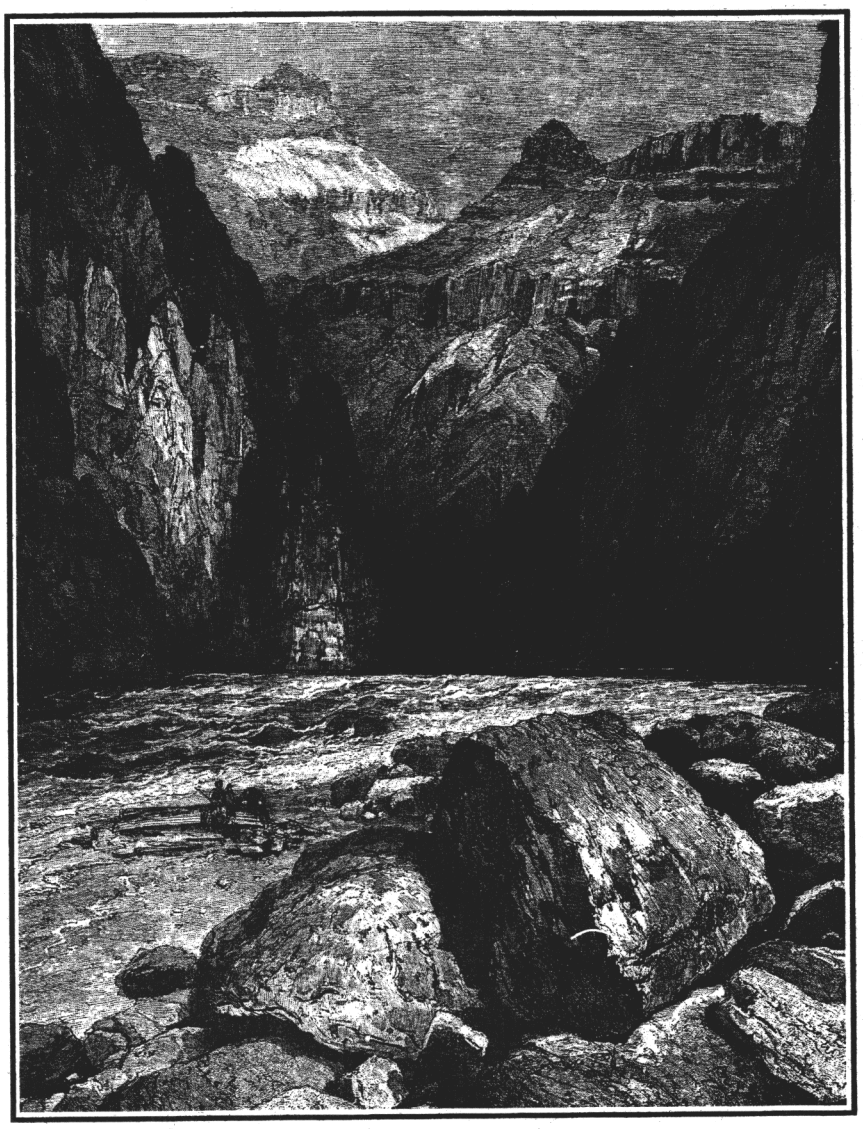
Life History and Ecology of the Humpback Chub (Gila cypha) in the Colorado River, Grand Canyon, Arizona

Supplement No. IV:

Grand Canyon Fisheries Integrated Database



Bureau of Reclamation

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Glen Canyon Environmental Studies

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Life History and Ecology of the Humpback Chub (Gila cypha) in the Colorado River, Grand Canyon, Arizona

Supplement No. IV
Fisheries Integrated Database

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CHAPTER 1: INTRODUCTION

GCES BACKGROUND

The Glen Canyon Environmental Studies (GCES) were initiated by the Department of Interior in December 1982 to assess the environmental impacts of Glen Canyon Dam operations on resources of Grand Canyon. Data collected by GCES researchers were used in the Environmental Impact Statement describing the operation of Glen Canyon Dam, and to develop and implement long-term monitoring and core research programs. The GCES data have been collected by personnel from federal and state agencies, universities, and private groups. Significant amounts of data were collected during both GCES Phase I (1982-88) and GCES Phase II (1988-95). For GCES Phase II, a Draft Integrated Research Plan (DIRP; U.S. Department of Interior 1990) was developed to organize biotic, abiotic and cultural resources studies into general groups (or components) (Fig. 1-1) and to provide research guidance for these studies. The Native and Endangered Fish Studies (NEFS) component of the DIRP outlined technical study plans for all fisheries-related investigations.

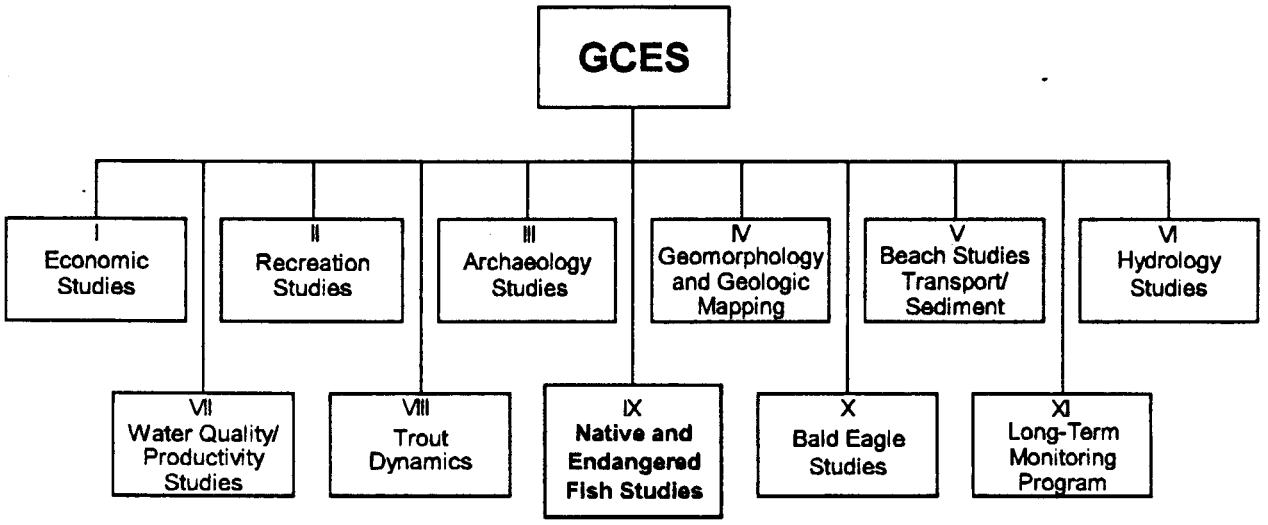

Fig. 1-1. Study components of the GCES Phase II Draft Integrated Research Plan.

GCFIN REPORT

The studies conducted under the NEFS yielded large amounts of information. However, simultaneous access to all information for one or more components of the NEFS has been difficult because of different methods for collecting and storing data. GCES coordinators recognized that to facilitate information use within and among the NEFS components, two general actions would have to be taken: (1) consolidate, or integrate, each database into one accessible database format, template, or structure, and (2) identify methods and programs necessary to simultaneously access the information among several NEFS components. The primary purpose of this document is to present a framework or roadmap for assimilating and integrating data for one DIRP component, the NEFS. Eventually, other components of the DIRP should develop integrated databases that will facilitate inter-disciplinary evaluation of data using elements of this project as a prototype.

This report provides GCES with the information and guidelines necessary for achieving two of its goals: (1) a uniform, centralized database for incorporating all fisheries data, and (2) a geographic information system (GIS) interface to query and analyze the fisheries data. Attaining these two goals will aid managers and administrators in making more informed decisions about the effect of Glen Canyon Dam operations on Grand Canyon resources. This effort to consolidate and document the individual fisheries databases and to integrate them, where possible, is referred to as the Grand Canyon Fisheries Integrated (GCFIN) Database project. This project represents a significant challenge as the fisheries information collected to date by individuals and organizations differs substantially in content and form. The content of the fisheries data ranges from qualitative historical notations made by early canyon pioneers to detailed, quantitative descriptions that precisely document life histories and ecology of fish species. The form of the data range from hand written notes to complex computer databases with notable variation occurring between different databases.

Fisheries investigations described in this GCFIN Report were conducted by Arizona State University (ASU), U.S. Fish and Wildlife Service (Service), University of Arizona (U of A), Arizona Game and Fish Department (AGFD), Northern Arizona University (NAU), and BIO/WEST Inc. (B/W).

A similar integrated database is being developed by the Navajo Natural Heritage Program (NHP) for the Little Colorado River. To facilitate integration of the two databases NHP data storage formats and database structures are similar to those identified and developed for GCES databases described in this document.

GCFIN DATABASE

The GCFIN Database will establish a means by which interested parties can readily access Grand Canyon fish information. The GCFIN Database will include two major resources: (1) an Integrated Database that will contain combined portions of individual databases, and (2) entire databases. The GCFIN Database will have a customized interface that allows users to access information on a particular subject, as well as analyze that information. By having one integrated database that is easily accessible, users will be able to easily locate information without having to search each individual database. However, since some parts of the various databases are dissimilar and cannot be combined into one completely integrated database, each database will also be available (Fig. 1-2).

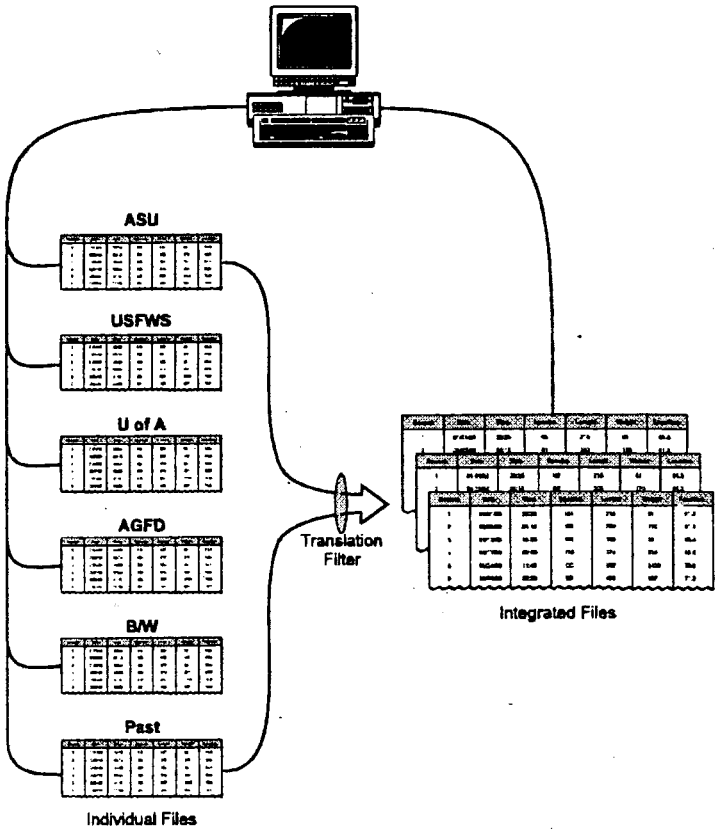

Fig. 1-2. GCFIN database organization showing storage of existing databases and incorporation of datasets into integrated files.

The framework for the GCFIN Database is an assimilation of datasets compiled from various investigators. Each of these datasets is formatted with field-specific data entries and frequently have a set of designated codes. Because many of these fields and codes were not compatible in their original form, the conversion steps necessary to make them compatible or interchangeable are included in this report. A significant effort was made to identify data fields that are compatible with the existing database fields for endangered fishes of the Upper Colorado River Basin (USFWS 1989). Insuring this compatibility allows for integration of key elements from both upper and lower basin databases for use by biologists and administrators.

Before developing the framework for the GCFIN Database, its potential uses and functions were evaluated. Database coordinators defined 10 of the most common informational needs for fisheries data. These needs, in turn, defined groups or "fields" of information to be incorporated into the database. Defining important fields within a database is especially challenging in the scientific world because new questions or hypotheses are always arising, hence the database fields selected may change over time. In developing this GCFIN Database framework, the database programmers attempted to define the most common questions that GCFIN Database users would ask. The programmers recognize that this list is not inclusive and that questions (and associated database fields) will be added, deleted, and modified over time. The intent of this database would be to allow users to gather information to address immediate questions and to allow for assimilation of this information to address future questions.

USES FOR AN INTEGRATED DATABASE

The potential uses for an integrated database are as varied as the purposes and objectives of the data users. All possible uses could be considered as the sum of all possible combinations of data fields. Hence, a comprehensive list of uses for this integrated database is not possible.

The following is a list of some of the more common needs of potential users of this database. The list was developed by biologists working in Grand Canyon at the time this report was written, and reflects some of the more common inquiries of fisheries databases in the Colorado River Basin.

1. List of Fish Tags and Associated Data

A comprehensive list of fish tags (i.e., PIT, Carlin, Floy tags) is a standard set of information used by all fisheries biologists in the basin. Fish are frequently captured, marked, and recaptured as a means of understanding movement, growth, survival, etc.

2. Meristics and Morphometrics

Measurements of individual fish are valuable for taxonomic evaluation of specimens and populations. This information brings together historic information, often from museum specimens, with recent information.

3. Habitat of Fish

Many investigations collect habitat data as an objective of the study or incidental to other activities. A consolidated dataset of habitat data is valuable for spatial and temporal comparisons of habitat by species and age group.

4. Food Habits

Diets of fish often reflect environmental conditions, and hence the health of fishes. Contents of stomachs from fish of various species and locations provides information on food availability, environmental conditions, competition, predation, etc.

5. Catch Rates

Catch data are rare but valuable. Past fisheries surveys have lacked quantification of effort, and estimations of fish density have been precluded. More recently, most fisheries studies include effort as a standard data entry, which provides valuable comparisons of relative fish density over time and between areas.

6. Age and Growth

Data from scales and otoliths for use in age determination are lacking for many native species, and the little available information needs to be assimilated. Age and growth data are valuable for characterizing populations.

7. Water Quality

Although water quality data are available from USGS stream gage records, site specific data are valuable for evaluating fish conditions and occurrence.

8. Species Interactions

Past analyses have failed to examine the interactions of non-native and native species, primarily because of a lack of available data. This dataset would provide information on numbers of fish, habitat, water conditions, and other environmental variables.

9. Parasites

The threat of fish parasites has recently become an important issue with humpback chub in Grand Canyon because of the discovery of the Asian tapeworm in a variety of species. The spread of this parasite, as well as the degree of infestation in individual fish is important information in monitoring effects of parasites.

10. Benthic Invertebrates

Information on invertebrates is valuable for evaluating effects of water conditions, and for evaluating food availability for fishes by season and area.

GCFIN GIS

Data contained in the GCFIN Database will be integrated into a Geographic Information System (GIS) to facilitate viewing multiple layers of information and analysis of multiple datasets or partitions. This will allow for interfacing fishery data with databases of other disciplines (e.g., geomorphology, riparian, cultural, etc.) to provide a more comprehensive representation and understanding of resources in Grand Canyon.

The role of GIS in this GCFIN project was to: 1) determine if the fisheries information can be integrated into a GIS, and 2) determine how GIS can be used to provide the access interface to the GCFIN Database. To fulfill the first role, the methodology to produce a simple view of fisheries data collection sites simultaneous to an existing geographic reference (i.e., orthophotos map sites, Werth

et al. 1993) was required. However, to fulfill the second role, a considerably greater effort was required. For this project, the conceptual methodology for constructing a GIS interface to access and analyze fisheries information was developed and tested using the BIO/WEST (B/W) fisheries data. The actual GIS interface to the entire GCFIN Database will need to be further developed and tested when the actual GCFIN Database is being constructed.

GCFIN REPORT ORGANIZATION

This document is arranged to assist the reader in recognizing the types of databases used by GCES investigators, understanding the similarities and differences between databases, determining potential courses of action for modifying similar database fields for incorporation into the GCFIN Database, and realizing the potentials of GIS to organize and provide access to fisheries information.

A general description of the chapter contents is presented below:

Chapter 1: Introduction
- ✓ Introduction to GCES studies and GCFIN Database with GIS component.

Chapter 2: Phase I - A Catalogue of Grand Canyon Fisheries Data
- ✓ An overview of the Grand Canyon investigations and description of database structures.
- ✓ Identification of common elements (e.g., field formats and data codes) between databases that would allow for assimilation into GCFIN Database, with some minor modifications.

Chapter 3: Phase II - Integration of Fisheries Databases from Grand Canyon
- ✓ Description of a prototype GCFIN Database that could include data described in Chapter 2.
- ✓ Description of templates that could be used to integrate data from the various databases into the prototype GCFIN Database.

Chapter 4: Phase III - Application of GIS to Fisheries Databases from Grand Canyon.
- ✓ Identification of informational layers for future integration of datasets into a Geographic Information System (GIS).

Chapter 5: Recommendations

CHAPTER 2: PHASE 1 - A CATALOGUE OF GRAND CANYON FISHERIES DATA

OVERVIEW OF DATABASES

The following overview provides a list of study objectives for each GCES fisheries research program and a general description of associated databases. General database descriptions include software used to enter, store, maintain, and analyze data, as well as a list of database specifications. The list includes the project file names, a description of the contents of each file, the number of records in the file, the length of each record in characters or numeric digits, the size of the file in bytes, and the anticipated number of file records at the conclusion of the study. Most of the information in this overview was received directly from each investigator.

Box 2-1. Description of data terms. Also see Fig. 2-1.

Database:	A compilation of all data collected by an individual investigative agency or firm (e.g., AGFD, Service, B/W). See Fig. 2-1.
Dataset:	Information associated with a particular topic (e.g., water quality, habitat, fish measurements) and usually stored in the same data file. See Fig. 2-1.
Data file:	A computer file (e.g., dBASE®) containing information collected during research studies.
Data field:	Each category of information within a data file (e.g., date, time, river mile, species). One 'column' of a database file. See Fig. 2-1.
Data record:	A set of all the data fields (one each) in a database file. One 'row' of a database file.

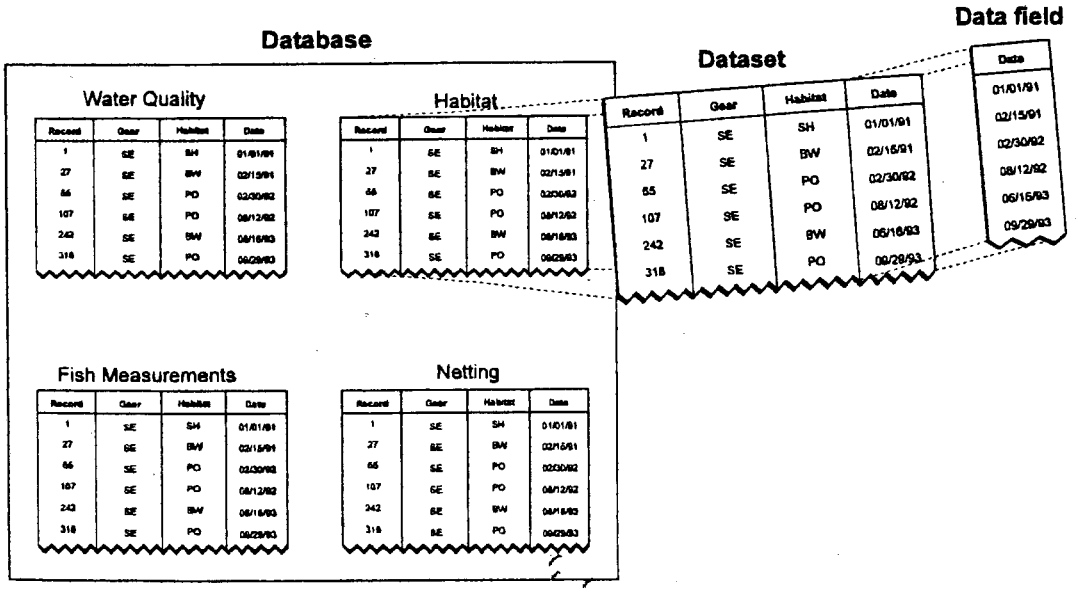

Fig. 2-1. Graphical representation of databases, datasets, and data fields.

ARIZONA STATE UNIVERSITY

ASU Study Objectives

A synopsis of the objectives of Arizona State University's (ASU) GCES Phase II investigation (to be completed October 1995) as described in their July 1990 Technical Proposal (Douglas and Marsh 1990) is as follows:

> "Although research to date has provided valuable information pertaining to life history and ecology of humpback chub in the Grand Canyon, a number of critically important questions remain unresolved, and data are required for future management of this unique and imperiled species. In particular, the duration and extent of movements by juvenile and adult humpback chub in the Little Colorado River, and their span of residency within that river are generally unknown, as is the basic reproductive biology of this fish. Investigations that will quantitatively define these major life-history characteristics are the focus of this research proposal."

General Description of ASU Database

Arizona State University's data are stored in ASCII text files on an IBM 3090 mainframe computer. The Wylbur mainframe editor is used to enter and maintain data, and Statistical Analysis System (SAS™) is used for analysis. The preferred file format for data distribution is non-delimited, ASCII text files. Table 2-1 lists the specifications for the ASU database. The file names listed in Table 2-1 were assigned by BIO/WEST since the actual file names were not provided in the ASU database documentation.

Table 2-1. Database specifications for the ASU Studies.

File Name	Number of Records	Record Length	Approximate Size(bytes)	Anticipated Number of Records	Contents
ASU91.DAT*	10,151	65	~659,815	10,151	Fish collection data, 1991
ASU92.DAT	9,120	65	~592,800	9,120	Fish collection data, 1992
ASU93.DAT	>8,941	65	~581,165	>8,941	Fish collection data, 1993

* File names assigned by BIO/WEST since these were not available from ASU.

U.S. FISH AND WILDLIFE SERVICE

Service Study Objectives

The major purpose of the U.S. Fish and Wildlife Service (Service) GCES Phase II fisheries studies was to address the reasonable and prudent alternatives proposed by the Service in the Biological Opinion (jeopardy determination) of 1978, and the Draft Biological Opinion of 1994 on the operation of Glen Canyon Dam. The focus of these investigations was on Conservation Measures 4, 5, 6, and 7 contained in that opinion.

The objectives of the Service studies (completion date of October 1995) according to Gorman (1994) were:

Objective 1: Determine habitat use by humpback chub and other native fishes in the Little Colorado River (LCR).

Objective 2: Evaluate the potential for establishing a second spawning aggregation of humpback chub in other tributaries of the Grand Canyon.

Objective 3: From the perspective of habitat requirements, evaluate how the humpback chub and native fishes are affected by the operation of the Glen Canyon Dam.

General Description of the Service Database

The Service uses dBASE IV® to store and maintain data, and SYSTAT™ for data analysis. Their preferred format for data distribution is dBASE IV®. Table 2-2 lists the specifications for the Service studies. The filenames in Table 2-2 were taken from Gorman 1993 and the contents of those files are the combined contents of individual files of the same type.

Table 2-2. Database specifications for the Service GCES Phase II Studies.

File Name	Number of Records	Record Length	Size (bytes)	Anticipated Number of Records	Contents
MNH.DBF	61,668	96	5,795,104	61,668	Service hoop net data
AHP.DBF	3,797	101	307,835	3,797	ASU hoop net data
TRN.DBF	37,889	62	2,307,866	37,889	Service transect data
MTP.DBF	5,758	84	511,294	5,758	Service minnow trap data
FSH.DBF	21,135	73	1,624,739	21,135	Service fish capture data
WTQ.DBF	353	76	43,551	353	Service water quality data
SEN.DBF	2,978	68	203,131	2,978	Service seining data

UNIVERSITY OF ARIZONA

U of A Study Objectives

The University of Arizona (U of A) studies (completion date of October 1993) were conducted under contract with the Service as part of their tributary studies. The objectives of the Service GCES Phase II tributary studies (hence the Uof A studies) according to Gorman (1994) were:

Objective 1: Describe and determine the availability of aquatic habitats on a seasonal basis.

Objective 2: Determine seasonal patterns of distribution and habitat use by native and exotic fishes.

Objective 3: Identify information and future studies required for possible enhancement of environmental conditions to protect and promote fish and wildlife populations in tributaries of the Colorado River.

Studies addressing these objectives led to four Master of Science theses: Allan 1993, Mattes 1993, Otis 1994, and Weiss 1993.

General Description of U of A Database

Information pending.

ARIZONA GAME AND FISH DEPARTMENT

AGFD Study Objectives

The objectives of the Arizona Game and Fish Department (AGFD) GCES Phase II studies (completion date of July 1995) according to Arizona Game and Fish Department (1990) were:

Objective 1: Continue the AGFD monitoring and research program for native fishes of the Colorado River and its tributaries in Grand Canyon.

Objective 2: Identify temporal and spatial distribution patterns and movements of early life stages of fishes in the Little Colorado River and, if necessary, other tributaries.

Objective 3: Provide for the propagation of native fishes of the Colorado River in Grand Canyon for use in laboratory or hatchery based studies necessary to satisfy the needs of the Section 7 Conservation Measures.

Objective 4: Determine changes in environmental conditions in mainstream and tributary confluence zone native fish rearing habitats under different flow regimes.

Objective 5: Determine algal and invertebrate standing crops and their relative contributions to diets of young native fishes in tributary, backwater, and main channel habitats under different flow regimes.

Objective 6: Determine the behavioral responses of larval through juvenile native fishes to changing environmental conditions in rearing habitats during controlled flows.

Objective 7: Determine age structure and growth rates of native fishes of the Colorado River in Grand Canyon. Relate these life history features to hydrologic and thermal conditions experienced by the fishes during their growth to present size.

Objective 8: Compare otolith edge chemistry of native fishes collected in tributary and mainstream habitats for use in growth and movement analysis.

Objective 9: Determine the extent to which limnological factors, with emphasis on water chemistry and aquatic productivity, potentially limit the distribution and abundance of native fishes in the Little Colorado River and other tributaries which might serve as streams for augmentation of humpback chub in Grand Canyon.

General Description of AGFD Database

The Arizona Game and Fish Department's database consists of two sets of data files for native fish studies; one for the Little Colorado River Studies (LCR Studies) and one for the mainstem Colorado River Studies (Mainstem Studies). Arizona Game and Fish Department uses dBASE IV® and FoxPro™ on DOS-based personal computers to store and maintain data, and dBASE IV® and

SPSS/PC™+ for data analysis. The preferred file format for data distribution is dBASE IV® files. Tables 2-3 and 2-4 list the specifications for the two components of the AGFD studies.

Table 2-3. Database secifications for the AGFD Little Colorado River Native Fish Studies.

File Name	Number of Records	Record Length	Size (bytes)	Anticipated Number of Records	Contents
ALGEMAS1.DBF	574	122	70,990	574	Algae chlorophyll analysis data; grids and quarterly, 1993
ALGAECOL.DBF	433	68	30,182	433	Algae and benthos collections (quarterly trips), 1991-1993
QBENTHOS.DBF	156	128	20,930	200	Quarterly benthos analysis data, 1993
BEHAVIOR.DBF	335	457	155,113	400	Behavioral data, 1991-1993
DRFTMAST.DBF	4,989	82	410,028	6,000	Drift analysis data, quantification of taxa, 1991-1993
DRIFTBIO.DBF	891	146	131,464	1,500	Drift biomass data, 1991-1993
HABITAT.DBF	1,049	144	152,370	1,049	Larval fish habitat data (grids), 1993
AVAILABL.DBF	9,378	80	750,914	9,378	Longitudinal habitat availability data, 1992-1993
HABUSE.DBF	11,084	89	987,278	11,084	Longitudinal habitat use data, 1993
LARVPRES.DBF	3,202	59	189,368	3,202	Longitudinal survey presence/absence data 1992
PRES193.DBF	4,339	70	304,244	4,339	Longitudinal survey presence/absence data 1993
MAS1FC93.DBF	7,820	163	1276,03	18,000	Fish collections data, 1993
MASTFC92.DBF	4,530	163	739,768	4,530	Fish collections data, 1992
MASTFC91.DBF	8,632	163	1408,39	8,632	Fish collections data, 1991
MASTERFC.DBF	20,982	163	3421,44	31,162	Fish collections data, 1991-1993
VISCMAST.DBF	3,488	168	586,978	4,500	Viscera analysis data, 1988-1993
MOVEMAS1.DBF	729	109	80,519	729	Larval fish movement data (traps), 1993
FCHABUSE.DBF	630	24	15,346	10,000	Fish collections habitat use data, 1991-1993
[a]HABPHOTO.DBF	-	-	-	-	Habitat photograph analysis (grids), 1993
[a]HABZOOPL.DBF	-	-	-	-	Habitat zooplankton analysis (grids), 1993

[a]Database file not yet created

Table 2-4. Database specifications for the AGFD Mainstem Colorado River Native Fish Studies.

File Name	Number of Records	Record Length	Size (bytes)	Anticipated Number of Records	Contents
ALLSONDE.DBF	8,325	57	475,071	30,000	Data from Hydrolab DataSondes
A_MASTER.DBF	840	82	69,586	1,200	Type A sample habitat data
BENTMAST.DBF	1,538	60	92,666	3,000	Benthos data
DIET_ANA.DBF	69	53	322	1,500	Fish diet analysis (stomach samples)
FISH_ALL.DBF	19,323	62	1,198,604	30,000	Fish capture data
MAP.DBF	242	110	27,294	400	Plane table mapping data
MAST_ALL.DBF	862	87	76,020	1,200	Master data sheet data
OPP_ALL.DBF	1,189	126	150,776	1,500	Opportunistic sampling data
PLANKTON.DBF	4,137	20	82,998	15,000	Plankton data
PRB3.DBF	7,014	47	330,204	7,014	Type B sample habitat data
SEDIMENT.DBF	506	56	28,626	750	Sediment data

BIO/WEST

B/W Study Objectives

The BIO/WEST (B/W) Grand Canyon fisheries database consists of two sets of files; one for the Mainstem Humpback Chub Studies (completion date of October 1994) and one for the Hualapai Aquatic Resources Studies (completion date of April 1995). Each study has its own set of objectives which are described below.

1) Mainstem Humpback Chub Studies

The purpose of B/W's humpback chub study was to describe the ecological and limiting factors of all life stages of humpback chub in the mainstem Colorado River, Grand Canyon, and to describe the effects of Glen Canyon Dam operations on the humpback chub. The B/W investigation was conducted in the mainstem Colorado River in Grand Canyon, from Lees Ferry (RM 0) to Diamond Creek (RM 226), concurrent with the AGFD mainstem studies. The specific objectives of the humpback chub investigations were:

Objective 1: Determine resource availability and use (i.e., habitat, food, water quality) of humpback chub in the mainstem Colorado River.

Objective 2: Determine distribution, abundance and movement of humpback chub in the mainstem Colorado River.

Objective 3: Determine reproductive capacity and success of humpback chub in the mainstem Colorado River.

Objective 4: Determine survivorship of early life stages of humpback chub in the mainstem Colorado River.

Objective 5: Determine important biotic interactions with other species for all life stages.

Objective 6: Determine the life history schedule for the Grand Canyon humpback chub population.

2) Hualapai Aquatic Resources Studies

The objectives of B/W's Hualapai investigation in the Lower Grand Canyon, from National Canyon (RM 166.4) to below Pierce Ferry at Lake Mead (RM 280) were:

Objective 1: Monitor the effects of interim flows from Glen Canyon Dam on the distribution, abundance, and behavior of native and non-native adult fish.

Objective 2: Monitor the effects of interim flows from Glen Canyon Dam on the distribution, abundance, and behavior of the larval and juvenile stages of native fishes.

Objective 3: Monitor the effects of interim flows from Glen Canyon Dam on the reproduction, food habits, and patterns of habitat use of piscivorous non-native fishes that may prey on native fishes.

Objective 4: Monitor the effects of interim flows from Glen Canyon Dam on the environmental conditions in the tributary mouths and shallow shoreline habitat, including water quality and degradation and/or aggradation of sediments.

Objective 5: Monitor the effects of interim flows from Glen Canyon Dam on the food base including productivity and algal standing crops.

General Description of B/W Database

The two B/W studies were conducted using similar sample designs and protocols (e.g., for fish sampling and water quality collections), so file structures for those datasets are nearly identical. The humpback chub database contains additional data files for information specific to humpback chub (e.g., morphometrics and meristics, scale analyses, radiotelemetry). BIO/WEST used dBASE IV® to store and maintain data, and dBASE IV® and SYSTAT™ for data analysis. Tables 2-5 and 2-6 list the specifications for the B/W Mainstem Humpback Chub and Hualapai databases.

HISTORICAL ACCOUNTS AND PAST COLLECTIONS

Historical accounts and past collections provide valuable insight into fisheries resources of Grand Canyon. Many historical accounts were descriptive and did not include quantitative data for use in a detailed, structured database. The earliest accounts of fish from Grand Canyon are from skeletal parts in 4,000 year-old flood deposits in Stanton's Cave (RM 31.5), and from cultural remains at Catclaw Cave (15 mi below Hoover Dam) that date from about 1100 A.D. None of the early Grand Canyon explorers, starting with Major John Wesley Powell in 1869, described the fish in the region.

Past collections included archival collections, reports of species occurrence and relative abundance, and most recently, quantitative datasets. The first written description (and photographs) of fish from Grand Canyon was of "bony tail" by Ellsworth and Emery Kolb in 1908 (Kolb and Kolb 1914). Collections by R.R. Miller (specimens stored at University of Michigan) in the mid to late 1940s provided the first quantitative information with morphometrics and meristics of several specimens of Gila sp. (Bookstein at al. 1985). R.D. Suttkus (Suttkus and Clemmer 1977) collected additional

Table 2-5. Database specifications for B/W Mainstem Humpback Chub Studies.

File Name	Number of Records	Record Length	Size (bytes)	Anticipated Number of Records	Contents
NETTING.DBF	16,643	192	3,080,614	16,643	Netting and trapping sample data, Oct 1990 - Nov 1993
ELECTRO.DBF	4,612	182	850,018	4,612	Electrofishing sample data, Oct 1990 - Nov 1993
SEINE.DBF	958	217	202,814	958	Seining sample data, Oct 1990 - Nov 1993
CHUB.DBF	6,294	214	1,235,258	6,294	Humpback Chub morphometrics and meristics, Oct 1990 - Nov 1993
FISH.DBF	26,542	163	4,194,948	26,542	All fish capture data, Oct 1990 - Nov 1993
SURVEIL.DBF	1,600	111	290,626	1,600	Radiotelemetry surveillance, Oct 1990 - Nov 1992
OBSERV_H.DBF	260	206	29,854	260	Header for radiotelemetry observations, Oct 1990 - Nov 1992
OBSERV_M.DBF	2,025	149	302,975	2,025	Movement for radiotelemetry observations, Oct 1990 - Nov 1992
SCALES.DBF	157	133	22,099	157	Humpback Chub scale analyses, Oct 1990 - Nov 1993
JUVHAB.DBF	282	155	44,832	282	Juvenile habitat measurements, Oct 1990 - Nov 1993
DRIFT.DBF	570	218	125,030	570	Drift net sample analysis data, Oct 1990 - Nov 1993
FOOD.DBF	552	253	142,570	552	Stomach pumping analysis data, 1993
REMOTE.DBF	26,583	14	452,493	26,583	Remote radiotelemetry station data, Oct 1990 - Nov 1992
DATASOND.DBF	43,586	45	2,000,000	43,586	Datasonde water quality data, Oct 1990 - Nov 1993
SURVEYOR.DBF	5,161	51	265,000	5,161	Surveyor II water quality data, Oct 1990 - Nov 1993

Table 2-6. Database specifications for B/W Hualapai Aquatic Resources Studies.

File Name	Number of Records	Record Length	Size (bytes)	Anticipated Number of Records	Contents
NETTING.DBF	1,202	213	267,869	2,000	Netting and trapping sample data, May 1992 - Dec 1994
ELECTRO.DBF	520	214	121,311	800	Electrofishing sample data, May 1992 - Dec 1994
SEINE.DBF	197	234	57,374	300	Seining sample data, May 1992 - Dec 1994
FISH.DBF	3,010	216	612,975	4,750	All fish capture data, May 1992 - Dec 1994
DRIFT.DBF	138	318	44,654	220	Drift net sample data, May 1992 - Dec 1994
DATASOND.DBF	1,954	45	90,000	3,070	Datasonde water quality data, May 1992 - Dec 1994
SURVEYOR.DBF	243	51	12,500	380	Surveyor II water quality data, May 1992 - Dec 1994

specimens in the early 1970s, which are in the collection at Tulane University. Various surveys from the 1950s through 1970s reported occurrence and relative abundance (i.e., abundant, common, rare) of fish species, but little information on habitat and other associated parameters (McDonald and Dotson 1960, Stone and Rathbun 1968, Miller and Smith 1972, Holden and Stalnaker 1975, Minckley and Blinn 1976). Surveys of the Colorado River and its tributaries in Grand Canyon, by Northern Arizona University in the late 1970s (Carothers and Minckley 1981), and by the Service in the early 1980s (Kaeding and Zimmerman 1983) provided the first structured datasets, including collection dates, sites, gear types, and habitats, as well as numbers of fish by species and effort expended. Investigations under GCES Phase I in 1984-86 by AGFD (Maddux et al. 1987) were the first comprehensive studies directed at evaluating effects of Glen Canyon Dam operations.

Data associated with historical accounts include archaeological finds, field notes, reports, photographs, and personal communications. Table 2-7 summarizes historical fisheries records for Grand Canyon, including the source of information, available citations, associated location information, and a description of the data. This information was compiled from Valdez et al. (1992), Kubly (1990), and from information provided by C.O. Minckley (Pers. Comm.).

Almost all past collections have been entered into computer files. The electronic databases include information collected by Carothers et al. (1981), Kaeding and Zimmerman (1983), and Maddux et al. (1987) and were described by Kubly (1990). These databases are held by AGFD and are stored in dBASE® files. The sizes of these files are not available to B/W at this time, but Table 2-8 lists the file names and a description of the file contents for these past databases. An additional dataset has been identified for morphometric and meristic data collected on the genus Gila from the Grand Canyon region by R.R. Miller in the 1940s. This database was made available to B/W by Dr. Michael Douglas of Arizona State University and is included in Table 2-8.

Table 2-7. Historical records of humpback chub in the Colorado River in Grand Canyon.[a]

Source	Citation	Location	Data Description
Kolb and Kolb, 1914	Kolb and Kolb (1914)	LCR - Beamer's Cabin	Reported as "bonytails", photos
Grand Canyon National Park, 1944; N.N. Dodge	Miller (1946)	Bright Angel Creek	Two complete bodies, one partial specimen used to describe species
R.R. Miller, 1955	Miller (1955)	Boulder Canyon (Catclaw Cave)	Remains from archaeological site (39 km below Hoover Dam)
Arizona State University, 1963	-		Specimen
J.L. Stone, 1964-65	Stone (1964)	Lees Ferry	Reported catches for identification by creel clerk - includes anglers, gill nets and electrofishing
J.L. Stone, 1965-66	Stone (1966)	Lees Ferry	All Gila "Rare", No Gila cypha records
Stone and Queenan, 1966-67	Stone and Queenan (1967)	Lees Ferry	Reported angler catch G. elegans (54 fish) "common"; G. cypha "Rare"
Miller and Smith, 1968	Miller and Smith (1968)	Lees Ferry to Diamond Creek (no defined location)	Reported occurrence
AGFD Personnel, 1967-68	Stone and Rathbun (1968)	Lees Ferry	Reported occurrence (17) G. cypha "Common"; G. elegans none
Holden and Stalnaker, 1967-73	Holden and Stalnaker (1975)	Glen Canyon	Reported occurrence
R.R. Miller, 1975	Miller (1975)		Reported occurrence
C.O. Minckley, 1975	Minckley and Blinn (1976)	LCR	Reported as "Gila elegans"
Suttkus et al, 1970-76	Suttkus et al (1976)	Mouth of LCR and Shinumo, RM 44, 61.5, 69 and 71	Reported occurrence; museum specimens collected
Suttkus and Clemmer, 1976	Suttkus and Clemmer (1977)	1967 below Glen Canyon Dam and Powell Reservoir/1976 Powell Reservoir	Reported occurrence; museum specimen collected
C.O. Minckley 1976-89	Minckley (1989)	Mouth of LCR, RM 69 and 71	Reported occurrence
Miller, 1971	Euler (1978)	Stanton's Cave/Catclaw Cave (near Lake Mead)	Remains
Miller and Smith, 1984	Miller and Smith (1984)	Stanton's Cave	Remains
Jones, 1985	Jones (1985)	Five sites along the Colorado River	Archaeological Remains
Wallis, O.L. 1955	Kubly (1990)	Spencer Creek	Reported occurrence

Table 2-8. Database specifications for past collections.

File Name	Contents
MNACATCH.DBF	Carothers et al. catch file
LKRARE.DBF	Kaeding and Zimmerman rare file
LKPHYS.DBF	Kaeding and Zimmerman physical file
LKCATCH.DBF	Kaeding and Zimmerman catch file
AGFDLARV.DBF	AGFD larval fish file
AGFDHAB.DBF	AGFD habitat file
AGFCATCH.DBF	AGFD catch file
MILLER.DBF	R.R. Miller Gila morphometric/meristic file

DATABASE STRUCTURES AND RELATIONAL LINKS

The previous Overview section reviewed each Grand Canyon fisheries database, including the study objectives that drive data collection, computer hardware and software used, number of data files, and file sizes. This section discusses the databases in terms of file organization, file structures, and ways that data in separate files can be used simultaneously.

Generally, database organization is determined by the quantity and complexity of the data collected. Small quantities of fisheries data can be stored in a single "flat" file (see Fig. 2-2). Large quantities of data, however, are more easily maintained and analyzed if segregated into separate flat files based on a common component such as trip number, month, or year (see Fig. 2-3). Large quantities of more diverse information are most efficiently maintained in a "relational" database that divides different types of data into separate files that can be "linked" together ("related") for analysis (see Fig. 2-4).

A relational link is a common data field in more than one database file, containing

Record	Date	Time	Species	Length	Weight	Location
1	01/01/91	20:25	HB	215	91	61.3
2	09/23/91	06:15	RB	260	170	61.3
3	01/12/92	18:35	RB	163	28	63.4
4	05/17/92	09:55	FM	374	534	66.5
5	03/24/93	11:40	CC	587	2438	70.0
6	09/03/93	22:20	SB	465	907	71.2

Fig. 2-2. Example of a single "flat" file database.

Record	Date	Time	Species	Length	Weight	Location
1	01/01/91	20:25	HB	215	91	61.3
2	09/23/91	06:15	RB	260	170	61.3

Record	Date	Time	Species	Length	Weight	Location
1	01/01/92	20:25	HB	215	91	61.3
2	09/23/92	06:15	RB	260	170	61.3

Record	Date	Time	Species	Length	Weight	Location
1	01/01/93	20:25	HB	215	91	61.3
2	09/23/93	06:15	RB	260	170	61.3
3	01/12/93	18:35	RB	163	28	63.4
4	05/17/93	09:55	FM	374	534	66.5
5	03/24/93	11:40	CC	587	2438	70.0
6	09/03/93	22:20	SB	465	907	71.2

Fig. 2-3. Example of a multiple "flat" file database, divided by year.

Record	Date	Gear	Habitat	Species	Weight	Location	Length	Temp.
1	01/01/91	SE	SH	HB	1	61.3	63	10
2	01/01/91	SE	SH	RB	1	61.3	52	10
3	01/01/91	SE	SH	CP	32	61.3	120	10
4	01/01/91	SE	SH	CP	12	61.3	89	10
5	06/18/93	SE	BW	FM	1	70.0	50	15
6	06/18/93	SE	BW	RB	6	70.0	75	15

Figure 2-4a. Example of seining and fish data in a "flat" file database.

Record	Location	Gear	Habitat	Temp.	Date
1	61.3	SE	SH	10	01/01/91
27	63.5	SE	BW	10	02/15/91
65	68.2	SE	PO	13	02/30/92
107	74.5	SE	PO	15	08/12/92
242	70.0	SE	BW	15	06/16/93
318	126	SE	PO	17	09/29/93

Date	Species	Length	Weight
01/01/91	HB	63	1
01/01/91	RB	52	1
01/01/91	CP	120	32
01/01/91	CP	89	12
10/24/92	RB	45	1
06/18/93	RB	50	1
06/18/93	FM	75	6
08/13/93	SD	20	1

Figure 2-4b. Example of seining and fish data in a "relational" database.

identical information, that can be used to connect the files together for simultaneous use. Relational databases have the following advantages:

- Data are organized logically into files of manageable size rather than having a large, cumbersome file containing many, possibly unrelated, data fields.
- Database maintenance is facilitated by minimizing the number of files that need to be changed or updated.
- Computer storage space is saved by minimizing redundant information within and among files.

Arizona State University's database is an example of a relatively uncomplicated database design. The ASU database consists of several "flat" files that are similar to each other in that they have identical data fields, (e.g., month, camp, fish species). Since the ASU study is a multi-year project resulting in a relatively large quantity of data, the data are separated into files by year. See Appendix A for a detailed description of data fields used by ASU.

The Service, AGFD, and B/W databases are relational databases. The data fields are organized into different files based on information type and data analyses. Some files can be linked on a single field, such as date, while others require more than one field to correctly link information in separate files. In addition to linking field-specific files, the B/W database also has links to a GIS. Names of the Service, AGFD, and B/W files that can be linked, and fields that can be used for linking, are provided in Tables 2-9 through 2-12. GIS links enable selected field-specific information to be displayed on GIS maps (e.g., net, trap, and electrofishing sample locations where humpback chub were caught), and also allow retrieval of field-specific data from selections on the GIS display (e.g., all netting data for a selected reach of river). Fig. 2-5 shows an example of linking to GIS. See Appendix A for detailed descriptions of the data fields and structures for these databases.

A description of the U of A database is not available at this time so the relational links for that database are unknown. Information on possible relational links for the Past Collections database also is not available at this time. See Appendix A for descriptions of the data fields and structures for this database.

Figure 2-4b. Example of seining and fish data in a "relational" database.

Table 2-9. Relational links for the Service database.

File 1	File 2	Linking Fields
MNH	TRN	ID, DATE, TIME
MNH	FSH	ID, DATE, TIME
AHP	TRN	ID, DATE, TIME
AHP	FSH	ID, DATE, TIME
MTP	TRN	ID, DATE, TIME
MTP	FSH	ID, DATE, TIME

Table 2-10. Relational links for AGFD Little Colorado River Native Fish database.

File 1	File 2	Linking Fields
ALGEMAS1	ALGAECOL	METER, SET_MO, SET_DA, SET_YR, SET_HR, SET_MM, SAMP_NO
ALGEMAS1	HABITAT	METER, SET_MO, SET_DA, SET_YR, SET_HR, SET_MM, CELL_NO
QBENTHOS	ALGAECOL	SET_MO, SET_DA, SET_YR, SET_HR, SET_MM, MILE, SIDE
BEHAVIOR	MAS1FC93	MILE, SIDE, RUN_MO, RUN_DA, RUN_YR, RUN_HR, RUN_MM
BEHAVIOR	MASTFC92	MILE, SIDE, RUN_MO, RUN_DA, RUN_YR, RUN_HR, RUN_MM
BEHAVIOR	MASTFC91	MILE, SIDE, RUN_MO, RUN_DA, RUN_YR, RUN_HR, RUN_MM
DRFTMAST	DRIFTBIO	MILE, SET_MO, SET_DA, SET_YR, SET_HR, SET_MM, NUMBER
HABITAT	MASTFC91	RUN_MO, RUN_DA, RUN_YR, RUN_HR, RUN_MM, METER, SIDE
HABITAT	MASTFC92	RUN_MO, RUN_DA, RUN_YR, RUN_HR, RUN_MM, METER, SIDE
HABITAT	MAS1FC93	RUN_MO, RUN_DA, RUN_YR, RUN_HR, RUN_MM, METER, SIDE
HABITAT	HABPHOTO	RUN_MO, RUN_DA, RUN_YR, RUN_HR, RUN_MM, METER, SIDE
HABITAT	HABZOOPL	RUN_MO, RUN_DA, RUN_YR, RUN_HR, RUN_MM, METER, SIDE
AVAILABL	HABUSE	RUN_MO, RUN_DA, RUN_YR, MILE, SIDE
AVAILABL	LARVPRES	RUN_MO, RUN_DA, RUN_YR, MILE, SIDE
HABUSE	MASTFC92	MILE, SIDE, RUN_MO, RUN_DA, RUN_YR, PRESERVE
HABUSE	MAS1FC93	MILE, SIDE, RUN_MO, RUN_DA, RUN_YR, PRESERVE
LARVPRES	MASTFC92	RUN_MO, RUN_DA, RUN_YR, SIDE, HM
PRES193	AVAILABL	RUN_MO, RUN_DA, RUN_YR, MILE, SIDE
MAS1FC93	MOVEMAS1	RUN_MO, RUN_DA, RUN_YR, RUN_HR, RUN_MM, MILE, SIDE
MAS1FC93	VISCMAST	RUN_MO, RUN_DA, RUN_YR, MILE, SIDE, STOM_NUM
MASTFC92	VISCMAST	RUN_MO, RUN_DA, RUN_YR, MILE, SIDE, STOM_NUM
MASTFC91	VISCMAST	RUN_MO, RUN_DA, RUN_YR, MILE, SIDE, STOM_NUM
MASTERFC	MOVEMAS1	RUN_MO, RUN_DA, RUN_YR, RUN_HR, RUN_MM, MILE, SIDE
MASTERFC	VISCMAST	RUN_MO, RUN_DA, RUN_YR, MILE, SIDE, STOM_NUM
FCHABUSE	MASTFC91	STUDY, PAGE
FCHABUSE	MASTFC92	STUDY, PAGE
FCHABUSE	MAS1FC93	STUDY, PAGE
FCHABUSE	MASTERFC	STUDY, PAGE

Note: All files in the AGFD mainstem Colorado River Native Fish database contain a STUDY field which can be used to relationally link any set of files. Other fields that can be used as relational links include SITE, HAB_CD, and SPECIES.

Table 2-11. Relational links for B/W mainstem humpback chub database.

File 1	File 2	Linking Fields
NET_MC	CHUB	KEY* (TYPE+TRIP+SAMPLE_NUM+REACH+CLIPBOARD)
NET_MC	FISH_MC	KEY (TYPE+TRIP+SAMPLE_NUM+REACH+CLIPBOARD)
ELEC_MC	CHUB	KEY (TYPE+TRIP+SAMPLE_NUM+REACH+CLIPBOARD)
ELEC_MC	FISH_MC	KEY (TYPE+TRIP+SAMPLE_NUM+REACH+CLIPBOARD)
SEIN_MC	CHUB	KEY (TYPE+TRIP+SAMPLE_NUM+REACH+CLIPBOARD)
SEIN_MC	FISH_MC	KEY (TYPE+TRIP+SAMPLE_NUM+REACH+CLIPBOARD)
OBSERV_H	OBSERV_M	TRIP_NUM, SAMPLE_NUM
NET_MC	GIS Sampling Location Maps	MAP_ID_NUM
ELEC_MC	GIS Sampling Location Maps	START_RM, END_RM

*or ease of linking and analysis, the five fields that constitute a unique sample identifier were combined into a single field called KEY.

Table 2-12. Relational links for B/W Hualapai Aquatic Resources database.

File 1	File 2	Linking Fields
NET_HU	FISH_HU	KEY* (TYPE+TRIP+SAMPLE_NUM+REACH+CLIPBOARD)
ELEC_HU	FISH_HU	KEY (TYPE+TRIP+SAMPLE_NUM+REACH+CLIPBOARD)
SEIN_HU	FISH_HU	KEY (TYPE+TRIP+SAMPLE_NUM+REACH+CLIPBOARD)

*For ease of linking and analysis, the five fields that constitute a unique sample identifier were combined into a single field called KEY.

used to
:IES.

Netting File

Record	Date	Gear	Habitat	Temp.	Map_ID_Num
1	01/01/91	GP	ED	10	46
27	02/15/91	GY	RI	10	47
65	02/30/92	HS	PO	13	
107	08/12/92	TL	PO	15	74
242	06/16/93	TL	EM	15	83
318	09/29/93	TM	RI	17	

GIS Database

Map_ID_Num	FNODE#	TNODE#
41	2C3349E8	885A1C13
47	DA5832E1	A12C38F5
53	6D93422F	67A9F321
68	48533E6A	B27F5C3B
83	C3E662F4	1C145F3E
84	99D3F222	7B55E1C8
87	3F11E7D9	F245C3F6
91	C6F13784	D455B2F1
95	729C8E54	67D4B36C
98	7A57C713	A43F7D9C

Display

GIS MAP

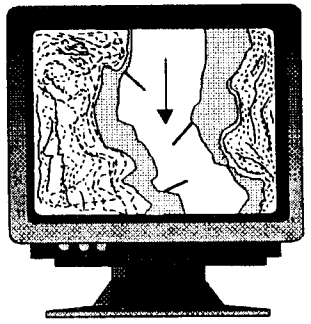

Fig. 2-5. Linking field-specific data to GIS.

COMMONALITIES IN EXISTING DATABASES

Resource managers need to use information from all of the fisheries databases, and one of the goals of the GCFIN project is to integrate the databases where possible. This section examines the Grand Canyon fisheries databases in terms of their similarities and the possibilities for integration.

Common Elements

Fisheries investigators in Grand Canyon have collected a variety of information, which has been incorporated into databases. Fig. 2-6 illustrates the diversity and complexity of fisheries data collected from different locations in Grand Canyon. Investigators collecting data in the mainstem Colorado River, the Little Colorado River, and other tributaries to the mainstem are identified in Table 2-13. General types of data collected are identified in Table 2-14, and itemized for each data type in Tables 2-15 through 2-23.

Table 2-13. Stream systems investigated by various research groups in Grand Canyon.

Stream System	ASU	Service	U of A	AGFD	B/W	Past
Mainstem				✓	✓	✓
Little Colorado	✓	✓		✓		✓
Other Tributaries		✓	✓			✓

Table 2-14. General types of data collected by fisheries investigators in Grand Canyon.

Data Types	ASU	Service	U of A*	AGFD	B/W	Past
Water Quality		✓	✓	✓	✓	✓
Fish Capture	✓	✓	✓	✓	✓	✓
Morphometric/Meristic					✓	✓
Food Habits (stomach)				✓	✓	
Habitat Quantification		✓	✓	✓	✓	✓
Invertebrates				✓	✓	
Organic Quantification				✓	✓	
Behavior/Movement				✓	✓	
Fish Sampling		✓	✓	✓	✓	✓

*Data types determined from Allan 1993, Mattes 1993, Weiss 1993, Otis 1994

Two levels of detail are used to examine more closely the general types of data listed in Table 2-14. A few of the data types can be examined at the level of database fields (e.g., water quality, fish capture, morphometric/meristic data) because the investigators used similar data collection protocols. The similarity in *Water Quality* data is a result of the equipment used by most of the investigators (e.g., Hydrolab Datasonde™ or Surveyor™ to collect water quality parameters and secchi discs/turbidity meters to collect water clarity information). The similarity within the *Fish Capture*

and *Morphometric/Meristic* information is from traditional methodologies for recording fish measurements and related observations used by most of the investigators. The remaining data types in Table 2-14 must be examined at a less detailed level. These data were not collected and recorded in a similar manner, since the investigators had different study objectives, sampling methodologies, and data recording methods. Hence, even apparently common information can be only broadly categorized.

Tables 2-15, 2-16, and 2-17 show the types of *Water Quality*, *Fish Capture*, and *Morphometric/Meristic* fields collected by respective investigators. The information in Tables 2-15, 2-16, and 2-17 generally corresponds to individual data fields. In the following section, COMPATIBILITY OF COMMON ELEMENTS, the specific fields within the *Water Quality*, *Fish Capture*, and *Morphometric/Meristic* data files of each researcher are compared.

Table 2-15. Water quality data collected by fisheries investigators in Grand Canyon.

Water Quality Fields	ASU	Service	U of A[a]	AGFD	B/W	Past[b]
Temperature		✓		✓	✓	✓
Turbidity - code					✓	✓
Turbidity - secchi		✓			✓	
Turbidity - NTU		✓			✓	
Conductivity		✓		✓	✓	✓
Dissolved oxygen		✓		✓	✓	✓
pH		✓		✓	✓	✓
Oxidation-Reduction Potential		✓		✓	✓	
Salinity		✓		✓		✓

[a]File structures not available at this time.
[b]Not all past collections data records include this information.

Table 2-16. Fish capture data collected by fisheries investigators in Grand Canyon.

Fish Capture Fields	ASU	Service	U of A[a]	AGFD	B/W	Past[b]
Date	✓	✓		✓	✓	✓
Location	✓	✓		✓	✓	✓
Species	✓	✓		✓	✓	✓
Total Length	✓	✓		✓	✓	✓
Fork Length					✓[c]	
Standard Length					✓	
Weight	✓	✓		✓	✓	✓
Sex	✓	✓		✓	✓	✓
PIT Tag	✓	✓		✓	✓	✓
Floy Tag	✓	✓			✓	
Carlin Tag	✓	✓			✓	
Gear Type	✓	✓		✓	✓	✓
Habitat				✓	✓	✓
Maturity	✓	✓		✓	✓	✓
Mark/Recapture		✓		✓	✓	✓
Disposition				✓	✓	✓
Parasites		✓		✓	✓	✓
Photo/Video					✓	

[a]File structures not available at this time.
[b]Not all past collections data records include this information.
[c]For humpback chub only.

Table 2-17. Morphometric and meristic data collected by fisheries investigators in Grand Canyon.

Morphometric/Meristic Fields	ASU	Service	U of A[a]	AGFD	B/W	Past[b]
Total Length					✓	✓
Fork Length					✓	
Standard Length					✓	✓
Weight					✓	✓
Pectoral to Pelvic Fin Distance					✓	✓
Nuchal depth					✓	✓
Caudal Peduncle Length					✓	
Min. Caudal Peduncle Depth					✓	
Max. Caudal Peduncle Depth					✓	
Head Length					✓	✓
Snout Length					✓	✓
Dorsal Fin Base					✓	✓
Anal Fin Base					✓	✓
Body Depth					✓	✓
Number of Dorsal Fin Rays					✓	✓
Number of Anal Fin Rays					✓	✓
Photo/Video					✓	

[a]File structures not available at this time.
[b]Not all past collections data records include this information.

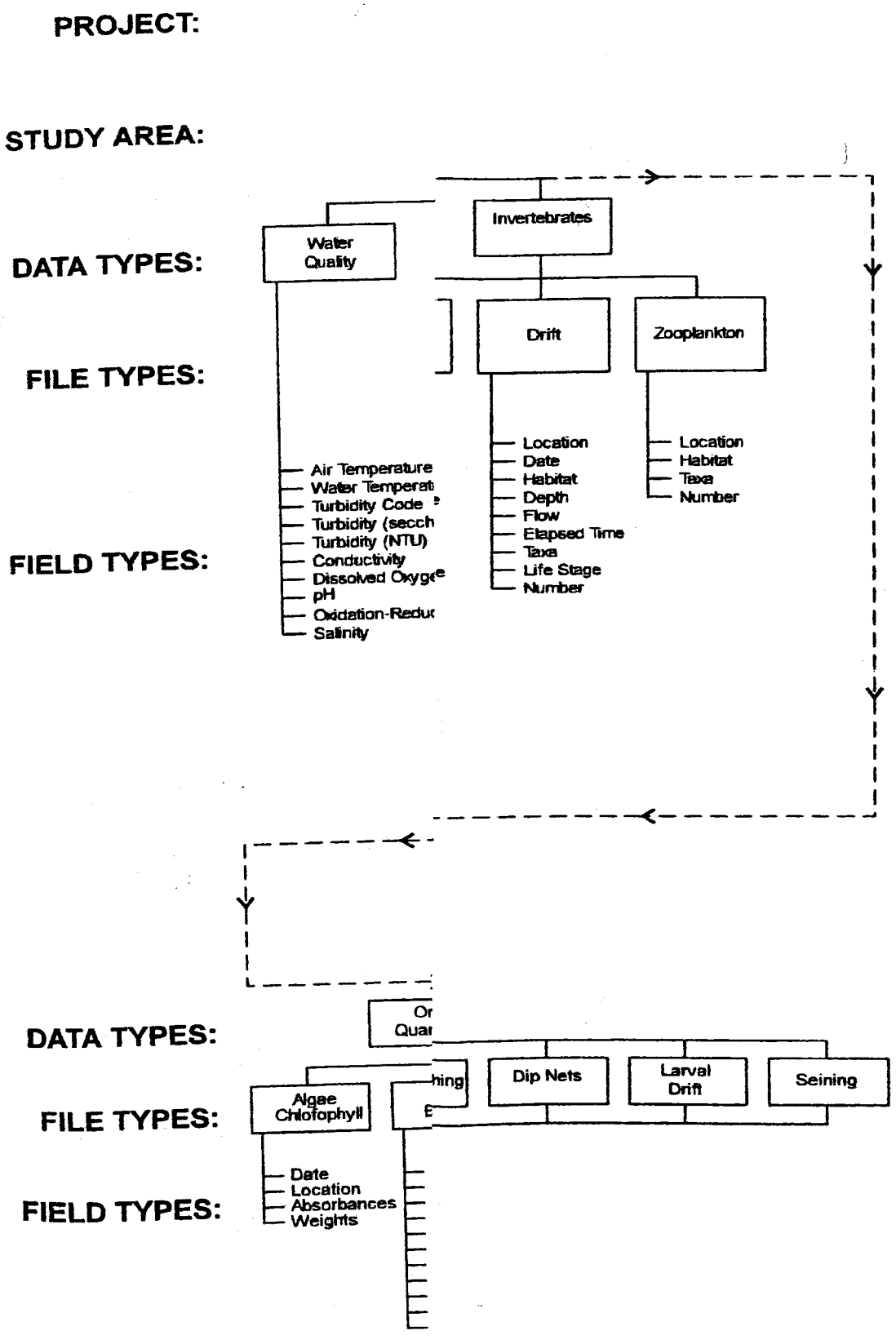

Fig. 2-6. Compartmental representation of

Other general types of data collected by fisheries investigators in Grand Canyon include *Food Habits* (Table 2-18), *Habitat Quantification* (Table 2-19), *Invertebrates* (Table 2-20), *Organic Quantification* (Table 2-21), *Behavior and Movement* (Table 2-22), and *Fish Sampling* (Table 2-23). The information in these tables is not specific data fields, but categories of data.

Table 2-18. Food habits information collected by fisheries investigators in Grand Canyon.

Food Habits Information	ASU	Service	U of A[a]	AGFD	B/W	Past[b]
Native Fish				?	✓	
Non-native Fish				?	✓	
Numerical				✓	✓	
Volumetric				✓		

[a]File structures not available at this time.
[b]Not all past collections data records include this information.

Table 2-19. Habitat quantification methods used by fisheries investigators in Grand Canyon.

Habitat Methods	ASU	Service	U of A[a]	AGFD	B/W	Past
Physical Habitat Measurements		✓	✓	✓	✓	✓
Surficial Habitat				✓	✓	✓

[a]Data types determined from Allan 1993, Mattes 1993, Weiss 1993, Otis 1994

Table 2-20. Invertebrate sampling methods used by fisheries investigators in Grand Canyon.

Sampling Methods	ASU	Service	U of A	AGFD	B/W	Past
Benthos				✓		
Drift				✓	✓	
Zooplankton				✓		

Table 2-21. Organic quantification methods used by fisheries investigators in Grand Canyon.

Methods	ASU	Service	U of A	AGFD	B/W	Past
Algae Chlorophyll				✓		
Drift Biomass				✓	✓	
Sediment Analysis				✓		

Table 2-22. Behavior and movement observations by fisheries investigators in Grand Canyon.

Observations	ASU	Service	U of A[a]	AGFD	B/W	Past
Habitat Use			✓	✓	✓	✓
Long-Range Movement					✓	
Local Movement and Activity				✓	✓	

[a]Data types determined from Allan 1993, Mattes 1993, Weiss 1993, Otis 1994

Table 2-23. Fish sampling methods used by fisheries investigators in Grand Canyon.

Sampling Methods	ASU	Service	U of A[a]	AGFD	B/W	Past
Trammel/Gill Nets	✓		✓	✓	✓	✓
Hoop Nets	✓	✓	✓	✓	✓	✓
Minnow Traps		✓	✓	✓	✓	
Angling	✓			✓	✓	✓
Seining (Bag/Straight)	✓	✓	✓	✓	✓	✓
Electrofishing (Boat/Backpack)			✓		✓	✓
Dip Nets				✓		
Larval Drift				✓		

[a]Data types determined by Allan 1993, Mattes 1993, Weiss 1993, Otis 1994

Compatibility of Common Elements

Although GCES fisheries investigators conducted similar kinds of studies, their research objectives, methods, and procedures for collecting, organizing, storing, and analyzing data often varied. As a result, much of the information collected is not directly comparable. However, some data, including *Water Quality*, *Fish Capture*, and *Morphometric/Meristic*, are similar enough for direct comparison. Other data, such as *Drift* and *Food Habits*, are not as similar, but with some modifications may be similar enough to integrate, so these datasets are also compared. Though *Fish Sampling* data vary greatly among Grand Canyon fisheries investigators, they are sufficiently important that an attempt is made to compare and potentially integrate them as well. In this section, the compatibility (i.e., format and content) of individual data fields within different databases for *Water Quality*, *Fish Capture*, *Morphometric/Meristic*, *Drift*, *Food Habits*, and *Fish Sampling* are compared.

Tables 2-24 through 2-26 identify the field names and field descriptions used by the different investigators for *Water Quality*, *Fish Capture*, and *Morphometric/Meristic* data. Although there are a number of apparent incompatibilities between the different data formats, most can be resolved by a simple translation. For instance, the *Water Quality* information (Table 2-24) is primarily numeric; the format differences are mainly the number of digits and decimal places used. These numeric data fields can easily be converted into a common format by adopting the largest number of digits and decimal places used by the investigators, and then translating all other fields into this format.

The numeric data fields of the *Fish Capture* information (Table 2-25) are compatible; no translation is necessary. Non-numeric *Fish Capture* fields are primarily incompatible, though a few fields (e.g., PIT tag number) are identical and require no translation. The reasons for incompatibility between non-numeric *Fish Capture* fields varies. Some information was recorded in different ways (e.g., left and right bank location looking upstream vs. looking downstream); some fields contain the same information recorded in different formats (e.g., a single date field vs. month, day, year in separate fields); while other fields have similar formats, but different codes for the same information (e.g., fish species codes). Fortunately, these incompatibilities can be corrected by electronically changing or "translating" the information into a chosen, consistent format or coding. Descriptions of the necessary translations are included in Chapter 3. See Appendix B for lists of the data codes used by the different investigators.

However, some *Fish Capture* information, such as location, involve more than a simple translation. This is partly because each researcher records location information differently, but also because river mile and meter locations are often imprecise. This can result in two investigators using different river mile designations for the same location, neither of which are exact. See Table 2-30 or a description of the river mile and meter standards used by fisheries investigators in Grand Canyon. Integrating location information into a field-specific, tabular database will be more complex than the field translations described previously unless an equivalency table is defined using the different river mile standards. A GIS can resolve this problem by defining unique river center lines using each river mile standard. See Chapter 4 for more information on using GIS for database integration.

Other than the uncertainty about location information, the *Water Quality* and *Fish Capture* data can be made compatible with the relatively straightforward translations described above. Much of the *Morphometric/Meristic* data (Table 2-26) are also numeric and can be made compatible with format translations similar to those described for the numeric *Fish Capture* data. However, some of the incompatibilities within the *Morphometric/Meristic* dataset are due to different data collection methods that are not compatible. For example, B/W measured maximum body depth while Miller measured body depth over the pectoral fin insertion, which may not necessarily be the maximum body depth. These two body depth measurements cannot be made compatible. An additional compatibility problem arises when dealing with past collections, including the Miller database, due to incomplete documentation of data collection methods. For example, Miller collected caudal peduncle depth, but it is not clear at what point on the caudal peduncle the measurement was taken. Unless this can be determined, this information cannot be made compatible with the B/W information.

The field names and field descriptions used for *Drift* and *Food Habits* information by AGFD and B/W, the only investigators who collected this information, are identified in Tables 2-27 and 2-28. The primary difficulty in comparing these datasets is the difference in file organization between the two databases. Both *Drift* and *Food Habits* data contain information on quantities of organisms at different life stages, but AGFD used a multiple-record format to store information (see Box 2-2), while B/W used a single-record file format. For example, if one adult Simuliid was in the sample, AGFD stored this information by entering "1" in the NUMBER field , "A" in the LIFE_STAGE field, and "SIM" in the TAXA field. Comparatively, B/W stored the same information by entering a "1" in the SIMADU field. The quantity information ("1" in the example) is comparable between the two kinds of formats, but the classification and life stage information are not comparable because in one format (multiple-record) the information is stored in the field, while in the other format (single-record) it is contained in the field name itself. Not only does this difference in file format make data

comparison difficult, it also makes data integration difficult. See Chapter 3 for a discussion of the integration of these datasets.

The field names and field descriptions used by the different investigators for *Fish Sampling* information are identified in Table 2-29. Of the six datasets identified for possible integration, *Fish Sampling* was the least similar among the investigators. This dataset was identified for integration based on the importance of the traditional analyses performed on *Fish Sampling* data (see Chapter 3), rather than on the similarity of the data among investigators. Examples of information used to perform these common analyses include numbers of fish captured in a sample, effort expended for a sample, and descriptive sample information (e.g., sampling gear used, water temperature, weather conditions, water clarity). One investigator's database may contain all of this information in one file, while another may require accessing multiple files to bring all the necessary information together. In addition to the difficulty of accessing the information, format and content differences exist that are similar to those described above for the other datasets, only some of which can be resolved by choice of format and/or data translations.

Box 2-2. Single-record, multiple-record, and relational file formats.

Fish Sampling information is used here to illustrate three common formats for designing database files: single-record, multiple-record, and relational file formats. A *sample* refers to a single sampling event (e.g., net set, electrofishing run, seine haul). *Header* information is the sample description (e.g., date, time, location, gear), and *summary* information summarizes the catch for that sample (e.g., number of young-of-year humpback chub, number of adult rainbow trout). A single-record format for *Fish Sampling* information is one in which all the data recorded for a sample are contained within a single record in the database file (Fig. 2-7a). A multiple-record format uses more than one record for storing the same information. The multiple-record format has a record for each species, summarizing the numbers of fish of that species captured, and the header information repeated in each of those records (Fig. 2-7b). A relational file format uses two related files, one containing the header information (one record per sample) and the other containing the summary information (one record per species). The two files are linked by a field that uniquely identifies an individual sample (Fig. 2-7c).

There are advantages and disadvantages to each of these three file arrangements. The single-record format is likely to be the least space-efficient design because there must be enough fields per record to contain summary information for all possible species for that type of sampling. A large number of fields in each record makes the information difficult to view on a computer screen and difficult to print. The single-record format is the easiest to work with when performing catch-per-effort (CPE) analyses. The multiple-record format is likely to be more space-efficient than the single-record format even though it contains redundant header information, because there is no empty space reserved in fields for every possible species and age group of fish captured. This format is also easier to view and print because the records are not as wide as in the single-record format. The multiple-record format is more cumbersome to use for CPE analyses because such analyses normally are performed by species, but catch information for different species is not recorded in separate fields. Some manipulation of the file format is usually required before CPE analyses can be performed. The relational file format is the most space-efficient because there is no redundant header information and no empty space reserved for information on all possible species; only the information recorded on the data sheets is stored. But files in this format are more difficult to view and print by the novice database user because they must be linked. CPE analyses are also more cumbersome for the same reasons that multiple-record files are, so some manipulation of file format is necessary for performing analyses.

A.

Record	Sample #	Date	Gear	Habitat	HBChub	RBTrout	BHSucker	
1	1	01/01/91	SE	SH	2	1	0	
2	1	01/01/91	SE	SH	5	0	30	
3	2	01/01/91	SE	SH	0	2	0	
4	2	01/01/91	SE	SH	1	5	2	
5	2	06/18/93	SE	BW	0	12	4	
6	3	06/18/93	SE	BW	2	8	1	

B.

Record	Sample #	Date	Gear	Habitat	Species	Number
1	1	01/01/91	SE	SH	HB	2
2	1	01/01/91	SE	SH	RB	1
3	2	01/01/91	SE	SH	CP	5
4	2	01/01/91	SE	SH	CP	30
5	2	06/18/93	SE	BW	FM	25
6	3	06/18/93	SE	BW	RB	2

C.

Record	Gear	Habitat	Date	Sample #
1	SE	SH	01/01/91	1
27	SE	BW	02/15/91	2
65	SE	PO	02/30/92	3
107	SE	PO	08/12/92	4
242	SE	BW	06/18/93	5
318	SE	PO	09/29/93	6

Date	Sample #	Species	Number
01/01/91	1	HBC	2
01/01/91	1	RBT	1
01/01/91	2	HBC	5
01/01/91	2	BHS	30
10/24/92	2	FMS	25
06/18/93	3	RBT	2
06/18/93	3	FMS	1
08/13/93	3	HBC	1

Fig. 2-7. *Fish Sampling* information in a single-record format (A), multiple-record format (B), and relational file format (C).

Table 2-24. Compatibility of Water Quality Fields Between Databases of Fisheries Investigators in Grand Canyon.

INFORMATION	INVESTIGATOR	FIELD NAME	FIELD DESCRIPTION	FIELD FORMAT
DATE	ASU	MONTH; DAY; YEAR	2-digits for each of month, day, year	(MM)(DD)(YY)
	USFWS	DATE	dBase data field	(MM/DD/YY)
	AGFD - LCR			
	AGFD - MC	RUN_MO; RUN_DA; RUN_YR	2-digits for each of month, day, year	(MM)(DD)(YY)
	B/W	DATE	6-character code	(YYMMDD)
TIME	ASU	HOUR	4-digit military time	(HHMM)
	USFWS	TIME	4-digit military time	(HHMM)
	AGFD - LCR			
	AGFD - MC	RUN_HR; RUN_MM	2-digit for each of hour and minute	(HH)(MM)
	B/W	TIME	4-digit military time	(HHMM)
LOCATION	ASU			
-Code	USFWS	CAMP	1-character code	(C)
	AGFD - LCR	STUDY	Last 3 digits of field	(999)
	AGFD - MC			
	B/W			
-River	ASU			
	USFWS			
	AGFD - LCR			
	AGFD - MC			
	B/W	RIVER	2-character river or tributary code	(CC)
-River Mile	ASU			
	USFWS			
	AGFD - LCR			
	AGFD - MC			
	B/W	RM	Numeric river mile from Belknap Guide and marked aerial photos	(999.99)
-Meter	ASU			
	USFWS	KM	Kilometers from mouth of LCR	(99999)
	AGFD - LCR			
	AGFD - MC			
	B/W	METER	Meters from mouth of tributary	(9999)
WATER TEMPERATURE	ASU			
	USFWS	TEMP	2-digit number with 1 decimal place (°C)	(99.9)
	AGFD - LCR			
	AGFD - MC	TEMP	2-digit number with 2 decimal places (°C)	(99.99)
	B/W	TEMP	2-digit number with 2 decimal places (°C)	(99.99)
AIR TEMPERATURE	ASU			
	USFWS	AMBT	3-digit number (°F)	(999)
	AGFD - LCR			
	AGFD - MC			
	B/W	AIR_T	2-digit number with 1 decimal place (°C)	(99.9)
pH	ASU			
	USFWS	PH	1-digit number with 2 decimal places	(9.99)
	AGFD - LCR			
	AGFD - MC	PH	1-digit number with 2 decimal places	(9.99)
	B/W	PH	2-digit number with 2 decimal places	(99.99)
CONDUCTIVITY	ASU			
	USFWS	COND	1-digit number with 2 decimal places (ms)	(9.99)
	AGFD - LCR			
	AGFD - MC	COND	1-digit number with 3 decimal places	(9.999)
	B/W	COND	2-digit number with 3 decimal places	(99.999)
DISSOLVED OXYGEN	ASU			
	USFWS	DO	2-digit number with 1 decimal place (ppm)	(99.9)
	AGFD - LCR			
	AGFD - MC	DOPERSAT	3-digit number with 1 decimal place (%sat)	(999.9)
		DOMGPERL	2-digit number with 2 decimal places (mg/L)	(99.99)
	B/W	DO	2-digit number with 2 decimal places	(99.99)
OXIDATION/REDUCTION POTENTIAL	ASU			
	USFWS	ORP	2-digit number with 2 decimal places	(99.99)
	AGFD - LCR			
	AGFD - MC	REDOX	3-digit number	(999)
	B/W	ORP	2-digit number with 3 decimal places	(99.999)
SALINITY	ASU			
	USFWS	SAL	2-digit number with 1 decimal place (%)	(99.9)
	AGFD - LCR			
	AGFD - MC	SALINITY	1-digit number with 1 decimal place	(9.9)
	B/W			
BATTERY VOLTAGE OF INSTRUMENT	ASU			
	USFWS			
	AGFD - LCR			
	AGFD - MC	VOLTS	3-digit number with 1 decimal place	(999.9)
	B/W	BATT	2-digit number with 2 decimal places	(99.99)
TURBIDITY	ASU			
-Code	USFWS			
	AGFD - LCR			
	AGFD - MC			
	B/W	TURBIDITY	2-character code	(CC)
-Secchi	ASU			
	USFWS	SECCHI	3-digit number (cm)	(999)
	AGFD - LCR			
	AGFD - MC			
	B/W	SECCHI	1-digit number with 2 decimal places (m)	(9.99)
-Turbidimeter	ASU			
	USFWS	TURBID	5-digit number (NTU)	(99999)
	AGFD - LCR			
	AGFD - MC			
	B/W	NTU	4-digit number with 2 decimal places (NTU)	(9999.99)

Table 2-25. Compatibility of fish capture fields between databases of fisheries investigators in Grand Canyon.

INFORMATION	INVESTIGATOR	FIELD NAME	FIELD DESCRIPTION	FIELD FORMAT
DATE	ASU	MONTH; DAY; YEAR	2-digits for each of month, day, year	(MM)(DD)(YY)
	USFWS	DATE	dBase date field	(MM/DD/YY)
	AGFD-LCR	RUN_MO; RUN_DA; RUN_YR	2digits for each of month, day, year	(MM)(DD)(YY)
	AGFD-MC	MST_MO; MST_DA; MST_YR	2 digits for each of month, day, year	(MM)(DD)(YY)
	B/W	DATE	6-character code	(YYMMDD)
TIME	ASU	HOUR	4-digit military time	(HHMM)
	USFWS	TIME	4-digit military time	(HHMM)
	AGFD-LCR	RUN_HR; RUN_MM	2 digits for each of hour and minute	(HH)(MM)
	AGFD-MC	MST_HR; MST_MM	2 digits for each of hour and minute	(HH)(MM)
	B/W	TIME	4-digit military time	(HHMM)
LOCATION				
-Code	ASU	LOCATION	USFWS transect code	(CCC)
	USFWS	ID	Transect code and bank location looking upstream	(CCCCCCCC)
	AGFD-LCR	FWS	USFWS transect code	(CCC)
	AGFD-MC			
	B/W			
-River	ASU	WACODE	2-digit AGFD tributary code	(99)
	USFWS			
	AGFD-LCR	REACH	2-digit AGFD tributary code	(99)
	AGFD-MC	REACH	3-digit AGFD tributary code	(999)
	B/W	RIVER	2-character river code	(CC)
-River Mile	ASU			
	USFWS			
	AGFD-LCR			
	AGFD-MC	MILE	Numeric river mile	(999.99)
	B/W	RM	Numeric river mile from Belknap Guide and marked aerial photos	(999.99)
-Meters	ASU			
	USFWS			
	AGFD-LCR	MILE	Meters from mouth of LCR	(99999.99)
	AGFD-MC	MILE	Meters from mouth of tributary	(999.99)
	B/W	METER	Meters from mouth of tributary	(9999)
-Side	ASU			
	USFWS	ID	Bank location facing upstream	(CCCCCCCC)
	AGFD-LCR	SIDE	Bank location facing downstream	(C)
	AGFD-MC	SIDE	Bank location facing downstream	(C)
	B/W	SIDE	Bank location facing downstream	(C)
SPECIES	ASU	SPECIES	2 and 3-character codes	(CC)(CCC)
	USFWS	SPP	3-character codes	(CCC)
	AGFD-LCR	SPECIES	3-character codes	(CCC)
	AGFD-MC	SPECIES	3-character codes	(CCC)
	B/W	SPECIES	2-character codes	(CC)
LENGTH	ASU	LENGTH	4-digit total length in mm	(9999)
	USFWS	LNTH	3-digit total length in mm	(999)
	AGFD-LCR	LENGTH	4-digit total length in mm	(9999)
	AGFD-MC	LENGTH	4-digit total length in mm	(9999)
	B/W	TL; SL	3-digit total length and standard length in mm	(999)(999)
WEIGHT	ASU	WEIGHT	4-digit weight in grams	(9999)
	USFWS	WGHT	4-digit weight in grams	(9999)
	AGFD-LCR	WEIGHT	5-digit weight in grams	(99999)
	AGFD-MC	WEIGHT	4-digit weight in grams	(9999)
	B/W	WT	4-digit weight in grams for natives; 2-digit lb/oz for non-natives	(9999)(99)(99)
SEX	ASU	SEX	1-digit number for unknown, male, female	(9)
	USFWS	SEX	1-character code for male, female	(C)
	AGFD-LCR	SEX	1-character code for male, female, undetermined, not checked	(C)
	AGFD-MC	SEX	1-character code for male, female	(C)
	B/W	SEX	1-character code for male, female, immature, undetermined	(C)
PIT TAG	ASU	TAG	10-character code	(CCCCCCCCCC)
	USFWS	PIT	10-character code	(CCCCCCCCCC)
	AGFD-LCR	TAGNUM	10-character code	(CCCCCCCCCC)
	AGFD-MC	TAG	10-character code	(CCCCCCCCCC)
	B/W	PIT_TAG	10-character code	(CCCCCCCCCC)
GEAR TYPE	ASU	GEAR	1-digit code	(9)
	USFWS	GEAR	3-character code	(CCC)
	AGFD-LCR	GEAR_TYP	2-character code (also fields for height, length, mesh)	(CC)
	AGFD-MC			
	B/W	GEAR	2-character code	(CC)
HABITAT	ASU			
	USFWS			
	AGFD-LCR			
	AGFD-MC	HAB_CD	2-character code	(CC)
	B/W			
-Channel	ASU			
	USFWS			
	AGFD-LCR	HABCHANN	2-character code	(CC)
	AGFD-MC			
	B/W	HAB1	2-character code	(CC)
-Primary	ASU			
	USFWS			
	AGFD-LCR	HABTYPE	2-character code	(CC)
	AGFD-MC			
	B/W	HAB2	2-character code	(CC)
-Secondary	ASU			
	USFWS			
	AGFD-LCR	HABTY2	2-character code	(CC)
	AGFD-MC			
	B/W			
-Shoreline	ASU			
	USFWS			
	AGFD-LCR			
	AGFD-MC			
	B/W	HAB3	2-character code	(CC)
MATURITY	ASU	MATURITY	1-digit code	(9)
	USFWS	REMARKS	recorded in remarks	
	AGFD-LCR	MATURITY	1-digit code	(9)
	AGFD-MC	MATURITY	1-digit code	(9)
	B/W	RIPE	2-character code	(CC)
MARK/RECAPTURE	ASU			
	USFWS	RECAP	1-character (yes or no)	(C)
	AGFD-LCR	MARK_REC	1-character code (mark or recapture)	(C)
	AGFD-MC	MARK_RECAP	1-character code (mark or recapture)	(C)
	B/W	RECAPTURE	1-character (yes or no)	(C)
OLD TAG	ASU	RECAPTURE	10-character field for old tag number	(CCCCCCCCCC)
	USFWS	REMARKS	recorded in remarks	
	AGFD-LCR	OLDTAG	1-character code (yes or no)	(C)
	AGFD-MC			
	B/W	OLD_TAG	10-character field for old tag number	(CCCCCCCCCC)
OTHER MARKS	ASU			
	USFWS	FIN	4-character fin clip code	(CCCC)
	AGFD-LCR	COMMENTS	character string	
	AGFD-MC			
	B/W	PIT_TAG; OLD_TAG	clip and punch info recorded in PIT_TAG and OLD_TAG field	(CCCCCCCCC)
DISPOSITION	ASU			
	USFWS			
	AGFD-LCR	DISPOSE	2-character code	*(CC)*
	AGFD-MC	DISP	2-character code	(CC)
	B/W	DISP	2-character code	(CC)
PARASITES	ASU			
	USFWS	REMARKS	recorded in remarks	
	AGFD-LCR	PARASITE	2-digit for number of parasites	(99)
	AGFD-MC			
	B/W	COMMENTS	recorded in comments	
PHOTO/VIDEO	ASU			
	USFWS			
	AGFD-LCR			
	AGFD-MC			
	B/W	PHOTO_VID	1-character code	(C)

Table 2-26. Compatibility of morphometric and meristic fields between databases of B/W and R.R. Miller in Grand Canyon.[a]

INFORMATION	INVESTIGATOR	FIELD NAME	FIELD DESCRIPTION	FIELD FORMAT
DATE	B/W Miller	DATE	6-character code	(YYMMDD)
TAG	B/W Miller	PIT_TAG	10-character code	(CCCCCCCCCC)
SPECIES	B/W Miller	SPECIES SP	2-character code 1-digit number	(CC) (9)
SEX	B/W Miller	SEX SX	1-character code 1-digit number	(C) (9)
LOCATION				
-Description	B/W Miller	LOC	50-character text string	
-River	B/W Miller	RIVER	2-character river code	(CC)
-River Mile	B/W Miller	RM	Numeric river mile from Belknap Guide and marked aerial photos	(999.99)
-Meters	B/W Miller	METER	Meters from mouth of tributary	(9999)
-Side	B/W Miller	SIDE	Bank location looking downstream	(C)
DORSAL RAY COUNT	B/W Miller	DORSAL_RAY DR	2-digit number 4-digit number with 1 decimal place	(99) (9999.9)
ANAL RAY COUNT	B/W Miller	ANAL_RAY AR	2-digit number 4-digit number with 1 decimal place	(99) (9999.9)
LENGTH				
-Total Length	B/W Miller	TL	3-digit number (mm)	(999)
-Fork Length	B/W Miller	FL	3-digit number (mm)	(999)
-Standard Length	B/W Miller	SL SL	3-digit number (mm) 4-digit number with 1 decimal place	(999) (999)
WEIGHT	B/W Miller	WT	4-digit number (g)	(9999)
HEAD LENGTH	B/W Miller	HEAD_LN HL	2-digit number with 1 decimal place (mm) 4-digit number with 1 decimal place	(99.9) (9999.9)
SNOUT LENGTH	B/W Miller	SNOUT_LN SNL	2-digit number with 1 decimal place (mm) 4-digit number with 1 decimal place	(99.9) (9999.9)
DORSAL FIN BASE	B/W Miller	DORSAL_FB DBASE	2-digit number with 1 decimal place (mm) 4-digit number with 1 decimal place	(99.9) (9999.9)
ANAL FIN BASE	B/W Miller	ANAL_FB ABASE	2-digit number with 1 decimal place (mm) 4-digit number with 1 decimal place	(99.9) (9999.9)
BODY DEPTH	B/W Miller	BODY_DEPTH BDP1	3-digit number with 1 decimal place (mm) (maximum body depth) 4-digit number with 1 decimal place (body depth over pectoral insertion)	(999.9) (9999.9)
CAUDAL PEDUNCLE DEPTH	B/W Miller	CPD	4-digit number with 1 decimal place (measurement points unknown)	(9999.9)
- Maximum depth	B/W Miller	CPMAXD	2-digit number with 1 decimal place (mm)	(99.9)
- Minimum depth	B/W Miller	CPMIND	2-digit number with 1 decimal place (mm)	(99.9)
CAUDAL PEDUNCLE LENGTH	B/W Miller	CPL AOCB	3-digit number with 1 decimal place (mm) (anal insertion to caudal base) 4-digit number with 1 decimal place (anal origin to caudal base)	(999.9) (99.9)
PECTORAL FIN TO PELVIC FIN LENGTH	B/W Miller	P1_P2 P1P2	2-digit number with 1 decimal place (mm) (distance between origins of fins) 4-digit number with 1 decimal place (measurement points unknown)	(99.9) (9999.9)
NUCHAL DEPRESSION DEPTH	B/W Miller	ND FRONDEP	2-digit number with 1 decimal place (mm) 3-digit number with 2 decimal places	(99.9) (999.99)
PHOTOGRAPH	B/W Miller	PHOTO_VIDEO	1-character code	(C)

[a]The other investigators did not collect this information.

Table 2-27. Compatibility of drift fields between databases of AGFD (LCR Studies) and B/W in Grand Canyon.[a]

INFORMATION	INVESTIGATOR	FIELD NAME	FIELD DESCRIPTION	FIELD FORMAT
DATE	AGFD-LCR	SET_MO; SET_DA; SET_YR	2-digit number for each of month, day, year	(MM)(DD)(YY)
	B/W	DATE	6-character code	(YYMMDD)
LOCATION				
-Code	AGFD-LCR	STUDY	Last three digits of field	(999)
	B/W			
-River	AGFD-LCR			
	B/W	RIVER	2-character river or tributary code	(CC)
-River Mile	AGFD-LCR			
	B/W	RM	3-digit number with 2 decimal places (Numeric river mile from Belknap Guide and marked aerial photos)	(999.99)
-Meters	AGFD-LCR	MILE	5-digit number (meters from mouth of tributary)	(99999)
	B/W	METER	4-digit number (meters from mouth of tributary)	(9999)
-Side	AGFD-LCR	SIDE	1-character code (bank location looking ?)	(C)
	B/W	SIDE	1-character code (bank location looking downstream)	(C)
HABITAT				
-Channel	AGFD-LCR	HABCHANN	2-character code	(CC)
	B/W	HAB1	2-character code	(CC)
-Primary	AGFD-LCR	HABTYPE	2-character code	(CC)
	B/W	HAB2	2-character code	(CC)
-Secondary	AGFD-LCR	HABTY2	2-character code	(CC)
	B/W			
-Shoreline	AGFD-LCR			
	B/W	HAB3	2-character code	(CC)
DEPTH	AGFD-LCR	DEPTH	3-digit number (measurement location unknown)	(999)
	B/W	DEPTH	3-digit number (height of net above water surface in cm)	(999)
DISTANCE	AGFD-LCR	DISTANCE	1-digit number with 2 decimal places (distance from shore in meters)	(9.99)
	B/W			
VELOCITY				
-Initial	AGFD-LCR	FLOW_INIT	1-digit number with 2 decimal places	(9.99)
	B/W	V1_INIT,V2_INIT,V3_INIT	1-digit number with 2 decimal places (three initial velocities averaged)	(9.99)
-Final	AGFD-LCR	FLOW_END	1-digit number with 2 decimal places	(9.99)
	B/W	V1_END,V2_END,V3_END	1-digit number with 2 decimal places (three final velocities averaged)	(9.99)
TIME				
-Initial	AGFD-LCR	SET_HH,SET_MM	2-digit numbers for each of hours and minutes	(HH)(MM)
	B/W	TIME_INIT	4-digit military time	(HHMM)
-Final	AGFD-LCR			
	B/W	TIME_END	4-digit military time	(HHMM)
TAXA	AGFD-LCR	TAXA	3-character code	(CCC)
	B/W	Fields names contain each taxa and life stage encountered		
LIFE STAGE	AGFD-LCR	LIFE_STAGE	1-character code	(C)
	B/W	Fields names contain each taxa and life stage encountered		
NUMBER	AGFD-LCR	NO	4-digit number	(9999)
	B/W	SIMADU,SIMPUP,SIMLAR, etc. (see structure)	4-digit number	(9999)
VOLUME	AGFD-LCR	TLV	4-digit number	(9999)
	B/W	SIMVOL,CHIRVOL,etc. (see structure)	1-digit number with 4 decimal places	(9.9999)
WEIGHT				
-Dry Weight	AGFD-LCR	DRY_WEIGHT	4-digit number with 4 decimal places	(9999.9999)
	B/W	CLADDRWT	2-digit number with 4 decimal places (dry weight of cladophora only)	(99.9999)
-Ash Weight	AGFD-LCR	ASH_WEIGHT	4-digit number with 4 decimal places	(9999.9999)
	B/W			

[a]The other investigators did not collect this information.

Table 2-28. Compatibility of food habits fields between databases of AGFD and B/W in Grand Canyon.[a]

INFORMATION	INVESTIGATOR	FIELD NAME	FIELD DESCRIPTION	FIELD FORMAT
DATE	AGFD-LCR	SET_MO; SET_DA; SET_YR	2-digit number for each of month, day, year	(MM)(DD)(YY)
	AGFD-MC			
	B/W	DATE	6-character code	(YYMMDD)
LOCATION				
-Code	AGFD-LCR	STUDY	Last three digits of field	(999)
	AGFD-MC	STUDY	Last three digits of field	(999)
	B/W			
-River	AGFD-LCR			
	AGFD-MC			
	B/W	RIVER	2-character river or tributary code	(CC)
-River Mile	AGFD-LCR			
	AGFD-MC			
	B/W	RM	3-digit number with 2 decimal places (Numeric river mile from Belknap Guide and marked aerial photos)	(999.99)
-Meters	AGFD-LCR	MILE	5-digit number (meters from mouth of tributary)	(99999)
	AGFD-MC			
	B/W	METER	4-digit number (meters from mouth of tributary)	(9999)
-Side	AGFD-LCR	SIDE	1-character code (bank location looking ?)	(C)
	AGFD-MC			
	B/W	SIDE	1-character code (bank location looking downstream)	(C)
SPECIES	AGFD-LCR	SPECIES	3-character code	(CCC)
	AGFD-MC	SPECIES	3-character code	(CCC)
	B/W	SPECIES	2-character code	(CC)
LENGTH				
-Total Length	AGFD-LCR	LENGTH	3-digit number (mm)	(999)
	AGFD-MC	LENGTH	3-digit number (mm)	(999)
	B/W	TL	3-digit number (mm)	(999)
-Standard Length	AGFD-LCR			
	AGFD-MC			
	B/W	SL	3-digit number (mm)	(999)
FISH WEIGHT	AGFD-LCR	WEIGHT	4-digit number (g)	(9999)
	AGFD-MC			
	B/W	WT	4-digit number (g)	(9999)
PIT TAG	AGFD-LCR			
	AGFD-MC			
	B/W	PIT_TAG	10-character code	(CCCCCCCCCC)
SEX	AGFD-LCR	SEX	1-character code	(C)
	AGFD-MC			
	B/W	SEX	1-character code	(C)
PARASITES	AGFD-LCR	PARCODE	1-character code (interval code)	(C)
	AGFD-MC	PARASITE	1-character code (y or n)	(C)
	B/W	TAPEWORMS	logical (presence or absence)	(L)
TAXA	AGFD-LCR	TAXA	3-character code	(CCC)
	AGFD-MC	TAXA	3-character code	(CCC)
	B/W	Field names contain each taxa and life stage encountered		
LIFE STAGE	AGFD-LCR	LIFE	1-character code	(C)
	AGFD-MC	LIFE_STAGE	1-character code	(C)
	B/W	Field names contain each taxa and life stage encountered		
NUMBER	AGFD-LCR	NUMBER	4-digit number	(9999)
	AGFD-MC	NUMBER	4-digit number	(9999)
	B/W	GAMMADU,GAMMIMM,etc. (see structure)	3-digit number	(999)
VOLUME	AGFD-LCR	VOLUME	3-digit number with 2 decimal places	(999.99)
	AGFD-MC			
	B/W	GAMMADUVOL,etc. (see structure)	4-digit number with 4 decimal places	(9999.9999)

[a] The other investigators did not collect this information.

Table 2-29. Compatibility of fish sampling fields between databases of fisheries investigators in Grand Canyon.

INFORMATION	INVESTIGATOR	FIELD NAME	FIELD DESCRIPTION	FIELD FORMAT
DATE	ASU	MONTH; DAY; YEAR	2-digits for each of month, day, year	(MM)(DD)(YY)
	USFWS	DATE	dBase data field	(MM/DD/YY)
	AGFD-LCR	RUN_MO; RUN_DA; RUN_YR	2-digits for each of month, day, year	(MM)(DD)(YY)
	AGFD-MC			
	B/W	DATE	6-character code	(YYMMDD)
TIME	ASU	HOUR	4-digit military time	(HHMM)
	USFWS	TIME	4-digit military time	(HHMM)
	AGFD-LCR	RUN_HR; RUN_MM	2-digit for each of hour and minute	(HH)(MM)
	AGFD-MC			
	B/W	TIME	4-digit military time	(HHMM)
LOCATION	ASU	LOCATION	USFWS transect code	(CCC)
-Code	USFWS	ID	Transect code and bank location looking upstream USFWS transect code	(CCCCCCCC)
	AGFD-LCR	FWS	last 3 digits of field	(CCC)
	AGFD-MC	STUDY		(999)
	B/W			
-River	ASU	WACODE	2-digit AGFD tributary code	(99)
	USFWS			
	AGFD-LCR	REACH	2-digit tributary code	(99)
	AGFD-MC			
	B/W	RIVER	2-character river code	(CC)
-River Mile	ASU			
	USFWS			
	AGFD-LCR			
	AGFD-MC			
	B/W	RM	Numeric river mile from Belknap Guide and marked aerial photos	(999.99)
-Meters	ASU			
	USFWS			
	AGFD-LCR	MILE	Meters from mouth of LCR	(99999.99)
	AGFD-MC			
	B/W	METER	Meters from mouth of tributary	(9999)
-Side	ASU			
	USFWS	ID	Bank location looking upstream	(CCCCCCCC)
	AGFD-LCR	SIDE	Bank location looking ?	(C)
	AGFD-MC			
	B/W	SIDE	Bank location looking downstream	(C)
HABITAT	ASU			
	USFWS			
	AGFD-LCR			
	AGFD-MC	HAB_CO	2-character code	(CC)
	B/W			
-Channel	ASU			
	USFWS			
	AGFD-LCR	HABCHANN	2-character code	(CC)
	AGFD-MC			
	B/W	HAB1	2-character code	(CC)
-Primary	ASU			
	USFWS			
	AGFD-LCR	HABTYPE	2-character code	(CC)
	AGFD-MC			
	B/W	HAB2	2-character code	(CC)
-Secondary	ASU			
	USFWS			
	AGFD-LCR	HABTY2	2-character code	(CC)
	AGFD-MC			
	B/W			
-Shoreline	ASU			
	USFWS			
	AGFD-LCR			
	AGFD-MC			
	B/W	HAB3	2-character code	(CC)
SUBSTRATE	ASU			
	USFWS	SUB,SBC	2-digit number and 4-character code	(99)(CCCC)
	AGFD-LCR	SUBS1,SUBS2	2-character substrate codes	(CC)(CC)
	AGFD-MC	SUBST_CD	2-character code	(CC)
	B/W	SUB1,SUB2	2-character codes	(CC)
WATER TEMPERATURE	ASU			
	USFWS			
	AGFD-LCR			
	AGFD-MC	TEMP	2-digit number with 1 decimal place	(99.9)
	B/W	TEMP_MC,TEMP_HAB	2-digit number with 1 decimal place	(99.9)
LIGHT	ASU			
	USFWS			
	AGFD-LCR			
	AGFD-MC	AMB_LITE	2-character code	(CC)
	B/W	LIGHT	2-character code	(CC)
GEAR	ASU	GEAR	1-digit number	(9)
	USFWS	GEAR	3-character code	(CCC)
	AGFD-LCR	GEAR_TYP,GEAR_H,GEAR_L,GEAR_M	2-character code,2-digit height,3-digit length,1-digit number with 5 decimal places for mesh	(CC)(99)(999)(9.99999)
	AGFD-MC		2-character code	
	B/W	GEAR_CD	2-character code	(CC)
		GEAR		(CC)
EFFORT	ASU			
	USFWS	SETD,SETT,PULD,PULT	dBASE dates,4-character times	(MM/DD/YY)(CCCC)
	AGFD-LCR			
	AGFD-MC	EFFORT	4-digit number with 2 decimal places (m^2 or hours)	(9999.99)
	B/W	TIME_ELAPS,SECONDS,SAMP_AREA	2-digit number with 2 decimal places (hours), 5-digit number (seconds),4-digit number with 2 decimal places (m^2)	(99.99)(99999)(9999.99)
SPECIES	ASU	SPECIES	2- and 3-character codes	(CC)(CCC)
	USFWS	SPP	3-character code	(CCC)
	AGFD-LCR	SPECIES	3-character code	(CCC)
	AGFD-MC	SPECIES	3-character code	(CCC)
	B/W	SPECIES	2-character code	(CC)
AGE	ASU			
	USFWS			
	AGFD-LCR			
	AGFD-MC			
	B/W	YOY,JUV,ADU	4-digit number counting number in each age group	(9999)(9999)(9999)
NUMBER	ASU			
	USFWS			
	AGFD-LCR			
	AGFD-MC			
	B/W	TOTAL	4-digit number counting total fish of a given species	(9999)

Table 2-30. River mile and meter standards used by fisheries investigators in Grand Canyon.

Researcher	River Mile/Meter Standard
ASU (Little Colorado River)	U.S. Fish and Wildlife Service transect code and/or generic site name
Service (Little Colorado River)	Service transect code
U of A (Tributaries)	Meters measured from tributary mouth
AGFD (Little Colorado River)	Service transect code and meters measured from mouth
AGFD (Mainstem Colorado River)	Stevens' River Guide and River miles marked on aerial photos
B/W (Mainstem Colorado River)	Belknap River Guide and River miles marked on aerial photos
Historical and Past Collections	Information not available at this time

CHAPTER 3: PHASE 2 - INTEGRATION OF FISHERIES DATABASES FROM GRAND CANYON

Chapter 2 described the data file structures of GCES fisheries databases and identified the particular datasets and fields within those datasets that are similar enough to be integrated into common data files. This chapter describes potential file structures for the integrated database (integration templates) and describes potential modifications or translations (i.e., translation filters) of databases for integration of data.

Integration templates are file structures for the integrated GCFIN Database files. Translation filtersare computer programs to convert data from existing field formats, codes, or definitions to fit the common standard established for the integration templates.

COMMON DATA STANDARDS AND TRANSLATIONS

Location, date and time, habitat, and sampling gear information are common throughout different GCES databases, but are not recorded in a consistent manner by the different investigators. These items are in many of the existing database files and are likely to be collected by researchers in future studies. Because these items are important identifiers for analysis and comparison of data, it is essential that they are consistently represented in the integrated database. This section discusses each of the items, the recommended standard format, and how existing data could be translated into the new format. Data standards are discussed which establish formats, codes, and definitions for data collection and storage.

Location Information

Grand Canyon fisheries investigators record location information in two ways: 1) a system of codes that represent locations, or 2) a measure of distance (i.e., river mile, meters) from a given point. The most common system of codes is that defined by the Service to represent locations in the Little Colorado River (Service transect codes). The Service transect codes are used by ASU, the Service, and AGFD (LCR Studies). The AGFD (LCR Studies) also uses the distance in meters upstream from the mouth of the Little Colorado River. AGFD (Mainstem Studies) and B/W use mainstem river miles (measured from Lees Ferry) and tributary meters (measured from the tributary mouth). Except for the Service, all investigators also use a code to identify the river or tributary, and except for ASU, all identify the side of the river or tributary as well.

A common system for representing location is required to integrate the information into one database. Because coded locations are difficult to use, a set of four commonly used and understood fields is recommended to represent location. The fields identify the river, river mile, tributary meters, and side of river, and are defined below.

Recommended Location Information

Field	Type	Field Length	Decimal Places	Description
RIVER	C	2	0	River or tributary code
RM	N	6	2	River mile
METERS	N	5	0	Meters from tributary mouth
SIDE	C	1	0	Side of river or tributary facing downstream

C=character
N=numeric

The following is a discussion of how individual researchers' location data can be integrated into the common format chosen for the templates. See Chapter 5 for further discussion of location information.

RIVER

Description: Identification of the river being sampled

Collectors: ASU, AGFD (Mainstem and LCR Studies), B/W

Integration: ASU and AGFD use the AGFD reach codes, which are two-digit numerical codes representing tributaries and reaches of the mainstem. B/W uses two-character codes which are an abbreviation of the name of the river or tributary. Two-character codes require no more space than two-digit numeric codes, so two-character codes were chosen because they are more descriptive of river and tributary names than numbers and therefore more easily identifiable. A translation filter can be used to convert ASU and AGFD numerical codes to characters. The Service databases do not have a field to identify the river or tributary. The Service data identified in this report are collected exclusively in the LCR, so a translation filter can simply replace the RIVER field for Service data with the code for the LCR. When the Service tributary data become available, a blanket replacement of the RIVER field with the LCR code will not be appropriate, so a different way of identifying the river or tributary and getting that information into the RIVER field of the integrated files may be necessary. See Appendix C for a list of standardized river and tributary codes.

RM

Description: River mile designation

Collectors: AGFD, B/W

Integration: Both AGFD and B/W have conducted studies in the mainstem Colorado River, and both record locations as river miles based on aerial photographs and river guides (e.g., Stevens Guide (Stevens 1983), Belknap Guide (Belknap and Evans 1989). It is not known at this time the extent to which the two agencies' river mile designations are compatible. When this is known, several options are available for integration: 1) leave both agencies' river mile designations as they are, but warn users of the integrated database that they are not exactly compatible, 2) select one agency's river mile designations as the standard and use a translation filter to convert the other's to that standard for the purposes of integration, 3) establish a river mile standard separate from either of those used by AGFD and B/W, and convert both databases to that standard, or 4) allow flexibility in the river mile designations included in the integrated files, giving the user a choice of the river mile standard included in a file. It is

recommended that Option 4) be adopted and the user interface to the integrated database be flexible enough to allow a user to specify which river mile standard to include. One or both databases would be converted to the specified standard.

METERS

Description: In tributary streams, the distance in meters from the mouth

Collectors: ASU, Service, AGFD, B/W

Integration: The investigators conducting studies in the Little Colorado River (ASU, Service, AGFD) primarily use the Service transects to identify locations in that tributary. AGFD (LCR Studies) also records location as distance in meters upstream from the mouth of the LCR. Other tributary investigations commonly use distance in meters upstream from the tributary mouth to identify locations. Although the LCR researchers all use the Service transect codes, those codes are meaningless to users of the integrated database who don't work in the LCR. For this reason, as well as to be consistent with the other tributary locations, distance in meters from the mouth is recommended for identification of all tributary locations, including those in the LCR. The LCR transect locations can easily be converted to meters by a translation filter. If the actual transect codes are important to LCR investigators, a field can be added to the templates to include them.

SIDE

Description: The bank of the river nearest to sample location

Collectors: Service, AGFD, B/W

Integration: Except for ASU, all investigators record the side of the river or tributary as part of the location information. The mainstem researchers (AGFD, B/W) consistently record the side of the river facing downstream. Except for the Service, LCR and tributary researchers also record side facing downstream. Facing downstream to determine side has become common practice (USDA 1985), and since most of the Grand Canyon fisheries researchers use the downstream method, it was chosen for the integration templates. A translation filter can easily convert Service data to be consistent with this standard.

Date and Time Information

Date and time information is collected in nearly every aspect of the Grand Canyon fisheries studies, but investigators record it in slightly different ways. Dates are recorded in multiple numeric fields, single character fields, and dBASE® date fields. Times are recorded in single and multiple numeric fields. The following are the recommended field formats for recording date and time in the integration templates:

Recommended Date/Time Information

Field	Type	Field Length	Decimal Places	Description
DATE	D	8	0	Date
TIME	N	4	0	Time

N=numeric
D=date

The following is a discussion of how individual researchers' date and time data can be integrated into the common format chosen for the templates.

DATE

Description: Date
Collectors: ASU, Service, AGFD, B/W
Integration: The dBASE® date format was chosen because it is consistent with the way most people write dates by hand (i.e., MM/DD/YY), and it allows for easy date calculations (e.g., number of days between two dates). Only the Service currently uses the dBASE® date format. ASU and AGFD use three separate two-digit fields for month, day, and year, while B/W uses a single six-character field. Translation filters can easily convert these formats to dBASE® date formats.

TIME

Description: Time
Collectors: ASU, Service, AGFD, B/W
Integration: All the investigators record time in military format and, except for AGFD, store it in one four-digit numeric field. A translation filter can convert the two two-digit fields (one for hours, one for minutes) used by AGFD to this standard.

Habitat Information

Habitat information is commonly collected by GCES investigators conducting fish sampling, fish measurements, or water quality studies. There is not a consistent scheme, however, for how habitat is classified and identified by the different investigators. One group describes primary and secondary habitat, another group identifies channel and shoreline types, while another group combines several aspects of habitat into a single coded field. Examination of the different habitat descriptions revealed that most investigators are interested in knowing three things about habitat: 1) the channel type (e.g., mainstem, tributary, lake), 2) the water hydraulic type (e.g., eddy, riffle, backwater), and 3) the shoreline type (e.g., sand, vegetation, cobble). Fields for these three habitat types were chosen for the integration templates and the following is a description of their formats:

Recommended Habitat Information

Field	Type	Field Length	Decimal Places	Description
CHANNEL	C	2	0	Channel type
HYDRAULIC	C	2	0	River hydraulic type
SHORELINE	C	2	0	Shoreline type

C=character

The following is a discussion of how individual researchers' habitat identification data can be integrated into the common format chosen for the templates.

CHANNEL

Description: River channel type (i.e., main channel, side channel, tributary stream)
Collectors: AGFD, B/W
Integration: AGFD and B/W record channel type, but codes vary. A translation filter can convert AGFD and B/W codes to the standard codes. See Appendix C for a list of standardized channel codes.

HYDRAULIC

Description: River hydraulic type (i.e., eddy, run, riffle, pool)
Collectors: AGFD, B/W
Integration: AGFD and B/W record hydraulic type, but codes vary. A translation filter can convert AGFD and B/W codes to the standard codes. See Appendix C for a list of standardized hydraulic codes.

SHORELINE

Description: River shoreline type (i.e., sand, vegetation, cobble)
Collectors: B/W
Integration: Shoreline type is directly recorded only by B/W, but two of the AGFD (mainstem) habitat codes indicate beach or boulder, that could be translated into shoreline types by a translation filter. Some B/W codes may require translation as well. See Appendix C for a list of standardized shoreline codes.

Sampling Gear Information

The type of sampling gear used to catch fish is important in the interpretation of fisheries data analyses. Different gear types select for different species and age groups of fish and must be taken into consideration when calculating catch-per-effort statistics. Grand Canyon fisheries investigators record gear type in different ways, with varying levels of detail. Some investigators record only a general category of gear type (e.g., trammel net, seine, angling), some record gear specifics in several different fields (e.g., net length, mesh size, number of hoops), while others record a gear code that represents a type of gear with certain specifications (e.g., the code 'SA' represents a 10' x 3' x ⅛" seine). Codes that represent gear specifications were chosen for the integration templates because they are used by both AGFD (mainstem) and B/W, as well as by researchers submitting data to the Upper Colorado River Basin Database (USFWS 1989). Maintaining consistency with Upper Basin databases will facilitate future integration of Upper and Lower Basin data. The gear type field format for the integration templates is as follows:

Recommended Sampling Gear Information

Field	Type	Field Length	Decimal Places	Description
GEAR	C	2	0	Gear type

C=character

The following is a discussion of how individual researchers' gear information can be integrated into the common format chosen for the templates.

GEAR

Description: Sampling gear type

Collectors: ASU, Service, AGFD, B/W

Integration: If Upper Basin gear codes are adopted for the GCFIN database, all the Grand Canyon fisheries databases will require some translation. B/W gear codes are based on the Upper Basin codes, with a few exceptions that will need to be converted and a few additions to the list. AGFD (mainstem) uses similar gear codes, but will also require some code translations and additions. ASU records only general gear types, so more information on gear specifications is required to translate these to more specific gear codes. AGFD (LCR) records a general gear type, gear height and length, and gear mesh. These fields can be used to determine equivalent gear codes, but more information on some gear specifications is necessary to identify all their gear types. The Service records a three-character gear code as well as gear mesh, number of hoops, and hoop diameter for identifying ASU hoop nets. As with AGFD (LCR), these fields can be used to determine equivalent gear codes, but more information is necessary to positively identify some gear types. See Appendix C for a list of standardized gear codes composed of Upper Basin gear codes and codes for additional gear types used in Grand Canyon.

INTEGRATION TEMPLATES

Six datasets were identified for possible integration in Chapter 2: *Water Quality, Fish Capture, Morphometric/Meristic, Drift, Food Habits, and Fish Sampling.* This section examines each of these datasets in detail, including a discussion of the dataset's utility for fisheries investigations, a recommended integrated file structure or example of recommended integrated information, and a discussion of how each data item can be taken from the existing databases and incorporated into an integrated database.

1. Water Quality Dataset

Water Quality data compiled by different groups can readily be integated into one common database because most of this information is collected with similar instruments and methods. Nearly all investigators use a Hydrolab® Datasonde™ or Surveyor™ to collect water quality parameters, and secchi disks and/or turbidity meters to collect water clarity information.

Utility of the Water Quality Dataset

Water Quality data normally are collected to determine possible relationships between *Water Quality* parameters and the life history, ecology, or condition of fish.

Structure of the Integrated Water Quality File

The following is a recommended file structure for *Water Quality* information. The recommended fields are the same as those in Table 2-24 of Chapter 2, with some additional fields identified as useful. Fields used to identify samples include date, time, location (river, river mile, tributary meters), and habitat (river hydraulic). Fields for information collected by a typical water quality instrument (e.g., Hydrolab® Datasonde™, Surveyor™) include water temperature, pH, conductivity, dissolved oxygen, oxidation-reduction potential, and salinity. Fields for information that may be collected manually at the same time as, or independently of, instrument readings include habitat temperature,

air temperature, secchi depth, and turbidity measurement. Additional information includes a field to identify the investigative agency collecting the *Water Quality* parameters and a field for comments.

Recommended Water Quality Information

Field	Type	Field Length	Decimal Places	Description
DATE	D	8	0	Date
TIME	N	4	0	Military time
RIVER	C	2	0	River or tributary code
RM	N	6	2	River mile
METERS	N	5	0	Meters from tributary mouth
SIDE	C	1	0	Side of river or tributary facing downstream
MC_TEMP	N	5	2	Temperature (°C)
HYDRAULIC	C	2	0	River hydraulic habitat type
HAB_TEMP	N	5	2	Habitat temperature (°C)
AIR_TEMP	N	4	1	Air temperature (°C)
INSTRUMENT	C	1	0	Water quality instrument used
PH	N	4	2	pH
CONDUCT	N	6	3	Conductivity
DO	N	5	2	Dissolved oxygen
ORP	N	6	3	Oxidation-reduction potential
SALINITY	N	4	1	Salinity
SECCHI	N	5	2	Secchi depth (m)
NTU	N	8	2	Turbidity (NTUs)
INVESTIGTR	C	5	0	Investigative agency
COMMENTS	C	30	0	Comments

C=character
N=numeric
D=date

Incorporation of Existing Databases into the Integrated Water Quality File

Table 2-24 in Chapter 2 compares the individual *Water Quality* fields of the different researchers' databases. Although the different *Water Quality* fields are compatible, many of them are not in identical formats. Many of the fields are numeric, so the differences lie mainly in the field length and number of decimal places. The standardized, numeric field sizes established for the integration template were chosen to accommodate the different size formats used by the various researchers. Other data fields that were considered useful and were collected by some researchers in addition to the established *Water Quality* fields discussed in Chapter 2 are air temperature, a river hydraulic (habitat) designation, habitat temperature, and comments. The formats for these fields were also chosen to accommodate existing field formats. Incorporation of existing date, time, and location

information into the recommended standard format was discussed previously within the Common Data Standards and Translations Section. The following is a detailed discussion of the incorporation of the remaining *Water Quality* fields into the integration template.

DATE
Description: Date
Collectors: ASU, Service, AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-4)

TIME
Description: Time
Collectors: ASU, Service, AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-4)

RIVER
Description: Identification of the river being sampled
Collectors: ASU, AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-2)

RM
Description: River mile designation
Collectors: AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-2)

METERS
Description: In tributary streams, the distance in meters from the mouth
Collectors: ASU, Service, AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-3)

SIDE
Description: The bank of the river nearest to sample location
Collectors: Service, AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-3)

MC_TEMP
Description: Main channel temperature
Collectors: Service, AGFD (Mainstem Studies), B/W
Integration: Only the Service uses a different format for mainstem temperature than that chosen for the integration template. It differs by having one decimal place instead of two, so can be copied directly without any loss of information.

HYDRAULIC
Description: River hydraulic type (i.e., eddy, run, riffle, pool)
Collectors: AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-5)

HAB_TEMP

Description: Habitat temperature

Collectors: Service, AGFD (Mainstem studies), B/W

Integration: Only the Service uses a different format for habitat temperature than that chosen for the integration template. It only differs by having one decimal place instead of two, so can be copied directly without any loss of information.

AIR_TEMP

Description: Air temperature

Collectors: Service, B/W

Integration: Only the Service and B/W record air temperature data, using degrees Fahrenheit and degrees Celsius, respectively. Degrees Celcius was the temperature unit chosen for the integration template so that air temperature units would be consistent with water temperature units. The Service air temperature data must be converted from Fahrenheit to Celsius by a translation filter.

INSTRUMENT

Description: Type of water quality instrument used

Collectors: None currently

Integration: The type of instrument used to collect water quality data (Hydrolab® Datasonde™, Hydrolab® Surveyor™, or manual collection) is not currently stored in databases by any of the researchers, so the data for this field may need to be entered manually. If researchers use particular instruments consistently, translation filters could be used to incorporate this information.

PH

Description: pH of water

Collectors: Service, AGFD (Mainstem studies), B/W

Integration: The field format chosen for the template is one digit before the decimal point and two decimal places. Although the B/W pH field format allows for two digits before the decimal point, pH values larger than 9.99 are unlikely in this river system. Therefore, all of the researchers' pH data can be copied directly into the template.

CONDUCT

Description: Conductivity of water

Collectors: Service, AGFD (Mainstem studies), B/W

Integration: Each investigator uses a different format for conductivity. A format was chosen that accommodates these different formats, so conductivity data from all the databases can be copied directly into the template.

DO

Description: Dissolved oxygen content of water

Collectors: Service, AGFD (Mainstem Studies), B/W

Integration: The Hydrolab® Datasonde™ and Surveyor™ water quality instruments collect dissolved oxygen measurements in units of milligrams per liter, and investigators use nearly the same formats for these data, so they can be copied directly into the

template. Only AGFD has a field for dissolved oxygen in units of percent saturation, so those data are not included in the integration template.

ORP

Description: Oxidation-reduction potential of water
Collectors: Service, AGFD (Mainstem Studies), B/W
Integration: Each investigator uses a different format for oxidation-reduction potential. A format was chosen that accommodates them all, so oxidation-reduction potential data can be copied directly into the template.

SALINITY

Description: Salinity of water
Collectors: Service, AGFD (Mainstem Studies)
Integration: Only the Service and AGFD collect salinity information, and they use slightly different formats. The format used by the Service can accommodate the AGFD format, so it was chosen for the integration template. Both agencies' data can be copied directly into the template.

SECCHI

Description: Secchi depth
Collectors: Service, B/W
Integration: The Service records depths in units of centimeters and B/W records depth in meters; both measure secchi depth to the nearest centimeter. Units of meters were chosen for the integration template, but units of centimeters are equally valid. The Service data must be passed through a translation filter to perform the simple conversion from centimeters to meters.

NTU

Description: Nephelometric turbidity units
Collectors: Service, B/W
Integration: Only the Service and B/W collect turbidity data using a turbidimeter. They use slightly different formats, so a format was chosen into which both investigators' data can be copied directly.

INVESTIGTR

Description: Identification of the investigative agency that collected the data
Collectors: None currently
Integration: As each investigator's data are passed through translation filters on their way to the integrated file structures, this field will be filled to identify the investigative agency collecting the data.

COMMENTS

Description: Comments
Collectors: None currently
Integration: This field may be filled with comments that are stored in each researcher's database (copied directly), or used for comments added later.

2. Fish Capture Dataset

As discussed in Chapter 2 the *Fish Capture* data can also be incorporated into an integrated database. Some fields are integrable in their existing formats while others will require modification or "translation."

Utility of the Fish Capture Dataset

Fish Capture data normally are used for recapture, length frequency, condition factor, and spawning analyses, that require individual fish information (i.e., tag number, length, weight, spawning condition). Because these kinds of analyses are usually performed for individual fish species, and because the *Fish Capture* dataset is very large, these data can be separated by species to reduce the size of any given file.

Structure of the Integrated Fish Capture File

The following is the recommended file structure for the *Fish Capture* information. The recommended fields are basically the same as those compared in Table 2-25, with some additional fields identified as being useful. The field for other marks (fin clips and punches) was not included because this information can be recorded in the fields designated for tagging information. In order to clarify tagging information and to be consistent with Upper Basin data formats, fields were added for tag type and tag color, mostly to accommodate Carlin and Floy tags. These fields are included to describe old tag information as well as new tags. A field was also added for the standard length of a fish since standard length is collected by some Grand Canyon fisheries researchers, and data from past studies which have not yet been made available in detail may contain fish measurements including standard length.

Recommended Fish Capture Information

Field	Type	Field Length	Decimal Places	Description
DATE	D	8	0	Date
TIME	N	4	0	Military time
RIVER	C	2	0	River or tributary code
RM	N	6	2	River mile of capture location
METERS	N	5	0	Meters upstream of tributary mouth (capture location)
SIDE	C	1	0	Side of river or tributary facing downstream
SPECIES	C	3	0	Fish species code
TL	N	4	0	Total length (mm)
SL	N	4	0	Standard length (mm)
WT	N	4	0	Weight (g)
SEX	C	1	0	Sex
TAG_NUM	C	10	0	Tag number
TAG_TYPE	C	1	0	Tag type
TAG_COLOR	C	1	0	Tag color

Field	Type	Field Length	Decimal Places	Description
GEAR	C	2	0	Gear code
CHANNEL	C	2	0	Channel type
HYDRAULIC	C	2	0	River hydraulic type
SHORELINE	C	2	0	Shoreline type
SPAWN_COND	C	2	0	Spawning condition
MARK_REC	C	1	0	Marked, recaptured, or only handled fish
OLD_TAG	C	10	0	Old tag number if fish is a recapture
OLD_TYPE	C	1	0	Old tag type if fish is a recapture
OLD_COLOR	C	1	0	Old tag color if fish is a recapture
DISP	C	2	0	Disposition code
PARASITE1	C	2	0	Parasite code (first parasite)
NUM_PAR1	N	2	0	Number of parasites (first parasite)
PARASITE2	C	2	0	Parasite code (if there is a second parasite)
NUM_PAR2	N	2	0	Number of parasites (second parasite)
PHOTO	C	1	0	Photographs taken
INVESTIGTR	C	5	0	Investigative agency
COMMENTS	C	30	0	Comments

C=character
N=numeric
D=date

Incorporation of Existing Databases into the Integrated Fish Capture File

Table 2-25 compares the individual *Fish Capture* fields of the different databases and illustrates the different formats used. Integration of date, time, location, habitat, and gear fields was discussed in Common Data Standards and Translations Section. The following is a detailed discussion of the incorporation of the *Fish Capture* fields into the integration template.

DATE
Description: Date
Collectors: ASU, Service, AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-4)

TIME
Description: Time
Collectors: ASU, Service, AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-4)

RIVER
Description: Identification of river being sampled
Collectors: ASU, AGFD (LCR Studies), B/W

Integration: See Common Data Standards and Translations (page 3-2)

RM
Description: River mile designation
Collectors: B/W
Integration: See Common Data Standards and Translations (page 3-2)

METERS
Description: In tributary streams, the distance in meters from the mouth
Collectors: AGFD (LCR Studies), B/W
Integration: See Common Data Standards and Translations (page 3-3)

SIDE
Description: The bank of the river nearest to the sample location
Collectors: Service, AGFD (LCR Studies), B/W
Integration: See Common Data Standards and Translations (page 3-3)

SPECIES
Description: Species of fish captured
Collectors: ASU, Service, AGFD, B/W
Integration: Most of the investigators use three-character codes to identify species, so a three-character species field was chosen for the template. All B/W species codes will have to be translated into three-character codes, as will some of the ASU codes. Not all of the researchers use the same three characters for their codes, so a standardized set of three-character species codes was developed which requires a few code translations for the Service and AGFD species data as well. See Appendix C for a list of standardized species codes.

TL
Description: Total length of fish
Collectors: ASU, Service, AGFD, B/W
Integration: Investigators use either three- or four-digit numeric fields to record total length in millimeters. A four-digit field was chosen for the template so all length data can be copied directly.

SL
Description: Standard length of fish
Collectors: B/W
Integration: Only B/W and possibly some past researchers collect standard length measurements. A four-digit field was chosen for the template to be consistent with the total length field.

WT
Description: Weight of fish
Collectors: ASU, Service, AGFD, B/W
Integration: Except for the AGFD (LCR) study, all the investigators use a four-digit field to record weight in grams. A four-digit field was chosen for the template so all weight data can be copied directly. The exception to this is B/W weights for non-

native fish, which are recorded in pounds and ounces and must be converted to grams by a translation filter. A translation to grams from pounds and ounces measured on a less accurate spring scale is not a very accurate or reliable translation, so those records should be flagged with a note in the COMMENTS field.

SEX

Description: Sex of fish
Collectors: ASU, Service, AGFD, B/W
Integration: Except for ASU, researchers normally use a one-character code to indicate the sex of a fish. ASU sex data must be passed through a translation filter to convert the one-digit number representing sex into a standard one-character sex code. See Appendix C for a list of standardized sex codes.

TAG_NUM

Description: Tag number of fish
Collectors: ASU, Service, AGFD, B/W
Integration: All the investigators use a ten-character code for tag number. The same format was chosen for the template, and all tag number data can be copied directly into it.

TAG_TYPE

Description: Type of tag on fish (i.e., PIT, Carlin, Floy)
Collectors: ASU, Service, AGFD, B/W
Integration: This field is not included in any of the existing databases, but was added to the template to help clarify tagging information. It is unclear at this time how ASU records information for tags and marks other than PIT tags, but assuming it is recorded in their TAG and RECAPTURE fields, the type of tag or mark may be extracted from those fields by a translation filter. For the Service the type of tag or mark can be extracted from the FIN and REMARKS fields by a translation filter as well. It is unclear how the AGFD mainstem database records other tag and mark information, but the AGFD LCR database records that information in the COMMENTS field from which it can be extracted by a translation filter. The B/W tag type and mark information can be extracted from the PIT_TAG field by a translation filter. See Appendix C for a list of standardized tag types.

TAG_COLOR

Description: Color of tag (for Carlin and Floy tags)
Collectors: ASU, Service, AGFD, B/W
Integration: This field is also not included in any of the existing databases, and added to the template to clarify tagging information. Tag color is associated with Carlin and Floy tags, so can probably be extracted from the fields previously identified that contain the tag type information (see TAG_TYPE). See Appendix C for a list of standardized tag colors.

GEAR

Description: Sampling gear type
Collectors: ASU, Service, AGFD (LCR Studies), B/W

Integration: See COMMON DATA STANDARDS AND TRANSLATIONS (page 3-6)

CHANNEL
Description: River channel type (i.e., main channel, side channel, tributary stream)
Collectors: AGFD (LCR Studies), B/W
Integration: See COMMON DATA STANDARDS AND TRANSLATIONS (page 3-5)

HYDRAULIC
Description: River hydraulic type (i.e., eddy, run, riffle, pool)
Collectors: AGFD, B/W
Integration: See COMMON DATA STANDARDS AND TRANSLATIONS (page 3-5)

SHORELINE
Description: River shoreline type (i.e., sand, vegetation, cobble)
Collectors: B/W
Integration: See COMMON DATA STANDARDS AND TRANSLATIONS (page 3-5)

SPAWN_COND
Description: Spawning condition of fish
Collectors: ASU, Service, AGFD, B/W
Integration: This field was modified for the template from the "maturity" information collected by many of the researchers. It was determined that the spawning condition information contained in the maturity fields was the most valuable, and that the age information was not well-enough defined to be included in the template. The spawning condition data can be extracted from each investigator's "maturity" information field (e.g. MATURITY, REMARKS, RIPE) by a translation filter. See Appendix C for a list of standardized spawning condition codes.

MARK_REC
Description: Indication of whether fish is a recapture (previously tagged)
Collectors: ASU, Service, AGFD, B/W
Integration: Except for ASU, all the researchers use a one-character field to indicate whether or not a fish is a recapture. The Service and B/W record the information as yes or no, while AGFD records it as marked or recaptured. A one-character field was chosen for the template with codes indicating whether a fish was marked, recaptured, or simply handled. A translation filter can convert the Service and B/W information to this format. The information for this field can be determined from the ASU database by a translation filter checking for the different combinations of information in the TAG and RECAPTURE fields, which indicate the tagging status of a fish.

OLD_TAG
Description: Tag number for a previously tagged fish (recapture)
Collectors: ASU, Service, AGFD, B/W
Integration: When a fish is recaptured, the old tagging information is handled differently by the different investigators. ASU and B/W have a separate field for the old tag number (RECAPTURE and OLD_TAG, respectively), the Service records the old tag number in REMARKS, and AGFD (LCR) has a yes/no field (OLDTAG) for

whether there is an old tag and records the tag number in COMMENTS. It is unclear how this information in handled in the AGFD mainstem database. For the template the old tag information was structured the same as for new tag information. In all cases except the AGFD mainstem database, translation filters can extract the old tag number from the field where it is recorded.

OLD_TYPE
Description: Tag type for a previously tagged fish (recapture)
Collectors: ASU, Service, AGFD, B/W
Integration: The old tag type can be extracted or surmised by a translation filter from the same fields identified above as containing the old tag information (see OLD_TAG above).

OLD_COLOR
Description: Tag color for a previously tagged fish (recapture)
Collectors: ASU, Service, AGFD, B/W
Integration: The old tag color can also be extracted by a translation filter from the fields identified above as containing the old tag information (see OLD_TAG above).

DISP
Description: Disposition of captured fish (e.g., released alive, preserved, stomach pumped)
Collectors: AGFD, B/W
Integration: All of the researchers recording disposition information use a two-character field. One conflicting code is used, however, so a translation filter will convert that code in the AGFD LCR database to a standardized code. See Appendix C for a list of standardized disposition codes.

PARASITE1
Description: First type of parasite encountered for a fish
Collectors: Service, AGFD (LCR Studies), B/W
Integration: Because of the increasing importance of parasite information in Grand Canyon, fields were chosen to make the information more useable. This field is used for recording the type of parasite, in the form of a two-character code. Parasite information is recorded by the Service and B/W in comment fields (REMARKS and COMMENTS, respectively), so a translation filter may be able to extract the type of parasite from those fields, if it has been entered in a consistent manner, otherwise it may need to be entered manually. The number of parasites is recorded by AGFD (LCR) in the PARASITES field, but it is unclear where the type of parasite is recorded, or whether it is always assumed to be the same type. If the number of parasites always refers to the same type of parasite, a translation filter can, based on that assumption, fill in this field with the assumed type. See Appendix C for a list of standardized parasite codes.

NUM_PAR1
Description: Number of first parasite encountered for a fish
Collectors: AGFD
Integration: This field is used for recording the number of parasites of the type indicated in the PARASITE1 field. This information may also be extracted from comment fields

for the Service and B/W if it has been consistently recorded in those fields, otherwise it may need to be entered manually. This information can be copied directly from the AGFD PARASITE field (see PARASITE1 above).

PARASITE2
Description: Second type of parasite encountered for a fish
Collectors: Service, AGFD (LCR Studies), B/W
Integration: This field was added to allow for the recording of information in the case of two types of parasites. See PARASITE1 above.

NUM_PAR2
Description: Number of second parasite encountered for a fish
Collectors: AGFD
Integration: This field is used for recording the number of the second type of parasite in the case of two types. See NUM_PAR2 above.

PHOTO
Description: Indication of whether a fish was photographed
Collectors: B/W
Integration: Although only B/W recorded whether or not a fish has been photographed, this field was included to accommodate that existing information and in anticipation of fish photographs in future research.

INVESTIGTR
Description: Identification of the investigative agency that collected the data
Collectors: None currently
Integration: As each investigator's data are passed through translation filters on their way to the integrated file structures, this field will be filled to identify the investigative agency collecting the data.

COMMENTS
Description: Comments
Collectors: Service, AGFD (LCR Studies), B/W
Integration: This field may be filled with comments that are stored in each researcher's database (copied directly), or used for comments added later.

3. Morphometric/Meristic Dataset

This discussion of the *Morphometric/Meristic* dataset includes the B/W and R.R. Miller databases only. According to Kubly (1990), Kaeding and Zimmerman's database also contains some *Morphometric/Meristic* measurements, but details of those datasets have not yet been made available.

Utility of the Morphometric/Meristic Dataset

Morphometric/Meristic data are typically used to distinguish between the different *Gila* species, or to determine sexual dimorphism within a species.

Structure of the Integrated Morphometric/Meristic File

The following is the recommended file structure for the *Morphometric/Meristic* information. Some of the fields in this structure are duplicates of fields contained in the structure for the *Fish Capture* data because the information is useful in both datasets.

Recommended Morphometric and Meristic Information

Field	Type	Field Length	Decimal Places	Description
DATE	D	8	0	Date
TAG_NUM	C	10	0	Tag number
TAG_TYPE	C	1	0	Tag type
TAG_COLOR	C	1	0	Tag color
SPECIES	C	3	0	Species code
SEX	C	1	0	Sex
BASIN	N	1	0	(1=NM,AZ,NV; 2=CO,WY,UT)
STATE	C	2	0	State abbreviation
LOCATION	C	50	0	Location Description
RIVER	C	2	0	River or Tributary code
RM	N	6	2	River mile
METERS	N	5	0	Meters upstream of tributary mouth
SIDE	C	1	0	Side of river or tributary facing
D_RAYS	N	2	0	Number of dorsal fin rays
A_RAYS	N	2	0	Number of anal fin rays
LL_SCALES	N	3	0	Lateral line scales
GILLRAKERS	N	2	0	Gill rakers (2nd arch)
TL	N	3	0	Total length
FL	N	3	0	Fork length
SL	N	6	1	Standard length
WT	N	4	0	Weight
HEAD_LEN	N	4	1	Head length
EYE_DIAM	N	4	1	Eye diameter
SNL	N	4	1	Snout length
PREANAL	N	5	1	Preanal length
HD_EYE	N	4	1	Head depth through eye
HD_OCCIP	N	4	1	Head depth at occiput
INTERORB	N	4	1	Interorbital, bony
OCCIP_SNOU	N	4	1	Occiput to snout tip
D_BASE	N	4	1	Dorsal fin base
A_BASE	N	4	1	Anal fin base
TRUNK_VERT	N	4	1	Trunk vertebrae

Field	Type	Field Length	Decimal Places	Description
CAUD_VERT	N	4	1	Caudal vertebrae
PREDORSAL	N	5	1	Predorsal length
PECT_LEN	N	4	1	Pectoral length
PELV_LEN	N	4	1	Pelvic length
UPJAW_LEN	N	4	1	Upper jaw length
MOUTH_WID	N	4	1	Mouth width
BD_P1	N	4	1	Body depth over P1 insertion
MAX_BD	N	5	1	Maximum body depth
CP_DEPTH	N	4	1	Caudal peduncle depth
CP_MAXDEP	N	4	1	Caudal peduncle max depth
CP_MINDEP	N	4	1	Caudal peduncle min depth
AO_CBASE	N	5	1	Anal origin to caudal base
AI_CBASE	N	5	1	Anal insertion to caudal base
PHAR_LEN	N	4	1	Length of pharyngeal arch
PHAR_WID	N	4	1	Width of pharyngeal arch
PHAR_T1	N	1	0	Pharyngeal teeth counts (#1)
PHAR_T2	N	1	0	Pharyngeal teeth counts (#2)
PHAR_T3	N	1	0	Pharyngeal teeth counts (#3)
PHAR_T4	N	1	0	Pharyngeal teeth counts (#4)
PHAR_POST	N	4	1	Length of posterior limb of pharyngeal
PHAR_ANT	N	4	1	Length of anterior limb of pharyngeal
P1_P2	N	4	1	Length between P1 and P2
NUCH_DEP	N	4	1	Nuchal depth
PHOTO	C	1	0	Photograph
INVESTIGTR	C	5	0	Investigative agency
COMMENTS	C	30	0	Comments

C=character
N=numeric
D=date

Incorporation of Existing Databases into the Integrated Morphometric/Meristic File

The following is a detailed discussion of the incorporation of the B/W and R.R. Miller *Morphometric/Meristic* data into the integration template.

DATE

Description: Date
Collectors: ASU, Service, AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-4)

TAG_NUM

Description: Tag number of fish
Collectors: B/W
Integration: The Miller database does not include tagging information. B/W uses a ten-character code for tag number. The same format was chosen for the template, so B/W tag number data can be copied directly into it.

TAG_TYPE

Description: Type of tag on fish (i.e., PIT, Carlin, Floy)
Collectors: B/W
Integration: This field is not included in any of the existing databases, but was added to the template to help clarify tagging information. The Miller database does not include tagging information. The B/W tag type and mark information can be extracted from the PIT_TAG field by a translation filter. See Appendix C for a list of standardized tag types.

TAG_COLOR

Description: Color of tag (for Carlin and Floy tags)
Collectors: B/W
Integration: This field is not included in any of the existing databases, and added to the template to clarify tagging information. Tag color is associated with Carlin and Floy tags, so can probably be extracted from the fields identified above that contain the tag type information (see TAG_TYPE above). See Appendix C for a list of standardized tag colors.

SPECIES

Description: Species of fish captured
Collectors: Miller, B/W
Integration: A three-character species code was chosen for this template to be consistent with the *Fish Capture* template. The Miller database uses a one-digit species number and the B/W database uses a two-character species code, so both databases must be passed through a translation filter to convert them to the standard species codes. See Appendix C for a list of standardized species codes.

SEX

Description: Sex of fish
Collectors: Miller, B/W
Integration: A one-character sex code was chosen for this template to be consistent with the *Fish Capture* template. The B/W data is already in this format, but the Miller database must be passed through a translation filter to convert the one-digit number representing sex into a standard one-character code. See Appendix C for a list of standardized sex codes.

BASIN

Description: Basin where fish was captured
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

STATE
Description: State name abbreviation
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

LOCATION
Description: Textual location description
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

RIVER
Description: Identification of river being sampled
Collectors: B/W
Integration: Only the B/W database contains this information directly (see COMMON DATA STANDARDS AND TRANSLATIONS (page 3-3), but the Miller database may have some of this information in its LOCATION field. Whatever information might be contained in the LOCATION field of the Miller database would likely have to be extracted from it manually, rather than with a translation filter, because it is contained within a written description rather than in specific fields.

RM
Description: River mile designation
Collectors: B/W
Integration: See RIVER above.

METERS
Description: In tributary streams, the distance in meters from the mouth
Collectors: B/W
Integration: See RIVER above.

SIDE
Description: The bank of the river nearest to the sample location
Collectors: B/W
Integration: See RIVER above.

D_RAYS
Description: Number of dorsal fin rays
Collectors: Miller, B/W
Integration: This information can be copied directly from both the Miller and B/W databases.

A_RAYS
Description: Number of anal fin rays
Collectors: Miller, B/W
Integration: This information can be copied directly from both the Miller and B/W databases.

LL_SCALES
Description: Lateral line scales
Collectors: Miller

Integration: Only the Miller database contains this information, so it may be copied directly.

GILLRAKERS
Description: Gill rakers
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

TL
Description: Total length of fish
Collectors: B/W
Integration: Only the B/W database contains this information, so it may be copied directly.

FL
Description: Fork length of fish
Collectors: B/W
Integration: Only the B/W database contains this information, so it may be copied directly.

SL
Description: Standard length of fish
Collectors: Miller, B/W
Integration: Both the Miller and B/W databases contain this information, but stored in slightly different formats. The Miller format was chosen for the template because it will accommodate the B/W data as well, so data from both databases can be copied directly.

WT
Description: Weight of fish
Collectors: B/W
Integration: Only the B/W database contains this information, so it may be copied directly.

HEAD_LEN
Description: Head length of fish
Collectors: Miller, B/W
Integration: This information can be copied directly from both the Miller and B/W databases.

EYE_DIAM
Description: Eye diameter of fish
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

SNL
Description: Snout length of fish
Collectors: Miller, B/W
Integration: This information can be copied directly from both the Miller and B/W databases.

PREANAL
Description: Preanal length of fish
Collectors: Miller

Integration: Only the Miller database contains this information, so it may be copied directly.

HD_EYE
Description: Head depth of fish through eye
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

HD_OCCIP
Description: Head depth of fish through occiput
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

INTERORB
Description: Interorbital, bony
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

OCCIP_SNOU
Description: Occiput to snout tip
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

D_BASE
Description: Length of dorsal fin base
Collectors: Miller, B/W
Integration: This information can be copied directly from both the Miller and B/W databases.

A_BASE
Description: Length of anal fin base
Collectors: Miller, B/W
Integration: This information can be copied directly from both the Miller and B/W databases.

TRUNK_VERT
Description: Trunk vertebrae
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

CAUD_VERT
Description: Caudal vertebrae
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

PREDORSAL
Description: Predorsal length
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

PECT_LEN
Description: Pectoral length
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

PELV_LEN
Description: Pelvic length
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

UPJAW_LEN
Description: Upper jaw length
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

MOUTH_WID
Description: Mouth width
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

BD_P1
Description: Body depth over pectoral insertion
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

MAX_BD
Description: Maximum body depth
Collectors: B/W
Integration: Only the B/W database contains this information, so it may be copied directly.

CP_DEPTH
Description: Caudal peduncle depth
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

CP_MAXDEP
Description: Maximum caudal peduncle depth
Collectors: B/W
Integration: Only the B/W database contains this information, so it may be copied directly.

CP_MINDEP
Description: Minimum caudal peduncle depth
Collectors: B/W
Integration: Only the B/W database contains this information, so it may be copied directly.

AO_CBASE
Description: Distance from anal fin origin to caudal peduncle base
Collectors: Miller

Integration: Only the Miller database contains this information, so it may be copied directly.

AI_CBASE
Description: Distance from anal fin insertion to caudal peduncle base
Collectors: B/W
Integration: Only the B/W database contains this information, so it may be copied directly.

PHAR_LEN
Description: Length of pharyngeal arch
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

PHAR_WID
Description: Width of pharyngeal arch
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

PHAR_T1
Description: Pharyngeal teeth counts (#1)
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

PHAR_T2
Description: Pharyngeal teeth counts (#2)
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

PHAR_T3
Description: Pharyngeal teeth counts (#3)
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

PHAR_T4
Description: Pharyngeal teeth counts (#4)
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

PHAR_POST
Description: Length of posterior limb of pharyngeal
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

PHAR_ANT
Description: Length of anterior limb of pharyngeal
Collectors: Miller
Integration: Only the Miller database contains this information, so it may be copied directly.

P1_P2
Description: Length between pectoral and pelvic fins
Collectors: Miller, B/W
Integration: This information can be copied directly from both the Miller and B/W databases.

NUCH_DEP
Description: Nuchal depth
Collectors: Miller, B/W
Integration: This information can be copied directly from both the Miller and B/W databases.

PHOTO
Description: Indication of whether fish was photographed
Collectors: B/W
Integration: Only the B/W database contains this information, so it may be copied directly.

INVESTIGTR
Description: Identification of the investigative agency that collected the data
Collectors: None currently
Integration: As each investigator's data are passed through translation filters on their way to the integrated file structures, this field will be filled to identify the investigative agency collecting the data.

COMMENTS
Description: Comments
Collectors: B/W
Integration: This field may be filled with comments that are stored in each researcher's database (copied directly), or used for comments added later.

4. Drift Dataset

This section discusses the potential integration of the AGFD and B/W *Drift* datasets.

Utility of the Drift Dataset

Drift data normally are collected to study food habits and food availability. Together with fish stomach contents, investigators can determine what the fish are eating relative to what is available and drifting in the system.

Structure of the Integrated Drift File

The following is a file structure for *Drift* information. This template was designed with a multiple-record format similar to the AGFD *Drift* files, with some additional fields added. This structure is presented not as the recommended structure for the integrated database, but as an illustration of the information that normally is used when analyzing *Drift* data. This multiple-record format is cumbersome to use for analysis. In this case, a single-record format would facilitate analysis, but a file including fields for all possibilities for drifting organisms would be unwieldy, if not impossible to create. Such a file would require fields for the number, volume, and weights of multiple life stages of as many as 100 taxa, and most of the fields would be empty. Rather than recommending a particular file structure for *Drift* data, it is recommended that the user interface to the integrated database be flexible enough to create data files based on individual users' needs, incorporating only

the information necessary for their analyses. See the B/W *Drift* file structure in Appendix A for an example of a single-record file used for analysis.

Recommended Drift Information

Field	Type	Field Length	Decimal Places	Description
DATE	D	8	0	Date of sample
RIVER	C	2	0	River or tributary code
RM	N	6	2	River mile
METERS	N	5	0	Meters upstream of tributary mouth
SIDE	C	1	0	Side of river or tributary facing downstream
CHANNEL	C	2	0	Channel type
HYDRAULIC	C	2	0	River hydraulic (habitat)
SHORELINE	C	2	0	Shoreline type
DEPTH	N	3	0	Depth of sample
DISTANCE	N	4	2	Distance from shore (m)
VEL_INIT	N	4	2	Initial velocity (m/s)
TIME_INIT	N	4	0	Starting time
VEL_END	N	4	2	Ending velocity (m/s)
TIME_END	N	4	0	Ending time
TIME_ELAPS	N	6	3	Elapsed time
NET_AREA	N	6	3	Area of net opening (m^2)
H2O_VOLUME	N	7	2	Water filtered through net (m^3)
ANAL_DATE	D	8	0	Date sample was analyzed
TAXA	C	3	0	Taxa code
LIFE_STAGE	C	1	0	Life stage code
NUMBER	N	4	0	Number of that taxa in sample
VOLUME	N	4	0	Volume of that taxa in sample (ml)
DRY_WT	N	8	4	Dry weight of taxa (g)
ASH_WT	N	8	4	Ash weight of taxa (g)
INVESTIGTR	C	5	0	Investigative agency
COMMENTS	C	30	0	Comments

C=character
N=numeric
D=date

Incorporation of Existing Databases into the Integrated Drift File

Although the file structure identified above is not necessarily that of an integrated file, the field formats and the information in the fields will be the same as those included in an integrated file, so those fields are used in the following discussion of incorporation.

DATE
Description: Date
Collectors: AGFD (LCR Studies), B/W
Integration: See COMMON DATA STANDARDS AND TRANSLATIONS (page 3-4)

RIVER
Description: Identification of river being sampled
Collectors: B/W
Integration: See COMMON DATA STANDARDS AND TRANSLATIONS (page 3-2)

RM
Description: River mile designation
Collectors: B/W
Integration: See COMMON DATA STANDARDS AND TRANSLATIONS (page 3-2)

METERS
Description: In tributary streams, the distance in meters from the mouth
Collectors: AGFD (LCR Studies), B/W
Integration: See COMMON DATA STANDARDS AND TRANSLATIONS (page 3-3)

SIDE
Description: The bank of the river nearest to the sample location
Collectors: AGFD (LCR Studies), B/W
Integration: See COMMON DATA STANDARDS AND TRANSLATIONS (page 3-3)

CHANNEL
Description: River channel type (i.e., main channel, side channel, tributary stream)
Collectors: AGFD (LCR Studies), B/W
Integration: See COMMON DATA STANDARDS AND TRANSLATIONS (page 3-5)

HYDRAULIC
Description: River hydraulic type (i.e., eddy, run, riffle, pool)
Collectors: AGFD (LCR Studies), B/W
Integration: See COMMON DATA STANDARDS AND TRANSLATIONS (page 3-5)

SHORELINE
Description: River shoreline type (i.e., sand, vegetation, cobble)
Collectors: B/W
Integration: See COMMON DATA STANDARDS AND TRANSLATIONS (page 3-5)

DEPTH
Description: Depth of water column, from bottom of river to center of mouth of net
Collectors: AGFD (LCR Studies), B/W

Integration: It is not known at this time how AGFD measures depth. B/W measures depth as the height of the net above the water surface, but this cannot be translated in any way to the depth measurement chosen for this field.

DISTANCE
Description: Distance of net from shore in meters
Collectors: AGFD (LCR Studies)
Integration: Only the AGFD database contains this information, so it may be copied directly.

VEL_INIT
Description: Velocity of water at start of sample
Collectors: AGFD (LCR Studies), B/W
Integration: The format for this field was chosen to accommodate the AGFD data format, so the data may be copied directly from their database. A translation filter can be used to calculate this as an average of the three initial velocities in the B/W database.

TIME_INIT
Description: Time at start of sample
Collectors: AGFD (LCR Studies), B/W
Integration: The B/W database contains this information in the same format as the template, so it may be copied directly. The AGFD database format for time uses two fields, so a translation filter is necessary to combine them together into the template format.

VEL_END
Description: Water velocity at end of sample
Collectors: AGFD (LCR Studies), B/W
Integration: The AGFD data may be copied directly from their database. A translation filter can be used to calculate this as an average of the three ending velocities in the B/W database.

TIME_END
Description: Time at end of sample
Collectors: AGFD (LCR Studies), B/W
Integration: The B/W database contains this information in the same format as the template, so it may be copied directly. The AGFD database format for time uses two fields, so a translation filter is necessary to combine them together into the template format.

TIME_ELAPS
Description: Elapsed time of sample
Collectors: AGFD (LCR Studies), B/W
Integration: The elapsed time can be calculated from the initial and ending times of the sample using a database program.

NET_AREA

Description: Area of net opening
Collectors: None currently
Integration: Neither the AGFD nor the B/W database contain this information, but the investigators must use it for the calculation of water volume filtered, so it could be entered manually This field was added primarily to accommodate future studies.

H2O_VOLUME

Description: Volume of water filtered
Collectors: AGFD (LCR Studies), B/W
Integration: This information may be copied directly from the AGFD database. The B/W database contains the elapsed time and water flow, so a translation filter can calculate the volume of water filtered through the drift net. In future studies the information for this field may be calculated from the velocity, time, and net area information.

ANAL_DATE

Description: Date sample was analyzed
Collectors: AGFD (LCR Studies)
Integration: This information may be copied directly from the AGFD database, and is not a part of the B/W database.

TAXA

Description: Taxonomic classification of organism
Collectors: AGFD (LCR Studies), B/W
Integration: In a multiple-record format, this information may be copied directly from the AGFD database. The B/W database is structured with a single-record format and must be passed through a translation filter to extract taxa information. If a single-record format is used, the B/W data can be copied directly, while the AGFD database would require translation. See Appendix C for a list of standardized taxa codes.

LIFE_STAGE

Description: Life stage of organism
Collectors: AGFD (LCR Studies), B/W
Integration: In a multiple-record format, this information may be copied directly from the AGFD database. The B/W database is structured with a single-record format and must be passed through a translation filter to extract life stage information. If a single-record format is used, the B/W data can be copied directly, while the AGFD database would require translation. See Appendix C for a list of standardized life stage codes.

NUMBER

Description: Number of organism in sample
Collectors: AGFD (LCR Studies), B/W
Integration: This information may be copied directly from both the AGFD and B/W databases.

VOLUME
Description: Volume of organism in sample
Collectors: AGFD (LCR Studies), B/W
Integration: This information may be copied directly from both the AGFD and B/W databases.

DRY_WT
Description: Dry weight of organism in sample
Collectors: AGFD (LCR Studies)
Integration: This information may be copied from the AGFD database after subtracting the crucible weight, which is also recorded in their database. The B/W database does not record this information.

ASH_WT
Description: Ash weight of organism in sample
Collectors: AGFD (LCR Studies)
Integration: This information may be copied from the AGFD database after subtracting the crucible weight, which is also recorded in their database. The B/W database does not record this information.

INVESTIGTR
Description: Identification of the investigative agency that collected the data
Collectors: None currently
Integration: As each investigator's data are passed through translation filters on their way to the integrated file structures, this field will be filled to identify the investigative agency collecting the data.

COMMENTS
Description: Comments
Collectors: None currently
Integration: This field may be filled with comments that are stored in each researcher's database (copied directly), or used for comments added later.

5. Food Habits Dataset

This section discusses the potential integration of the AGFD and B/W *Food Habits* datasets.

Utility of the Food Habits Dataset

Food Habits data are normally collected to study what the fish are eating. Together with *Drift* data, investigators can determine what the fish are eating relative to what is available and drifting in the system.

Structure of the Integrated Food Habits File

The following is a file structure for *Food Habits* information. As with *Drift* information, this template was designed with a multiple-record format similar to the AGFD *Food Habits* file with some additional fields identified as useful. The file design issues for *Food Habits* information are the same as those for *Drift*. A single-record format is desirable for analysis, but one that can accommodate all the measurements (number, volume, weights) for all life stages of all organisms is impractical, if not impossible. Therefore it is recommended that the user interface to the integrated database be flexible enough to create files containing fields specified by the user, rather than creating a standard set of

fields. See the B/W *Food Habits* file structure in Appendix A for an example of a single-record file used for analysis.

Recommended Food Habits Information

Field	Type	Field Length	Decimal Places	Description
DATE	D	8	0	Date of sample
RIVER	C	2	0	River or tributary code
RM	N	6	2	River mile
METERS	N	5	0	Meters upstream of tributary mouth
SPECIES	C	3	0	Fish species
TL	N	4	0	Total length of fish (mm)
WT	N	5	0	Weight of fish (g)
TAG_NUM	C	10	0	Tag number
TAG_TYPE	C	1	0	Tag type
TAG_COLOR	C	1	0	Tag color
SEX	C	1	0	Sex of fish
PARASITE1	C	2	0	First parasite code
NUM_PAR1	N	3	0	Number of parasite 1
PARASITE2	C	2	0	Second parasite code
NUM_PAR2	N	3	0	Number of parasite 2
TAXA	C	3	0	Taxa code
LIFE_STAGE	C	1	0	Life stage code
NUMBER	N	4	0	Number of that taxa in sample
VOLUME	N	6	2	Volume of that taxa in sample (ml)
DRY_WT	N	8	4	Dry weight of sample (g)
ASH_WT	N	8	4	Ash weight of sample (g)
INVESTIGTR	C	5	0	Investigative agency
COMMENTS	C	30	0	Comments

C=character
N=numeric
D=date

Incorporation of Existing Databases into the Integrated Food Habits File

Although the file structure identified above is not necessarily that of an integrated file, the field formats and the information in the fields will be the same as those included in an integrated file, so those fields are used in the following discussion of incorporation.

DATE
Description: Date
Collectors: AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-4)

RIVER
Description: Identification of river being sampled
Collectors: B/W
Integration: See Common Data Standards and Translations (page 3-2)

RM
Description: River mile designation
Collectors: B/W
Integration: See Common Data Standards and Translations (page 3-2)

METERS
Description: In tributary streams, the distance in meters from the mouth
Collectors: AGFD (LCR Studies), B/W
Integration: See Common Data Standards and Translations (page 3-3)

SPECIES
Description: Species of fish whose stomach contents are being examined
Collectors: AGFD, B/W
Integration: Most of the investigators use three-character codes to identify species, so a three-character species field was chosen for the template. All B/W species data will have to be translated into three-character codes. A standard set of three-character species codes was determined which requires a few code translations for the AGFD species data as well. See Appendix C for a list of standardized species codes.

TL
Description: Total length of fish whose stomach contents are being examined
Collectors: AGFD, B/W
Integration: Investigators use either three- or four-digit numeric fields to record total length in millimeters. A four-digit field was chosen for the template so all length data can be copied directly.

WT
Description: Weight of fish whose stomach contents are being examined
Collectors: AGFD (LCR Studies), B/W
Integration: Except for the AGFD LCR study, all the investigators use a four-digit field to record weight in grams. A four-digit field was chosen for the template so all weight data can be copied directly. The exception to this is B/W weights for non-native fish, which are recorded in pounds and ounces, which must be converted to grams by a translation filter. A translation to grams from pounds and ounces measured on a less accurate spring scale is not a very accurate or reliable translation, so those records should be flagged with a note in the comments field.

TAG_NUM

Description: Tag number of fish whose stomach contents are being examined
Collectors: B/W
Integration: All the investigators use a ten-character code for tag number. The same format was chosen for the template, and all tag number data can be copied directly into it.

TAG_TYPE

Description: Type of tag on fish whose stomach contents are being examined
Collectors: B/W
Integration: This field is not included in any of the existing databases, but was added to the template to help clarify tagging information. It is unclear how the AGFD mainstem database records other tag and mark information, but the AGFD LCR database records that information in the COMMENTS field from which it can be extracted by a translation filter. The B/W tag type and mark information can be extracted from the PIT_TAG field by a translation filter. See Appendix C for a list of standardized tag types.

TAG_COLOR

Description: Color of tag (Carlin and Floy tags) on fish whose stomach contents are being examined
Collectors: B/W
Integration: This field is also not included in any of the existing databases, and added to the template to clarify tagging information. Tag color is associated with Carlin and Floy tags, so can probably be extracted from the fields identified above that contain the tag type information (see TAG_TYPE above). See Appendix C for a list of standardized tag colors.

SEX

Description: Sex of fish whose stomach contents are being examined
Collectors: AGFD (LCR Studies), B/W
Integration: Except for ASU, whose database does not include *Food Habits* information, researchers normally use a one-character code to indicate the sex of a fish. A one-character field was chosen for the template, so both AGFD and B/W data may be copied directly. See Appendix C for a list of standardized sex codes.

PARASITE1

Description: First type of parasite encountered for the fish whose stomach contents are being examined
Collectors: AGFD, B/W
Integration: Because of the increasing importance of parasite information in Grand Canyon, fields were chosen to make the information more useable. This field is used for recording the type of parasite, in the form of a two-character code. Parasite information is recorded by B/W in a comment field (COMMENTS), so a translation filter may be able to extract the type of parasite from that field if it has been entered in a consistent manner, otherwise it may need to be entered manually. The number of parasites is recorded by AGFD (LCR) in the PARASITES field, but it is unclear where the type of parasite is recorded, or whether it is always

assumed to be the same type. If the number of parasites always refers to the same type of parasite, a translation filter can, based on that assumption, fill in this field with the assumed type. See Appendix C for a list of standardized parasite codes.

NUM_PAR1
Description: Number of first parasite encountered
Collectors: AGFD
Integration: This field is used for recording the number of parasites of the type indicated in the PARASITE1 field. This information may also be extracted from the comment field for B/W if it has been consistently recorded in those fields, otherwise it may need to be entered manually. This information can be copied directly from the AGFD PARASITE field (see PARASITE1 above).

PARASITE2
Description: Second type of parasite encountered
Collectors: AGFD, B/W
Integration: This field was added to allow for the recording of information in the case of two types of parasites. See PARASITE1 above.

NUM_PAR2
Description: Number of second type of parasite encountered
Collectors: AGFD
Integration: This field is used for recording the number of the second type of parasite in the case of two types. See NUM_PAR1 above.

TAXA
Description: Taxonomic classification of organism in stomach
Collectors: AGFD, B/W
Integration: In a multiple-record format, this information may be copied directly from the AGFD database. The B/W database is structured with a single-record format and must be passed through a translation filter to extract taxa information. If a single-record format is used, the B/W data can be copied directly, while the AGFD database would require translation. See Appendix C for a list of standardized taxa codes.

LIFE_STAGE
Description: Life stage of organism in stomach
Collectors: AGFD, B/W
Integration: In a multiple-record format, this information may be copied directly from the AGFD database. The B/W database is structured with a single-record format and must be passed through a translation filter to extract life stage information. If a single-record format is used, the B/W data can be copied directly, while the AGFD database would require translation. See Appendix C for a list of standardized life stage codes.

NUMBER
Description: Number of organism in stomach
Collectors: AGFD, B/W

Integration: This information may be copied directly from both the AGFD and B/W databases.

VOLUME
Description: Volume of organism in stomach
Collectors: AGFD (LCR Studies), B/W
Integration: This information may be copied directly from both the AGFD and B/W databases.

DRY_WT
Description: Dry weight of organism in stomach
Collectors: AGFD
Integration: This information may be copied from the AGFD database after subtracting the crucible weight, which is also recorded in the AGFD database.

ASH_WT
Description: Ash weight of organism in stomach
Collectors: AGFD
Integration: This information may be copied from the AGFD database after subtracting the crucible weight, which is also recorded in their database.

INVESTIGTR
Description: Identification of the investigative agency that collected the data
Collectors: None currently
Integration: As each investigator's data are passed through translation filters on their way to the integrated file structures, this field will be filled to identify the investigative agency collecting the data.

COMMENTS
Description: Comments
Collectors: AGFD (Mainstem Studies), B/W
Integration: This field may be filled with comments that are stored in each researcher's database (copied directly), or used for comments added later.

6. Fish Sampling Dataset

Fish Sampling information is extremely important in fisheries investigations as the data indicate where fish are located and in what quantities. Although methods used to collect and record *Fish Sampling* information vary considerably among the different Grand Canyon investigators, an attempt was made to create an integrated file for this dataset because of the widespread use and importance of this information.

Utility of the Fish Sampling Dataset

Fish Sampling data normally are used for catch-per-effort (CPE) analyses, which indicate the number of fish of a particular species captured in a given effort. Catch-per-effort is calculated differently for different sampling methods (e.g., fish/hour for electrofishing, fish/area for seining, fish/net-hour for netting), and is often calculated by age group (young-of-year, juvenile, adult) as well as for the total number of fish caught in a sample. Catch-per-effort analyses typically look at how catch rates vary according to different factors (e.g., time-of-day, location, habitat type, turbidity, water temperature) so that the requirements of the fish can be determined. Catch-per-effort values are not compared

directly between different sampling methods, so it is recommended that these data be separated into files by sampling type to reduce the size of any given file.

Structure of the Integrated Fish Sampling File

The following is a file structure for *Fish Sampling* information. This structure is a multiple-record format similar to the B/W sampling files, but with fewer fields. As with *Drift* and *Food Habits*, this structure is not presented as the recommended structure for integration, but as an illustration of the field formats and types of information typically used for analyzing *Fish Sampling* data. A single-record format (see Box 1) is desirable for analysis, but would be unwieldy if it contained fields for numbers and CPEs of all age groups of all possible species of fish. It is recommended that the user interface to the integrated database be flexible enough to create file structures containing fields specified by the user.

Recommended Fish Sampling Information

Field	Type	Field Length	Decimal Places	Description
DATE	D	8	0	Date of sample
TIME	N	4	0	Time of sample
RIVER	C	2	0	River or tributary code
RM	N	6	2	River mile
METERS	N	5	0	Meters upstream of tributary mouth
SIDE	C	1	0	Side of river or tributary facing downstream
CHANNEL	C	2	0	Channel type
HYDRAULIC	C	2	0	River hydraulic (habitat)
SHORELINE	C	2	0	Shoreline type
SUBSTRATE	C	2	0	Substrate code
H2O_TEMP	N	5	2	Water temperature
LIGHT	C	2	0	Ambient light code
WEATHER	C	2	0	Weather code
GEAR	C	2	0	Sampling gear code
EFFORT	N	7	2	Sampling effort (hours for nets, traps, electrofishing; area for seining)
SPECIES	C	3	0	Species code
YOY	N	3	0	Number of young-of-year caught
JUV	N	3	0	Number of juveniles caught
ADU	N	3	0	Number of adults caught
TOTAL	N	3	0	Total number of fish caught
CPE_YOY	N	6	2	Catch per effort for young-of-year
CPE_JUV	N	6	2	Catch per effort for juveniles
CPE_ADU	N	6	2	Catch per effort for adults

Field	Type	Field Length	Decimal Places	Description
CPE_TOTAL	N	6	2	Catch per effort for all fish
INVESTIGTR	C	5	0	Investigative agency
COMMENTS	C	30	0	Comments

C=character
N=numeric
D=date

Incorporation of Existing Databases into the Integrated Fish Sampling File

Although the file structure identified above is not necessarily that of an integrated file, the field formats and the information in the fields will be the same as that included in an integrated file, so those fields are used in the following discussion of incorporation.

DATE
Description: Date
Collectors: Service, AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-4)

TIME
Description: Time
Collectors: Service, AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-4)

RIVER
Description: Identification of river being sampled
Collectors: AGFD (LCR Studies), B/W
Integration: See Common Data Standards and Translations (page 3-2)

RM
Description: River mile designation
Collectors: B/W
Integration: See Common Data Standards and Translations (page 3-2)

METERS
Description: In tributary streams, the distance in meters from the mouth
Collectors: AGFD (LCR Studies), B/W
Integration: See Common Data Standards and Translations (page 3-3)

SIDE
Description: The bank of the river nearest to the sample location
Collectors: Service, AGFD (LCR Studies), B/W
Integration: See Common Data Standards and Translations (page 3-3)

CHANNEL
Description: River channel type (i.e., main channel, side channel, tributary stream)
Collectors: AGFD (LCR Studies), B/W

Integration: See Common Data Standards and Translations (page 3-5)

HYDRAULIC
Description: River hydraulic type (i.e., eddy, run, riffle, pool)
Collectors: AGFD (LCR Studies), B/W
Integration: See Common Data Standards and Translations (page 3-5)

SHORELINE
Description: River shoreline type (i.e., sand, vegetation, cobble)
Collectors: B/W
Integration: See Common Data Standards and Translations (page 3-5)

SUBSTRATE
Description: Substrate type at sample location
Collectors: Service, AGFD, B/W
Integration: Except for the Service, researchers use two-character codes to represent substrate types, so a two-character field was chosen for the template. Each investigator uses a different system for classifying substrate types, though they all appear to be based on the Modified Wentworth classification for substrate particle sizes (Cummins 1962 in Nielsen and Johnson 1983), some having more resolute classifications than others. Broad classifications can not be made more resolute, but fine divisions can be combined into broader categories (e.g., "gravel" and "pebble" are combined into a single "gravel" category). The Service's substrate information has the finest categorical resolution, and the categories are represented by numerical codes, so the data require a translation filter that both translates the numeric codes to character and combines categories together. The other databases also require translation filters to standardize a few codes. See Appendix C for a list of standardized substrate codes.

H2O_TEMP
Description: Water temperature at sample location
Collectors: AGFD (Mainstem Studies), B/W
Integration: The format for this field was chosen to accommodate the formats used in the different databases. The B/W and AGFD mainstem temperature data can be copied directly. The Service and AGFD Little Colorado River studies do not collect water temperature in conjunction with sampling but have it in other files (water quality and larval fish habitat, respectively). If the Service water quality data were collected simultaneously with sampling it may be possible to pull the temperature information from the water quality file based on date and time. It does not appear as though the water temperatures collected in the AGFD larval fish habitat file are appropriate to pull into a sampling catch file.

LIGHT
Description: Ambient light at time of sample start
Collectors: AGFD (Mainstem Studies), B/W
Integration: Only the AGFD mainstem and B/W databases contain ambient light information. The databases use nearly identical two-character codes to represent light, differing only in the representation of dawn and dusk lighting. B/W uses the same code

(DD) for both dawn and dusk periods, while AGFD uses two codes (DN, DK). The B/W dawn/dusk data can be translated into two separate codes by passing through a filter that uses the time to determine whether the 'DD' code represents dawn or dusk.

WEATHER

Description: Weather at time of sample start
Collectors: B/W
Integration: Only the B/W database contains weather information, so it may be copied directly.

GEAR

Description: Sampling gear type used
Collectors: Service, AGFD, B/W
Integration: See Common Data Standards and Translations (page 3-6)

EFFORT

Description: Sample effort expended
Collectors: Service, AGFD (Mainstem Studies), B/W
Integration: The format for this field was chosen to accommodate the different investigators' data as well as different units of effort (e.g., m^2 for seining, hours for netting and electrofishing). AGFD mainstem and B/W sampling effort can be copied directly from their sampling files. The Service's sampling effort must be calculated by a translation filter from the sample set date/time and the sample pull date/time. AGFD Little Colorado River sampling effort could be calculated from seining length and width and from sample set date/time and run date/time in their fish collections file, but they do not appear to record effort information for samples in which no fish were caught.

SPECIES

Description: Species of fish captured in sample
Collectors: Service, AGFD, B/W
Integration: Three-character species codes were chosen for this template as discussed in the *Fish Capture Dataset* section. B/W species information can be pulled from their sampling files and translated from two-character to three-character codes. The Service and AGFD mainstem sampling files do not contain species information, but they can link to their respective *Fish Capture* files and the species information extracted from there. AGFD Little Colorado River species information also can be extracted from their fish collections file since they don't have sampling files.

YOY

Description: Number of young-of-year fish of species captured in sample
Collectors: B/W
Integration: This field contains the number of young-of-year of the corresponding species. The B/W sampling files contain this information, so it may be copied directly. For the other investigators the number of YOY of a species can be determined from the length data recorded in their *Fish Capture* files, or this field can be left blank.

JUV
Description: Number of juvenile fish of species captured in sample
Collectors: B/W
Integration: This field contains the number of juveniles of the corresponding species. The B/W sampling files contain this information, so it may be copied directly. For the other investigators the number of juveniles of a species can be determined from the length data recorded in their *Fish Capture* files, or this field can be left blank.

ADU
Description: Number of adult fish of species captured in sample
Collectors: B/W
Integration: This field contains the number of adults of the corresponding species. The B/W sampling files contain this information, so it may be copied directly. For the other investigators the number of adults of a species can be determined from the length data recorded in their *Fish Capture* files, or this field can be left blank.

TOTAL
Description: Total number of fish of species captured in sample
Collectors: Service, AGFD, B/W
Integration: This field contains the total number of fish of the corresponding species. The B/W sampling files contain this information, so it may be copied directly. The Service and AGFD databases contain counts of fish captured and measurements of individual fish in their *Fish Capture* files, so a translation filter can sum the total number of fish of a given species in a given sample.

CPE_YOY
Description: Catch-per-effort for young-of-year fish captured in sample
Collectors: Service, AGFD, B/W
Integration: This field can be calculated by dividing the number of young-of-year (YOY) fish captured in the sample by the effort for the sample.

CPE_JUV
Description: Catch-per-effort for juvenile fish captured in sample
Collectors: Service, AGFD, B/W
Integration: This field can be calculated by dividing the number of juvenile (JUV) fish captured in the sample by the effort for the sample.

CPE_ADU
Description: Catch-per-effort for adult fish captured in sample
Collectors: Service, AGFD, B/W
Integration: This field can be calculated by dividing the number of adult (ADU) fish captured in the sample by the effort for the sample.

CPE_TOTAL
Description: Catch-per-effort for total number of fish captured in sample
Collectors: Service, AGFD, B/W
Integration: This field is calculated by dividing the total number of fish captured in the sample by the effort for the sample.

INVESTIGTR

Description: Identification of the investigative agency that collected the data
Collectors: None currently
Integration: As each investigator's data are passed through translation filters on their way to the integrated file structures, this field will be filled to identify the investigative agency collecting the data.

COMMENTS

Description: Comments
Collectors: Service, B/W
Integration: This field may be filled with comments that are stored in each researcher's database (copied directly), or used for comments added later.

RELATIONAL LINKS

The function and importance of relational links were discussed in Chapter 2. Linking some of the integrated files may be useful for some analyses. For example, *Drift* and *Food Habits* data are often examined together to determine what fish are eating relative to what is available and drifting in the same area at approximately the same time. Integrated database users may want to link other sets of files together as well, such as *Water Quality* with *Fish Sampling*, or *Fish Capture* with *Fish Sampling*. Table 3-1 provides a list of integrated files that can be linked, and the fields used for linking them. Possibilities exist for linking other sets of data files, as long as those files have the appropriate fields in common.

Table 3-1. Relational links for integrated data files.

File 1	File 2	Linking Fields
DRIFT	FOOD	DATE
WQ	CATCH	DATE
FISH	CATCH	DATE, TIME, RM, INVESTIGTR
FISH	FOOD	DATE, TAG_NUM, TAG_TYPE, TAG_COLOR

CHAPTER 4: PHASE 3 - APPLICATION OF GIS TO FISHERIES DATABASES FROM GRAND CANYON

As discussed in Chapter 1, there are two actions that must be taken to access information collected within and between the different Draft Integrated Research Plan (DIRP) components: (1) consolidating or integrating each researchers database(s) into one accessible database format, template or structure; and (2) identifying the methods and programs necessary to access the information. Chapters 2 and 3 described potential methods for integrating Grand Canyon fisheries tabular databases. This chapter discusses the second step; identifying the methods and programs necessary to access the information. This includes specific methods of how the BIO/WEST (B/W) fisheries database can be accessed using a GIS. Within this chapter we also provide a conceptual overview of using GIS as the interface tool for not only the GCFIN database, but also the entire GCES database.

INTRODUCTION

For years fisheries researchers have been collecting information from large and small aquatic ecosystems without explicit concern for integrating their data into large databases. Fisheries and other aquatic information collected by researchers working within the same ecosystem can be collectively analyzed. This collective analysis can provide more information to better understand the variables that may affect relationships between or among ecosystem components or organisms.

The problem in sharing data is that fisheries researchers working in the same ecosystem design experiments to address their specific set of questions. Consequently, the data collection and data storage methods used and geographic referencing of sampling sites can vary from researcher to researcher. In Grand Canyon for example, five groups have been performing major native fish studies for the past 5 years. The research groups are studying fish diet, distribution, behavior, reproduction, habitat preferences and habitat requirements. Fisheries researchers are studying in overlapping regions of the canyon and probably on the same populations of fish. Presently, none of the fisheries research data have been integrated for collective analysis or data sharing.

An additional problem that exists is the lack of data sharing or integration among and between the other DIRP components under study. Numerous agencies have been collecting data on resources such as vegetation, wildlife, recreation, geomorphology and beaches (all DIRP components). To date, few if any of these researchers have attempted to integrate their data with the fisheries research and vice versa. However, there is one common element to all of the research conducted to data; geography. All of the studies have occurred within approximately the same place.

To overcome the lack of data sharing and consequent lack of combined data analysis, an approach that capitalizes on the common element of geography is proposed. A GIS provides the tools for access to GCFIN information via geography and can be used to access data collected for not only the fisheries database (GCFIN), but also the other DIRP components. To develop the full suite of GIS tools to access and analyze each resources database individually and/or collectively is a much larger task than was intended for this GCFIN project. Therefore, the purposes of this chapter are limited to the following:

- ✓ Present a method for integrating aquatic, primarily fisheries related, resource data using a geographic information system (GIS).
- ✓ Document the GIS database developed for B/W Grand Canyon fisheries research data.

The body of this chapter consists of essential concepts for organizing fisheries ecosystem data into a GIS format and an example of those concepts using actual data. First we present an overview of GIS and how it can be used as the database integration tool for entire ecosystems and second an application of how GIS is used to organize B/W's Grand Canyon native fish database. Included in the discussion on GIS with B/W's data is identification of data gaps that would need to be filled prior to integrating other agencies Colorado River in Grand Canyon ecosystem fish databases into a GIS. Documentation of B/W's GIS data file structures are found in the Appendix E.

GIS FOR INTEGRATING ECOSYSTEM DATABASES

Today, ecosystem resource information may be readily stored in computer database management systems where it can be easily accessed and updated using desktop personal computers. Because information is routinely updated and available on-line, the most current information is always available. Information having a geographic component is particularly suitable for storage in computer databases, since maps can be the medium of organizing information. A geographic information system (GIS) is a database management system designed specifically for storing, retrieving, and analyzing geographically-referenced data.

A GIS functions by storing maps and tabular information linked by a common identifier, usually a number. For example, if a GIS database of stream gages were created, the location of each gage would be located on an electronic (digitized) version of a topographic map and labeled with a unique identifier. Information collected at a gage, such as flow, could also be stored in the stream gage table. Using traditional databases, the tabular data, (e.g., flow), could be analyzed at the gage. However, if the information at the gage was part of a GIS-based watershed land use study, the gage data could be queried and analyzed relative to other watershed information.

Modern GIS technology is no longer exclusively available in the form of expensive, difficult-to-operate UNIX workstations; it is also available on personal desktop computers running Microsoft Windows®. Where GIS once was the tool of specialists, it is now the tool for everyone who uses data containing a geographic element. Geographic elements can range from traditional map referencing schemes such as latitude-longitude, to Universal Transverse Mercator (UTM) coordinates produced using GPS receivers or even abstract references such as river mile. The modern GIS is integrated with other Windows® based software such as spreadsheets, wordprocessors, databases and statistical analysis software allowing data sharing between packages to perform a variety of functions. Because of the same look and feel of other Windows®-based software programs, the learning curve for using GIS has been significantly reduced.

The modern GIS for ecosystem managers consists of three primary components:

- ✓ Software tools
- ✓ Geographic data types
- ✓ Tabular databases

These three components will each be discussed as they would apply to a research scientist or manager of an aquatic ecosystem. Table 4-1 shows examples of all three components.

Table 4-1. Ecosystem GIS components.

Software Tools	Geographic Data Types	Examples	Tabular Databases
GIS Graphical User Interface (e.g., ArcView)	Observation Specific	Radio Telemetry	Date, Time
		Surface Habitat Maps	Habitat Type
		Current Maps	Current Type
	Repeat Sampling Sites	Net Sets	Multiple files of Sampling Effort Results
		Minnow Traps	
		Backwaters	
	Abstract Reference	Electrofishing	Multiple files of Sampling Effort Results
		Seining	
		Water Quality	

COMPONENTS OF A GIS FOR AN AQUATIC ECOSYSTEM

Software Tools

Managers and researchers alike want to view, query, and analyze data in more sophisticated forms than tables of data. Software tools were developed to help accomplish the goals of data visualization, query, and analysis by using geography, that is location, to organize information. Software tools are computer programs assembled to create a user interface. In the past, a specialized set of programs had to be written for even the most simple user interface. In 1994, a product called ArcView® (Version 2.0) was released that contained an extensive set of tools for a Windows® based user interface. If needed, ArcView® can be completely customized for special applications. The tools and functionality of ArcView® have made GIS a reality for managers.

Visualization of data is accomplished by including a map or photograph as a backdrop and then overlaying the data set of interest. Scanned aerial photographs and topographic maps are common backdrops. Any geographic data set of the particular area (e.g., soils, geology, geomorphology, or fish observations) can also be added and graphically manipulated. Geographically referenced tabular data can also be linked to either repeat sampling sites, or abstract referenced data using a pre-determined link or identifier in both the tabular and geographic data. Legends and classification schemes can be applied to best represent the features of interest.

Querying both geographic and tabular data can be performed by either using logical statements or by selecting features on the computer screen. A logical statement, for example, could be: show all sampling sites after 1991 with fish length longer than 200 mm. This statement would initiate selection of all the records in the tabular database meeting the date and length requirements and would display them on the computer screen. The selected set of records could be further reduced by selecting features that fall within a geographical polygon designated on the screen.

Analysis of the data can be performed using simple statistics in the GIS or written out to a file to be imported directly into a more sophisticated statistics software package such as NCSS®, SPSS®, SAS®, or SYSTAT®. Graphs and maps can be dynamically linked to the query and analysis functions so that every time a query is made, the charts or analyses are updated to reflect the information selected using the query functions.

Geographic Data Types

Geographic data can be thought of as electronically stored maps. Like any map, the geographic data are used to identify location. The tabular data describe what is at a location, the geographic data describe where the actual location is. In a GIS context, there are three types of geographic data:

- ✓ Observation specific
- ✓ Repeat sampling sites
- ✓ Abstract reference

Observation Specific

Observation specific data occur, or have occurred, at a site. For example, a survey monument is observation specific because it is known to occur at some location. A habitat map is also described as observation specific data because it represents environmental conditions at a moment in time. In fisheries studies, locations of fish (e.g. being tracked with radio telemetry equipment) is a typical example of observation specific data because each fish observation occurs at a site at a specific time. A fish may be observed at a specific site, at a specific time, and on a specific day to create one observation. If a fish revisits the same site at the same time, on a different day, it is recorded as a separate observation on the map because of the different date.

Repeat Sampling Sites

Repeat sampling sites are mapped sampling locations that have multiple sets of information associated with that location. For example, a specific location may be fished with a particular gear type, such as nets, on many occasions. Each time the net is set, different results are recorded in the tabular data, but the location of the net remains the same. Another example would be backwaters that are sampled multiple times, but each sampling effort yields a new set of tabular data.

Abstract Reference

Abstract reference is more of a method than an actual set of data. Abstract location referencing is a method of recording locations where data were collected, storing the location information with the other tabular data, and requiring users to infer a location. For example, river mileage is recorded in a tabular database with sampling results, but the actual location is inferred from the river mileage; it is not physically presented on a map. If a location on the Colorado River in Grand Canyon was reported as river mile 60.2, researchers familiar with the river would know approximately where that location was. However, someone unfamiliar with the specific river mileage scheme would not be able to find that location on a map. In smaller streams this abstract location system of referencing is also used. For example, sampling in tributaries that enter the Colorado River in Grand Canyon frequently have the sample locations referenced in meters upstream from the confluence of the tributary with the Colorado River.

The geographic data files necessary to use abstract referenced data in a GIS are mapped versions of the inferred real world feature. For data referenced by river miles, such as in the Colorado River in Grand Canyon, this is a river centerline. In smaller tributaries it may be the actual stream channel.

In the Colorado River the centerline is "attributed" with river mileage that corresponds with the referencing in the tabular database. For tributaries, or any other stream in the watershed, the stream must be identified (e.g., name or some other identifier) and referenced with the measurement scheme such as meters from the confluence.

Geographic data files are created using specialized software packages, such as ARC/INFO®, by a GIS specialist using some type of standard design. Adherence to standards allows multiple users to access these geographic data files and assists them in relating their tabular data to geographic locations. Ideally, geographic data files need to be created only one time and attributed with standard referencing systems (e.g., stream names, distance measurement system). The manager need not encumber themselves by trying to learn a package like ARC/INFO® when easier to use desktop GIS packages are available to perform most tasks a manager would need.

An important consideration of the geographic data is the inherent geographic accuracy of the original data. For fisheries information, the levels of accuracy can be useful for categorizing each type and set of data for analysis and interpretation. Because of fish mobility, a high degree of accuracy is not always required for the data to be useful. Hougaard and Valdez (1994) proposed a conceptual six-level structure for fisheries information, ranging from level one, as the most geographically accurate, to level six, as the least geographically accurate.

Level One: Surveyed Information. Level one is survey information with sub-centimeter accuracy. Survey information is collected primarily by GCES contract surveyors working with the fisheries biologists.

Level Two: 1:2,400-Scale Mapping. Level two is primarily for information referenced to or mapped onto 1:2,400-scale orthophotos developed for the GCES projects.

Level Three: 1:1,200-Scale Mapping. From Uncorrected Aerial Photography. Level three is for information mapped directly onto photographs enlarged to 1:1,200 scale.

Level Four: 1:24,000-Scale Mapping. Level four is for information collected throughout the entire Grand Canyon corridor. This scale is useful at a more general planning level. Additionally, information at this scale exists for the entire Grand Canyon area.

Level Five: River Mile Referencing. Level five contains the least spatially accurate data. Samples or observations are recorded to the nearest 0.20 river miles. River mileage is not a coordinate mapping system and was never intended to be a precise locating system. It is intended to provide a system for referencing a position along the river corridor.

Level Six: Historical Information. The historical information is geographically referenced using whatever means are necessary. Because of the wide variety of accuracies for spatially referencing historic fisheries data and because much of the location identification is done on a "best guess" basis, level six has no specific spatial requirements.

Tabular Databases

Tabular databases contain information that describes features or objects (e.g., fish, netting results) at a location. Fish size, age, condition, diet, etc. are recorded in a tabular data format with location being only one piece of information recorded. The location at which the data were collected is

important, but only rarely is the specific location the primary item of interest. The purpose for organizing the data in tabular fashion is most often to facilitate statistical analysis, not geographic analysis. However, spatial analysis can be important to identify movement patterns or to limit the geographic area for performing statistical analysis.

Tabular data are stored in computer database files created using software packages such as FoxPro®, dBASE®, Oracle®, and Paradox®. One of the most recent advances in GIS is the ability to use these files directly, without the need for translations, reformatting, or data duplication. The files are used intact just as they were originally created and stored.

Chapters 2 and 3 describe the tabular data that is available in the GCFIN database.

SUMMARY OF MODERN GIS TECHNOLOGY FOR INTEGRATING ECOSYSTEM DATABASES

Today, managers and research scientists alike can access GIS technology on their desktop computer through a Windows® environment. The ability of modern GIS's to integrate tabular databases and geographic data through a software interface that allows data to be viewed, queried and analyzed, has opened a whole new world of opportunities for understanding and managing aquatic ecosystems.

ORGANIZING BIO/WEST'S COLORADO RIVER IN GRAND CANYON FISHERIES DATA WITH A GIS

Of the many fisheries studies performed in the Colorado River in Grand Canyon, none have been as geographically extensive or collected as much annual information as the studies performed by B/W. For this reason their data have been selected to demonstrate how GIS can be applied to organizing aquatic ecosystem data. Many of the methods developed for their data sets can be directly applied to not only other Colorado River fisheries databases, but also to riverine aquatic ecosystems anywhere.

Within this section we discuss these four topics:

- ✓ BIO/WEST's Tabular Database
- ✓ BIO/WEST's Geographic Database
- ✓ GIS Software Tools and Methods
- ✓ Integrating Other Agencies Fisheries Databases with a GIS

Without using a GIS, access and query of the B/W tabular database was only performed by specialists that were intimately familiar with the data. Virtually all of the geographic data used by specialists was from memory, aerial photographs or hard copy maps. The purpose of developing the GIS for the aquatic database was to link tabular data with geographic locations, and to provide access to and query capabilities of the database by individuals that are not as intimately involved with the actual database.

BIO/WEST's Tabular Database

B/W's tabular database contains dBASE® format data files. The detailed contents of the files are contained in Chapter 2. In general, the files include the following information: chub morphometrics

and meristics, fish netting and trapping, electrofishing, fish seining, fish captured, radio telemetry observation, surveillance, and remote station, drift net, fish stomach pump results, water quality, juvenile habitat measurements, and humpback chub scales.

The geographic link for many of the tabular data files is river mile, based on an interpretation of the Belknap River Guide (Belknap and Evans 1989). Some data sets, electrofishing runs for example, have both a start and end river mile recorded. Netting and minnow trap data are linked to the geographic data by a unique identifier stored in both the geographic data and for each record in the tabular data. Radiotelemetry data have unique identifiers stored with both the geographic data and the tabular data (i.e., there is a geographic point for every record in the tabular data).

BIO/WEST's Geographic Database

The B/W geographic database consists of multiple data files that relate to fisheries or fish habitat databases. These data files were created in either ArcCAD or ARC/INFO and are in the same geographic space as other GCES GIS data files. The GIS products are still being developed so the quantity of GIS data in the following table is only an estimate. Table 4-2 lists the specifications for the B/W mainstem GIS database.

Table 4-2. GIS Database specifications for B/W mainstem humpback chub studies.

GIS Data	Number of Files	Anticipated Size (bytes)	Contents
Sampling Location Maps	2	~1,000,000	Net and trap locations plotted on orthophoto overlays
Surficial Habitat Maps	27	~100,000	Surficial hydraulic features outlined on aerial photos for four selected sites
Hydraulic Maps	2	~3,000,000	Surficial hydraulic features and shoreline types mapped on orthophoto overlays from LCR to Tanner
Substrate Maps	1	~45,000	Substrates outlined for LCR confluence
River Centerline	1	>1,000,000	Approximate river thalweg interpreted from 1:2,400 orthophotos
Fish Photographs	240	depends on resolution	Digitized fish slides

Geographic data are of three types;

- ✓ Observation specific
- ✓ Repeat sampling sites
- ✓ Abstract reference

Each geographic data type are discussed in detail here, with actual data structures found in Appendix E.

Observation Specific. Observation specific data describe an observation at a specific time at a specific location. In the B/W database these consist of habitat maps and radiotelemetry data. Habitat

maps are of two types: surface habitat maps and current pattern maps. Surface habitat maps contain surface habitats mapped onto 1:1,200 uncorrected aerial photographs at specific locations of interest. Multiple maps were created with each map depicting habitat conditions at a specific river level or flow. Each map for each site for each flow was registered to the orthophoto maps of the area by rubber-sheeting. Surface habitat maps are of larger geographic extent (approx. 80% of site 5) and are for a single "high" and a single "low" flow. Two types of data are stored for both surface habitat maps and current pattern maps; shoreline habitat types and the current or surface habitat.

Two types of radio telemetry data are recorded in the geographic database: surveillance and observation. Surveillance data were collected by identifying locations of radio-tagged fish. Each fish location was plotted onto the orthophoto then digitized into the database and information about the observation such as date and time were recorded. Observation data were used to monitor individual fish over time to identify fish movements. At each time of observation, the location of the fish was plotted onto an aerial photograph. These points were later transferred to orthophotos and digitized into the database. Data describing the date and time for each observation were also recorded.

Repeat Sampling Sites.

Repeat sampling sites are locations where the same types of data were collected on multiple occasions. Two types of repeat sampling site data are used in the B/W database: net set locations and minnow trap locations. Each net set or minnow trap sampling location was assigned a unique, location identification number in the geographic database. Each time that a net or minnow trap was used to sample the river at a previously sampled location, a new set of tabular data was recorded. For each record in each tabular database, the unique location identification number was recorded. Each record in each tabular database could then be related to a specific net set or minnow trap location using the unique, location identification numbers recorded in both the tabular and geographic data.

Abstract Reference. Abstract referencing is used with the B/W database to describe the approximate location of sampling efforts. A river centerline is used as the actual geographic data set to depict the center of the river. The river centerline is the most important geographic data set for linking over 80% of B/W's data to geographic locations. The lines that represent the river centerline follow the approximate river thalweg and are separated from each other at each whole number river mile value. An additional feature class unique to ARC/INFO® called a *route* is created using the centerline. This route is coded with a stream segment identifier and calibrated for length (measurement system) using B/W's interpretation of the Belknap River Guide (Belknap and Evans 1989) river mileage. Electrofishing, seining, angling and other data sets all have their location referenced in the tabular database using this river mileage scheme. Consequently, each data set can be geographically referenced to the river centerline.

GIS Software Tools and Methods

The success of integrating B/W's tabular and geographic data is largely the result of tools included in ArcView® 2. The ability to "link" geographic and tabular data dynamically on the PC and the ability to customize the interface, including access to third party programs, has changed the way GIS can be used.

The conceptual overview of how GIS, namely ArcView® fits into integrating B/W's tabular and geographic data is shown in Table 4-3. The GIS is used as a data organizer for linking the tabular data to the geographic data. For example, to view netting data for multiple trips down the river, the

geographic net set data file is selected. Then a specific netting results file, stored in dBASE® native format is selected. The "link item" in common to both data sets are identified, in this case NET_ID. Then both "tables" are "joined" by the GIS software to create a "data view" of that particular combined set of data. This process does not physically change the geographic data, nor the dBASE® data, but allows them to be used together.

Once the tables have been joined to create the "data view", geographic selections can be made by selecting nets on the screen. Alternatively, tabular queries such as selecting all net sets that caught more than three fish can be performed and drawn graphically on the screen.

Table 4-3. Links between geographic and tabular data.

	Geographic Data Types	Examples	Link Item	Associated Tabular Data
Interface Tools (ArcView®)	Observation Specific	Radio Telemetry	Explicitly Stored Together	Date, Time
		Surface Habitat Maps		Habitat Type
		Current Maps		Current Type
	Repeat Sampling Sites	Net Sets	NET_ID	Multiple files of Sampling Effort Results
		Minnow Traps	MNTRP_ID	
	Abstract Reference	Electrofishing	River Mile	Multiple files of Sampling Effort Results
		Seining	River Mile	
		Water Quality	River Mile	

Multiple dBASE® files containing netting results can be simultaneously joined to the same geographic data set, using the same methodology described previously to create different views. In the "table of contents" of a particular GIS session, each geographic and dBASE® tabular data file that has been linked to create a data view would appear as a separate set of data that could be queried.

If more sophisticated analyses are to be performed from multiple data views, each data view would be queried separately and the results written to a third file. This third file can be saved as a dBASE® file or as an ASCII text file for importing into a statistical packages.

A similar process is used to locate information referenced by river mile, such as electrofishing or seining. The river centerline file is opened and the geographic reference "link item" is selected, and the dBASE® file is opened and the river mile "link item(s)" are selected. Then the GIS software performs the link creating the data view. The difference between river mile referenced information and site specific data is that with river mile referencing the GIS must infer the location of the sample

by interpolating between known river mile points. The tools in ArcView® even allow a stretch of river to be specified using beginning and ending points.

The process of adding multiple dBASE® tables for multiple trips down the canyon is the same as for site specific points. Each dBASE® table for each trip is linked to the same centerline file based on river mile, but is stored as a separate data view that can be queried.

Integrating Other Agencies Fisheries Databases with a GIS

Using existing GIS technology it is possible to integrate all of the existing Grand Canyon fisheries data and make it available through a Windows®-based environment. Knowing what is required to integrate existing data also provides insight into creating a system for integrating fisheries information over entire watersheds and ecosystems.

To integrate existing fisheries data each tabular database needs to be identified, catalogued, and documented. Commonalities, differences, and most importantly geographic referencing for each database must be identified. Commonalities and differences are documented in Chapter 2 of this report and revisions and geographic referencing are documented in Chapter 3. To integrate the various databases geographically, the most important item catalogued is the recording method used to locate field sampling sites.

Databases from various fisheries investigations can be integrated via a GIS interface in one of two principal ways. Each database can be treated in its entirety, independent of the other databases, or data fields can be translated and linked to common fields of other databases. We have demonstrated in Chapter 3 that most databases will not link in their entirety because of unique or incompatible data fields.

The option to use databases in their entirety or as components of an integrated database provides the user of a GIS with great analytical flexibility. Analyses can be performed independently on databases, portions of databases, or on inter-relational linkages from several databases. This capability is a powerful analytical tool for researchers and managers needing synthesized information and integrated analyses.

CHAPTER 5: DATABASE RECOMMENDATIONS

EXISTING DATABASES

Immediate Actions

GCFIN Database

1. Gather Outstanding Databases and Documentation. Currently there are portions of databases or database documentation that are not included in this GCFIN Report. Without this remaining information it is impossible to consider this a complete and thorough examination of what will be incorporated into an integrated fisheries database. It is recommended that a final attempt is made to procure this outstanding information to complete the analysis and proceed with the implementation of a prototype database. The information needed includes the following:

US Fish and Wildlife Service

- All information pertaining to University of Arizona tributary databases, including:
  a. Type of platform used,
  b. Software used to create, maintain, and analyze databases.
  c. Data distribution format,
  d. File structures (field names, types, sizes, codes, and descriptions; calculated fields; accuracy qualifiers),
  e. Relational links,
  f. Number of files,
  g. Current and anticipated size of files (number of records and number of bytes per record),
  h. A subsample of data (minimum of 500 records).

- The electronic file containing the Service's Little Colorado River transect codes and corresponding locations. This will be required at some point to implement a translation filter.

Arizona Game and Fish Department

- Information on past collections (Kaeding*, Minckley, Carothers, Maddux) including:
  a. Type of platform used,
  b. Software used to create, maintain, and analyze databases,
  c. Data distribution format,
  d. Data field codes, field descriptions, calculated fields, and accuracy qualifiers (field names, types, and sizes were extracted from Kubly 1990),
  e. Relational links,
  f. Number of files,
  g. Current and anticipated size of files (number of records and number of bytes per record),
  h. A subsample of data (minimum of 500 records).

*Bill Persons of Arizona Game and Fish Department provided data from Lynn Kaeding for 1980 and 1981 work in the Little Colorado River and mainstem Colorado River near the mouth of the LCR. These data are in the dBASE® file structure that AGFD is using to compile a "master" file of all available data, which is different from the file structures provided for use in the GCFIN reports.

All Investigators

- A detailed list of gear specifications from each agency. We could send out a list of gear specifications for gear known to be used in the Grand Canyon and Upper Basin, and have each agency add the specifications for their gear types not already on the list.
- Clarification of how tags and marks other than PIT tags are recorded by each agency.
- Clarification of geographic referencing used by each agency

2. Compile a List of Integrated Database User Needs. Before the development of GCFIN Integrated Database can proceed, the needs of the potential users must be assessed. These needs will drive the design and development of the user interface to the integrated database as well as the internal workings (i.e., analyses, additional file structures). It is recommended that potential users and interested parties (e.g., researchers working in both the Upper and Lower Basins of the Colorado River) meet to discuss the desired uses for the database..

3. Develop River Mile Equivalency Table. If multiple fisheries databases are going to be integrated, or data from multiple databases compared in any way, it is essential that a common river mile referencing system be developed. Chapter 3 discussed possibilities for integrating the different databases using translation filters to convert particular items within the databases into a common format or system of codes. One of these translation filters would convert river miles from one investigator's system to another. In order to do this it is recommended that an equivalency table be developed. Perhaps the simplest way to develop a river mile equivalency table would be to initially generate the river center lines for GIS, and then use the GIS to equate the different systems in a way that can be used as a translation filter for the tabular database.

GCFIN GIS

4. Generate River Mile Calibrated Centerline Referencing System for Each Agency. Chapter 4 described the application of GIS to the B/W fisheries database. During the development of the B/W GIS a river center line was generated to reference the river miles used by B/W. In order to include other researchers' databases in a GCFIN GIS there needs to be a way of referencing their databases by river miles as well. Hence, it is recommended that a river center line "route" be generated for each different river mile standard used in the Grand Canyon fisheries databases.

5. Map Other Agencies' Geographic Information. Each agency should map both their observation specific data (e.g., habitat) and their repeat sampling sites (e.g., net sets, back waters) onto base maps. Additionally, each repeat sampling site should be assigned a location identification number in both the geographic database and tabular databases. The preferred base maps are the orthophotos created by Horizon's Inc. for each of the Grand Canyon study sites. Each set of maps would then be digitized into the geographic database. This would create a GIS data file for each set of observation specific and repeat sampling site data. The commonality of databases could then be linked not only upon geography, but also tabular database contents.

6. Identify Other Agencies' Geographic Referencing of Non-mainstem Information. Each agency should identify via maps, sketches on photos and written descriptions of how they geographically referenced information for tributaries. Any benchmarks or reference points should be specifically noted.

Eventual Actions

GCFIN Tabular Database

1. Develop Database User Interface. Once the needs of the potential users of the GCFIN Database are assessed, a user interface must be developed to meet those needs. The GIS using ArcView allows a user to access the data through geographic references, and could potentially serve as the user interface to the tabular database for graphical and statistical analysis as well. Because ArcView links directly to most spreadsheet, statistics, and database packages via Dynamic Data Exchange (DDE) or Structured Query Language (SQL), all of the analysis could be performed from the GIS interface. If, however, geographic-based analysis or geographic linkages to other datasets are not required, a powerful, user-friendly interface to the GCFIN Database could be developed using a database package such as Paradox or dBASE® for Windows. The development of either of these user interface options will require the expertise of either a GIS programmer, a database programmer, or both. It is recommended that one or both of these user interfaces be chosen and steps taken toward the initiation of their development and implementation.

FUTURE DATABASES

Immediate Actions

1. Standardize Grand Canyon Location Information. A crucial aspect of long-term fisheries investigations is sampling repeatability, both temporal and spatial. Investigators examine what happens at a particular location over a period of time, as well as what happens at different locations at approximately the same time. Location identification is an extremely important part of repeatability. Investigators must be able to return to specific locations for repeated sampling.

Each Grand Canyon fisheries investigator has a method of recording location information. These methods range from a set of location codes developed and used by an individual agency, to the river mile designations set forth in several commonly used river guides (e.g., Stevens Guide (Stevens 1983), Belknap Guide (Belknap and Evans 1989). Any of these methods works well for an individual investigative agency as long as it is used consistently. Unfortunately, the different methods are not always compatible for integration of location information. One investigator's coded locations may have no meaning to another investigator. And though river miles appear to be a more consistent, well-understood system, river mile designations are neither precise indications of location nor consistent among the different river guides. A river mile designation for a location in the Stevens Guide may differ from that in the Belknap Guide.

Studies of the mainstem Colorado River by AGFD and B/W used aerial photographs with river miles marked on them in addition to river guides to identify locations. Although these photo guides do not necessarily increase the precision with which researchers identify a location, they do increase the accuracy and consistency. Photos show the hydraulic features of the river as well as more detailed shoreline features than the printed river guides, and seem to be preferred by field crews. For these reasons it is recommended that a standard set of aerial photos (1:2400 or 1:1200 scale) of the mainstem Colorado River in Grand Canyon with river miles superimposed be issued to investigators at the beginning of a study. Aerial photographs of tributary streams and orthophotos of GIS sites should also be issued to researchers working within those areas. For some aspects of their studies, researchers should be encouraged to mark sampling locations on Mylar overlays to the aerial photos and orthophotos. The photos and overlays will increase the accuracy and consistency of location information, as well as facilitate the incorporation of the fisheries data into a GIS.

2. Develop Data Collection Protocol. The information identified as integrable among the different Grand Canyon investigators is primarily information that is commonly collected by fisheries researchers. Future incorporation of fisheries data into the GCFIN Database would be facilitated by investigators using common field names, field formats, and data codes. It is recommended that GCES follow the example of the Upper Colorado River Basin Database, and issue a list of field names, formats, and codes (USFWS 1989) that researchers must use when submitting their data to GCES. Investigators may collect the data in any way they choose, but it must be submitted to GCES with the field names, formats, and codes specified in the document. This system makes the researchers, who are most familiar with their data, responsible for making sure it is in the proper format for integration. It may also encourage them to incorporate these standards into their own databases rather than having to convert data each time they submit it to GCES. Translation filters can be used by each investigator to convert dissimilar data codes or entries to compatible codes. Each of those translation filters must be maintained and potentially modified each time a researcher submits data if the given database has changed since the previous submittal. The investigator is more familiar with how a database has changed and can more easily convert it to the standard format. Investigators may develop new field names and codes for data that are not already on the list and submit them to GCES for addition. See Appendix E for details of the recommended data collection protocol.

3. Develop Quality Control Procedures. Because quality control is an extremely important aspect of database management, it is also recommended that the data collection protocol document include a section on quality control. Quality control should include procedures for field collection of data as well as those for handling data in the office. Field collection procedures should include the use of well-designed data forms to guide field personnel in correctly recording data, data code handbooks and laminated code sheets ("cheat sheets") for field personnel to reference, and inspection of data forms for completeness and accuracy in the field within a short time after recording. Office procedures should include visual inspection of database files where necessary, as well as electronic quality checks in the form of error-trapping input screens or programs run after the data are entered. It is recommended that investigators provide detailed quality control procedures as part of the Data Collection Plan submitted to GCES prior to commencement of field trips. See Appendix F for an illustration of data flow for quality control.

Eventual Actions

1. Develop Database Documentation Requirements (Metadata). A critical aspect of database management is thorough documentation. It is especially important for databases that will be integrated with others. It is recommended that each database submitted to GCES be accompanied by a Data Collection Plan which contains detailed information on study objectives, sampling design and methods, data forms, database file structures and field descriptions, data codes (including missing value descriptors), data flow, data handling protocol, and quality control.

2. Develop Colorado River Geographic Referencing System. Although scientists, biologists and others have been collecting fisheries information throughout the entire Colorado River watershed for decades, evaluating the effects of any one activity on the other locations in the watershed have been very difficult if not impossible. To some extent this is because there is no one standard way of identifying sampling locations. The State of Washington Department of Natural Resources (DNR) had a similar problem in their state relative to management and assessment of anadromous fish stocks. To help relieve some of the problems in handling data that came from multiple agencies and researchers, the state developed a stream referencing system that uniquely identified every stream segment in the entire state, including intermittent streams. This stream

segment identifier must now be used for every fishery data collection conducted in the state, regardless of agency affiliation.

We would suggest that a similar system be developed for all streams in the Colorado River Watershed. This should be done cooperatively between state and federal agencies to ensure cooperation and compliance. Each agency's data would then be referenced to the same set of location identifiers. A good starting place would be to use the U.S. Environmental Protection Agency (USEPA) Reach File 3 (RF3). This RF3 system is being developed at the 1:100,000 scale and uniquely identifies all streams mapped at that scale. However, we suggest a more detailed system similar to the Washington State example be used for watershed aquatic ecological databases.

The system that we are suggesting is for every stream identified (or that could be delineated) upon a 1:24,000 scale map to be divided into segments broken at tributaries with a node separating each segment. Each stream segment would then be assigned an identification number based upon the latitude and longitude of the upstream node. These nodes could be either stream tributary junctions or terminal nodes of first-order streams. This would allow every stream segment in the watershed (or conceivably the world) to be uniquely identified. Field observations would then be recorded as segment identification number and distance (e.g., meters, miles etc.) from a node.

By referencing every river or stream study within the watershed to one standard set of stream reach identifiers, every study could be geographically viewed, queried, and analyzed. Any person interested in analyzing their data in conjunction with others' data would, at a minimum, have the vehicle to see their data together. Managers in particular would benefit because the volumes of data that they must consider when making decisions would be available from their desktop using a familiar Windows® interface. Managing entire watersheds and ecosystems would then be a reality, not just a topic of discussion.

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GLOSSARY OF TERMS

ASCII: Abbreviation of American Standard Code for Information Exchange, an alphanumeric information code for data processing.

byte: A unit of binary digits, usually in eight bits representing two numerals or one character.

confluence zone: The area where the Little Colorado River flows into the Colorado River.

database: A compilation of all data collected by an individual investigative agency or firm.

database field: A category of information within a data file. One "column" of a database file.

database record: A set of all the database fields (one each) in a database file. One "row" of a database.

dataset: Information in a database associated with a particular topic.

data standards: Established formats, codes, and definitions for data collection and storage.

geographic referencing: The method used for identifying a geographic location (e.g., maps, latitude/longitude, UTMs, river miles).

integration templates: File structures for the GCFIN Database files.

interim flows: The flows from Glen Canyon Dam decreed by Secretary of Interior Manuel Lujan to begin August 1, 1991 and continue through the issuance of the Record of Decision for the Glen Canyon Dam Environmental Impact Statement.

larval: Within the period of development from hatching to complete development of the full complement of fins.

life history: The series of successive stages through which an organism passes from its first stage to its last.

limnologic: Pertaining to the science of the biological and other phenomena of fresh water, especially of ponds and lakes.

metadata: Data about data, providing such information as the characteristics of a data set, the history of a data set, and organizations to contact to obtain a data set.

otolith: A granule of calcium carbonate in the inner ear of some fishes.

piscivorous: Fish-eating.

relational database: A database consisting of multiple data files that are related to each other by some common information.

relational link: A common data field in more than one database file, containing identical information, that can be used to connect the files together for simultaneous use.

reproductive capacity: A measure of the ability of fish to reproduce.

survivorship: The rates at which fish survive through different life stages.

tabular database: A database organized into tables of information, primarily for the purpose of facilitating statistical analysis (vs. geographic analysis).

template: A file structure into which different investigators' data can be pulled.

translation filter: A computer program to convert data from existing field formats, codes, or definitions to fit the common standard established for the integration templates.

ABBREVIATIONS

AGFD	Arizona Game and Fish Department
ASU	Arizona State University
B/W	BIO/WEST, Inc.
GCES	Glen Canyon Environmental Studies
GIS	Geographic Information System
GPS	Global Positioning System
LCR	Little Colorado River
Service	United States Fish and Wildlife Service
U of A	University of Arizona

APPENDIX A

DATABASE FILE STRUCTURES FOR INDIVIDUAL DATABASES

Note:

This appendix contains detailed lists of field contents within each file structure identified from Phase I of this project. Data field types (TYPE) are consistent with dBASE™ definitions:

C = character
N = numeric
D = date
L = logical

A-1. ARIZONA STATE UNIVERSITY FILE STRUCTURES

File: **ASU9X (X = 1, 2, 3, etc.)**
Contents: **Fish collection data**

Field	Type	Size	Dec	Description
CAMP	C	1	0	Camp code
TRIP	N	2	0	Trip number
YEARCODE	C	1	0	Year code
WACODE	N	2	0	AGFD reach code: 22=Little Colorado River
LOCATION	C	8	0	USFWS transect code and/or generic site name
GEAR	N	1	0	Gear code
MONTH	N	2	0	Date
DAY	N	2	0	Date
YEAR	N	2	0	Date
METERS	N	7	1	Meters above the mouth
HOUR	N	4	0	Time
SPECIES	C	3	0	Fish species
LENGTH	N	4	0	Total length
WEIGHT	N	4	0	Weight
SEX	N	1	0	Sex code
MATURITY	N	1	0	Maturity code
TAG	C	10	0	Tag number
RECAPTURE	C	10	0	Tag number of recaptured fish

A-2. U.S. FISH AND WILDLIFE SERVICE FILE STRUCTURES

The following field descriptions were extracted from Gorman (1993), and the file names are those of the sample data sets provided by USFWS.

File: MNH.DBF
Contents: USFWS mini-hoop nets

Field	Type	Size	Dec	Description
GEAR	C	3	0	Gear code
ID	C	8	0	LCR transect and bank location coding
DATE	D	8	0	Date when measured
TIME	C	4	0	Time when measured
SETD	D	8	0	Date set
SETT	C	4	0	Time set
PULD	D	8	0	Date pulled
PULT	C	4	0	Time pulled
LATDS	N	4	0	Lateral distance to set
UPDN	N	4	0	Distance up or downstream of transect
LATP	N	4	0	Lateral distance to nearest bank or edge
MO	N	3	0	Depth of water at mouth of hoop
MTH	N	3	0	Distance below water surface to top of hoop (mouth)
PO	N	3	0	Depth of water at point of net
PTH	N	3	0	Distance below water surface to top of front hoop
T	C	1	0	Transect letter for hoop net habitat meas. grid
P	N	1	0	Point or column number for hoop net hab. meas. grid
EDG	N	3	0	Distance (cm) when <=100 to edge
DPH	N	3	0	Depth (cm)
CUR	N	1	0	Current category
CC	C	2	0	Current comments
SUB	N	2	0	Primary substrate
SBC	C	4	0	Secondary substrate descriptor
OVH	C	4	0	Overhang, vert. edge
CVR	N	2	0	Cover
CCV	N	2	0	Corrected cover

File: **AHP.DBF**
Contents: **ASU hoop nets**

Field	Type	Size	Dec	Description
GEAR	C	3	0	Gear code
GEARD	C	5	0	Gear description
ID	C	8	0	LCR transect and bank location coding
DATE	D	8	0	Date when measured
TIME	C	4	0	Time when measured
SETD	D	8	0	Date set
SETT	C	4	0	Time set
PULD	D	8	0	Date pulled
PULT	C	4	0	Time pulled
LATDS	N	4	0	Lateral distance to set
UPDN	N	4	0	Distance up or downstream of transect
LATP	N	4	0	Lateral distance to nearest bank or edge
MO	N	3	0	Depth of water at mouth of hoop
MTH	N	3	0	Distance below water surface to top of hoop (mouth)
PO	N	3	0	Depth of water at point of net
PTH	N	3	0	Distance below water surface to top of front hoop
T	C	1	0	Transect letter for hoop net habitat meas. grid
P	N	1	0	Point or column number for hoop net hab. meas. grid
EDG	N	3	0	Distance (cm) when <=100 to edge
DPH	N	3	0	Depth (cm)
CUR	N	1	0	Current category
CC	C	2	0	Current comments
SUB	N	2	0	Primary substrate
SBC	C	4	0	Secondary substrate descriptor
OVH	C	4	0	Overhang, vert. edge
CVR	N	2	0	Cover
CCV	N	2	0	Corrected cover

A-2. U.S. Fish and Wildlife Service File Structures - cont.

File: TRN.DBF
Contents: USFWS transect data

Field	Type	Size	Dec	Description
KM	N	5	0	Distance in km from Zero Rock (confluence)
M	N	1	0	Indicates 100 transect or other
ID	C	8	0	LCR transect ID
GEAR	C	3	0	Always TRN
DATE	D	8	0	Date transect measured
TIME	N	4	0	Time transect measured
PT	N	3	0	Habitat point number
ELV	N	4	0	Change in elevation of water surface between transects
LATP	N	4	0	Lateral distance to nearest stream bank
EDG	N	2	0	Distance (cm) when <=100 to edge
DPH	N	3	0	Depth (cm)
CUR	N	1	0	Current category
CC	C	2	0	Current comments
SUB	N	2	0	Primary substrate
SBC	C	4	0	Secondary substrate descriptor
OVH	C	4	0	Overhang, vert. edge
CVR	N	2	0	Cover
CCV	N	2	0	Corrected cover

File: **MTP.DBF**
Contents: **USFWS minnow trap data**

Field	Type	Size	Dec	Description
ID	C	8	0	LCR transect ID, trap number, and bank position arrow
DATE	D	8	0	Date when measured
TIME	C	4	0	Time when measured
GEAR	C	3	0	Always MTP
SETD	D	8	0	Date set
SETT	C	4	0	Time set
PULD	D	8	0	Date pulled
PULT	C	4	0	Time pulled
CNFG	C	4	0	Configuration
LATP	N	4	0	Distance from closest bank to middle of trap
UPDN	N	4	0	Distance up or downstream of transect line
POS	N	3	0	Depth to top of trap
EDG	N	2	0	Distance (cm) when <=100 to edge
DPH	N	3	0	Depth (cm)
CUR	N	1	0	Current category
CC	C	2	0	Current comments
SUB	N	2	0	Primary substrate
SBC	C	4	0	Secondary substrate descriptor
OVH	C	4	0	Overhang, vert. edge
CVR	N	2	0	Cover
CCV	N	2	0	Corrected cover

File: FSH.DBF
Contents: USFWS fish capture data

Field	Type	Size	Dec	Description
DATE	D	8	0	Date fish was measured
TIME	C	4	0	Time fish was measured
PER	C	1	0	Period of day fish was measured
ID	C	8	0	LCR transect, bank location, trap/net number
GEAR	C	3	0	Gear code
SPP	C	3	0	Fish species
NUM	N	3	0	Number of fish
LNTH	N	3	0	Length of fish (mm)
WGHT	N	4	0	Weight of fish (g)
SEX	C	1	0	Sex
FIN	C	4	0	Fin clip code for new captures and recaps
PIT	C	10	0	PIT tag number
RECAP	C	1	0	Recapture or new capture
REMARKS	C	20	0	Remarks

File: WTQ.DBF
Contents: USFWS water quality data

Field	Type	Size	Dec	Description
GEAR	C	3	0	Water quality instrumentation
CAMP	C	1	0	Camp
KM	N	5	0	Kilometers
DATE	D	8	0	Date measured
TIME	N	4	0	Time measured
DHI	N	3	0	Daily high air temperature (°F)
DLO	N	2	0	Daily low air temperature (°F)
AMBT	N	3	0	Present ambient air temperature (°F)
TEMP	N	4	1	Water temperature (°C)
COND	N	4	2	Conductivity (mS)
PH	N	4	2	pH
DO	N	4	1	Dissolved oxygen (ppm)
ORP	N	5	2	Oxidation/reduction potential (hydrolab only)
SAL	N	4	1	Salinity (percent)
SECCHI	N	3	0	Secchi depth (cm)
TURBID	N	5	0	Turbidity (NTUs)
RELEV	N	4	0	Depth of river above base flow (cm)
GAUGE	N	5	1	Reading on staff gauge
CELEV	N	5	0	Corrected river elevation

A-3. UNIVERSITY OF ARIZONA FILE STRUCTURES

File structure information on U of A data are not available at this time. Since these data were collected as part of the USFWS tributary studies, they may be incorporated into the existing USFWS file structures by USFWS.

A-4. ARIZONA GAME AND FISH DEPARTMENT FILE STRUCTURES

Little Colorado River Native Fish Studies

File: ALGEMAS1.DBF
Contents: Algae chlorophyll ('a') analysis data; grids and quarterly, 1993

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
REACH	N	2	0	Colorado River Reach 22=Little Colorado River
ANALYST	C	3	0	Person who analyzed sample
ANAL_MO	N	2	0	Month analyzed
ANAL_DA	N	2	0	Day analyzed
ANAL_YR	N	2	0	Year analyzed
SET_MO	N	2	0	Month of collection
SET_DA	N	2	0	Day of collection
SET_YR	N	2	0	Year of collection
SET_HR	N	2	0	Hour of collection
SET_MM	N	2	0	Minute of collection
METER	N	5	0	Meter above mouth
SIDE	C	1	0	Side of river: R=right, L=left, C=center
CELL_NO	C	5	0	Sample or cell number
XTR_VOL	N	3	0	Volume of methanol (ml) for chlorophyll extraction
B480	N	5	3	Pre-acidification absorbance, 480 nm, ±.001 nm
B7501	N	5	3	Pre-acidification absorbance, 750 nm, ±.001 nm
B666	N	5	3	Pre-acidification absorbance, 666 nm, ±.001 nm
B7502	N	5	3	Pre-acidification absorbance, 750 nm #2, ±.001 nm
A7501	N	5	3	Post-acidification absorbance, 750 nm, ±.001 nm
A666	N	5	3	Post-acidification absorbance, 666 nm, ±.001 nm
A7502	N	5	3	Post-acidification absorbance, 750 nm #2, ±.001nm
CRUC_NO	N	4	0	Crucible number, used to burn sample
CRUC_WEIGH	N	9	4	Crucible weight, ±.0001 g
DRY_WEIGHT	N	9	4	Dry weight of sample, ±.0001 g
ASH_WEIGHT	N	9	4	Ash weight of sample, ±.0001 g
CHNGDATE	D	8	0	Date of record change
CHNGTIME	N	4	0	Time of record change

File: ALGAECOL.DBF
Contents: Algae and benthos collections (quarterly trips), 1991-1993

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD Study Number
PAGE	N	3	0	Page of data sheets
MILE	N	5	0	Meters upstream from mouth
SET_MO	N	2	0	Month of collection
SET_DA	N	2	0	Day of collection
SET_YR	N	2	0	Year of collection
SET_HR	N	2	0	Hour of collection
SET_MM	N	2	0	Minute of collection
GEAR_TYP	C	2	0	Gear type code
HABCHAN	C	2	0	Channel type code
HABTYPE	C	2	0	Primary habitat code
SUBS1	C	2	0	Primary substrate code
SUBS2	C	2	0	Secondary substrate code
DISTANCE	N	4	1	Distance from shore (m), to the nearest dm
DEPTH	N	3	0	Depth (cm), to the nearest cm
FLOW	N	5	2	Flow (m/s) ±.015 m/s
AMOUNT	N	2	0	Amount of sample collected (cc), if core sample.
PHOTO_ROLL	N	2	0	Film roll number
PHOTO_NO	N	2	0	Photograph number
SAMP_NO	C	4	0	Sample number
CHNGDATE	D	8	0	Date of record change
CHNGTIME	N	4	0	Time of record change

A-4. Arizona Game and Fish Department File Structures - cont.
Little Colorado River Native Fish Studies

File: QBENTHOS.DBF
Contents: Quarterly benthos analysis data, 1993

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
MILE	N	5	0	Meter above confluence
SET_MO	N	2	0	Month of sample collection
SET_DA	N	2	0	Day of sample collection
SET_YR	N	2	0	Year of sample collection
SET_HR	N	2	0	Hour of sample collection
SET_MM	N	2	0	Minute of sample collection
HABCHAN	C	2	0	Channel type code
HABTYPE	C	2	0	Primary habitat type code
HABTY2	C	2	0	Secondary habitat type code
SIDE	C	1	0	Side of river: R=right, L=left, C=center
SUBS1	C	2	0	Primary substrate code
SUBS2	C	2	0	Secondary substrate code
DISTANCE	N	4	1	Distance from shore (m)
DEPTH	N	3	0	Depth (cm)
FLOW	N	6	2	Current velocity (m/s), ±.01m/s
SAMP_NO	C	3	0	Sample number
ANALYST	C	3	0	Person who analyzed sample
DATE_ANAL	N	6	0	Date analyzed
TAXA	C	3	0	Taxa code
LIFE_STAGE	C	1	0	Life Stage
NO	N	20	2	Number per taxa and life stage
DRY_WEIGHT	N	8	3	Dry weight (g) of sample+crucible, ±.0001g
ASH_WEIGHT	N	8	4	Ash weight (g) of sample+crucible, ±.0001g
CRUC_WGHT	N	8	4	Crucible weight (g), ±.0001g
CRUC_NO	N	8	4	Number assigned to crucible
CHNGDATE	D	8	0	Date record was changed
CHNGTIME	N	4	0	Time record was changed

A-4. Arizona Game and Fish Department File Structures - cont.
Little Colorado River Native Fish Studies

File: **BEHAVIOR.DBF**
Contents: **Behavioral data, 1991-1993**

Field	Type	Size	Dec	Description
MILE	N	8	0	Meter above mouth
SIDE	C	9	0	Side of river: R=right, L=left, C=center
RUN_MO	N	2	0	Month of observations
RUN_DA	N	2	0	Day of observations
RUN_YR	N	2	0	Year of observations
RUN_HR	N	2	0	Hour of observations
RUN_MM	N	2	0	Minute of observations
SPECIES	C	9	0	Species code
LENGTH	N	8	0	Length interval code (mm)
HABCHAN	C	9	0	Channel type code
HABTYPE	C	5	0	Habitat type code
HM	N	4	0	Hectometer above the mouth
NUM	N	5	0	Number assigned to habitat
POOL_DIM	N	8	0	Pool dimensions (cm^2)
OBSERVER	C	9	0	Observer
AREA	N	8	0	Area covered by fish (cm^2)
CALCIUM	N	8	4	Percent of time feeding on the calcium carbonate
CLAY	N	8	4	Percent of time feeding on the clay
SILT	N	8	4	Percent of time feeding on the silt
SAND	N	8	4	Percent of time feeding on the sand
ROCK	N	8	4	Percent of time feeding on the rock
ALGAE	N	8	4	Percent of time feeding on the algae
MAC	N	8	4	Percent of time feeding on the macrophyte
SURFACE	N	8	4	Percent of time feeding on the surface
COLUMN	N	8	4	Percent of time feeding in the water column
SWIM	N	8	4	Percent of time swimming
SCHOOL	N	8	4	Percent of time schooling
CHASER	N	8	4	Percent of time chasing another fish
CHASEE	N	8	4	Percent of time being chased by another fish
OTHER	N	8	4	Percent of time doing any other behavior
DEPTH	N	8	4	Depth of fish at behavior change (code)
TOTAL	N	8	0	Total percent = 100
TCC	N	8	0	Total seconds feeding in calcium carbonate
TCL	N	8	0	Total seconds feeding in clay
TSI	N	8	0	Total seconds feeding in silt
TSA	N	8	0	Total seconds feeding in sand
TRO	N	8	0	Total seconds feeding in rock
TALG	N	8	0	Total seconds feeding in algae
TMAC	N	8	0	Total seconds feeding in macrophytes
TSUR	N	8	0	Total seconds feeding on the surface
TCOL	N	8	0	Total seconds feeding in the water column
TSWIM	N	8	0	Total seconds swimming
TSCH	N	8	0	Total seconds schooling
TCHER	N	8	0	Total seconds chasing another fish
TCHEE	N	8	0	Total seconds being chased by another fish
TO_	N	8	0	Total seconds doing any other behavior
FCC	N	8	0	Frequency of feeding in calcium carbonate
FCL	N	8	0	Frequency of feeding in clay
FSI	N	8	0	Frequency of feeding in silt
FSA	N	8	0	Frequency of feeding in sand

A-4. Arizona Game and Fish Department File Structures - cont.
Little Colorado River Native Fish Studies

FRO	N	8	0	Frequency of feeding in rock
FALG	N	8	0	Frequency of feeding in algae
FMAC	N	8	0	Frequency of feeding in macrophytes
FSUR	N	8	0	Frequency of feeding on the surface
FCOL	N	8	0	Frequency of feeding in the water column
FSWIM	N	8	0	Frequency of swimming
FSCH	N	8	0	Frequency of schooling
FCHER	N	8	0	Frequency of chasing another fish
FCHEE	N	8	0	Frequency of being chased by another fish
FO	N	8	0	Frequency of doing any other behavior
CHNGDATE	D	8	0	Date of record change
CHNGTIME	N	4	0	Time of record change

File: DRFTMAST.DBF
Contents: Drift analysis data, quantification of taxa, 1991-1993

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
MILE	N	5	0	Meter above the mouth
SET_MO	N	2	0	Month net set
SET_DA	N	2	0	Day net set
SET_YR	N	2	0	Year net set
SET_HH	N	2	0	Hour net set
SET_MM	N	2	0	Minute net set
HABCHAN	C	2	0	Channel type code
HABTYPE	C	2	0	Primary habitat type code
HABTY2	C	2	0	Secondary habitat type code
SIDE	C	1	0	Side of river: R=right, L=left, C=center
DISTANCE	N	4	2	Distance from shore (m)
DEPTH	N	3	0	Depth (cm), to the nearest cm
FLOW_INIT	N	4	2	Flow (m/s) at time of net set
FLOW_END	N	4	2	Flow (m/s) at time of net run
SUBSAMPLE	N	1	0	Fraction of sample analyzed, denominator
AMOUNT	N	3	0	Duration of net set, minutes
NUMBER	N	3	0	Sample number
ANALYST	C	3	0	Person who analyzed sample
ANAL_MO	N	2	0	Month analyzed
ANAL_DA	N	2	0	Day analyzed
ANAL_YR	N	2	0	Year analyzed
TAXA	C	3	0	Taxa, a three letter code
LIFE_STAGE	C	1	0	Life stage code
NO	N	4	0	Number counted in subsample
CHNGDATE	D	8	0	Date of record change
CHNGTIME	N	4	0	Time of record change

A-4. Arizona Game and Fish Department File Structures - cont.
Little Colorado River Native Fish Studies

File: DRIFTBIO.DBF
Contents: Drift biomass data, 1991-1993

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
MILE	N	5	0	Meter above mouth
SET_MO	N	2	0	Month net set
SET_DA	N	2	0	Day net set
SET_YR	N	2	0	Year net set
SET_HH	N	2	0	Hour net set
SET_MM	N	2	0	Minute net set
HABCHAN	C	2	0	Channel type code
HABTYPE	C	2	0	Primary habitat type code
HABTY2	C	2	0	Secondary habitat type code
SIDE	C	1	0	Side of river: R=right, L=left, C=Center
DISTANCE	N	4	2	Distance from shore (m)
DEPTH	N	3	0	Depth (cm), to the nearest cm
FLOW_INIT	N	4	2	Flow (m/s) at net set
FLOW_END	N	4	2	Flow (m/s) at net pull
SUBSAMPLE	N	1	0	Fraction of sample analyzed, denominator
AMOUNT	N	3	0	Duration of net set (minutes)
NUMBER	N	3	0	Sample number
ANALYST	C	3	0	Person who analyzed sample
ANAL_MO	N	2	0	Month analyzed
ANAL_DA	N	2	0	Day analyzed
ANAL_YR	N	2	0	Year analyzed
DATE	N	6	0	Date analyzed
SAMP_NO	N	3	0	Sample number
SUB_TOP	N	1	0	Subsample fraction, numerator
SUB_BOTT	N	1	0	Subsample fraction, denominator
TAXA	C	3	0	Taxa code, three letters
LIFE_STAGE	C	1	0	Life stage code
NO	N	4	0	Number counted per subsample
TLV	N	4	0	Total volume
SUBVOL	N	3	0	Liquid subsample volume burned
CRUC_WEIGH	N	9	4	Crucible weight (g), ±.0001g
CRUC_NO	N	3	0	Number assigned to specific crucible
DRY_WEIGHT	N	9	4	Dry weight (g), sample+crucible; ±.0001g
ASH_WEIGHT	N	9	4	Ash weight (g), sample+crucible; ±.0001g
ANLYST	C	3	0	Person who burned sample
DATE_BURN	N	6	0	Date burned
VERSION	N	1	0	Version of data set, number for each modification
STATUS	C	2	0	Status of data file; Initials of modifier
CHG_DATE	D	8	0	Date record was changed
CHG_TIME	C	8	0	Time record was changed

File: HABITAT.DBF
Contents: Larval fish habitat data (grids), 1993

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
RUN_MO	N	2	0	Month data recorded
RUN_DA	N	2	0	Day data recorded
RUN_YR	N	2	0	Year data recorded
RUN_TIME	N	4	0	Time data recorded
MILE	N	5	0	Meters above the mouth
SIDE	C	1	0	Side of river: R=right, L=left, C=center
FWS	C	3	0	Fish and Wildlife Service transect number
HABTYPE	C	2	0	Primary habitat type code
FISH	C	1	0	Fish present?: Y=yes, N=no
PHOTOS	C	1	0	Photographs taken?: Y=yes, N=no
ROLL_NO	C	4	0	Film roll number
START_MO	N	2	0	Month began taking pictures
START_DA	N	2	0	Day began taking pictures
START_YR	N	2	0	Year began taking pictures
START_TIME	N	4	0	Time of day began taking pictures
END_MO	N	2	0	Month finished taking pictures
END_DA	N	2	0	Day finished taking pictures
END_YR	N	2	0	Year finished taking pictures
END_TIME	N	4	0	Time of day finished taking pictures
CELL	C	2	0	Grid cell code
TIME_AM	N	4	0	Time in morning that recorded minimum temperature
C_MIN	N	4	1	Minimum temperature (°C)
TIME_PM	N	4	0	Time in afternoon that recorded maximum temp.
C_MAX	N	4	1	Maximum temperature (°C)
VOL_FILTER	N	2	0	Volume of water filtered (ml), zooplankton sample
SUBS1	C	2	0	Primary substrate code
SUBS2	C	2	0	Secondary substrate code
DEPTH	N	5	1	Depth (cm), to the nearest cm
M_SEC	N	5	2	Current velocity (m/s), ±.015 m/s
SEC	N	3	0	Number of seconds it took bead to traverse dist.
FEATURE1	C	2	0	Primary feature code
FEATURE2	C	2	0	Secondary feature code
FEATURE3	C	2	0	Tertiary feature code
FEATURE4	C	2	0	Quaternary feature code
ALGAE	C	1	0	Algae collected: check if yes
COMMENTS	C	30	0	Comments
CHNGDATE	D	8	0	Date of record change
CHNGTIME	N	4	0	Time of record change

File: AVAILABL.DBF
Contents: Longitudinal habitat availability data, 1992-1993

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
RUN_MO	N	2	0	Month data recorded
RUN_DA	N	2	0	Day data recorded
RUN_YR	N	2	0	Year data recorded
MILE	N	5	0	Meter above the mouth
SIDE	C	1	0	Side of river: R=Right, L=Left, C=Center
FWS	C	3	0	Fish and Wildlife Service transect number
CM_SHORE	N	4	0	Distance from shore (cm)
DEPTH	N	3	0	Depth (cm)
FLOW	N	5	2	Flow (m/s)
SUBS1	C	2	0	Primary substrate code
SUBS2	C	2	0	Secondary substrate code
FEATURE1	C	2	0	Primary feature code
FEATURE2	C	2	0	Secondary feature code
FEATURE3	C	2	0	Tertiary feature code
FEATURE4	C	2	0	Quaternary feature code
COMMENTS	C	20	0	Comments
CHNGDATE	D	8	0	Date of record change
CHNGTIME	N	4	0	Time of record change

A-4. Arizona Game and Fish Department File Structures - cont.
Little Colorado River Native Fish Studies

File: **HABUSE.DBF**
Contents: **Longitudinal habitat use data, 1993**

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
RUN_MO	N	2	0	Month data recorded
RUN_DA	N	2	0	Day data recorded
RUN_YR	N	2	0	Year data recorded
MILE	N	5	0	Meter above the mouth
SIDE	C	1	0	Side of river: R=Right, L=Left, C=Center
FWS	C	3	0	Fish and Wildlife Service transect number
TRANSECT	N	1	0	Transect number
CM_SHORE	N	3	0	Distance from shore (cm)
DEPTH_CM	N	3	0	Depth (cm)
FLOW	N	6	2	Flow (m/s), ±.015 m/s
SUBS1	C	2	0	Primary substrate code
SUBS2	C	2	0	Secondary substrate code
FEATURE1	C	2	0	Primary feature code
FEATURE2	C	2	0	Secondary feature code
FEATURE3	C	2	0	Tertiary feature code
FEATURE4	C	2	0	Quaternary feature code
COLLECT	C	1	0	Collect?: Y=yes, N=no
NO_COLL	N	2	0	Number Collected
HEADSTOM	C	5	0	Sample code
COMMENTS	C	20	0	Comments
CHNGDATE	D	8	0	Date of record change
CHNGTIME	N	4	0	Time of record change

File: LARVPRES.DBF
Contents: Longitudinal survey presence/absence data 1992

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
RUN_MO	N	2	0	Month data recorded
RUN_DA	N	2	0	Day data recorded
RUN_YR	N	2	0	Year data recorded
HM	N	3	0	Hectometer above the mouth
SIDE	C	1	0	Side of river: R=right, L=left, C=center
PRESENCE	C	1	0	Are fish present?: Y=yes, N=no
COLLECT	C	1	0	Collect?: Y=yes, N=no
PRESERVE	C	1	0	Preservative type: E=ethanol, F=formalin
COMMENTS	C	25	0	Comments, includes sample number
CHNGDATE	D	8	0	Date of record change
CHNGTIME	N	4	0	Time of record change

File: PRES193.DBF
Contents: Longitudinal survey presence/absence data 1993

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
RUN_MO	N	2	0	Month data recorded
RUN_DA	N	2	0	Day data recorded
RUN_YR	N	2	0	Year data recorded
HM	N	3	0	Hectometer above the mouth
SIDE	C	1	0	Side of river: R=right, L=left, C=center
PRESENCE	C	1	0	Presence or absence: +=present, -=absent
COLLECT_	C	1	0	Fish collected?: Y=yes, N=no
MILE	N	5	0	Meter above mouth that fish was collected
NO_COLLE	N	2	0	Number of fish collected
HEADSTOM	C	5	0	Sample code
COMMENTS	C	25	0	Comments
CHNGDATE	D	8	0	Date record was changed
CHNGTIME	N	4	0	Time record was changed

A-4. Arizona Game and Fish Department File Structures - cont.
Little Colorado River Native Fish Studies

File: **MAS1FC93.DBF**
Contents: **Fish collections data, 1993**

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
REACH	N	3	0	Colorado River reach, 22=Little Colorado River
LINE	N	3	0	Line of data on data sheet
MILE	N	8	2	Meter upstream from mouth
SIDE	C	1	0	Side of river: L=left, R=right, C=center
FWS	C	3	0	Fish and Wildlife Service transect number
SET_MO	N	2	0	Month net set
SET_DA	N	2	0	Day net set
SET_YR	N	2	0	Year net set
SET_HR	N	2	0	Hour net set
SET_MM	N	2	0	Minute net set
GEAR_TYP	C	2	0	Gear type code
GEAR_H	N	2	0	Gear height (ft), to the nearest ft
GEAR_L	N	3	0	Gear length (ft), to the nearest ft
GEAR_M	N	7	5	Gear mesh (inches), to the hundredths of an inch
SEINE_L	N	7	5	Length of seine haul (m), to nearest m
SEINE_W	N	7	5	Width of seine haul (m), to nearest m
HABCHAN	C	2	0	Channel type code
HABTYPE	C	2	0	Primary habitat type code
HABTY2	C	2	0	Secondary habitat type code
SPECIES	C	3	0	Species code, three letters
LENGTH	N	4	0	Total length of fish (mm), to the nearest mm
WEIGHT	N	5	0	Weight of fish (g), ±1 g
SEX	C	1	0	Sex code
MATURITY	N	1	0	Maturity code
PARASITE	N	2	0	Numbers of parasites (interval code)
TAGNUM	C	0	0	Tag number
MARK_REC	C	1	0	Mark or Recapture: M=mark, R=recapture
OLDTAG	C	1	0	Old tag = floy or carlin, present?: Y=yes, N=no
HEADSTOM	C	5	0	Sample collection code
HEAD_NUM	N	5	0	Head sample number
STOM_NUM	N	5	0	Stomach sample number
DISPOSE	C	2	0	Disposition of fish
RUN_MO	N	2	0	Month that net was run
RUN_DA	N	2	0	Day that net was run
RUN_YR	N	2	0	Year that net was run
RUN_HR	N	2	0	Hour that net was run
RUN_MM	N	2	0	Minute that net was run
COMMENTS	C	25	0	Comments
CHNGDATE	D	8	0	Date record was changed
CHNGTIME	N	4	0	Time record was changed

A-4. Arizona Game and Fish Department File Structures - cont.
Little Colorado River Native Fish Studies

File: MASTFC92.DBF
Contents: Fish collections data, 1992

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheet
REACH	N	3	0	Colorado River reach: 22 = Little Colorado River
LINE	N	3	0	Record line, from data sheet
MILE	N	8	2	Meter above mouth
SIDE	C	1	0	Side of River: R=right, L=left, C=center
FWS	C	3	0	Fish and Wildlife Service transect number
SET_MO	N	2	0	Month net set
SET_DA	N	2	0	Day net set
SET_YR	N	2	0	Year net set
SET_HR	N	2	0	Hour net set
SET_MM	N	2	0	Minute net set
GEAR_TYP	C	2	0	Gear type code
GEAR_H	N	2	0	Gear height (feet), to the nearest ft
GEAR_L	N	3	0	Gear length (feet), to the nearest ft
GEAR_M	N	7	5	Gear mesh (inches), to the hundredth of an inch
SEINE_L	N	7	5	Seine length (m), to the nearest meter
SEINE_W	N	7	5	Seine width (m), to the nearest meter
HABCHAN	C	2	0	Channel type code
HABTYPE	C	2	0	Primary habitat type code
HABTY2	C	2	0	Secondary habitat type code
SPECIES	C	3	0	Species code
LENGTH	N	4	0	Total length (mm)
WEIGHT	N	5	0	Weight (g), ±1g
SEX	C	1	0	Sex code
MATURITY	N	1	0	Maturity code
PARASITE	N	2	0	Numbers of parasites (interval code)
TAGNUM	C	10	0	Tag number
MARK_REC	C	1	0	Mark or recapture?: M=mark, R=recapture
OLDTAG	C	1	0	Old tag (external)?: Y=yes, N=no
HEADSTOM	C	5	0	Sample number
HEAD_NUM	N	5	0	Head (otolith) sample number
STOM_NUM	N	5	0	Stomach sample number
DISPOSE	C	2	0	Disposition
RUN_MO	N	2	0	Month net was run
RUN_DA	N	2	0	Day net was run
RUN_YR	N	2	0	Year net was run
RUN_HR	N	2	0	Hour net was run
RUN_MM	N	2	0	Minute net was run
COMMENTS	C	25	0	Comments
CHNGDATE	D	8	0	Date record was changed
CHNGTIME	N	4	0	Time record was changed

A-4. Arizona Game and Fish Department File Structures - cont.
Little Colorado River Native Fish Studies

File: **MASTFC91.DBF**
Contents: **Fish collections data, 1991**

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
REACH	N	3	0	Colorado River Reach: 22= Little Colorado River
LINE	N	3	0	Data line, from data sheet
MILE	N	8	2	Meter above mouth
SIDE	C	1	0	Side of river: R=right, L=left, C=center
FWS	C	3	0	Fish and Wildlife Service transect number
SET_MO	N	2	0	Month net set
SET_DA	N	2	0	Day net set
SET_YR	N	2	0	Year net set
SET_HR	N	2	0	Hour net set
SET_MM	N	2	0	Minute net set
GEAR_TYP	C	2	0	Gear type code
GEAR_H	N	2	0	Gear height (feet), to the nearest ft
GEAR_L	N	3	0	Gear length (feet), to the nearest ft
GEAR_M	N	7	5	Gear mesh (inches), to the hundredths of an inch
SEINE_L	N	7	5	Length of seine haul (m) to the nearest meter
SEINE_W	N	7	5	Width of seine haul (m) to the nearest meter
HABCHAN	C	2	0	Channel type code
HABTYPE	C	2	0	Primary habitat type code
HABTY2	C	2	0	Secondary habitat type code
SPECIES	C	3	0	Species code
LENGTH	N	4	0	Total length of individual (mm)
WEIGHT	N	5	0	Weight of individual (g) ±1g
SEX	C	1	0	Sex code
MATURITY	N	1	0	Maturity code
PARASITE	N	2	0	Number of parasites, interval code
TAGNUM	C	10	0	Tag number
MARK_REC	C	1	0	Mark or recapture?: M=mark, R=recapture
OLDTAG	C	1	0	Old external tag present? Y=yes, N=no
HEADSTOM	C	5	0	Collected sample code
HEAD_NUM	N	5	0	Collected head sample number
STOM_NUM	N	5	0	Collected stomach sample number
DISPOSE	C	2	0	Disposition
RUN_MO	N	2	0	Month net was run
RUN_DA	N	2	0	Day net was run
RUN_YR	N	2	0	Year net was run
RUN_HR	N	2	0	Hour net was run
RUN_MM	N	2	0	Minute net was run
COMMENTS	C	25	0	Comments
CHNGDATE	D	8	0	Date of record change
CHNGTIME	N	4	0	Time of record change

A-4. Arizona Game and Fish Department File Structures - cont.
Little Colorado River Native Fish Studies

File: MASTERFC.DBF
Contents: Fish collections data, 1991-1993

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
REACH	N	3	0	Colorado River reach: 22=Little Colorado River
LINE	N	3	0	Line of data on data sheet
MILE	N	8	2	Meter above mouth
SIDE	C	1	0	Side of river: R=right, L=left, C=center
FWS	C	3	0	Fish and Wildlife Service transect number
SET_MO	N	2	0	Month of net set
SET_DA	N	2	0	Day of net set
SET_YR	N	2	0	Year of net set
SET_HR	N	2	0	Hour of net set
SET_MM	N	2	0	Minute of net set
GEAR_TYP	C	2	0	Gear type code
GEAR_H	N	2	0	Gear height (ft)
GEAR_L	N	3	0	Gear length (ft)
GEAR_M	N	7	5	Gear mesh (in)
SEINE_L	N	7	5	Length of seine haul
SEINE_W	N	7	5	Width of seine haul
HABCHAN	C	2	0	Channel type code
HABTYPE	C	2	0	Primary habitat type code
HABTY2	C	2	0	Secondary habitat type code
SPECIES	C	3	0	Species code
LENGTH	N	4	0	Total length (mm)
WEIGHT	N	5	0	Weight (g), ±1g
SEX	C	1	0	Sex code
MATURITY	N	1	0	Maturity code
PARASITE	N	2	0	Number of parasites
TAGNUM	C	0	0	Tag number
MARK_REC	C	1	0	Mark or recapture? M=mark, R=recapture
OLDTAG	C	1	0	Old external tag? Y=yes, N=no
HEADSTOM	C	5	0	Sample code
HEAD_NUM	N	5	0	Head sample code
STOM_NUM	N	5	0	Stomach sample code
DISPOSE	C	2	0	Disposition code
RUN_MO	N	2	0	Month net run
RUN_DA	N	2	0	Day net run
RUN_YR	N	2	0	Year net run
RUN_HR	N	2	0	Hour net run
RUN_MM	N	2	0	Minute net run
COMMENTS	C	25	0	Comments
CHNGDATE	D	8	0	Date of record change
CHNGTIME	N	4	0	Time of record change

File: VISCMAST.DBF
Contents: Viscera analysis data, 1988-1993

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
DATE	N	6	0	Date sample collected
TIME	N	4	0	Time sample collected
STOMNUM	C	4	0	Stomach number
SPECIES	C	3	0	Species code
REACH	N	3	0	Colorado River reach: 22 = Little Colorado River
MILE	N	5	0	Meter above confluence
LENGTH	N	3	0	Total length (mm)
WEIGHT	N	4	0	Weight (g), ±1g
GEAR	C	2	0	Gear type code
SEX	C	1	0	Sex code
TOTGONAD	N	7	2	Total gonad weight
EGGS	N	6	2	Weight per 100 eggs
MAT	N	1	0	Maturity code
PARCODE	C	1	0	Number of parasites (interval code)
COMMENTS	C	30	0	Comments
MEATYPE	C	1	0	Viscera content measurement type
GUTFULL	N	6	2	Initial gut fullness
DATANAL	N	6	0	Date analyzed
BY	C	3	0	Person who performed the analysis
TAXA	C	3	0	Taxonomic code
LIFE	C	1	0	Life stage code
NUMBER	N	4	0	Number of each taxa found in gut
VOLUME	N	6	2	Volume or weight of each taxa in gut
COMMENT2	C	30	0	Comments
STATUS	C	1	0	Status of data file
CHG_DT	D	8	0	Date of record change
CHG_TIME	C	8	0	Time of record change
VERSION	N	2	0	Version of data file

File: MOVEMAS1.DBF
Contents: Larval fish movement data (traps),1993

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	3	0	Page of data sheets
METER	N	5	0	Meter above mouth
SIDE	C	1	0	Side of river: R=right, L=left, C=center
FWS	C	3	0	Fish and Wildlife Service transect number
HAB_TYPE	C	2	0	Habitat type code
SET_MO	N	2	0	Month trap set
SET_DA	N	2	0	Day trap set
SET_YR	N	2	0	Year trap set
SET_HR	N	2	0	Hour trap set
SET_MM	N	2	0	Minute trap set
RECORDER	C	3	0	Person who recorded data
RUN_MO	N	2	0	Month trap was run
RUN_DA	N	2	0	Day trap was run
RUN_YR	N	2	0	Year trap was run
RUN_HR	N	2	0	Hour trap was run
RUN_MM	N	2	0	Minute trap was run
IN_CATCH	N	3	0	Number of fish caught in the inflow trap
OUT_CATCH	N	3	0	Number of fish caught in the outflow trap
POOLS	N	3	0	Estimated number of fish in pool
DOWN_CATCH	N	3	0	Number of fish caught in downstream facing trap
TRAP_SIZE	C	1	0	Trap size: S=small, L=large
CM5	N	5	2	Current velocity (m/s), 5 cm from shore, ±.015m/s
CM15	N	5	2	Flow (m/s), 15 cm from shore, ±.015 m/s
CM25	N	5	2	Flow (m/s) at 25 cm from shore, ±.015 m/s
CM35	N	5	2	Flow (m/s) at 35 cm from shore, ±.015 m/s
CM45	N	5	2	Flow (m/s) at 45 cm from shore, ±.015 m/s
CM55	N	5	2	Flow (m/s) at 55 cm from shore, ±.015 m/s
DRFT_CHECK	C	1	0	Drift taken? yes indicated as a check
COMMENTS	C	10	0	Comments
CHNGDATE	D	8	0	Date record was changed
CHNGTIME	N	4	0	Time record was changed

File: FCHABUSE.DBF
Contents: Fish collections habitat use data, 1991-1993

Field	Type	Size	Dec	Description
STUDY	N	5	0	AGFD study number
PAGE	N	4	0	Page of data sheets
BOTTOM	C	2	0	Bottom substrate code
DEPTH	N	4	0	Depth (cm)
FLOW	N	6	2	Current velocity (m/s), ±.01m/s
FEATURE	C	2	0	Cover feature code

A-4. ARIZONA GAME AND FISH DEPARTMENT FILE STRUCTURES

Mainstem Colorado River Native Fish Studies

File: ALLSONDE.DBF
Contents: Data from Hydrolab Datasondes

Field	Type	Size	Dec	Description
STUDY	N	5	0	Study number: trip and location numbers
SITE	N	3	0	Site number at that location
MONTH	N	2	0	Date
DAY	N	2	0	Date
YEAR	N	2	0	Date
HOUR	N	2	0	Time of day
MIN	N	2	0	Time of day
TEMP	N	5	2	Temperature (°C)
PH	N	4	2	pH
COND	N	5	3	Conductivity
SALINITY	N	3	1	Salinity
DOPERSAT	N	5	1	Dissolved oxygen (% Saturation)
DOMGPERL	N	5	2	Dissolved oxygen (mg/L)
REDOX	N	3	0	Redox potential
LEVEL	N	4	2	Depth of sonde
VOLTS	N	4	1	Battery strength

File: A_MASTER.DBF
Contents: Type A sample habitat data

Field	Type	Size	Dec	Description
STUDY	N	5	0	Study number: trip and location numbers
BY	C	3	0	Initials of data recorder
SITE	N	2	0	Site number at that location
HAB_CD	C	2	0	Habitat code
DEPTH	N	3	0	Depth
VELOCITY	N	3	0	Water velocity (cm/s)
TEMP	N	4	1	Temperature
SUBST_CD	C	2	0	Substrate code
TURB	N	6	0	Turbidity (NTU)
DO_PCNT	N	5	1	Dissolved oxygen (% saturation)
DO_MGL	N	5	2	Dissolved oxygen (mg/L)
COND	N	4	0	Conductivity (microsiemens)
AMB_LITE	C	2	0	Ambient light
PH	N	5	2	pH
GEAR_CD	C	2	0	Gear code
HAULS	N	2	0	Number of hauls taken with that gear
EFFORT	N	7	2	Effort (m^2 for seines or hours for traps)
STATUS	C	1	0	dBase information
CHG_DATE	D	8	0	dBase information
CHG_TIME	C	8	0	dBase information
VERSION	N	2	0	dBase information

File: BENTMAST.DBF
Contents: Benthos data

Field	Type	Size	Dec	Description
TRIP_NO	N	2	0	Trip number
PAGE	N	3	0	Page number of data sheet
OFPAGE	N	3	0	Total number of pages
STUDY	N	5	0	Study number: trip and location numbers
SITE	C	5	0	Site number at that location
TAXA	C	9	0	Taxa of organism
NUMBER	N	5	0	Number of that taxa counted
CRUC_NO	N	3	0	Crucible number
CRUC_WGHT	N	8	4	Crucible weight
DRY_WEIGHT	N	8	4	Dry weight of organisms
ASH_WEIGHT	N	8	4	ash weight of organisms

File: DIET_ANA.DBF
Contents: Fish diet analysis (stomach samples)

Field	Type	Size	Dec	Description
STUDY	C	5	0	Study number: trip and location numbers
HAB_CD	C	2	0	Habitat code
SPECIES	C	3	0	Fish species
LENGTH	N	3	0	Total length
TAXA	C	3	0	Taxa of food organism
LIFE_STAGE	C	1	0	Life stage of food organism
NUMBER	N	4	0	Number of food organism counted
PARASITE	C	1	0	Parasitic: Y or N
NOTES	C	30	0	Descriptive notes

A-4. Arizona Game and Fish Studies File Structures - cont.
Mainstem Colorado River Fish Studies

File: **FISH_ALL.DBF**
Contents: **Fish capture data**

Field	Type	Size	Dec	Description
STUDY	N	5	0	Study number: trip and location numbers
SITE	N	3	0	Site number at that location
HAB_CD	C	2	0	Habitat code
HAUL_NO	N	3	0	Haul number
SPECIES	C	3	0	Fish species
LENGTH	N	4	0	Total length
WEIGHT	N	4	0	Weight
NO_COLL	N	3	0	Number collected
SEX	C	1	0	Sex
MATURITY	N	1	0	Maturity code
TAG	C	10	0	Type of mark or tag number (if marked or tagged)
MARK_RECAP	C	1	0	Mark or recapture (if tagged)
DISP	C	2	0	Disposition
STATUS	C	1	0	dBase information
CHG_DATE	D	8	0	dBase information
CHG_TIME	C	8	0	dBase information
VERSION	N	2	0	dBase information

A-4. Arizona Game and Fish Studies File Structures - cont.
Mainstem Colorado River Fish Studies

File: MAP.DBF
Contents: Plane table mapping data

Field	Type	Size	Dec	Description
STUDY	N	5	0	Study number: trip and location numbers
NUMBR_SITE	C	3	0	Site number and habitat code
BM_H20	N	3	0	Benchmark to water elevation
DEEP_PT	N	3	0	Maximum depth
TOT_PERIM	N	6	1	Total perimeter length
NET_LNGTH	N	5	1	Width of backwater at net location
AREA_TOT	N	6	1	Total area
AREA_25	N	6	1	Area < 25 cm deep
AREA_25_50	N	6	1	Area > 25 cm and < 50 cm deep
AREA_50_1	N	6	1	Area > 50 cm and < 100 cm deep
AREA_10_15	N	6	1	Area > 100 cm and < 150 cm deep
AREA_15	N	6	1	Area > 15 cm deep
SILT	N	6	1	Area with predominantly silt substrate
SAND	N	6	1	Area with predominantly sand substrate
GRAVEL	N	6	1	Area with predominantly gravel substrate
PEBBLE	N	6	1	Area with predominantly pebble substrate
COBBLE	N	6	1	Area with predominatly cobble substrate
BOULDER_LD	N	6	1	Area with boulder or ledge substrate
TERR_VEG	N	6	1	Area with terrestrial vegetation
RT_AQ_VEG	N	6	1	Area with rooted aquatic vegetation

A-4. Arizona Game and Fish Studies File Structures - cont.
Mainstem Colorado River Fish Studies

File: **MAST_ALL.DBF**
Contents: **Master data sheet data**

Field	Type	Size	Dec	Description
STUDY	N	5	0	Study number: trip and location numbers
SITES	N	3	0	Site number at that location
MILE	N	6	2	River mile: distance from Lee's Ferry
SIDE	C	1	0	Side of the river (L or R) when facing downstream
REACH	N	3	0	Reach number
MST_MO	N	2	0	Month
MST_DA	N	2	0	Day
MST_YR	N	2	0	Year
MST_HR	N	2	0	Hour
MST_MM	N	2	0	Minute
FLOWCD	C	2	0	Flow code
FLOW	N	5	0	Estimated flow (cfs)
TYPE_A	N	2	0	Type A sample taken
TYPE_B	N	2	0	Type B sample taken
ANGLING	N	2	0	Angling sample taken
OPPORTUN	N	2	0	Opportunistic sample taken
SONDE	N	2	0	DataSonde set
BENTHOS	N	2	0	Benthos sample taken
SEDIMENT	N	2	0	Sediment sample taken
CHLOROPYLL	N	2	0	Chlorophyll sample taken
PLANKTON	N	2	0	Plankton sample taken
MAP_TOTAL	N	2	0	Total station map drawn
MAP_PLANE	N	2	0	Plane table map drawn
VISCERA	N	2	0	Viscera sample taken
DRIFT	N	2	0	Drift sample taken
TYPE_A2ND	N	2	0	Type A secondary sample taken
FISHCOLL	N	4	0	Total number of fish collected
STATUS	C	1	0	dbase information
CHG_DATE	D	8	0	dbase information
CHG_TIME	C	8	0	dbase information
VERSION	N	2	0	dbase information

A-4. Arizona Game and Fish Studies File Structures - cont.
Mainstem Colorado River Fish Studies

File: OPP_ALL.DBF
Contents: Opportunistic sampling data

Field	Type	Size	Dec	Description
STUDY	N	5	0	Study number: trip and location numbers
BY	C	3	0	Initital of data recorder
SITE	N	2	0	Site number at that location
HAB_CD	C	2	0	Habitat code
DEPTH	N	3	0	Depth (cm)
VELOCITY	N	3	0	Water veleocity (cm/s)
TEMP	N	4	1	Temperature (°C)
SUBST_CD	C	2	0	Substrate code
TURB	N	6	0	Turbidity (NTU)
DO_PCNT	N	6	2	Dissolved oxygen (% saturation)
DO_MGL	N	5	2	Dissolved oxygen (mg/L)
COND	N	4	0	Conductivity (microsiemen)
AMB_LITE	C	2	0	Ambient light
GEAR_CD	C	2	0	Gear code
LENGTH	N	3	0	Length of net
HEIGHT	N	4	1	Height of net
MESH	N	7	5	Mesh size of net
EFFORT	N	7	2	Effort (m^2 for seines or hours for traps)
SET_TIME	N	4	0	Trap set time
END_TIME	N	4	0	Trap check time
DISTANCE	N	5	0	Distance upstream from mainstem (tributaries only)
SITE_L	N	6	2	Site length
SITE_W	N	6	2	Mean site width
SITE_D	N	6	2	Mean site depth
PH	N	5	2	pH
STATUS	C	1	0	dbase information
CHG_DATE	D	8	0	dbase information
CHG_TIME	C	8	0	dbase information
VERSION	N	2	0	dbase information

A-4. Arizona Game and Fish Studies File Structures - cont.
Mainstem Colorado River Fish Studies

File: **PLANKTON.DBF**
Contents: **Plankton data**

Field	Type	Size	Dec	Description
STUDY	N	5	0	Study number: trip and location numbers
HAB_CD	C	3	0	Habitat code
SUBSAMPLE	N	1	0	Subsample number
MAG	N	3	0	Microscope magnification used
ROW	N	1	0	Row number on counting slide
TAXA	C	3	0	Taxa of plankton organism
TOTAL	N	3	0	Total number counted of that taxa

File: **PRB3.DBF**
Contents: **Type B sample habitat data**

Field	Type	Size	Dec	Description
STUDY	N	5	0	Study number: trip and location numbers
SITE	N	3	0	Site number at that location
TRAP_NUM	N	2	0	Minnow trap number
CHK_MO	N	2	0	Month
CHK_DA	N	2	0	Day
CHK_YR	N	2	0	Year
CHK_HR	N	2	0	Hour
CHK_MM	N	2	0	Minute
HAB_CD	C	2	0	Habitat code at time of trap check
SUBST_CD	C	2	0	Substrate code
TEMP	N	5	2	Temperature
FLOW_CD	C	2	0	Flow code
FLOW_CFS	N	5	0	Estimate flow (cfs)
DEPTH	N	3	0	Depth (cm)
VELOCITY	N	4	2	Water velocity (cm/s)
NUM_FISH	N	3	0	Number of fish caught

File: **SEDIMENT.DBF**
Contents: **Sediment data**

Field	Type	Size	Dec	Description
STUDY	N	5	0	Study number: trip and location numbers
HABITAT	C	3	0	Habitat code and site number
HAB_CD	C	2	0	Habitat code
CRU_WT	N	9	4	Crucible weight
DRY_WT	N	9	4	Dry weight of sediments
ASH_WT	N	9	4	Ash weight of sediments
PET_WT	N	9	4	Petri dish weight
PET_65	N	9	4	Weight of sediments > 65 µm

A-5. BIO/WEST, INC. FILE STRUCTURES

File: CHUB.DBF
Contents: Humpback chub morphometrics and meristics, Oct 1990-Nov1993

Field	Type	Size	Dec	Description
PIT_TAG	C	10	0	PIT tag number
DATE	C	6	0	Date (year,month,day)
RIVER	C	2	0	River or tributary code
METER	N	4	0	Meters above tributary mouth (±20m)
TYPE	C	1	0	Type of sample
GEAR	C	2	0	Gear code
SAMPLE_NUM	C	3	0	Sample number
TRIP	C	5	0	Trip code
REACH	C	1	0	Mainstem Colorado River reach code
CLIPBOARD	C	1	0	Clipboard number
TL	N	3	0	Total length (mm)
FL	N	3	0	Fork length (mm)
SL	N	3	0	Standard length (mm)
WT	N	4	0	Weight (g), ±1g
SEX	C	1	0	Sex code
RIPE	C	3	0	Gonadal maturity code
P1_P2	N	4	1	Distance between insertions of pectoral and pelvic fins (mm)
ND	N	4	1	Nuchal depression depth (mm)
CPL	N	5	1	Caudal peduncle length (mm)
CPMAXD	N	4	1	Maximum caudal peduncle depth (mm)
CPMIND	N	4	1	Minimum caudal peduncle depth (mm)
HEAD_LN	N	4	1	Head length (mm)
SNOUT_LN	N	4	1	Snout length (mm)
DORSAL_FB	N	4	1	Dorsal fin base (mm)
ANAL_FB	N	4	1	Anal fin base (mm)
BODY_DEPTH	N	5	1	Body depth (mm)
DORSAL_RAY	N	2	0	Number of dorsal fin rays
ANAL_RAY	N	2	0	Number of anal fin rays
RECAPTURE	C	1	0	Recaptured fish
OLD_TAG	C	10	0	Old tag number if fish is recapture
DISP	C	2	0	Disposition code
CAMERA_NUM	C	2	0	Camera number
ROLL_NUM	C	2	0	Roll number
FRAME_NUM	C	5	0	Frame numbers
VIDEO_NUM	C	2	0	Video number
RM_CAPTURE	N	6	2	River mile of capture location (to 1/20 rm)
RM_RELEASE	N	6	2	River mile of release location (to 1/20 rm)
RADIO	C	1	0	Radio-tagged fish
COMMENTS	C	60	0	Comments

File: NET_MC.DBF
Contents: Netting and trapping sample data, Oct 1990-Nov 1993 (humpback chub)

File: NET_HU.DBF
Contents: Netting and trapping sample data, May 1992-Dec 1994 (Hualapai)

Field	Type	Size	Dec	Description
TYPE	C	1	0	Type of sample
TRIP	C	5	0	Trip code
REACH	C	1	0	Mainstem Colorado River reach code
CLIPBOARD	C	1	0	Clipboard number
DATE	C	6	0	Date (year,month,day)
RIVER	C	2	0	River or tributary code
RM	N	6	2	River mile (to 1/20 rm)
METER	N	4	0	Meters above tributary mouth (±20m)
GEAR	C	2	0	Gear code
HAB1	C	2	0	General habitat
HAB2	C	2	0	Specific habitat
HAB3	C	2	0	Shoreline habitat
SIDE	C	1	0	Side of river looking downstream
PROFILE	C	1	0	Cross-section fathometer profile status
MAX_DEPTH	N	4	1	Maximum depth at gear location (m)
SUB1	C	2	0	Dominant substrate
SUB2	C	2	0	Secondary substrate
FISH_PRES	C	1	0	Fish or other materials preserved
NO_BOTTLES	N	1	0	Number of bottles with preserved materials
CAMERA_NUM	C	2	0	Camera number
PHOTO_ROLL	C	2	0	Roll number
FRAME_NUM	C	5	0	Frame numbers
CREW	C	8	0	Initials of crew members
SINGLE	C	1	0	Marks one of multiple records for a sample
SAMPLE_NUM	C	3	0	Sample number
TIME_SET	N	4	0	Net set time
TIME_PULL	N	4	0	Net pull time
END_DATE	C	6	0	Net pull date (year,month,day)
TIME_ELAPS	N	5	2	Elapsed time
LIGHT	C	2	0	Ambient light
WEATHER	C	2	0	Weather
TURBIDITY	C	2	0	Turbidity
TEMP_AIR	N	4	1	Air temperature (°C)
TEMP_MC	N	4	1	Main channel temperature (°C)
TEMP_HAB	N	4	1	Habitat temperature (°C)
FLUCT	C	2	0	River stage change
SPECIES	C	2	0	Fish species code
YOY	N	4	0	Number of young-of-year fish
JUV	N	4	0	Number of juvenile fish
ADU	N	4	0	Number of adult fish
TOTAL	N	4	0	Total number of fish
COMMENTS	C	0	0	Comments
MAP_ID_NUM	C	4	0	Unique net location ID to link with GIS

File: ELEC_MC.DBF
Contents: Electrofishing sample data, Oct 1990-Nov 1993 (humpback chub)

File: ELEC_HU.DBF
Contents: Electrofishing sample data, May 1992-Dec 1994 (Hualapai)

Field	Type	Size	Dec	Description
TYPE	C	1	0	Type of sample
SAMPLE_NUM	C	3	0	Sample number
TRIP	C	5	0	Trip code
REACH	C	1	0	Mainstem Colorado River reach code
CLIPBOARD	C	1	0	Clipboard
DATE	C	6	0	Date (year,month,day)
RIVER	C	2	0	River or tributary code
START_RM	N	6	2	River mile at start of sample (to 1/20 rm)
END_RM	N	6	2	River mile at end of sample (to 1/20 rm)
METER	N	4	0	Meters above tributary mouth (±20m)
TIME_START	N	4	0	Sample start time
TIME_END	N	4	0	Sample end time
SECONDS	N	5	0	Seconds electrofished
VOLTS	N	3	0	Voltage setting
AMPS	N	4	1	Amperage level
LIGHT	C	2	0	Ambient light
HAB1	C	2	0	General habitat
HAB2	C	2	0	Specific habitat
HAB3	C	2	0	Shoreline habitat
SUB1	C	2	0	Dominant substrate
SUB2	C	2	0	Secondary substrate
TEMP_AIR	N	4	1	Air temperature (°C)
TEMP_MC	N	4	1	Main channel temperature (°C)
TEMP_HAB	N	4	1	Habitat temperature (°C)
TURBIDITY	C	2	0	Turbidity
WEATHER	C	2	0	Weather
FLUCT	C	2	0	River stage change
FISH_PRES	C	1	0	Fish or other materials preserved
NO_BOTTLES	N	1	0	Number of bottles of preserved materials
CAMERA_NUM	C	2	0	Camera number
PHOTO_ROLL	C	2	0	Roll number
FRAME_NUM	C	5	0	Frame number
CREW	C	8	0	Initials of crew members
SINGLE	C	1	0	Marks one of multiple records for a sample
SPECIES	C	2	0	Fish species code
YOY	N	4	0	Number of young-of-year fish
JUV	N	4	0	Number of juvenile fish
ADU	N	4	0	Number of adult fish
TOTAL	N	4	0	Total number of fish
COMMENTS	C	60	0	Comments

File: SEIN_MC.DBF
Contents: Seining sample data, Oct 1990-Nov 1993 (humpback chub)

File: SEIN_HU.DBF
Contents: Seining sample data, May 1992-Dec 1994 (Hualapai)

Field	Type	Size	Dec	Description
TYPE	C	1	0	Type of sample
SAMPLE_NUM	C	3	0	Sample number
TRIP	C	5	0	Trip code
REACH	C	1	0	Mainstem Colorado River reach code
CLIPBOARD	C	1	0	Clipboard number
DATE	C	6	0	Date (year,month,day)
RIVER	C	2	0	River or tributary code
RM	N	7	2	River mile (to 1/20 rm)
METER	N	4	0	Meters above tributary mouth (±20m)
GEAR	C	2	0	Gear code
TIME_START	N	4	0	Sample start time
HAB1	C	2	0	General habitat
HAB2	C	2	0	Specific habitat
HAB3	C	2	0	Shoreline habitat
SUB1	C	2	0	Dominant substrate
SUB2	C	2	0	Secondary substrate
TEMP_AIR	N	4	1	Air temperature (°C)
TEMP_MC	N	4	1	Main channel temperature (°C)
TEMP_HAB	N	4	1	Habitat temperature (°C)
QUANT	C	1	0	Quantitative seine haul
SUBSAMPL	C	1	0	Subsampled habitat
LIGHT	C	2	0	Ambient light
WEATHER	C	2	0	Weather
TURBIDITY	C	2	0	Turbidity
FLUCT	C	2	0	River stage change
HABL	N	5	1	Habitat length (m)
HABW	N	5	1	Habitat width (m)
SAMP_LN	N	5	1	Sample length (m)
SAMP_WID	N	5	1	Sample width (m)
SAMP_AREA	N	7	2	Sample area (m^2)
MAX_DEPTH	N	4	1	Maximum depth of habitat (ft)
DEPTH_1	N	4	1	Depth halfway between max and one side (ft)
DEPTH_2	N	4	1	Depth halfway between max and other side (ft)
FISH_PRES	C	1	0	Fish or other materials preserved
NO_BOTTLES	N	1	0	Number of bottles of preserved materials
CAMERA_NUM	C	2	0	Camera number
PHOTO_ROLL	C	2	0	Roll number
FRAME_NUM	C	5	0	Frame number
CREW	C	8	0	Initials of crew members
SINGLE	C	1	0	Marks one of multiple records for a sample
SPECIES	C	2	0	Fish species code
LAR	N	4	0	Number of larval fish
YOY	N	4	0	Number of young-of-year fish
JUV	N	4	0	Number of juvenile fish
ADU	N	4	0	Number of adult fish
TOTAL	N	4	0	Total number of fish
COMMENTS	C	60	0	Comments

File: FISH_MC.DBF
Contents: All fish capture data, Oct 1990-Nov 1993 (humpback chub)

File: FISH_HU.DBF
Contents: All fish capture data, May 1992-Dec 1994 (Hualapai)

Field	Type	Size	Dec	Description
TYPE	C	1	0	Type of sample
SAMPLE_NUM	C	3	0	Sample number
TRIP	C	5	0	Trip code
REACH	C	1	0	Mainstem Colorado River reach code
CLIPBOARD	C	1	0	Clipboard
DATE	C	6	0	Date (year,month,day)
GEAR	C	2	0	Gear code
HAB1	C	2	0	General habitat
HAB2	C	2	0	Specific habitat
HAB3	C	2	0	Shoreline habitat
SUB1	C	2	0	Dominant substrate
SUB2	C	2	0	Secondary substrate
SPECIES	C	2	0	Fish species code
TL	N	3	0	Total length (mm)
SL	N	3	0	Standard length (mm)
LB	N	2	0	Pounds
OZ	N	2	0	Ounces
WT	N	4	0	Weight (g), ±1g
PIT_TAG	C	10	0	PIT tag number
RECAPTURE	C	1	0	Recaptured fish
OLD_TAG	C	10	0	Old tag number if fish is recapture
PHOTO	C	1	0	Photographs taken
VIDEO	C	1	0	Video footage taken
SEX	C	1	0	Sex
RIPE	C	2	0	Gonadal maturity code
DISP	C	2	0	Disposition code
RIVER	C	2	0	River or tributary code
RM	N	6	2	River mile of capture location (to 1/20 rm)
METER	N	4	0	Meters above mouth of tributary (±20m)
RM_RELEASE	N	6	2	River mile of release location (to 1/20 rm)
COMMENTS	C	60	0	Comments

File: SURVEIL.DBF
Contents: Radiotelemetry surveillance, Oct 1990-Nov 1992

Field	Type	Size	Dec	Description
SAMPLE_NUM	C	3	0	Sample number
TRIP_NUM	C	2	0	Trip code
REACH	C	1	0	Mainstem Colorado River reach code
CLIPBOARD	C	1	0	Clipboard number
SINGLE	C	1	0	Marks one of multiple records for a sample
MODE	C	2	0	Type of surveillance
START_DATE	N	6	0	Date at start of surveillance (year,month,day)
START_TIME	N	4	0	Time at start of surveillance
END_DATE	N	6	0	Date at end of surveillance (year,month,day)
END_TIME	N	4	0	Time at end of surveillance
TIME_ELAPS	N	6	2	Time elapsed during surveillance
START_RMI	N	5	1	Starting river mile of surveillance (to 1/20 rm)
END_RMI	N	5	1	Ending river mile of surveillance (to 1/20 rm)
LIGHT	C	2	0	Ambient light
WEATHER	C	2	0	Weather code
TURBIDITY	C	1	0	Turbidity code
SECHI_DISK	N	4	2	Secchi depth (m)
NTU	N	6	1	Turbidity (NTU)
FLUCT	C	2	0	River stage change during surveillance
CREW	C	8	0	Initials of crew members
DATE	N	6	0	Date of individual fish contact (year,month,day)
TIME	N	4	0	Time of individual fish contact
RIVER	C	2	0	River or tributary code
RM	N	6	2	River mile (to 1/20 rm)
SIDE	C	1	0	Side of river looking downstream
FREQ	N	3	0	Tag frequency (40.XXX MHz)
PULSE	N	3	0	Tag pulse rate (pulses/minute)
CONFIDENCE	C	1	0	Observer confidence in location accuracy
HAB2	C	2	0	Specific habitat
COVER	C	2	0	Instream cover
PIT_TAG	C	10	0	PIT tag number
COMMENTS	C	75	0	Comments

File: OBSERV_H.DBF
Contents: Header for radiotelemetry observations, Oct 1990-Nov 1992

Field	Type	Size	Dec	Description
SAMPLE_NUM	C	3	0	Sample number
TRIP_NUM	C	2	0	Trip code
REACH	C	1	0	Mainstem Colorado River reach code
CLIPBOARD	C	1	0	Clipboard number
SINGLE	C	1	0	Marks one of multiple records for a sample
START_DATE	N	6	0	Date at start of observation (year,month,day)
START_TIME	N	4	0	Time at start of observation
END_DATE	N	6	0	Date at end of observation (year,month,day)
END_TIME	N	4	0	Time at end of observation
TIME_ELAPS	N	6	0	Time elapsed during observation
RIVER	C	2	0	River or tributary code
RM	N	6	2	River mile (to 1/20 rm)
MODE	C	2	0	Mode of observation
HAB_MAP_NO	C	10	0	Habitat map number
BENCHMARK	C	6	0	Temporary benchmark code
CONFIDENCE	N	1	0	Observer confidence in location accuracy
CAMERA_NUM	C	2	0	Camera number
PHOTO_ROLL	C	2	0	Roll number
FRAME_NUM	C	5	0	Frame numbers
CREW	C	8	0	Initials of crew members
PIT_TAG	C	10	0	PIT tag number
TL	N	3	0	Total length when implanted (mm)
WT	N	4	0	Weight when implanted (g), ±1g
SEX	C	1	0	Sex
TAG_SIZE	N	2	0	Weight of tag (g)
FREQ_1	N	3	0	Original tag frequency
FREQ_2	N	3	0	Strongest tag frequency observed
PULSE_1	N	2	0	Original tag pulse rate
PULSE_2	N	2	0	Tag pulse rate during observation
SURGEON	C	2	0	Initials of surgeon

File: **OBSERV_M.DBF**
Contents: **Movement for radiotelemetry observations, Oct 1990-Nov 1992**

Field	Type	Size	Dec	Description
SAMPLE_NUM	C	3	0	Sample number
TRIP	C	5	0	Trip code
REACH	C	1	0	Mainstem Colorado River reach code
CLIPBOARD	C	1	0	Clipboard number
SINGLE	C	1	0	Marks one of multiple records for a sample
PIT_TAG	C	10	0	PIT tag number
START_DATE	N	6	0	Date at start of observation block (year,month,day)
START_TIME	N	4	0	Time at start of observation block
START_RMI	N	6	2	River mile location at start of observation block (to 1/20 rm)
START_HAB	C	2	0	Specific habitat at start of observation block
START_GAGE	N	5	1	River stage at start of observation block
START_LITE	C	2	0	Ambient light at start of observation block
START_WEAT	C	2	0	Weather code at start of observation block
START_TURB	C	2	0	Turbidity code at start of observation block
END_DATE	N	6	0	Date at end of observation block (year,month,day)
END_TIME	N	4	0	Time at end of observation block
END_RMI	N	6	2	River mile location at end of observation block (to 1/20 rm)
END_HAB	C	2	0	Specific habitat at end of observation block
MOVEMENT	N	3	0	Movement during observation block (m)
END_GAGE	N	5	1	River stage at end of observation block
END_LITE	C	2	0	Ambient light at end of observation block
END_WEAT	C	2	0	Weather code at end of observation block
END_TURB	C	2	0	Turbidity code at end of observation block
TIME_ELAPS	N	6	2	Time elapsed during observation block
GAGE	N	6	1	River stage change during observation block (cm)
STAGE_RATE	N	7	2	Rate of river stage change (cm/hr)

File: **REMOTE.DBF**
Contents: **Remote radiotelemetry station data, Oct 1990-Nov 1993**

Field	Type	Size	Dec	Description
JUL_DATE	N	3	0	Julian date
TIME	N	4	0	Time
FREQ	N	3	0	Tag frequency (40.XXX MHz)
PULSE	N	3	0	Tag pulse rate (pulses/minute)

File: DRIFT_MC.DBF
Contents: Drift net sample analysis data, Oct 1990-Nov 1993 (humpback chub)

File: DRIFT_HU.DBF
Contents: Drift net sample analysis data, May 1992-Dec 1994 (Hualapai)

Field	Type	Size	Dec	Description
DATE	N	6	0	Date of sample (year,month,day)
TIME_INIT	N	4	0	Time of sample start
TIME_END	N	4	0	Time of sample end
TIME_ELAPS	N	2	0	Elapsed time of drift sample (min)
V1_INIT	N	4	2	First velocity at sample start
V2_INIT	N	4	2	Second velocity at sample start
V3_INIT	N	4	2	Third velocity at sample start
V1_END	N	4	2	First velocity at sample end
V2_END	N	4	2	Second velocity at sample end
V3_END	N	4	2	Third velocity at sample end
VELOCITY	N	4	2	Average velocity
REACH	N	1	0	B/W reach designation
RIVER	C	2	0	River or tributary code
RM	N	6	2	River mile (to 1/20 rm)
METERS	N	3	0	Meters upstream from tributary mouth
STAGE	C	2	0	River stage change
HAB	C	2	0	Channel habitat
DEPTH	C	3	0	Height of net above water surface (cm)
SIMADU	N	4	0	Number of adult simuliids
SIMPUP	N	4	0	Number of pupa simuliids
SIMLAR	N	4	0	Number of larval simuliids
SIMTOT	N	4	0	Total number of simuliids
SIMPER	N	10	8	Percentage simuliids by number
SIMVOL	N	6	4	Volume of simuliids
SIMVP	N	10	8	Percentage simuliids by volume
CHIRADU	N	4	0	Number of adult chironomids
CHIRPUP	N	4	0	Number of pupa chironomids
CHIRLAR	N	4	0	Number of larval chironomids
CHIRTOT	N	4	0	Total number of chironomids
CHIRPER	N	10	8	Percentage chironomids by number
CHIRVOL	N	6	4	Volume of chironomids
CHIRVP	N	10	8	Percentage chironomids by volume
GAMMADU	N	4	0	Number of adult gammarus (>7mm)
GAMMIMM	N	4	0	Number of immature gammarus (<7mm)
GAMMTOT	N	4	0	Total number of gammarus
GAMMPER	N	10	8	Percentage gammarus by number
GAMMVOL	N	6	4	Volume of gammarus
GAMMVP	N	10	8	Percentage gammarus by volume
OTHER	N	4	0	Number of other aquatic invertebrates
OTHERPER	N	10	8	Percentage other aquatic invertebrates by number
OTHERVOL	N	6	4	Volume of other aquatic invertebrates
OTHERVP	N	10	8	Percentage other aquatic invertebrates by volume
INVERT	N	4	0	Total number of invertebrates
INVERTVOL	N	6	4	Total volume of invertebrates
TERR	N	4	0	Number of terrestrial insects
TERRPER	N	10	8	Percentage terrestrial insects by number
TERRVOL	N	6	4	Volume of terrestrial insects

A-5. BIO/WEST, Inc. File Structures - cont.

TERRVP	N	10	8	Percentage terrestrial insects by volume
CLADDRWT	N	7	4	Cladophora dry weight (g)
CLADPER	N	2	0	Percent cladophora
CLADVOL	N	7	4	Volume of cladophora
CLADVP	N	10	8	Percentage cladophora by volume
LABVOL	N	3	0	Sample volume after preservation (ml)
FIELDVOL	N	3	0	Sample volume before preservation (ml)
REHYDVOL	N	3	0	Sample volume after rehydration in lab (ml)
CMH	N	7	2	Water filtered through net (Cubic meters per hour)

File: FOOD.DBF
Contents: Stomach pumping analysis data, 1993

Field	Type	Size	Dec	Description
TYPE	C	1	0	Type of sample
SAMPLE_NUM	C	3	0	Sample number
TRIP	C	5	0	Trip code
REACH	C	1	0	Mainstem Colorado River reach code
CLIPBOARD	C	1	0	Clipboard
DATE	N	6	0	Date of sample (year,month,day)
RIVER	C	2	0	River or tributary code
RM	N	5	1	River mile (to 1/20 rm)
METERS	N	3	0	Meters upstream of tributary mouth
SPECIES	C	3	0	Species of fish stomach pumped
AGE	C	2	0	Age of fish (adult or juvenile)
SEX	C	1	0	Sex
TL	N	3	0	Total length (mm)
SL	N	3	0	Standard length (mm)
LB	N	3	0	Weight in pounds
OZ	N	3	0	Weight in ounces
WT	N	4	0	Weight in grams
PIT_TAG	C	10	0	PIT tag number
GAMMADU	N	3	0	Number of adult gammarus (>7mm)
GAMMIMM	N	3	0	Number of immature gammarus (<7mm)
GAMMTOT	N	3	0	Total number of gammarus
GAMMPCT	N	5	3	Percent gammarus by number
GAMMADUVOL	N	9	4	Volume of adult gammarus
GAMMIMMVOL	N	9	4	Volume of immature gammarus
GAMMTOTVOL	N	9	4	Total volume of gammarus
GAMMVOLPCT	N	5	3	Percent gammarus by volume
SIMADU	N	3	0	Number of adult simuliids
SIMLAR	N	3	0	Number of larval simuliids
SIMPUP	N	3	0	Number of pupa simuliids
SIMTOT	N	3	0	Total number of simuliids
SIMPCT	N	5	3	Percent simuliids by number
SIMADUVOL	N	3	0	Volume of adult simuliids
SIMLARVOL	N	3	0	Volume of larval simuliids
SIMPUPVOL	N	3	0	Volume of pupa simuliids
SIMTOTVOL	N	3	0	Total volume of simuliids
SIMVOLPCT	N	5	3	Percent simuliids by volume
CHIRADU	N	3	0	Number of adult chironomids
CHIRPUP	N	3	0	Number of pupa chironomids
CHIRLAR	N	3	0	Number of larval chironomids
CHIRTOT	N	3	0	Total number of chironomids
CHIRPCT	N	5	3	Percent chironomids by number
CHIRADUVOL	N	3	0	Volume of adult chironomids
CHIRPUPVOL	N	3	0	Volume of pupa chironomids
CHIRLARVOL	N	3	0	Volume of larval chironomids
CHIRTOTVOL	N	3	0	Total volume of chironomids
CHIRVOLPCT	N	5	3	Percent chironomids by volume
ANNELID	N	3	0	Number of annelids
ANNELPCT	N	5	3	Percent annelids by number
ANNELIDVOL	N	9	4	Volume of annelids
OTHER_AQUA	N	3	0	Number of other aquatic insects
O_A_PCT	N	3	0	Percent other aquatic insects+annelids by number

A-5. BIO/WEST, Inc. File Structures - cont.

OTHER_AVOL	N	9	4	Volume of other aquatic insects
O_A_VOLPCT	N	5	3	Percent other aquatic insects by volume
TERR	N	3	0	Number of terrestrial insects
TERRPCT	N	5	3	Percent terrestrial insects by number
TERRVOL	N	9	4	Volume of terrestrial insects
TERRVOLPCT	N	5	3	Percent terrestrial insects by volume
TOTALINVER	N	4	0	Total number of invertebrates
TOTINVVOL	N	9	4	Volume of invertebrates
INVVOLPCT	N	5	3	Percent invertebrates by volume
CLADVOL	N	3	0	Volume of cladophora (ml)
CLADVOLPCT	N	5	3	Percent cladophora by volume
NEMOTODES	L	1	0	Presence of nematodes
TAPEWORMS	L	1	0	Presence of tapeworms
FISH	C	1	0	Presence of fish
TOTALVOL	N	9	4	Total volume of sample
MEMO	C	200	0	Details of sample

File: DSOND_MC.DBF
Contents: Datasonde water quality data, Oct 1990-Nov 1993 (humpback chub)

File: DSOND_MC.DBF
Contents: Datasonde water quality data, May 1992-Dec 1994 (Hualapai)

Field	Type	Size	Dec	Description
DATE	N	6	0	Date (year,month,day)
TIME	N	4	0	Military time
RIVER	C	2	0	River or tributary code
RM	N	6	2	River mile (to 1/20 rm)
TEMP	N	5	2	Temperature (°C)
PH	N	5	2	pH
COND	N	6	3	Conductivity
DO	N	5	2	Dissolved oxygen
BATT	N	5	2	Battery voltage

File: SURV_MC.DBF
Contents: Surveyor II water quality data, Oct 1990-Nov 1993 (humpback chub)

File: SURV_HU.DBF
Contents: Surveyor II water quality data, May 1992-Dec 1994 (Hualapai)

Field	Type	Size	Dec	Description
DATE	N	6	0	Date (year,month,day)
TIME	N	4	0	Military time
RIVER	C	2	0	River or tributary code
RM	N	6	2	River mile (to 1/20 rm)
TEMP	N	5	2	Temperature (°C)
PH	N	5	2	pH
TRUEDO	N	5	2	Dissolved oxygen
COND	N	6	3	Conductivity
ORP	N	6	3	Oxidation-reduction potential
BATT	N	5	2	Battery voltage

File: JUVHAB.DBF
Contents: Juvenile habitat measurements, Oct 1990-Nov 1993

Field	Type	Size	Dec	Description
SAMPLE_NUM	C	3	0	Sample number
TRIP	C	5	0	Trip code
REACH	C	1	0	Mainstem Colorado River reach code
DATE	N	6	0	Date (year,month,day)
RIVER	C	2	0	River or tributary code
RM	N	5	2	River mile (to 1/20 rm)
SIDE	C	1	0	Side of river looking downstream
TBM	C	8	0	Temporary benchmark location code
GAGE_BEG	N	4	0	River stage at beginning of sample
GAGE_END	N	4	0	River stage at end of sample
TIME_BEG	N	4	0	Time at start of sample
TIME_END	N	4	0	Time at end of sample
LC_MC_FLOW	N	5	0	Approximate discharge in cfs
SHORETYPE	C	15	0	Shoreline type
CREW	C	8	0	Initials of crew members
FISHPRESNT	C	1	0	Fish present
COMMENTS	C	20	0	Comments
TRAN_NUM	N	2	0	Transect number
DIST_05_DP	N	5	2	Depth 0.5 meters from shore (ft)
DIST_05_VL	N	5	2	Velocity at 0.6 depth, 0.5 meters from shore (ft/s)
DIST_05_S1	C	2	0	Dominant substrate 0.5 meters from shore
DIST_05_S2	C	2	0	Secondary substrate 0.5 meters from shore
DIST_10_DP	N	5	2	Depth 1.0 meter from shore (ft)
DIST_10_VL	N	5	2	Velocity at 0.6 depth, 1.0 meter from shore (ft/s)
DIST_10_S1	C	2	0	Dominant substrate 1.0 meter from shore
DIST_10_S2	C	2	0	Secondary substrate 1.0 meter from shore
DIST_15_DP	N	5	2	Depth 1.5 meters from shore (ft)
DIST_15_VL	N	5	2	Velocity at 0.6 depth, 1.5 meters from shore (ft/s)
DIST_15_S1	C	2	0	Dominant substrate 1.5 meters from shore
DIST_15_S2	C	2	0	Secondary substrate 1.5 meters from shore
DIST_25_DP	N	5	2	Depth 2.5 meters from shore (ft)
DIST_25_VL	N	5	2	Velocity at 0.6 depth, 2.5 meters from shore (ft/s)
DIST_25_S1	C	2	0	Dominant substrate 2.5 meters from shore
DIST_25_S2	C	2	0	Secondary substrate 2.5 meters from shore

File: SCALES.DBF
Contents: Humpback chub scale analysis, Oct 1990-Nov 1993

Field	Type	Size	Dec	Description
BOX	C	2	0	Box number of slide location
FISH_NO	C	2	0	Sequential fish number
SINGLE	C	1	0	Marks one of multiple scales per fish
SAMPLE_NO	C	8	0	Unique sample identifier
DATE	N	6	0	Date (year,month,day)
SPECIES	C	2	0	Fish species code
RIVER_MILE	N	6	2	Mainstem river mile (to 1/20 rm)
METERS	N	5	0	Meters from tributary mouth (for AGF scales)
TL	N	3	0	Total length (mm)
SL	N	3	0	Standard length (mm)
SCALE_RAD	N	4	1	Length from nucleus to scale margin (μm)
NO_CIRC	N	2	0	Total number of circuli
A1	N	4	1	First annulus from nucleus (μm)
NO_CIRC_A1	N	2	0	Number of circuli to first annulus
A2	N	4	1	Second annulus from nucleus (μm)
NO_CIRC_A2	N	2	0	Number of circuli to second annulus
A3	N	4	1	Third annulus from nucleus (μm)
NO_CIRC_A3	N	2	0	Number of circuli to third annulus
A4	N	4	1	Fourth annulus from nucleus (μm)
NO_CIRC_A4	N	2	0	Number of circuli to fourth annulus
A5	N	4	1	Fifth annulus from nucleus (μm)
NO_CIRC_A5	N	2	0	Number of circuli to fifth annulus
A6	N	4	1	Sixth annulus from nucleus (μm)
NO_CIRC_A6	N	2	0	Number of circuli to sixth annulus
X	N	4	1	Length from nucleus to transitional check (μm)
NO_CIRC_X	N	2	0	Number of circuli to transitional check
AGE	N	1	0	Age of fish when scale collected
YEAR_CLASS	N	4	0	Year fish was hatched
RELIABLE	C	1	0	Reliability of scale information
PCX	N	5	2	Proportional total length at trans. check
BCX	N	5	2	Back-calculated total length at trans. check (mm)
BC1	N	5	2	Back-calculated total length at first annulus (mm)
PC1	N	5	2	Proportional total length at first annulus
BC2	N	5	2	Back-calculated total length at second annulus (mm)
BC3	N	5	2	Back-calculated total length at third annulus (mm)
BC4	N	5	2	Back-calculated total length at fourth annulus (mm)
BC5	N	5	2	Back-calculated total length at fifth annulus (mm)
BC6	N	5	2	Back-calculated total length at sixth annulus (mm)

A-6. PAST COLLECTIONS FILE STRUCTURES

The following structures were described by Kubly (1990). Data field descriptions are not available at this time.

File: **MNACATCH.DBF**
Contents: **Carothers et al. catch file**

Field	Type	Size	Dec	Description
WACODE	N	4	0	
WATER	C	5	0	
GEAR	N	1	0	
DATE	N	6	0	
EFFORT	N	5	0	
STATION	C	5	0	
TIME	N	4	0	
SPECIES	C	3	0	
LENGTH	N	5	0	
WEIGHT	N	5	0	
SEX	C	1	0	
MAT	N	1	0	
TAGNO	N	10	0	
RECAPNO	N	10	0	

File: LKRARE.DBF
Contents: Kaeding and Zimmerman rare file

Field	Type	Size	Dec	Description
RIVER	C	2	0	
STRATUM	C	1	0	
RIVERMILE	N	4	1	
TYPE	C	1	0	
DATE	C	6	0	
START	N	4	0	
STOP	N	4	0	
GEAR	C	2	0	
HAB_1	C	2	0	
HAB_2	C	2	0	
DEPTH	N	4	1	
VELOCITY	N	3	1	
SUBSTR_1	C	2	0	
SUBSTR_2	C	2	0	
SPECIES	C	2	0	
SEX	C	1	0	
TL_MM	N	5	0	
WT_G	N	5	1	
DORSFIN	N	2	0	
ANALFIN	N	2	0	
P1_P2	N	3	1	
D	N	3	1	
TAGNO	C	5	0	
COLOR	C	1	0	
RECAP	C	1	0	
LERNAEA	N	8	0	
DEPOSITION	C	2	0	
AGECLASS	C	2	0	

File: LKPHYS.DBF
Contents: Kaeding and Zimmerman physical file

Field	Type	Size	Dec	Description
RIVER	C	2	0	
STRATUM	C	1	0	
RIVERMILE	N	3	1	
DATE	N	6	0	
TIME	N	4	0	
H2OTEMP_C	N	3	1	
AIRTEMP_C	N	2	0	
DO_PPM	N	2	0	
CONDUCT	N	4	0	
SALIN	N	2	1	
TURB	N	2	0	
PH	N	2	1	
WIDTH_1	N	3	0	
MAXD_1	N	3	1	
MEAND_1	N	3	1	
S2D_1	N	4	1	
WIDTH_2	N	3	0	
MAXD_2	N	3	1	
MEAND_2	N	3	1	
S2D_2	N	4	1	
WIDTH_3	N	3	0	
MAXD_3	N	3	1	
MEAND_3	N	3	1	
S2D_3	N	4	1	

File: LKCATCH.DBF
Contents: Kaeding and Zimmerman catch file

Field	Type	Size	Dec	Description
STRATUM	N	1	0	
RIVERMILE	N	4	1	
TYPE	C	1	0	
DATE	N	6	0	
START	N	4	0	
STOP	N	4	0	
GEAR	C	2	0	
HAB_1	C	2	0	
HAB_2	C	2	0	
AREA	N	4	0	
DEPTH	N	4	1	
VELOCITY	N	3	1	
SUBSTR_1	C	2	0	
SUBSTR_2	C	2	0	
SPECIES	C	2	0	
YOY	N	4	0	
JUV	N	3	0	
ADU	N	3	0	

File: AGFDLARV.DBF
Contents: AGFD larval fish file

Field	Type	Size	Dec	Description
WACODE	N	4	0	
HAB	C	1	0	
SUB	C	1	0	
COVER	C	1	0	
TEMP	N	4	0	
GEAR	N	1	0	
MONTH	N	2	0	
DAY	N	2	0	
YEAR	N	2	0	
EFFORT	N	5	0	
STATION	C	5	0	
TIME	N	4	0	
SPECIES	C	3	0	
LENGTH	N	5	0	
WEIGHT	N	5	0	
COLNO	N	3	0	
DEPTH	N	4	0	
VELOCITY	N	4	0	
NAME	C	4	0	

File: AGFDHAB.DBF
Contents: AGFD habitat file

Field	Type	Size	Dec	Description
MONTH	N	2	0	
DAY	N	2	0	
YEAR	N	2	0	
NAME	C	20	0	
RIVERMILE	N	5	0	
POWER	C	1	0	
TIME	N	4	0	
SHORE	C	1	0	
HAB	C	1	0	
SUB	C	1	0	
VEG	C	1	0	
SPECIES	C	3	0	
AGE	C	1	0	

A-6. Past Collections File Structures - cont.

File: AGFCATCH.DBF
Contents: AGFD catch file

Field	Type	Size	Dec	Description
WACODE	N	4	0	
WATER	C	5	0	
GEAR	N	1	0	
DATE	N	6	0	
EFFORT	N	5	0	
STATION	C	5	0	
TIME	N	4	0	
SPECIES	C	3	0	
LENGTH	N	5	0	
WEIGHT	N	5	0	
SEX	C	1	0	
MAT	N	1	0	
TAGNO	N	10	0	
RECAPNO	N	10	0	

File: MILLER.DBF
Contents: R.R. Miller Morphometric/Meristic file

Field	Type	Size	Dec	Description
SP	N	1	0	Species number (3=gila elegans)
NUM	N	3	0	Specimen number
SX	N	1	0	Sex
BASIN	N	1	0	(1=NM,AZ,NV; 2=CO,WY,UT)
STATE	C	2	0	State abbreviation
LOC	C	50	0	Location Description
SL	N	6	1	Standard length
DR	N	6	1	Number of dorsal fin rays
AR	N	6	1	Number of anal fin rays
LL	N	6	1	Lateral line scales
GR	N	6	1	Gill rakers (2nd arch)
SL	N	6	1	Standard length
HL	N	6	1	Head length
EYE	N	6	1	Eye diameter
SNL	N	6	1	Snout length
PREANL	N	6	1	Preanal length
HDE	N	6	1	Head depth through eye
HDO	N	6	1	Head depth at occiput
IORB	N	6	1	Interorbital, bony
OSNT	N	6	1	Occiput to snout tip
DBASE	N	6	1	Dorsal fin base
ABASE	N	6	1	Anal fin base
TV	N	6	1	Trunk vertebrae
CV	N	6	1	Caudal vertebrae
PREDOR	N	6	1	Predorsal length
LPEC	N	6	1	Pectoral length
LPEL	N	6	1	Pelvic length
UJAW	N	6	1	Upper jaw length
MW	N	6	1	Mouth width
BDP1	N	6	1	Body depth over P1 insertion
CPD	N	6	1	Caudal peduncle depth
AOCB	N	6	1	Anal origin to caudal base
LPHAR	N	6	1	Length of pharyngeal arch
WPHAR	N	6	1	Width of pharyngeal arch
T1	N	6	1	Pharyngeal teeth counts (#1)
T2	N	6	1	Pharyngeal teeth counts (#2)
T3	N	6	1	Pharyngeal teeth counts (#3)
T4	N	6	1	Pharyngeal teeth counts (#4)
LPOSTL	N	6	1	Length of posterior limb of pharyngeal
LANTL	N	6	1	Length of anterior limb of pharyngeal
P1P2	N	6	1	Length between P1 and P2
FRONDEP	N	6	2	Nuchal depth

APPENDIX B

DATABASE CODE DEFINITIONS FOR INDIVIDUAL DATABASES

B-1. ARIZONA STATE UNIVERSITY
DATABASE CODE DEFINITIONS

CAMP

C	Confluence
P	Powell
S	Salt

TRIP

Numbered sequentially from 1-12+ for a given year

YEAR CODE

A	1991
B	1992
C	1993
etc	

WACODE

22	Little Colorado River

LOCATION

USFWS transect code and/or generic site name

GEAR

2	Trammel
3	Seine
5	Hoop
6	Angling

SPECIES

RBT	Rainbow trout
BRT	Brown trout
HBC	Humpback chub
STB	Striped bass
FHM	Fathead minnow
RGK	RioGrand killifish
CRP	Common carp
SD	Speckled dace
FMS	Flannelmouth sucker
CCF	Channel catfish
BHS	Bluehead sucker
BBH	Black bullhead
YBH	Yellow bullhead
RBS	Razorback sucker
BG	Bluegill

SEX

0	Unknown
1	Male
2	Female

MATURITY

0	Immature
2	Mature
3	Ripe
4	Spent
6	Mortality

B-2. U.S. FISH AND WILDLIFE SERVICE DATABASE CODE DEFINITIONS

GEAR

AHP	ASU hoopnet
MNP	FWS mini-hoopnet
MTP	FWS minnow trap
SEN	FWS seine
TRN	FWS transect
ICM	ICM meter
HDL	Hydrolab
HDLL	Hydrolab with logger

GEARD (mesh, # hoops, hoop diameter)

mesh	25	1/4"
	50	1/2"
# hoops	4	
	5	
	6	
	etc.	
diameter	50	
	60	
	70	
	80	
	90	

CUR

0	none (0-.02 m/s)
1	very slow (.02-.10 m/s)
2	slow (.10-.30 m/s)
3	moderate (.30-.70 m/s)
4	fast (.70-1.20 m/s)
5	very fast (>1.20 m/s)

CC (current comments)

E	backcurrent or eddy
T	turbulent flow
P	plunge pool or waterfall
+	slightly faster current
-	slightly slower current

SUB

M	marl
0	silt or marl (<.06 mm)
1	silt-sand (.07-.10 mm)
2	sand (.11-2.0 mm)
3	gravel (2.1-15 mm)
4	pebble (16-31 mm)
5	rock (32-100 mm)
6	cobble (101-255 mm)
7	small boulder (256-1000 mm)
8	boulder (1-3 m)
9	large boulder (>3 m)
10 or T	travertine
11	bedrock

SBC (substrate descriptor)

M	marl
T	travertine
H	rough or horny travertine
Q	travertine dam or terrace
B	smooth or bottom/basement travertine
V	vegetation
A	algae
P	pondweed
R	roots
F	phragmites stems
C	cattail stems
S	shrubs or small tree
D	detritus
W	wood
L	leaves
G	dry ground or land
Z	particle is composed of solid travertine

M

0	20m transect
1	100m transect

CVR

0	none
1	slight
2	little
3	moderate
4	extensive
5-8	deep water cover negative values unsuitable habitat

VER

0	no vertical structure
1	V in OVH and depth 10-25 cm
2	V in OVH and depth 25-50 cm
3	V in OVH and depth 50-100 cm
4	V in OVH and depth >100 cm
+1	E and O,L,U, or W in OVH and depth >25 cm

VEG

0	no vegetation
1	small macrophytes or filamentous algae
2	roots and small emergent vegetation, rushes
3	large emergent vegetation

MAR

0	no marl
1	mixture of marl and silt or sand
2	marl coating on larger substrates
3	thick marl deposit as primary substrate

TRA

0	no travertine
1	travertine coated substrates
2	smooth or rough travertine as primary substrate
3	rough travertine and solid travertine masses associated with travertine dams and reefs

SHA

0	<10% or no shade
1	10-50% shade
2	50-75% shade
3	>75% shade

DEB

0	no debris
1	detritus and leaves
2	sticks and small logs
3	large submerged logs

B-2. U.S. Fish and Wildlife Service Database Code Definitions - cont.

PER	
M	midnight sample (22:00-02:00)
A	night time sample (02:00-10:00)
P	daytime sample (10:00-22:00)
SPP	
HBC	humpback chub
BHS	bluehead sucker
FMS	flannelmouth sucker
SPD	speckled dace
CCF	channel catfish
FHM	fathead minnow
CCP	common carp
KLF	plains killifish
RBT	rainbow trout
BNT	brown trout
CUT	cutthroat trout
GSF	green sunfish
LMB	largemouth bass
RBS	razorback sucker
RSH	red shiner
FIN	
UCRP	upper caudal, right pectoral
UCLP	upper caudal, left pectoral
LCRP	lower caudal, right pectoral
LCLP	lower caudal, left pectoral
CAMP	
S	Salt camp
P	Powell camp
A	Atomizer
B	Blue Springs
C	confluence
SECCHI	
0	<0.5
1	0.5-1.0

B-3. ARIZONA GAME AND FISH DATABASE CODE DEFINITIONS
Little Colorado River

REACH

022	Little Colorado River
020	Colorado above LCR
030	Colorado below LCR

MILE

Confluence at 61.5
Use meters above mouth for LCR

SIDE

L	Left (looking downstream)
R	Right (looking downstream)
C	Center

GEAR-TYPE

BS	Bag Seine
SS	Straight Seine
MT	Minnow Trap
HN	Hoop Net (round, no leads)
AN	Angling
DP	Dip Net

GEAR-H (height)

Record to the nearest ft.

GEAR-L (length)

Record to the nearest ft.

GEAR-M (mesh)

0.03	1/32 in.
0.06	1/16 in.
0.12	1/8 in.
0.25	1/4 in.
0.50	1/2 in.
0.75	3/4 in.
1.00	1 in.
1.50	1-1/2 in.
2.00	2 in.
E	Experimental

AREAL EFFORT-LEN

Length of seine haul to nearest meter
Length of dip net sweep to nearest cm

AREAL EFFORT-WID

Width of seine haul to nearest meter
Width of dip net to nearest cm

CHANNEL TYPE

MC	Main Channel
SC	Side Channel
TS	Tributary Stream
TM	Tributary Mouth

1° HABITAT

CB	Connected backwater
IB	Isolated backwater
ED	Eddy
RI	Riffle
RU	Run
EW	Edgewater
CO	Cove
SC	Springflow Channel (arising from sidechannel)
PO	Pool

2° HABITAT

PL	Plunge Pool
DP	Dammed Pool
PW	Pocket Water (pool)
TP	Travertine Pool
LP	Lateral Scour Pool
PP	Peripheral Pool
CA	Cascade (riffle)

SUBSTRATE

BD	Bedrock (>4.096 m)
BO	Boulder (0.256-4.096 m)
CO	Cobble (64-256 mm)
PB	Pebble (32-64 mm)
GR	Gravel (2-32 mm)
SA	Sand (0.062-2 mm)
SI	Silt (4-62 µm)
CL	Clay (0.24-4 µm)
DE	Detritus
CC	Calcium carbonate floc
TR	Travertine (tufa)

FEATURES

DE	Depth >0.5 m
TU	Turbulence
LE	Ledge
BO	Boulder
UB	Undercut Bank
TD	Turbidity
OV	Overhanging Vegetation
IV	Instream Vegetation
WD	Woody Debris
DA	Dam (upstream)

SPECIES

BHS	Bluehead mountain sucker
FMS	Flannelmouth sucker
RBS	Razorback sucker
SUC	Unidentified sucker
HBC	Humpback chub
SPD	Speckled dace
FHM	Fathead minnow
RSH	Red shiner
CRP	Carp
PKF	Plains killifish
CCF	Channel catfish
RBT	Rainbow trout
UID	Unidentified species
SHY	Sucker hybrid

B-3. Arizona Game and Fish Database Code Definitions - cont.
Little Colorado River

SEX

M	Male
F	Female
U	Undetermined
N	Determination not attempted

MAT (maturity)

3	Ripe-gametes extrudable
4	Spent female-fish has expelled gametes
5	Tuberculate (not ripe)
6	Undeterminable
7	Not attempted

PAR #

Number of external parasites (Lernea) visible
Record location codes in comments!

EXT-Y/N (external tag) - Record type code, color code, and number in Comments

F	Floy tag (type)
C	Carlin tag (type)
Y	Yellow
G	Green
B	Blue
O	Orange
R	Red

HEAD-STOM - Record 2-letter code followed by 2-digit number

HE	Head, ethanol
SF	Stomach, formalin
BE	Body (entire fish), ethanol
BF	Body (entire fish), formalin
HS	Head and stomach preserved in ethanol and formalin, respectively

DIS (disposition)

RA	Released alive
DN	Dead, not taken
DP	Dead, preserved
DS	Dead, skeletonized
SP	Sacrificed, preserved
SS	Sacrificed, skeletonized
MN	Mortality, not taken
MP	Mortality, preserved
MS	Mortality, skeletonized

COMMENT CODES

00	Fishless
01	Coloration
02	Fishless w/ qualification
03	Equipment failure
04	External tag
05	Body scars/bruising
06	Predator bite scars
07	Fin condition
08	Pulled net
09	Pit tag/external tag scar
10	Upper caudal + RP2 fin clips
11	Upper caudal + LP2 fin clips
12	Lower caudal + RP2 fin clips
13	Lower caudal + LP2 fin clips
14	Dorsal fin punch
15	Caudal fin punch
16	Radio tagged
20	Escaped
21	PIT tagged but number not recorded
22	More than one tag injected
23	Collected from longitudinal survey
24	Proto larva
25	Meso larva
26	Meta larva

LENGTH

01	<6 mm
02	6-10 mm
03	11-20 mm
04	21-30 mm
05	31-40 mm
06	41-50 mm
07	51-60 mm
08	61-70 mm
09	71-80 mm
10	81-90 mm
11	91-100 mm
etc	

HABTYPE

PP	Periferal pool
VS	Vegetated shoreline
OS	Non-vegetated shoreline
SC	Spring-flow channel

B-3. Arizona Game and Fish Database Code Definitions - cont.
Little Colorado River

DRIFT AND VISCERA INVERTEBRATE CODE SHEET

INSECTS	
Diptera	DPA
Simulidae	SIM
Chironomidae	CHI
Empididae	EMP
Ceratopogonida	CPG
Dixidae	DIX
Dolichopodidae	DOL
Sciaridae	SCI
Ephydridae	EPY
Schizophora-DIV	SCZ
Trixoscelidae	TRX
Hemiptera	HMA
Gerridae	GER
Veliidae	VEL
Miridae	MIR
Tingidae	TNG
Berytidae	BEY
Saldidae	SAL
Hebridae HEB	
Mesoveliidae	MES
Macroveliidae	MAC
Homoptera	HOM
Cicadellidae	CDL
Aphididae	APH
Psyllidae PSY	
Trichoptera	TRI
Hydropsychidae	HPS
Hydroptilidae	HPT
Hymenoptera	HYM
Encyrtidae	ENC
Pteromalidae	PTE
Formicidae	FOR
Braconidae	BRA
Eulophidae	EUL
Apoidea	APO
Eurytomidae	EUR
Coleoptera	CLA
Elmidae	ELM
Dryopidae	DRY
Chrysomelidae	CHR
Curculionoidae	CUR
Hydrophilidae	HYP
Ephemeroptera	EPH
Baetidae	BAT
Siphlonuridae	SIP
Megaloptera	MEG
Corydalidae	CYD
Embioptera	EMB
Odonata	ODO
Gomphidae	GPH
Thysanoptera	THY
Thripidae	THR
Phloeothripidae	PHL
Collembola	COL
Psocoptera	PSO
Plecoptera	PLE
Neuroptera	NEU
Thysanura	THU
Orthoptera	ORT
Lepidoptera	LEP
Stretsiptera	STR
Isoptera	ISO
Mallophaga	MLO
OTHERS	
Araneida	ARA
Acarina	ACA
Hydracarina	HYD
Ostrocoda	OST
Amphibia	AMP
Bufo	BFO
Mollusca	MOL
Bivalvia	BIV
Gastropoda	GAS
Tapeworm(s)	TPW
Nematoda	NEM
Annelids	ANN
Hirundea HIR	
Oligochaeta	OLI
Rotifera	ROT
Cladocera	CLC
Copepoda	COP
Taxa	TAX
Chlorohydra	HYA
WHOLE SAMPLE	
Fish(UKN)	FFF
Sucker	SUW
Flannel Mth	FMW
Bluehead	BHW
Speck. Dace	SPW
Humpback Chub	HBW
Fathead Minn.	FHW
Killifish	PKW
Catfish	CCW
Carp	CRW
QUARTER SAMPLE	
FISH (UKN)	FHS
Sucker	SUC
Flannel Mth	FMS
Bluehead	BHS
Speck Dace	SPD
Humpback Chub	HBC
Fathead Minn.	FHM
Killifish	PKF
Catfish	CCF
Carp	CRP
Eggs(UKN)	EGG
Fish eggs-100%	EEE
Fish eggs-25%	EGF
Insect eggs	EGI
Amph. eggs	EGA
MISCS.	
Body parts	BPS
Pollen	POL
Seeds	SEE
Crustacea	CRU
Algae	ALG
Other Misc. Org.	OMO
Detritus	DET
Sand, Gravel	ROC
Empty	EPT
LIFE STAGE	
Adult	A
Pupae	P
Larva	L
Nymph	N
Prolarva	R
Mesolarva	M
Metalarva T	
Juvenile	J
MATURITY	
No Maturity	0
Many Sm eggs	1
Mature	2
Ripe	3
Spent	4
Unknown Mat.	6
PARASITE CODES	
None	0
1-10	1
11-100+	2

B-3. ARIZONA GAME AND FISH DATABASE CODE DEFINITIONS
Mainstem Colorado River

AMB_LITE: Ambient Light Codes

SU	Sunny
PC	PTly Cloudy (<50% cloud cover)
CL	Cloudy (>50% cloud cover)
SH	Shade
NI	Night
ML	Moonlight
DN	Dawn
DK	Dusk

DISP: Disposition codes

RA	Released Alive
MN	Mortality
MP	Mortality, Preserved
SP	Sacrificed, Preserved
OB	Observed

FLOW_CD: Flow Codes

AC	Ascending
DC	Descending
SH	Stable High
SL	Stable Low

GEAR_CD: Gear codes

BS	Small Bag Seine 15' x 6' x 1/8" (1/32" bag mesh)
BL	Large Bag Seine 30' x 6' x 1/4" (1/8" bag mesh)
SS	Small Straight Seine 15' x 4' x 1/8"
SL	Large Straight Seine 30' x 6' x 1/16"
KS	Kick Seine 3' x 3' x 1/32"
DS	Small Mesh Dip Net 1/16"
DL	Large Mesh Dip Net 3/16"
MH	Mini-Hoop Net 1.5' x 4' x 3/8"
HN	Hoop Net 3' x 5' x 3/8" x 40' wings
TN	Trammel Net (Set)
TS	Trammel Net (Used As A Seine)
LD	Larval Drift
MT	Minnow Trap
AN	Angling

HAB_CD: Habitat Codes

<u>Backwaters</u>

BE	Backwater Eddy
BW	Backwater
BM	Backwater Mouth - Connected Mouth
BC	Backwater Center - Connected Center
CB	Connected Backwater
CC	Connected Center
CE	Connected Eddy
CF	Connected Foot
CM	Connected Mouth
DW	Dewatered (used for trap sets)
IB	Isolated Backwater
IP	Isolated Pool
SC	Side Channel

<u>Mainchannel</u>

BF	Beach Face
BO	Boulder Shoreline
CO	Cove
DM	Dewatered (used for trap sets)
ED	Eddy
MC	Mainchannel
ME	Mainchannel Eddy
MR	Main River
MS	Mainstream
SC	Side Channel

<u>Tributaries</u>

DT	Dewatered (used for trap sets)
ED	Eddy
PO	Pool
RA	Rapid
RI	Riffle
RU	Run
TM	Tributary Mouth
TS	Tributary Side Channel
PL	Pool
TS	Tributary Side Channel
TB	Tributary

LIFE_STAGE: Life stage codes for diet analysis

A	Adult
P	Pupae
L	Larva
N	Nymph
R	Prolarva
M	Mesolarva
T	Metalarva
J	Juvenile
U	Unknown

MATURITY

0	Larval, Juvenile
1	Adult, Non-breeding
2	Gravid
3	Ripe
4	Spent
5	Tuberculate
6	Undetermined
7	Not Attempted
8	High Color

PARASITE

0	None
1	1-10
2	11-100+

REACH

010	Mainstem: Glen Canyon Dam to Lees Ferry (RM 0)
011	Paria River (RM 0.9)
020	Mainstem: Lees Ferry to Little Colorado River (RM

B-3. Arizona Game and Fish Database Code Definitions - cont.
Mainstem Colorado River

	61.5)
021	Nankoweap Creek (RM 52.2R)
022	Little Colorado R. (RM61.5L)
030	Mainstem: LCR to Bright Angel Creek (RM 87.62)
031	Clear Creek (RM 84.03R)
032	Bright Angel Creek (RM 87.62R)
040	Mainstem: Bright Angel to National Canyon (RM 166.4)
401	Pipe Creek (RM 88.95L)
041	Crystal Creek (RM 98.04R)
042	Shinumo Creek (RM 108.6R)
402	Elves Chasm (RM 116.5L)
403	Stone Creek (RM 131.8R)
043	Tapeats Creek (RM 133.83R)
044	Deer Creek (RM 136.25R)
045	Kanab Creek (RM 143.5R)
404	Olo Canyon (RM 145.5L)
046	Havasu Creek (RM 156.93L)
047	Diamond Creek (RM 225.6L)
050	Mainstem: National Canyon to Diamond Creek (RM 225.6)
060	Mainstem: Diamond Creek to Lake Mead (RM 270?)
061	Travertine Creek (RM 229.0L)
062	Spencer Creek (RM 246.0)

Sex Codes

F	Female
M	Male

SPECIES

Common Species

BBH	Black Bullhead
BGS	Bluegill
BHS	Bluehead Sucker
BKT	Brook Trout
BNT	Brown Trout
CCF	Channel Catfish
CRP	Common Carp
CUT	Cutthroat Trout
FMS	Flannelmouth Sucker
GSH	Golden Shiner
HBC	Humpback Chub
LMB	Largemouth Bass
PKF	Plains Killifish
RBS	Razorback Sucker
RBT	Rainbow Trout
RSH	Red Shiner
SMB	Smallmouth Bass
SPD	Speckled Dace
STB	Striped Bass
TFS	Threadfin Shad
UTC	Utah Chub
YBH	Yellow Bullhead
SUC	Sucker (unidentified)
UID	Unidentified

SUBST_CD: Substrate Codes

SI	Silt
SA	Sand
GR	Gravel
PE	Pebble
CO	Cobble
BO	Boulder
BD	Bedrock

TAG: Tag Codes and Fin Clips/Punches

Tag Types

C	Carlin
F	Floy
P	PIT

Fin Clips/Punches

D	Dorsal
UC	Upper Caudal
LC	Lower Caudal
CD	Caudal
RP2	Right Pelvic
LP2	Left Pelvic

TAXA

ALG	Algae
ACA	Acarina
AMP	Amphibia
ANN	Annelids
APD	Amphipod
APH	Aphididae
APO	Apoidea
ARA	Araneida
BAT	Baetidae
BEY	Berytidae
BFO	Bufo
BIV	Bivalvia
BPS	Body parts
BRA	Braconidae
CDL	Cicadellidae
CHI	Chironomidae
CHR	Chrysomelidae
CIL	Ciliate
CLA	Coleoptera
CLC	Cladocera
COL	Collembola
COP	Copepoda
CPG	Ceratopogonidae
CRU	Crustacean
CST	Cestoda
CUR	Curculionoidae
CYD	Corydalidae
DET	Detritus
DIA	Diatom
DIX	Dixidae
DOL	Dolichopodidae
DPA	Diptera
DRY	Dryopidae
ECT	Ectoproct
ELM	Elmidae
EMB	Embioptera
EMP	Empididae
ENC	Encyrtidae
EPH	Ephemeroptera
EPT	Empty
EPY	Ephydridae
EUL	Eulophidae
EUR	Eurytomidae
FOR	Formicidae
GAS	Gastropoda
GER	Gerridae

B-3. Arizona Game and Fish Database Code Definitions - cont.
Mainstem Colorado River

GPH	Gomphidae
HEB	Hebridae
HIR	Hirundea
HMA	Hemiptera
HOM	Homoptera
HPS	Hydropsychidae
HPT	Hydroptilidae
HYA	Chlorohydra
HYD	Hydracarina
HYM	Hymenoptera
HYP	Hydrophilidae
ISO	Isoptera
LEP	Lepidoptera
MAC	Macroveliidae
MEG	Megaloptera
MES	Mesoveliidae
MIR	Miridae
MLO	Mallophaga
MOL	Mollusca
NAP	Copepod nauplius
NEM	Nematoda
NEU	Neuroptera
ODO	Odonata
OLI	Oligochaeta
OMO	Other Misc. Org.
ONP	Ostracod nauplius
ORT	Orthoptera
OST	Ostrocoda
PHL	Phloeothripidae
PLE	Plecoptera
POL	Pollen
PRO	Protozoan
PSO	Psocoptera
PSY	Psyllidae
PTE	Pteromalidae
ROC	Sand, Gravel
ROT	Rotifera
SAL	Saldidae
SCI	Sciaridae
SCZ	Schizophora
SEE	Seeds
SIM	Simulidae
SIP	Siphlonuridae
STR	Stretsiptera
THR	Thripidae
THU	Thysanura
THY	Thysanoptera
TIP	Tipulidae
TNG	Tingidae
TRI	Trichoptera
TRX	Trixoscelidae
VEL	Veliidae
VOL	Volvox

B-4. BIO/WEST Inc., DATABASE CODE DEFINITIONS

AMBIENT LIGHT

SU	Sunny
CL	Cloudy (> 50% cloud cover)
PC	Partly cloudy (< or 50% cloud cover)
SH	Shadow
NI	Night
ML	Moonlight
DD	Dawn/dusk

DISPOSITION

RA	Returned alive (no radio implant)
RI	Returned with newly implanted radio
RR	Returned with active radio transmitter
RN	Returned with non-active radio transmitter (removed external antennae but did not re-implant)
RS	Returned alive with stomach contents removed
DR	Dead, released (non-native fish)
DP	Dead, preserved
DS	Dead, stomach contents preserved

FLUCTUATIONS OR FLUCT

RI	Rising
FA	Falling
SL	Steady at a low stage
SH	Steady at a high stage

GEAR

EL	Electrofishing
BP	Backpack electrofishing
FR	Frame net
SA	10'x3'x1/8" seine
SB	30'x4'x1/4" seine
SC	15'x4'x1/8" seine
SG	30'x5'x1/4" seine
DL	Larval fish drift net
DR	Invert drift net
SU	Surber
AQ	Aquarium net
KS	Kick screen
TK	75'x6'x1"x12" Trammel net
TL	75'x6'x1 1/2"x12" Trammel net
TF	Floated Trammel net RECORD AREA SAMPLED
TM	50'x6'x1"x12" Trammel net
TN	50'x6'x1.5"x12"
GM	100'x6'x2" gill net
GP	100'x6'x1 1/2" gill net
GX	100' experimental gill net
GZ	60' experimental gill net
GY	50'x6'x1.5" gill net
GF	Floated gill net RECORD AREA SAMPLED
MT	Minnow trap
HL	Large hoop net (4' diam.)
HM	Medium hoop net (3' diam.)
HS	Small hoop net (2' diam.)
AN	Angling
TW	75'x6'x1/2"x10
TZ	TL with attached floats
TY	TK with attached floats

HAB1: General habitat

MC	Main channel
TS	Tributary stream
SC	Side channel
LK	Lake

HAB2: Specific habitat

BA	Backwater
ED	Eddy
EM	Embayment
RI	Riffle
RU	Run
SH	Shoreline
PO	Pool
RC	Return channel

HAB3: Shoreline habitat

TS	Talus scree
SW	Shear wall
LE	Ledge
BE	Bedrock
SI	Silt
SA	Sand
CO	Cobble
BO	Boulder field
CB	Cut bank
VG	Vegetation
DF	Debris flow
TV	Travertine

RIPE: State of gonadal maturity of fish

TU	Tubercled only
TC	Tubercled and colored
MI	Running milt
EG	Expressible eggs
SP	Spent
CO	Colored only

SUB1: Dominant substrate

SI	Silt
SA	Sand
GR	Gravel
CO	Cobble
BO	Boulder
BE	Bedrock
OR	Organic matter

SUB2: Secondary substrate

SI	Silt
SA	Sand
GR	Gravel
CO	Cobble
BO	Boulder
BE	Bedrock
OR	Organic matter

TURBIDITY OR TURB

H	High secchi = < 0.5m
L	Low secchi = > 0.5m

WEATHER

SU	Sunny
CS	(SU) clear skies

B-4. BIO/WEST, Inc. Database Code Definitions - cont.
Mainstem Colorado River

CL	Cloudy (> 50% cloud cover)
PC	Partly cloudy (< or 50% cloud cover)
OV	Overcast or foggy
RA	Raining
SN	Snowing

SPECIES CODE OR SPECIES: Code for fish species

HB	Humpback chub
FM	Flannelmouth sucker
BH	Bluehead sucker
SD	Speckled dace
RZ	Razorback sucker
FH	Fathead minnow
CC	Channel catfish
BB	Black bullhead
CP	Carp
RB	Rainbow trout
BR	Brown trout
BK	Brook trout
PK	Plains killifish (Fundulus zebrinus)
SB	Striped bass
WE	Walleye
FR	Flannelmouth X razorback hybrid
SU	Unidentified sucker
YB	Yellow bullhead
BG	Bluegill
GA	Gambusia
GS	Green sunfish
LG	Largemouth bass
RS	Red shiner
TS	Threadfin shad
BC	Black crappie
NP	Northern pike
RT	Roundtail chub
SH	Shiner (red or sand)
SM	Smallmouth bass
SS	Sandshiner

OLD TAG

UCRP2	Upper caudal plus RP2
UCLP2	Upper caudal plus LP2
LCRP2	Lower caudal plus RP2
LCLP2	Lower caudal plus LP2
DP	Dorsal punch
UCP	Upper caudal punch
LCP	Lower caudal punch
PIT	PIT tag number
Floy tag number	
Carlin tag number	

REACH

0	Lees Ferry to Kwagunt (RM 0-56.0)
1	Kwagunt to Hance (RM 56-76.6)
2	Hance to Havasu (RM 76.6-156.7)
3	Havasu to Diamond Creek (RM 156.7-226)
4	Diamond Creek to Pearce Ferry (RM 226-280)

RIVER

CO	Mainstem Colorado River
LC	Little Colorado River
BA	Bright Angel Creek
KN	Kanab Creek
HV	Havasu Creek
TP	Tapeats Creek
SH	Shinumo Creek
DC	Deer Creek
NK	Nankoweap
CL	Clear Creek
CR	Crystal Creek
ST	Stone Creek
CB	Carbon Creek
DI	Diamond Creek
SP	Spencer Creek
SU	Surprise Creek
LO	Lost Creek

SAMPLE TYPE

E	Electrofishing
N	Gill/Trammel nets
S	Seining
T	Traps,i.e. hoop nets, minnow traps

SEX

M	Male
F	Female
I	Immature
U	Undetermined

SIDE

R	River right (looking downstream)
L	River left (looking downstream)
C	Center (tributary hoop net sets)

CONFIDENCE

1	High, excellent reception
2	Low, poor reception
3	Only a few "hits", use for location only

COVER

OB	Overhanging bank
SV	Streamside vegetation
NC	No cover

MODE

IM	Implant
LO	Locate
2H	2-hour
24	24-hour
TF	Test flow

APPENDIX C

STANDARDIZED DATA CODES FOR THE INTEGRATED DATABASE

SPECIES

BHS	BLUEHEAD SUCKER
FMS	FLANNELMOUTH SUCKER
RBS	RAZORBACK SUCKER
SUC	UNIDENTIFIED SUCKER
HBC	HUMPBACK CHUB
SPD	SPECKLED DACE
FHM	FATHEAD MINNOW
RSH	RED SHINER
CRP	CARP
PKF	PLAINS KILLIFISH
CCF	CHANNEL CATFISH
RBT	RAINBOW TROUT
UID	UNIDENTIFIED SPECIES
SHY	SUCKER HYBRID
BBH	BLACK BULLHEAD
BGS	BLUEGILL
BKT	BROOK TROUT
BRT	BROWN TROUT
CUT	CUTTHROAT TROUT
GSH	GOLDEN SHINER
LMB	LARGEMOUTH BASS
SMB	SMALLMOUTH BASS
STB	STRIPED BASS
TFS	THREADFIN SHAD
UTC	UTAH CHUB
YBH	YELLOW BULLHEAD
GSF	GREEN SUNFISH
WEY	WALLEYE
FRZ	FLANNELMOUTH RAZORBACK HYBRID
GAM	GAMBUSIA
BKC	BLACK CRAPPIE
NPK	NORTHERN PIKE
RTC	ROUNDTAIL CHUB
SHN	SHINER (RED OR SAND)
SSH	SAND SHINER
BTC	BONYTAIL CHUB

CHANNEL

MC	MAIN CHANNEL
SC	SIDE CHANNEL
TS	TRIBUTARY STREAM
LK	LAKE

HYDRAULIC

CB	CONNECTED BACKWATER
IB	ISOLATED BACKWATER
ED	EDDY
RI	RIFFLE
RU	RUN
PO	POOL
BW	BACKWATER
IP	ISOLATED POOL
RC	RETURN CHANNEL
EM	EMBAYMENT
EW	EDGEWATER
SC	SPRINGFLOW CHANNEL
BF	BEACH FACE
DM	DEWATERED
BE	BACKWATER EDDY
BM	BACKWATER MOUTH (CONN. MOUTH)
BC	BACKWATER CENTER(CONN. CENTER)
CC	CONNECTED CENTER
CE	CONNECTED EDDY
CF	CONNECTED FOOT
CM	CONNECTED MOUTH

SHORELINE

TA	TALUS
DF	DEBRIS FAN
BE	BEDROCK
SA	SAND
VG	VEGETATION
CO	COBBLE

SPAWN_COND

TU	TUBERCULATE
TC	TUBERCULATE AND COLORED
MI	RUNNING MILT
EG	EXPRESSIBLE EGGS
SP	SPENT
CO	COLORED
RI	RIPE
GR	GRAVID

MARK_REC

M	MARKED
R	RECAPTURED
H	HANDLED ONLY

DISP

RA	RELEASED ALIVE
DN	DEAD, NOT TAKEN
DP	DEAD, PRESERVED
DK	DEAD, SKELETONIZED
SP	SACRIFICED, PRESERVED
SS	SACRIFICED, SKELETONIZED
MN	MORTALITY, NOT TAKEN
MP	MORTALITY, PRESERVED
MS	MORTALITY, SKELETONIZED
OB	OBSERVED
RI	RELEASED, NEWLY IMPLANTED RADIO TAG
RR	RELEASED, ACTIVE RADIO TRANSMITTER
RN	RELEASED, NON-ACTIVE RADIO TAG
RS	RELEASED, STOMACH CONTENTS REMOVED
DR	DEAD, RELEASED (NON-NATIVE)
DS	DEAD, STOMACH CONTENTS PRESERVED

INVESTIGTR

ASU	ARIZONA STATE UNIVERSITY
USFWS	U.S. FISH AND WILDLIFE SERVICE

Standardized Data Codes, cont.

UOFA	UNIVERSITY OF ARIZONA
AGFD	ARIZONA GAME AND FISH DEPARTMENT
B/W	BIO/WEST INC.

TAG_TYPE

F	FLOY
C	CARLIN
P	PIT
N	NOSE (CODED WIRE)
M	MARK (CLIP OR PUNCH)

TAG_COLOR

G	GREEN
R	RED
Y	YELLOW
W	WHITE
B	BLUE
O	ORANGE

SEX

F	FEMALE
M	MALE
I	IMMATURE
U	UNDETERMINED
N	NOT ATTEMPTED

RIVER

CO	MAINSTEM COLORADO RIVER
LC	LITTLE COLORADO RIVER
BA	BRIGHT ANGEL CREEK
KN	KANAB CREEK
HV	HAVASU CREEK
TP	TAPEATS CREEK
SH	SHINUMO CREEK
DC	DEER CREEK
NK	NANKOWEAP
CL	CLEAR CREEK
CR	CRYSTAL CREEK
ST	STONE CREEK
CB	CARBON CREEK
DI	DIAMOND CREEK
SP	SPENCER CREEK
SU	SURPRISE CREEK
LO	LOST CREEK

INSTRUMENT

S	SURVEYOR 2
D	DATASONDE
M	MANUAL

PARASITE

LC	LERNEA
BA	ASIAN TAPEWORM

SUBSTRATE

MA	MARL (CALCIUM CARBONATE)
SI	SILT (0.00024-0.062mm)
SA	SAND (0.062-2mm)
GR	GRAVEL (2-64mm)
CO	COBBLE (64-256mm)
BO	BOULDER (256-4096mm)
BE	BEDROCK (>4096mm)
TR	TRAVERTINE (TUFA)
DE	DETRITUS (ORGANIC MATTER)

LIGHT

SU	SUNNY
PC	PARTLY CLOUDY (<50%)
CL	CLOUDY (>50%)
SH	SHADE
NI	NIGHT
ML	MOONLIGHT
DN	DAWN
DK	DUSK

TAXA

ALG	ALGAE
ACA	ACARINA
AMP	AMPHIBIA
ANN	ANNELIDS
APD	AMPHIPOD
APH	APHIDIDAE
APO	APOIDEA
ARA	ARANEIDA
BAT	BAETIDAE
BEY	BERYTIDAE
BFO	BUFO
BIV	BIVALVIA
BPS	BODY PARTS
BRA	BRACONIDAE
CDL	CICADELLIDAE
CHI	CHIRONOMIDAE
CHR	CHRYSOMELIDAE
CIL	CILIATE
CLA	COLEOPTERA
CLC	CLADOCERA
COL	COLLEMBOLA
COP	COPEPODA
CPG	CERATOPOGONIDAE
CRU	CRUSTACEAN
CST	CESTODA
CUR	CURCULIONOIDAE
CYD	CORYDALIDAE
DET	DETRITUS

Standardized Data Codes, cont.

DIA	DIATOM
DIX	DIXIDAE
DOL	DOLICHOPODIDAE
DPA	DIPTERA
DRY	DRYOPIDAE
ECT	ECTOPROCT
EGG	EGGS (UNKNOWN)
EEE	FISH EGGS-100%
EEF	FISH EGGS-25%
EGI	INSECT EGGS
EGA	AMPH. EGGS
ELM	ELMIDAE
EMB	EMBIOPTERA
EMP	EMPIDADAE
ENC	ENCYRTIDAE
EPH	EPHEMEROPTERA
EPT	EMPTY
EPY	EPHYDRIDAE
EUL	EULOPHIDAE
EUR	EURYTOMIDAE
FOR	FORMICIDAE
GAS	GASTROPODA
GER	GERRIDAE
GPH	GOMPHIDAE
HEB	HEBRIDAE
HIR	HIRUNDEA
HMA	HEMIPTERA
HOM	HOMOPTERA
HPS	HYDROPSYCHIDAE
HPT	HYDROPTILIDAE
HYA	CHLOROHYDRA
HYD	HYDRACARINA
HYM	HYMENOPTERA
HYP	HYDROPHILIDAE
ISO	ISOPTERA
LEP	LEPIDOPTERA
MAC	MACROVELIIDAE
MEG	MEGALOPTERA
MES	MESOVELIIDAE
MIR	MIRIDAE
MLO	MALLOPHAGA
MOL	MOLLUSCA
NAP	COPEPOD NAUPLIUS
NEM	NEMATODA
NEU	NEUROPTERA
ODO	ODONATA
OLI	OLIGOCHAETA
OMO	OTHER MISC. ORGANISM
ONP	OSTRACOD NAUPLIUS
ORT	ORTHOPTERA
OST	OSTROCODA
PHL	PHLOEOTHRIPIDAE
PLE	PLECOPTERA
POL	POLLEN
PRO	PROTOZOAN
PSO	PSOCOPTERA
PSY	PSYLLIDAE
PTE	PTEROMALIDAE
ROC	SAND, GRAVEL
ROT	ROTIFERA
SAL	SALDIDAE
SCI	SCIARIDAE
SCZ	SCHIZOPHORA
SEE	SEEDS
SIM	SIMULIDAE
SIP	SIPHLONURIDAE
STR	STRETSIPTERA
TAX	TAXA
THR	THRIPIDAE
THU	THYSANURA
THY	THYSANOPTERA
TIP	TIPULIDAE
TNG	TINGIDAE
TPW	TAPEWORM
TRI	TRICHOPTERA
TRX	TRIXOSCELIDAE
VEL	VELIIDAE
VOL	VOLVOX

LIFE_STAGE

A	ADULT
P	PUPAE
L	LARVA
N	NYMPH
R	PROLARVA
M	MESOLARVA
T	METALARVA
J	JUVENILE
U	UNKNOWN

APPENDIX D

BIO/WEST GIS DATA FILES

The BIO/WEST (B/W) GIS data files are all ARC/INFO® vector coverages referenced to the same coordinate system as the Horizon's, Inc. produced orthophotos; Arizona State Plane. Coverages have only been developed for Site 5. The information contained herein is current for all B/W Grand Canyon studies through November 1994.

OBSERVATION SPECIFIC

Radio Telemetry Surveillance and Radio Telemetry Observation

Coverage names: RTSURV and RTOBS

Geographic Data Source: Fish "finds" originally recorded on 1:1,200 aerial photos. Later transferred to 1:2,400 orthophotos and digitized into database. At time of this writing exact contents of what was and was not to be recorded within the ARC/INFO® coverage was not determined.

ITEM	DEFINITION	DESCRIPTION
AREA	8, 18, F, 3	Not used for points
PERIMETER	8, 18, F, 3	Not used for points
COVNAME#	4, 5, B	Point sequence number
COVNAME-ID	4, 5, B	Point identification number
RADIOTAG#		
DATE		
TIME		
Others ...		

Surface Habitat Maps

Coverage names: Variable. Each contains the name of the site and identification of the flow at which the map was created.

Geographic Data Source: Field maps were originally recorded on 1:1,200 aerial photos. Later these maps were digitized into the GIS using control points taken from 1:2,400 orthophotos.

Notes: Two data types are stored in each coverage, lines for shoreline habitat, and polygons for surface water habitat types.

Line attributes used for shoreline habitat

ITEM	DEFINITION	DESCRIPTION
FNODE#	4, 5, B	Sequence number of the from-node
TNODE#	4, 5, B	Sequence number of the to-node
LPOLY#	4, 5, B	Sequence number of the left-polygon
RPOLY#	4, 5, B	Sequence number of the right-polygon
LENGTH	4, 12, F, 3	Length in feet
COVERNAME#	4, 5, B	Arc sequence number
COVERNAME-ID	4, 5, B	Arc ID
STYPE	3, 3, C	Shoreline habitat type

Polygon attributes used for surface habitat

ITEM	DEFINITION	DESCRIPTION
AREA	4, 12, F, 3	Area of the polygon
PERIMETER	4, 12, F, 3	Perimeter of the polygon
COVERNAME#	4, 5, B	Polygon sequence number (internal to ARC/INFO®)
COVERNAME-ID	4, 5, B	Polygon identification number
MACROHAB	8, 8, C	Surface macro habitat type

Current Pattern Maps

Coverage names: HABHI and HABLO. HABHI is for "high" flows and HABLO is for "low" flows.

Geographic Data Source: Field maps were originally recorded on 1:1,200 aerial photos. Later these maps were transferred to the 1:2,400 orthophotos and digitized directly into the GIS.

Notes: Two data types are stored in each coverage, lines for shoreline habitat, and polygons for surface water habitat types.

Line attributes used for shoreline habitat

ITEM	DEFINITION	DESCRIPTION
FNODE#	4, 5, B	Sequence number of the from-node
TNODE#	4, 5, B	Sequence number of the to-node
LPOLY#	4, 5, B	Sequence number of the left-polygon
RPOLY#	4, 5, B	Sequence number of the right-polygon
LENGTH	4, 12, F, 3	Length in feet
COVERNAME#	4, 5, B	Arc sequence number
COVERNAME-ID	4, 5, B	Arc ID
TYPE	3, 3, C	Shoreline habitat type

Polygon attributes used for surface habitat

ITEM	DEFINITION	DESCRIPTION
AREA	4, 12, F, 3	Area of the polygon
PERIMETER	4, 12, F, 3	Perimeter of the polygon
COVERNAME#	4, 5, B	Polygon sequence number (internal to ARC/INFO®)
COVERNAME-ID	4, 5, B	Polygon identification number
HYDRAULICS	2, 2, C	Surface current pattern type

REPEAT SAMPLING SITES

Minnow Traps

Coverage names: MINNTRAP

Geographic Data Source: Set locations of minnow traps were originally recorded on aerial photos. Later they were transferred to 1:2,400 orthophotos and digitized into the geographic database.

ITEM	DEFINITION	DESCRIPTION
AREA	8, 18, F, 3	Not used for points
PERIMETER	8, 18, F, 3	Not used for points
MINNTRAP#	4, 5, B	Point sequence number
MINNTRAP-ID	4, 5, B	Point identification number
MNTRP_ID	4, 4, I	Location identification number

Net Sets

Coverage names: NETS

Geographic Data Source: Net set locations were originally recorded on aerial photos. Later they were transferred to 1:2,400 orthophotos. After each location was assigned a location identification number the net locations were digitized into the geographic database.

ITEM	DEFINITION	DESCRIPTION
FNODE#	4, 5, B	Sequence number of the from-node
TNODE#	4, 5, B	Sequence number of the to-node
LPOLY#	4, 5, B	Sequence number of the left-polygon
RPOLY#	4, 5, B	Sequence number of the right-polygon
LENGTH	4, 12, F, 3	Length in feet
NETS#	4, 5, B	Arc sequence number
NETS-ID	4, 5, B	Arc ID
NET_ID	3, 3, I	Net set location identification number

ABSTRACT REFERENCE

River Center Line

Coverage names: CENLINE

Geographic Data Source: Approximate river thalweg was drawn on 1:2,400 orthophotos by BIO/WEST field biologists then digitized into the database and attributed with river mile.

Arcs defining the centerline

ITEM	DEFINITION	DESCRIPTION
FNODE#	4, 5, B	Sequence number of the from-node
TNODE#	4, 5, B	Sequence number of the to-node
LPOLY#	4, 5, B	Sequence number of the left-polygon
RPOLY#	4, 5, B	Sequence number of the right-polygon
LENGTH	4, 12, F, 3	Length in feet
CENLINE#	4, 5, B	Arc sequence number
CENLINE-ID	4, 5, B	Arc ID
FRM	6, 6, N, 2	From river mile for the arc
TRM	6, 6, N, 2	To river mile for the arc
REACH	2, 2, I	Reach identification number

BIO/WEST routes based upon Belknap's River Guide

ITEMS	DATA TYPE	DESCRIPTION
BWRM#	4, 5, B	Route sequence number
BWRM-ID	4 ,5, B	Route ID
REACH	2, 2, I	Reach identification number

APPENDIX E

RECOMMENDED DATA COLLECTION PROTOCOL

DATA COLLECTION PROTOCOL
Grand Canyon Fisheries Investigations

NOTE TO READERS: This introduction is provided to familiarize readers with the Data Collection Protocol. The volume of the protocol prohibits including the document in its entirety in this Appendix. Copies of the Data Collection Protocol are available from BIO/WEST or GCES.

Glen Canyon Environmental Studies (GCES) has coordinated fisheries investigations in Grand Canyon since 1983. Numerous investigations were conducted as part of Phase I (1983-87) and Phase II (1988-95), and several investigations had been conducted previously. The need to integrate findings of these and future studies is vital to monitoring aquatic resources in Grand Canyon and to management of Glen Canyon Dam.

This Data Collection Protocol (DCP) provides the guidance for standardized fisheries data collection in Grand Canyon. While not all investigators are likely to collect the same data, most will collect the same basic information. This protocol provides a list of data codes and specifications (data type, field width, description) that will enable all investigations to become linked to a central integrated database.

This DCP indexes and defines all known data fields, and provides a set of standard data codes. Many of these codes were adopted from the List of Field Names and Data Codes, Upper Colorado River Basin Database (U.S. Fish and Wildlife Service 1989). These codes may not be compatible with the codes currently in use by some investigators in Grand Canyon, but a standard set of codes should be incorporated as soon as possible to maximize compatibility of databases throughout the Colorado River Basin. The goal of this DCP is to have all investigators using the same data codes by January 1997.

Following the Introduction of this report are Specifications and Descriptions of Field Names. Field names and specifications in this DCP are partitioned into the following 12 data groups. Field names, data type, field size, decimal place, and a description are provided for each group.

Age Determination	Fish Collections	Morphometrics/Meristics
Behavior	Food Habits	Primary Production/Sediment
Benthic Invertebrates	Habitat	Radiotelemetry
Drift	Individual Fish Data	Water Quality

APPENDIX F

DATA FLOW FOR QUALITY CONTROL