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Desktop Geographic Information System for Salmonid Resources in the Columbia River Basin

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Paul V. Genovese and Robert L. Emmett*

Maryland Department of Fisheries
Tawes State Office Building, B2
580 Taylor Avenue, Annapolis, MD 21401, USA

and

National Marine Fisheries Service, NOAA
* Northwest Fisheries Science Center
Fish Ecology Division
Mark O. Hatfield Marine Science Center
2030 S. Marine Science Drive, Newport, OR 97365, USA
and
Department of Fish and Wildlife
Oregon State University
Corvallis, Oregon 97331

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ABSTRACT

We developed a desktop geographic information system (GIS) of Northwest salmonid resources in the Columbia River Basin based on a series of ArcView projects. The system includes data on chinook salmon (*Oncorhynchus tshawytscha*), chum salmon (*O. keta*), coho salmon (*O. kisutch*), pink salmon (*O. gorbuscha*), sockeye salmon (*O. nerka*), and steelhead (*O. mykiss*). Each ArcView project is categorized into salmonid spawning escapement, hatchery releases, and presence/absence tabular data. Salmonid spawning escapement data sets are further divided by observation type (i.e., dam counts, fish per mile, etc.) and linked to spatial data sets (i.e., coverages - digitized geographic files) representing streams and rivers within the Columbia River Basin. Additional coverages (dams, hatchery locations, state boundaries, and land ownership) have been incorporated into each project to provide geographic reference and permit data analysis. This desktop GIS allows scientists and managers to view salmonid population characteristics and geographic features simultaneously over varying spatial scales. The addition of detailed habitat information (e.g., land use, roads/mile, water temperatures) in the future will enable scientists to identify how past and future watershed activities will affect salmonid populations in the Northwest.

CONTENTS

INTRODUCTION

Geographic Information Systems (GIS) are valuable for finding equitable solutions to long-term land and resource management problems. They are especially useful for tracking and visualizing oil spills, identifying endangered species habitat, acid rain, deforestation, desertification, wetland destruction, and depletion of the ozone layer (Cowen 1994).

The National Marine Fisheries Service (NMFS), in cooperation with NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) and Environmental Services Data Information Management (ESDIM) program, initiated the development of a desktop GIS database to consolidate recent west coast salmonid spawning-escapement estimates, hatchery releases, and relevant spawning and rearing habitat information.

We developed a desktop GIS to address salmonid population and habitat issues related to the decline of salmonid populations within the Pacific Northwest. Once-abundant populations of salmonid stocks in the Northwest are currently at record low levels. These low population sizes are related to a variety of factors including dams, destruction of spawning and rearing habitat, overfishing, poor ocean conditions, water pollution, loss of genetic integrity, and disease. Consequently, commercial and sport harvests of Northwest anadromous resources have declined significantly. The Columbia River in particular, which once had the largest chinook salmon (*Oncorhynchus tshawytscha*) runs in the world with annual harvest over 45.5 million pounds, had only 1.4 million pounds or 115,000 salmon commercially harvested in 1993 (WDFW & ODFW 1994). There once were many salmon canneries operating on the Columbia River, employing many people, but today there are none.

Many populations of salmon are at very low levels. Nehlsen et al. (1991) identified 214 Northwest salmon stocks as either threatened, endangered, at risk, or of special concern. They also concluded that at least 106 Northwest salmon populations are now extinct. The plight of Northwest salmon populations is evident by the listing of Sacramento River (California) winter chinook salmon, the Snake River spring/summer and fall chinook salmon stocks, and Snake River sockeye salmon (*O. nerka*) as threatened or endangered under the Endangered Species Act (ESA).

Since salmon utilize freshwater habitats to rear and spawn, they are relatively easy to enumerate, both at dam or weir passage facilities or on the spawning grounds. Counts of adult salmon have been the traditional method used by fishery managers to calculate adult run sizes. Although many state, federal, and tribal resource agencies presently collect salmonid adult spawning escapement and habitat data, no agency has assumed the responsibility for developing a coastwide database or monitoring program. Nehlsen et al. (1991) recommended developing such a long-term monitoring program to track the status of all anadromous fish populations on the Pacific Coast.

A comprehensive Northwest salmonid GIS database of salmonid resources and habitat characteristics will have wide-ranging applications. It will assist the Pacific Fishery Management Council with the difficult task of managing mixed-stock fisheries and assist NMFS in considering

petitioned west coast salmonid stocks for ESA listing. Furthermore, the GIS will help identify how past and future habitat alterations affect salmonid populations. A salmonid GIS will save resources spent on data searches as well as provide fishery scientists a multi-layered view of related data sets. Viewing data in a spatial and graphical environment greatly enhances the ability to analyze data, draw conclusions, and predict outcomes (Burrough 1986).

Ideally the physical and biological data can be updated quickly, and new attributes can be added as needed. This is important when NMFS is determining whether local salmonid populations qualify as distinct population segments or as habitat management decisions are made. A GIS can also help determine whether trends in a salmon population's abundance are the result of some region-wide or large-scale environmental or climatological event, or the result of local environmental perturbations such as habitat degradation.

Developing a complete, working salmonid GIS database for the entire Northwest is a large project that requires many steps before completion. As such, we initiated a pilot study, with the Columbia River Basin selected as our initial watershed. The Columbia River Basin was chosen because it (1) has a long history of salmonid habitat data collections, (2) is the largest river basin in the Northwest, (3) has many different stocks of salmonids and habitats, and (4) has undergone significant development. Furthermore, any technical problems or obstacles hindering development of a salmonid GIS database would become evident while working on a river basin of this complexity.

Three earlier studies were initially evaluated to identify similar techniques that could be employed to build a salmonid GIS database. One of the earliest efforts towards developing a database of west coast salmonid spawning streams and hatchery production was made by Wahle & Pearson (1987). They listed all Pacific coast salmon spawning streams and hatcheries producing chinook and coho salmon and estimated the number of spawners and the number of hatchery fish released during 1984-1985 (Wahle & Pearson 1987). Their study provided an excellent reference of spawning streams by species along with estimates of adult salmon spawners in each stream during 1984-1985, but did not provide any historical values. Unfortunately, a similar follow-up survey has not been conducted.

A second study by Konkel & McIntyre (1987) identified population trends in spawning populations of Pacific anadromous salmonids from 1968 to 1984. They developed a computerized database containing more than 25,000 escapement records for more than 1,000 locations. Using this database, Konkel & McIntyre (1987) tabulated salmonid population trends by region and identified areas with major data deficiencies. They found significant trends in 30% of the populations, with chum and coho salmon escapement trends predominately decreasing. In general, there were three populations that decreased for every site with an increasing trend in adult salmon escapement.

The Wilderness Society (1993) described the present and past geographic distribution of salmonid populations in the Northwest. Using a GIS, they showed the distribution of salmon

species in the Northwest and calculated what percentage of these populations were extinct, endangered, of special concern, or not known to be declining. They concluded that damage to spawning and rearing habitat caused problems for all salmon species, and that essentially all Northwest salmonid species have populations that are either extinct or at risk of extinction over a majority of their range.

Following the literature review, we identified three primary objectives: (1) Determine whether a GIS for salmonid resources could be developed for the Columbia River Basin and, if so, then (2) create a salmon GIS that would show geographic and historical data sets by stream, and (3) gather and show physical data which could be associated with salmon habitat and population abundance.

METHODS

Study Area Description

The Columbia River is the second largest river in the United States with a drainage basin encompassing 660,480 km² that ranges over seven states and two Canadian Provinces (Simenstad et al. 1990). While this basin initially contained approximately 79,176 km of streams accessible to salmon in the U.S. portion, only 49,088 km of streams in the U.S. portion are now accessible (Fig. 1). The construction of Grand Coulee Dam (completed in 1942) eliminated access to over 958 km of spawning habitat (Fulton 1968).

Computer Systems and Software

We developed the salmonid GIS using primarily a UNIX-based Sun SPARC station 10 and a PC, using Environmental Systems Research Institute's (ESRI: Redland, CA) Arc/Info and ArcView software. Arc/Info was used to create and edit coverages (digitized geographic data sets) and formalize attributes and data related to the coverages. All coverages and related data sets were then integrated using ArcView version 2.1. Separate projects were developed within ArcView, based upon each specific salmonid species. The project interface was then customized using Avenue (ArcView's programming language) to enable users unfamiliar with ArcView to use simple pull-down menus to query various spatial and related tabular data sets.

Primary Spatial Data Set

Primary geographic data were unpublished information obtained from the Bonneville Power Administration (BPA), and included streams of the Columbia River Basin displayed at the 1:250,000 scale. This coverage was further enhanced by adding additional stream sections to include important smaller stream segments which were normally not visible at the 1:250,000 scale. Complete descriptions of all spatial data sets currently available in the salmonid GIS are provided in Appendix A.

Primary Tabular Data Set

The primary source for Columbia River Basin salmonid escapement and hatchery release data was the StreamNet program of the Pacific States Marine Fisheries Commission (PSMFC). StreamNet is a multi-agency program developed to compile and disseminate salmonid population and habitat information for the Columbia River Basin (Stan Allen, PSMFC, Gladstone, OR 97027, pers. commun., Nov. 1995). Primarily funded by the BPA, StreamNet is a personal computer database containing information on salmonid life history, habitat, distribution, natural and hatchery production, harvest, escapement, and a bibliography of published and unpublished references. The initial tabular data sets for our project were created using Microsoft Access to query the various StreamNet data files and then exporting these data into a usable GIS format on the UNIX computer. Complete descriptions of all tabular data sets currently available are provided in Appendix B.

RESULTS

We developed the Columbia River Basin salmonid GIS on a UNIX-based Sun SPARC station 10 with OpenWindows 3.4 and a Pentium 90 mhz PC with 16 megabytes of RAM running Windows 95. The salmonid GIS is currently composed of four separate ArcView Projects. A total of 140 megabytes hard disk space is required for the four projects, which includes over 400 separate shape (ArcView's spatial data file format) and tabular files and 43 coverages. In addition, the ArcView software requires a minimum of 13 megabytes of hard disk space. ESRI's minimum recommendation for running ArcView on a PC is a 486/66 mhz with 12 megabytes of RAM. Due to the size of our data files, consider our configuration as the minimum for developing or running this GIS.

Each Project brings together the primary benefits of a GIS, linking digitized geographic files to a tabular database (Fig. 2). Data sets used in this system were associated with the spatial data in two different ways: directly and related/linking (Fig. 3). The direct method involved adding fields to the attribute table of a particular digitized geographic file and then inputting records (i.e., stream name). The related/linking method involved the establishment of a "common related" item between the attribute table and the independent tabular data, the same principle as for a relational database. The "principle related" item we used was the River Reach Code number (RRN). The RRN number is a national river reach coding system developed by the Environmental Protection Agency (EPA). A list of River Reach Code numbers for Oregon, Washington, and Idaho rivers, can be obtained from the Bonneville Power Administration, Portland, OR. Each RRN consists of a hierarchical 15-digit number with one decimal which is unique within the country and represents region, river basin, sub-basin, reach segment, and reach segment mile (Fig. 4). Each RRN stream segment within the primary stream coverage has a unique RRN.

The four ArcView Projects created were named primarily for the species data they

represent: Coho, Chinook, Steelhead, and Other (includes chum, pink, and sockeye salmon data). Each project was composed of Views, Tables, and Charts. The spatial (i.e., geography) data were located under Views, the tabular data were located under Tables, and Charts displayed the counts for corresponding years for each event as a histogram.

We further enhanced the GIS, adding three new categories to the ArcView menu: *Stocks*, *Attributes*, and *Imagery*. Under each of these categories is a list of options from which the user can choose. Each option runs a script in Avenue (ArcView's programming language) which automatically opens various views, tables, or charts related to that particular option (Table 1). For example, under the *Stocks* category the user can view information on escapement, presence/absence, data from Wahle & Pearson (1987), and hatchery release information.

To provide a visual geographic reference of the tabular escapement data, Arc/Info's dynamic segmentation module was used. Routes depicting salmon upriver migration were created, with each individual route terminating at the last escapement observation location (an event location). From the event tables, event markers were placed at the end of each route showing the location of the escapement observation. The escapement data were linked to the event table, and a correlated histogram was created, showing annual counts at the particular location. Table 2 shows the number of events currently in the projects. Summer steelhead had the largest number of events for a stock/species (314) and pink salmon had the fewest (4). An example of the actual GIS output (on screen) for coho salmon escapement is shown in Figure 5. An example of GIS output for hatchery-release information is shown in Figure 6.

Each project has species-specific data sets under the *Stocks* category for spawning escapement, hatchery releases, presence/absence, and run-size data from Wahle & Pearson (1987). However, most of the spatial data are uniform within all the projects. The escapement data sets are the main focus for the individual projects and are presented similarly. *Routes* and *Events* which represent the escapement observation locations, were further separated according to the type of observation they represented. For example, within the Coho Project the user may choose between *Total Live Fish* (TLF), *Fish Per Mile, Peak or Index Live Fish, Dam Events, Sport*, or *Other*.

Finally, some watershed attributes, which undoubtedly play a large role in the health and viability of salmon populations in the Northwest, are included in the GIS. In each project under the *Attribute* category are found geo-referenced data on the following subcategories: Main Dams, Hatcheries, Land Ownership, Evolutionarily Significant Units (Waples 1991), and Hydrologic Units. Simple tabulation of *Land Ownership* data reveals that almost half the land in the Columbia River Basin is controlled by the Federal Government (Table 3). Further analysis would allow users to identify the primary salmonid species or stocks that inhabit these lands, trends in their abundance, or any number of other questions.

DISCUSSION

When we initiated this GIS program, much of the GIS computer software and hardware was difficult and expensive to use or not yet available. Our primary GIS software engine, Arc/Info, still has a steep learning curve and performs best on a UNIX-based machine. However, the recent arrival of ArcView and other desktop GIS software, which can be effectively used on either an IBM-based PC or UNIX system, permits resource scientists and managers to have a GIS on their desktop. Furthermore, they can use a developed GIS with a limited amount of training. We developed the ArcView projects on a PC to identify this potential. We hope to eventually publish the Columbia River Basin salmonid GIS as a compact disk (CD) and make it available to resource agencies.

Developing and building a working GIS is a labor-intensive operation. Obtaining and developing accurate, geo-referenced data are often difficult. Fortunately, we were able to obtain many coverages from other state and federal natural resource agencies.

Although a GIS can assist with many facets of natural resource management, it is only as good as the data it contains. When we first began this project, the Pacific States Marine Fisheries Commission salmonid database (StreamNet) was unavailable. Fortunately these data are now available to all resource agencies. However, many important data sets are still unavailable. For example, although our GIS has adult escapement estimates from many streams, estimates of total run size (harvest plus escapement) for each river and stream are not yet available. Furthermore, information on habitat (water quality, number of pools, riparian vegetation, forest health, etc.) and estimates for salmonid carrying capacity for each river need to be added to the GIS. This appears to be particularly true for most of the watersheds outside the Columbia River Basin, where these types of data are unavailable or very dispersed.

At present, the tabular database supporting the salmonid GIS is in an Info database, which is not easily updated. The entire database must be rebuilt (i.e., queries conducted and related items updated) every time new data are added. This is slow, cumbersome, and inefficient. Recent agreements and software enhancements by Arc/Info and Oracle (a relational database software) now permit Arc/Info to link directly to an Oracle database. We intend to transfer the database to Oracle in the near future, which would eliminate the need to rebuild the database after updates.

Almost every state and federal natural resource agency in the Northwest is developing some kind of GIS. For example, the U.S. National Biological Service is conducting a Gap Analysis Program (GAP) (Jennings et al. 1996), which is mapping natural land cover, vertebrate species distributions, and lands managed for biological diversity. The objective of GAP is to identify the "gaps" in the network of conservation lands protecting sensitive species. NOAA is conducting a Coastal-Change Analysis Program (C-CAP) (Dobson et al. 1995) which is relating changes in coastal landscapes (using satellite imagery) to changes in living marine resources. State resource agencies are using GIS to identify and track changes in many of their resources. Eventually many of the coverages developed by other agencies can be added to the salmonid GIS

(or the salmonid GIS added to their coverages) to allow insightful views of the relationships between topography, watershed vegetation, watershed land-use activities, water quality, and salmonid population abundance. We believe that a fully developed Northwest salmonid GIS will lead to better management of salmonid freshwater ecosystems and allow agencies to readily identify stocks and habitats of highest concern. Furthermore, it promises to provide valuable insights into the key freshwater problems affecting salmonid stocks and encourage innovative management options to restore these valuable salmonid stocks.

ACKNOWLEDGMENTS

Many helpful individuals and agencies provided technical information, data, coverages, and encouragement. Particular thanks go to Duane Anderson and Stan Allen of the Pacific States Marine Fish Commission, Tom Pansky of the Bonneville Power Administration, Milton Hill of the Oregon Department of Fish and Wildlife, and Martin Hudson of the Washington Department of Fish and Wildlife.

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Table 1
Options currently available under each category in the ArcView projects.

Stocks	Attributes	Imagery
Escapement	Main dams	Lower Columbia River infrared
Presence/absence	Hatcheries	Pacific Northwest elevation
Wahle & Pearson 1987	Land Ownership	
Hatchery releases	Evolutionarily Significant Units	
	Hydrologic Units	

Table 2
Numbers of event locations (i.e., recorded observations), hatchery release sites, and streams with fish present for each species within the Columbia River Basin salmonid GIS.

		Chinook salmon			Steelhead				
	Coho salmon	Fall chinook	Spring chinook	Summer chinook	Summer steelhead	Winter steelhead	Chum salmon	Pink salmon	Sockeye salmon
Number of event locations	162	157	268	59	314	132	25	4	16
Number of hatchery release locations	240	83	162	18	128	42	8	0	17
Number of streams with presence	169	86	414	82	924	164	15	0	17

Table 3
Ownership of each state's land area within the Columbia River Basin represented in square kilometers (km^2) and as a percentage of the state's total land area.

Land Owner	Oregon		Washington		Idaho		Total land area	
	km^2	%	km^2	%	km^2	%	km^2	%
Federal	65,003.6	45.49	41,423.1	27.25	136,005.3	52.60	242,432.7	43.80
State	2,160.3	1.51	9,094.8	5.98	10,553.2	4.08	21,808.4	3.94
Private	73,663.9	51.55	89,932.3	59.17	108,942.8	42.13	272,540.1	49.24
Native American	2,063.9	1.44	11,338.0	7.46	3,057.7	1.18	16,459.7	2.97
City	0.4	0.00	0.0	0.00	0.0	0.00	0.4	0.00
County	11.8	0.01	43.4	0.03	0.0	0.00	55.2	0.01
Other	0.0	0.00	167.7	0.11	0.0	0.00	167.7	0.03
Totals	142,903.9		151,999.3		258,559.0		553,462.2	

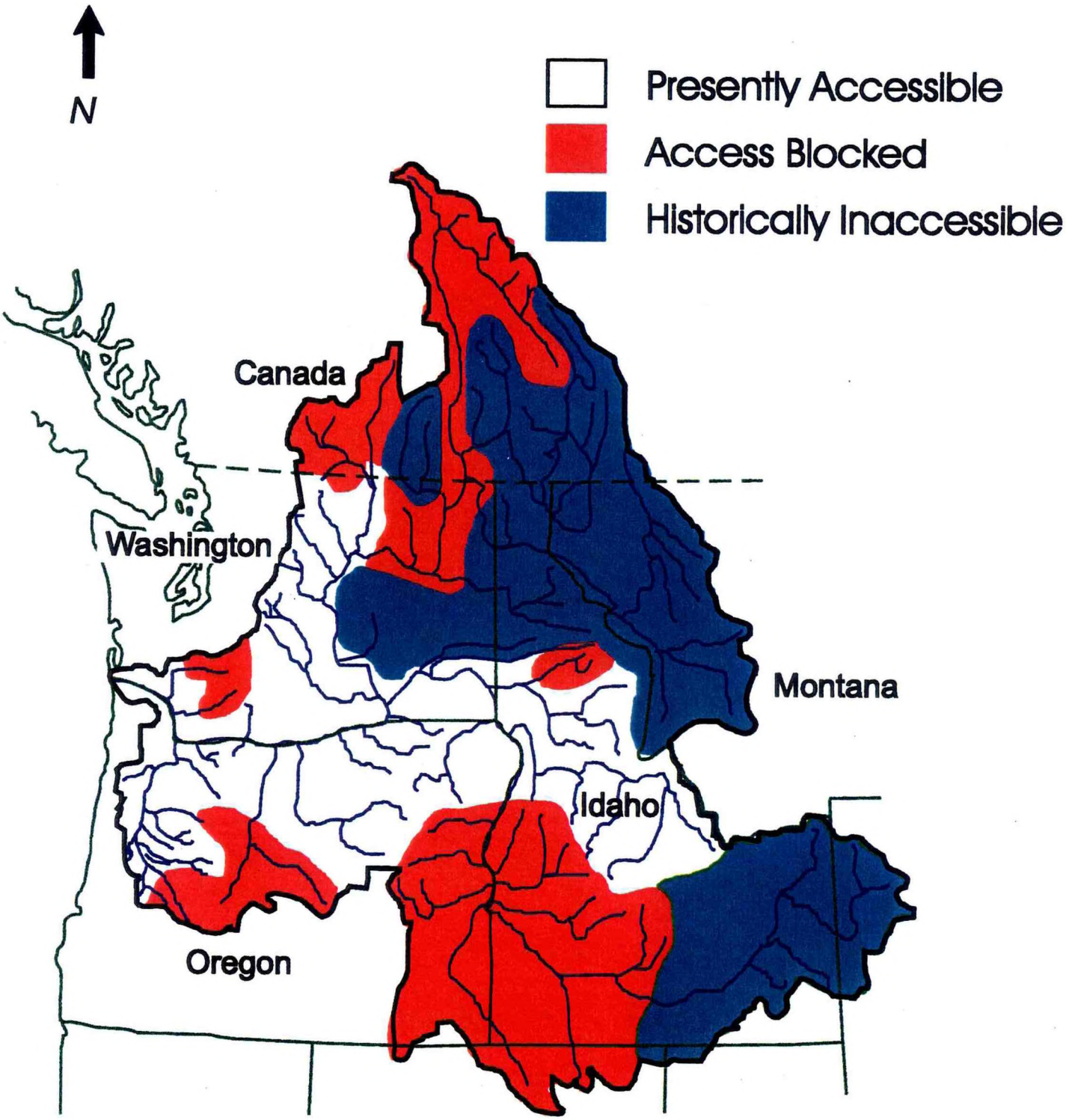

Figure 1. Map of Columbia River Basin showing areas presently and historically available to salmon and steelhead. From WDFW and ODFW 1994.

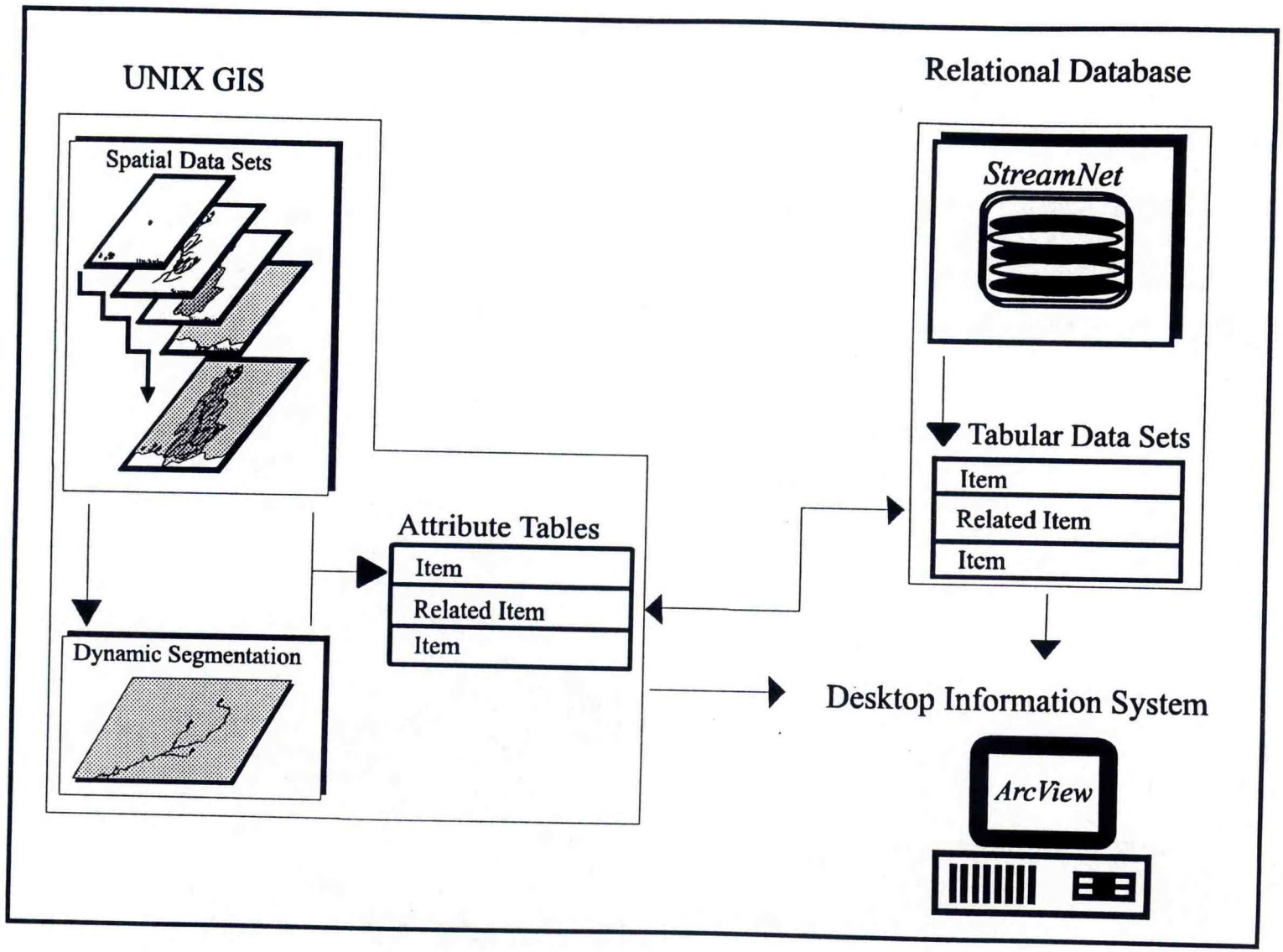

Figure 2
Components of the salmonid desktop GIS for the Columbia River Basin.

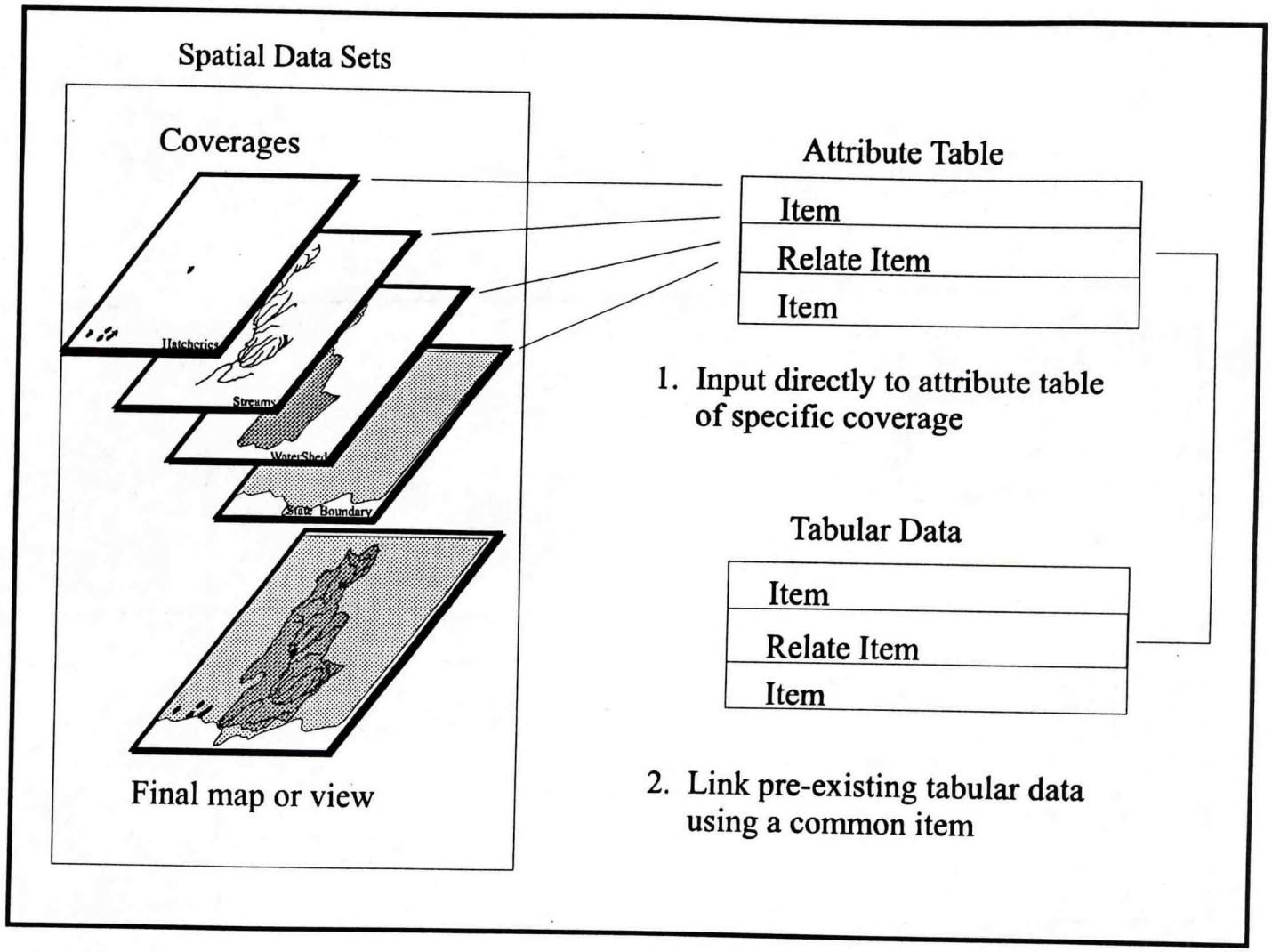

Figure 3
Graphic presentation showing how data were added to the desktop GIS directly and through a related item.

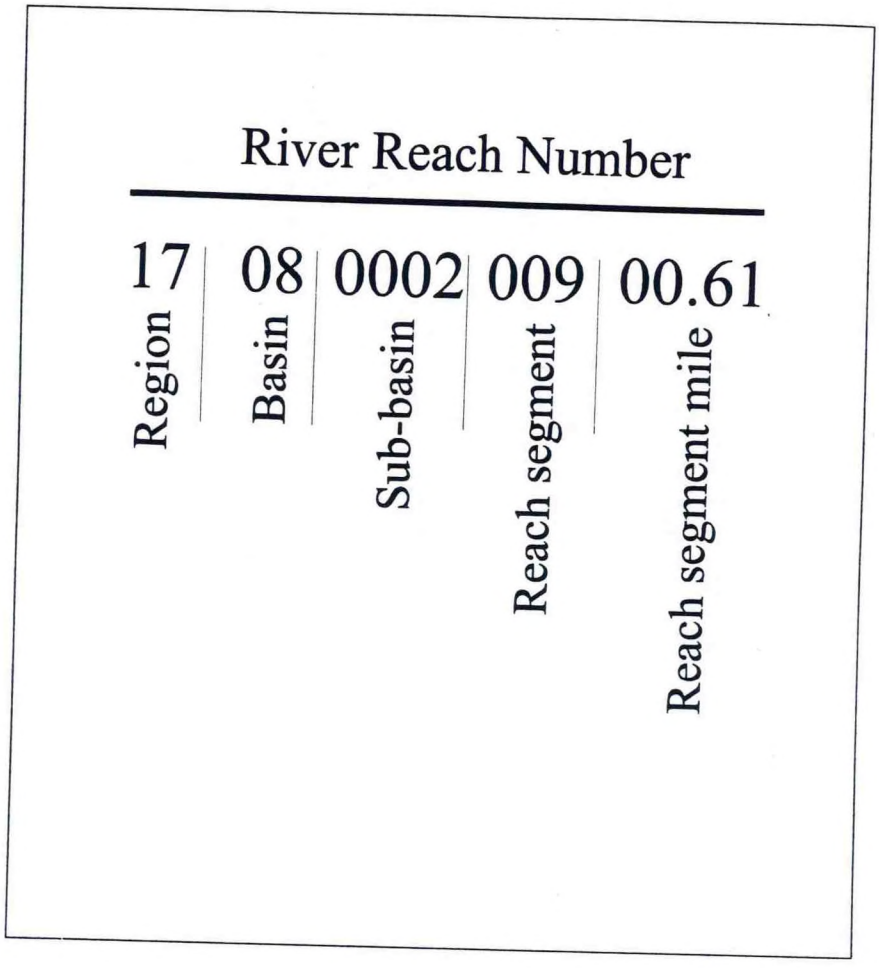

Figure 4
Example of 15-digit Environmental Protection Agency river reach number (RRN). For example, numbers for the river mile segment located in the Northwest region (17), the lower Columbia River Basin (08), the Lewis River sub-basin (0002), reach segment 009, and reach segment mile 00.61.

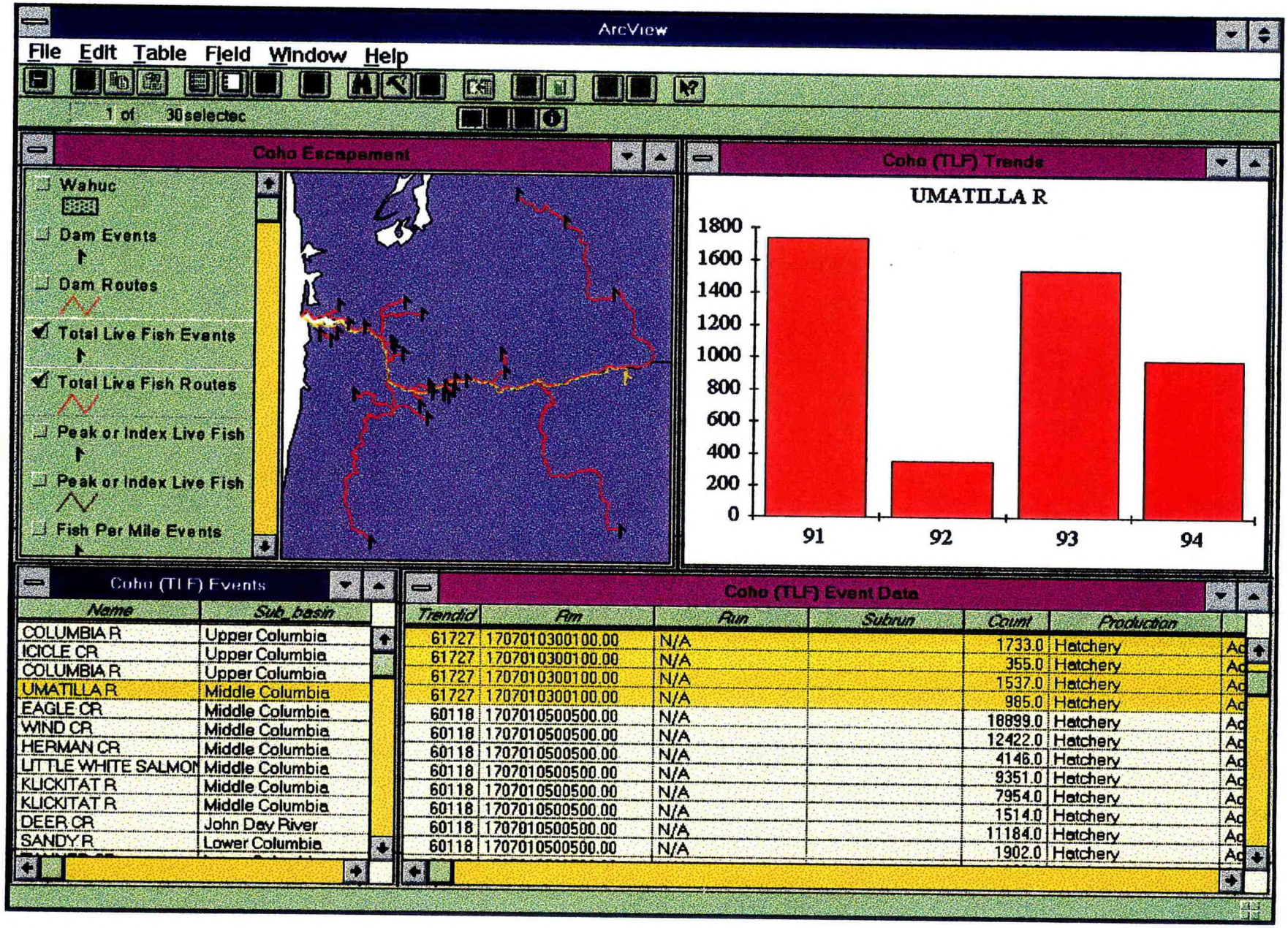

Figure 5. Example of a computer screen view of escapement data from the salmonid GIS "Project Coho." Figure depicts escapement type 'Total Live Fish' (TLF) with view, event table, event data table, and trends histogram for the Umatilla River. The geographic location of the event location and fish travel route are shown in yellow.

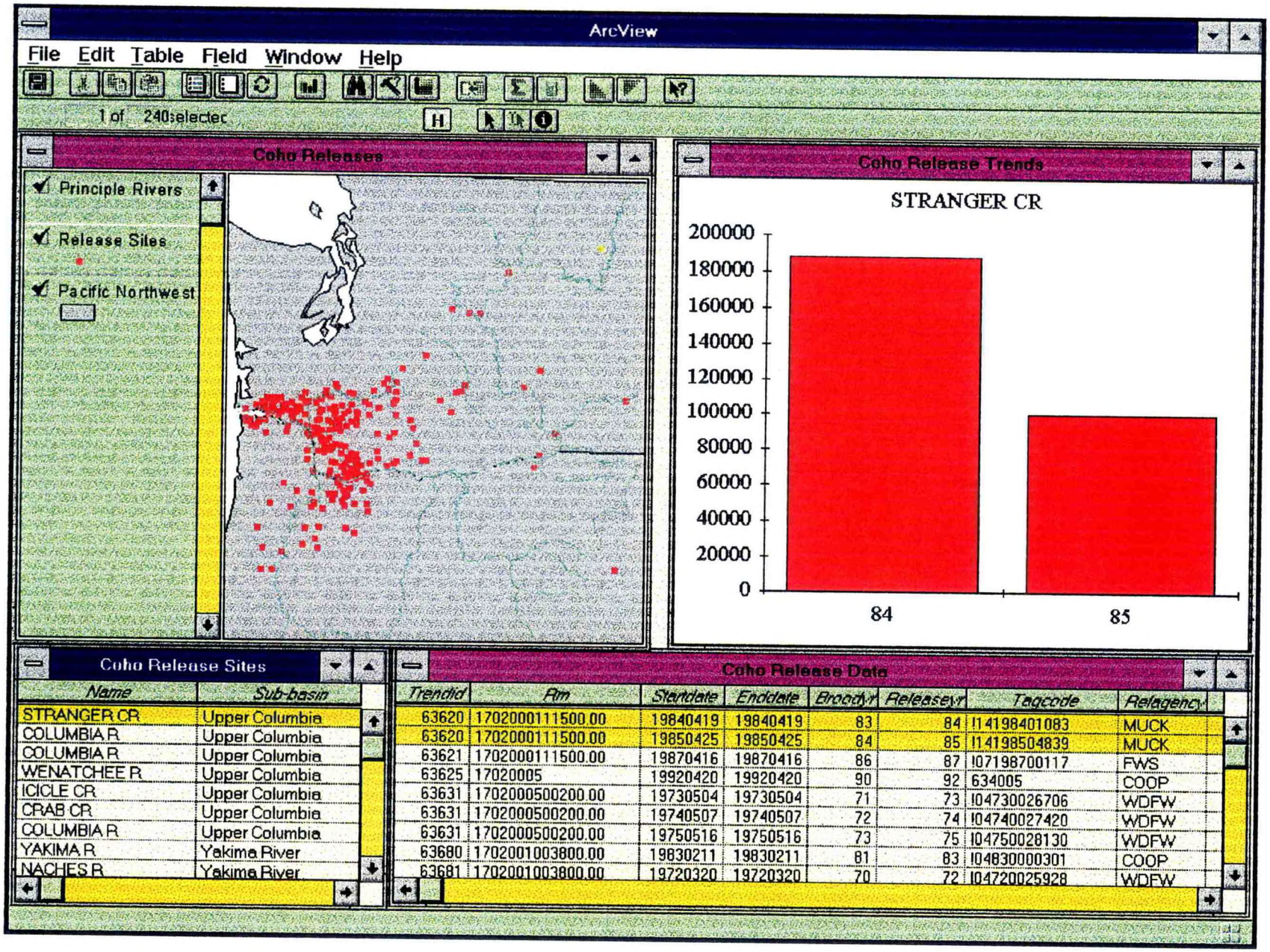

Figure 6. Example of hatchery release information from the salmonid GIS "Project Coho." Figure shows coho salmon hatchery release location, Release Sites table, Release Data table, and Release Trends histogram for Stranger Creek. Data and geographic location are highlighted in yellow.

APPENDIX A: SPATIAL DATA SETS

APPENDIX A: Spatial Data Sets

The following tables describe the attributes of ArcView shape files and Arc/Info coverages currently available within the Desktop GIS of Northwest salmonid resources for the Columbia River Basin. The name of the data set is listed first, followed by the original source of the data set (if known). Internal Arc/Info attributes (i.e., number and codes created and used by Arc/Info) are simply denoted as ARC attributes.

Appendix Table 1A. Description of "Nwstates.shp," a shape file showing state boundaries of California, Idaho, Oregon and Washington. Source: Environmental Systems Research Institute, Redlands, CA 92373 (from USA coverage).

Field	Description
SHAPE	----------
AREA	
PERIMETER	ARC Attributes
STATE#	
STATE_ID	----------
STATE_NAME	State name
STATE_FIPS	State FIPS Code
SUB_REGION	States regional location
STATE_ABBR	State postal abbreviation

Appendix Table 2A. Description of "Streams," an Arc/Info coverage representing Streams within the Columbia River Basin. Source: Bonneville Power Administration, Portland, OR 97232.

Field	Description
SHAPE	----------
FNODE#	
TNODE#	
LPOLY#	ARC Attributes
RPOLY#	
LENGTH	
COL2#	
COL2-ID	----------
RRN	River reach number
NAME	Stream name
STRORD	Stream order (all streams are not ordered)

Appendix Table 3A. Description of "Principle Rivers" coverage (part of Arc/Info Coverage "Mainrivs"), representing primary rivers within the Columbia River Basin. Source: Bonneville Power Administration, Portland, OR 97232.

Field	Description
Same as "Streams" coverage	

Appendix Table 4A. Description of "Dams" coverage, representing dams located in the Columbia River Basin. Source: Bonneville Power Administration, Portland, OR 97232.

Field	Description
SHAPE	----------
AREA	
PERIMETER	ARC Attributes
COLDAMS#	
COLDAMS-ID	----------
NAME	Dam name
RRN	RRN of dam site
POWER_STATUS	Hydropower status
FERC_NO	Project number
PURPOSE	C, flood control; D, debris control; F, fisheries; H, hydro-power; I, irrigation; N, navigation; P, farm pond; Q, water quality; R, recreation; S, water supply; Z, other.
COMPLETION	Date dam was completed
HEIGHT(FT)	Height of dam
FISH_SCREEN	Fish screen status
FISH_PASSAGE	Fish passage status
IMPOUNDMENT	Length of impoundment (miles)
FISH	A, spring chinook salmon; B, summer chinook salmon; C, fall salmon; X, chinook salmon (unspecified); D, chum salmon; E, coho salmon; F, kokanee salmon; G, pink salmon; H, sockeye salmon; I, brook trout; J, brown trout; K, cutthroat (anadromous); L, cutthroat (resident); M, Dolly Varden; N, lake trout; O, rainbow trout; P, summer steelhead; Q, winter steelhead; Y, steelhead (unspecified); R, warmwater fish; S, dace and sculpins; T, white sturgeon; U, whitefish; V, smallmouth bass; W, other.

Appendix Table 5A. Description of "Main Dams" coverage, representing main dams located on the Columbia and Snake rivers. Source: Bonneville Power Administration, Portland, OR 97232.

Field	Description
Same as "Dams", Columbia Basin coverage	

Appendix Table 6A. Description of "Hatcheries" coverage, representing hatchery locations within the Columbia River Basin. Some records are not current. Source: Bonneville Power Administration, Portland, OR.

Field	Description
SHAPE	----------
AREA	
PERIMETER	ARC Attributes
HATCH#	
HATCH-ID	----------
HATCH_NAME	Name of hatchery
OPERATOR	Federal, State, Tribal, etc.
ADDRESS	Mailing address
CITY	City
ZIP	Zip code
CONTACT	Contact name
PHONE	Phone number
RRN	River reach number
STREAM	Stream name
START_UP	Hatchery start up date
LONGITUDE	Longitude
LATITUDE	Latitude

Appendix Table 7A. Description of "Columbia Drainage" coverage, representing Columbia River Basin drainage area. Source: National Marine Fisheries Service, Portland, OR 97232.

Field	Description
Internal ARC attributes only; no additional attributes added.	

Appendix Table 8A. Description of "coho salmon ESUs" coverage, representing distinct Coho salmon Evolutionarily Significant Units (ESU) throughout the U.S. Pacific Northwest Region (as of Dec. 1996). Source: Bonneville Power Administration and National Marine Fisheries Service, Portland, OR 97232.

Field	Description
SHAPE	----------
AREA	
PERIMETER	ARC Attributes
COHOESU#	
COHOESU-ID	----------
NAME	Name of Evolutionarily Significant Unit (ESU)
STATUS	Status code of ESU

Appendix Table 9A. Description of "Idhuc" (Idaho Hydrologic Unit Codes) representing hydrologic unit codes (HUCS) for watersheds within the state of Idaho. Source: Idaho Department of Fish and Game, Boise ID 83707.

Field	Description
SHAPE	----------
AREA	
PERIMETER	ARC Attributes
IDHUC#	
IDHUC-ID	----------
HUC_NO	Hydrologic Unit Code number
BTROUT	Presence of brown trout
REGION	No data
BULLDIST	Bull trout distribution
DIGIT4	First 4 digits of Hydrologic Unit Codes
DIGIT6	First 6 digits of Hydrologic Unit Codes

Appendix Table 10A. Description of "Orhuc" (Oregon Hydrologic Unit Codes) coverage. This coverage represents hydrologic unit codes (HUC) for watersheds within the State of Oregon. Source: Oregon State Service Center for GIS, Salem, OR 97310.

Field	Description
SHAPE	----------
AREA	
PERIMETER	ARC Attributes
ORHUC#	
ORHUC-ID	----------
TILE-NAME	Directory name of Hydrologic Unit Code
HUC	Hydrologic Unit Code
BASIN-NAME	Geographic name of Hydrologic Unit Code
QUAD-NAME	Geological Survey quad map name

Appendix Table 11A. Description of "Wahuc" (Washington Hydrologic Unit Codes) coverage, representing hydrologic unit codes (HUCS) within the state of Washington. Source: Washington Department of Fish and Wildlife, Olympia WA 98507.

Field	Description
SHAPE	----------
AREA	
PERIMETER	ARC Attributes
WAHUC#	
WAHUC-ID	----------
HYDROUNIT	Hydrologic Unit Code
BASIN-NAME	Geographic name of Hydrologic Unit Code
QUAD-NAME	Geological Survey quad map name
TILE-NAME	Directory name of Hydrologic Unit Code

Appendix Table 12A. Description of "Idown2" (Idaho Land Ownership), representing land ownership information within the state of Idaho. Source: U.S. Bureau of Land Management, Portland, OR 97208.

Field	Description
SHAPE	----------
AREA	
PERIMETER	ARC Attributes
IDOWN2#	
IDOWN2-ID	----------
OWN	Owner identification code
NAME	Owner name identification code
CHNAME	Site name, if known

Appendix Table 13A. Description of "Orown2" (Oregon Land Ownership) coverage, representing land ownership parcels within the state of Oregon. Source: U.S. Bureau of Land Management and/or Oregon State Service Center for GIS, Salem, OR 97310.

Field	Description
Attributes same as coverage "Idown2" (Appendix Table 12A)	

Appendix Table 14A. Description of "Waown2" (Washington Land Ownership) coverage representing land ownership parcels within the state of Washington. Source: U.S. Bureau of Land Management, Portland, OR 97208.

Field	Description
Attributes same as coverage "Idown2" (Appendix Table 12A)	

Appendix Table 15A. Description of "Species" coverage, representing salmon presence or absence for all streams represented within this study area. Sources: Idaho Department of Fish and Game, Boise; Oregon Department of Fish and Wildlife, Portland; and Washington Department of Fish and Wildlife, Olympia.

Field	Description
SHAPE	----------
FNODE#	
TNODE#	
LPOLY#	ARC Attributes
RPOLY#	
LENGTH	
PASPECIES#	
PASPECIES-ID	----------
RRN	River Reach Number
COHO	Coho salmon presence; 0=no, 0-1=upper extent, 1=yes
CHUM	Chum salmon presence; 0=no, 0-1=upper extent, 1=yes
CHSP	Spring chinook salmon presence; 0=no, 0-1=upper extent, 1=yes
CHSU	Summer chinook salmon presence; 0=no, 0-1=upper extent, 1=yes
CHFA	Winter steelhead presence; 0=no, 0-1=upper extent, 1=yes
STJU	Juvenile steelhead presence; 0=no, 0-1=upper extent, 1=yes
STUK	Steelhead (unknown race) presence; 0=no, 0-1=upper extent, 1=yes
STR-NAME	Stream name
COUNTY	County name
HUC	Hydrologic Unit Code
SEG	Stream segment
RMI	River mile
SEGRMI	Stream segment and river mile
HYDROUNIT	Hydrologic unit

APPENDIX B: TABULAR DATA SETS

APPENDIX B: Tabular Data Sets

The following tables describe the tabular data sets contained within the four ArcView Projects. Each table lists the field (item) names for the data set and a brief description of the field name.

Appendix Table 1B. Description of species "Events" location tables which list the location of escapement events. There are unique species event tables for each type of escapement (dam count, total live fish, etc.) within each project.

Field	Description
NAME	Name of stream where event occurred
SUB-BASIN	Name of sub-basin where event occurred
RRN	River reach number of event location
RTNO	Unique identifier for route on which event is located
T_MEAS	Number of meters event is upstream from mouth of Columbia River
Km_UPSTREAM	Number of kilometers event is upstream from mouth of Columbia River

Appendix Table 2B. Description of species "Event data" tables for escapement which list pertinent escapement data for each escapement event. Each species "Event data" table is related to a particular species "Events" table through the Relate Item river reach number (RRN).

Field	Description
TRENDID	Unique identifier for data input
RRN	River reach number of event location
SUBRUN	Signifies sub-run of species
COUNT	Number of observations of particular type
PRODUCTION	Origin of species (i.e., natural, hatchery)
STAGE	Life stage of species at time of observation
TYPE	Type of count
METHOD	How species were counted
HATCHID	Unique identifier of hatchery
DAMID	Unique identifier of dam
STARTYEAR	First year of observation for particular trend
ENDYEAR	Latest year of observation for particular trend
TRENDCOM	Additional comments referring to trend
MEANVAL	Mean value of counts for particular trend
CATEGORY	Type of count, substantiated
YEAR	Year of observation
COUNTCOM	Additional comments referring to count

Appendix Table 3B. Description of species "Release sites" table, listing the location of hatchery release sites. There are unique species "Release sites" tables for each project.

Field	Description
NAME	Name of stream where release occurred
SUB-BASIN	Name of sub-basin where release occurred
RRN	River reach number of release location
T_MEAS	Number of meters release is upstream from mouth of Columbia River
Km_UPSTREAM	Number of kilometers release is upstream from mouth of Columbia River

Appendix Table 4B. Description of species "Release data" tables, listing pertinent hatchery release data for each hatchery-release event within each project. Each species "Release data" table relates to a particular species Release Sites table through the Relate Item river reach number (RRN).

Field	Description
TRENDID	Unique identifier for data input
RRN	River reach number of release site
RELEASE DATE	Date of release
BROODYR	Brood year of released fish
RELEASEYR	Release year
TAGCODE	Coded wire tag code if present
RELAGENCY	Release agency
NOCWT	Number released with coded wire tag
NOSHEDCWT	Number which shed their coded wire tag
NOUNTAG	Number released untagged
TOTALREL	Total number of fish released
WEIGHT	Average weight in grams at release date
LENGTH	Average length in millimeters at release date
COMMENT	Additional release comments
PRODUCTION	Origin of brood stock (i.e., natural, hatchery)
STAGE	Life stage at release date
TYPE	Type of release
METHOD	Method used to obtain release count
HATCHID	Unique identifier of hatchery
YEAR	Year of release
REFID	Unique identifier for references

Appendix Table 5B. Description of "Dam information" table which lists physical Information about dams within the Columbia River. Source: Pacific States Marine Fisheries Commission (PSMFC), Gladstone, OR.

Field	Description
DAMID	Unique identifier for individual dam
NAME	Dam name
YEARBUILT	Year dam was built
DAMTYPE	Type of dam
HEIGHT	Height of dam (feet)
MAXCAP	Maximum holding capacity
OWNER	Principle owner of dam
CAPACITY(max)	Acre feet
AFFILIATION	Private, state, or federal
COMMENT	Location comments
USE	Purpose of dam

Appendix Table 6B. Description of "Fishery data" obtained from Wahle & Pearson (1987). Information within table was derived directly from the report section pertaining to the Columbia River Basin.

Field	Description
STREAM	Stream name
NTRL_SPWNR	Number of natural spawners present
HTCHRY_REL	Number of hatchery fish released into stream
REFERENCE	Where data were obtained

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30 **Grant, W.S. (editor). 1997.** Genetic effects of straying of non-native hatchery fish into natural populations. Proceedings of the workshop, June 1-2, 1995, Seattle Washington. 130 p. NTIS number pending.

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20 **Hinton, S.A., and R.L. Emmett. 1994.** Juvenile salmonid stranding in the lower Columbia River, 1992 and 1993. 48 p. NTIS PB-95-199352.

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