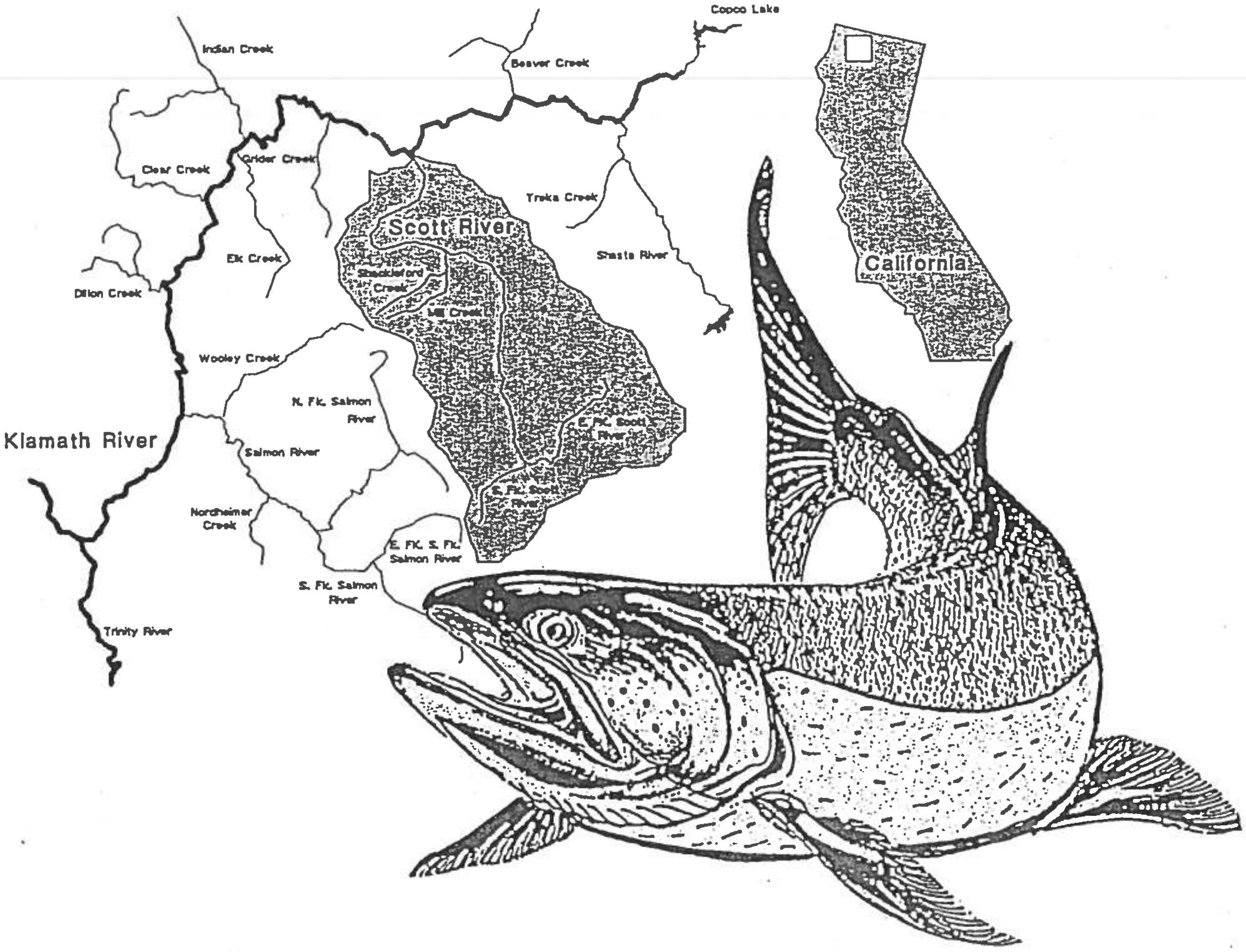
1992 Chinook Salmon Spawning Survey

Scott River Subbasin



1992 Chinook Salmon Spawning Survey

Scott River Subbasin
Klamath Basin

January 1993

by

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INTRODUCTION

The 1992 redd/carcass survey on the Scott River marked the first year of a cooperative effort between California Department of Fish and Game (CDFG) and the Klamath National Forest (KNF). Due to budget short comings, the Salmon and Scott River marking weirs were not installed in 1992; Therefore, a more intensive redd/carcass survey was employed to estimate fall chinook spawning escapement to the subbasin. Previously, KNF personnel made bi-weekly counts of newly excavated redds from Jones Beach to the Klamath-Scott confluence while CDFG separately performed carcass surveys to recover salmon marked at the weir.

This years cooperative effort involved surveying nine reaches (from the Highway 3 bridge at Ft. Jones to the Klamath-Scott confluence) twice each week during the fall chinook spawning run. Carcass and redd surveys were conducted on the first pass with just carcass surveys being done on the second pass of the week. Carcass data and scale samples were analyzed by CDFG (contact Mark Pizano or Bill Chesney, Yreka, CA 916-841-2550), and this report describes and summarizes the redd survey data.

STUDY AREA

The Scott River is tributary to the Klamath River at river-kilometer 230 (mile 143; Figure 1). Subbasin elevation ranges from 498 m (1560 ft) at the confluence to 2,729 m (8,542 ft) at China Mountain. The East Fork and South Fork Scott Rivers converge at Callahan, California (T40N R8W SE1/4 Sec 17) forming the mainstem Scott River which courses 90 km (56 mi) northwest to the Klamath River (Figure 2). The lower 34 km (21 mi) has an average gradient of 2.5% with cobble and boulders as the dominant substrate (B2-B4 channel types; Rosgen 1990). Conversely the upper 56 km (35 mi) has a sand-gravel substrate and meandering channel with an average gradient of < 0.5% (C4-C5 channel types; Rosgen 1990). Mean monthly flows for October, November, and December are 80 cfs, 357 cfs, and 782 cfs, respectively, based on a 13-year average (USGS Gage Data 1979-1991; Station #1151950 located 16 km (10 mi) below Ft. Jones, CA). However, mean monthly flows for the past five drought years during October-December have been considerably less (October = 47 cfs, November = 128 cfs, and December 160 cfs, based on a five-year average from 1986-1991).

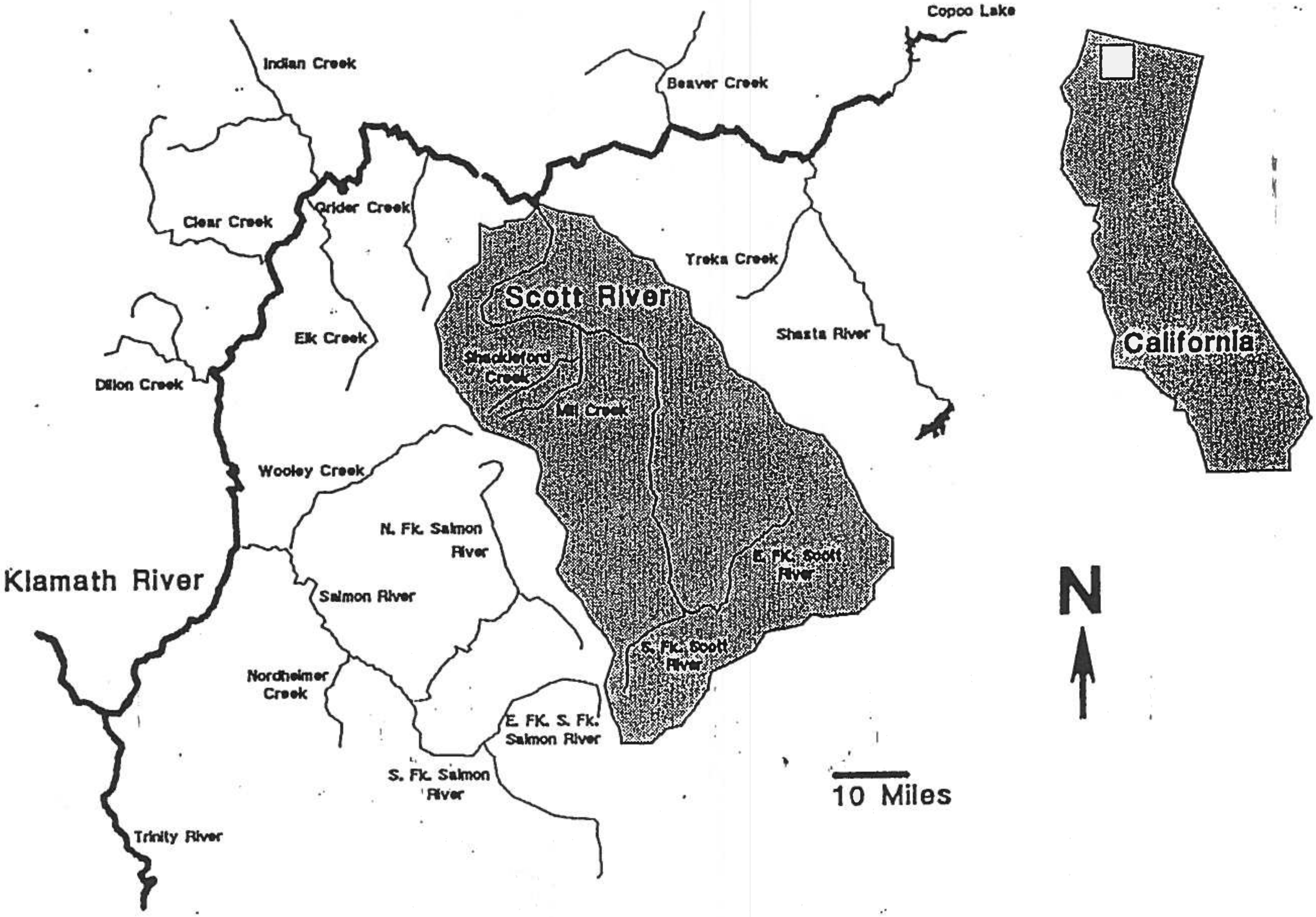


Figure 1. Location of the Scott River subbasin in the Klamath River basin.

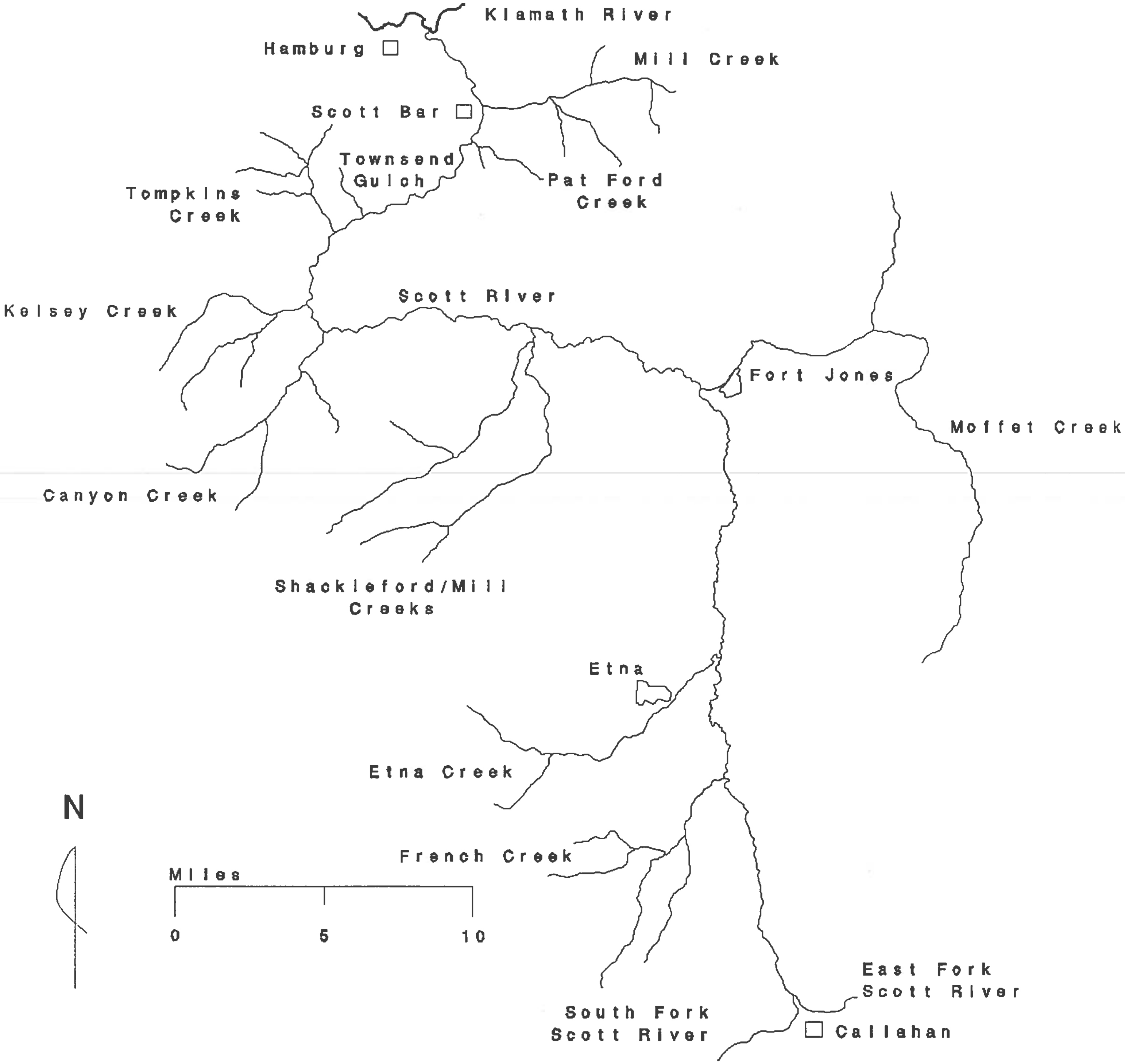


Figure 2. Study area map showing the portion of the Scott River surveyed during the 1992 chinook salmon spawning survey.

METHODS

Cooperative Reaches

Prior to initiating redd surveys, the lower Scott River from the Highway 3 Bridge at Ft. Jones to the confluence was divided into nine reaches ranging in length from 4.5 km (2.8 mi) to 7.3 km (4.5 mi) (Figure 3). The starting point on each reach was marked with flagging to allow reach identification in the field and ensure that reach delineation remained constant for each survey period.

Two passes were made through each reach every week. For each pass, 14 people were divided into 2-person teams which would wade or float downstream through their assigned reach(es). Carcass and redd data was collected on each Tuesday pass with only carcass data being collected on the Friday pass. Newly excavated redds were marked by hanging a single flag in the bank vegetation directly adjacent to the redd pot in order to prevent double counting of redds on subsequent passes. Flags were marked with the date and redds were tallied on the data form along with the type of habitat the redd occupied (Figure 4). Habitat type classification followed the modified Bisson scheme used by region 5 USFS fisheries (McCain et al. 1990; Appendix A). Habitats associated with pools were also noted. For example, habitat type 1 on Figure 4 is a Low Gradient Riffle (LGR) and habitat type "1/Pool" is a low gradient riffle associated with a pool habitat.

Redd distribution within each reach was mapped on the final pass through each reach. Groups of redds were marked on 7.5 minute series topographic maps and all flags marking redd locations and reach delineations were removed.

Replicate counts were conducted on all reaches throughout the survey period in order to validate redd identification and assess sampling error. Replicate counts were conducted within four hours of the current weeks survey or from 1-3 days following the most recent survey. Replicate counts conducted within in four hours were capable of assessing error associated with under-counter (i.e. not observing or missing redds) and over-counting redds (i.e. flagging false or non-redds). Conversely, replicate counts conducted 1-3 days following a pass could only be used to validate redds and assess over-counting. Because new redds may have been excavated within the 1-3 day lag, under-counting could not be evaluated. All replicate counts were conducted by the same person in order to minimize observer variability as much as possible. Replicate counts were used to estimate the sampling error (standard deviation) for each reach. A confidence interval on all redds in the subbasin was derived by summing the sampling error for all reaches and then multiplying by the desired precision level coefficient (Ott 1983).

Tributaries and Non-Cooperative Reaches

Kelsey Creek and spawning channel, Canyon Creek, and Shackleford Creek, were periodically redd surveyed by FS personnel but no carcass surveys occurred in any of the tributaries. Furthermore, the upper Scott River from Ft. Jones to Callahan was divided into nine reaches (four from Callahan to Etna and five from Etna to Ft. Jones; Figure 2) and was surveyed over a two-day period (11-15 and 11-16). The total number of redds, adult salmon, grilse, and carcasses per reach were recorded. No replicate counts were conducted in any of the tributaries due to low spawner use but replicate counts were conducted in two upper river reaches receiving the most spawner use.

Water Temperature, Flow Data and Precipitation

Water temperature data for the fall spawning period was taken at two sites on the mainstem Scott River using continuously recording Ryan TempMentors sampling at two-hour intervals. Site one was located at the USGS Gage Station approximately 16 km (10 mi) downstream from Ft. Jones and site two was located at Johnson Bar River Access approximately 2.4 km (1.5 mi) above the Klamath-Scott confluence.

Flow data was obtained from the USGS Gaging Station at the above location, and precipitation amounts were obtained from the USFS weather station located at the Scott River District office in Ft. Jones.

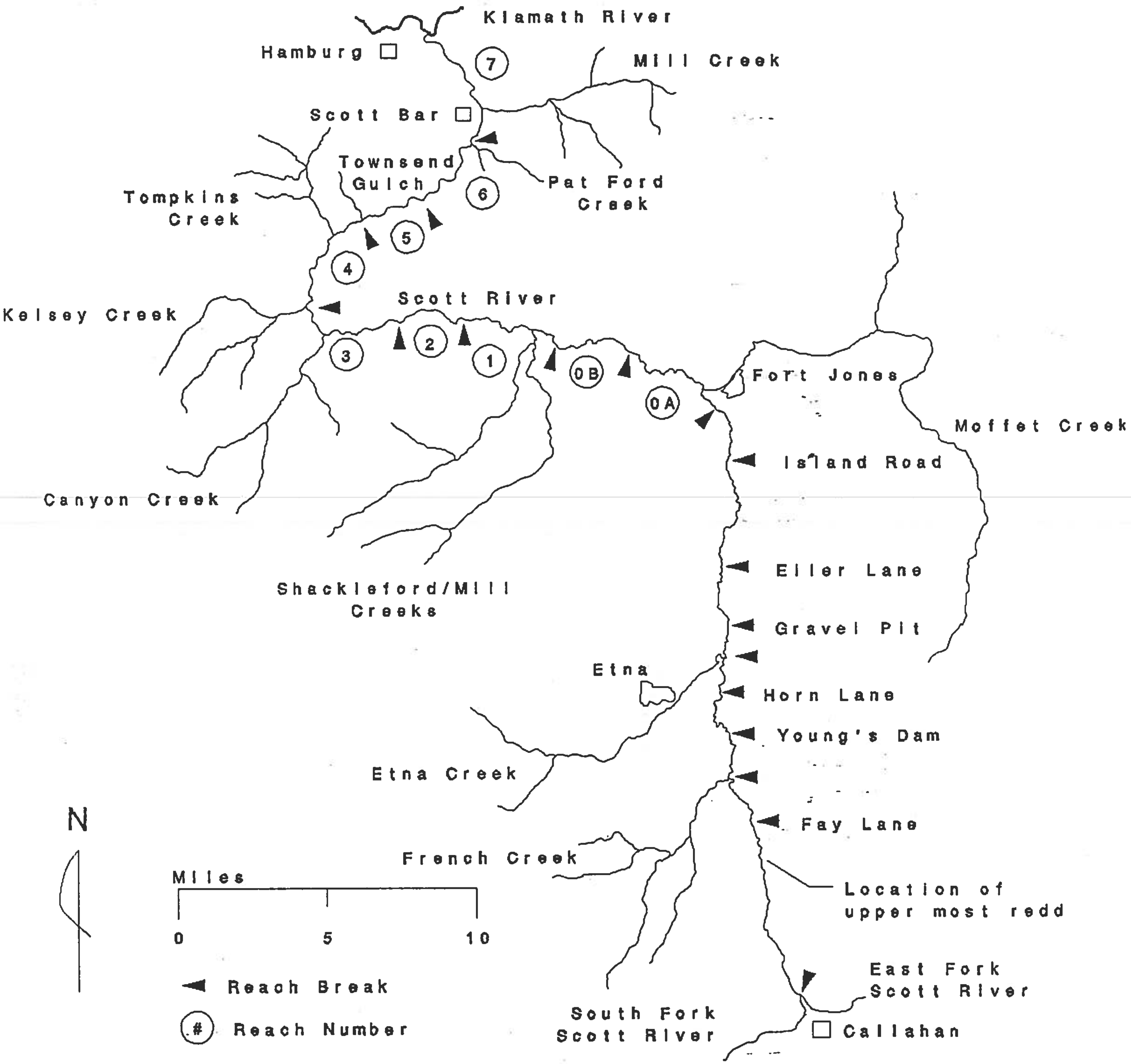
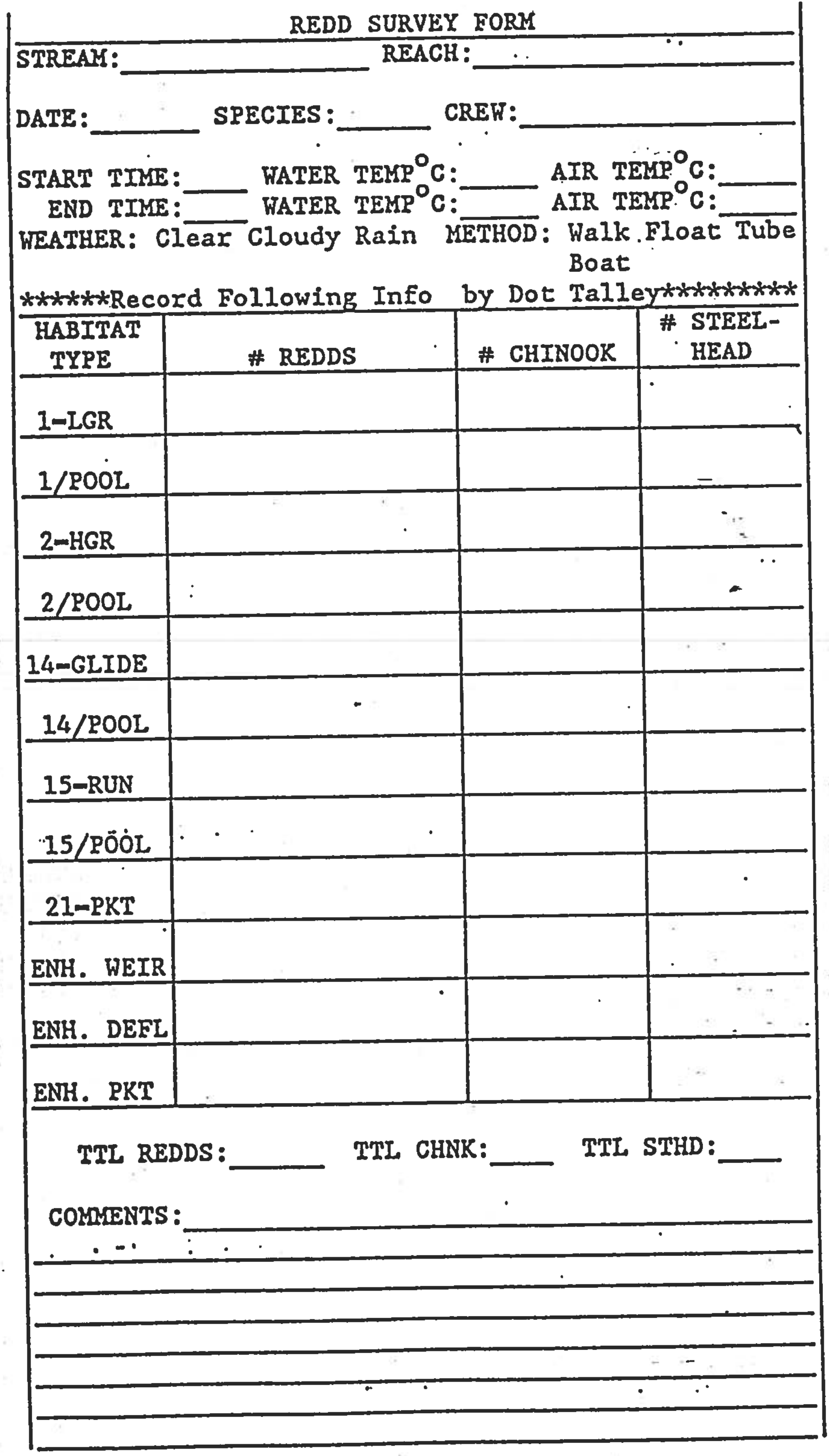


Figure 3. Reach delineations of the Scott River for the 1992 chinook salmon spawning survey.



REDD SURVEY FORM

STREAM:______________ REACH:______________

DATE:______ SPECIES:_____ CREW:______________

START TIME:____ WATER TEMP°C:_____ AIR TEMP°C:_____
END TIME:____ WATER TEMP°C:_____ AIR TEMP°C:_____

WEATHER: Clear Cloudy Rain METHOD: Walk Float Tube Boat

******Record Following Info by Dot Talley*********

HABITAT TYPE	# REDDS	# CHINOOK	# STEEL-HEAD
1-LGR			
1/POOL			
2-HGR			
2/POOL			
14-GLIDE			
14/POOL			
15-RUN			
15/POOL			
21-PKT			
ENH. WEIR			
ENH. DEFL			
ENH. PKT			

TTL REDDS:_____ TTL CHNK:____ TTL STHD:____

COMMENTS:______________

Figure 4. Field data form for the 1992 chinook salmon spawning survey of the Scott River.

RESULTS

Redd surveys began on 13 October and ended 1 December 1992. Seven surveys were conducted during the eight week period with no survey the week of 3 November due to poor water clarity (secchi disc reading < 0.5 m) caused by runoff from late October rains. Table 1 summarizes the total number of redds in the subbasin by reach or tributary.

The earliest redds (two) were observed in reach 7 on 10 October with the peak of spawning occurring the first week of November. During the first three weeks of the survey, all redds (98) were constructed in the lower five reaches with 70% of these occurring in reach 7 (Figure 5). By week 6, 56% of all redds were located in reach 1 as salmon moved upstream in response to late October rains which raised the river stage 1.8 ft. The distribution of redds within each reach are located in Appendix B.

Spawner use by habitat was highly variable (Figure 6). Low gradient riffles (#1) and runs (#15) held 36% and 37%, respectively, of all redds constructed in the nine lower reaches (Table 3).

In the upper Scott River (Ft. Jones to Callahan), 126 adults, 45 grilse, and 8 carcasses were observed during the 15 and 16 November surveys (Table 2). The upper most salmon redds were located near Facey Gulch approximately 2 km (1.3 mi) upstream from the Fay Lane Bridge (Figure 3). The objective of these visual counts was to get a rough estimate of spawner escapement into the upper subbasin and determine the upper most point of spawner use. It is not intended to be a total escapement estimate for the upper Scott River.

Two separate replicate counts were conducted from Young's Dam to the mouth of Etna Creek on 22 and 28 November (one and two weeks after the initial survey). A total of 5 more redds were counted in the Young's Dam to Horn Lane reach and 3 more redds in the Horn Lane to Etna Creek reach; However, since redds were not flagged on the initial survey, these subsequent surveys were treated as replicate counts to assess sampling error for the upper river.

Tributary spawning was limited to Canyon Creek and Shackleford Creek. All redds (6) in Canyon Creek were located in the lower 300 meters; furthermore, all these redds were constructed in gravel trapped by boulder weir structures. The five redds constructed in Shackleford Creek were located below the Quartz Valley Road bridge. Prior to 1 November, there was no surface flow from Shackleford into the Scott River. The late October rains made the creek accessible to salmon, but as flows receded, two of the five redds became 70% de-watered.

Water temperatures during the fall spawning period ranged from 16.8°C to 4.0°C at the USGS Gage station monitoring site and 17.1°C to 2.5°C at the Johnson Bar monitoring site (Figure 7).

Flow data for the first three months of the 1993 water year had not been posted at the time this report was compiled.

Table 1. The total number of chinook salmon redds counted in the Scott River subbasin by reach or tributary during the 1992 spawning survey.

Reach # and Description		Number of Redds
Cooperative Reaches:		
0A	Hwy 3 Bridge -- Gravel Pit	71
0B	Gravel Pit -- Meamber Bridge	20
1	Meamber Bridge -- USGS Gage Station	378
2	USGS Gage -- Jones Beach	32
3	Jones Beach -- Kelsey Bridge	44
4	Kelsey Bridge -- Townsend Gulch	8
5	Townsend -- George Allen Gulch	25
6	George Allen -- Pat Ford Creek	17
7	Pat Ford -- Klamath River	111
	Subtotal	706
Upper Scott River:		
Callahan -- Fay Lane Bridge		7
Fay Lane -- French Creek		12
French Creek -- Young's Dam		6
Young's Dam -- Horn Lane Bridge		38
Horn Lane Bridge -- Etna Creek		35
Etna Creek -- Gravel Pit Bridge		5
Gravel Pit Bridge -- Eller Lane		1
Eller Lane -- Island Road		0
Island Road -- Hwy 3 Bridge		0
	Subtotal	104
Tributaries:		
Kelsey Creek and Spawning Channel		0
Canyon Creek		6
Shackleford Creek		5
	Subtotal	11
	Subbasin Total	821 ± 60 (95%C.I.)

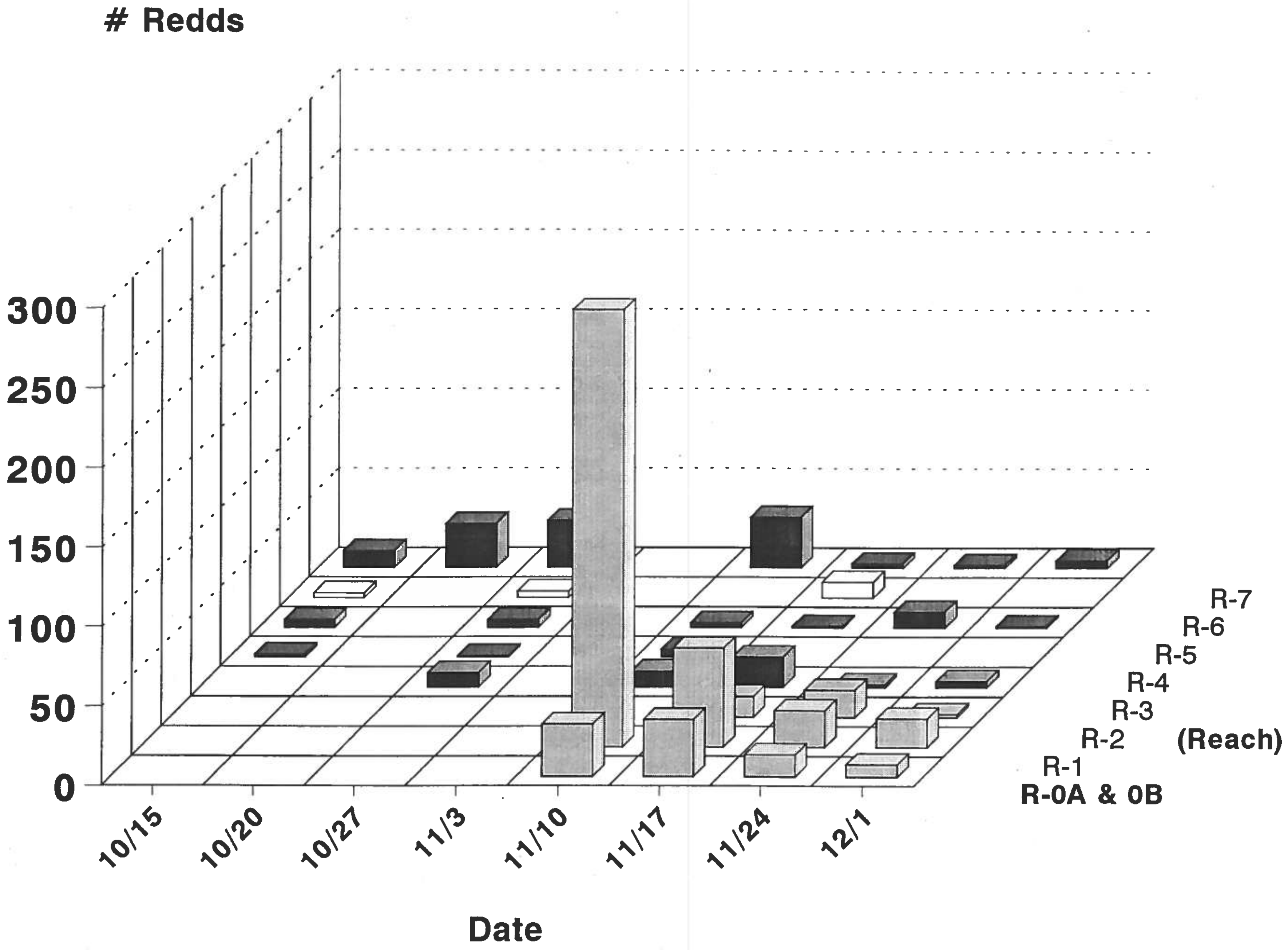
Table 2. Number of chinook redds occurring in each habitat type for all cooperatively surveyed reaches on the Scott River in 1992.

	Habitat Types									
Reach #	1	1-P	2	2-P	14	14-P	15	15-P	21	Total
0A	55				1		14	1		71
0B	14	1			2	1	2			20
1	111	2	1		70	19	168	7		378
2	14		1				17			32
3	22	2			3		15		2	44
4	2				3		2	1		8
5	3		1		3		14	3	1	25
6	1	2		1	7	3	3			17
7	34	6	9	1	15	8	24	14		111
Totals	256	13	12	2	104	31	259	26	3	706

Table 3. Numbers of redds, adult chinook, grilse, and carcasses observed in the upper Scott River during the 15 and 16 November, 1992 spawning survey.

Reach	Redds	Adults	Grilse	Carc
Callahan -- Fay Lane Bridge	7	9	4	1
Fay Lane Bridge -- French Creek	12	14	9	1
French Creek -- Young's Dam	6	3	1	1
Young's Dam -- Horn Lane Bridge	38	56	22	2
Horn Lane Bridge -- Etna Creek	35	33	9	3
Etna Creek -- Gravel Pit Bridge	5	4	0	0
Gravel Pit Bridge -- Eller Lane	1	4	0	0
Eller Lane -- Island Road	0	2	0	0
Island Road -- Hwy 3 Bridge	0	1	0	0
Total	104	126	45	8

Note: These numbers are not a total escapement estimate for the upper Scott River.



Note: No survey on 11/3 due to poor water clarity.

Figure 5. Temporal and spatial distribution of chinook salmon redds in the lower nine reaches of the Scott River in 1992.

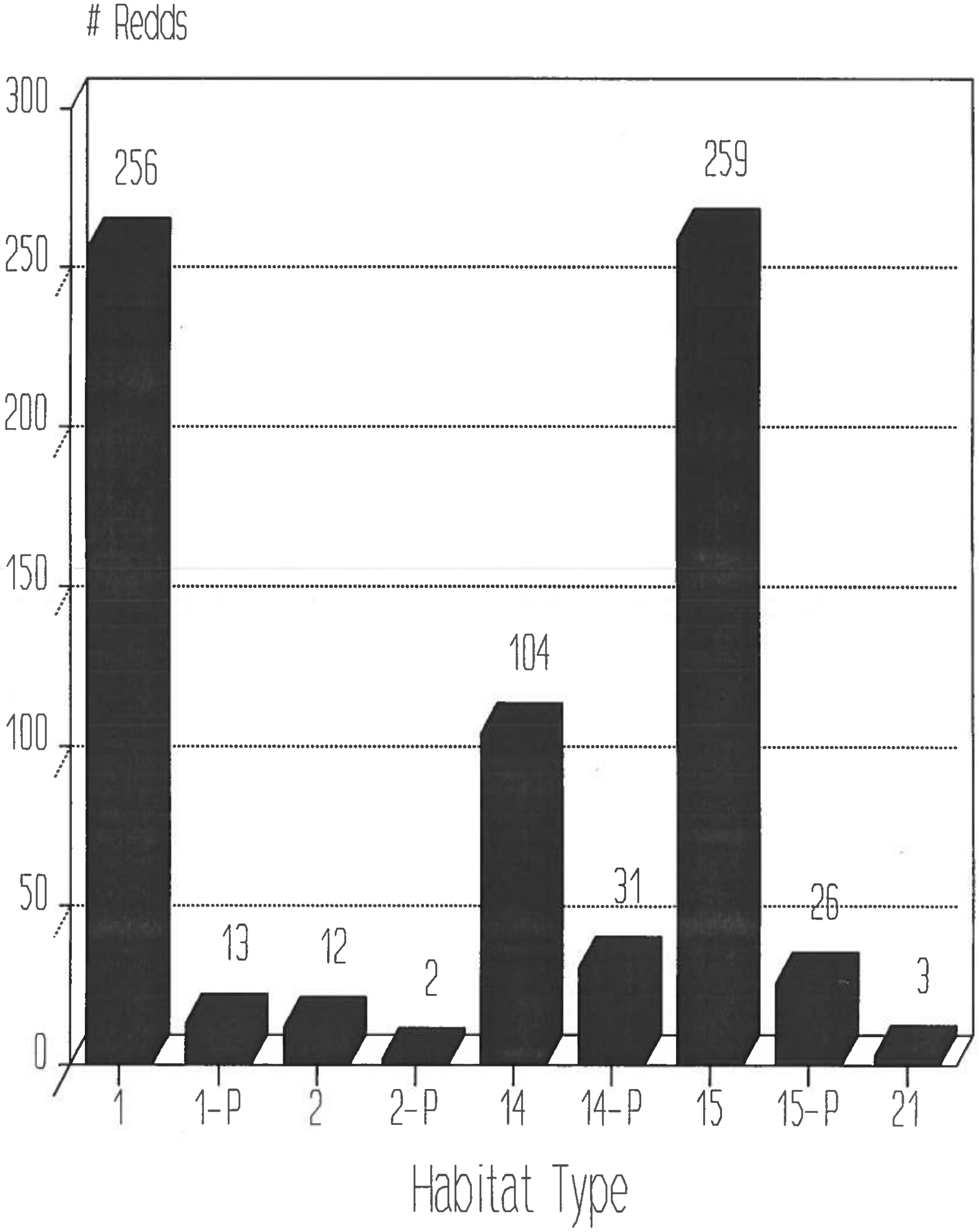


Figure 6. Total number of chinook salmon redds occurring in each habitat type for the nine lower reaches of the Scott River in 1992.

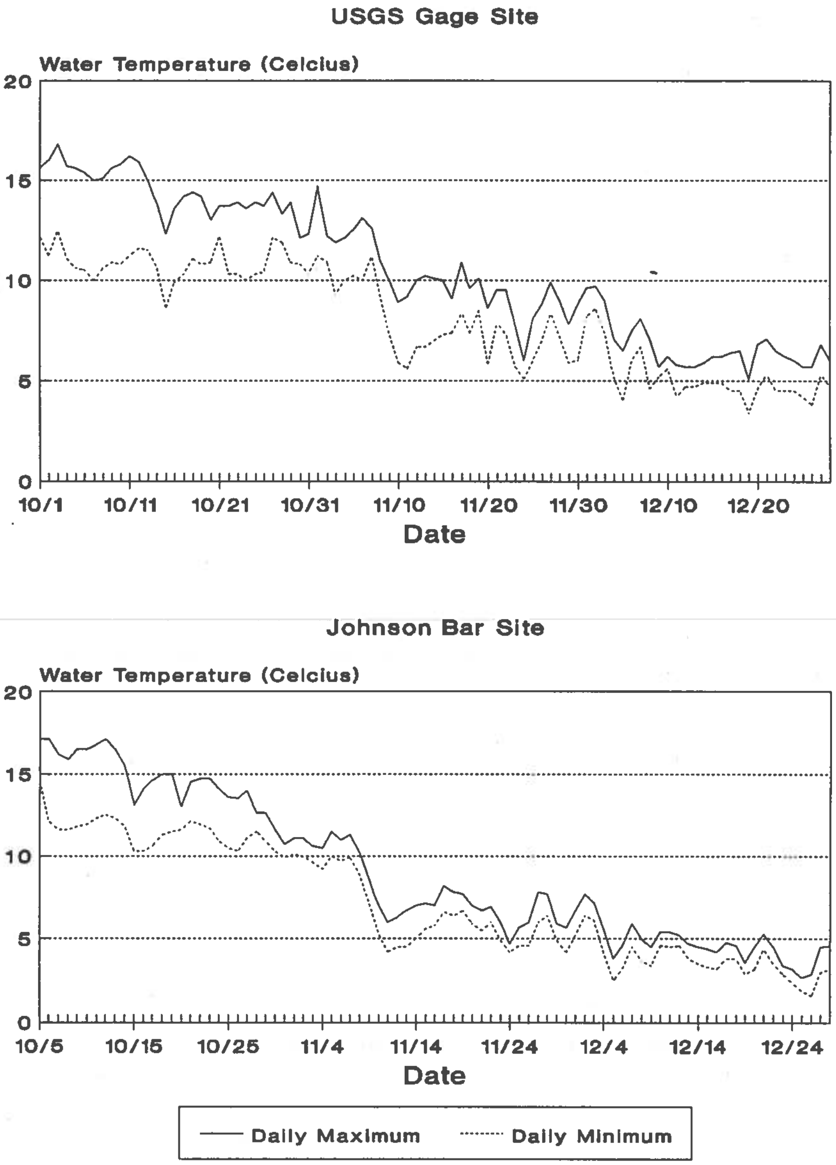


Figure 7. Daily maximum and minimum water temperatures for the Scott River measured during the 1992 chinook salmon spawning period.

DISCUSSION

Temporal and spatial distribution of redds in the Scott River subbasin in 1992 appeared to be influenced most by precipitation and its effect on flows (Figure 8). Prior to 30 October, large numbers of salmon were observed in the lower reaches (Kelsey Creek to the Klamath) with the greatest concentrations observed in the two lowest reaches (6 and 7). After receiving 1.7 inches of rain from 27 October to 2 November, salmon were most abundant in reaches 1 and 2 which resulted in reach 1 having 54% of the redds in the lower river and 43%-50% of the estimated total number of redds in the entire subbasin. FS spawning surveys in past years have not included this reach but an aerial survey of the entire Scott River conducted in 1962 indicated this reach was a principal spawning area as well as the upper river section from Etna Creek to French Creek (Figure 6). Comparing Table 1 with Figure 6 it appears that spawning areas receiving high use in 1992 are much the same as those in 1962.

The concentrated use of spawning habitat in reach 1 caused partial superimposition of numerous redds in several locations which most likely will reduce survival to emergence as embryos are dislodged from the gravel by subsequent redd excavation and washed downstream. Based on casual observations of substrate composition, spawning gravel appear to have an abundance of sand. Core samples taken in this reach in 1989 indicated that percent fines (particles ≤6.4 mm) averaged 34 percent (Sommarstrom et al. 1990). Using the regression equation developed by Cederholm (1982), predicted survival to emergence rates would range from 0 to 40 percent (95% C.I.); However, more local information on survival to emergence is needed to accurately assess habitat quality in terms of embryo survival.

Other potential detriments to spawning and embryo survival were observed. In reach 0A (Hwy 3 Bridge to the Gravel Pit Bridge), ATV and 4-wheel drive vehicle tracks crossed the channel in numerous locations. Many of these crossings were on top of newly constructed redds. Since adjacent land ownership in this reach is all private, some public education prior to the spawning season may help to raise awareness levels thereby reducing impacts.

Substrate disturbance was also noted in the lower river (Scott Bar to river-km 4 [mile 2.5]). Suction dredging resulted in piles of spawning gravel protruding up to 1 meter above the water surface. Most of these are unavailable to spawning salmon given the low flows. Some are used for spawning as rising water levels inundate the gravel piles, but a subsequent drop in flows partially or completely de-waters the redd killing the developing embryos. This problem is exacerbated by the lack of "normal" or high spring flows which usually have enough energy to level the tailing piles. The result is an accumulation of tailing mounds that are more susceptible to de-watering as flows fluctuate. A possible solution to this problem would be to require dredging permittees to flatten their tailing piles to within one-half a foot of the undisturbed streambed elevation at the end of each operating season.

Previous Year Comparisons

Comparing 1992 spawning data with previous years is difficult because the 1992 survey covered more reaches than past surveys (Figure 10). For example, in examining Figure 10 it appears that more spawning occurred in 1991 than 1992, but it is unknown what portion of the 1991 spawning took place above reach 3. Conversely, CDFG spawning escapement estimates show that escapement in 1992 (preliminary 2,581) is up slightly over 1991 returns (2,165; (CDFG 1992). The CDFG estimate is probably a more accurate index since carcass surveys included the upper river reaches.

Only 29% of the redds in 1992 occurred in the reaches below Jones Beach (i.e., in the Klamath National Forest). This percentage certainly varies from year to year due to variation in timing and intensity of fall rains, river flows, and run-timing. For example, in years with low flows and little or no fall precipitation, salmon encounter more low water obstacles which may hinder or slow upriver migration. Consequently, more spawning would take place lower in the system during these years. Figure 10 indicates that 1988 may have been this type of year. September and October precipitation only totaled 0.14 inches in 1988, and mean monthly flows were 11.9 cfs and 27.3 cfs, respectively, for the same months. For the same period in 1989, precipitation totaled 4.05 inches and mean monthly flows were 32.1 cfs and 140 cfs, respectively, for September and October.

In the short term, it's hoped that funding levels will continue to support cooperative efforts such as this in order to better assess spawning escapement on a subbasin scale. But for the long range, the aspiration is to see run sizes return to levels where these surveys are no longer needed.

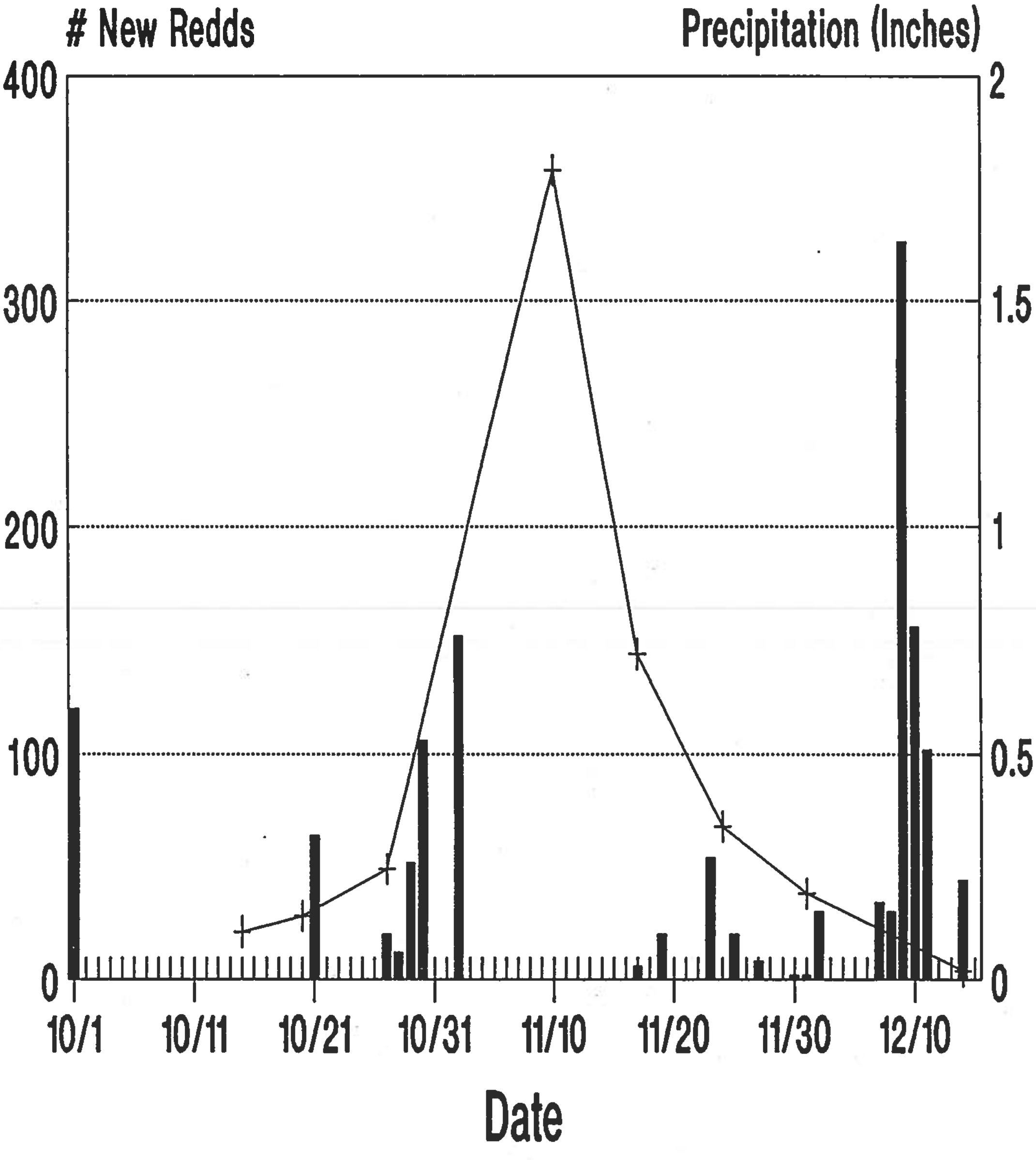


Figure 8. The timing of chinook salmon redd construction in relation to precipitation received on the Scott River for 1992. (Precipitation amounts measured at Ft. Jones weather station).

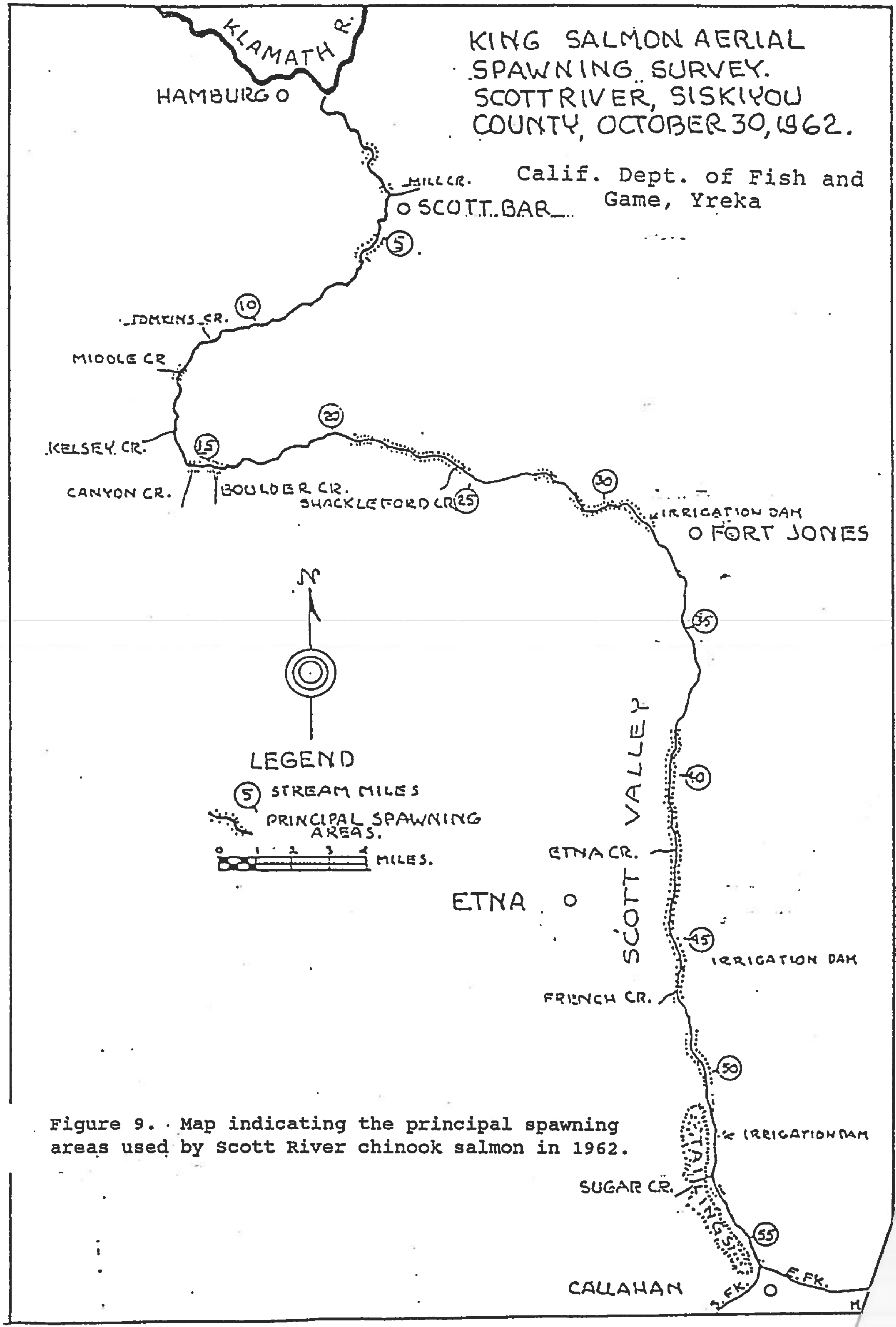


Figure 9. Map indicating the principal spawning areas used by Scott River chinook salmon in 1962.

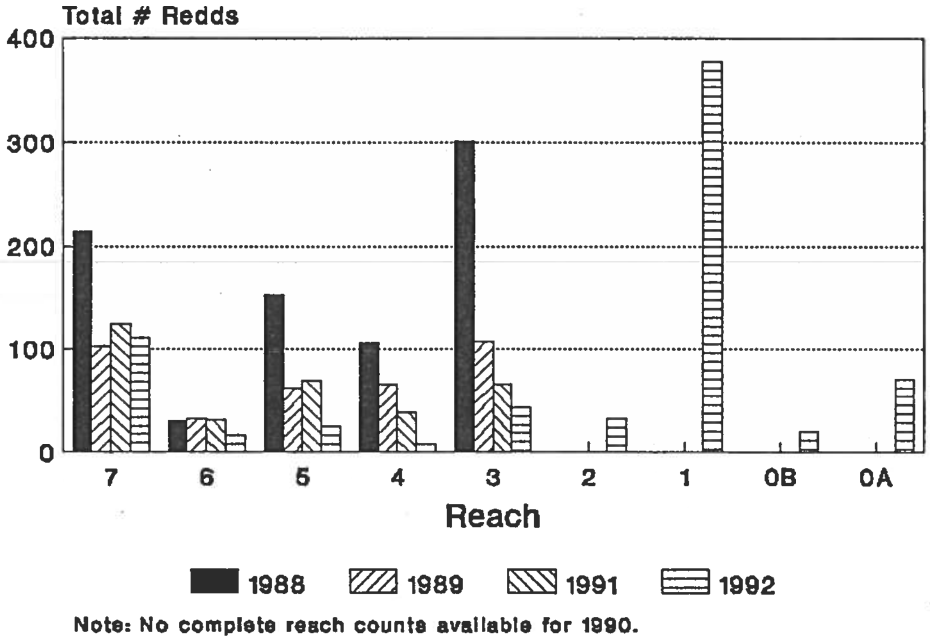


Figure 10. Total number of chinook salmon redds occurring in each reach of the Scott River for 1988, 1989,1991, and 1992.

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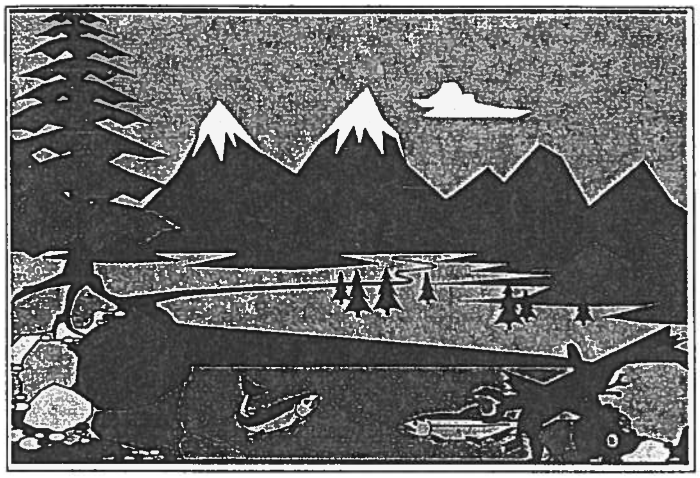
Appendix A

Modified Bisson Habitat Classification Scheme



FHR CURRENTS...

R-5's FISH HABITAT RELATIONSHIPS TECHNICAL BULLETIN

NUMBER ONE

FHR Currents . . . Purpose

The Fish Habitat Relationships (FHR) Program of R-5 USFS has been established to research and develop information on fish ecology and to coordinate effective applications of this knowledge in managing and protecting our fisheries. By relating life stage requirements of specific species to physical habitat parameters, we are aiming at our main objective: developing a methodology to manage fisheries through the management of habitat.

STREAM HABITAT CLASSIFICATION AND INVENTORY PROCEDURES FOR NORTHERN CALIFORNIA

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Introduction

The objective of this bulletin is to describe a stream habitat inventory procedure that will classify and quantify fish habitat in terms of channel features. The procedure is based on information gathered in gravel and boulder-bed streams in the western Cascade Mountains of Oregon and Washington and in the Klamath Mountains of California (Bisson et al., 1981; Sullivan, 1986; Grant et al., in review; Decker et al., in progress). A stream habitat inventory as outlined here can give information on the sequence, distribution, and availability of pool, riffle and run habitat units, and yields a graphic picture of the stream channel (Figure 1). Areas which may be limited in terms of specific habitat (spawning, rearing, etc.) can be identified.

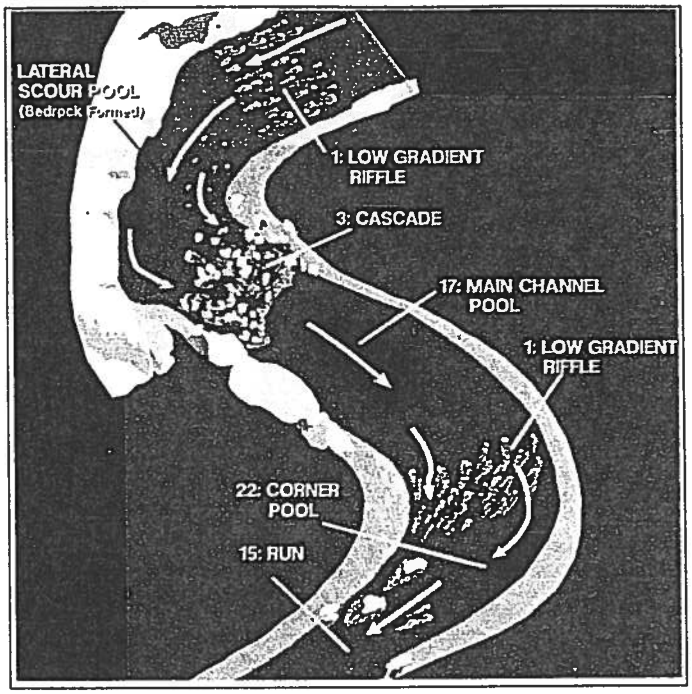


Figure 1. Illustrated above are habitat types in association with channel features such as: logs, boulders, gradient, bedrock and meanders.

Present day fishery management is very complex, involving several different agencies, user groups and land managers. While millions of dollars are being spent annually to restore and enhance anadromous fisheries, man's effect on stream habitat is increasing through the ever growing demands on timber, water, and other resources. A key to effectively protecting, maintaining, restoring, and enhancing anadromous fisheries in light of these demands is an understanding of the relationships between physical habitat parameters (e.g. channel morphology) and fish production factors (food and habitat requirements) for all age classes of each species for the duration of stream residency. Habitat requirements of anadromous salmonids rearing in streams are known to differ between species, age classes, and seasons (Everest and Chapman, 1972; Reiser and Bjornn, 1979).

Because of the diversity in management groups, several different habitat survey or assessment techniques are employed in northern California. This lack of standardization complicates the comparison of information between agencies and often creates barriers in developing and implementing efficient management strategies. This bulletin outlines a standardized habitat assessment procedure with built in flexibility to be workable with varying budgets and manpower.

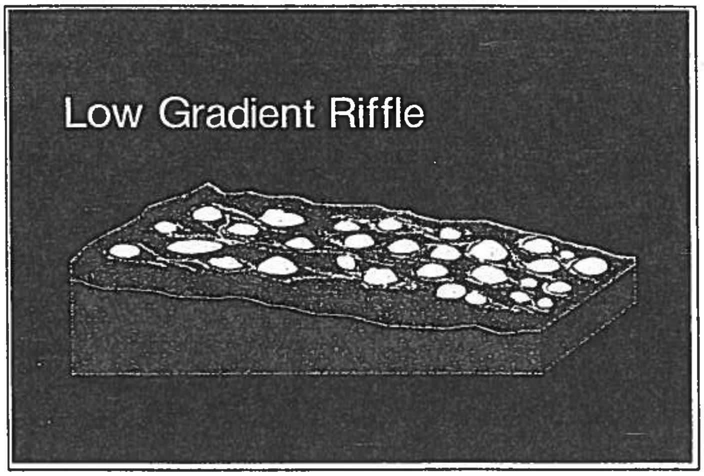
Background

This system of naming habitat is derived from work on stream channel morphology, pool-riffle and step-pool formation, and fish habitat utilization in western Washington and Oregon (Bisson et al., 1981; Sullivan, 1986; Grant et al., in review). The development of pool-riffle or step-pool sequences is a fundamental stream channel process (Ying 1971). These main channel features, along with others formed by smaller scale local effects (e.g. logjams and slides), can be recognized as distinct channel units or habitat types. A total of 22 habitat types have been identified and delineated in northern California to date as the refinement of the system continues *(figure 2, following pages).*

Figure 3 illustrates how the 22 types are classified. Three categories (proceeding from shallow to deep water) are riffles, runs and pools. All of the 22 types are members of the 3 main categories. Riffles are differentiated on the basis of water surface gradient. Pools are differentiated at two levels: (1) the position of the pool in the stream channel (secondary channel, backwater, lateral, or main channel), and then (2) the cause of the scour (obstruction, blockage, constriction, or merging flows). Run habitat types have low gradients, and are differentiated on the basis of depth and velocity. The five-pointed star plots of each type in *Table 1* illustrate the ratio of five physical habitat variables (mean depth, width, and length, and area and volume) for Hurdygurdy Creek, California. The pattern of the starplot describes the "mean shape" of the habitat types. Types with similar star plots have similar morphometry.

Generally, a given stream won't contain all 22 habitat types, instead the mix will be dominated by a few habitat types which are reflective of the overall channel gradient, flow regime, cross-sectional profile, and substrate particle size. (Grant et al. in review) found that the mix of habitat types in western Cascade streams with gradients in excess of 2% and large boulder substrate consisted of 4 types: pool, riffle, rapid, and cascade. Bisson et al. (1981) recognized 14 distinct habitat types in small streams with gradients less than 2%. Basins that exhibit a wide range in channel gradient will also have a

Figure 2. List of 22 habitat types in Northern California.

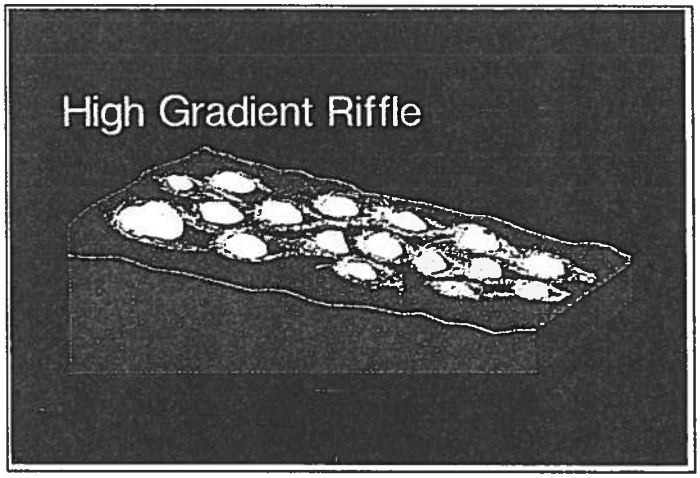


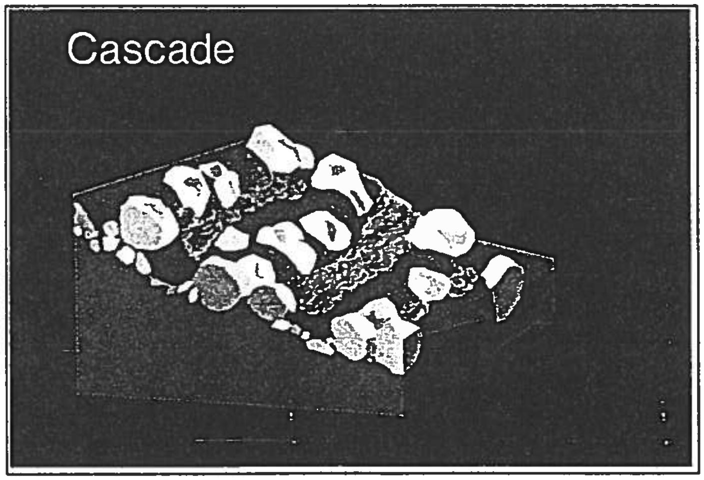
1 — Low Gradient Riffles "LGR"

Shallow reaches with swiftly flowing, turbulent water with some partially exposed substrate. Gradient < 4%, substrate is usually cobble dominated.

2 — High Gradient Riffles "HGR"

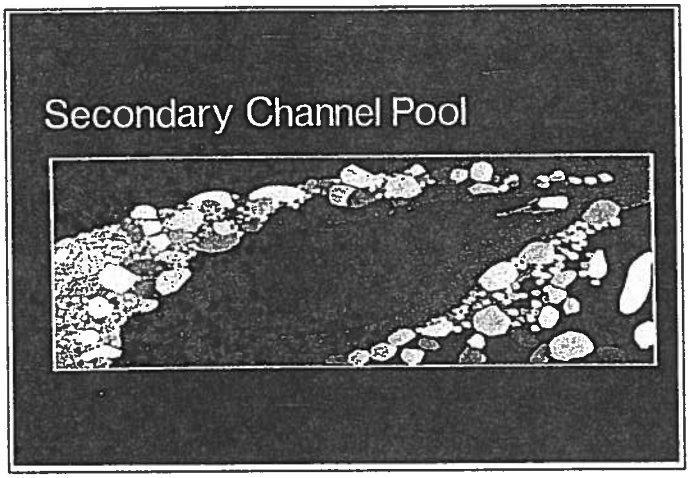
Steep reaches of moderately deep, swift, and very turbulent water. Amount of exposed substrate is relatively great. Gradient is > 4%, and substrate is boulder dominated.





3 — Cascade "CAS"

The steepest riffle habitat, consists of alternating small waterfalls and shallow pools. Substrate is usually bedrock and boulders

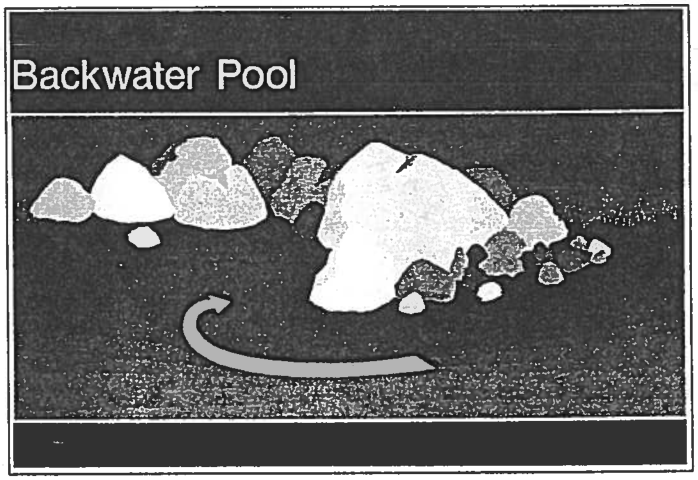

Secondary Channel Pool

4 — Secondary Channel Pool "SCP"

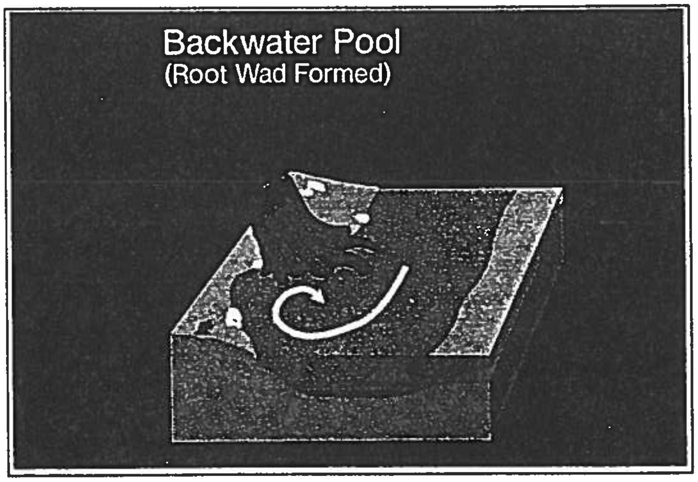
Pools formed outside of the average wetted channel. During summer these pools will dry up or have very little flow. Mainly associated with gravel bars and may contain sand and silt substrates.

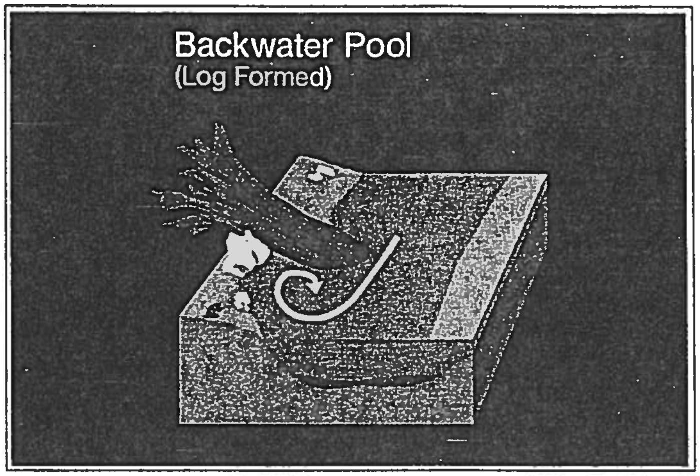
5 — Backwater Pool "BWP"
Boulder Formed

Found along channel margins and caused by eddies around obstructions such as boulders, rootwads, or woody debris. These pools are usually shallow and are dominated by fine-grain substrates. Current velocities are quite low.

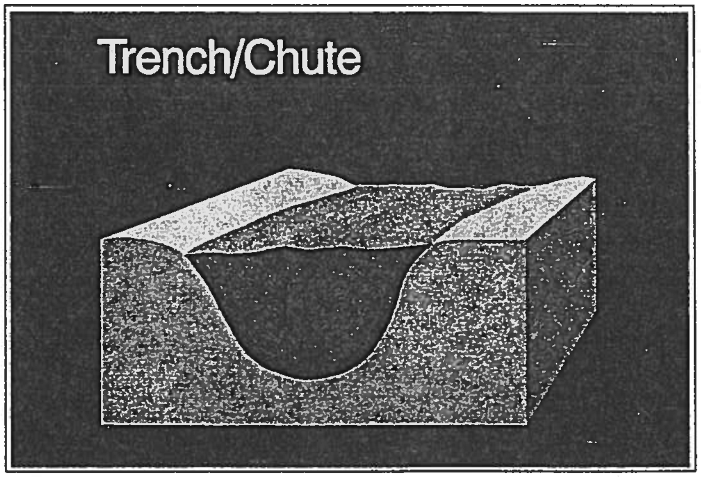

Backwater Pool

6 — Backwater Pool "BWP"
Root Wad Formed


Backwater Pool
(Root Wad Formed)



**7 — Backwater Pool "BWP"
Log Formed**

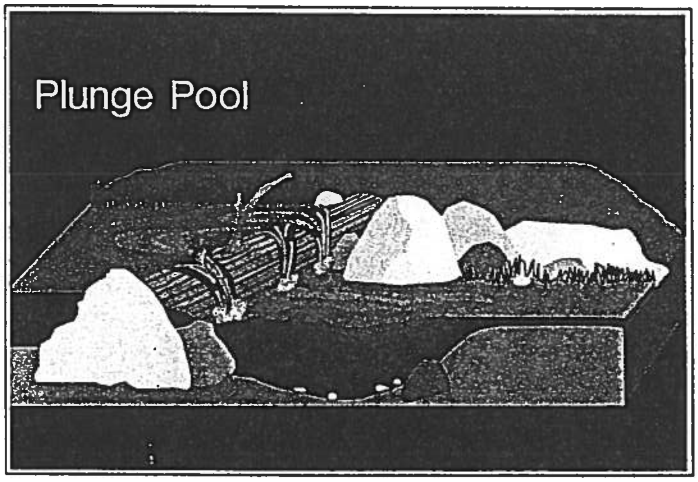


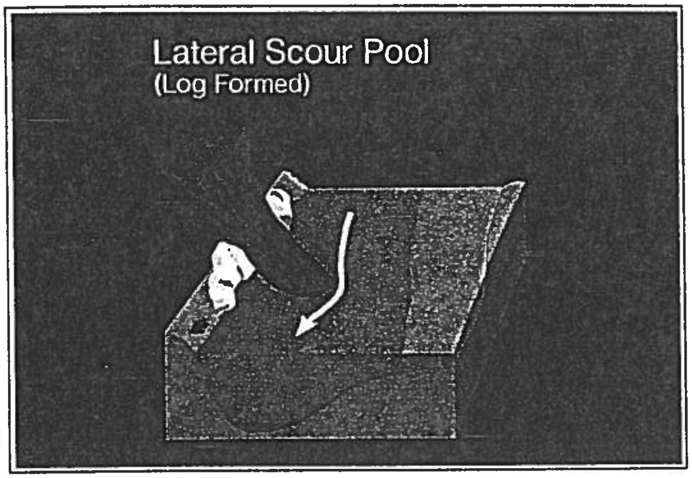
8 — Trench/Chute "TRC"

Channel cross sections typically U-shaped with bedrock or coarse grained bottom flanked by bedrock walls. Current velocities are swift and the direction of flow is uniform. May be pool-like.

9 — Plunge Pool "PLP"

Found where stream passes over a complete or nearly complete channel obstruction and drops steeply into the streambed below, scouring out a depression, often large and deep. Substrate size is highly variable.

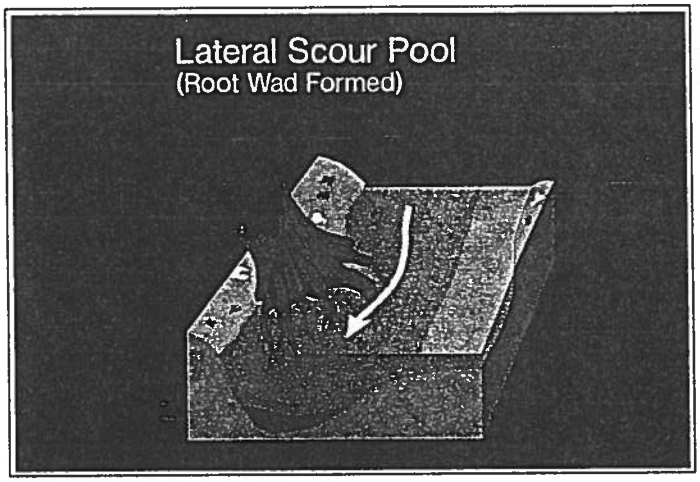




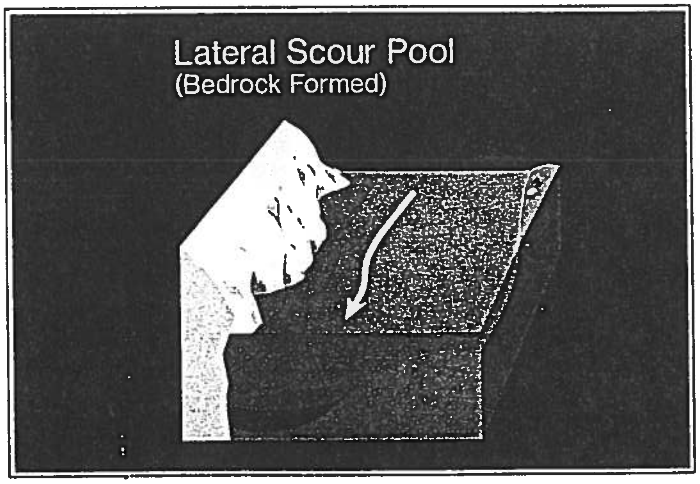
10—Lateral Scour "LSP" Log Formed

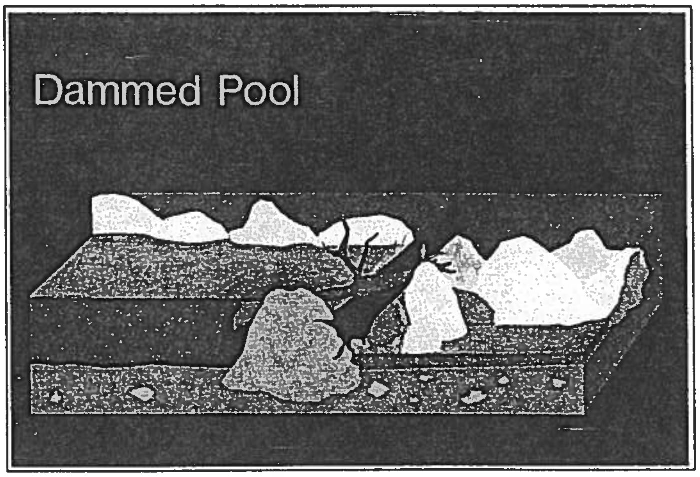
Formed by flow impinging against one stream bank or against a partial channel obstruction. The associated scour is confined to < 60% of wetted channel width. Channel obstructions include rootwads, woody debris, boulders, and bedrock.

11 — Lateral Scour Pool "LSP"
Root Wad Formed



12 — Lateral Scour Pool "LSP"
Bedrock Formed



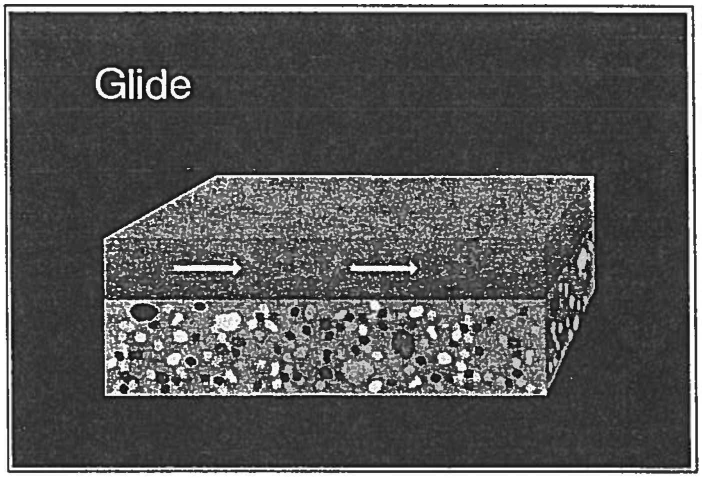


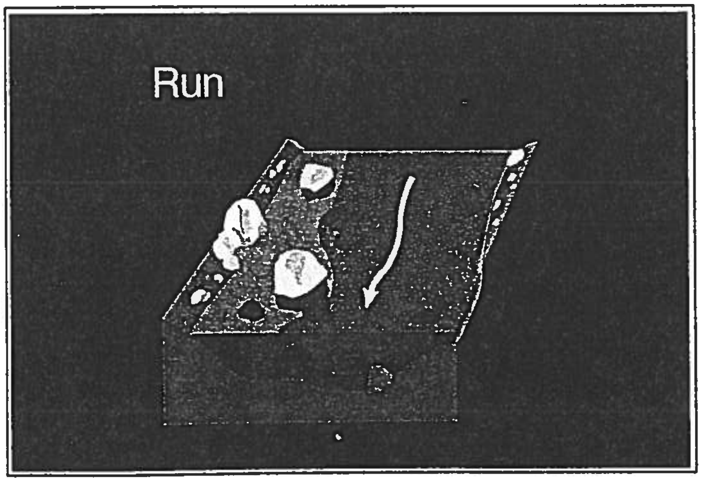
13 — Dammed Pool "DPL"

Water impounded from a complete or nearly complete channel blockage (debris jams, rock landslides or beaver dams). Substrate tends toward smaller gravels and sand.

14 — Glides "GLD"

A wide shallow pool flowing smoothly and gently, with low to moderate velocities and little or no surface turbulence. Substrate usually consists of cobble, gravel and sand.



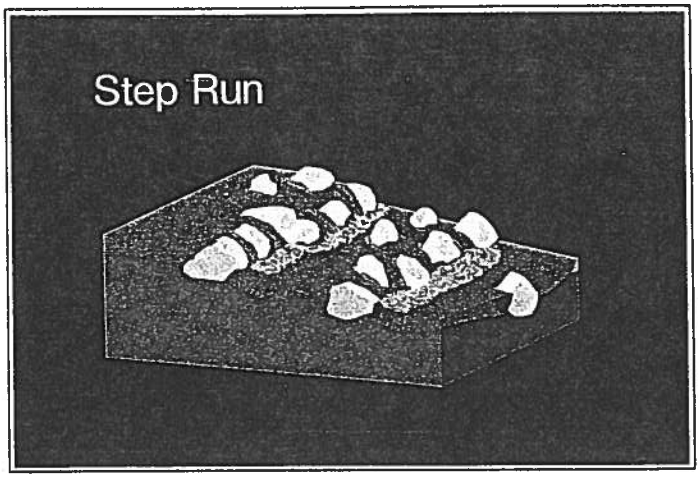


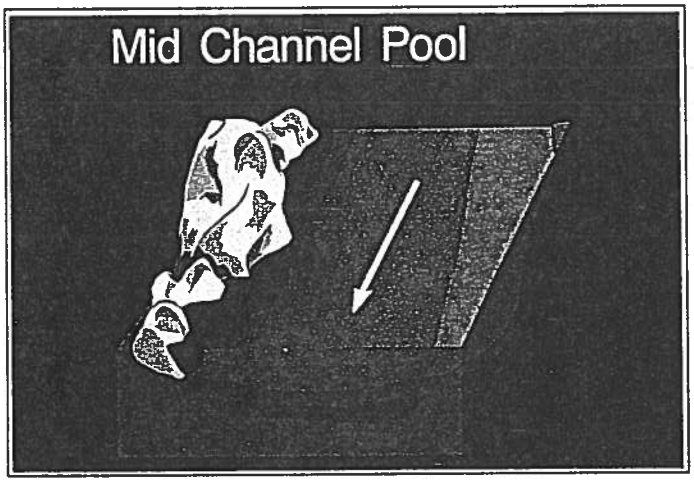
15 — Run "RUN"

Swiftly flowing reaches with little surface agitation and no major flow obstructions. Often appears as flooded riffles. Typical substrates are gravel, cobble and boulders.

16 — Step Run "SRN"

A sequence of runs separated by short riffle steps. Substrates are usually cobble and boulder dominated.



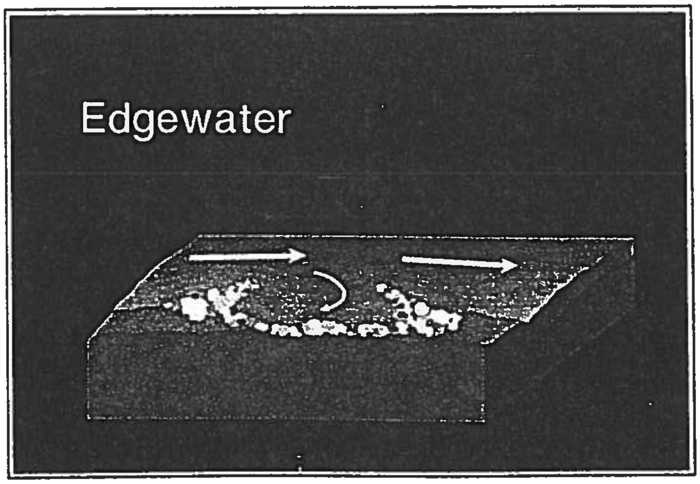


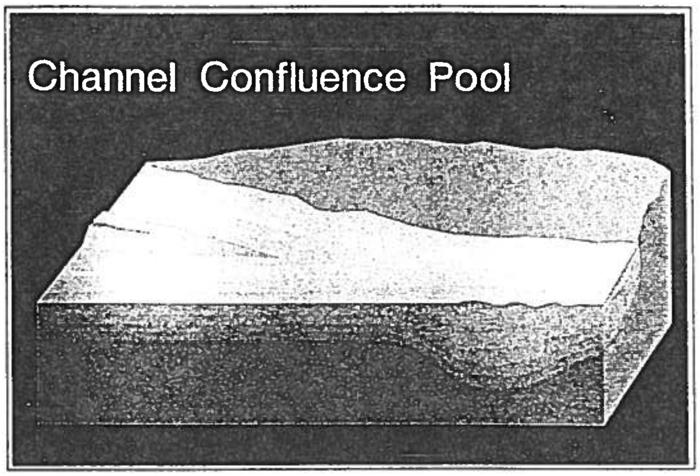
17 — Mid-Channel Pool "MCP"

Large pools formed by mid-channel scour. The scour hole encompasses more than 60% of the wetted channel. Water velocity is slow, and the substrate is highly variable.

18 — Edgewater "EGW"

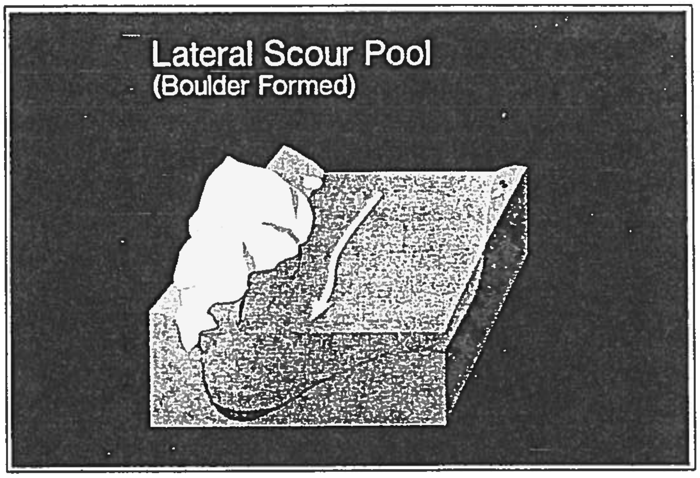
Quiet, shallow area found along the margins of the stream, typically associated with riffles. Water velocity is low and sometimes lacking. Substrate varies from cobbles to boulders.





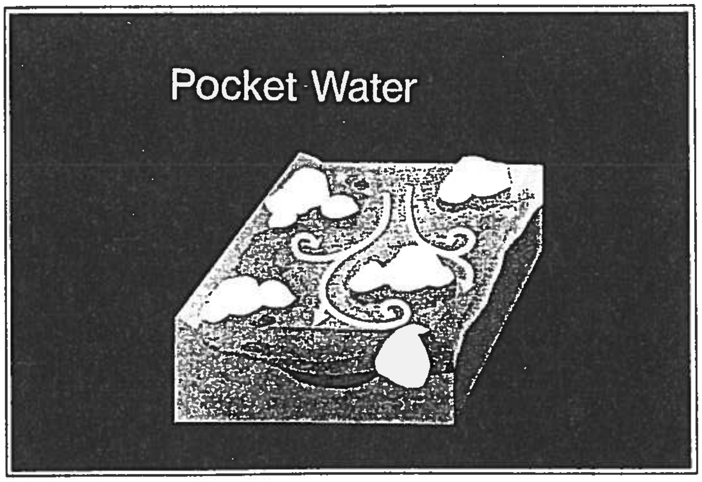
19 — Channel Confluence Pool "CCP"

Large pools formed at the confluence of two or more channels. Scour can be due to plunges, lateral obstructions or downscour at the channel intersections. Velocity and turbulence are usually greater than those in other pool types.



20 — Lateral Scour Pool "LSP" Boulder Formed

Formed by flow impinging against boulders that create a partial channel obstruction. The associated scour is confined to < 60% of wetted channel width.

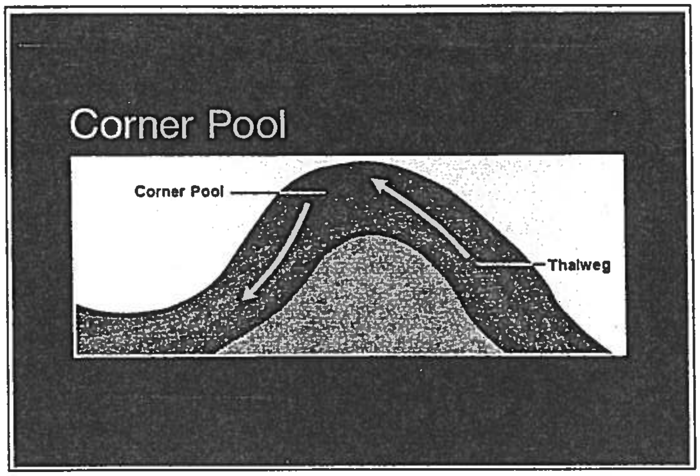


21 — Pocket Water "POW"

A section of swift flowing stream containing numerous boulders or other large obstructions which create eddies or scour holes (pockets) behind the obstructions.

22 — Corner Pool "CRP"

Lateral scour pools formed at a bend in the channel. These pools are common in lowland valley bottoms where stream banks consist of alluvium and lack hard obstructions.



broad mix of habitat types. Stratifying such a basin by gradient and confinement is therefore suggested to aid in predicting the location of certain habitat types (see Rosgen, 1985).

Procedures

Inventory Scale

In assessing habitat for a stream reach or an entire basin, the intent is to gather information that will adequately describe the area of interest. Conducting a habitat inventory can be time consuming, so work must be carried out quickly and efficiently. The level or scale of inventory to be employed is dependent on the project objectives. We have employed this system at two scales: basin level and project level. Basin level habitat classification is on the scale of a stream's naturally occurring pool-riffle-run units, where habitat unit size depends on stream size and order. As a general rule in a basin level inventory, homogeneous areas of habitat that are approximately equal or greater in length than one channel width are recognized as distinct habitat units. In comparison, project level habitat assessment operates on a scale of less than one channel width for use on reaches of intense management or study. Project level habitat typing is used to evaluate and quantify changes in habitat as the result of fish habitat restoration/enhancement projects (*figure 4*). This information, in combination with juvenile rearing population estimates or spawning ground surveys, documents and quantifies the project's ability to provide the necessary habitats for fish production. Project level habitat size delineation depends on the nature and objectives of the particular study or work being done, which depends on the niche, size, life stage(s), etc. of the targeted species. Both levels use the same habitat types (*figure 2*).

Data Collection

Habitat typing can be accomplished efficiently by two or three field people. Describing and measuring all 22 habitat types is very labor intensive; an average of one mile per day can be accomplished by trained surveyors. Decisions are best reached by a consensus among the team after a discussion of the facts. This approach balances out the biases inherent in each observer and insures quality in the data collected.

The basic method of habitat typing is relatively simple. Starting at the mouth of a stream and working upstream insures a known starting point. Use a measuring device (tape, rod, optical rangefinder, or hip chain) to measure mean length and width of

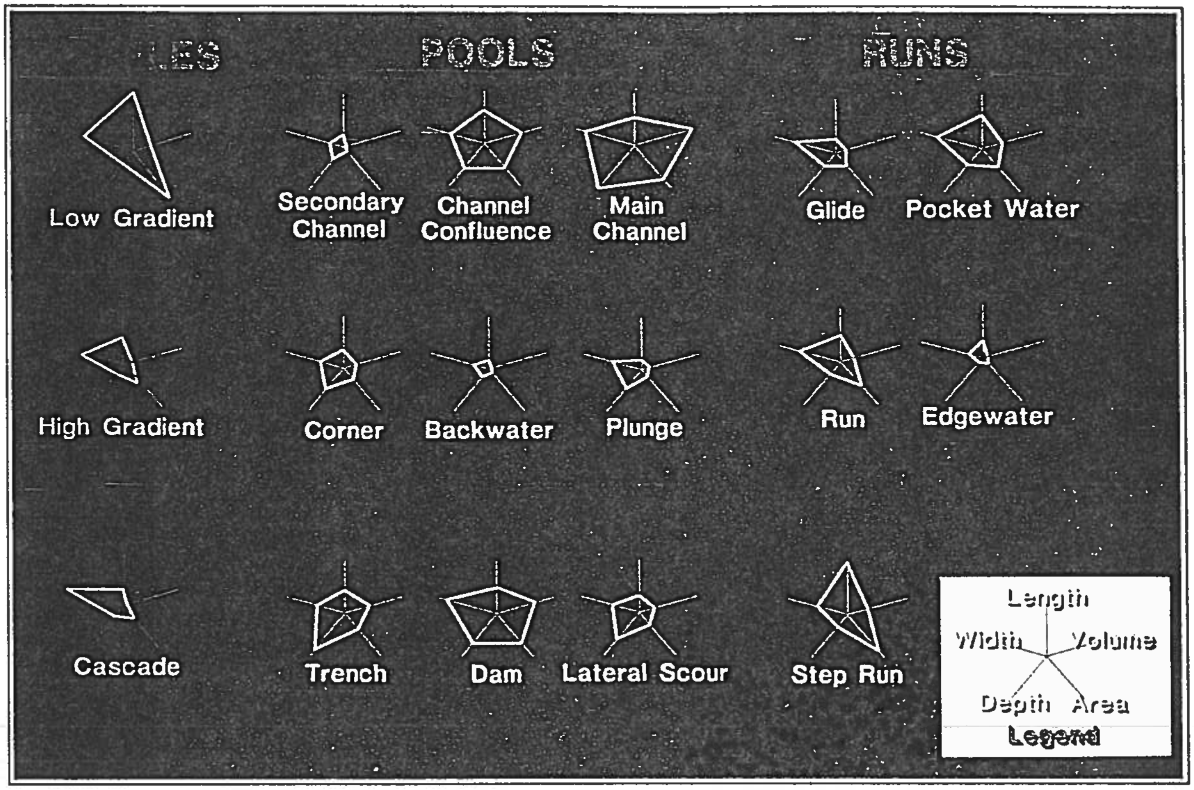


Table 1 —
Starplots of 5 main physical habitat variables. These show ratios of: mean depth, width, length, area and volume for each habitat type. Examples are from Hurdygurdy Creek, CA for Decker et al. 1984.

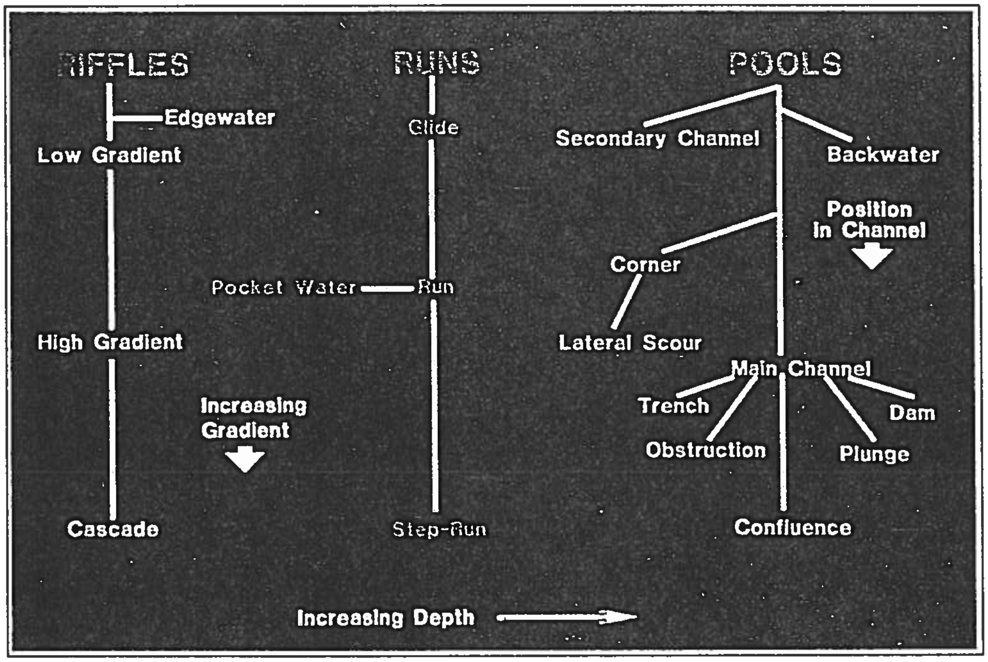


Figure 3 —
A diagram of the habitat classification system used for inventory in northern California.

each unit. Three to five width measurements are sufficient. Along each width measurement transect use a graduated leveling rod (or similar device) to take several depth measurements from bank to bank and estimate mean depth. If a significant portion (>10%) of the measured habitat includes exposed boulders and/or islands, that portion should be estimated and subtracted from calculations of area (total area - exposed area = wetted area). Other variables such as stream substrate, in-stream cover elements and abundance, canopy cover, riparian quality, etc. can be collected along with the habitat type data.

As with any classification system an occasional habitat unit may not fit distinctly into any one habitat type. In an inventory, a certain amount of subjective decision making is involved and accuracy depends heavily on a basic understanding of stream processes, a good knowledge of the classification system, and consistency (see Beschta and Platts, 1986; Lisle, 1986; and Ying, 1971).

Discussion

The basin level habitat classification and inventory procedures described will provide a channel descriptor of fish habitat availability (number, length, area, volume) and its relationship to channel features. Measurement of all 22 types gives a clear picture of the streams make-up, the type and quantity of scour forming material (logs, boulders, bed-

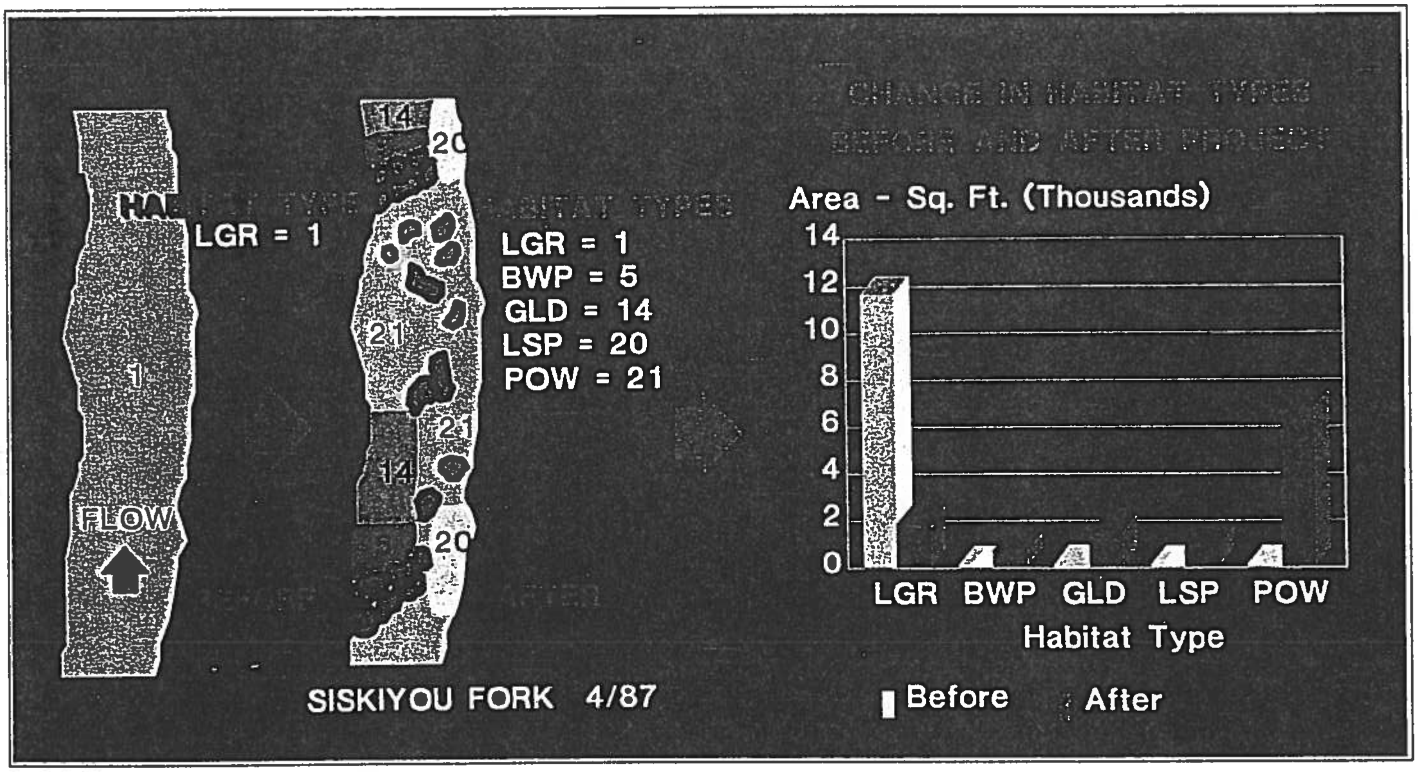


Figure 4 —
Project level habitat typing is utilized to quantify changes in specific habitat types resulting from habitat restoration/enhancement work.

rock, etc.) that governs the mix and availability of certain habitat units. When pairing this information with population estimates per habitat unit and with fish-habitat relationship studies, the manager has the basic data for limiting factor analysis and fish production estimates *(figure 5)*.

Fish-Habitat Relationship Studies

Models are being developed and tested by the Fish Habitat Relationships (FHR) program of the USFS to aid in predicting potential fish production in a basin. Physical and biological habitat variables such as depth, velocity, substrate, cover, temperature, and food availability are being investigated in terms of their relation and relative importance to fish distribution, abundance, and community structure. The links between biological attributes such as food availability, survival, growth, age structure and physical habitat attributes such as water velocity and temperature, channel morphology, substrate particle size distribution, and habitat complexity can help managers predict the potential impacts on the fishery from watershed disturbances (logging, mining, grazing, hillslope failures and slides). The database needed to build such a predictive model must include a standardized basin level inventory of fish populations and habitat availability (Parsons, 1984). Figure 6 illustrates seasonal critical habitat needs for different fish species and life stages, serving as a basis for determining factors limiting fish production and planning habitat restoration/enhancement projects.

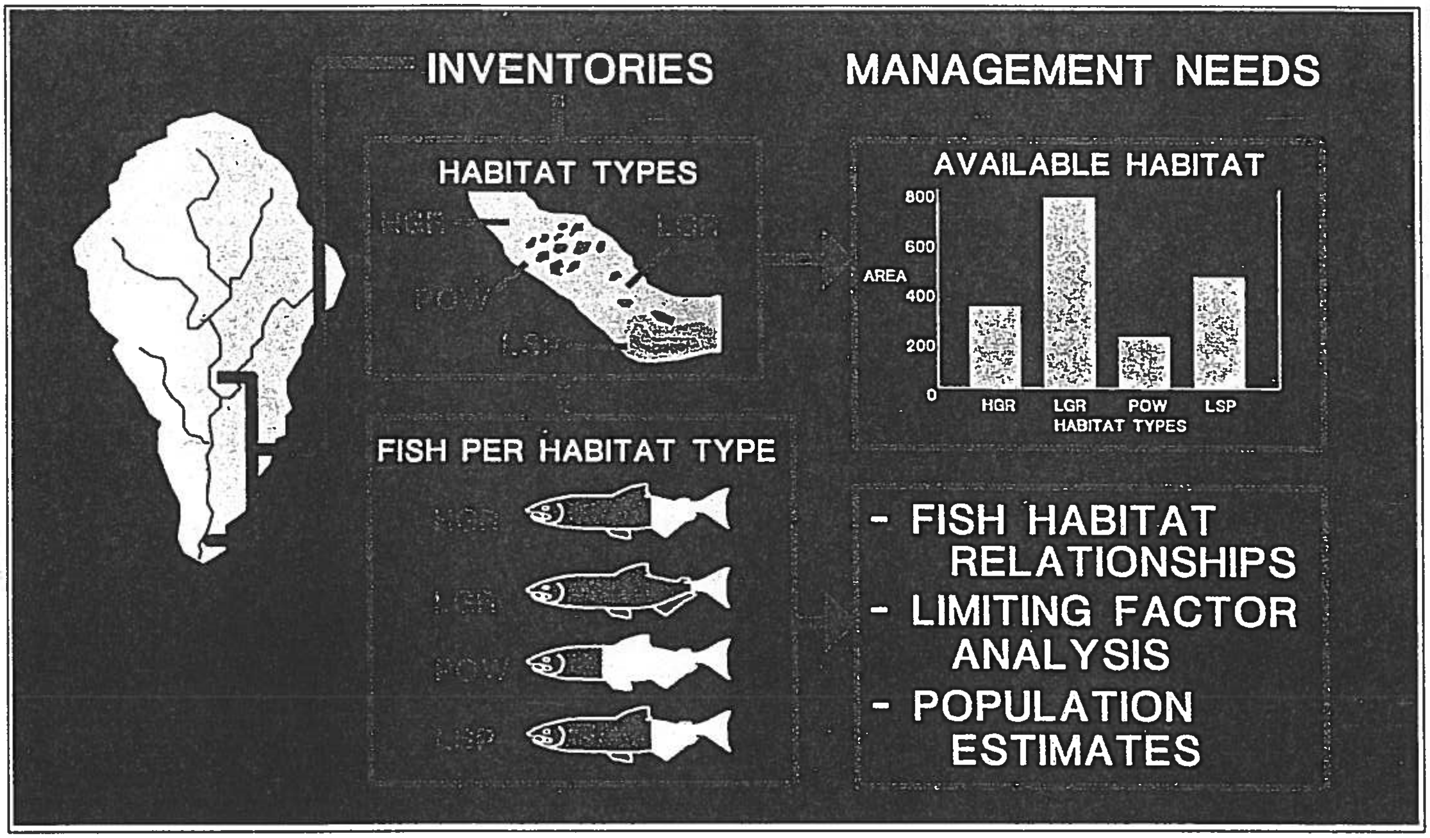


Figure 5 —
Habitat typing inventories, in conjunction with population estimates per habitat units, provide fishery managers with basic information (habitat availability, watershed fish production) for evaluating the status and potential of the watershed to produce fish.

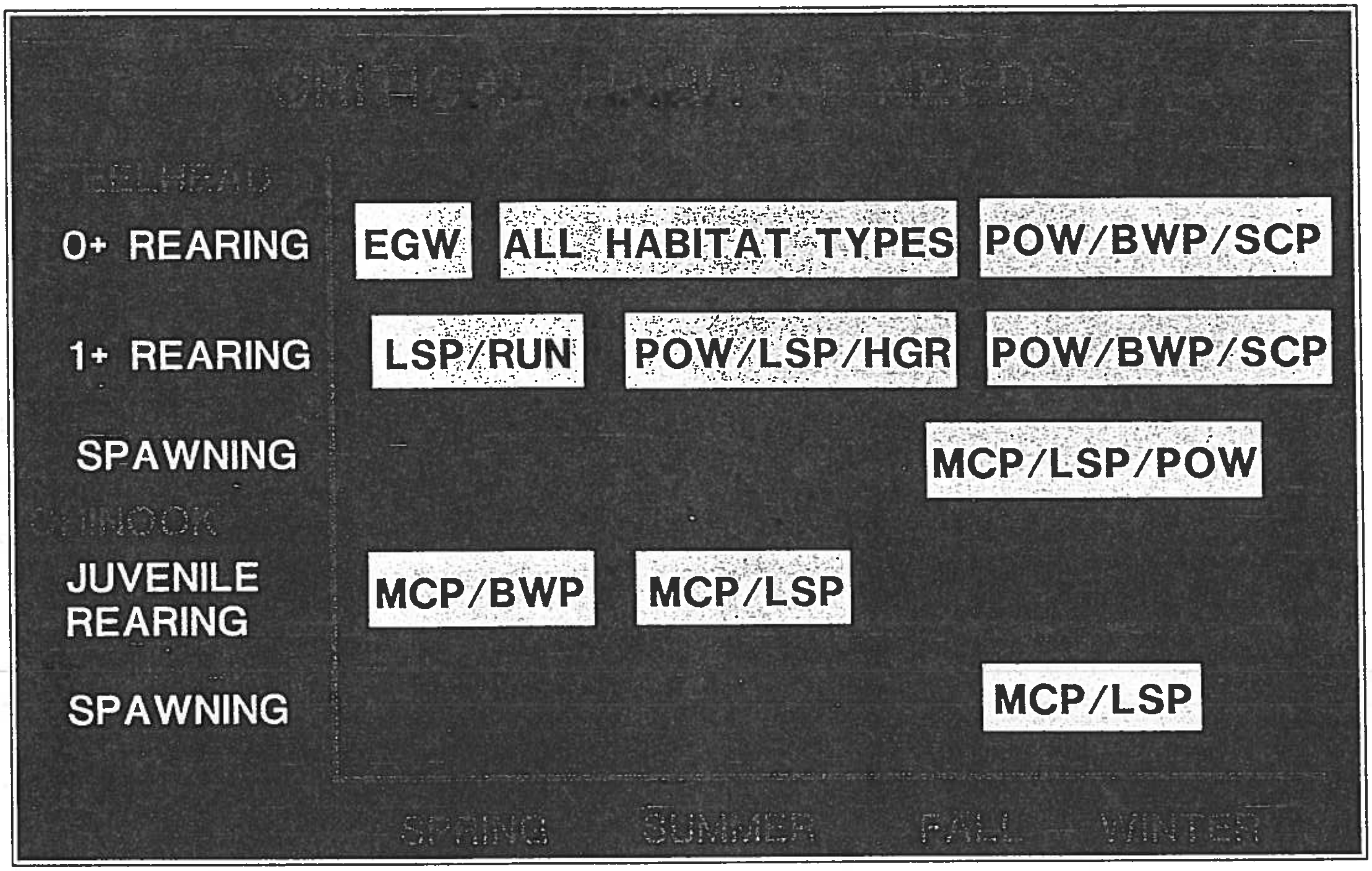


Figure 6 —
An example of seasonal habitat needs for different life stages of anadromous salmonids.

Conclusion

Habitat classification and inventories can be applied at different scales or levels and can provide basic information with which to determine the availability and importance of habitats to fish, and therefore further our understanding of fish-habitat relationships. Development of fish-habitat relationship models will increase the value of habitat information to both researchers and managers by allowing insight into the relative importance and function of physical and biological habitat parameters in the ecology of stream fishes. Aquatic habitat inventory information can serve as valuable baseline data. For example, project level habitat type information provides the habitat restoration/enhancement project designer with insight on the relationship between channel features and habitat development, and allows projects to be evaluated by quantifying the changes in habitat created by the project. Basin level information can enable researchers to develop sampling schemes based on natural habitat units.

There is a need for standardized methods in collecting stream habitat inventory information. Our fishery resources cross several management jurisdictional boundaries. Therefore, proper use and management of this resource requires responsible agencies to communicate and work together through shared information.

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Six Rivers National Forest.

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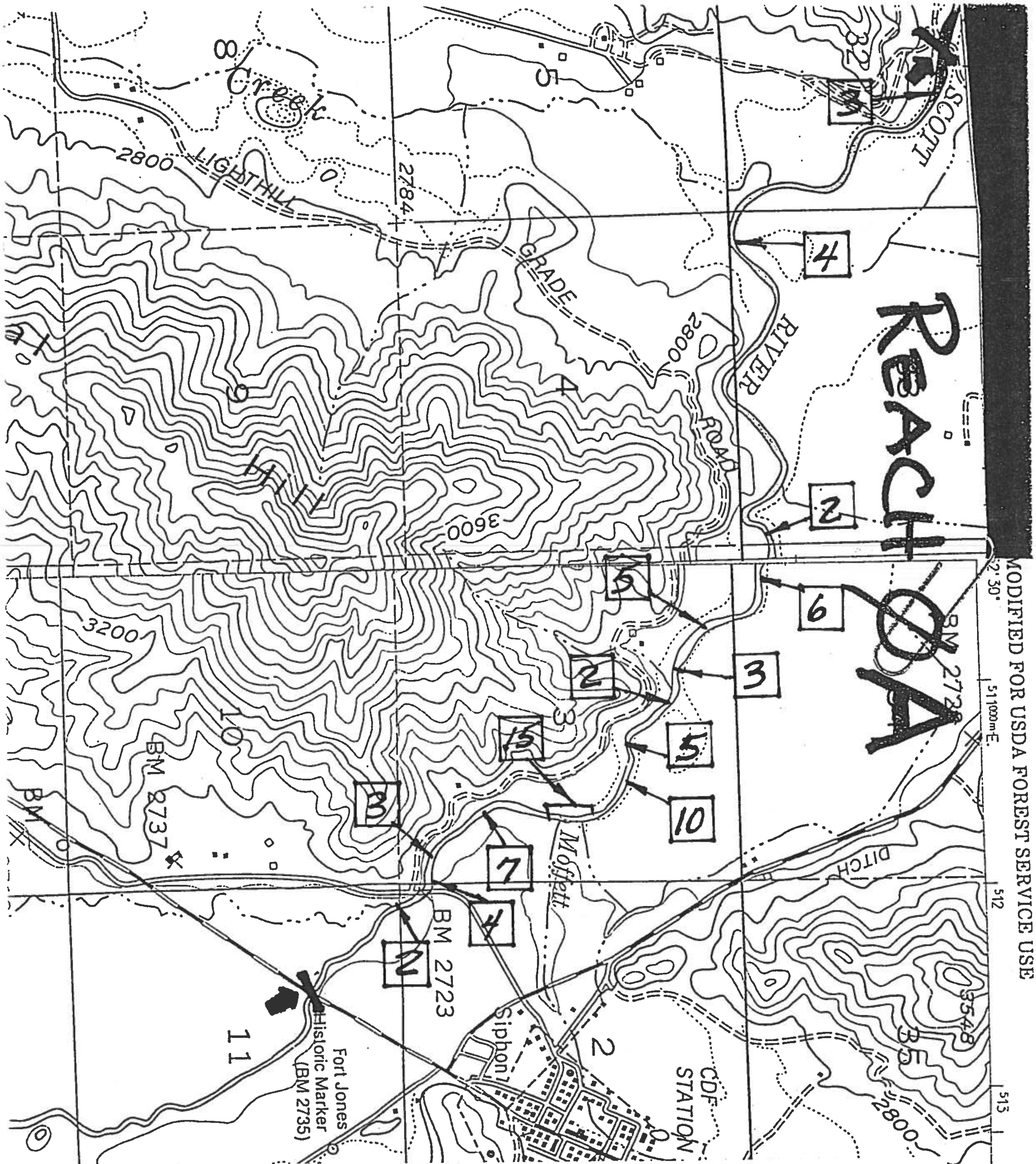
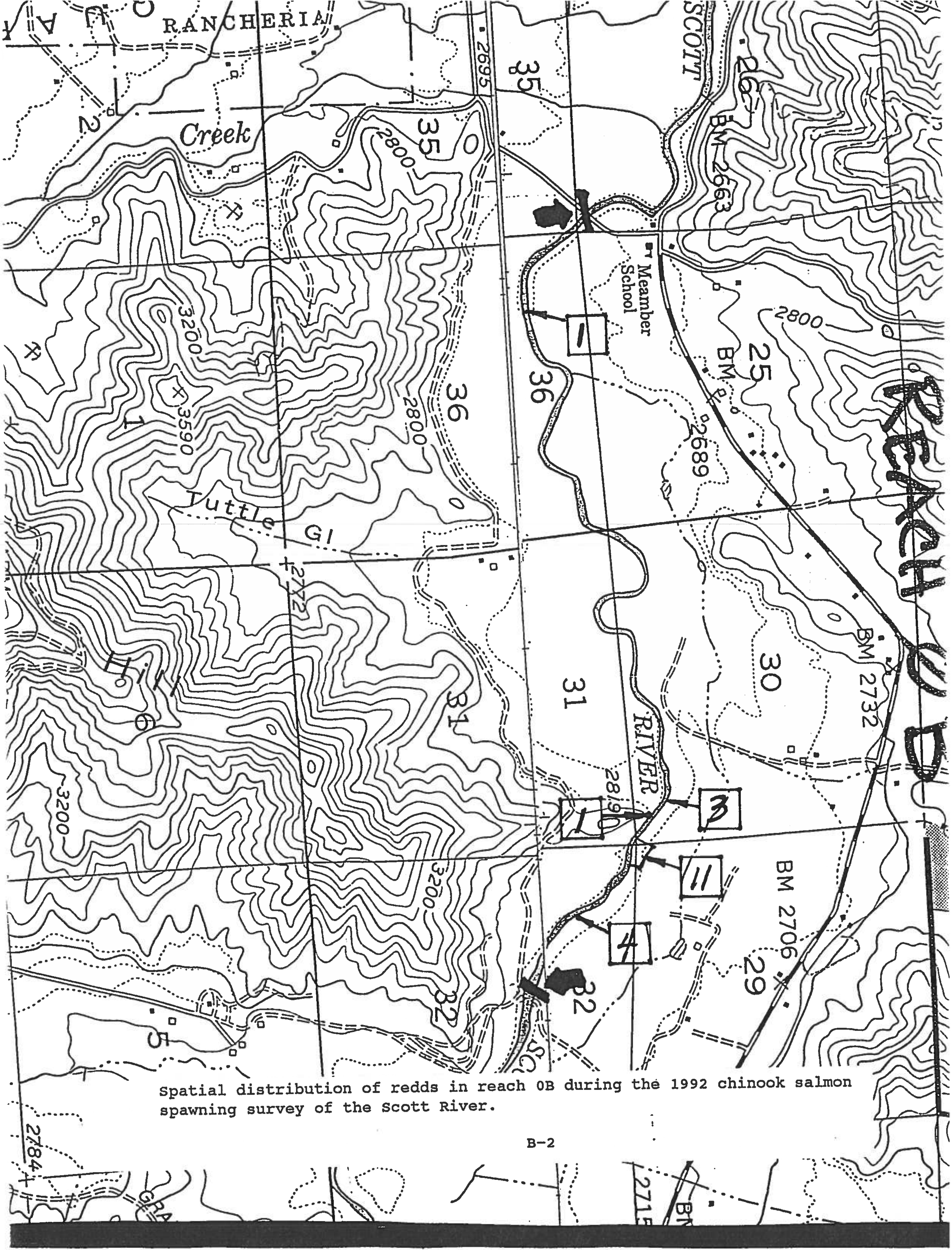
Appendix B

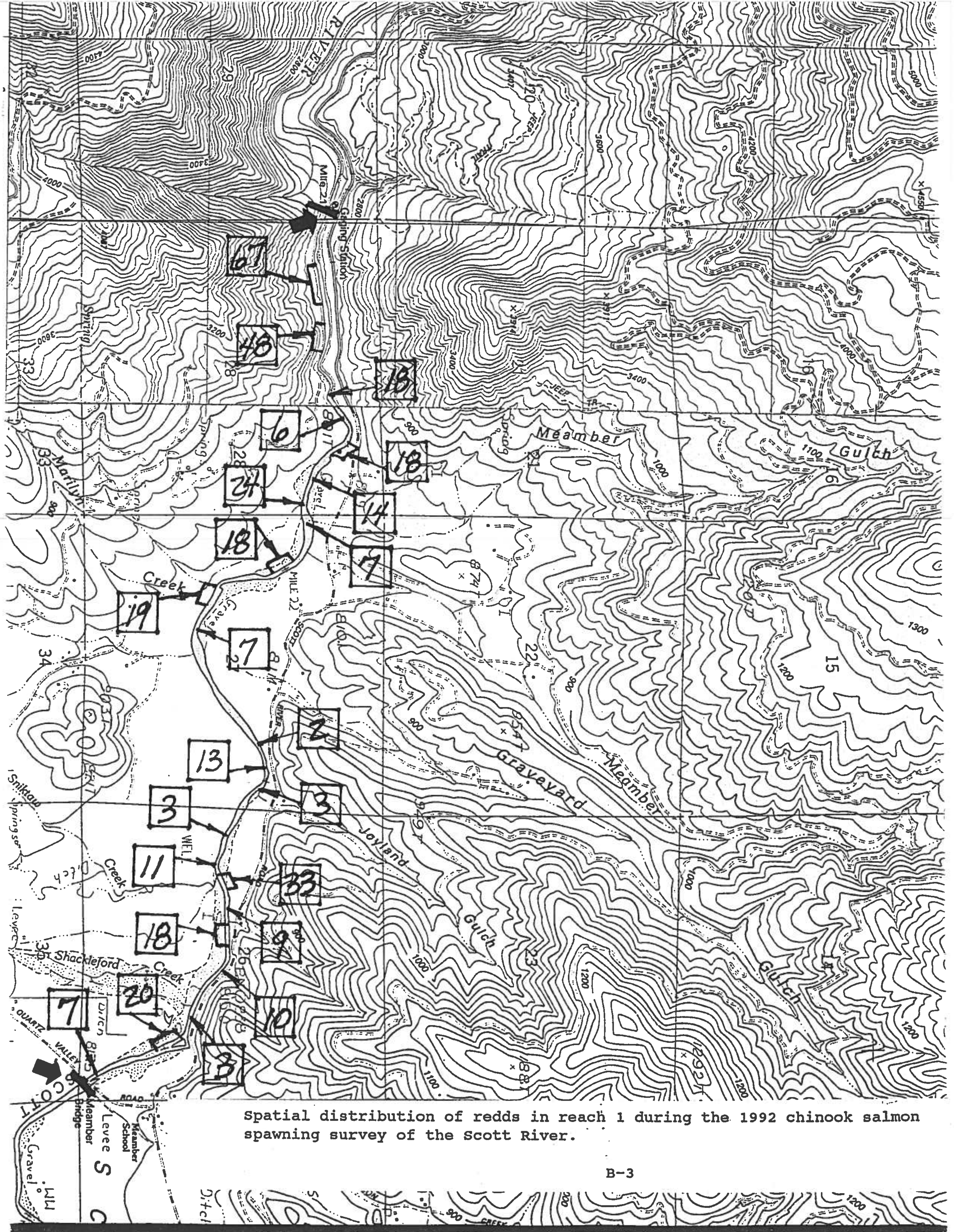
Spatial Distribution of Redds by Reach



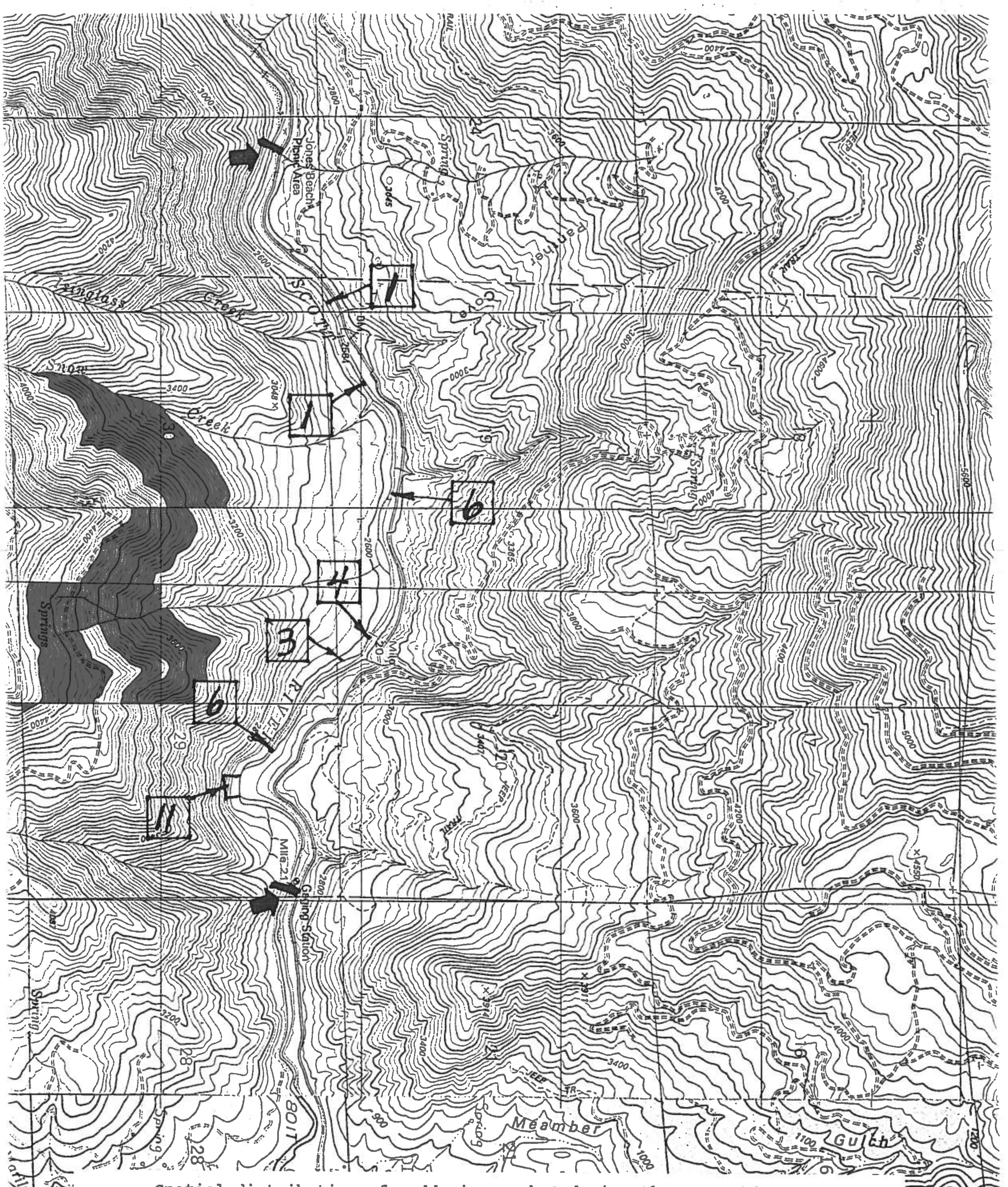
Spatial distribution of redds in reach 0A during the 1992 chinook salmon spawning survey of the Scott River.



Spatial distribution of redds in reach 0B during the 1992 chinook salmon spawning survey of the Scott River.



Spatial distribution of redds in reach 1 during the 1992 chinook salmon spawning survey of the Scott River.



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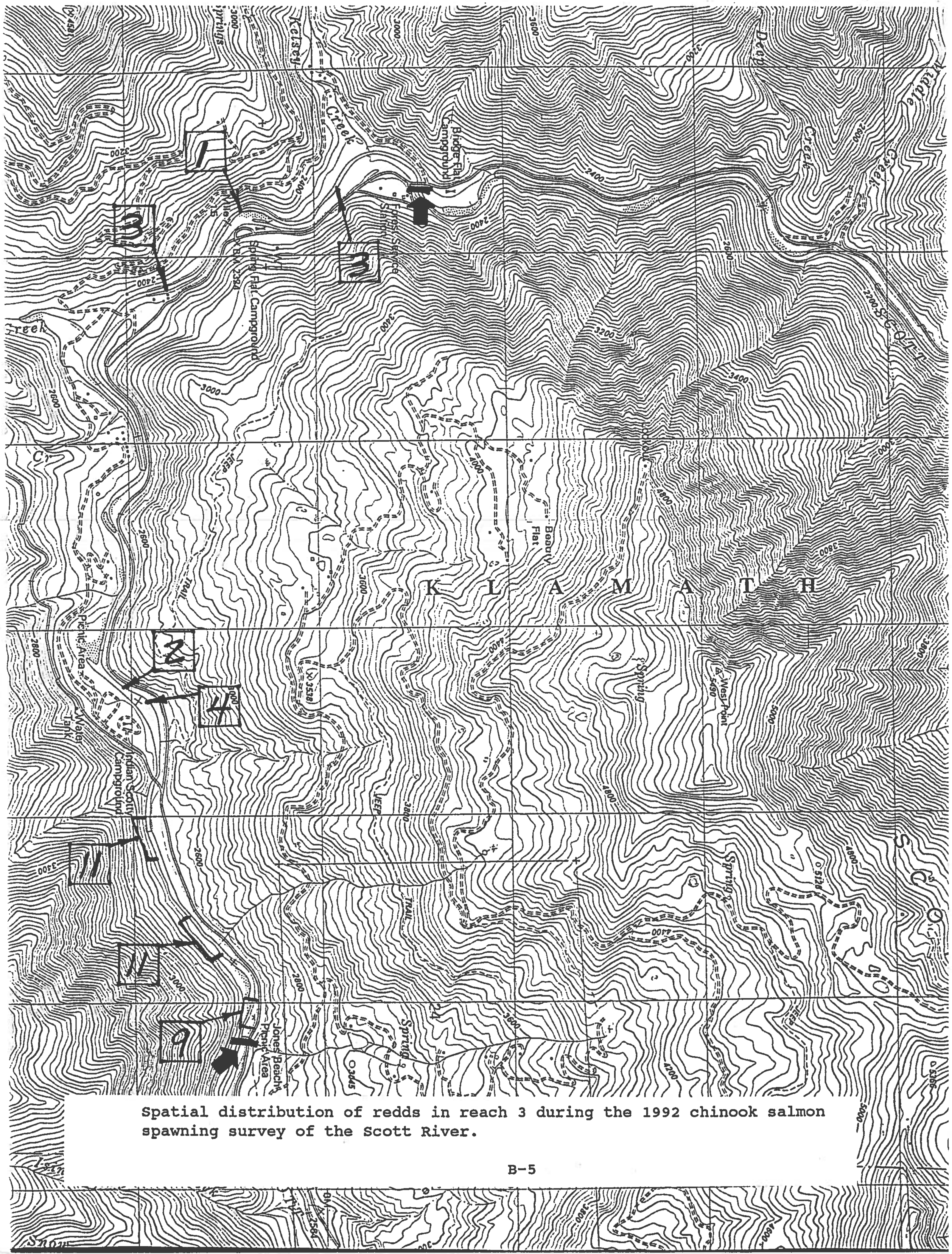
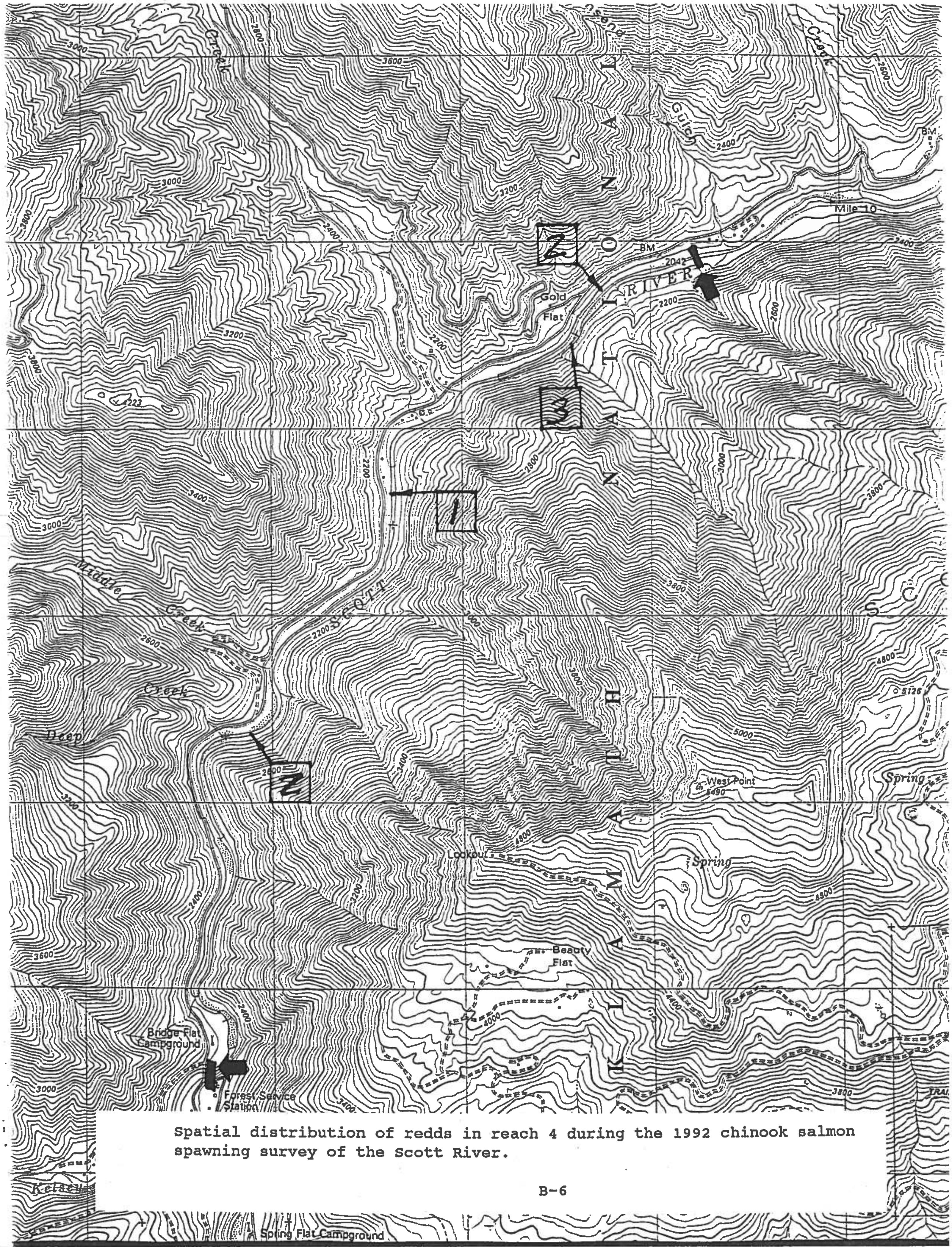
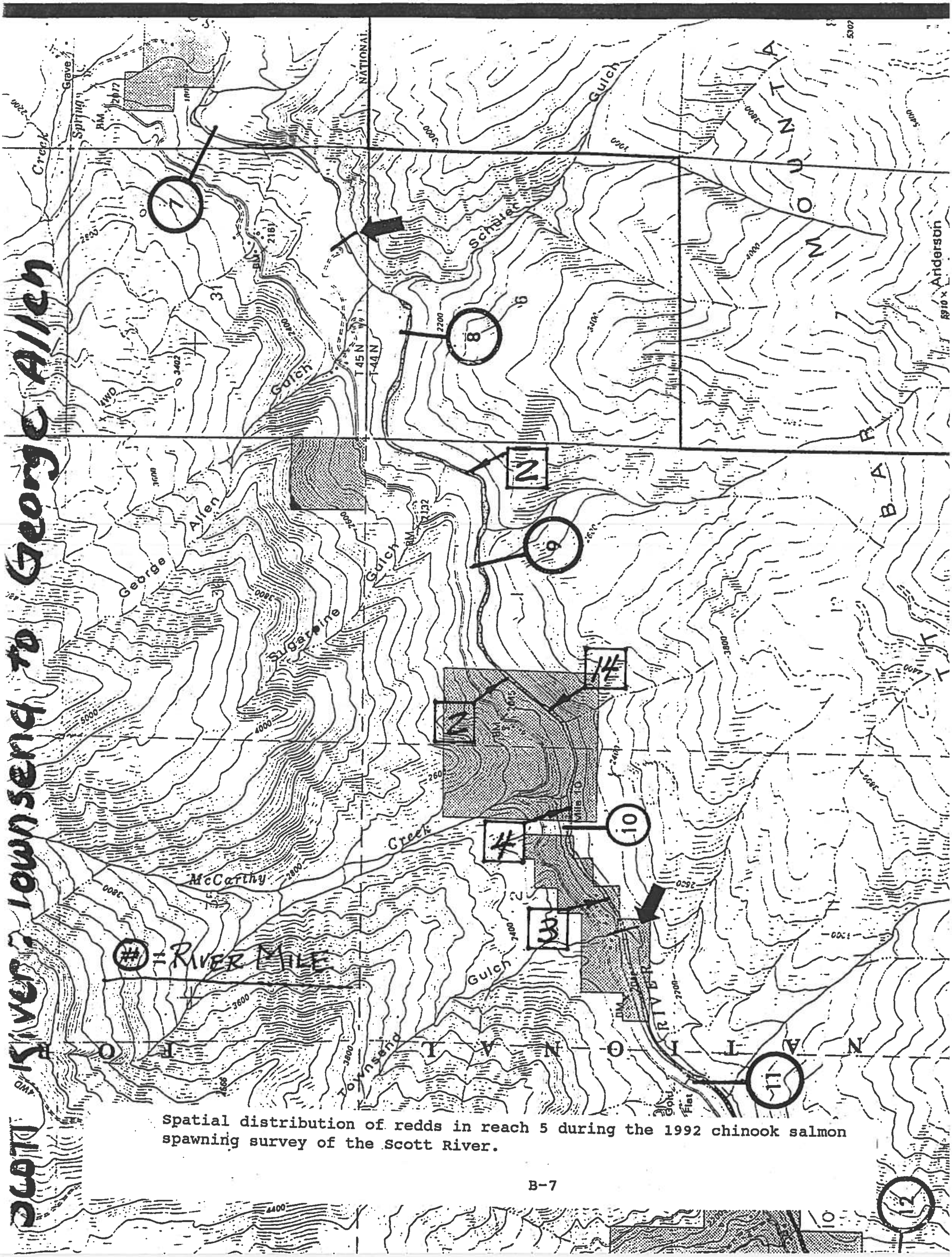


Spatial distribution of redds in reach 3 during the 1992 chinook salmon spawning survey of the Scott River.



Spatial distribution of redds in reach 4 during the 1992 chinook salmon spawning survey of the Scott River.



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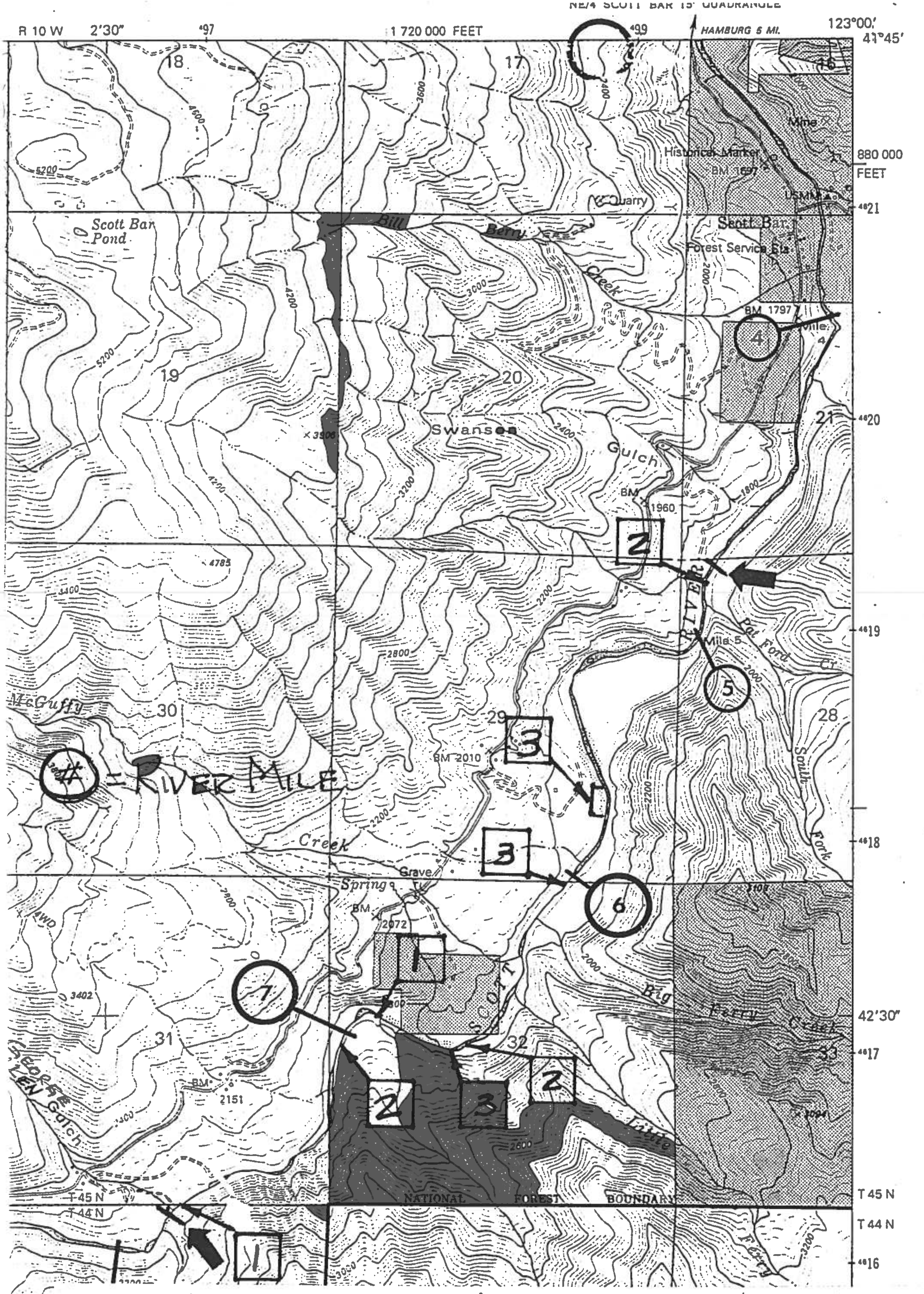

Spatial distribution of redds in reach 6 during the 1992 chinook salmon spawning survey of the Scott River.

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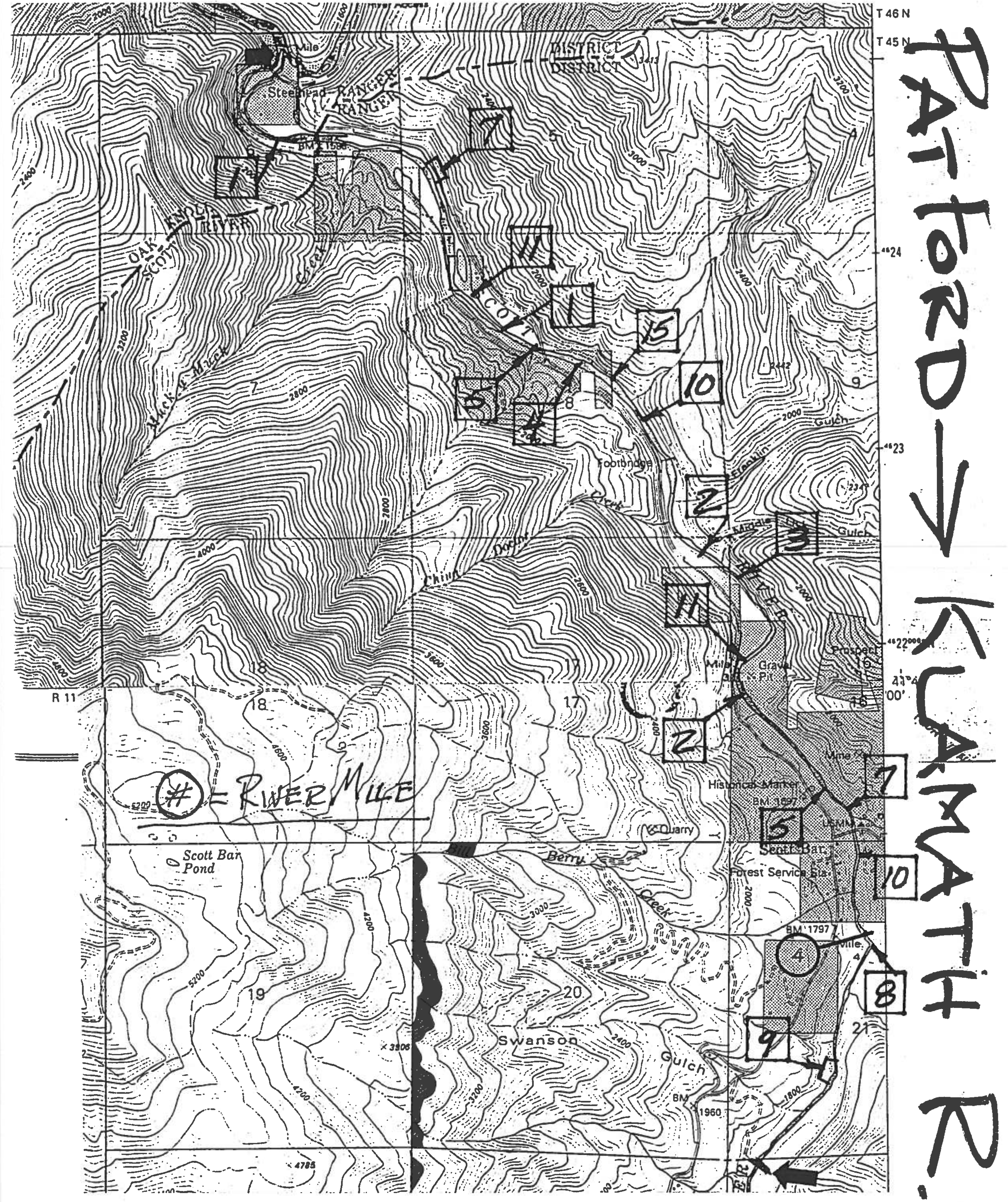

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