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A Data Analysis System for Monitoring the Seaward Migration of Juvenile Salmonids in the Snake–Columbia River System

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U.S. DEPARTMENT OF COMMERCE
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ABSTRACT

A large part of the research activities conducted by the Coastal Zone and Estuarine Studies Division (CZES) at the Northwest and Alaska Fisheries Center (NWAFC) require monitoring the movement rates and relative abundance of migrating juvenile salmonids in the Snake-Columbia River system. This paper describes the data network and the computer file/program system which was developed to process the information.

Species composition and mark-recapture data are collected at key index sites (hydroelectric dams) and relayed to the NWAFC computer. This information is then processed in conjunction with the U.S. Army Corps of Engineers Columbia River Operations and Hydronet Management System (CROHMS) files as well as mark-release information provided by various research and management groups. The system provides information regarding the status of river flow conditions, dam operations, and fish migration. This information is necessary for fisheries managers to determine if additional river flow or spill should be provided to expedite fish passage though the river system.

CONTENTS

INTRODUCTION

Since 1966, the Coastal Zone and Estuarine Studies Division (CZES) of the National Marine Fisheries Service (NMFS) has been responsible for monitoring the seaward migration of juvenile salmon, Oncorhynchus spp., and steelhead, Salmo gairdneri, in the Snake-Columbia River system. The program has had several objectives, including: 1) defining the timing of migrations, 2) measuring travel time, and 3) estimating population sizes and survival of juvenile salmonids at key damsites in the system.

At the start of the program, monitoring was established to define the impact of new dams and reservoirs on survival and travel time of smolts. The data obtained showed that dams did, in fact, adversely affect smolt survival (Raymond 1979). Data obtained from monitoring have recently been used to 1) assess the timing of the smolt migration so that daily spill and augmented river flows at dams can be utilized by management agencies concomitant with peak fish passage (Northwest Power Planning Council 1982), 2) ensure that spill allocated for fish passage by hydroelectric entities is judiciously used, 3) estimate the percentage of the total smolt migration that is being transported downstream from upstream collector dams (Basham et al. 1983), and 4) assess the success of the annual smolt migration.

In recent years, the volume of data has increased dramatically as more agencies have participated in numerous research and management programs. In 1983 alone, more than 400 unique brands were released and over 1.5 million fish of all species were sampled and examined for brands at three index sites (Lower Granite, McNary, and John Day Dams). This expansion of

data necessitated the development of a computer-based Columbia River data analysis system which is operational on the Northwest and Alaska Fisheries Center's (NWAFC) Burroughs 7800.[1] This paper describes the major components of the system and how it operates. Specific analysis procedures (e.g., population estimation, survival estimation, etc.) are not discussed in detail; however, an overview is presented to provide fundamental information pertinent to understanding the analysis system.

OVERVIEW

One technique used by both researchers and managers to assess their various programs is to freeze brand (Mighell 1969) representative samples of different segments of a population (e.g., a hatchery release) or groups exposed to various treatments (e.g., different diets or vaccines, etc.); release those groups into the river system; and monitor their migration rate to, and abundance at, designated recapture sites--typically hydroelectric dams. A fundamental need for the assessment of many mark-recapture programs is the ability to estimate the number of fish bearing a unique brand which arrive at a specific site on a specific day. Many other research and management programs require the ability to estimate daily population numbers for individual species. In either case, the procedure for generating the estimate is the same.

Nearly all juvenile salmonids approaching a dam pass the facility via the spillway or through the powerhouse; relatively few are routed through the navigation locks and fish ladders. To make a population estimate, it

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[1]Reference to trade names does not imply endorsement by National Marine Fisheries Service (NMFS).

is necessary to account for fish passing by way of both primary conduits (spillway and powerhouse). In powerhouses equipped with juvenile bypass facilities (Fig. 1), some fraction of the fish are diverted by submersible traveling screens (STS) from the turbine intake, into the gatewell, through the orifice, and into the collection (bypass) facility. The rest pass through the turbines.

The fraction actually entrained in the collection facility is species specific, dictated by the behavorial responses peculiar to each species and their vertical distribution as they enter the turbine intake. This means that any model which estimates the efficiency at which smolts are entrained is unique to each species, as well as to each damsite. For example, proportionately more steelhead are entrained than yearling chinook salmon, O. tshawytscha, presumably a consequence of chinook salmon sounding deeper than steelhead as they approach the turbine intake and/or greater avoidance of the STS.

A portion of the fish entrained in the powerhouse collection facility are diverted by a mechanical gate sampler into a sample holding tank where they are held until processing. The sample gate intercepts every fish passing through the collection conduit during the time it is open. The sampler can be adjusted to take a systematically timed sample over each 24-h period. The sampled fish are examined, the species and brand type are enumerated, and the fish are returned to the system.

These data are used to generate daily populations estimates:

DATA (daily)	→ MODEL →	REPORT
Enumerated mark-recaptures Species composition		Daily population estimates

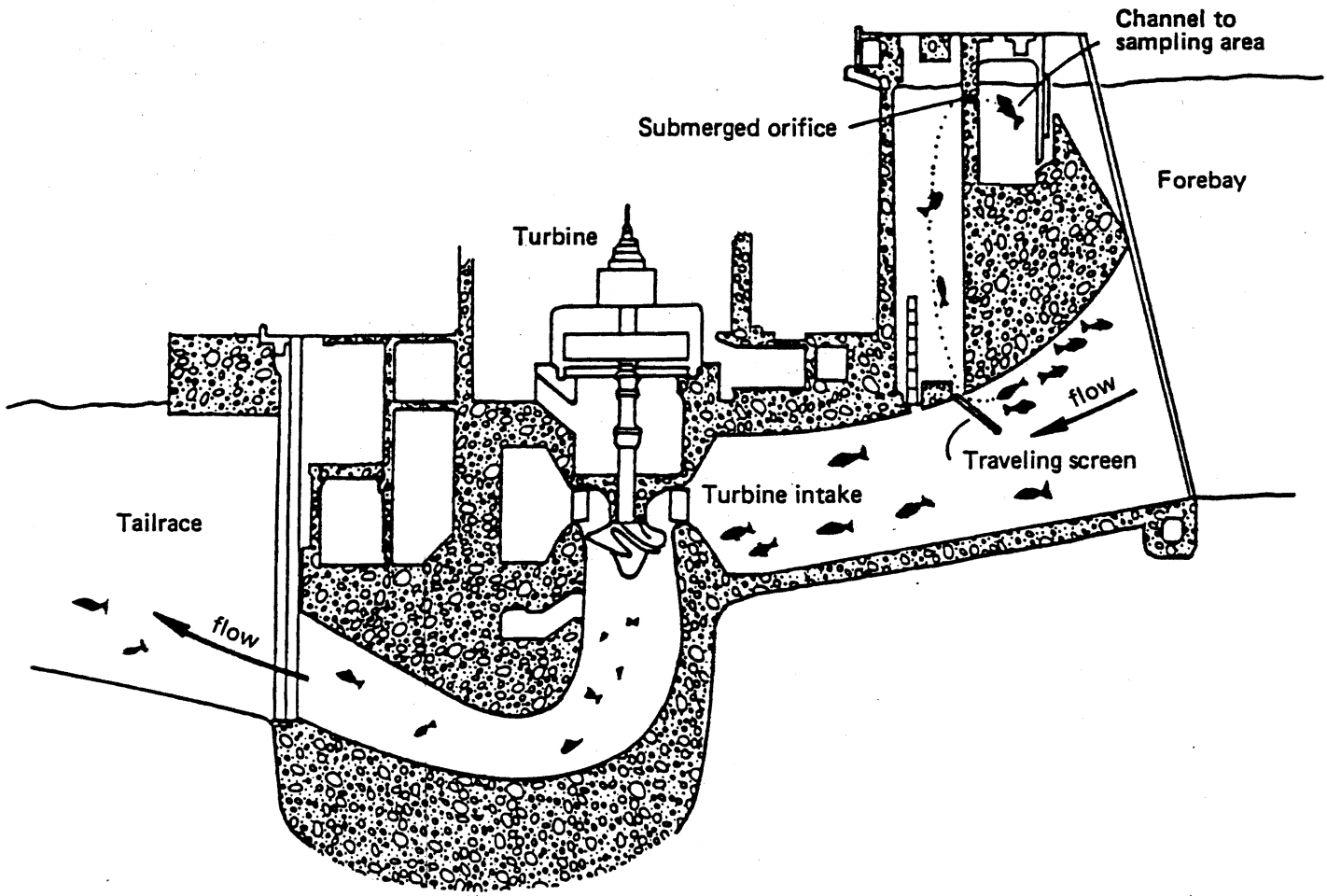

Figure 1.--Cross sectional view of a powerhouse equipped with a fingerling collection (bypass) facility.

DATA ANALYSIS SYSTEM

Data Files

All data files are consolidated on the NWAFC Burroughs 7800 computer. The three primary data files (VALID/BRANDS, SMOLT, and FLOWDATA) which constitute the data analysis system are depicted in Figure 2. SMOLT file, mark-recapture, and species abundance data are accumulated daily and recorded on cassette tapes at each of several dams (index sites). Data captured on cassette can then be transmitted via phone line or physically transported to the mainframe (Burroughs 7800) at the NWAFC (Fig. 3). The data cassettes also serve as a backup for data stored on the disc pack until a proper magnetic backup tape is made. A separate series of files are maintained for each index site.

Data in VALID/BRANDS files come from release information pertaining to marked fish provided to the NMFS by investigators from the various federal, state, and tribal agencies, and academic institutions conducting research or management programs requiring the release of freeze branded fish into the Snake-Columbia River system during any calendar year (Fig. 3). Each unique brand[2] present on a particular species is entered into the computer based file via keyboard. A separate VALID/BRANDS file is maintained for each index site, and all branded lots of fish released above a particular index site are included in that file. To ensure that only brands reported as having been released above a particular index site are processed in the ensuing analysis programs, VALID/BRANDS files are programmatically checked

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[2]Each unique brand is defined by the symbol, the rotation of the symbol in 90° increments, and its relative location on the body.

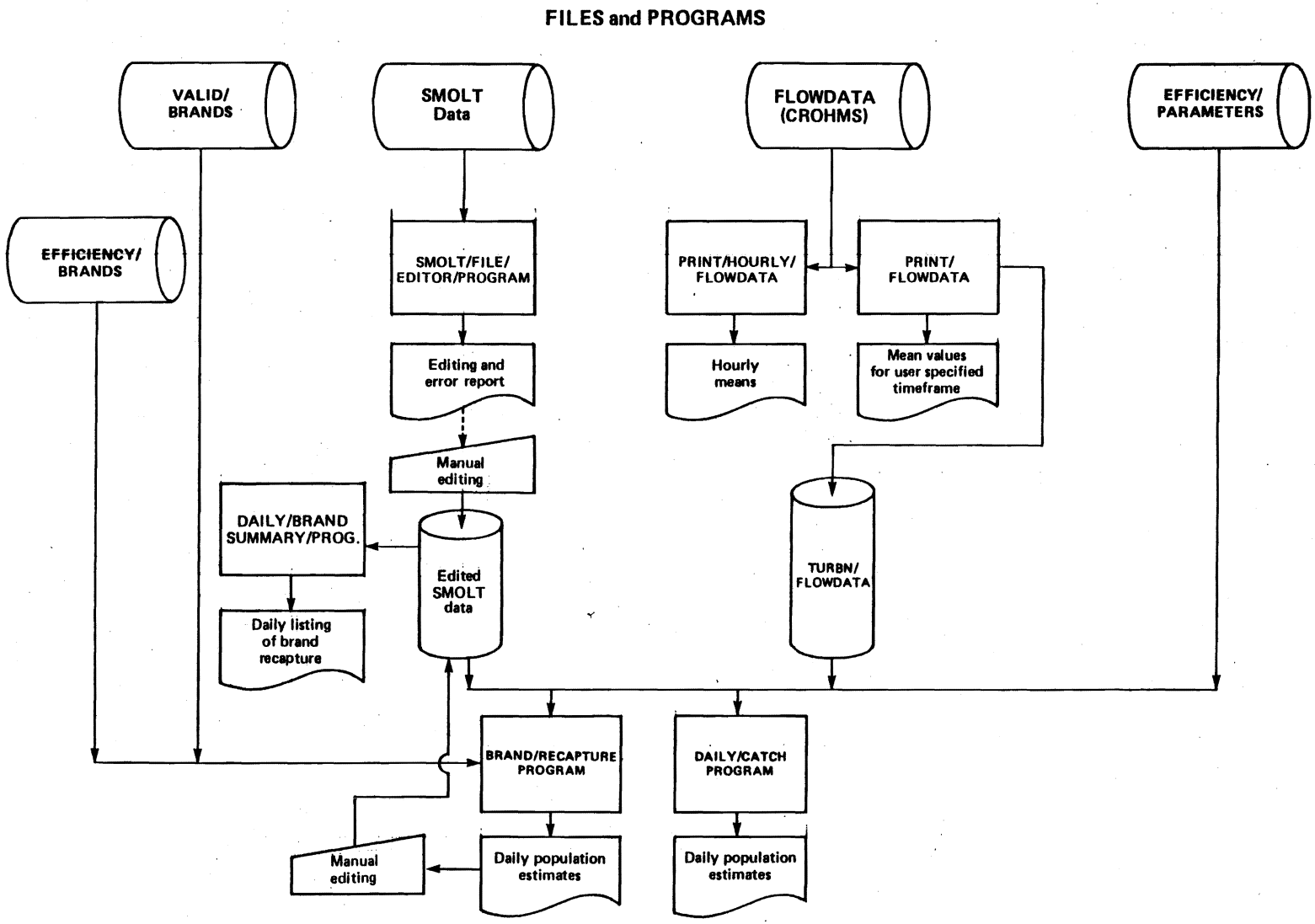

Figure 2.--Flow chart depicting the association between data files and programs comprising the Columbia River data analysis system of the Northwest and Alaska Fisheries Center.

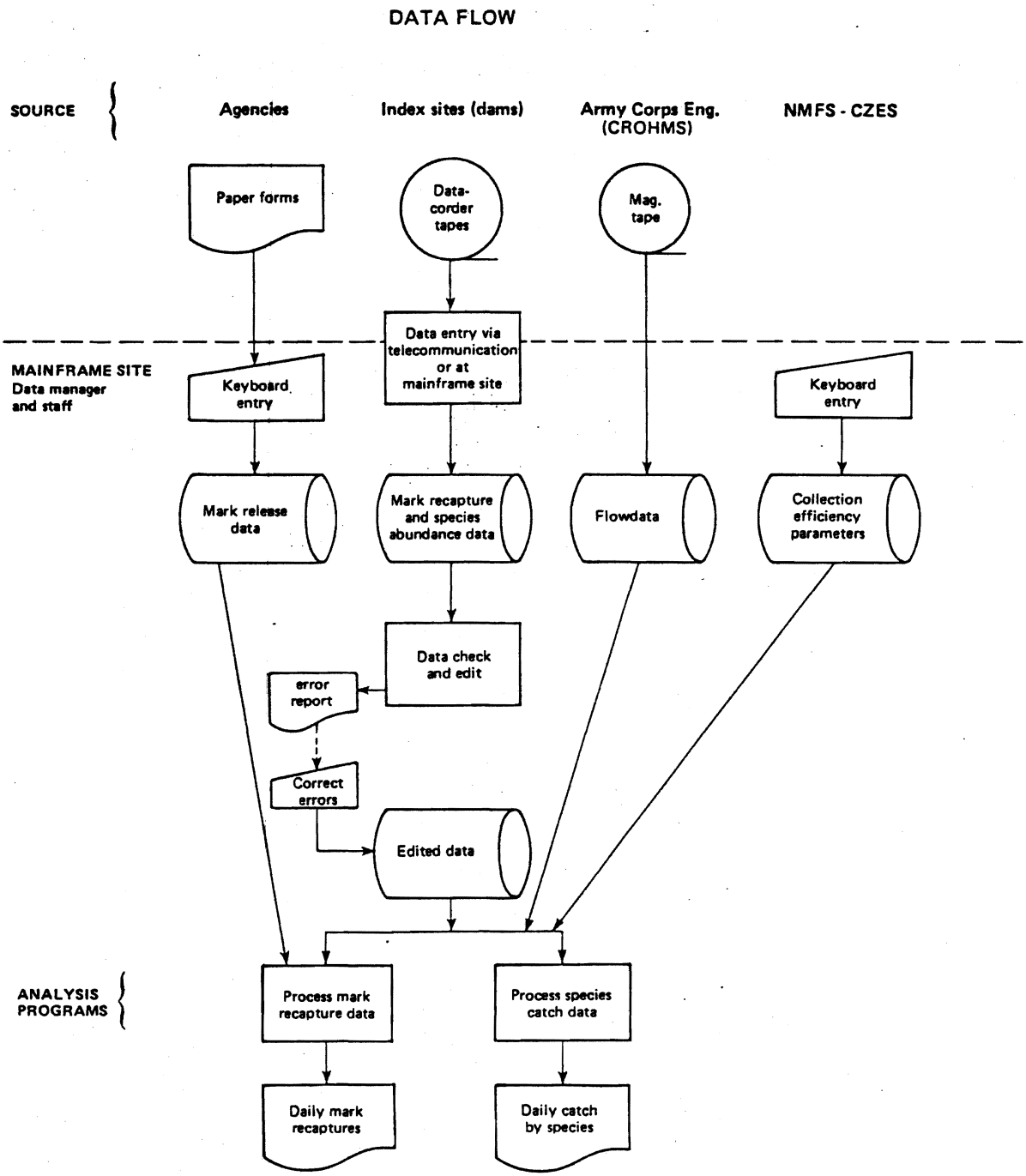

Figure 3.--Generalized data flow for the Columbia River data analysis system of the Northwest and Alaska Fisheries Center.

against mark-recapture data; unreconcilable brands are flagged as invalid in the report generated by the BRAND/RECAPTURE/PROGRAM. The EFFICIENCY/BRANDS file is a subset of VALID/BRANDS which contains only brands used specifically for calibrating the sampling efficiency of index damsites (Sims et al. 1983).

River flow and dam operations data, designated FLOWDATA (Figs. 2 and 3), are acquired from the U.S. Army Corps of Engineers, Columbia River Operations and Hydronet Management Systems (CROHMS). Data obtained by CROHMS are an integral part of our analysis system. A discrete FLOWDATA file is maintained for each damsite for the duration of the research program. One particular parameter, powerhouse discharge as a proportion of the combined spillway and powerhouse discharge, is generated from the FLOWDATA files and stored as a separate file, TURBINE/FLOWDATA. This file is accessed in the execution of both the DAILY/CATCH and BRAND/RECAPTURE programs and, in both cases, is necessary to generate the daily passage estimates.

Backup tapes are made of the various files at frequent intervals to minimize loss should there be a system failure or user error.

Efficiency Parameters

These files, one for each dam, contain species specific regression parameters (α, β) from collection efficiency-powerhouse discharge models (Sims et al. 1983). These models have been developed for several species at select damsites by CZES and are updated as additional data are accumulated. The regression parameters are used to generate daily population estimates at a particular dam in the following manner:

$$N_i = S_i \left[T_i \cdot (\alpha + \beta X_i) \right]^{-1}. \qquad (1)$$

Where: N_i = Daily (i) population estimate, by either species or brand.

S_i = The number of particular species or brand present in the sample on day i.

T_i = Fraction of each hour which the sampler subsampled from the juvenile collection/bypass system.

α, β = Parameters from the collection efficiency-powerhouse discharge models (Sims et al. 1984).

X_i = The % of the combined spill and powerhouse flow discharged through the powerhouse during a specifed 24-h period or subset thereof.

Programs

Following entry into the computer, mark-recapture and species-composition data are processed by an editing program (SMOLT/FILE/EDITOR) which identifies format errors (e.g., incorrect field alignment, inappropriate characters, missing records, etc.), checks the species subtotals against the total sample catch, and searches for file redundancy. Errors are then manually edited, and the corrected data are stored on disk (Fig. 2).

Two programs which process the CROHMS flowdata and generate reports are PRINT/FLOWDATA and PRINT/HOURLY/FLOWDATA. The PRINT/FLOWDATA program will display, for any user specified time period, the average discharge volumes expressed as kilo-cubic feet per second (kcfs) associated with a particular damsite as well as several ratios of those volumes (Appendix Table 1). The report generated by the PRINT/HOURLY/FLOWDATA program displays hourly averages of the same information for every hour of each day requested (Appendix Table 2). The PRINT/FLOWDATA program also creates a secondary

data file (TURBINE/FLOWDATA) containing select ratios. This program is accessed by both of the analysis programs, BRAND/RECAPTURE/PROGRAM and DAILY/CATCH/PROGRAM, which generate the daily population estimates.

The DAILY/CATCH and BRAND/RECAPTURE programs generate daily population estimates by species (Appendix Table 3) and brand (Appendix Table 4), respectively, for individual damsites. Both programs access data in the SMOLT, FLOWDATA, and EFFICIENCY/PARAMETERS files, with the BRAND/RECAPTURE/PROGRAM also accessing the VALID/BRANDS file as well as the EFFICIENCY/BRANDS file, if specified.

The reports from both programs do the following:

1. Specify the files which were or were not successfully accessed and processed.
2. Perform error checks additional to those flagged in the SMOLT/FILE/EDITOR/PROGRAM; e.g., the BRAND/RECAPTURE/PROGRAM identifies invalid brands which are not present in the VALID/BRANDS file. Invalid brands are not processed and must be reconciled by the data processing staff (Fig. 2).
3. Detail daily the number of each species or each brand present in the sample, the estimated number entrained in the entire collection system, and the population estimate of juvenile salmonids passing the dam.
4. Indicate season totals to date.

In addition, the report from the DAILY/CATCH/PROGRAM does the following:

1. Specifies the parameters accessed from the EFFICIENCY/PARAMETERS file.

2. Indicates both the powerhouse discharge (% of total flow) and sampling efficiency estimates which are used to generate the daily population estimates (Eq. 1) as well as the dates when 10, 50, and 90% of the total migration have passed the dam.

The DAILY/BRAND/SUMMARY/PROGRAM is an ancillary program which reports how many fish of each brand were recaptured on a given day and displays error messages. The report generated from this program can be used for diagnostic purposes in identifying and correcting invalid brands.

Both the DAILY/BRAND/SUMMARY/PROGRAM and the BRAND/RECAPTURE/PROGRAM perform sorting routines before the reports are printed.

DISCUSSION

Since the mid-1960s, fisheries agencies have attempted to estimate the sizes of salmonid migrations and marked lots of fish traversing the Snake-Columbia River system. In 1977 the scope of the effort expanded as fisheries agencies under the auspices of the Committee of Fishery Operation initiated a smolt monitoring program. In 1983 this program was meshed with the Bonneville Power Administration (BPA) funded Water Budget Program. Together, these management programs were designed to provide adequate river flows and spill (if necessary) when concentrations of downstream migrants approach key segments of the river.

In its management role, the Water Budget Center requires daily reporting of population estimates as well as river and dam operation conditions at index sites--requirements which this data analysis system can fulfill should BPA desire to implement it. However, daily analyses can only be performed if all necessary data are resident on the computer on any

particular day. CROHMS data are now acquired from the U.S. Army Corps of Engineers on a weekly schedule; to satisfy management program requirements it would be necessary to access it daily. In the current system, the mark-release information provided by the various fisheries agencies is not always timely enough, resulting in high numbers of misread brands at the recapture sites. The misread brands cannot be reconciled until the end of the annual migration when, historically, the accurate mark-release information is available. If brands were reported prior to release, they could be more easily and correctly interpreted at recapture. Timely and accurate mark-release information is an essential component of an efficient data analysis system and should be required by project managers.

As the system has progressed from a state of development to a finalized form, confidence in it has allowed more attention to the collection and correction of data, analysis of the interactions between downstream migrants and river management, and more timely addition to the data base.

Over the last 2 years, the data analysis system has demonstrated its effectiveness as a research tool for CZES (Sims et al. 1983, 1984). With minor procedural modifications (i.e., acquiring the necessary data on a daily schedule rather than on a weekly or monthly basis), the system can provide daily updating on the status of river flow conditions, dam operations, and fish migration. Furthermore, the system provides a sound prototype for the development of any future data analysis system for the Columbia Basin or any research or management program having similar objectives and data components.

ACKNOWLEDGMENTS

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APPENDIX

SAMPLE REPORTS GENERATED BY THE DATA ANALYSIS SYSTEM

Appendix Table 1.--Report: average hourly flow data. Produced by PRINT/HOURLY/FLOWDATA program.

HOURLY RIVER FLOW DATA AT MCNARY DAM

DATE YY/MM/DD	HOUR	HOURLY FLOWS (KCFS) TOTAL RIVER	TURBINE (ALL)	SPILL	OTHER	SELECTED FLOW RATIOS TURBINE TOTAL	TURBINE TRB+SPL	SPILL TOTAL	OTHER TOTAL	COMMENTS
83 8 26	1	71.5	68.3	0.0	3.2	0.9552	1.0000	0.0000	0.0448	
83 8 26	2	64.6	61.4	0.0	3.2	0.9505	1.0000	0.0000	0.0495	
83 8 26	3	51.5	48.3	0.0	3.2	0.9379	1.0000	0.0000	0.0621	
83 8 26	4	50.5	47.3	0.0	3.2	0.9366	1.0000	0.0000	0.0634	
83 8 26	5	58.8	55.6	0.0	3.2	0.9456	1.0000	0.0000	0.0544	
83 8 26	6	88.1	84.9	0.0	3.2	0.9637	1.0000	0.0000	0.0363	
83 8 26	7	136.0	131.3	0.0	4.7	0.9654	1.0000	0.0000	0.0346	
83 8 26	8	150.9	147.7	0.0	3.2	0.9788	1.0000	0.0000	0.0212	
83 8 26	9	144.7	141.5	0.0	3.2	0.9779	1.0000	0.0000	0.0221	
83 8 26	10	163.3	158.6	0.0	4.7	0.9712	1.0000	0.0000	0.0288	
83 8 26	11	165.8	162.6	0.0	3.2	0.9807	1.0000	0.0000	0.0193	
83 8 26	12	168.7	164.0	0.0	4.7	0.9721	1.0000	0.0000	0.0279	
83 8 26	13	169.3	166.1	0.0	3.2	0.9811	1.0000	0.0000	0.0189	
83 8 26	14	166.3	163.1	0.0	3.2	0.9808	1.0000	0.0000	0.0192	
83 8 26	15	168.9	165.7	0.0	3.2	0.9811	1.0000	0.0000	0.0189	
83 8 26	16	149.5	146.3	0.0	3.2	0.9786	1.0000	0.0000	0.0214	
83 8 26	17	148.7	144.0	0.0	4.7	0.9684	1.0000	0.0000	0.0316	
83 8 26	18	147.2	144.0	0.0	3.2	0.9783	1.0000	0.0000	0.0217	
83 8 26	19	150.7	147.5	0.0	3.2	0.9788	1.0000	0.0000	0.0212	
83 8 26	20	151.5	148.3	0.0	3.2	0.9789	1.0000	0.0000	0.0211	
83 8 26	21	155.0	151.8	0.0	3.2	0.9794	1.0000	0.0000	0.0206	
83 8 26	22	136.2	133.0	0.0	3.2	0.9765	1.0000	0.0000	0.0235	
83 8 26	23	124.3	121.1	0.0	3.2	0.9743	1.0000	0.0000	0.0257	
83 8 26	24	98.5	95.3	0.0	3.2	0.9675	1.0000	0.0000	0.0325	
83 8 27	1	89.2	86.0	0.0	3.2	0.9641	1.0000	0.0000	0.0359	
83 8 27	2	86.4	83.2	0.0	3.2	0.9630	1.0000	0.0000	0.0370	
83 8 27	3	87.8	83.1	0.0	4.7	0.9465	1.0000	0.0000	0.0535	
83 8 27	4	85.2	82.0	0.0	3.2	0.9624	1.0000	0.0000	0.0376	
83 8 27	5	108.6	105.4	0.0	3.2	0.9705	1.0000	0.0000	0.0295	
83 8 27	6	114.3	111.1	0.0	3.2	0.9720	1.0000	0.0000	0.0280	
83 8 27	7	116.3	113.1	0.0	3.2	0.9725	1.0000	0.0000	0.0275	
83 8 27	8	121.2	116.5	0.0	4.7	0.9612	1.0000	0.0000	0.0388	
83 8 27	9	120.0	115.3	0.0	4.7	0.9608	1.0000	0.0000	0.0392	
83 8 27	10	131.3	128.1	0.0	3.2	0.9756	1.0000	0.0000	0.0244	
83 8 27	11	134.1	130.9	0.0	3.2	0.9761	1.0000	0.0000	0.0239	
83 8 27	12	135.3	132.1	0.0	3.2	0.9763	1.0000	0.0000	0.0237	
83 8 27	13	135.3	132.1	0.0	3.2	0.9763	1.0000	0.0000	0.0237	
83 8 27	14	136.8	132.1	0.0	4.7	0.9656	1.0000	0.0000	0.0344	
83 8 27	15	117.7	114.5	0.0	3.2	0.9728	1.0000	0.0000	0.0272	
83 8 27	16	108.8	104.1	0.0	4.7	0.9568	1.0000	0.0000	0.0432	
83 8 27	17	111.9	107.2	0.0	4.7	0.9580	1.0000	0.0000	0.0420	
83 8 27	18	134.7	131.5	0.0	3.2	0.9762	1.0000	0.0000	0.0238	
83 8 27	19	127.0	122.3	0.0	4.7	0.9630	1.0000	0.0000	0.0370	
83 8 27	20	141.7	138.5	0.0	3.2	0.9774	1.0000	0.0000	0.0226	
83 8 27	21	161.5	158.3	0.0	3.2	0.9802	1.0000	0.0000	0.0198	
83 8 27	22	149.4	146.2	0.0	3.2	0.9786	1.0000	0.0000	0.0214	
83 8 27	23	146.4	143.2	0.0	3.2	0.9781	1.0000	0.0000	0.0219	
83 8 27	24	143.9	140.7	0.0	3.2	0.9778	1.0000	0.0000	0.0222	

Appendix Table 2.--Report: average values of flow data for user time specified interval. Produced by PRINT/FLOWDATA program.

THIS REPORT WAS PRODUCED TO SHOW, FOR A USER SPECIFIED TIME PERIOD, THE AVERAGE WATER FLOWS ASSOCIATED WITH A PARTICULAR DAMSITE, AND SEVERAL RATIOS OF THESE FLOWS. THE SPECIFIED TIME PERIOD USED FOR THIS REPORT IS INDICATED BY ASTERISKS BENEATH ALL INCLUDED HOURS. THE DATE COLUMN HAS THE DATE OF THE LAST HOUR FOR THE SPECIFIED TIME PERIOD. FLOWS ARE MEASURED IN KILO CUBIC FEET PER SECOND (KCFS).

SPECIFIED TIME PERIOD

```
(FIRST DAY)    1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2    (SECOND DAY)   1 1 1 1 1 1 1 1 1 1 2 2 2 2
 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
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RIVER FLOW DATA AT THE MCNARY DAM SITE

DATE YY/MM/DD	AVERAGE HOURLY FLOWS				SELECTED FLOW RATIOS				COMMENTS
	TOTAL RIVER	TURBINE (ALL)	SPILL	OTHER	TURBINE / TOTAL	TURBINE / TUR+SPL	SPILL / TOTAL	OTHER / TOTAL	
83 1 1	131.2	127.7	0.0	3.5	0.9737	1.0000	0.0000	0.0263	* HOURLY RECORD MISSING *
83 1 2	136.3	132.6	0.0	3.7	0.9729	1.0000	0.0000	0.0271	
83 1 3	143.0	139.8	0.0	3.2	0.9776	1.0000	0.0000	0.0224	
83 1 4	126.2	122.7	0.0	3.5	0.9720	1.0000	0.0000	0.0280	
83 1 5	139.3	135.6	0.0	3.7	0.9734	1.0000	0.0000	0.0266	
83 1 6	186.2	182.5	0.0	3.7	0.9801	1.0000	0.0000	0.0199	
83 1 7	131.5	128.0	0.0	3.5	0.9731	1.0000	0.0000	0.0269	
83 1 8	106.9	103.7	0.0	3.2	0.9701	1.0000	0.0000	0.0299	
83 1 9	150.3	146.9	0.0	3.4	0.9776	1.0000	0.0000	0.0224	
83 1 10	149.7	146.3	0.0	3.4	0.9775	1.0000	0.0000	0.0225	
83 1 11	169.0	165.6	0.0	3.4	0.9801	1.0000	0.0000	0.0199	
83 1 12	151.3	148.1	0.0	3.2	0.9789	1.0000	0.0000	0.0211	
83 1 13	225.9	68.5	154.0	3.4	0.3032	0.3077	0.6819	0.0149	
83 1 14	214.5	92.5	118.8	3.2	0.4314	0.4379	0.5537	0.0149	
83 1 15	211.7	162.0	46.5	3.2	0.7652	0.7769	0.2197	0.0151	
83 1 16	159.9	155.9	0.0	4.0	0.9748	1.0000	0.0000	0.0252	
83 1 17	154.0	150.8	0.0	3.2	0.9792	1.0000	0.0000	0.0208	
83 1 18	194.8	191.3	0.0	3.5	0.9820	1.0000	0.0000	0.0180	
83 1 19	208.7	205.2	0.0	3.5	0.9831	1.0000	0.0000	0.0169	
83 1 20	185.7	182.0	0.0	3.7	0.9801	1.0000	0.0000	0.0199	
83 1 21	152.3	148.9	0.0	3.4	0.9779	1.0000	0.0000	0.0221	
83 1 22	180.0	176.3	0.0	3.7	0.9794	1.0000	0.0000	0.0206	
83 1 23	138.4	134.7	0.0	3.7	0.9733	1.0000	0.0000	0.0267	
83 1 24	168.0	164.5	0.0	3.5	0.9790	1.0000	0.0000	0.0210	
83 1 25	150.0	146.4	0.0	3.5	0.9764	1.0000	0.0000	0.0236	
83 1 26	190.5	186.8	0.0	3.7	0.9808	1.0000	0.0000	0.0192	
83 1 27	207.8	204.6	0.0	3.2	0.9847	1.0000	0.0000	0.0153	
83 1 28	155.5	152.4	0.0	3.2	0.9796	1.0000	0.0000	0.0204	
83 1 29	189.2	185.9	0.0	3.4	0.9822	1.0000	0.0000	0.0178	
83 1 30	148.6	145.3	0.0	3.4	0.9773	1.0000	0.0000	0.0227	
83 1 31	159.4	156.2	0.0	3.2	0.9799	1.0000	0.0000	0.0201	
83 2 1	160.4	157.4	0.0	3.0	0.9813	1.0000	0.0000	0.0187	
83 2 2	160.9	157.9	0.0	3.0	0.9811	1.0000	0.0000	0.0189	
83 2 3	206.0	202.8	0.0	3.2	0.9846	1.0000	0.0000	0.0154	
83 2 4	203.7	200.4	0.0	3.4	0.9835	1.0000	0.0000	0.0165	
83 2 5	207.6	197.2	7.2	3.2	0.9499	0.9648	0.0347	0.0154	
83 2 6	206.2	203.0	0.0	3.2	0.9845	1.0000	0.0000	0.0155	
83 2 7	209.6	206.4	0.0	3.2	0.9847	1.0000	0.0000	0.0153	

Appendix Table 3.--Report: daily population estimates.
Produced by DAILY/CATCH/PROGRAM.

DAILY SAMPLE CATCH AND PASSAGE ESTIMATE SUMMARY 1983

STEELHEAD MCNARY DAM DATE OF REPORT: 3/8/84

EFFICIENCY = 0.000 + 0.290(FLOW) WHEN FLOW < 35.0%
EFFICIENCY = -25.890 + 1.030(FLOW) WHEN FLOW >= 35.0%

DATE	TURBINE FLOW (%)	SAMPLING EFFICIENCY	NUMBER SAMPLED	NUMBER COLLECTED	ESTIMATED PASSAGE	
830424	27.62	8.01 %	118	356	4,446	
830425	23.47	6.81	374	629	9,237	
830426	33.02	9.58	1,151	1,476	15,409	
830427	24.07	6.98	633	1,319	18,889	
830428	25.37	7.36	1,354	1,736	23,593	
830429	51.09	26.73	913	1,535	5,741	
830430	34.38	9.97	749	2,456	24,633	
830501	30.95	8.98	1,702	3,545	39,499	
830502	37.87	13.12	1,718	3,579	27,284	
830503	38.55	13.82	3,831	9,505	68,792	-10%
830504	48.64	24.21	5,782	14,345	59,255	
830505	34.59	10.03	4,005	14,695	146,498	
830506	56.68	32.49	2,570	9,509	29,268	
830507	43.74	19.16	2,354	8,653	45,158	
830508	33.82	9.81	1,661	5,446	55,531	
830509	38.23	13.49	2,196	4,572	33,900	
830510	45.81	21.29	2,878	9,430	44,286	
830511	27.61	8.01	1,825	7,450	93,041	
830512	20.45	5.93	1,573	3,838	64,709	
830513	48.97	24.55	4,483	12,221	49,784	
830514	30.17	8.75	2,049	8,363	95,584	-50%
830515	39.95	15.26	2,906	8,303	54,412	
830516	41.58	16.94	2,775	7,928	46,808	
830517	71.91	48.18	2,521	7,687	15,955	
830518	79.94	56.45	1,972	9,619	17,041	
830519	73.86	50.19	1,642	9,330	18,590	
830520	66.39	42.49	2,731	13,322	31,352	
830521	72.27	48.55	2,120	9,506	19,581	
830522	69.03	45.21	2,420	12,804	28,321	
830523	50.29	25.91	2,320	11,558	44,609	
830524	30.99	8.99	3,596	11,791	131,200	
830525	73.98	50.31	4,568	9,515	18,913	
830526	37.52	12.76	1,540	7,319	57,380	
830527	38.84	14.12	2,227	5,525	39,144	
830528	50.06	25.67	2,734	6,719	26,172	
830529	50.37	25.99	821	2,692	10,358	
830530	47.94	23.49	1,331	4,364	18,581	
830531	50.63	26.26	2,013	5,751	21,902	
830601	52.69	28.38	1,421	5,224	18,405	-90%
830602	36.18	11.38	1,649	5,407	47,534	
830603	37.37	12.60	1,508	3,741	29,690	
830604	55.15	30.91	1,236	3,067	9,919	
830605	55.60	31.38	864	3,176	10,122	
830606	56.37	32.17	797	2,930	9,107	
830607	63.11	39.11	373	1,371	3,506	
830608	57.39	33.22	365	1,490	4,485	
830609	56.33	32.13	424	1,559	4,851	

DATE		TURBINE FLOW (%)	SAMPLING EFFICIENCY	NUMBER SAMPLED	NUMBER COLLECTED	ESTIMATED PASSAGE
830610		60.24	36.16 %	579	2,128	5,887
830611		61.64	37.60	376	1,382	3,676
830612		64.83	40.88	510	2,287	5,593
830613		68.65	44.82	457	2,049	4,572
830614		60.76	36.69	267	1,302	3,550
830615		69.84	46.05	182	755	1,639
830616		76.00	52.39	198	966	1,844
830617		72.59	48.88	200	1,212	2,480
830618		72.54	48.83	27	540	1,106
830619		89.48	66.27	26	628	947
830620		76.40	52.80	23	460	871
830621		77.86	54.31	30	600	1,105
830622		74.73	51.08	189	1,165	2,280
830623		95.77	72.75	30	470	645
830624		100.00	77.11	14	700	908
830625		100.00	77.11	1	50	65
830626		100.00	77.11	6	300	389
830627		100.00	77.11	7	350	454
830628		100.00	77.11	5	250	324
830629		100.00	77.11	52	116	150
830630		100.00	77.11	110	262	340
830701		100.00	77.11	14	280	363
830702		100.00	77.11	12	239	309
830703		100.00	77.11	5	100	130
830704		100.00	77.11	6	120	156
830705		100.00	77.11	5	250	324
830706		99.99	77.10	5	250	324
830707		100.00	77.11	19	211	274
830708		100.00	77.11	32	320	415
830709		100.00	77.11	3	150	195
830710		100.00	77.11	115	166	215
830711		100.00	77.11	42	109	142
830712		100.00	77.11	18	273	354
830713		100.00	77.11	1	25	33
830714		100.00	77.11	1	20	26
830715		100.00	77.11	7	84	109
830716		100.00	77.11	4	26	34
830717		51.59	27.25	3	166	610
830718		100.00	77.11	6	70	91
830719		98.52	75.59	5	35	47
830720		100.00	77.11	25	76	98
830721		100.00	77.11	19	59	77
830722		100.00	77.11	18	59	76
830723		100.00	77.11	13	54	70
830724		100.00	77.11	1	50	65
830725		100.00	77.11	23	41	53
830726		100.00	77.11	11	42	55
830727		100.00				
830728	2	100.00	77.11	14	28	36
830729		100.00	77.11	10	14	19
830730		100.00	77.11	2	4	5
830731		100.00	77.11	0		
830801		100.00	77.11	11	13	17
830802		100.00	77.11	5	6	8
830803		100.00	77.11	3	7	9

DATE	TURBINE FLOW (%)	SAMPLING EFFICIENCY	NUMBER SAMPLED	NUMBER COLLECTED	ESTIMATED PASSAGE
830804	100.00	77.11 %	0		
830805	100.00	77.11	2	3	4
830806	100.00	77.11	3	24	31
830807	100.00	77.11	0	0	0
830808	100.00	77.11	0	0	0
830809	100.00	77.11	2	41	54
830810	100.00	77.11	3	4	5
830811	100.00	77.11	3	4	5
830812	100.00	77.11	0	0	0
830813	100.00	77.11	0	0	0
830814	100.00	77.11	0	0	0
830815	100.00	77.11	1	20	26
830816	100.00	77.11	0	0	0
830817	100.00	77.11	3	3	4
830818	100.00	77.11	3	3	4
830819	100.00	77.11	3	5	7
830820	100.00	77.11	0		
830821	100.00	77.11	0	0	0
830822	100.00	77.11	2	40	52
830823	100.00	77.11	0		
830824	100.00	77.11	3	3	4
830825	100.00	77.11	0	0	0
830826	100.00	77.11	2	40	52
830827	100.00	77.11	0	0	0
830828	100.00	77.11	0	0	0
830829	100.00	77.11	1	14	18
	TOTALS		96,571	317,879	1,736,305

Appendix Table 4.--Report: daily brand recapture summary.
Produced by BRAND/RECAPTURE/PROGRAM.
Only page 1 of the report is presented to
illustrate its contents.

BRAND RECAPTURE SUMMARY MCNARY DAM PAGE 1

EFFECTIVE DATES: 4/1/83 THRU 8/31/83

LA G 3 MARKED CHINOOK 1*S

DATE	NUMBER SAMPLED	NUMBER COLLECTED	ESTIMATED PASSAGE
830501	1	2	16
TOTALS	1	2	16

RA G 3 MARKED CHINOOK 1*S

DATE	NUMBER SAMPLED	NUMBER COLLECTED	ESTIMATED PASSAGE
830426	1	1	9
830506	1	4	16
TOTALS	2	5	25

RD G 1 MARKED CHINOOK 1*S

DATE	NUMBER SAMPLED	NUMBER COLLECTED	ESTIMATED PASSAGE
830505	1	4	26
TOTALS	1	4	26

RD G 3 MARKED CHINOOK 1*S

DATE	NUMBER SAMPLED	NUMBER COLLECTED	ESTIMATED PASSAGE
830424	1	3	26
830426	1	1	9
830430	1	3	23
830502	1	2	13
TOTALS	4	9	71

LA IC 2 MARKED CHINOOK 1*S

DATE	NUMBER SAMPLED	NUMBER COLLECTED	ESTIMATED PASSAGE
830425	1	2	17
TOTALS	1	2	17