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Automated Telemetry Data Retrieval and Organization

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Whether using remotely sensed tags for small-scale animal movement studies or large-scale survival and behavioral analyses, data retrieval and organization are often the most time-consuming and technically challenging aspects of a telemetry research project. Furthermore, the complexity and quantity of telemetry data can make analysis and interpretation difficult. Using a radiotelemetry study of juvenile salmonid passage and survival as an example, we describe steps one can take to automate much of this process, increasing overall project productivity as well as data accuracy and retrieval reliability.

From 2 May to 15 July 2005, we radio-tagged and released almost 15,000 juvenile salmonids in the Snake River and tracked their downstream migration through the hydropower system, generating over 4 gigabytes of raw data. Release locations ranged from the Ice Harbor Dam tailrace to the forebay of Lower Monumental Dam, a distance of about 60 km. We collected positional data using an array of 74 stationary radiotelemetry receivers distributed within a 120-km reach of the lower Snake and mid-Columbia rivers (Figure 1).

Figure 1. A typical stationary radiotelemetry site, near McNary Dam on the Columbia River. An antenna and two solar panels provide power to the radiotelemetry receiver located in the cabinet under the bottom solar panel.

We released tags on nine separate frequencies, and each of our stationary receivers was programmed to listen for all frequencies simultaneously. When a tag was detected, the receiver decoded the signal and recorded one line of data to a local file containing the time stamp of the detection, the channel and code (that together uniquely identify the fish), and power (signal strength) recorded in a hexadecimal format. This data collection sequence is common to most telemetry studies.

Receivers grouped in the same geographical area, such as a dam, were networked to a local computer using wireless Ethernet radios. The computer was connected to the Internet, allowing access to the receivers and their data from anywhere with an Internet connection (Figure 2). Files were automatically downloaded from the receivers using a program called Tracker2. This program was produced via contract by the White Salmon Group (White Salmon, Washington) to help organize the downloading and maintenance of radiotelemetry receivers. On a preset schedule, Tracker2 contacted each receiver, downloaded the current file, reset the receiver's clock (to maintain consistency between receivers), and cleared the memory of the receiver. In addition to automated downloading, we were able to contact each receiver directly using Tracker2 for diagnostics.

Each morning, we collated all the files from the previous day and sent them to a local server via file transfer protocol (FTP). To help accomplish this task, we used an FTP program, FTPShell, which allowed 1) a script to send the appropriate files (using its own native scripting language) and 2) scheduling scripts so that file transfers could be done automatically.

Once all the files for a given day were stored on our FTP server (ftp.afsc.noaa.gov), we transferred them to the Linux server that runs our Oracle database. We used a script scheduling capability in Linux to deal with the files and the data. Each file was converted from hexadecimal format to ASCII text (using a C program) and loaded into a temporary table in Oracle using sqlldr, an Oracle bulk data loading program. Filters were then applied to the data with Procedural Language/Structured Query Language (PL/SQL) code, which sorted out the potentially informational records from the obvious noise records, associated tag detections with the appropriate release record, and flagged any duplicate records. By using one piece of code stored in the database, we ensured that all data were treated equally (i.e., the exact same "rules" were applied to all data), increasing data quality. Furthermore, if we decided to change the rules, a simple alteration of the PL/SQL code and rerunning the PL/SQL program was all that was necessary.

We then summarized the data, again using PL/SQL, and generated reports specifying the content of the files received that day. These reports were sent via e-mail to a list of recipients specific to each type of data. For example, the reports associated with tagging and release events were sent to one group of researchers while a report describing receiver diagnostics was sent to another group of researchers. These e-mail lists were maintained on the server and used a script written in Perl. All processing, receiver diagnostics, and detection summary reports were complete and e-mailed by 7 AM daily.

Occasionally difficulties arose with some of these automated tasks. Sometimes a server would be inadvertently shut down, or a script might encounter an error while running. When this occurred, we were alerted to the failure either by the contents of the reports we received or by specific system error e-mail reports. Sometimes an error simply meant rerunning a script; other times it meant checking a list of files or a receiver in the field for troubleshooting. However, the delays caused by these events were minor compared to the amount of time necessary to run a project of this size without the use of automation.

Automation of remote data retrieval, filtering, and summarization ensured that we addressed problems with receivers, such as a loss of power, in a timely manner and that abnormal fish behavior could be recognized in season. This timely supply of information can often drive the schedule for tagging additional fish or receiver maintenance and repair, reducing the downtime of receivers, and increasing the efficiency and success of the researchers' efforts. Moreover, any or all of these steps can be modified to fit individual research projects, regardless of scope or tagging methodology. As with most aspects of research, some foresight and initial time investment can ultimately result in large savings of time and money, as well as an increase in data quality.

Figure 2. The wireless arrangement for one receiver-antenna combination (not shown) installed on the on the deck of the McNary Dam. All of the receivers are connected to a local computer, which can be accessed through the Internet.