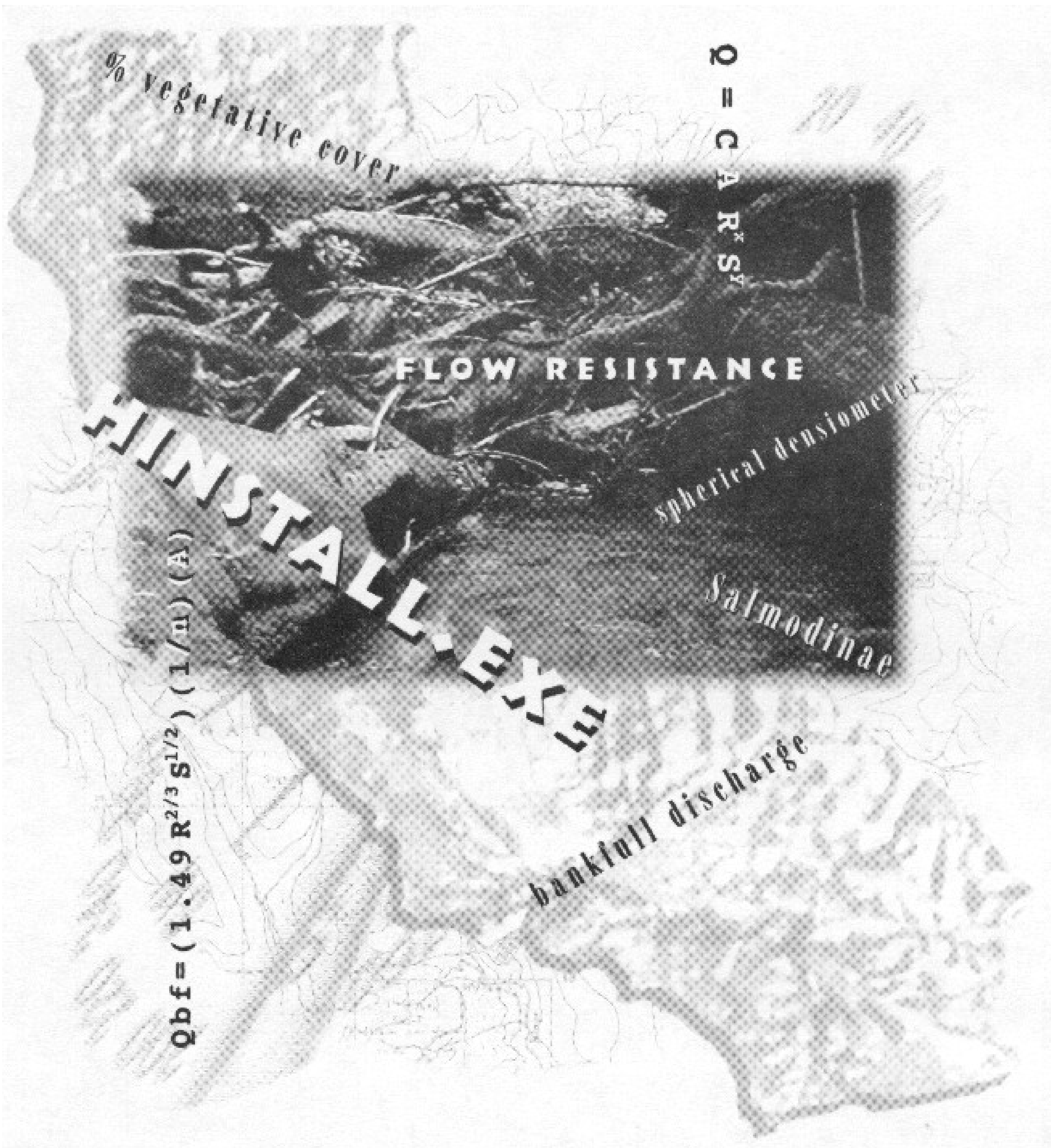
CALIFORNIA SALMONID STREAM HABITAT RESTORATION MANUAL

PART V

WORKING WITH THE DATA



PART V WORKING WITH THE DATA

A stream habitat inventory using the methodology presented in Part III will generate a formidable stack of data forms. The task of reducing this stack of paper to a manageable series of summaries can be facilitated with the help of a computer. Development of fish habitat improvement recommendations from this information requires the expertise of a qualified fishery specialist with appropriate field experience. To facilitate management of all this material, the Department of Fish and Game Inland Fisheries Division has developed two digital tools. The first is a DOS based program for entering, summarizing and analyzing data known as "HABITAT"; the second tool is a Geographic Information System (GIS) for viewing and mapping the habitat data. DFG also has standardized stream report formats for presenting the findings and results of the surveys. The HABITAT program, GIS format, and stream report format are discussed in this section. More detailed information on these programs and their operations can be found in Appendix I.

DATA ENTRY

Computer data entry from field forms can be a tedious, time consuming process that is fraught with chances for introducing errors. Adoption of a system for maintaining integrity of data during entry operations is imperative for production of high quality reports and recommendations.

For collection of field data, DFG recommends the data forms presented in Part III of this manual, which have been extensively field tested, be reproduced on waterproof paper. The resulting forms will be very durable and can be used under field conditions with a minimum of special training. The data on the forms can be efficiently entered into database files in the office using the HABITAT program. The forms should be archived and will serve as a valuable, permanent backup to computer files and provide vital quality control as needed.

DFG has adopted the dBASE database system. Data entry in dBASE (.dbf) files can be accomplished using commercially available dBASE, version IV or newer, programs, or using various other programs that can convert the data into dBASE files, or using the HABITAT program.

The computerized data should be quality checked after being entered. Several quality control/quality assurance methods can be used. A complete entry-by-entry visual check of the database file against the original forms is time consuming, but effective. A partial check of randomly selected entries does not correct all errors but does provide a measure of data quality control accuracy. A commercial data entry service that uses a double-entry data keying program is another effective method of reducing error. The HABITAT program contains a File Check program to detect several common errors.

Another way of reducing entry errors is by having the field personnel enter the data, as they collect it, directly into a special waterproof field computer. This procedure eliminates the need for paper forms and later data entry, which can save time and reduce the chance for transcription errors. However, there are several possible problems. A large investment is required in equipment, computer program development and personnel training. In addition, there are increased possibilities for data loss through mechanical and electrical equipment failure. Further, if a data entry error occurs in the field during electronic data entry, there is no way to detect that an error has occurred, which could affect the balance of the survey as well as the particular erroneous sample.

DATA SUMMARY AND ANALYSIS

Once the data has been entered and checked for errors, the process of summarizing is routine using the HABITAT program. Analysis of data summaries, however, is a job for experienced fish habitat specialists.

Data Summary

The HABITAT program provides a fully automated fish habitat inventory data summary. Examples of summarized data are presented below in Tables 1 through 10. A wide variety of computer programs and manual methods can be used for creating custom data summaries, tables and graphs. Data presentation in graphical form as illustrated below in Graphs 1 through 4 may be useful in illustrating specific points. Graphics can be easily created using computer graphics programs and the spreadsheet files the HABITAT program produces.

Table V-1. Summary of riffle, flatwater, and pool habitat types. Summarizes Level II riffle flatwater, and pool habitat types.

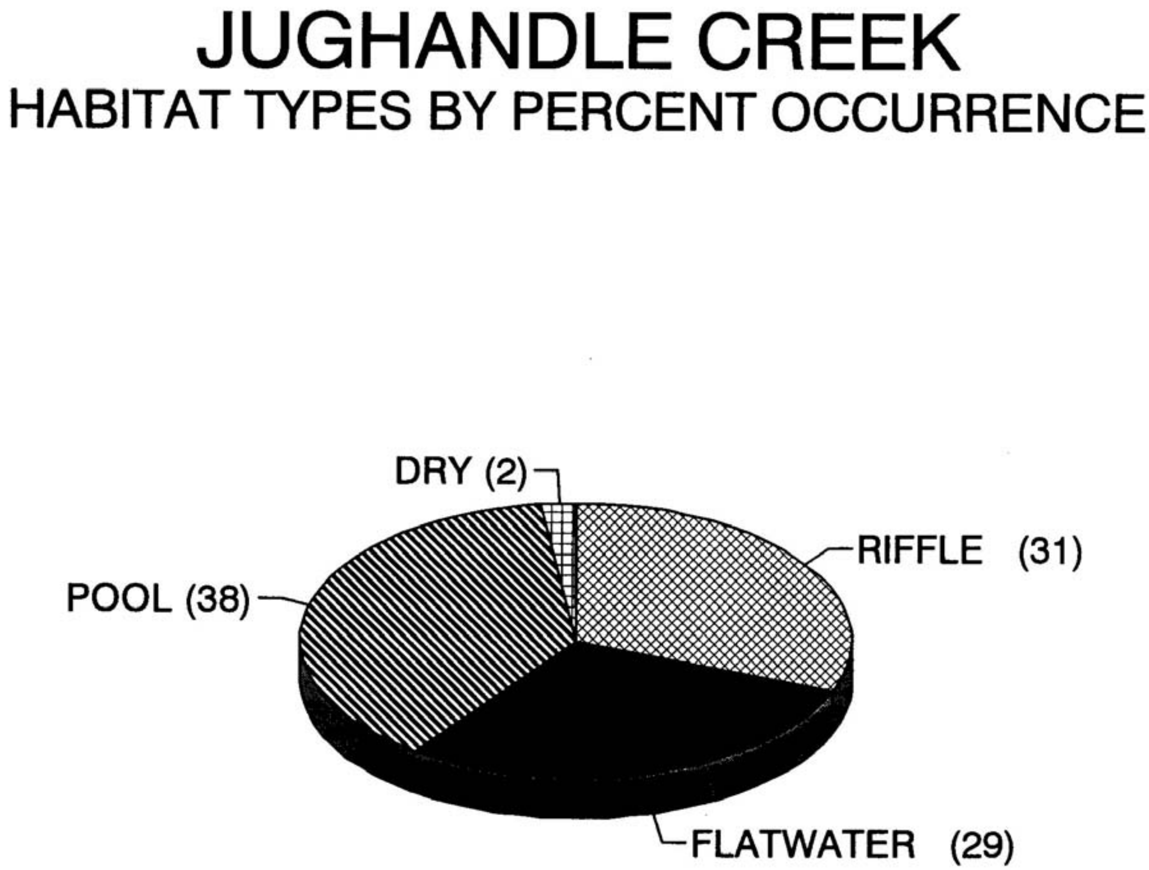
JUGHANDLE CREEK | Drainage: PACIFIC OCEAN

Table 1 - SUMMARY OF RIFFLE, FLATWATER, AND POOL HABITAT TYPES | Survey Dates: 10/28/96 to 10/30/96

Confluence Location: QUAD: FORT BRAGG LEGAL DESCRIPTION: | LATITUDE:39°22'37" LONGITUDE:123°48'55"

HABITAT UNITS	UNITS FULLY MEASURED	HABITAT TYPE	HABITAT PERCENT OCCURRENCE	MEAN LENGTH (ft.)	TOTAL LENGTH (ft.)	PERCENT TOTAL LENGTH	MEAN WIDTH (ft.)	MEAN DEPTH (ft.)	MEAN AREA (sq.ft.)	ESTIMATED TOTAL AREA (sq.ft.)	MEAN VOLUME (cu.ft.)	ESTIMATED TOTAL VOLUME (cu.ft.)	MEAN RESIDUAL POOL VOL (cu.ft.)	MEAN SHELTER RATING
103	13	RIFFLE	31	18	1900	22	5.5	0.2	114	11762	35	3573	0	12
97	10	FLATWATER	29	39	3819	44	6.6	0.4	171	16560	61	5878	0	32
127	23	POOL	38	22	2761	32	7.7	0.8	169	21409	153	19471	118	37
5	0	DRY	2	15	74	1	0.0	0.0	0	0	0	0	0	0
1	0	CULVERT	0	38	38	0	0.0	0.0	0	0	0	0	0	0

TOTAL UNITS	TOTAL UNITS	TOTAL LENGTH (ft.)	TOTAL AREA (sq. ft.)	TOTAL VOL. (cu. ft.)
333	46	8592	49731	28921



Graph V-1. Comparison of Level II habitat types by percent occurrence.

Table V-2. Summary of habitat types and measured parameters. Summarizes Level IV physical fish habitat of the stream surveyed. From this data, graphs can be generated to compare habitat types by percent occurrence, total length, percent total length, total volume, etc.

JUGHANDLE CREEK   Drainage: PACIFIC OCEAN

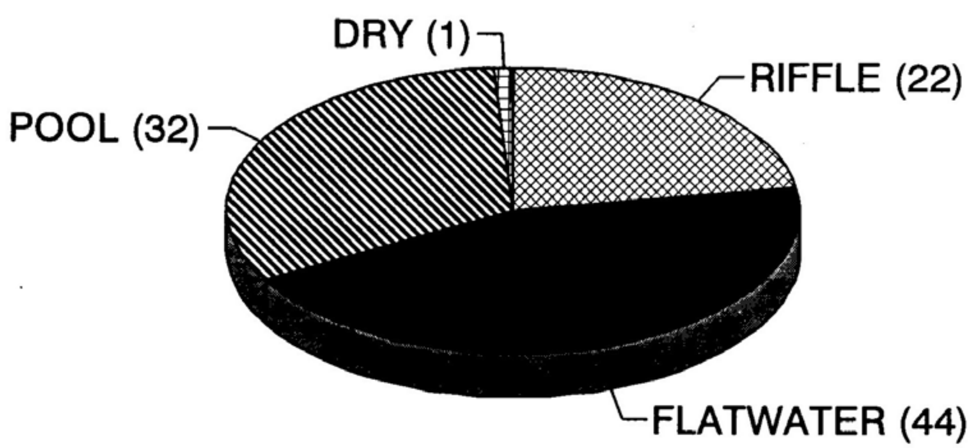
Table 2 - SUMMARY OF HABITAT TYPES AND MEASURED PARAMETERS   Survey Dates: 10/28/96 to 10/30/96

Confluence Location: QUAD: FORT BRAGG LEGAL DESCRIPTION: LATITUDE:39°22'37" LONGITUDE:123°48'55"

HABITAT UNITS #	UNITS FULLY MEASURED	HABITAT TYPE	HABITAT OCCURRENCE %	MEAN LENGTH ft.	TOTAL LENGTH ft.	TOTAL LENGTH %	MEAN WIDTH ft.	MEAN DEPTH ft.	MAXIMUM DEPTH ft.	MEAN AREA sq.ft.	TOTAL AREA EST. sq.ft.	MEAN VOLUME cu.ft.	TOTAL VOLUME EST. cu.ft.	MEAN RESIDUAL POOL VOL cu.ft.	MEAN SHELTER RATING	MEAN CANOPY %
100	11	LGR	30	18	1828	21	5	0.2	0.7	93	9270	21	2149	0	6	99
1	1	HGR	0	8	8	0	8	0.1	0.3	45	45	5	5	0	10	100
2	1	CAS	1	32	64	1	10	0.5	1.1	420	840	210	420	0	70	92
41	6	RUN	12	21	860	10	7	0.4	0.9	179	7357	60	2462	0	12	97
56	4	SRN	17	53	2959	34	6	0.4	0.7	158	8828	61	3440	0	63	99
3	1	TRP	1	57	170	2	6	1.0	2.6	366	1098	366	1098	183	10	100
84	12	MCP	25	23	1915	22	8	0.8	2.7	162	13645	141	11858	113	40	98
4	2	LSL	1	20	81	1	10	1.1	2.3	212	848	224	898	171	38	100
5	2	LSR	2	21	105	1	7	1.0	2.1	136	680	173	866	157	40	100
2	1	LSBk	1	26	51	1	8	0.7	1.9	224	448	157	314	134	5	100
23	3	PLP	7	14	331	4	6	0.8	2.3	91	2101	76	1746	63	35	98
6	2	BPL	2	18	108	1	8	0.7	1.9	184	1104	143	859	102	48	98
5	0	DRY	2	15	74	1	0	0.0	0.0	0	0	0	0	0	0	0
1	0	CUL	0	38	38	0	0	0.0	0.0	0	0	0	0	0	0	0

TOTAL UNITS	TOTAL UNITS	LENGTH (ft.)	AREA (sq.ft)	TOTAL VOL. (cu.ft)
333	46	8592	46264	26114

JUGHANDLE CREEK
HABITAT TYPES BY PERCENT TOTAL LENGTH



Graph V-2. Comparison of Level IV habitat types by percent occurrence.

Table V-3. Summary of pool types. Summarizes Level III pool habitat types.

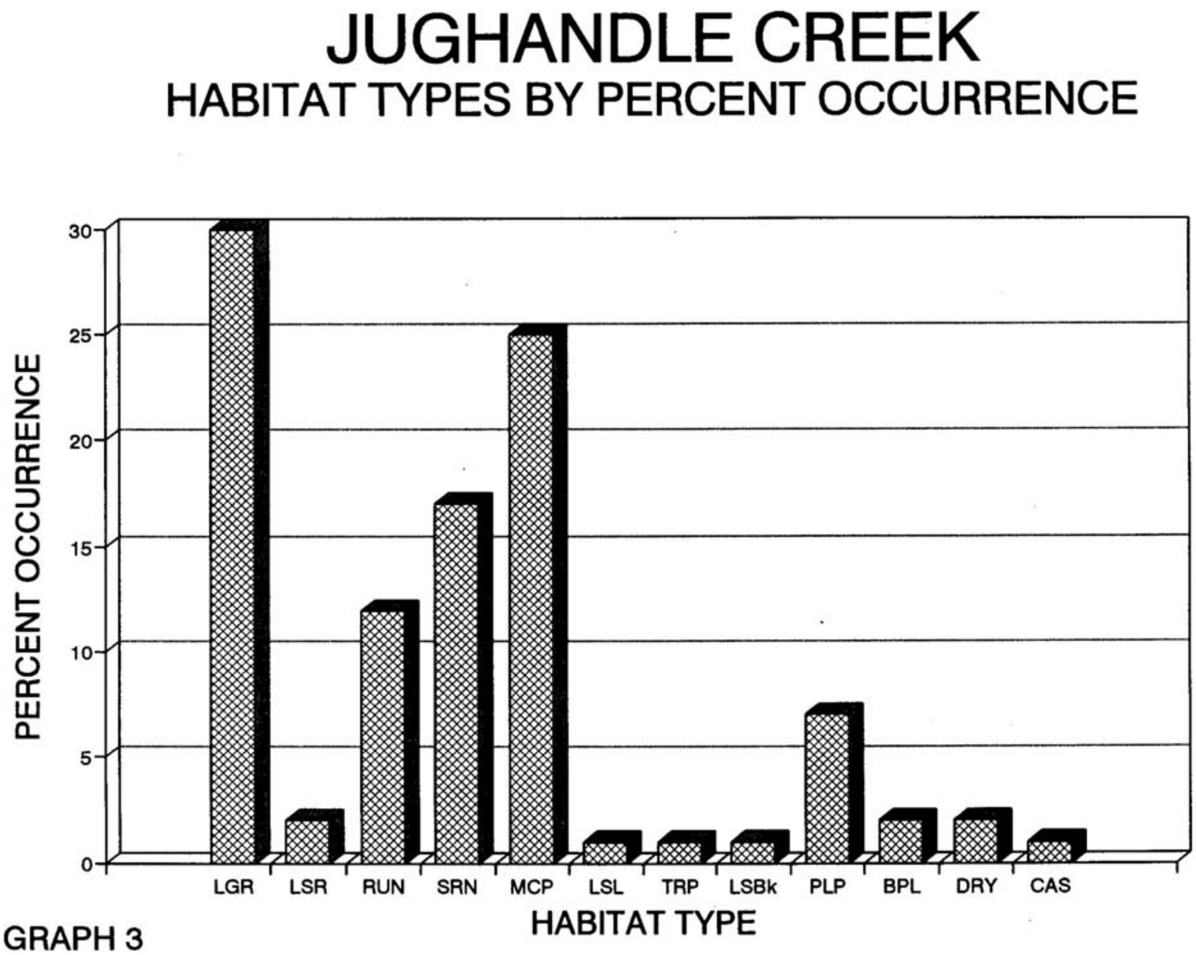
JUGHANDLE CREEK | Drainage: PACIFIC OCEAN

Table 3 - SUMMARY OF POOL TYPES | Survey Dates: 10/28/96 to 10/30/96

Confluence Location: QUAD: FORT BRAGG LEGAL DESCRIPTION: | LATITUDE:39°22'37" LONGITUDE:123°48'55"

HABITAT UNITS	UNITS FULLY MEASURED	HABITAT TYPE	HABITAT PERCENT OCCURRENCE	MEAN LENGTH (ft.)	TOTAL LENGTH (ft.)	PERCENT TOTAL LENGTH	MEAN WIDTH (ft.)	MEAN DEPTH (ft.)	MEAN AREA (sq.ft.)	TOTAL AREA EST. (sq.ft.)	MEAN VOLUME (cu.ft.)	TOTAL VOLUME EST. (cu.ft.)	MEAN RESIDUAL POOL VOL. (cu.ft.)	MEAN SHELTER RATING
87	13	MAIN	69	24	2085	76	7.8	0.9	178	15495	158	13786	118	37
34	8	SCOUR	27	17	568	21	7.5	0.9	149	5075	147	5014	122	33
6	2	BACKWATER	5	18	108	4	8.0	0.7	184	1104	143	859	102	48

TOTAL UNITS	TOTAL UNITS	TOTAL LENGTH (ft.)	TOTAL AREA (sq.ft.)	TOTAL VOL. (cu.ft.)
127	23	2761	21673	19660



Graph V-3. Comparison of Level III pool habitat types by percent occurrence.

Table V-4. Summary of maximum pool depths by pool habitat types. Summarizes Level IV pool depths by habitat type.

JUGHANDLE CREEK Drainage: PACIFIC OCEAN

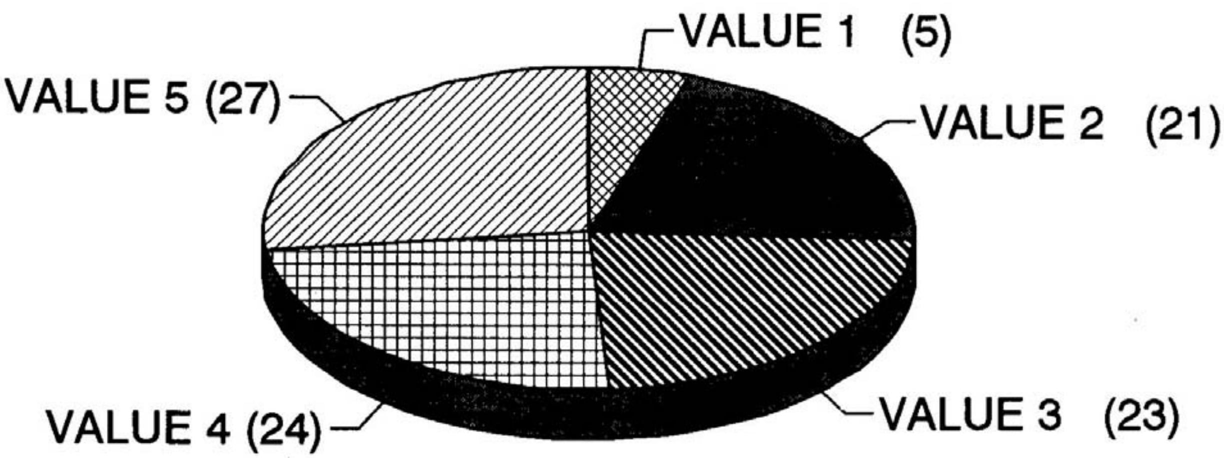
Table 4 - SUMMARY OF MAXIMUM POOL DEPTHS BY POOL HABITAT TYPES Survey Dates: 10/28/96 to 10/30/96

Confluence Location: QUAD: FORT BRAGG LEGAL DESCRIPTION: LATITUDE:39°22'37" LONGITUDE:123°48'55"

UNITS MEASURED	HABITAT TYPE	HABITAT PERCENT OCCURRENCE	<1 FOOT MAXIMUM DEPTH	<1 FOOT PERCENT OCCURRENCE	1-<2 FT. MAXIMUM DEPTH	1-<2 FOOT PERCENT OCCURRENCE	2-<3 FT. MAXIMUM DEPTH	2-<3 FOOT PERCENT OCCURRENCE	3-<4 FT. MAXIMUM DEPTH	3-<4 FOOT PERCENT OCCURRENCE	>=4 FEET MAXIMUM DEPTH	>=4 FEET PERCENT OCCURRENCE
3	TRP	2	0	0	1	33	2	67	0	0	0	0
84	MCP	66	4	5	61	73	16	19	3	4	0	0
4	LSL	3	0	0	2	50	2	50	0	0	0	0
5	LSR	4	3	60	1	20	1	20	0	0	0	0
2	LSBk	2	0	0	2	100	0	0	0	0	0	0
23	PLP	18	0	0	14	61	8	35	0	0	1	4
6	BPL	5	0	0	5	83	1	17	0	0	0	0

TOTAL
UNITS
127

JUGHANDLE CREEK
PERCENT EMBEDDEDNESS



Graph V-4. Summary of mean percent embeddedness of substrate in pool trail.

Table V-5. Summary of mean percent cover by habitat type. In this example the majority of the cover consists of small and large woody debris.

JUGHANDLE CREEK Drainage: PACIFIC OCEAN

Table 5 - SUMMARY OF MEAN PERCENT COVER BY HABITAT TYPE Survey Dates: 10/28/96 to 10/30/96

Confluence Location: QUAD: FORT BRAGG LEGAL DESCRIPTION: LATITUDE:39°22'37" LONGITUDE:123°48'55"

UNITS MEASURED	UNITS FULLY MEASURED	HABITAT TYPE	MEAN % UNDERCUT BANKS	MEAN % SWD	MEAN % LWD	MEAN % ROOT MASS	MEAN % TERR. VEGETATION	MEAN % AQUATIC VEGETATION	MEAN % WHITE WATER	MEAN % BOULDERS	MEAN % BEDROCK LEDGES
100	8	LGR	0	69	0	0	9	0	0	23	0
1	1	HGR	0	0	0	0	0	0	0	100	0
2	1	CAS	0	0	10	0	0	0	0	90	0
41	4	RUN	15	25	30	0	13	0	0	18	0
56	4	SRN	25	13	38	0	0	0	0	25	0
3	1	TRP	30	70	0	0	0	0	0	0	0
84	12	MCP	3	28	54	3	0	0	1	11	0
4	2	LSL	0	15	85	0	0	0	0	0	0
5	2	LSR	30	25	45	0	0	0	0	0	0
2	1	LSBk	0	100	0	0	0	0	0	0	0
23	3	PLP	13	0	23	17	0	0	3	43	0
6	2	BPL	25	40	35	0	0	0	0	0	0
5	0	DRY	0	0	0	0	0	0	0	0	0
1	0	CUL	0	0	0	0	0	0	0	0	0

Table V-6. Summary of dominant substrate by habitat type. Summarizes dominant substrate of Level IV habitat types. In this example the majority of substrates consist of sand and gravel.

JUGHANDLE CREEK

Drainage: PACIFIC OCEAN

Table 6 - SUMMARY OF DOMINANT SUBSTRATES BY HABITAT TYPE

Survey Dates: 10/28/96 to 10/30/96

Confluence Location: QUAD: FORT BRAGG LEGAL DESCRIPTION:

LATITUDE:39°22'37" LONGITUDE:123°48'55"

TOTAL HABITAT UNITS	UNITS FULLY MEASURED	HABITAT TYPE	% TOTAL SILT/CLAY DOMINANT	% TOTAL SAND DOMINANT	% TOTAL GRAVEL DOMINANT	% TOTAL SM COBBLE DOMINANT	% TOTAL LG COBBLE DOMINANT	% TOTAL BOULDER DOMINANT	% TOTAL BEDROCK DOMINANT
100	11	LGR	0	0	82	18	0	0	0
1	1	HGR	0	0	0	100	0	0	0
2	1	CAS	0	0	0	0	0	100	0
41	5	RUN	0	20	80	0	0	0	0
56	4	SRN	0	25	75	0	0	0	0
3	1	TRP	0	0	100	0	0	0	0
84	12	MCP	25	33	42	0	0	0	0
4	2	LSL	0	50	50	0	0	0	0
5	2	LSR	0	50	50	0	0	0	0
2	1	LSBk	0	0	100	0	0	0	0
23	3	PLP	33	67	0	0	0	0	0
6	2	BPL	0	0	100	0	0	0	0
5	0	DRY	0	0	0	0	0	0	0
1	0	CUL	0	0	0	0	0	0	0

Table V-7. Summary of Mean Percent Vegetative Cover for Entire Stream

Mean Percent Canopy	Mean Percent Conifer	Mean Percent Percent Deciduous	Mean Percent Percent Open units	Mean Right Right Bank % Cover	Mean Left Bank % Cover
98	36	64	0	93.8	93.2

Note: Mean percent conifer and deciduous for the entire reach are means of canopy components from units with canopy values greater than zero.

Open units represent habitat units with zero canopy cover.

Table V-8. Fish Habitat Inventory Data Summary

STREAM NAME: JUGHANDLE CREEK
SAMPLE DATES: 10/28/96 to 10/30/96
STREAM LENGTH: 8327 ft.
LOCATION OF STREAM MOUTH:
USGS Quad Map: FORT BRAGG Latitude: 39E 22'37"
Legal Description: Longitude: 123E 48'55"

SUMMARY OF FISH HABITAT ELEMENTS BY STREAM REACH

STREAM REACH 1

Channel Type: F4
Channel Length: 8028 ft.
Riffle/flatwater Mean Width: 6ft.
Total Pool Mean Depth: 0.8 ft.
Base Flow: 0.4 cfs
Water: 048- 050EF air: 042-056EF
Dom. Bank Veg.: Brush
Vegetative Cover: 96%
Dom. Bank Substrate: Cobble/Gravel

Canopy Density: 98%
Coniferous Component: 38%
Deciduous Component: 62%
Pools by Stream Length: 33%
Pools >=3 ft. Deep: 3%
Mean Pool Shelter Rtn: 38
Dom. Shelter: Large Woody Debris
Occurrence of LOD: 36%
Dry Channel: 26 ft.

Embeddedness Value 1. 5% 2. 20% 3. 23% 4. 25% 5. 27%

STREAM REACH 2

Channel Type: A4
Channel Length: 299 ft.
Riffle/flatwater Mean /Width: 9 ft.
Total Pool Mean Depth: 1.0 ft.
Base Flow: 0.4 cfs
Water: 049- 049EF Air: 049-049EF
Dom. Bank Veg.: Brush
Vegetative Cover: 94%

Canopy Density: 98%
Coniferous Component: 10%
Deciduous Component: 90%
Pools by Stream Length: 24%
Pools >=3 ft. Deep: 0%
Mean Pool Shelter Rtn: 27
Dom. Shelter: Boulders
Occurrence of LOD: 8%

Dom. Bank Substrate: Cobble/Gravel Dry Channel: 48 ft.

Embeddedness Value: 1. 0% 2. 50% 3. 17% 4. 9% 5. 33%

Table V-9. Mean Percentage of Dominant Substrate

Dominant Class of Substrate	Number Units Right Bank	Number Units Left Bank	Total Mean Percent
Bedrock	1	2	3.33
Boulder	0	3	3.33
Cobble/Gravel	24	18	46.67
Silt/clay	20	22	46.67

Mean Percentage of Dominant Vegetation

Dominant Class of Vegetation	Number Units Right Bank	Number Units Left Bank	Total Mean Percent
Grass	11	12	25.56
Brush	25	24	54.44
Decid. Trees	2	4	6.67
Conif. Trees	7	5	13.33
No Vegetation	0	0	0

Total stream embeddedness value for pool 3.39

Table V-10. Mean Percent of Shelter Cover Types for Entire Stream

Stream: JUGHANDLE CREEK Drainage PACIFIC OCEAN

Survey Date: 10/28/96 to 10/30/96

	RIFFLES	FLATWATER	POOLS
UNDERCUT BANKS	8.41	17.78	9.13
SMALL WOODY DEBRIS	31.14	16.67	29.13
LARGE WOODY DEBRIS	30.23	30	45.65
ROOTS	2.05	0	3.91
TERRESTRIAL VEG	2.73	5.56	0
AQUATIC VEG	0	0	0
WHITEWATER	0.45	0	0.87
BOULDERS	18.18	18.89	11.30
BEDROCK LEDGERS	0	0	0

Data Analysis

Table V-1 shows a basic Level II look at the stream in terms of riffles, pools and flatwater. This view emphasizes the percent occurrence and percent total length of major habitat types and how they relate in terms of water area, depth and volume. Table V-1 also shows total percent pool habitat units to percent riffle and flatwater habitat units, but shows little about critical habitats.

Table V-2 provides a more detailed Level IV summary of the habitats in the surveyed stream. This table shows details such as predominant habitat types, the existence of special habitat types, critical habitats shelter ratings, and the amount of vegetation on the stream bank.

Table V-3 provides a Level III summary of pool habitats. This table displays useful information about the back water and scour pool percent occurrence, volume and shelter. These pool types can provide habitats especially important to salmonids, particularly coho during certain life stages. Refer to Table V-2 for more detailed Level IV information on special pool types which may have specific fish species importance.

Table V-4 provides a detailed look at pool habitats in terms of depth. Primary pools provide critical summer habitat for steelhead and coho under low flow conditions. DFG habitat typing data indicate the better coastal coho streams may have as much as 40 percent of their total habitat length in primary pools. In first and second order streams a primary pool is defined to have a maximum depth of at least two feet, occupy at least half the width of the low-flow channel, and be as long as the low-flow channel width. In third and fourth order streams the criteria is the same, except maximum depth must be at least three feet. Looking at existing primary pool habitat types provides design information for creating additional primary pools.

Table V-5 emphasizes the amount and type of cover found in all the Level IV habitat types. These data describe the stream and are useful for comparison with other streams. These data also display information about the number of habitat units that provide escape cover with large woody debris (LWD). Shelter values of 80 or higher are desirable.

Table V-6 presents stream substrate detail. This information is useful in determining the suitability of the stream=s substrate for spawning salmonids. The spawning habitat types for individual species are presented later in Part V.

Table V-8 displays a summary of 19 measurements for each stream reach surveyed. Stream reaches, determined by their unique stream channel types, are a useful way of analyzing the possibilities for stream habitat improvements.

GIS FORMAT

The development of GIS technology has ushered in a whole new era of spatially assisted data analysis. GIS can graphically present the location and frequency of particular critical habitat types, fish species distribution and use, identified problem and project sites, and other important watershed features. This information is useful in the planning, evaluation, and monitoring process associated with watershed and stream improvement programs.

Software

DFG uses Arc/Info and ArcView GIS software. The suite of tools in Arc/Info allows for finer articulation of spatial features and analysis. A GIS specialist uses Arc/Info in preparing the data and interface for the field biologists and end users. ArcView is a desktop software package. DFG uses this software for the simple display and query of the spatial questions field biologists and managers have. For more information, see Appendix I.

Data

DFG uses hydrographic features, like blue line streams, from the USGS Digital Line Graph and the EPA River Reach File as a base upon which to portray collected habitat information. The habitat data is stored in an ArcView format for use by biologists. Data sources like Digital Elevation Models, soil surveys, slope stability indices, property ownership records, and road system maps, among others, are useful for analysis of watershed restoration potential. These types of spatial data can be obtained from a number of local, state and federal entities. Local GIS users groups can provide useful data contacts.

Analytical Tools

DFG has developed an ArcView interface to display stream characteristics based upon the habitat inventory data exported from the HABITAT program. For example, pool distribution, riffle location, riparian vegetation, and bank composition can all be spatially represented. This information can be displayed and printed on a map for management use.

STREAM REPORTS

Each surveyed stream should have a written report. The report should include the information from the watershed overview (Part II), a summary of the habitat inventory (Part III), results of the biological survey (Part IV), and a listing of specific problems discovered during the field survey. The DFG report format is found in Appendix J. These reports are used by fish habitat specialists, biologists, and landowners to plan and analyze habitat improvements.

The information entered on the Watershed Overview Work Sheet serves as the summary report for the watershed assessment. A brief statement about historical stream surveys, sediment sources, and basin hydrology should be included in this report.

The field data collected is most useful when presented in summary tables and graphs. Information on biological observations, significant landmarks and conditions observed during the habitat inventory are included in the report.

DATA MANAGEMENT

Data Storage

Once data has been collected, analyzed, and reports generated, the original purpose of the data collection effort may have been accomplished. There are, however, benefits from maintaining both the original data and the reports so they are both secure from loss and easily accessible. Traditionally, storage of these data have been in filing cabinets or boxes, which often limit distribution and access. Data are often lost when storage space becomes an issue, and files are discarded. Electronic storage facilitates data security, access, and sharing.

Data Distribution

Distribution of the data and final reports to several locations will insure against loss and will make the information more widely available. Within DFG, all computerized stream habitat inventory information is sent to the GIS specialist at Inland Fisheries Division (IFD) in Sacramento. All previous habitat data collected and their associated reports are stored on a server at IFD. Additional copies of the reports are sent to the appropriate DFG regional offices, and other involved agencies and landowners. Other possible data repositories include colleges, universities, and state agencies with land and water management responsibilities.

RECOMMENDATIONS

Interpreting Physical Habitat and Biological Inventories and Relating this Information to Critical Habitat Needs

Critical habitat needs must be met for a species or community to exist or prosper in a specified environment. A habitat inventory conducted to assess the need for stream channel improvements should provide sufficient detail to enable the investigator to identify these needs. The inventory will identify and quantify the physical habitat available and include fish distribution surveys to record species present. This will provide baseline data to identify unmet critical habitat needs. Based on this information, some predictions can be made regarding potential habitat gains and losses for each species before habitat work is initiated.

Whenever possible, at least two surveys should be done at different times of the year. One survey should be completed during summer low flow to estimate summer rearing habitat, identify which species of salmonids are using this habitat, and their distribution in the stream. A second should be done during the winter to determine winter rearing area, spawning gravel, early rearing habitat, and the salmonid species present.

Factors other than physical habitat may limit production of juvenile salmonids in any given year. Biological factors such as disease, predation, competition, and food availability, or factors such as water quality, weather, or water management practices may account for some of the variation in salmonid production.

Habitat improvement is typically accomplished for the benefit of a particular species or species group. Therefore, the identified critical habitat needs must be keyed to the target species. Each life stage of the target species during freshwater residency needs to be identified, and the critical habitat needs ascertained. For example, typical life stages for steelhead trout in an inland environment include spawning migration, spawning, year-round rearing and emigration. Once all the critical habitat needs for the target species are identified, they will need to be defined in terms of habitat type prior to initiation of any habitat modification project.

Region 5, USFS, has established a "Fish Habitat Relationships Program." The purpose of this program is to "...research and develop information on fish ecology and to coordinate effective applications of this knowledge in managing and protecting fisheries. By relating life stage requirements of species to physical habitat parameters, we are aiming at our main objective: developing a methodology to manage fisheries through the management of habitat." To develop these fish habitat relationships, physical and biological habitat variables are being considered. These include depth, velocity, substrate, cover, temperature, and food availability in a stream as they relate to fish distribution, abundance, and community structure. An illustration of the seasonal critical habitat needs for steelhead and chinook salmon at various life stages is given in Figure V-1. Research such as the "Fish Habitat Relationships Program" serves as a basis for determining critical habitat needs, and for planning habitat improvement projects.

Habitat inventory coupled with fish distribution surveys provides the basic information to determine the need for habitat restoration or enhancement. The fish habitat relationship models being developed and tested by the USFS should provide a tool to aid in conversion of stream survey results to working restoration plans.

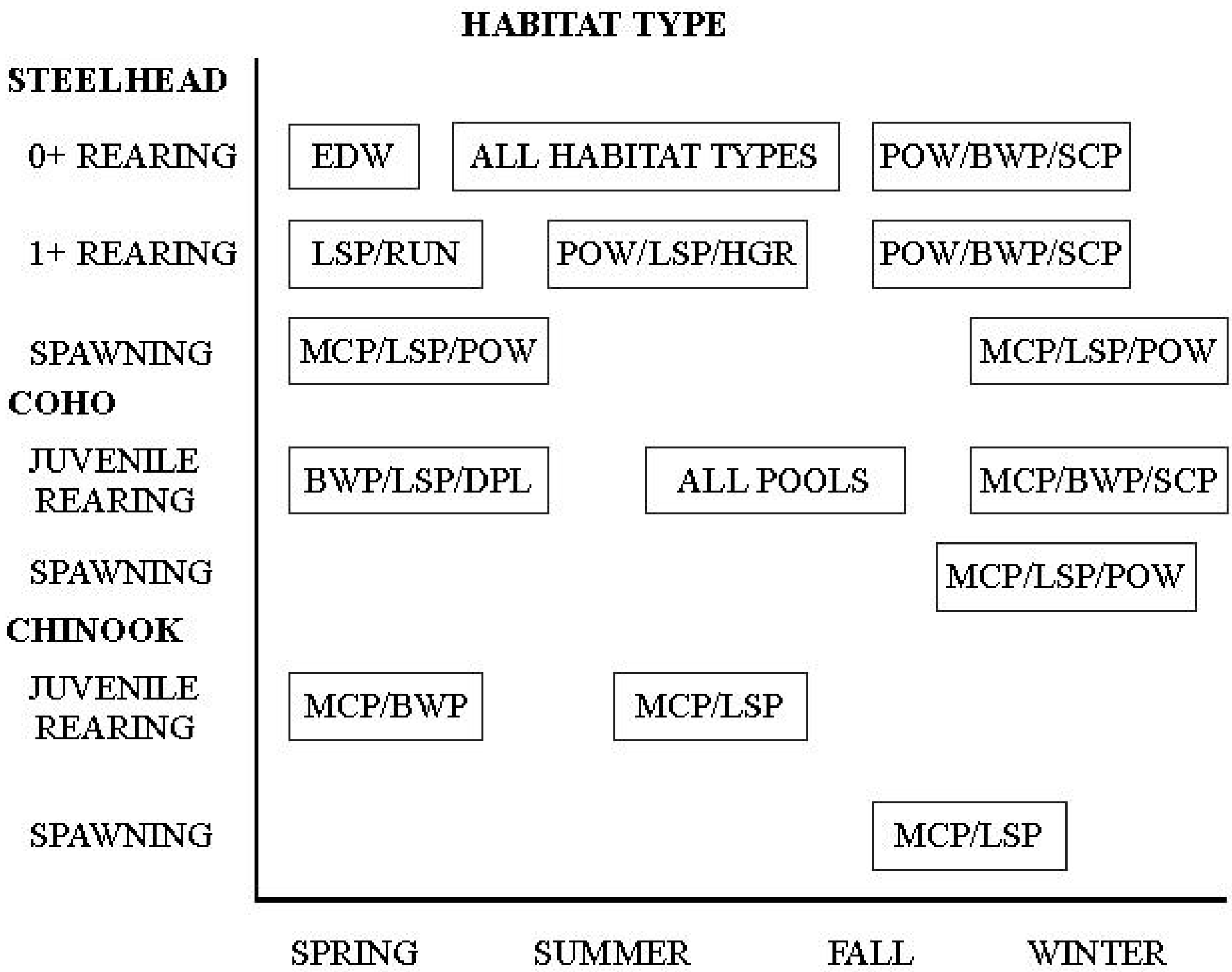


Figure V-1. Critical habitat needs. LSP represents all lateral scour pools. BWP represents all backwater pools. (McCain, Fuller, Decker, and Overton, 1990).

The "Summary of Habitat Types and Measured Parameters", Table V-2 above, compiled from the Jughandle Creek habitat inventory data showed that 22 percent of the total length of the stream was low-gradient riffle, 44 percent was flatwater run and the other 34 percent consisted of various types of pool habitats. Summer electrofishing was conducted and found some 0+ steelhead and a few 1+ and 2+ steelhead as well. Based on fish habitat relationship studies (Figure V-1), the assumption can be made that by converting some flatwater run habitat into mid-channel pools, lateral scour pools, and/or pocket water, spawning and rearing habitat could benefit this species. Further bioinventory should be utilized to detect coho or chinook presence if it should occur.

Salmonid Habitat Requirements and Suggestions for Instream Structures to Enhance Critical Habitat

Each species of salmonid has a unique life cycle and habitat requirements. Understanding critical habitat needs is essential to developing effective enhancement projects. This section will discuss: 1) general habitat requirements for anadromous fish species; and 2) reliance upon instream structures to meet critical habitat requirements.

Depending on the stream and time of year, more than one species of salmonid may be present. Adding structures to a stream with more than one species may benefit all species to some degree. To mimic natural conditions, a variety of structures can be installed to create a diversity of desirable habitats. Creation of complex depths, velocities, substrate, and cover types at various flow levels will maximize the probability that appropriate niches will be provided for all species. However, some structures will benefit one species more than others.

For example, addition of escape cover structures to long pools typically will benefit juvenile chinook, coho and steelhead. Juvenile salmon and trout tend to utilize the head and tail of a pool, but its center may not be occupied. By anchoring several logs in the pool, it can be divided into essentially two or more pools with increased effective cover.

Project design process provides the transition from assimilation of habitat inventory data to habitat modification projects. The following are brief discussions, by species, of habitat requirements and suggestions for instream structures to enhance critical habitat.

Chinook Salmon

Bays, estuaries, and the lower reaches of mainstem streams are important habitats for chinook salmon. These habitats provide holding areas for adults and rearing areas for juveniles. In many river systems these vital habitats have been reduced by the effects of land use, development, and natural events. Examples include water diversion, diking, tide gating, gravel extraction, and high levels of sediment deposition. These activities usually reduce pool habitat and escape cover, and leave shallow open channels. These problems can restrict adult access to preferred upper basin reaches where spawning success is highest. It is very difficult to improve these large areas with instream treatments. Improved land use practices within the watershed will eventually improve conditions in the lower stream reaches.

Adult holding areas are particularly important to spring chinook who must reside in the stream throughout the summer months. In low water years or during low rainfall periods holding areas may also be especially important for adult fall chinook. Both spring and fall chinook select large, deep pools with complex cover or glides and riffles with sufficient water depth and log and/or boulder cover. Typical ways to enhance holding areas for chinook are by securing logs along pool edges, or submerging logs to increase pool cover. Large boulders or groups of boulders added to pools, glides or riffles can also enhance and/or create chinook holding habitat.

Chinook salmon generally spawn in water from one to three feet deep. However, spawning can occur in depths from 0.5 to greater than 20 feet deep. Other criteria include water velocities of 1 to 3 feet per second, a gradient of 0.2 to 1.0 percent, and substrate from 0.5 to 10 inches dominated by 1- to 3-inch cobble. Escape cover for spawning adults is also important. The location of spawning will vary from one year to another depending on the timing and amount of fall and winter rains. In drought years, spawning may occur in mainstem rivers, while during years of higher flows, spawning may occur in upper basin tributaries. In mainstem or large tributaries, large boulder, diagonal or downstream "V" weirs can capture and stabilize spawning gravel. Boulder or log cover structures can be installed in conjunction with the weir structures. Boulder clusters, and single and opposing wing-deflectors are also effective in maintaining and stabilizing chinook spawning gravel. In rivers or streams lacking gravel for recruitment, such as those below dams, gravel may need to be added on a regular basis.

Immediately after emergence, the chinook fry are found in quiet water areas, along the stream bank, close to cover such as tree roots or logs. Juvenile chinook move into locations of higher velocity, either along the stream margin or in boulder runs away from the shore. Most chinook smolts migrate to the estuary or ocean in the spring. Some juveniles may remain in large pools with complex cover until they emigrate in the fall. Structures that create quiet water or debris accumulation at the stream margins are beneficial for fry survival following emergence. The enhancement or creation of large, deep pools with abundant cover can increase rearing potential for chinook juveniles.

Coho Salmon

Coho salmon have a more extended freshwater stage in their life history than chinook. Young coho spend their first year of life in the riverine environment prior to migrating to the ocean. Consequently, adequate cover, cool water, and sufficient food to sustain them through their fry and juvenile stages become critical habitat components. Juveniles are normally found in relatively slow current, and prefer water temperatures within the range of 48° to 60° Fahrenheit. In California, coho rearing habitat is generally more limiting than spawning habitat.

The quantity of spawning gravel for coho salmon is generally adequate in most California streams, although quality of the gravel may be a problem in some areas. Structures to develop pools for rearing habitat usually improve spawning reaches by trapping gravel, and creating hydraulic conditions that keep fine sediments in suspension. Instream log and boulder weirs, boulder clusters, log and boulder deflectors in series, or other structures, including the placement of large wood and root wads, will create improved habitat conditions.

Emergent coho fry require shallow, quiet areas, usually associated with backwater pools, and dammed pools, but they are also found in side channels and along the quiet water margins of other types of habitats. In periods of high flows and cold water temperatures, juvenile coho shift to slow, deep pools, beaver ponds, or to side channels and backwater pools off the main stream. Under these conditions, the young fish are torpid and seek cover under rocks, tree roots, logs, debris, and in log jams. Projects should be designed that will create backwater, dammed, and secondary channel pool habitat, and add cover complexity to coho streams lacking these elements.

During summer, preferred habitats are primary pools or backwater eddies in association with an undercut bank, submerged tree roots, or branches and logs. During summer periods young coho require cool water temperatures. Stream canopy should be approximately 80 percent to maintain suitable water temperatures. Projects should be designed to protect and develop multi-storied near-stream forests to provide shade, woody debris, and organic nutrients to the stream. Boulder-root wad combinations, large wood accumulations, whole trees, boulder clusters, and digger logs provide escape cover and can be used to create primary pools. Tree tops, branches, and other small woody debris provide especially good summer cover for coho.

Steelhead

Adult spring-run steelhead (sometimes referred to as summer steelhead), like spring-run chinook, require cool, deep pools for holding through the summer, prior to spawning in the winter. These races of fish are not abundant, and are found primarily in parts of the Klamath and Eel systems. Although water quality and holding cover are crucial, poaching may be the most serious threat to their survival. The more abundant fall and winter races of steelhead share habitats common to coho and chinook salmon. Steelhead have more variable life histories than salmon. Although they generally remain in fresh water for two years prior to entering the ocean, some steelhead enter the ocean after one year in fresh water, some after three or more years, and some never leave fresh water. Those that stay longer in fresh water, thus entering the ocean at a larger size, are more likely to return as fully mature spawners.

Steelhead spawning habitat requirements are similar to those for coho salmon. The gravel size preferred by steelhead is generally 0.5 to 6 inches dominated by 2- to 3-inch gravel. Unlike salmon, steelhead will spawn in relatively small pockets of gravel. Generally, spawning habitat is not thought to limit steelhead production. Instream structures, such as log and boulder weirs, deflectors, and clusters, installed to enhance steelhead rearing often also improve spawning habitat.

During their first summer, steelhead are generally found in relatively shallow areas, with cobble or boulder bottoms at pool tailouts, or in riffles less than 24 inches deep. In winter, they are found under large boulders in shallow riffles and quiet backwater areas. Preferred summer habitat of young-of-year (YOY) juveniles include log debris accumulations, heads of pools, runs, and riffles. Large boulder substrate is important in runs and riffles. Surface turbulence or white water is also an important overhead cover feature in these areas. During winter, YOY steelhead are found in pools, or along stream margins containing debris, logs or boulders. Most cover structures, such as boulder clusters and root wads, provide both summer and winter rearing. In very cold areas, adequate and stable interstitial habitat and low velocities are needed for lethargic YOY steelhead, since they tend to enter the substrate when temperatures reach approximately 40° Fahrenheit.

Summer rearing habitat that provides cool water pools with extensive cover for 1+ and older steelhead is typically a factor limiting steelhead production in California streams. Sometimes, turbulence and depth alone may be adequate sources of cover. In large streams, 1+ fish also rear in glides and riffles with wood or boulder cover or in pocket water around boulders. Narrowing and deepening the channel, and providing adequate shade can reduce summertime stress on steelhead by keeping maximum temperatures below 65E Fahrenheit. Branches from hardwood trees can be cabled in pools to provide cover. Boulder clusters added to riffles create good summer rearing habitat for 1+ fish. Boulder weirs provide turbulence and edge cover, creating desirable rearing habitat. On bedrock streams, pools may be created with weirs or by blasting. After blasting a pool in bedrock, addition of a weir or channel constriction is often necessary to keep the pool from filling in with silt or gravel.

Backwater pools, secondary channel pools, and pocket water are winter habitat types that provide refuge during periods of high water. These habitats may be limited in California and can be difficult to create. Boulder clusters added to riffles, log and root wad cover added to lateral scour pools and quiet water areas, and undercuts associated with weirs can provide these critical habitats.

Coast Cutthroat Trout

Coast cutthroat trout prefer low-gradient streams with log debris accumulations, and extensive shade canopy. Cutthroat trout may reside in fresh water for several years prior to emigration, or they may reproduce having never made an ocean journey. Stream improvement efforts should focus on creating optimum year-round stream habitats similar to those required for coho and steelhead.

Resident Trout

Resident trout encounter many of the same problems, and benefit from many of the same types of projects designed for salmon and steelhead. Determination of critical habitat needs should be made with a thorough understanding of the species in question. It is always necessary to know the management strategy for the stream before planning projects and to obtain specific information about local conditions and species life history.

Lack of instream cover and overhead canopy, plus stream aggradation caused by extensive ground disturbance from land management activities, are common problems in resident trout streams. These conditions can lead to increased water temperatures, loss of pools, and reduced habitat diversity. Long-term solutions to these problems can only be achieved with adoption of better land use practices. Stream habitat restoration activities can help increase fish production and meet critical habitat needs.

Trout habitat in streams flowing through meadow areas are commonly degraded by livestock grazing. Fencing, or other means of preventing livestock access to the riparian vegetation adjacent to the stream, is often all that is necessary to allow the natural recovery process to begin. Recovery may be hastened by intensive restoration efforts such as riparian plantings, log cribbing to reestablish undercut banks, or stream elevation control structures to stop down-cutting and raise the water table. Restoration plans for meadow areas must include long-term agreements for control of access to the riparian corridor. Without an adequate grazing management plan or an agreement to maintain fencing, money and effort spent on restoration will be wasted.