.	2.	350.
200.	774.	2.	358.
225.	851.	4.	365.

CHINOOK SALMON

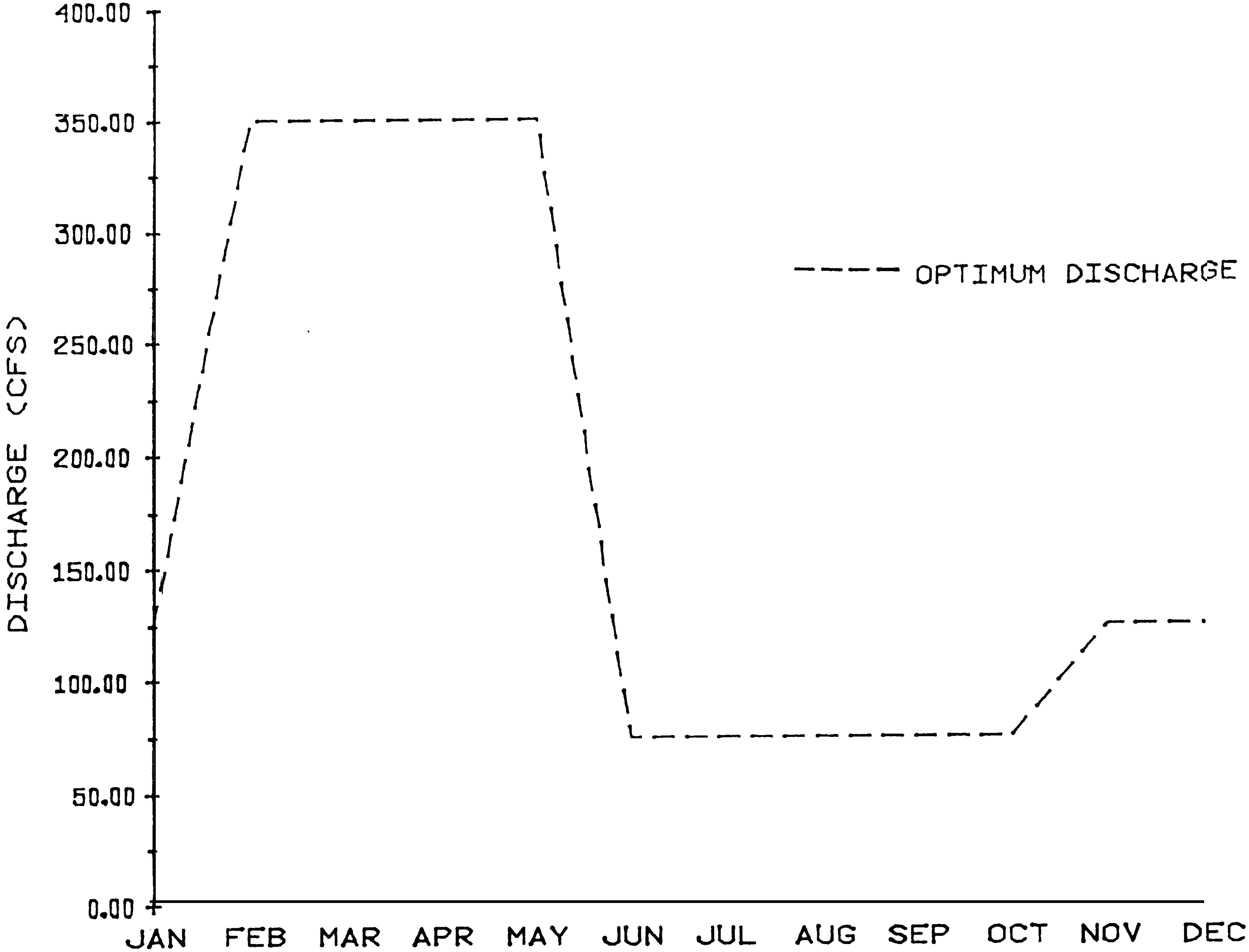
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
7.	1549.	0.	0.	0.
10.	2299.	0.	0.	0.
30.	5867.	0.	0.	0.
50.	6717.	0.	0.	18.
70.	6743.	1.	0.	62.
90.	6175.	3.	0.	115.
110.	6094.	5.	0.	176.
130.	6178.	8.	0.	242.
150.	6335.	11.	0.	330.
175.	6658.	15.	0.	404.
200.	7541.	20.	0.	440.
225.	7836.	28.	0.	465.

STEELHEAD

DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
7.	29.	10.	0.	0.	1.
10.	47.	28.	0.	0.	2.
30.	182.	234.	9.	0.	8.
50.	396.	529.	122.	0.	34.
70.	490.	619.	190.	0.	79.
90.	498.	626.	107.	1.	157.
110.	519.	647.	95.	5.	265.
130.	548.	662.	85.	7.	344.
150.	574.	676.	72.	8.	413.
175.	620.	679.	54.	7.	418.
ZOO.	668.	679.	38.	8.	520.
225.	739.	714	29.	9.	551.

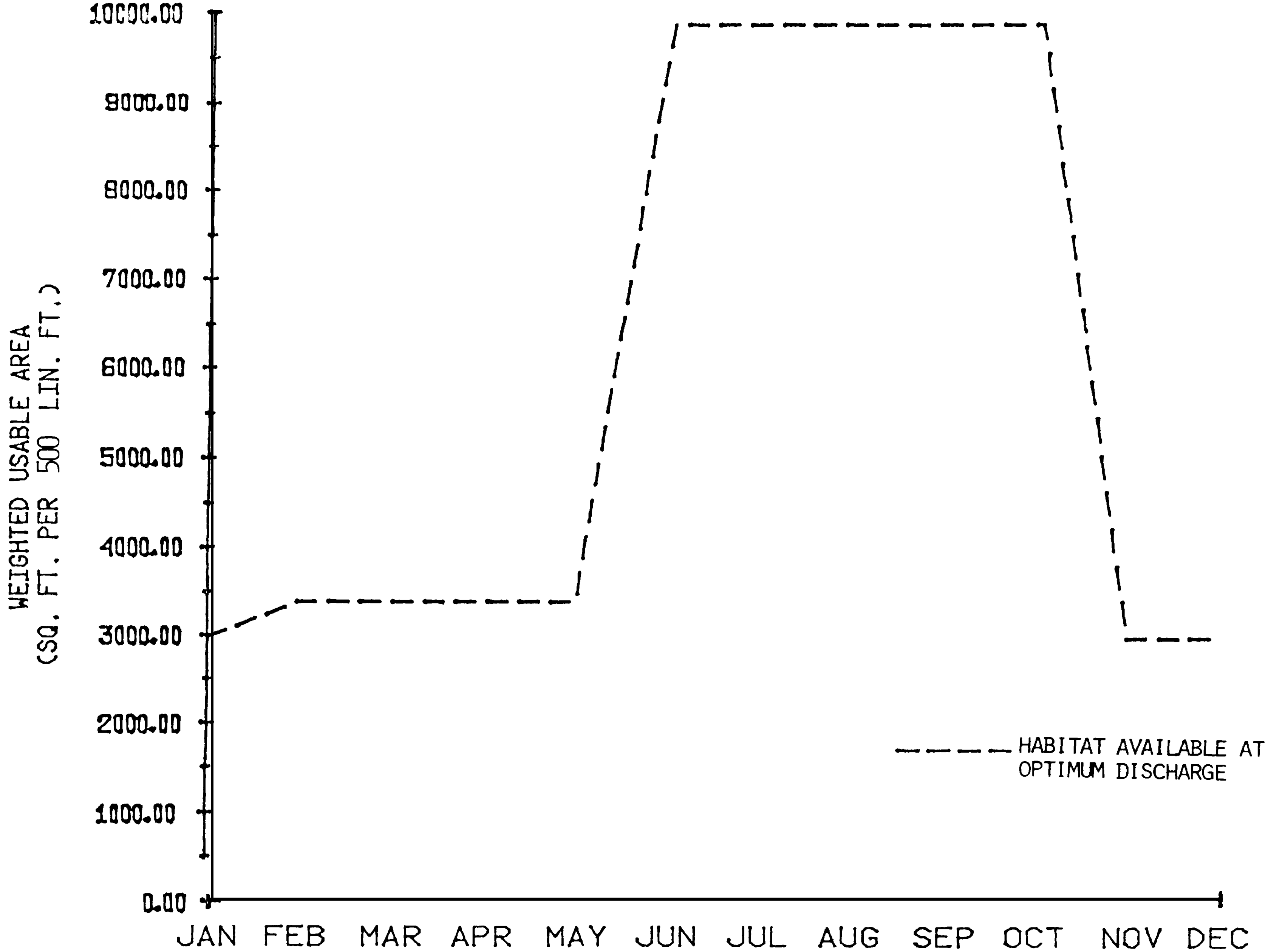


UMATILLA RIVER AT ECHO (U 3)



OPTIMUM DISCHARGE FOR STEELHEAD

UMATILLA RIVER AT ECHO



ANNUAL STEELHEAD HABITAT

UMATILLA RIVER AT ECHO

UMATILLA RIVER AT ECHO

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

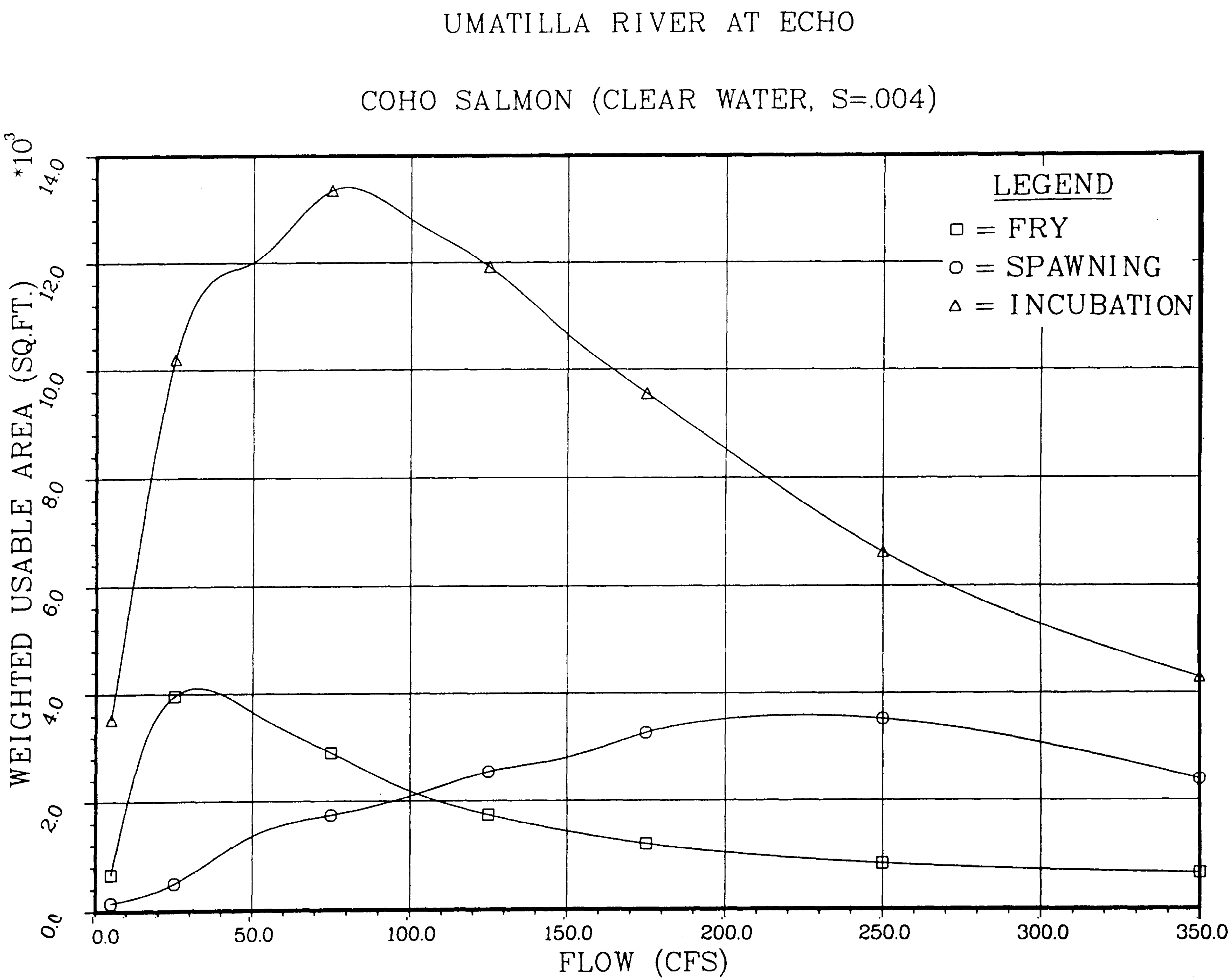
DISCHARGE	FRY	SPAWNING	INCUBATION
5.	642.	142.	640.
15.	2980.	272.	3043.
25.	3995.	505.	4034.
50.	3710.	1409.	8231.
75.	2497.	1820.	12636.
100.	2218.	2193.	15251.
125.	1758.	2663.	16916.
150.	1438.	2981.	16976.
175.	1194.	3412,	16237.
200.	1021.	3628.	15636.
250.	830.	3621.	14488.
350.	655.	2566.	12129.

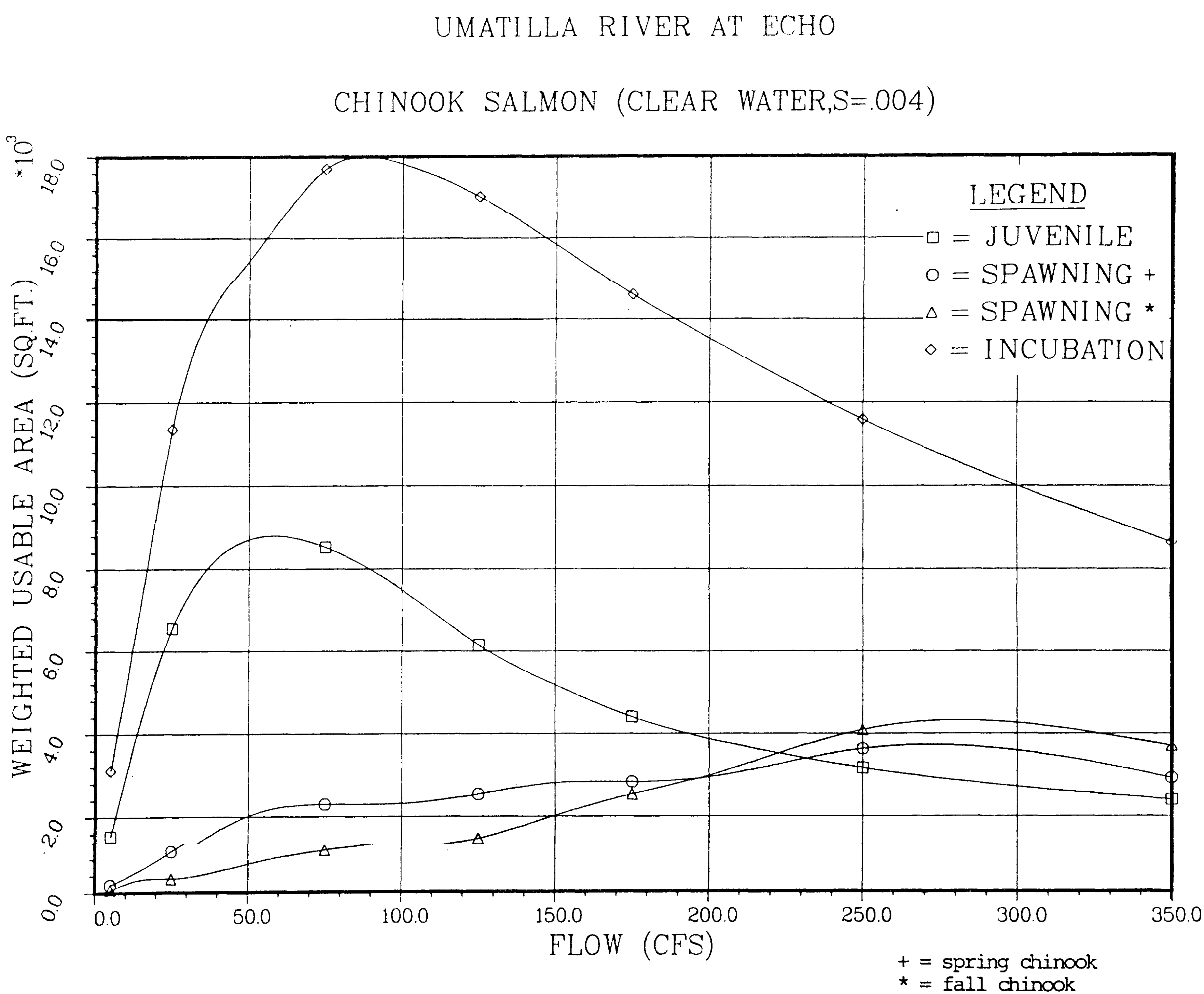
CHINOOK SALMON

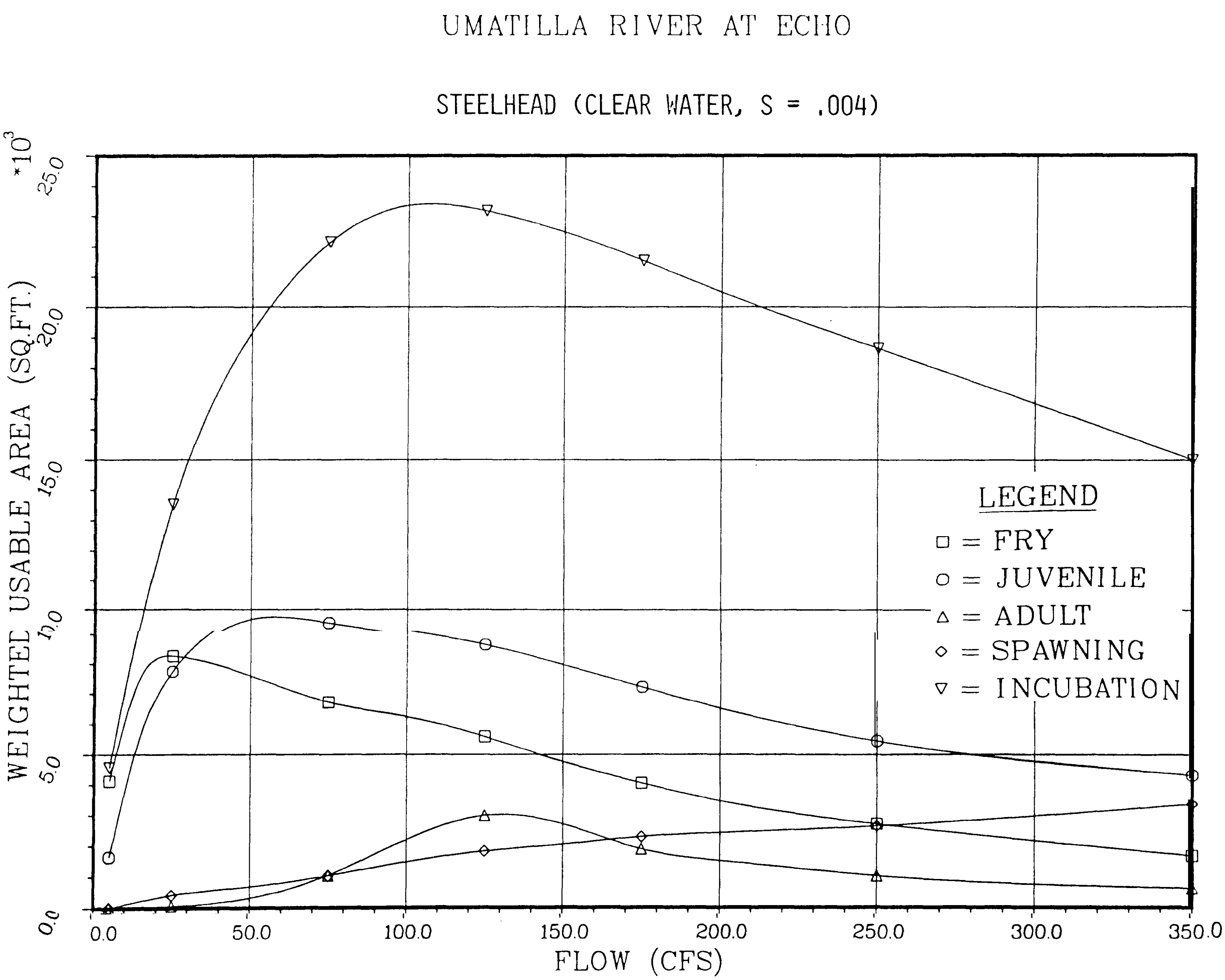
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
5.	1537.	177.	70.	566.
15.	4374.	555.	305.	2953.
25.	6589.	994.	330.	3974.
50.	8840.	2055.	685.	8835.
75.	8704.	2408.	1051.	14736.
100.	7694.	2423.	1265.	18395.
125.	6334.	2663.	1532.	20974.
150.	5357.	2907.	2044.	22001.
175.	4607.	2928.	2531.	21980.
200.	4100.	3031.	2973.	31919.
250.	3402.	3678.	4066.	21549.
350.	2638.	3211.	3794.	19786.

STEELHEAD

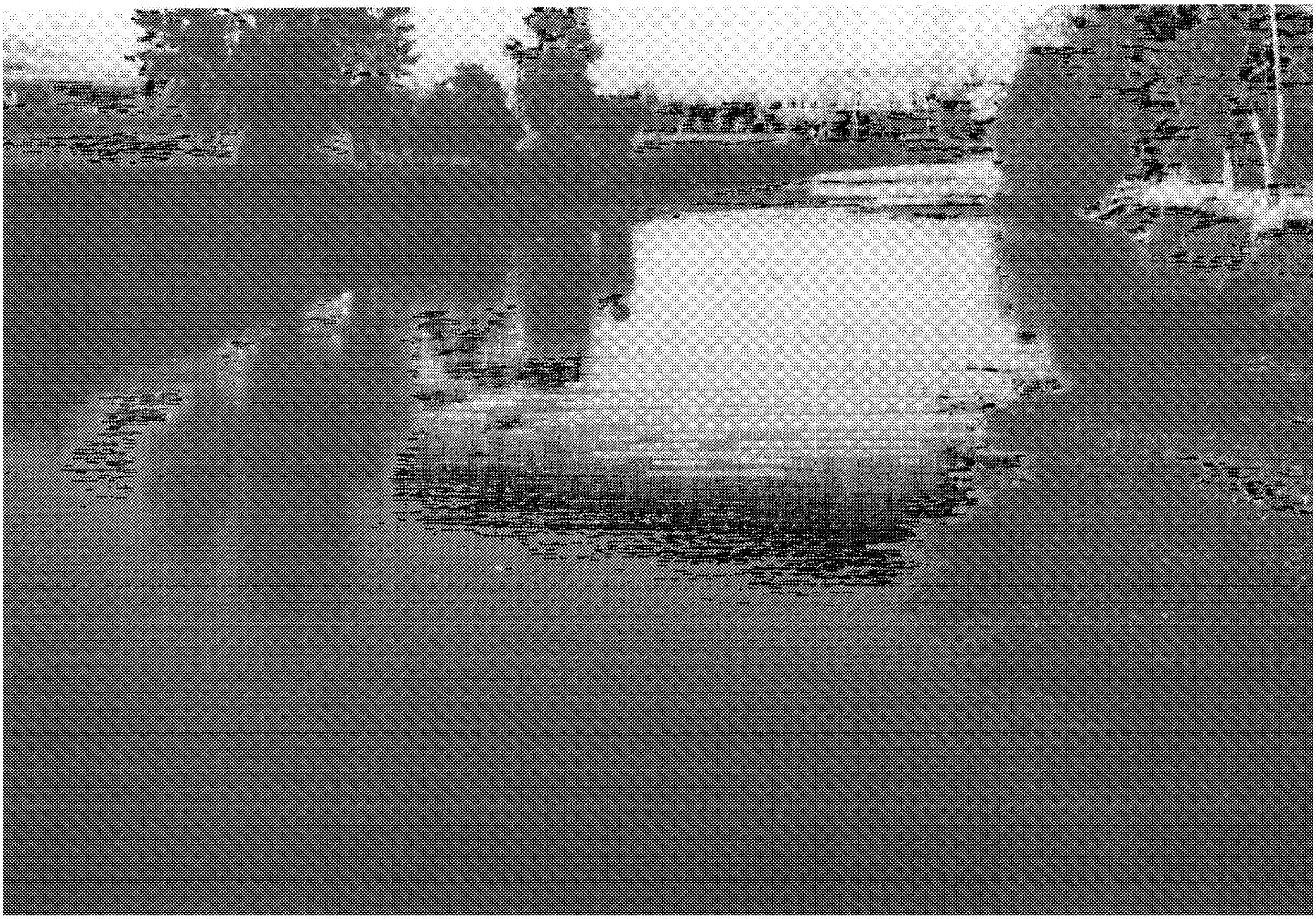
DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
5.	1236.	1657.	23.	17.	1208.
15.	7713.	5692.	39.	226.	3741..
25.	8464.	7815.	64.	418.	5761.
50.	7826.	9816.	287.	693,	10441.
75.	7044.	9864.	921.	1044.	14849.
100.	6550.	9517.	2098.	1491,	18556.
125.	5892.	9053.	2980.	1841.	21233.
150.	5063.	8418.	2807.	2021.	23141.
175.	4328.	7684.	2041.	2300.	24269.
zoo.	3713.	6932.	1580.	2461.	24939.
250.	2897.	5770.	1114.	2689.	25674.
350.	1782.	4436.	659.	3392.	25871.


UMATILLA RIVER AT ECHO
COHO SALMON (CLEAR WATER, S=.004)
LEGEND
□ = FRY
○ = SPAWNING
△ = INCUBATION
WEIGHTED USABLE AREA (SQ.FT.)
*10^3
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
FLOW (CFS)

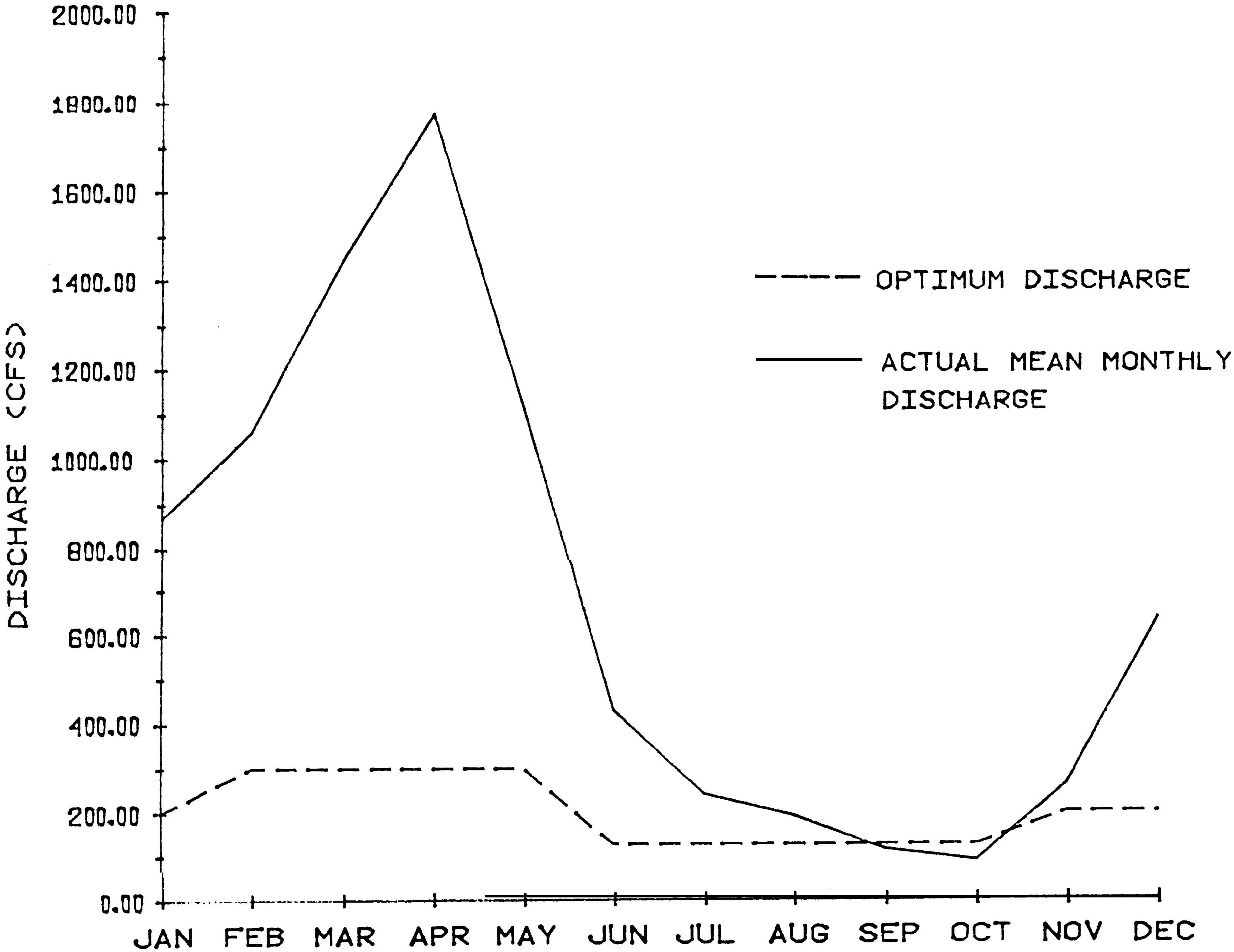

UMATILLA RIVER AT ECHO
CHINOOK SALMON (CLEAR WATER,S=.004)
*10^3
WEIGHTED USABLE AREA (SQ.FT.)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
FLOW (CFS)
LEGEND
□ = JUVENILE
○ = SPAWNING +
△ = SPAWNING *
◇ = INCUBATION
+ = spring chinook
* = fall chinook



UMATILLA RIVER AT ECHO
STEELHEAD (CLEAR WATER, S = .004)
WEIGHTED USABLE AREA (SQ.FT.)
*10^3
0.0
5.0
10.0
15.0
20.0
25.0
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
FLOW (CFS)
LEGEND
□ = FRY
○ = JUVENILE
△ = ADULT
◇ = SPAWNING
▽ = INCUBATION

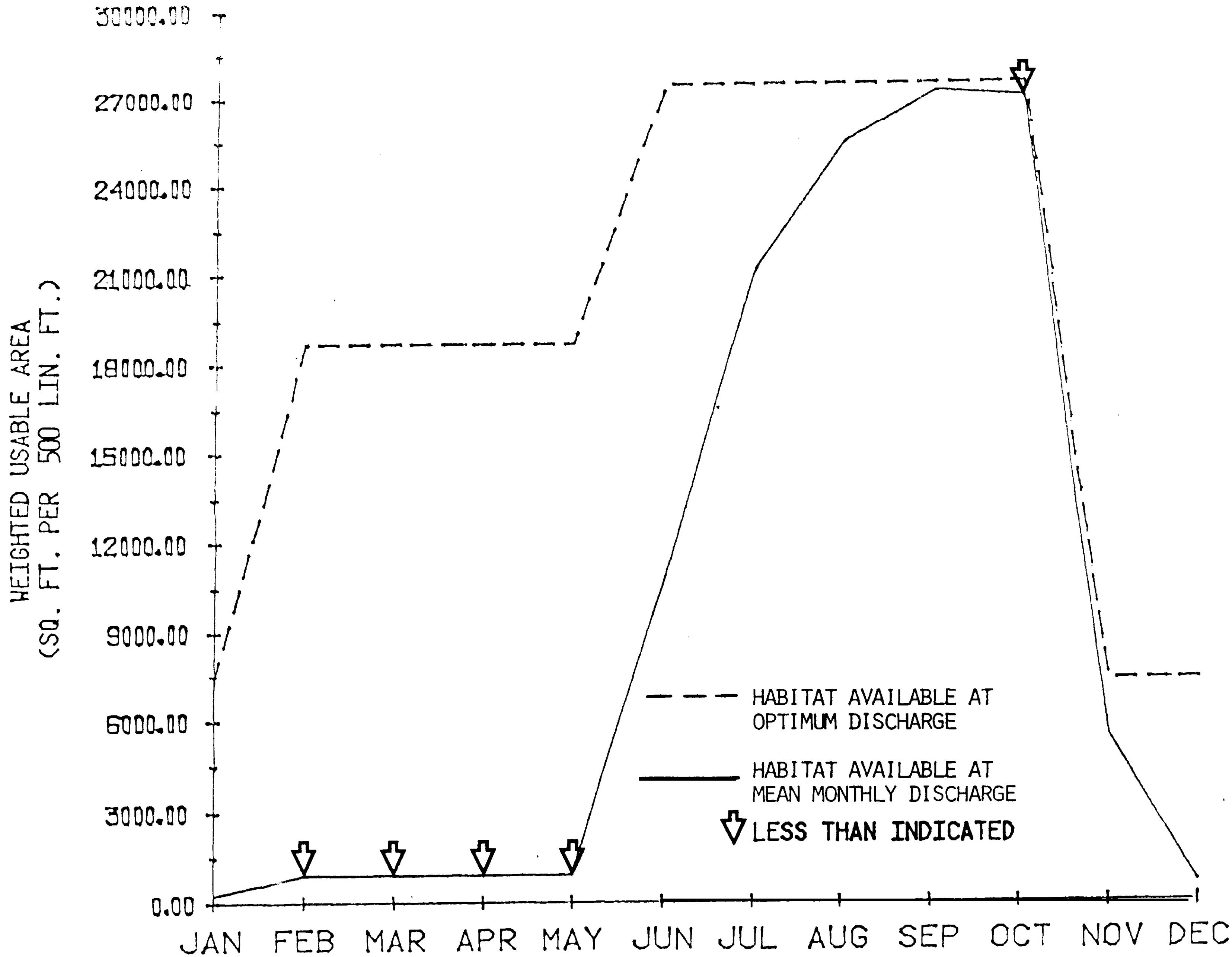


UMATILLA RIVER AT YOAKUM (U 4)



ACTUAL AND OPTIMUM DISCHARGE FOR STEELHEAD

UMATILLA RIVER AT YOAKUM. OREGON



ANNUAL STEELHEAD HABITAT

UMATILLA RIVER AT YOAKUM, OREGON

UMATILLA RIVER AT YOAKUM, OREGON
Discharge in cubic feet per second.

Period of record
1904 - 1916, 1961-1977

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	869	1063	1448	1775	1108	428	241	190	114	87.7	263	638
(standard Deviation)	(606)	(684)	(917)	(987)	(625)	(261)	(145)	(148)	(85.8)	(29.6)	(204)	(550)
Highest Average Flow	2284	2874	3654	4636	2685	1462	445	404	305	171	827	2054
(Year)	(1965)	(1907)	(1972)	(1904)	(1912)	(1906)	(1961)	(1961)	(1974)	(1914)	(1904)	(1965)
Lowest Average Flow	118	115	413	404	256	72	25.6	18.7	30.3	50.6	90.4	96.9
(Year)	(1977)	(1977)	(1977)	(1968)	(1968)	(1910)	(1910)	(1914)	(1908)	(1911)	(1970)	(1977)

(*) many years of record
(Source: U.S.G.S.)

Normal Annual Mean = 683

UMATILLA RIVER AT YOAKUM

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

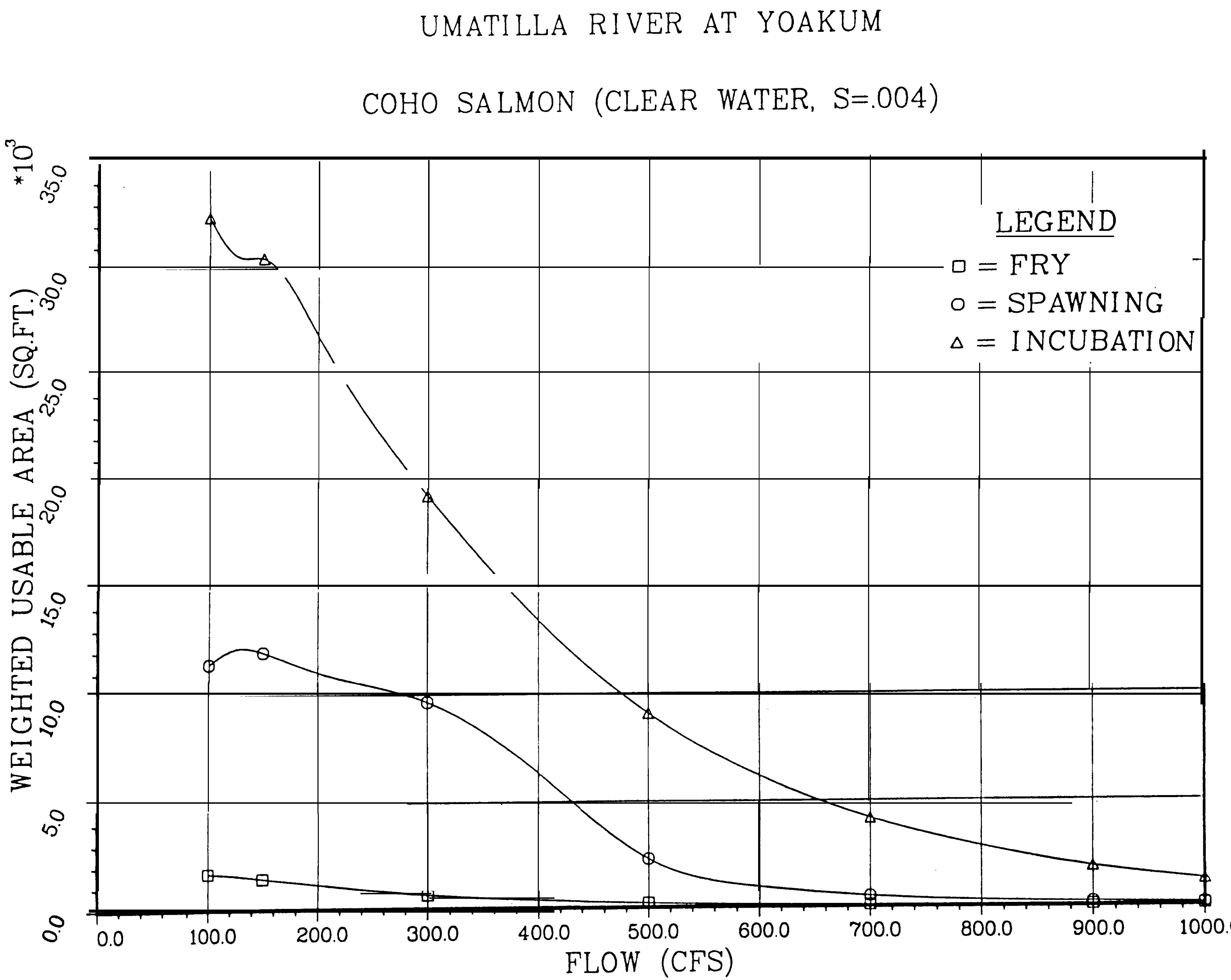
DISCHARGE	FRY	SPAWNING	INCUBATION
100.	1709.	11473.	33129.
125.	1613.	12192.	35828.
150.	1463.	12015.	37088.
200.	1171.	11075.	36482.
300.	647.	9655.	35499.
400.	377.	6370.	30100.
500.	209.	2298.	25511.
600.	119.	960.	21441.
700.	73.	505.	18310.
800.	61.	277.	15889.
900.	57.	187.	13875.
1000.	58.	137.	12203.

CHINOOK SALMON

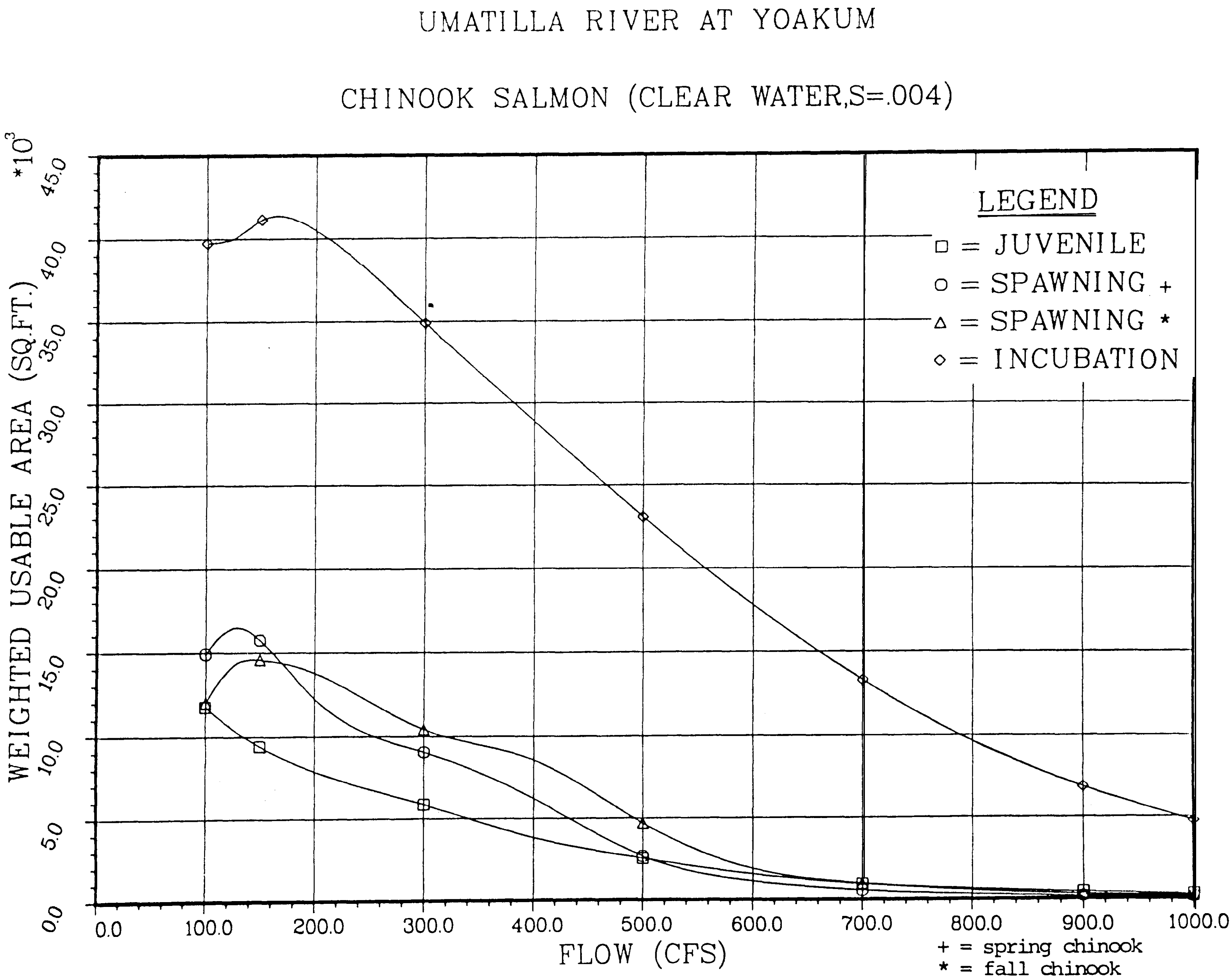
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
100.	11794.	14943.	12040.	32559.
125.	10486.	16485.	14229.	36268.
150.	9424.	15755.	14591.	38977.
200.	7888.	12273.	13787.	41993.
300.	5870.	9050.	10433.	46788.
400.	3839.	6230.	8562.	45991.
500.	2549.	2689.	4693.	44227.
600.	1565.	1120.	1903.	42047.
700.	937.	545.	967.	39543.
800.	632.	299.	534.	36858.
900.	425.	175.	291.	34170.
1000.	277.	116.	178.	31582.

STEELHEAD

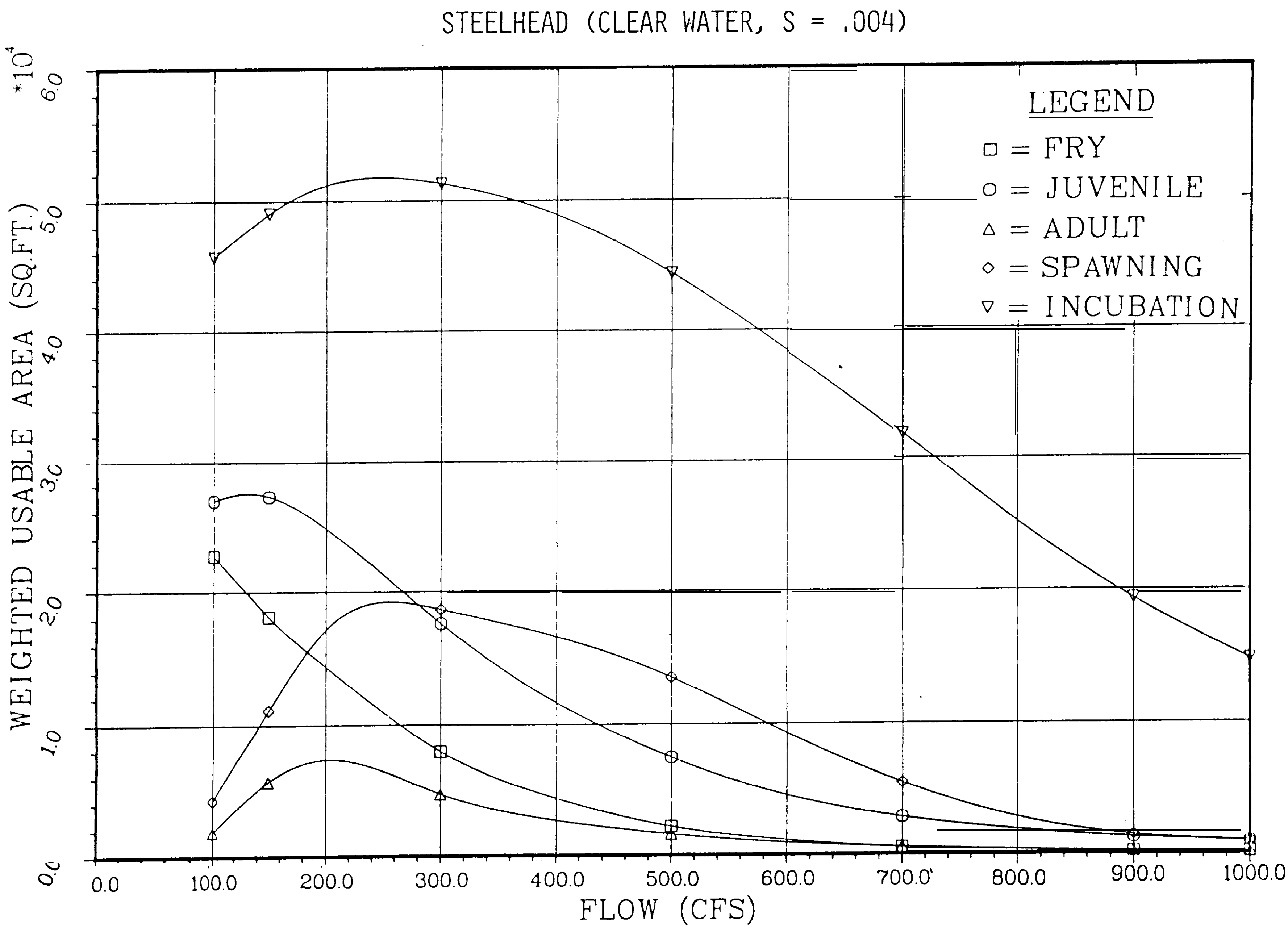
DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
100.	22709.	26871.	1878.	4282.	29530.
125.	20490.	27388.	3847.	7675.	34160.
150.	18180.	27186.	5702.	11163.	37748.
200.	14486.	24789.	7339.	17220.	42791.
300.	8009.	17651.	4729.	18693.	48823.
400.	4385.	11697.	2685.	16654.	51861 l
500.	2195.	7460.	1589.	13593.	53070.
600.	1111.	4554.	913.	9289.	53565.
700.	527.	2865.	573.	5488.	53544.
800.	294.	1865.	357.	2804.	53073.
900.	166.	1240.	224.	1415.	52206.
1000.	105.	916.	153.	909.	50920.



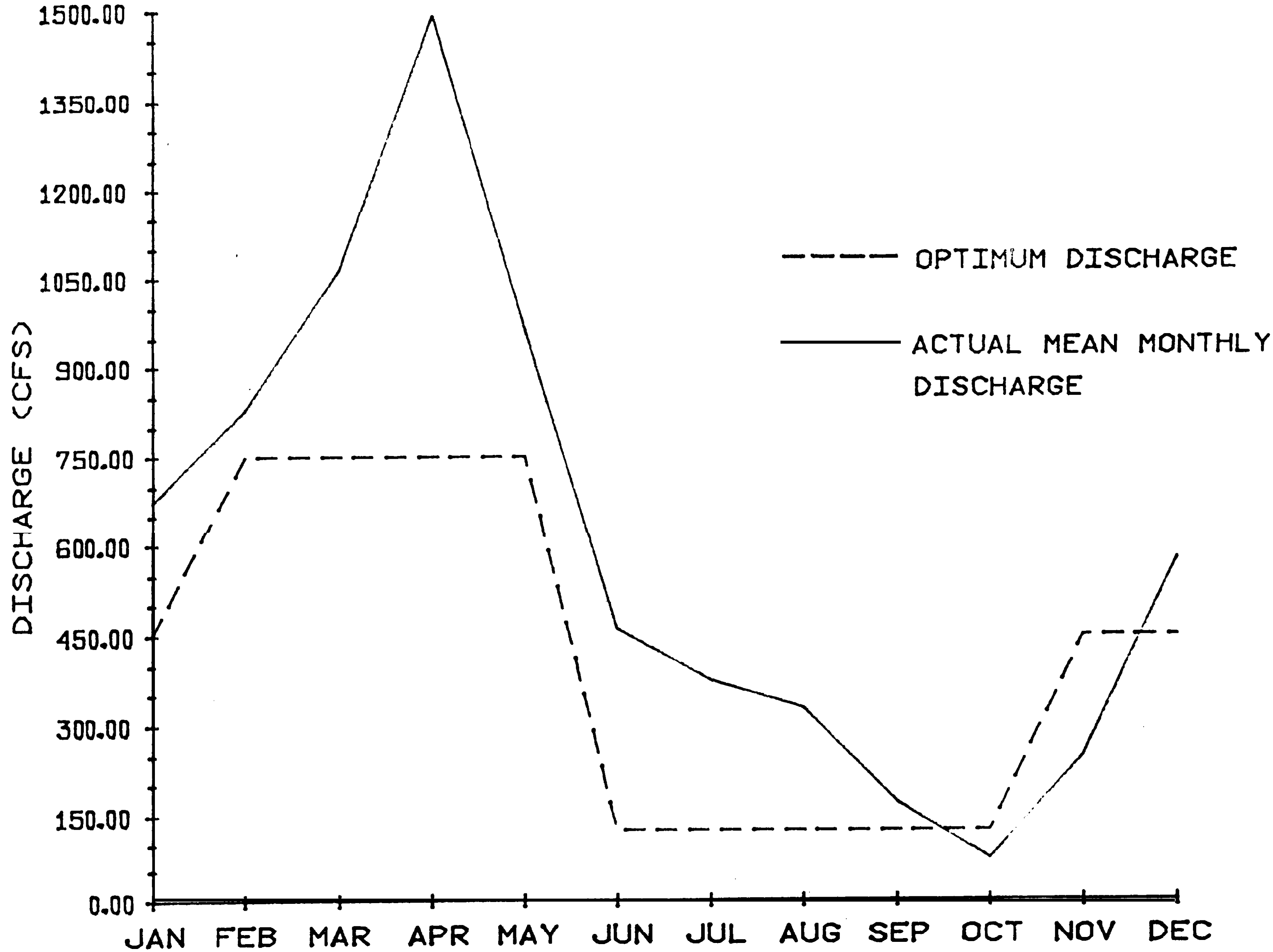
UMATILLA RIVER AT YOAKUM
COHO SALMON (CLEAR WATER, S=.004)
LEGEND
□ = FRY
○ = SPAWNING
△ = INCUBATION
WEIGHTED USABLE AREA (SQ.FT.)
*10^3
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
800.0
900.0
1000.0
FLOW (CFS)


UMATILLA RIVER AT YOAKUM
CHINOOK SALMON (CLEAR WATER,S=.004)
LEGEND
□ = JUVENILE
○ = SPAWNING +
△ = SPAWNING *
◇ = INCUBATION
WEIGHTED USABLE AREA (SQ.FT.)
*10^3
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
800.0
900.0
1000.0
FLOW (CFS)
+ = spring chinook
* = fall chinook

UMATILLA RIVER AT YOAKUM

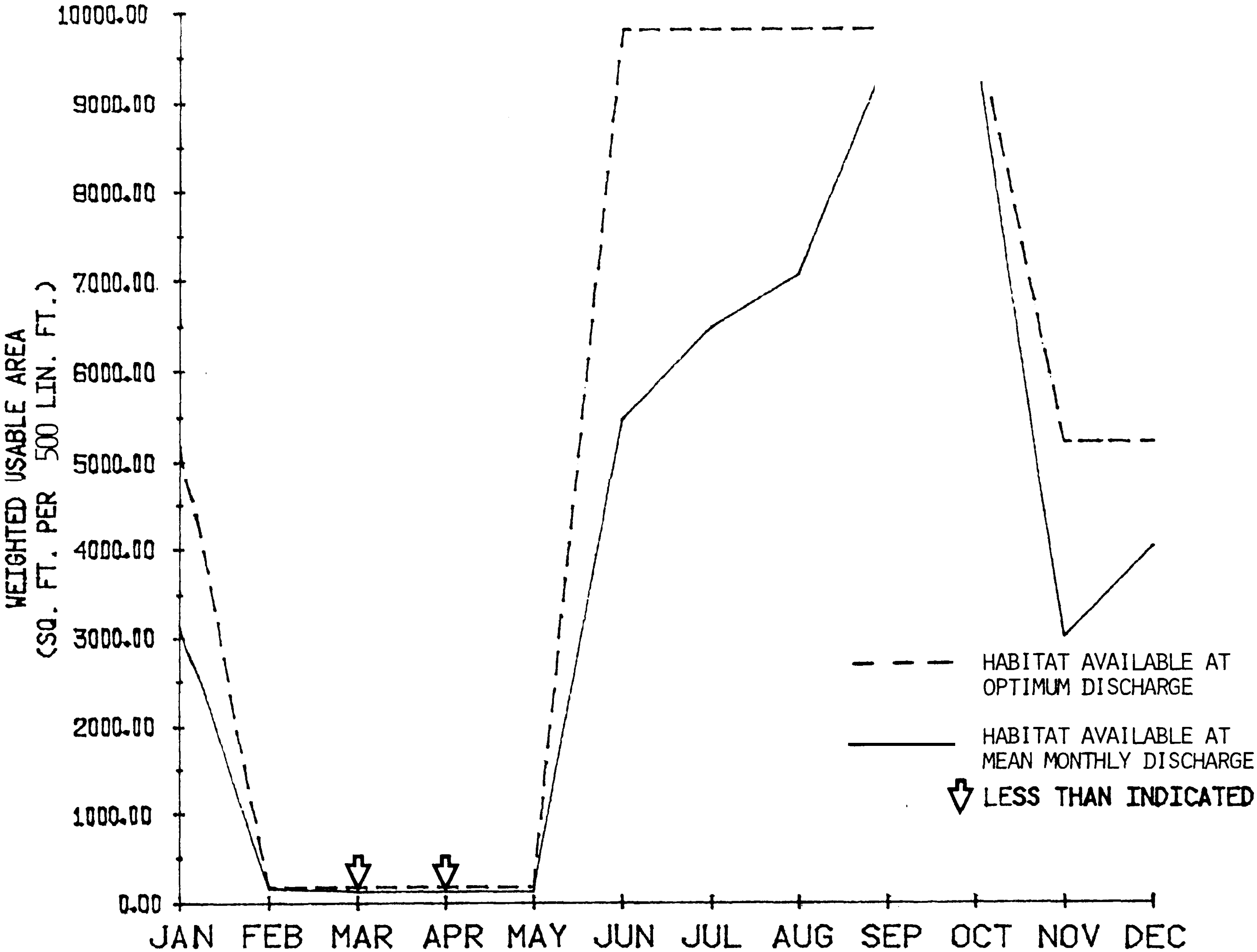


UMATILLA RIVER AT RIETH, OREGON (U 5)



ACTUAL AND OPTIMUM DISCHARGE FOR STEELHEAD

UMATILLA RIVER AT RIETH



ANNUAL STEELHEAD HABITAT

UMATILLA RIVER AT RIETH

UMATILLA AT RIETH
Discharge in cubic feet per second.

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	674.0	829.4	1068	1495	960.8	460	374.3	327.8	170.8	75.5	249	579.2
(Standard Deviation)	(487)	(427)	(504)	(600)	(472)	(216)	(72.4)	(76.9)	(74.7)	(44.9)	(209)	(465)
Highest Average Flow (Year)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lowest Average Flow (Year)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Mean discharge records are approximated by combining the flows of the Umatilla River at Pendleton (1904-1905, 1935-1977) and McKay Creek near Pendleton (1948 - 1977).
High and low flows are unavailable.

Normal Annual Mean 605

(Source: U.S.G.S.)

UMATILLA RIVER AT RIETH

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

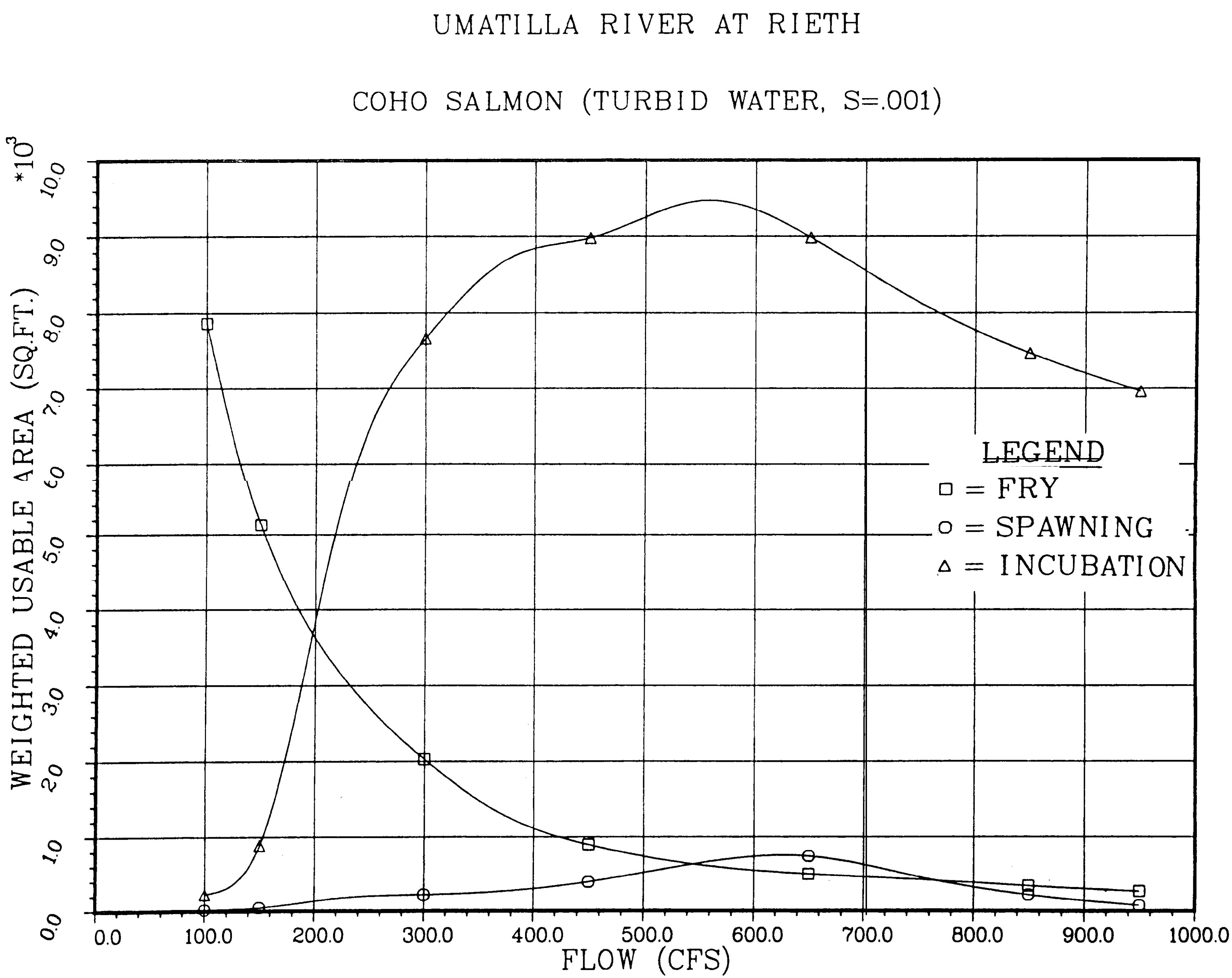
DISCHARGE	FRY	SPAWNING	INCUBATION
100.	7865.	17.	226.
125.	6303.	29.	351.
150.	5133.	46.	887.
225.	3125.	177.	5418.
300.	2032.	218.	7664.
375.	1277.	268.	8712.
450.	898.	391.	8982.
550.	624.	646.	9466.
650.	496.	742.	8990.
750.	426.	461.	8134.
850.	339.	217.	7467.
950.	268.	77.	6961.

CHINOOK SALMON

DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
100.	18382.	63.	0.	233.
125.	18117.	67.	2.	335.
150.	17221.	82.	13.	848.
225.	13463.	104.	121.	5396.
300.	9947.	240.	276.	8013.
375.	7318.	462.	274.	9558.
450.	5572.	558.	279.	10074.
550.	4255.	589.	292.	11368.
650.	3278.	433.	242.	11498.
750.	2451.	277.	159.	11322.
850.	1881.	185.	103.	11143.
950.	1514.	113.	57.	10956.

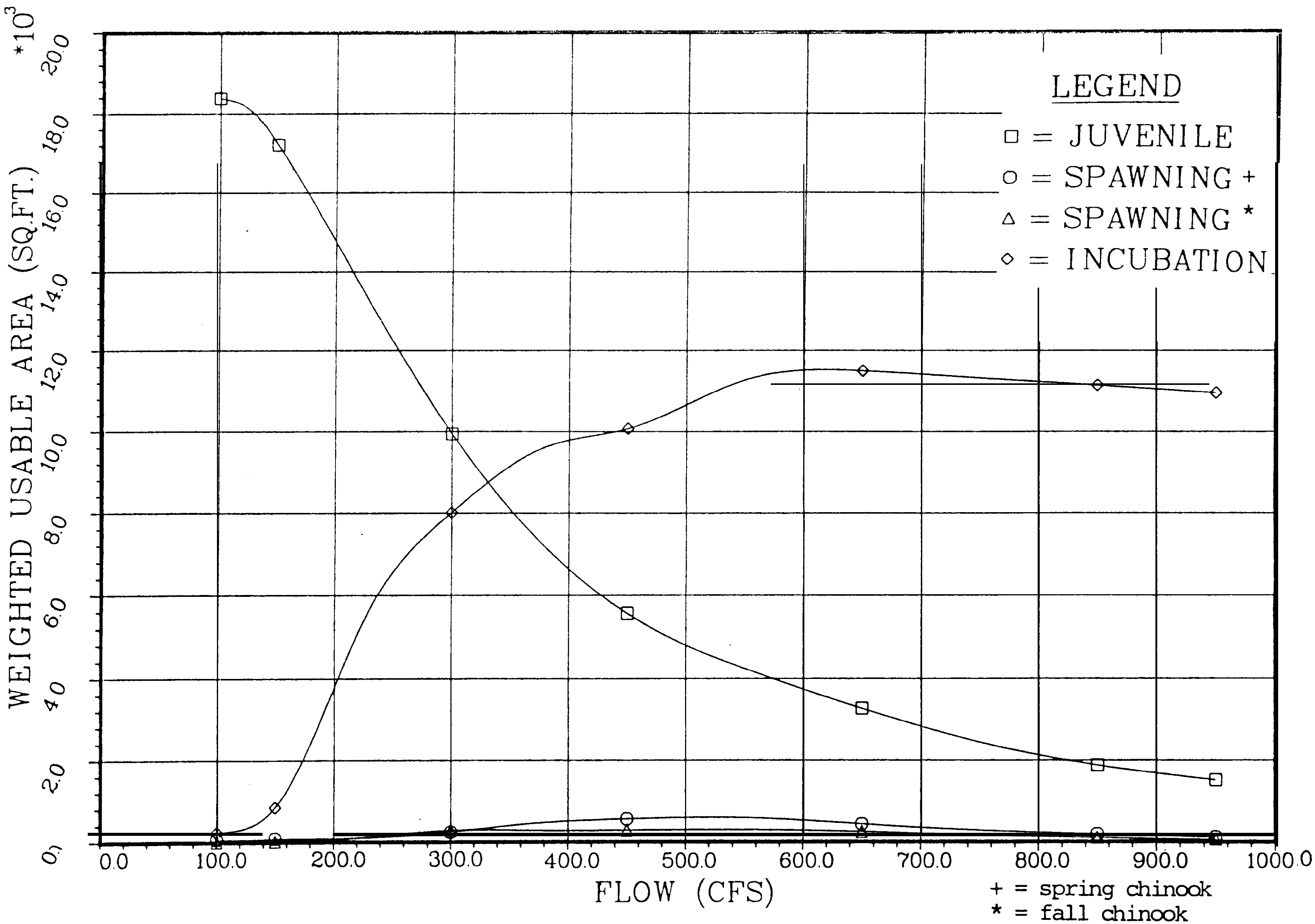
STEELHEAD

DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
100.	1994,	9527.	1127.	35.	2086.
125.	1945.	9788.	1590.	51.	2566.
150.	1906.	9766.	2006.	52.	3045.
225.	1843.	8819.	2743.	49.	4426.
300.	1580.	7651.	3737.	80.	5796.
375.	1368.	6479.	5111.	97.	7182.
450.	1121.	5461.	5192.	104.	8588.
550.	790.	4404.	4258.	120.	10315.
650.	555.	3574.	3293.	157.	11511.
750.	401.	2971.	2702.	152.	12293.
850.	309.	2528.	2457.	146.	12729.
950.	237.	2193.	2004.	126.	13045.


UMATILLA RIVER AT RIETH
COHO SALMON (TURBID WATER, S=.001)
WEIGHTED USABLE AREA (SQ.FT.)
*10^3
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
800.0
900.0
1000.0
FLOW (CFS)
LEGEND
□ = FRY
○ = SPAWNING
△ = INCUBATION

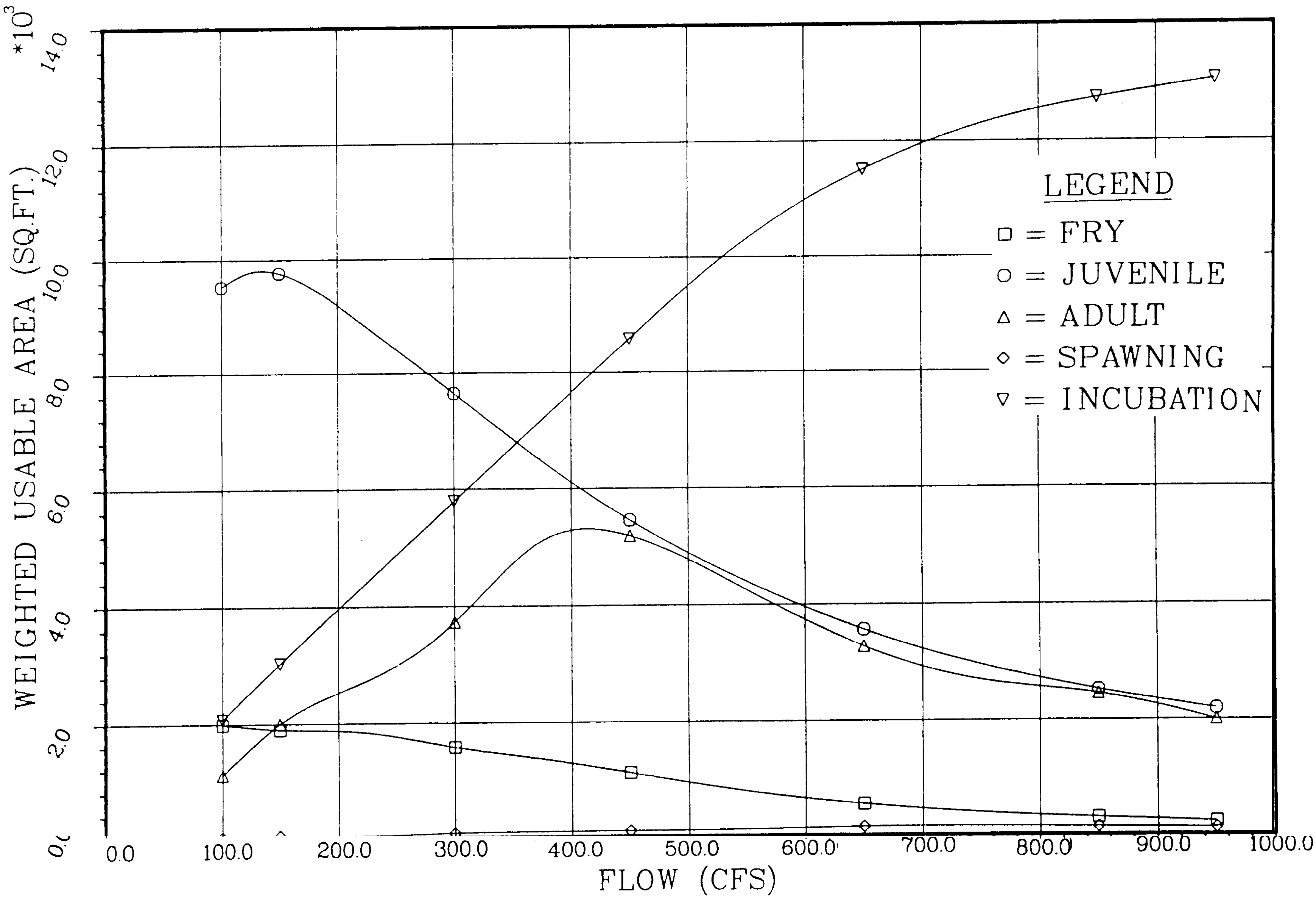
UMATILLA RIVER AT RIETH

CHINOOK SALMON (TURBID WATER,S=.001)

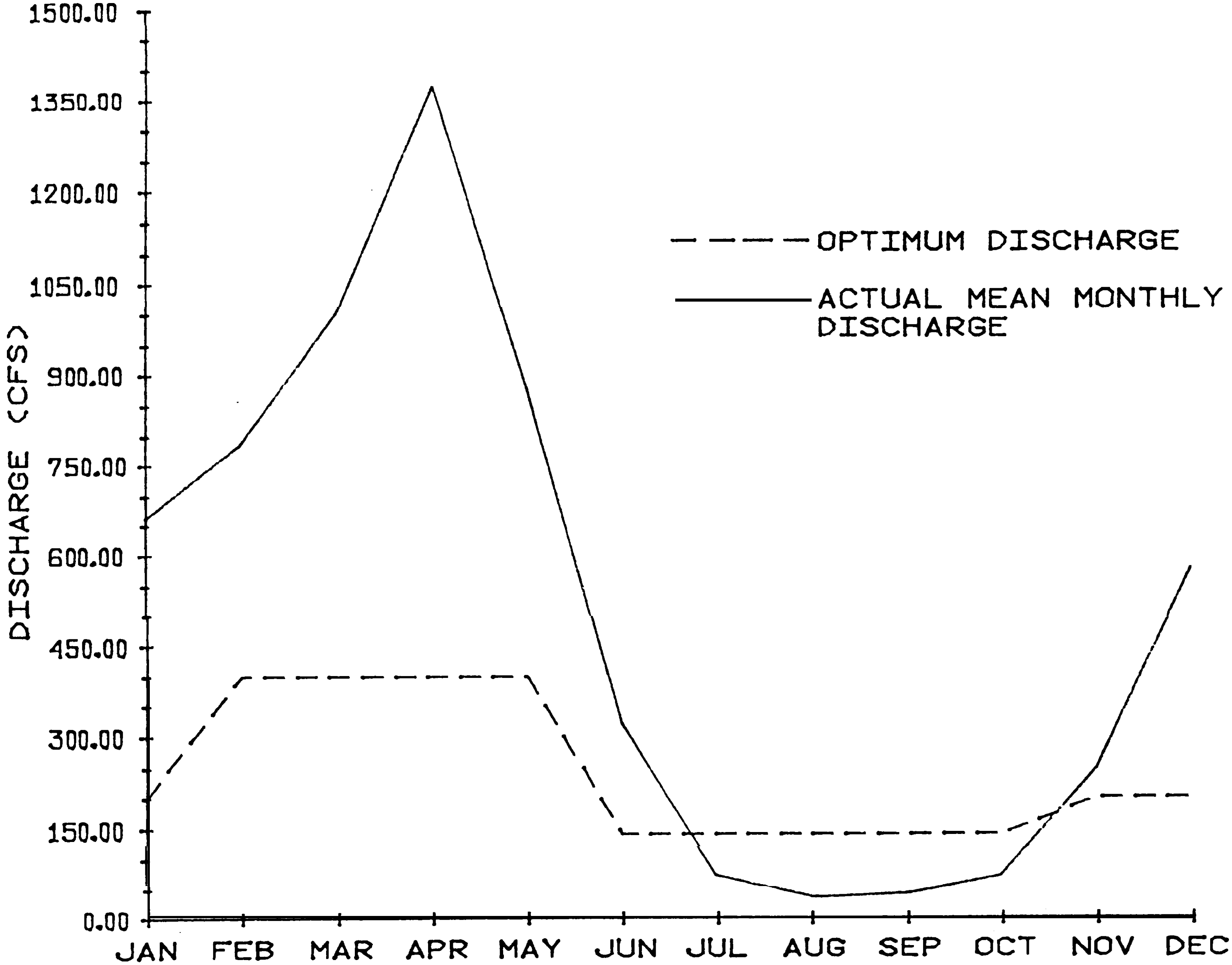


UMATILLA RIVER AT RIETH

STEELHEAD (TURBID WATER, S = .001)

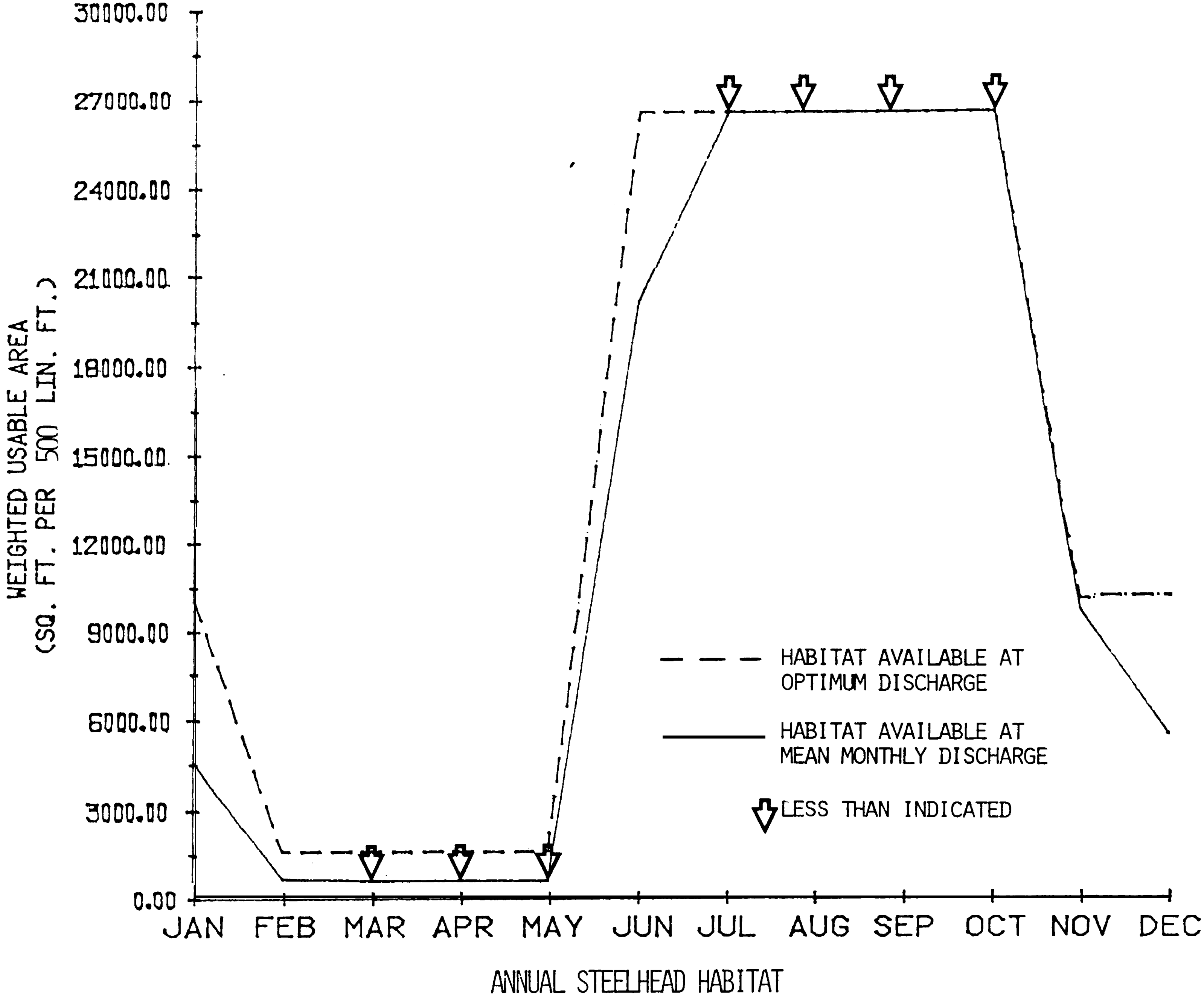


UMATILLA RIVER AT PENDLETON, OREGON (U 6)



ACTUAL AND OPTIMUM DISCHARGE FOR STEELHEAD

UMATILLA RIVER AT PENDLETON. OREGON



UMATILLA RIVER AT PENDLETON. OREGON

UMATILLA RIVER AT PENDLETON, OREGON
Discharge in cubic feet per second.

Period of record
1904-1905, 1935-1977

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	662	788	1004	1374	877	321	74.3	36.8	43.8	73.3	249	579
(Standard Deviation)	(486)	(412)	(490)	(577)	(460)	(206)	(37.7)	(12.0)	(12.4)	(44.6)	(209)	(465)
Highest Average Flow	2088	1695	2672	3538	2519	892	189	76.2	67.8	246	855	1786
(Year)	(1970)	(1958)	(1972)	(1904)	(1948)	(1974)	(1942)	(1976)	(1977)	(1960)	(1904)	(1974)
Lowest Average Flow	69.6	107	410	299	198	64.4	19.4	16.9	22.9	36.8	55.8	69.3
(Year)	(1937)	(1977)	(1977)	(1941)	(1968)	(1940)	(1940)	(1939)	(1904)	(1940)	(1937)	(1937)

(*)many years of record
(Source: U.S.G.S.)

Normal Annual Mean = 500

UMATILLA RIVER AT PENDLETON, OR

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

DISCHARGE	FRY	SPAWNING	INCUBATION
140.	3199.	202.	9981.
175.	2633.	180.	10759.
200.	2425.	142.	10820.
250.	1717.	110.	10360.
300.	1375.	125.	9824.
350.	1144.	196.	9199.
400.	1008.	125.	8533.
450.	969.	127.	8016.
500.	1001.	171.	7607.
600.	1023.	458.	6690.
700.	981.	680.	5343.
800.	910.	829.	4308.

CHINOOK SALMON

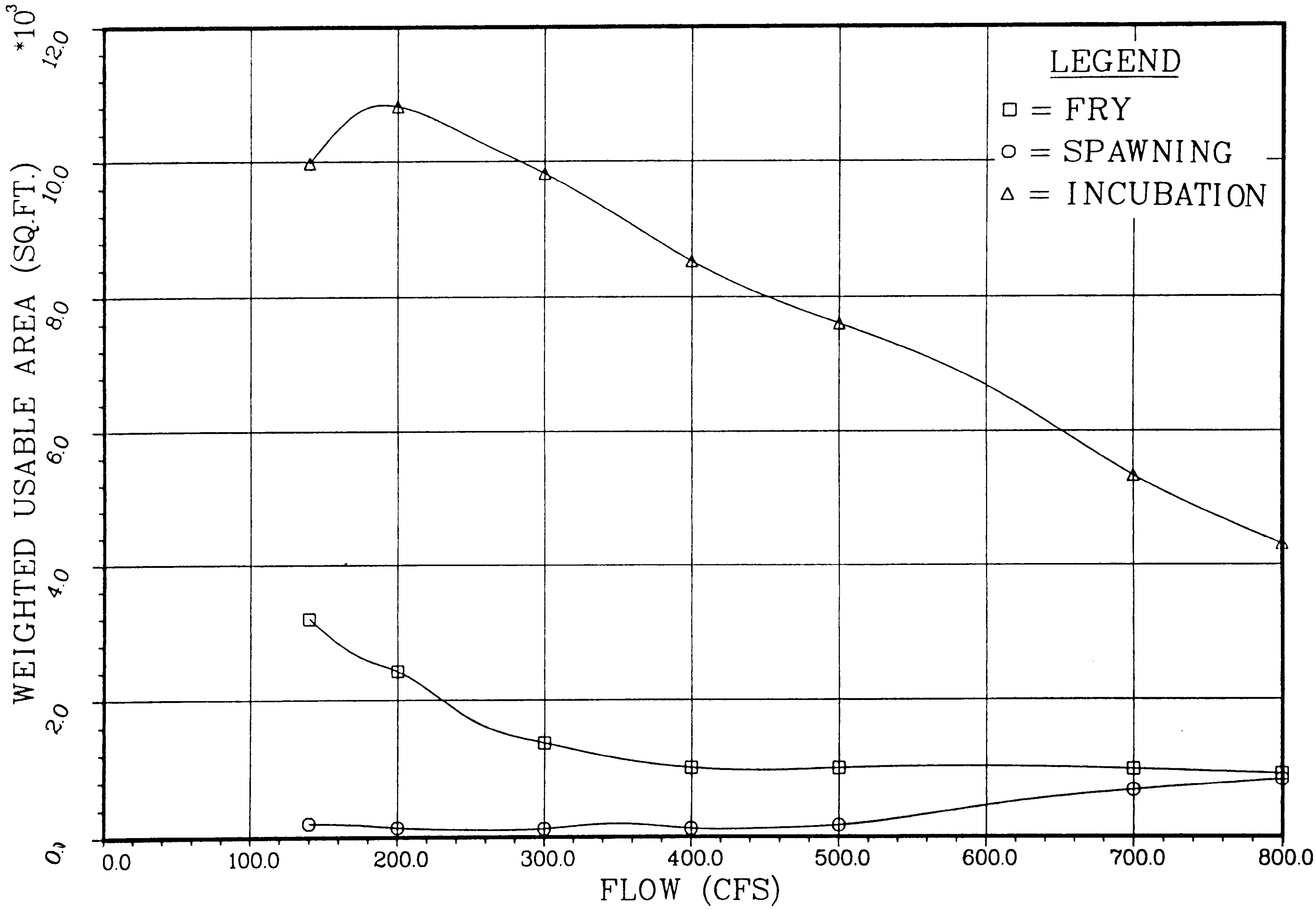
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
140.	16621.	911.	176.	13046.
175.	15134.	1046.	276.	14384.
200.	14336.	1018.	287.	14864.
250.	11973.	992.	165.	14902.
300.	9832.	1175.	135.	14902.
350.	8331.	1104.	205.	14768.
400.	7453.	798.	320.	14406.
450.	6276.	714.	245.	13997.
500.	5432.	680.	181.	13595.
600.	4339.	767.	106.	12477.
700.	3146.	969.	91.	10786.
800.	2407.	1020.	322.	9235.

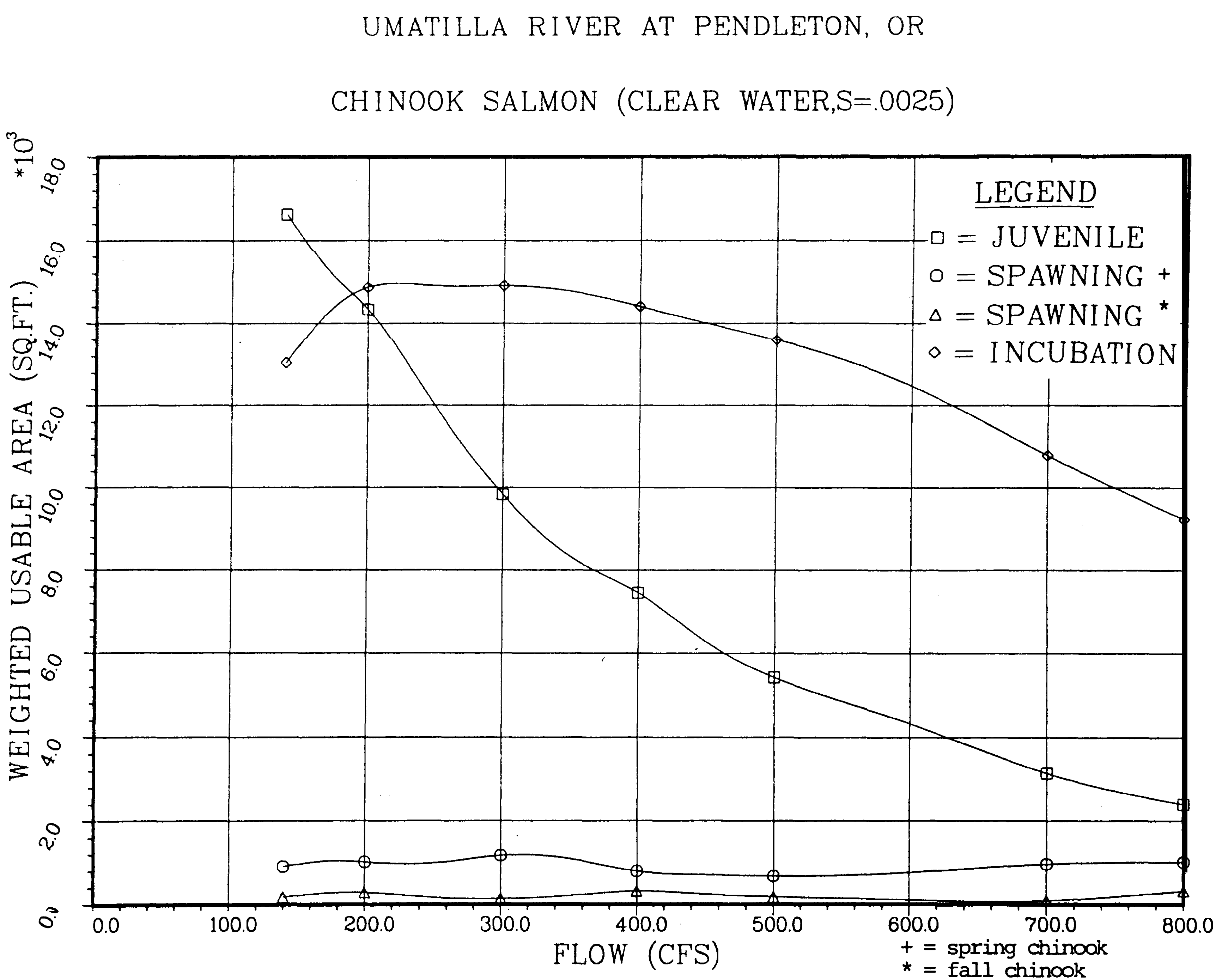
STEELHEAD

DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
140.	14299.	26496.	5999.	642.	16442.
175.	12764.	26268.	9222.	951.	18049.
200.	11868.	25630.	10075.	1109.	18944.
250.	10208.	23916.	9674.	1347.	20425.
300.	8689.	21543.	8517.	1502.	21526.
350.	7418.	18805.	6941.	1617.	22055.
400.	6128.	15976.	5902.	1622.	22288.
450.	5041.	13755.	5055.	1592.	22337.
500.	4098.	11942.	5122.	1538.	22220.
600.	2754.	8929.	5626.	1281.	21413.
700.	1949.	7186.	3590.	922.	20248.
800.	1421.	5835.	2971.	632.	18754.

UMATILLA RIVER AT PENDLETON, OR

COHO SALMON (CLEAR WATER, S=.0025)

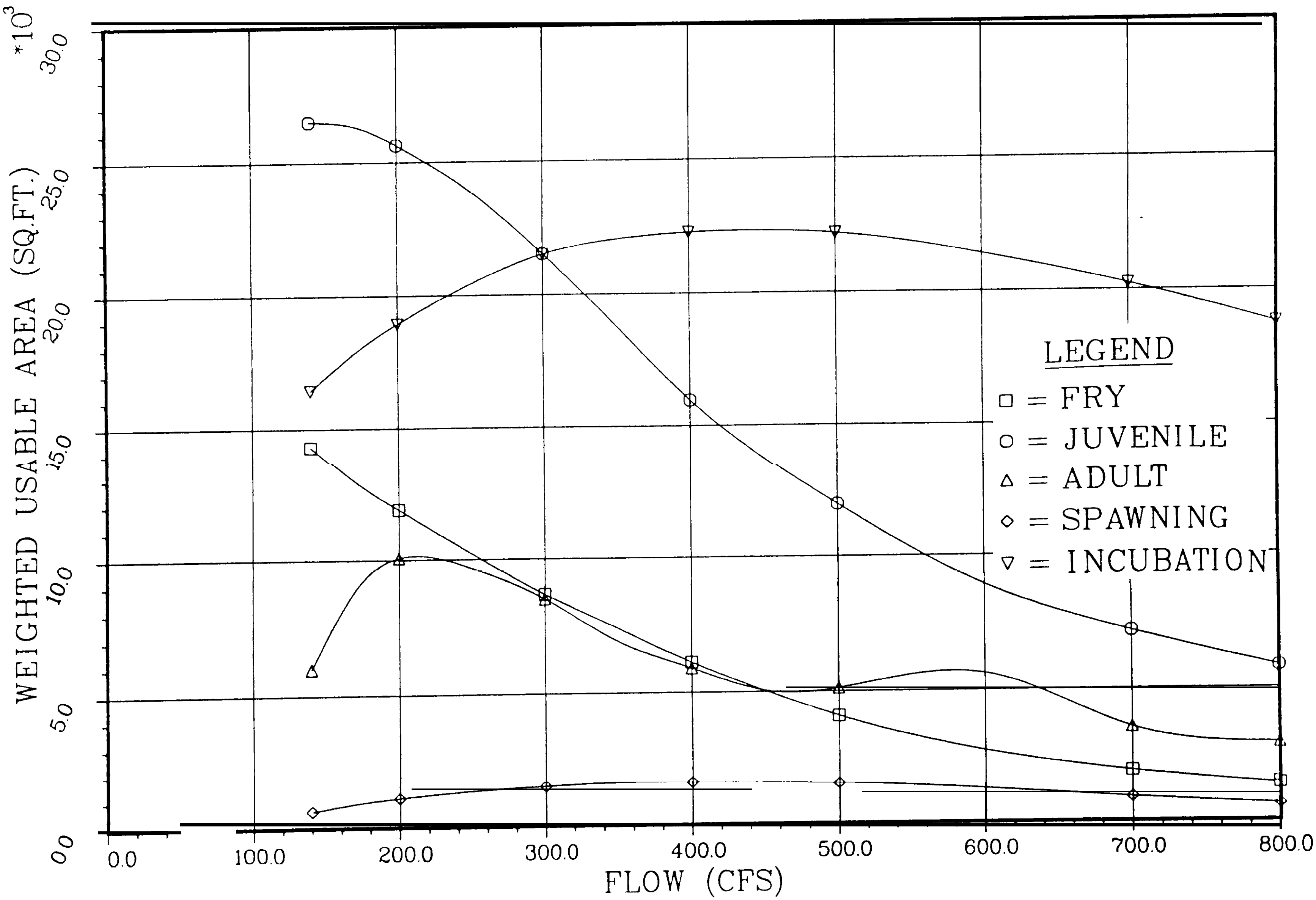


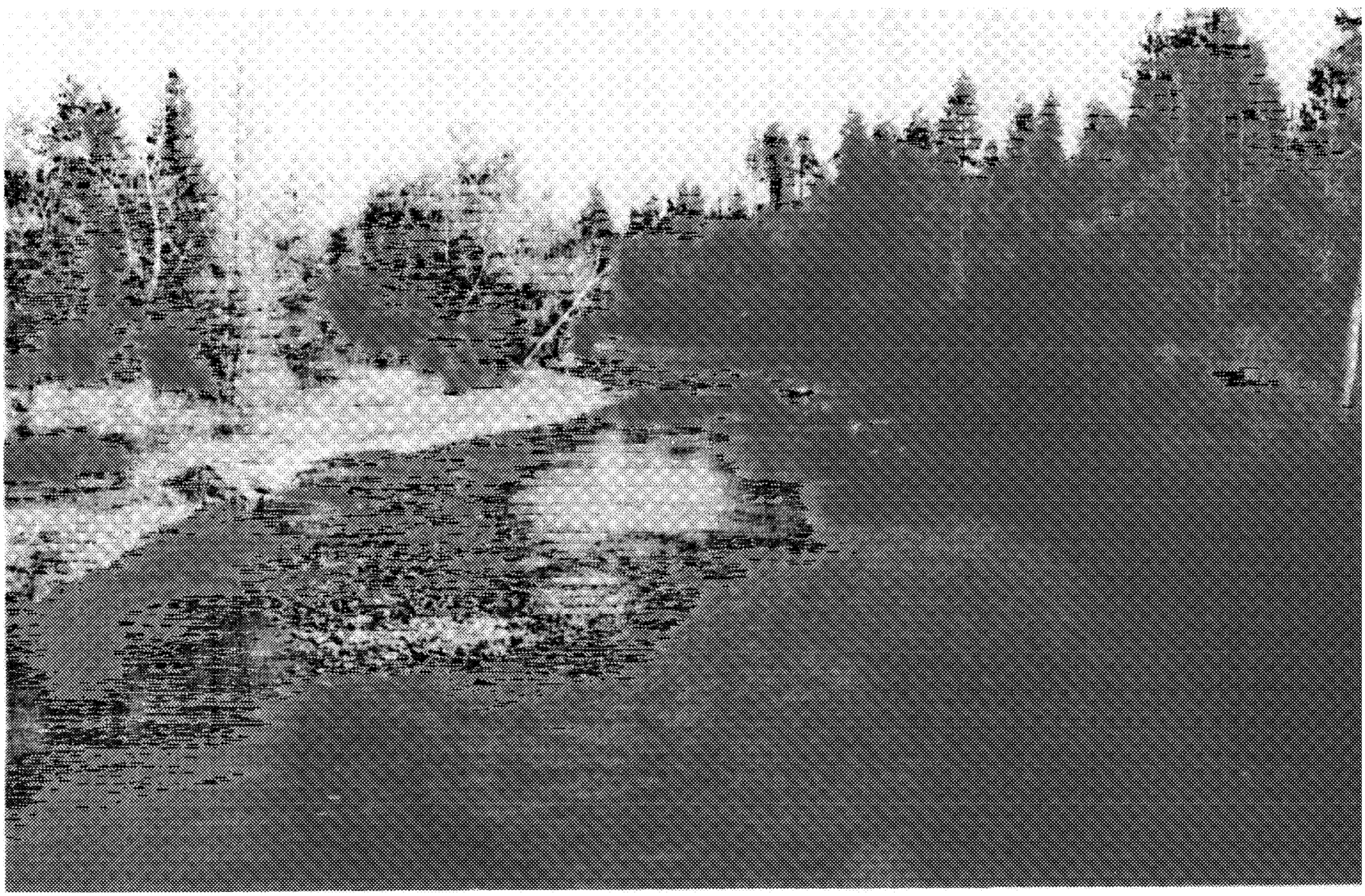


UMATILLA RIVER AT PENDLETON, OR
CHINOOK SALMON (CLEAR WATER,S=.0025)
WEIGHTED USABLE AREA (SQ.FT.)
*10^3
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
800.0
FLOW (CFS)
LEGEND
□ = JUVENILE
○ = SPAWNING +
△ = SPAWNING *
◇ = INCUBATION
+ = spring chinook
* = fall chinook

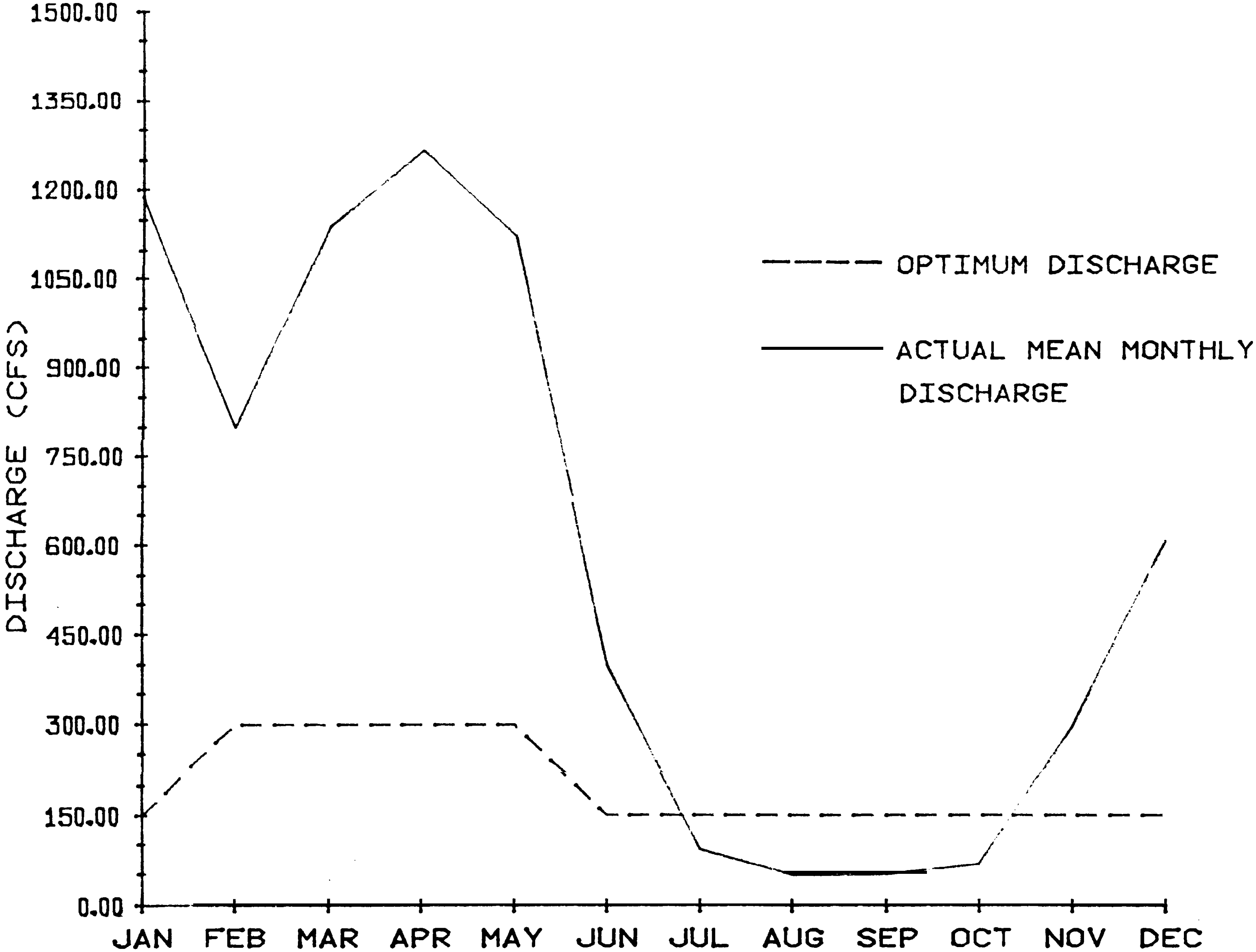
UMATILLA RIVER AT PENDLETON, OR

STEELHEAD (CLEAR WATER, S = .0025)



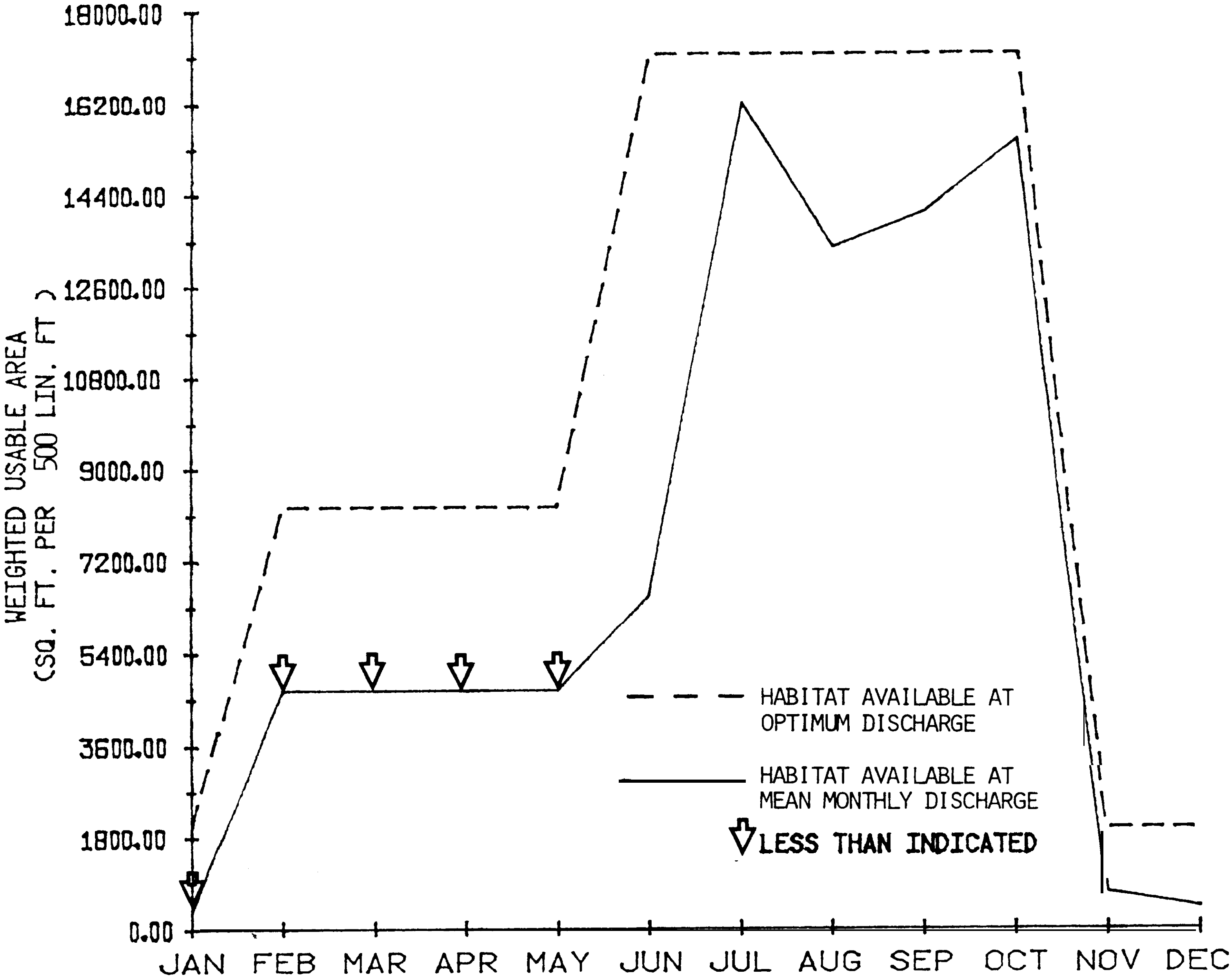


UMATILLA RIVER AT CAYUSE, OREGON (U 7)



ACTUAL AND OPTIMUM DISCHARGE FOR STEELHEAD

UMATILLA RIVER AT CAYUSE



ANNUAL STEELHEAD HABITAT

UMATILLA RIVER AT CAYUSE

UMATILLA AT CAYUSE
Discharge in cubic feet per second.

Period of Record
1969 - 1975

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	1187.0	799.0	1138.0	1265.0	1123.0	400.0	91.2	48.9	51.2	68.0	301.0	615.0
(Standard Deviation)	(446)	(373)	(741)	(606)	(505)	(255)	(30.8)	(8.26)	(3.93)	(13.2)	(260.0)	(509.0)
Highest Average Flow	1778	1362	2730	2177.0	1697	878	138	63.1	57.5	87.8	787.0	1691
(Year)	(1970)	(1972)	(1972)	(1974)	(1975)	(1974)	(1974)	(1975)	(1971)	(1969)	(1974)	(1974)
Lowest Average Flow	518	266	457	462	270	79.5	45.0	37.7	46.2	53.0	67.1	208
(Year)	(1973)	'(1973)	(1973)	(1973)	(1973)	(1973)	(1973)	(1973)	(1969)	(1975)	(1975)	(1970)

(*)many years of record
(Source: U.S.G.S.)

Normal Annual Mean = 590

UMATILLA AT CAYUSE

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

DISCHARGE	FRY	SPAWNING	INCUBATION
40.	1343.	2237.	26646.
70.	1377.	1940.	36018.
100.	882.	2310.	36197.
150.	493.	3858.	35172.
200.	294.	4801.	29119.
250.	204.	4355.	23613.
300.	172.	3402.	19209.
350.	157.	2914.	15795.
400.	127.	2427.	12673.
450.	171.	1964.	10378.
550.	124.	1384.	6671.
650.	95.	966.	4956.

CHINOOK SALMON

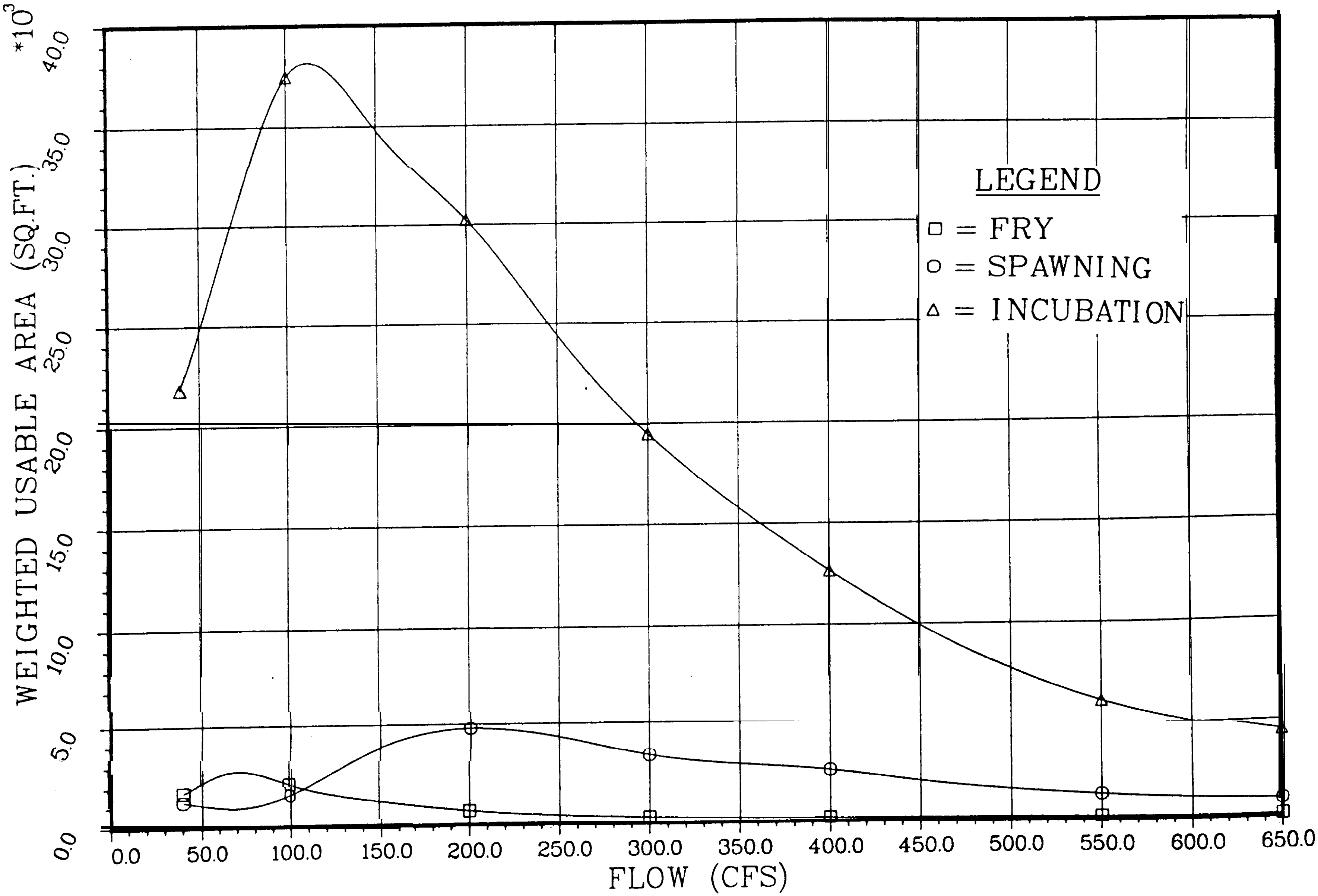
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
40.	5419.	4358.	3994.	28354.
70.	7072.	5193.	4228.	40134.
100.	6537.	5185.	3608.	42657.
150.	4455.	5497.	4576.	43446.
200.	3352.	6671.	6929.	40833.
250.	2847.	6825.	8086.	37466.
300.	2330.	6090.	7237.	33669.
350.	1899.	4970.	5793.	29608.
400.	1398.	3043.	4044.	24551.
450.	1310.	2713.	3463.	22060.
550.	885.	1882.	2822.	, 15147.
650.	753.	1308.	2302.	11056.

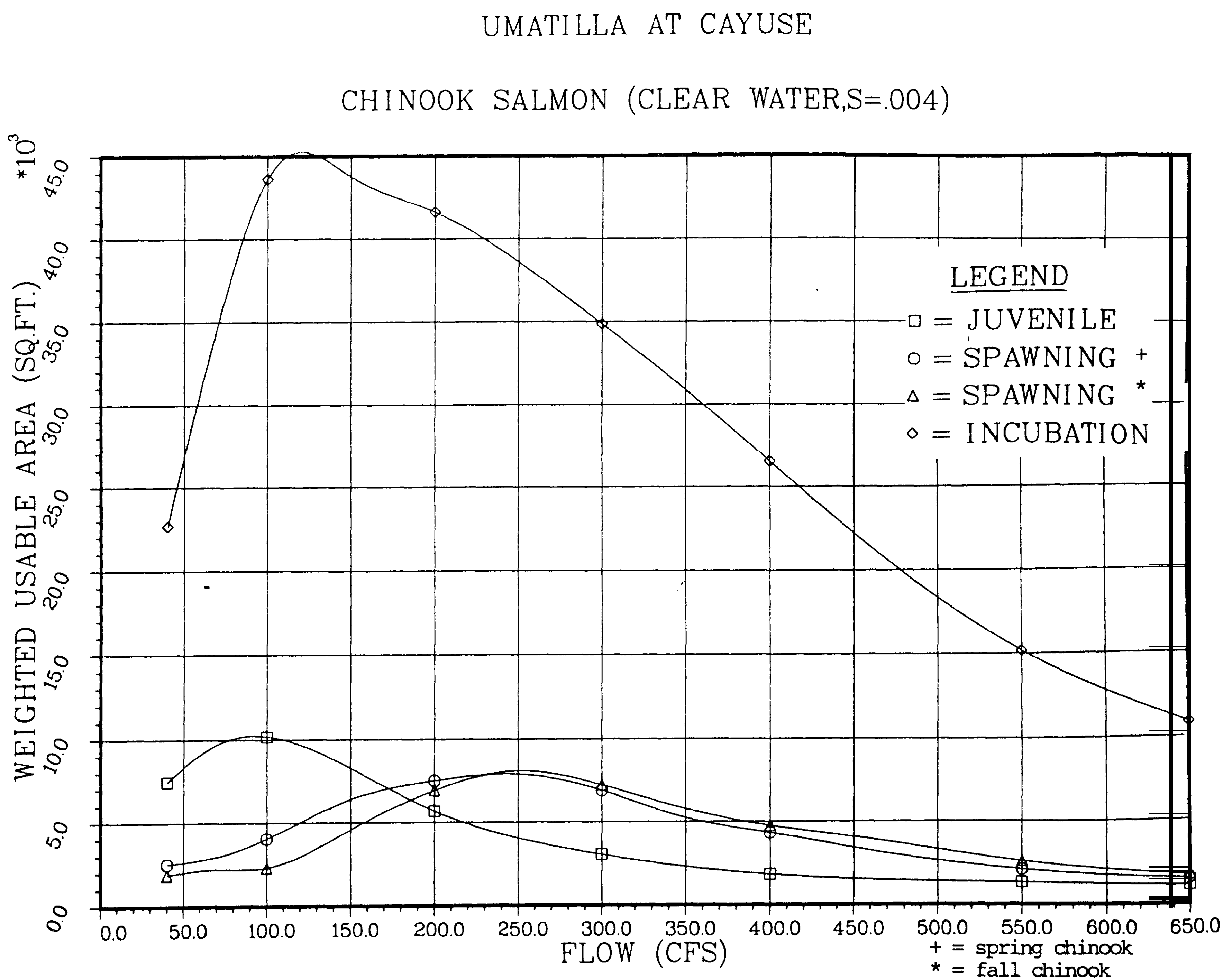
STEELHEAD

DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
40.	20273.	12686.	287.	1356.	30584.
70.	23382.	15475.	710.	3153.	43224.
100.	23106.	16894.	1388.	4493.	48666.
150.	20191.	17186.	2030.	4522.	52051.
200.	15877.	16785.	1990.	6370.	51465.
250.	10824.	14008.	946.	7511.	50298.
300.	7043.	11052.	689.	8262.	48759.
350.	5220.	8685.	754.	8074.	46259.
400.	3712.	6523.	872.	5846.	40487.
450.	3180.	6776.	1078.	5968.	38520.
550.	2280.	5101.	531.	5163.	29450.
650.	1738.	4125.	384.	4666.	22795.

UMATILLA AT CAYUSE

COHO SALMON (CLEAR WATER, S=.004)

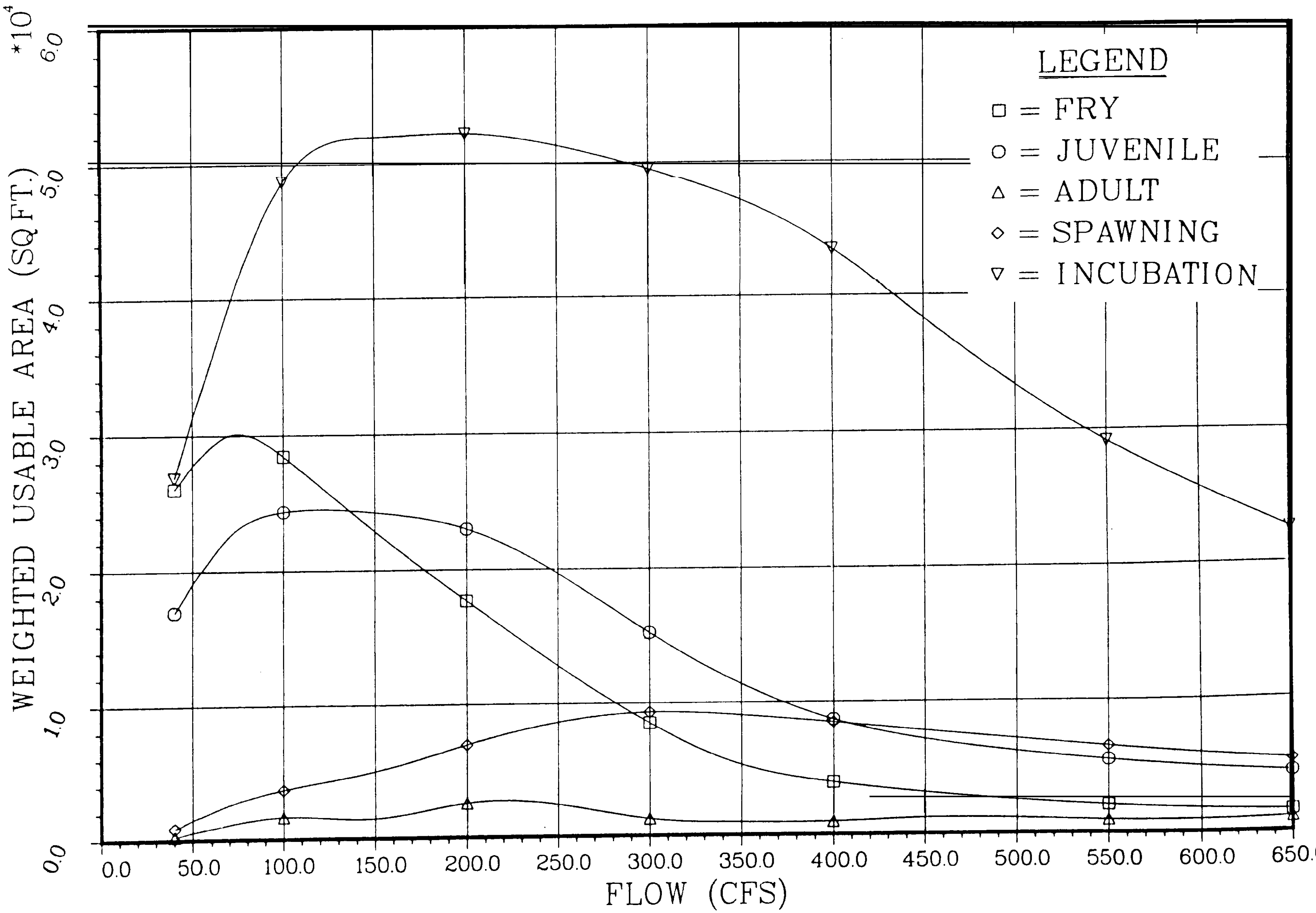


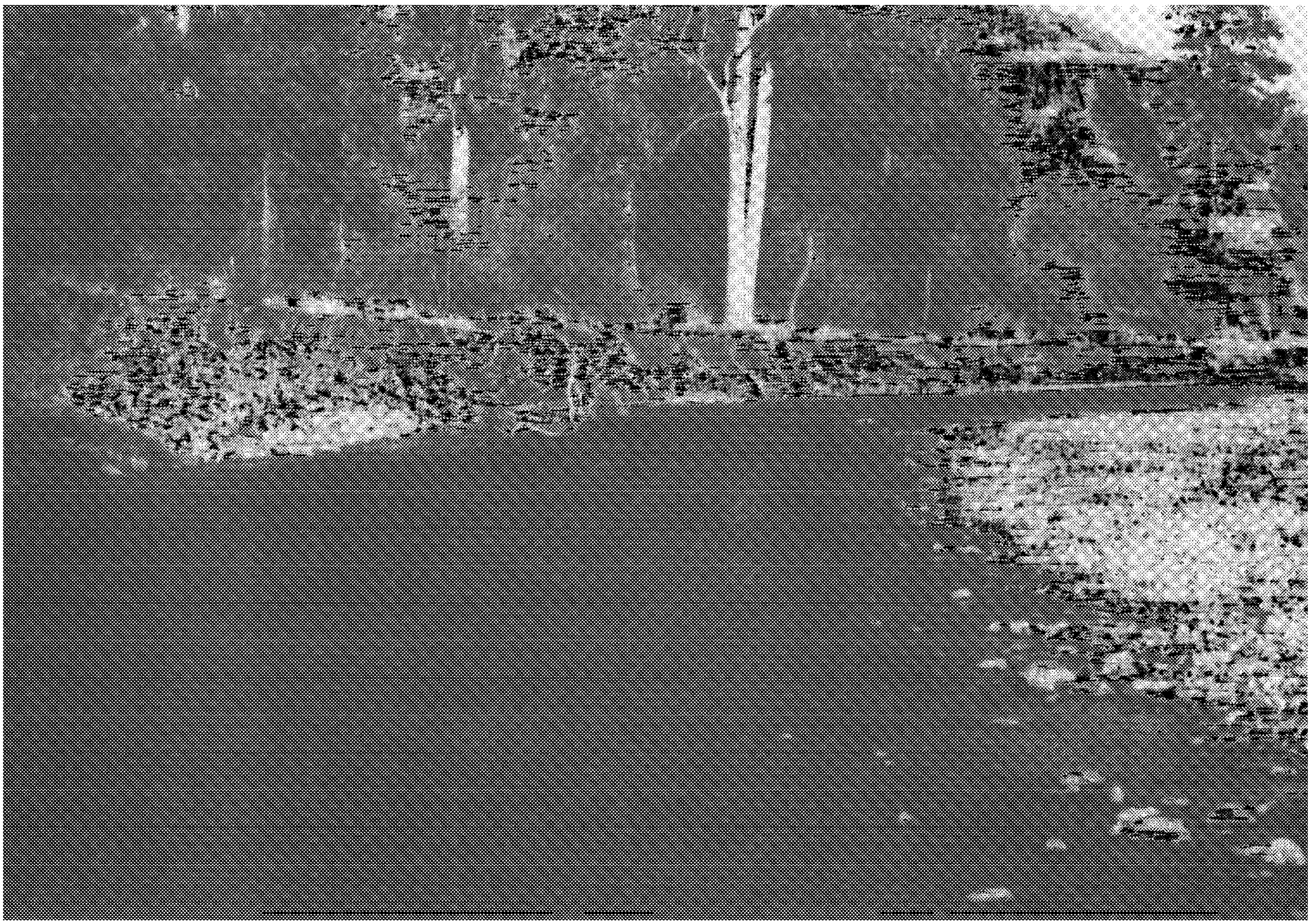


UMATILLA AT CAYUSE
CHINOOK SALMON (CLEAR WATER,S=.004)
WEIGHTED USABLE AREA (SQ.FT.) *10^3
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
LEGEND
□ = JUVENILE
○ = SPAWNING +
△ = SPAWNING *
◇ = INCUBATION
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
FLOW (CFS)
+ = spring chinook
* = fall chinook

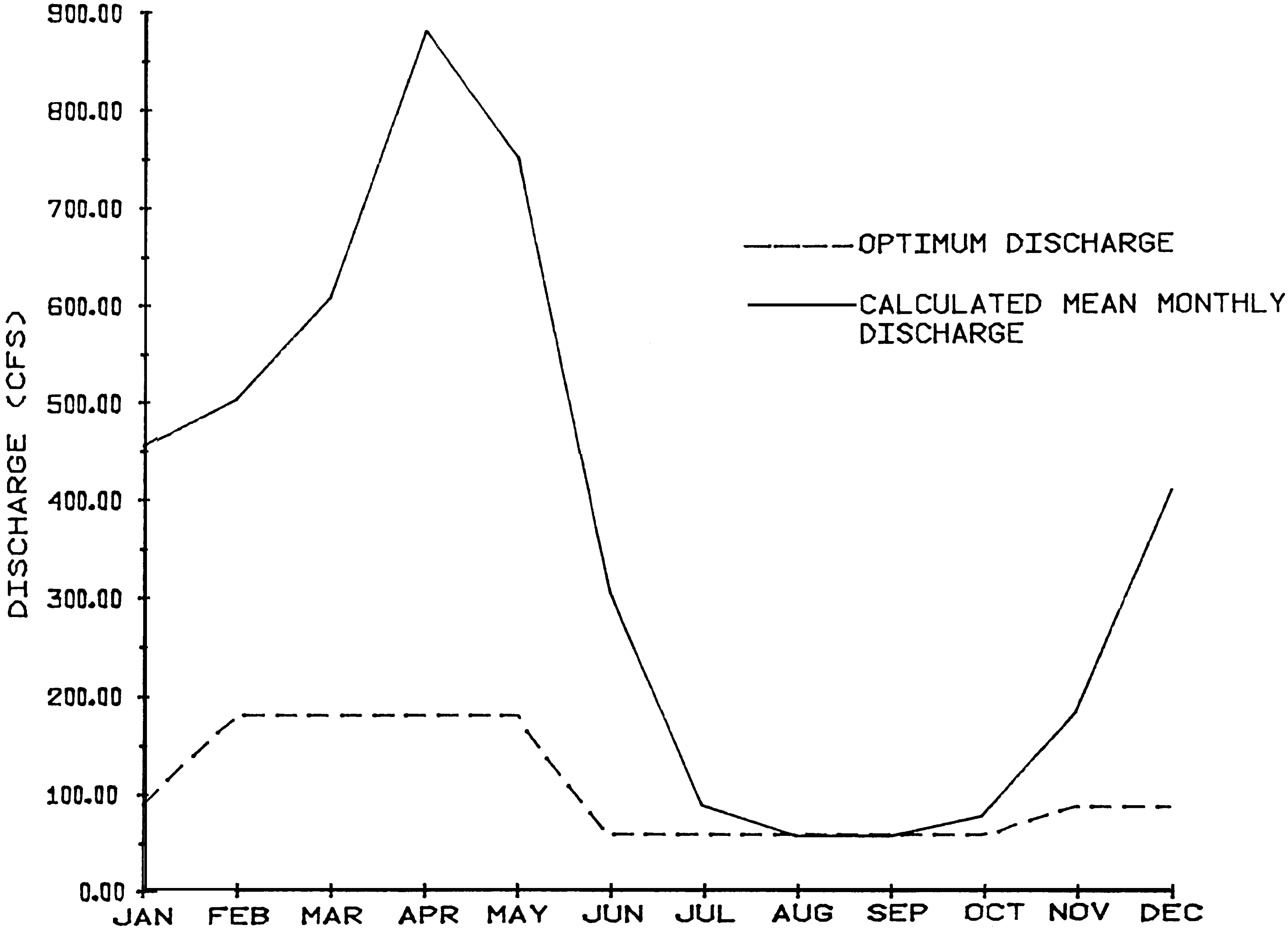
UMATILLA AT CAYUSE

STEELHEAD (CLEAR WATER, S = .004)



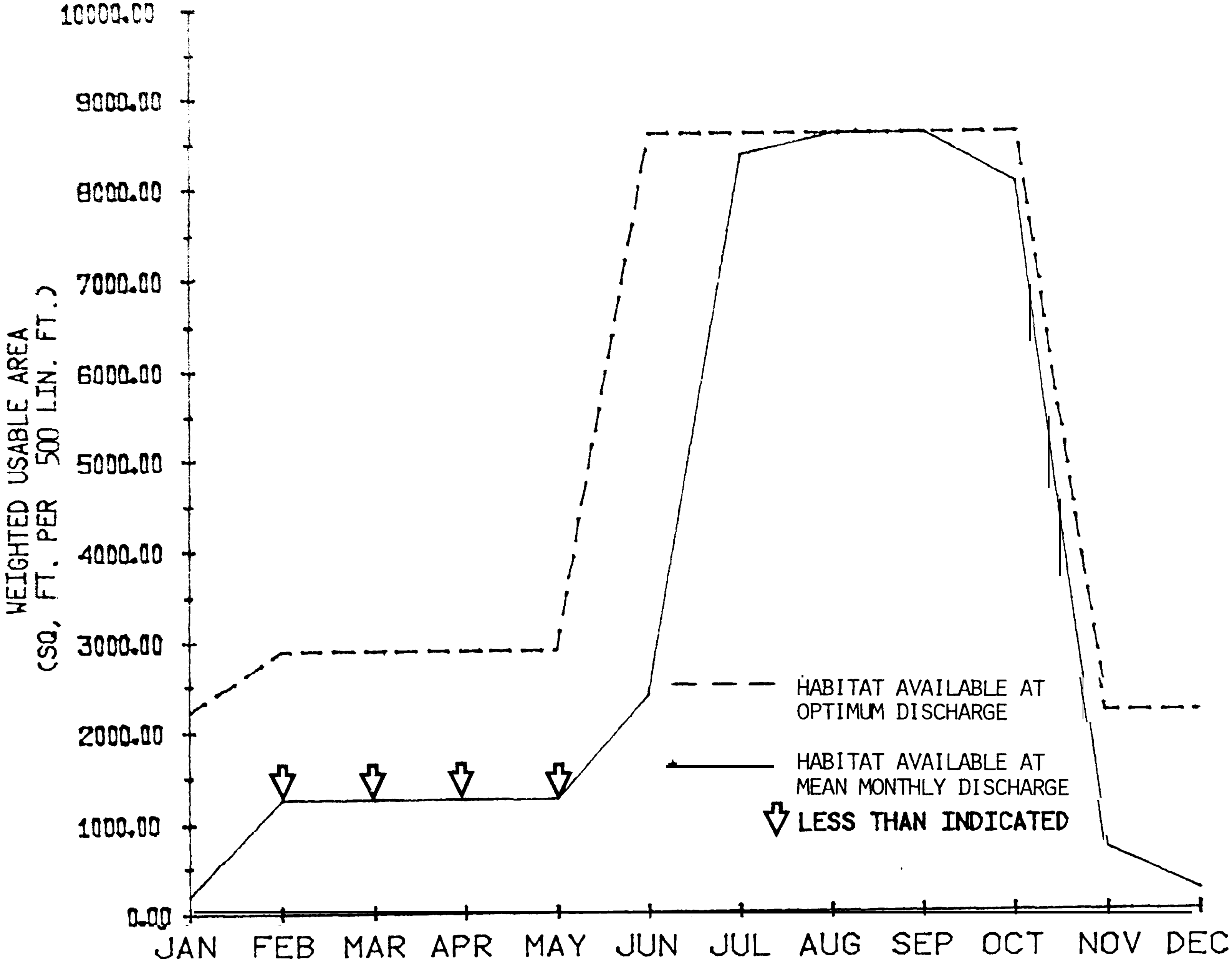


UMATILLA RIVER ABOVE SQUAW CREEK (U 8)



ACTUAL AND OPTIMUM DISCHARGE FOR STEELHEAD

UMATILLA RIVER ABOVE SQUAW CREEK



ANNUAL STEELHEAD HABITAT

UMATILLA RIVER ABOVE SQUAW CREEK

UMATILLA RIVER ABOVE SQUAW CREEK
Discharge in cubic feet per second.

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	456	506	611	882	751	307	89.8	59.8	59.6	79.7	187	413
(Standard Deviation)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Highest Average Flow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lowest Average Flow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A'	N/A	N/A	N/A

-

Normal Annual Mean = 367
Source (Copp, 1977; U.S.G.S.)

Mean records approximated by combining discharge of Umatilla River above Meacham Creek and Meacham Creek below North Fork.

UMATILLA RIVER ABOVE SQUAW CREEK

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

DISCHARGE	FRY	SPAWNING	INCUBATION
40.	697.	243.	10437.
60.	653.	500.	10700.
90.	643.	713.	11102.
120.	580.	744.	9876.
150.	458.	1073.	9139.
180.	310.	1199.	8289.
210.	268.	1537.	7336.
250.	227.	1393.	6285.
300.	208.	836.	4901.
350.	204.	601.	3557.
400.	208.	438.	2609.
450.	212.	263.	2101.

CHINOOK SALMON

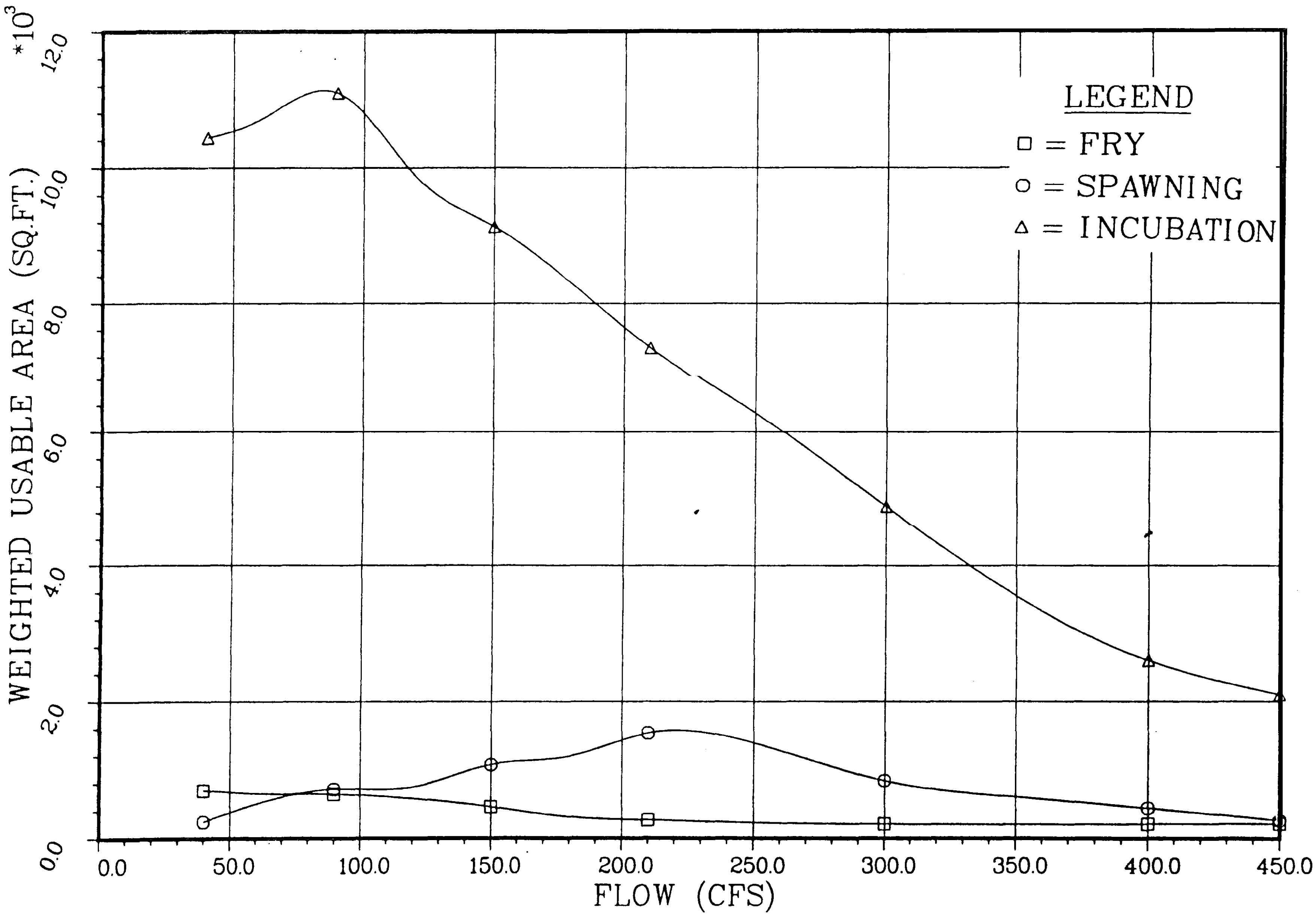
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
40.	3706.	1227.	94.	13029.
60.	3725.	1215.	206.	13990.
90.	3104.	1547.	972.	14997.
120.	2641.	1955.	1389.	14367.
150.	2204.	2332.	1625.	13965.
180.	1899.	2315.	2214.	13276.
210.	1621.	2175.	2168.	12416.
250.	1332.	1618.	2078.	10851.
300.	1204.	1145.	1365.	8540.
350.	1091.	959.	1140.	6289.
400.	1071.	628.	810.	4798.
450.	1056.	521.	700.	3922.

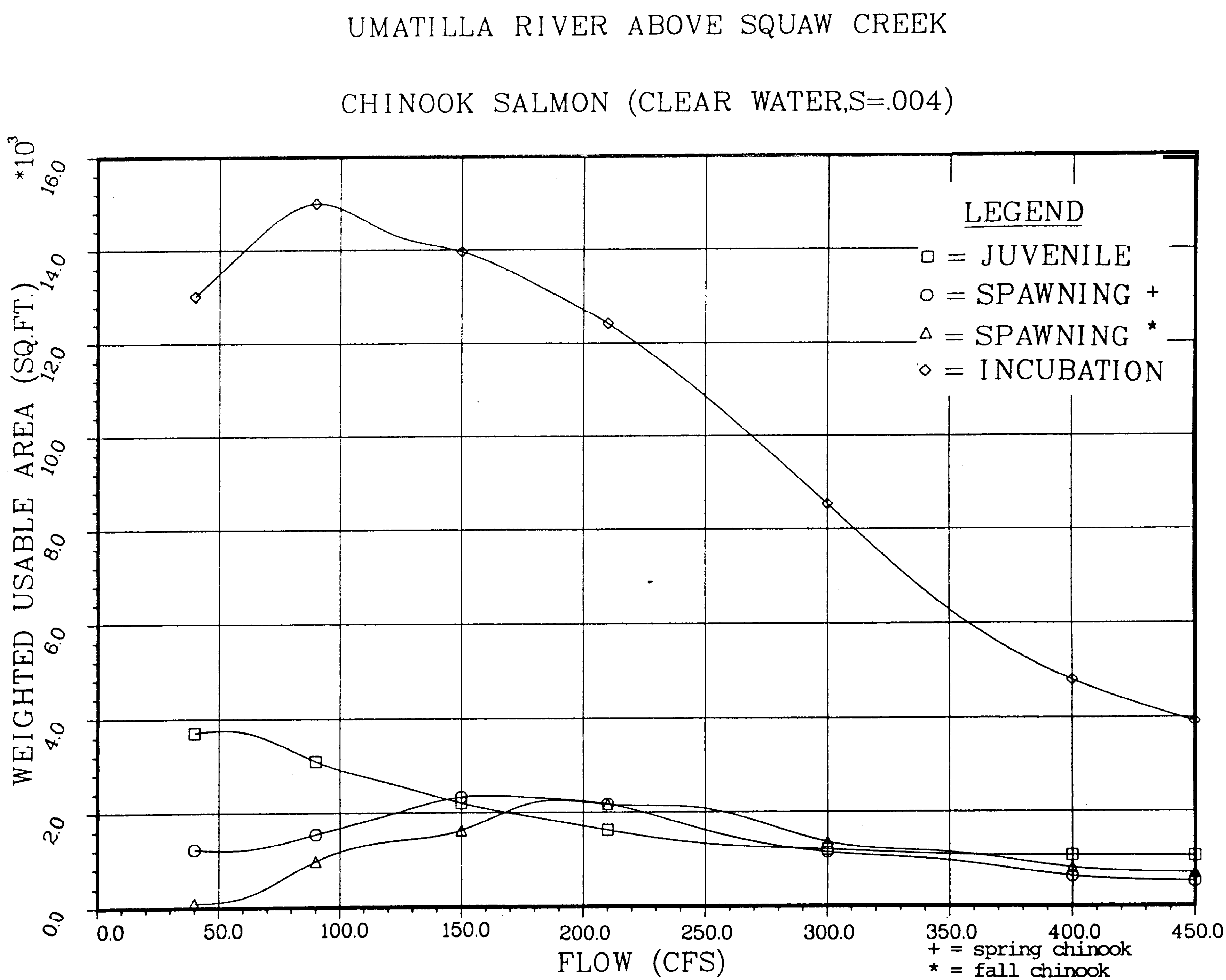
STEELHEAD

DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION -
40.	8292.	8224.	490.	1527,	15598.
60.	8403.	8577.	1397.	2245.	17496.
90.	7980.	8346.	2213.	2480.	19397.
120.	6660.	7693.	1463.	2593.	19880.
150.	5335.	6633.	948.	2733.	20022.
180.	4059.	5416.	714.	2900.	19948.
210.	3159.	4355.	551.	2806.	19732.
250.	2406.	3214.	419.	2397.	18542.
300.	1655.	2377.	359.	1901.	16115.
350.	1567.	2152.	252.	1380.	13431,
400.	1442.	2038.	210.	1255.	11260.
450.	1319.	1969.	196.	1253.	9575.

UMATILLA RIVER ABOVE SQUAW CREEK

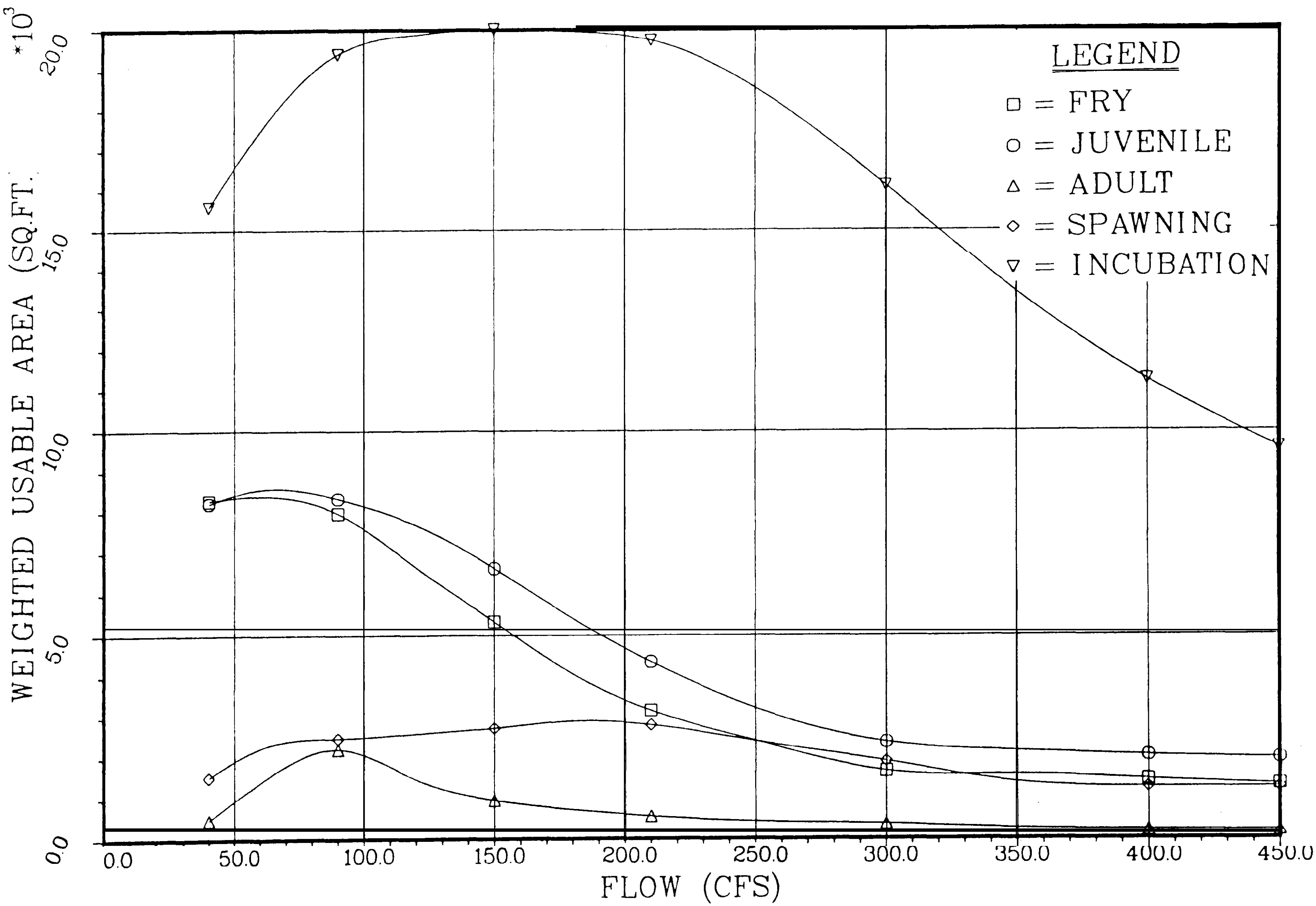
COHO SALMON (CLEAR WATER, S=.004)

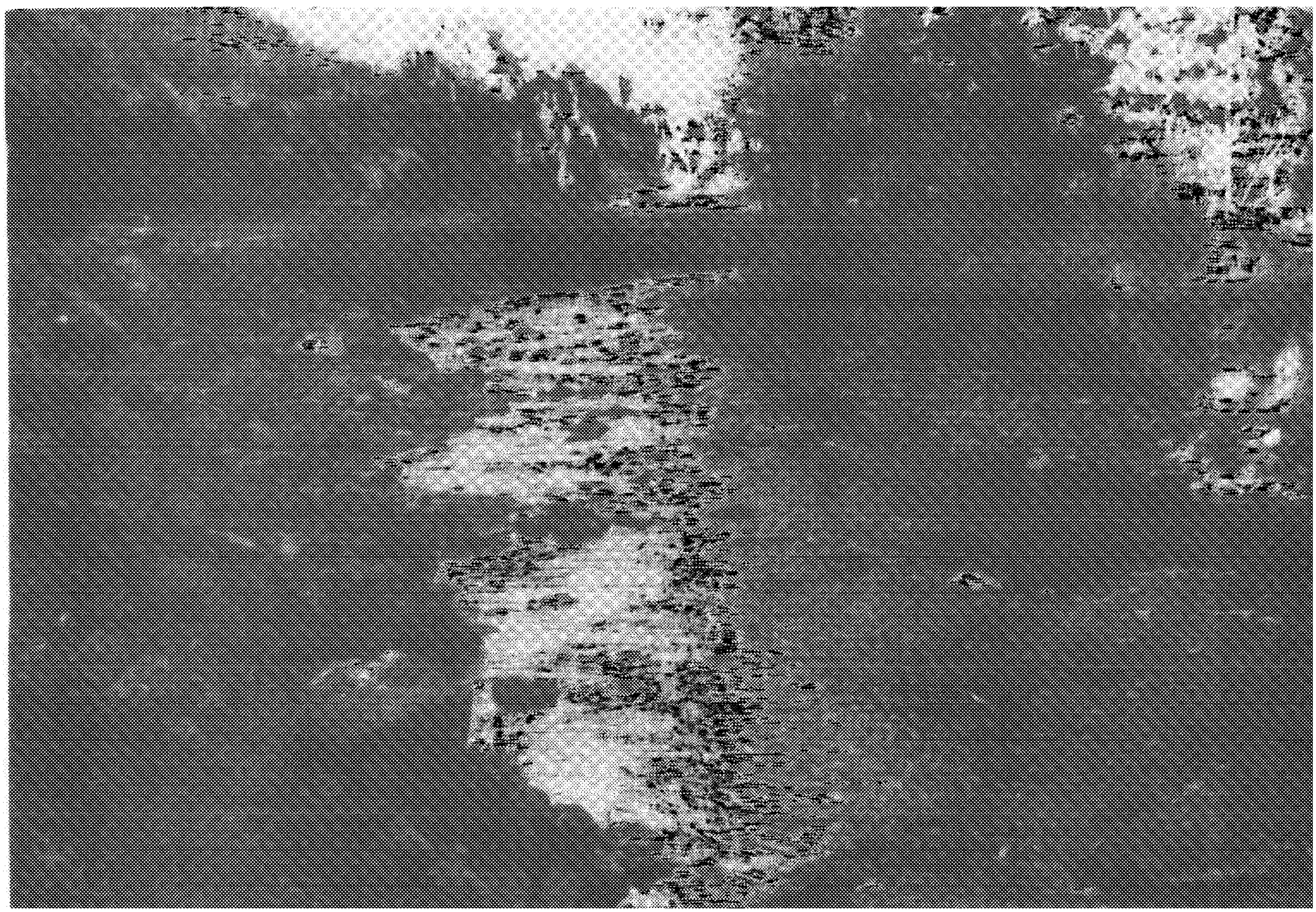



UMATILLA RIVER ABOVE SQUAW CREEK
CHINOOK SALMON (CLEAR WATER,S=.004)
WEIGHTED USABLE AREA (SQ.FT.)
*10^3
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
LEGEND
□ = JUVENILE
○ = SPAWNING +
△ = SPAWNING *
◇ = INCUBATION
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
FLOW (CFS)
+ = spring chinook
* = fall chinook

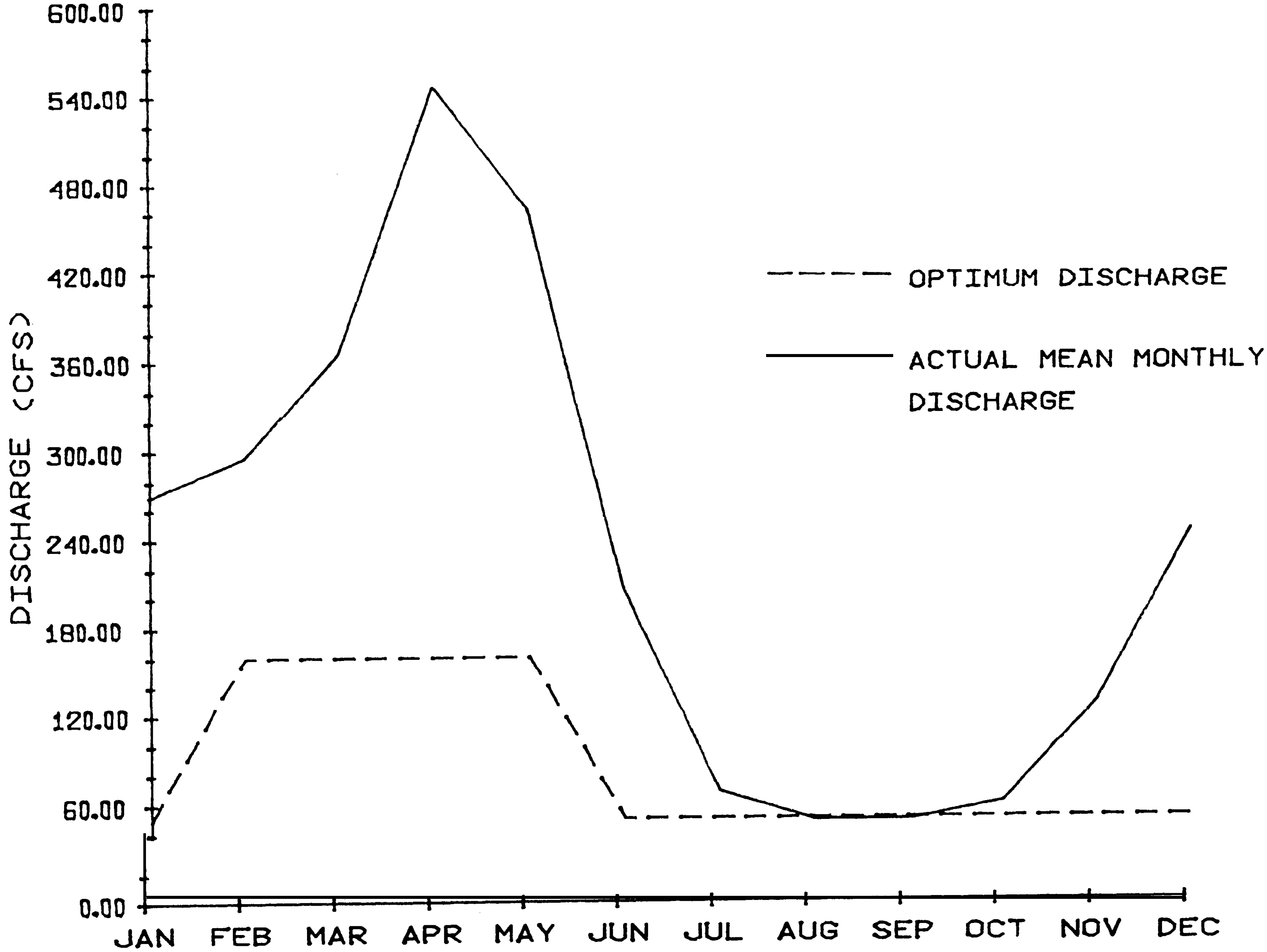
UMATILLA RIVER ABOVE SQUAW CREEK

STEELHEAD (CLEAR WATER, S = .004)



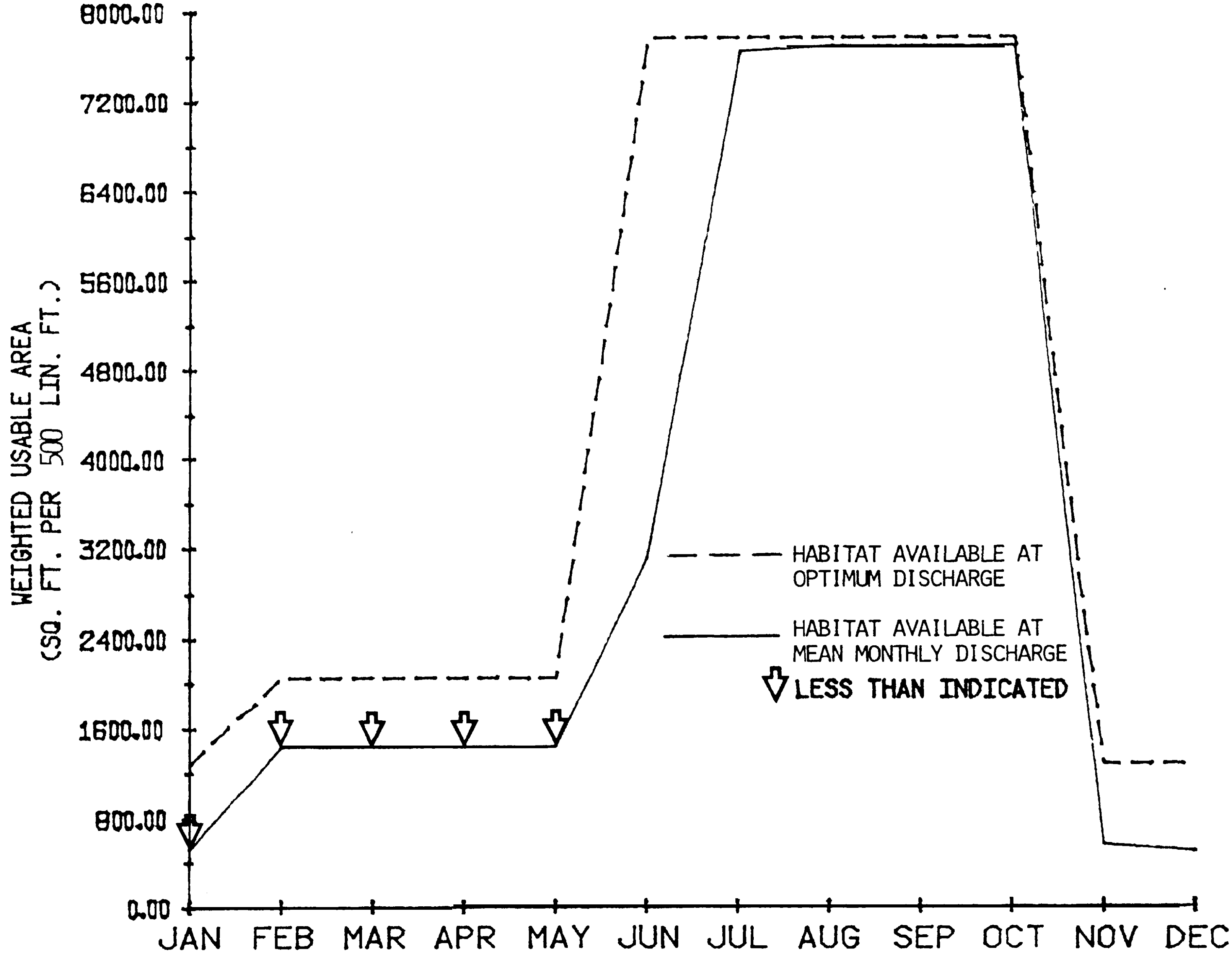


UMATILLA RIVER ABOVE MEACHAM CREEK (U 9)



ACTUAL AND OPTIMUM DISCHARGE FOR STEELHEAD

UMATILLA RIVER ABOVE MEACHAM CREEK



ANNUAL STEELHEAD HABITAT

UMATILLA RIVER ABOVE MEACHAM CREEK

UMATILLA RIVER ABOVE MEACHAM CREEK NEAR GIBBON, OREGON
Discharge in cubic feet per second.

Period of record
1933 - 1977

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	270	296	366	546	462	206	66.8	47.8	47.6	59.7	128	245
(Standard Deviation)	(167)	(147)	(155)	(185)	(214)	(122)	(19.5)	(6.31)	(8.5)	(26.1)	(82.8)	(176)
Highest Average Flow	656	647	688	869	1135	591	110	63.4	81.6	169	405	716
(Year)	(1965)	(1961)	(1939)	(1958)	(1948)	(1974)	(1948)	(1975)	(1959)	(1952)	(1948)	(1976)
Lowest Average Flow	45.7	71.8	189	162	152	63.7	39.5	36.9	34.9	39.1	40.2	44.4
(Year)	(1937)	(1977)	(1955) (1973)	(1941)	(1968)	(1934)	(1934)	(1939)	(1935)	(1936)	(1936)	(1966)

(*) many years of record

Normal Annual Mean = 226

UMATILLA RIVER ABOVE MEACHAM CREEK

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

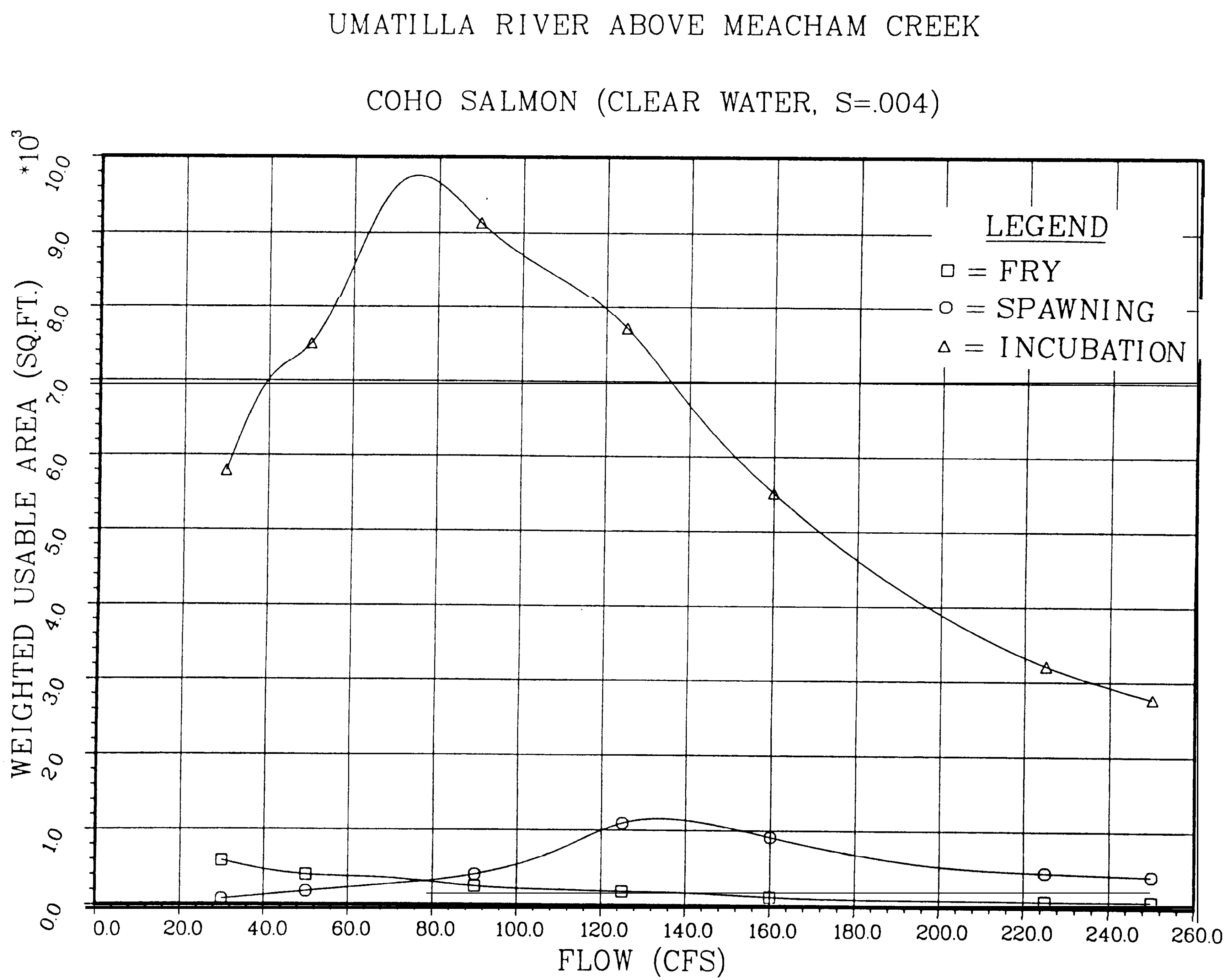
DISCHARGE	FRY	SPAWNING	INCUBATION
30.	577.	74.	5793.
40.	461.	123.	7019.
50.	395.	176.	7501.
70.	352.	272.	9621.
90.	248.	403.	9136.
110.	205.	738.	8373.
125.	185.	1097.	7713.
140.	171.	1139.	6681.
160.	118.	913.	5519.
200.	86.	529.	3900.
225.	81.	453.	3214.
250.	79	411.	2772.

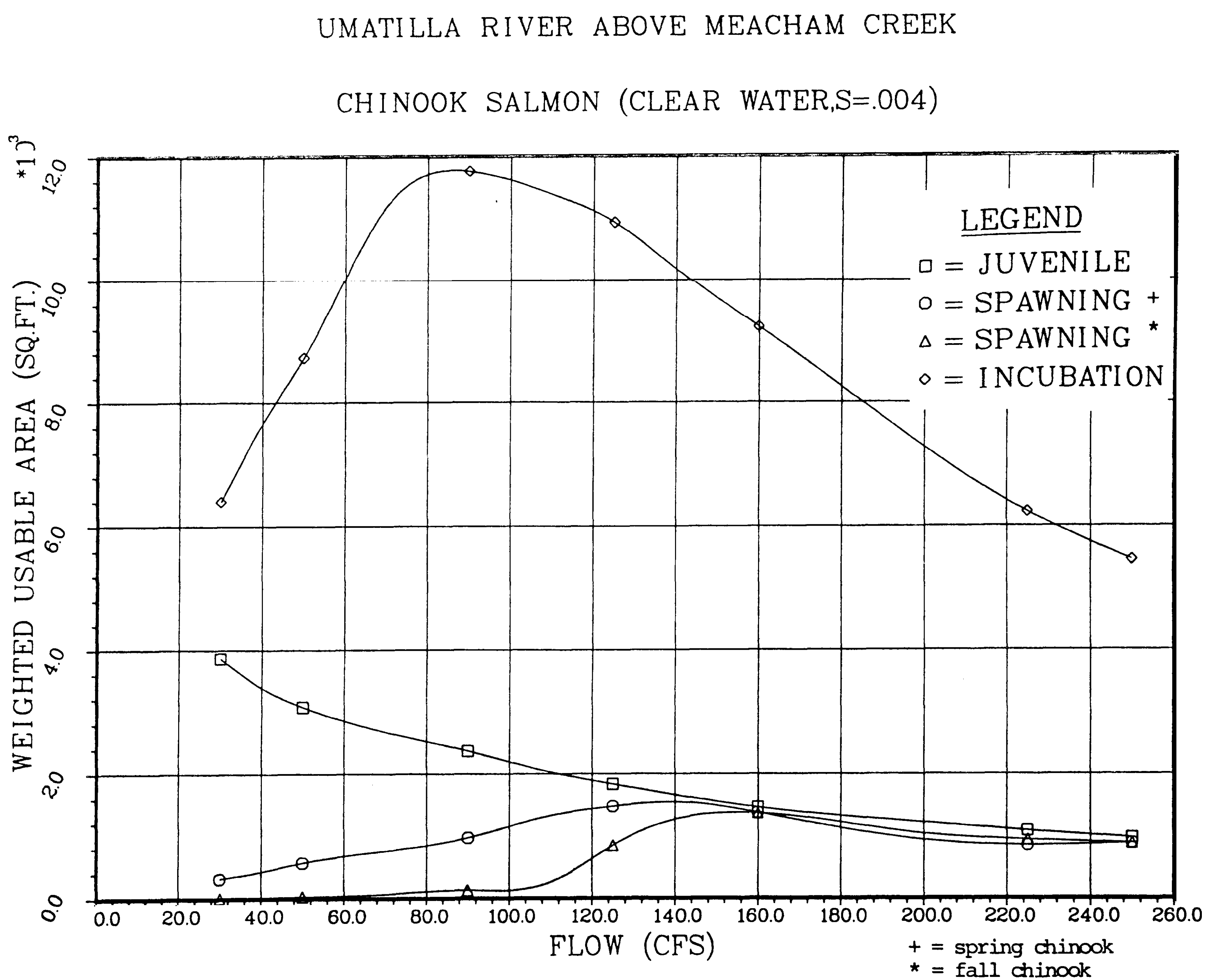
CHINOOK SALMON

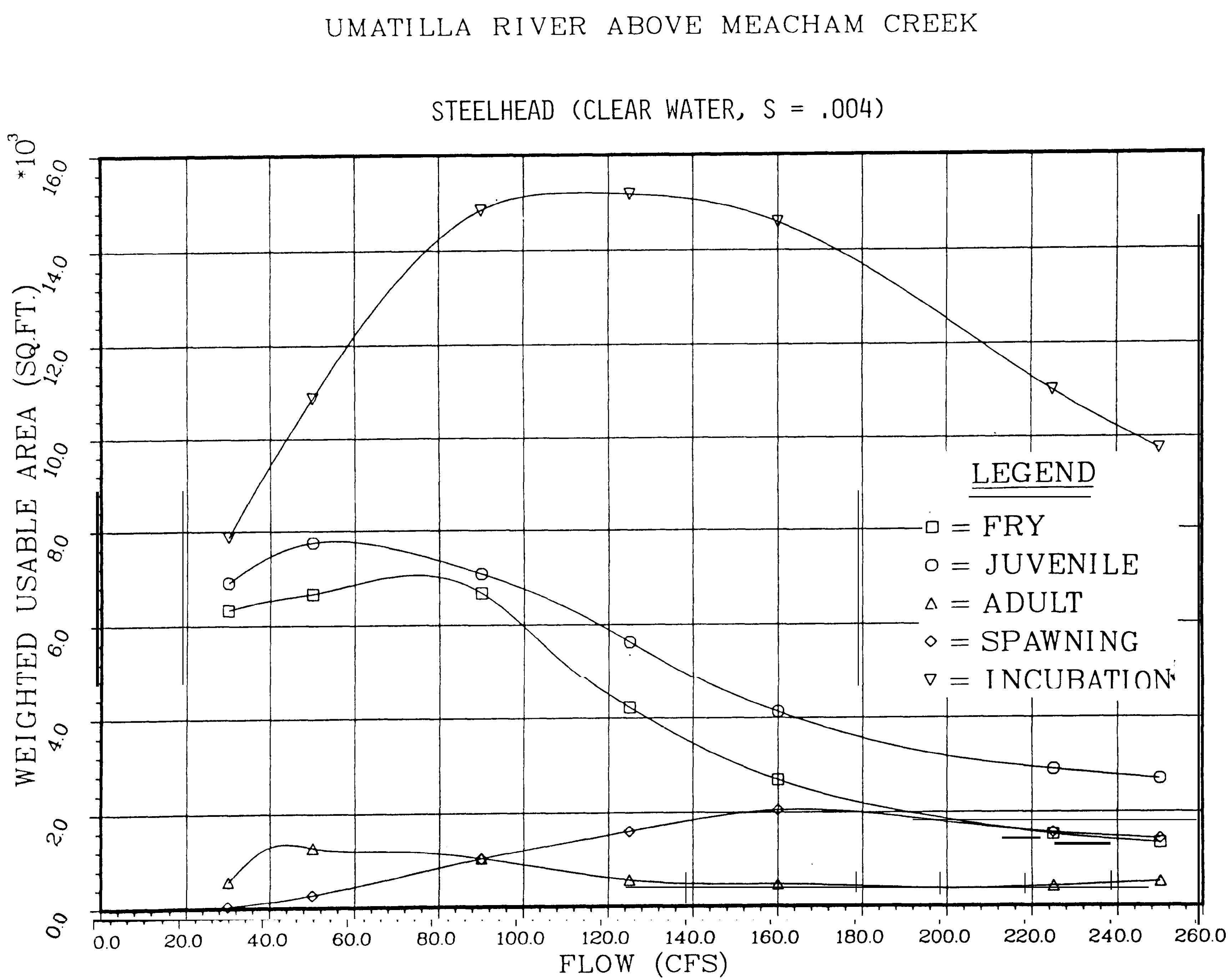
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
30.	3868.	316.	13.	6408.
40.	3387.	429.	19.	7660.
50.	3076.	569.	31.	8732.
70.	2677.	760.	69.	11187.
90.	2372.	970.	130.	11760.
110.	2029.	1325.	252.	11381.
125.	1839.	1477.	845.	10924.
140.	1667	1551.	1266.	10174.
160.	1466.	1380.	1370.	9227.
200.	1216.	933.	1034.	7280.
225.	1083.	849.	937.	6230.
250.	970.	885.	882.	5456.

STEELHEAD

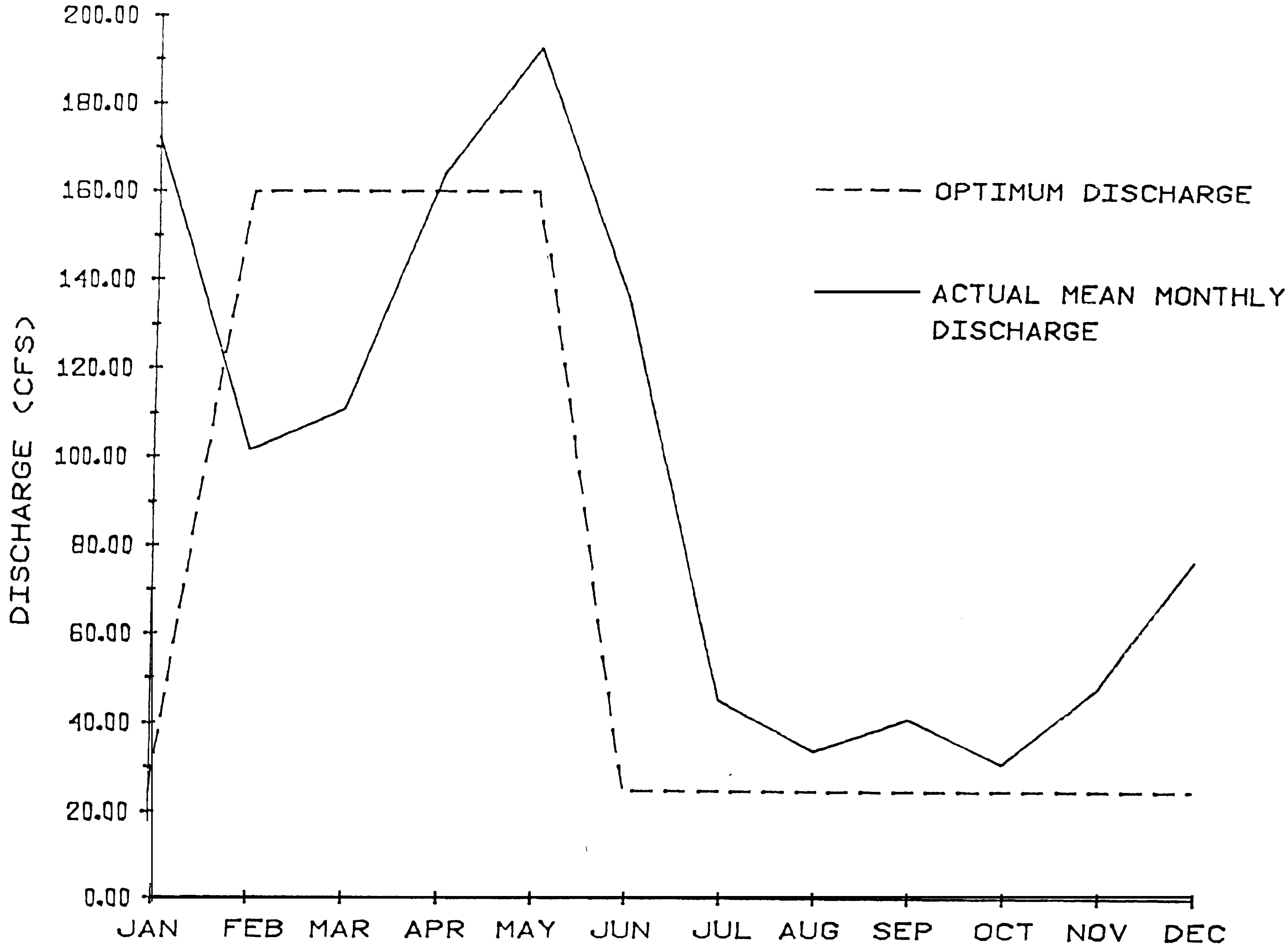
DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
30.	6337.	6911.	574.	40.	7874.
40.	6536.	7477.	1307.	128.	9429.
50.	6670.	7758.	1282.	270.	10883.
70.	7031.	7604.	1197.	641.	13346.
90.	6676.	7081.	1042.	1035.	14839.
110.	5158.	6374.	761.	1365.	15194.
125.	4227.	5639.	568.	1603.	15167.
140.	3468.	4892.	481.	1844.	15055.
160.	2696.	4134.	472.	2057.	14582.
200.	1862.	3186.	380.	1795.	12534.
225.	1530.	2910.	423.	1567.	11007.
250.	1347.	2706.	521.	1436.	9749.


UMATILLA RIVER ABOVE MEACHAM CREEK
COHO SALMON (CLEAR WATER, S=.004)
WEIGHTED USABLE AREA (SQ.FT.)
*10^3
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
220.0
240.0
260.0
FLOW (CFS)
LEGEND
□ = FRY
○ = SPAWNING
△ = INCUBATION


UMATILLA RIVER ABOVE MEACHAM CREEK
CHINOOK SALMON (CLEAR WATER,S=.004)
WEIGHTED USABLE AREA (SQ.FT.) *10^3
0.0
2.0
4.0
6.0
8.0
10.0
12.0
LEGEND
□ = JUVENILE
○ = SPAWNING +
△ = SPAWNING *
◇ = INCUBATION
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
220.0
240.0
260.0
FLOW (CFS)
+ = spring chinook
* = fall chinook

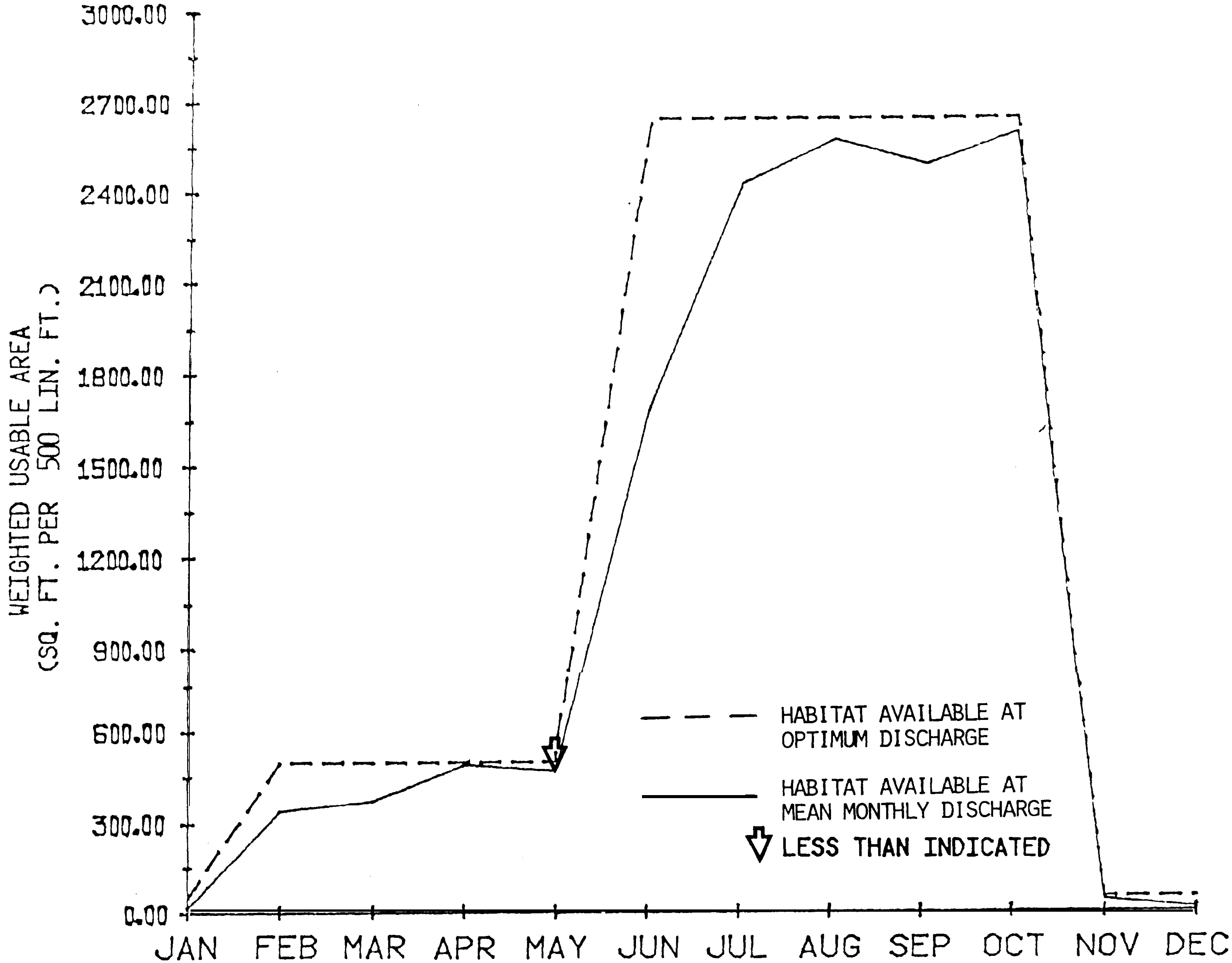

UMATILLA RIVER ABOVE MEACHAM CREEK
STEELHEAD (CLEAR WATER, S = .004)
WEIGHTED USABLE AREA (SQ.FT.)
*10^3
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
220.0
240.0
260.0
FLOW (CFS)
LEGEND
□ = FRY
○ = JUVENILE
△ = ADULT
◇ = SPAWNING
▽ = INCUBATION

NORTH FORK UMATILLA RIVER (T 1)



ACTUAL AND OPTIMUM DISCHARGE FOR STEELHEAD

NORTH FORK UMATILLA RIVER



ANNUAL STEELHEAD HABITAT

NORTH FORK UMATILLA RIVER

NORTH FORK UMATILLA RIVER
Discharge in cubic feet per second.

Period of record
1967 - 1976

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	172.21	101.74	110.94	164.24	192.84	134.52	45.25	33.67	41.33	31.16	48.03	77.09
(Standard Deviation)	(13.21)	(10.09)	(10.53)	(12.84)	(13.88)	(11.63)	(6.73)	(5.80)	(6.43)	(5.58)	(6.93)	(8.701
Highest Average Flow	295.94	169.67	209.06	257.04	281.40	376.26	73.30	42.54	39.91	70.64	42.19	160.76
(Year)	(1970)	(1975)	(1972)	(1969)	(1974)	(1974)	(1974)	(1975)	(1975)	(1970)	(1970)	(1976)
Lowest Average Flow	59.29	46.07	56.87	70.20	79.6	39.86	27.89	23.05	20.68	31.73	24.60	24.41
(Year)	(1968)	(1973)	(1973)	(1973)	(1968)	(1973)	(1973)	(1973)	(1973)	(1972)	(1973)	(1966)

(Source: U.S. Forest Service)

Normal Annual Mean = 96

NORTH FORK UMATILLA RIVER

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

DISCHARGE	FRY	SPAWNING	INCUBATION
25.	47.	69.	3854.
35.	30.	121.	3931.
45.	27.	101.	4489.
55.	25.	131.	4453.
65.	26.	160.	4115.
75.	16.	177.	4143.
85.	14.	178.	3852.
100.	11.	180.	3906.
120.	9.	258.	3537.
140.	8.	411.	2977.
160.	9.	529.	2520.
180.	12.	597.	2151.

CHINOOK SALMON

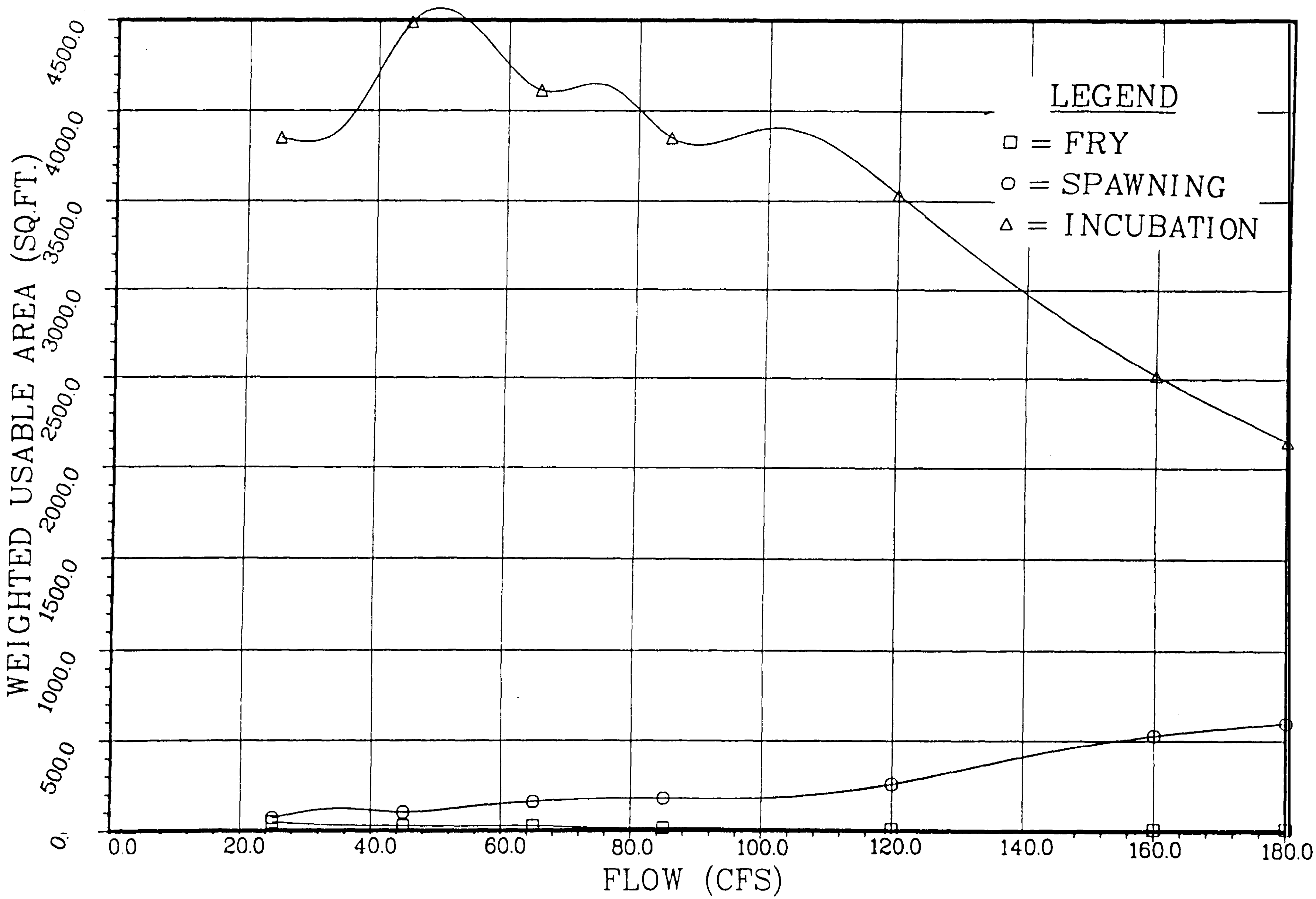
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
25.	612.	229.	104.	5076.
35.	581.	215.	97.	5419.
45.	518.	232.	133.	6036.
55.	467.	226.	100.	6220.
65.	440.	246.	141.	5884.
75.	397,	269.	113.	5959.
85.	358.	259.	72.	5687.
100.	322.	291.	80.	5604.
120.	270.	374.	177.	5252.
140.	226.	464.	299.	4747.
160.	200.	510.	546.	4210.
180.	189.	506.	568.	3659.

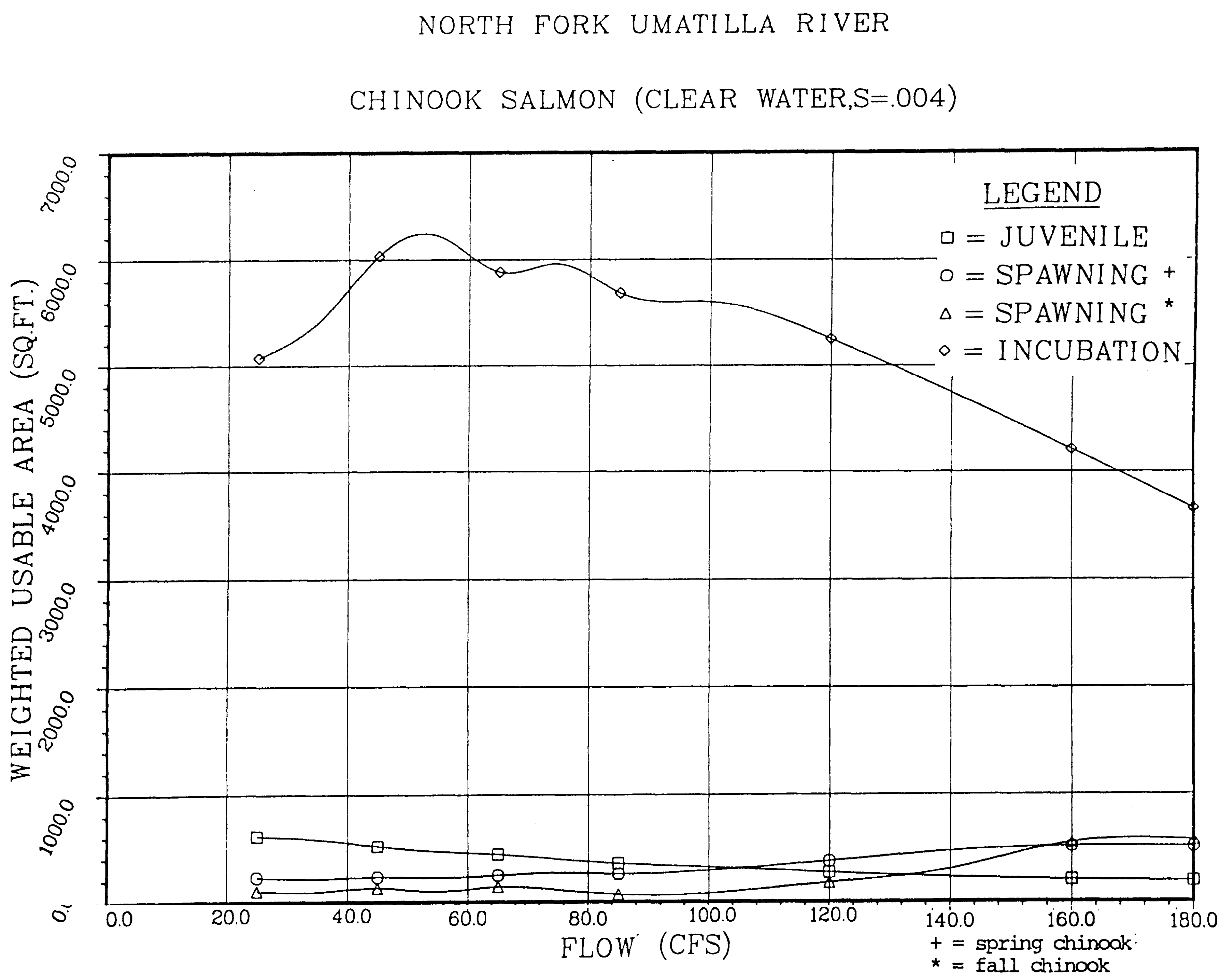
STEELHEAD

DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
25.	3810.	2637.	51.	250.	7066.
35.	3639.	2544.	27.	269.	7702.
45.	3262.	2425.	36.	260.	8572.
55.	3140.	2465.	27.	259.	8887.
65.	3123.	2388.	9.	256.	8886.
75.	2796.	2404.	6.	269.	9064.
85.	2459.	2329.	7.	278.	8809.
100.	2192.	2122.	13.	343.	8636.
120.	1940.	1747.	14.	405.	8057.
140.	1445.	1486.	15.	485.	7457.
160.	1101.	1252.	18.	500.	6892.
180.	864.	1020.	21.	464.	6229.

NORTH FORK UMATILLA RIVER

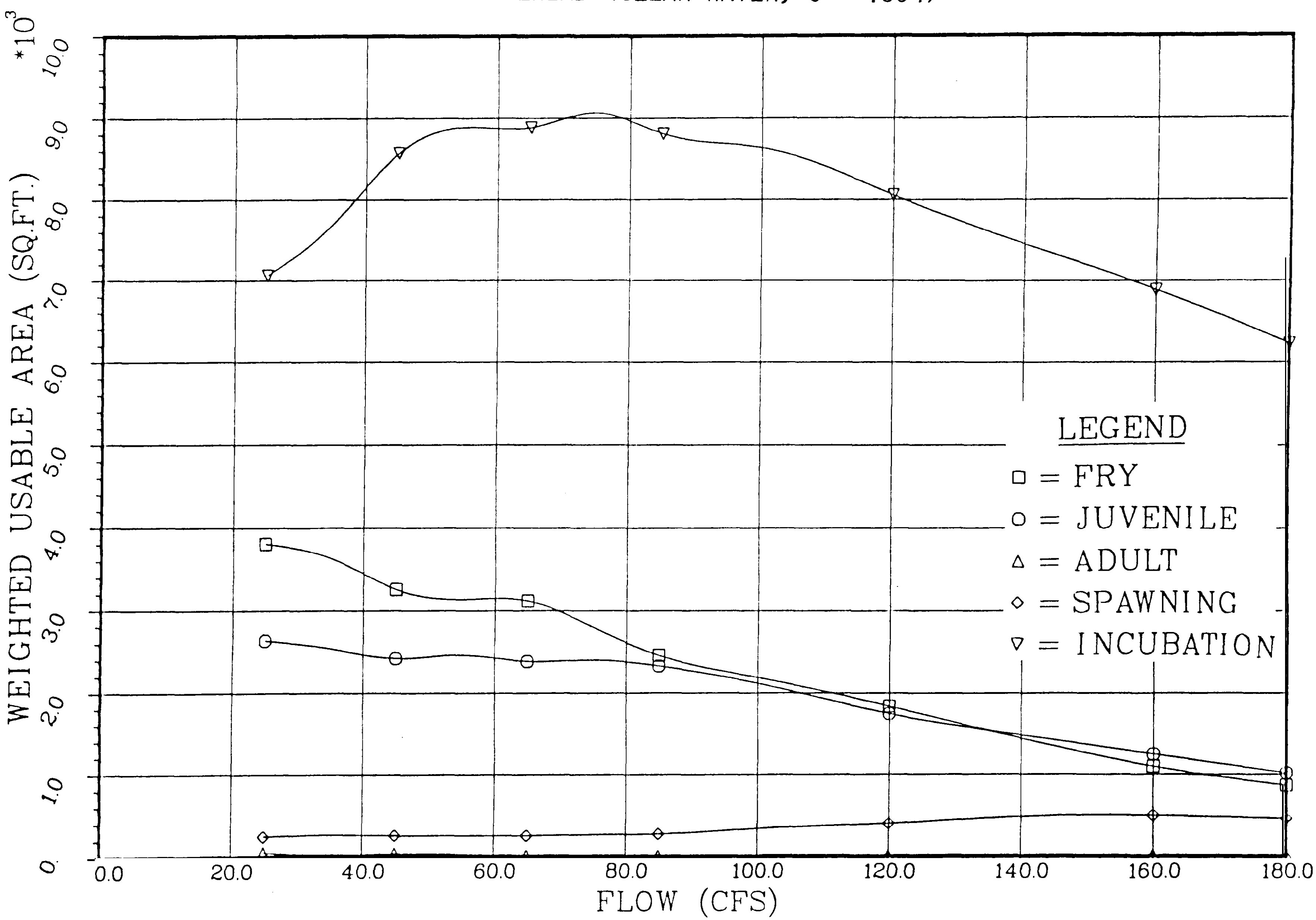
COHO SALMON (CLEAR WATER, S=.004)

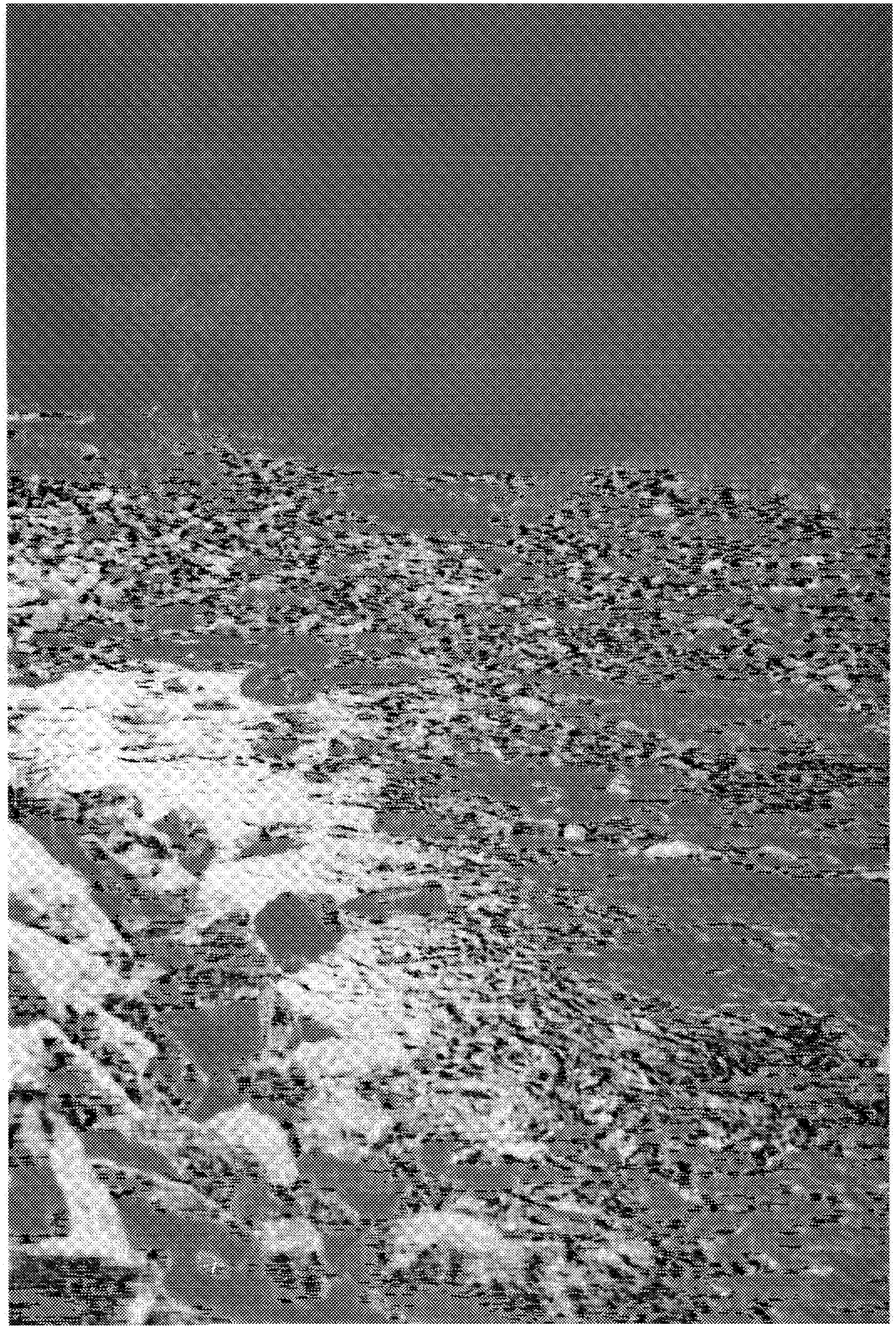



NORTH FORK UMATILLA RIVER
CHINOOK SALMON (CLEAR WATER,S=.004)
LEGEND
□ = JUVENILE
○ = SPAWNING +
△ = SPAWNING *
◇ = INCUBATION
WEIGHTED USABLE AREA (SQ.FT.)
0.0
1000.0
2000.0
3000.0
4000.0
5000.0
6000.0
7000.0
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
FLOW (CFS)
+ = spring chinook
* = fall chinook

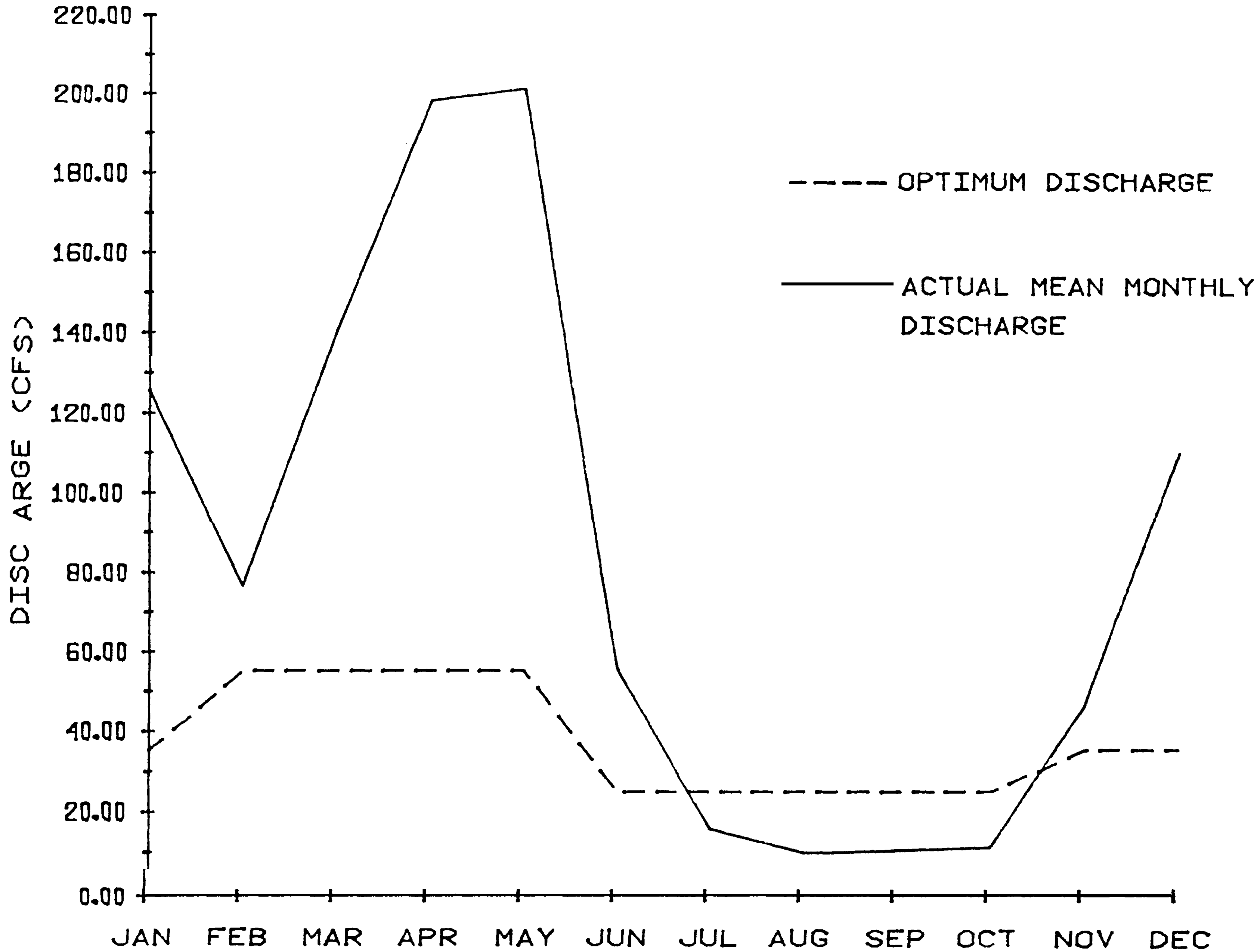
NORTH FORK UMATILLA RIVER

STEELHEAD (CLEAR WATER, S = .004)



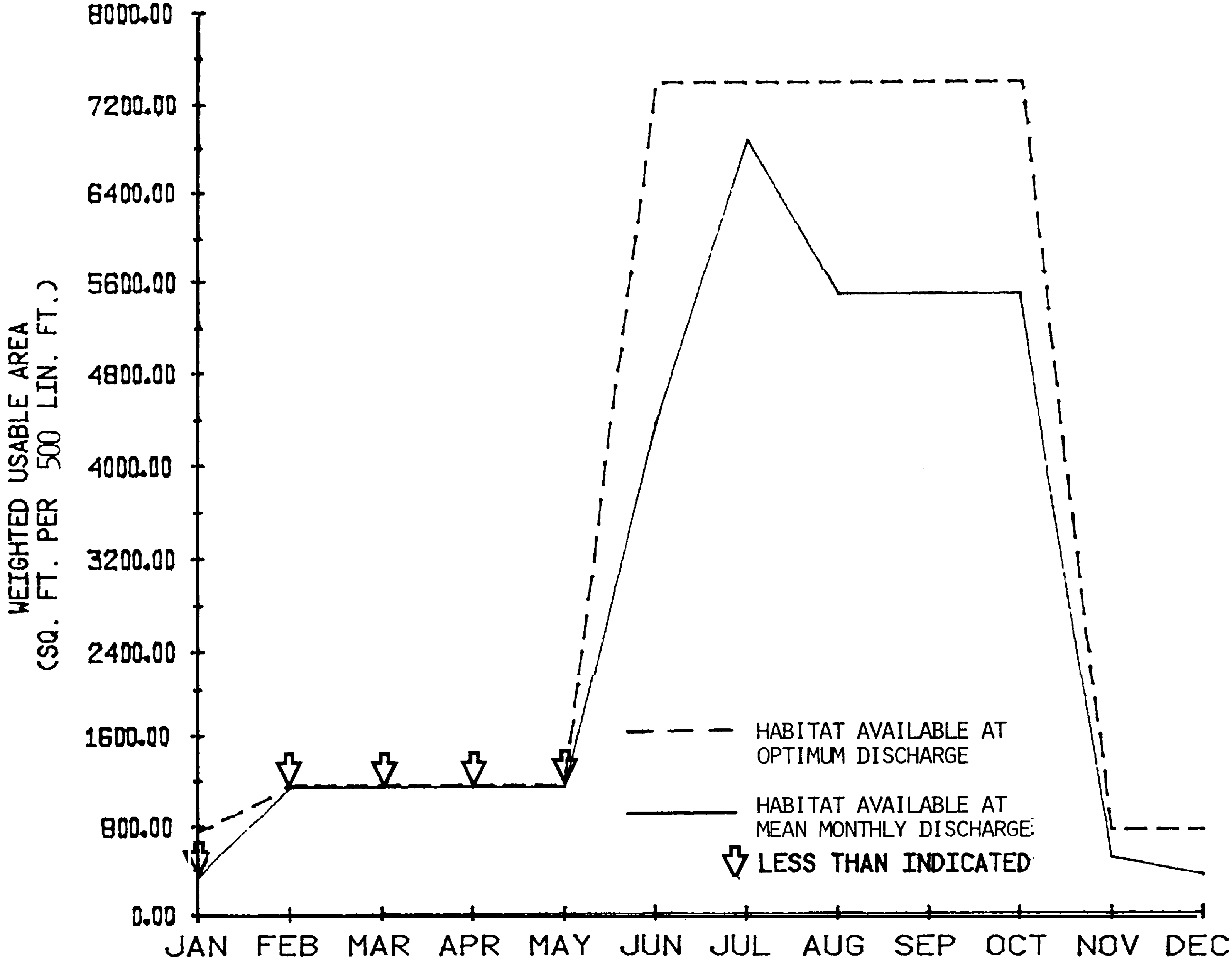


SOUTH FORK UMATILLA RIVER (T 2)



ACTUAL AND OPTIMUM DISCHARGE FOR STEELHEAD

SOUTH FORK UMATILLA RIVER



ANNUAL STEELHEAD HABITAT

SOUTH FORK UMATILLA RIVER

SOUTH FORK UMATILLA RIVER
Discharge on cubic feet per second.

Period of record
1968 - 1976

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	125.69	76.47	140.24	197.73	200.88	55.40	15.46	9.65	10.33	11.09	46.33	110.23
(Standard Deviation)	(11.2)	(8.74)	(11.84)	(14.06)	(14.17)	(7.44)	(3.93)	(3.11)	(3.21)	(3.33)	(6.81)	(10.51)
Highest Average Flow	217.08	125.84	292.02	466.41	408.48	184.56	32.65	19.38	16.87	42.42	136.55	351.01
(Year)	(1975)	(1971)	(1975)	(1976)	(1975)	(1974)	(1974)	(1975)	(1975)	(1968)	(1968)	(1975)
Lowest Average Flow	61.80	31.24	64.31	80.79	48.80	11.71	6.04	3.64	5.28	5.23	6.06	24.59
(Year)	(1972)	(1973)	(1973)	(1968)	(1973)	(1973)	(1973)	(1969)	(1970)	(1969)	(1969)	(1969)

(Source: U.S. Forest Service)

Normal Annual Mean = 83

SOUTH FORK UMATILLA RIVER

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

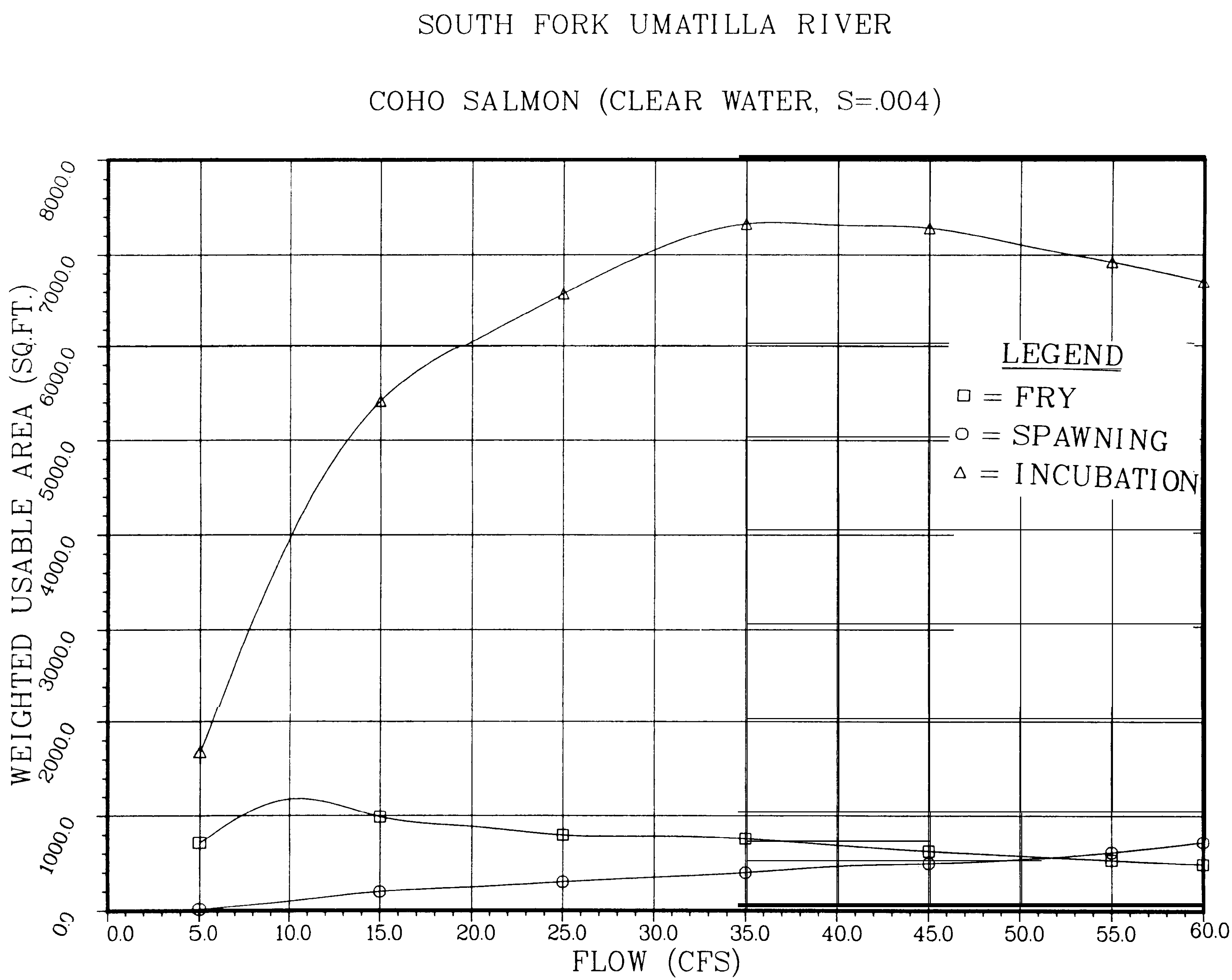
DISCHARGE	FRY	SPAWNING	INCUBATION
5.	718.	16.	1684.
10.	1177.	95.	3969.
15.	991.	197.	5417.
20.	889.	246.	6072
25.	798.	300.	6585.
30.	787.	349.	7053.
35.	759.	398.	7326.
40.	689.	466.	7313.
45.	626.	497.	7285.
50.	577.	539.	7107.
55.	532.	614.	6924.
60.	490.	723.	6712.

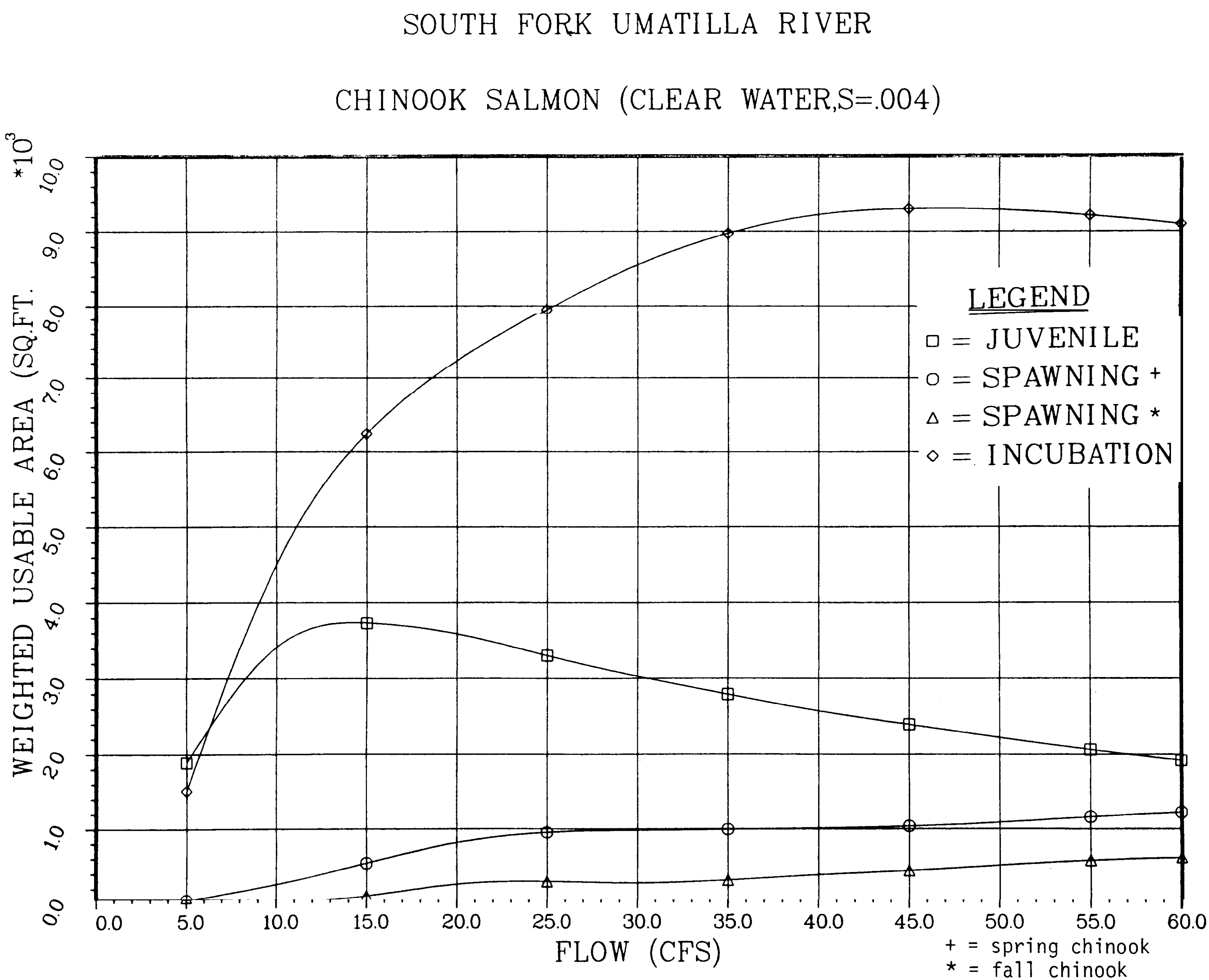
CHINOOK SALMON

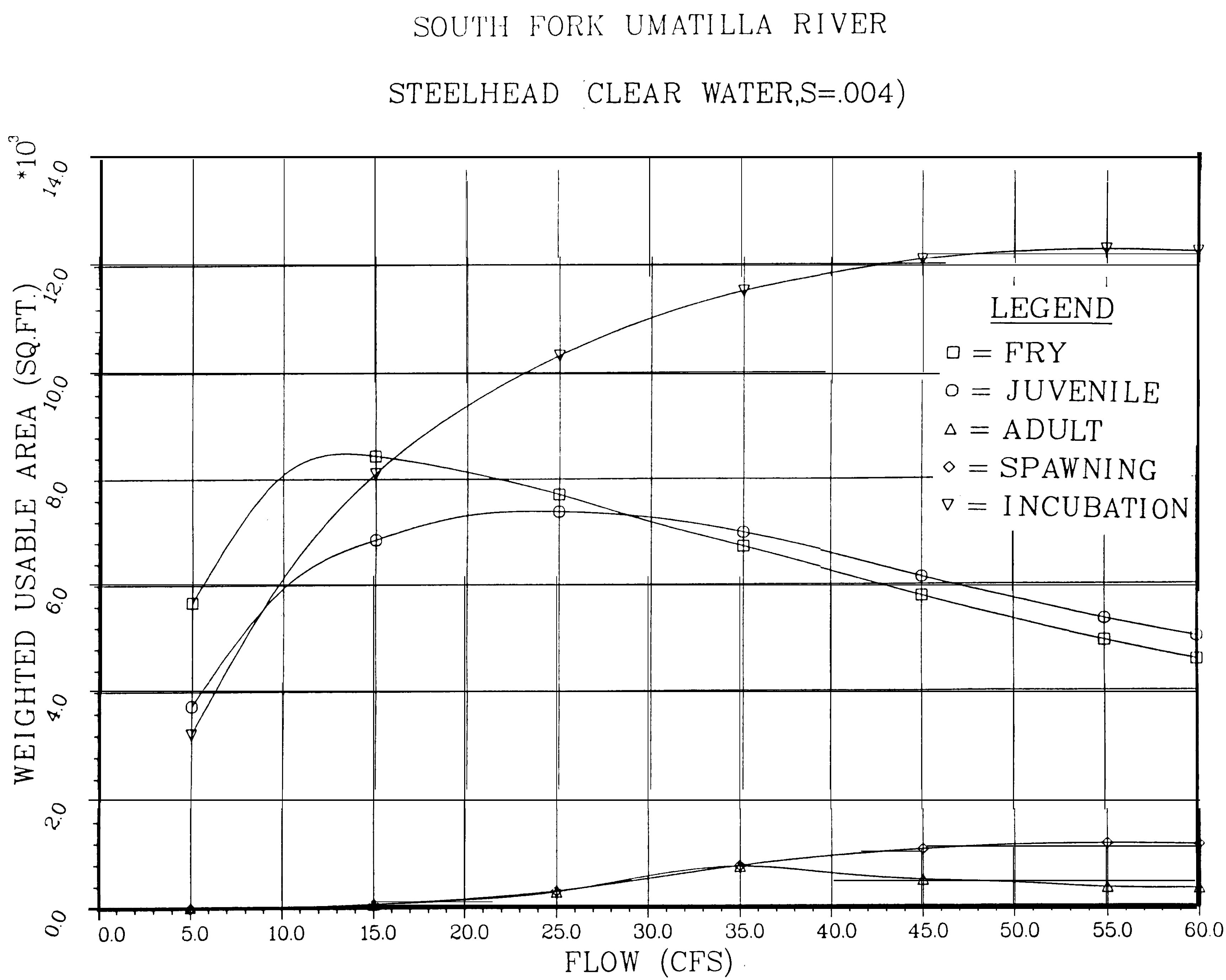
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
5.	1891.	44.	0.	1511.
10.	3415.	256.	15.	4502.
15.	3732.	538.	104.	6242.
20.	3588.	812.	257.	7231.
25.	3304.	953.	295.	7947.
30.	3031.	984.	274.	8551.
35.	2794.	995.	314.	8976.
40.	2575.	1013.	382.	9225.
45.	2396.	1040.	439.	9305.
50.	2224.	1091.	508.	9292.
55.	2065.	1163.	574.	9216.
60.	1920.	1225.	613.	9099.

STEELHEAD

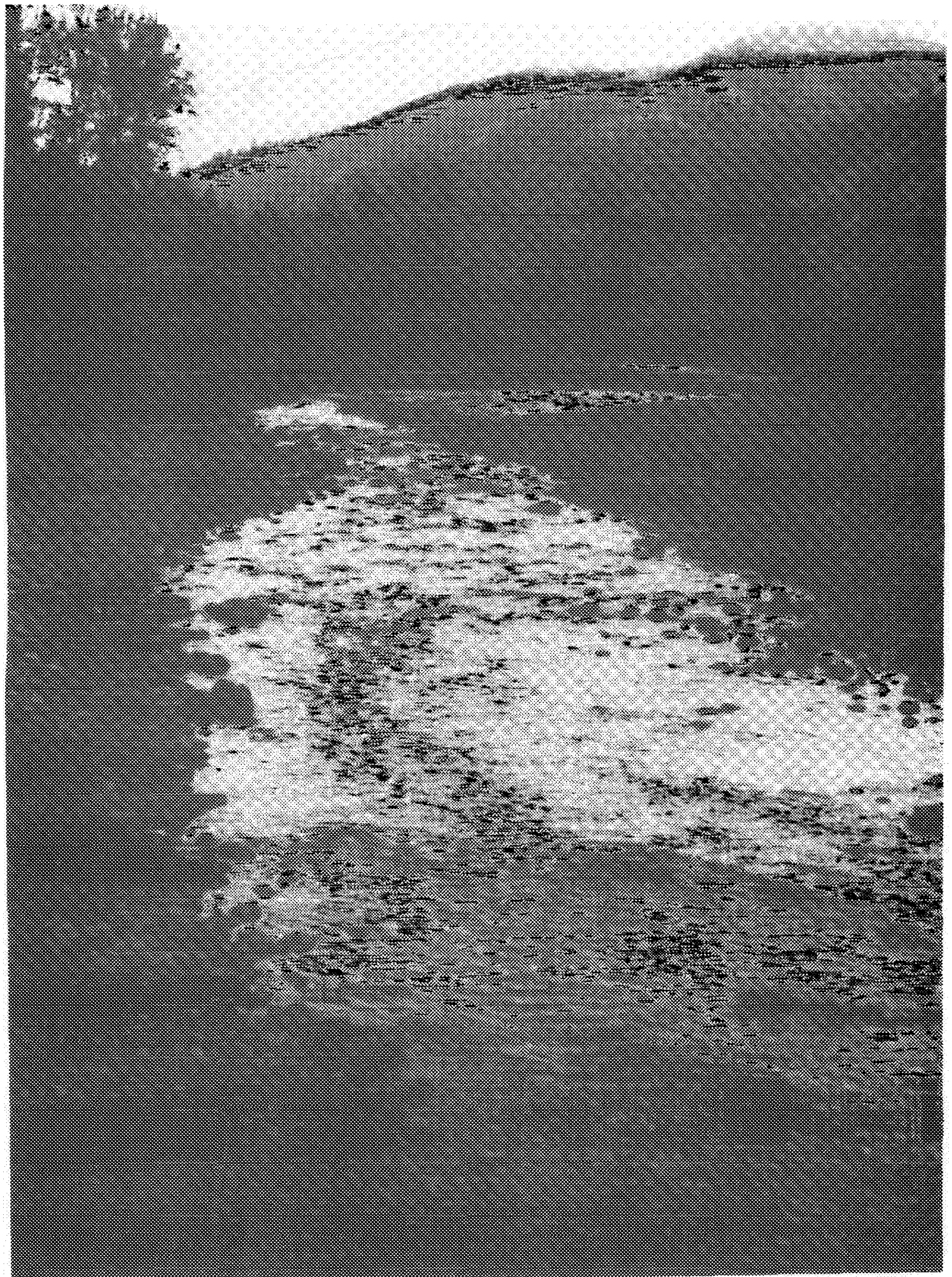
DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
5.	5677.	3738.	17.	0.	3216.
10.	8088.	5496.	24.	10.	6144.
15.	8440.	6858.	59.	71.	8107.
20.	8136.	7314.	135.	156.	9387.
25.	7711.	7382.	284.	302.	10324.
30.	7182.	7269.	573.	523.	11015.
35.	6724.	6988.	749.	763.	11843.
40.	6259.	6595.	621.	941.	11843.
45.	5788.	6147.	497.	1062.	12089.
50.	5342.	5736.	438.	1137.	12220.
55.	4938.	4347.	350.	1160.	12259.
60.	4581.	5012.	336.	1142.	12210.


SOUTH FORK UMATILLA RIVER
COHO SALMON (CLEAR WATER, S=.004)
WEIGHTED USABLE AREA (SQ.FT.)
FLOW (CFS)
LEGEND
□ = FRY
○ = SPAWNING
△ = INCUBATION
0.0
1000.0
2000.0
3000.0
4000.0
5000.0
6000.0
7000.0
8000.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0

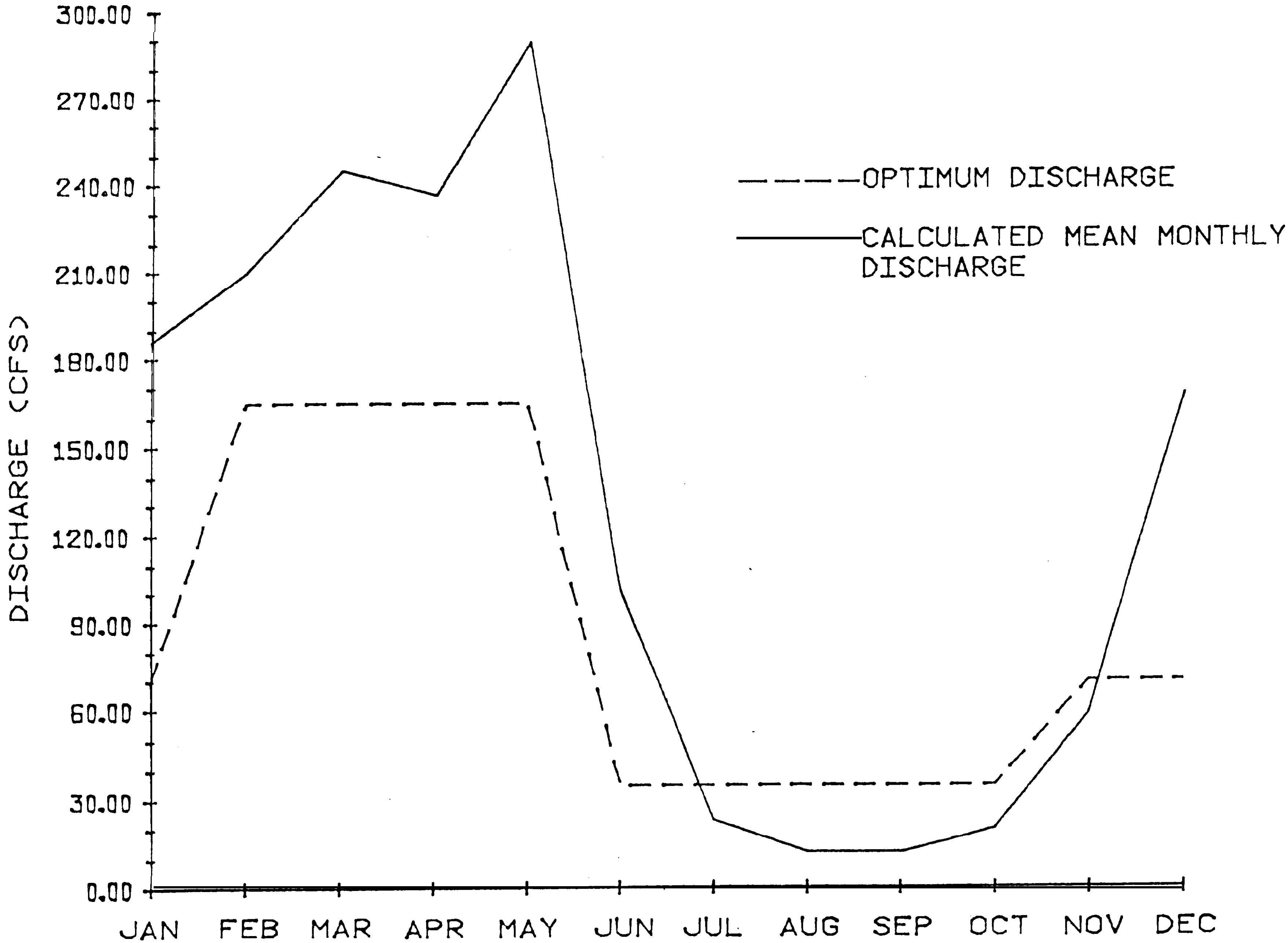

SOUTH FORK UMATILLA RIVER
CHINOOK SALMON (CLEAR WATER,S=.004)
WEIGHTED USABLE AREA (SQ.FT. *10^3
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
FLOW (CFS)
LEGEND
□ = JUVENILE
○ = SPAWNING +
△ = SPAWNING *
◇ = INCUBATION
+ = spring chinook
* = fall chinook



SOUTH FORK UMATILLA RIVER
STEELHEAD (CLEAR WATER,S=.004)
WEIGHTED USABLE AREA (SQ.FT.)
*10^3
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
FLOW (CFS)
LEGEND
□ = FRY
○ = JUVENILE
△ = ADULT
◇ = SPAWNING
▽ = INCUBATION

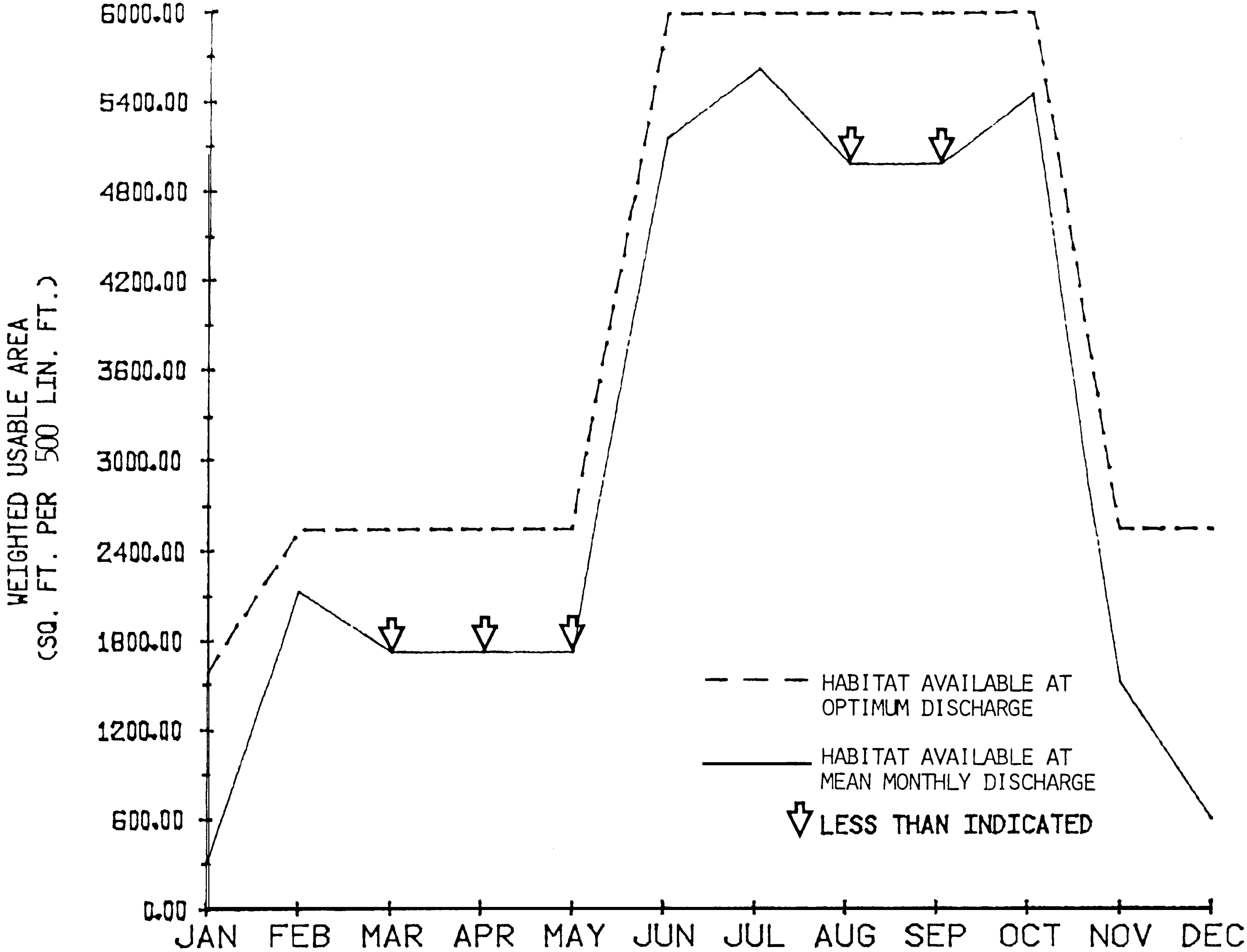


MEACHAM CREEK ABOVE BONIFER, OREGON (T 3)



ACTUAL AND OPTIMUM DISCHARGE FOR STEELHEAD

MEACHAM CREEK ABOVE BONIFER



ANNUAL STEELHEAD HABITAT

MEACHAM CREEK ABOVE BONIFER

MEACHAM CREEK BELOW CONFLUENCE WITH NORTH FORK*
Discharge in cubic feet per second.

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	186	210	245	236	289	101	23	12	12	20	59	168
(Standard Deviation)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Highest Average Flow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lowest Average Flow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Normal Annual Mean = 133

(flows are representative flows for section and reach (T 3) above Bonifer, Oregon.
Calculated values (Source: Copp, 1977)

MEACHAM CREEK ABOVE BONIFER, OREGON

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

DISCHARGE	FRY	SPAWNING	INCUBATION
15.	1149.	242.	4143.
20.	1199.	332.	4269.
25.	1039.	378.	4591.
35.	816.	383.	5203.
50.	660.	733.	6326.
70.	414.	1247.	7241.
90.	310.	1987.	6690.
110.	237.	2802.	6047.
135.	170.	2854.	5076.
165.	129.	2435.	3606.
190.	123.	1193.	2512.
225.	142.	302.	1733.

CHINOOK SALMON

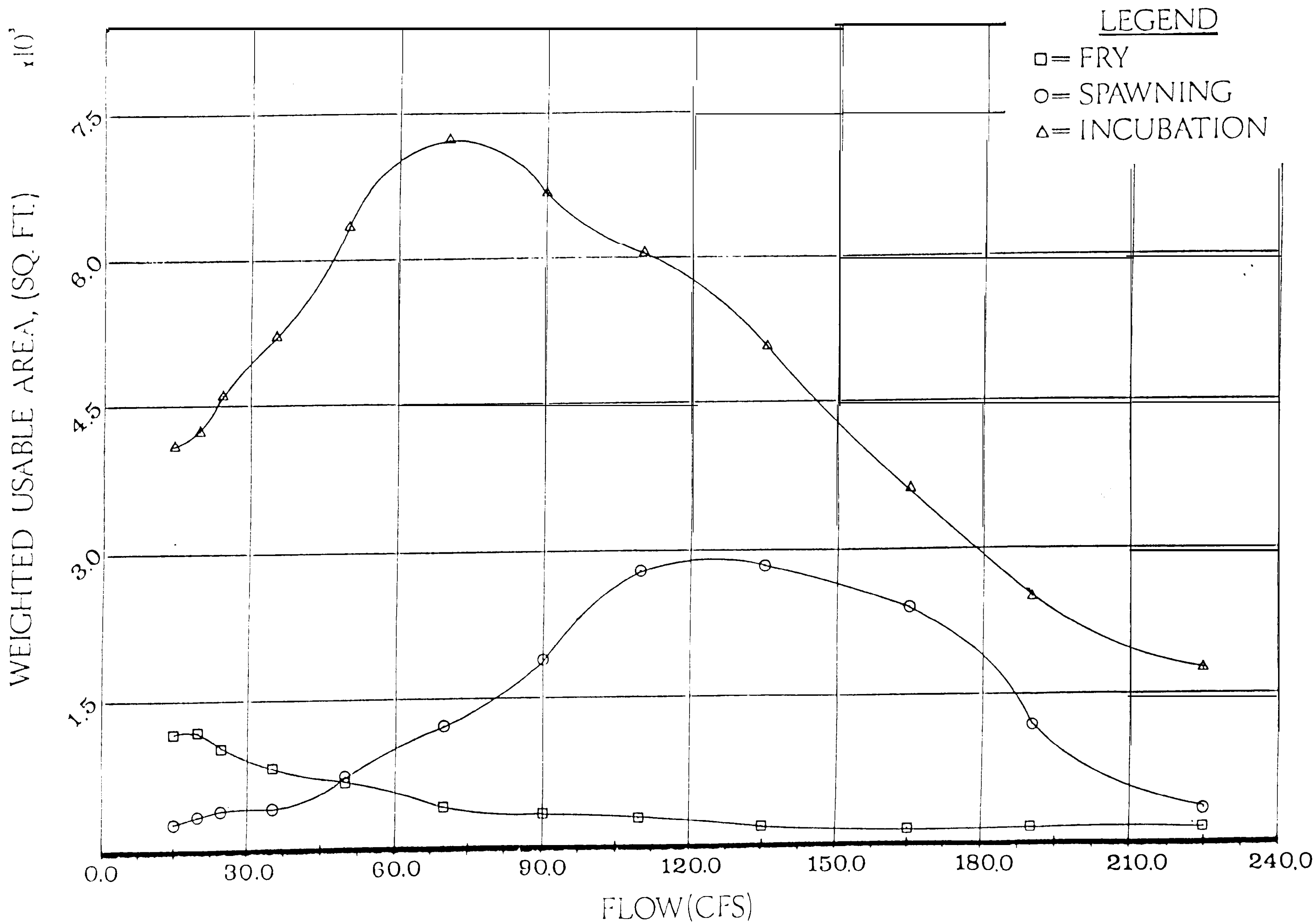
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
15.	3603.	710.	48.	5294.
20.	3871.	791.	107.	5759.
25.	3936.	790.	174.	6367.
35.	3894.	786.	271.	7010.
50.	3400.	827.	388.	8570.
70.	2654.	1145.	576.	9610.
90.	2076.	1766.	936.	9363.
110.	1670.	2201.	1771.	8854.
135.	1267.	2464.	2343.	8093.
165.	963.	1748.	1687.	8820.
190.	897.	931.	1091.	5585.
225.	1035.	503.	655.	4287.

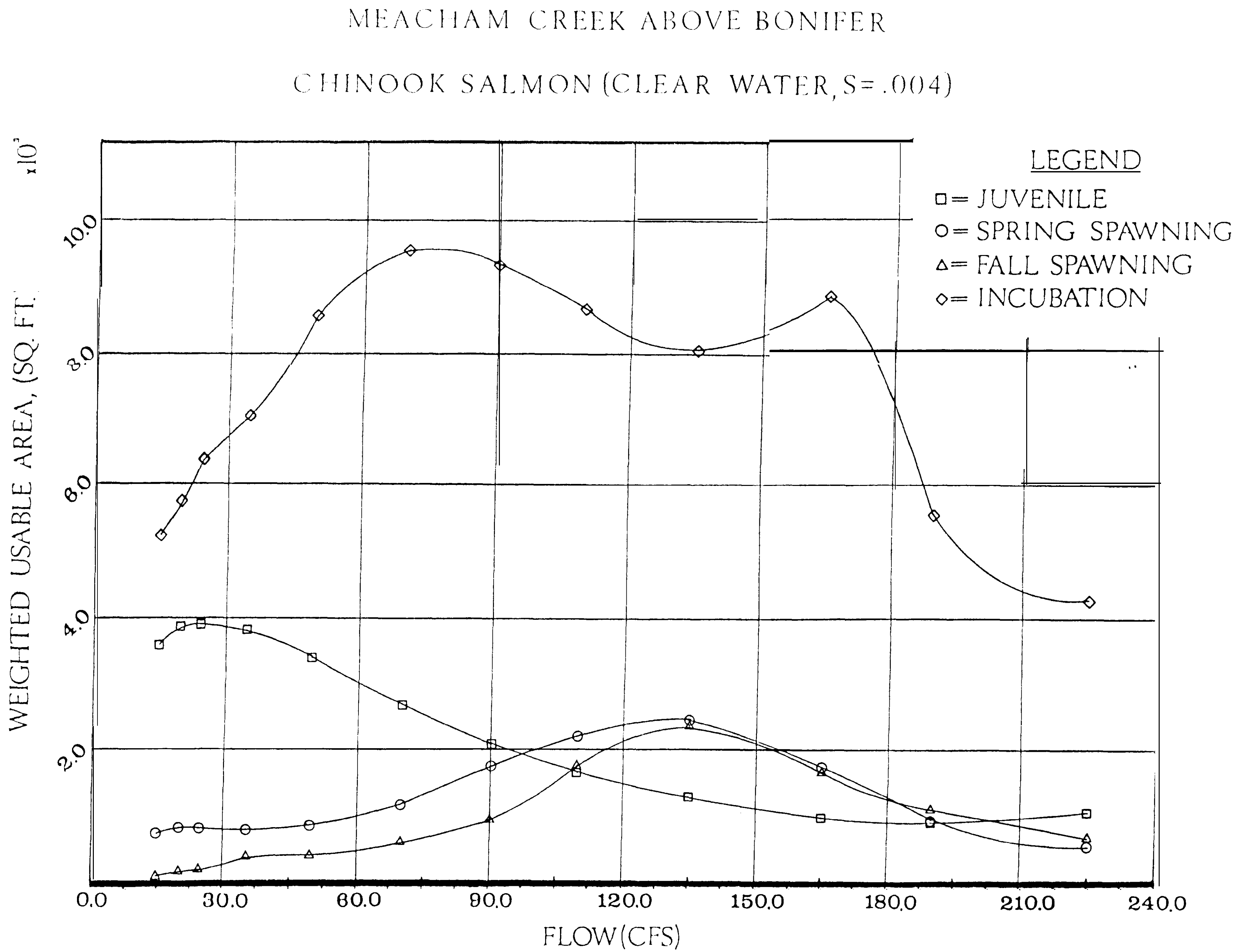
STEELHEAD

DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
15.	4485.	4971.	78.	197.	6796.
20.	4392.	5431.	183.	387.	7748.
25.	4296.	5778.	349.	633.	8819.
35.	4553.	5968.	839.	1015.	10165.
50.	4672.	5864.	1436.	1378.	11961.
70.	4317.	5686.	1582.	1562.	13421.
90.	3669.	5359.	1389.	1669.	13897.
110.	3068.	4933.	853.	1787.	13925.
135.	2233.	4164.	544.	2189.	13693.
165	1513.	3277.	592.	2537.	12797.
190.	1040.	2539.	290.	2519.	11899.
225	675.	1824.	156.	1720.	10448.

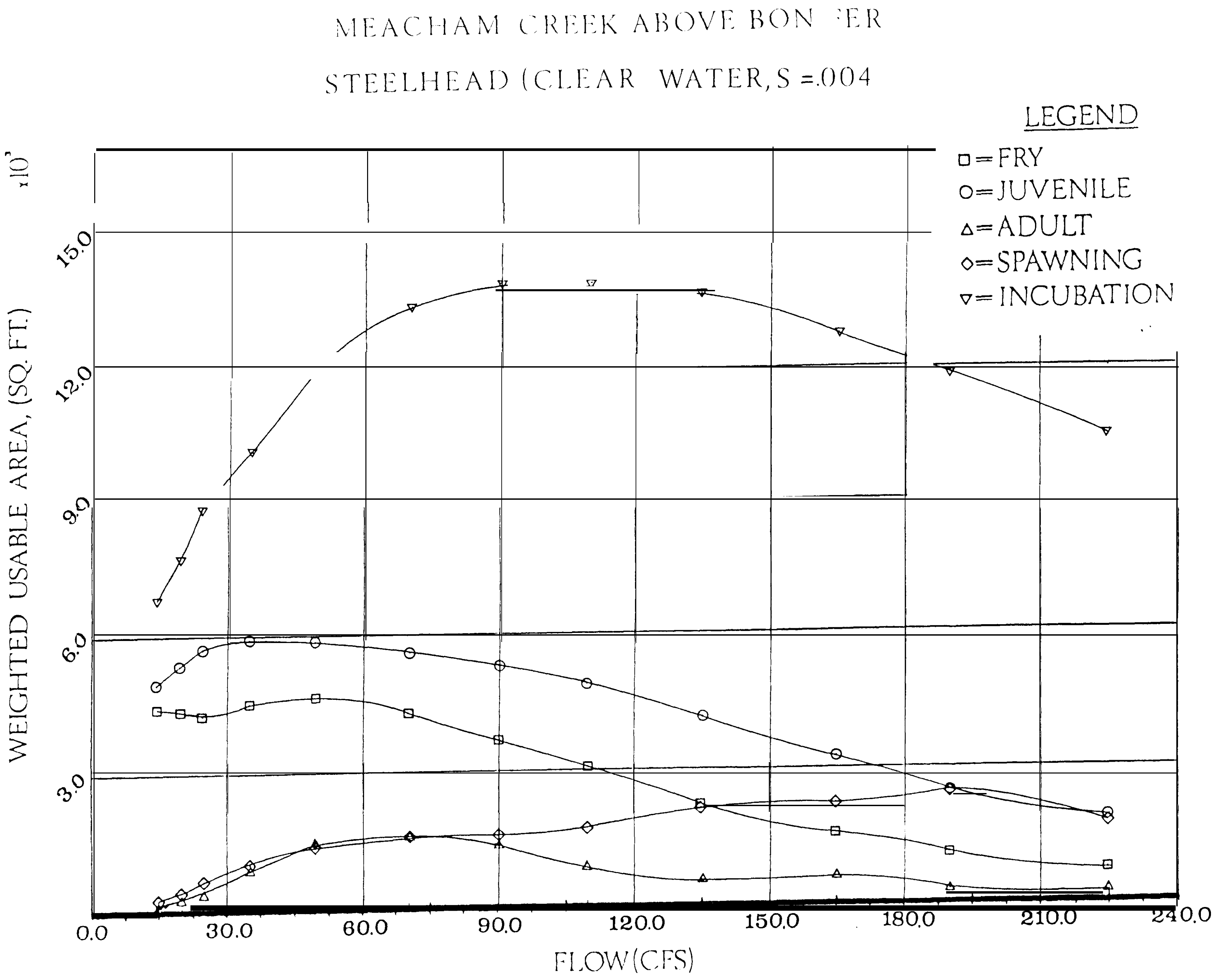
MEACHAM CREEK ABOVE BONIFER

COHO SALMON (CLEAR WATER, S=.004

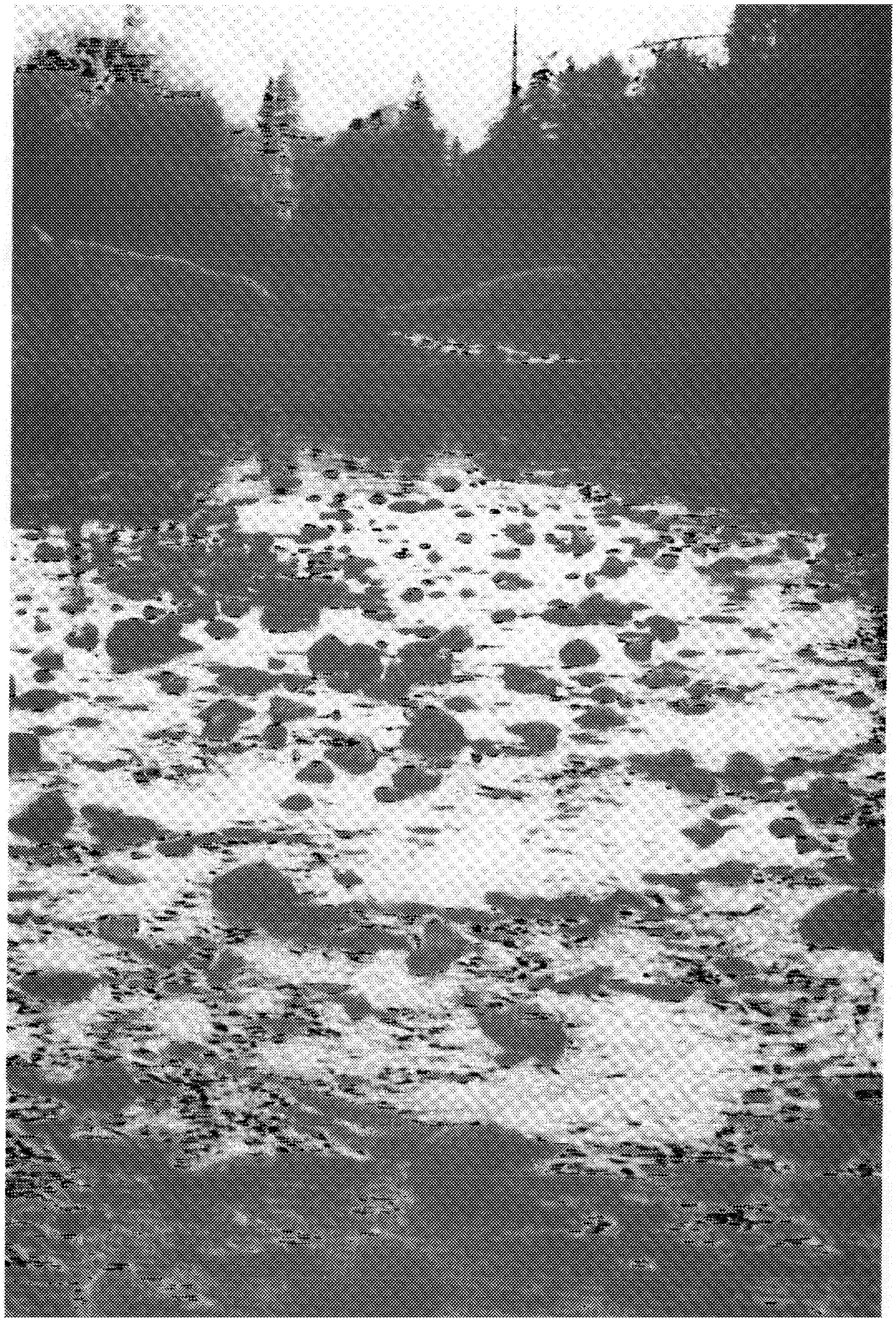




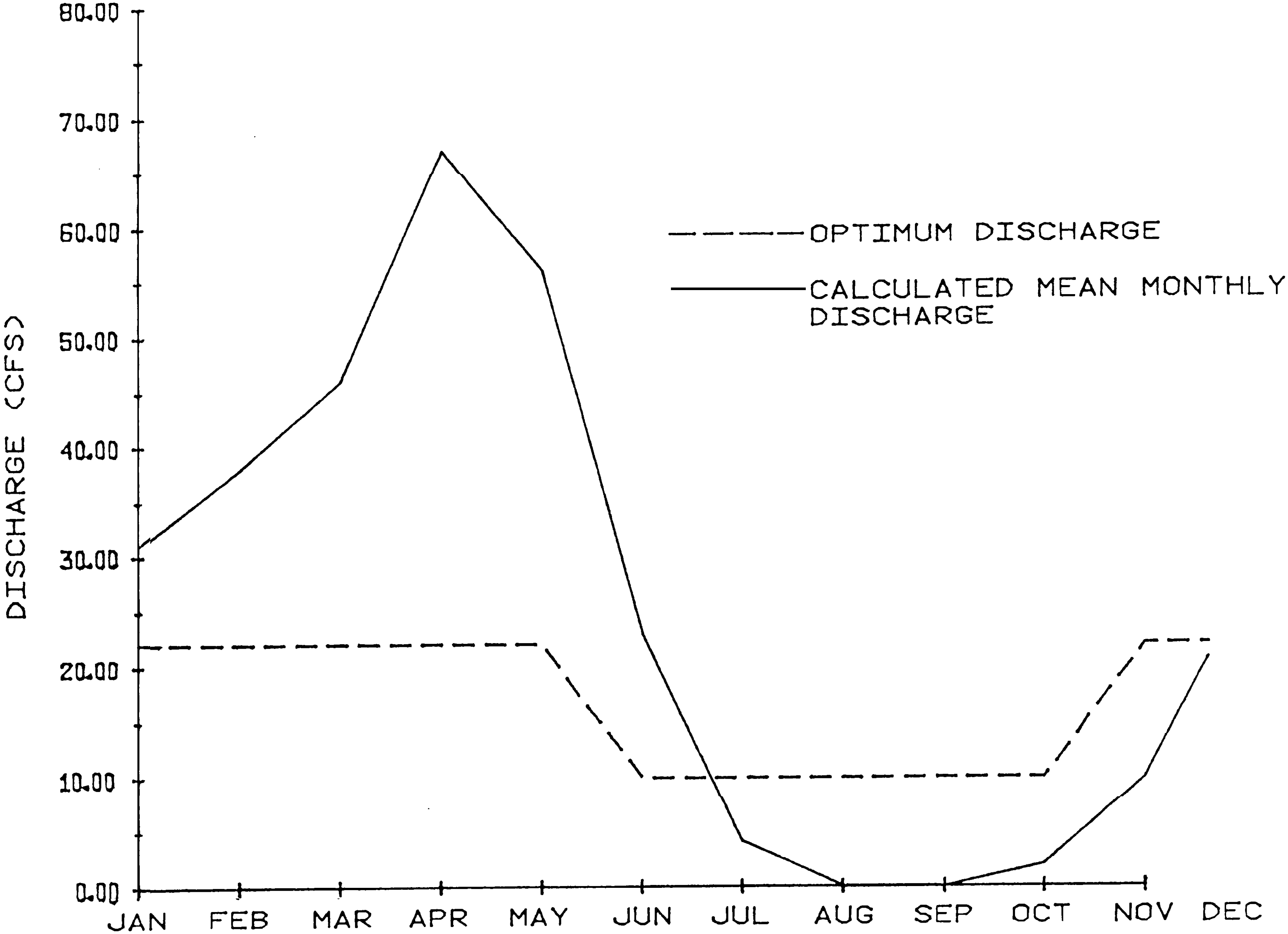
MEACHAM CREEK ABOVE BONIFER
CHINOOK SALMON (CLEAR WATER, S= .004)
LEGEND
□= JUVENILE
○= SPRING SPAWNING
△= FALL SPAWNING
◇= INCUBATION
WEIGHTED USABLE AREA, (SQ. FT.) x10³
2.0
4.0
6.0
8.0
10.0
0.0
30.0
60.0
90.0
120.0
150.0
180.0
210.0
240.0
FLOW (CFS)



MEACHAM CREEK ABOVE BON ER
STEELHEAD (CLEAR WATER, S =.004
LEGEND
□=FRY
○=JUVENILE
△=ADULT
◇=SPAWNING
▽=INCUBATION
x10³
WEIGHTED USABLE AREA, (SQ. FT.)
15.0
12.0
9.0
6.0
3.0
0.0
30.0
60.0
90.0
120.0
150.0
180.0
210.0
240.0
FLOW (CFS)

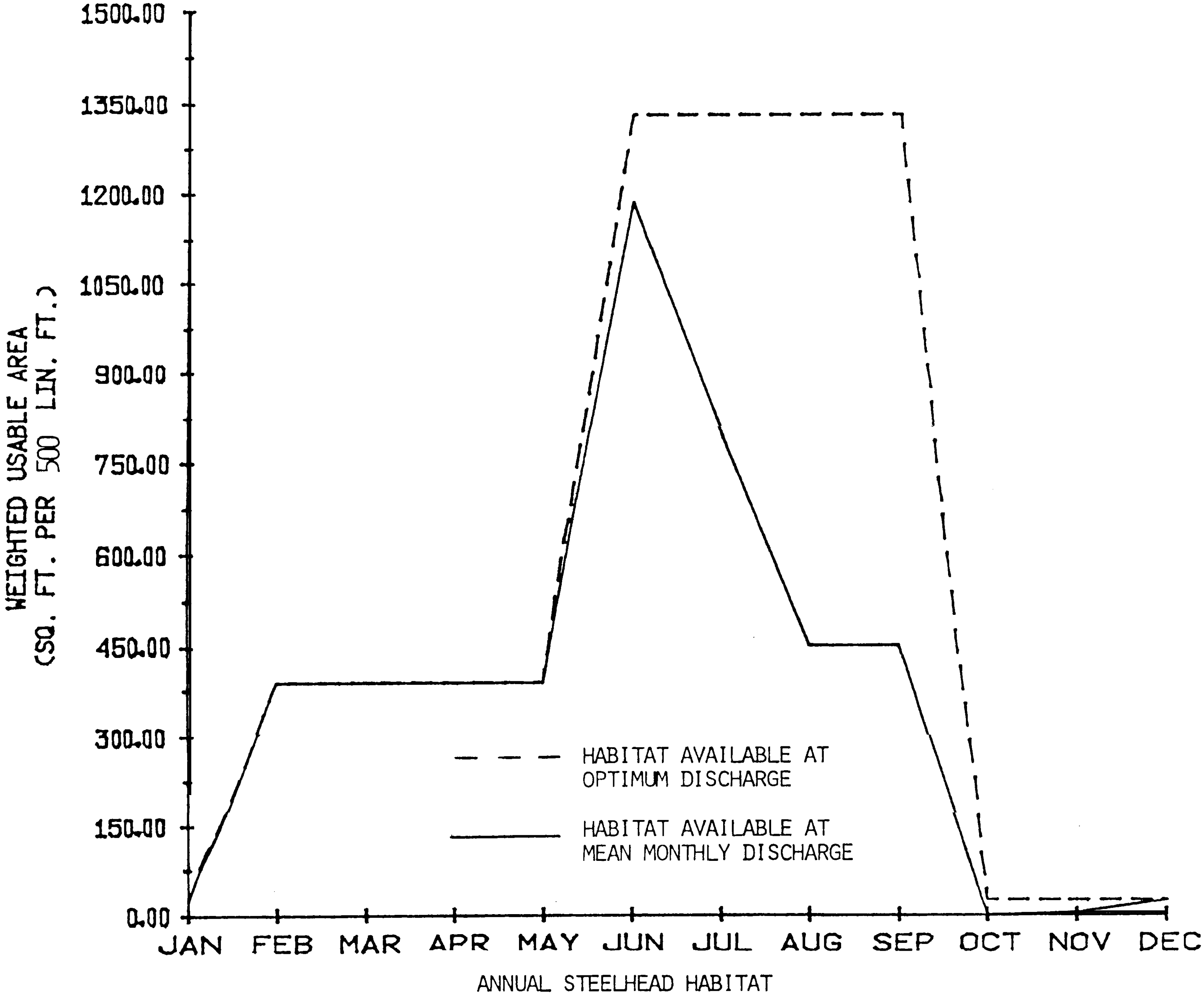


SQUAW CREEK BELOW BACHELOR CANYON (T 4)



ACTUAL AND OPTIMUM DISCHARGE FOR STEELHEAD

SQUAW CREEK BELOW BACHELOR CANYON



SQUAW CREEK BELOW BACHELOR CANYON

SQUAW CREEK BELOW BACHELOR CANYON
Discharge in cubic feet per second.

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	31.2	36.8	45.0	66.4	55.3	21.6	3.2	.5	.5	2.4	10.3	26.9
(Standard Deviation)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Highest Average Flow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Year												
Lowest Average Flow	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Year												

(Source: FAO Calculations base on constants derived by Copp, 1977)

Normal Annual Mean = 31.1

SQUAW CREEK BELOW BACHELOR CANYON

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

DISCHARGE	FRY	SPAWNING	INCUBATION
1.	21.	1.	1550.
2.	81.	9.	2708.
4.	235.	116.	3633.
6.	285.	258.	3939.
8.	268.	333.	4103.
10.	233.	359.	4055.
12.	194.	351.	3878.
14.	177.	346.	3528.
16.	152.	327.	3180.
18.	132.	295.	2920.
20.	121.	269.	2764.
22.	114.	247.	2630.

CHINOOK SALMON

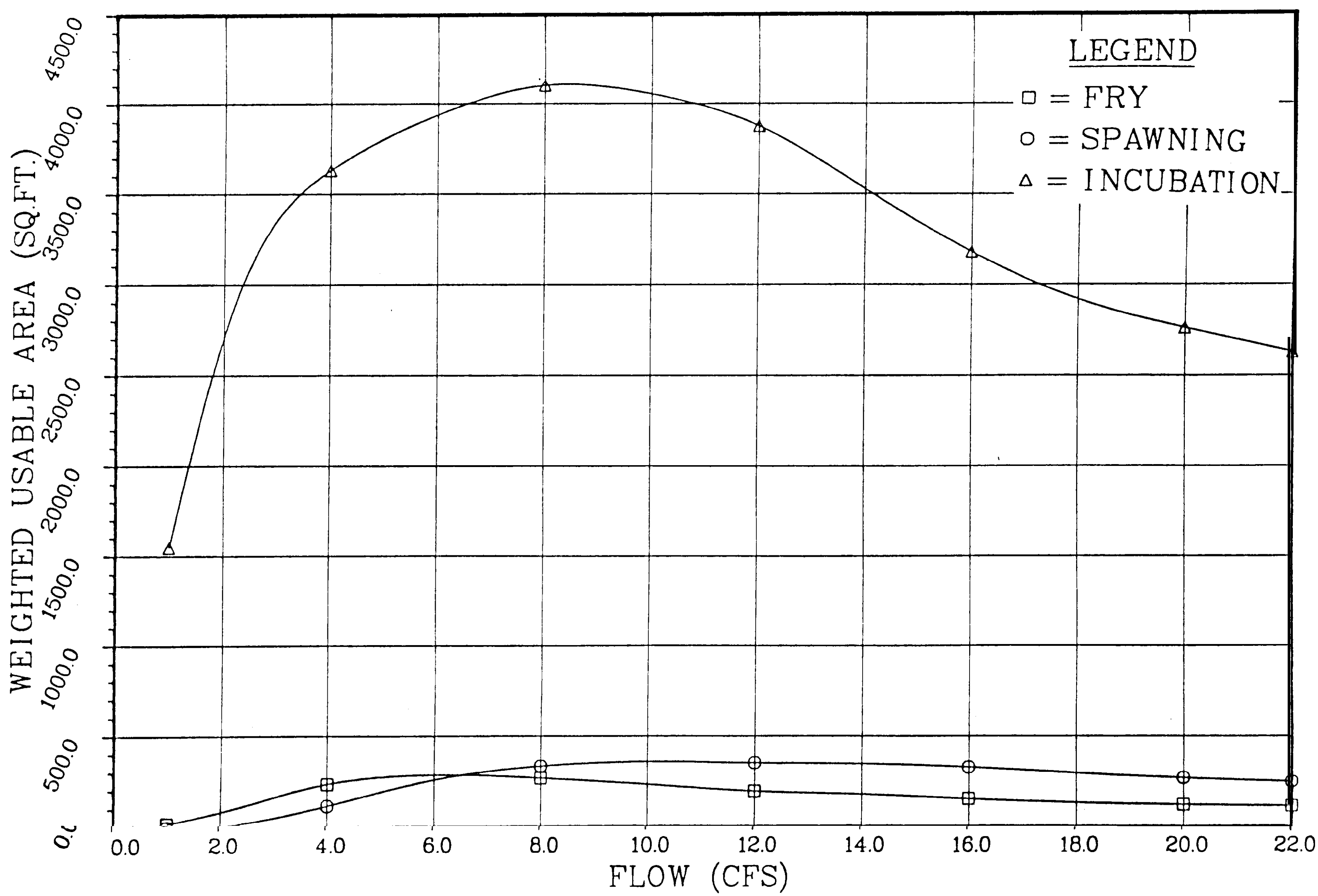
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
1.	195.	11.	0.	1466.
2.	341.	58.	0.	2690.
4.	521.	224.	21.	3805.
6.	607.	340.	95.	4419.
8.	627.	430.	197.	4775.
10.	617.	491.	294.	4908.
12.	586.	536.	429.	4885.
14.	547.	543.	474.	4687.
16.	504.	503.	518.	4399.
18.	465.	474.	532.	4162.
20.	434.	446.	513.	3958.
22.	410.	431.	501.	3777.

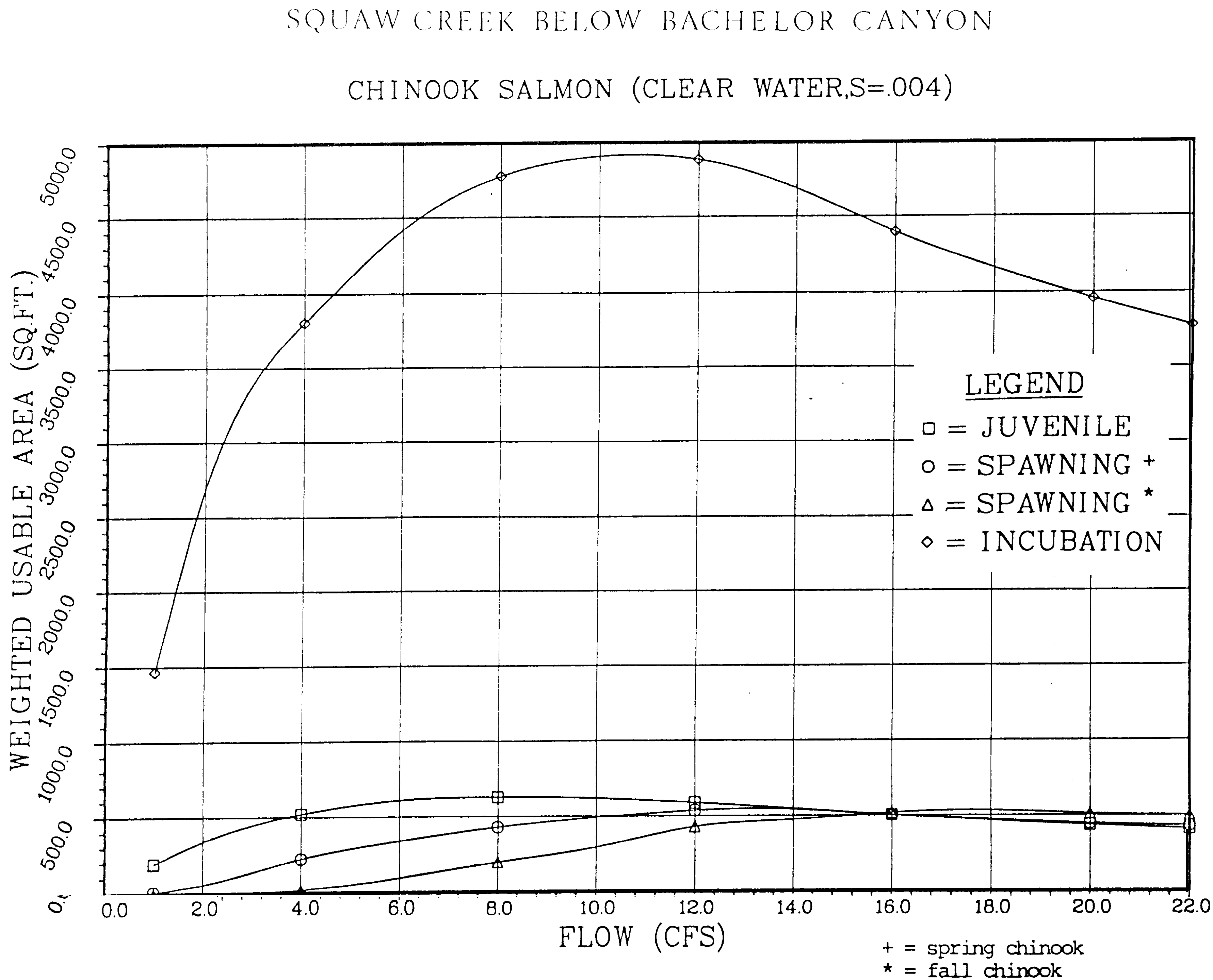
STEELHEAD

DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
1.	1489.	317.	0.	0.	1987.
2.	2195.	588.	0.	0.	3230.
4.	2492.	1012.	1.	4.	4631.
6.	2494.	1239.	1.	23.	5400.
8.	2278.	1325.	2.	72.	5882.
10.	1979.	1327.	3.	128.	6164.
12.	1710.	1304.	5.	176.	6333.
14.	1471.	1270.	8.	219.	6426.
16.	1314.	1239.	13.	271.	6395.
18.	1191.	1215.	19.	328.	6310.
20.	1101.	1197.	23.	366.	6218.
22.	1047.	1173.	25.	391.	6131.

SQUAW CREEK BELOW BACHELOR CANYON

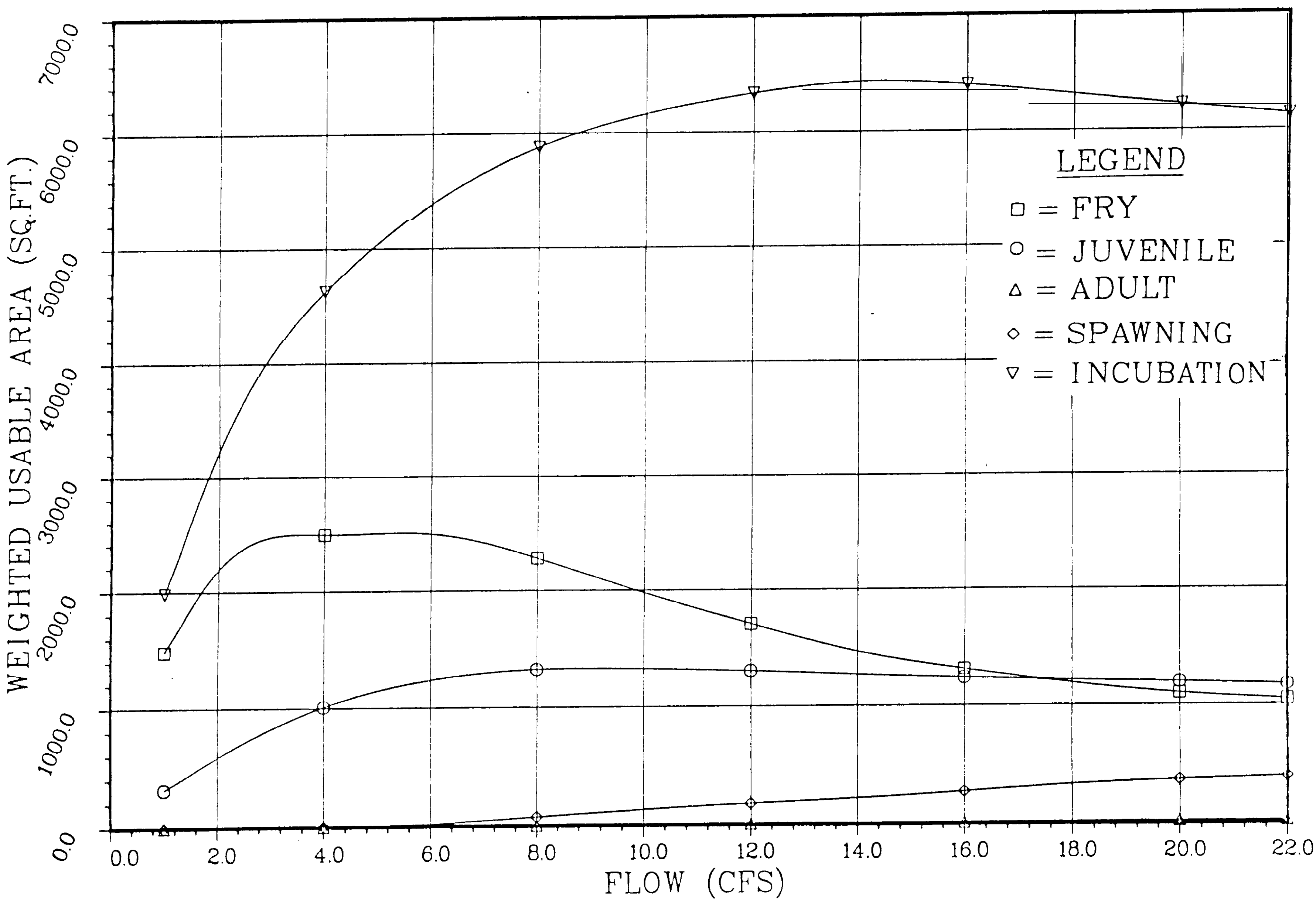
COHO SALMON (CLEAR WATER, S=.004)

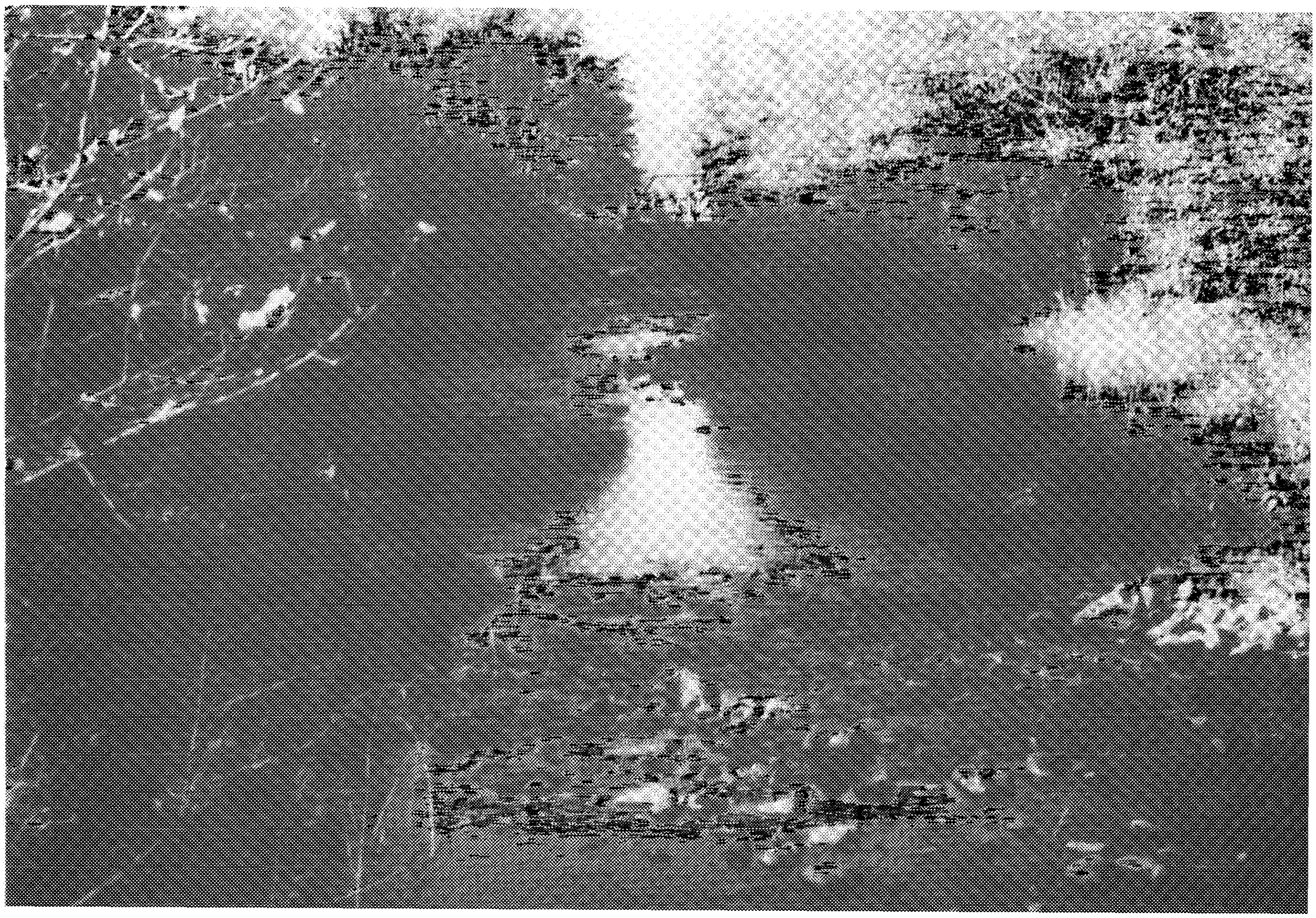



SQUAW CREEK BELOW BACHELOR CANYON
CHINOOK SALMON (CLEAR WATER,S=.004)
WEIGHTED USABLE AREA (SQ.FT.)
0.0
500.0
1000.0
1500.0
2000.0
2500.0
3000.0
3500.0
4000.0
4500.0
5000.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
FLOW (CFS)
LEGEND
□ = JUVENILE
○ = SPAWNING +
△ = SPAWNING *
◇ = INCUBATION
+ = spring chinook
* = fall chinook

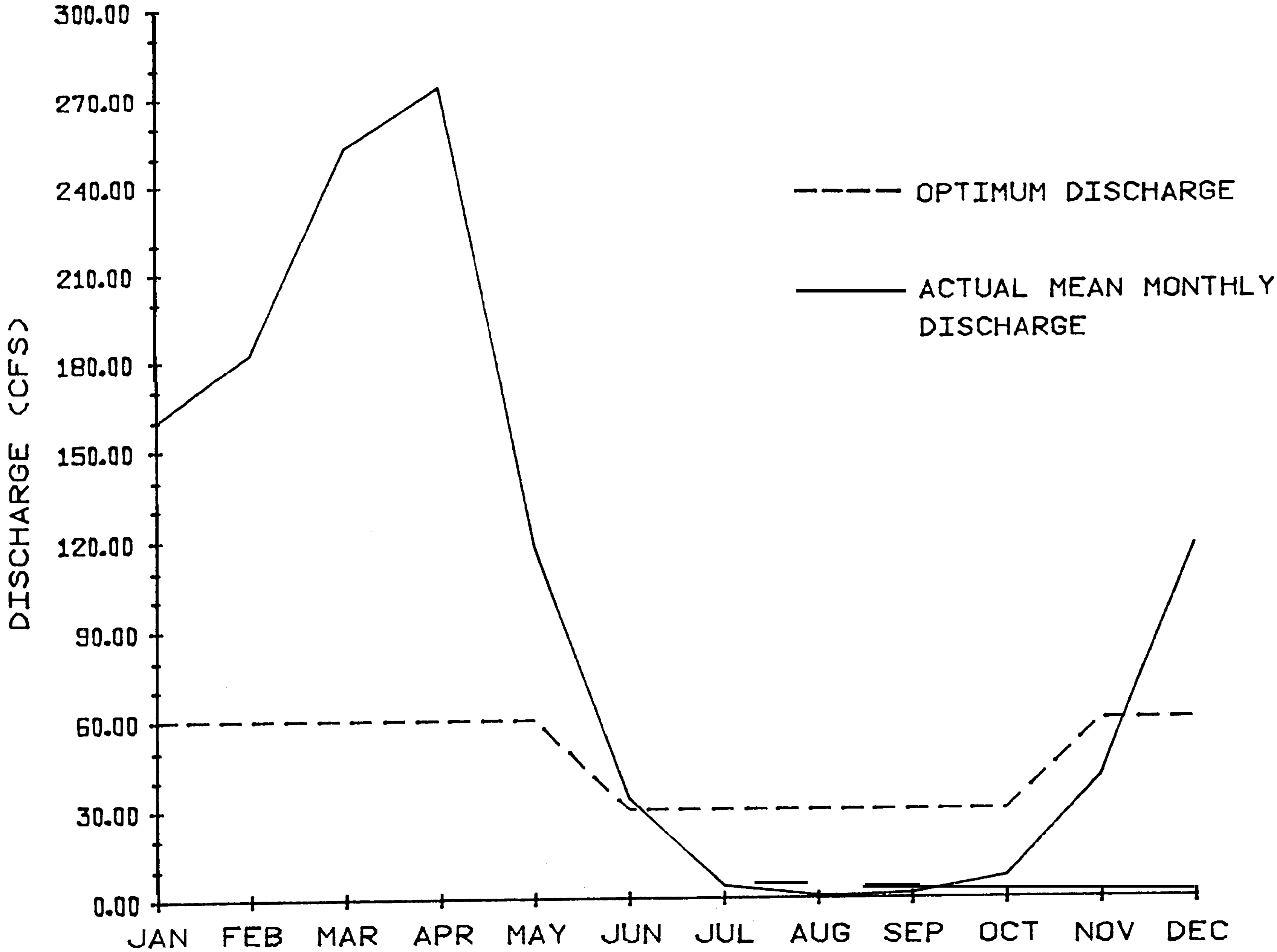
SQUAW CREEK BELOW BACHELOR CANYON

STEELHEAD (CLEAR WATER, S = .004)



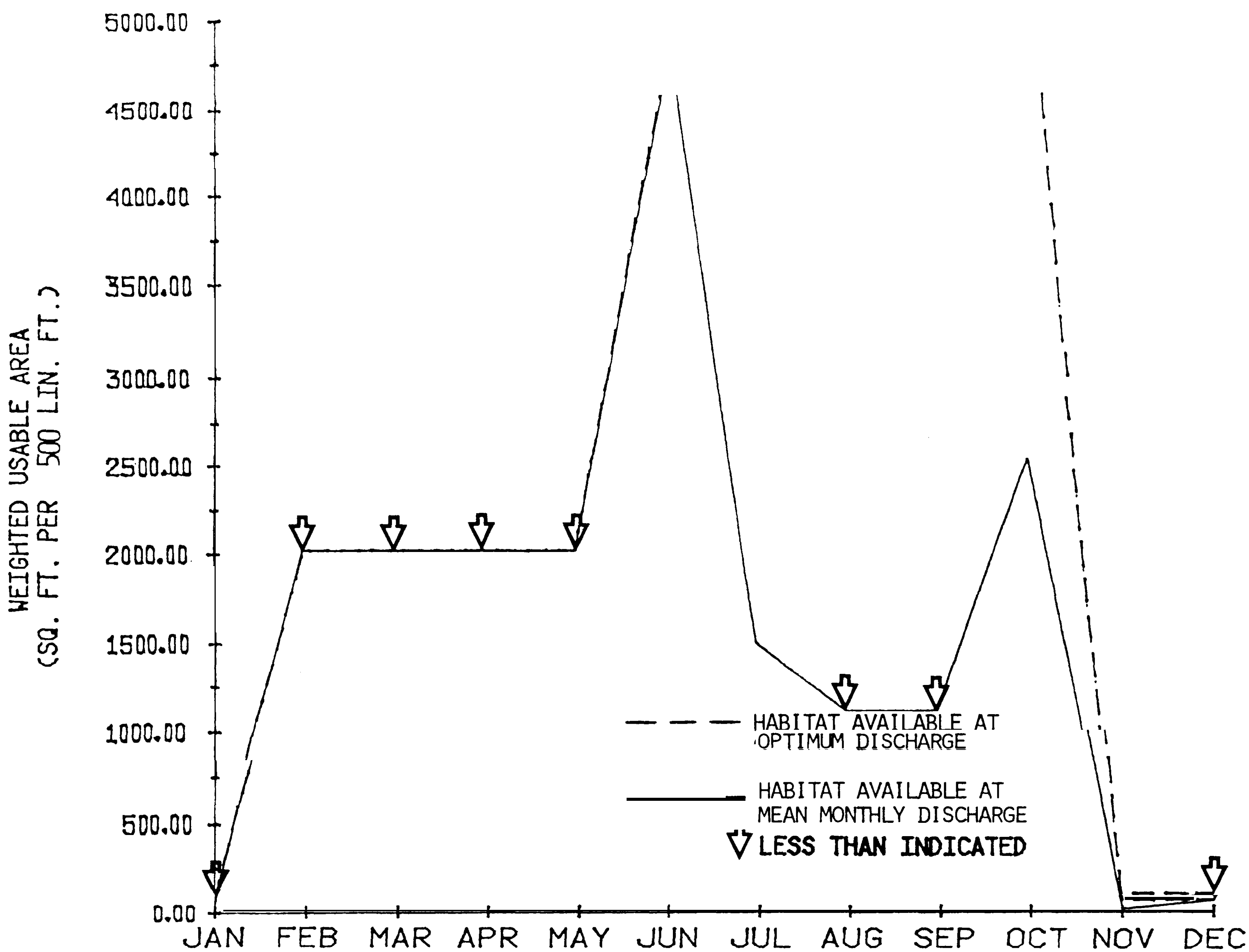


McKAY CREEK NEAR PILOT ROCK, OREGON (T 5)



ACTUAL AND OPTIMUM DISCHARGE FOR STEELHEAD

MCKAY CREEK NEAR PILOT ROCK, OREGON



ANNUAL STEELHEAD HABITAT

MCKAY CREEK NEAR PILOT ROCK, OREGON

MCKAY CREEK NEAR PILOT ROCK, OREGON
Discharge in cubic feet per second.

Period of record
1921, 1927 - 1977

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	160	183	253	274	118	33.8	4.23	0.62	1.66	7.21	41.1	118
(Standard Deviation)	(144)	(108)	(132)	(134)	(99.3)	(43.2)	(7.18)	(0.86)	(4.22)	(17.6)	(55.5)	(114)
Highest Average Flow	460	367	757	782	500	173	45.0	3.74	280	79.5	257	460
(Year)	(1976)	(1972)	(1932)	(1958)	(1948)	(1942)	(1942)	(1975)	(1941)	(1928)	(1928)	(1974)
Lowest Average Flow	5.00	11.4	67.4	42.4	8.39	1.01	0.00	0.00	0.00	0.00	0.47	3.78
(Year)	(1930)	(1977)	(1968)	(1941)	(1934)	(1931)	(1940)	(*)	(*)	(*)	(1930)	(1977)

(*) many years of record
(Source: U.S.G.S.)

Normal Annual Mean = 98.4

MCKAY CREEK NEAR PILOT ROCK, OREGON

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

DISCHARGE	FRY	SPAWNING	INCUBATION
3.	9.	13.	4639.
4.	14.	36.	5581.
6.	28.	138.	7212.
8.	43.	265.	7958.
10.	57.	444.	8427.
15.	68.	1206.	8332.
20.	72.	1854.	7996.
25.	77.	2054.	7438.
30.	80.	1904.	6896.
40.	80.	1484.	5780.
50.	80.	1117.	4705.
60.	83.	825.	3891.

CHINOOK SALMON

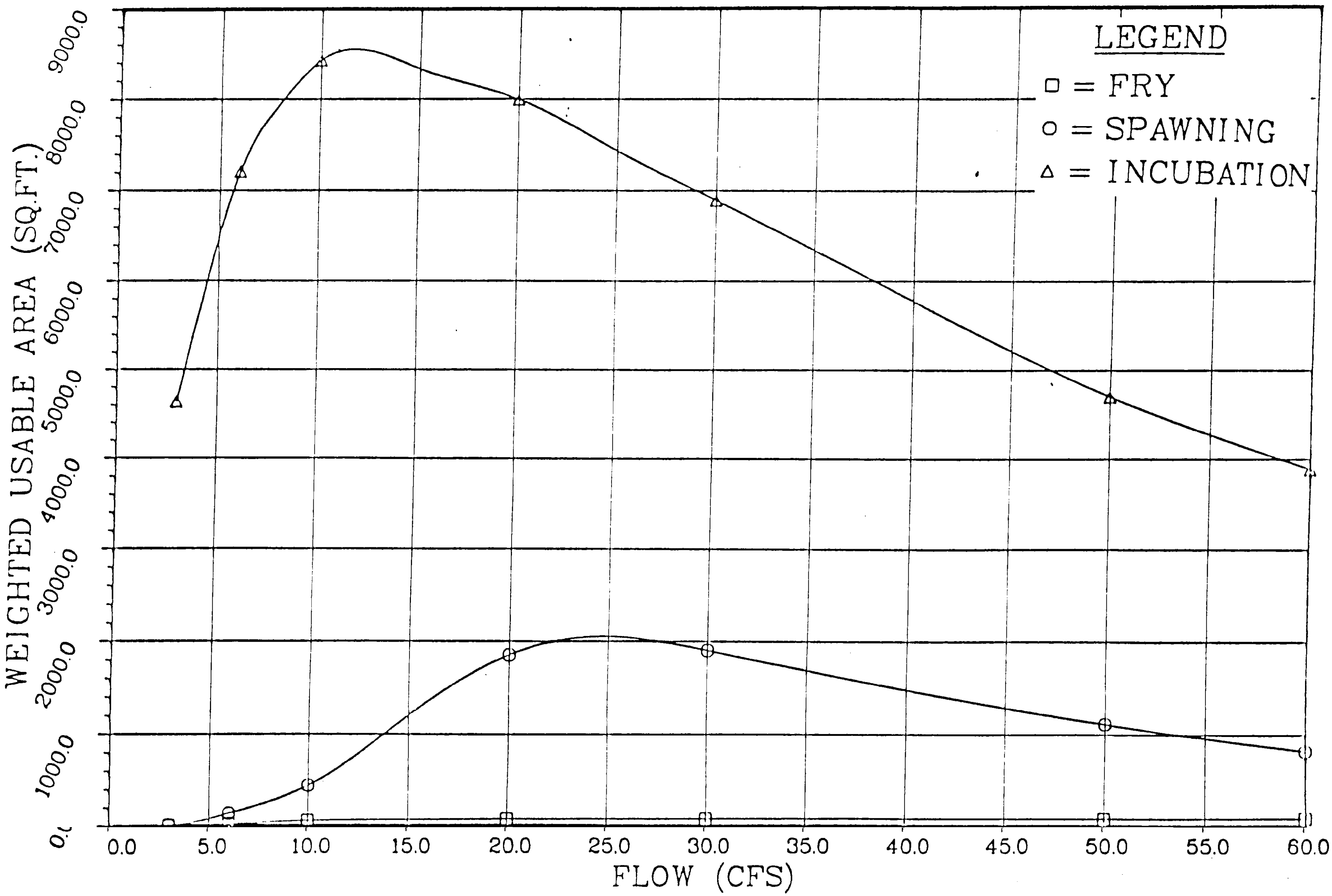
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
3.	482.	72.	1.	4378.
4.	587.	117.	3.	5345.
6.	746.	252.	12.	7202.
8.	877.	437.	36.	8163.
10.	972.	653.	93.	8800.
15.	1059.	1125.	404.	9321.
20.	1041.	1405.	833.	9461.
25.	987.	1620.	1291.	9356.
30.	914.	1765.	1700.	9185.
40.	799.	1677.	1924.	8560.
50.	737.	1417.	1730.	7772.
60.	704.	1165.	1458.	6961.

STEELHEAD

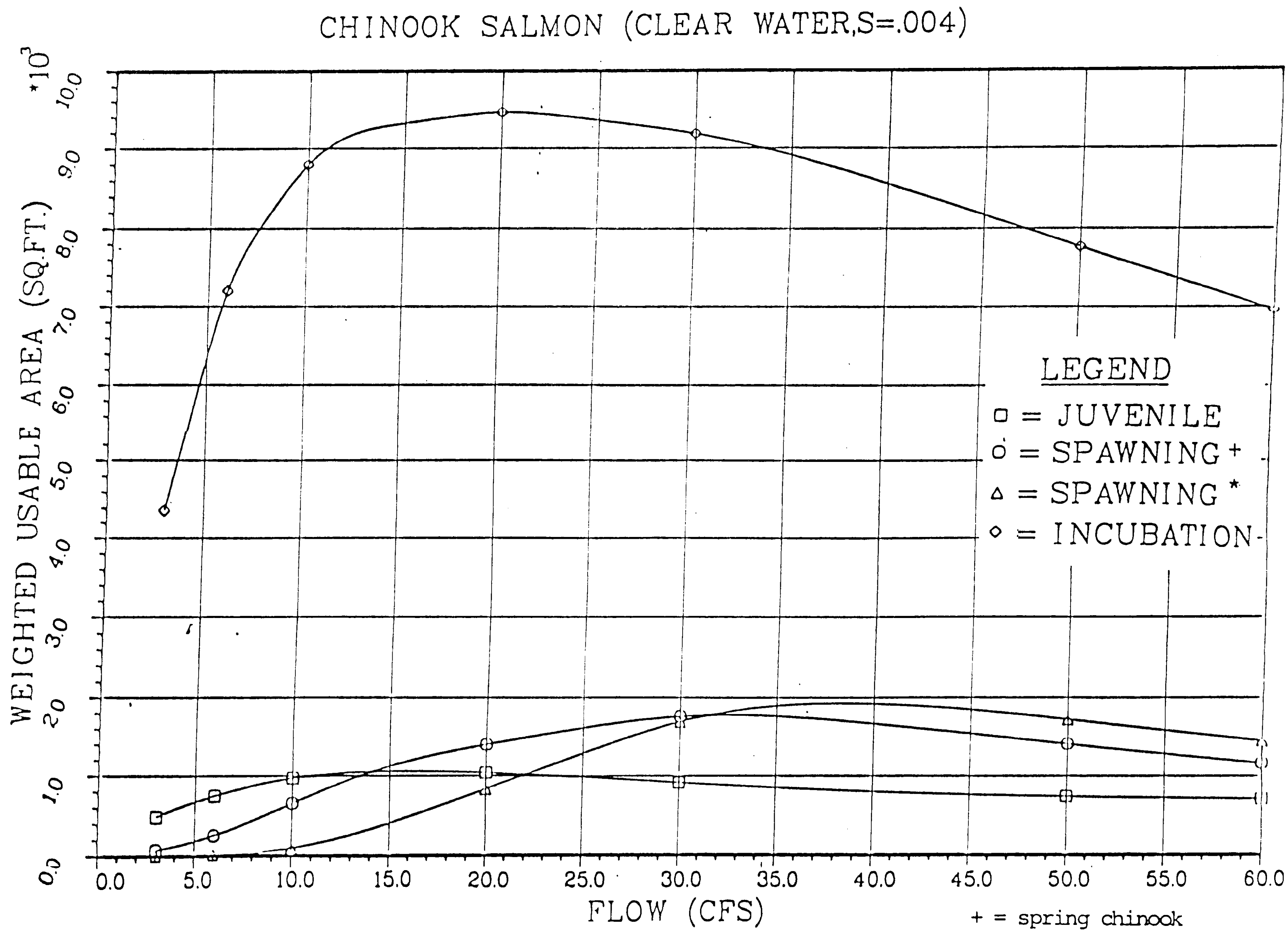
DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
3.	3709.	1116.	0.	1.	5291.
4.	4478.	1503.	0.	2.	6370.
6.	5887.	2260.	0.	11.	8061.
8.	6649.	2826.	0.	32.	9071.
10.	6936.	3291.	0.	67.	9801.
15.	6811.	4134.	0.	206.	10859.
20.	6185.	4592.	0.	432.	11370.
25.	5477.	4810.	9.	728.	11642.
30.	4789.	4898.	21.	1035.	11767.
40.	3717.	4623.	18.	1506.	11730.
50.	2861.	3985.	36.	1841.	11481.
60.	2374.	3297.	74.	2017.	11008.

MCKAY CREEK NEAR PILOT ROCK, OREGON

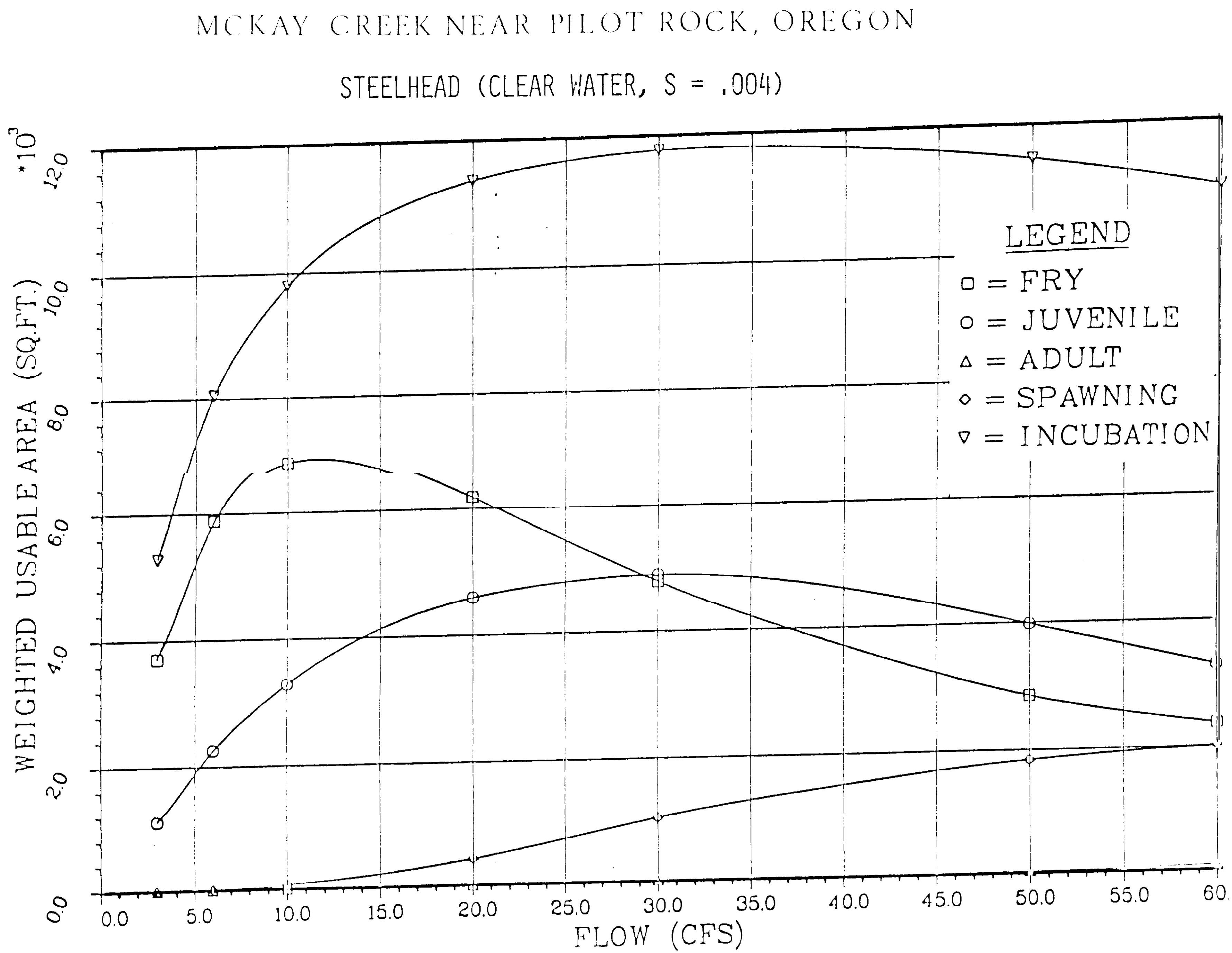
COHO SALMON (CLEAR WATER, S=.004)



MCKAY CREEK NEAR PILOT ROCK, OREGON

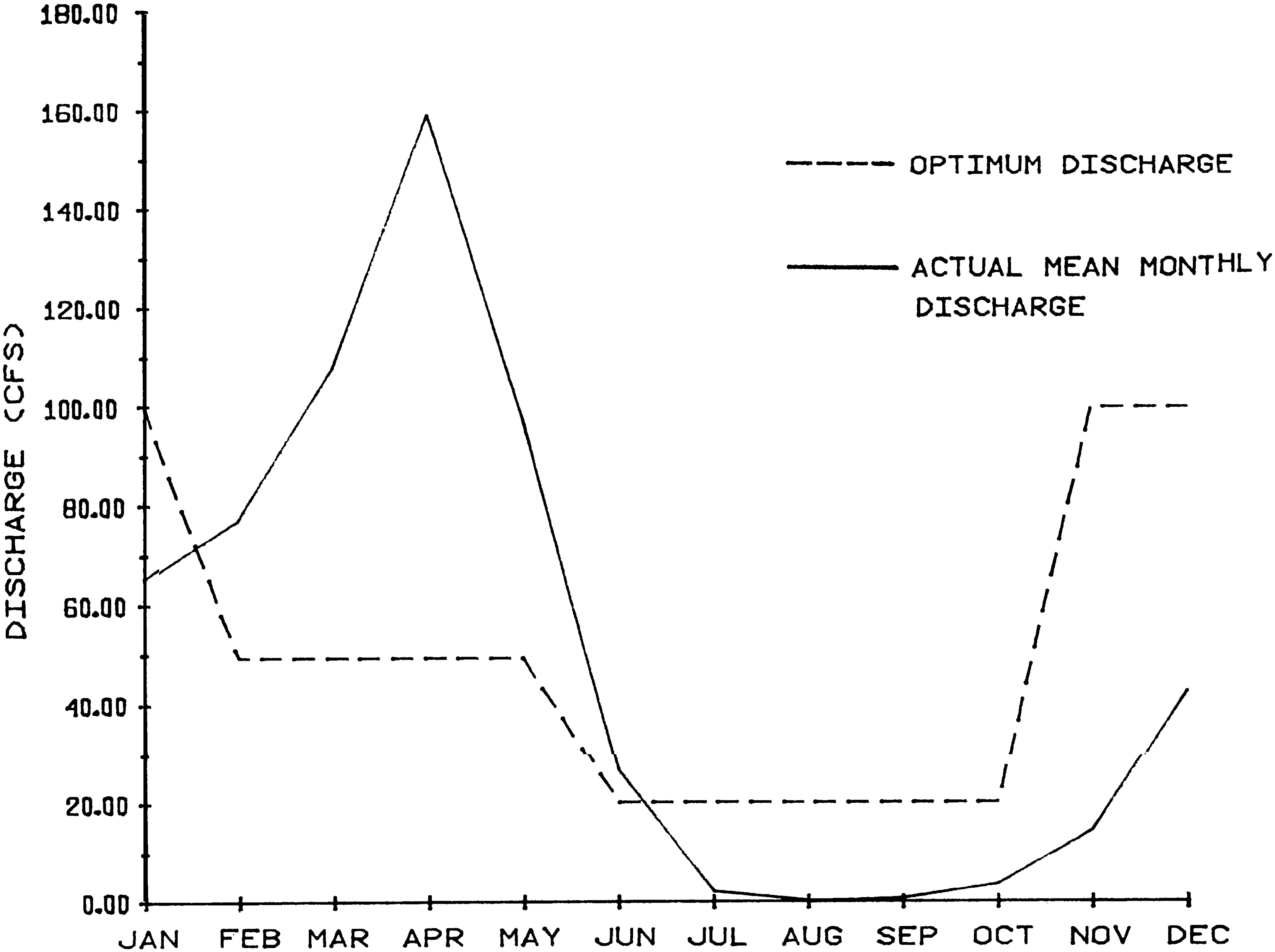


+ = spring chinook
* = fall chinook



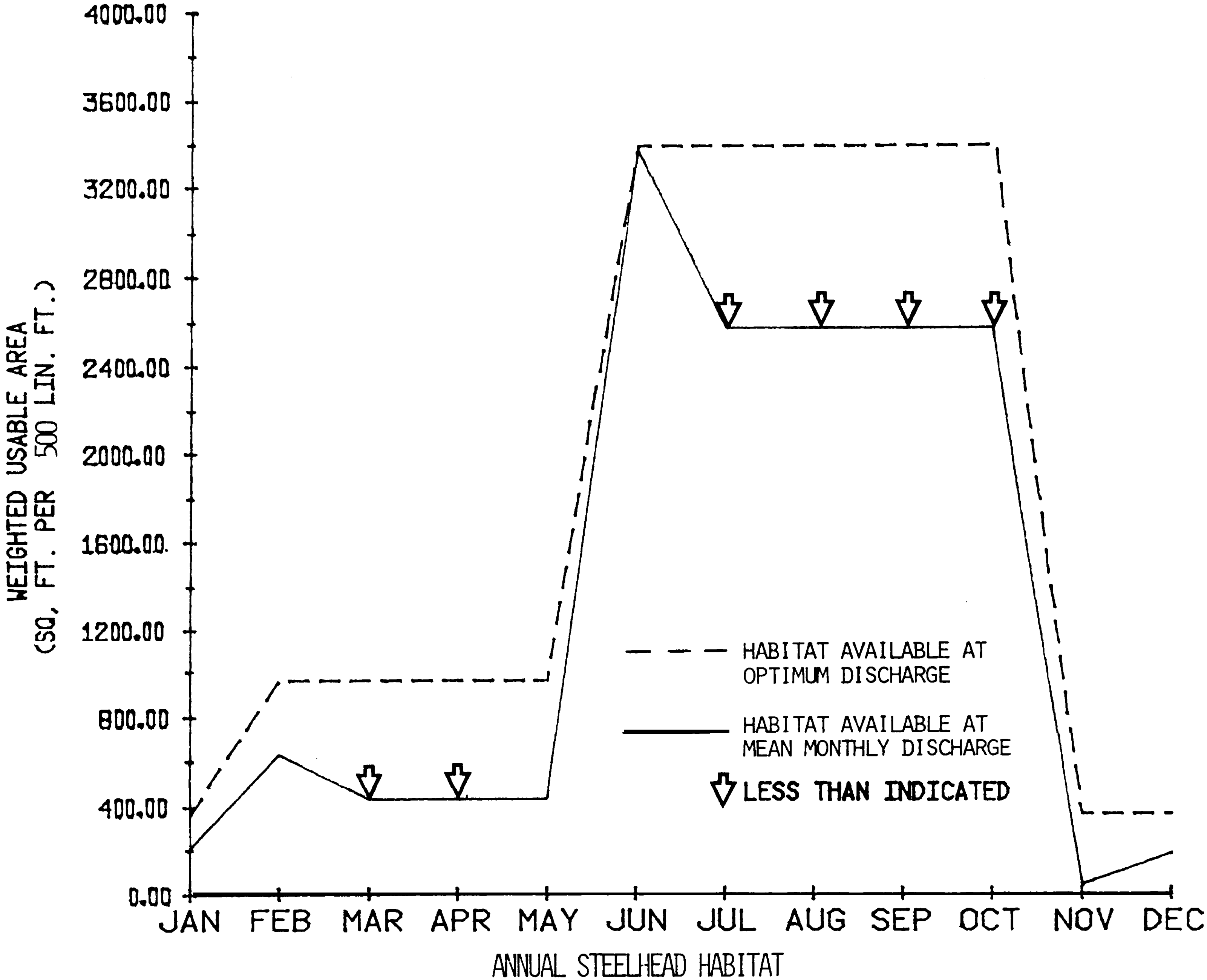
MCKAY CREEK NEAR PILOT ROCK, OREGON
STEELHEAD (CLEAR WATER, S = .004)
WEIGHTED USABLE AREA (SQ.FT.)
*10³
0.0
2.0
4.0
6.0
8.0
10.0
12.0
FLOW (CFS)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
60.0
LEGEND
□ = FRY
○ = JUVENILE
△ = ADULT
◇ = SPAWNING
▽ = INCUBATION

BIRCH CREEK AT PILOT ROCK, OREGON (T 6)



ACTUAL AND OPTIMUM DISCHARGE FOR STEELHEAD

BIRCH CREEK AT PILOT ROCK, OREGON



BIRCH CREEK AT PILOT ROCK, OREGON

BIRCH CREEK AT RIETH, OREGON**
Discharge in cubic feet per second.

Period of record
1921 - 1976

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	65.3	77.5	108.0	159.0	97.4	26.6	1.87	.35	.75	3.57	14.4	43.5
(Standard Deviation)	(68.4)	(57.7)	(59.2)	(76.4)	(86.0)	(33.4)	(4.53)	(.82)	(1.97)	(7.64)	(18.5)	(47.2)
Highest Average Flow	320	268	355	323	434	161.	26.7	2.0	4.0	47.5	96.0	172
(Year)	(1965)	(1965)	(1972)	(1922)	(1948)	(1950)	(1942)	(1923)	(1927)	(1942)	(1942)	(1965)
Lowest Average Flow	2.45	12.2	18.0	3.3	.14	.01	0.0	0.0	0.0	0.0	0.0	0.0
(Year)	(1937)	(1933)	(1935)	(1934)	(1930)	(1940)	(*)	(*)	(*)	(*)	(*)	(1936)

(*) many years of record
(Source: U.S.G.S.)
(**) Above flows are representative flows for section and reach (T 6) at Pilot Rock.

Normal Annual Mean 48.6

BIRCH CREEK AT PILOT ROCK

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

DISCHARGE	FRY	SPAWNING	INCUBATION
6.	71.	13.	2880.
8.	69.	34.	3127.
10.	69.	58.	3499.
12.	70.	89.	3795.
15.	67.	142.	3981.
20.	54.	220.	4162.
30.	63.	306.	3965.
40.	65.	235.	3696.
50.	72.	125.	2945,
65.	90.	40.	1776.
80.	101.	14.	1247.
100.	129.	8.	927

CHINOOK SALMON

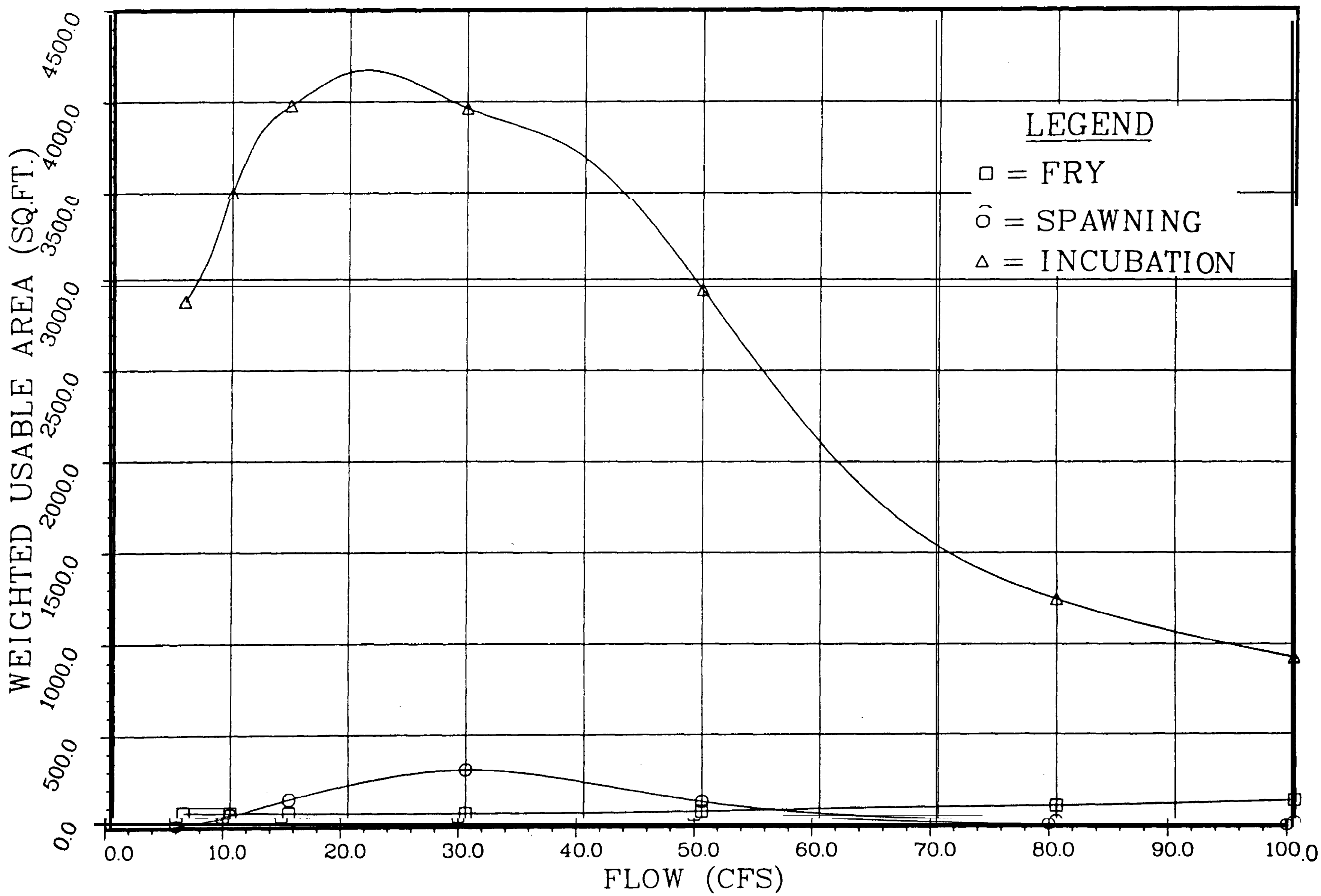
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
6.	704.	200.	0.	2957.
8.	728.	281.	6.	3303.
10.	744.	334.	26.	3755.
12.	758.	373.	51.	4106.
15.	775.	445.	93.	4447.
20.	785.	526.	140.	4800.
30.	708.	545.	199.	5190.
40.	664.	490.	309.	5271.
50.	622.	304.	235.	4601.
65.	571.	145.	119.	3421.
80.	598.	105.	66.	2766.
100.	652.	62.	23.	2245.

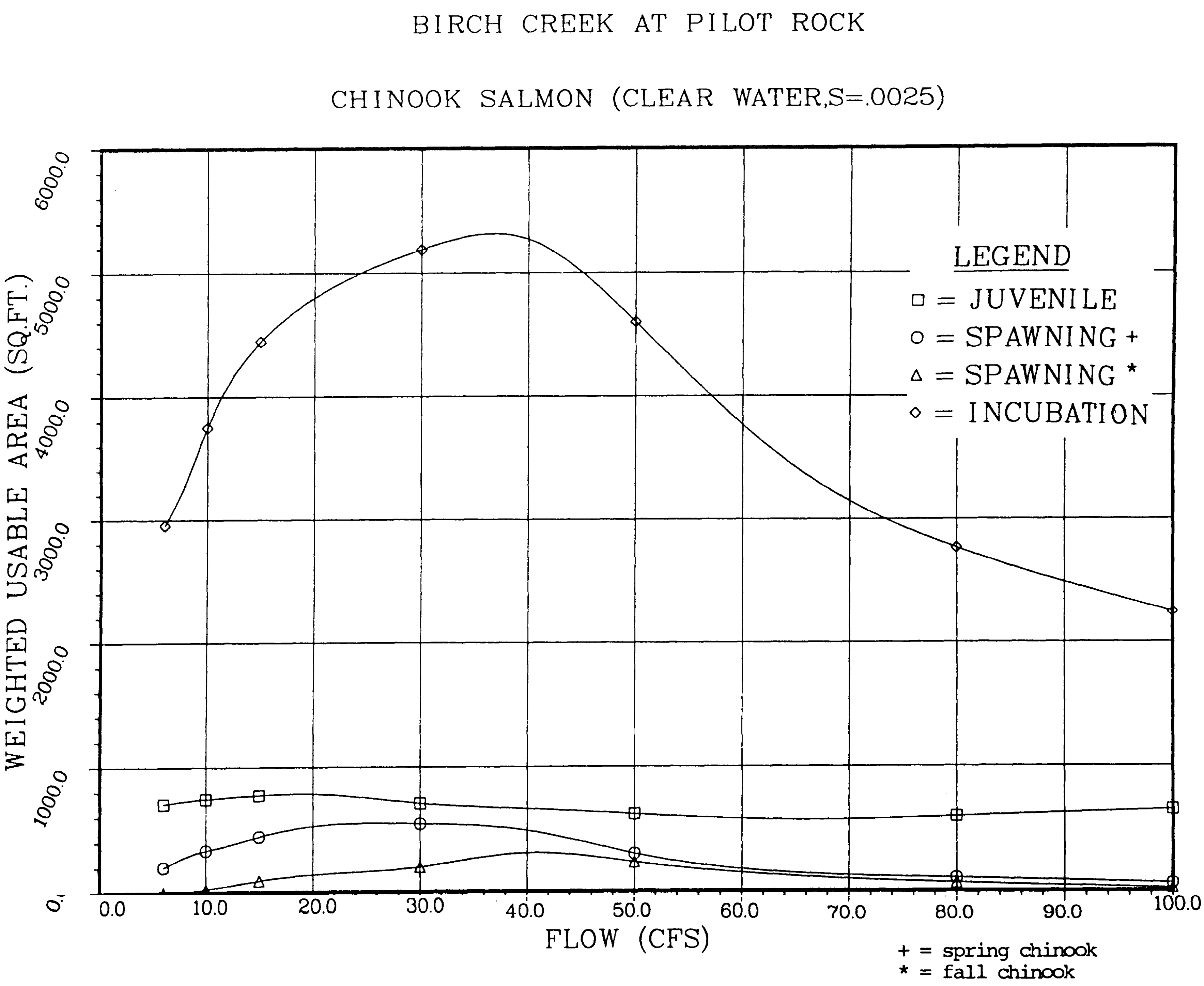
STEELHEAD

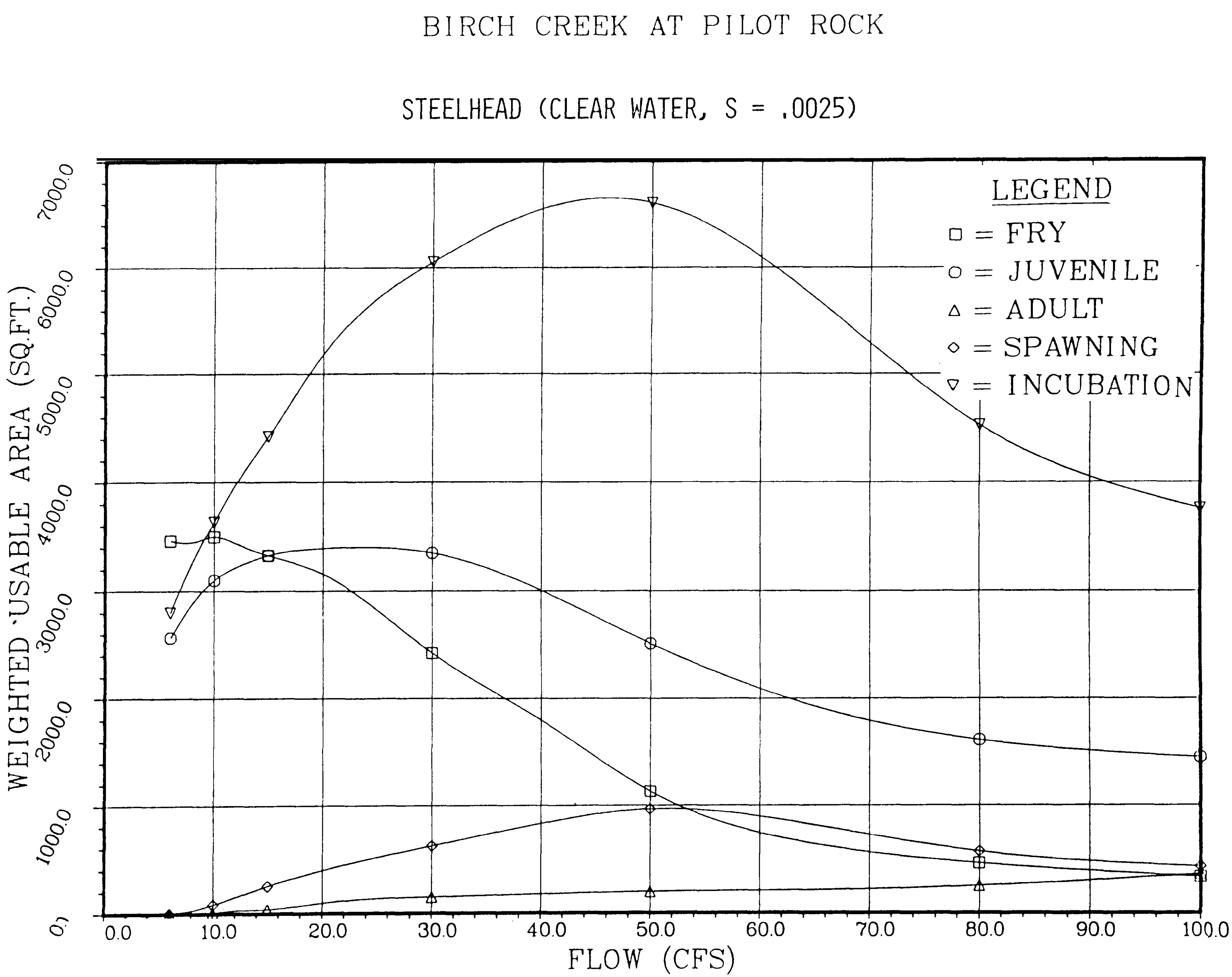
DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
6.	3463.	2571.	0.	3.	2802.
8.	3448.	2881.	2.	29.	3265.
10.	3501.	3102.	12.	85.	3637.
12.	3439.	3219.	31.	151.	3985.
15.	3328.	3328.	39.	253.	4423.
20.	3157.	3393.	97.	397.	5185.
30.	2425.	3350.	152.	624.	6054.
40.	1802.	3006.	177,	830.	6552.
50.	1134.	2515.	198.	967.	6606.
65.	639.	1928.	212.	815.	5707.
80.	461.	1617.	252.	571.	4527.
100.	336.	1654.	361.	431.	3758.

BIRCH CREEK AT PILOT ROCK

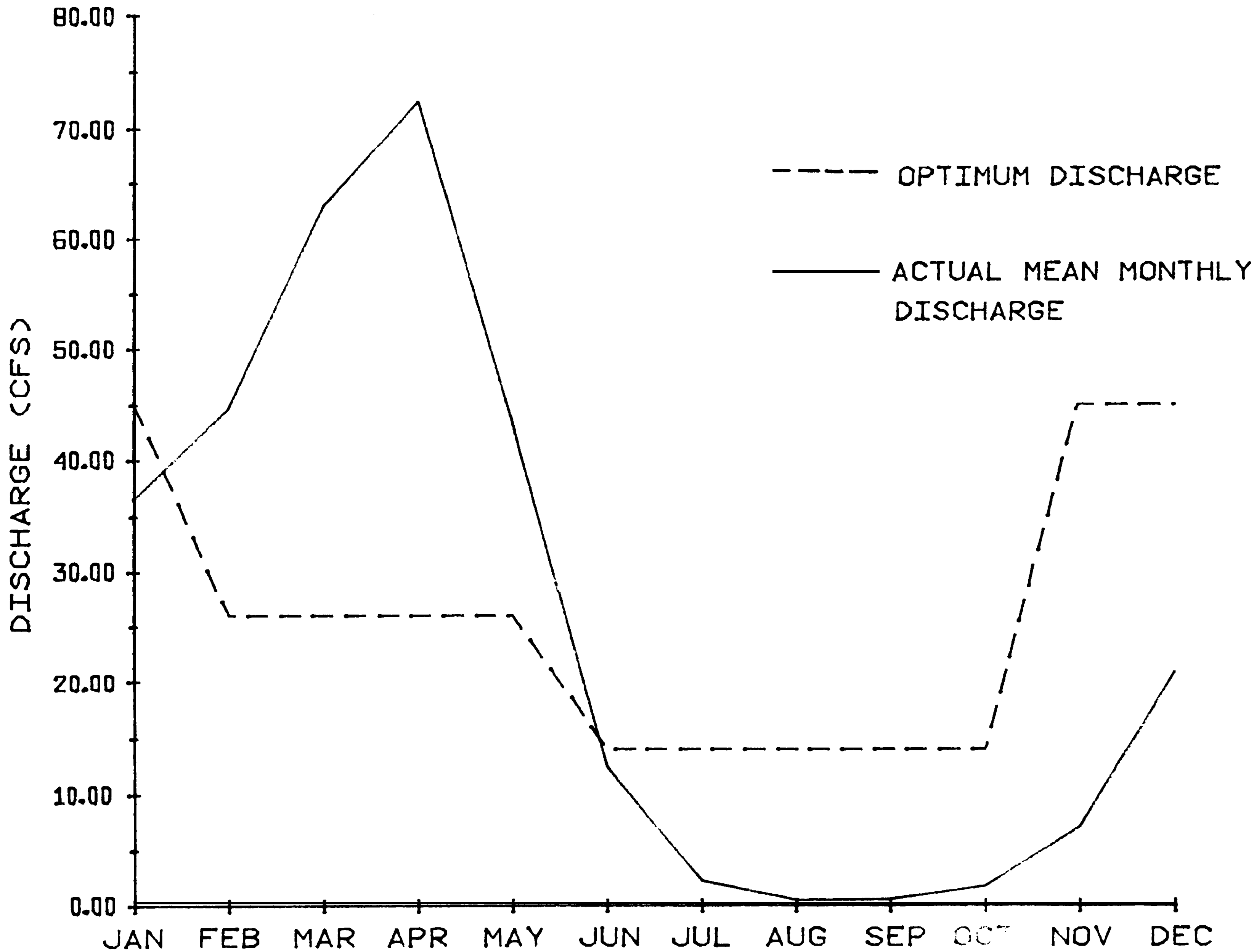
COHO SALMON (CLEAR WATER, S=.0025)




BIRCH CREEK AT PILOT ROCK
CHINOOK SALMON (CLEAR WATER,S=.0025)
WEIGHTED USABLE AREA (SQ.FT.)
6000.0
5000.0
4000.0
3000.0
2000.0
1000.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
FLOW (CFS)
LEGEND
□ = JUVENILE
○ = SPAWNING +
△ = SPAWNING *
◇ = INCUBATION
+ = spring chinook
* = fall chinook

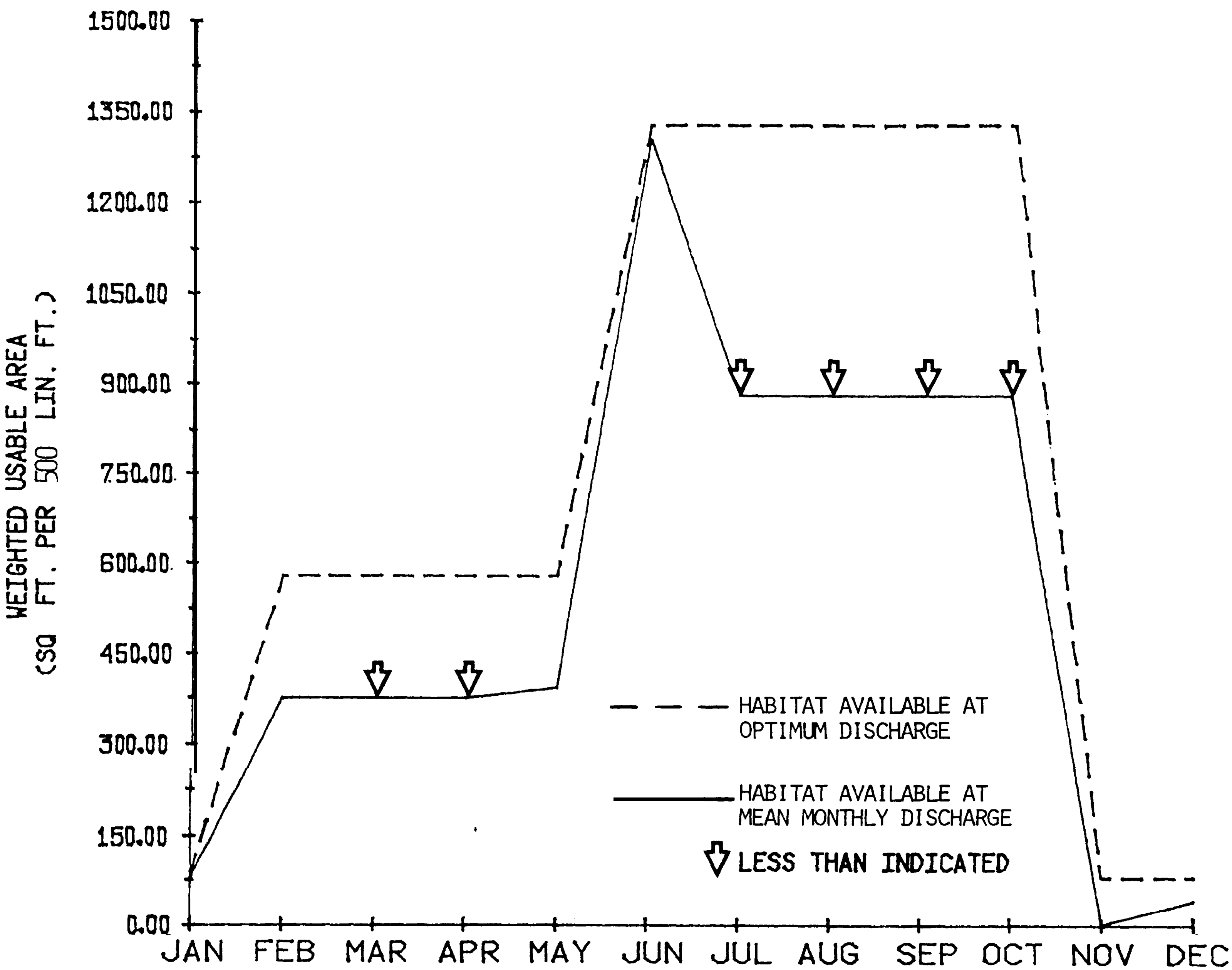

BIRCH CREEK AT PILOT ROCK
STEELHEAD (CLEAR WATER, S = .0025)
LEGEND
□ = FRY
○ = JUVENILE
△ = ADULT
◇ = SPAWNING
▽ = INCUBATION
WEIGHTED USABLE AREA (SQ.FT.)
0.0
1000.0
2000.0
3000.0
4000.0
5000.0
6000.0
7000.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
FLOW (CFS)

BUTTER CREEK NEAR PINE CITY, OREGON (T 7)



ACTUAL AND OPTIMUM DISCHARGE FOR STEELHEAD

BUTTER CREEK NEAR PINE CITY, OREGON



ANNUAL STEELHEAD HABITAT

BUTTER CREEK NEAR PINE CITY, OREGON

BUTTER CREEK NEAR PINE CITY, OREGON
Discharge in cubic feet per second.

Period of record
(1928 - 1977)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
Mean Discharge	36.4	44.7	63.0	72.4	43.3	12.4	2.17	0.52	0.58	1.87	7.10	20.9
(Standard Deviation)	(48.4)	(37.5)	(34.2)	(34.5)	(29.4)	(9.89)	(2.70)	(2.70)	(0.85)	(1.71)	(9.23)	(30.6)
Highest Average Flow	259	144	151	148	128	49.9	12.5	5.14	3.81	5.77	47.6	142
(Year))	(1965)	(1958)	(1972)	(1958)	(1948)	(1948)	(1948)	(1948)	(1965)	(1949)	(1974)	(1974)
Lowest Average Flow	0.00	2.96	7.77	4.47	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.-00
(Year)	(1937)	(1939)	(1935)	(1934)	(1934)	(*)	(*)	(*)	(*)	(*)	(*)	(*)

(*)many years of record
(Source: U.S.G.S.)

Annual Mean = 25.1

BUTTER CREEK NEAR PINE CITY, OR

DISCHARGE (CFS) VS. AVAILABLE HABITAT AREA (SQ.FT.) PER 500 FEET OF STREAM

COHO SALMON

DISCHARGE	FRY	SPAWNING	INCUBATION
4.	43.	52.	1914.
6.	75.	63.	2224.
a.	90.	73.	2352.
10.	89.	96.	2361.
14.	78.	164.	2197.
la.	63.	191.	1790.
22.	56.	181.	1434.
26.	49.	115.	1133.
30.	45.	65.	931.
35.	45.	41.	773.
40.	47.	25.	660.
45.	52.	14.	573.

CHINOOK SALMON

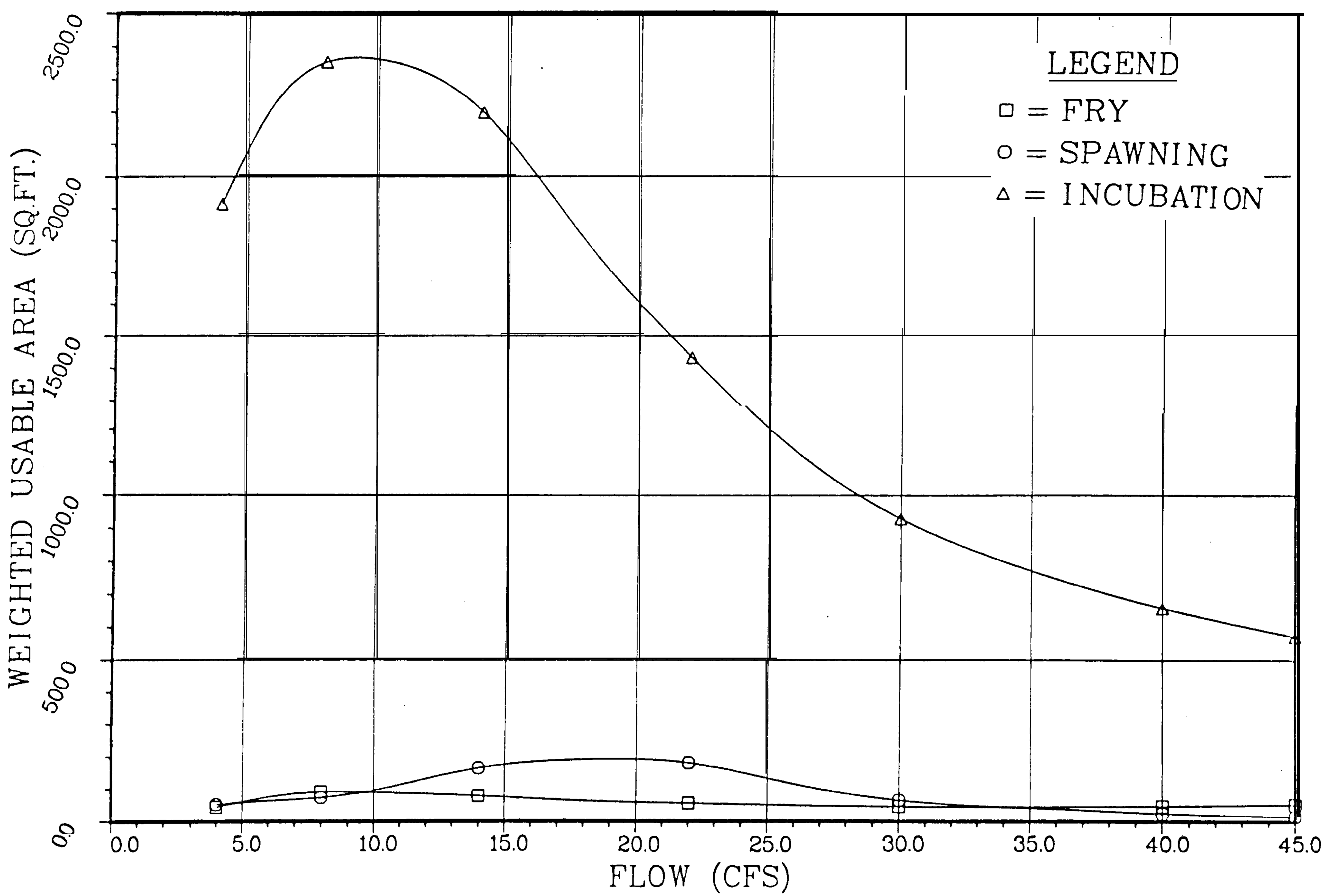
DISCHARGE	JUVENILE	SPRING SPAWNING	FALL SPAWNING	INCUBATION
4.	349.	116.	7.	1854.
6.	441.	204.	13.	2313.
a.	489.	264.	18.	1584.
10.	501.	325.	22.	2730.
14.	475.	356.	53.	2807.
18.	431.	347.	103.	2560.
22.	383.	266.	106.	2220.
26.	349.	217.	97.	1898.
30.	330.	172.	77.	1627.
35.	325.	135.	53.	1380.
40.	333.	113.	31.	1192.
45.	353.	98.	19.	1050.

STEELHEAD

DISCHARGE	FRY	JUVENILE	ADULT	SPAWNING	INCUBATION
4.	1731.	884.	1.	28.	2041.
6.	1745.	1094.	1.	71.	2539.
8.	1674.	1236.	1.	119.	2922.
10.	1563.	1327.	1.	180.	3162.
14.	1193.	1285.	6.	304.	3461.
18.	855.	1140.	27.	420.	3497.
22.	662.	1010.	56.	527.	3324.
26.	549.	902.	67.	579.	3071.
30.	477.	831.	73.	570.	2834.
35.	433.	781.	77.	508.	2446.
40.	408.	765.	80.	444.	2192.
45.	387.	757.	81 .	377.	1981.

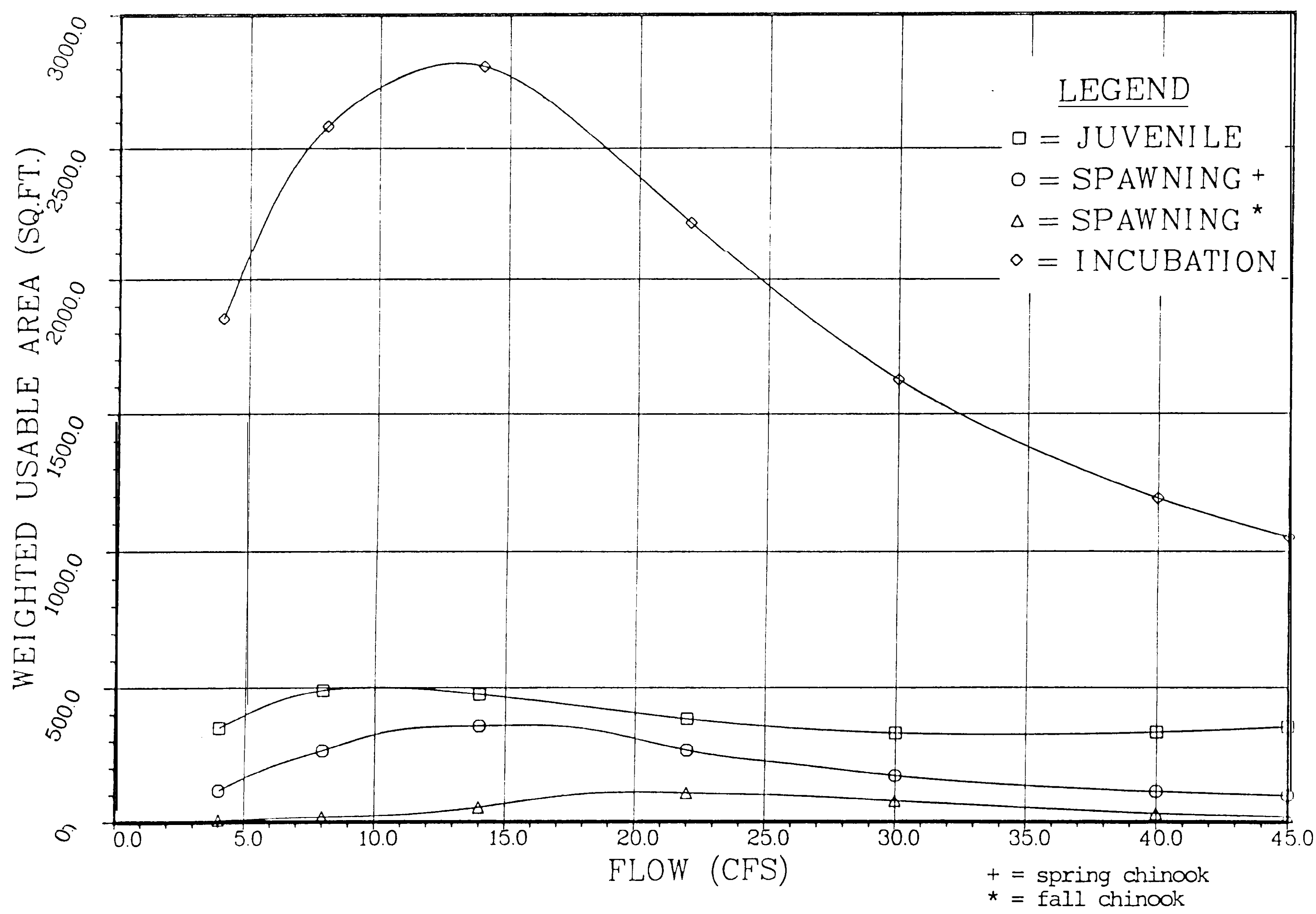
BUTTER CREEK NEAR PINE CITY, OREGON

COHO SALMON (CLEAR WATER, S=.004)



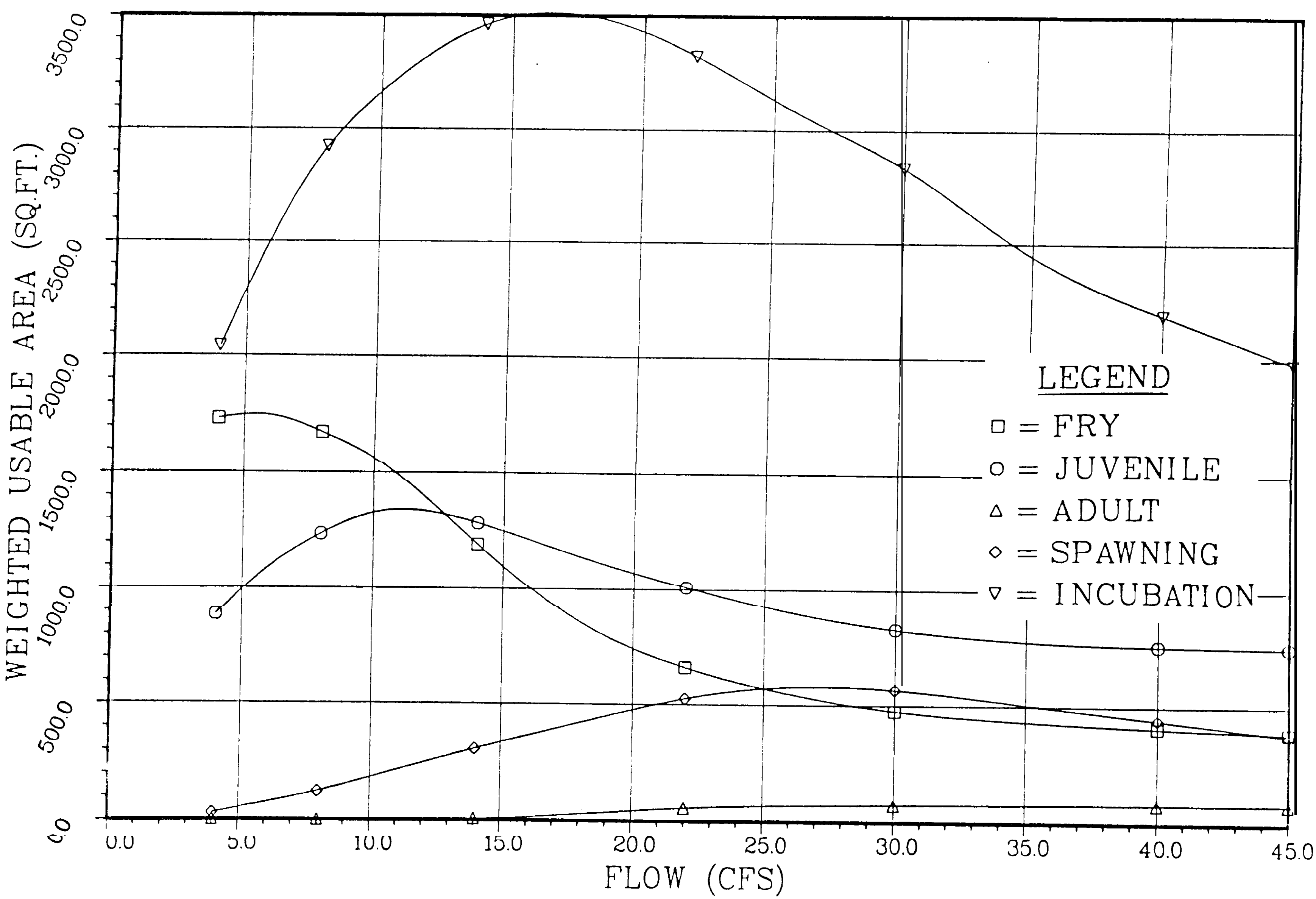
BUTTER CREEK NEAR PINE CITY, OREGON

CHINOOK SALMON (CLEAR WATER,S=.004)



BUTTER CREEK NEAR PINE CITY, OREGON

STEELHEAD (CLEAR WATER, S = .004)



THE UMATILLA RIVER: AN OVERVIEW

Within the scope of this study, anadromous fish habitat was analyzed by four (4) geographical sections: (1) Three Mile Dam to the confluence with the Columbia River, (2) Three Mile Dam to McKay Creek, (3) McKay Creek to eastern Reservation boundary and (4) Tributary streams.

Section 1: Three Mile Dam to the Confluence with the Columbia River

This section of the river, while by far the shortest of the mainstem sections, is critical to anadromous fish runs in the Umatilla River. All fish migrating into or out of the system must utilize this section. Summer and fall flows are often inadequate for passage. In an average year, the period of severely reduced flows begins in June and lasts until November. During many years of record, discharge in this section has reached a Summer low of zero c.f.s. Restoration of salmon runs to the Umatilla River would require careful management of passage flows in this section.

In analyzing discharge v. passage, no single optimum flow regime can be established. Increasing flow will, within the range of modeled discharges, always eventually result in better passage conditions. Likewise, at discharges down to 10 cfs, some passage of fish can occur; however, flows this low will result in water quality degredation and loss of significant attraction flow.

The discharges which FAO considers to be appropriate for minimum passage flows downstream from Three Mile Dam are 100 cfs for adult steelhead and coho; 150 cfs for adult chinook salmon; and 50 cfs for passage of downstream migrant salmonids.

Section 2:. Three Mile Dam To McKay Creek

In this section of the river, only the free flowing sections have been evaluated. As stated earlier, analysis of habitat present within the pools created by irrigation dams is not within the scope of the model. It is probable, however, that at least for spawning, these pools reduce available habitat to near zero within their zones of influence.

This section potentially contains large amounts of habitat for all life history stages of steelhead trout and chinook salmon. Of the river section studied, this section also contains the largest amount of potential coho salmon habitat; however, it is much less than either steelhead and chinook.

Summer mean monthly flows in this section are near or slightly above those which physically produce maximum amount of rearing habitat; however, this habitat is almost 100% unrealized. During the summer months, water temperatures are usually well above the tolerance range of any anadromous salmonid species. During late June, July, August and a portion of September, McKay Creek Reservoir is the primary source of water in this section of the river. Although the reservoir provides adequate rearing flows, the water temperature is not cool enough to maintain summer rearing habitat for salmonids. Return irrigation water also contributes to the increased temperatures, and undoubtedly lowers water quality. As McKay Reservoir fails to provide further water, discharges fall below optimum from June through October. Later, discharges increase and temperatures gradually decline to the point where habitat is once again available for salmonids.

High winter and spring flows dramatically reduce the amount of spawning habitat that is potentially available. This is due to the high velocities that are associated with the flows.

Although the flows in this section of the river physically provide considerable anadromous fish habitat, at present it contributes little to anadromous fish production because of the water temperature problem discussed above.

Section 3: McKay Creek to Eastern Reservation Boundary

The mainstem Umatilla River upstream from the mouth of McKay Creek exhibits a pattern of extreme high discharge in the spring, and sub-optimal to optimal summer discharge in August and September. In this entire section of river, winter and spring discharges greatly exceed the optimum and drastically reduce the available spawning habitat. Summer discharges in the lower half of this section (downstream from Squaw Creek) are lower than optimum; in addition, daily maximum temperatures often exceed the tolerance range for anadromous salmonids. In the section upstream from Squaw Creek, summer discharge approximates the optimum, and temperatures are less a problem than in the lower half, usually remaining well within the tolerance range of salmonids; consequently the maximum summer rearing habitat may actually be presently occurring.

Section 4: Tributary Streams

Meacham Creek and the South Fork of the Umatilla River were found to contain the most potential habitat for anadromous salmonids; however both tributaries experience the same basic problems: high winter flows, and low summer flows. These streams are of special value to anadromous fish production because of their low summer water temperatures. With warm temperatures found in most of the mainstem, these tributary streams become especially important for rearing juvenile salmonids, and may well be critical to anadromous salmonid production within the Reservation boundary.

The North Fork does not provide large amounts of anadromous fish habitat. This is due largely to the slope of the stream channel. High gradient within this area causes the maximum amount of habitat to occur at relatively low discharges since extreme velocities are encountered at higher discharges. The present flow regime in this section does provide a fairly good approximation of maximum habitat available. February and March flows are slightly less than needed for maximum habitat, and discharges during the remainder of the year are somewhat higher than those needed for maximum habitat.

Birch and Squaw Creeks are presently utilized by steelhead; however, they supply an extremely limited amount of rearing habitat during the critical summer months. Both creeks have flows which approach zero during mid summer. Water temperatures at this time of year often exceed 80°F which prohibits use by salmonids, except in limited sections where small springs maintain adequate water temperature.

McKay Creek and Butter Creek are blocked for use by anadromous salmonids. Upper McKay Creek is blocked by McKay Dam. The lower section of the creek is usually dry from October through March when the reservoir is filling. At the request of Oregon Department of Fish and Wildlife, McKay Creek upstream from McKay Reservoir was the section of stream included within the study. With supplemental flows during the July through September period, significant habitat for anadromous salmonids would be produced. However, present water temperatures along much of the creek rise to levels higher than the tolerance range of anadromous salmonids. Even with increased flow, salmonid production may be limited because of high water temperatures. Winter flows in this stream are well above the level needed to produce maximum habitat. Passage at McKay Dam would be required for this section of stream to be important for anadromous fish production.

Butter Creek does not presently provide habitat for anadromous salmonids due to a total lack of flow during a large part of the year downstream from the confluence with Little Butter Creek. In addition, flows in the upper creek (including the study reach) are less than optimum for more than one-half the year. This flow deficit is the most severe of any area studied. Only in March and April are optimum flows greatly exceeded. If the formidable water shortage problems encountered within the reach could be surmounted, a moderate amount of habitat would be available in this section of the stream. Conversations with local residents indicate that steelhead utilized this stream as recently as 1965 but recent increases in irrigation withdrawals have eliminated it for anadromous fish production.

POTENTIAL FOR IMPROVEMENT

In analyzing the Umatilla River system for anadromous fish production, passage and high water temperatures are critical factors. At the present time passage restrictions downstream from Three Mile Dam prevent significant use of the drainage by species other than summer steelhead, which migrate at a time when there are adequate passage flows. If passage conditions could be provided for other species, high water temperatures in the summer may become the critical factor in the development of coho and spring chinook runs. Water temperatures would not present the same problem for fall run chinook salmon. If adequate passage, both up and downstream were supplied for fall chinook, low summer flows would not present a problem, since fall run chinook would leave the system before summer low flows and high temperatures become a problem. The potential for competition between this race and the existing summer steelhead run is the lowest for any of the salmonid races.

Improvement potential within the Umatilla River system falls into two areas: improvements which would benefit the existing summer steelhead run, and those which would develop other species and races of anadromous salmonids.

The existing summer steelhead run could be improved by increasing the low flow regime in the tributaries. Tributary flows should be increased to the flows that are needed to provide maximum rearing habitat. Along with the increase in summer flow, a decrease in summer water temperatures to within the tolerance limits would increase the usable habitat available. These changes in flow regimes would require additional water from sources such as ground water or storage reservoirs.

The following example indicates the benefit to summer steelhead that could be provided by increasing summer discharges within two tributary streams. If discharges during June through October (the critical period for rearing juvenile summer steelhead) were increased to provide maximum habitat within the South Fork of the Umatilla River and Meacham Creek, the amount of habitat available within these tributaries and in the main river upstream from McKay Creek would increase by approximately 14.5 percent. This assumes no loss of water through the system. If as a result of increased flows, water temperatures decreased, additional benefit would be realized.

Summer steelhead production could also be increased by the placement of structures to increase depth and lower velocity. This could be done by locating structures such as wing deflectors to extend partly across the channel. These structures should be high enough to cause flow to be directed along the deflectors' length during low and moderate flow conditions. This would effectively lengthen the channel, reduce the gradient and provide a more suitable depth-velocity ratio. The structures should also be low enough to pass high flows over them without dislodging the structures. Streams with extreme gradient would benefit most from these structures; therefore the best location for such structures would be the north fork of the Umatilla River. Portions of the South Fork, Upper Meacham Creek and the East Fork of Birch could also benefit from such structures. The British Columbia Fish and Wildlife Department has experimented with the placement of these types of structures. In streams which were nearly devoid of pools, the alterations resulted in a two- to three-fold increase in smolt production (Narver, 1979).

The following example indicates the potential for improving spawning habitat for chinook salmon in certain sections of the river.

Spawning habitat currently available for spring and fall chinook was compared to spawning habitat available under optimum modeled discharges. This comparison was made for the Umatilla River upstream from the Pendleton River section and includes the north and south forks of the river. Based upon the mean monthly discharge during the peak spawning month, the amount of spawning habitat currently available for spring chinook was estimated at 1,037,666 square feet of weighted usable area; spawning habitat for fall chinook was estimated at 925,858 square feet of weighted usable area. Optimum modeled discharges indicate that spawning habitat for spring chinook can be increased approximately 68.6% by maintaining optimum discharge through the peak spawning month; fall chinook can be increased approximately 113.2% (Table 4). No tributary systems are included in these estimates.

Table 4: Actual and Optimum Spawning Habitat (square feet of weighted usable area) for the Mainstem Umatilla River Upstream From Pendleton.

	Spring Chinook		Fall Chinook	
Reach Location	Actual (sq.ft.)	Optimum (sq.ft.)	Actual (sq.ft.)	Optimum (sq.ft.)
South Fork (T2)	9,191	43,982	539	22,009
North Fork (Tl)	14,945	32,852	6,248	36,588
Umatilla above Meacham (U9)	64,893	176,888	3,535	156,246
Umatilla above Squaw (U5)	28,227	54,177	22,582	51,436
Umatilla above Cayuse (U7)	920,410	1,441,440	892,954	1,707,763
Totals	1,037,666	1,749,339	925,858	1,974,042

Although moderate to high levels of spring chinook spawning and juvenile rearing habitat are potentially present, summer flow would need to be increased and temperatures decreased before the rearing habitat could be utilized. To realize any degree of chinook production in the system, fall passage conditions at Three Mile Dam would also have to be solved.

Coho face the same problems regarding rearing as the other species with long-term fresh water rearing periods. Potential available habitat for coho is the lowest for any of the anadromous species examined.

It is the opinion of FAO that small reservoirs, or ground water sources, located on tributary streams could be used to regulate the flow in these tributaries as well as aid in re-structuring mainstem flows and possibly water temperatures. The South Fork of the Umatilla River, Meacham Creek, and Squaw Creek provide the best situations for altered flow regimes in the tributaries studied.

With regard to re-establishment of species other than steelhead, the single greatest barrier is inadequate passage flow downstream from Three Mile Dam for both adult and juvenile migrants. As has been mentioned earlier, a late running race of fall chinook salmon might be developed to utilize habitat not presently used by steelhead. This race would not be present during periods when low flow and high temperatures severely restrict habitat. In order to maintain such a run in the system, flow downstream from Three Mile Dam must be available to pass both the upstream and downstream migrating fish.

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